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Drift fences, coverboards, and other traps

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13.1 Introduction

Many of the simplest yet most highly productive sampling methods in herpetological field research use some type of trap or attraction device to increase capture rates or target secretive species. These techniques fall into two general categories: those that actually trap animals, accumulating captures on their own over time (passive traps) and those that attract animals but require an observer to actively capture them at the moment of the census (active traps). The most popular examples of these two trap categories are drift fences (generally with pitfall and/or funnel traps) and coverboards, respectively. Both of these methods are inherently simple concepts, and their description and explanation need not be made complex or complicated. Both techniques are usually best modified by the investigator who can use common sense to focus on the needs of a particular project that involves capturing animals in a field situation. However, we provide a general discussion of some of the fundamental issues that investigators who use these techniques must face, with particular emphasis on how choice of capture method and sampling design influence interpretation of capture data.

13.2 Drift fences, funnel traps, and other passive capture methods

13.2.1 What are passive traps?

Passive capture methods are designed to restrain animals that enter the trap of their own accord, accumulating captures that are then assessed upon regular censuses by the observer. Passive traps are among the more intensive methods for sampling amphibians in terms of time and effort, but often yield higher capture rates and more standardized samples than opportunistic or visual searches. Perhaps

most importantly, passive traps are the most effective ways to sample many rare or secretive amphibian species, many of which are of conservation concern.

A huge variety of passive amphibian traps have been developed for nearly any imaginable habitat or situation; however, nearly all are variants on two basic trap types, the funnel trap and the pitfall trap. Funnel traps consist of a tapering funnel-shaped entrance that guides animals into a larger holding chamber (Figure 13.1). Once within the chamber, animals are unable to find their way back out the small entrance hole, becoming trapped. Pitfall traps work on a similar principle, consisting of some type of container that is sunk into the ground, with the rim level with the surface (Figure 13.2). Animals that fall into pitfalls are unable to climb out, becoming trapped. First described for use with herpetofauna by Gibbons and Bennett (1974) and Gibbons and Semlitsch (1981), drift fences are vertical barriers that intercept the intended trajectory of amphibians moving from one location to another. The fence typically guides animals toward a pitfall bucket, funnel trap, or other capture device (Figure 13.2). In most terrestrial and some aquatic situations, drift fences dramatically increase amphibian capture rates (Friend *et al.* 1989) and, under some circumstances, have been responsible for more amphibian captures per day, month, year, or decade than any other method used in field studies of amphibians (Pechmann *et al.* 1991; Gibbons *et al.* 2006). Although drift
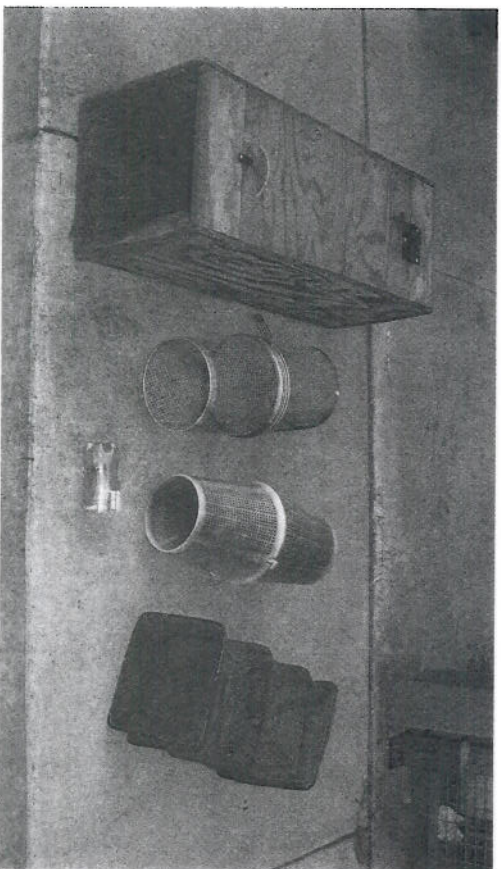

