Evaluation of Techniques for Assessment of Amphibian and Reptile Populations in Wisconsin

by

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Abstract

This study was part of a project to develop techniques for sampling terrestrial vertebrates quantitatively and qualitatively by nonspecialized biologists. Drift fences combined with traps proved to be a practical way to uniformly census reptiles and amphibians. Drift fences made from aluminum valley caught more animals per 15 m of fence than those made of either screening or galvanized metal. Aluminum valley is easy to handle and stands up well with continued use. Generally, the more fence set, the more animals caught. Fences shorter than 15 m, however, did not catch enough animals to make their use worthwhile. A height of 50 cm proved effective. A system of 18.9-L traps, 7.6-L traps with funnel rims, and funnel traps were necessary to capture the entire spectrum of amphibians and reptiles in the communities sampled. We believe that several short sampling periods staggered throughout the season are more effective in obtaining an estimate of species composition and populations than a longer sampling period at any one time. Procedures are recommended for using drift fences and traps in various habitats.

Reptiles and amphibians are sometimes difficult to census, as they may remain inactive for weeks if weather conditions are not within their activity range. Temperature, precipitation, soil moisture, humidity, light intensity, wind, and season greatly control their activity patterns. Thus, any census technique must take into consideration the effects of these factors on the animals' biology.

The present study was part of a project to develop techniques for sampling terrestrial vertebrates quantitatively and qualitatively by a nonspecialized biologist. The emphasis was on a uniform sampling method that could be applied to the Till Plain of the northern United States, while maximizing efficiency without losing accuracy.

A number of sampling methods have been used to determine species density and diversity of amphibians and reptiles. Most environmental impact statements give species lists of reptiles and amphibians seen or captured through random search and seize procedures. The success of the techniques varies greatly with the training of the individuals involved, the time of the day and year the collecting is done, the rareness or agility of a species, and the type of habitats sampled. Though fast-moving or secretive species may actually be fairly common, they may not be found if the observer is not looking in the right place. For example, in this study, over 50 h were spent

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looking for reptiles and amphibians over a 5-year period at the Portage site, but not until drift fences were employed did *Ophisaurus* appear in the sample. Different species vary in their daily and seasonal activity patterns; thus an observer might notice few salamanders above ground on bright, sunny days, no lizards active during a rain, or snakes active on cloudy, windy days. The long-term use of an area must also be considered if habitat has to be destroyed while searching for specimens.

Population estimates and other quantitative comparisons require extensive search and capture, and often marking. The time of sampling and training of observers are also important. The animals must be marked so that individuals are not counted more than once unless the animals are removed from the population. Salamanders, lizards, frogs, and turtles can all be easily toe-clipped for short-term marking, and snakes can be scale-clipped (Blanchard and Finster 1933; Martof 1953).

Call indices for frogs are of limited use; only mature male frogs call, and in many species only dominant males call. A pond with 18 calling males may have an additional 64 mature subdominants, or may have none, but the population estimate would be the same (Fellers 1975). A call index is, however, a good estimate of the size of the breeding area – the more widespread the calling males, the larger the breeding area. Difficulty in estimating the number of nonterritorial frogs or frogs with very small territories must also be considered. *Hyla crucifer* and *Rana sylvatica* often call in dense choruses numbering in the hundreds. Separating the individual calls is nearly impossible, except possibly by taping and computer analysis.

Frogs are also highly seasonal, and calling is affected by temperature and time of day (see Wiest, this volume). Though only a few frogs may be heard early and late in the season, hundreds may be calling at the peak of the breeding season. In Wisconsin, *Rana sylvatica* calls for only a 2-week interval in early spring. At this time, only *Pseudacris* and *H. crucifer* are also calling. Later in the season *Pseudacris*, *H. crucifer*, *H. versicolor*, and *Bufo* may all be heard calling in the same area, while *Acris* and *R. clamitans* have yet to start. A sampling period would need to cover the entire range of breeding time and on nights of proper temperature and moisture for each species. Its value as a census technique is generally limited to data on species presence. Call differences, however, are the surest way for the nonspecialist to differentiate some species of frogs (e.g., *Hyla chrysoscelis* from *H. versicolor*, or *Rana blairi* from *R. pipiens*).

Fitch (1951) described using funnel traps with and without doors for capturing snakes, lizards, and frogs. He was interested in population dynamics of snakes and set the traps along natural drift fences, e.g., logs and rock ledges. This was an effective method for capturing animals moving along these areas, but choosing such areas requires knowledge of the types of animals being studied. Funnel traps with drift fences were also found to be highly effective by Imler (1945) for bull snakes (*Pituophis*); 1,729 were caught in four summers. Milstead (1959) used drift fences with funnel traps for catching lizards in Texas. Campbell and Christman (this volume) have used funnel traps effectively.

Pit traps of various depths and diameters with and without drift fences have been used in various studies. Covered pit traps are effective in catching lizards (Banta 1957; Lillywhite 1977). Moreover, when they are employed with a drift fence, results have often been exceptional (Shoop 1968; Gibbons and Bennett 1974; Rittschof 1975; B. Hellmich, personal communication; D. Tinkle, personal communication; Campbell and Christman, this volume). Drift fencing seems to be the most effective method of reducing inherent observer bias.

D. Tinkle (personal communication) walked along drift fences and counted animals that came up to the barrier and were trying to move around it. This is satisfactory for long (over 100 m) permanent fences that are irregularly monitored. Short fences (less than 100 m) need restraining devices such as pit and funnel traps associated with them to be effective.

Although drift fences and traps are more cumbersome and expensive than walking a line transect or searching a quadrat, these drawbacks are more than compensated by the elimination of the observer and temporal biases. Because of its effectiveness and efficiency, the drift fence and trap method seem the best way to standardize sampling of reptile and amphibian communities.

The present study, undertaken from April through November 1976, was devised to test different aspects of drift fences with pits and fun-

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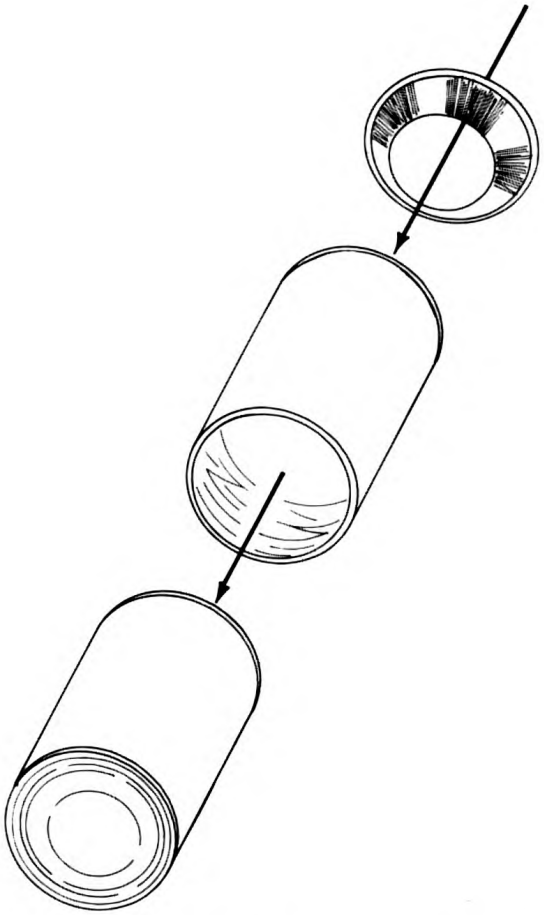

Fig. 1. Construction of a 7.6-L pit trap with funnel.

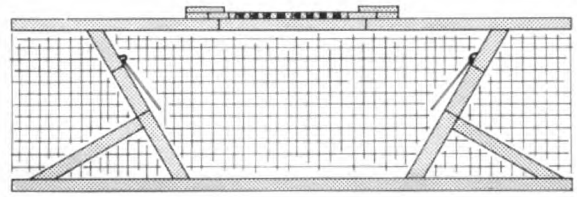

Fig. 2. Funnel trap (after Fitch 1951).

