LESSON FIVE CASE STUDIES: ERADICATION

OBJECTIVES

Students will learn about the eradication of Invasive Species including the process, measures of success and unintended consequences. Case studies include the problem, solution, challenges, and outcome in four distinct island ecosystems.

- Haida Gwaii (British Columbia) rat removal
- Guadalupe Island (Mexico) goat removal
- Isle of Scilly (Great Britain) rat eradication
- Juan Fernández Islands (Chile) invasive species removal

BACKGROUND

When considering invasive species, biosecurity refers to the implementation of actions to reduce the risk of invasive species introduction to a particular area (e.g., island) and also respond if there is an invasive species incursion. A biosecurity plan provides the public and land managers with detailed guidelines and information on how to address an invasive species incursion. The plan includes actions that can be taken to identify pathways of invasion, along with strategies for preventing or reducing the probability of new introductions/reinvasions. Biosecurity is comprised of three primary components: prevention, detection, and response. These components must be implemented in concert and regularly monitored. For the plan to work, vigilance must be maintained in order to prevent, or rapidly respond, to an invasive species (re)invasion.

ERADICATING INVASIVES

If an invasive species has become established, the best course of action is the rapid removal of all individuals of the target species. Eradication is the complete and permanent removal of an invasive plant or animal species from the target region such as an island. The goal of an invasive species eradication is to encourage the natural restoration of native wildlife and ecosystems that have been negatively impacted by that invasive species. An eradication is not the same as permanent control (reducing the population) or containment (preventing the spread) of an invasive species.

Invasive species eradications for the purpose of wildlife and habitat conservation have become an important management tool, particularly for island restoration projects targeting invasive vertebrate species. To date, the majority of eradication projects undertaken worldwide have targeted invasive terrestrial (land) mammal species, for example rats, mice, rabbits, domestic goats, feral pigs, and domestic cats. To date, more than 1300 whole-island invasive animal eradications have been carried out worldwide with a success rate of 80%; more than half of these have targeted rats. It is much more difficult to eradicate or even control invasive aquatic species, including vertebrates such as Asian carp (of which there are several different species) and invertebrates such as zebra mussels (*Dreissena polymorpha*); invasive aquatic plants [e.g., water hyacinth (*Eichhornia crassipes*)]; and terrestrial plants [e.g., orange hawkweed (*Pilosella aurantiaca*)] because these organisms spread easily (e.g. on wind or ocean currents) and have high reproductive rates (i.e., they produce a large number of seeds, larvae, or young).

Every invasive species eradication operation is different. However, there are three fundamental principles that maximize the chances of success, i.e. of removing 100% of the target population:

1. Every individual of the target species must be at risk of the eradication technique;
2. The target species must be eradicated faster than they can breed/replace themselves;
3. Immigration must be maintained at zero, or be manageable (i.e., land managers must be able to rapidly respond to and eliminate potential invaders).

Eradication projects have significant risk factors which must be taken into account during the planning process. These projects are only feasible when all breeding individuals of a population can be removed and the risk of immediate or rapid reinvasion of the area is either zero or low enough that managers can quickly respond to new incursions. The biology of the target species must be well understood, including how they reproduce and how often, where they live and what they eat, and potential ability to spread.

LESSON FIVE CASE STUDIES: ERADICATION

The eradication method(s) used must be effective when the population is large or small to ensure that all individuals are detected and removed.

In addition to how effective the eradication method is on the target species, care must be taken to ensure that potential impacts to non-target species (e.g. native species) are minimized. These impacts may be direct, such as poisoning of non-target species if they ingest rodenticide (poison) used to eradicate mice or rats. Impacts can also be indirect when poisoned invasive species are consumed by scavenger species (e.g., Common Raven, Bald Eagle) and become poisoned themselves. All possible impacts to non-target species must be considered when choosing an eradication method.