Fig. 13.1 Several varieties of funnel trap are commonly used to sample amphibians in terrestrial and aquatic habitats. Front: soft-drink bottle funnel trap; back (left to right): plywood and hardware cloth box trap, steel "Gee" minnow trap, plastic minnow trap, and collapsible nylon trap. Photograph by John Willson, Savannah River Ecology Laboratory.

fences have been used most extensively in the southeastern USA, they have proven effective for many amphibian species worldwide (e.g. Gittins 1983; Friend 1984; Bury and Corn 1987; Friend *et al.* 1989; Jehle *et al.* 1995; Weddeling *et al.* 2004). However, drift fences were relatively ineffective for sampling anurans in forests of Queensland, Australia (Parris *et al.* 1999) and recorded lower numbers of anuran species than automated recording devices or nocturnal line-transect surveys in Taiwan (Hsu *et al.* 1985).

13.2.2 How are passive traps constructed, aligned, and monitored?

Funnel traps can be nearly any size and have been constructed of a variety of materials including twine netting, hardware cloth, window screen, nylon mesh, plywood, PVC pipe, and plastic soft-drinks bottles (Figure 13.1; Griffiths 1985; Shaffer *et al.* 1994; Adams *et al.* 1997; Buech and Egeland 2002; Willson *et al.* 2005). The wide range of funnel trap variants makes them effective for most species in nearly any habitat, aquatic or terrestrial. Likewise, pitfalls can be any size from small coffee cans to multi-gallon drums, but must be sufficiently deep to prevent escape of the target species. Pitfall traps are typically metal or plastic. Several studies have been conducted weighing the strengths and weaknesses of different trap types for various amphibian species (e.g. Vogt and Hine 1982; Friend 1984; Friend *et al.* 1989; Mitchell *et al.* 1993; Greenberg *et al.* 1994; Enge 2001; Ryan *et al.* 2002; Stevens and Paszkowski 2005; Todd *et al.* 2007), and we refer readers to these sources rather than discussing the merits of each trap type in detail here.
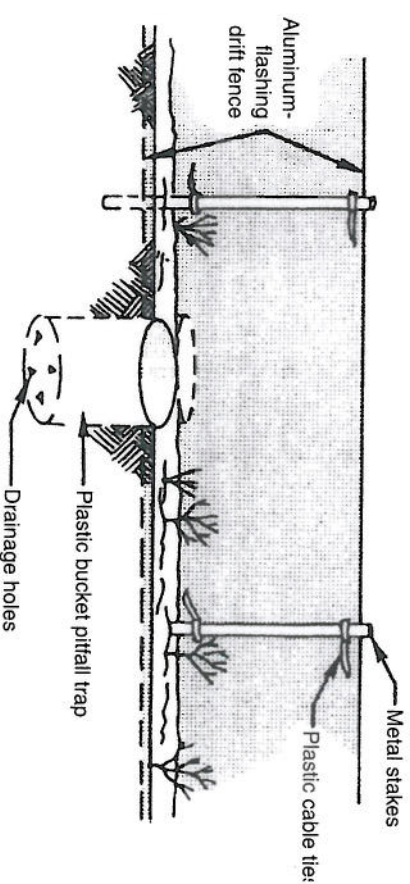

Fig. 13.2 Schematic of a terrestrial drift fence with large pitfall traps. Figure reprinted from Gibbons and Semlitsch (1981).

The evolution of the drift-fence technique in herpetology has resulted in the use of a variety of construction materials for the fence, including chicken wire, hardware cloth, aluminum flashing, stiff plastic, and erosion/silt fencing (Gibbons and Bennett 1974; Dodd and Scott 1994; Enge 1997a). Likewise, habitat constraints and the traits of particular target species have given rise to a variety of suggestions for the alignment of fencing within the habitat and an endless array of configurations of fences and traps is possible (see Corn 1994; Dodd and Scott 1994; Rice et al. 2006). No single construction material or trap type is universally "the best" because of several factors whose importance will vary depending upon the particular project. Among the issues that must be considered are goals of the study and how the data will be analyzed, the cost and availability of materials, anticipated longevity of the project and maintenance effort required, the size and behavior of target species, potential safeguards against predators, and the terrain and topography of the habitat itself. Mechanisms to minimize trespass by climbing species, drowning of captured individuals in buckets or dehydration in buckets or funnel traps, and predation by a variety of species continue to be developed to address specific situations. Rather than dictate what the most effective materials and trap configuration should be, we recommend that the investigator tailor drift-fence applications on the basis of budgets, time availability, and the general goals and specific objectives of the project. Following are examples of how differing goals can temper the style of fencing and type of traps.

