Biology, Policy and Law in Endangered Species Conservation: II. A Case History in Adaptive Management of the Island Fox on Santa Catalina Island, California

Gary W. Roemer1
C. Josh Donlan2

1Department of Fishery and Wildlife Sciences, New Mexico State University, Las Cruces, New Mexico 88003-8003
2Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, New York 14853-2701 and Island Conservation, Center for Ocean Health, Santa Cruz, California 95060

Abstract

Successful recovery of endangered species at first would seem to have a clear answer: simply remove the anthropogenically-induced agent(s) and recovery should follow. While programs attempt to focus conservation efforts in such directions, endangered species recovery is more complex than biology alone, encompassing several, mostly human-related, dimensions. Two separate but concurrent programs involving the island fox (Urocyon littoralis) highlight the many dimensions of species recovery efforts, and the roles they play in hastening or preventing successful recovery. The non-profit organization, the Catalina Island Conservancy, successfully averted the potential extinction of the Catalina Island fox (U. l. catalinae) after a decline occurred due to canine distemper virus. To the north, the National Park Service and partners continue on-going efforts to recover three subspecies of the island fox on the northern Channel Islands that declined owing to heightened predation by golden eagles (Aquila chrysaetos). In-place monitoring programs, biology of the decline agents, geography, adaptive management, organizational structure, and public perception all played influential roles in the island fox recovery efforts. On Catalina Island, many of these factors contributed to a speedy, successful recovery. On the northern Channel Islands, some factors have slowed and inhibited recovery; however, substantial progress is being made. Elucidating novel mechanisms and policies that can mitigate for factors that impede species recovery should be of paramount importance.

Resumen

La recuperación exitosa de una especie en peligro de extinción parece tener, a primera instancia, una contestación clara: simplemente remover los agentes antropogénicamente inducidos y la recuperación ocurrirá. Mientras algunos programas intentan enfocar sus esfuerzos de conservación en esta dirección, la recuperación de especies en peligro de extinción es mas compleja que solamente la biología, incorporando varias dimensiones, incluyendo algunas dimensiones humanas. Dos programas separados pero concurrentes con relación al zorro isleño (Urocyon littoralis) llaman la atención a las muchas dimensiones de los esfuerzos para la recuperación de una especie, y los papeles que estos juegan en acelerar o prevenir una recuperación exitosa de esta. La organización sin fines de lucro, Conservación de la isla Catalina, ha evitado exitosamente la posible extinción del zorro isleño (U. l. catalinae) en la isla Catalina luego de una disminución que ocurrió debido al virus de trastorno canino. Al norte, el Servicio de Parques Nacionales y sus socio continúan con los esfuerzos de recuperar tres sub-especies del zorro isleño que disminuyeron en el norte de las islas Channel debido a un aumento en la depredación por el águila real (Aquila chrysaetos). Programas de monitoreo, la biología de los agentes de disminución, la geografía, el manejo adaptable, la estructura de la organización, y la percepción pública tuvieron papeles importantes en los esfuerzos de recuperación del zorro isleño. En la isla Catalina, muchos de estos factores contribuyeron a una recuperación rápida y exitosa. En el área norteña de las islas Channel, algunos factores han disminuido o impedido la recuperación; sin embargo, se ha hecho un gran progreso. Iniciar políticas y mecanismos innovadores que puedan mitigar los factores que impiden la recuperación de una especie debe ser de importancia suprema.
Introduction
In contemporary time, species endangerment is all too often a consequence of anthropogenic influences that reduce population viability. Successful recovery of species at risk at first would seem to have a clear answer: simply reverse the impacts or remove the anthropogenically induced agent(s) and recovery should follow. Although recovery programs attempt to focus conservation efforts in such directions, endangered species recovery is more complex than biology alone, encompassing several, mostly human-related dimensions (Clark, Reading & Clarke 1994). Successful implementation and subsequent recovery often depend heavily on attitudes, societal values, institutional policy, political agendas, and the organizational structure of recovery teams and stakeholders. These dimensions are the real aspects of endangered species recovery. One way to elucidate their importance and to derive practical lessons for improvement is to compare programmatic differences in recovery programs.

