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Expanding single-species monitoring toward system management: an example from Santa Barbara Island, California

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Introduction

For over a decade, the National Park Service (NPS) has conducted annual monitoring of vegetation, seabirds, landbirds, terrestrial vertebrates, and weather on Santa Barbara Island in Channel Islands National Park. We are now able with some confidence to define the normal range of variation for these ecosystem elements. Consequently, we should be prepared to take action, if only to increase our observations, if population numbers or other indexes diverge drastically from these levels. Additionally, several of the protocols for monitoring have undergone peer review and are being or have already been modified to reflect recommended changes to the program.

Our challenge now is to use the data from these somewhat disjunct monitoring programs to understand more thoroughly the processes and levels of tolerance within island ecosystems. Our natural systems should ultimately be the resource with which we as land managers are concerned, and in the future should be the unit at which we direct our preservation and management efforts. In too many cases the lack of understanding of system processes and ecological relationships within systems has allowed us to take incorrect actions or no actions at all towards the preservation of resources within parks (Blaustein 1993; McAuliffe 1996; Coonan et al. 1998).

Santa Barbara Island is one of the smallest and, arguably ,the simplest of the island systems within Channel Islands National Park. The island is 2.6 sq km in size, and supports only two terrestrial vertebrate species. The vegetation communities contain a mixture of grass and shrublands, and eight community types have been identified (Hochberg et al. 1979). The most dynamic component of the island's ecology is the assemblage of seabirds which utilize the island for roosting and nesting during the spring and summer seasons. During this period, thousands of birds, including California brown pelicans *(Pelecanus occidentalis californicus),* western gulls *(Larus occidentalis),* Xantus' murrelets *(Synthliboramphus hypoleucus),* and others will be found across the island.

The only terrestrial mammal on the island is a subspecies of deer mouse, *Peromyscus maniculatus elusus*. This species has been monitored for approximately 15 years, both by NPS since 1992, and by several researchers during the 1970s and 1980s (Collins et al. 1979 for a summary; Drost 1989; Drost and Fellers 1991). For many years it was noted that the numbers of mice on Santa Barbara Island were often extremely high, and it was suggested by some that land cover alterations caused by the introduction of non-native plant species might be the cause of these artificially high numbers. If so, the presence of so many mice on Santa Barbara Island might be having negative effects on native plants and seabirds that would not be seen in the system were mice present at levels similar to those to which these other groups have evolved.

The park is currently compiling mouse data from park islands for trend analysis (Schwemm and Coonan, in draft). Beginning with Santa Barbara Island, we have

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begun to relate these data to those from other monitoring programs to identify the most significant driving processes within the system, and to answer some specific questions regarding relationships between deer mice and some of these other groups.

In this paper we examine two of the theories that have implicated mice as a threat to native species on Santa Barbara Island, and use monitoring data to determine whether or not relationships exist. The first involves predation by mice on the eggs of Xantus' murrelets, a small, cliff-nesting seabird. As part of the seabird monitoring program, biologists record the number of eggs laid, as well as the fate of the eggs. Evidence from egg-shell fragments is used to determine whether eggs have hatched, have been abandoned, or have been preyed upon by mice. Several researchers have stated that predation by mice is a significant threat to productivity for Xantus' murrelets on Santa Barbara Island (Murray et al. 1983; McChesney 1995; McChesney et al. 2000).

We also looked at the relationship between mouse numbers and productivity of *Coreopsis gigantea*, a native shrub which was decimated by non-native animals and fires on Santa Barbara Island during the last century. Mice directly prey on the stems of *Coreopsis*, particularly in late summer and fall when the somewhat succulent nature of the plant provides water. It is unknown whether or not mice prefer *Coreopsis* seeds over other seeds, but if so it has been suggested that, between the effects of granivory and direct predation, unusually high numbers of mice may be having significant negative effects on the recovery of *Coreopsis* on the island (Salas 1990).