First, perhaps the situation for which drift fences are most commonly employed is to intercept wetland-breeding amphibians as they undertake seasonal breeding migrations between terrestrial refugia and aquatic breeding sites (Figure 13.3a; e.g. Gittins 1983; Pechmann et al. 1991; Dodd and Scott 1994; Arntzen et al. 1995; Weddeling et al. 2004). In these applications the wetland could be completely encircled by a drift fence, allowing enumeration of the entire annual breeding population at that site. Alternatively, if the wetland is large or if resources are limited, smaller partial sections of drift fence could be placed at intervals around all or part of the aquatic/terrestrial interface (Figure 13.3a). Some studies have used concentric circular drift fences to monitor terrestrial dispersal of pond-breeding salamanders away from wetlands (Johnson 2003). Trap types used to monitor pond-breeding amphibians could vary depending on the target species. For studies focusing solely on ambystomatid salamanders, for example, small, coffee-can-sized pitfalls would be sufficient to capture individuals of all species, including the largest (Ambystoma tigrinum; Gibbons et al. 2006). Large plastic buckets, however,
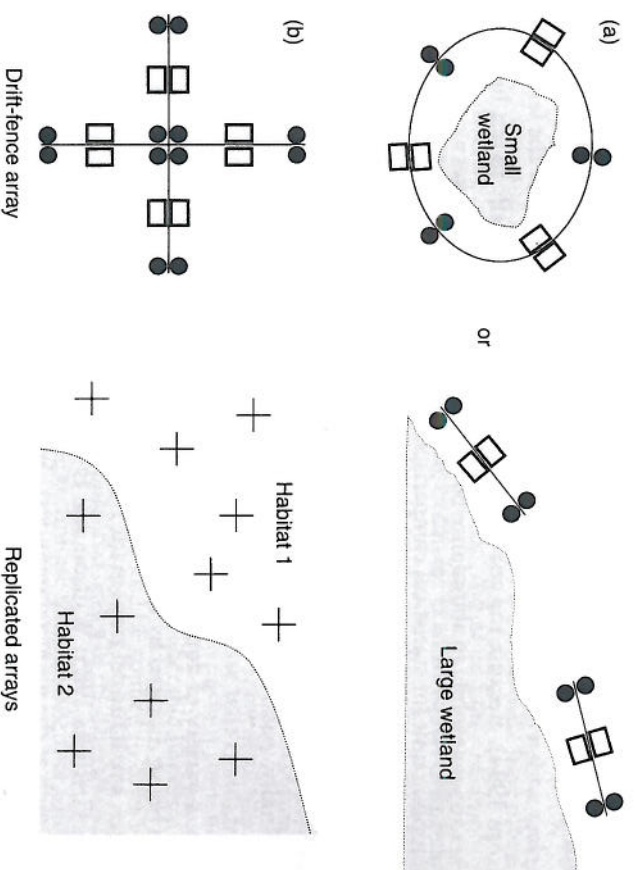
Drift-fence array

Replicated arrays

Fig. 13.3 Examples of drift-fence and passive-trap configurations used to address different research questions. Solid lines represent sections of drift fence, filled circles represent pitfalls, and open rectangles represent funnel traps. (a) Drift-fence configurations used to sample pond-breeding amphibians migrating to and from wetland breeding sites; (b) a drift-fence array pattern designed to compare amphibian abundance across two habitat types.

would be necessary to capture high numbers of most species, especially larger anurans (e.g. ranid frogs and toads) that could jump out of a smaller can (Mitchell et al. 1993). Larger buckets also increase the time that climbing hylids and microhylids are likely to remain within the trap. In some situations, funnel traps are the best single trap type for capturing many amphibian species (Enge 2001; Todd et al. 2007); however, funnel traps are generally more costly to construct, more time-consuming to maintain, and more prone to desiccating captured amphibians than are pitfalls. In nearly all situations, a combination of trap types (e.g. alternating large pitfalls and funnel traps) will produce the best possible assessment of the entire amphibian community (Vogt and Hine 1982; Greenberg et al. 1994; Todd et al. 2007).