Measures can be taken to help minimize potential impacts on non-target species. However, the need to reduce impacts must be balanced with the probability of eradication success. Successful eradication campaigns can have significant long-term and long-lasting benefits to island ecosystems and communities. Therefore, short-term impacts of an eradication process to non-target species on an individual animal basis (i.e., not impacting a species at a population level) are generally acceptable In the case of rat eradications, the presence of native rodents on the target island will determine how a rodenticide can be applied and what potential mitigative measures can be used to minimize impacts to the native rodents. Measuring the outcome of an eradication operation, including whether it was a success or failure, any negative effects on non-target species, and the response of the ecosystem to the removal of the target invasive species, is an important aspect of conservation projects. A conservation measures program is used to monitor, measure, and map certain native plants and animals before and after invasive vertebrate removal to help scientists understand the outcome of the conservation action, including how it affected native species. Quantitative assessments provide data to measure the effectiveness of the eradication and are also important to inform other planned island restoration techniques that might be used in combination with the eradication, such as invasive weed management or the need to re-introduce a species to the project island (e.g., repopulating an ecosystem with a previously extirpated species). Collecting data before and after each eradication project also contributes to our global understanding of how invasive vertebrate eradications can be improved upon (e.g., what techniques work or don't work) and help us better understand how and why native species may be negatively impacted by eradication operations.

The recovery of native island species following an eradication of invasive species can sometimes occur rapidly, but may also take many years to be fully realized. To monitor recovery, biologists use short-term conservation measures (1-5 years post invasive species removal) that are indicative of longer term change. Innovative techniques such as automated recording units (ARUs) are used to record bird vocalizations that can be used to identify the species present on an island and identify changes in bird calling activity over time (this can help to determine if the population size of a particular species is changing). Other proven techniques, such as studying the number and extent of plant species, breeding success of seabirds, and encounter rates of reptiles are also used to measure ecosystem change over time.

MATERIALS

Case studies, see below.

PROCEDURE

Divide the class into four groups. Ask each group to give a presentation on one of the case studies. Encourage the students to use PowerPoint, Prezi, or create a poster to present their information.

DISCUSSION

What were the different techniques used to eradicate the invasive species?

Were there any unintended consequences?

How was the community involved?

How do these communities plan to continue monitoring the ecosystem to avoid re-invasion?

RESOURCES

Case Study 1: Haida Gwaii, British Columbia, Canada
http://coastalconservation.ca/projects/night-birds-returning-haida-gwaii-british-columbia/

Case Study 2: Guadalupe Island, Mexico
https://mbgecologicalrestoration.wordpress.com/2015/03/11/guadalupe-island-baja-california-invasive-mammal-eradication-and-perspectives-for-ecological-restoration/

Case Study 3: Isles of Scilly Seabird Recovery Project, Great Britain
http://ios-seabirds.org.uk/

Case Study 4: Juan Fernández Islands Invasive Species, Chile
http://oikonos.org/juan-fernandez-islands-conservancy/

Rat Island, Predators in Paradise and the World's Greatest Wildlife Rescue. 2011. William Stolzenburg. ISBN: 978-1608191031

LESSON FIVE LAB CASE STUDY #1: HAIDA GWAII

SGin Xaana Sdiihltl'lxa: Night Birds Returning - Rat removal on Haida Gwaii, British Columbia

Haida Gwaii, British Columbia, Canada, is an isolated marine archipelago, renowned for its rugged coastline, temperate rainforest landscape, and distinct flora and fauna that have evolved during 14,000 years of isolation from the mainland. Approximately 1.5 million seabirds from 13 species nest on more than 200 offshore islands, islets, and rocks. Given the abundance of seabirds breeding on Haida Gwaii, Birdlife International (www.birdlife.org) has designated 19 locations as globally important bird areas (IBAs). The IBA program is a science-based initiative that monitors and conserves the world's most important places for birds and biodiversity.

THE PROBLEM:

The accidental introduction of Norway and black rats to several Haida Gwaii islands has resulted in a drastic decline in nesting seabird populations, including that of the Ancient Murrelet (*Synthliboramphus antiques*). Rats have significant negative impacts on seabirds, consuming eggs, chicks, and adults and causing seabird population declines, with the most severe impacts on highly vulnerable burrow-nesting seabirds. Ecologically, impacts to colonial nesting seabirds are also of great concern due to the potential for population-level impacts, which may lead to extirpation or even extinction of a particular species.

In addition to direct predation of seabirds, rats also prey on a wide variety of intertidal invertebrates normally found in the mid to very low intertidal zone, affecting the abundance and the age structure of these species. Rats also feed on plants, eating seeds and seedlings and altering the structure of the plant communities within the island ecosystem, which in turn can have an indirect negative effect on the nesting habitat quality for other bird species such as songbirds.