Recovery programs have received much attention, from special sections or summaries that have extensively reviewed numerous recovery plans and their efficacy (Clark et al. 2002; Karieva 2002), to edited works that have drawn upon detailed case histories and the professionals directly involved (Clark, Reading & Clarke 1994), to requests from Congress for a greater understanding of how science is used in species recovery (National Research Council 1995). A wealth of information exists providing salient recommendations for improving endangered species recovery efforts. Here, we provide a detailed comparison of two contemporaneous recovery programs dealing with independent declines of the same species. The first is a recovery program implemented by a non-profit organization, the Catalina Island Conservancy, that successfully averted the potential extinction of the Santa Catalina Island fox (*Urocyon littoralis catalinae*) after a drastic decline occurred due to canine distemper virus (CDV). The second is an on-going effort implemented initially by the National Park Service with subsequent support from The Nature Conservancy and the U.S. Fish and Wildlife Service; this effort is attempting to recover three subspecies of the island fox on the northern Channel Islands that declined owing to heightened predation by golden eagles (*Aquila chrysaetos*). We examine the program elements that have led to success and/or setbacks in the respective recovery efforts, with a particular focus on the Catalina program. A more detailed account of past efforts in the recovery program for the northern Channel Islands can be found elsewhere (Coonan 2003; Coonan et al. 2004, 2005; Roemer & Donlan 2004); however, we do provide an update here. Because these recovery programs differed in manifold ways, our comparison is focused into six areas: (1) the agents that caused the declines, (2) the spatial extent of the declines, (3) the science-based strategies and adaptive management used, (4) the speed of implementation, (5) the public
and legal support for recovery actions and (6) the institutional structure and policy of the organizations involved. Our purpose is not to pit one effort against another or to suggest that one organization performed better than the other, but rather to examine, in detail, why one effort has been successful and the other, still ongoing, has an uncertain but promising future.

From Abundant to Rare to Near Extinction: How the Island fox Declined

Santa Catalina Island (194 km) is located approximately 42 km off the coast of southern California, almost due west of one of the largest urban centers in North America – Los Angeles, California. Catalina is a major tourist attraction, with over 400,000 visitors per year, and contains two small communities, Avalon and Two Harbors; total resident population is approximately 4,000 people (Catalina Island Chamber of Commerce & Visitors Bureau, www.visitcatalina.org). Catalina’s residents and visitors can own and transport pets, including domestic dogs, to and from the island. Among other unique and endemic taxa, Catalina is home to the Santa Catalina Island fox (Moore & Collins 1995). At some point in 1998 or 1999, it is hypothesized that a domestic dog infected with CDV was brought to Catalina. This dog infected the endemic fox population and a CDV epizootic ensued.

Reduced sightings of foxes by island residents and biologists coupled with observations by island residents of “sick foxes” were the first signs of a decline. These observations were followed by an intensive island-wide trapping effort that revealed a significant reduction in fox trap success on the eastern portion of the island (Timm et al. 2000). In the course of seven months of trapping, only ten foxes were captured in 1,046 trap nights (0.96% capture success) on the east side; however, on the western end of the island 137 trap nights yielded 49 fox captures (35.7% capture success). Capture success of healthy island fox populations typically varies from approximately 10% to over 40% (Roemer et al. 1994, 2000a, 2002; Timm et al. 2000). A subsequent more intensive trapping effort corroborated earlier results with a total of 20 individual foxes being captured on the much larger eastern portion of the island compared with 166 individual foxes captured on the west end (Timm et al. 2002). These data strongly suggested that a decline had occurred and that the decline was restricted to the larger eastern portion of the island.