Second, another common application of drift fences in terrestrial habitats is to compare abundances of amphibians in different areas (Figure 13.3b; e.g. habitat types, experimental treatments). In such cases, fences are generally located far

from any obvious breeding wetland, hibernaculum, or other habitat focal point. For such applications, drift fences are often constructed in cross- or X-shaped arrays with a central trap and traps placed along each section of the fence (see Corn 1994). Because the goal of this type of study is generally to test hypotheses about amphibian abundance between areas, each array makes a convenient sampling unit for statistical comparisons. In this case, care should be taken to ensure that arrays are comparable (same length of fencing, number of traps, etc.) and that arrays are located randomly or systematically across the treatments or habitats.

Finally, passive traps can be used for quantitative sampling of aquatic amphibians that are not easily captured by other methods. For this application, a variety of aquatic funnel traps can be effective, with the size of the trap being dictated by the size of the target species. For small species or life stages, small funnel traps made from plastic soft-drinks bottles would suffice (e.g. Griffiths 1985; Willson and Dorcas 2003), while targeting larger species such at the giant salamanders, *Siren* and *Amphiuma*, would require larger traps such as commercially available minnow or crawfish traps (Johnson and Barichivich 2004; Willson *et al.* 2005). In most cases, aquatic traps should be set in water shallow enough to allow captured animals access to air and care should be taken to monitor fluctuations in water level that could submerge traps. Specific microhabitats where traps are set will vary by species, but heavily vegetated shallow areas are often preferable. Capture rates may also be increased by setting aquatic traps along natural barriers such as submerged logs or the shoreline or by the use of aquatic drift fences to direct amphibians into traps (Enge 1997b; Willson and Dorcas 2004; Palis *et al.* 2007). Finally, as in the previous example, traps may be set in any number of spatial configurations. Often a simple linear transect along a shoreline is sufficient. However, if the goal of the study is to compare captures statistically across different treatments (habitats, wetlands, etc.) standardized arrays of traps can be set that will serve as the sampling units in statistical comparisons.

Passive traps restrain captured animals, so frequent (generally at least daily) monitoring of traps is necessary to avoid mortality of captured animals. During hot or dry periods it is often advisable to provide access to moisture (e.g. a water bowl or damp sponge) within traps to avoid desiccation of captured animals. Finally, natural amphibian predators such as mid-sized mammals, birds, and large snakes often learn to target drift fences, and predator-control measures (raised covers for pitfalls, live-trapping and removal, or wide-width steel mesh trap covers, etc.) may be necessary to avoid undue predation.

13.2.3 What can passive traps tell you? What can they not tell you?

Passive traps, especially when used in conjunction with drift fences, have proved highly effective for determining the distribution and abundance of amphibians both spatially and temporally. Many examples exist in which drift-fence captures revealed the presence of species that were rare or not even known to be present in an area, as well as providing a comparative assessment of annual and seasonal activity among species. Drift fences have also been used to capture large numbers of specific life stages of study species for laboratory experiments. The application of drift fences to a conservation effort was aptly demonstrated by Aresco (2005), who used silt fencing to create a barrier to prevent amphibians and reptiles from crossing a busy highway. Despite considerable hand-waving about the statistical approaches that could and should be applied to drift-fence data, as long as an investigator is aware of potential biases in the effectiveness of the fence and what is being revealed, the technique remains one that unquestionably can reveal natural history information about amphibians that may be unobtainable or unlikely to be discovered in any other way.

Generally, amphibians are only captured in passive traps when they are actively moving through the area where traps are deployed. Thus, the number of amphibians captured (often expressed as a rate, such as captures per trap per night) is ultimately a function of three major factors: (1) the density of animals within the area sampled, (2) the activity (movement) levels of those animals, and (3) the probability that an individual animal encountering a trap will be captured and not escape. Although trap capture rates can be extremely informative, consideration of all three factors is critical to interpreting capture data.