Fig. 3. Drift fence made from aluminum valley. Note bend in fence around a rock (Point Beach, Line A).

nels. The materials, length, height, and positioning of fence, the size and type of pits and funnel traps, the season and weather, and the length of time needed to sample were tested to formulate a standardized method.

Materials and Methods

The sampling unit is defined here as the length of the drift fence. In the text, drift fence refers to either the fence alone or the drift fence with its associated traps. The exact meaning should be clear from the context.

The following materials were tested for fencing and traps: aluminum valley (or flashing), 15-m roll, 50 cm high; aluminum window screen, 15-m roll, 60 cm high; galvanized sheet metal, 3 m by 60 cm; 3.8-L cans with funnel rims; 7.6-L cans made by cutting the bottom out of one can and securing two cans together with 7.5 cm duct tape (Fig. 1); plastic bowls with bottoms removed for attachment to 3.8-L and 7.6-L cans as funnel rims (Fig. 1) and bowl lids; 18.9-L plastic ice cream buckets with lids; 18.9-L metal paint cans with lids; and two-door funnel traps (Fig. 2).

Drift fences made from the aluminum valley were set up in either 15 or 30-m lengths in a 10-cm trench (Fig. 3) with a galvanized metal stake set at each end of the valley. The aluminum screen was set in 7.5 to 30-m lengths, buried 10 cm underground, and staked with wood lathe every 2 m. The galvanized metal sheets were fastened together, buried 15 cm underground, and staked with galvanized angle iron between each sheet (Fig. 4).

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

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Fig. 4. Drift fence made from galvanized metal (Blue River, Line 1).

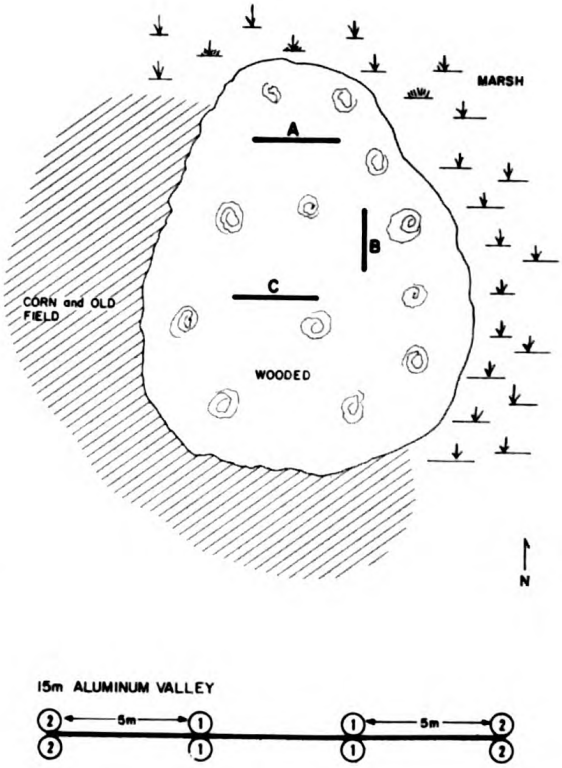

Fig. 5. Shaw Marsh site, Wisconsin. All three lines were constructed in a similar fashion. The symbols 1 and 2 refer to the positions of 3.8 and 7.6-L pit traps.

side of the fence. If weather conditions were not right, covers were placed on pit and funnel traps until the weather became more suitable.

Test trap lines were set up with the same number of each type of trap on both sides of the fence. The low number of animals caught did not warrant the rotation of trap positions. All trapping of reptiles and amphibians was conducted in 1976 unless otherwise designated. Scientific and common names for reptiles and amphibians encountered in the study are listed in the Appendix.

Study Areas

Three main habitat types were used for testing various aspects of drift fencing in southern Wisconsin: oak–hickory woodlots, wetlands, and old fields and prairie. A short period of trapping was also conducted in mixed deciduous forest.

Oak–Hickory Woodlots

These areas were chosen to compare results of reptile and amphibian sampling in an area where small mammals, birds, and vegetation were also being censused. Small deciduous woodlots in southern Wisconsin are not notably productive of a high diversity of reptiles or amphibians. The effectiveness of 3.8-L vs. 7.6-L pits and the position bias of the fence were tested at these sites. Traps were open for 24 days, between 27 April and 21 May.

Shaw Marsh Woodlot, Dodge County (T11N R14E, Sec 22 NW 1/4)

This oak–hickory forest (Fig. 5) had a mean of 245 trees (≥ 10 cm diameter) and 746 saplings per ha. There was a dense herbaceous understory with many fallen logs, mostly elm, which provided excellent cover for woodland amphibians and reptiles. The forest was bordered by a cattail marsh and an intermittent stream on the north and east. To the south and west it was bordered by cornfields and an old field.

Busse Tract, Columbia County (T12N R12E, Sec 22 SW 1/4)

This oak–hickory woodlot (Fig. 6) had a mean of 264 trees and 469 saplings per ha. A small irrigation ditch and canary grass field were to the west and north of the woods. A young (6 to 8 years) pine plantation was on the east and a cornfield on the south.

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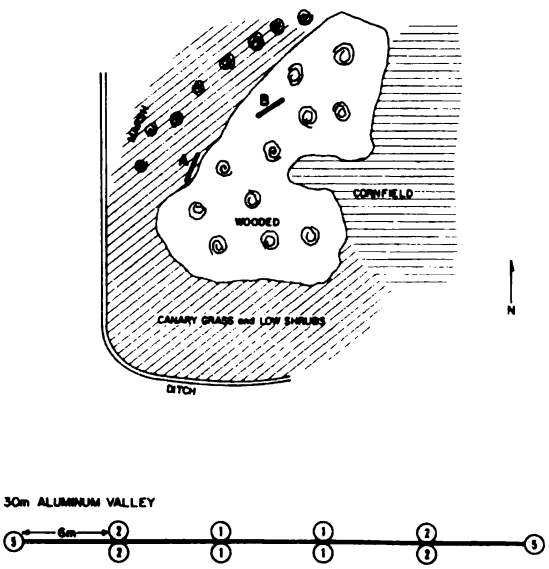

Fig. 6. Busse Tract site, Wisconsin. Both lines were constructed in a similar fashion. The symbols 1, 2, and 5 refer to the positions of 3.8, 7.6, and 18.9-L pit traps.

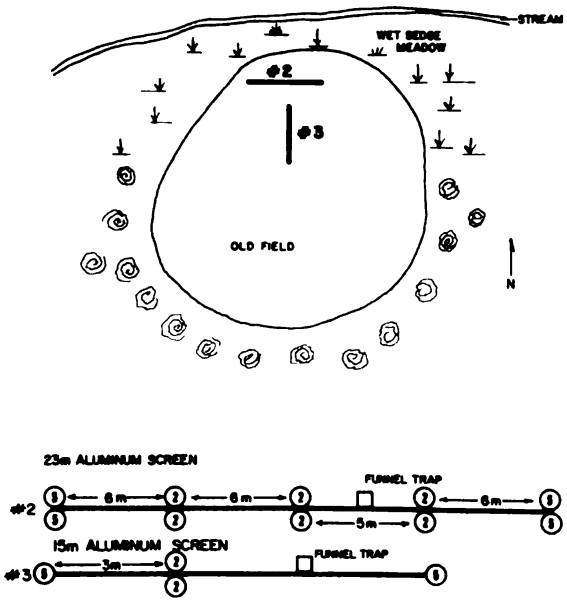

Fig. 7. Portage A site, Wisconsin. The symbols 2 and 5 refer to the positions of 7.6 and 18.9-L pit traps.