THE SOLUTION:

The goal of the Night Birds Returning project is to restore seabird habitat and associated ecosystem processes on several remote islands within Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve, and Haida Heritage Site (Haida Gwaii, British Columbia) through the removal of invasive rats from affected islands.

The project was undertaken in two phases. Phase One was completed in 2011 and involved the removal of Norway rats (*Rattus norvegicus*) from Arichika and the Bischof islands using specialized locking bait stations containing rodenticide bait, arranged on a 50 x 50 metre grid across the islands to ensure a lethal quantity of bait was present in every potential rat territory on the islands. During the eradication operation the bait stations were regularly monitored and rodenticide bait replenished until preliminary eradication success was confirmed when bait was no longer being removed from the stations. The success of the project was officially assessed two years after the eradication operation. This time frame gives any remaining rats enough time to reproduce and repopulate the island to densities that can be easily detected; the longer you wait the easier it becomes to detect rats if they remain.

Phase Two, which was completed in 2013, focused on the eradication of black rats (*Rattus rattus*) from Murchison and Faraday islands, two islands within the Ramsay and Juan Perez Sound Islands IBA. International eradication experts from New Zealand, Mexico, and the United States were involved in the planning and implementation of the eradication operation to maximize the probability of successfully removing the rats while minimizing impacts to native species during the eradication operation.

The size and complex terrain of these islands (e.g., cliffs, steep slopes, and jagged coastlines) required the use of an aerial application of rodenticide bait pellets rather than a bait station approach, which is more suited to smaller islands that lack challenging topography. Aerial broadcast of rodenticide bait pellets has become the most common method of rodent eradication on large islands internationally and has been used in the majority of successful rodent eradications worldwide.

The rodenticide bait pellets were spread over Murchison and Faraday islands by a helicopter using a bait-dispersing hopper. Care was taken to ensure that the bait was evenly distributed to all areas of each island at a pre-determined application rate, ensuring that all rat territories received bait and all rats had access to a lethal amount of rodenticide bait. Two applications of bait, three weeks apart, ensured that the bait was present long enough for every rat to encounter it including any young rats that were still in the nest during the first application.

During and after the eradication operation, both islands were intensively searched for rat carcasses as well as non-target carcasses (native species), which were collected and removed from the islands to reduce the risk of secondary and tertiary poisoning of non-target species such as Bald Eagles (*Haliaeetus leucocephalus*) and Common Ravens (*Corvus corax*).

CHALLENGES:

Rat neophobia: rats will often avoid novel objects in their territory, a behavior that is referred to as neophobia. During Phase 1, the plastic bait stations on certain project islands caused rat neophobia. Several methods were used to overcome this, including placing bait near the entrance of the bait stations and/or adding sardine oil to the bait blocks to make them more attractive to the rats. Both methods eventually helped the rats to overcome their neophobia to the bait stations.

Bait competition:
During Phase 2, the presence of non-native Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) on Murchison and Faraday islands presented two issues: (1) bait competition with black rats (deer were attracted to and consumed the bait), which could impact eradication success through reduced bait availability for rats; and (2) potential for primary poisoning of deer through the consumption of the rodenticide bait. Primary poisoning of deer also increased the risk of secondary poisoning to scavenging native species such as Bald Eagles, Common Ravens, Northwestern Crows (*Corvus caurinus*), black bears, and gulls (e.g., California Gull [*Larus californicus*] and Glaucous-winged Gull [*Larus glaucescens*]).

To address this bait competition, most of the deer were removed (culled) from the project islands before the eradication operation was undertaken. This greatly reduced bait competition and therefore maximized the probability of successfully eradicating rats.

Bait interception by the forest canopy:
During Phase 2, the high forest canopy closure (the presence of large trees) on Murchison and Faraday islands was predicted to intercept a portion of the aerially broadcasted rodenticide bait. Bait interception by the forest canopy would reduce the bait application rate on the ground. Lower bait application rates might mean that not all rats would have access to a lethal amount of the rodenticide bait; allowing some rats to survive the eradication operation would lead to eradication failure. The bait application rates were consequentially increased to compensate for the amount of bait that was predicted to be intercepted by the forest canopy.