In situations where the population density of amphibians can be assumed to be relatively constant (e.g. within a single population over a fairly short time), most of the variation in capture rates can be assumed to be due to shifts in activity. Thus, drift fences have been instrumental in allowing investigators to identify seasonality and orientation of amphibian breeding migrations and environmental correlates of migratory activity (e.g. Semlitsch 1985; Semlitsch and Pechmann 1985; Phillips and Sexton 1989; Todd and Winne 2006). Likewise, when trap captures are pooled over relatively long intervals (e.g. seasons or years), thus minimizing short-term variation in activity due to environmental conditions, long-term shifts in abundance or activity can be assessed (e.g. Jehle *et al.* 1995). Ideally, studies wishing to use trap capture rates as abundance indices should test the assumption of equal catchability through mark–recapture, occupancy modeling, or similar methods (Chapter 24; Mazerolle *et al.* 2007). Additionally, marking captured animals allows the researcher to distinguish between novel

individuals and recaptures, improving census counts by eliminating multiple counts of the same individual animal (Weddeling *et al.* 2004).

Although it is often tempting to attempt interspecific comparisons of abundance using capture-rate data, such comparisons are nearly always tenuous, given that species often differ in seasonal timing of activity levels and vary in their susceptibility to being captured by a particular trap type. For example, some species, such as many hylid and microhylid frogs, are adept at climbing out of buckets and over fences, whereas even small pitfalls are highly effective for capturing many salamanders and terrestrial anurans (Friend *et al.* 1989; Dodd 1991; Enge 2001; Todd *et al.* 2007). Thus, it would clearly be inappropriate to conclude that because more salamanders were captured in drift fences, they were actually more abundant than treefrogs within the habitat. Some conservative interspecific comparisons of abundance are possible, however, given careful consideration of potential biases. For example, if a wetland were to be completely surrounded by a drift fence with large pitfalls for an entire breeding season, it would probably be safe to compare total annual breeding population sizes of ambystomatid salamander species using that wetland. However, Arntzen *et al.* (1995) demonstrated that even for relatively small terrestrial species (*Bufo bufo* and *Triturus cristatus*), drift-fence efficiencies (proportion of breeding population captured) were often low and varied between species.

13.3 Coverboards and other traps that require active capture

13.3.1 What are coverboards and other active traps?

Unlike passive traps such as funnel traps or pitfalls, some so-called traps do not actually restrain or capture animals, but instead concentrate free-ranging amphibians to facilitate their capture by an active observer (usually by hand). For example, a herpetologist may lay down boards or other artificial cover objects that attract amphibians and allow them to be captured without disturbing natural cover such as logs, rocks, or vegetation. Such active traps generally operate on the principle of creating optimal microhabitats for the target species, attracting animals that can then be collected more easily than would otherwise be possible.

Because many amphibians are partially or exclusively fossorial for much of their lives and most prefer moist habitats, coverboards and other artificial cover objects are the most widely used active traps for amphibians. Coverboards simply consist of sections of cover material, most commonly wood or metal, which

are placed on the ground in habitats preferred by target species. Coverboards act in the same way as natural-cover objects, trapping moisture and providing refugia for a variety of amphibian species. Amphibians are captured when an observer gently lifts the cover object and collects any animals observed hiding beneath. Because coverboards generally create moist subterranean microhabitats, this technique is most frequently used for amphibian species that prefer such habitats and include most terrestrial salamander species and some of the more fossorial anurans such as toads (e.g. *Bufo* and *Scaphiopus*) and microhylid frogs (e.g. *Gastrophryne*).

Other active capture methods have been developed, many for specific species or situations. One example is the use of PVC pipes for collecting hylid treefrogs (Moulton *et al.* 1996; Boughton *et al.* 2000). Pipes are placed vertically within the habitat, creating a moist arboreal microclimate favored by treefrogs for diurnal refugia. Pittman *et al.* (2008) used an extensive grid of PVC refugia within a wetland and surrounding upland habitats to document seasonal activity patterns, habitat use, and site fidelity in a North Carolina population of gray treefrogs (*Hyla chrysoscelis*). Additional examples of active traps include leaf-litter bags to aid in capture of aquatic salamanders and their larvae (Pauley and Little 1998; Waldron *et al.* 2003) and artificial pools to assess breeding activity of various anuran species (Resetarits and Wilbur 1991; Gascon 1994).

