The Problem of Research on Endangered Species: Are Experiments on Proxy Species a Solution?

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Abstract: In many situations, it is not ethical or even feasible to test the effects of changes in habitat of rare or endangered species due to factors such as forestry or agricultural practices. Many of the measures for species' protection make the broad assumption that protecting particular kinds of habitats through Wildlife Habitat Areas or other provisions will be effective. In order to test these measures, we need to consider the use of direct experimental manipulations and the use of proxy species *in lieu* of the target species. We explore the idea of using proxy species, identify some of the traits that proxy species may share with rare and endangered species, and discuss some limitations of the proxy species approach. We also provide a framework for using proxy species and give three examples that illustrate the proxy species concept. The need to act before an endangered species continues to decline will necessitate careful thinking about creative ways to obtain information that may aid in conservation strategies.

Key Words: endangered species, proxy species, experimental manipulation, management

Introduction

Research on rare or endangered species can be problematic. Performing experiments on species with low population sizes raises ethical issues, and often, sample sizes are too low to allow for statistically rigorous testing. Faced with these problems, we must consider alternative ways of obtaining information that can aid in the development of management plans and recovery strategies. Conducting experiments using a common species that shares key life history traits with the rare or endangered species of interest is one possible solution; we term these species 'proxy species'. The choice of proxy species will be of great importance, but may be problematic in some cases. We provide a list of traits that proxy species might share with a target rare or endangered species, as well as a framework for using proxy species. We present three case studies to illustrate the general principles of using proxy species: the barred owl (*Strix varia*) as a proxy species for the northern spotted owl (*S. occidentalis caurina*); the northwestern salamander (*Ambystoma gracile*) as a proxy species for other coastal terrestrial amphibians; and common subspecies as proxy species for endangered subspecies. The use of proxy species, however, has limitations. For instance, appropriate proxy species may not be available for some endangered species that have unique life histories, and results of experiments on proxy species should be applied cautiously to the target endangered species. Despite these limitations, the need to act before an endangered species continues to decline will demand consideration about creative, and perhaps unconventional, ways of obtaining information necessary for tailoring management plans and refining recovery strategies.

Proxy Species: Traits, Use, and Limitations

Good proxy species will be sufficiently common that they will not be imperiled by research experiments, and key aspects of their life history will match those of the target rare or endangered species (hereafter ‘target species’). Choosing which aspects of their life history match will depend on the experiments planned, and may include one or more of the traits listed in Table 1. Proxy species may or may not be congeners of the target species, and they will not necessarily overlap in range with the target species.

Table 1. A list of traits that may be shared by a proxy species and a target rare or endangered species. The proxy species may share one or more of these traits with the target species depending on the experiment planned.

*Traits of Proxy Species**
• Similar habitat preferences
• Similar diet
• Similar demographic features
• Similar breeding season
• Similar breeding location (e.g., cavity nester, pond breeder)
• Similar predators
• Similar physiology
• May be congener
• Common species

*In reference to target rare or endangered species.

Observational studies on the target species are the starting point for any program where research on proxy species will be used (Fig. 1). These studies provide information on the general biology of the target species and permit generation of testable hypotheses about which factors the target species is most sensitive to in its natural habitat. Once a hypothesis has been chosen for experimental testing, a suitable proxy species is chosen based on key characteristics that it shares with the target species, and which relate to the hypothesis. For example, if it is hypothesized that prey availability in a certain habitat type causes declines in the target species, a proxy species with a similar diet and hunting mode would be chosen for an experiment. If a suitable proxy species is found, experiments can be conducted, such as placing the species in experimental enclosures in different habitat types or using radiotelemetry to assess its response to different habitats via movement patterns. The results of these studies can then be applied cautiously to the target species. This may involve enhancing habitat in marginal areas, increasing nesting sites, or improving habitat for prey populations. Although these applications appear to be common sense for any recovery effort, results of the proxy species experiments can help prioritize the applications based on what may be most crucial to the target species. This is advantageous when working with a finite recovery budget and limited time. After application of the results, observational studies on the target species can be carried out to monitor the response and generate additional hypotheses for testing as needed.

