Diversity

Darwinian Decision Making: Putting the Adaptive into Adaptive Management

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The best management decisions are based on the best science, or so scientists are taught. In this issue Seddon et al. (2007) review reintroduction of science and note that much of it has been ad hoc and not designed to be experimental. Moreover, managers are not benefiting as much as they could from population viability analysis and geographic information systems. This is surprising because of the general emphasis in the literature on "active adaptive management" (Walters & Holling 1990). Adaptive management plans are modified on the basis of the results of well-designed experiments that collect data on factors or variables that are demonstrably important for conservation or management (e.g., Ministry of Forest and Range 2001).

As Seddon et al. (2007) discuss, the results of properly designed experiments can be revealing. Comparison of proper controls with formal treatments is an essential part of such experiments because it helps isolate the effect of a particular manipulation (Underwood 1992). If, for instance, one manipulation is done in one year and another manipulation is done in another year, the difference between years may not be a result of the manipulations, but rather some other factor that varied across years. Thus, managers could make spurious conclusions and management decisions may not be scientifically sound.

Nonetheless, managers may resist designing studies with control groups (Johnson 1999; Lee 1999) for several reasons. First, there may be too few animals with which to conduct a proper study. For instance, in lieu of an experimental approach, managers charged with recovering the Po'ouli (*Melamprosops phaeosoma*)—a critically endangered Hawaiian honeyeater—opted for a probabilistic decision-tree analysis (VaderWerf et al. 2006). Second, there may be many factors that have to be manipulated simultaneously. In this case it is rare with an endangered species that one would have sufficient sample sizes to isolate the effect of each of a number of manipulations on subsequent breeding or reintroduction success. Third, there is mortality risk with control groups (Johnson 1999). If it is known that current practice is insufficient, managers worry that continuing current practice as a control group might lead to unnecessary deleterious consequences and hinder recovery. Thus, when changes are made, they are applied to all individuals.

I know of few managers working with critically endangered species who are willing to employ active adaptive-management experiments. Rather, it is more common for them to apply conventional wisdom or modify management activities based on monitoring results (Johnson 1999). In both cases if managers are right, they may save a control group from a certain fate, and thus they may more quickly reach their recovery goals. If they are wrong they may perpetrate folk wisdom and may incorporate poor decisions into management plans that may hinder recovery.

Should scientists who are members of recovery teams hold the line and insist on adaptive-management experiments? And if so, when? I suggest that adaptive-management experiments be conducted in two situations: (1) when the management option is not routine and when its outcome cannot be predicted, or is highly uncertain and (2) when the costs or risks associated with applying an incorrect management option are great. In these cases adaptive-management experiments should be considered.

For instance, in the context of captive breeding, experiments do not necessarily have to be done to decide to clean cages or provide fresh food and water daily. It is known from many species that such husbandry is routine, reduces disease risk, and increases health. If one decided, however, it was important to manage body mass

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to manipulate offspring sex ratio (e.g., Robertson et al. 2006), then an experiment would be mandated because the outcome would be unknown.

Management options may have several costs and risks: opportunity costs (including financial opportunities) and welfare risks (including the loss of animals). Predator deterrence by a disruptive stimulus (e.g., fladry, Shivik et al. 2003) or by stationing personnel next to recently introduced animals (Marmot Recovery Foundation 2005) can be expensive. In this case one would want to be sure that any increase in survival could be attributed to this specific action. Welfare risk is often difficult to address, and managers often cite this when opposing adaptive management. For instance, should one formally study the results of a soft release and compare it with the results from a hard release given that available evidence suggests that best practice should involve soft releases (Kleiman 1989)? Perhaps not, but if animals are trained to be more wary of predators (Griffin et al. 2000), then appropriate control groups should exist because training may have both costs and risks and may not be successful (Seddon et al. 2007).

Given the general reluctance to use adaptive management, how might managers increase the validity of their decisions? I suggest that creating an "adaptive environment" might be an effective means to increase the speed at which we learn from experience. For conservation purposes, the key elements of an adaptive environment include variation and selection. Artificial selection is the quickest route to obtain directional evolutionary change. In the context of conservation management, there are a variety of possible solutions to a problem that are pitted against each other and the better or best solution is used.

Surowiecki (2004) points out that the collective decision-making ability of a group often surpasses expert opinion. Such collective decision-making works best when the group has diverse opinions, and individuals are unconstrained in expressing their opinions. Recovery teams implicitly capitalize on this principle when they incorporate people from diverse backgrounds to brainstorm possible solutions. Problems may arise when such groups are not sufficiently diverse.

I suggest that the efficacy of recovery teams solving particular problems can be increased by explicitly breaking the team into subunits and brainstorming possible solutions. Rather than pitting a single treatment against a single control, choose the two best options and pit the suggestions of the subunits against each other by designing an experiment that identifies which suggestion works better. Repeating these experiments over time might be described as Darwinian decision making, and this might be an effective way to rapidly generate efficient strategies to recover endangered species and to manage populations.

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