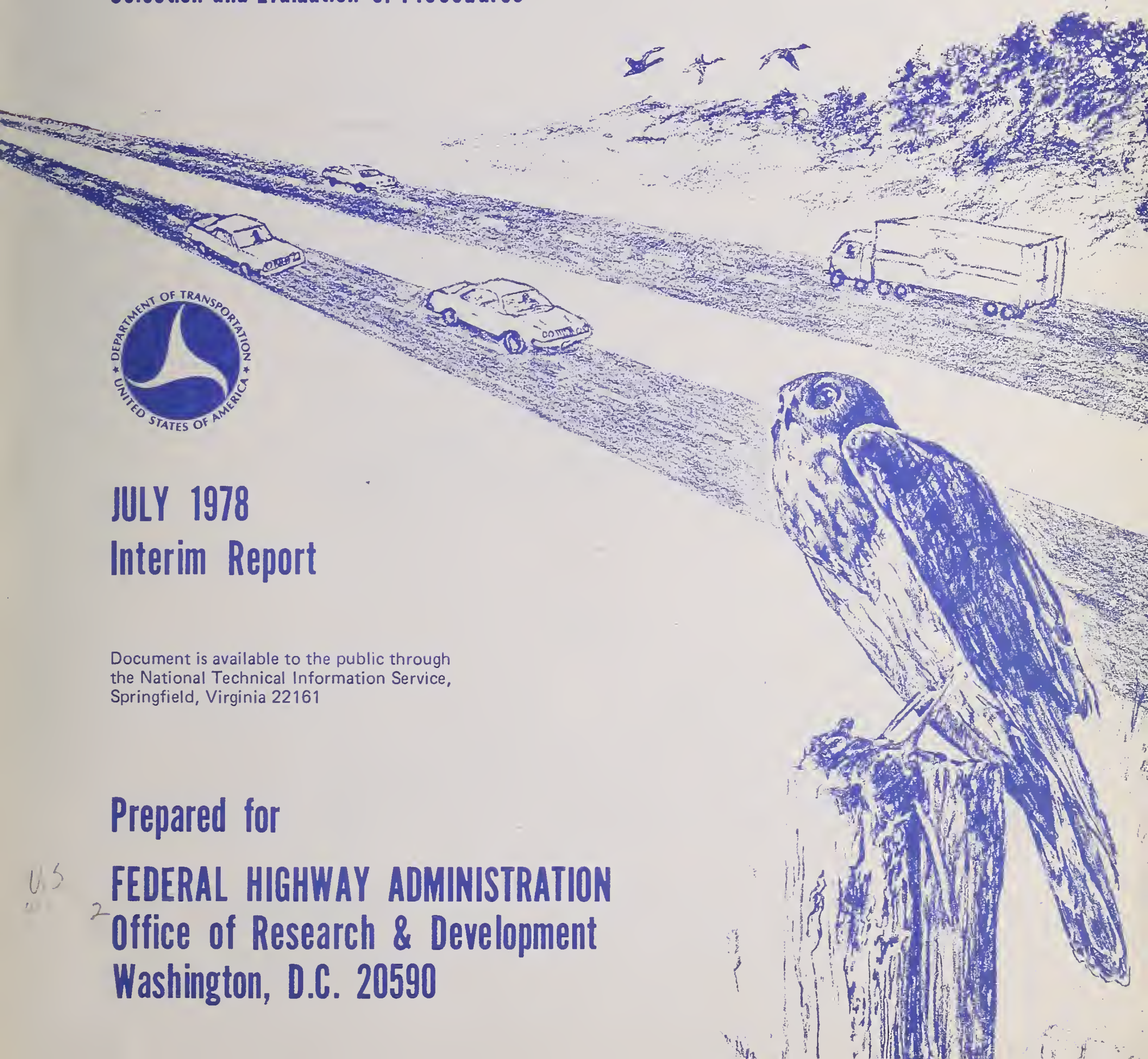
ort No. FHWA-RD-78-92

FECTS OF HIGHWAYS ON WILDLIFE POPULATIONS AND HABITATS

Phase 1

Selection and Evaluation of Procedures



JULY 1978

Interim Report

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Prepared for

FEDERAL HIGHWAY ADMINISTRATION
Office of Research & Development
Washington, D.C. 20590

FOREWORD

This report documents the work conducted under Phase I of a study concerned with effects of highways on wildlife populations and habitats. The report discusses the development of sampling procedures for use in Phase II of the study. These procedures will be of value to environmental specialists responsible for impact assessments and to wildlife biologists in other agencies with similar concerns.

Research concerning the impact of highway design, construction, maintenance, or operation on wildlife is included under Task 2 of Project 3F, "Pollution Reduction and Environmental Enhancement" of the Federally Coordinated Program of Research and Development. Dr. Howard Jongedyk is the Project Manager and Mr. Douglas L. Smith is the Task Manager.

Sufficient copies of the report are being distributed to provide one copy to each FHWA regional and division office, two copies to each State highway agency, and one copy to the State's wildlife agency. Direct distribution is being made to the division offices.

Charles F. Scheffey
Director, Office of Research
Federal Highway Administration

NOTICE

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16. Abstract

This work summarizes Phase I of a two-part investigation into the effects of highways on wildlife populations and habitats. Phase I was undertaken to select, test, and evaluate techniques and procedures for rapid and efficient assessment of wildlife populations and habitats in relation to roads and highways in the Pacific Northwest, the Midwest Tillplain, and the Southern Piedmont of the United States. Specific recommendations are made concerning cluster configuration for sampling units, and habitat, bird, mammal, amphibian, reptile, and wildlife road mortality surveys for Phase II of the study. In addition, detailed field procedures selected for the second phase of the study are presented.

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Dr. George V. Burger, General Manager, Max McGraw Wildlife Foundation, provided a comfortable meeting place mid-way through the study for all parties involved to discuss their work up to that point.

Reviewer comments by D.L. Leedy, D.L. Smith, and T.M. Franklin were helpful as were editorial comments by A.S. Federighi and R.H. Hissey. The difficult task of typing the final copy was performed by L.E. Dove.

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INTRODUCTION

This study was undertaken by the Department of Transportation, Federal Highway Administration, and contracted to the U.S. Fish and Wildlife Service to help determine the effects of highways on the environment. The study was divided into two parts: an investigation of appropriate field techniques and procedures (Phase I), and the collection and analysis of data (Phase II). This report discusses the Phase I portion of the study, which was supervised by Dr. Aelred D. Geis of the U.S. Fish and Wildlife Service. Much of Phase I and all of Phase II will be carried out by personnel of the Urban Wildlife Research Center under the direction of Dr. Lowell W. Adams.

The study is designed to evaluate the effects of highways on animal distribution and abundance in the Pacific Northwest, the Midwest Tillplain, and the Southern Piedmon Specific objectives are to:

1 - determine what effects, either positive or negat highways have on the diversity and spatial distr bution of wildlife species and their habitats;
2 - develop a system of predicting and evaluating th impact of roads on plant and animal communities;
3 - make general recommendations on how to minimize adverse effects and maximize beneficial effects; and
4 - make recommendations for further research.

Phase I was undertaken to select, test, and evaluate techniques and procedures for rapid and efficient assessments of wildlife populations and habitats in relation to roads and highways. Work under this phase was performed by personnel associated with the Oregon Cooperative Wildlife Research Unit (OCWRU), the Urban Wildlife Research Center, Inc. (UWRC), and the Wisconsin Cooperative Wildlife Research Unit (WCWRU). Work was performed in different parts of the country in anticipation of potential problems arising from applying a standardized technique developed in one region to other areas of the country.

Although these procedures and techniques were developed specifically for Phase II of the current study, they also should be applicable elsewhere, specifically, for use by Federal and State highway personnel in determining effects of their actions on the environment and for use by other organizations charged with the same task.

To date, agencies faced with determining impacts of various human activities on the environment have operated under severe time restraints. In general, adequate time has not been allowed to obtain the data necessary to adequately determine environmental impacts.

Techniques utilized for many of these impact assessments should be standardized (for comparative purposes) and be capable of rapid and efficient execution (so that quantitative data can be obtained for predictive purposes early in the planning process). With this in mind, procedures and techniques selected for testing and evaluation in this phase of the study were those yielding quantitative indices to wildlife populations.

Specific objectives of Phase I were to determine:

1 - the best techniques for obtaining valid indices to animal use of study plots;
2 - the best plot sizes and arrangement of plots in relation to roads for sampling birds, mammals, amphibians and reptiles, and habitat;
3 - the appropriate time of year for sampling each animal group;
4 - the appropriate time of day for sampling each animal group;
5 - the appropriate control distance (from road) for each animal group;
6 - the appropriate amount of time that should be spent on each animal group;
7 - the best method for surveying road-killed animals; and
8 - appropriate habitat measurements for use in correlation with wildlife populations.

The Selection and Evaluation of Techniques and Procedures section of this report summarizes the final reports submitted by the above-mentioned organizations to the U.S. Fish and Wildlife Service (Getz et al. 1977, Bruner et al. 1977, Tabor and Meslow 1977). The contents of each section are presented essentially as they appeared in final reports for each study. The material has been reorganized by subject; tables of quantitative data were omitted to produce a more easily readable document that still contains all essential information of the work performed in Phase I.

We have summarized the recommendations made in Phase I of this study (Appendix A). The reader interested in more detail should contact one of the authors of this report.

As the reader will note from this report, recommendations differ among the three organizations that conducted Phase I of the study. In some cases this reflects different geographical conditions, but in others, different opinions of the investigators. Final decisions on field procedures for the operational phase were made following critical reviews of Phase I final reports, further discussions with the biologists involved with those reports, discussions with other biologists, and our own experience. The field procedures we selected for Phase II (Appendix B) are the ones we believe will allow us to meet the objectives of this study most effectively.

Common names of plants and animals are used exclusively in the report, but appropriate scientific names are included in Appendix C.

SELECTION AND EVALUATION OF TECHNIQUES AND PROCEDURES

AMPHIBIANS AND REPTILES

Oregon Study Area
James E. Tabor

Methods

Techniques - Methods tested for sampling amphibians and reptiles during the spring and summer sampling periods emphasized counts of animals made during searches of circular plots of 50 m^2 (4-m radius) and 100 m^2 (approximately 5.6-m radius) in size. During the winter sampling period, drift fences were employed in addition to the methods described above.

Surveys were conducted along one 100-m x 450-m belt transect perpendicular to the road at each of eight study areas. Visual observation of amphibians and reptiles in the seventy-eight 50-m^2 circular plots per study area during large mammal pellet group and sign counts and during daily visits to the plots to tend small mammal traps, was one method of inventory evaluated during each sampling period. During this count, the plots were not disturbed; only the surface of the ground and objects on it were examined. All reptiles and amphibians observed and the general weather conditions were recorded.

A more intensive search made specifically for amphibians and reptiles was conducted in the circular plots after the count made in conjunction with pellet group and sign counts, and after small mammal trapping had been completed in each area during the spring and winter. During this search, the surface of the ground, and rocks, logs, tree trunks, stumps and other objects within the 50-m^2 plots were examined. All rocks, logs, bark, and other objects lying on the ground were moved in order to inspect the ground surface under them. Loose bark on logs and stumps was removed. Rotten logs and stumps present in the plot were torn apart. Areas containing loose gravel or rock were raked or dug to a depth of 10-15 cm. Streams or pools of water were examined carefully. After each 50-m^2 plot was searched in the manner described above, an additional 50 m^2 contained in a band approximately 1.6 m wide around the periphery of the original 50-m^2 plot was searched in the same manner. Animals observed in this extended plot were recorded separately from those recorded within the original plot. This procedure was followed during the spring and summer sampling periods. Only the large plot (100 m^2) was surveyed in winter.

Drift fences were constructed and operated at each study area during the winter sampling period. In addition, ground searches were conducted at each study area after drift fences had been in operation for at least one week in order to compare the relative efficiences of the two methods. Four fences, 15.2 m in length, were constructed at each study area. Fences were located in the roadside ditch, and at 100, 200, and 300 m from the road. The first and third fences were oriented parallel to the road, the second and fourth perpendicular to the road. Black sheet plastic, 0.9 m in height, was used for the fences. The plastic was stapled to lath stakes for support. The bottom of the plastic was buried in a shallow trench, or if this was not possible, soil was placed on the plastic in such a way as to insure that an amphibian or reptile could not pass under the fence. Two No. 10 food cans were buried level with the surface of the ground on each side of the fence, and two cans were placed at each end of the fence (total of 6 cans) to catch animals moving along the fence. Most cans were fitted with a "funnel" made from plastic-coated paper bowls; the remaining were made twice the original depth by removing the bottom of one can and taping it to another can. One wire funnel trap made from screen wire was used on each side of the fences constructed at the clearcut Douglas-fir study area. Fences were examined at 1-3 day intervals and all animals caught were released.

In addition to searches conducted in circular plots and sampling with drift fences, all amphibians and reptiles seen or heard while sampling mammals, birds, and vegetation were recorded.

Season - Methods for sampling amphibians and reptiles were field-tested during three sampling periods - spring (19 April - 11 June), summer (13-26 July), and winter (8 November-31 January). In addition, a small amount of sampling was done in fall (30 September - 7 November).

Findings

Several species of amphibians and reptiles known to occur in western Oregon and Washington and northwestern California were not observed in our study areas (Stebbins 1966). Inventory methods we tested should, however, be appropriate for sampling all species present in the Pacific Northwest.

Data obtained for the winter sampling period were very disappointing. The number of observations of amphibians was far below what was expected. The Pacific Northwest experienced a much drier, colder, and earlier winter in 1976 (when sampling was done) than normal for the region. The dry and cold conditions were not conducive to the normal winter activity of amphibians. Amphibians were not active on the surface of the ground nor present near the surface where they could be found consistently with the methods we tested. As a result of the inactivity of amphibians, we were unable to adequately evaluate the sampling methods for this animal group.

Techniques - Each of the three sampling methods tested in spring (i.e. superficial ground search conducted in conjunction with the pellet group and sign count survey, intensive ground search made specifically for amphibians and reptiles, and audio and visual observations made while sampling birds) produced observations of both amphibians and reptiles. During the winter sampling period, each of the three methods used in spring and the drift fence technique (not tested in spring) produced data on amphibians. Reptiles (one species at one study area) were identified only during superficial counts in winter. The primary reason for this was that the superficial searches were conducted earlier in the season than the other three methods. Reptiles were not active because of cold weather later in the season when the other methods were tested. The only method tested in all study areas in summer, the intensive ground search, was successful for both amphibians and reptiles. Drift fences operated in the clearcut Douglas-fir study area during early fall (29 September - 13 October) captured a small number of reptiles.

Additional observations were made with methods other than the four tested for amphibians and reptiles. Several rough-skinned newts, several northern alligator lizards, and one western fence lizard were captured in snap traps set for small mammals in spring. Occasional observations of the rough-skinned newt, Pacific giant salamander, western red-backed salamander, Pacific treefrog, western fence lizard, western skink, northern alligator lizard, southern alligator lizard, common garter snake, and northwestern garter snake were made while tending small mammal traps and while sampling vegetation.

Intensive ground searches, which involved looking specifically for amphibians and reptiles in suitable microhabitats, provided the most data for this animal group. A larger number of species and total number of individuals were found with this method in both summer and winter when compared with the other techniques. Sixty-one metres of drift fence operated for a total of 180 nights (7-74 nights of operation per study area) during the fall and winter in eight study areas did not provide as many observations (49) as the intensive ground search (52).

Intensive ground searches produced more individuals of more species of amphibians in both spring and winter. In spring, this method was far superior to other methods tested. In winter, the catch made at drift fences during a 7-day period that included the date of the intensive ground search, included almost as many species but considerably fewer total observations than the intensive ground search. Observations while sampling birds in winter produced only 35 percent fewer total observations than the intensive ground search but identified only two species, as compared to six identified by the search. Superficial ground searches produced few observations and identified only four species in winter.

The intensive ground search was clearly the best of the methods tested for salamanders in both sampling seasons in terms of volume of data produced. This method accounted for 98 percent of all observations of salamanders in spring. In winter, 71 percent of all salamanders were observed during intensive ground searches, 21 percent recorded from drift fences, 6 percent recorded from superficial searches, and 2 percent (one individual) recorded during sampling of birds.

Most observations of frogs, almost exclusively Pacific treefrogs, during both seasons, were made while sampling birds. Almost all observations were auditory. Only two of 46 (4 percent) observations made while sampling birds were visual.

Spring and winter sampling seasons used in this study were marginal times of the year for sampling reptiles because weather conditions during most of each season were not conducive to reptile activity. As a result, few reptiles were observed during these seasons. Successful sampling of reptiles depended on their being active on or near the ground surface. We were not successful in finding reptiles in areas where they were known to occur unless they were active on the surface. Drift fences operated in the clearcut Douglas-fir study area, where we previously had observed northwestern garter snakes, common garter snakes, northern alligator lizards, and western fence lizards, captured these species except the common garter snake, though not in large numbers. The drift fences, operated for 15 days (29 September - 13 October) produced two northern alligator lizards, one western fence lizard, and one northwestern garter snake.

Because the methods were not tested at exactly the same time the data do not adequately evaluate the methods for sampling reptiles. Tremendous variation was observed in activity of reptiles from day to day on the same areas. If a method was tested at an area on a day, or even a particular time of day, when reptiles were active, the results could not be compared "fairly" to results of a method tested at the same area on a day when reptiles were inactive.

The amount of effort (man-hours) required to sample amphibians and reptiles was least for the superficial ground search and observations while sampling birds, primarily because sampling was done in conjunction with other surveys. The intensive ground search and drift fence methods required more effort than the other two methods; not only because sampling was done specifically for amphibians and reptiles, but, also, the actual sampling process was more time-consuming. The drift fence method required by far the greatest amount of effort.

Superficial ground searches, conducted along with pellet group and sign count surveys for large mammals, required an average of 4 hours per study area for seventy-eight 50-m^2 circular plots and ranged from about 2.5 to 8 hours. Time required to conduct the intensive ground search (excluding pellet and sign counts for mammals) in 100-m^2 plots at the same 78 sites at each study area averaged about the same as time required for the superficial search but ranged from 1.5 to 10 hours per area. Amount of time required for the intensive search depended on how many logs, large rocks, or other objects were present. Those objects (microhabitats) required time to be torn apart or moved. Plots 100 m^2 in size containing no such objects actually required less time to search intensively for amphibians and reptiles than was required to conduct the superficial ground search during which pellet groups also were counted.

Man-hours of effort spent for operation of drift fences consisted of time required to construct the fence, maintain it, and visit it for recording captured animals. We spent an average of about 8 hours per study area to erect four 15.2-m fences. Construction was relatively simple and fast in places where the terrain was flat and where thick vegetation, especially shrubs, was absent. At sites where the terrain was irregular and/or where thick vegetation occurred, fences were very difficult to establish. We spent about 20 man-hours constructing four 15.2-m fences at the clearcut Doublas-fir study area.

Plot size for intensive ground search - The number of species and individuals found in the 1.6-m band around each 50-m^2 plot provided an appreciable number of observations as expected. The additional time required to sample the extra 50-m^2 area was insignificant. In plots with no hiding places for amphibians and reptiles (e.g., large rocks, logs, ponds), no extra time was needed because a radius of 5.6 m could be searched just as quickly as one of 4 m for amphibians and reptiles active on the surface. In plots containing hiding places, sampling time was increased slightly.

We did not examine it specifically, but the number of amphibians and reptiles (especially amphibians) appeared to be positively correlated with the number of hiding places contained within the plot.

Control distance - Our data do not provide a reliable indication of the effect of roads on the distribution and abundance of amphibians and reptiles as a group. The presence of suitable microhabitat, in our opinion, not distance from the road, accounted for the differences in number of observations in this study.

Wisconsin Study Area

Ruth L. Hines, Richard C. Vogt

Methods

Drift fences were tested and evaluated from April through November 1976 for use as an amphibian and reptile survey technique. Material, length, height, and positioning of fence, size and type of pits, funnel traps, season, weather, and length of time needed to sample were tested in order to formulate a standardized method.

A drift fence is a barrier to movements of terrestrial amphibians and reptiles. The fence must be high enough to prevent animals from going over it, tight to the ground to prevent animals from going under it, and of such a nature as to induce animals to move along it rather than through it. Reptiles and amphibians moving through their habitat are stopped by the fence; as they attempt to go around it they are captured in traps. The sampling unit in this study was defined as the length of the drift fence.

The following materials were used for fencing and traps:

- Aluminum valley (or flashing) - 15-m rolls, 50 cm high
- Aluminum window screen - 15-m rolls, 60 cm high
- Galvanized sheet metal - 3 m x 60 cm
- 1-m angle iron stakes
- 1-m wire stakes
- 1-m wood lath
- 3.8-litre cans (No. 10) with funnels
- 7.6-litre cans, made by cutting the bottom out of one No. 10 can and securing it to another No. 10 can with 7.5 cm duct tape
- Plastic bowls with bottoms removed (and lids) for attachment to 3.8-and 7.6-litre cans as funnels
- 18.9-litre plastic ice cream buckets with lids
- 2-door funnel traps (after Fitch 1951)

Drift fences made from the aluminum valley were set up in either 15-m or 30-m lengths, with the lower 10 cm below the ground surface to keep animals from going under the fence. A galvanized metal stake was set at each end of the aluminum (Fig. 1). The aluminum screen was set in 7.5-m to 30-m lengths, with the lower 10 cm below the ground surface, and staked with wood lath every 2 m. The galvanized metal sheets were fastened together, buried 15 cm underground, and staked with galvanized angle iron between each sheet.

A combination of funnel traps and the following types of pit traps were used: 3.8-litre cans with and without funnels, 7.6-litre cans with and without funnels, and 18.9-litre buckets. Traps were set at various distances along the fence. Pit traps were buried flush with the surface of the soil; funnel traps were set against the fence and tight against the soil. Traps were checked at least every other day and all animals caught were marked and released 3 m from the trap on the opposite side of the fence.

Test trap lines were set up with the same number of each type of trap on both sides of the fence. Usually the same number of each type of trap was used per line. The quantity of animals that was being caught did not warrant the rotating of trap positions.

Sampling was conducted in three basic habitat types - oak-hickory woodlots, wetland/old fields, and prairies. Shaw Marsh, Busse Tract, and Point Beach sites were located in oak-hickory woodlots; Portage and Long Lake sites were located in wetland/old field habitats. The Blue River site consisted of active sand dunes, flat sand barrens and stabilized dunes forested with oaks. The Spring Green site consisted of sand barrens, prairie and old fields.

Findings

Drift fence material - In comparing aluminum valley, aluminum screen, and galvanized metal for use as drift fence materials, their effectiveness in catching animals, convenience, durability, and cost were considered. The traditional measurement for animals caught in traps is number caught per trap day. Our data indicated a slightly higher catch rate for the aluminum screen fence.

The number of traps was not the best measurement of catch, however, since they were not a limiting factor (i.e., the traps present were never full and an animal always had an "opportunity" to be caught). Therefore, the unit of measurement regarded as most reliable was number of animals caught per 15 m of fence. With this measurement, a slightly higher

Fig. 1. A drift fence used for capturing amphibians and reptiles.

number of animals were caught with drift fences made from aluminum valley than fences made from aluminum screen (33 and 31 animals per 15 m of fence-day x 100, respectively).

Fences made with both materials also caught all forms and all but the rarest species present. A potential drawback to the screen is the ability of some animals to crawl over it. This may have happened with the salamanders - only six salamanders were caught with 120 m of screen while there were 18 caught with only 7.5 m of aluminum. On three separate occasions, garter snakes were seen going over the screen fences, once without being pursued, and twice when an observer was walking along the fence. The same size snakes were never seen going over the aluminum valley. The use of numerous stakes along the screen fence provided "ladders" for many small snakes, lizards and salamanders to work their way over the fence. This was not the case with aluminum valley.

Galvanized metal used at our Blue River site was an effective barrier to all forms known to inhabit that prairie. Drift fencing made from galvanized metal was successful in catching animals (25 per 15 m of fence-day x 100). However, these results are not directly comparable to the catch resulting from the use of the other two fence materials because of the differences in the study areas. Evidence from trails in the sand showed no snakes or lizards going over the fence.

Screen weighs much less than the solid aluminum and, therefore, is easier to carry. A roll of aluminum weighs 9.1 kg, rolls into 41 cm in diameter, and is not much more difficult to carry than the screen. The aluminum has nearly the same flexibility as screen for going around logs, rocks and trees. With both materials, a trench must be dug and the fence slipped into it and covered. With aluminum fence, a stake is needed only at each end; with screen a stake is needed at least every 3 m or the fence sags and animals crawl over it more easily. Aluminum fence stands up better over continued use; screen tends to tear and get matted with dirt and debris.

Galvanized metal is excellent for a permanent fence, but since sheets weigh 18.1 kg apiece and cannot be rolled and transported easily, it was ruled out as a possible material for this study.

Based on prices at the time of the study, aluminum valley was approximately 40 percent higher in cost than the screen.

<u>Length, height and position of fence</u> - Fence lengths of 3-60 m were tested. Generally, the more fence set, the

more animals caught. Pieces of fence shorter than 15 m, however, were too short to yield enough animals to make their use worthwhile. A comparison of the catch along two pairs of 30-m and 15-m lengths of fence set perpendicular to each other was made in two old fields at our Portage site. The use of twice as much fence resulted in the catch of about twice as many animals during the same length of time (5 months). Two 30-m sections set perpendicular to each other in a third old field caught comparable numbers of animals.

A fence needs to be high enough to discourage snakes from attempting to crawl over it or adult frogs from jumping over it. The minimum height used, 50 cm, was sufficient to capture two 20 cm fox snakes, seven snakes over 40 cm, and hundreds of smaller ones. Any fence higher than this would be too unwieldly and apparently is not necessary for a census method.

There were considerable differences in catch along various sections of fence even within the same field and between adjacent fence lines. For example, at our Portage site, on 12 October, one 18.9-litre pit trap caught 14 snakes while the other nine pit traps and two funnel traps caught a total of only five snakes. This suggests that several shorter lengths of fence in different areas of the habitat, facing different compass directions, are more effective in recording both numbers and diversity of animals than a few long lengths of fence. Evidence for this was displayed at most areas trapped.

The examples below show the importance of setting fences perpendicularly to one another in order to obtain the best sample of the amphibian and reptile community of an area. At the Portage site, line 2 (set parallel to the marsh edge) produced only 19 snakes on the marsh side of the line while the upland side yielded 48. Line 3, set perpendicularly to line 2, showed no difference in the number of snakes on either side of the fence. For amphibians, line 2 showed no difference in the number caught on either side (40 vs. 49) while on line 3, 68 amphibians were caught on the east side and only 16 on the west side. (Twenty-nine of the 68 were northern leopard frogs caught on a single day after a rain on 5 October.) It is possible that the frogs were moving toward Duck Creek, a potential hibernaculum which was on the west side of the fence. Line 5 was set perpendicularly to line 4 and showed no side bias for snakes or amphibians. Line 4 showed no side bias for snakes, but 18 of 21 amphibians were caught on the west side of the fence.

Types of traps - Four different types of traps were set along drift fences to determine which were most effective and most efficient in capturing amphibians and reptiles. Funnel traps were clearly more effective than pit traps for catching lizards. Of the pit traps, 18.9- and 7.6-litre traps with funnels were more effective than the 7.6-litre traps without funnels or 3.8-litre traps with funnels.

Funnel traps also proved to be effective for catching snakes. At Blue River, nine snakes, all over 40 cm and two over 1.2 m, were caught in funnel traps. Only one longer than 18 cm was caught in a pit trap. This compares to Portage old fields where all seven snakes over 40 cm were caught in funnel traps. Only small snakes were retained in pit traps. The largest pit traps (18.9 litre) obviously were superior to the same number of 7.6-litre cans (4.6 vs. 0.6 snakes caught per trap-day x 100).

Amphibians were caught equally in both 7.6-and 18.9-litre pit traps tested at the Portage sites. The smallest pit traps (3.8 litre) with funnels caught only a negligible number of amphibians. At the woodland pond site at Portage, the use of 3.8-litre traps with funnels vs. 7.6-litre traps without funnels was tested; 7.6-litre traps were highly superior, capturing 50 individuals as compared with five for the smaller traps. Adult green frogs were observed at Blue River getting out of 7.6-litre traps without funnels, but not out of those with funnels. However, 7.6-litre traps without funnels worked well for juvenile frogs.

Frogs and salamanders were caught rarely in funnel traps. Although there were numerous tree frogs calling at Portage in the spring, very few were collected. This may have been due in part to the location of the majority of fences outside the woods or to the ability of the frogs with their suction feet to crawl readily over fences and out of pit traps.

There were no differences in the capturing of toads among 3.8-, 7.6-, and 18.9-litre pit traps (all without funnels) at the Busse Tract, while at Shaw Marsh there was a much higher catch with the 3.8-litre traps.

The largest pit trap (18.9 litre) was necessary for capturing large adult turtles. Fifteen of the 21 adult turtles caught at Blue River were in this type trap. Four fell into 7.6-litre cans and two jammed their shells into 3.8-litre cans with funnels. Portage also showed this with nine turtles caught in 18.9-litre, 11 in 7.6-litre, and three in 3.8-litre traps. Hatchling turtles at both areas fell readily into any size pit.

In summary, 18.9-litre pit traps are necessary for trapping adult turtles and are highly effective for small snakes and amphibians and lizards. Two trap sizes (7.6- and 18.9-litre) are effective for frogs and lizards, but the addition of the funnels on the 7.6-litre traps appeared to yield an even higher catch. Funnel traps were best for lizards and the only trap for large snakes. The smallest trap (3.8- litre) was unsuitable for everything but salamanders, hatchling turtles, and toads. A system of 18.9- and 7.6-litre pit traps with funnels and funnel traps seems necessary to capture the complete amphibian-reptile spectrum.

Effect of weather and season - Precipitation very markedly controls the activity of amphibians and reptiles. This was noticed especially in 1976 when Wisconsin experienced the worst drought in 40 years. When there was rain amphibians moved immediately. For example, prior to rain, 0 to 3 animals were caught per 2-day interval at Portage, and 1 to 2 at Busse Tract and Shaw Marsh. On 15-16 May, 3.76 cm of rain fell and the response was 12 animals caught at Portage, 69 at Busse, and 67 at Shaw. At Point Beach in the month of October, 18 frogs and 1 salamander were caught during a 2-day period prior to rain; after 1.09 cm of rain on 5 October, 257 frogs and 7 salamanders were caught within 24 hours. Similar responses to rain were noted at Blue River on 7 June, 18 June and 5 July.

Lizards and snakes, unlike amphibians, moved about in greater numbers when temperatures rose after precipitation. The 5 October rain at Portage produced 97 amphibians and reptiles (mostly frogs), but on 12 October the temperature rose and 38 snakes were caught.

Rain and temperature affected both the documentation of species present and estimates of population levels. The movement of lizards at Blue River clearly showed this effect. Drought and high temperatures forced lizards to remain underground for days. Then, after a rain, there was much more activity than normal, resulting in high population estimates.

Spring and fall dispersal and migration also are responsible for increased activity. At Blue River in mid-August there was an abrupt rise in the catch of hatchling lizards dispersing from natal areas. Post-metamorphic migrations of toads were demonstrated at the Busse Tract in early July when 38 toads were caught along one side of a drift fence one night. All were newly transformed and dispersing from the breeding ponds. The same phenomenon was observed at Portage in late August when the large number of snakes caught were mostly young of the year wandering away from their place of birth. Many species of salamanders spend most of their time underground or at least under cover. Because of this their presence was determined only during dispersal or migration times. This was apparent at Portage where only two tiger salamanders were caught in late fall.

High numbers of amphibians and reptiles caught after spring and fall rains may not necessarily mean that the habitat where they were caught is excellent for supporting such populations. These animals often travel a kilometre or more between summer foraging grounds and winter hibernacula, traversing many unsuitable foraging areas enroute. More realistic estimates of the numbers of snakes, lizards or frogs a particular habitat supports can be obtained in June and July after spring migration and before the dispersal of young.

Length of trapping period - Because of seasonal activity, staggered reproductive strategies and migration patterns, it is impossible to adequately sample all amphibian and reptile species present in an area at the same time. The length of time it takes, then, to obtain an index to the diversity of animals present becomes an important factor in evaluating any census method.

Density and diversity of frogs, snakes and turtles at Portage and turtles at Blue River were great enough, and trapping periods long enough, to indicate the trapping time needed to show species composition and abundance at different seasons. At Portage 3-5 days of trapping during optimum weather conditions were needed to get the most common species of reptiles and amphibians. In summer, 1, 2 or 3 months of continuous trapping were required at each trap line at Portage to take the four common species of snakes, while the same four species were caught in 1-4 days in September and October. Summer trapping of the three common species of frogs at Portage required over 1 month, while all three often were caught on a single day or at least within 3 days during September and October. In 2 days at Blue River two of the four species of turtles known to nest in the area were caught. The other two less common species never appeared. We used the Jolly stochastic model (Jolly 1965) for population estimates of six-lined racerunners. Data from 4-day intervals from 30 May to 28 July gave population estimates that ranged from 0-75 animals during that time, while three 15-day intervals gave population estimates that ranged from 29-60 animals.

The catch of all species over the months of trapping in this study showed many periods of very low catch or no catch at all. Since movement normally is associated with favorable weather and migration activity, several short sampling periods staggered throughout the season should give a much better representation of species composition and populations than a longer sampling period at any one time.

Effectiveness - In this study, the drift fence was an effective method for sampling amphibians and reptiles. The species composition at the Portage sites was known from 5 years of previous data. Drift fence trapping for the present study collected individuals from all species that have ever been recorded at Portage. In addition, two species (the rare glass lizard and tiger salamander) that were recorded in previous years near the site, but never on it, were trapped.

At Point Beach, in 5 days of trapping without rain, three of the 10 amphibian species known to be in the forest were caught. In 5 days during which rain occurred, six of the 10 were caught. Two of the species not caught are rare in the area - one is normally uncommon and the other was uncommon because of the drought. In 15 hours of intensive searching in the area during the summer, only one additional species was found.

At Long Lake, 420 leopard frogs were captured and marked from 1 April to 10 September 1976. Nearly all of these were caught in an alfalfa field adjacent to the marsh where the population was estimated to be 4,004 individuals. Soil moisture conditions required the two 15-m drift fences for the present study to be set 5 m away from the field in the marsh. Even though about 75 leopard frogs were seen in the alfalfa field at the time the fences were set up, only four were caught in two 6-day trapping periods in the marsh. This emphasizes the point of setting several fences throughout an area in various habitats.

Population estimates of the number of six-lined racerunners caught at line 2 at Blue River ranged from 0-75 (average 36) for eleven 4-day intervals. Forty-five lizards were caught in the fence during this time period. The transect of 10 funnel traps set perpendicularly to Blue River fence No. 2 caught marked racerunners a maximum of 20 m from either side of the fence. Since the next trap was 40 m on each side, it suggests that a drift fence samples an area less than 80 m wide for stationary species such as six-lined racerunners. Funnel traps without drift fences proved effective for capturing this species (36 captures over a 41-day period compared to 45 for 60 m of fence with traps). Funnel traps without fences seem to be an effective way of sampling lizard populations, but more concentrated trapping comparing population estimates would have to be done to show efficiency.

Manpower and costs - The most time-consuming part associated with drift fences was setup time. It took two people

1.5 hours to set 30 m of aluminum fence with eight pit traps and two funnel traps. Relatively little time was needed to check the traps. A dozen animals were removed and marked from 15 m of fence in 5-10 minutes. Even when large numbers of animals were caught, removal time was relatively short. For example, 267 animals were removed from 41 m of fence and marked by two people in less than 1 hour. Distance between trap lines dictated the number which could be checked per day. A site with a total of 90 m of fence could be checked in less than 1 hour; and if the sites were less than an hour apart, four sites could be surveyed per day easily. Therefore, a two-person crew could easily operate eight areas per day after setup. Setup time would require 4.5 hours per site.

Once the fence was set up, it was convenient to operate it only during ideal weather conditions. Funnel traps were picked up and pit traps covered when not in use. A 15-m fence with pit and funnel traps was removed by one person in 5 minutes.

The initial cost was $48 for 30 m of fence with traps. However, the fence can be used for many areas. Equipment costs for eight sites would be approximately $1,150. This would be the total equipment cost for the entire season.

BIRDS

Oregon Study Area

M.E. Eltzroth, James E. Tabor

Methods

Techniques - Three sample census methods were tested and evaluated for surveying birds:

1. Mean observational distance
2. Fixed circular plot
3. Belt transect

For Method 1, the observer remained stationary at marked sample locations and recorded all birds seen or heard in all directions within a radius of 450 m. For each observation, the distance from the observer to the bird was estimated with a rangefinder. Density of each species was estimated as the number of individuals observed (audio and visual observations recorded separately) in a circular plot with a radius equal to the mean observational distance of each species.

For Method 2 (fixed circular plot), density of birds in plots of 20-, 35-, and 50-m radiuses was calculated from the number of birds observed within each of these plots (with observer at the center).

Belt transects, 100 m x 450 m, were used in Method 3. The observer slowly walked (with frequent stops) along the center of the transect at a rate of 20 m per minute. All birds seen or heard within 50 m of the path of the observer were recorded.

Control distance - Surveys utilizing all three of the above methods were conducted along one 100-m x 450-m belt transect perpendicular to the road at each of eight study areas. Five observational points (for methods 1 and 2) were located along each transect at the road edge and at distances of 100, 200, 300 and 400 m from the roadside. The survey began with the roadside plot and continued through plot five.

Observation time per plot - Ten minutes were spent at each of the five observational points, with observations made during the first 5 minutes at a point recorded separately from those of the second 5 minutes. Following completion of the circular plot count at 400 m from the road, the observer walked to the end of the transect (450 m from the road) and began the method 3 survey back to the road. During the belt transect survey observations were recorded separately for each 50-m segment.

Time of day - Morning surveys were conducted at all eight study sites. Afternoon surveys were conducted at four sites from approximately 90 minutes before sunset to sunset.

Season - Surveys were conducted at each area on 4 days spaced at 2-to 3-week intervals during the breeding season, and on 3 days at approximately the same intervals during the winter. Surveys during the breeding season were conducted 4-12 May, 20-27 May, 3-11 June and 30 June-7 July 1976. Surveys during the winter season were conducted 8-15 November, 22 November-3 December and 6-13 December 1976.

Findings

Techniques - During both the breeding and wintering seasons, there was a significant difference ($P < 0.025$) among the mean number of species and mean densities of birds (species combined) produced from the five survey procedures tested. In both seasons the mean number of species identified by mean detection distance, belt transect, and 50-m fixed plot methods was significantly greater ($P < 0.005$) than the number of species identified with 20-m and 35-m fixed plots. The number of species identified on 35-m plots was significantly higher ($P < 0.005$) than the number identified on 20-m plots in both seasons. There was no apparent difference ($P > 0.05$) in the mean number of species identified with the mean detection distance, belt transect, and 50-m fixed plot methods in which the maximum distance observed was equal (50 m).

Estimates of density from the mean detection method were significantly higher ($P < 0.025$) than estimates from all other methods in the winter surveys. Both the mean detection distance method and the 20-m plot method yielded significantly higher ($P < 0.005$) mean densities than the other methods in the breeding surveys. There were no significant differences ($P > 0.05$) between the mean densities estimated with the mean detection distance method and the 20-m plot method.

Control distance - There was no significant difference ($P > 0.05$) among the mean numbers of species or density (all species combined) observed at each distance from the road (50-m segments) in breeding season or in winter. Selected individual species and groups of species were tested separately but no apparent relationships with roads were discovered. However, sample sizes were small in many cases and possibly did not reflect accurate relationships.