Methods

Deer mouse monitoring is conducted in spring and fall on two sampling grids, one in *Coreopsis* habitat and one in habitat dominated by exotic grasses. Resulting data analysis provides population and density estimates, along with general trend information regarding sex ratios, reproductive effort, and average weights (Fellers et al. 1988; Figure 72.1). We compared mouse densities with levels of murrelet egg predation and productivity as measured by the seabird monitoring program (Lewis et al. 1988). When comparing mouse densities and predation rates of murrelet eggs, we used only spring mouse densities since eggs are only present during that time.

Vegetation monitoring is conducted using line-intercept methodology, in which the species and height is recorded for every plant that touches a designated point (Halvorson et al. 1988). *Coreopsis* predation is not directly measured, so we looked at the number of total hits of *Coreopsis* on three specific transects and as averaged over all island transects as indicators of trends in *Coreopsis* productivity.

Because weather data collection from Santa Barbara Island has been sporadic, weather data from Santa Catalina Island, 40 km to the east, was used for analysis.

Results

Mouse densities fluctuated seasonally and in multi-annual cycles of approximately three to four years (Channel Islands National Park terrestrial vertebrate monitoring data; Schwemm 1995; Schwemm 1996; Austin 1996; Austin 1998). The highest density recorded since 1985 was 666 per ha in the fall of 1993 on the *Coreopsis* grid. The lowest was in the spring of 1999 on the grassland grid, when one individual was caught twice. (In several cases when captures were extremely low, an estimate of 10 per ha was included in the final data analysis to indicate that some animals, albeit only a few, were present. There was never an instance when no animals were captured.) When compared over all years, numbers of mice were significantly higher on the *Coreopsis* grid than on the grassland grid (t = 3.129, p = .007, n = 16). The greatest within-year increase in density occurred on the *Coreopsis* grid in 1993, when the estimate rose from 42 per ha in the spring to 666 per ha in the fall. There was no correlation between within-year spring and fall densities.

Murrelet productivity, as measured by eggs hatched per nest attempt, ranged from 0.5 in 1992 to 1.3 in 2000. However, in only three of the last 18 years was productivity greater than 1.0. The average number of eggs lost to predation within the two colonies ranged from over 70% to less than 20%. In 14 of 17 years, predation rates were greater within the Cat Canyon colony (Channel Islands National Park seabird monitoring data; Ingram and Carter 1997; Martin and Sydeman 1998; Martin 2000). We found no correlation between mouse densities and egg predation, although the sample size was small (n = 7). There is a general negative effect of egg predation on productivity, suggesting that mice are having detrimental effects on the murrelet population.

Figure 72.1. Weighing a deer mouse on a hand-held scale.

Spring mouse densities were correlated with the total number of hits on vegetation transects the previous spring (r^2 = 24.9, f = 4.97, p = 0.042). A postulated relationship between fall mouse densities and total hits on *Coreopsis* on the vegetation transect closest to the *Coreopsis* mouse grid was not significant (r^2 = 48.5, f = 4.71, p = 0.082). No other significant relationships were found between mouse densities and any measure of vegetation, including natives versus non-natives, life form, or species.

There was a significant correlation between previous winter rains and mouse densities during the following spring (r^2 = 78.2, f = 17.910, p = 0.008), and a slight but significant negative correlation between winter rains and current spring mouse densities (r^2 = 26.3, f = 6.41, p = 0.021).

Discussion

Mouse densities on Santa Barbara Island routinely reach extremely high numbers. Data from the monitoring program combined with historical observations suggest that this is the normal condition of the population on this island. Many studies have suggested that island populations of *P. maniculatus* and other species of small mammals occur generally in higher densities in island habitats (Redfield 1976; Sullivan

1977; Gliwicz 1980) and are less aggressive than mainland populations (Halpin and Sullivan 1978; Halpin 1981). These authors suggest that densities are maintained in greater numbers on islands to prevent extinction in an environment to which there would be no recolonization, and that the increased tolerance by individuals to conspecifics is likely an adaptation to this situation (Halpin and Sullivan 1978; Adler and Levins 1994). While monitoring data do not provide direct measurements of such factors, indirect measurements of behavior and dispersal might be sufficient to examine more closely how the ecology of the deer mouse population on Santa Barbara Island may reflect responses to an insular ecosystem (Schwemm and Coonan, in draft).