Wetlands and Old Fields

Portage site, Columbia County (T12N R9E, Sec 28, 33: T11N R9E, Sec 4)

Drift fences and traps were set in three old fields adjacent to wetlands and around a woodland pond. All four sites were on the land of Wisconsin Power and Light Coal Generating Plant, south of Portage. Traps were monitored from 22 April to 3 November. These lines were set to test position bias, effectiveness of trap types, and length and type of fence.

North Knoll—old field along Duck Creek (Fig. 7).—The area was bordered by a lowland hardwood forest to the south and sedge meadow to the north. During the spring, the sedge meadow is flooded by Duck Creek.

North Knoll—adjacent to the Intake Channel (Fig. 8).—This area was an old field adjacent to a short strip of marsh about 50 m wide, adjacent to the intake channel from Duck Creek to the Power Plant. It was bordered on the east and west by lowland hardwood forest and to the south by a large sand blow which was used for nesting by turtles.

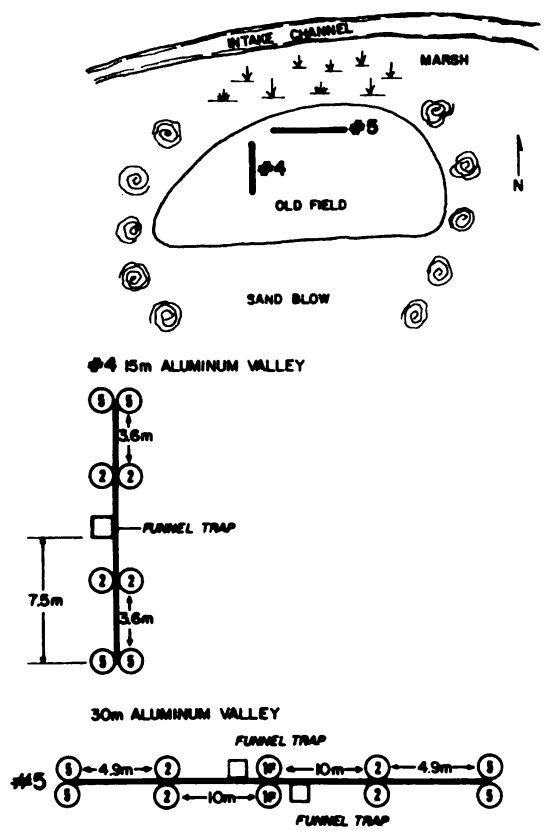

Fig. 8. Portage B site, Wisconsin. The symbols 2, 5, and 1F refer to the positions of 7.6 and 18.9-L pit traps and 3.8-L pit traps with funnels.

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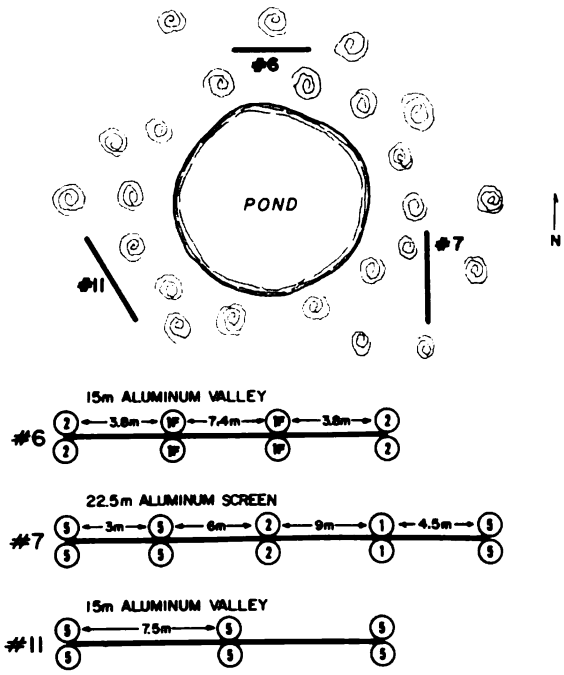

Fig. 9. Portage C site, Wisconsin. The symbols 1, 2, 5, and 1F refer to the positions of 3.8, 7.6, and 18.9-L pit traps and 3.8-L pit traps with funnels.

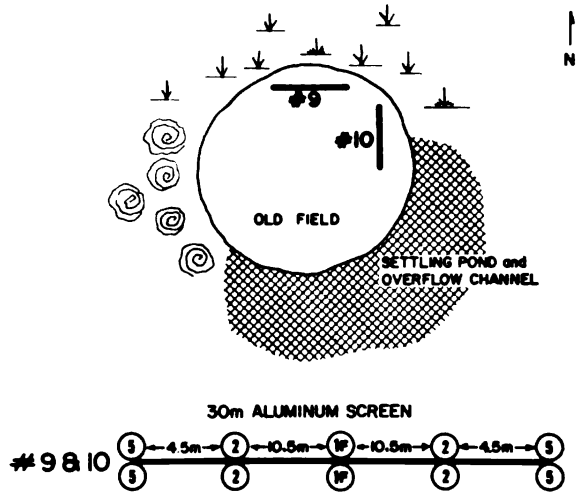

Fig. 10. Portage D site, Wisconsin. The symbols 2, 5, and 1F refer to the positions of 7.6 and 18.9-L pit traps and 3.8-L pit traps with funnels.

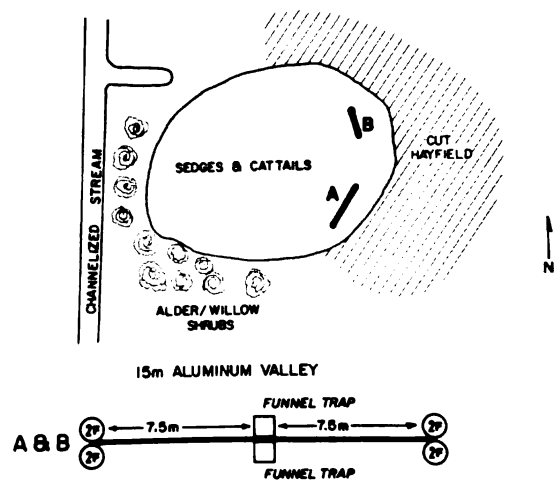

Fig. 11. Long Lake site, Wisconsin. The symbols 2 F refer to the positions of 7.6-L pit traps with funnels.

North Knoll – Woodland Pond (Fig. 9). – Three pieces of fencing were installed on the north, east, and west sides of a woodland pond, 3 m from the shore. The pond was about 30 × 30 m and 1.5 m deep, surrounded by a young oak, hickory, and paper birch woods.

South Knoll (Fig. 10). – This site was in an old field on clay soil adjacent to a small cattail marsh to the north and a lowland hardwood forest to the west. The east and south borders of the field were bordered by the settling pond and overflow channel.

Long Lake, Manitowoc county, (T19N R21E, Sec 6)

The northeast edge of the lake was bordered by a cattail marsh and an alfalfa field upland from the cattails (Fig. 11). This area was chosen to test the efficiency of drift fences versus hand capture. Between 1 April and 10 September, 200 man-hours were spent by another researcher marking frogs in the area. Because of dry soil conditions, the two 15-m aluminum drift fences were set 5 m from the alfalfa field in the marsh, and traps were open for 12 days in September and October.