Minimizing impacts to non-target species:
The use of rodenticide bait to eradicate rats from a target island also places some individuals of native birds and mammals at risk of poisoning, either directly through consumption of bait pellets (primary poisoning), or indirectly through scavenging poisoned animals (secondary or tertiary poisoning). In order to minimize impacts to non-target species, the eradication of Norway rats during Phase 1 involved the use of locking, tamper-resistant bait stations. These stations prevented non-target species such as Common Ravens from directly accessing the bait. However, some scavenging species (individual animals) did die as a result of eating other animals (e.g., rats) that had consumed the bait.

During Phase 2, the eradication operation was planned to occur when most migratory birds had left the island (i.e., less non-target species present during the eradication operation, which was predicted

to reduce the risk of non-target poisoning). The bait pellets were also designed to be too large for small song birds such as Song Sparrows (*Melospiza melodia*) to easily consume and were dyed green, which appears to make the pellets less visible, and presumably less attractive, to some bird species.

During both phases, quantified, systematic, and intensive searches were also undertaken by field personnel on all treated islands. Any animal remains (rat and non-target species) that were found were collected in order to minimize the risk of secondary and tertiary poisoning of non-target species as a result of scavenging by species such as Bald Eagles and Common Ravens.

Personnel safety:
Weather conditions on Haida Gwaii are often unpredictable from the late fall to early spring, when severe storms regularly batter the islands, often for days or weeks at a time, making the islands a risky work environment for the project team members. Both phases were implemented in the late summer and early fall when weather conditions are most favorable on Haida Gwaii.

COMMUNITY INVOLVEMENT:

Night Birds Returning is a joint project of Parks Canada Agency, the Haida First Nation, and the Archipelago Management Board. Phase 1 and Phase 2 were also undertaken with significant involvement of local community members under the direction of non-governmental organizations specializing in invasive species eradications, such as Coastal Conservation and Island Conservation. Involving locals in the Night Birds Returning project resulted in a sense of community ownership of the project and increased awareness regarding the negative impacts of invasive species such as rats, not only on seabirds but on entire island ecosystems.

OUTCOME:

Arichika Island (Phase 1) was declared rat free in April 2015, and while the Bischof islands eradication was also declared a success, rats appear to have re-invaded the island. Preliminary results suggest that Phase 2 was also successful. However, eradication success is not confirmed until two years post-eradication. This provides sufficient time for any residual rat populations to increase to detectable levels using various monitoring techniques.

Continued monitoring of the project islands is essential, both to evaluate the success of the project, and to ensure that the islands remain rat-free. Surveys of Arichika and the Bischof islands indicate that native species are already benefitting from the eradication operations. Native shrew populations have already reached numbers comparable to other rat-free islands, and Black Oystercatchers (*Haematopus bachmani*), a shorebird that responds quickly to changes in ecosystem health, are increasing in numbers and fledging more chicks than they did when rats were present on the islands.

In order to continue to monitor the islands' wildlife, automated recording units (ARUs) have been installed both on Arichika and the Bischof islands. Recordings from these devices will be used to determine the frequency and distribution of various bird species; a measure that can be used to gauge the project's success.

Parks Canada Agency has also implemented a long term monitoring program to measure rat presence/absence on the Night Birds Returning project islands over the coming years. This monitoring program is also being used to track ecosystem health over time, and will continue for several years to determine how native species are responding following the removal of black rats from Murchison and Faraday islands.

Removal of feral mammals from Guadalupe Island, Mexico

Guadalupe Island is a 100 square-mile volcanic island located 150 miles off the west coast of Baja California Peninsula, Mexico. One of the most biodiverse and unique islands in the Pacific, Guadalupe Island is home to more than 150 native species, including more than 34 endemic plants, 7 extant (living) endemic bird species or subspecies, 8 breeding seabirds, and more than 29 endemic invertebrates. The southern part of the island is bare, while the northern end is rich with trees and fertile valleys. A small military garrison (Mexican Navy) and a community of approximately 70 fishermen and their families also live on the island. The island and surrounding marine environment have been a pinniped (seal) sanctuary since 1975 and were protected as the Guadalupe Biosphere Reserve in 2005.