It does not appear that mice have a negative effect on productivity of *Coreopsis*, as might be suggested by observations of the damage mice can inflict on individual plants. We examined data from three vegetation transects in *Coreopsis* habitat, and found the total number of hits on those transects to be stable or increasing. Anecdotally, botanists on the island have noticed a substantial increase in the number of seedlings and overall recruitment of *Coreopsis* over the last decade (D. Rodriguez 2001; Junak et al. 1993). These seedlings may or may not be the cause of the overall increase in *Coreopsis* hits (older plants increasing in size may also be responsible), but the existing data and observations suggest that the species appears to be increasing in abundance on the island. This evidence does not support the hypothesis that large areas of exotic grasslands on the island are supporting mouse densities at artificially high levels. Because *Coreopsis* habitat appears to provide superior habitat for mice over grasslands, it may be that as the island recovers from previous impacts and *Coreopsis* distribution continues to increase, mouse numbers island-wide will actually rise.

Finally, it appears that regardless of the number of mice present on the island during the spring, the amount of predation by mice on murrelet eggs will generally be high. Even if mouse densities are low, a certain number of individuals will apparently travel the necessary distance to obtain eggs. If mouse numbers are not artificially high, it is possible that this level of egg predation is normal, and that the birds have evolved strategies to meet this threat. In this scenario, the birds would be successful as a group, despite these high levels of predation. However, murrelets are not currently meeting levels of productivity that will sustain the species (Sydeman et al. 1996). If mouse predation is a normal process in the ecology of the two species, other off-island factors may be working to affect the success of the birds (Carter et al. 2000).

Conclusion

Data from four monitoring programs on Santa Barbara Island are beginning to provide information which describes a system regulated in large measure by seasonal rains. Varying amounts of winter precipitation result in changes in annual vegetative productivity, which in turn affect mouse population dynamics for the following year. This relationship is not linear, however, and even moderate levels of plant productivity apparently provide a food source sufficient enough to allow mice to reproduce continually throughout the summer and fall. We suggest that mouse productivity is limited by significant food shortages, severity of winter weather, and natural mortality.

Eggs appear to be the most preferred food, and mice are apparently driven to take murrelet eggs at levels great enough to affect bird productivity regardless of levels of plant productivity. Changes in weather regimes or other processes that may alter the relative frequency of specific plant species or groups of species do not appear to result in corresponding changes in mouse numbers or egg predation.

These results are of importance for two current management issues. First, the productivity of Xantus' murrelets appears to be decreasing throughout their range (Sydeman et al. 1996), and the bird may soon be proposed for federal listing as a species of concern. Several authors have identified the greatest threat to birds on land as predation by terrestrial rodents, and some type of snap-trapping or direct reduction strategy might be necessary to protect birds during the nesting season. Although this is not a desirable alternative, the monitoring data strongly indicate that the mouse population on the island would not suffer any long-term impacts from such a temporary, localized loss of individuals. The park will look very closely at any proposal to protect the birds that includes killing mice, and data from the monitoring programs will certainly be included in any analysis of potential impacts.

Secondly, an effort beginning this fall to eliminate black rats from Anacapa Island will almost certainly result in the loss of all mice from treated areas (Howald 2001). Mitigation measures for mice include the capture and holding of mice during the treatment, followed by a post-treatment release, most likely in the spring. Data from the deer mouse monitoring program on Santa Barbara and Anacapa islands are being used to develop this mitigation strategy, and to determine methodologies for release protocols. For example, since Xantus' murrelets also nest on Anacapa Island, one aspect of our release strategy may be to hold the animals until after the murrelet nesting period. Alternatively, mice could be re-introduced only to interior areas of the island, where they will be less likely to reach shoreline cliffs and murrelet nests before the eggs have hatched.

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