The reason for the restricted spatial distribution of the decline was likely related to the location of a community, Two Harbors, and the causal agent, CDV. Two Harbors is located between two small bays on the western portion of the island on what is essentially a constriction that forms an isthmus (Figure 1). The isthmus separates the island into a larger eastern portion (87% of the island area) and a smaller west end (remaining 13%). This natural topographic feature and the location of the com-

![Figure 1](image_url). A map of Santa Catalina Island, California showing the rugged topography, location of the two communities, Avalon and Two Harbors and the East and West Ends of the island.
munity likely played a role in the spatial extent of the decline by preventing infected foxes from freely crossing the isthmus, a fortuitous geographic occurrence.

Although sparse, the evidence showing that a CDV epizootic had occurred on the island was conclusive. During the initial trapping effort, two foxes on the east side had high serological titers for CDV (1:256+ and 1:128+) compared to foxes from the west end (< 1:24+). High titer values indicated that these foxes had likely been exposed to CDV and recovered (Timm et al. 2000). Further, tissues from a single fox carcass submitted for histopathological analysis showed evidence of septic pneumonia secondary to viral infection and viral inclusion bodies in the pulmonary alveolar tissue that were a result of CDV (Timm et al. 2000). Circumstantial evidence also suggested that CDV was the agent of decline. After the decline was documented and publicized, subsequent discussions with the on-island small animal veterinarian revealed that a domestic dog pup treated in Avalon showed symptoms of a clinical CDV infection. At the time this particular disease was not implicated in the pup’s diagnosis (S. Timm, pers. comm.), perhaps because CDV had never before occurred on the island. This series of observations supported the contention that foxes on Catalina had suffered a CDV epizootic that swept through the eastern portion of the island and which had reduced the entire island fox population by 90%.

The etiology of the decline on the northern Channel Islands was quite different. Although disease was initially suspected as a contributory agent, further investigation proved that the primary driver of the fox population declines was the presence of an exotic species, the feral pig (*Sus scrofa*) and the predator it attracted, the golden eagle (*Aquila chrysaetos*) (Roemer et al. 2000a, 2001, 2002; Roemer & Donlan 2004). Pigs, by acting as an abundant food, enabled mainland golden eagles to colonize the northern Channel Islands. Pigs indirectly caused the decline in foxes through a process known as hyperpredation. Hyperpredation is a form of apparent competition whereby an introduced prey, well adapted to high predation pressure, indirectly facilitates the extinction of an indigenous prey by enabling a shared predator to increase in population size (Holt 1977; Courchamp et al. 1999). Pigs, by producing large numbers of piglets, sustained the eagle population and because of their high fecundity could cope with the increased levels of predation.

In addition, as piglets mature, they eventually escape predation by growing beyond the size range that eagles typically prey upon (Roemer et al. 2002). Foxes, on the other hand, are small, active during the day, and produce relatively few young each year. Predation by eagles had an asymmetrical effect on the unwary fox, driving the fox populations toward extinction.

Unlike Catalina, the decline in foxes was not restricted to a portion of one island but rather occurred across three islands: Santa Cruz, Santa Rosa and San Miguel (Roemer et al. 2004). Further, unlike Catalina, where CDV swept through the eastern portion of the island and apparently “burned out”, golden eagles have been a continuous presence on the northern Channel Islands for over a decade (1994 – 2005) despite a vigorous campaign to live-capture and relocate the eagles (Latta 2005). Thus, the agents of the declines and the spatial and temporal extent of the declines differ considerably between the two scenarios. Although these biological differences played a momentous role in the relative success of the recovery programs, other factors influenced the character of the recovery efforts with arguably equal import.
Swift Action, Science-based Conservation and Adaptive Management: Their Importance to Successful Recovery

The Catalina Island fox Recovery Program can be characterized as adaptive management with swift implementation of science-based strategies that ultimately led to a successful recovery. This success can be largely attributed to the work of the Institute for Wildlife Studies (IWS), the non-profit organization supported by the Catalina Island Conservancy and charged with recovering the Santa Catalina Island fox. This program was adaptive in that data analyses were routinely employed to update and improve conservation strategies, which were then quickly implemented and subsequently modified so that benefits accrued by learning from both the mistakes and successes. A chronology of events elucidates these points.