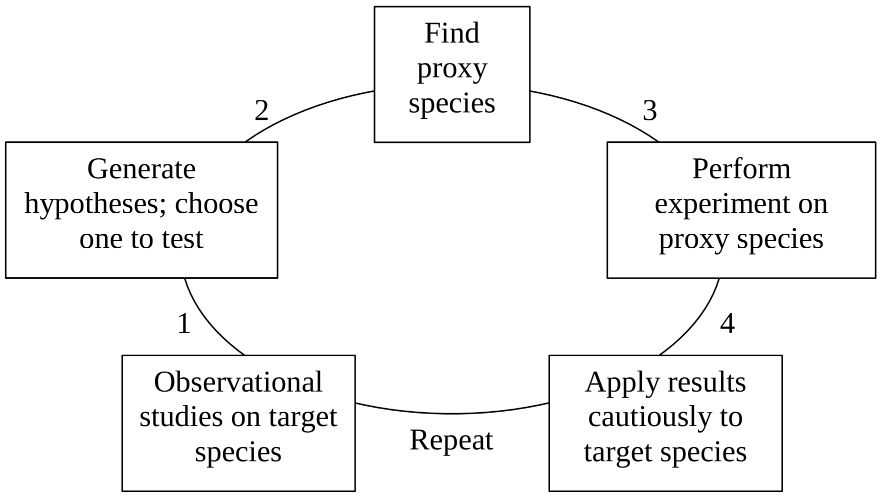

Figure 1. A framework for using proxy species. Numbers in diagram refer to step sequence.

Using proxy species has limitations that need to be acknowledged. In cases where the target species has a unique life history, it may not be possible to find a suitable proxy species for an experiment. In this case, research on the target species itself is the only option. Information gathered from a proxy species experiment should be applied cautiously to the target species. Conservative actions are warranted due to uncertainty about whether or not the target species would respond in the same way as the proxy species.

Case Studies

The following three case studies illustrate the principles of using proxy species. The first two case studies are specific to research in the Pacific Northwest; the third is more general.

Case Study 1—The Northern Spotted Owl

In British Columbia (B.C.), the northern spotted owl population has been declining over the last decade (Blackburn et al. 2002). Although it is speculated that habitat loss is one of the key reasons for the species' decline, a number of other factors may also play a role: declining prey populations/fluctuations in prey availability; nest failures due to successive years of inclement weather during the breeding season; high overwintering mortality of juveniles due to successive years of harsh winters; and competition with barred owls (SORT 1994; Blackburn et al. 2002). The population of spotted owls in B.C. is so small that it is difficult to impossible to conduct a study to determine which of these factors may be most important in driving the current population trend. Knowing which factors disproportionately influence the spotted owl population would aid in developing management plans, prioritizing recovery efforts, and setting realistic goals for population recovery.

The barred owl is a close relative of the spotted owl, and its distribution completely overlaps that of the spotted owl in B.C. (Dunbar et al. 1991). There are more barred owls in B.C. than spotted owls (Dunbar et al. 1991), although barred owls have shown a rate of decline similar to that of the spotted owl over the past decade (Blackburn et al. 2002). This decline may indicate that spotted owls and barred owls are facing similar threats. Barred owls and spotted owls use similar habitat (Nicholls and Warner 1972; Forsman et al. 1984), have the same breeding season (Devereaux and Mosher 1984; Forsman et al. 1984), and have similar nest site preferences (Forsman et al. 1984; Mazur et al. 1997; Postupalsky et al. 1997). Barred owls are generalist predators, although their diet consists mainly of small mammals (Hamer et al. 2001). Spotted owls are specialist predators which concentrate on northern flying squirrels (*Glaucomys sabrinus*), bushy-tailed woodrats (*Neotoma cinerea*), and deer mice (*Peromyscus maniculatus*) (Forsman et al. 1984; Horoupian et al. 2000). Both owls are similar in size and appear to be susceptible to predation from great horned owls (*Bubo virginianus*) (Forsman et al. 1984).