Prairie

Blue River Cactus and Dunes, Grant County, (T8N R1W, Sec 6 E 1/2)

This 52.6-ha area featured a variety of xeric plant community types including sand blows, active dunes, flat sand barrens, and stabilized dunes forested with oaks (Fig. 12). *Hudsonia* is

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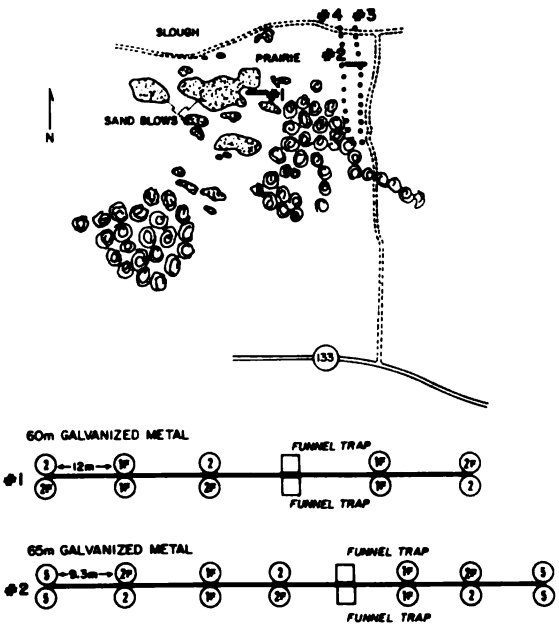

Fig. 12. Blue River site, Wisconsin. The symbols 2, 5, 1F, and 2F refer to the positions of 7.6 and 18.9-L pit traps and 3.8 and 7.6-L pit traps with funnels.

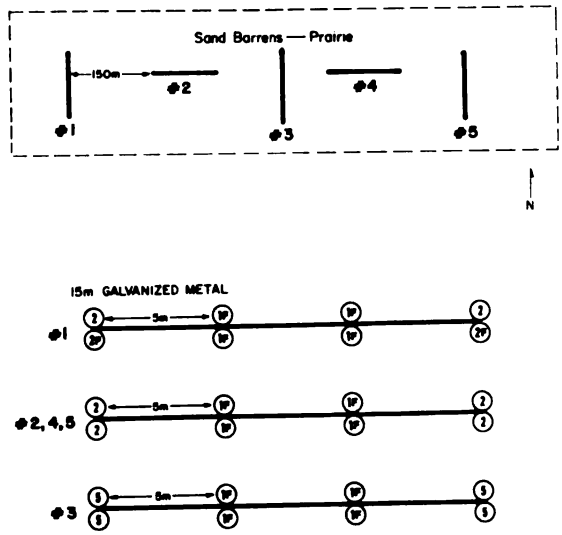

Fig. 13. Spring Green site, Wisconsin. The symbols 2, 5, 1F, and 2F refer to the positions of 7.6 and 18.9-L pit traps and 3.8 and 7.6-L pit traps with funnels.

abundant; other dune binders include *Arctostaphylos*, *Selaginella*, fungi (*Geaster*), mosses, and green algae. Two succulents, *Talinum rugospermum* and *Opuntia compressa*, occurred here. Nearly 12 ha were forested with oaks, often with an understory dominated by *Carex*. The soil type was Sparta loamy fine sand. It is almost certain that the area was once cultivated; subsequent wind erosion and loss of fine soil particles resulted in abandonment of the land.

Two fence and trap systems were set (Fig. 12). Line No. 1 was near the southeast end of a large sand blow (Fig. 4). Line No. 2 was in the northeast corner of the area in the center of the sand prairie and 3 m from the dirt road at the boundary. The traps were open for 85 days, between 26 May and 25 August.

Ten funnel traps, facing north-south, were set 20 m apart in a transect perpendicular to the center of drift fence No. 2 (position No. 3 on Fig. 12). After two weeks, the transect was moved to the west edge of drift fence No. 2 (position No. 4 on Fig. 12). These transects were run to determine the feasibility of using funnel traps without drift fences and also to see how far individual lizards moved within the study area.

Spring Green Reserve, Sauk County (T8N R4E, Sec 5, 6)

This area consisted of 113.3 ha of sand barrens—prairie and old fields bordered by a dry-lime prairie and a southern dry-mesic forest on the hills on the northern boundary, with crop lands on the east, south, and west borders (Fig. 13). There was no temporary or permanent water or wetlands within a 2½-km radius. Position of fence, type of trap, and movement of animals were being tested at this site. Relative numbers of each species were known from work over the previous 15 years by one of us (RCV). Three species of lizards, seven species of snakes, and one species of turtle were known to inhabit this area. This area was chosen to test the trapping procedure on an area of high species diversity and known species composition.

Mixed Deciduous Forest

Point Beach State Forest, Manitowoc County, (T20N R25E, Sec 29)

This area was a mixed deciduous forest with a dense canopy and thick understory of herbaceous plants and mulch (Fig. 14). The area was used to test the use of drift fences, as opposed to counting frogs in quadrats, and to check the reliability of drift fences in determining species composition. Three adjacent 9 × 9-m quadrats (1, 2, and 3, Fig. 14) and one separate quadrat (4, Fig. 14) were censused by another experienced investigator who walked back and forth counting frogs for 2.5 h.

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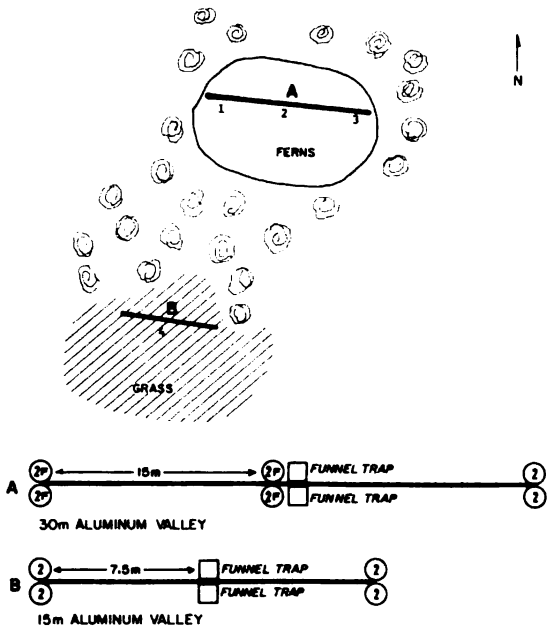

Fig. 14. Point Beach site, Wisconsin. The symbols 2 and 2F refer to the positions of 7.6-L pit traps and 7.6-L pit traps with funnels.

Evaluation of Drift Fence Trap Techniques

Effectiveness of Fencing Materials

The traditional measurement for animals caught in traps is number caught per trap day. Drift fences made from aluminum screening caught a slightly greater number of reptiles and amphibians per trap-day than did fences made of either aluminum valley or galvanized metal (Table 1).

In testing the various fencing materials, however, the number of animals caught per trap-day was not the best measurement of effectiveness, since the number and size of pit traps associated with individual fence lines were variable. Therefore, the unit of measurement regarded as most reliable was number of animals caught per 15 m of fence (Table 1). This new measurement of effectiveness showed a slightly greater number of animals caught with drift fences made from aluminum valley than with aluminum screen (33 and 31 animals per 15 m of fence-day × 100, respectively).

Fences caught all forms of reptiles and amphibians regardless of fencing material. 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 in 120 m of screen, whereas 18 were caught in 7.5 m of aluminum. On three 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. 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 a problem with aluminum. Galvanized metal used at Blue River was an effective barrier to all forms known to inhabit that prairie and caught animals at the rate of 12 animals per 15 m of fence-day × 100 (Table 1).

Table 1. *Numbers of animals caught with different drift fence materials in southern Wisconsin.*

	Portage Area		Blue River Area
	Aluminum valley	Aluminum screen	Galvanized metal
Frogs and toads	154	228	–
Salamanders	18	6	–
Snakes and legless lizards	69	114	167
Turtles	15	11	–
Total	256	359	167
No. traps	35	46	28
No. trap days	5,198	6,550	4,760
Animals/trap day × 100	4.9	5.4	3.5
No. 15-m lengths of fence	5	8	8
No. 15-m fence days	733	1,145	1,360
Animals/15-m fence-day × 100	35	31	12

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Evidence from trails in the sand showed no snakes or lizards going over the fence. However, these results are not directly comparable to the catch with the other two fence materials, because of the habitat differences of the study areas.