The fox decline on Catalina was investigated within months after it was suspected that something was amiss. In 1998, during a serological survey of canine heartworm (*Dirofilaria immitis*), fox capture success was relatively high (26%; Roemer et al. 2000a; Timm et al. 2000). But a decline in fox sightings on Catalina in the summer of 1999 coupled with observations of sick foxes prompted additional investigation. Trapping was initiated in October-November 1999, followed by a more intensive effort from January through April 2000.

During this same timeframe, with mounting evidence suggesting that CDV played a role, the IWS began a vaccination trial using an experimental CDV recombinant vaccine that utilized a canarypox virus as a vector (Timm et al. 2000). Canarypox virus will not cause disease in mammals, but can express recombinant DNA from CDV and thereby elicit an immune response in the vaccinated mammal. The trial used only 6 foxes, with 5 animals receiving the vaccine and a single control; such few foxes were justified because of the severity of the decline. All foxes were serologically tested for CDV prior to vaccination and 4 foxes were vaccinated twice (initial vaccination followed by a booster) in an effort to assess the level of seroconversion and whether one injection of vaccine would confer CDV protection. Two independent laboratories analyzed the serum collected. Only the vaccinated foxes seroconverted, showing that the experimental vaccine was safe and would elicit an immune response with a single injection. A booster, however, appeared necessary to maintain a high titer after six weeks. The next step was to vaccinate the remaining wild foxes to ensure some degree of protection in case another CDV epizootic were to occur.

In fall of 2000, less than one year after the decline in the fox population, the IWS began an island-wide serology assessment and vaccination program against CDV. Within a year, 159 wild foxes were vaccinated in an experimental approach: 82 received two shots of vaccine, 42 received a single shot, and 35 received a control shot of sterile water (Timm et al. 2002). Annual boosters were also delivered to another 50 foxes (Timm et al. 2002). Of 141 fox serum samples tested before vaccination, eight (6%) tested positive to CDV indicating exposure to the disease. This vaccination program represented swift and aggressive action that would likely have prevented another CDV epizootic from occurring or at least curtailed its impact.

In addition to the vaccination program, a captive breeding program was initiated to aid in repopulating the east end of the island. The captive breeding effort involved 12 large pens (279 m) with den boxes buried with earth to simulate real dens, prey boxes that allowed the introduction of live prey, environmental enhancements and native vegetation including prickly pear...
cactus (Opuntia littoralis) for pup education, and an extensive 72-camera, video monitoring system with den box cameras and infrared cameras for night-time viewing. Pen construction and design allowed for almost complete monitoring of the captive animals without human intervention.

