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Journal
Proceedings of the Vertebrate Pest Conference, 24(24)

ISSN
0507-6773

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Publication Date
2010

DOI
10.5070/V424110435

The Removal of Feral Cats from San Nicolas Island: Methodology

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ABSTRACT: Feral cats are considered one of the most detrimental invasive species within island ecosystems. Non-native feral cats have been on San Nicolas Island (5,896 ha, or 14,562 acres) since at least 1952. In an effort to counter the negative impacts of feral cats on marine and terrestrial birds, the San Nicolas seabird restoration project, with the goal of eradicating cats, was initiated in June 2009. Although aimed at seabird restoration, feral cat eradication is expected to aid in the protection of endemic terrestrial species, including the federally threatened island night lizard, federally threatened western snowy plover, a subspecies of deer mouse, and the state threatened island fox. Methods including the use of altered padded leg-hold live traps, detection dogs, and hunting are being utilized to deliver a successful eradication within a short window of opportunity. In addition, a trap monitoring system, operated in tandem with field PCs and GIS, has proven effective in managing large numbers of traps. Since initiation, a rotation of staff has provided an average of 6 field personnel on-island at any one time to staff the project continuously over 10 months. Eradication was complicated by the similarly sized island fox, rugged topography, restricted access to parts of the island by Navy activities, marine mammal presence on the beaches, and sea and shore birds nesting and roosting. Island eradications require multiple methods to effectively remove all cats, and operations on larger islands benefit from the intensive use of management tools such as GIS. The systems developed on the San Nicolas Seabird Restoration Project will advance the global effort to reduce the threats of invasive species, particularly feral cats.

KEY WORDS: eradication, *Felis silvestris catus*, feral cats, introduced species, island restoration, live traps, non-target species, San Nicholas Island, trap monitoring, trapping

Proc. 24th Vertebr. Pest Conf. (R. M. Timm and K. A. Fagerstone, Eds.)
Published at Univ. of Calif., Davis. 2010. Pp. 72-78.

INTRODUCTION

Islands support a high diversity of life rich in endemic species and provide critical habitat for seabirds and marine mammals. Non-native mammals are overwhelmingly the major driver of biodiversity loss and ecosystem degradation on islands. The feral cat (*Felis silvestris catus*), a generalist predator, is among the most detrimental of invasive animals, causing declines and extinction in a diverse array of species including small mammals, reptiles, and birds (Nogales et al. 2004). Feral cats on San Nicolas Island (SNI) are known to depredate birds, both marine and terrestrial, including Brandt's cormorants (*Phalacrocorax penicillatus*) and western gulls (*Larus occidentalis*), as well as the federally listed threatened island night lizard (*Xantusia riversiana*) and the island endemic deer mouse (*Peromyscus maniculatus exterus*) (Kovach and Dow 1981, McChesney 1997). In addition, cats are likely competitors with the state-listed threatened island endemic San Nicolas Island fox (*Urocyon littoralis dickeyi*) (Kovach and Dow 1981).

SNI holds the largest population of island fox of any of the Channel Islands, with >600 individuals (Garcelon and Hudgens 2008). Fortunately, safe techniques to remove feral cats from islands have been developed, making feral cat eradications possible on islands (Campbell et al. 2010). The eradication of introduced species, such as cats, has become a widely accepted method for restoring island ecosystems. The goal of the project outlined here is to restore seabird populations and ecosystem function on SNI by eradicating feral cats. The SNI restoration project is currently ongoing and this manuscript describes activities to date.