Screen weighs much less than the solid aluminum and is a little easier to carry; a roll of aluminum weighs about 9 kg and rolls into a cylinder 41 cm in diameter. It has nearly the same flexibility as screen for going around logs, trees, and rocks. Though aluminum needs a stake at each end only, screen requires staking at least every 3 m or the fence sags and animals crawl over it more easily. Aluminum stands up better over continued setting and pulling of fences; screen tends to tear and get matted with dirt and debris. The galvanized metal is excellent for a permanent fence, but there are disadvantages since the sheets weigh about 20 kg apiece and cannot be rolled and transported easily.

Length, Height, and Position of Fence

Fence lengths of 3-60 m were tested. Generally, the more fence set, the more animals caught. Drift fences shorter than 15 m, however, did not catch 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 Portage (Table 2). Twice as much fence resulted in the catch of about twice as many animals. Two 30-m sections set perpendicular to each other in a third old field caught comparable numbers of animals.

Since a fence must be high enough to discourage snakes from attempting to crawl over it or adult frogs from jumping over it, there is some optimum height needed to ensure the effectiveness of the fence and still maintain a manageable size. The minimum height used (50 cm) was sufficient to capture two 20-cm fox snakes, seven snakes over 40 cm, and hundreds of small snakes. Anything higher than this would be very unwieldly and is apparently not necessary for a census method.

There were often considerable differences in catch along various sections of fence within the same field and between adjacent fence lines. For example, at Portage (location No. 5) on 12 October, one 18.9-L pit trap caught 14 snakes, whereas the other 9 pit traps and 2 funnel traps caught a total of only 5 snakes. Other differences in catch between fence lines in similar habitats are given in Table 3. Position of fence is especially important for migrating reptiles and amphibians. Fences set parallel to diverse habitat boundaries are more likely to pick up migrating animals than those set perpendicular to them, as animals are often moving across vegetation gradients (i.e., into or out of ponds, marshes, nesting grounds, and hibernacula). At Portage A, the northern marsh side of line 2 produced only 19 snakes, while the upland side had 48. However, line 3, set perpendicular to line 2, showed no difference in the number of snakes on either side of the fence (Fig. 7).

The catches of amphibians from the same fences, however, differed. Line 2 had no difference in the number caught on either side (40 vs. 49), but on line 3, 68 amphibians were caught

Table 2. *Comparison of numbers of animals caught in a 5-month period with 30-m and 15-m lengths of drift fence at the Portage site.*

	Lines 2 & 3		Line 4		Lines 9 & 10	
	30 m	15 m	30 m	15 m	30 m	15 m
Snakes	76	20	38	23	9	9
Turtles	7	2	4	0	1	1
Frogs and toads	90	83	49	22	20	14
Total	173	105	91	45	30	24
Animals/m	6	7	3	3	1	1.5

Table 3. *Differences between catches of selected groups of reptiles on different sampling lines in three similar habitats in southern Wisconsin.*

Location and group	Line number				
	1	2	3	4	5
Blue River					
Elaphe vulpina	4	0	–	–	–
Heterodon	3	0	–	–	–
Chrysemys	14	0	–	–	–
Emydoidea	7	0	–	–	–
Cnemidophorus	108	58	–	–	–
Portage					
Ophisaurus	–	–	–	2	0
Spring Green					
Cnemidophorus	10	0	0	2	13

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on the east side and only 16 on the west side (29 of the 68 were *Rana pipiens* 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 is on the west side of the fence.

At Portage B, line 5 showed no side bias for snakes or amphibians; line 4 had no side bias for snakes, but 18 of 21 amphibians were caught on the west side of the fence (Fig. 8). These examples show the importance of fixed migration patterns and the necessity for fences to be set as barriers in all directions to obtain the best sample.

Spring migrations of *Bufo* were obvious at both Shaw Marsh and Busse Tract. Catches at Shaw Marsh (Fig. 5) on 17 May indicated a definite movement towards the marsh. Thirty-four, 11, and 11 *Bufo* were caught on the sides of lines A, B, and C that faced away from the marsh, whereas 0, 6, and 5 were caught on sides nearest the marsh. The Busse woods (Fig. 6) showed the same phenomenon the same day—40 *Bufo* were caught on the eastern woods side of line A and 9 on the marsh side, and 19 *Bufo* were caught on the southeastern woods side of line B and 6 on the marsh side.

The Busse Tract also showed the desirability of placing several fences in different areas. On 9 July no amphibians were caught on line B in the woods, but 37 *Bufo* were caught on line A, all on the marsh side of the fence (all newly transformed young dispersing from the breeding ponds).

Types of Traps

Six different types of traps were set along drift fences to determine which were most effective and efficient (Table 4). Different kinds of reptiles and amphibians showed strikingly different responses to the various trap types.

Funnel traps were clearly more effective for catching lizards than pit traps. Of the pit traps, 18.9-L and 7.6-L traps with funnel rims were more effective than the 7.6-L traps without funnel rims (generally twice as many lizards caught) or 3.8-L traps with funnel rims.

Funnel traps were also effective for catching snakes. At Blue River, nine snakes, most over 40 cm, two over 1.2 m, were caught in funnel traps. Only one larger than 19 cm was caught in a pit trap. Similarly, in the Portage old field, all seven snakes over 40 cm were caught in funnel traps. The 18.9-L cans were superior to the 7.6-L cans. The 3.8-L cans with funnel rims were also ineffective for snakes. Salamanders and frogs were rarely caught in funnel traps, but pitfalls were effective. Amphibians were caught in similar numbers in 7.6 and 18.9-L rimless pit traps, tested at the Portage sites. The 3.8-L cans with funnel rims caught a negligible number of amphibians. At the woodland pond site at Portage, the use of 3.8-L traps with funnel rims vs. 7.6-L traps without funnel rims was tested; the 7.6-L traps caught almost 10 times as many amphibians as the 3.8-L traps with funnel rims. Adult green frogs were observed at Blue River escaping from 7.6-L traps without funnel rims, but not out of the same sized traps with rims. However, 7.6-L traps without funnel rims worked well for juvenile frogs.

There was no difference in the catchability of frogs and toads between 3.8, 7.6, and 18.9-L pit traps, all without funnel rims, at the Busse Tract, but at Shaw Marsh there was a much higher catch in the 3.8-L traps. Although there were numerous tree frogs calling at Portage in the spring, very few were collected. This may be due in part to the location of the majority of fences outside the woods, or to the ability of the frogs with their adhesive feet to crawl readily over fences and out of pit traps.

The 18.9-L cans are necessary for capturing large adult turtles. Fifteen of the 21 adult turtles caught at Blue River were in the four 18.9-L buckets. Four turtles fell into the 12 7.6-L cans and 2 jammed their shells into the 3.8-L cans with funnel rims. Portage showed a similar pattern: 9 turtles in 30 18.9-L, 11 in 26 7.6-L, and 3 in 10 3.8-L traps. Hatchling turtles at both areas fell readily into any size pit. They were caught in both 7.6 and 3.8-L traps with funnel rims at Portage line No. 6.

In summary, 18.9-L pit traps are necessary for trapping adult turtles and are highly effective for small snakes and amphibians and lizards. The 7.6 and 18.9-L traps were effective for frogs and lizards, but the addition of the funnel rim on the 7.6-L traps (Blue River and Spring Green) appeared to yield an even higher catch. Funnel traps are best for lizards and are the only suitable trap for large snakes. The 3.8-L cans were unsuitable, except for some hatchling turtles and toads. A system of 18.9-L traps, 7.6-L traps with funnel rims, and funnel traps seems

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Table 4. *Effectiveness of funnel traps and different sizes of pit traps set along drift fences for catching amphibians and reptiles.* Animals caught expressed as number caught/trap day × 100.