The barred owl may be a suitable proxy species for the spotted owl for studies on the effects of weather on nesting success and overwinter survival, predation risk in fragmented habitats, effects of prey availability (e.g., prey population size and fluctuations) on survival and reproduction, nest site availability, and movements in fragmented landscapes. Sample sizes would be much larger for studies that involve barred owls rather than spotted owls, and the risk of disturbing the small population of spotted owls would be minimized, especially for studies that require radiotelemetry or observations around a nest site. Although barred owls may be less sensitive to some of the above factors than spotted owls (e.g., since barred owls are generalist feeders they may be less sensitive to fluctuations in prey availability), their response may indicate an even greater importance of the factor (e.g., fluctuations in prey availability) for spotted owls. In other words, although the results of a study on barred owls may not tell us exactly how spotted owls would respond, it should give us an indication of the direction and strength of the response for spotted owls.

Case Study 2—Terrestrial Amphibians

All terrestrial amphibians have a physiological constraint that makes them susceptible to changes in their habitat: they have moist skin that absorbs and releases water and is used for respiration (Stebbins and Cohen 1995; Corkran and Thoms 1996). Terrestrial amphibians have been shown to decline in population size and diversity in timber-harvested areas throughout North America (deMaynadier and Hunter 1995), although studies in the Pacific Northwest have had varied results (Cole et al. 1997; Maxcy 2000; Naughton et al. 2000). Several ideas have been proposed to explain this trend: compaction of soil during harvesting may limit access to moist refuges (Grialou et al. 2000); drying of the environment due to increased solar radiation may increase desiccation stress and limit foraging ability (Ash 1997); alteration of microclimates may reduce quality or availability of prey (Bury 1983; Pough et al. 1987); or amphibians may move into adjacent forested sites until habitat conditions in harvested areas improve (Ash and Bruce 1994). Amphibian species will likely respond differently to changes in their environment due to their behavioral differences, but their shared physiological limitations should result in some similarities in response.

The northwestern salamander, a common pond-breeding salamander in southwestern B.C., may be a good proxy species for other coastal terrestrial amphibians. Its physiology, diet of invertebrates (Corkran and Thoms 1996), predators (Corkran and Thoms 1996), and preference for mature forest (Aubry and Hall 1991) are similar to those of other amphibians. Northwestern salamanders breed in ponds, as do several other coastal terrestrial amphibians (e.g., long-toed salamander [*Ambystoma macrodactylum*], red-legged frog [*Rana aurora*], and western toad [*Bufo boreas*]) (Corkran and Thoms 1996), and are easy to capture in large numbers around breeding sites in late spring (personal observation), which allows large sample sizes to be used in studies. The northwestern salamander is also sufficiently common that it will not be imperiled by research experiments (Aubry 2000; Maxcy 2000).

Despite these similarities, the northwestern salamander differs from other coastal terrestrial salamander species in a few ways. Northwestern salamanders are capable of migrations of up to 1 km during the breeding season (Maxcy 2000), and consequently, may be expected to migrate out of timber-harvested areas if conditions are unsuitable. In contrast, many other species of terrestrial amphibians are more restricted in their movements (Maxcy 2000), and may remain within harvested areas. Northwestern salamanders use deep underground refuges (up to 1 m deep) (Angela Stringer, pers. comm.) in small mammal tunnels. Other terrestrial amphibians, such as ensatinas (*Ensatina eschsholtzii*) and western redback salamanders (*Plethodon vehiculum*) primarily use decayed logs for refuges, although they may use underground refuges during dry or cold weather (Corkran and Thoms 1996). Providing the ground has not been too compacted in harvested areas, northwestern salamanders may be expected to fare better than other terrestrial salamanders since they are readily able to escape the surface conditions and retreat to deep underground burrows. Some terrestrial amphibians breed on land (e.g., plethodontid salamanders such as the ensatina and western redback salamander) where they must find moist, decayed logs in which to lay their eggs (Corkran and Thoms 1996). Since northwestern salamanders breed in ponds, they may be less affected by forest harvesting than these species, although migration to breeding sites may be influenced. Studies on northwestern salamanders would likely not provide insight into the effects of forest harvesting on the reproductive success of these plethodontid salamanders.