Observation time per plot - Both the mean number of species and the estimated bird density (all species combined) were significantly higher ($P < 0.005$) for the 10-minute count at each observation point as compared with the 5-minute count during the summer survey. In winter, the mean number of species observed after 10 minutes was significantly higher ($P < 0.005$) than that after 5 minutes, but the mean density of birds did not differ significantly ($P > 0.2$).

The total number of species and estimated bird density after 10 minutes of sampling was greater at each sampling area and during both seasons than that after 5 minutes. An average of 24 percent (range of 13-43 percent) of species identified at each study area was observed only during the second 5 minutes of sampling in the breeding season. The estimated density of an average of 62 percent of species was higher after 10 minutes, an average of 12 percent was lower, and an average of 26 percent of the species was not changed. In winter, an average of 24 percent (range of 0-40 percent) of species identified at each study area was observed only during the second 5 minutes. The estimated density of an average of 66 percent of species was higher after 10 minutes, 18 percent was lower, and 16 percent was unchanged.

Time of day - There was little difference ($P > 0.05$) among the numbers of species and individuals of birds observed at each of five time periods. The time periods tested were 30 minutes before to 45 minutes after sunrise, 45 minutes to 2 hours after sunrise, 2 to 3.25 hours after sunrise, 3.25 to 4.5 hours after sunrise, and 90 minutes before to 15 minutes before sunset.

Season - There was no significant difference ($P > 0.1$) during either the breeding or winter season among the mean number of species or number of individuals observed on each date sampling was conducted. Therefore, sampling dates tested for each season were neither too early nor too late for sampling at the study areas in west-central Oregon, all of which were located at relatively low elevations (below 300 m).

Illinois and Virginia Study Areas
Dwight Clark, James R. Karr

Methods

Techniques - Birds were surveyed within 100-m x 100-m plots, five of which made up a belt transect 100 m x 500 m oriented perpendicularly to a road. Transects were paired and three pairs comprised a cluster (Fig. 2). In Illinois, eight clusters each were established along county roads and interstate highways in the east-central part of the state. In Virginia, three clusters each were established along secondary county roads and a primary road containing a median.

In Illinois, three techniques were evaluated for surveying birds. These were:
- 4-minute random walk (4RW);
- 8-minute random walk (8RW); and
- 4-minute straight walk (4SW).

The techniques evaluated in Virginia were:
- alternating 5-and 7-minute straight walks through plot centers (for breeding birds);
- alternating 5-and 8-minute straight walks through plot centers (for wintering birds); and
- the Emlen technique (Emlen 1971) with the modification of limiting birds recorded to 50 m on either side of a straight line transect walked by the observer.

The two major differences between the Emlen technique and the other two techniques used in Virginia were that perpendicular distances from the bird to the transect line were estimated, and surveys were not standardized by time with the Emlen technique.

In Illinois, individual birds were recorded as seen, heard, or flyovers. The same was done in Virginia, except flyovers were not counted unless it was determined they were entering or leaving the plot being surveyed.

For the 4RW, the observer walked around in each plot as he deemed most effective for finding birds in that particular plot. Exactly 4 minutes were spent in each 100-x 100-m plot.

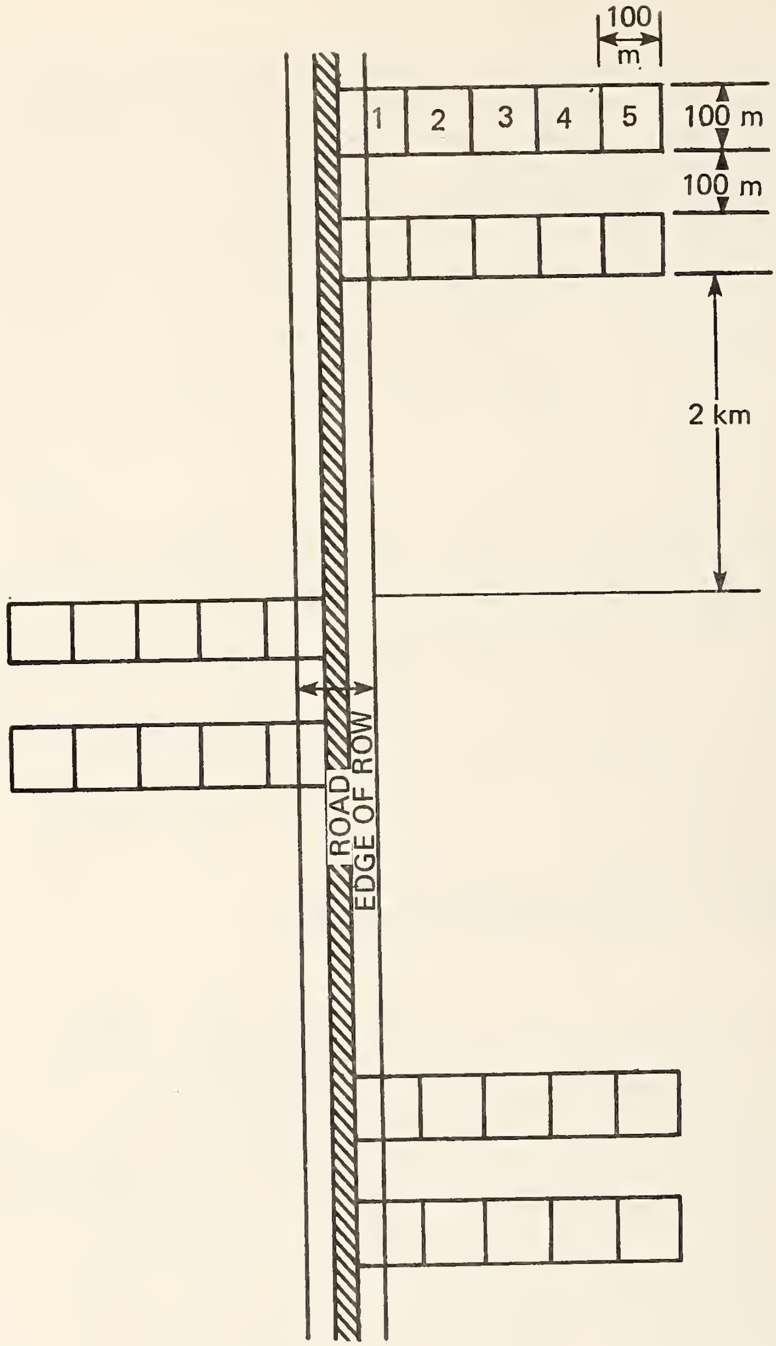

Fig. 2. Plot and transect arrangement for an idealized sample cluster in the Illinois and Virginia Study Areas. Five plots comprised a transect and transects were paired, always 100 m apart. Transect pairs were never closer than 1.6 km, but in some cases the distance was somewhat longer in order to avoid houses, other roads, or similar obstructions. (Schematic).

The 8RW was conducted in the same fashion as the 4RW with the exception that 8, rather than 4 minutes, were spent in each plot. For the 4SW, the observer slowly walked (stopping occasionally) through the center of each plot. The 5-, 7-, and 8-minute straight walks were similar to the 4SW with the exception of the time spent per plot.

Season - In Illinois, winter bird residents were surveyed between 15 December and 15 February. Breeding birds were surveyed during the last week in May through the first three weeks in June. In Virginia, winter bird surveys were conducted from 16 February through 11 March, and breeding bird surveys were conducted from 15 June through 8 July.

Time of day - In Illinois, bird surveys began 20 minutes before sunrise and continued for 3 hours and 40 minutes. In Virginia, morning surveys began 15 minutes before sunrise and continued for 4 hours and 10 minutes. Afternoon surveys began 5 hours and 40 minutes after sunrise and continued for 4 hours and 30 minutes.

Findings

Techniques - In Illinois, there was little variation in the number of species observed with the random walk and the straight walk methods. However, for number of individuals, the straight walk method was more variable. As would be expected, more individuals were recorded on 8-minute than on 4-minute surveys.

In Virginia, for total number of individuals, time spent per plot (5- vs 8-minutes for winter, and 5- vs 7-minutes for summer) was marginally significant for both winter ($P = 0.06$) and summer ($P = 0.07$) straight walk surveys. In each case, more birds were detected with the longer survey times.

The modified Emlen technique resulted in a clumping of birds at the plot boundaries (50 m on either side of the observer), which is a characteristic problem with counting birds in plots. Also, data from this method indicated that time standardization is important if comparisons of bird counts between plots are to be made because more birds were recorded for longer time periods per plot. The data indicated that for wooded areas (coniferous and deciduous), more time was spent by the observer in those plots containing more birds.

Season - Time of year for conducting bird surveys was not tested. Past experience has shown that winter birds can be surveyed from 15 December through 15 February, and breeding birds can be surveyed throughout the month of June in the geographical areas under investigation. Of course, annual weather conditions are important in determining exact dates.

Time of day - Within the morning data from Illinois, the mean number of individuals recorded declined as the morning progressed. The mean number of individuals (all species combined) recorded in the period 1 hour 40 minutes to 3 hours 9 minutes after sunrise was less than one-fourth of the mean number recorded in the interval 20 minutes before sunrise to 10 minutes after sunrise. The mean number of species observed was relatively stable throughout the morning. This same pattern held for all three survey techniques used in Illinois. Generally, data obtained during the first 4 hours following sunrise can be pooled together as one survey (data indicate numbers of individuals generally decrease, but not significantly).

In Virginia, when the bird data were lumped into two time periods (a.m. vs p.m.), time of day had a significant effect (P=0.0001) on mean number of birds detected in winter - morning surveys yielding higher counts than afternoon surveys. We have no explanation for this at the present time, but it should be explored further because previous experience has shown that wintering birds can be counted through late afternoon without differing significantly from morning counts. Time of day (a.m. vs p.m.) was marginally significant (P=0.06) for breeding birds. Again, more birds were detected in the morning surveys.

Control distance - Results on control distance were not conclusive. Bird distribution and abundance in relation to roads were determined for three habitat types in Virginia. The mean number of total birds observed per plot increased with distance from the road for the deciduous forest and deciduous/coniferous forest habitat types for winter surveys. Mean number of total birds for coniferous forest (winter survey) and for all three habitat types for summer surveys was variable with no clear trend indicated.

Over combined habitat types in Illinois, the distribution of number of individuals of all species recorded in winter surveys in relation to roads was bimodal. The first peak occurred in the 0-100-m plot, and the second peak in the 300-400-m plot. For summer data, number of individuals per plot slowly declined with distance from the road. For number of species, no strong relationships were found.

Individual bird species demonstrated one of four patterns with respect to distance from the road: an essentially level curve with no apparent relationship to the road, increase in numbers of individuals with increasing distance from the road, decrease in numbers of individuals with increasing distance from the road, a roadside peak followed by an immediate decline then a gradual increase in numbers with distance from the road. These relationships were determined only for those species with a minimum of 25 observations from a single season. In nearly all cases, the information obtained by the time 400 m were reached was similar to that obtained with the inclusion of an additional 100 m (500 m distance from the road).

Wisconsin Study Area

Nancy G. Tilghman, Donald H. Rusch

Methods

Several quadrat and transect sampling methods which have proven to be fairly efficient in the past were tested and evaluated for use in this study. Data were gathered for all quadrats and transect sampling methods at the same time. Observers walked transects, recording all birds seen or heard out to 46 m on either side of the transect. Other data recorded were the radial detection distance, horizontal angle of detection, time and habitat in which the bird was located. Data concerning flocks of birds were recorded as for a single bird with a notation as to estimated number of birds in the flock.

Evaluation of the accuracy of census methods for songbirds requires that the true population density be known. Due to the great mobility of birds and the lack of practicable methods for obtaining the true density of songbirds, an estimate of the actual density must be used in the evaluation procedure. In this study, we used the International mapping method (Robbins 1970) to give the best estimate of the actual density of birds on an area. The term "best estimate" as used in this paper refers to this estimate of the true breeding density of birds derived from the International method. Because of the great amount of time involved in using the International method, the comparison of accuracy of the methods was limited to six of the wooded study areas.

Quadrats - Contiguous quadrats of various sizes and perpendicular to roads were evaluated by means of computer simulated boundaries with data gathered along transect lines. The six dimensions of the quadrats used were 30.5 x 30.5 m, 61 x 61 m, 91.4 x 91.4 m, 91.4 x 183 m, 91.4 x 274.5 m, and 91.4 x 366 m.

Transects - The transect sampling methods evaluated and their formulas for estimating animal populations are given in Table 1. The first 10 methods listed are the same as those evaluated by Robinette et al. (1974) in a study which primarily involved the estimation of numbers of inanimate objects. In addition, two other transect methods were tested - Emlen I

Table 1. Transect methods used in the present study of songbird techniques. (After Robinette *et al.*, 1974)

Method	Formula for Population Estimate	Source
	Based on radial sighting distances	
King	$P = nA/2L\bar{R}$	Leopold (1933)
Hayne	$P = nA/L\bar{H}$	Hayne (1949)
Gates II	$P = (2n-1)A/2L\bar{R}$	Gates (1969)
Gates III	$P = nA/2L\bar{G}$	Gates (1969)
	Based on perpendicular distances	
Webb	$P = nA/2L\bar{R}\sin\bar{T}$	Webb (1942)
Leopold	$P = nA/2L\bar{Y}$	Leopold (1933)
Gates I	$P = (n-1)A/2L\bar{Y}$	Gates *et al*. (1968)
Frye	$P = n'\ A/2L\bar{Y}$	Overton (1971)
Kelker	$P = n''\ A/2LD$	Kelker (1945)
Anderson & Pospahala	(See authors' paper)	Anderson & Pospahala (1970)
Emlen I	(See author's paper)	Emlen (1971)
Emlen II	(See author's paper)	Emlen (1977)

A=area to be censused; D=estimated perpendicular threshold distance beyond which some animals were probably missed; G=geometric mean of sighting distances; H=harmonic mean of sighting distances; L=length of census lines; n=number of animals seen; n'=number of animals seen within $\bar{2Y}$; n''= number of animals seen within 2D; P=estimated animal population; $\bar{R}$=mean sighting distance; $\bar{T}$=mean sighting angle; $\bar{Y}$=mean perpendicular distance.

(1971) with a "coefficient of detectability" and Emlen II (1977), the new specific-strip method.

Season - Winter censuses were conducted from January to March, and breeding census from mid-May to mid-July. Fifty-four woodlots and 88 adjacent-habitat transects were censused during the winter, each being covered five times during the 3-month period. All 78 woodlots and 187 adjacent-habitat transects were censused five times during the 2-month study period in the summer.

Time of day - Breeding bird censuses were conducted from one-half hour before to 5 hours after sunrise. Winter bird surveys were limited only to daylight hours.

Findings

Quadrats - The quadrat methods evaluated in this study were a series of contiguous blocks of six different dimensions. Results from these methods were expressed as density estimates (number of birds per km^2) and as indices to density (mean number of birds per block). Density estimates were calculated for the territorial bird species by combining the results of six woodlots. These population estimates then were compared with our best estimate of the true population density on these same six woodlots. The block estimates of population density showed consistent negative bias, regardless of the dimensions of the blocks. The relative accuracy of the block estimates ranged from 30 to 41.5 percent of the best estimate. The variability associated with these density estimates derived from the contiguous blocks method was negligible, with blocks 91.4 x 274.3 m being the most precise (CV=5%). The smallest block, 30.5 x 30.5 m, had the highest coefficient of variation (18%).

For the contiguous blocks method, the mean number of birds per block increased as block size increased. As the width of the blocks increased from 30.5 to 91.4 m, however, the percentage of birds observed decreased. This was seen in the general decrease in number of birds per square kilometre as the width increased. These density figures then remained nearly the same for the four block sizes where the width was 91.4 m.

The variability of the mean number of birds per block decreased as block size increased. Although the standard deviation increased with larger block sizes, the variability relative to the size of the mean decreased.

Frequency distributions of the numbers of birds per block varied for the six different block sizes. The two smallest block sizes showed a positively skewed distribution. With the

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30.5-x 30.5-m block size, more than half of all the blocks were empty. The numbers of birds per block associated with the remaining four block sizes were almost normally distributed, although small sample sizes and the presence of flocking species of birds caused some irregularities.

Regression analysis between the best estimate of percent species composition and the contiguous blocks estimates of percent species composition for four different block widths resulted in values for the slope that were all very close to unity (from 0.91 to 1.01). The 95% confidence intervals associated with the block estimates of percent species composition generally included the best estimate of the same values, regardless of block width. Those species for which percent compositions consistently were overestimated or underestimated generally were species with high and low detectabilities, respectively.

The variability associated with the block estimates of percent species composition was fairly low for each of the four block widths tested. The lowest variability of the percent composition estimates was found with blocks 91.4 m wide, in which the mean coefficient of variation was 66 percent with a range from 11 to 224 percent. The correlation coefficient between the best estimate of percent species composition and the four sets of block estimates of percent species composition was highest for blocks 91.4 m wide (r=0.87). The high r value is another indication of the fairly high degree of precision associated with species composition estimates from the contiguous blocks method for blocks 91.4 m wide.

Uncommon species in the woodlots were those that represented less than one percent of the total birds on the area. The best estimate of species composition showed that there were six uncommon species on the combined woodlot study area. Two of these species, red-bellied woodpecker and eastern kingbird, were very conspicuous when present in a woodlot. Thus the block estimates of percent species composition for these species were high for all four block widths used. The other four uncommon bird species - scarlet tanager, chestnut-sided warbler, American redstart, and veery - were much less conspicuous; therefore, the block methods gave negatively biased estimates of the percent species composition for these species.

Transects - The accuracies of the 12 transect methods were evaluated for six woodlots with the International mapping method as the best estimate of actual density. Regression analyses were performed on the mapping estimate for each species against the corresponding estimates from each of the 12 transect methods. The two methods which showed the least bias were Hayne's and Gates's II. Three other methods which were within 20 percent of the mapping estimate were Leopold's, Gates's I, and Emlen's I.

The correlation coefficients between the mapping density estimates and estimates from each of the 12 transect methods all were highly significant ($P < 0.001$). An estimation of the r values indicated that although all methods demonstrated a high degree of precision, the Emlen I method was the most precise. King's, Gates's II, Leopold's, Gates's I, and Kelker's methods showed nearly the same degree of precision.

For the purpose of further analysis on other study areas in which the International mapping method was not used, Emlen I was used as the best index to the true population density of birds. Emlen I was chosen because of its high degree of precision and its acceptable degree of accuracy.

Season - Analysis of variance was used in the evaluation of the effects of changes in seasonality on the estimation of population densities of birds. Data from winter 1976 showed no significant differences ($P > 0.8$) between mean bird densities when grouped according to the day on which counts were made. When the effects of seasonality on indices made during the summer field season were analyzed, no significant effects ($P=0.3$) were found for density estimates in all habitat types, except woodlots. Gradually decreasing mean bird estimates with progression of the season were evident upon examination of data from woodlots during the summer of 1976 ($P=0.0006$).

Time of day - When grouped according to the time of day in which sample censuses were run, Emlen I estimates of mean bird densities in woodlots during the winter of 1976 showed no consistent or significant trends. Analysis of variance of these data supported this position ($F=0.15$, $P=0.82$). The same lack of effect of time of day on bird densities was found in agricultural habitats during the winter of 1976 ($F=0.74$, $P=0.48$).

A more complex analysis involving two time of day groups for four major habitat types (agricultural, hedgerow, roadside, wetland) during the summer of 1976 showed no predictable change in population estimates with changes in time of day ($F=1.46$, $P=0.23$). Similar analysis of censuses conducted in woodlots during the summer of 1976 again showed no effect of time of day on the population estimates ($F=0.43$, $P=0.52$).

Observer - The effects of different observers on estimates of bird densities were examined with data from woodlots during the summer of 1976. Effects due to seasonality were minimized since each of the three observers sampled birds at the woodlots throughout the 2-month field season. Differences in population estimates due to observers were found to be significant (F=11.30, P < 0.0001).

Differences in observer ability to identify bird species by territorial songs and calls as well as by sight can add greatly to the variability in population estimates. Almost 80 percent of all birds recorded during the summer of 1976 were recognized by audio clues, either songs or calls. In the woodlots, over half of all observations were identified by means of the territorial song. In more open habitats, about half of all detections of birds were by recognition of the call note (sometimes in conjunction with visual detection).

Habitat - The mean detection distances of birds were significantly different in different habitat types (F=25.4, P < 0.0001). Birds in grains and mixture (shrubs-grasslands) habitats had the longest mean detection distances, and birds in hedgerows produced the shortest mean detection distances. Mean detection distances were found to be longer for singing observations than for either calling or visual observations.

An examination of the mean horizontal detection angle of birds in various habitat types showed that the mean detection angle for summer and winter data was nearly the same (56 degrees). The mean detection angles for the various habitat types ranged from 34 to 120 degrees in winter, and from 44 to 83 degrees in summer.

Winter bird densities were highest in farmyards and woodlots. During the summer, the highest bird densities were associated with wetland areas, legumes, roadsides and woodlots. The lowest bird densities were found in grain fields. As mentioned earlier, in closed habitats such as wooded areas, most detections were made by means of the territorial songs of the birds. In more open habitats, the percentage of identifications made from songs dropped off considerably.

Efforts to determine the significance of variability in population estimates made in different habitat types relied on analysis of variance procedures. Data from winter 1976 were not extensive enough for statistical analysis. Summer population estimates, however, were shown to be significantly different when habitats were grouped into four major types (F=7.31, P=0.0001).

For block simulations, the mean number of birds per block of 91.4 x 91.4 m during the summer of 1976 was highest for legume, pasture, and grassland habitats. The lowest indices of density were found for corn and grain fields. Variability of the index estimates were highest in legume, pasture, and grassland habitats. Indices derived from contiguous blocks along hedgerows also showed high variability.

Species composition - The presence of large flocks of birds on the areas that were sampled added to the variability of population estimates. Large flocks of bobolinks, red-winged blackbirds, and starlings were present in hedgerows, legumes, pastures, and grasslands.

Distance from road - Some of the variation in indices to densities of birds was shown to be associated with the distance of the sampled area from the nearest road. A higher number of birds per block was found in blocks closest to the road in each of four major habitat types. A second increase in the number of birds per block was seen in the block 274 to 366 m from the road.

Observer rate of speed - Rates of speed used when sampling woodlots usually were slower than speeds used in more open habitats. In many habitat types, low bird densities were associated with samples taken at higher rates of speed.

A more precise look at the effect of rate of speed on bird densities was made by evaluating data from six woodlots each sampled by the same observer on 5 consecutive days. Correlation coefficients for each woodlot were calculated between the five rates of speed used in the different replications and the five Emlen I estimates of bird density. None was significant. These low r values suggest that on areas in which bird populations were assumed to be nearly the same for consecutive days, changes in the rates of speed of traverse had no predictable effect on the population indices.

The amount of time involved in arriving at a population estimate for a specified woodlot was lower considerably for each of the transect methods than for the International mapping method. All the transect methods except Emlen II required about 5 percent of the time necessary to complete the International method due to the need for at least five visits to the study area to determine song frequencies for each of the territorial species.

The amount of time required for the contiguous blocks method would be more than that required for the transect methods. Time spent on calculation of mean number of birds per block would be minimal.

Oregon Study Area

James E. Tabor, Mark S. Hinschberger

Methods

Control distance - The general sampling scheme tested for small mammals involved the use of snap traps set at sampling stations located on 13 transects established parallel to the road adjacent to each study area. One transect was located in the roadside habitat equidistant between the edge of the road and the adjacent "homogeneous" habitat. The other 12 transects were in the adjacent habitat at 25-m intervals out to 300 m from the road. The number of species and individuals of small mammals captured at each distance from the road provided data for estimating the minimum perpendicular distance from the road to establish control sampling points for future studies.

Season - Sampling was conducted during a spring period (19 April - 11 June) and a winter period (1 November - 10 December).

Trap type and bait - Victor rat, museum special, and Victor mouse traps were the types of traps tested. Baits tested included peanut butter, a peanut butter-rolled oats-beef suet-raisin mixture (Taber and Cowan 1971:278), and rolled oats. Only two types of bait, peanut butter and the mixed bait, were tested on rat traps. Museum special and Victor mouse traps were set without bait and also with peanut butter, the mixed bait, and rolled oats. Dry rolled oats were mixed with water to form a thick paste.

Trap placement - The specific manner in which each trap was placed was recorded. Categories used for describing placement of traps included: (1) in the open, (2) base of tree, shrub, or clump of grass, (3) near hole in ground, (4) in runway through vegetation, (5) near log, (6) near rock, (7) near edge of water, and (8) on log.

The number of each species of small mammal captured in each trap-bait combination and placement category was recorded in order to determine the most effective type of trap, bait, and placement in terms of number of species and individuals captured.

Trapping intensity - Trapping was conducted on 4 consecutive days and nights at each study area. Thirty-nine stations, three on each transect, were established at each study area for sampling small mammals. The stations were circular plots, each with a radius of approximately 4 m. One station on each transect had 10 traps (two rat, four museum special, and four Victor mouse traps). and the other two stations had five traps each. One of the five-trap stations had one rat trap and four museum specials. The other five-trap station had one rat trap and four Victor mouse traps. All trap-bait combinations were used at 10-trap stations. Rat traps at the five-trap stations with museum specials were baited with the mixed bait; those at the five-trap stations with Victor mouse traps were baited with peanut butter. One museum special or Victor mouse trap at each five-trap station was unbaited; the other three were baited with the three types of bait.

Small mammals captured during both the spring and winter sampling periods were classified as to juvenile or adult on the basis of external characteristics including body size and pelage coloration for most species, and tooth wear for shrews. These data were used as an indication of the time of year new individuals were recruited into the trappable population. The most appropriate time to obtain an index to abundance would be before or after this recruitment interval.

Findings

Twenty-three species of small mammals were identified in this geographic region. These species represent about 70 percent of those known to occur in western Oregon and Washington and northwestern California (Burt and Grossenheider 1964). The deer mouse was found in all areas sampled in both the spring (19 April - 11 June) and winter (1 November - 10 December) seasons. The Trowbridge shrew was the second most widely distributed species. The vagrant shrew and creeping vole also were found in a relatively wide range of habitats.

A total of 861 small mammals was captured in this study. The deer mouse was by far the most frequently captured of 20 species captured in spring and 18 species captured in winter. This species made up 48 percent of 498 small mammals captured in spring and 68 percent of 363 captured in winter. The second most frequently captured species in both seasons was the Trowbridge shrew which was the second most widely distributed species as to habitat. The vagrant shrew, creeping vole, and gray-tailed vole made up the third largest percentage of the catch.

The overall success rate of capture for both seasons combined was 5 percent. Rate of success for all study areas combined was 5.3 percent in spring and 3.9 percent in winter. Success ranged from a low of 1.1 percent in ryegrass cropland to a high of 11.7 percent in a riparian community sampled only for small mammals in spring. In winter, rate of success was again lowest in ryegrass (1.5 percent), but was highest (7.7 percent) in oak shrub, an area sampled only in winter.

Control distance - Our data indicated a possible inverse relationship between distance from the road and both the number of species and the number of individuals of small mammals out to a distance of 100-125 m from the road. Also indicated was a possible positive relationship from 125-200 m out to 300 m from the road.

There were significant differences among the mean number of individuals captured per study area at each distance sampled in spring ($F=3.16$; 12, 120 df; $P < 0.005$) and winter ($F=2.4$; 12, 108 df; $P < 0.025$). The only significant differences between means were that in spring the roadside habitat had a higher mean number of individuals captured than all other distances except 300 m, and that the 300 m distance produced a higher mean than distances 100-200 m from the road in spring and two distances (125 m and 200 m) in winter.

There were no significant differences among means for number of species in spring ($F=1.18$; 12, 120 df; $P > 0.25$) or winter ($F=1.78$; 12, 108 df; $P > 0.05$). However, the number of species appeared to be slightly higher in the roadside habitat.

If our data accurately reflect the effect of roads on distribution and abundance of small mammals, the minimum control distance should be at least 300 m from the road. However, the greater number of individuals captured at the maximum distance from the road (300 m) may not have resulted from a higher density of animals. The increased number of small mammals captured at this distance may have resulted from immigration of animals from the untrapped area beyond 300 m from the road. On the other hand, the higher number of small mammals captured in the roadside habitat, the proximal edge of the study area, probably did reflect higher density. The road probably reduced immigration from the untrapped area on the opposite side of the road. We feel that the observed higher density and greater species diversity of small mammals in the roadside habitat were due to habitat and "edge effect". In addition, roadside habitat in several study areas was a more productive type of habitat for small mammals than the adjacent habitat.

If the observed increase in the number of small mammals captured at 300 m from the road resulted from some factor other than the effect of the road, as we believe, the minimum control distance should be about 150 m from the road.

Season - More species of small mammals were identified and a higher capture rate was made in the spring sampling period (19 April - 11 June) than in the winter sampling period

(1 November - 10 December). Twenty species were captured in spring compared to 18 in winter. Success rate of capture was 5.3 percent in spring and 3.9 percent in winter. The lower success rate in winter could have resulted from several factors including reduced density of small mammals and reduced effectiveness of the sampling methods.

The rather intensive trapping, and thus removal of mammals, in spring may have depressed densities in study areas so low that numbers were not back to "normal" 6 months later when the areas were trapped again in winter. In addition to this reduced trapping success, possibly caused by the study, the trapping methods tested may have been less effective in winter. Falling and fallen leaves created a problem in winter. Falling leaves reduced the effectiveness of snap-type traps by covering them and sometimes releasing the triggers of mouse traps. The layer of fallen leaves present at some sampling sites reduced trapping efficiency because those small mammals that traveled under this layer of leaves were less likely to locate our traps.

The most appropriate time of year to sample small mammals, we believe, would be when populations are at their annual highest and most stable levels (i.e., as soon as possible after annual recruitment ends), assuming that sampling methods can be employed effectively at this time. Recruitment of new individuals into the trappable populations of small mammals appeared to have been occurring at a considerably higher rate in winter than in spring based on the occurrence of very young animals in our samples. Juveniles made up 46 percent of all small mammals captured in winter compared to 16 percent in spring.

Of the two sampling seasons used in this study, spring appeared to be more appropriate for sampling small mammals because it was the more stable time in terms of recruitment, and trapping success was higher. Although we did not sample during late winter and very early spring, this time of year probably would provide the above mentioned desirable conditions for sampling.

Trap type and bait - There were significant differences in both spring and winter among the mean number of species ($F = 15.65$; 2,20 df; $P < 0.005$ and $F = 3.94$; 2, 22 df; $P < 0.05$) and mean number of individuals ($F = 6.11$; 2, 20 df; $P < 0.025$ and $F = 5.09$; 2,22 df; $P < 0.025$) of small mammals captured with each of the three types of traps tested. The Victor rat trap produced significantly fewer species and individuals than either the Victor or museum special mouse traps. The mean number of species and individuals captured was very similar for the two types of mouse traps.

Although the rat trap captured fewer species and individuals, it accounted for almost all of the larger species of small mammals trapped. All Norway rats, California ground squirrels, flying squirrels, bushy-tailed woodrats, dusky-footed woodrats, brush rabbits, short-tailed weasels, and most Townsends chipmunks were captured in rat traps. The Victor rat trap produced seven species, Pacific shrew, Pacific water shrew, deer mouse, California red-backed vole, gray-tailed vole, Pacific jumping mouse, and house mouse, also taken in the smaller Victor and museum special mouse traps.

The species composition of small mammals trapped with the Victor mouse trap was very similar to that resulting from use of the museum special. One species, the northern flying squirrel, was captured only with the museum special. The number of individuals of each species captured in an equal number of trap nights for the two types of traps differed significantly. The Victor mouse trap produced a greater number of individuals of six species of insectivores than the museum special trap (paired $t=2.92$, 5 df, $P < 0.05$). Even though it was not tested statistically because of the very small sample size, the Victor mouse trap appeared to be slightly less effective than the museum special for the larger sized species such as the Townsends chipmunk, long-tailed vole, and Townsends vole. We believe, however, that the Victor mouse trap was more effective overall than the museum special.

The Victor mouse trap was the easier and faster of the two types of mouse trap to use. We found that this trap, because of its smaller size, could be placed in the characteristically small spaces that provided the most suitable microhabitat for small mammals. Placement also was accomplished with little or no preparation of the site. More time and effort were required to prepare these small trap sites for effective placement of the museum special trap.

There was a significant difference among the mean number of species and mean number of individual small mammals captured in mouse traps (Victor and museum special combined) with each of four bait types (unbaited considered as a bait type) in spring ($F=3.97$; 3, 30 df; $P < 0.025$ and $F=5.18$; 3, 30 df; $P < 0.025$). In winter, there was a significant difference among the mean number of individuals ($F=5.18$; 3, 33 df; $P < 0.025$), but there was no significant difference among the mean number of species captured with the four bait types tested ($F=2.66$; 3, 33 df; $P > 0.05$). In spring, oats produced a significantly greater ($P < 0.025$) number of individuals and species than peanut butter and no bait. There was no significant difference ($P > 0.05$) between the mean number of species and mean number of individuals captured with oats and mix or between those caught with peanut butter and no bait. In winter, unbaited mouse traps produced significantly fewer ($P < 0.025$) individuals than oats and mix. There was no significant difference ($P > 0.05$) between no bait and peanut butter or among peanut butter, mix, and oats. In summary, oats appeared to be the most effective bait in spring (followed closely by mix) and mix the most effective bait in winter (followed closely by oats).

We also examined the relative effectiveness of the four bait types for the more efficient Victor mouse trap separately. In spring, there was no significant difference in the mean number of individual small mammals caught among the four bait types ($F=1.8$.; 3, 30 df; $P > 0.1$), even though peanut butter appeared to produce considerably fewer captures than the other bait types. There was, however, a significant difference among the mean number of species in spring ($F=3.16$; 3, 30 df; $P < 0.05$). Oats produced significantly more species than peanut butter and no bait. In winter, there was no significant difference due to bait for either the number of species or number of individuals caught ($F=1.80$; 3, 33 df; $P > 0.1$). Although differences were not significant, mixed bait appeared to produce slightly more species and individuals in winter.

The relative effectiveness of only two types of bait (peanut butter and mix) was evaluated for use with Victor rat traps. There was no significant difference in spring or winter among the mean number of species (paired $t=0.95$, 9 df, $P > 0.2$ and paired $t=0.77$, 11 df, $P > 0.4$) or mean number of individuals (paired $t=1.65$, 9 df, $P > 0.1$ and paired $t=0.90$, 11 df, $P > 0.2$) captured with each type of bait. In our opinion, however, mix was the more successful bait for the rat trap, especially in spring.

Trap placement - Traps placed in specific locations where small mammals were expected to travel were more successful than traps set at random (in open, as we classified it). Traps placed at bases of trees, near holes in the ground, in runways through vegetation, near logs, and near large rocks had much higher success rates than traps set in the open during the spring sampling period. Traps placed on logs were less successful than traps set in the open. Those set on logs were, however, essentially set in the open. In winter, traps placed in the same types of microhabitat as in spring produced higher rates of capture, also, but the differences were less dramatic. Only traps placed near the edge of water were less successful than traps set in the open, and too few trap nights were tested for this type of placement to adequately evaluate it.

Traps placed in the open in our tests were sprung without capturing a small mammal more often than traps placed inside cavities of, or near, trees, logs, and rocks, in holes in the ground, and under overhanging vegetation and other objects. Rainfall and falling leaves and twigs were the principal causes for sprung traps.

Trapping intensity - Trapping intensity, as determined by density of traps and number of days of trapping, had a major influence on the results of small mammal inventories. In general, we found that by increasing trapping intensity, we increased the number of species identified at study areas. The success rate of capture (i.e., number of individual small mammals captured per 100 trap-nights of effort) decreased with increased trapping intensity, however. Increased density of traps reduced the success rate only slightly, whereas increasing the number of days of trapping at the study areas to more than one day reduced the success rate substantially.

In the spring, trap stations with 10 traps per 50 m^2 identified a mean of 5.0 species of small mammals per study area after 4 days of trapping compared to a mean of 3.2 recorded from stations with 5 traps per 50 m^2. In winter, stations with 10 and 5 traps each produced means of 3.0 and 2.2 species per study area, respectively. Thus, the high-density trap stations identified 56 and 36 percent more species than low density stations in spring and winter, respectively.

The cumulative mean number of species identified per study area increased with each additional day of trapping for both trap densities used and in both seasons. The highest rate of increase was observed between the first and second days, and the rate of increase became increasingly smaller each day thereafter for each trap density and season. The highest overall rate of increase between the first and fourth day was a 100 percent increase, from a mean of 2.5 to 5.0 species per study area, for the 10 trap stations in spring.

It is important to note that even though the rate at which additional species were identified decreased from the first to the fourth day of trapping, additional species were identified on the fourth or last day we trapped with both trap densities. More species could possibly have been identified with additional days of effort.

Illinois and Virginia Study Areas

Lowell L. Getz

Methods

Techniques - The survey technique for small mammals consisted of four trap lines per transect, each line containing 20 standard snap traps (mouse-size) with traps spaced at 5-m intervals. One rat-size snap trap was placed at every fifth station in non-cultivated habitats and in roadside habitats. Trap lines were parallel to the road. The trap line nearest the road was centered in the roadside habitat. Remaining trap lines were placed at 10, 250, adn 450 m from the edge of the roadside habitat. Trap lines in this experiment in Illinois were run for 3 days and 3 nights during February and March, and those in Virginia were run for 1 day and 1 night during March and April.

Bait - In most cases, traps were baited with peanut butter; however, an experiment conducted in Illinois compared peanut butter baited traps with prebaited traps (chemically baited at the factory). For this experiment, the same basic trap line was employed. One peanut butter baited trap and one prebaited trap were placed at each station. Trapping was conducted during a warm period (above freezing) in early November and during a period of very low temperature (-18 to -15^{o} C) in December.

Use of county roadsides - In Illinois, an experiment was conducted in late summer to determine the use of county roadsides by small mammals in relation to mowing disturbance. Twenty-four sites were selected that had not been mowed all summer. Sixty-six sites were selected that had been mowed during the summer although vegetation at the time of the survey was approximately 30 cm high. Vegetational structure and species composition were determined for each trap line.

Trap spacing and trap line length - Trap line length and spacing of traps were tested during the month of June in the following way. Parallel rows of traps, one with 20 stations spaced at 5-m intervals (total length 95 m), the other with 20 stations spaced at 10-m intervals (total length 195 m) were positioned 200 m apart in cultivated fields. Another group of paired lines with similar trap intervals were placed end to end along the same side of interstate highways with 50 m between ends of trap lines. The traps were baited with cotton saturated with peanut butter.

Findings

Techniques - In Illinois, total numbers of small mammals (all species) increased with distance from county roads. Low animal numbers in the roadside habitat were attributed to the frequent disturbance (mowing) of this area and the relatively small total area trappable. Thus, few individuals of species requiring habitats of dense vegetation would be expected in these sites. In addition, the most common species of small mammals in adjacent cultivated fields (the deer mouse) avoids grassy habitats such as are common along most county roads.

The lower total catch for the second trap line (10 m from road) also could be attributable to a reduced trapping area (compared with trap lines 3 and 4). Captures on lines 3 and 4 were similar.

Total captures of small mammals in the interstate highway clusters were greatest in the roadside habitat. This resulted from the high captures of meadow voles and short-tailed shrews. The former are particularly abundant in grassy habitats, achieving much higher densities than the deer mouse in its optimal habitat in east-central Illinois, open fields.

Small mammals requiring a dense grassy habitat did not forage out into the adjacent cultivated fields; none was caught in trap line 2 located only 10 m from the edge of the roadside habitat. Captures away from the roadside habitat involved primarily deer mice. Similar conclusions apply to both road types in terms of numbers of small mammals and distance from the road.

Bait - Captures of small mammals with chemically prebaited traps did not compare favorably with captures by peanut butter baited traps. Total captures were significantly fewer with the prebaited traps as determined by the t-test ($P < 0.01$).