As with all recovery programs, however, mistakes were made, yet knowledge gained was used toward programmatic improvements. For example, during the construction of the captive facility a decision was made to bring pregnant foxes into captivity in late spring 2001. Twelve of 18 pups born in captivity subsequently died, owing to apparent stress-related abandonment by the females (Timm et al. 2002). In the subsequent breeding season, a cautious approach was adopted under the premise that capturing and “imprisoning” pregnant females may have contributed to the inanition observed (S. Timm, pers. comm.). Females were monitored, but little attempt was made to intervene. Of 14 pups born in the facility, 6 died, and one mother was observed eating a newborn pup, the event captured on video (Kohlmann et al. 2003). After aberrant female behaviors and pup deaths were observed in two consecutive reproductive periods, a more proactive approach was adopted. During the 2003 breeding season, females were intensively monitored. Ultrasound was used to assess pregnancy, physical exams were administered, video monitoring was employed during and after parturition, and pups were pulled from inattentive mothers, often receiving intensive care in the form of incubation and tube feeding. Pups were subsequently cross-fostered into pens with other mothers. Of 19 pups born in 2003, two died, one cross-fostered pup became habituated to humans owing to repeated but necessary veterinary care and was subsequently used as a captive, educational ambassador, and the 15 remaining healthy pups were vaccinated and released into the wild in November (IWS 2003a, b, c, d, e). Captive care continually improved throughout the program, with the successful rearing of 33%, 57%, 79% and 83% of 18, 14, 19 and 12 pups that were eventually readied for release into the wild from 2001-2004, respectively. This success can be largely attributed to a comprehensive husbandry and veterinary care program that learned from its mistakes, capitalized on its successes and continually adapted itself to ensure improvement. Such adaptive management was not restricted to the captive-breeding program but also occurred in both the release and translocation strategies.

In addition to the release of captive-reared foxes, animals from the disease-free west end were captured, transported, and released to areas on the east side of the island. All released or translocated foxes (along with some remaining wild foxes) were fitted with radio telemetry collars and monitored on a regular basis to assess their movements, survival, pair formation and reproduction (Timm et al. 2002; Kohlmann et al. 2003; Schmidt et al. 2005). Due to these efforts, island-wide population esti-
mates have steadily increased (Table 1). Nevertheless, the west end population appeared to be declining, perhaps related to the translocation efforts and because breeding pairs were captured on the west end and placed into the captive facility. To address this potential impact of the recovery strategy, and assess overall extinction risk for the fox population, a comprehensive population viability analysis was conducted (Kohlmann et al. 2005). At the time of the analysis, the total island population size was estimated at 207 foxes (95% CI = 200 – 219). Based on model inference, a recommendation was made to maintain a total island population of 300 foxes to maintain an acceptable risk of extinction, solely based on demographic stochasticity. The analysis further suggested that transporting foxes from the west end to the east side influenced the extinction probability of both subpopulations, but in opposite directions. It appeared that the west end subpopulation was not large enough to handle the annual management action of transporting 12 foxes from west to east. Further, the east side subpopulation showed higher growth rates compared to the west, perhaps owing to lower density and positive density dependent effects at low population size; even without further management, the eastern subpopulation was predicted to recover. Translocation of foxes from the west end to the east side was stopped and all captive foxes were released into the eastern subpopulation. The program was a resounding success – by September 2004 a total of 262 individual foxes were known to be alive on the island with an estimated total population size of 360 (Schmidt et al. 2005). The recovery of the population is all but certain.

The IWS and Catalina Island Conservancy used a multifaceted approach to ensure recovery of the Santa Catalina Island fox. Island-wide surveys of population decline and serological assessment documented the decline and determined its cause. An experimental vaccine trial was administered to determine its efficacy and safety after which an island-wide vaccination program was implemented to protect the remaining wild foxes. An adaptively managed, captive-breeding program increased the number of pups that were released on the east side. Foxes also were translocated from the unaffected west end and all released foxes were intensively monitored.

Finally, a population viability analysis revealed the potential impact of translocating foxes from the west end subpopulation leading to a cessation of this management action. The analyses also lent support that while still vulnerable to further catastrophic events, the overall fox population had recovered to the point that the captive-breeding program could be disbanded. In sum, the Catalina Island Fox Recovery program is a case study in conservation that within five years recovered a critically endangered subspecies.