Animal group and area	Pit Traps					Funnel traps
	3.8 L	3.8 L (with funnel rims)	7.6 L	7.6 L (with funnel rims)	18.9 L	
Lizards						
Blue River (340–680 trap days)	–	4.5	3.1	7.2	6.5	16.4
Spring Green (80–800 trap days)	–	0.8	1.9	7.5	0	5.4
Snakes and Legless Lizards						
Portage (540–3,780 trap days)	–	0.3	0.6	–	4.6	2.4
Blue River (340–680 trap days)	–	0	0	0	0.2	2.6
Frogs and Toads						
Blue River (340–680 trap days)	–	0	0.5	2.1	1.7	0.2
Portage (540–3,780 trap days)	–	0.4	3.0	–	3.3	0.6
Shaw Marsh (288 trap days)	23.0	–	9.7	–	–	–
Busse Tract (96–192 trap days)	33.3	–	29.2	–	30.2	–
Salamanders						
Portage (540–3,780 trap days)	–	0.3	0.2	–	0.1	0.4
Turtles						
Portage (540–3,780 trap days)	–	0	0.2	–	0.3	0
Blue River (340–680 trap days)	–	0.3	0.8	0	4.4	0

necessary to capture the spectrum of amphibians and reptiles in a community, although tree frogs were not adequately sampled by any of our methods.

Effect of Weather and Season

Precipitation markedly affects the activity of amphibians and reptiles. In 1976, Wisconsin experienced the worst drought in 40 years. When there was rain, amphibians moved immediately (Fig. 15). For example, before the rain, 0-5 animals were caught per 2-day interval at Portage, and 1-2 at Busse Tract and Shaw Marsh. On 15-16 May, 3.8 cm of rain fell; the response was 12 animals at Portage (Fig. 15), 69 at Busse, and 67 at Shaw. At Point Beach on 4 October, 18 frogs and 1 salamander were caught; after 1.1 cm of rain on 5 October, 257 frogs and 7 salamanders were caught within 24 h. Similar responses to rain were noted at Blue River (Fig. 15).

Lizards and snakes, unlike amphibians, often moved about 2 to 3 days after precipitation, whenever temperatures rose. The 5 October rain at Portage produced 97 amphibians and reptiles (mostly frogs), but on 12 October, several days after the rain, the temperature rose and 38 snakes were caught.

Both rain and temperature affected not only estimates of the presence of species, but also determinations of population levels (26 June–5 July). The movement of lizards at Blue River was highly erratic, due primarily to the summer weather conditions. Drought and high temperatures forced lizards to remain underground for

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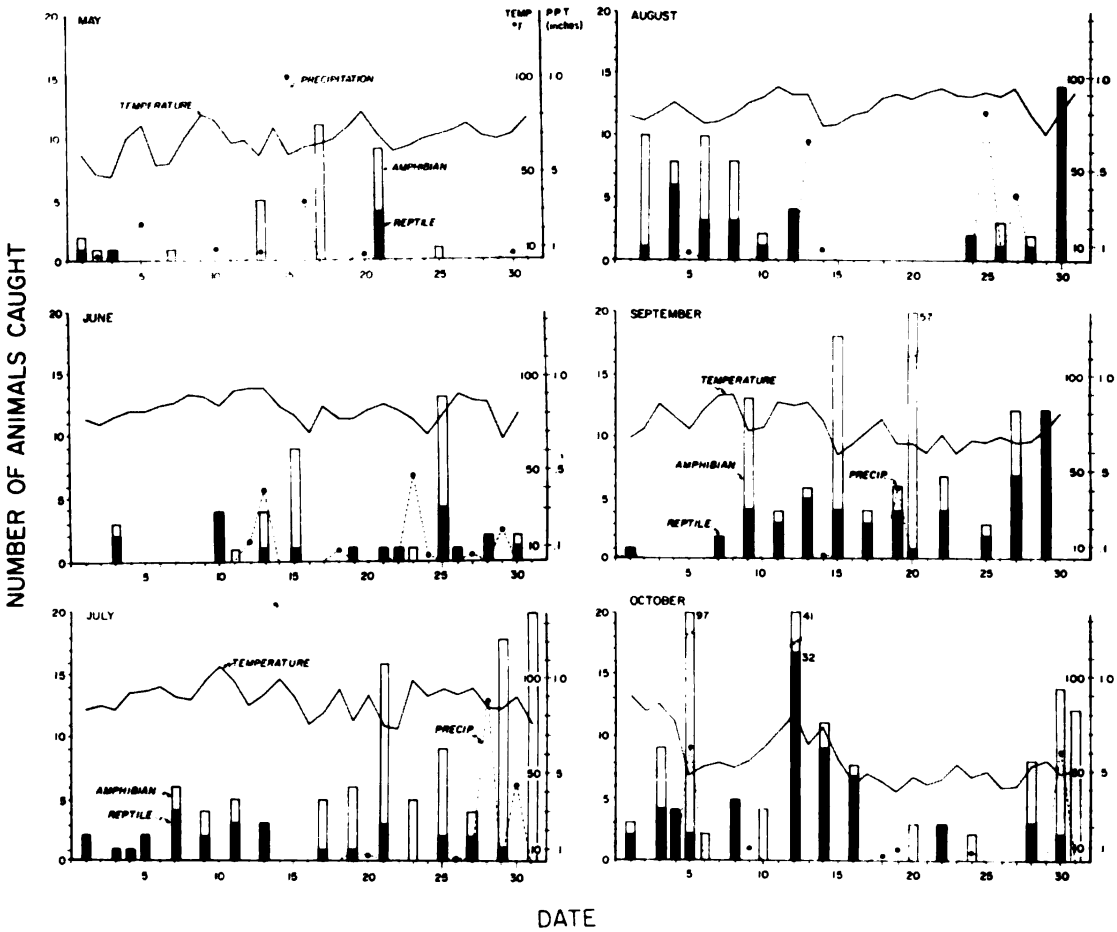

Fig. 15. Relation between catch of all reptiles and amphibians at Portage, Wisconsin, and precipitation and temperature.

days; after a rain, however, there was much more activity than normal, resulting in high population estimates (Fig. 16). A 4-day sample gave as accurate a population estimate as a 15-day sample. Normally, individual *Cnemidophorus* are active for a day or two of feeding, then retreat underground for a couple of days.

Spring and fall dispersal and migrations are also responsible for increased activity. At Blue River in mid-August there was an abrupt rise in the catch of lizards (Fig. 16). Most of these were hatchlings just emerging. Although the adults became inactive for the year at this time, the young remained active until mid-September.

Post-metamorphic migrations of toads were seen on the Busse Tract in early July, when 38 toads were caught along one side of a drift fence in 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, presumably wandering away from their place of birth.

Amphibians and reptiles move to winter hibernacula in September and October. At Portage, more animals were caught in the fall following rain than in summer under similar conditions. In August and September, hatchling turtles were caught moving from the nesting sites to water.

Many species of salamanders spend most of their time underground or under cover, and their presence is usually known only during dispersal or migration times. This was apparent at Portage, where the only two *Ambystoma tigrinum* recorded were caught in late fall. Turtles caught at Portage and Blue River were aquatic, but females must come to land to lay eggs from late May to early July.