Use of county roadsides - In Illinois, approximately 90 percent of county roadsides are mowed by farmers during the summer. Most are mowed several times, and the vegetation seldom reaches a height of 30 cm. During this study, 25 percent of the study plots were mowed during the 3-day trapping period. Trapping data from unmowed sites resulted in an average capture of 2.7 species and 7.2 individuals per trap line (3 days total). An average of 2.0 species and 4.0 individuals were taken in those mowed roadsides with vegetation 30 cm high.

Trap spacing and trap line length - The standard deviations of adjacent 95-m and 195-m trap lines (with 5-m and 10-m intervals between traps, respectively) were almost identical for both open agricultural fields and dense grassy situations. Average captures per trap line were slightly higher (but not significantly) for the longer trap line.

In Virginia, fewer individuals were captured per trap line because trapping was conducted one day and night rather than for three days and nights. Average catches per trap line for roadside habitat, and at distances of 10, 250, and 450 m from the road were 6.2, 1.5, 3.5, and 3.8 animals, respectively. The meadow vole was most prevalent in the grassy roadside habitat and did not show up in the two more distant lines.

Wisconsin Study Area
James R. March

Methods

No small mammal survey techniques were tested and evaluated specifically for this study. However, the procedure recently used by Wisconsin Department of Natural Resources personnel in some of their work is presented here. Trap lines of 50 or 100 "Holdfast" (mouse-size) snap traps (Woodstream Corporation, Lititz, Pa. 17543) are set at 9- or 15-m intervals. In addition, one rat trap is set at every fifth station along the trap line (ratio of four mouse traps to one rat trap) to capture more of the larger chipmunk-sized mammals. Nonhomogenized peanut butter is used as bait, dispensed from a plastic squeeze bottle. When trap lines exceed the overall length of a cover unit, they are doubled back with at least 10-m intervals maintained between line segments. Lines are operational for 10 consecutive nights and are checked daily. Lost traps and baits are replaced. Traps are not staked down.

Findings

Our data indicate that catch per 1000 trap-nights was higher on nights 2-5 than on the first night at two of the three locations trapped. The three species of shrews caught generally were not trapped in highest numbers until the second 5 days of trapping. All other species usually were taken in greatest numbers during the first 5 days. Trapping for only 1 night would have missed nine of the species eventually caught at the three locations. Trapping for two nights would have missed only three species, and after three nights only two species had not been caught.

LARGE MAMMALS

Oregon Study Area
James E. Tabor

Methods

For purposes of this study, large mammals were defined as species at least as large as chipmunks, and included specifically deer, elk, rabbits, hares, furbearers, porcupines, chipmunks, tree squirrels, ground squirrels, mountain beaver, moles, and gophers. Field evaluation of methods for sampling large mammals was conducted concurrently with testing of methods for small mammals during spring and winter seasons. In addition, terrestrial furbearer scent stations were operated 14-30 July 1976.

Deer, elk, rabbit, hare - The principal method tested for sampling deer, elk, rabbits and hares was the pellet group and sign count survey made in six circular plots (4-m radius), including the three small mammal trap stations located at 20-m intervals along each transect parallel to the road. A total of 78 plots were searched in each study area. Counts were made before small mammal traps were set. Alternate methods tested for this group of large mammals were visual observations of deer, elk, rabbits and hares made while sampling birds, and the identification of tracks at terrestrial furbearer scent stations.

Terrestrial furbearers - Presence of tracks at scent stations was the principal method tested for sampling terrestrial furbearers and porcupines.

Two scent stations, located 100 m apart, were employed at sample transects located at the roadside, and at distances of 100, 200, and 300 m from the road. One station on each transect was baited with a commercially prepared egg-based food scent (Mast's #6 coyote bait, purchased from Joseph A. Garcia & Son, 3761-81 Fairview Road, Hollister, Ca. 95023); the other station was baited with canned sardines to determine the relative efficiency of the two baits. Stations were a circular area of bare, soft soil (1-m radius) with bait placed in the center. Soil was sifted through a 0.32-cm screen.

Tracks and other sign of terrestrial furbearers seen in the 4-m radius plots examined for deer, elk, rabbit, and hare was an alternate method tested. Tracks and other signs of all species of mammals observed at scent stations or in plots were recorded.

Squirrels and chipmunks - Visual observation during bird sampling and captures in small mammal traps were the two methods tested for chipmunks and tree and ground squirrels.

Moles, gophers, and mountain beaver - Counts of mountain beaver burrows, mole mounds, and gopher mounds in the circular plots used for pellet group counts was the only method tested for these species.

Findings

Deer, elk, rabbit, hare - Data for this category of large mammals were obtained from pellet group and sign counts in 50-m^2 circular plots, scent stations, and observations of living animals while sampling birds during spring and summer.

In addition, two brush rabbits were captured in rat traps set for small mammals. We consider these latter captures to have been "accidental", however, and believe this method is not appropriate for this species or other rabbits and hares.

The pellet group and sign count survey, a method implemented in this study specifically for this group, produced the most consistent and greatest volume of data (number of observations) during both sampling periods. Deer, rabbits and hares were identified in a greater percentage of the study areas from the pellet group and sign count survey than from the other two techniques used. The amount of effort required to produce the number of observations presented for each of the three methods was not equal; therefore, the number of observations produced by each is not directly comparable. They do, however, provide a rough estimate of the relative amount of data generated. All represent an observation at a specific distance from a road.

In this study, determination of the amount of data produced per unit of effort (i.e., man-hours) was not a simple matter. One reason for this is that each method provided data for various groups of animals. Pellet group and sign counts, in addition to providing data on deer, elk, rabbits, and hares, also produced data on other categories of large mammals and reptiles and amphibians. Deer, rabbit and hare observations at scent stations were supplemental to data obtained for terrestrial furbearers. Mammal observations made while sampling birds were supplemental to the bird observations.

Some generalizations concerning amount of effort required to obtain observations can be made, however. Time required to conduct a pellet group and sign count survey in one 50-m^2 circular plot averaged approximately 3 minutes for one person, varying between 2-6 minutes depending on conditions affecting visibility of the ground surface. Pasture and ash habitats required the least amount of time to conduct counts. These two habitats had an herbaceous vegetative layer composed of low-growing species and a very sparse shrub layer, both of which allowed good visibility of the ground surface. Clearcut and old Douglas-fir required the greatest amount of time to conduct counts because of the tall, thick herbaceous layer and thick shrub layer.

Effort required to produce data from scent stations involved construction of the station and daily visits to the station afterward to record tracks. Construction of 64 scent stations required approximately 100 man-hours of effort. Number of visual observations made while sampling birds in spring represented about 240 man-hours over a 32 day period. For the winter observations, about 170 man-hours over 24 days were spent. It is important to note that at least 2 days at each sample site were required to obtain data from scent stations.

The amount of data produced by a method, irrespective of the effort required to obtain it, will be of major importance in the operational phase of the study. There will be a certain minimum amount of data, the amount depending to a large degree on the amount of within treatment variability, necessary to formulate valid conclusions concerning the effects of highways on wildlife populations. Unfortunately, we were unable to estimate within habitat variability for deer, rabbits and hares in this study because of the combination of small sample sizes and the low frequency of observations. It is apparent from our data, however, that a relatively small amount of data on deer, rabbit and hare use can be expected, even from a large amount of effort. Therefore, it may be desirable to use the method expected to produce the most data. Pellet group and sign counts produced the greatest volume of data in our tests. This method generated more observations in more study areas than either of the other two methods during both sampling seasons. Alder, old Douglas-fir, and clearcut Douglas-fir produced the greatest number of observations in spring. In winter, oak, clearcut Douglas-fir, old Douglas-fir, and pasture gave the highest numbers.

Not only did the pellet group and sign count method yield the most data, it produced the most useful type of data, in our opinion. Number of pellet groups provides an estimate of the amount of time spent, or amount of use, by deer, rabbits and hares at a particular distance from roads. Visual observations of these mammals and presence of their tracks at a particular time do not provide a measure of amount of time spent at the point of observation.

Since the pellet group survey provided the greatest volume, and what we felt was the most useful data, we used the results from this survey to estimate the minimum distance from roads to a "control" area for deer, rabbits and hares. Sample sizes were inadequate for deer, rabbits and hares to determine if there was a relationship between number of pellet groups and distance from the road within habitats during either of the two sampling seasons. The effect of distance from the road on deer, rabbit and hare use was examined with two-way analysis of variance and data from all habitats combined. There was no significant difference among means of deer pellet groups according to distance from road in spring ($F=1.01$; 12, 72 df; $P > 0.25$). There also was no significant difference among means of rabbit and hare pellet groups according to distance from road in spring ($F=0.98$; 12, 48 df; $P > 0.25$) or winter ($F=0.83$; 12, 48 df; $P > 0.25$).

Fewer data were obtained from the same amount of effort in winter than in spring on deer, rabbits and hares from all three inventory methods. We believe this was due primarily to a lowered efficiency of the methods rather than decreased use by deer, rabbits and hares. We attribute the observed decrease in number of pellet groups from spring to winter to the presence of fallen leaves from deciduous trees and shrubs covering the ground surface and probably covering pellet groups also. The number of deer pellet groups found in winter was approximately half what was found in spring. Pellet group counts can be expected to be less efficient for gathering data on deer, rabbit and hare use in winter than in spring.

Terrestrial furbearers - Pellet group and sign counts, scent stations, and observations of living animals while sampling birds provided data on terrestrial furbearers. No observations of terrestrial furbearers were made while sampling birds in winter. The largest number of species was identified at scent stations in both seasons, and the largest number of observations was made at scent stations in winter. Pellet group and sign counts produced the largest number of observations in spring. It should be noted, however, that 89 percent of these observations were made at one study area (ash) at a time when conditions for observing tracks were optimal due to a thin layer of soft mud covering the ground surface of almost the entire study area. Also, the ground surface was almost totally free of vegetation. This optimal situation for tracks was observed at no other study area during pellet group and sign counts and is a situation that can be expected to occur rarely. In general, conditions encountered during this study were consistently unfavorable for finding identifiable sign of terrestrial furbearers. In winter, no observations of terrestrial furbearers were made in the ash study area. The soil was dry and hard in this area during the winter sampling period and was not suitable for tracks.

Observations of terrestrial furbearers made while sampling birds were infrequent and cannot be considered an appropriate method to inventory this group of large animals. One short-tailed weasel was taken in a small mammal trap in spring. This method could potentially be the best of all methods for short-tailed weasels especially if a flesh bait were used. Short-tailed weasel tracks are very difficult to differentiate from similar-sized chipmunks and other small mammals.

The amount of effort required to obtain data for terrestrial furbearers with pellet group and sign counts, scent stations, and observations of living animals was discussed above in relation to gathering data on deer, elk, rabbits and hares with the same three methods. The pellet group and sign count method requires the least amount of effort. But, as stated for deer, elk, rabbits and hares, the amount of data produced by a method is of major importance in that a certain minimum amount of data will be required in the operational phase of the study. We made fewer observations of terrestrial furbearers, even considering all species as a group, in this study than of either deer or rabbits and hares and, therefore, were even less capable of making estimates of precision for this animal group. Since all three methods produced a similar type of data, we suggest the possibility of using all three. If a single method were used, it should be the scent station because it was most consistent in producing observations and identified more species. Observations of terrestrial furbearers were made in six habitats in spring with scent stations, four with pellet group and sign counts, and five with observations of living animals. In winter, scent stations produced data in five habitats, sign counts in three, and observations while sampling birds in none.

Observations of terrestrial furbearers (even with all species and habitats combined) were too few in number to allow us to make a reliable estimate of minimum control distance. If one assumes that our small sample is representative, the occurrence of terrestrial furbearers as a group does not appear to be related to distance from road within 300 m of the road. It must be emphasized, however, that individual species may respond differently to roads. For example, the opossum and perhaps other species may possibly occur at a greater frequency near roads because of availability of carrion upon which they feed. Coyotes, on the other hand, may avoid roads with traffic because of their secretive, shy nature.

Eight species of furbearers were identified in both spring and winter. If the observations made under the "rare" conditions at the ash study area in spring are omitted, more total observations were made in winter. The number of observations made and number of species identified were lower in summer than in spring and winter. The relative number of observations according to season probably represent an integration of furbearer density and activity.

The number of observations of each species of terrestrial furbearers per 1000 scent station-nights made in this study are probably representative of what can be expected throughout western Oregon and Washington and northwestern California. It should be noted that frequency of observations for this low-density group of mammals was low.

The scent station method was implemented specifically for terrestrial furbearers, and as a result, two tests specific to this method were planned and made. These tests included evaluating the relative effectiveness of two types of bait and determining the most efficient number of nights to operate stations. There appeared to be little difference in the effectiveness of the two baits. Egg and sardine bait produced essentially the same number of observations each season and identified the same number of species.

There were approximately one-half as many observations made the first night of operation as each of the other three nights. Number of observations made the second, third, and fourth nights were about equal. Furbearers may have avoided the scent stations the first night because of the presence of human scent which probably disappeared before the second night. The cumulative number of species identified at scent stations increased with each additional night of operation in all seasons except during summer when no additional species were added the fourth night. The greatest number of new species was added the second night. One night of operation appears to be inefficient for terrestrial furbearer scent stations.

In addition to the tests just discussed for bait and number of station-nights, there are several other details concerning scent stations that should be mentioned. The effectiveness of this method depends entirely upon the presence of tracks that can be identified to species. A fine-textured, loose soil is an absolute necessity for obtaining tracks that can be identified. We found that soil present at some sites and on some occasions was not suitable for preparing a reliable scent station. On such occasions, imported soil was used to make the station. Wet clay could not be sifted through a fine enough mesh to prepare an adequate tracking surface. Dry, coarse sand, on the other hand, produced "indistinct" tracks that could not be identified. A thin layer (0.64-1.27 cm) of fine-textured soil over a hard surface produced tracks of the highest quality. In addition to problems with soil type and preparation, we experienced problems with rain and fallen leaves. Rain destroyed tracks; fallen leaves prevented animals from making tracks. Both of these problems can be reduced to some extent by not placing scent stations under trees. Large drops of water drip from trees even when rain is very light.

Even so, the scent station is probably the best technique for gathering data on terrestrial furbearers in the operational phase of the study. From our experience, one cannot rely on the presence of sign at unprepared and unbaited sites to provide adequate data for estimating the effects of roads on the distribution and abundance of terrestrial furbearers. Sign identifiable to species is restricted almost entirely to tracks, and it was our experience that suitable conditions for tracks can be expected rarely in western Oregon and Washington and northwestern California. The common type of observation is of scat, which usually is not identifiable to species.

Data from scent stations, sign counts, and observations of living animals are comparable, in our opinion, and could be pooled. We suggest that all three methods be used in the operational phase.

<u>Squirrels and chipmunks</u> - Observations of squirrels and chipmunks were made during pellet group and sign counts, at scent stations, while sampling birds, and during small mammal trapping. In winter, no squirrels or chipmunks were recorded at scent stations. Townsends chipmunks and California ground squirrels were the only species taken in small mammal (rat) traps. Only two California ground squirrels, one in each season, were trapped. Rat traps are too small to be effective for this species. However, rat traps are an appropriate size for Townsends chipmunks. Some of these chipmunks were even taken in mouse traps.

Visual and auditory observations while sampling birds provided by far the most data and is probably the only method that can be relied upon to census diurnal mammals of this group. Only two observations were made with the sign count method - both were California ground squirrel burrows found in spring. The only observations made at scent stations were four records of Townsends chipmunks. One problem with the sign count and scent station methods for squirrels and chipmunks was identification of tracks and sign; we could not differentiate species. While sampling birds, 221 observations were made of Douglas squirrels, western gray squirrels, and Townsends chipmunks in winter. Observations of California ground squirrels and western gray squirrels were infrequent in this study primarily because these species were present at only a small number of our study areas. Observing these species while surveying birds should be a very appropriate method of sampling, however.

Observations made in conjunction with sampling birds should provide adequate data for all species of tree and ground squirrels and chipmunks to evaluate the effects of roads on their distribution and abundance. We obtained 89 observations of Douglas squirrels in five (63 percent) of the study areas in spring and 88 observations in the same five areas in winter. One hundred and twenty-nine Townsends chipmunks were seen or heard in five study areas in spring and 89 in three (38 percent) of the study areas in winter. The largest number of Douglas squirrels was observed in young and old Douglas-fir habitats during both seasons. Townsends chipmunks were observed most frequently in old and clearcut Douglas-fir.

Eleven Townsends chipmunks were trapped during the spring sampling season for small mammals. They were taken in alder, clearcut Douglas-fir, and riparian habitats. Only two chipmunks were caught in winter; they were trapped in old and clearcut Douglas-fir. Chipmunks were trapped in all areas where they had been observed while sampling birds and also in the riparian habitat which was not sampled for birds.

Very little data were obtained in this study upon which to base estimates of control distances. Eighty-seven observations of Townsends chipmunks and 27 observations of the Douglas squirrel, recorded in four 100-m intervals away from roads, were made. Sample sizes were far too small, in our opinion, to draw any meaningful conclusions. We suggest, however, that since observations of squirrels and chipmunks will probably be made in conjunction with bird surveys, estimation of a control distance for this group is probably unnecessary because the control distance used will be the same as that used for birds.

Moles, gophers, and mountain beaver - The pellet group and sign count technique was essentially the only method that provided data on this category of large mammals. Observations made with other methods include one mountain beaver heard while sampling birds and two moles caught in small mammal traps. The species in this group of mammals usually produce easily observable and identifiable sign of their presence. Counts of sign is probably the most practical method to inventory them. One problem that exists, however, is that species of moles and gophers cannot be differentiated on the basis of sign. If desired, species can be identified by trapping a sample of moles and gophers at each site where sign is present.

Mole mounds were observed during both spring and winter in the same seven study areas (88 percent) and at approximately the same frequency both seasons. In spring, 102 (16 percent) of the plots (all study areas combined) contained mole mounds, and in winter 116 (19 percent) of the plots contained mounds. Mole mounds were found in all habitats except ryegrass. They were most abundant in oak during spring and in pasture during fall. Gopher mounds were observed in fewer study areas in spring (38 percent) and in fall (25 percent) and at a much lower frequency than mole mounds. Only 1.3 and 3.2 percent of plots had gopher mounds in spring and fall, respectively. Mountain beaver burrows were found in 38 percent of the study areas in spring and in 25 percent in winter. Burrows of this species occurred in 2 percent of plots in spring and 3 percent in winter. Gopher sign was present in pasture, oak, and clearcut Douglas-fir habitats and was most abundant in the clearcut. Mountain beaver burrows were found in young Douglas-fir, alder, and clearcut Douglas-fir. Burrows were encountered most frequently in alder.

Observations of gophers and mountain beaver were too few in number to make an estimate of the minimum distance to a control area for these animals. The mean number of mole mounds per study area plot was used to evaluate the effect of roads on mole activity. Mean numbers of mounds counted in the roadside habitat and at 25-m intervals away from the road out to 300 m were not significantly different in spring ($F=0.4$; 12, 72 df; $P > 0.25$) or in winter ($F=1.2$; 12, 72 df; $P > 0.25$). However, it appeared that mole activity, as measured by number of mounds, was less in the roadside habitat during both seasons. We believe that the control area for moles could be placed as close as 100 m to the road, if desired.

Wisconsin Study Area
James R. March

Methods

Scent stations - Single scent stations (Richards and Hine 1953, Linhart and Knowlton 1975) were operative in each of 19 woodlots during September 1975 and May 1976. Stations consisted of a circle about 91 cm in diameter of fine or sifted sand. A small capsule filled with either a commercial fermented-egg product (Linhart and Knowlton 1975) or a locally-produced commercial fox lure was attached (3-5 cm above the ground) to a wooden stick placed in the center of the circle (Fig. 3). Egg attractant was used for all the September stations. In May, egg attractant was combined with fox lure at stations set out in eight stands. Fox lure alone was used at stations in the other 11 stands.

All station sites were within the woodlot interiors, but not all were placed in the center of a stand. Usually, stations were operative for 5 consecutive nights with daily checks made to record visits (tracks) by mammals and other animals. Any missing capsules or attractants were replaced when stations were checked. Not all stations were operational for 5 nights, since heavy rains wiped out tracks on several occasions. In the analysis, visits per station-night were calculated only for the actual number of nights a station was operational.

Scent stations also were evaluated in woody habitats during June-August 1976. These additional tests were conducted to compare rates of visitation to different baits and the effects of placing multiple stations in the same cover unit. All experiments were conducted in two woodlots, 7.7 ha and 4.4 ha in size (for later reference called stands No. 8 and No. 2, respectively). Stand No. 8 was immediately adjacent to a county road; stand No. 2 was 400 m east of a paved town road.

Multiple scent stations were evaluated in stand No. 2 during June and July with egg plus fox lure, fox lure alone,

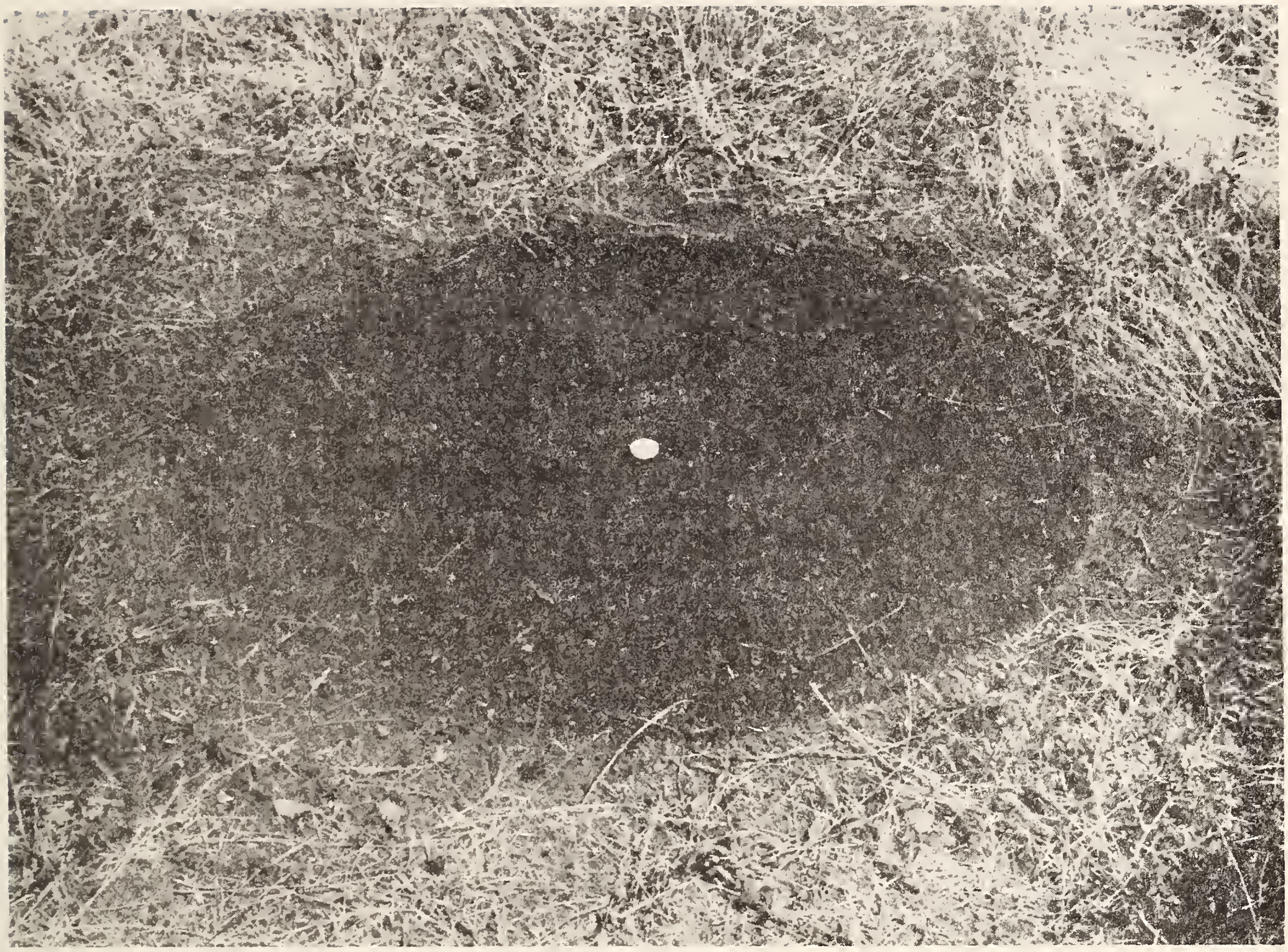

Fig. 3. A completed scent station. The capsule contains a scent attractant, and is supported 3-5 cm above the ground surface by a wooden stake. (Photo courtesy of U.S. Fish and Wildlife Service).

and field corn as attractants. Each of five stations was baited with one of the three attractants. In stand No. 8 five stations were operational during the same time period in July. For the first 5 nights, stations had no attractant. After a 2-day "rest" period, all five stations were baited with fox lure and operated for 5 additional nights. Single scent stations, baited with fox lure, also were operative in the two stands for 3 nights in August.

Individual scent stations were constructed (June-July 1976) in each of the five 0.8-ha plots on the Shaw transect, one of the six established to evaluate techniques in non-woody habitats. Cover types on the five plots were mixtures of grasses, forbs, and alfalfa. The Shaw transect lay perpendicularly to a county highway. For the first sequence (limited by rain to only 3 nights) stations in two plots received only fox lure, two were baited with egg attractant plus fox lure, and one station had only egg attractant. For the second sequence (held purposely to only 3 nights for comparability with the first sequence), each station was baited with a cob of field corn.

Baited and unbaited scent stations also were compared (July 1976) on one 0.8-ha plot along the Stegner transect, another non-woody area. Unbaited stations were operational for 5 nights at two locations. One station was immediately adjacent to a fenceline and the second was placed about 60 m east in idle cropland. After a 2-day rest period, the same stations were baited with fox lure and operated for 5 additional nights.

One additional test of attractants was made by placing five scent stations, each with a different bait, in the same corn field. Fox lure, egg attractant, egg attractant plus fox lure, liquid smoke (a commercial food seasoner), and liquid smoke plus dead fish (black bullhead) were used as baits. Stations were placed 2.5 m apart in a pentagon pattern. In addition to the tracks left in the scent station sand, mammal tracks in the soft soil of the field could be followed to determine the response to individual baits by an animal passing through the area.

The final evaluation of scent stations was made in non-woody habitats during October 1976. To more efficiently use available manpower, we conducted these tests off the main study area at two locations in Dane County, Wisconsin. Individual scent stations were placed 23 m and 114 m from highways in each of six cover types. In addition, stations were established 206 m from the road in four cover types, and at 297 m from the road in three cover types. All stations were baited with fox lure and were operational for 5 consecutive nights.

Pellet and scat surveys - April pellet surveys were used to obtain indices to presence and relative abundance of cottontail rabbits and white-tailed deer in 18 woodlots and in 0.8-ha plots on five of six transects in non-woody habitat. Presence and number of scats deposited by other medium-sized mammals also were recorded by species during these surveys.

Preliminary tests of sampling unit sizes and estimates of the potential variability associated with pellet counts were conducted in one 4.4-ha woodlot (stand No. 63). Previous visits and surveys indicated that stand No. 63 received rabbit and deer use equal to or greater than any of the other 18 stands. Fifty-two points were located systematically within the woodlot from a randomly selected starting point. In the main body of the woods, 45 sampling points were distributed at 33-m intervals along three transects (15 points on each line) perpendicular to the road and following the long axis of the stand. The remaining points were located systematically in the 0.7-ha portion adjacent to the main stand. At each point, rabbit pellets were counted in a 0.0004-ha rectangular plot; deer pellet groups were counted in a 0.0016-ha circular plot. In addition, at every fourth and sixth point rabbit pellets were counted in cross-shaped 0.0016-ha plots, and deer pellet groups were counted in 0.008-ha circular plots.

Based on the initial surveys in stand No. 63, 0.0004-ha rectangular plots and 0.0016-ha circular plots were selected as the basic sampling units for pellet surveys in other woodlots. Points in each stand were selected systematically from a random starting location. Distance between points was varied to insure that a minimum of 30 points were sampled in each stand. In stand No. 63 a range of 0-184 rabbit pellets was found in the fifty-two 0.0004-ha plots. We considered this complete enumeration of rabbit pellets to be inefficient, so recorded only "presence" or "absence" of pellets in all subsequent 0.0004-ha plots. Results were calculated as percent frequency of occurrence. Frequency of occurrence of rabbit pellets also was recorded for all subsequent 0.0016-ha deer pellet group plots.

In non-woody habitats, rabbit pellet densities and presence were sub-sampled in 0.0004-ha rectangular quadrats at 40 systematically selected points (from a random start) within the 0.8-ha plots. At every fourth point deer pellet groups were sub-sampled within a 0.0016-ha circle and at every tenth point within an 0.008-ha circle. The 0.0004-ha and 0.0016-ha units sampled 2 percent of each plot; the 0.008-ha units, 4 percent.

One additional index to relative deer and rabbit use was obtained in stand No. 63 and the 0.8-ha plots by walking diagonal transects across the woodlot and plots. All rabbit pellets, deer pellet groups or other mammalian scats encountered on these transects, plus the number of paces walked, were recorded. Results from both diagonals were combined and expressed as the number of pellets or pellet groups encountered per 1000 paces. In the 0.8-ha plots, counts from the diagonal transects were compared with similar combined counts of pellets made along two transects originating from randomly selected points along the plot edge and running perpendicularly to that edge.

Some insight into the spring deterioration rate of rabbit pellets in woodlots was obtained by counting the numbers of pellets in the same plots on 2 April 1976 and again on 19 April 1976. Counts were made in three 0.008-ha circular plots in stand No. 8.

In July 1976 numbers of mammal scats found on transects inspected by walking across 0.8-ha plots in permanent grass-forbs or corn were compared with numbers of scats found in complete searches of each plot. Three different transect patterns were used in each plot.

<u>Den and nest surveys</u> - Eighteen woodlots and the six 0.8-ha non-wooded plots were searched completely for active mammal dens in May and June 1976. No active dens were found in any of the 0.8-ha plots. In the woodlots, known species composition of active dens was compared with results from other mammal surveys. Squirrel leaf nests (Uhlig 1956) were counted in the 18 woodlots between 9-13 February 1976. The objective was to tally all such nests and compare this index to squirrel abundance with results from other surveys in the same stands.

<u>Deer trail counts</u> - Deer trail counts were made in 11 of 18 woodlots on 20 October 1975. Trails were identified and counted according to the criteria of McCaffery (1976). All miscellaneous deer tracks, pellets, beds, and fresh buck "rubs" seen on the trail survey also were recorded.

<u>Time-area counts for squirrels</u> - During February 1976, time-area counts (Flyger 1959) were tried in five woodlots as a technique for estimating squirrel abundance in those stands. Observation periods were begun one-half hour before sunrise and continued one-half hour after the last squirrel was observed. Observations were made from a single point located approximately in the center of each stand. Distance from the observer to each squirrel seen was estimated by pacing at the end of the observation period. A maximum of five counts was made in a single stand.

Winter track surveys - It was recognized that persistent snowfall normally is not available in many parts of the till plain. However, the use of track counts in snow was investigated as an alternative technique for obtaining indices to winter mammal presence and abundance. We compared indices obtained from track counts with the results from other surveys.

Beginning in December 1975 and continuing through March 1976, monthly mammal track and trail counts were made in 18 woodlots and the six 0.8-ha plots in non-woody habitat. Counts were made 1 or 2 days after a fresh snowfall. Whenever possible, all mammal tracks were identified to species. In the woodlots, track counts were made along two diagonal transects. Results from both diagonals were combined to obtain a stand's track index. Several different transect patterns were used for the 0.8-ha non-woody plots, and the results from each were compared.

Live-trapping - To meet the objectives of this study, indices to animal use of defined areas were needed rather than population estimates of animals within defined areas. However, live-trapping data for tree squirrels and cottontails were available from other studies at 18 woodlots, and these data were used to compare differences in relative abundance between woodlots and served as a check on the results of other indices to squirrel and rabbit abundance.

The woodlots were live-trapped during three periods in 1976-1977: September, January through February, and May. Traps remained operational for 10 days and nights during each of the three periods. One 15- x 15- x 48-cm "Tomahawk" wire live-trap and one handmade wooden box trap were set per 2.5 ha of woods. Cob corn was used for bait. In addition, during September, non-homogenized peanut butter was spread on the treadles of the wire traps; in May, black walnuts were placed in each trap. Individual squirrels were toe-clipped for later identification if recaptured. Numbered aluminum fingerling tags were placed in the ear of each rabbit. Live-trapping results gave minimum estimates of abundance of rabbits and squirrels in each woodlot and provided "presence" information on a number of other species also.

Findings

Scent stations - When we compared visits by all mammals, egg attractant and commercial fox lure performed equally well when used separately as scent station baits. The actual recorded visits per total scent station-nights did not differ between the two attractants (chi-square=0.52, 1 df, $P > 0.25$). Stations with either bait were visited about twice as often as stations baited with egg attractant plus fox lure or with cob corn. Corn was a particularly poor bait since it attracted many small mammals and birds whose tracks obscured those of rabbits, squirrels and other medium-sized mammals.

Skunks, red fox, and tree squirrels responded better to egg attractant than to fox lure, but the latter bait attracted more raccoons and opossums. Except for weasels and cottontails, stations baited with egg were visited by the same kinds of mammals as stations baited with fox lure. In practice, the plastic capsules filled with egg attractant were easier to store and to handle than the fox lure. The fox lure we used had a particularly foul smell, and its wet, pasty consistency made station baiting more difficult. The fox lure, however, reduced interference by domestic carnivores since cats and dogs responded better to the egg bait (13 visits per 100 station-nights) than to the fox lure (4 visits per 100 station-nights).

The few scent stations set without bait were visited with about the same frequency as stations baited with egg attractant or fox lure. However, four of the 16 mammal visits recorded were at unbaited stations located in a known travel lane along a fence. Four of the other visits were made on the same night to four of five unbaited stations in stand No. 8. All four visits were thought to be made by the same opossum that presumably was following our scent from station to station.

Although mean visits per 100 station-nights were numerically higher for the first night of operation, there were no significant differneces ($P > 0.05$) between means for individual nights. Differences were not detectable at that level of significance with individual sample sizes of 47-64 station-nights in woodlots and 23-39 station-nights in other habitats. Similarly, when we tested actual mammal visits for total station-nights with chi-square, visitation rates for individual nights were not different ($P > 0.05$).

When we looked at individual responses of the various mammals utilizing woodlots, visits per 100 station-nights on the first night were generally similar to mean visits per 100 station-nights obtained for all 5 nights. However, only white-tailed deer had their highest recorded woodlot visitation rate on the first night. Foxes made the most visits on the fourth and fifth nights. In non-woody habitats, scent stations were the most attractive on the first night for all species except rabbits and deer.

At woodlot scent stations ultimately visited by one or more mammals, the frequencies of initial visits were higher on the first night of operation for all groups except skunks and foxes. In general, at least 50 percent of the initial visits occurred by the second night of operation. Exceptions were initial visits by raccoons and foxes which did not reach 50 percent until the third and fourth nights, respectively. Within non-woody habitats, initial visits by deer and rabbits did not reach 50 percent until the third night; at least half of all other initial visits were recorded on the first night a station was operative.

The visitation rate for multiple scent stations (65 station-nights) set out in stands No. 2 and No. 8 was 89.2 visits per 100 station-nights. The visitation rate for all single stations in the same two stands was 86.7 visits per 100 station-nights. With single stations, raccoons (27 percent), opossum (27 percent), and skunks (23 percent) made the greatest proportions of the visits. With multiple stations in the same stands, opossum accounted for 69 percent of all visits. Tracks and other evidence suggested that at least one individual opossum visited all five stations in one stand on the same night. This same "bait happy" individual also may have made a number of visits on other nights. Although the multiple stations were placed about 100 m apart, the presence of one station and/or the trails of human scent between them may have attracted mammals to the other stations in the stand. The use of multiple stations did not appear to add a great deal of information and may actually have encouraged multiple visits by one animal.

Distances from roadways to scent stations in woodlots and in the 0.8-ha plots were estimated from aerial photographs. Visitation rates were examined at 100-m intervals starting at the roadway and continuing to beyond 400 m from the road. For all mammals combined, mean visits per 100 station-nights were not significantly different ($P > 0.05$) for any of the 100-m intervals. Mean visitation rates for stations set 1-100 m and 401+ m from roads were identical. When we looked at visitations by small carnivores only, the mean rate of visitation at stations placed 0-100 m from the road in woodlots was significantly greater ($P < 0.05$) than the mean visitation rate at 101-200-m stations. Mean visitation rates for small carnivores at stations for all other intervals in both woody and non-woody habitats were not different ($P > 0.05$).

Visitation rates in habitats immediately adjacent to roads were not estimated. The closest roadside stations were 23 m from the highways. Stations at 23 m had 30.0 visits per 100 station-nights compared to a combined rate of 33.8 visits per 100 station-nights for stations located 114 m, 205 m, and 297 m from roads.

The several groups of mammals were not consistent in their spatial preference for woodlot scent stations. Foxes did not visit scent stations placed within 100 m of the road. The highest visitation rate for foxes was recorded at stations 201-300 m from a road. When we compared total visits on all station-nights for each kind of mammal, opossum visitations at stations within 100 m of the roadway were significantly higher (chi-square=6.88, 1 df, $P < 0.01$) than visitations at the more distant stations. Tree squirrels utilized stations within 100 m of the road at a significantly lower rate (chi-square= 5.09, 1 df, $P < 0.05$). All other mammals visited stations at rates that were not significantly different ($P > 0.05$) in regard to distance from roads.

Mean visitations by all mammals (± standard error of the mean) per 100 station-nights in all habitats was 52.2 ± 6.9 (n = 111) for stations within 100 m of the roadway. For all stations more than 100 m from the road, mean visitation rate by all mammals was 51.0 ±4.1 per 100 station-nights (n = 259). This difference was not significant ($P > 0.05$). When we considered only visits by small carnivores, means were 47.7 ± 6.1 and 39.0 ± 3.7 visits per 100 station-nights for stations 0-100 m and 101+ m from the road, respectively. This difference was not considered significant (t=1.252, 368 df, P=0.20).

Mean visitation rates for woodlot scent stations operative in June through August were significantly higher ($P < 0.05$) than mean visitation rates for May or September through October stations. Based on chi-square tests of total visits on all station-nights, skunk and tree squirrel visitation rates in woodlots were greatest September through October. Visitations by raccoons were higher in May and June-August, while opossum visitation rates were higher in June-August than in either of the other two periods. Visitation rates for foxes did not differ between September-October and May. No foxes were recorded at stations June-August.

Scent stations in non-woody habitats had a numerically higher visitation rate in September-October but not significantly so ($P > 0.05$). Skunk and opossum visited stations in the fall at higher rates than in summer in this type of habitat. Raccoon visits per 100 station-nights were not different between periods, and foxes were recorded at stations in non-woody habitats only in summer.

Mammal visits per 100 station-nights were quite variable between habitats, and also within the same habitat, depending on month(s) of operation and kind of attractant used. Two of the three rates exceeding one visit per station-night were recorded in woodlots with fox lure as bait. An unbaited fence-line station also exceeded one visit per station-night. Visitations per 100 station-nights in woodlots were twice those recorded in all non-woody habitats combined. The visitation rates obtained from individual woodlots ranged from 0 to 110 visits per 100 station-nights. Stations in 11 of 18 woodlots had 50 or less visits per 100 station-nights, five had 51-75 visits per 100 station-nights, and two woodlots had more than 75 visits per 100 station-nights.

Visitation rates in larger blocks of cover or in cultivated lands were only about one-third as great as rates from strip habitats. Strips of cover apparently were used more as travel lanes, and scent stations placed in such locations probably were easier for mammals to detect.