### Current Status of the Recovery Program on the Northern Channel Islands

Since our summarization of the island fox recovery program on the Northern Channel Islands (Roemer & Donlan 2004), substantial progress has been made. On Santa Cruz Island annual survival estimates of adult, wild foxes for 2004 increased above a threshold level of 80% that was predicted to drive deterministic population decline (V. Bakker et al. Unpubl. data; Roemer et al. 2000b; Coonan et al. 2005); the wild fox population is now estimated at over 200

<table>
<thead>
<tr>
<th>Year</th>
<th>East End</th>
<th>West End</th>
<th>Total Foxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>28</td>
<td>75</td>
<td>103</td>
</tr>
<tr>
<td>2001</td>
<td>59</td>
<td>166</td>
<td>225</td>
</tr>
<tr>
<td>2002</td>
<td>96</td>
<td>119</td>
<td>215</td>
</tr>
<tr>
<td>2003</td>
<td>144</td>
<td>102</td>
<td>246</td>
</tr>
<tr>
<td>2004</td>
<td>219</td>
<td>141</td>
<td>360</td>
</tr>
</tbody>
</table>

Table 1. Estimates of the size of the Santa Catalina Island fox population from 2000 to 2004. Adapted from Figure 5 of Schmidt et al. (2005).
individuals (S. Morrison, pers. comm.). This increase in wild fox numbers may be related to an evolutionary response by the foxes to become more nocturnal in the face of eagle predation (Roemer et al. 2002). Although captive-bred, released foxes on Santa Cruz have fared poorly in the face of golden eagle predation (Cournchamp et al. 2003; Dratch et al. 2004; Roemer et al. 2004), captive foxes are successfully breeding, and the facility currently houses 62 foxes (20 pups were produced in 2005 breeding season; Coonan et al. 2005). Because of high predation rates on released, captive-reared foxes, it is unlikely that animals will be released in 2006 unless eagle predation is significantly reduced. This conservative strategy appears justified because other management actions in progress may contribute to ensuring fox recovery in the near future. Bald eagles (Haliaeetus leucocephalus) were reintroduced to Santa Cruz Island (approximately 25 reside on the northern islands) and a feral pig eradication program began in early 2005 with 3,500 pigs already removed from approximately 3/5 of the island (N. Macdonald & S. McKnight, pers. comm.). Bald eagles may act as potential deterrent to nesting golden eagles and feral pigs may represent the essential food resource golden eagles need to persist on the islands (Roemer et al. 2001, 2002). Once pigs are eradicated, golden eagles may be unable to breed on the island. These efforts should improve the outlook for releasing foxes on Santa Cruz Island in the very near future.

Captive foxes recently released on Santa Rosa Island have also experienced golden eagle predation (5 of 13 foxes released in 2004 were killed by eagles). Nonetheless, some foxes have avoided predation and successfully bred (one litter was produced in 2004 and three litters were produced in 2005; Coonan et al. 2005). Foxes recently released on San Miguel Island, where golden eagles are absent, are doing even better: ten foxes (6 males and 4 females) were released from the captive facility in 2004, all have survived and each female produced a litter in 2005 (Coonan et al. 2005). In addition to these efforts on the ground, a recent population viability analysis workshop sponsored by The Nature Conservancy brought together empirical biologists, managers, and quantitative ecologists and the resulting analyses provided instructive management recommendations (G. Roemer, pers. obs.). Although it is too early to tell if recovery of these populations is assured, the outlook is much brighter than a decade ago when the decline and its cause were first discovered.

A Comparison of Biological and Organizational Realities in the Recovery of the Island fox