High numbers of amphibians and reptiles

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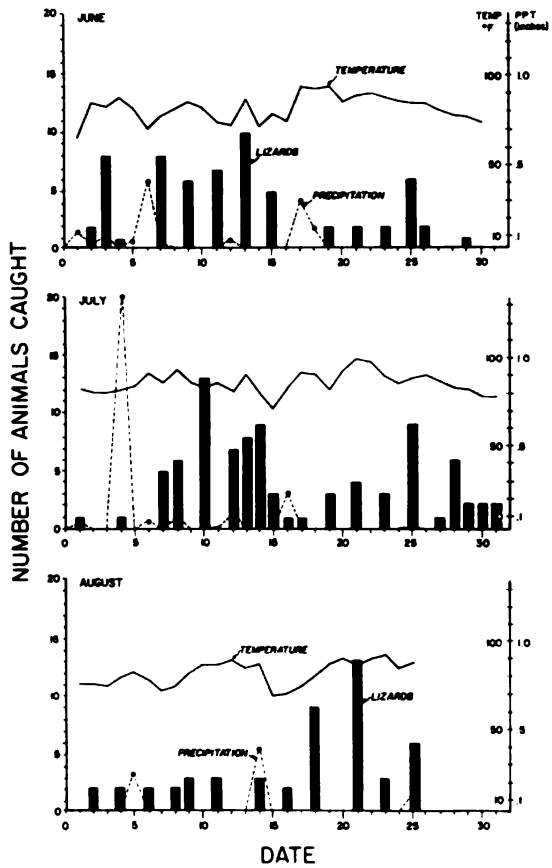

Fig. 16. Relation between catch of *Cnemidophorus* at Blue River and precipitation and temperature.

caught after spring and fall rains may not necessarily indicate large populations in the habitat where they are caught. They often travel a mile or more from summer foraging grounds to winter hibernacula, and many unsuitable foraging areas are often traversed enroute. Better estimates of the number of snakes, lizards, or frogs in a particular habitat can be obtained in June and July, after the spring migrations and before the appearance of young.

Length of Trapping Period

Because of seasonal activity, staggered reproductive strategies, and migration patterns, it is impossible to adequately sample all species present in an area at the same time. Thus, the length of time necessary to obtain a good estimate of the diversity of animals present is an important factor in evaluating any census method.

Density and diversity of frogs, snakes, and turtles at Portage and turtles at Blue River were high and the trapping periods long; thus the trapping time needed to show species composition and abundance at different seasons could be determined by examining the catch over the entire period. At Portage, drift fences were in operation for 162 days, but only 3-5 continuous days of trapping during optimum weather conditions were needed to capture the most common species of reptiles and amphibians.

The three most common species of turtles were taken in 3 days during the laying season in June at Portage. The fourth species, *Trionyx spiniferus*, was not caught in the nesting season but was taken during the August posthatching dispersal. In 2 days at Blue River, two of the four species of turtles known to nest in this area were caught. The other two never appeared, but they are less common.

In mid-summer, 1 to 3 months of continuous trapping were required at each trapline at Portage to take the four common species of snakes, whereas the same four species were caught in 1 to 4 days in September and October. Summer trapping of the three common species of frogs at the Portage sites required over 1 month, whereas all three were often caught on a single day or at least within 3 days in September and October.

Racerunner population estimates were made with the Jolly stochastic model (Jolly 1965). Catches for 4-day intervals from 30 May to 28 July ranged from 0 to 75, whereas those from three 15-day intervals ranged from 29 to 60 during that time. Omitting the two periods of no catches yields a 4-day interval range of 22 to 75, which is roughly comparable with the estimate given by 15-day intervals.

The catch of all species over the months of trapping in this study showed many periods of low or no success. Since movement normally is associated with favorable weather and migration activity, several short sampling periods staggered throughout the season should give a

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better estimate of species composition and populations than a longer period at any one time.

Overall Effectiveness

Overall effectiveness of the fence-trap systems was measured through comparison of catches in areas of known species composition and in areas which were being sampled by other methods. The species composition at the Portage sites has been known from 5 years of searching. All these species at Portage were also taken through drift fence trapping. Also, two species (the glass lizard and tiger salamander) that were recorded in previous years only near Portage were also trapped by drift fences.

At Point Beach, in 5 days of trapping without rain, 3 of the 10 known species of amphibians in the forest were caught. In 5 days, during which a rain occurred, 6 of the 10 were caught. Of the two species not caught by traps, one is normally uncommon and the other was uncommon because of the drought.

The drought conditions apparently affected the sampling at Spring Green. In 2 months of trapping, only 2 of the 12 known species of reptiles in this area were caught. In 15 h of intensive searching in the area during the summer, however, only three species were found.

Two of our study areas were being studied by other researchers. At Long Lake, B. Hellmich (personal communication) marked 420 leopard frogs from 1 April to 10 September. Nearly all of these were caught in an alfalfa field rather than in a marsh, and he estimated the population to be 4,004 individuals. Although about 75 leopard frogs were seen in the alfalfa field at the time the fence-trap systems were set up in the adjacent marsh, only four were caught in two 6-day trapping periods. This illustrates the need of setting several fences throughout an area in various habitats. Hellmich also saw about 20 toads, 30 green frogs, and 70 wood frogs (mostly in the marsh) in the area. While trapping in each of the two 6-day intervals, we caught 3 of the 4 anuran species known from the area. Thus the use of drift fencing to determine species composition appears to be effective.

Before the trapping system was set at Point Beach, all the *Rana sylvatica* were censused in two 9 × 27-m areas by walking back and forth and counting frogs. In 2 h and 46 min, 120 *R. sylvatica*, mostly juveniles, were found in area A and two in area B. Drift fence line A (30 m) produced 75 *R. sylvatica* and line B (15 m) produced 20. The difference between the catches and the frog counting represents time-of-day bias. Counting was done from 1512-1758 CDT, whereas the traps were open for 24 h. When a trained person walked back and forth across the quadrat, more frogs were seen, but some of them could have been counted more than once. The drift fence was stationary and caught only the frogs moving to it. Collecting proceeded 24 h/day with little effort after the initial set-up, and with little observer bias. Therefore, many areas can be compared by different people during the same time span and relatively comparable data can be obtained.

Population estimates (Jolly 1965) of the number of six-lined racerunners caught at line 2 at Blue River ranged from 0 to 75 ($\bar{x}$ = 36) for 11 4-day intervals. This compares with 45 *Cnemidophorus* caught by the fence during the same time period. If the two 4-day periods when population estimates were zero due to severe weather conditions are eliminated, then the mean population estimate corresponds closely to the actual number caught over the summer (45 compared to $\bar{x}$ = 44 estimated).

The transect of 10 funnel traps set perpendicular to Blue River fence No. 2 caught marked animals a maximum of 20 m from the fence. Since the next traps were 40 m on each side of the fence, these results suggest that a drift fence collects from an area less than 80 m wide for relatively sedentary species such as *Cnemidophorus*. Funnel traps without drift fences were effective for capturing *Cnemidophorus:* 36 captures in 10 traps over a 41-day period compared with 45 in 60 m of fence with 12 traps. Funnel traps without fences seem to be an effective way of sampling some lizard populations. Further trapping is needed to compare population estimates.

Manpower and Cost

The most time-consuming part of running drift fences is set-up time. It took two people 1½ h each to establish 30 m of aluminum fence with 8 pit traps and 2 funnel traps. A dozen animals were removed and marked from 15 m of fence in 5-10 min. Even when large numbers of

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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 h. Distance between traplines dictated the number which could be checked per day. A site with a total of 90 m of fence would require ½ day to set up, and could be checked in less than 1 h by one person; moreover, if the sites were less than an hour apart, four sites could easily be done per day.

Once the fence was established, it was convenient to leave it open only during ideal weather conditions, particularly when several sites 25-50 km apart are being monitored. 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 min. The initial cost was about $50 for 30 m of fence with traps. However, the fence can be used for many areas. Operating cost for eight sites would be about $1,200 for an entire season.

Recommended Procedures

Materials

Although somewhat more costly and heavier to carry than screening, aluminum valley seems to be the best fence material. It should be more economical over longer periods since it is far more durable than screen. Hardware cloth was not used because of the same disadvantages of the screen and it costs as much as aluminum valley. C. R. Shoop (personal communication) has been using a plastic-coated screen successfully for salamanders in Massachusetts. It is lighter than aluminum and less expensive, but its durability needs testing.

The following materials are recommended for fencing and traps: aluminum valley (or flashing), 1-m angle iron stakes (two per fence line), 18.9-L plastic ice cream buckets with lids, 7.6-L cans with funnel rims (Fig. 1) and lids, and two-door funnel traps (Fig. 2).