Opossums (33 percent), raccoons (26 percent), and skunks (13 percent) were the three mammals most frequently recorded at scent stations. Based on our general knowledge of relative species abundance in southern Wisconsin, raccoons apparently visited scent stations with greater frequency than expected on the basis of abundance alone. Either that, or scent stations were not as attractive to skunks as they were to raccoons. Both skunks and opossums in the general region are thought to be more abundant than raccoons which are subject to a higher exploitation rate because of their pelt values. Woodlots biased the results somewhat in favor of raccoons, with the species comprising 26 percent of the visits in woodlots and 22 percent of the visits in non-woody habitats. Skunks, which might be expected to more commonly frequent the open or grassy habitats, represented 14 percent of the woodlot visits and 13 percent of the visits in other habitats. Weasels also were considerably more abundant than indicated by scent stations. Tracks of domestic dogs and cats, chipmunks, cows, pheasants, crows, and small birds frequently were recorded at scent stations. Almost all stations had small mammal tracks in them.

The data suggest that scent stations were our most efficient and accurate method of detecting presence of raccoons, skunks, and foxes in woodlots. Scent stations were less efficient at detecting presence of opossums and tree squirrels and did a relatively poor job of attracting deer, rabbits, weasels, and woodchucks. With regard to deer, rabbits, and tree squirrels, observations made incidental to other surveys gave a better indication of presence than did scent stations. The scent station was the only survey technique that detected the presence of skunks in eight stands, foxes in six, raccoon in five, and opossums in three. Conversely, scent stations in some stands did not attract any opossum, skunk, or raccoon, even though the species were known to be present. Apparently, weasels also are not readily attracted to the baits we used.

The high visitation rate recorded for opossum suggested that once individual animals locate a station they may make repeated visits. In general, however, scent stations were not very efficient in detecting opossum presence.

Pellet and scat surveys - The three sampling units tested in stand No. 63 gave similar mean numbers of rabbit pellets per hectare. However, variances associated with each of the means were different. When each quadrat sampled in the 21 clusters of four 0.0004-ha quadrats was treated as an individual sampling unit, precision was about one-third better than that obtained by sampling 52 individual 0.0004-ha quadrats, but sampling time was increased about 40 percent. Pooling the data from each quadrat in the cluster of four did not improve precision but did increase the frequency of occurrence to 95 percent.

Mean numbers of deer pellet groups per hectare were not significantly different ($P > 0.05$) between sampling units. By increasing the size of the sampling unit by a factor of five and doubling the area sampled, we produced a small increase in precision, but this procedure required 20 percent more time to complete the survey. Frequency of occurrence was doubled by the five-fold increase in the sampling unit size. When the area of 0.008-ha circles sampled equalled the same area as fifty-two 0.0016-ha circles, sampling time was reduced but precision was poorer than for either of the other two estimates.

The time required to search individual sampling units was 30 seconds, 5 minutes, and 15 minutes, respectively, for the 0.0004-ha quadrats, the 0.0016-ha circles, and the 0.008-ha circles. Travel times between sampling points were 30 seconds for single 0.0004-ha plots and 0.0016-ha circles, and 1.5 minutes for 0.0004-ha clusters and 0.008-ha circles.

Based on initial tests in stand No. 63, all additional rabbit pellet sampling recorded only the absence or presence of pellets in single 0.0004-ha rectangles and in 0.0016-ha circles. Because they required less time to search per unit the 0.0016-ha circles also were selected as the basic unit for sampling deer pellet groups in all other woodlots.

At the same points in each stand, frequency of occurrence of rabbit pellets in the 0.0016-ha circles was about one-fourth greater than for the 0.0004-ha quadrats, but each of the larger units required 1.5 minutes longer to search. Frequencies of pellet occurrence obtained by either sampling unit were significantly correlated with total numbers of rabbits we live-trapped in each stand.

Frequency of occurrence of deer pellet groups in 0.0016-ha circles was less than 6 percent overall, and no pellet groups were found in eight of the stands sampled.

From the results of all our surveys and observations, rabbits were known to be present in all 19 woodlots. Pellet surveys indicated presence in 18 stands. Pellet surveys were less effective for determining deer presence since pellet groups were found in only 10 stands - deer were known to use at least 16. However, we found deer pellets in two stands where presence had not been established by other surveys.

Deer pellet groups were not found in any of the 0.0016-ha or 0.008-ha units examined in four non-woody habitat 0.8-ha plots. Complete searches of the same plots also failed to locate any pellet groups. Since habitats in the remaining 0.8-ha plots were similar to those in the four plots sampled, no additional 0.8-ha plots were considered in the pellet group surveys.

For three 0.8-ha plots in permanent grass-forb cover, rabbit pellets were found in 3 percent, 12 percent, and 17 percent of the 0.0004-ha, 0.0016-ha, and 0.008-ha sampling units, respectively. On one 0.8-ha plot in pasture and plowed cropland, frequencies of occurrence were 20, 33, and 50 percent, respectively. Mean numbers of pellets per hectare were quite variable, depending on which sampling unit was used and the number of units sampled. Sample sizes were too small to be meaningful in most instances, and rapid deterioration of pellets occurred during the sampling period. Daily losses of pellets probably biased our results in non-woody cover; continued deterioration made sampling of pellets in additional 0.8-ha plots meaningless.

In stand No. 63, 20 deer pellet groups were encountered along two diagonal transects, and 16 pellet groups were encountered on two perpendicular transects. Either pattern of transects required about 10 minutes to complete. Contrast these results with the 47 pellet groups found in twenty-one 0.008-ha circles which required 5.75 hours to examine or the 15 pellet groups found in fifty-two 0.0016-ha circles which took 4.75 hours to search. The two diagonal transects covered 798 paces; the perpendicular transects, 776 paces. Deer pellet groups encountered per 100 paces were 25 and 21 for diagonal and perpendicular routes, respectively. Along diagonals, 163 rabbit pellets (204 per 1000 paces) were encountered; 118 rabbit pellets (152 per 1000 paces) were found on perpendicular transects. Assuming an observer searched a strip one metre wide, about 800 rabbit pellets per hectare were estimated from the transects. This was considerably lower than the 15,000 pellets per hectare obtained from defined sampling units. An estimated 80-100 deer pellet groups were present per hectare-densities about one-half those estimated from defined sampling units. The transects did provide an index to presence and relative abundance, however. Variances of transect counts might be determined by considering each pace as a unit and recording numbers and locations of pellets found on the transects by individual paces.

On the 0.8-ha plots, no deer pellet groups were seen on diagonal (n = 16) or perpendicular (n = 8) transects. Considerably more rabbit pellets were encountered on the diagonal transects than on perpendicular routes. Each diagonal required about 70 paces, compared to about 50 paces for perpendicular routes. Five minutes were required to complete each set of two transects in a 91- x 91-m plot. There were no differences in pellets encountered per transect for either of the diagonals walked in all plots. Treating individual transects as sampling units, means for the two transects were 10.4 and 12.1 pellets encountered per route.

Rabbit pellet indices from diagonal transects in four 0.8-ha plots and numbers of pellets found in 0.0004-, 0.0016-, and 0.008-ha sampling units in those four plots both indicated highest use occurred in the same two plots. Diagonals also identified rabbit presence (encounters with one or more pellets) in the same three plots as the defined sampling units.

On the 0.8-ha plots, area and numbers of units sampled were held constant. Numbers of 0.0004- and 0.0016-ha units sampled in the woodlots ranged from 5-32 per hectare for woody vegetation. Percent frequencies of occurrence for rabbit pellets and deer pellet groups, and also the number of deer pellet groups found per plot, were not directly related to the number of sampling units examined per hectare (simple correlation coefficients of less than 0.150 in all cases, 17 df).

By treating data from stand No. 63 as three separate transects, occurrence and number of rabbit pellets were compared at various distances from the roadway. Overall, frequencies of occurrence and mean pellets per unit sampled were not different ($P > 0.05$) between transects or between distances from the roadway. Two 0.0004-ha units on transect No. 2 (running through the center of the stand), which contained 184 and 60 pellets, respectively, were mainly responsible for the larger means and variances associated with 0 - 100-m and 301+ m plots. When those two values were excluded, means for all transects and distances were quite similar.

Frequencies of occurrence and mean numbers of deer pellet groups per 0.0016-ha unit sampled were not different between transects or distances from the road ($P > 0.05$). Although mean numbers of pellet groups per 0.008-ha sampling unit were not different between transects or distances, frequency of occurrence was higher in units 101-300 m from the road.

On 2 April 1976, 52, 182, and 399 rabbit pellets were counted in three 0.008-ha units in stand No. 8. Within each of the larger circles, 0.0016-ha circles contained 10, 14, and 106 rabbit pellets. No pellets were found within 0.0004-ha rectangular quadrats examined at each point. On 19 April 1976, when the same units were re-examined, only a single rabbit pellet was found in the 0.008-ha circles. Rain fell in the Horicon vicinity on 5 of the 17 days (cumulative amount of about 2 cm) between the counts. About half that precipitation fell on 15 April and, apparently, was the major factor influencing pellet disappearance.

Only one mammal scat, probably raccoon, was found in units sampled in woodlots for deer or rabbit pellets. No mammal scats were found in any defined sampling unit or on any of the transects walked across the 0.8-ha plots in non-woody cover. Complete searches of three of those plots found three logs with one raccoon scat on each and one log with six raccoon scats on it. No other scats were found.

Den and nest surveys - Woodchuck dens were found in six stands during the course of complete searches of all woodlots. As many as five active woodchuck den complexes were found in a single stand. One raccoon den tree also was located in a stand. Additional den trees undoubtedly were present, but their locations were difficult to determine, and verification of occupants was generally not possible without climbing trees. Current occupants of ground dens also were difficult to identify without tracks, hair or visual contacts. No active ground burrows or tree dens were found on the twenty-eight 0.8-ha plots during May or June. We did locate raccoon and opossum tree dens on one shrub-carr plot in February 1976, and several woodchuck holes were being used by an unknown occupant in a grass-forb plot during March.

Numbers of squirrel leaf nests found ranged from 0 (four stands) to 21 (one stand). Mean number of nests per hectare was 2.0, with a maximum density of 10 nests per hectare. Total leaf nests per stand and nests per hectare were not correlated with either the number of squirrels live-trapped per woodlot or the number captured per hectare ($P > 0.05$). Neither were nests correlated with mean numbers of squirrel tracks counted in each stand during January and February. Squirrels were live-trapped in three of four woodlots in which no leaf nests were found. Conversely, two stands in which no squirrels were trapped had five and eight leaf nests. Uhlig (1956) suggested that since most gray squirrel leaf nests are built by juveniles, population estimates based on leaf nest counts are not valid unless the number of adults is known or can be estimated reasonably.

Deer trail surveys - Deer trail counts were made in only 11 of 18 woodlots. No trail counts were made on the 0.8-ha non-woody plots. Results in woodlots were not conclusive since only a single stand had more than one trail. The presence of cattle also made accurate identification of deer trails difficult. Trail counts did indicate presence of deer in five woodlots during the fall and suggested that one stand was used more extensively than others. Although definite trails were absent, deer pellets and "buck rubs" indicated that deer also used five additional woodlots during the period of trail counts.

In November 1976, additional deer trail counts were made in Governor Dodge State Park, located in southwestern Wisconsin. The park represents a mosaic of small woodlots, open grasslands and cropland (both cultivated and retired). Topography is broken, with steep-sided, wooded ridges, broad ridge tops and narrow valleys. Deer trails were counted on 26 transects established from random starting points (obtained from aerial photos). Each transect was 0.4 km long, with the number of deer trails intersected recorded by each 80-m interval along the transect. Procedures for defining trails, tallying results, and estimating deer abundance were the same as reported by McCaffery (1976). About 16 trails were counted per transect - this should indicate a deer density of about 34 deer per km^2. Mean trails counted per 80-m segment of transect were not different between segments. Each 0.4-km transect required one man about 15-20 minutes to complete once the starting point was located. Each of six transects was covered twice by different observers. Mean trails per 80-m segment were not different between observers. Trails per transect also were similar for the two counts.

Time-area counts for squirrels - At least one 2-hour morning observation period was required to determine presence of squirrels in individual stands. In stand No. 16, with a marked population of 16 animals, no squirrels were seen during 2 hours of observation. During five observation periods in stand No. 4, three to seven squirrels were seen per period (average of five). During a total of 9 hours, a maximum of three fox squirrels and six gray squirrels were counted. Our "known" live-trapped sample from stand No. 4 was seven gray and two fox squirrels.

Winter track surveys - Squirrel and rabbit tracks counted monthly after fresh snows were quite variable within stands; ranges of counts generally were broad. However, mean numbers of tracks counted in January and February were correlated with live-trapping results for individual stands. Rabbit track indices also were correlated with spring pellet frequencies. Based on these relationships, tracks counted immediately after fresh snows provide a valid index to presence and abundance of rabbits and squirrels. Tracks also indicated deer, fox, raccoon, skunk and weasel winter use in woodlots, and fox, raccoon, weasel and opossum use in 0.8-ha non-woody plots during February. Tracks made in the snow were the only signs of foxes and weasels found in most of the woodlots examined. In our woodlots and also on the 0.8-ha non-woody plots, diagonal transects appeared to be the most efficient pattern for counting tracks. Three perpendicular transects were required to cover about the same relative area as the two diagonal routes in a 91- x 91-m plot. Diagonals also provided a greater opportunity to intersect all tracks crossing a plot.

Incidental observations - A number of mammal observations were collected incidental to formal surveys associated with our woodlot studies. Field personnel were instructed to record all animals observed on each visit to a woodlot. The average visit would last about one hour, with a range of from only a few minutes up to 4 hours in a stand. Even the more conspicuous diurnal mammals were seen on less than 10 percent of the visits. Probability of observing a small carnivore was close to zero. When fresh signs were included in these observations, the ability to detect presence from incidental visual records was still less than 10 percent.

Tree squirrels, rabbits and deer were seen in over half the stands known to contain these species, but no other medium-sized mammals except woodchucks were detected by incidental observations of animals or fresh signs in more than about one-third of the stands with known presence. Woodchucks, which are a protected species in Wisconsin, are often quite tame and were seen commonly in openings or around piles of debris. Incidental observations were of value for deer, skunks, opossums, and woodchucks. Deer or their sign were found in three stands where presence was not detected by other methods. Skunks (one stand), opossums (two stands), and woodchucks (two stands) seen incidental to other surveys also were the only records of those mammals collected in one or more stands. In the 0.8-ha non-woody plots, six cottontail rabbits were the only mammals seen during 75 visits (8 percent).

Our observation frequencies were obtained in woodlots of various sizes. The ability to see animals varied with the amount of undergrowth and stem densities. Poor visibility was undoubtedly at least partially responsible for the low observation frequencies in woodlots. However, in the more open non-woody habitats, observations again were obtained in less than 10 percent of all visits. Apparently mammals did not use the 0.8-ha non-woody plots we examined; either that, or most use was nocturnal. Scent station results suggest the latter explanation.

ROAD MORTALITY

Oregon Study Area
James E. Tabor

Methods

Twelve 3.2-km segments of roads were examined for road-killed animals 13-30 July and again 2 November-23 December 1976. Eight of these segments were centered on our established study areas. The other four segments were portions of moderate to high traffic volume roads near study areas. Observers searched the 3.2-km segments from a car moving at 48-64 km per hour between approximately 0800-0900 hours, on foot immediately following the car survey, and again on foot in the afternoon between 1300-1800 hours. During July, the afternoon survey was made only if animals were found during the morning surveys. The afternoon survey was conducted at each segment during the winter sampling period.

Animals observed from the car were compared to those observed during the morning walk to evaluate the efficiency of detecting road-killed animals from a moving vehicle. The afternoon walk survey was designed primarily to determine if road-killed animals observed in the morning were visible in the afternoon of the same day and whether morning surveys differed from afternoon surveys in terms of numbers of animals and/or species composition.

A 14.5-km segment of U.S. Highway 20 between Corvallis and Albany, Oregon, was monitored 10 June 1976-10 January 1977 for the purpose of obtaining data concerning longevity of road-killed animals. This segment of highway was driven most days during the period it was monitored, but some days, and occasionally periods up to 6-8 consecutive days, were missed. The species, date and time found, exact location, and position on road (shoulder, in road, median) were recorded for each road-killed animal observed. Condition of the animal's body, relative to its visibility from a moving car, was recorded each time the road was driven until the animal was visible no longer.

Findings

Comparison of methods - A comparison of the number of road-killed animals observed during searches of the same segments of road from a moving vehicle with the walking survey showed that sampling from a moving vehicle was much less effective. A greater number of species and individuals were found with the walking survey during both sampling seasons. The difference was greatest for small species and all animals found on the shoulder of the road and in the ditch. The combined data from both seasons showed that 86, 93, and 97 percent fewer road-kills were found on the road, shoulder, and in the ditch, respectively, from the car survey compared to the walking survey. Carcasses of road-killed animals that remained on the road were seen more easily from a car than carcasses on the shoulder and in the ditch. Also, species composition of the sample from the car survey favored large animals since these were more easily observed than small animals. Time required to sample a 3.2-km segment of road (about 15 minutes) differed greatly from time required to conduct the walking survey (about 1.5-2.0 hours).

Longevity of road-killed animals - The effect of time of day on sampling road-killed animals was evaluated by comparing results of morning and afternoon surveys. Slightly fewer road-kills of all species combined were found in the afternoon during summer. In winter, more were found in the afternoon. Difference between morning and afternoon counts during each season was due both to disappearance of some carcasses and the addition of some diurnal species killed between the time the two counts were made. In summer, more road-kills disappeared than were killed during the day. A high percentage of those that disappeared were small birds. We believe that disappearance was due to several causes, but that removal by avian scavengers, primarily crows, accounted for many. In addition, amphibians dehydrated very quickly during the day and were difficult to see as a result. In winter, some road-kills disappeared during the day but were more than replaced by animals killed during the day. Many of these animals were rough-skinned newts. Also in winter, furbearers are often removed from roads by persons desiring to sell the pelts. Deer may disappear during the day because these animals are routinely removed by state and local police in many areas. Our data indicate that differences in species composition and number of individuals of some species killed on roads can be expected as a result of sampling during different times of day.

We also examined longevity of road-kills over periods longer than one day. All sampling for this purpose was done from a car. Therefore, data are limited primarily to larger species and those animals that remained on or very near the road after being killed. Longevity appeared to vary according to species, season of year, and position of carcass in relation to road. Even though the data are limited to a small number of observations over a 7-month period (10 June-10 January) they indicate that larger species remained visible longer than smaller ones. For example, 11 opossums remained visible for an average of 24.1 days compared to 11 California ground squirrels with an average of 3.4 days. An important exception to this generalization is the rapid disappearance of furbearers in winter and deer throughout the year. Our observations, stratified by season, leave few data to compare differences in longevity due to season. Based on observations of opossums and striped skunks alone, longevity appeared to be greater in fall and winter than summer. We did not sample in late winter and spring. For most species for which comparable data were available, longevity was appreciably greater for those individuals on the road shoulder than those on the road proper.

Effect of season - Species composition and number of individuals of road-kills observed in this study varied considerably according to season. Obviously, species that are present for only a portion of the year, such as migratory birds, occurred in our sample only during those seasons when they were present. In addition, some resident species appeared to be more vulnerable on roads in some seasons than others. For example, amphibians, especially the rough-skinned newt, were killed in much larger numbers during our winter sampling period. This species is more vulnerable because it migrates to breeding areas in late fall and winter. Species of mammals that are inactive during the winter, such as the California ground squirrel, either were not observed as road-kills or were observed infrequently.

More species of animals were observed as road-kills in summer than in winter. However, total number of individuals of all species combined was higher in winter. This was true for mammals, reptiles, and amphibians as separate groups. The number of birds, though, was considerably greater in summer.

Data from the 14.5-km segment of highway monitored continuously from 10 June-10 January indicated a decline from summer to winter in the number of species and individuals of mammals, birds, and reptiles killed. No amphibians were observed. In our opinion, the data from the 14.5-km segment more accurately estimates the number of large mammals killed according to season. Therefore, we conclude that more large mammals are killed in summer than in winter.

Illinois and Virginia Study Areas

Lowell L. Getz

Methods

Data on road mortality of wildlife were obtained from four procedures.

1. In Illinois, a count was made of all road-kills

observed along county roads during a portion of the small mammal trapping in February and March. A total of 1770 km were driven at a speed of 48-56 km per hour. In addition, observations were made along 169 km of two-lane state highways in mid - February. Driving speed was 80.5 km per hour. Road-kills were not identified to species.

2. Road-killed animals were counted along an interstate highway between Indianapolis, Indiana, and Youngstown, Ohio, a distance of 885 km, on 13 and 15 May 1976. Road-killed animals were not identified to species.
3. Road-kills along interstate highways were recorded in five 80.5-km sections of major habitat types in Indiana, Ohio, Pennsylvania, and New York. Each 80.5-km section was broken into five 16.1-km subsections. The observations were made 1 - 7 June 1976 at a driving speed of 88.5 km per hour. Some species identifications were made.
4. In Illinois, a 362-km route of interstate highway in a region of intensive agriculture was driven daily for 4 days at a speed of 72.4 km per hour. A driver and one additional person made observations, recording exact location of the animal along the road, location of animal in reference to the road (on the road, median, or shoulder), species, and condition of carcass.

Findings

In the comparative study of road mortality on county and state roads in Illinois, 0.75 road-kills per 100 km were noted for county and 7.08 road-kills per 100 km were noted for state roads. Sample sizes in both cases were small. Road-kills per 100 km of interstate averaged 19.45 on the road trip between Indianapolis, Indiana, and Youngstown, Ohio, in May 1976.

The number of road-kills recorded in the five 16.1-km segments through major habitat types from Indiana through Ohio, and Pennsylvania to New York, showed habitat effects. Highest mortality occurred on roads through wooded areas; lowest mortality occurred on roads through intensive agricultural areas.

The study of animal species and persistence of road-kills indicated that most species observed from a car were medium-sized mammals. In general, persistence was highly variable and depended, at least in part, on animal size and where the animal landed after being hit by a moving vehicle. Smaller animals did not persist as long as those remaining on roadway shoulders. Deer and other large animals were removed from interstates by maintenance crews.

HABITAT DESCRIPTION

Oregon Study Area
Steven Smith

Methods

The vegetative sampling methods evaluated in this study were selected to measure attributes of plant communities considered important as components of wildlife habitat. The attributes selected for measurement were floristic structure, canopy cover, frequency, tree density, tree basal area, and shrub and tree height. Floristic structure was defined as the plant species present in a community and was expressed in the form of species lists of plants identified in each study area. Canopy cover for an individual plant species was estimated as percent of the ground surface covered by the canopy of that species and was expressed in cover classes (Table 2). Percent of the ground surface covered by live vegetation (basal area cover), litter, rock, and bare ground also was estimated for each study area. Ocular estimates were made within plots used for sampling herbaceous vegetation and were recorded in all sampling plans except reconnaissance. Frequency was used to indicate the distribution of constancy of a species throughout a study area. Frequency was expressed as the percent of sample plots in which a species occurred.

Nested frequency values also were recorded for herbaceous species identified within microplots (30 x 60 cm and 20 x 50 cm). Nested frequency was determined by marking the microplots into segments equal to 10, 25, and 50 percent of the microplot area. Species occurring in the 10 percent area received a value of 1, species within the 25 percent area a value of 2, species within 50 percent of the area, 3, and species occurring in the entire microplot a value of 4. Each species received only one nested value per plot. For example, a species receiving a value of 1 was included automatically in the remaining area of the plot.

Density of trees was expressed in square metres per hectare. Prisms of 10, 20, or 40 basal area factor (BAF) were used to estimate basal area of trees in one method tested. Dilworth (1971) stated that a BAF that produced a tree count of 4-8 trees per point should be used. Basal area estimates made with a second method were based on conversions from diameter at breast height (dbh) measurements. Heights of trees and shrubs

Table 2. Cover class values (for each species) used for estimating plant cover in this study.

Cover class (for a species)	Class Range (% cover)	Midpoint (% cover)
1	0-1	0.5
2	1-5	3.0
3	5-10	7.5
4	10-25	17.5
5	25-50	37.5
6	50-75	62.5
7	75-95	85.0
8	95-100	97.5

were expressed in height classes (Table 3). Trees with a dbh of less than 7.6 cm were considered shrubs.

Six sampling plans were evaluated, each containing a specific method for sampling trees, shrubs, and herbaceous vegetation of plant communities. Efficiency of sampling plans, and individual methods in the plans, were estimated on the basis of amount of data produced per unit of effort (Lindsey et al. 1958). Total field time required to sample each study area with each sampling plan was recorded. Time required for each plan was recorded separately for trees and the understory (shrubs and herbaceous vegetation). Time required for one plot was estimated by dividing the total time used by the number of plots. Precision of estimates of the various attributes of plant communities made with specific methods within plans also was evaluated. Precision was expressed by a coefficient of variation in percentage (Snedecor and Cochran 1967, Piper 1973). Increased coefficient of variation values indicated increased variation, thus reduced precision.

Intensity of sampling for all methods was intended to be high enough to insure that each plant community was more than adequately sampled. As discussed above, estimates of plant community attributes and their coefficients of variation were calculated from data gathered from maximum sampling intensity. We also calculated estimates of the same attributes and coefficients of variation with data from reduced sampling

Table 3. Height classes used for vegetation in this study (Adapted from Kuchler 1967).*

Height Class	Height in Metres	Class Midpoint in Metres
1	< 0.1	0.05
2	0.1 - 0.6	0.35
3	0.6 - 2.1	1.35
4	2.1 - 4.9	3.50
5	4.9 - 10.1	7.50
6	10.1 - 20.2	15.15
7	20.2 - 35.1	27.65
8	35.1 - 50.0	42.55
8'	>50	61

* converted from feet to metres for this report.

intensities. This was done to determine how much the intensity could be reduced and still maintain an acceptable degree of precision. Intensity of sampling was reduced by randomly or systematically omitting all data from a portion of the sample units (i.e., plots, sample points, or transects).

Vegetation was sampled within four 100- x 100-m (1-ha) segments of each study area and within the roadside ditch which varied in size between study areas. Units of measurement for plot size and for plant attributes were in some cases metric, and in others, English, for our convenience because of availability of equipment. To be consistent in this report, all units are presented as metric.

The specific methods used for each of the six sampling plans evaluated are discussed below. The reconnaissance plan was used in both the ditch and adjacent habitat of each area. Three plans, Bitterlich-nested plot, Bitterlich-line plot, and point-centered quarter-line transect, were used only for that portion of each study area adjacent to the ditch. Two of the sampling plans, line transect, and nested transect, were used only for roadside ditch habitat.

Unless specified otherwise, all distances were paced, tree basal areas were determined with a wedge prism, and tree heights were determined with a clinometer.

Reconnaissance - Vegetative reconnaissance was the first habitat sampling technique used at each study area. The following information was gathered during the reconnaissance:

1) A species list with each species assigned a dominance rating (Table 4);
2) Height class estimates of trees and shrubs (Table 3);
3) Cover class estimates of tree and shrub canopy coverage (Table 2);
4) Slope and aspect(s); and
5) Soil characteristics.

The initial procedure during reconnaissance was to walk through the study area and note its general characteristics (slope, soil, and distinct vegetative communities), identify plants, and collect plants for later identification. After a list of species was formed, the study area was examined again and vegetative parameters were estimated. Estimates were made at several locations, the number varying between areas and depending on the density of understory vegetation. More estimates were made in areas where dense understory vegetation reduced visibility. The estimates recorded at each location were later averaged to produce the estimates presented for the reconnaissance sampling technique.

A vegetative map was drawn during the second examination of each study area. Distinct vegetative communities and the slopes and aspects were delineated on the map. The primary purpose of these maps was to insure that quantitative field comparisons were conducted in homogeneous plant communities.

The time required to complete the vegetative reconnaissance varied among study areas due to complexity of vegetation.

Bitterlich-nested plot - Each 100-m segment (1-ha sampling unit) of each study area was divided into four quarters by two right angle bisectors. Four 0.08-ha circular plots (16.1-m radius) were established in each sampling unit for sampling trees. Plot centers were located on the bisectors 22.9 m from their intersection (center of the sampling unit) (Fig. 4). Trees within each plot were identified to species, counted, and measured for height and basal area.

A 0.004-ha circular plot (3.5-m radius) was used for sampling shrubs and herbaceous vegetation (understory). The 0.004-ha plot centers were located at the same center points used for 0.08-ha tree plots and are referred to as "nested plots" (Fig. 4). Canopy cover classes were estimated for all species

Table 4. Definitions of dominance ratings used in vegetative reconnaissance sampling.

Dominance Rating	Definition
1.	Species which can be seen only by searching for them in and around other plants. Species which occur in extremely widely scattered and isolated patches would rate a 1-dominance provided they did not represent an inclusion of a different plant community.
2.	The species which can be seen only by moving around in the stand or by looking intently while standing in one place. Species occurring in patches encountered by moving about are rated 2-dominance although within the patch the species may rate a higher dominance value.
3.	The species which are easily seen by standing in one place and casually looking around.
4.	The species which are codominant in the aspect of the layer. These are the species which share dominance with another or which are subordinant only to the layer dominant which rates 5.
5.	The species which dominates the aspect of the layer. It is dominant in the sense of its impact on the microenvironment beneath its canopy. There must be no more than one 5 per layer; some stands may not have a 5 rating.

identified in the plot, and frequency values were calculated. The average height class of each species of shrub in each 0.004-ha plot also was estimated and recorded. Each study area contained 16 understory and 16 overstory sample plots.

Ocular estimates of canopy cover for understory species were difficult to obtain because of the large size of the sample plot. In an attempt to avoid possible bias of estimates made in such a large plot, this sampling plan was tested prior to testing the other two quantitative plans in each study area.

<u>Bitterlich-line plot</u> - Each of the four 1-ha sampling units of a study area contained four 0.04-ha circular plots

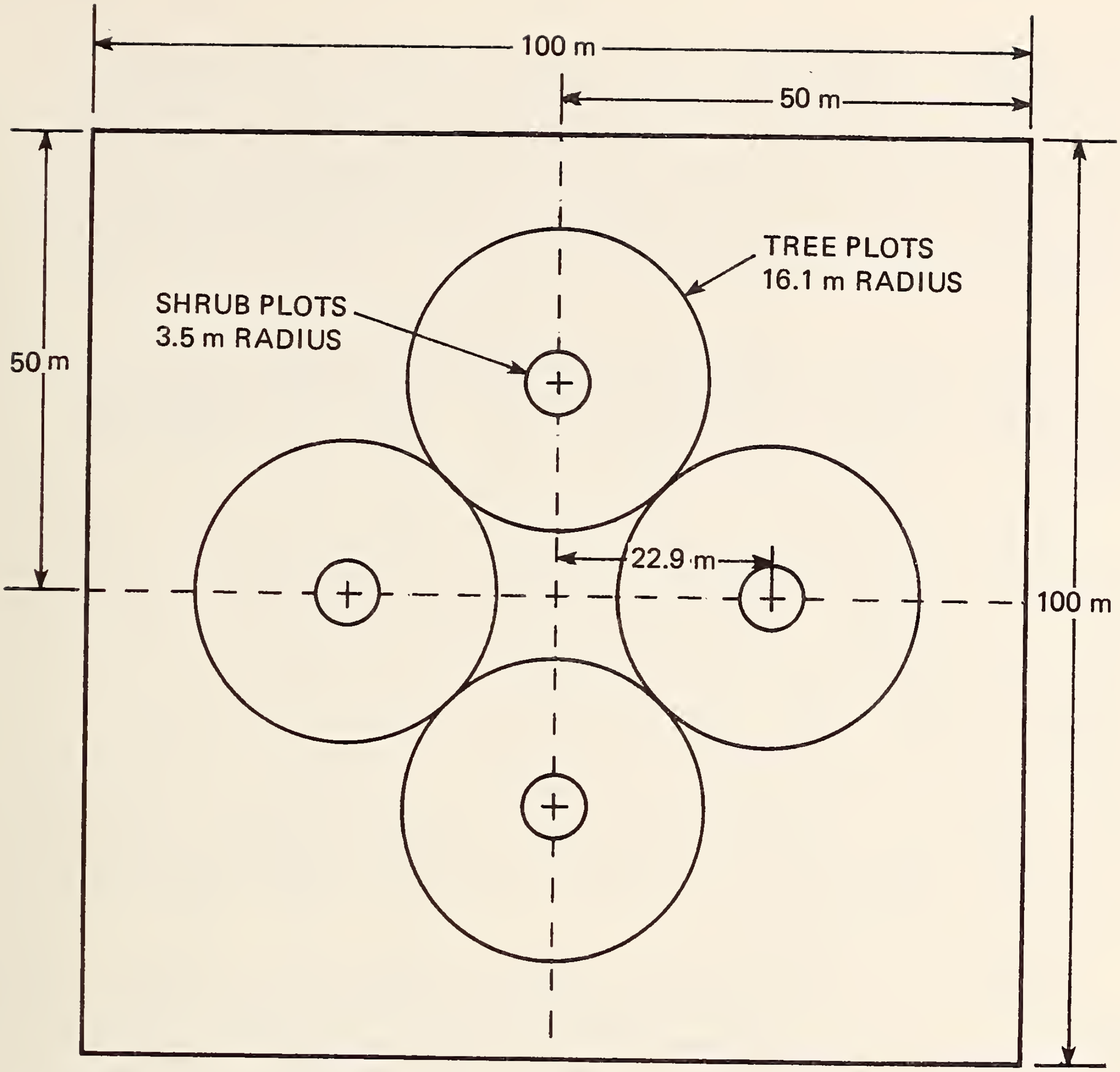

Fig. 4. The Bitterlich-nested plot design for measuring tree, shrub, and herbaceous vegetation on the 100- x 100-m study plots in Oregon. (Schematic).

for sampling trees (Fig. 5). Plot placement was designed to equal a 20 percent intensive timber cruise on the study areas (Dilworth 1971). Tree plot centers were located at 45.7-m intervals along two transect lines perpendicular to the road. The two transect lines were 45.7 m apart. Because all study sites with tree canopies were relatively homogeneous, the same plot location always was used for tree sampling.

Trees present within each circular plot were identified, counted by species, measured for basal area and height, and recorded by height classes (Table 3). This tree sampling method was outlined by Lindsey et al. (1958) and Dilworth (1971).

Ocular estimates of canopy cover class and height class were made for shrub species in 9.3-m^2 circular plots (1.7-m radius) (Fig. 6). Eight circular shrub plots were placed systematically within each of four randomly selected 0.04-ha tree plots. The selected tree plots were divided into four quarters by two right angle bisectors; the bisectors had lengths equal to the circle diameter (22.6 m). Each radial bisector had one 9.3-m^2 circular plot placed 3.7 m from the center point of the 0.04 ha-macroplot. The other four plots were located 7.3 m from the center of the macroplot on lines at 45 degree angles to the circle bisectors described above. Frequency values were calculated for all species identified within the shrub plots.

Herbaceous vegetation was sampled along the two tree plot diameters in 30- x 60-cm microplots (Poulton and Tisdale 1961) placed at 1.2-m intervals (18 microplots per diameter, 36 per 0.04-ha macroplot). Canopy cover classes and nested frequency values were recorded for all herbaceous species identified within the microplots.

Point-centered quarter-line transect - Thirty tree sample points were uniformly spaced 45.7 m apart along three transects in each study area (Fig. 7). Transect lines were perpendicular to the road, parallel to each other and 33.3 m apart. A compass bearing was used to insure straight transect lines, and thus a uniform sample distribution. This method of distributing sample points provided excellent coverage within the area, but analysis of data obtained in this way was complex and time-consuming. A statistical model for analysis of the data was not available; therefore, precision values were not calculated for this technique.

A second line perpendicular to the compass line was established at each tree sample point forming four quarters. In each quarter, the tree nearest the sample point over 0.9 m

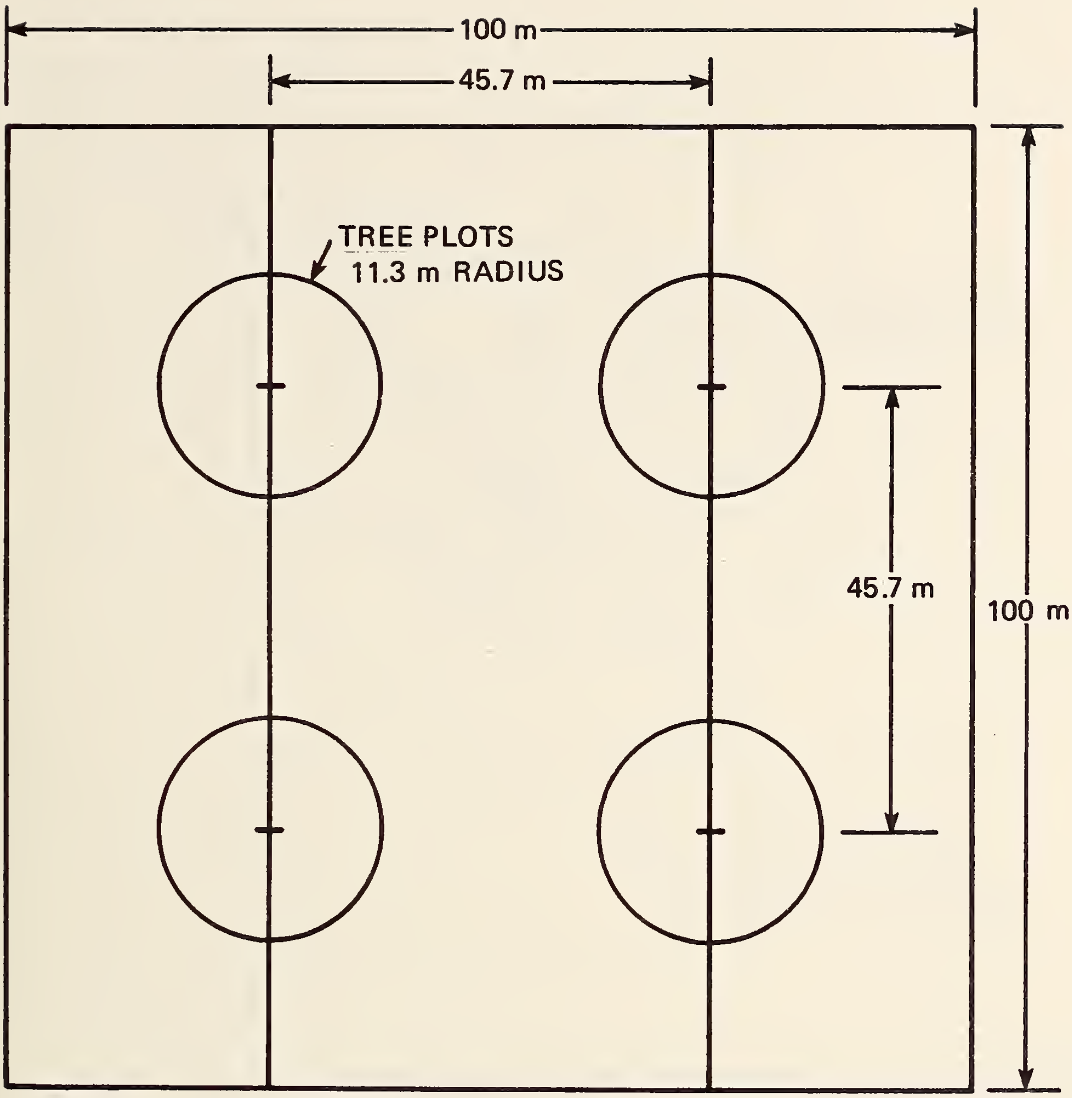

Fig. 5. The Bitterlich-line plot design for measuring trees on the 100- x 100-m study plots in Oregon. (Schematic).