13.3.2 How are active traps constructed, aligned, and monitored?

Coverboards may be constructed from nearly any material and the most suitable material likely varies depending on the target species, research budget, habitat, and other characteristics of the study site (e.g. proximity to roads, terrain). For most amphibians, wooden boards are probably the best all-round option as they create moist conditions preferred by many species. Indeed, wood coverboards have been used in studies of a variety of woodland and stream-dwelling salamander species (Figure 13.4; Degraaf and Yamasaki 1992; Fellers and Drost 1994; Houze and Chandler 2002; Moore 2005; Luhring and Young 2006). Moore (2005) suggested using boards cut *in situ* from native trees for studying redback salamanders (*Plethodon cinereus*), providing a cost-effective coverboard option that can be used in habitats that are difficult to traverse. Although coverboards consisting of roofing tin or other metals are frequently used in reptile studies, these materials heat quickly and create conditions too hot and dry for amphibians in most situations. Indeed, Grant *et al.* (1992) found that amphibian captures in South Carolina were highest under plywood coverboards, while reptiles preferred tin. As most amphibian species are small,

boards generally need not be large, but at least one study reported a positive correlation between the size of coverboards and the number of salamanders captured per board (Moore 2005). Moreover, larger or thicker boards may be preferable in warm or dry habitats as they generally hold moisture better than smaller boards. One study conducted in southern Georgia, USA, noted lower amphibian captures under coverboards than natural-cover objects, presumably resulting from warmer and more variable temperatures under boards (Houze and Chandler 2002). As some time is often necessary for suitable microhabitats (e.g. rotten leaf litter, burrows) to develop under refugia, the investigator should consider allowing boards to "weather" for several weeks or months before amphibian censuses are initiated.

Construction of other active traps varies, but the general goal is to create microhabitat conditions that attract target amphibian species. For example, sections of PVC pipe may be inserted vertically into the ground or affixed to tree trunks to provide arboreal refugia for hylid treefrogs (Moulton et al. 1996; Boughton et al. 2000). Johnson (2005) described several modifications to the so-called hylid tube technique, maximizing standardization of microhabitat within tubes and increasing ease of census and frog capture.

Fig. 13.4 Example of a coverboard used to monitor woodland salamanders. Note that the low barrier around the board is part of an experiment and would normally not be used with coverboards used for general monitoring purposes. Photograph by Thomas Luhring, Savannah River Ecology Laboratory.

As uses of coverboards and other active traps vary, so will the designs for their placement. In general active traps should be placed in habitats that are favorable for amphibians, including well-shaded areas with abundant moisture. For species that breed in aquatic habitats, breeding sites may be the most appropriate places to maximize captures. For example, an obvious location to deploy PVC tubes for hylid frogs would be around the periphery of wetland breeding sites. The spatial distribution of active traps also depends on the goals of the study. For simple amphibian inventories (documenting species presence) or collecting individuals for use in the laboratory, placing devices haphazardly in the most optimal habitats is the most cost-effective method. For studies where statistical comparisons are to be made, replicated sampling units must be designated. In general, because captures per individual trap are low, arrays of several boards or other traps are usually designated as the sampling unit. An array can consist of any arbitrary number of traps, generally arranged in a systematic pattern (e.g. a grid or transect). Replicate arrays are then placed systematically or randomly within treatments. Ideally, a power analysis can be used to determine the number of arrays (sample size) that is needed to obtain sufficient statistical power for the analysis.

For example, a researcher might wish to compare salamander abundance across three forest types within a relatively small geographical area. Having determined that salamanders are generally fairly common (say, an average of one salamander found per five coverboards checked), an array of 10 coverboards, spaced 5 m apart in a linear transect, might be determined as the sampling unit. Geographic Information Systems (GIS) technology could then be used to generate randomized locations for five arrays to be placed within each of the three habitat types. Thus, the total number of boards to be used would be 150 (10 boards/array × 5 arrays per habitat treatment × 3 habitats) and the sample size would be five per treatment.