Time of Trapping

Season

In Wisconsin, from 1 April through 15 June, all of the species of reptiles and amphibians using a terrestrial habitat may be expected to be active. Trapping in the early part of April is necessary to collect many terrestrial and fossorial salamanders (*Ambystoma maculatum*, *A. laterale*, *A. tremblayi*, and *A. tigrinum*). A trapping period in early September will also produce these species when the young are leaving the ponds. However, in dry years, reproduction may not be successful, and a fall trapping period would not be necessary.

Trapping in late April–early May yields fewer species of salamanders, but most species of frogs and many snakes are moving. In late May, most species of snakes and lizards may be caught, but fewer species of frogs and salamanders. During the first 2 weeks of June, turtles begin to nest.

For a complete assessment of the herpetological community, at least four trapping periods of 3 to 5 days each coinciding with rain in early April, late April–early May, and late May and mid-June are recommended. The following exceptions apply if the area to be censused is farther than 3 km from water: (1) the June trapping period is not necessary because turtles seldom go that far in search of a nesting site; and (2) the early April trapping and late April–early May periods are not needed because salamanders and frogs seldom move more than 3 km between breeding sites and summer home ranges.

Weather

Drift fences may be put in at any time, but traps should be kept closed until rain is expected. The most productive trapping period for amphibians is in the 24 h after a rain starts. They will be active on the surface while temperatures are greater than 4° C.

In Wisconsin, snakes and lizards become active after rains when air temperatures reach 21° C or higher. Overcast humid days above 15° C are ideal for catching aquatic turtles in terrestrial habitats.

Habitat Assessment

This section presents a simplified method for evaluating the habitat characteristics in the sample area and the types of reptiles and amphibians that might be present. This evaluation is necessary for proper trap selection and placement. The analysis is specific to the northern midwestern states, but it can be modified for any site.

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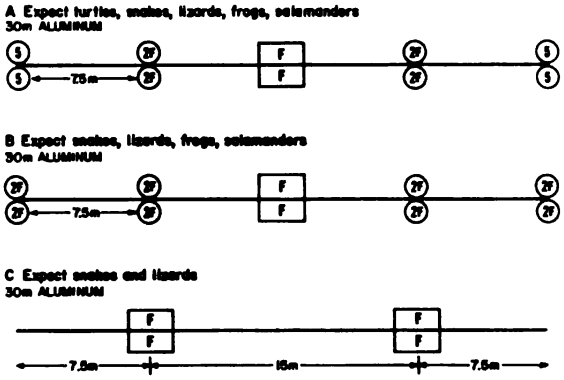

Fig. 17. Type and placement of traps dictated by expectation of catch based on habitat assessment. The symbols 5, 2F, and F refer to the positions of 18.9-L pit traps, 7.6-L pit traps with funnels, and funnel traps.

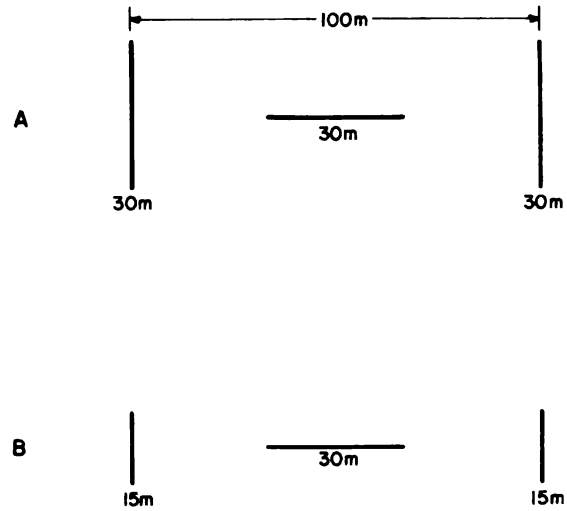

Fig. 18. Proposed placement of drift fences.

If an area is within 3 km of permanent water, expect all major groups of reptiles and amphibians (Fig. 17A). If the area is farther than 3 km from permanent water but within 3 km of temporary ponds, marshes, or streams, or if the area is heavily wooded, expect snakes, lizards, frogs, and salamanders (Fig. 17B). If a prairie, old field, or savannah is more than 3 km from any open water, either permanent or temporary, expect only snakes and lizards (Fig. 17C).

Position and Length of Fence Line

At least two 30-m lengths of fence with traps should be placed 100 m apart parallel to the vegetation gradient and another 30 m set perpendicular to and halfway between the other two lines (Fig. 18A). If two adjoining habitat types are being assessed, a 30-m fence parallel to the habitat gradient and another 30-m fence perpendicular to the gradient is needed in each area to show the difference between use of an area as a home range and use of an area as a migratory corridor. In situations where the width of the habitat does not allow 30-m lengths of fence to be used, 15-m lengths on either side of the line parallel to the strip can be used (Fig. 18B). Areas which are less than 15 m wide need not have any perpendicular fences.

Installation

It is recommended that V-shaped trenches for the fence lines be about 10 cm deep and about 15 cm wide. A wedge of earth can be removed and then replaced firmly in the trench. One side of the trench should be vertical for a tight fit with the fence. The aluminum can be easily cut and bent to go around logs, rocks, or tree roots (Fig. 3). Mounds of soil and rocks can then be placed over those sections to hold them firmly in place. If more than one roll of aluminum is used, they can be joined together by a strip of duct tape on each side after overlapping the aluminum 6-8 cm.

If weather conditions are right for immediate trapping, 2.5 cm of water should be placed in each pit trap. The water prevents dehydration and also kills ants, beetles, shrews, and mice which might otherwise kill or injure other small animals. Holes drilled 2.5 cm up on the sides of the can allow overflow. Digging the pit slightly deeper in the center leaves a cavity for excess water to drain, preventing rain from filling cans and allowing escapes. A wet piece of cloth should be placed in funnel traps to prevent desiccation of the specimens.

Operation

Traplines should be open continuously for the 3- to 5-day trapping period and checked at least every other day. They should be checked within 24 h after heavy rains because of the likelihood of increased animal movement as well as the accumulation of water in the traps. Animals should be removed, identified, and, if necessary,

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measured, tallied, marked, and released 2 or 3 m away on the opposite side of the fence.

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Appendix

Common and scientific names of reptiles and amphibians cited in text or taken during study in southern Wisconsin.

REPTILES

Turtles	
Snapping turtle	*Chelydra serpentina*
Blanding's turtle	*Emydoidea blandingi*
Ornate box turtle	*Terrapene ornata*
Painted turtle	*Chrysemys picta*
Map turtle	*Graptemys geographica*
Spiny soft-shell turtle	*Trionyx spiniferus*
Lizards	
Glass lizard	*Ophisaurus attenuatus*
Six-lined racerunner	*Cnemidophorus sexlineatus*
Snakes	
Hognose snake	*Heterodon platyrhinos*
Smooth green snake	*Opheodrys vernalis*
Blue racer	*Coluber constrictor*
Black rat snake	*Elaphe obsoleta*
Fox snake	*E. vulpina*
Bull snake	*Pituophis melanoleucus*
Milk snake	*Lampropeltis triangulum*
Prairie garter snake	*Thamnophis radix*
Eastern garter snake	*T. sirtalis*
Brown snake	*Storeria dekayi*
Red-bellied snake	*S. occipitomaculata*

AMPHIBIANS

Caudates	
Blue-spotted salamander	*Ambystoma laterale*
Spotted salamander	*A. maculatum*
Tiger salamander	*A. tigrinum*
Central newt	*Notophthalmus viridescens*
Red-backed salamander	*Plethodon cinereus*
Anurans	
American toad	*Bufo americanus*
Cricket frog	*Acris crepitans*
Western chorus frog	*Pseudacris triseriata*
Northern gray tree frog	*Hyla versicolor*
Cope's gray tree frog	*H. chrysoscelis*
Spring peeper	*H. crucifer*
Bull frog	*Rana catesbeiana*
Green frog	*R. clamitans*
Leopard frog	*R. pipiens*
Wood frog	*R. sylvatica*

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