The most common techniques used for removing cats from islands are trapping, hunting, and toxic bait (Campbell et al. 2011). Currently, no toxin is registered in the U.S. for use on cats, thus this was not an option for SNI. On SNI, foxes have been trained through positive conditioning to enter cage traps for a food reward during annual population surveys, which would lead to an unacceptably high recapture rate for foxes. Furthermore, cage traps are ineffective at capturing all feral cats in a population (Bester et al. 2002, Domm and Messersmith 1990, Twyford et al. 2000). Kill traps would put foxes at risk of capture and death. Additionally, immune-contraceptive agents that have been successfully used in other species have been ineffective when trialed on cats, and searches for other agents have not revealed any effective agents to date (Levy et al. 2005). Trap-Neuter-Return (TNR) campaigns are ineffective at reducing cat populations to zero and have never been successful in eradicating an insular feral cat population (Campbell et al. 2010, Longcore et al. 2009). Further, the U.S. Navy has a policy prohibiting feral cat TNR programs on Navy lands. Once completed, SNI will be the fifth largest island to be eradicated of feral cats to date, and the largest cat eradication to be completed without toxic baiting (Campbell et al. 2010).

SITE DESCRIPTION

The California Islands are a biogeographic region that extends from San Miguel Island at Point Conception, U.S. in the north, to Asuncion Island at Point Eugenia, Mexico in the south. The 18 islands or island groups in this region all share a similar suite of flora and fauna. Many have also shared the same introduced mammals (McChesney and Tershy 1998). Sixteen of the 18 islands /island groups have at one time supported populations of cats. Presently, only 5 islands still support cats. Within the biogeographic region, cats are wholly or partly responsible for several extinctions of birds and mammals (Diamond and Jones 1980, McChesney and Tershy 1998, Wolf 2002).

SNI (5,896 ha, or 14,562 acres) is solely owned by the U.S. Navy and is one of 4 southern Channel Islands. The island is roughly 19 km long and 8 km wide, and the highest elevation is 290 m. In general, the island exhibits sparse vegetation that is mostly attributable to past sheep ranching, the island's arid climate, and high winds. Despite historic heavy grazing, two SNI endemic plants are extant: *Eriogonum grande tamorum* and *Malacothrix foliosa polycephala*. There is no public access to the island, primarily due to security requirements.

METHODOLOGY

Environmental compliance was conducted in accordance with the National Environmental Policy Act and took 24 months to complete. The Final Environmental Assessment produced as a result of this process describes the action in detail, and it guided our actions throughout the project (USFWS 2009).

The SNI feral cat eradication campaign used primarily trapping, and limited use of hunters with detection dogs, as removal methods for feral cats. Detection methods utilized were: sign searching, camera traps, leg-hold trapping, track pads, and dogs. Methods were implemented sequentially, but in quick succession, in an effort to reduce the duration of the campaign (Figure 1).

Trial Study

Based on a trial study conducted by Island Conservation (IC) on SNI in 2006 using leg-hold traps, trap aversion by the island fox was demonstrated while trapping for cats (Island Conservation, unpubl. data). Foxes essentially became trap shy post-capture. Trap alterations and methodologies intended to reduce the risk of injury to foxes were incorporated and tested. This 20-day trial consisting of 784 trap-nights, demonstrated that modifications to the trap and trap sets produced few injuries to foxes and that those injuries were typically minor. A total of 64 foxes (41 separate individuals) were captured, with only 1 individual requiring veterinary attention. Fourteen cats were removed during the trial. Trap modifications included shortening and changing the type of anchor chain, the inclusion and positioning of two large barrel swivels (one more than the standard), and the addition of a more flexible shock absorbing spring (Figure 2).

Figure 2. Victor Oneida #1 leg-hold live trap showing chain, spring, and swivel setup as used on the San Nicolas Island feral cat eradication campaign.