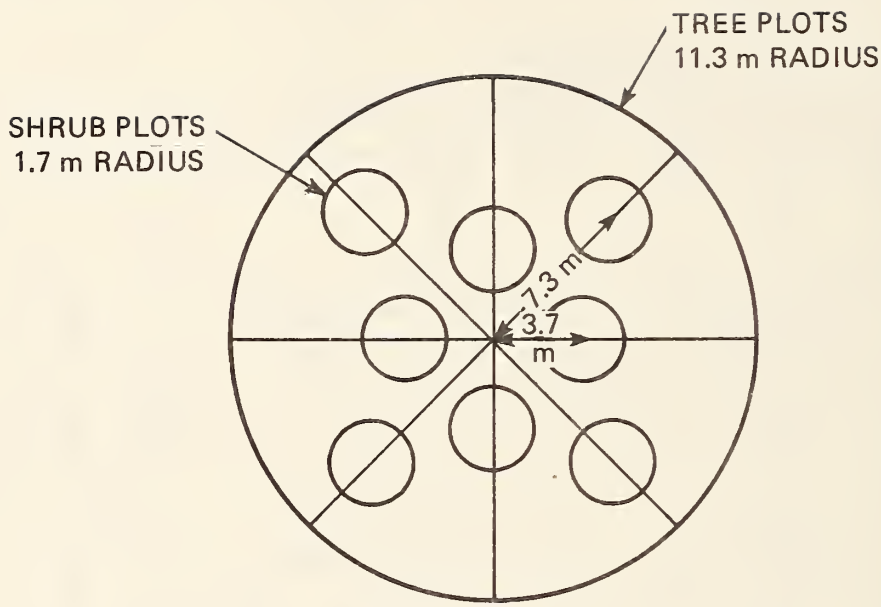

Fig. 6. Plot design for sampling shrubs for the Bitterlich-line plot sampling plan. Eight circular shrub plots (1.7-m radius) were placed within each of the four tree plots in each 100- x 100-m study unit. (Schematic).

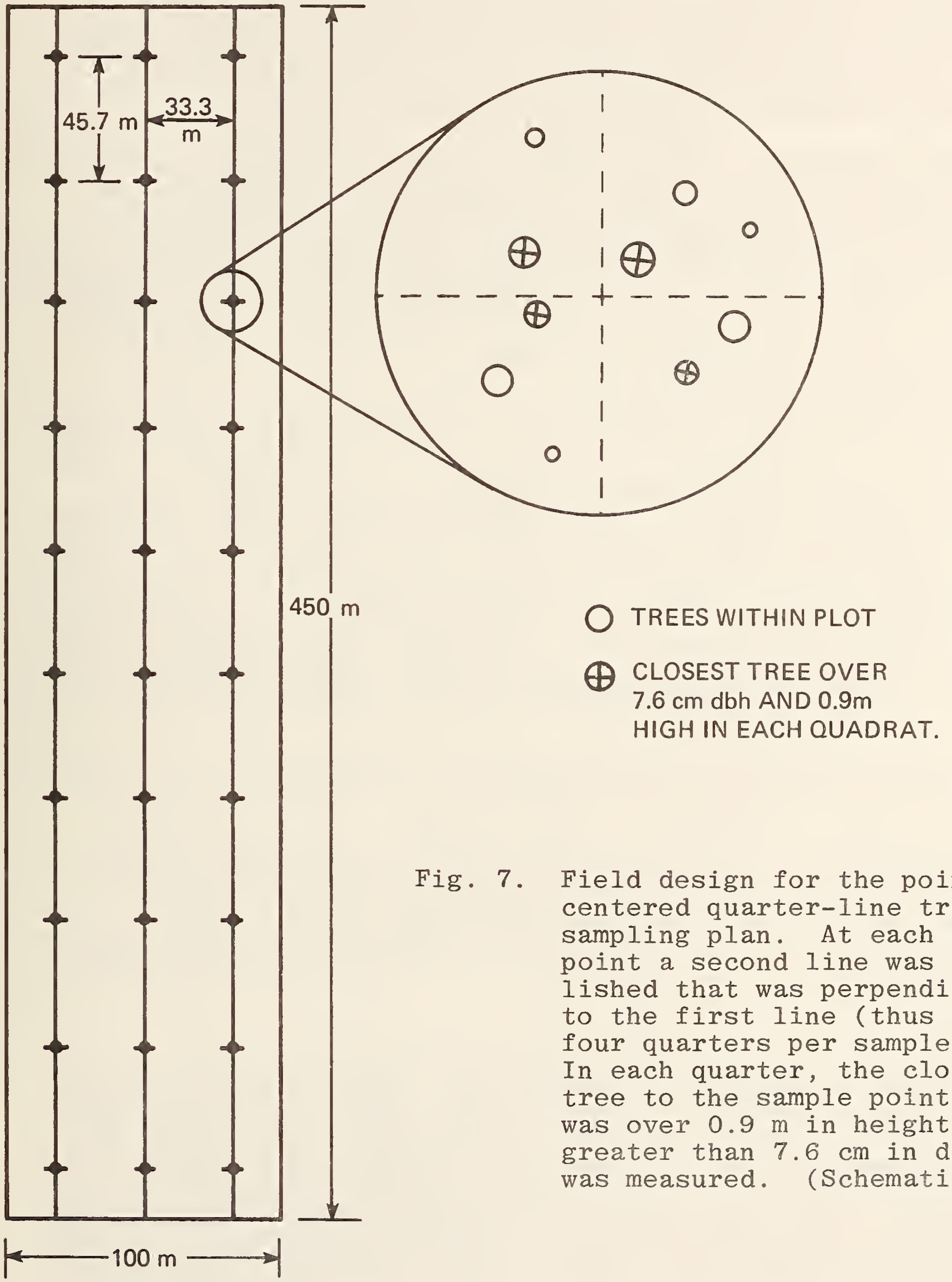

Fig. 7. Field design for the point-centered quarter-line transect sampling plan. At each sample point a second line was established that was perpendicular to the first line (thus forming four quarters per sample point). In each quarter, the closest tree to the sample point that was over 0.9 m in height and greater than 7.6 cm in diameter was measured. (Schematic).

in height and greater than 7.6 cm in diameter was measured. Tree species with small dimensions were included in shrub analyses. Diameter at breast height (dbh) was measured at 1.4 m (Piper 1973); basal area estimates were converted from dbh measurements (Dilworth 1971). Data on tree heights were recorded in height classes (Table 3). This method of tree sampling was adopted from Cottam and Curtis (1956).

Line transect - Line transects 15.2 m in length for sampling understory (shrub) vegetation were placed parallel to the highway and oriented toward the center of the study area. This was to insure that all transect lines remained within the study area boundaries. Transect starting points were selected randomly from a grid of the study area. If a transect beginning point was located near the center of the study area, a coin was tossed to determine whether the tape was stretched to the right or the left.

Shrub data were collected in 1-m^2 plots. Ten shrub plots were placed on each 15.2-m transect at 1.5-m intervals. Canopy cover and height were estimated ocularly for each species occurring within the plot. Canopy cover estimates were recorded in cover classes (Table 2) and heights were recorded in height classes (Table 3). Frequency of occurrence in the plots also was recorded for all species of shrubs identified. In addition, canopy cover of trees was estimated from the 15.2-m transects by the intercept method. A vertical line was projected ocularly from the tape to the tree canopy. The canopy intercept was estimated by one observer and recorded by an assistant.

Nested transect - This design was established in conjunction with the line transect sampling plan. Ten 20- x 50-cm microplots were placed at the same points along the transect as the shrub plots (thus these microplots were nested within the shrub plots). The 10 microplots per transect were used for estimating canopy cover classes (Table 2) and nested frequency values for all herbaceous species identified within the microplots.

Findings

Results of vegetative sampling and comparisons of the sampling plans (methods) are presented for each study area. Vegetation was not sampled in the ryegrass study area. This area was a homogeneous stand of perennial ryegrass in a field of approximately 60 ha. The grass averaged about 0.9 m in height at maturity. The field, like most in grass seed production in the Northwest, was harvested for seed in July and the stubble burned shortly afterward. The soil was not plowed because the grass is perennial. The grass remained short and green from early fall until rapid growth began in spring.

Definitions of dominance ratings, cover class values, and height class values referred to below are presented in Tables 2, 3, and 4. Since all estimates of height for shrubs and trees were made with the same techniques in all vegetative sampling methods tested, we did not discuss estimation of height in method comparisons. These estimates are provided for their descriptive value of the habitats we sampled.

The estimated time required to sample each study area with the reconnaissance method was not directly comparable to the estimated time required for the other methods because it included time to initially identify species of plants present on the areas.

Pasture - Five widely spaced Oregon white oak trees were present within the study area boundaries. These trees had an average dbh of 86.4 cm and a height class of 6. No specific tree sampling methods were tested in this study area.

Shrubs were not common in the study area - nine species were identified; reconnaissance sampling accounted for 78 percent of these species, the line transect method accounted for 67 percent, and Bitterlich-line plot and Bitterlich-nested plot each accounted for 56 percent. Poison oak occurred more frequently than other species of shrubs. The Bitterlich-nested plot method estimated the highest frequency value for this species. Widely scattered, shrub-sized Oregon oak trees were identified only by the reconnaissance and Bitterlich-line plot methods. All methods produced low cover class values for shrubs. The Bitterlich-nested plot method gave the most precise estimate of cover class as indicated by the low coefficient of variation.

Forty herbaceous species were identified in the sampling area; reconnaissance accounted for 80 percent; Bitterlich-line plot, 68 percent; line transect, 65 percent; and Bitterlich-nested plot, 55 percent. Bentgrass was identified as the dominant herbaceous species (cover class 5) by all methods, occurring with a frequency of nearly 100 percent. Nested frequency data showed that frequency values for bentgrass remained above 75 percent with considerably smaller plots nested in the line transect and Bitterlich-line plot methods. Plot size with Bitterlich-nested plot (0.004 ha) was too large for this habitat as indicated by the high frequency values attained by herbaceous species with relatively low frequency values with the small plots. Canopy cover values for the dominant bentgrass were most precise with Bitterlich-nested plot as indicated by the low coefficient of variation. Bitterlich-line plot and line transect methods appeared to provide the best combination of cover class and frequency estimates for herbaceous species.

The reconnaissance sample method compared favorably with the quantitative methods in describing the vegetative characteristics of this study area.

The most efficient method used for sampling pasture habitat was Bitterlich-line plot. Time required per plot was 1.4 minutes. At the reduced sampling intensity of 16 shrub and 48 herbaceous plots, 90 minutes would have been required to conduct sampling. The Bitterlich-nested plot required twice as much sampling time.

Oak - The tree canopy of the study area consisted almost entirely of Oregon white oak. Only one other species of tree, an apple, was identified in the area. Frequency for Oregon white oak was 100 percent for all sampling methods. The point-centered quarter method gave a much lower estimate of density for oak than either the Bitterlich-nested or Bitterlich-line plot methods. Bitterlich-nested plot gave the most precise estimates of density. Little difference was observed between estimates of basal area made with each method although estimates made with Bitterlich-nested plot data were the most precise.

Eleven species of shrubs were recorded in the study area; reconnaissance sampling identified 73 percent of these, Bitterlich-nested plot and Bitterlich-line plot identified 64 percent, and line transect accounted for 55 percent. All methods identified poison oak as the dominant species with a cover class value of 6. The Bitterlich-line plot method gave the most precise estimates of cover for poison oak. Estimates of frequency for this species (97-100 percent) were about equal for the methods tested.

Reconnaissance sampling identified 85 percent of 34 species of herbaceous plants recorded at the study area. The Bitterlich-line plot and line transect methods identified 59 percent of the herbaceous species known to be present. Fifty-six percent of the species were recorded with the Bitterlich-nested plot method. Woods strawberry was identified as a dominant species by all methods. Frequencies estimated for all species were higher with the Bitterlich-nested plot method than frequencies estimated with the Bitterlich-line plot and line transect methods. This was directly related to the larger plot size used in the Bitterlich-nested plot method. The most precise estimate of coverage for woods strawberry was obtained by the Bitterlich-nested plot sampling plan. The smaller-sized plots used in the Bitterlich-line plot and line transect methods also resulted in more variable cover class data.

The point-centered quarter method was the least efficient method for sampling trees in the oak habitat. This method required 4.6 minutes per plot or 2.5 hours total time as compared to total sampling times of 54 and 75 minutes for the Bitterlich-line plot and Bitterlich-nested plot methods, respectively. These times were calculated by multiplying minutes per plot by total number of plots. A major problem encountered with the point-centered quarter method was caused by poison oak which grew around the oak trunks. We had difficulty measuring dbh of trees because of the presence of poison oak vines on the trunks.

At reduced sampling intensities, the line transect and Bitterlich-line plot methods were the most efficient methods for understory analysis. The line transect method required 0.9 minutes per plot, and at the reduced sampling intensity of 35 shrub plots and 21 herbaceous plots, 53 minutes would have been used. The Bitterlich-line plot also would have required 53 minutes at reduced sampling intensity.

Young Douglas-fir - Although the overstory vegetation of this study area was clearly dominated by a young, dense stand of Douglas-fir (approximately 40 years old), four other species of trees were identified. All five species were recorded by the Bitterlich-nested plot method. The other methods identified all species except cascara, of which only one tree was found. All methods estimated the frequency of Douglas-fir at 100 percent. The point-centered quarter method estimated a lower frequency for alder, maple, and oak than the other methods. Estimates of density for all tree species made with the point-centered quarter technique also were lower than estimates made with the other methods. Estimates of density and precision of the estimates from the two plot methods differed little. Estimates of basal area were similar for all three methods. Precisions of estimates from both plot methods were nearly equal, so the more efficient smaller plot (Bitterlich-line plot) could be used without a loss in data quality. This method appeared to be the better of the methods tested for trees in this habitat.

Fourteen species of shrubs were identified in the study area. Reconnaissance accounted for 93 percent; Bitterlich-nested plot, 71 percent; Bitterlich-line plot, 36 percent; and line transect, 29 percent. California hazel and salal were identified as the dominant shrubs by all methods. Bitterlich-nested plot gave slightly higher estimates of frequency for California hazel. The Bitterlich-line plot method produced slightly higher estimates of frequency for salal. The point-centered quarter method gave lower estimates of frequency for both of the dominant shrubs. Cover class values for California hazel and salal were equal for all methods. The Bitterlich-line plot method produced the most precise estimates of cover for both dominant species.

A total of 43 herbaceous species were recorded under the Douglas-fir canopy. Reconnaissance sampling identified 91 percent of these. Bitterlich-line plot, Bitterlich-nested plot, and line transect methods accounted for 65, 61, and 51 percent, respectively. Mosses, lichens, sword fern, and western bracken fern were identified as dominants by all methods. The Bitterlich-nested plot method produced the highest estimates of frequency for these dominants; estimates by the Bitterlich-line plot and line transect methods were very similar. Cover class values for mosses and lichens and bracken were equal for all methods. Estimated coverage of sword fern was lower by the line transect method. Precision of coverage estimates for sword and bracken fern was low for all methods, especially the point-centered quarter method. Bitterlich-nested plot produced the most precise estimates of cover for both species of fern.

The Bitterlich-line plot and Bitterlich-nested plot methods were the most efficient overstory sampling methods; both required 5.6 minutes per plot for a total of 90 minutes. The point-centered quarter method required 6.0 minutes per plot and a total of 3 hours to sample trees.

The Bitterlich-nested plot method was the most efficient for understory analysis at maximum sampling intensities; this method required 5.6 minutes per plot for a total sampling time of 90 minutes. At reduced sampling intensity, the Bitterlich-line plot method was the most efficient. With reduced intensity of 16 shrub plots and 48 herbaceous plots, this method would have required an estimated sampling time of 76 minutes (1.2 minutes per plot).

Alder - The tree canopy of the study area consisted predominantly of red alder, but three other tree species were identified. All four species were recorded by the Bitterlich-nested plot method. The other methods identified all species except cascara buckthorn. All methods recorded 100 percent frequency for red alder. The point-centered quarter method estimated a lower frequency for bigleaf maple and Douglas-fir than the other two methods. Estimates of density for red alder made by the point-centered quarter technique also were lower than estimates made by the other methods. The precision of density estimates were similar for both plot techniques. Basal area estimates for red alder were highest with the point-centered quarter method but were most precise with the Bitterlich-line plot technique which had the lowest basal area estimate. The Bitterlich-line plot technique appeared to be the best method tested for trees in this habitat because of the precise basal area estimates and the comparable density data obtained by the use of smaller, more efficient plots.

Nineteen species of shrubs were identified in the study area. Reconnaissance accounted for 68 percent; Bitterlich-nested plot, 58 percent; Bitterlich-line plot, 32 percent; and line transect, 37 percent. Salmonberry was identified as the dominant shrub species by all methods. The Bitterlich-nested plot technique produced the highest frequency value for salmonberry; the line transect technique produced the lowest frequency value. The Bitterlich-line plot technique recorded a higher cover class value for the dominant species than the other methods. Bitterlich-nested plot produced the most precise estimates of cover for salmonberry but was only slightly better than the Bitterlich-line plot method at the reduced sampling intensity.

A total of 34 herbaceous species were identified under the red alder canopy. Reconnaissance identified 71 percent of the species, followed by Bitterlich-nested plot, Bitterlich-line plot, and point-centered quarter method with 65, 50, and 44 percent of the understory herbaceous species, respectively. All methods indicated a co-dominance of mosses, sword fern and pig-a-back plant. The Bitterlich-nested plot method showed that Oregon oxalis was a co-dominant species also. This is attributed to the large plot size used with this method for herbaceous sampling. The high frequency values recorded for all co-dominant species by the Bitterlich-nested plot method are related to the large plot size. Cover class values for mosses, sword fern, and pig-a-back plant were equal for all methods. Precision of cover estimates were highest with the Bitterlich-nested plot method for all the co-dominant species.

The point-centered quarter method was the least efficient method for sampling the overstory vegetation. The Bitterlich-nested plot method was the most efficient with a total sampling time of 90 minutes.

The Bitterlich-nested plot method also was the most efficient method for understory analysis; 90 minutes were required. At the reduced sampling intensity, the line transect method approached the estimated efficiency of the Bitterlich-nested plot method. Sampling time for the 26 shrub plots and 56 herbaceous plots for the reduced intensity would have required 1.3 minutes per plot for a total of 1 hour and 47 minutes.

Ash - Four tree species were identified in this study area. All methods identified Oregon ash as the dominant species. However, the plot techniques did not record apple. Frequency for Oregon ash was 100 percent for all sampling methods. Black cottonwood and black hawthorn had equal frequency values recorded with the Bitterlich-nested plot and Bitterlich-line plot methods, but estimates of frequency from the point-centered quarter technique were lower than estimates from the two plot methods for black cottonwood and higher than estimates from the plot methods for black hawthorn. The point-centered quarter technique gave a much lower density estimate for Oregon ash than either plot method. The Bitterlich-nested plot technique gave the most precise estimate of density. Considerable variation occurred among estimates of basal area. The Bitterlich-nested plot method recorded the highest estimate of basal area; the point-centered quarter technique recorded the lowest. The intermediate basal area value recorded by the Bitterlich-line plot method was the most precise.

The understory of this area consisted of three distinct plant communities. These communities paralleled the stream which bisected the area, and are referred to here as north side, riparian, and south side. Twelve shrub species in the north side community were identified. Reconnaissance accounted for 83 percent; Bitterlich-nested plot accounted for 75 percent; Bitterlich-line plot, 58 percent; and the point-centered quarter technique, 50 percent. Himalayan blackberry, Nootka rose, and snowberry were the dominant shrubs. The frequency and cover class values for these species were quite variable among methods.

A total of 24 herbaceous species were identified in the north side community; moneywort and fringecup dominated. Frequency and cover class values were essentially equal for these species with the Bitterlich-line plot and line transect techniques. The Bitterlich-nested plot technique was not designed for this type of stratified sampling, and, therefore, its results are not comparable with the other methods. Precision of the cover class estimates was low for all methods.

The riparian community was under direct influence of the stream water level. Bare ground was the dominant feature within this community. Thirteen herbaceous species were identified. Reconnaissance identified 92 percent of these. Bitterlich-line plot and the line transect techniques accounted for 31 and 8 percent, respectively. Shrubs occurred rarely in this area with only three species recorded. Reconnaissance and line transect methods identified 67 percent of the total, and the Bitterlich-line plot identified 33 percent.

Ten species of shrubs were identified in the south side community. Bitterlich-nested plot recorded 100 percent of the shrubs followed by reconnaissance, Bitterlich-line plot, and line transect with 60, 40, and 30 percent, respectively. Black-hawthorn and Nootka rose were the dominant shrub species. Frequency values were equal for black hawthorn with Bitterlich-line plot and line transect techniques, but the former technique recorded a higher frequency value for Nootka rose. The cover class values for the dominant shrub species varied among methods. The most precise canopy cover estimate for black hawthorn was recorded by the Bitterlich-line plot method; the most precise canopy cover estimate for Nootka rose was recorded by the line transect method. These precision values were observed at reduced sampling intensities.

Herbaceous vegetation was very diverse in the south community. This area was not under a complete tree canopy as were other parts of the study area. A total of 51 herbaceous species were identified. Reconnaissance accounted for 80 percent of these; Bitterlich-line plot, 51 percent, and line transect, 47 percent. All methods indicated that bentgrass was a dominant species. Reconnaissance listed moneywort and American vetch as co-dominant with bentgrass, but this was not supported by the quantitative data. Bitterlich-line plot data showed bluegrass as a co-dominant with bentgrass. Frequency values for bentgrass were similar between quantitative methods, but the line transect method recorded a higher cover class value for bentgrass. Precision of the cover class estimates was highest with the line transect method at the reduced sampling intensity.

The two plot techniques were the most efficient for sampling trees. Both of these methods required 7.5 minutes per plot, for a total sampling time of 2 hours each. The point-centered quarter method required 3 hours and 6 minutes for overstory analysis.

The Bitterlich-nested plot method was the most efficient method at the maximum sampling intensity even though the time required per plot was highest. The line transect method had a more efficient time per plot (1.5 minutes), and at the reduced sampling intensity of 40 shrub and 40 herbaceous plots, this method equalled the sampling efficiency of the Bitterlich-nested plot method (2 hours).

Old Douglas-fir - Eight species of trees were identified in this study area. Point-centered quarter and Bitterlich-line plot methods recorded 88 percent of these. Reconnaissance and Bitterlich-nested plot methods each recorded 75 percent of the species. All methods indicated that Douglas-fir was the dominant tree. Frequency for Douglas-fir was near 100 percent for all sampling methods. The point-centered quarter technique gave much lower density and basal area estimates for Douglas-fir than either plot technique. Bitterlich-line plot gave the highest density and basal area estimates; these estimates also were the most precise.

Bitterlich-nested plot sampling identified 82 percent of

22 shrub species present in the study area. Reconnaissance recorded 59 percent of the species, followed by point-centered quarter and Bitterlich-line plot with 50 and 45 percent, respectively. Salal and California hazel were the co-dominant species recorded by all sampling methods. Bitterlich-nested plot and line transect methods recorded similar frequency values for the co-dominant species, but the frequency values for the two species were considerably higher with the Bitterlich-line plot technique. A cover class value of 5 was recorded for salal by all quantitative methods, while the reconnaissance method estimated a cover class of 6. Reconnaissance and Bitterlich-nested plot recorded a cover class of 4 for California hazel, but Bitterlich-line plot and line transect methods recorded a cover class of 5. The Bitterlich-line plot gave the most precise estimates of cover for both salal and California hazel.

A total of 53 herbaceous species were identified on the study area. Reconnaissance accounted for 85 percent of these; line transect recorded 66 percent; Bitterlich-nested plot and Bitterlich-line plot each recorded 55 percent of the identified species. Reconnaissance identified sword fern and bracken fern as co-dominant species, but analyses by all quantitative methods showed only sword fern as a dominant species. Frequency values estimated for sword fern and other identified species were higher with the Bitterlich-nested plot method than those estimated with the other methods. This higher value was directly related to the larger plot size used during stand analysis with the Bitterlich-nested plot method. All methods recorded a cover class of 5 for sword fern. The cover class estimates were most precise with the Bitterlich-nested plot method.

The Bitterlich-line plot method was most efficient for sampling trees, requiring 4.9 minutes per plot, for a total sampling time of about 78 minutes. In contrast, the least efficient method was the point-centered quarter method which required 5 hours and 18 minutes (10.6 minutes per plot).

At the reduced sampling intensity of 24 shrub and 24 herbaceous plots, the line transect method was the most efficient method for sampling understory vegetation, requiring 1.5 minutes per plot. The estimated time required to sample understory with the line transect was 1 hour and 47 minutes compared to 1 hour and 51 minutes for the Bitterlich-nested plot method.

<u>Clearcut Douglas-fir</u> - This study area contained three distinct plant communities: Upland shrub, annual grass, and riparian. These communities were mapped and sampled independently .

A total of 28 species of shrubs were identified within the upland shrub community. Reconnaissance sampling accounted for 89 percent of the species, followed by Bitterlich-line plot, line transect, and Bitterlich-nested plot with 61, 57, and 46 percent, respectively. All methods indicated a co-dominance among young Douglas-fir, vine maple, California hazel, salal, and wild trailing blackberry. Douglas-fir was recorded as a shrub species in this community because most individuals were smaller than 7.6 cm dbh. Frequency values for the co-dominant species were highest with the Bitterlich-nested plot, intermediate with Bitterlich-line plot, and lowest with the line transect method. Wild trailing blackberry was the most frequently occurring shrub with all methods. California hazel was recorded as cover class 4 with all methods. Douglas-fir, vine maple, and wild trailing blackberry were recorded as cover class 4 by all methods except line transect. With the line transect method, vine maple was recorded as cover class 3 and Douglas-fir and wild trailing blackberry were recorded as cover class 5. Salal was recorded as cover class 5 with Bitterlich-nested plot and reconnaissance, but was recorded as cover class 4 with the other methods. The Bitterlich-nested plot method was consistently more precise in cover class estimation for most of the co-dominant species. The line transect gave the most precise canopy cover estimates for wild trailing blackberry at both maximum and reduced sampling intensities. At reduced sampling intensity, the line transect also was most precise for the canopy cover estimate of California hazel.

Herbaceous cover was not prevalent in the shrub-dominated upland community. However, there was considerable diversity; 49 herbaceous species were identified. Reconnaissance identified 80 percent; Bitterlich-nested plot, 57 percent; Bitterlich-line plot, 53 percent; and line transect, 51 percent of the species. Sword fern was identified as the dominant forb by all methods. Frequency values were highest with the Bitterlich-nested plot method. Sword fern had the highest cover class value, but big deer-vetch and small-flowered willow weed had higher frequency values than sword fern. Precision of canopy cover estimates were low for the dominant herbaceous species. Bitterlich-nested plot produced the most precise results.

A total of 13 species of shrubs were recorded by the quantitative methods in the annual grass community. Bitterlich-nested and Bitterlich-line plot methods each identified 77 percent, and line transect identified 38 percent of these. Wild trailing blackberry was the most frequently occurring shrub recorded by all methods. Cover class estimates varied greatly between methods, but Douglas-fir, vine maple, California hazel, and wild trailing blackberry contributed the most canopy cover to the area. The Bitterlich-nested plot gave the most precise estimates of canopy cover for the latter shrub species.

Herbaceous vegetation was the dominant feature of the annual grass community; 29 species were identified. Bitterlich-nested plot recorded 76 percent of these; Bitterlich-line plot, 72 percent; and line transect, 55 percent. Soft chess was the dominant species recorded by all methods. Several species of minor significance to this community received high frequency values with the Bitterlich-nested plot method because of the large plot size. Frequency values with the other two methods were similar. Soft chess was recorded as cover class 5 with the Bitterlich-nested plot, and as cover class 4 with the other methods. Small-flowered willow weed and diffuse hairgrass were recorded as cover class 4 with the line transect method but did not have frequency values high enough to be considered co-dominant species. Bitterlich-nested plot recorded cover values of 4 and 2 for small-flowered willow weed and diffuse hairgrass, respectively, and Bitterlich-line plot recorded cover class values of 3 and 2, respectively. The Bitterlich-nested plot method gave the most precise estimates of canopy cover for soft chess, small-flowered deervetch, and diffuse hairgrass.

The riparian community was the only portion of the study area which had a tree canopy. Red alder was the dominant species recorded by all methods and had a frequency value of 100 percent with each method. Estimates of density for alder varied from a high of 1621 to a low of 702 trees per ha. The low estimate was the most precise; it was recorded with the Bitterlich-nested plot method. The Bitterlich-line plot method gave the most precise estimate of basal area. The Bitterlich-nested plot method was the most efficient for sampling trees in this community; 30 minutes were required compared to 36 minutes for the Bitterlich-line plot and 90 minutes for the point-centered quarter method.

Fifteen species of shrubs were recorded in this community. Reconnaissance identified 93 percent; Bitterlich-nested plot, 60 percent; and Bitterlich-line plot and point-centered quarter methods, 40 and 53 percent, respectively. Salmonberry was the dominant shrub species recorded by all methods. A frequency value of 100 percent for salmonberry was recorded by Bitterlich-nested plot and Bitterlich-line plot methods. Line transect recorded a frequency of 80 percent for this species. All quantitative methods recorded the same cover class value for salmonberry. The Bitterlich-nested plot method provided the most precise estimates of canopy cover.

Herbaceous vegetation was relatively diverse in the riparian area; 38 species were identified. Of these, reconnaissance identified 74 percent; Bitterlich-nested plot, 71 percent;

Bitterlich-line plot, 58 percent; and line transect, 53 percent. Frequency values were higher substantially with the Bitterlich-nested plot method than with the other methods. The Bitterlich-line plot and line transect methods recorded similar frequency values. Moss occurred most frequently and provided considerable ground cover throughout the area. Mexican betony was the most common forb but did not occur consistently throughout the area, as indicated by the moderate frequency values. The Bitterlich-nested plot gave the most precise estimates of canopy cover.

The Bitterlich-line plot method was most efficient for sampling the clearcut habitat for shrub and herbaceous composition. With an average sampling time of 2 minutes per plot, a total of 2 hours and 32 minutes would be required to sample this habitat. The dense shrub cover and diverse species composition of the area resulted in a very low efficiency for the Bitterlich-nested plot method; 18 minutes per plot were required to sample the area.

Illinois and Virginia Study Areas
James R. Karr

Methods

Vegetational structure and species composition on sample plots were determined with a technique described by Karr (1968). A 100-m line transect parallel to the road was sampled in each 100- x 100-m plot, and two transects were sampled in the plot immediately adjacent to the road - one in the roadside habitat, the other in the adjacent habitat beyond the right-of-way. Transect location was determined randomly for each plot.

Presence or absence of vegetation was recorded over points 1 (and in some cases, 5) metre apart along the transect line. At each point, presence or absence of vegetation was recorded for 28 height intervals which were:

Ht. above ground (m)	Interval
G (ground)	vegetation within 15.2 cm of the ground
0.3-4.9	fifteen 30.4-cm intervals
4.9-6.4	one 1.5-m interval
6.4-30.8	eight 3-m intervals
30.8-45.7	two 7.6-m intervals
> 45.7	one interval

At each sample point along the transect line, the observer recorded a plus for each height interval where vegetation was present. The following information was recorded for the ground interval: living vegetation (+); dead vegetation (DV); bare soil (BG); rock, gravel, etc. (R); or water (W).

Plant species composition of study plots was determined by sampling three height intervals at each sample point along the transect. These intervals were: from 0-0.6 m; from 0.6-6.1 m; and from 6.1 m to the canopy top. The tallest plant species in the first interval was recorded. The most abundant plant species in the 0.6-6.1-m interval was recorded, and the species of the canopy plant (over the sample point) was recorded for the third interval.

Findings

The procedure for determining vegetational structure and species composition provided a means of quantitatively (graphically or otherwise) depicting the vertical structure of the habitat on study plots. Also, plant species composition can be obtained at various height intervals. Plot cover maps in Virginia made it possible to group wildlife observations by habitat type prior to looking at road effects on distribution and abundance of wildlife.

Wisconsin Study Area

Forest Stearns, Marc C. Bruner

Methods

Species composition and abundance - The objectives of the study and the constraints imposed by the resources anticipated limited choice of methods for field testing habitat evaluation techniques. The time required to obtain adequate samples with objective (quantitative) methods appeared unwarranted in proportion to the benefits gained in information quality. Lindsey (1956) stated that subjective evaluation of vegetation by experienced observers can be as accurate as objective estimates based on extensive samples. The nature of the information desired prompted us to look in the direction of subjective methods, based on efficiency in field time. Such techniques tend to rely on ranking or scaled systems in which each species in a stand is assigned an estimated value from a given scale.

The Stratum-Rank technique was one method chosen for vegetation assessment. This method was developed by Lindsey *et al*. (1969) for the assessment of natural plant communities in Indiana. It is a rapid, subjective method, assigning dominance or stratum-rank values to species based on integration of observed numerical abundance, cover, and individual size.

The method was originally practiced by walking a zig-zag path through a stand, but may be used with random walk or linear transect patterns. The method can be used for all strata and is effective for tree, sapling, and shrub layers in forest systems. The method does not require division of the basic vegetation unit into sub-samples or plots.

Our field tests of the Stratum-Rank technique utilized linear transects. As the observer proceeded along a transect, he recorded the species encountered and observed cover, dominance (size), and abundance. These observations were integrated mentally into a stratum-rank value for each species. The reference area was a variable-width belt-transect. Direct line-of-sight was the only limit placed on the distance at which a species was observed. When the end of the transect was reached, the species listed were assigned their final stratum-rank values. We recorded the length of the transect in paces and the time required to complete the transect.

The second approach applied the Braun-Blanquet cover-abundance scale. This system, in common use in European phytosociological work, ranks species according to cover or number of individuals. Percent cover is estimated if the species is abundant; number of individuals is estimated if the individuals of the species are rare or few in number. In practice, a single large plot is determined subjectively to be representative of the stand as a whole. This serves as the reference area in which species are recorded and ranked. This reference area may range from 50-500 square metres, depending on the nature of the vegetation (Mueller-Dombois and Ellenberg 1974). The entire stand or plot was chosen as the reference area for the present study. This minimized worker bias in reference area selection and increased efficiency by eliminating the need to sub-divide the basic vegetational unit. With this modification, the Braun-Blanquet method was applicable to the same vegetational units as the Stratum-Rank technique.

Field tests of the Braun-Blanquet method used the same transect system as did the Stratum-Rank observations. Species presence was recorded as observed and at the end of the transect pass, cover and abundance values were assigned to species based on the Braun-Blanquet scale. Time and distance records also were kept to determine efficiency. The Braun-Blanquet approach was used for old fields and forest herbaceous strata; Stratum-Rank was used for tree and sapling layers in forest systems.

Community structure - Since wildlife habitat was being evaluated, it was necessary to obtain information on the physical structure (i.e. stratification and density, of the plant community). Density and layering is a critical habitat feature for birds (Emlen 1956, MacArthur and MacArthur 1961) and is important to other species as well. However, most quantitative measures of density do not give satisfactory results in terms of precision, accuracy, or efficiency (Kinsinger *et al.* 1960, Lyon 1968). For this study, visual estimation of density may serve as a more useful and efficient technique. A sighting board was suggested as a guide in making estimates and was tested in several vegetational types. The board used for this study was modified from that used by Wight (1938) and Robel *et al.* (1970) and is described below.

A sighting pole 5 cm wide and 150 cm tall was divided into alternating black and white decimetre blocks. These blocks served as guides in assessing the visibility of three sub-units of the pole: 0-0.5 m, 0.6-1.0 m, 1.1-1.5 m. The visibility (or obscurity) of each of these sub-units was determined at a series of points in the stand. In operation, a worker estimated the percent of each sub-unit obscured when the board was held at a distance of four paces by a second worker. The percent obscurity for each sub-unit was rated low (0-35% cover), medium (35-70%), or high (70-100%).

Four sets of readings in the four cardinal directions were used at each sample point. The points can be located in the stand in any pattern, but the most effective system (especially in dense woods or wetlands) is to locate them at regular intervals on the transect lines used for vegetational assessment. The points at which readings on the density pole were obtained also served as locations to make visual estimates of the height and percent ground cover for each strata of the community. Cover estimates can be expressed in percentage, or in classes similar to those used for the density pole. Height estimates are made by averaging the height of the strata. Estimates are based on the vegetation that can be observed from the sample point.

Twenty-four stands were used to field test the sampling methods. Seven of these stands were of non-forest vegetation; the remaining seventeen were forested. Ten of the forest stands (ranging in size from 2-18 ha) were located in metropolitan Milwaukee. The vegetation of these stands was of the southern-mesic type (Curtis 1959), except for one wet-mesic stand. Quantitative data on these were available from previous vegetational studies (Whitford and Salamun 1954, Levenson 1976). The remaining seven forest stands, which ranged from 2-8 ha, were located in the Horicon and Beaver Dam area. The vegetation in this area was of the dry-mesic type (Curtis 1959). It had been sampled previously with quantitative methods in conjunction with a wildlife abundance survey (March 1977).

Six of the non-forest sites were in the Milwaukee area; the seventh was located near Horicon. Three sites were old fields with a combination of herbaceous and shrubby vegetation; the remaining were dominated by herbs and grasses. No quantitative data were available on the non-forest sites to permit comparison of sampling methods.

Findings

Species composition and abundance - Compilation of a plant species list for each community was one sampling objective. Such a list suggests the species that may serve as indicators of habitat quality. Species lists were compiled in the course of data collection, and these were compared to data collected with the quantitative samples to determine how sensitive the methods tested were in detecting species.

For the eight stands in the Milwaukee area, the Stratum-Rank method detected 99 percent of the tree species found by quantitative sampling. In the Horicon area stands, 93 percent of the species found with the quantitative samples were detected by the Stratum-Rank method.

For shrubs and other plants in that layer, the Braun-Blanquet technique (as used in this study) detected more species in the Milwaukee area stands than did quantitative sampling. In the Horicon stands, the Braun-Blanquet method detected 90 percent of the shrub species and associated species found with quantitative sampling.

Since two sets of data were available, the indices assigned to species by our techniques were compared to the results of quantitative sampling. The Stratum-Rank values (Table 5) for the 10 species with the highest constancy in the Milwaukee data were plotted against the average importance values derived from quantitative sampling. The precision (relative agreement) of the values for species falling in the lower Stratum-Rank classes was not as good as that for the higher classes. However, this is a function of the rarity of the species rather than a shortcoming of the technique. The quality of information on rare or subordinate species is not the same as that for dominants, with any type of sampling method.

Braun-Blanquet cover values were plotted against relative densities of shrub species sampled in Milwaukee area stands. This technique was less precise than the Stratum-Rank technique.

Community structure - Both techniques used to analyze community structure were proved efficient. The time required to take a set of readings with the density board or make a series of height and cover estimates at a point were minimal. Usually, a set of readings could be made in a minute or less once one became familiar with the techniques. The principal time requirement for the height, cover, and density board measurements was that required for moving from one location to the next. This time requirement can be overcome by incorporating the height, cover, and density board techniques into another phase of the sampling plan that requires movement along a transect.

Table 5. Stratum rank classes (from Lindsey *et al*. 1969).

Class	Description
Stratum Rank 9.	A sole dominant species, no other species in stand exceeds SR2.
Stratum Rank 8.	A species so outstanding as to be called the sole dominant in the stand, no other species exceeds SR 6. (Given to only one species in a stand).
Stratum Rank 7.	A species sharing dominance in the stand, given to one, but rarely more than two, species in a stand. (e.g. beech and maple).
Stratum Rank 6.	A species sharing dominance with another in the stand, but markedly less important than the main dominant. Or, a species sharing dominance more or less equally with a number of species.
Stratum Rank 5.	Given to the third or fourth subdominant in a stand with two clear dominants, usually given only if all remaining species have rather low SR's.
Stratum Rank 4.	A subordinate species, not dominant or subdominant, but contributing significantly to both numbers and cover.
Stratum Rank 3.	A species with three to several individuals furnishing substantial cover.
Stratum Rank 2.	A species with two to several individuals, but infrequent in number and inconsequential in cover.
Stratum Rank 1.	A species for which only a single individual is observed in the stand.