THE PROBLEM:

Non-native species of plants (46) and animals (8) were introduced to Guadalupe Island in the 19th and 20th centuries. Four of the introduced mammals (goats, dogs, cats, and mice) became feral. Feral cats are thought to have been responsible for the extinction of six endemic bird species and the reduced populations of other birds and invertebrates. The most devastating effects on the island's ecosystem were caused by a population of feral goats, which consumed the majority of native plant vegetation—including the seeds and seedlings of the rare and endemic Guadalupe Cypress (*Cupressus guadalupensis guadalupensis*) and Guadalupe Island Monterey Pine (*Pinus radiata* var. *binata*)—eating the vegetation down to bare rock in some areas. An expedition to evaluate the status of the island in 2000 concluded that there had been no new recruitment (new seedlings) of pines, palms, oaks, or cypress trees in 150 years (most trees were at least 100 years old) and found that many species were on the brink of extinction. It was clear that the feral goat population (estimated in 2000 to be 4000 goats; Leon de la Luz et al., 2003) on the island needed to be eradicated immediately; failure to do so was estimated to cause the disappearance of the remaining native flora and fauna within 10 to 20 years.

THE SOLUTION:

The first step in the restoration project was to inventory the existing native plant species and exclude the goats from 12 of the most sensitive areas using fences so that native flora could have an opportunity to reproduce in the absence of goat herbivory. After an extended planning period, a combination of trapping, ground hunting, and helicopter hunting by trained professionals was used to successfully remove all goats from the island.

Feral dogs, which were a threat to native birds and pinnipeds, were also eradicated from the island in 2007. The eradication of feral cats and mice poses yet another major challenge, due to the size and complexity of Guadalupe Island. As yet, these species have not been removed, although options for their removal are being assessed. In the meantime, cats have been controlled around seabird nesting areas on the island since 2003 to prevent further extinctions.

CHALLENGES:

Geography: A number of challenges were faced during this project, and continue to be faced today during ongoing monitoring and conservation efforts. The island is very large, rugged, and remote. Two volcanos, Mount Augusta and El Picacho, reach heights of 4,259 and 3,199 ft., respectively, and the coastline of the island is comprised of steep rock bluffs, making access difficult and providing places for smaller, more agile creatures such as cats and mice to take refuge.

Legal protection of the island's flora and fauna: A the beginning of this project, there was no legal protection for the island or infrastructure to support conservation efforts. This has changed with the creation of the Guadalupe Biosphere Reserve, and Grupo de Ecologia y Conservación de Islas (GECI) has built a research station on the island to facilitate year round research and monitoring.

LESSON FIVE LAB CASE STUDY #2: GUADALUPE ISLAND

COMMUNITY INVOLVEMENT:

The Mexican Navy and the local fishing community have both been involved with the eradication activities throughout the project. Both communities participated in the trapping and removing of goats, assisting GECI and Mexican ranchers from Sonora, who were enlisted to help with the project. Environmental education and public outreach has been undertaken to educate residents about how invasive species eradications help to improve quality of life, not only for native plants and animals but also for people.

OUTCOME:

The eradication of goats and other invasive species from Guadalupe Island is having a profound positive effect on native plant species. Seedlings of endemic trees such as cypress, pine, palms, and oaks have begun to grow again and critically rare plant species, including 5 species that were believed to have been extinct or absent from the island, are also recovering; demonstrating the longevity of native seed banks. The recovery of trees on the island is providing vital habitat for the endemic Guadalupe Island Junco (*Junco insularis*), and the regrowth of native ground cover plant species will create much needed soil and ground cover to support the recovery of a variety of burrow and crevice-nesting seabirds.

The Isles of Scilly Seabird Recovery Project

The Isles of Scilly form an archipelago of five inhabited islands approximately 140 rocky islets, located 28 miles west of the southwestern tip of the Cornish peninsula of Great Britain. The islands are the breeding habitat for 14 species of seabirds, approximately 20,000 birds in all, including the European Storm Petrel (*Hydrobates pelagicus*) and Manx Shearwater (*Puffinus puffinus*), and are also home to the native Scilly shrew (*Crocidura suaveolens*).

THE PROBLEM:

Introduced Norway rats were impacting seabird populations on the inhabited islands of St. Agnes and Gugh, as well as affecting the native Scilly shrew and an unknown number of invertebrates and rare plants. The rats were also impacting the local community by causing a nuisance in homes, shops, and restaurants, and on farms. Seabird populations on the islands have been in decline since 1983 and, in 2006, were found to have dropped by 25%.