Unlike passive traps, active traps can be monitored on nearly any temporal schedule, and the timing of censuses will reflect the question of interest. Generally, as animals may remain within the same refuge for extended periods, allowing some time (e.g. a few days or a week) between censuses may minimize repeated counts of the same individual animal. Alternatively, animals may avoid boards that are disturbed too frequently; one study noted that salamander captures under coverboards that were checked daily were reduced compared to boards that were censused on longer time intervals (1 or 3 weeks; Marsh and Goicochea 2003). Similarly, when designing a monitoring scheme, care should be taken to make samples as repeatable as possible. This typically means that environmental conditions should be as comparable as possible

between samples, and many researchers set up environmental criteria for determining census times based on the biology of the study animal. For example, coverboard arrays might be checked once-weekly at 7–9 am on days without precipitation or only on nights with a temperature greater than 15°C and at least 1 cm of rain.

13.3.3 What can active traps tell you? What can they not tell you?

Coverboards and other active traps have several advantages as sampling methods for amphibians. First, in many cases, these are among the best methods for collecting large numbers of target species and can be the only ways to collect highly fossorial species or those that do not form breeding aggregations. Moreover, unlike passive traps, which require high-intensity monitoring on a daily basis to avoid mortality of captured animals, active traps can be monitored on a low-intensity or periodic basis because animals are not restrained and are not prone to accidental mortality or unnaturally high levels of predation. Also, because active traps generally concentrate animals into a highly searchable area (e.g. under a board, or in a PVC tube), these methods minimize the effects of observer bias, which can be substantial in other active capture methods such as visual searches. Finally, because artificial refugia are standardized for size and material, they create more repeatable microhabitats than natural-cover objects, yielding more standardized measures of abundance, and can be censused with minimal disturbance to the habitat (Heyer et al. 1994).

Because active traps yield high capture rates of target species, they can be useful for assessing patterns of abundance over time or space (e.g. population trends over time or variation in abundance across habitats). Generally, studies designed to investigate these types of questions compare capture rates among arrays of traps placed in different locations (e.g. two habitat types) or capture rates within an array or set of arrays over time. In these types of studies, the dependent variable is generally an index of relative abundance, typically the number of animals captured over some unit of time and effort (e.g. captures per array per census). However, as with any abundance index, data collected using these methods may be biased in a variety of ways, all of which must be considered when interpreting capture data.

The key assumption when comparing indices of relative abundance is that the capture probability of an individual animal is the same across arrays or time intervals. Thus, differences in capture rate among arrays reflect true differences in population density between sampling units. Although this assumption may be met in some situations, it is relatively easy to imagine situations where this

premise is violated. Perhaps the most obvious case where the equal catchability assumption is violated is when comparing capture rates among species, as noted for the drift-fence method. It is often the case, regardless of the sampling method, that some species are highly catchable, while others are seldom encountered. Thus, it is generally unreasonable to assume that simply because one species is captured more frequently than another, that it is truly more abundant. Likewise, differences in catchability across time are critical to consider in temporal comparisons and the potential for activity patterns to influence catchability must be considered when interpreting capture rates. For example, in warm climates, salamanders often retreat deep underground during the summer and are seldom captured using any method. In this case, low capture rates of salamanders in the summer are best explained by seasonal differences in catchability rather than by changes in actual abundance within the landscape. A growing body of literature uses mark–recapture or occupancy modeling to incorporate detection probability (catchability) in interpretations of amphibian abundance data (Chapter 24; Mazerolle et al. 2007). Ideally, any researcher wishing to use abundance indices as indicators of population size or density should consider using these methods to test the equal catchability assumption.

A final consideration when using active traps is the potential for use of these methods to actually improve the overall quality of the habitat for target species. For example, if one of the factors limiting population size in an amphibian species is availability of suitable refugia, adding boards, hylid tubes, or other artificial refugia to the habitat may permit an increase in population density. Although such a situation would probably be favorable in studies designed to conserve at-risk amphibian species, it is worth remembering that population densities estimated in areas with abundant artificial refugia may not necessarily be representative of those in unaltered habitats. To our knowledge the potential for artificial refugia to improve habitat quality for amphibians has not been addressed experimentally and warrants future investigation.

13.4 References

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