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Appendix A. Summary of recommended field procedures for Phase II of the study.

	Oregon Cooperative Wildlife Research Unit	Urban Wildlife Research Center	Wisconsin Cooperative Wildlife Research Unit
Cluster Configuration	4-6 transects, each 100 x 450 m perpendicular to road.	6 transects, each including a near road plot and a control plot. Minimum of 100 m between adjacent transects. 3 transects on one side of road and 3 directly opposite on other side of road. 100-m square plots in open habitat and 50-m square plots in shrubs and woods.	2 U-shaped transects, each 1005 m long with base of U at center of road. Plot sizes 91.4 x 91.4 m.
Bird Indices	Observation points and a fixed-sized circular plot of about 50 m in radius. 1st plot a semicircle at roadside, and plot centers at 100, 200, 300, and 400 m from road. Belt transect may be good if observer routinely stops along the line.	Random walk within each plot.	Obtain index by walking a straight transect bisecting the plot. The radial sighting distance and the sighting angle for each observation should be recorded. Average of 5 replications on each area if possible. If not, adequate replication in space may serve.
Season	Breeding and wintering.	Breeding and wintering.	Breeding and wintering.

Appendix A. (Continued).

	Oregon Cooperative Wildlife Research Unit	Urban Wildlife Research Center	Wisconsin Cooperative Wildlife Research Unit
Time of day	0.25 h before sunrise to about 5 h after sunrise and about 1.5 h before sunset to sunset for both breeding and wintering birds.	Both morning and evening counts should be made.	First 5 h after sunrise for breeding birds and all day for wintering birds.
Control distance	Observation point at 400 m from road.	Plot 250-350 m from road.	Plots 3 and 4 (182.9-365.8 m from road).
Time per plot	5- and 10- minute counts at each plot.	10 minutes for 100-m square plot and 15-20 minutes for 50-m square plot.	Fairly even rate of speed. About 5 minutes per 100-m square plot is reasonable in habitats encountered in Wisconsin.
What to count	All bird species as well as all medium and large mammal species observed (small mammals not recorded).	All bird species as well as deer (no small or medium sized mammals should be recorded).	All bird species as well as all medium and large mammal species observed (small mammals not recorded).
Small Mammal Indices			
Control distance	100-125 m from road.	10 m from roadside right-of-way vegetation probably sufficient.	Not examined.

Appendix A. (Continued).

	Oregon Cooperative Wildlife Research Unit	Urban Wildlife Research Center	Wisconsin Cooperative Wildlife Research Unit
When to sample	Once a year in spring (April-May) or possibly late winter.	Late winter.	September and May.
Method	Snap traps within circular plots of 2-3-m radius. Locate plots at 10-20-m intervals along transects oriented perpendicular to road. Keep lines at least 30 m apart. Trap density at least 10 traps/50 m^2. Trap for a minimum of 2 consecutive nights. Victor rat and Victor mouse traps are suggested for use. Mixed bait (peanut butter-rolled oats-beef suet-raisin) better than peanut butter on rat traps. Prebaited (chemically treated at factory) traps compared favorably with others.	20 station trap line, with 1 trap per station at 5-m intervals. Also place 1 rat trap at stations 1, 5, 10, and 20. Bait with peanut butter. Run for 3 days and 3 nights.	50 traps at 10-m intervals in each plot (straight line transect). Ratio of 4 mouse to 1 rat trap. Nonhomogenized peanut butter for bait. Run for minimum of 2 days and 2 nights.

Appendix A. (Continued).

	Oregon Cooperative Wildlife Research Unit	Urban Wildlife Research Center	Wisconsin Cooperative Wildlife Research Unit
Medium and Large Mammal Indices			
Deer, Rabbits, Hares			
Control distance	200-300 m should be adequate.	Not investigated.	Not investigated.
Method	Pellet group counts in 2-3-m wide belt transects or circular plots with 4-5-m radius. Optimal time for sampling in early spring prior to new vegetation.	Count deer during bird surveys.	Pellet group counts for deer in March-April or mid-winter on two 0.008-ha sampling units per plot. Presence or absence of rabbit pellets on two 0.0016-ha sampling units (subunits of the 0.008-ha units) or diagonal transects. Sample rabbits same time as deer are sampled. Also count other mammal scats, dens, burrows, tracks, and other sign on the 0.008-ha units, or along diagonal transects within plots. Also trail counts for deer in fall along a

Appendix A. (Continued).

	Oregon Cooperative Wildlife Research Unit	Urban Wildlife Research Center	Wisconsin Cooperative Wildlife Research Unit
			400-m transect (perpendicular to road), with one 100-m segment per plot, plus one 100-m segment along road.
Terrestrial Furbearers			
<u>Control distance</u>	Suggest at least 300-400 m be used.	Not investigated.	Not investigated.
<u>Method</u>	Scent stations in combination with sign counts and audio and visual observations. Paste made from canned sardines produced acceptable results at scent stations. Sampling in conjunction with small mammals most efficient.	Not investigated.	Scent stations in September or October. Three stations per transect, each station run for 2 consecutive nights.
Squirrels and Chipmunks			
<u>Control distance</u>	Same as for birds.	Not investigated.	Same as for birds.

Appendix A. (Continued).

	Oregon Cooperative Wildlife Research Unit	Urban Wildlife Research Center	Wisconsin Cooperative Wildlife Research Unit
Method	Observations in conjunction with sampling birds.	Not investigated.	Observations in conjunction with sampling birds.
Moles, Gophers, and Mountain Beaver			
Control distance	Same as for deer, rabbits, and hares.	Not investigated.	Not investigated.
Method	Counts of mounds and burrows in conjunction with pellet group counts.	Not investigated.	Not investigated.
All Medium and Large Mammals			Track counts following snow. Run diagonal transects across each plot.
Amphibians and Reptiles			
Control distance	Insufficient data.	Not investigated.	Insufficient data.
Method	Observation of frogs and toads while sampling birds, and ground searches for other	Not investigated.	Ten, 15- or 30-m drift fences per cluster. Sample 50% of all clusters.

Appendix A. (Continued).

	Oregon Cooperative Wildlife Research Unit	Urban Wildlife Research Center	Wisconsin Cooperative Wildlife Research Unit
	species of amphibians and reptiles are recommended. Use same plots as used for pellet group counts.		
Sampling interval	Same as for birds, and deer/rabbit/hare pellet group counts.		Operate fences for 3-5 days.
When to sample	Once in fall, winter, or spring for amphibians, and once in summer for reptiles.		These should coincide with rain in early April, late April-early May, late May, and, with warm temperatures, mid-June, for complete assessment of herpetological community.
Road Mortality			
Method	Sampling from car while traveling between sites. Sampling on foot (about 1.6 km lengths) near sampling sites. Standardize searches as to time of day. Sample	Sample from car and sample only interstates. Sample unit should be an 80-km section of interstate, subdivided into 16-km sections. Driver plus 1 other	Not investigated.

Appendix A. (Continued).

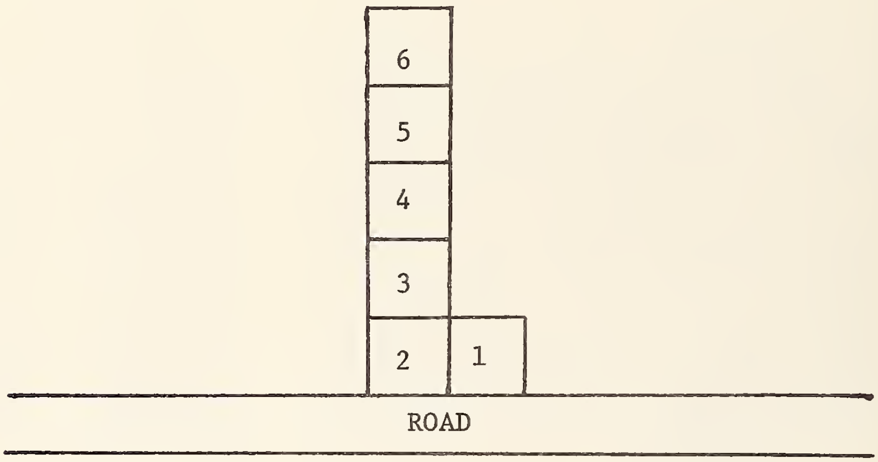
	Oregon Cooperative Wildlife Research Unit	Urban Wildlife Research Center	Wisconsin Cooperative Wildlife Research Unit
	twice per year - early summer and winter. Data should be "corrected" for length of detectability for species and seasons.	observer in car. Walk sections of highway for calibrating counts made from car.	
Habitat Description	Suggest both qualitative and quantitative methods be used. Qualitative method would determine plant communities within a unit. Suggest use of plots and points located along linear transects for quantitative method. Six 20- x 50-cm plots at 2.4-m intervals along a 15-m transect should be adequate for herbaceous vegetation. Four 1- x 1-m plots along the 15-m transect should be adequate for shrubs. Number of transects depends upon size of community. Should be no fewer than 2.	Suggest a cover map be made for each plot followed by the "Karr" technique. Record presence and absence of vegetation over points. Also record the species for the tallest plant under 0.6 m, the species for the most abundant plant in the 0.6-6.1 m height range, and the species for the canopy plant above the sampling point. Run two transects per plot, forming an X pattern.	Suggest the stratum-rank method for plant species composition and abundance in wooded areas and the Braun-Blanquet method for use in non-forest plots. Obtain horizontal structure with a density-board and vertical structure with "Karr" technique. Obtain a description of the area surrounding sample sites.

Appendix A. (Continued).

	Oregon Cooperative Wildlife Research Unit	Urban Wildlife Research Center	Wisconsin Cooperative Wildlife Research Unit
	Obtain tree data from sampling points (variable-sized plots) within communities. Suggest about 4 points per hectare. Maximum of 4 within the 100- x 450-m unit. Place points along the 15-m transects. Obtain information on species frequency, basal area, and height.		

General Procedures Applicable to all Wildlife and Habitat Surveys

Surveys (with the exception of the wildlife road mortality survey) are conducted on 80- x 80-m sample plots, six of which make up a transect that is oriented to the road in the following manner:



In actual practice, plot 1 may be placed on the left side of plot 2 if field circumstances make it impractical to place it as shown above.

Five such transects within a 1.6-km section of road make up a sample cluster. The five transects are numbered consecutively (one through five) from west to east or from north to south (depending upon road direction). Transects are marked with color ribbon (flagging) or staked flags and only the center lines through each plot (perpendicular to the road) are marked. The center line is marked at more frequent intervals in wooded areas than in non-wooded areas, and in both cases, the beginning and ending points for each plot are marked with different colored flagging from that used for marking within a plot. This is done so the observer can readily determine when he leaves a particular plot and enters an adjacent plot. Transects are clustered in groups of five to increase sampling efficiency. Prior to beginning work in the field, the observer will be given county highway maps showing the location of each cluster site. Also provided will be an aerial photograph of the cluster depicting actual location of sample plots and transects. Cover maps will be provided indicating the habitat type (or types) on each plot.

Field forms for all surveys are designed to aid computer key punch operators in entering data onto cards or tape for computer analysis. The numbers in parentheses refer to computer card columns and are of primary importance to the key punch operator. However, as a field worker, you should know that the numbers or letters you enter into each block must not exceed the columns allocated for that block. (Column numbers are marked below each block). For all forms, always use upper case (capital) letters.

Each observer will be assigned a two-digit number by the project coordinator, and this number (your name to the computer) will not change from day to day or survey to survey. It will be your number for the duration of the study. Always make certain you use only your number for the surveys you conduct.

The date you conduct a particular survey is coded on the field form in the order of month, day, and year. The following codes are to be used for this purpose:

Month	Code	Month	Code
January	01	July	07
February	02	August	08
March	03	September	09
April	04	October	10
May	05	November	11
June	06	December	12

Day - This is the day of the month the survey is conducted.

01
02
03
.
.
.
31

Year	Code
1977	77
1978	78
1979	79

Suppose you conducted a survey on June 9, 1977. This date is coded as 060977. These six numbers are entered in the date block on the field form.

A unique (for each cluster) three-digit number will be assigned (by the project coordinator) to each sample cluster. Also, transects will be marked as one, two, three, four, or five. Maps showing this information will be distributed to each individual conducting surveys. Again, be extremely careful to fill in the correct information in these (and all other) blocks.

In order for the key punch operators to distinguish numerical zeros from alphabetical "Oh's", always place a slash mark through alphabetical "Oh's".

Examples illustrating the above instructions accompany each wildlife and habitat survey procedure.

Cover Maps of Study Plots

A cover map is prepared for each 80- x 80-m sample plot and should be made when plots and transects are laid out in the field.

The example included with these instructions (page 114) is a cover map of transect 5 of cluster 100 that was mapped on June 5, 1977 by John Doe. Plot 1 contains two habitat types {see the habitat type descriptions (page 115) included with these instructions}. The roadside habitat (11AB00) comprises 20% of the plot. The first three digits of this code refer to the general cover present, and the last three digits refer to special features about the habitat (fence rows, power lines, and streams). In this example, the first three digits (11A) tell us the roadside habitat in this plot is at least 70% mowed grass less than six inches in height. The fourth digit (B) tells us a cleared fence row is present, the fifth digit (0) tells us no power line is present, and the sixth digit (0) tells us no stream is present. The remaining habitat in Plot 1 (05AA01) comprises 80% of the plot. The code tells us this is an oak-hickory deciduous forest type containing no fence row or power line; however, a stream is present. The codes 1A and 1B simply indicate that Plot 1 is divided into two types. For all sites, Plots 1 and 2 will always contain two habitat types - the roadside habitat and the habitat beyond the roadside.

Plot 2, in our example, is similar in composition to Plot 1, so no further description is necesssary.

Plot 3 contains a single habitat type (05A) which is oak-hickory. In this plot, there are no fence rows, power lines, or streams. Note that the plot is coded as 3A rather than simply as 3. It will aid key punch operators if we keep the plot codes the same length, so please follow this example.

Plot 4 is similar to Plot 3.

Plot 5 consists of two habitat types, oak-hickory and shortleaf-Virginia pine, each comprising 50% of the plot. No fence rows, power lines, or streams are present in either habitat type.

Plot 6 consists of a single habitat type, shortleaf-Virginia pine.

If a habitat type comprises less than 10% of a plot, do not list that habitat type. For example, if you were in an old field containing a thicket which comprised 5% of the plot, the entire plot would be recorded as old field. If this thicket had comprised 10% or more of the plot, the plot would have been divided into two habitat types - old field and thicket, with appropriate percentage values for each. The only exception to this rule is for roadside habitat. Roadside habitat should always be recorded separately, even if less than 10% of the plot. If a right-of-way fence is present, it should be recorded with the roadside habitat. Habitat percentages per plot should total 100 percent.

COVER MAP FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Road, Ellicott City, MD 21043

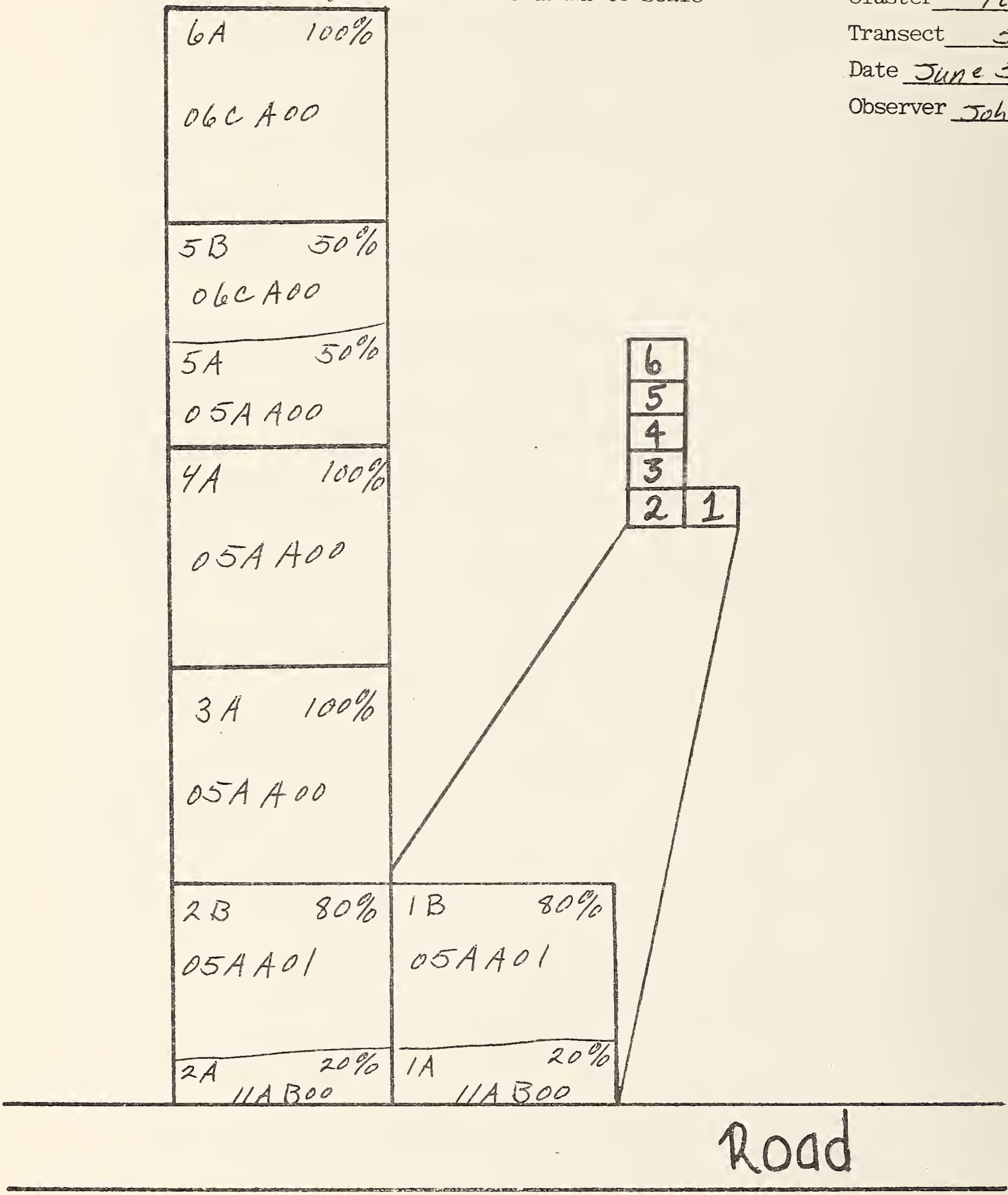
Survey transect - not drawn to scale

Cluster 100

Transect 5

Date June 5, 1977

Observer John Doe



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DESCRIPTIONS OF HABITAT TYPES USED FOR COVER MAPPING IN THE HIGHWAY-WILDLIFE STUDY

Urban Wildlife Research Center, Inc.
12789 Folly Quarter Road, Ellicott City, Maryland 21043

Code	Habitat Type	Description
01A	Bare field I	Plowed, disced, etc. Not presently planted in crops. Most recent crop unknown.
01B	Bare field II	Plowed, disced, etc. Not presently planted in crops. Most recently used for hay, pasture, silage, tobacco, or other crop for production of herbaceous plant growth. Waste grain noticeably absent.
01C	Bare field III	Plowed, disced, etc. Not presently planted in crops. Most recently used for corn, small grain, soybean, or other crop for production of seed. Waste grain present.
02A	Crops (corn and soybean)	Land intensively farmed for crop production.
02B	Crops (small grain)	Land intensively farmed for crop production.
02C	Crops (grass seed)	Land intensively farmed for crop production.
02D	Crops (tobacco)	Land intensively farmed for crop production.
02E	Crops (hay field without woody vegetation)	Land intensively farmed for crop production. Herbaceous vegetation less than 6 inches in height. No woody growth of 2 feet or more in height nor covering 10% or more of the area.
02F	Crops (hay field without woody vegetation)	Land intensively farmed for crop production. Herbaceous

		vegetation 6 inches or more in height. No woody growth of 2 feet or more in height nor covering 10% or more of the area.
02G	Crops (hay field with scattered woody vegetation)	Land intensively farmed for crop production. Herbaceous vegetation less than 6 inches in height. Some woody growth of 2 feet or more in height covering less than 10% of the area.
02H	Crops (hay field with scattered woody vegetation)	Land intensively farmed for crop production. Herbaceous vegetation 6 inches or more in height. Some woody growth of 2 feet or more in height covering less than 10% of the area.
02I	Crops (other)	Land intensively farmed for crop production. Name the crop.
02J	Crops (fruit orchard)	Land intensively farmed for crop production.
02K	Crops (nut orchard)	Land intensively farmed for crop production.
03A	Pasture without woody vegetation	Open land consisting mostly of herbaceous vegetation less than 6 inches high. No woody growth of 2 feet or more in height nor covering 10% or more of the area. Generally grazed during some portion of the year.
03B	Pasture without woody vegetation	Open land consisting mostly of herbaceous vegetation 6 inches or more in height. No woody growth of 2 feet or more in height nor covering 10% or more of the area. Generally grazed during some portion of the year.
03C	Pasture with scattered woody vegetation	Open land consisting mostly of herbaceous vegetation less than 6 inches high. Some woody growth of 2 feet or more in height covering less than 10% of the area. Generally grazed during some portion of the year.

03D	Pasture with scattered woody vegetation	Open land consisting mostly of herbaceous vegetation 6 inches or more in height. Some woody growth of 2 feet or more in height covering less than 10% of the area. Generally grazed during some portion of the year.
03E	Marshy pasture	Pasture with cattails, sedges, and/or other wetland vegetation comprising more than 10% of the area. Generally grazed during some portion of the year.
03F	Ungrazed grassland	Same as 03A except ungrazed
03G	Ungrazed grassland	Same as 03B except ungrazed
03H	Ungrazed grassland	Same as 03C except ungrazed
03I	Ungrazed grassland	Same as 03D except ungrazed
03J	Marshy land	Same as 03E except ungrazed
03K	Pasture with woody vegetation	Open land, mostly herbaceous vegetation of any height. Woody growth to include trees in 10-50% of area. Grazed during year.
04A	Fallow field	A field used for growing crops, but left idle (normally for a portion of a year) except for tillage in order to destroy weeds and accumulate water and nutrients for use of a crop to be planted later. Predominately of herbaceous vegetation which may consist of previous crop residue, various grasses, weeds, low vines, and small seedlings of woody plants (the latter comprising less than 10% of the area).
04B	Old field I	Overgrown land with shrubs and young trees less than 20 feet high on 10-49% of the area. Herbaceous vegetation less than 6 inches in height.
04C	Old field I	Overgrown land with shrubs and young trees less than 20 feet

		high on 10%-49% of the area. Herbaceous vegetation 6 inches or more in height.
04D	Old field II	Overgrown land with shrubs and young trees less than 20 feet high on 50%-89% of the area. Herbaceous vegetation less than 6 inches in height.
04E	Old field II	Overgrown land with shrubs and young trees less than 20 feet high on 50%-89% of the area. Herbaceous vegetation 6 inches or more in height.
04F	Thicket	Dense stand of shrubs or small trees less than 20 feet high and covering 90%-99% of the area.
05A	Deciduous forest (oak-hickory--post oak, black oak, scarlet oak, white oak, red oak, hickory) (SAF types 40, 41, 52, 53)	Species listed in the type name comprise more than 70% of the area. See the description in <u>Forest Cover Types of North America (Exclusive of Mexico)</u>. 1954. Society of American Forests, Bethesda, MD, for midwest and southeast areas; and Franklin, Jerry F. and C.T. Dyrness. 1973. <u>Natural Vegetation of Oregon and Washington.</u> USDA Forest Service General Technical Report PNW-8, Forest Service, U.S. Dept. of Agriculture, Portland, OR, for those states.
05B	Deciduous forest (bur oak) (SAF type 42)	" "
05C	Deciduous forest (northern red oak--northern red oak, basswood, white ash, mockernut hickory, sweetgum) (SAF types 54, 55, 56)	" "
05D	Deciduous forest (yellow poplar--yellow poplar, hemlock, white oak, northern red oak) (SAF types 57, 58, 59)	" "

05E	Deciduous forest (black locust) (SAF type 50)	Species listed in the type name comprise more than 70% of the area. See the description in <u>Forest Cover Types of North America (Exclusive of Mexico)</u> for midwest and southeast areas and <u>Natural Vegetation of Oregon and Washington</u> for those states.
05F	Deciduous forest (beech-sugar maple) (SAF type 60)	" "
05G	Deciduous forest (river birch-sycamore) (SAF type 61)	" "
05H	Deciduous forest (silver maple-American elm) (SAF type 62)	" "
05I	Deciduous forest (cottonwood) (SAF type 63)	" "
05J	Deciduous forest (sassafras-persimmon) (SAF type 64)	" "
05K	Deciduous forest (pin oak-sweetgum) (SAF type 65)	" "
05L	Deciduous forest (black willow) (SAF type 95)	" "
05M	Deciduous forest (southern bottomland hardwoods--swamp chestnut oak, cherrybark oak, cottonwood, sweetgum, nuttal oak, willow oak, sugarberry, American elm, green ash, sycamore, pecan, black willow, overcup oak, water hickory) (SAF types 91, 63, 92, 93, 94, 95, 96)	" "
05N	Deciduous forest (northwest bottomland hardwoods--black cottonwood, willow, Oregon ash, red alder, bigleaf maple) (SAF type 235)	" "
05Ø	Deciduous forest (alder) (SAF type 221)	" "
05P	Deciduous forest (ash) (No	" "

SAF type number).

05Q	Deciduous forest (Oregon white oak, California black oak, Pacific madrone) (SAF type 234)	Species listed in the type name comprise more than 70% of the area. See the description in <u>Forest Cover Types of North America (Exclusive of Mexico)</u> for midwest and southeast areas and <u>Natural Vegetation of Oregon and Washington</u> for those states.
05R	Deciduous forest (sweetgum-yellow poplar) (SAF type 87)	" "
05S	Black cottonwood-willow (SAF type 222)	" "
05T	Pure Oregon white oak (SAF type 233)	" "
05U	California black oak (SAF type 246)	" "
06A	Coniferous forest (shortleaf pine) (SAF type 75)	" "
06B	Coniferous forest (Virginia pine) (SAF type 79)	" "
06C	Coniferous forest (shortleaf-Virginia pine) (SAF type 77)	" "
06D	Coniferous forest (loblolly pine) (SAF type 81)	" "
06E	Coniferous forest (loblolly-shortleaf pine) (SAF type 80)	" "
06F	Coniferous forest (eastern red cedar) (SAF types 46-49)	" "
06G	Coniferous forest (Douglas fir) (Similar to SAF type 244)	" "

06H	Coniferous forest (Douglas fir, grand fir, incense cedar, bigleaf maple, ponderosa pine, sugar pine, white fir) (SAF type 243)	Species listed in the type name comprise more than 70% of the area. See the description in Forest Cover Types of North America (Exclusive of Mexico) for midwest and southeast areas and Natural Vegetation of Oregon and Washington for those states.
07A	Mixed coniferous/deciduous forest (shortleaf pine-oak) (SAF type 76)	Hardwoods and conifers each comprise between 31% and 70% of the area. See the description in Forest Cover Types of North America (Exclusive of Mexico) for midwest and southeast areas and Natural Vegetation of Oregon and Washington for those states.
07B	Mixed coniferous/deciduous forest (Virginia pine-oak) (SAF type 78)	" "
07C	Mixed coniferous/deciduous forest (loblolly pine-hardwood) (SAF type 82)	" "
08A	Clearcut (Douglas-fir)	70%-100% of the crown canopy removed.
08B	Clearcut (other coniferous)	" "
08C	Clearcut (deciduous)	" "
09A	Brushfields (snowbrush, ceanothus, redstem ceanothus, deerbrush, squawcarpet, mountain whitethorn ceanothus, golden chinkapin, canyon live oak, Saskatoon serviceberry, hoary manzanita, tanoak) (SAF type 242)	Described in Natural Vegetation of Oregon and Washington.
10A	Xeric "meadows" (cryptogams, pinemat manzanita, squawcarpet, lemon needlegrass, western needlegrass, bottlebrush, squirreltail, creamy stonecrop	" "
11A	Roadside (mowed grass)	At least 70% mowed grass (less than six inches high).

11B	Roadside (other herbaceous)	At least 70% herbaceous plants between six inches and two feet in height.
11C	Roadside (shrubs)	At least 70% shrubs between two feet and 20 feet in height.
11D	Roadside (trees)	At least 70% trees greater than 20 feet in height.
11E	Roadside (mowed grass/ other herbaceous)	Types 11A and 11B each comprise between 31% and 70% of the roadside habitat.
11F	Roadside (mowed/ shrubs)	Types 11A and 11C each comprise between 31% and 70% of the roadside habitat.
11G	Roadside (mowed/ trees)	Types 11A and 11D each comprise between 31% and 70% of the roadside habitat.
11H	Roadside (other herbaceous/shrubs)	Types 11B and 11C each comprise between 31% and 70% of the roadside habitat.
11I	Roadside (other herbaceous/trees)	Types 11B and 11D each comprise between 31% and 70% of the roadside habitat.
11J	Roadside (shrubs/ trees)	Types 11C and 11D each comprise between 31% and 70% of the roadside habitat.
11K	Roadside (other herbaceous)	Herbaceous plants taller than 2 feet. Especially aquatic vegetation such as cattails, but any herbaceous plants taller than 2 feet. (Note kind).
11L	Roadside (cut bank or fill)	Essentially devoid of vegetation.

The following codes are to be used (<u>in the order listed</u>) in conjunction with the habitat codes listed above:

Fence Rows

A No fence row

B Fence row, cleared - At least 70% mowed grass (less than six inches high).

C Fence row, herbaceous - At least 70% herbaceous plants between six inches and two feet in height.

D Fence row, shrubs - At least 70% shrubs between two feet and 20 feet in height.

E Fence row, trees - At least 70% trees greater than 20 feet in height.

F Fence row, cleared/herbaceous - Each comprise between 31% and 70% of the fence row.

G Fence row, cleared/shrubs - Each comprise between 31% and 70% of the fence row.

H Fence row, cleared/trees - Each comprise between 31% and 70% of the fence row.

I Fence row, herbaceous/shrubs - Each comprise between 31% and 70% of the fence row.

J Fence row, herbaceous/trees - Each comprise between 31% and 70% of the fence row.

K Fence row, shrubs/trees - Each comprise between 31% and 70% of the fence row.

L Fence row, cleared with herbicide

Power Lines

0 No power line

1 Power line present

Streams

0 No stream

1 Stream present

2 Pond

Example of habitat code:

0 1 B D 0 1

- D — Fence row with shrubs
- 0 — No power line
- 1 — Stream present in plot
- 01B — Bare field II

Quantitative Vegetation Survey

This survey, conducted during July and August, provides information on the vegetational structure and plant species composition of study plots. It is designed to supplement the plot cover maps (page 112).

The survey is conducted on all plots except monotypic stands of agricultural crops and monotypic rights-of-way adjacent to agricultural crops. An updated cover map, including the crop present and its average height at time of the breeding bird survey will suffice for these types of plots. For non-monotypic rights-of-way adjacent to agricultural plots, conduct the survey as described below, <u>but only in the right-of-way portions of the plots</u>.

Two transect lines are laid out diagonally across each 80- x 80-m plot to be sampled, forming an X pattern. The base of the X is at the plot edge nearest the road. Thus, the first line in each plot begins at one of the two plot corners nearest the road, and the other line begins at the remaining plot corner nearest the road.

Data are collected along each line at 23 sample points. The first sample point on a line is 1.5 m from the plot corner. Subsequent points are spaced at 5-m intervals (paced), with the last point (letter W) located a distance of 1.5 m from the far corner (this distance will vary slightly due to difficulty in precisely determining a 45° angle in the field, difficulty in walking a straight compass line, and difficulty in accurately pacing distances.

Vegetational structure at each sample point is determined for four height intervals (0-0.15 m, 0.16-0.60 m, 0.61-6 m, and canopy). Structure is determined by looking vertically above each sample point and recording one of the following codes for the height intervals where vegetation is directly above the sample point.

1 - living vegetation
B - bare soil
L - leaf litter
D - dead herbaceous vegetation
F - fallen dead tree
S - standing dead tree
R - rock, gravel
W - water

If no vegetation is present at a particular height interval, record a zero for that interval.

Plant species composition of sample plots is determined from data collected in the following manner. At each of the 23 sample points per line, (1) record the species for the tallest plant material in the 0 through 0.15-m interval, (2) record the species for the tallest plant material in the 0.16- through 0.60-m interval, (3) record the species for the most abundant plant in the 0.61- through 6-m interval, and (4) record the species for the canopy plant above the sample point. If no vegetation is present at a particular height interval, record a zero for that interval. An exception to the above set of rules is that grasses and forbs beyond the managed roadside habitat need not be recorded to species. Simply code these as either GRAS or FORB on the field form.

Four digit codes of scientific names are used to record plant species on the field form. Each code consists of the first two letters of the plant Genus, and species names, respectively.

Please maintain a list of plant species encountered and codes used for each species. This list should be helpful to you in the field, and it will be helpful to us in checking for duplicate codes.

Let's look at an example of a completed field form (pages 127-128). The person conducting the survey in our example was given the code 01, and the survey was conducted on July 10, 1978, on cluster 100, transect 5, plot 5.

The block for line refers to one of the two diagonal transect lines discussed above. Line 1 begins at the left plot corner (when you are facing away from the road), and line 2 begins at the right plot corner.

The letters on the left side of the form (A through W) refer to the 23 sampling stations per line. One row of blocks is allocated for each sample point. Four of these blocks are for recording vegetational structure, and the other four blocks are for recording plant species composition at the sample point.

For the sake of brevity, only 2 of the sample points will be discussed here. Let's start with sample point A. In terms of vegetational structure, leaf litter was present in the 0-0.15-m height interval, living vegetation was present in the 0.16-0.60-m interval, and no vegetation was present in the remaining two height intervals (0.61-6 m and canopy). For species composition at sample point A, a zero was placed in the block for the 0-0.15-m interval, since the only thing present there was leaf litter. A southern red oak (<u>Quercus falcata</u>) seedling was recorded in the 0.16-0.60-m height interval. No

VEGETATION SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, MD 21043

Observer (1-2)	Date (3-8)	Cluster (9-11)	Transect (12)	Plot (13)	Line (14)
01	071078	100	5	5	1

	STRUCTURE				SPECIES COMPOSITION			
	0-0.15m	0.16-0.60m	0.61-6 m	Canopy	0-0.15m	0.16-0.60m	0.61-6m	Canopy
A (15)	L (16)	1 (17)	0 (18)	0 (19)	0 (20-23)	QUFA (24-27)	0 (28-31)	0 (32-35)
B (36)	L (37)	0 (38)	1 (39)	1 (40)	0 (41-44)	0 (45-48)	CØFL (49-52)	QUFA (53-56)
C (57)	F (58)	F (59)	0 (60)	1 (61)	CAØV (62-65)	CAØV (66-69)	0 (70-73)	QUFA (74-77)
D (78)	L (79)	1 (80)	0 (81)	1 (82)	0 (83-86)	CØFL (87-90)	0 (91-94)	CAØV (95-98)
E (99)	L (100)	0 (101)	1 (102)	1 (103)	0 (104-107)	0 (108-111)	CØFL (112-115)	QUFA (116-119)
F (15)	R (16)	0 (17)	0 (18)	0 (19)	0 (20-23)	0 (24-27)	0 (28-31)	0 (32-35)
G (36)	L (37)	0 (38)	1 (39)	1 (40)	0 (41-44)	0 (45-48)	SAAL (49-52)	CAØV (53-56)
H (57)	L (58)	0 (59)	1 (60)	1 (61)	0 (62-65)	0 (66-69)	SAAL (70-73)	QUFA (74-77)
I (78)	L (79)	0 (80)	0 (81)	1 (82)	0 (83-86)	0 (87-90)	0 (91-94)	QUVE (95-98)
J (99)	L (100)	1 (101)	0 (102)	0 (103)	0 (104-107)	QUVE (108-111)	0 (112-115)	0 (116-119)

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VEGETATION SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, MD 21043

Observer (1-2)	Date (3-8)	Cluster (9-11)	Transect (12)	Plot (13)	Line (14)
01	071078	100	5	5	1

STRUCTURE					SPECIES COMPOSITION			
	0–0.15m	0.16–0.60 m	0.61–6 m	Canopy	0 – 0.15 m	0.16–0.60 m	0.61–6 m	Canopy
K (15)	W (16)	0 (17)	1 (18)	1 (19)	0 (20-23)	0 (24-27)	CECA (28-31)	QUVE (32-35)
L (36)	L (37)	1 (38)	0 (39)	0 (40)	0 (41-44)	QUFA (45-48)	0 (49-52)	0 (53-56)
M (57)	1 (58)	1 (59)	1 (60)	1 (61)	QUFA (62-65)	QUFA (66-69)	CØFL (70-73)	QUFA (74-77)
N (78)	L (79)	0 (80)	0 (81)	1 (82)	0 (83-86)	0 (87-90)	0 (91-94)	CAØV (95-98)
Ø (99)	L (100)	1 (101)	0 (102)	0 (103)	0 (104-107)	SAAL (108-111)	0 (112-115)	0 (116-119)

STRUCTURE					SPECIES COMPOSITION			
P (15)	L (16)	0 (17)	1 (18)	1 (19)	0 (20-23)	0 (24-27)	LIBE (28-31)	CATØ (32-35)
Q (36)	R (37)	0 (38)	0 (39)	0 (40)	0 (41-44)	0 (45-48)	0 (49-52)	0 (53-56)
R (57)	L (58)	1 (59)	0 (60)	1 (61)	0 (62-65)	CATØ (66-69)	0 (70-73)	QUFA (74-77)
S (78)	L (79)	0 (80)	1 (81)	1 (82)	0 (83-86)	0 (87-90)	LIBE (91-94)	QUVE (95-98)
T (99)	L (100)	0 (101)	0 (102)	1 (103)	0 (104-107)	0 (108-111)	0 (112-115)	CATØ (116-119)

STRUCTURE					SPECIES COMPOSITION			
U (15)	F (16)	F (17)	0 (18)	0 (19)	QUFA (20-23)	QUFA (24-27)	0 (28-31)	0 (32-35)
V (36)	L (37)	0 (38)	1 (39)	1 (40)	0 (41-44)	0 (45-48)	CØFL (49-52)	QUFA (53-56)
W (57)	L (58)	0 (59)	0 (60)	1 (61)	0 (62-65)	0 (66-69)	0 (70-73)	QUVE (74-77)

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species were recorded in the remaining two height intervals.

At sample point C, a fallen shagbark hickory tree (*Carya ovata*) was present in the first two height intervals. No vegetation was present in the third interval (0.61-6 m), but a red oak tree was present in the fourth interval (canopy).

Please review the remaining sample points shown in the example.

Vegetation Structure Survey for Correlation with Small Mammal Indices

This survey provides data on the vegetational structure of habitats sampled by the small mammal trap lines. It is conducted at the time trap lines are set out. Sample points for each trap line are the center points of each of the 20 trapping stations per trap line (see Field Procedures for Small Mammal Surveys).

Trapping stations are 4 m apart, and distances are paced. Set your pace so that station centers (4 m apart) fall at the tip of your boot. In this way you can determine vegetational structure prior to your tramping around the station.

Vegetational structure at each sample point is determined for four height intervals (0-0.15 m, 0.16-0.60 m, 0.61-6 m, and canopy). Structure is determined by looking vertically above each sample point and recording one of the following codes for the height intervals where vegetation is directly above the sample point.

1 - living vegetation
B - bare soil
L - leaf litter
D - dead herbaceous vegetation
F - fallen dead tree
S - standing dead tree
R - rock, gravel
W - water

If no vegetation is present at a particular height interval, record a zero for that interval.