THE SOLUTION:

The Isles of Scilly Seabird Recovery project is a partnership between government agencies, non-profit organizations, and the local community that is focused on the removal of Norway rats from the Isles of Scilly. Started in 2006, this 25 year project aims to prevent further declines in seabird populations on the isles through the removal of invasive rats, maintaining the rat-free status of the uninhabited seabird islands (biosecurity), and educating both the community and visitors about the risks of invasive rats and the benefits of seabird recovery.

Between October 2013 and April 2014, a ground-based eradication operation was undertaken on St. Agnes and Gugh islands. Locking bait stations containing rodenticide bait blocks were placed across all parts of the islands, as well as within the homes of all residents (74 homes). Passive detection methods, including flavored wax chew blocks, tracking tunnels, and remotely triggered cameras, were also used to monitor the progress of the eradication, and long-term monitoring will continue for two years before the eradication outcome is known (success or failure).

A detailed biosecurity plan for the islands of St. Agnes and Gugh was developed and implemented to reduce the risk of invasive species introduction and ways to respond to a confirmed invasive species incursion. Prevention involves inspecting all high risk items that are transported to the islands (e.g., hay, animal food, fresh produce). Harbors and boats maintain bait stations, and all boats are checked regularly for rat sign, especially if they have visited an island (or mainland) inhabited by rats. Residents and visitors are also asked to manage waste well (i.e., reduce food sources for rats). Detection of potential incursions is achieved through monitoring stations containing wax chew blocks that have been placed around the islands as well as the vigilance of residents and visitors who keep a look out for rats or rat sign. A dedicated phone line (“Rat on a Rat”) is maintained to report rat sightings.

CHALLENGES:

Unlike most eradication operations, the challenges faced by this project were easily overcome. Funding was readily available and all homeowners agreed to install the bait stations in their houses and outbuildings, which maximized the probability of successfully eradicating the rats. Occasional storm events resulted in some coastal bait stations being destroyed but these were quickly replaced following the inclement weather. The project team also observed some cattle tampering with the bait stations but this was addressed by employing a more sturdy method of securing the bait stations in place.

LESSON FIVE LAB CASE STUDY #3: ISLAND OF SCILLY

COMMUNITY INVOLVEMENT:

The community of St. Agnes and Gugh have been involved with this project since the earliest consultation stages and have assisted both with the eradication itself (moving equipment and bait around the island for deployment, reporting the location of any rat or non-target carcasses) and the long-term and biosecurity monitoring (community members were trained to identify rats and rat sign to assist with the permanent biosecurity measures on the islands).

During the eradication operation, school students took part in the "Rat Awareness Days" community event and acted as "Seabird Ambassadors", informing visitors to the islands about the project and how to report any rat sightings or other issues of concern. Following completion of the eradication operation the students have begun to monitor native species recovery and continue to educate visitors about invasive species issues.

OUTCOME:

Although only one year has passed since the eradication was completed, initial results appear promising. Active Manx Shearwater (*Puffinus puffinus*) burrows were recorded during the 2014 breeding season (immediately following the eradication), and the first chick to fledge (leave the nest) on St. Agnes in living memory was observed in September 2014. Scilly shrew population numbers appear to be higher than prior to the eradication. A four-year monitoring project measuring changes to vegetation, invertebrates, native mammals (namely the Scilly shrew), and birds (both land and seabirds) will report annually on changes on the islands.

The Isles of Scilly Environmental Trust (now Isles of Scilly Wildlife Trust) has been removing Norway rats from the uninhabited islands within the Isles of Scilly since 1998. Because of this ongoing biosecurity work, the most important seabird islands are being maintained "rat-free," although incursions of rats from the inhabited islands still occur frequently in the winter months.

Juan Fernández Islands

The Juan Fernández Islands are an archipelago comprised of three islands, Robinson Crusoe, Alejandro Selkirk, and Santa Clara, and several small rock stacks located approximately 670 km (415 miles) off the coast of central Chile. The seabird community of the islands contains six breeding species, four of which are globally listed as Vulnerable and which breed only in Chile. The six species include the Pink-footed Shearwater (*Ardenna creatopus*), four species of petrels (*Pterodroma* sp.) and the White-bellied Storm-Petrel (*Fregetta grallaria*). In addition, there are two Critically Endangered land birds, the Másafuera Rayadito (*Aphrastura masafuerae*) and Juan Fernández Firecrown (*Sephanoides fernandensis*), whose entire global populations are restricted to single islands in the archipelago.