The two recovery programs discussed here were similar in some respects but also differed in many key aspects (Table 2). For example, the programs were similar in that monitoring programs were in place and biologists/veterinarians were present on the islands. In both cases, this facilitated rapid identification of fox population declines and their cause. Yet the biological agents responsible for the declines, their duration of impact, and the required interventions necessary to encourage recovery were quite different. On Catalina Island, efforts put in place to deal with the CDV outbreak were rapid and widely accepted in both the scientific and public communities; there was no public outcry against dealing with a disease. In the case of the northern Channel Islands, we suggested that golden eagle removal was paramount to fox recovery and that lethal take should have been explored; however, there was significant public opposition to such action and this, along with other sociopolitical, economic and legal considerations made both the National Park Service and The Nature Conservancy unwilling to pursue such
action (Courchamp et al. 2003; Dratch et al. 2004; Roemer et al. 2004; Roemer & Donlan 2004). From a biological standpoint, lethal removal of golden eagles made sense because it likely would have prevented fox deaths, hastened recovery, and reduced long-term economic costs. The implementation of such an action, however, could have precipitated serious adverse impacts on the solvency of the recovery program and on the public’s perception of both the program and organizations involved. From an organizational, social representation, and trust standpoint, these are not trivial considerations (Cvetkovich & Winter 2003). Golden eagles also are protected by at least two federal laws, the Migratory Bird Treaty Act and the Bald Eagle and Golden Eagle Protection Act, although exemption for lethal take under these acts is not unprecedented (Roemer & Donlan 2004).

The Catalina Island Fox Recovery Program also benefited from observing earlier recovery actions and interventions on the Channel Islands. In general, the IWS had previous experience in containment of island foxes and in the successful captive-rearing, release and monitoring of vertebrates (Garcelon & Roemer 1990; Roemer & Wayne 2003). This extensive experience may have aided in the swift recovery of the Santa Catalina Island fox. For example, an attempt was made to limit captive-reared fox exposure to humans unless necessary (i.e., during whelping and cross-fostering); this approach, also used by the IWS for over 20 years in the Catalina Island Bald Eagle Reintroduction Project, may have lowered stress on captive foxes. Similarly, just as video cameras were employed to monitor wild nests and captive bald eagle chicks (G. Roemer, pers. obs.), video monitoring was employed to ensure breeding success of foxes.

### The Role of Organizational Structure

The organizational structure of the institutions involved in the recovery programs likely played a role in the character of the responses and actions. The effects of organizational structure on program outcome is seen in other disciplines; for example, in primary healthcare, large managed care organizations often fail to provide quality care due to complexities and fragmentation of the organization (Barr 1995). Large gov-

<table>
<thead>
<tr>
<th>Character</th>
<th>SCI</th>
<th>NCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent of Decline</td>
<td>Canine Distemper Virus</td>
<td>Golden Eagle</td>
</tr>
<tr>
<td>Duration of Decline</td>
<td>~ 1 year</td>
<td>&gt; 10 years</td>
</tr>
<tr>
<td>Extent of Decline</td>
<td>Portion of one island</td>
<td>Three entire islands</td>
</tr>
<tr>
<td>Source Population Present</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Biologists Present</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Monitoring Program Present</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Advisory Group Available</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Reintroduction Experience</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Financial Directors Present</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Flexible Funds</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Organizational Structure</td>
<td>Heterarchical</td>
<td>Hierarchical</td>
</tr>
<tr>
<td>Legal Impediments</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Public Trust and Support</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 2. A comparison of recovery programs for the island fox on Santa Catalina Island (SCI) and the northern Channel Islands (NCI) involving biology, policy, law and economic and organizational characters.
ernmental organizations, such as the National Park Service, face many challenges when decisions need to be made swiftly (e.g., when a species is rapidly declining) given the multi-layered, largely hierarchical decision-making infrastructure. Further, annual federal budgets have funds “ear-marked” for specific purposes but rarely are flexible funds available that can be used in an emergency. In contrast, many non-governmental organizations, such as the Catalina Island Conservancy, are often small with decision-making more horizontal in nature, and have flexible funding allocations. Heterarchical organizations can hold a number of advantages over those more hierarchical in structure, including speed of action (Fairtlough 2005). For example, the Conservancy had a modest reserve account of funds that was originally setup for the purpose of infrastructure maintenance, but was subsequently used to fund the fox vaccination and captive breeding programs (A. Muscat, pers. comm.). Ready access to flexible funds is more easily achieved by private organizations that are not bound to annual fiscal constraints, as are most, if not all, governmental organizations. Further, the Conservancy’s Board of Directors were life-long residents of the island and witnessed the decline with “their own eyes”; this led to the sense of urgency in the matter (A. Muscat, pers. comm.). While such intimacy is also often true with “on-the-ground” governmental managers, this is not the case with regional or national directors who are far removed from the day-to-day occurrences in the field but who typically make fiscal decisions for governmental organizations. The above characteristics of private organizations make swift decision-making and intervention easier.