Let's look at an example of a completed field form (pages 130-131). The form also is used for the quantitative vegetation survey, consequently not all of it is used for the present survey. The identifying information, including observer, date, cluster, and transect and plot, is similar to that

VEGETATION SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, MD 21043

Observer (1-2)	Date (3-8)	Cluster (9-11)	Transect (12)	Plot (13)	Line (14)
35	051577	200	5	5	1

STRUCTURE					SPECIES COMPOSITION			
	0–0.15 m	0.16–0.60 m	0.61–6 m	Canopy	0–0.15 m	0.16–0.60 m	0.61–6 m	Canopy
K (15)	1 (16)	0 (17)	0 (18)	0 (19)	(20-23)	(24-27)	(28-31)	(32-35)
L (36)	B (37)	0 (38)	0 (39)	0 (40)	(41-44)	(45-48)	(49-52)	(53-56)
M (57)	B (58)	0 (59)	0 (60)	0 (61)	(62-65)	(66-69)	(70-73)	(74-77)
N (78)	B (79)	0 (80)	0 (81)	0 (82)	(83-86)	(87-90)	(91-94)	(95-98)
Ø (99)	1 (100)	0 (101)	0 (102)	0 (103)	(104-107)	(108-111)	(112-115)	(116-119)

P (15)	B (16)	0 (17)	0 (18)	0 (19)	(20-23)	(24-27)	(28-31)	(32-35)
Q (36)	B (37)	0 (38)	0 (39)	0 (40)	(41-44)	(45-48)	(49-52)	(53-56)
R (57)	1 (58)	0 (59)	0 (60)	0 (61)	(62-65)	(66-69)	(70-73)	(74-77)
S (78)	B (79)	0 (80)	0 (81)	0 (82)	(83-86)	(87-90)	(91-94)	(95-98)
T (99)	1 (100)	0 (101)	0 (102)	0 (103)	(104-107)	(108-111)	(112-115)	(116-119)

U (15)	(16)	(17)	(18)	(19)	(20-23)	(24-27)	(28-31)	(32-35)
V (36)	(37)	(38)	(39)	(40)	(41-44)	(45-48)	(49-52)	(53-56)
W (57)	(58)	(59)	(60)	(61)	(62-65)	(66-69)	(70-73)	(74-77)

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VEGETATION SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, MD 21043

Observer (1-2)	Date (3-8)	Cluster (9-11)	Transect (12)	Plot (13)	Line (14)
35	051577	200	5	5	1

	STRUCTURE				SPECIES COMPOSITION			
	0-0.15 m	0.16-0.60 m	0.61-6 m	Canopy	0-0.15 m	0.16-0.60 m	0.61-6 m	Canopy
A (15)	1 (16)	0 (17)	0 (18)	0 (19)	(20-23)	(24-27)	(28-31)	(32-35)
B (36)	B (37)	0 (38)	0 (39)	0 (40)	(41-44)	(45-48)	(49-52)	(53-56)
C (57)	1 (58)	0 (59)	0 (60)	0 (61)	(62-65)	(66-69)	(70-73)	(74-77)
D (78)	B (79)	0 (80)	0 (81)	0 (82)	(83-86)	(87-90)	(91-94)	(95-98)
E (99)	B (100)	0 (101)	0 (102)	0 (103)	(104-107)	(108-111)	(112-115)	(116-119)
F (15)	B (16)	0 (17)	0 (18)	0 (19)	(20-23)	(24-27)	(28-31)	(32-35)
G (36)	1 (37)	0 (38)	0 (39)	0 (40)	(41-44)	(45-48)	(49-52)	(53-56)
H (57)	B (58)	0 (59)	0 (60)	0 (61)	(62-65)	(66-69)	(70-73)	(74-77)
I (78)	B (79)	0 (80)	0 (81)	0 (82)	(83-86)	(87-90)	(91-94)	(95-98)
J (99)	B (100)	0 (101)	0 (102)	0 (103)	(104-107)	(108-111)	(112-115)	(116-119)

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described in the instructions for the Quantitative Vegetation Survey, and will not be explained further here. Line (column 14) refers to the number of survey transect lines run per plot (this will always be 1 for this survey). The letters A through W on the left side of the form represent sample points. For this survey, we are concerned only with the first 20 points (these correspond to our 20 sampling stations for small mammals). For each point, four blocks are present for recording information on habitat structure (one block for each of the four height intervals). In our example, living vegetation was present in the 0-0.15-m interval at stations A, C, G, K, Ø, R and T. Bare soil was present in this interval at stations B, D, E, F, H, I, J, L, M, N, P, Q and S. At all other height intervals for all 20 stations, no vegetation was present (thus 0 in all of these).

Amphibian and Reptile Survey

This animal group is perhaps the most difficult one we will survey. Activity of amphibians and reptiles is extremely dependent upon weather conditions - temperature, precipitation, soil moisture, humidity, light intensity, wind, and season are all significant factors. Thus, standardizing data collection for these animals is a difficult task.

Our survey technique for this animal group is an intensive ground search of the subplots used in the pellet survey (page 159), and is conducted simultaneously with that survey throughout April and May.

For this survey, the surface of the ground, rocks, logs, tree trunks, stumps, and other objects are examined within the subplot. All rocks, logs, bark, and other objects lying on the ground are moved in order to inspect the ground surface under them. Loose bark on logs and stumps is removed. Rotten logs and stumps present in the subplot are torn apart. Areas containing loose gravel or rock are raked or dug to a depth of 10-15 cm. Streams or pools of water are examined carefully. Please make an effort to record each individual only once in a subplot.

When possible, animals are identified to species and recorded by four-letter codes on the field form. A list of amphibians and reptiles observed in Phase I, along with associated four-letter codes, is included with this procedure (pages 134-135). This is not a complete list of amphibians and reptiles we will record in Phase II. Please keep a list of additional species (and codes) you encounter, and send a copy of the list to the Center. We will maintain a complete list here (for all areas) and check for duplicate codes.

Let's run through an example of a completed survey (pages 136-137). The identifying information through the plot block (columns 13-14) is the same as that for the pellet survey (page 159). In our example, plot 2 consists of two habitat types. Subplots 1 and 8 are located in the habitat type designated 2A on the field form. No animals were observed in subplot 1 so a zero was recorded on the field form. One red-backed salamander was recorded on subplot 8. Subplots 2 through 7 of plot 2 are located in the habitat type designated 2B on the field form. One red-backed salamander was recorded in subplot 2, 1 eastern box turtle was recorded in subplot 5, 2 red-backed salamanders and 1 eastern garter snake were recorded in subplot 7. No amphibians or reptiles were observed in subplots 3, 4, and 6.

Subplots in plot 3 also crossed two habitat types (coded 3A and 3B on the field form). Subplots 1, 2, 7, and 8 are in the habitat type coded 3A on the field form. No animals were recorded in subplot 1. One eastern garter snake was recorded in subplots 2 and 7. Three species were recorded in subplot 8: one eastern box turtle, one red-backed salamander, and one eastern garter snake. Note that the third species, the garter snake, was recorded on a second form since there is room on a form for only two species within each plot box. As with the other surveys, this presents no problem as long as the correct identifying information is provided at the top of the page. The only observation recorded on the subplots in 3B was five spring peepers in subplot 5.

All subplots in plot 5 were located within a single habitat type coded 5A. Five spring peepers were recorded in subplot 2, one eastern box turtle and two red-backed salamanders in subplot 4, one eastern garter snake in subplot 6, and one red-backed salamander in subplot 8. Subplots 1, 3, 5, and 7 contained no observations, thus zeros were entered for these.

List of amphibians and reptiles recorded in Phase I (Oregon)

Species	Code
AMPHIBIANS	
Frog, Pacific tree (*Hyla regilla*)	PATR
Red-legged (*Rana aurora*)	RLFR
Newt, Rough-skinned (*Taricha granulosa*)	RSNE
Salamander, Clouded (*Aneides ferreus*)	CLSA
Dunns (*Plethodon dunni*)	DUSA
Ensatina (*Ensatina eschscholtzi*)	ENSA
Long-toed (*Ambystoma macrodactylum*)	LTSA
Marys Peak (*Plethodon gordoni*)	MPSA
Northwestern (*Ambystoma gracile*)	NOSA
Olympic (*Rhyacotriton olympicus*)	OLSA
Pacific giant (*Dicamptodon ensatus*)	PGSA
Western red-backed (*Plethodon vehiculum*)	WRSA
REPTILES	
Lizard, Northern alligator (*Gerrhonotus coeruleus*)	NALI
Southern alligator (*Gerrhonotus multicarinatus*)	SALI
Western fence (*Sceloporus occidentalis*)	WFLI
Western skink (*Eumeces skiltonianus*)	WESK
Snake, Northwestern garter (*Thamnophis ordinoides*)	NGSN
Western yellow-bellied racer (*Coluber constrictor*)	WYRA

List of amphibians and reptiles recorded in Phase I (Wisconsin)

Species	Code
AMPHIBIANS	
Frog, Bull (*Rana catesbeiana*)	BUFR
Cricket (*Acris crepitans blanchardi*)	CRFR
Green (*Rana clamitans melanota*)	GRFR
Leopard, Northern (*Rana pipiens pipiens*)	NLFR
Northern Gray Tree (*Hyla versicolor versicolor*)	NGTF
Southern Gray Tree (*Hyla chrysoscelis*)	SGTF
Spring Peeper Tree (*Hyla crucifer crucifer*)	SPTF
Western Chorus (*Pseudacris triseriata triseriata*)	SCFR
Wood (*Rana sylvantica*)	WOFR
Newt, Central (*Notophthalmus viridescens louisianensis*)	CENE
Salamander, Blue-spotted (*Ambystoma laterale*)	BSSA
Red-Backed (*Plethodon cinereus cinereus*)	RBSA
Spotted (*Ambystoma maculatum*)	SPSA
Tiger (*Ambystoma tigrinum tigrinum*)	TISA
REPTILES	
Lizard, Glass (*Ophisaurus attenuatus attenuatus*)	GLLI
Six-lined Racerunner (*Cnemidophorus sexlineatus sexlineatus*)	SLRA
Snake, Black rat (*Elaphe obsoleta obsoleta*)	BRSN
Blue Racer (*Coluber constrictor foxi*)	BLRA
Bull (*Pituophis melanoleucus sayi*)	BUSN
Eastern Garter (*Thamnophis sirtalis sirtalis*)	EGSN
Eastern Milk (*Lampropeltis triangulum triangulum*)	EMSN
Hognose (*Heterodon platyrhinos*)	HOSN
Northern Brown (*Storeria dakayi*)	NBSN
Prairie Garter (*Thamnophis radix radix*)	PGSN
Red-bellied (*Storeria occipitomaculata occipitomaculata*)	RBSN
Smooth Green (*Opheodrys vernalis*)	SGSN
Western Fox (*Elaphe vulpina vulpina*)	WFSN
Turtle, Blandings (*Emydoidea blandingi*)	BLTU
Map (*Graptemys geographica*)	MATU
Midland Painted (*Chrysemys picta marginata*)	MPTU
Ornate (*Terrapene ornata ornata*)	OBTU
Snapping (*Chelydra serpentina serpentina*)	SNTU
Spiny Soft-shell (*Trionyx spiniferus spiniferus*)	SSTU
Western Painted (*Chrysemys picta belli*)	WPTU

AMPHIBIAN AND REPTILE SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, Maryland 21043

Observer (1-2)	Date (3-8)	Cluster (9-11)	Transect (12)
01	051677	100	5

Plot (13-14): 2A

	Species	No.	Species	No.
SUBPLOT 1	(15-18) 0	(19-20)	(21-24)	(25-26)
SUBPLOT 2	(27-30)	(31-32)	(33-36)	(37-38)
SUBPLOT 3	(39-42)	(43-44)	(45-48)	(49-50)
SUBPLOT 4	(51-54)	(55-56)	(57-60)	(61-62)
SUBPLOT 5	(63-66)	(67-68)	(69-72)	(73-74)
SUBPLOT 6	(75-78)	(79-80)	(81-84)	(85-86)
SUBPLOT 7	(87-90)	(91-92)	(93-96)	(97-98)
SUBPLOT 8	(99-102) RBSA	(103-104) 01	(105-108)	(109-110)

Plot (13-14): 2B

	Species	No.	Species	No.
SUBPLOT 1	(15-18)	(19-20)	(21-24)	(25-26)
SUBPLOT 2	(27-30) RBSA	(31-32) 01	(33-36)	(37-38)
SUBPLOT 3	(39-42)	(43-44)	(45-48)	(49-50)
SUBPLOT 4	(51-54)	(55-56)	(57-60)	(61-62)
SUBPLOT 5	(63-66) EBTU	(67-68) 01	(69-72)	(73-74)
SUBPLOT 6	(75-78)	(79-80)	(81-84)	(85-86)
SUBPLOT 7	(87-90) RBSA	(91-92) 02	(93-96) EGSN	(97-98) 01
SUBPLOT 8	(99-102)	(103-104)	(105-108)	(109-110)

Plot (13-14): 3A

	Species	No.	Species	No.
SUBPLOT 1	(15-18) 0	(19-20)	(21-24)	(25-26)
SUBPLOT 2	(27-30) EGSN	(31-32) 01	(33-36)	(37-38)
SUBPLOT 3	(39-42)	(43-44)	(45-48)	(49-50)
SUBPLOT 4	(51-54)	(55-56)	(57-60)	(61-62)
SUBPLOT 5	(63-66)	(67-68)	(69-72)	(73-74)
SUBPLOT 6	(75-78)	(79-80)	(81-84)	(85-86)
SUBPLOT 7	(87-90) EGSN	(91-92) 01	(93-96)	(97-98)
SUBPLOT 8	(99-102) EBTU	(103-104) 01	(105-108) RBSA	(109-110) 01

Plot (13-14): 3B

	Species	No.	Species	No.
SUBPLOT 1	(15-18)	(19-20)	(21-24)	(25-26)
SUBPLOT 2	(27-30)	(31-32)	(33-36)	(37-38)
SUBPLOT 3	(39-42) 0	(43-44)	(45-48)	(49-50)
SUBPLOT 4	(51-54) 0	(55-56)	(57-60)	(61-62)
SUBPLOT 5	(63-66) SPTF	(67-68) 05	(69-72)	(73-74)
SUBPLOT 6	(75-78) 0	(79-80)	(81-84)	(85-86)
SUBPLOT 7	(87-90)	(91-92)	(93-96)	(97-98)
SUBPLOT 8	(99-102)	(103-104)	(105-108)	(109-110)

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AMPHIBIAN AND

REPTILE SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, Maryland 21043

Observer (1-2)	Date (3-8)	Cluster (9-11)	Transect (12)
01	051677	100	5

Plot (13-14): 5A

	Species	No.	Species	No.
SUBPLOT 1	0 (15-18)	(19-20)	(21-24)	(25-26)
SUBPLOT 2	SPTF (27-30)	05 (31-32)	(33-36)	(37-38)
SUBPLOT 3	0 (39-42)	(43-44)	(45-48)	(49-50)
SUBPLOT 4	EBTU (51-54)	01 (55-56)	RBSA (57-60)	02 (61-62)
SUBPLOT 5	0 (63-66)	(67-68)	(69-72)	(73-74)
SUBPLOT 6	EGSN (75-78)	01 (79-80)	(81-84)	(85-86)
SUBPLOT 7	0 (87-90)	(91-92)	(93-96)	(97-98)
SUBPLOT 8	RBSA (99-102)	01 (103-104)	(105-108)	(109-110)

Plot (13-14): 3A

	Species	No.	Species	No.
SUBPLOT 1	(15-18)	(19-20)	(21-24)	(25-26)
SUBPLOT 2	(27-30)	(31-32)	(33-36)	(37-38)
SUBPLOT 3	(39-42)	(43-44)	(45-48)	(49-50)
SUBPLOT 4	(51-54)	(55-56)	(57-60)	(61-62)
SUBPLOT 5	(63-66)	(67-68)	(69-72)	(73-74)
SUBPLOT 6	(75-78)	(79-80)	(81-84)	(85-86)
SUBPLOT 7	(87-90)	(91-92)	(93-96)	(97-98)
SUBPLOT 8	EGSN (99-102)	01 (103-104)	(105-108)	(109-110)

Plot (13-14):

	Species	No.	Species	No.
SUBPLOT 1	(15-18)	(19-20)	(21-24)	(25-26)
SUBPLOT 2	(27-30)	(31-32)	(33-36)	(37-38)
SUBPLOT 3	(39-42)	(43-44)	(45-48)	(49-50)
SUBPLOT 4	(51-54)	(55-56)	(57-60)	(61-62)
SUBPLOT 5	(63-66)	(67-68)	(69-72)	(73-74)
SUBPLOT 6	(75-78)	(79-80)	(81-84)	(85-86)
SUBPLOT 7	(87-90)	(91-92)	(93-96)	(97-98)
SUBPLOT 8	(99-102)	(103-104)	(105-108)	(109-110)

Plot (13-14):

	Species	No.	Species	No.
SUBPLOT 1	(15-18)	(19-20)	(21-24)	(25-26)
SUBPLOT 2	(27-30)	(31-32)	(33-36)	(37-38)
SUBPLOT 3	(39-42)	(43-44)	(45-48)	(49-50)
SUBPLOT 4	(51-54)	(55-56)	(57-60)	(61-62)
SUBPLOT 5	(63-66)	(67-68)	(69-72)	(73-74)
SUBPLOT 6	(75-78)	(79-80)	(81-84)	(85-86)
SUBPLOT 7	(87-90)	(91-92)	(93-96)	(97-98)
SUBPLOT 8	(99-102)	(103-104)	(105-108)	(109-110)

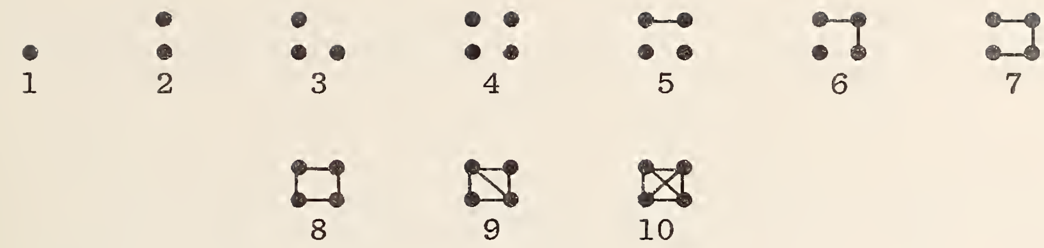
Bird Survey

Bird surveys are conducted during two periods of the year - a wintering bird survey during January and February, and a breeding bird survey during the month of June. The exact dates for each will be scheduled later.

Let's discuss the bird field form (pages 145-148). The identifying information at the top of the form was discussed earlier (page 110), so will not be considered here. Plots are described by a two-digit code that must match the plot codes used for cover mapping, so obtain plot numbers from the cover maps. Habitat description is allocated six columns (19 through 24). This code also is taken from the cover map as is the percentage of the plot consisting of that habitat (columns 25 through 27 on the form).

Species observed (bird or other animal) are recorded by major habitat type within a plot. Most plots will be of a single habitat type; however, some will be composed of two or maybe more major types. Again, you will have cover maps of each plot prior to conducting your bird survey, and habitat types within a plot will be designated on the cover map. During your survey, be sure to include all habitat types marked on the cover map. Each habitat type will be marked by a two-digit code. For example, let's assume there are two major types in Plot 6 (the farthest plot from the road). One of these types would be marked 6A and the other would be marked 6B on the cover map. Thus, on the bird field form, two plots would be coded - one plot coded 6A and one plot coded 6B. This should be done for all plots in a cluster prior to going to the field. By entering this information on the bird field form prior to going to the field, you are less likely to overlook habitat types. Species observed in a habitat type within a plot are recorded in the blocks under SPECIES. Seven species can be recorded per plot (or habitat type) under this system. However, if more than seven species are observed per plot (and this will happen occasionally) simply go to a new form and enter the same plot number (<u>be sure to add the correct identifying information at the top of the field form, too - this can be done following the plot count</u>). Thus, another seven species may be recorded (for the same plot).

Birds (and other animals) detected are recorded as seen or heard. The dot and line system is convenient for recording observations and is shown below:



This method of recording observations is recommended for use. There are seven blocks for each of the SEEN and HEARD categories to match the seven blocks for species. When a bird is detected, the appropriate four-letter code (from Klimkiewicz, M.K. and C.S. Robbins. 1978. Standard abbreviations for common names of birds. North American Bird Bander 3(1):16-25) is entered in the first block under SPECIES. Then a dot is entered in the adjacent SEEN or HEARD block (whichever is appropriate). If the bird is heard, but never seen, record in the HEARD block. If the bird is heard first and then later seen, record in the SEEN block only (if previously recorded in the HEARD block, then erase that mark). We want to total the birds in the SEEN and HEARD blocks (by computer) to get total birds (by species) detected per plot or habitat type within a plot. Only make estimates of birds present where a flock is too large to count individuals. Do not attempt to estimate birds present on a plot that were neither seen nor heard. If no bird (or other animal) is detected on a plot (or in a particular habitat type if more than one habitat type is present per plot) then enter a 0 in either the SEEN or HEARD block. If this is not done, plots of this sort (containing no wildlife observations) will be treated as missing values and will not be included in the analysis. We do not want this to happen. Plots that are surveyed, but contain no observations, must be included in the analysis, so please remember the above rule. The small square blocks under the SEEN and HEARD columns are for recording the total number of birds (or other animal) of a particular species in that plot. Keep totals separate for SEEN and HEARD observations. This total number (be sure to put a number in this block) should be entered after the survey is completed so as not to interfere with your ability to conduct the survey. It is a simple tally of your dots and lines. For example, if four cardinals were seen in a plot and no other cardinals were heard, then total up your four dots and enter the number four in the small square block under the SEEN column. It is not necessary to enter 0 in the HEARD block. The only time it is necessary to enter a 0 in a SEEN or HEARD block is under the case mentioned above when no bird or other species is recorded per plot or habitat type. In this case, enter a 0 in the small square block under either the SEEN or HEARD column. The seven blocks for AOU numbers also correspond to the seven blocks for species. AOU numbers pertain only to birds and these numbers are entered in the evening (or other time) following the survey. Do not attempt to enter them during the survey. AOU numbers are contained in the reference cited above.

Prior to going to the field to begin a survey, the following information should be entered on the field form: observer, date, time (can be added when you begin survey), cluster, transect, plot (enter all those shown on the cover maps ; in this way, you will be less likely to miss a particular habitat type when you are in the field), habitat (obtained from the cover maps), and percent (obtained from the cover maps).

At least three forms will be needed per transect, but you should carry at least four forms per transect with you (20 total per cluster). You do not want to run short of forms when you are away from your car.

You are now ready to begin your field survey. Park your car at least 100 m from the center of Plot 1 or 2 (whichever is nearest) of the transect to be surveyed, and walk to the Plot 2 center line on the opposite side of the road from Plot 2. If you are working on an interstate site, walk in the median to the center line of Plot 2. When you are directly across the road from the Plot 2 center line, cross the road and begin your survey in Plot 2. You should walk slowly through the center of Plot 2 (stopping frequently to record data or just to look and listen) and count all birds (and other animals seen and/or heard out to 40 m on either side of the center line. Birds flying overhead are not counted unless you judge that they are entering or leaving the plot during the survey period. Count only those birds (and other animals) that are detected within the particular plot you are surveying. There is one exception to this rule. If you judge that a bird (or other animal) is flushed (because of your presence) from the next plot you are to survey, record this observation under the appropriate plot (the plot the bird flushed from). Gauge your speed such that exactly 5 minutes are spent in each 80- x 80-m plot.

When you finish your survey in Plot 2, continue with Plots 3 through 6. After your count in Plot 6, remain stationary (at the end of Plot 6) and conduct a "Standard North American Breeding Bird Survey" (not conducted during winter surveys) as described below. Use the same field form as utilized for the transect surveys. The plot code for the "Standardized North American Breeding Bird Survey", conducted at the Plot 6 location, is 63. An easy way to remember this number is to let the 6 represent Plot 6 (the last plot surveyed) and let the 3 represent the 3-minute "Standard North American Breeding

Bird Survey". Again, you may use as many field forms as you need. Just remember to use the correct plot code and fill in all identifying information at the top of the field form. For the "Standard North American Breeding Bird Survey", remain stationary for exactly 3 minutes, record the number of birds of each species seen within a 0.4-km radius in all directions, and all birds of each species heard regardless of distance. Count individuals of all species seen or heard that can be identified. Any bird known to be a non-breeder (late migrant, injured bird, or summer vagrant) should be included, but noted as such on the back of the field form. Estimates are permissible only in those cases where a flock is too large to count, bird by bird, in the brief time it is seen. Do not use check marks even for abundant species. No one will detect all birds within hearing or seeing distance of his observation points. Observers should not try to estimate birds that are missed or include them on their report forms, even if they are known to be present (but not seen or heard). We wish to have reported only those birds actually seen or heard during the prescribed 3-minute time period. Remember, for this survey, birds flying are recorded regardless of their origin or destination.

To be comparable, counts must be run under satisfactory weather conditions: good visibility, little or no precipitation, light winds. Occasional light drizzle, or a very brief shower may not affect bird activity; but, fog, steady drizzle, or prolonged rain should be avoided. Except in those prairie states where winds normally exceed Beaufort 3, counts preferably should be made when the wind is less than 12 km per hour and not taken if the wind exceeds 19 km per hour. These conditions apply to all bird surveys. The first six categories of Beaufort's scale are listed below (kilometres per hour were converted from miles per hour):

Beaufort number	Name	Kilometres/Hour	Description
0	Calm	2	Calm; smoke rises vertically.
1	Light	2-5	Direction of wind shown by smoke but not by wind vanes.
2	Light	6-11	Wind felt by face; leaves rustle; ordinary vane moved by wind.
3	Gentle	12-19	Leaves and small twigs in constant motion; wind extends light flag.

4	Moderate	20-29	Raises dust and loose paper; small branches are moved.
5	Fresh	30-39	Small trees in leaf begin to sway; crested wavelets form on inland waters.

If you feel weather conditions are marginal, go ahead and conduct the survey rather than postpone it.

Survey Plot 1 in the opposite direction from which you surveyed Plots 2 through 6. To do this, walk back the transect you just traversed through Plots 6, 5, 4, and 3 until you can locate the transect flag for Plot 1. Move diagonally to that point and begin your survey of Plot 1 back to the road. After completion of your survey in Plot 1, move to the beginning point of the Plot 2 survey (edge of county road or edge of berm for interstate) and make a "Standard North American Breeding Bird Survey" (not conducted during winter surveys). Remember, the plot code for this survey conducted at the end of Plot 6 was 63. The code for this survey conducted at the beginning of Plot 2 is 23 (2 representing Plot 2 and three representing the 3-minute survey). We are conducting this "Standard North American Breeding Bird Survey" at these two locations to determine if the road (or highway) has any effect on the results obtained from the survey. If you feel traffic noise is hindering your ability to detect birds on any of the surveys, indicate this on the back of the field form.

Begin surveys 15 minutes before local sunrise and complete one cluster (this should take approximately 4½ hours).

During the plot surveys (not during the 3-minute North American Breeding Bird Surveys) also count deer, squirrels, chipmunks, turtles, rabbits, woodchucks, etc.) seen or heard on the plots. Record these as discussed above.

Let's run through an example of a completed survey (pages 145-148) for a single transect, and see how data are entered on the field form.

Observer - The individual conducting the survey in the example was given the code 01.
Date - The survey was conducted on June 9, 1977.
Time - The survey was begun at 6:30 A.M.
Cluster - Cluster number was 100.
Transect - Transect number was 5.
Plot - As with the above information (except for time),

plot codes were entered on the forms prior to going to the field, and they were entered in the order the survey would be run, starting with Plot 2 and continuing through Plot 6, picking up Plot 1 on the return trip to the road.

Plot 2 was divided into two habitat types (2A and 2B). Remember, the habitat type information is obtained from the cover maps. The code 2A refers to roadside habitat, and 2B refers to deciduous forest (see the habitat descriptions on pages 115-124). The respective proportions of each habitat type in Plot 2 are 20% and 80%. No observations were recorded in the roadside habitat (2A), so a zero was entered in the first block under SEEN. In 2B, two bird species were seen, a red-eyed vireo and a cardinal. A total of four vireos were seen and an additional two were heard. The four-digit AOU numbers are entered following completion of the survey.

A total of seven red-eyed vireos were detected in Plot 3.

In Plot 4, a total of five rufous-sided towhees were detected. Note that the alphabetical "Oh" in RSTØ contains a slash mark.

Plot 5 contains two habitat types, deciduous forest and coniferous forest, each comprising 50% of the plot.

Seven species were recorded under the initial 5A block, so the observer simply went to a blank block and continued recording species. In this example, one additional species, an ovenbird, was picked up. Note that the appropriate identifying information for that plot (in this case habitat type) was recorded correctly. No observations were recorded in 5B or 6A.

Following the 5-minute survey in Plot 6, the observer conducted a 3-minute "Standard North American Breeding Bird Survey". For this survey, the code 63 was entered in a blank plot block and species detected were recorded in the same fashion as before. Note that a total of eight species were detected.

Following the 3-minute "North American Breeding Bird Survey", the observer surveyed Plot 1. Again, note the two habitat types of Plot 1.

Following the survey in Plot 1, the observer conducted a 3-minute "Standard North American Breeding Bird Survey" at the beginning of the Plot 2 transect. Note that this survey was coded as 23.

Edit forms for correctness.

Reread these procedures often. Become completely familiar with them.

BIRD SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, MD 21043

Observer (1-2)	Date (3-8)	Time (9-12)	Cluster (13-15)	Transect (16)
01	060977	0630	100	5

Plot (17-18)	Habitat (19-24)	Percent (25-27)
2A	11AB00	020

SPECIES	SEEN	HEARD	AOU
(28-31)	(32-34) 0	(35-37)	(38-41)
(42-45)	(46-48)	(49-51)	(52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

Plot (17-18)	Habitat (19-24)	Percent (25-27)
2B	05AA01	080

SPECIES	SEEN	HEARD	AOU
REVI (28-31)	4 (32-34)	2 (35-37)	6240 (38-41)
CARD (42-45)	2 (46-48)	1 (49-51)	5930 (52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

Plot (17-18)	Habitat (19-24)	Percent (25-27)
3A	05AA00	100

SPECIES	SEEN	HEARD	AOU
REVI (28-31)	2 (32-34)	5 (35-37)	6240 (38-41)
(42-45)	(46-48)	(49-51)	(52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

Plot (17-18)	Habitat (19-24)	Percent (25-27)
4A	05AA00	100

SPECIES	SEEN	HEARD	AOU
RSTO (28-31)	2 (32-34)	3 (35-37)	5870 (38-41)
(42-45)	(46-48)	(49-51)	(52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

BIRD SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, MD 21043

Observer (1-2)	Date (3-8)	Time (9-12)	Cluster (13-15)	Transect (16)
01	060977	0630	100	5

Plot (17-18)	Habitat (19-24)	Percent (25-27)	
5A	05AA00	050	
SPECIES	**SEEN**	**HEARD**	**AOU**
REVI (28-31)	•• 2 (32-34)	• 1 (35-37)	6240 (38-41)
RSTO (42-45)	• 1 (46-48)	•• 2 (49-51)	5870 (52-55)
CARD (56-59)	• 1 (60-62)	••• 3 (63-65)	5930 (66-69)
INBO (70-73)	• 1 (74-76)	•• 2 (77-79)	5980 (80-83)
YSFL (84-87)	• 1 (88-90)	(91-93)	4120 (94-97)
RUGR (98-101)	• 1 (102-104)	(105-107)	3000 (108-111)
BLJA (112-115)	•• 2 (116-118)	• 1 (119-121)	4770 (122-125)

Plot (17-18)	Habitat (19-24)	Percent (25-27)	
5B	06CA00	050	
SPECIES	**SEEN**	**HEARD**	**AOU**
(28-31)	0 (32-34)	(35-37)	(38-41)
(42-45)	(46-48)	(49-51)	(52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

Plot (17-18)	Habitat (19-24)	Percent (25-27)	
6A	06CA00	100	
SPECIES	**SEEN**	**HEARD**	**AOU**
(28-31)	0 (32-34)	(35-37)	(38-41)
(42-45)	(46-48)	(49-51)	(52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

Plot (17-18)	Habitat (19-24)	Percent (25-27)	
63			
SPECIES	**SEEN**	**HEARD**	**AOU**
REVI (28-31)	(32-34)	• 1 (35-37)	6240 (38-41)
MODO (42-45)	(46-48)	•• 2 (49-51)	3160 (52-55)
BLJA (56-59)	(60-62)	••• 3 (63-65)	4770 (66-69)
YSFL (70-73)	(74-76)	•• 2 (77-79)	4120 (80-83)
INBU (84-87)	(88-90)	• 1 (91-93)	5980 (94-97)
CARD (98-101)	(102-104)	•• 2 (105-107)	5930 (108-111)
RSTO (112-115)	(116-118)	• 1 (119-121)	5870 (122-125)

DOT/FHWA 11/77

BIRD SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, MD 21043

Observer (1-2)	Date (3-8)	Time (9-12)	Cluster (13-15)	Transect (16)
01	060977	0630	100	5

Plot (17-18): 1B | Habitat (19-24): 05AA01 | Percent (25-27): 080

SPECIES	SEEN	HEARD	AOU
REVI (28-31)	(32-34)	• 1 (35-37)	6240 (38-41)
(42-45)	(46-48)	(49-51)	(52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

Plot (17-18): 1A | Habitat (19-24): 11AB00 | Percent (25-27): 020

SPECIES	SEEN	HEARD	AOU
(28-31)	0 (32-34)	(35-37)	(38-41)
(42-45)	(46-48)	(49-51)	(52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

Plot (17-18): 5A | Habitat (19-24): 05AA00 | Percent (25-27): 050

SPECIES	SEEN	HEARD	AOU
ØVEN (28-31)	(32-34)	• 1 (35-37)	6740 (38-41)
(42-45)	(46-48)	(49-51)	(52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

Plot (17-18): 63 | Habitat (19-24): | Percent (25-27):

SPECIES	SEEN	HEARD	AOU
CØCR (28-31)	(32-34)	•• 2 (35-37)	4880 (38-41)
(42-45)	(46-48)	(49-51)	(52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

DOT/FHWA 11/77

BIRD SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, MD 21043

Observer (1-2)	Date (3-8)	Time (9-12)	Cluster (13-15)	Transect (16)
01	060977	0630	100	5

Plot (17-18)	Habitat (19-24)	Percent (25-27)
23		

SPECIES	SEEN	HEARD	AOU
COCR (28-31)	1 (32-34)	2 (35-37)	4880 (38-41)
OVEN (42-45)	(46-48)	2 (49-51)	6740 (52-55)
REVI (56-59)	1 (60-62)	1 (63-65)	6240 (66-69)
CARD (70-73)	1 (74-76)	2 (77-79)	5930 (80-83)
RSTO (84-87)	1 (88-90)	1 (91-93)	5870 (94-97)
INBO (98-101)	(102-104)	2 (105-107)	5980 (108-111)
(112-115)	(116-118)	(119-121)	(122-125)

Plot (17-18)	Habitat (19-24)	Percent (25-27)

SPECIES	SEEN	HEARD	AOU
(28-31)	(32-34)	(35-37)	(38-41)
(42-45)	(46-48)	(49-51)	(52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

Plot (17-18)	Habitat (19-24)	Percent (25-27)

SPECIES	SEEN	HEARD	AOU
(28-31)	(32-34)	(35-37)	(38-41)
(42-45)	(46-48)	(49-51)	(52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

Plot (17-18)	Habitat (19-24)	Percent (25-27)

SPECIES	SEEN	HEARD	AOU
(28-31)	(32-34)	(35-37)	(38-41)
(42-45)	(46-48)	(49-51)	(52-55)
(56-59)	(60-62)	(63-65)	(66-69)
(70-73)	(74-76)	(77-79)	(80-83)
(84-87)	(88-90)	(91-93)	(94-97)
(98-101)	(102-104)	(105-107)	(108-111)
(112-115)	(116-118)	(119-121)	(122-125)

Small Mammal Survey

Small mammals (members of the Orders Insectivora and Rodentia up to the size of the gray squirrel) are surveyed from approximately the first of March through May by a standardized snap-trapping technique. Exact dates for trapping will be scheduled later.

Small mammals are surveyed on three of the five transects per cluster site and three of the six plots per transect. Plots 2 and 3 are always sampled, and either plot 5 or plot 6, depending upon which is more similar in habitat to plot 3. If plot 5 is more similar to plot 3 than is plot 6, then choose plot 5. If plot 6 is more similar to plot 3 than is plot 5, then choose plot 6. You have the responsibility of selecting three transects out of the total of five per cluster for sampling small mammals. Select transects that will yield the best homogeneity of habitat between plots 3 and plots 5 or 6. Trap lines in plots 3, 5, and 6 are oriented perpendicularly to the road, and are placed through the centers of the plots. Actually, the trap lines should be placed 1-2 m to either the right or left of the plot center lines since trails may be developed through plot centers as a result of laying out the transects, cover mapping, and conducting winter bird surveys. Trap lines in plot 2 are parallel to the road and are centered in the roadside right-of-way habitat. For those county roads with a roadside right-of-way habitat less than 2 m wide, maintain the plot 2 trap line 1 m from the road edge. Conduct one trapping period (3 days and 3 nights) per cluster, and survey both the interstate site and associated county road site during the same trapping period.

A standardized trap line is employed which consists of 20 mouse snap-traps and four rat snap-traps per 80-m trap line. The line consists of one mouse trap per station, with stations spaced at 4-m intervals. One rat trap is placed at every fifth station, beginning at station three. Thus, rat traps are placed at stations 3, 8, 13, and 18. All traps must be located within the plot being surveyed (traps must not be on plot edges). Therefore, the first station in a trap line is located 2 m from one edge of the plot to be surveyed. With stations spaced at 4-m intervals, the last station in the trap line will be located 2 m from the opposite plot edge.

Traps are placed within a 1-m radius of the station, with the actual location representing the "best" or "most likely" spot for capturing small mammals (at base of tree, near logs, near holes, near rocks, in runways through vegetation). Where possible, place traps under some convenient object to protect them from the rain that might release the triggers. Traps should be placed perpendicularly to the expected direction of the travel of small mammals. At stations containing both mouse and rat traps, place the mouse trap first, and then place the rat trap no closer than 0.5 m to the mouse trap. Traps are baited with peanut butter, and new bait must be added if bait is removed during a trapping period. A squeeze tube (the type used by backpackers for carrying food) works well for dispensing bait onto the traps. Also, a small bag (approximately 25 x 25 x 8 cm) with a shoulder strap works well for carrying traps. When you are ready to set out a trap line, it is a good idea to place only 22 mouse traps and 6 rat traps in this bag. By doing this, you do not need to keep track of the number of traps you set (except that at every fifth station a rat trap is set). When you set all but the last 2 mouse and 2 rat traps in your shoulder bag, you know the line is completed. Also, the extra traps can be used as replacements for broken traps. When you are setting out lines in plots 3, 5, or 6, you will want to carry enough traps for two lines. These should be carried in a sack separate from that used to set the actual line. If a trap line crosses more than one habitat type within a plot, then on your return trip back to the road you should determine the number of traps per habitat type for each trap line (this is recorded on the field form).

Traps are checked once a day, first thing in the morning. A couple of extra traps should be carried along when traps are checked as replacements for missing or broken traps. All small mammals captured per plot or habitat type within a plot (see explanation below for entering data on the field form) are placed in a plastic bag and the bag numbered as to cluster, transect, plot (habitat type within plot if more than one type is present), and dated. A small card or tag with this information written in pencil or permanent ink can be placed within the bag. Plot or habitat bags should be placed into transect bags and transect bags should be placed into cluster bags. Bags should be stored in an iced styrofoam container in the field. In the evening, the following data are recorded for each animal: species, sex, age (immature, sub-adult, adult), weight (in grams), total length (including tail), length of tail, length of hind foot, length of ear. Following the collection of this information, animals should be returned to the appropriate plastic bags and frozen.