THE PROBLEM:

The archipelago was only discovered in 1574, with a permanent human community only established in the late 1870s. Despite centuries of only sporadic visitation and after only slightly more than 125 years of permanent settlement, the archipelago's ecosystems have suffered from the cumulative impacts of humans, including extensive deforestation and the widespread effects of introduced plants and mammals. Invasive mammals, including feral cats, rats, coatimundis, European rabbits, and goats have impacted native ecosystems and species through habitat alteration, competition, and predation.

THE SOLUTION:

There have been several different efforts focused on controlling and eradicating invasive species on the islands. From 1998-2003, the Proyecto Holanda (Holland Project) significantly reduced the feral goat population on Alejandro Selkirk Island, developed control techniques for several extremely aggressive invasive plant species, and, significantly, eradicated European rabbits from Santa Clara Island. The removal of rabbits from Santa Clara left the island free of introduced mammals, and the responses by breeding Pink-footed Shearwaters and native plant species have been impressive.

Island Conservation has led efforts to develop feasibility studies for eradication programs on the two main islands, Robinson Crusoe and Alejandro Selkirk, and to build capacity in Chilean government agencies for eradication efforts of the magnitude required for these islands. In addition, Island Conservation and Oikonos have worked extensively with the local community to build awareness of the impacts of invasive species and, ultimately, support for eradication goals for the archipelago.

At present, eradication programs are still in the evaluation and planning stages and additional community support will be required before any eradications can take place. Biosecurity programs are also being developed by the Chilean government for the islands but have not yet been implemented on a permanent basis.

CHALLENGES:

The challenges confronting eradication efforts in the archipelago are significant and varied. They include the considerable size (approximately 4,900 ha or 11,000 acres each) and rugged topography of the two main islands, Robinson Crusoe, and Alejandro Selkirk. The relatively remote location of the islands, hundreds of miles off the coast of Chile, also makes eradication efforts logistically more complex. Because there are several invasive mammal species on the two main islands, an eradication program cannot focus on a single species but must address multiple species simultaneously, thereby adding considerable complexity.

The local community of the islands is generally supportive of eradication efforts, but there is still resistance to the idea of eliminating certain species, notably feral goats on Alejandro Selkirk and

European rabbits on Robinson Crusoe. Both species are still hunted and, therefore, are considered supplemental food sources by the community.

Given that eradication is a relatively new conservation strategy in the country, the Chilean government is still developing the capacity to support and manage eradication projects.

COMMUNITY INVOLVEMENT:

The community of the islands has been invited to participate in discussions, both formal and informal, about eradication from early on in the process. Although virtually the entire archipelago is national park and, thus, under control of a Chilean federal agency (Corporación Nacional Forestal, CONAF), the park administration has wisely included the local community in considerations related to eradications in the archipelago. Local support is obviously essential for long-term success of any eradications and CONAF, along with Island Conservation and Oikonos, have focused considerable efforts on engaging the community, building awareness and creating opportunities to train residents to work on projects related to biodiversity conservation, including the construction of mammal-excluding fences to protect seabird nesting colonies, restoration of native plant communities, and control of invasive plant species. In addition, trained residents work on a project focused on eradicating incipient (newly established) invasive plant species on both main islands, with the goal of eliminating them before they become widely established and, therefore, damaging to local ecosystems.

OUTCOME:

The only eradication outcome to date is the elimination of European rabbits from Santa Clara. The eradications necessary to safeguard the biodiversity of the two main islands, Robinson Crusoe and Alejandro Selkirk, are still pending, with the ultimate decision about whether or not to allow them in the hands of the Chilean government. Interim outcomes include the construction of cattle, rabbit and cat-proof fences to protect important breeding colonies of Pink-footed Shearwaters, the restoration of native plant communities in shearwater colonies, the ongoing control of invasive plant species in critical habitat, and the eradication of incipient invasive plant species. Community support continues to increase, but it will likely be several years before island-wide eradications.