Other aspects of governmental organizations that may prevent swift action is their adherence to internal policy, as well as the pressures of public opinion and perception on the role of governmental agencies. For example, prior to the listing of the fox, the management of Channel Islands National Park was apprehensive regarding guidance from the Island fox Conservation Working Group (Coonan 2001), an ad hoc group of island fox experts that later became the Island fox Integrated Recovery Team. The National Park Service also was reticent regarding the lethal removal of golden eagles (Dratch et al. 2004; Roemer et al. 2004). While the decision not to pursue lethal take of golden eagles may have been important in improving the public view and its trust of the National Park Service, the act itself was based on sound science, was legally tractable, and would have hastened recovery (Roemer et al. 2001, 2002; Courchamp et al. 2003; Roemer & Donlan 2004). One potential avenue to mitigate for such conflicts may be to implement science-based policies and/or to shift from internal policy setting to informed public involvement (Hutchings et al 1997; Wagner 2001). With internal policy making, an agency may have tendencies to resist science that is critical of its own decision-making (Downs 1967; Wagner 2001). Mostly in response to important legislation (e.g., National Environmental Policy Act), some governmental agencies (e.g., U.S. Forest Service and Bureau of Land Management) have integrated public involvement in policy setting procedures. In general, the National Park Service has done so with less verve (Wagner 2001).

Conclusions
Species decline is often a convoluted process; species recovery is more complex yet. On Catalina and the northern Channel Islands, monitoring programs, the natural history of the agents causing the declines, geography, an adaptive strategy, organizational structure, and public relations all played pivotal roles in contributing to the speed and success of island fox recovery efforts.
On Catalina Island, a swift recovery of the fox subspecies was aided by the etiology of the disease agent and island geography. A number of facets of the Catalina Island Conservancy’s organizational structure likely contributed to a speedy recovery including flexibility in funding allocations, intimate knowledge of the decline by decision makers, an adaptive approach to decision-making, and a more heterarchical structure. For the following factors, the opposite was true for the northern Channel Islands and the National Park Service: fox decline was cosmopolitan and severe; the agent of decline, the golden eagle, itself a protected and charismatic species, maintained its presence; and the agency is highly hierarchical with, to a certain degree, distant decision makers tied to inflexible budgets. Such conditions clearly make recovery programs more challenging and progress slower.

Because endangered species recovery programs often call for interventions that are risky and contentious, human dimensions dealing with public trust and perception also can slow or inhibit progress of recovery plans. Elucidating novel mechanisms and policies that can mitigate for factors that slow or impede species recovery should be of paramount importance. As Tim Coonan (Coonan 2001), National Park Service Director of Island fox recovery put it “Ecological crises will continue to occur more rapidly than bureaucratic wheels can turn. NPS thus needs to become more comfortable with management actions borne of necessity, or else develop effective Service-wide tools and funding mechanisms to deal with rapid ecological crises.” While easier said than done, such changes may be crucial if certain species or populations are to be saved from extinction.

Acknowledgements

We would like to acknowledge the assistance of the Catalina Island Conservancy who freely provided access to unpublished reports, made helpful comments on the manuscript, provided Figure 1 and stimulating discussion. In particular, we thank the following members of the CIC: Carlos de la Rosa, Anne Muscat, Peter Schuyler and Frank Starkey. We also thank Tim Coonan for his continued cooperation regarding the Northern Channel Islands fox recovery program and we are eager to see it reach success.

Literature Cited