Let's review the field form at this point (page 153). The identifying information at the top of the form was discussed earlier (page 126), so will not be addressed here. Plots are described by a two-digit code that must match the plot codes used for cover mapping, so obtain plot numbers from the cover maps. Traps sprung (columns 16-17 for day 1, columns 18-19 for day 2, and columns 20-21 for day 3) refer to those traps that are sprung, but contain no small mammals. If a trap is missing, record it as a sprung trap. In the block under "No. of Traps" enter the number of traps present in the plot (if the trap line goes through a single habitat type) or the number of traps in that particular habitat type if the trap line goes through more than one habitat type.

Species captured are recorded by major habitat type within a plot. Most plots will be of a single habitat type; however, some will be composed of two or maybe more major types. Again, you will have a cover map of each plot prior to conducting your small mammal survey, and habitat types within a plot will be designated on the cover map. Make certain you record all habitat types a trap line crosses within a plot. Each habitat type will be marked by a two-digit code. For example, let's assume there are two major types in plot 6 (the farthest plot from the road). One of these types would be marked 6A and the other would be marked 6B on the cover map. Thus, on the small mammal field form, two plots would be coded - one plot coded 6A and one plot coded 6B. This should be done for all plots to be sampled in a cluster prior to going to the field. By entering this information on the field form prior to going to the field, you are less likely to overlook habitat types. Species trapped in a habitat type within a plot are recorded in the blocks under "Species". Seven species can be recorded per plot (or habitat type) under this system. However, if more than seven species are captured per plot, simply go to a new form and enter the same plot number (be sure to add the correct identifying information at the top of the field form, too - this can be done following the plot count). Thus, another seven species may be recorded (for the same plot or habitat type within plot).

If no small mammal is captured per plot (or in a particular habitat type if more than one habitat type is present per plot) during the 3-day and 3-night trapping period, then enter a zero in the first block under either day 1, day 2, or day 3. If this is not done, plots of this sort (containing no captures) will be treated as missing values and will not be included in the analysis. We do not want this to happen. Plots that are surveyed, but contain no observations, must be included in the analysis, so please remember the above rule. Four-letter codes, following the format of bird codes (page 138), are used to describe small mammal species. These codes are entered in the blocks under "Species" on the field form for those mammals caught (one code per block). The total number of individuals captured per species is recorded for day 1, day 2, and day 3 of the trapping period.

Small mammal surveys should be halted only for extremely bad weather conditions. Do not set trap lines during heavy rains, or when extremely muddy conditions prevail. However, light showers should not be avoided, and snow should not present a problem for these surveys. Keep notes on the general weather conditions during sample periods. These should be recorded on the back of the field survey form.

Let's run through an example of a completed survey (page 153), for a single transect, and see how data are entered on the field form.

- Observer - The individual conducting the survey in the example was given the code 01.
- Date - The survey started on May 15, 1977.
- Cluster - Cluster number was 100.
- Transect - Transect number was 5.
- Plot - Plot 2A was the roadside right-of-way habitat. Five meadow voles were captured the first day and two additional traps were sprung. On day 2, three meadow voles were captured and one additional trap was sprung. On day 3, three meadow voles were captured and no additional traps were sprung. The total number of traps was 24. Plot 3 consisted of two habitat types (coded 3A and 3B). Remember, the habitat type information is obtained from the cover maps. One half of the traps (12) in the trap line were present in each habitat type. No captures were obtained in the habitat type coded 3A, so a zero was entered under the first block under day 1. No traps were sprung on day 1, but one each was sprung on day 2 and day 3. Two species were captured in the habitat type coded 3B. Four, two, and one deer mice were captured on days 1, 2, and 3 respectively. Also, two, two, and one eastern chipmunk were captured on days 1, 2, and 3 respectively. Again, note the number of sprung traps. Plot 5 consisted of one habitat type (coded 5A), and all 24 traps were placed in that type. Two species of small mammals were captured, the deer mouse and the eastern harvest mouse. Note the numbers of each that were captured as well as the additional sprung traps (with no captures).

SMALL MAMMAL SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, MD 21043

Observer (1-2)	Date (3-8)	Cluster (9-11)	Transect (12-13)
01	051577	100	05

Plot (14-15)	Traps Sprung (16-17)	(18-19)	(20-21)	No. of Traps (22-23)
2A	02	01	00	24

Species	Total Day 1	Day 2	Day 3
MEVØ (24-27)	05 (28-29)	03 (30-31)	03 (32-33)
(34-37)	(38-39)	(40-41)	(42-43)
(44-47)	(48-49)	(50-51)	(52-53)
(54-57)	(58-59)	(60-61)	(62-63)
(64-67)	(68-69)	(70-71)	(72-73)
(74-77)	(78-79)	(80-81)	(82-83)
(84-87)	(88-89)	(90-91)	(92-93)

Plot (14-15)	Traps Sprung (16-17)	(18-19)	(20-21)	No. of Traps (22-23)
3A	00	01	01	12

Species	Total Day 1	Day 2	Day 3
(24-27)	0 (28-29)	(30-31)	(32-33)
(34-37)	(38-39)	(40-41)	(42-43)
(44-47)	(48-49)	(50-51)	(52-53)
(54-57)	(58-59)	(60-61)	(62-63)
(64-67)	(68-69)	(70-71)	(72-73)
(74-77)	(78-79)	(80-81)	(82-83)
(84-87)	(88-89)	(90-91)	(92-93)

Plot (14-15)	Traps Sprung (16-17)	(18-19)	(20-21)	No. of Traps (22-23)
3B	01	00	02	12

Species	Total Day 1	Day 2	Day 3
DEMØ (24-27)	04 (28-29)	02 (30-31)	01 (32-33)
EACH (34-37)	02 (38-39)	02 (40-41)	01 (42-43)
(44-47)	(48-49)	(50-51)	(52-53)
(54-57)	(58-59)	(60-61)	(62-63)
(64-67)	(68-69)	(70-71)	(72-73)
(74-77)	(78-79)	(80-81)	(82-83)
(84-87)	(88-89)	(90-91)	(92-93)

Plot (14-15)	Traps Sprung (16-17)	(18-19)	(20-21)	No. of Traps (22-23)
5A	02	01	01	24

Species	Total Day 1	Day 2	Day 3
DEMØ (24-27)	05 (28-29)	04 (30-31)	02 (32-33)
EHMØ (34-37)	03 (38-39)	02 (40-41)	02 (42-43)
(44-47)	(48-49)	(50-51)	(52-53)
(54-57)	(58-59)	(60-61)	(62-63)
(64-67)	(68-69)	(70-71)	(72-73)
(74-77)	(78-79)	(80-81)	(82-83)
(84-87)	(88-89)	(90-91)	(92-93)

DOT/FHWA 1/78

Terrestrial Furbearer Survey

This survey is conducted in conjunction with the small mammal survey (page 149), and is conducted on the same three transects per cluster as is that survey. Scent stations are set up in pairs on selected transects. The near-road station is set up in plot 1 in the following manner. The station is centered in the roadside habitat where practical, and is placed 20 m to the left or right (flip coin for each station) of the center transect line, which is perpendicular to the road. For those county roads with a roadside right-of-way habitat less than 3 m wide, maintain scent station centers 1.5 m from the road edge.

Ideally, the control station away from the road is set up in plot 6. In this plot the station is placed 20 m to the left or right (flip coin) of the center transect line, measured from the plot center. We will have difficulty establishing control stations at some sites, particularly in certain agricultural areas planted to small grain, hay, pasture, etc. Do not damage agricultural crops in order to set up scent stations, but rather than omit stations completely in these areas, follow the steps below in selecting site locations. These are listed on a priority basis from highest to lowest.

1 - Place scent station in plot 5 rather than plot 6, following the same guidelines as outlined above for plot 6.

2 - Return to the original plot 6 location and move laterally (parallel to road) in the direction offering the shortest distance to a suitable site without crossing another transect (you may leave plot 6, however). Do not construct a station closer than 100 m to another station. This procedure may get you to the end of a field, where a station can be constructed.

3 - Return to plot 5 and follow the guidelines outlined in "2" above.

4 - Move to one of the two remaining transects in the cluster (the nearest one to you) and start the selection process from the beginning.

Scent stations are similar in design to those used by the U.S. Fish and Wildlife Service in several western states for the western predator survey (Roughton, R.D. 1976. Indices of predator abundance in the western United States. Progress Report, U.S. Department of the Interior, Fish and Wildlife Service, Denver Wildlife Research Center, Denver, Colorado). Each station consists of a circle of sifted soil 91.4 cm in diameter, in the center of which is placed a plastic capsule containing a scent attractant. The attractant has been premixed and should remain tightly sealed in the plastic bag and glass jar (stored in a cool, dry place) until you are ready to fill the capsules.

The capsules (5 mm x 2.54 cm, round) are filled in the following way. Place a 2.54-cm diameter, round, gummed label inside the bottom of each capsule to prevent leakage of the attractant. Completely fill the capsule with attractant. Do not pack the attractant, rather fill the capsule loosely. Place a piece of clear plastic tape over the holes in the lid of the filled capsule (to prevent leakage) until it is placed in the field. Store capsules in a tight container and keep cool. When possible, fill all capsules (maximum of 12 per two clusters) and place tape over lids the day before you set them out. Do not fill the capsules with the attractant more than 2 days prior to field use.

The soil at each station must be suitable for track impressions. Therefore, an initial step in most cases will be to use a shovel or hoe to "scalp" off or remove grass, or other vegetation from the site prior to further site preparation. It may be necessary to import soil if that present at the site is unsuitable. Soil must be fine-textured and must be sifted through a 0.32-cm (1/8 inch) mesh screen. A wooden frame 40 cm x 60 cm with 0.32-cm hardware cloth (wire) works well as a sifter. Where fine, dry dust is available, a piece of window screen cut to fit inside the frame of the sifter and supported by the hardware cloth will sift ideal powder-dust for reading tracks. Cover the station site with approximately 0.7 cm of the sifted earth. A 91.4-cm diameter circle made of garden hose or stiff wire is useful for making a proper-sized station.

After sifting the required amount of earth, insert a 2- x 2- x 15-cm sharpened stake into the ground in the center of the circle. Leave the top 1.3 cm of the stake above the ground surface. This will help to prevent clogging of the capsule holes in the event of windy conditions. Tack the capsule to the top of the wood stake with a 2.54-cm brad.

At this point, make a light boot imprint at the circle boundary. This will be the key as to whether a station was operative or inoperative the previous night. If the boot imprint remains visible, assume the station to be operative, even if the capsule is missing, because (1) animals may be attracted even with the capsule gone because of lingering scent or just the presence of a disturbed site, and (2) tracks present may have been made before the capsule was carried off or chewed up at the station. In some cases (such as after a rain or wind) you may barely be able to identify a track. In such cases, record the species and assume the station to be operable. If an unidentifiable track is present at an otherwise washed out, blown out, run over, or trampled station, record the station as inoperable and do not record the track. Never record a visit to a station considered inoperable. If a station is inoperable, rake the soil in the circle, replace the capsule, and place another boot imprint at the boundary.

Check stations daily, in the morning hours, in conjunction with checking the small mammal trap lines. Replace, daily, any capsules that have been carried off by animals, destroyed otherwise, or clogged with dirt.

Ideally, this survey is continued for 3 operative days and nights. However, because it is coordinated with other mammal surveys at a particular cluster site, fewer than 3 operative days and nights may be accumulated. If the small mammal survey and the deer, elk, rabbit, hare pellet survey are completed at a site, then the terrestrial furbearer survey should be terminated.

Whenever possible, record the species of animal that visited a station. Small mammals should not be recorded in this survey. Also, generally, birds should not be recorded. However, those of special interest (eagles, for example) that can be recorded to species from tracks should be recorded. Regardless of the number and/or size of tracks of a single species at a station on any one day, record them as one (single) visit. Record only tracks located inside the 91.4-cm circle. Some animals may come close to the station, without entering the circle. Do not record these. After data have been recorded on the field form for a particular day, obliterate any tracks present by lightly raking and/or brushing the dirt within the circle. A whisk broom or foxtail brush works well for this purpose. Remember to always leave a boot print for determining the operational status of the station. If no animal tracks are present at a station, the capsule and boot impression are intact, and the dirt is loose (suitable for track impressions), raking and/or brushing of the station is not necessary. If stations are operative, but no tracks are recorded for a particular day, enter 0 for that day beside the first species block on the field form.

Let's run through an example to illustrate how data are recorded on the field form (page 158). The form used for this survey is very similar to the one used for the small mammal survey, therefore, much of the detailed description of that form also applies here, but is not repeated. Refamiliarize yourself with the small mammal survey form description, if necessary, before continuing further here.

The attached field form for this example shows complete data for two scent stations on one transect. In plot 1A (the roadside habitat), a gray fox visit was recorded for day 1, a raccoon visit was recorded on days 1, 2, and 3, and an opossum visit was recorded for days 2 and 3. In plot 6A, an opossum visit was recorded for days 1 and 2, and a raccoon visit was recorded on day 2.

TERRESTRIAL FURBEARER SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, MD 21043

Observer (1-2)	Date (3-8)	Cluster (9-11)	Transect (12)
01	051577	100	5

Plot (13-14): 1A

Number of Visits

Species	Day 1	Day 2	Day 3
GRFØ (15-18)	/ (19)	(20)	(21)
RACC (22-25)	/ (26)	/ (27)	/ (28)
ØPØS (29-32)	(33)	/ (34)	/ (35)
(36-39)	(40)	(41)	(42)
(43-46)	(47)	(48)	(49)
(50-53)	(54)	(55)	(56)
(57-60)	(61)	(62)	(63)

Plot: 6A

Number of Visits

Species	Day 1	Day 2	Day 3
ØPØS (15-18)	/ (19)	/ (20)	(21)
RACC (22-25)	(26)	/ (27)	(28)
(29-32)	(33)	(34)	(35)
(36-39)	(40)	(41)	(42)
(43-46)	(47)	(48)	(49)
(50-53)	(54)	(55)	(56)
(57-60)	(61)	(62)	(63)

Plot (13-14):

Number of Visits

Species	Day 1	Day 2	Day 3
(15-18)	(19)	(20)	(21)
(22-25)	(26)	(27)	(28)
(29-32)	(33)	(34)	(35)
(36-39)	(40)	(41)	(42)
(43-46)	(47)	(48)	(49)
(50-53)	(54)	(55)	(56)
(57-60)	(61)	(62)	(63)

Plot (13-14):

Number of Visits

Species	Day 1	Day 2	Day 3
(15-18)	(19)	(20)	(21)
(22-25)	(26)	(27)	(28)
(29-32)	(33)	(34)	(35)
(36-39)	(40)	(41)	(42)
(43-46)	(47)	(48)	(49)
(50-53)	(54)	(55)	(56)
(57-60)	(61)	(62)	(63)

DOT/FHWA 1/78

Deer, Elk, Rabbit, and Hare Survey

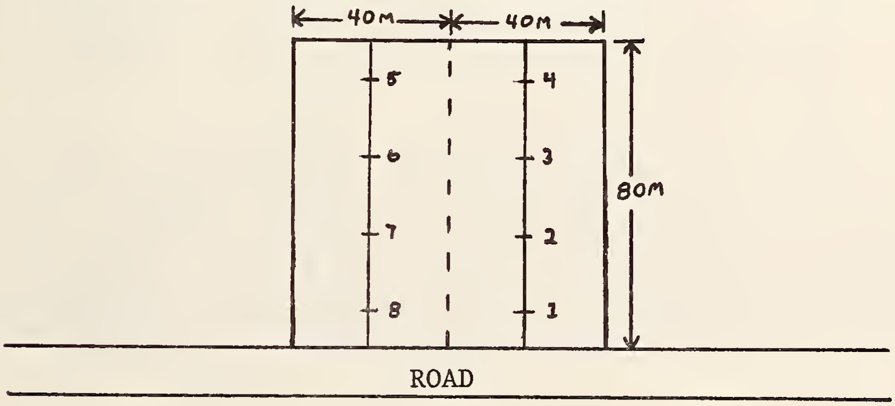
This survey is conducted in conjunction with the small mammal and terrestrial furbearer surveys, and is conducted on the same three transects per cluster and the same three plots per transect as is the small mammal survey. Within the selected 80- x 80-m plots, presence or absence of pellets (rabbits and hares) and number of pellet groups (deer and elk) are counted in 0.005-ha circular subplots (4-m radius) along two transects, each spaced 20 m to one side of the center line of the 80- x 80-m plots.

Thus, subplots are smaller sampling units within the larger 80- x 80-m plots. Subplot 1 is always 10 m from the plot edge nearest the road except for plot 2. This plot is adjacent to the road, and so, where possible, it samples the roadside right-of-way habitat. Thus, for plot 2, subplots 1 and 8 should be centered in the roadside right-of-way habitat. In those cases where positioning subplots in this manner results in a portion of the subplot overlapping the road, move the subplot center 4 m away from the road edge. This will result in an overlap of the subplot into the habitat beyond the right-of-way, probably resulting in a subplot of two habitat types. Special note should be made when this occurs. Regardless of where subplots 1 and 8 are located, subplots 2 and 7 should always be 30 m from the road for plot 2, and 20 m from subplots 1 and 8 for plots 3, 5, and 6. Subplot 3 is always 20 m from subplots 2 and 4, and subplot 6 is always 20 m from subplots 5 and 7.

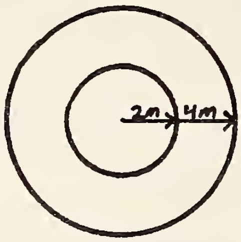
All subplots should be numbered in the manner shown in the diagram. Maintaining the same numbering system will be important in recording data on the field form.

All distances refer to subplot centers.

A diagramatic plot 2 with subplot layouts is shown below.



One of two procedures may be used for laying out subplots. For procedure one, a plot cord, 4 m in length (with a knot in the center for 2-m measurements) may be used. For this technique, one end of the cord is attached to a stake at the subplot center, and the length of the cord marks the subplot radius (see the following diagram).



Pellet counts are made in the inner 2-m circle first, and then counts are made in the outer 2-m portion of the subplot.

Search subplots carefully. In many habitats, it is quite easy to overlook pellets and pellet groups. On the other hand, also be careful not to record pellet groups more than once. This is particularly critical at the inner circle boundary. After recording a pellet (rabbit/hare) or pellet group (deer/elk), press it into the ground with your foot. This should eliminate your recording it a second time.

For procedure two, a stick, or sawed piece of lumber, exactly 2 m in length may be used. For this technique, a stake, rock, or some other available object is placed at the subplot center, and the inner circle boundary is marked with the aid of the 2-m stick. A light boot mark should work well for marking this boundary. Be careful not to disrupt any rabbit/hare pellets, or deer/elk pellet groups in marking this circle. After the inner circle is marked, survey it for pellets and pellet groups, and then with the 2-m stick (one end following the inner circle boundary) as a guide, survey the outer 2-m width of the subplot. Observations of pellet groups on each 2-m survey are combined for a subplot total (for deer and elk). It is not necessary to total observations for rabbits and hares since only presence or absence of pellets per subplot are recorded for these species.

Searching in the above manner will provide better coverage of the subplots, thus reducing the number of pellets and pellet groups missed by the observer. Each subplot is counted once, and no counts should be made when snow is on the ground. Where questions arise as to whether pellets or pellet groups are in or out of a subplot, please recheck the distance measurement from the subplot center and follow the procedure below.

Numbers of pellet groups are to be tallied for deer and elk, but only presence or absence of rabbit and hare pellets is recorded, due to the difficulty of determining pellet groups for these species. A minimum of 30 pellets must be present to count as a group for deer and elk. Groups should be considered within a subplot if at least one-half of the group is contained in the subplot. Adjacent pellet groups of very similar appearance are counted separately unless they definitely are connected by scattered pellets. In that case count only as one group.

Let's run through an example to illustrate how data are recorded on the field form (pages 163-164). The form used for these surveys is quite similar to the one used for the small mammal survey, therefore, much of the detailed description of that form also applies here, but is not repeated. Refamiliarize yourself with the small mammal survey form description, if necessary, before continuing here.

As with the small mammals, data on deer, elk, rabbit, and hare are collected by major habitat type. If a plot (80- x 80 m) consists of a single habitat type then all subplots (4-m radius circle) will be in that type. However, if a plot consists of more than one habitat type, subplots are associated with the particular type in which they are located.

For the attached example, plot 2 is divided into two habitat types - (1) the roadside habitat (2A), and (2) the habitat beyond the roadside right-of-way (2B). In this plot, subplots 1 and 8 were located in the right-of-way habitat (2A), and subplots 2 through 7 were located in the habitat type beyond the right-of-way. For 2A, two deer pellet groups were detected in subplot 1, and one group in subplot 8. Rabbit presence was detected in subplot 1 but not in subplot 8. For 2B, no deer pellet groups were observed in subplots 2, 5, and 6, but two, one, and three groups were recorded for subplots 3, 4, and 7, respectively. Rabbit presence was detected in subplots 2, 4, 5, and 7, but no sign was observed in subplots 3, and 6.

Subplots in plot 3 crossed two habitat types (coded 3A and 3B on the field form). Subplots 1, 2, 7, and 8 were in the habitat type coded 3A and contained no deer sign, however, rabbit presence was detected in subplot 1 (but not in subplots 2, 7, or 8). Subplots 3, 4, 5, and 6 were contained in the habitat type coded 3B. No deer pellet groups were recorded in subplots 5 and 6, but two groups were recorded in subplot 3 and one group was recorded in subplot 4. Rabbit presence was detected in subplots 3 and 6, but not in subplots 4 and 5.

Plot 5 consisted of a single habitat type (coded 5A on the field form). Two, one, one, and two deer pellet groups were recorded in subplots 3, 4, 6, and 7, respectively. Subplots 1, 2, 5, and 8 contained no deer pellet groups. Rabbit presence was detected in subplots 2, 3, 6 and 8, but not in subplots 1, 4, 5, and 7.

It is possible that elk pellet groups will show up on some subplots in the Pacific Northwest, therefore, space is present on the field form for this species. However, <u>do not</u> record zeros for this species. Only make entries on the data form when pellet groups are observed. We will know from the recordings for deer and rabbit whether or not a particular subplot was sampled, and not recording zeros will save time for both field people and keypunch operators.

During your subplot searches, also record woodchuck burrows (and in the Northwest, mountain beaver burrows and gopher mounds) <u>found on the subplots only</u>. Record each burrow or mound as an individual observation even though you feel two or more may be part of the same underground system. Also record whether active or inactive (when this can be determined). Record this information on the back of your field form.

DEER, ELK, RABBIT, AND HARE SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, Maryland 21043

Observer (1-2)	Date (3-8)	Cluster (9-11)	Transect (12)
01	051677	100	5

Plot (13-14): 2A

	Deer	Elk	Rabbit/Hare
SUBPLOT 1	02 (15-16)	(17-18)	1 (19)
SUBPLOT 2	(20-21)	(22-23)	(24)
SUBPLOT 3	(25-26)	(27-28)	(29)
SUBPLOT 4	(30-31)	(32-33)	(34)
SUBPLOT 5	(35-36)	(37-38)	(39)
SUBPLOT 6	(40-41)	(42-43)	(44)
SUBPLOT 7	(45-46)	(47-48)	(49)
SUBPLOT 8	01 (50-51)	(52-53)	0 (54)

Plot (13-14): 2B

	Deer	Elk	Rabbit/Hare
SUBPLOT 1	(15-16)	(17-18)	(19)
SUBPLOT 2	00 (20-21)	(22-23)	1 (24)
SUBPLOT 3	02 (25-26)	(27-28)	0 (29)
SUBPLOT 4	01 (30-31)	(32-33)	1 (34)
SUBPLOT 5	00 (35-36)	(37-38)	1 (39)
SUBPLOT 6	00 (40-41)	(42-43)	0 (44)
SUBPLOT 7	03 (45-46)	(47-48)	1 (49)
SUBPLOT 8	(50-51)	(52-53)	(54)

Plot (13-14): 3A

	Deer	Elk	Rabbit/Hare
SUBPLOT 1	00 (15-16)	(17-18)	1 (19)
SUBPLOT 2	00 (20-21)	(22-23)	0 (24)
SUBPLOT 3	(25-26)	(27-28)	(29)
SUBPLOT 4	(30-31)	(32-33)	(34)
SUBPLOT 5	(35-36)	(37-38)	(39)
SUBPLOT 6	(40-41)	(42-43)	(44)
SUBPLOT 7	00 (45-46)	(47-48)	0 (49)
SUBPLOT 8	00 (50-51)	(52-53)	0 (54)

Plot (13-14):

	Deer	Elk	Rabbit/Hare
SUBPLOT 1	(15-16)	(17-18)	(19)
SUBPLOT 2	(20-21)	(22-23)	(24)
SUBPLOT 3	02 (25-26)	(27-28)	1 (29)
SUBPLOT 4	01 (30-31)	(32-33)	0 (34)
SUBPLOT 5	00 (35-36)	(37-38)	0 (39)
SUBPLOT 6	00 (40-41)	(42-43)	1 (44)
SUBPLOT 7	(45-46)	(47-48)	(49)
SUBPLOT 8	(50-51)	(52-53)	(54)

DEER, ELK, RABBIT, AND HARE SURVEY FORM - HIGHWAY STUDY

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, Maryland 21043

Observer (1-2)	Date (3-8)	Cluster (9-11)	Transect (12)
01	051677	100	5

Plot (13-14): 5A

	Deer	Elk	Rabbit/Hare
SUBPLOT 1	00 (15-16)	(17-18)	0 (19)
SUBPLOT 2	00 (20-21)	(22-23)	1 (24)
SUBPLOT 3	02 (25-26)	(27-28)	1 (29)
SUBPLOT 4	01 (30-31)	(32-33)	0 (34)
SUBPLOT 5	00 (35-36)	(37-38)	0 (39)
SUBPLOT 6	01 (40-41)	(42-43)	1 (44)
SUBPLOT 7	02 (45-46)	(47-48)	0 (49)
SUBPLOT 8	00 (50-51)	(52-53)	1 (54)

Plot (13-14):

	Deer	Elk	Rabbit/Hare
SUBPLOT 1	(15-16)	(17-18)	(19)
SUBPLOT 2	(20-21)	(22-23)	(24)
SUBPLOT 3	(25-26)	(27-28)	(29)
SUBPLOT 4	(30-31)	(32-33)	(34)
SUBPLOT 5	(35-36)	(37-38)	(39)
SUBPLOT 6	(40-41)	(42-43)	(44)
SUBPLOT 7	(45-46)	(47-48)	(49)
SUBPLOT 8	(50-51)	(52-53)	(54)

Plot (13-14):

	Deer	Elk	Rabbit/Hare
SUBPLOT 1	(15-16)	(17-18)	(19)
SUBPLOT 2	(20-21)	(22-23)	(24)
SUBPLOT 3	(25-26)	(27-28)	(29)
SUBPLOT 4	(30-31)	(32-33)	(34)
SUBPLOT 5	(35-36)	(37-38)	(39)
SUBPLOT 6	(40-41)	(42-43)	(44)
SUBPLOT 7	(45-46)	(47-48)	(49)
SUBPLOT 8	(50-51)	(52-53)	(54)

Plot (13-14):

	Deer	Elk	Rabbit/Hare
SUBPLOT 1	(15-16)	(17-18)	(19)
SUBPLOT 2	(20-21)	(22-23)	(24)
SUBPLOT 3	(25-26)	(27-28)	(29)
SUBPLOT 4	(30-31)	(32-33)	(34)
SUBPLOT 5	(35-36)	(37-38)	(39)
SUBPLOT 6	(40-41)	(42-43)	(44)
SUBPLOT 7	(45-46)	(47-48)	(49)
SUBPLOT 8	(50-51)	(52-53)	(54)

DOT/FHWA 1/78

Wildlife Road Mortality Survey

This survey is conducted in conjunction with the breeding bird survey (page 138) at all cluster sites. The bird survey is conducted in the morning, followed by the road mortality survey in the afternoon (beginning between noon and 1 P.M.).

For this survey, the 1.6-km length of road which defines a cluster site is searched on foot by the observer, and all dead animals observed are recorded to species (when possible) on the field form.

No time limit is placed on the observer for this survey, and he is free to move laterally to cover specific spots or to make positive identifications. A comfortable rate of speed should be used such that the observer feels he is detecting all road-killed animals.

Most road related animal mortality will be on the road and beside the road out to the roadside ditch, therefore, this area should be observed most carefully. However, some animals will be found beyond the roadside ditch, and these also should be recorded. Do not walk to the bottom of large fill areas looking for road kills; stay near the road.

On the interstate sites, 6.4 km are walked at each cluster site (each side of both lanes are surveyed). From previous work, we have found this to take about 2 hours, but this will vary somewhat from area to area.

On county road sites, only 3.2 km are surveyed at each cluster (both sides of the 1.6-km length of road defining the cluster site).

This survey usually is conducted in conjunction with the breeding bird survey to improve efficiency. It is not critical that it be conducted the same day as the bird survey at a particular site if it is not practical to do so. Use your own good judgment on this point.

You should not conduct more than 1 road-kill survey per day on the interstate sites; however, you may be able to conduct 2 surveys per day at county road sites. This particularly may be possible on days when you are unable to conduct bird surveys (it may be too demanding, though, on days when you do run a bird survey).

Let's look at an example of a completed field form (page 167). The identifying information at the top of the form is the same as for previous forms, so will not be discussed further.

Road-killed animals detected on the survey are recorded in the blocks under the species heading. Use one block for each animal (do not combine individuals of the same species within a block).

Location of each road-killed animal is recorded in the blocks beside the appropriate species block. The term "on the road" refers to the roadway proper. Roadside edge (for hard-top roads) is defined as that portion of the roadway from the edge of the hard-topped traveled portion of the road to the roadside vegetation. On gravel roads, the roadside edge includes the mound of gravel that generally is present on gravel roads, and any remaining area over to the roadside vegetation. Roadside habitat is defined as the area beyond the roadside edge. On interstates, the median edge is similar to roadside edge, the only exception being that it is located on the median side of the roadway. Median habitat is defined as that portion of the median beyond the median edge. Individual animals are recorded only once. Special caution is needed in this regard on interstate sites with narrow medians.

Carcass age refers to the length of time since the animal's death. Obviously, this is a difficult parameter to measure accurately. For our purposes, we will only make an attempt to distinguish fresh road-kills (killed within the previous 24 hours) from old road-kills (killed prior to the previous 24 hours). Code 2 on the field form allows for some of the uncertainty associated with this judgment call.

In the example, one woodchuck was found on the road, and one on the roadside edge. Three field sparrows were found, all in the roadside habitat. Two meadowlarks were found, one in the roadside habitat, and one in the median habitat.

The same four-letter codes are used for animal species in this survey as were used in previous surveys.

Record the general weather conditions at the time of the survey, and during the previous 24 hours. Also note the general habitat conditions on both sides of the road for each road-killed animal. The presence of a stream, either passing beneath the road or very near the road, may be an important factor and should be noted on the field form. This information may provide some insight into "preferred crossings" by wildlife. If inadequate room is available on the front of the form for recording these observations, please use the back of the form.

Roadkill Survey Form - Highway Study

Urban Wildlife Research Center, Inc., 12789 Folly Quarter Rd., Ellicott City, MD 21043

Observer (1-2)	Date (3-8)	Time (9-12)	Cluster (13-15)
01	061578	1200	100

SPECIES	Where Found	Carcass Age	SPECIES	Where Found	Carcass Age
WØØD (16-19)	1 (20)	2 (21)	(16-19)	(20)	(21)
WØØD (22-25)	2 (26)	2 (27)	(22-25)	(26)	(27)
FISP (28-31)	3 (32)	1 (33)	(28-31)	(32)	(33)
MEAD (34-37)	3 (38)	1 (39)	(34-37)	(38)	(39)
FISP (40-43)	3 (44)	2 (45)	(40-43)	(44)	(45)
FISP (46-49)	3 (50)	1 (51)	(46-49)	(50)	(51)
MEAD (52-55)	5 (56)	1 (57)	(52-55)	(56)	(57)
(58-61)	(62)	(63)	(58-61)	(62)	(63)

Code	Where Found
1	on road
2	roadside edge
3	roadside habitat
4	median edge
5	median habitat

Code	Carcass Age
1	Known less than 24 hours
2	May be less than 24 hours
3	Known more than 24 hours

Notes ____

DOT/FHWA

Appendix C. Common and Scientific Names of Animals and Plants Cited in the Text.

AMPHIBIANS

American Toad - *Bufo americanus americanus*
Frog, Green - *Rana clamitans melanota*
  Northern Gray Tree - *Hyla versicolor versicolor*
  Northern Leopard - *Rana pipiens pipiens*
  Pacific Treefrog - *Hyla regilla*
  Tree - *Hyla spp.*
  Wood - *Rana sylvantica*
Newt, Rough-skinned - *Taricha granulosa*
Salamander, Pacific giant - *Dicamptodon ensatus*
  Tiger - *Ambystoma tigrinum tigrinum*
  Western red-backed - *Plethodon gordoni*

REPTILES

Lizard, Glass - *Ophisaurus attenuatus attenuatus*
  Northern alligator - *Gerrhonotus coeruleus*
  Six-lined racerunner - *Cnemidophorus sexlineatus sexlineatus*
  Southern alligator - *Gerrhonotus multicarinatus*
  Western fence - *Sceloporus occidentalis*
Skink, Western - *Eumeces skiltonianus*
Snake, Common garter - *Thamnophis sirtalis*
  Eastern Garter - *Thamnophis sirtalis sirtalis*
  Prairie Garter - *Thamnophis radix radix*
  Western Fox - *Elaphe vulpina vulpina*

BIRDS

American redstart - *Setophaga ruticilla*
Bobolink - *Dolichonyx oryzivorus*
Chestnut-sided warbler - *Dendroica pensylvanica*
Common crow - *Corvus brachyrhynchos*
Eastern kingbird - *Tyrannus tyrannus*
Red-bellied woodpecker - *Centurus carolinus*
Red-winged blackbird - *Agelaius phoeniceus*
Ring-necked pheasant - *Phasianus colchicus*
Scarlet tanager - *Piranga olivacea*
Starling - *Sturnus vulgaris*
Veery - *Hylocichla fuscescens*

Appendix C. (Continued).

MAMMALS

Beaver, Mountain - *Aplodontia rufa*
Chipmunk, Eastern - *Tamias striatus*
  Townsend's - *Eutamias townsendii*
Cottontail, Eastern - *Sylvilagus floridanus*
Deer, White-tailed - *Odocoileus virginianus*
Fox, Red - *Vulpes fulva*
Gopher, Camus pocket - *Thomomys bulbivorous*
  Mazama pocket - *Thomomys mazama*
Mole, Pacific - *Scapanus orarius*
  Townsend's - *Scapanus townsendii*
Mouse, Deer - *Peromyscus maniculatus*
  House - *Mus musculus*
  Pacific jumping - *Zapus trinotatus*
Opossum - *Didelphis marsupialis*
Rabbit, Brush - *Sylvilagus bachmani*
Raccoon - *Procyon lotor*
Rat, Norway - *Rattus norvegicus*
Shrew, Pacific - *Sorex pacificus*
  Short-tailed - *Blarina brevicauda*
  Trowbridge's - *Sorex trowbridgii*
  Vagrant - *Sorex vagrans*
  Water - *Sorex palustris*
Skunk, striped - *Mephitis mephitis*
Squirrel, California ground - *Spermophilus beecheyi*
  Douglas - *Tamiasciurus douglasii*
  Eastern gray - *Sciurus carolinensis*
  Fox - *Sciurus niger*
  Northern flying - *Glaucomys sabrinus*
  Western gray - *Sciurus griseus*
Vole, creeping - *Microtus oregoni*
  Grey-tailed - *Microtus canicaudis*
  Long-tailed - *Microtus longicaudis*
  Meadow - *Microtus pennsylvanicus*
  Western, Red-backed - *Clethrionomys occidentalis*
Weasel, Short-tailed - *Mustela erminea*
Woodchuck - *Marmota monax*
Woodrat, Bushy-tailed - *Neotoma cinerea*
  Dusky-footed - *Neotoma fuscipes*

Appendix C. (Continued).

TREES

Apple - *Malus spp.*
Bigleaf maple - *Acer macrophyllum*
Black cottonwood - *Populus trichocarpa*
Black walnut - *Suglans nigra*
Cascara buckthorn - *Rhamnus purshiana*
Douglas-fir - *Pseudotsuga menziesii*
Oregon ash - *Fraxinus latifolia*
Oregon white oak - *Quercus garryana*
Red alder - *Alnus rubra*

SHRUBS

Blackhawthorn - *Crataegus douglasii*
California hazel - *Corylus cornuta*
Himalayan blackberry - *Rubus discolor*
Trailing blackberry - *Rubus ursinus*
Poisonoak - *Rhus diversiloba*
Salal - *Gaultheria shallon*
Salmonberry - *Rubus spectabilis*
Snowberry - *Symphoricarpos albus*
Vine maple - *Acer circinatum*
Nootka rose - *Rosa nutkana*

GRASSES

Bentgrass - *Agrostis spp.*
Bluegrass - *Poa spp.*
Diffuse hairgrass - *Aira elegans*
Perennial ryegrass - *Lolium perenne*
Soft chess - *Bromus mollis*

FORBS

American vetch - *Vicia americana*
Big deervetch - *Lotus crassifolius var. sub glaber*
Fringecup - *Tellima grandiflorum*
Mexican betony - *Stachys mexicana*
Moneywort - *Lysimachia nummularia*
Oregon oxalis - *Oxalis oregana*
Pig-a-back - *Tolmiea menziesii*
Small-flowered willow weed - *Epilobium minutum*
Sword fern - *Polystichum munitum*
Vetch - *Vicia spp.*
Western bracken fern - *Pteridium aquilinum*
Woods strawberry - *Fragaria vesca*

FEDERALLY COORDINATED PROGRAM OF HIGHWAY RESEARCH AND DEVELOPMENT (FCP)

The Offices of Research and Development of the Federal Highway Administration are responsible for a broad program of research with resources including its own staff. contract programs. and a Federal-Aid program which is conducted by or through the State highway departments and which also finances the National Cooperative Highway Research Program managed by the Transportation Research Board. The Federally Coordinated Program of Highway Research and Development (FCP) is a carefully selected group of projects aimed at urgent. national problems. which concentrates these resources on these problems to obtain timely solutions. Virtually all of the available funds and staff resources are a part of the FCP. together with as much of the Federal-aid research funds of the States and the NCHRP resources as the States agree to devote to these projects.*

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems connected with the responsibilities of the Federal Highway Administration under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware. signing. and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology. by improving designs for existing as well as new facilities. and by keeping the demand-capacity relationship in better balance through traffic management techniques such as bus and carpool preferential treatment. motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements which affect the quality of the human environment. The ultimate goals are reduction of adverse highway and traffic impacts. and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge of materials properties and technology to fully utilize available naturally occurring materials. to develop extender or substitute materials for materials in short supply. and to devise procedures for converting industrial and other wastes into useful highway products. These activities are all directed toward the common goals of lowering the cost of highway construction and extending the period of maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural designs. fabrication processes. and construction techniques. to provide safe. efficient highways at reasonable cost.

6. Prototype Development and Implementation of Research

This category is concerned with developing and transferring research and technology into practice. or. as it has been commonly identified. "technology transfer."

7. Improved Technology for Highway Maintenance

Maintenance R&D objectives include the development and application of new technology to improve management. to augment the utilization of resources. and to increase operational efficiency and safety in the maintenance of highway facilities.

* The complete 7-volume official statement of the FCP is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161 (Order No. PB 242057, price $45 postpaid). Single copies of the introductory volume are obtainable without charge from Program Analysis (HRD-2), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.

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