We are conducting an experiment using northwestern salamanders to learn about the stressors that affect amphibians in timber-harvested areas. We have placed juvenile northwestern salamanders in large field enclosures in harvested and forested sites, and are manipulating food availability in half the enclosures. Holding northwestern salamanders in enclosures ensures that they are exposed to the conditions in harvested areas that other less motile species would experience. From this study, we hope to learn if this species is food-limited in harvested sites and how it responds (in terms of growth and survival) to being in a harvested area. If the enclosure experiment shows that northwestern salamanders respond negatively to living in harvested areas, this may give us some indication that other terrestrial amphibians would fare worse; thus, responses of northwestern salamanders in our experiment may be extrapolated to other species of terrestrial amphibians, even if the various species have slightly different behaviors.

Another key element to understanding how amphibians respond to harvested areas is to gain knowledge about their movements and their abilities to select suitable habitat. Since many amphibians are very small (several are less than 5 g), it is often not feasible to attach radio transmitters to them to track their movements. Small transmitters with a long enough battery life to track an animal over several months are currently unavailable. Northwestern salamanders are large (they can weigh up to 30 g), and they can carry an implanted radio transmitter that has a three-month battery life (Angela Stringer, pers. comm.). The northwestern salamander then, is a suitable proxy species for studying amphibian habitat use, movement patterns, and habitat preferences.

Case Study 3—Endangered Subspecies

Species are often split into subspecies due to geographic isolation or morphological, physiological, or behavioral differences. Within a particular species, one subspecies may be considered at risk while the other subspecies are considered to be secure. There are a number of such examples in B.C. The snowshoe hare (*Lepus americanus*), has been divided into seven subspecies in the province (Nagorsen 1990). One subspecies, *L .a. washingtonii*, is found only in the Fraser Valley and is threatened by loss of habitat due to urban and agricultural development (Cannings et al. 1999); consequently, it has been placed on the provincial Red List, meaning that it is threatened with becoming endangered or extinct (see the B.C. Species and Ecosystems Explorer web site at http://srmapps.gov.bc.ca/apps/eswp/ for information on provincial listings). The other six subspecies of *L. americanus* are not considered to be at risk; therefore, the species has been placed on the provincial Yellow List, meaning that it is secure and not at risk of extinction. There are two subspecies of northern goshawk (*Accipiter gentilis*) in B.C. *A. g. laingi* is found on the Queen Charlotte Islands and Vancouver Island and is threatened by logging of old-growth forests (Fraser et al. 1999); consequently, it has been placed on the provincial Red

List. *A. g. atricapillus*[1] is found in the interior of B.C. and is on the Yellow List. Additionally, the common water shrew (*Sorex palustris*) has been split into two subspecies in the province: *S. p. brooksi* is restricted to Vancouver Island, is threatened by loss of riparian habitat (Cannings et al. 1999), and is on the provincial Red List, whereas the mainland subspecies, *S. p. navigator*[2], is on the Yellow List.

In cases such as these, experiments on the subspecies that is not at risk (i.e., the ‘secure’ subspecies) may be useful since that subspecies could serve as a proxy for the subspecies that is at risk. The suitability of a secure subspecies for such experiments would depend on the hypotheses to be tested and on how well the two subspecies match in the areas of their life histories that are of interest. Such experiments may provide insight into the relative importance of various environmental stressors, and into interactions between these stressors for the at-risk subspecies.

Conclusions

There are many challenges facing managers of endangered species, not the least of which is often a paucity of information about the target species. Despite this knowledge gap, studying these species is often unethical or not feasible due to their small population sizes. In some cases, studying a more common species that exhibits similarities to the target endangered species in key areas of its life history can increase knowledge and help tailor better management plans. This idea, however, is not without its problems. Choosing an appropriate proxy species will be difficult in some cases, and the results of research experiments should be applied cautiously to management or recovery of the target species. We have presented three cases where experiments on proxy species may be useful: the barred owl could act as a proxy species for the northern spotted owl; the northwestern salamander could be a proxy species for other coastal terrestrial amphibians; and some common subspecies could act as proxy species for threatened or endangered subspecies. These are starting points—we invite you to consider the species you work on and determine if anything can be gained by using this approach. The need to act before endangered species continue to decline will necessitate careful thinking about creative measures of obtaining crucial information for directing management and recovery efforts.

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[2]The BC Species and Ecosystems Explorer (September 2004) currently does not list *navigator* as a subspecies of the common water shrew.

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