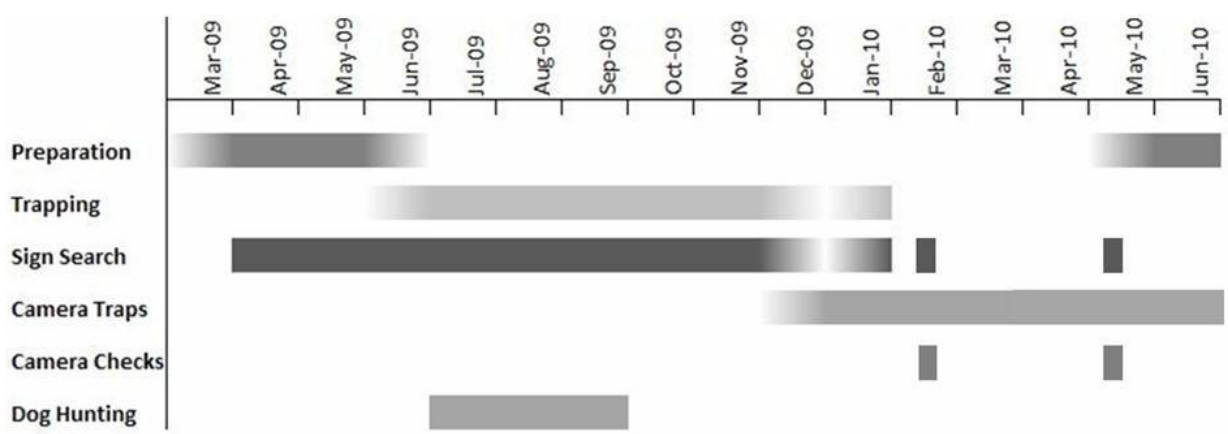

Figure 1. Timeline and sequence of methods used during the San Nicolas Island feral cat eradication campaign.

Additional trialing of equipment and methods took place on Isla de la Plata, Ecuador. Prior to the initialization of eradication on SNI, IC's trapping team were able to successfully capture cats, utilizing the modified traps designed for minimal impact on foxes. It was concluded that the modifications and trap set style were adequate to target the majority of an island's population of cats. One modification was the preparation of traps with spray-on rust prohibitive paint. On Isla de la Plata, it was suspected that paint on the surface of the rubber jaws and the fine clay substrate had lead to an increased percentage of escapes (pull-outs) by trapped cats (Island Conservation, unpubl. data). All paint was removed from any rubber jaws in an attempt to prevent this.

Trapping

Traps for SNI were prepared by first de-greasing and then painting with natural tone spray paint. Care was taken to prevent paint from coating the padding on the trap jaws. This method of rust prevention was chosen over more common commercial dyes, due to the ease and speed of preparation. However, after 6 weeks of deployment, trap operation began to be affected by corrosion. Although less time was required to paint traps compared to other techniques, durability proved to be an issue. The paint was prone to scratching, chipping, and flaking from normal handling and was further damaged during capture events. The exposed bare metal quickly oxidized and corrosion began to interfere with the traps' operation. Commercially available speed dip (Formula One Instant Trap Kote, Snare One, Port Republic, NJ), and logwood trap dye and wax, were tried as alternatives to painting and produced a more durable alternative. However, the problem persisted where traps were deployed in moist saline soils. To solve this problem, traps were routinely checked for excessive corrosion and replaced with refurbished traps when necessary.

SNI is an active military installation, and operations conducted on island often restrict access to large areas of terrain. These closures provide a challenge in operating an island-wide trap line, as closures would restrict ability to access traps and release animals in a timely manner. The island was divided into 11 zones based on geographic features, roads, and access points before any traps were set (Figure 3). The formation of zones facilitated clear communication of personnel location and allowed a trapper's effort to be directed and managed more effectively. Upon imminent operational closures, all traps within the affected area were de-activated to prevent captures and reopened once the operation was complete. Traps were de-activated by placing a board over the top of the entire set, weighted down with a rock. Operational closures due to the Navy's range activities varied in length from a single day to several weeks. Areas involved typically covered three or more zones. All terrain vehicle (ATV) tracks were installed where needed to facilitate access to several areas. Tracks were first marked by personnel on foot, then inspected by Navy archaeologists and natural resource managers, and re-routed when cultural or natural resources might be put at risk. ATV access was permitted only after this was completed. Historic vehicle access tracks were used where possible.

The identification and selection of strategic trap site locations is critical for trapping cats (Veitch 2001, Wood et al. 2002). Trappers searched areas for sign of cat activity and only placed traps when sign suggested cat presence. Personnel continued to revisit areas throughout the project and perform searches to scout new trap locations. This process of revisiting areas is essential to

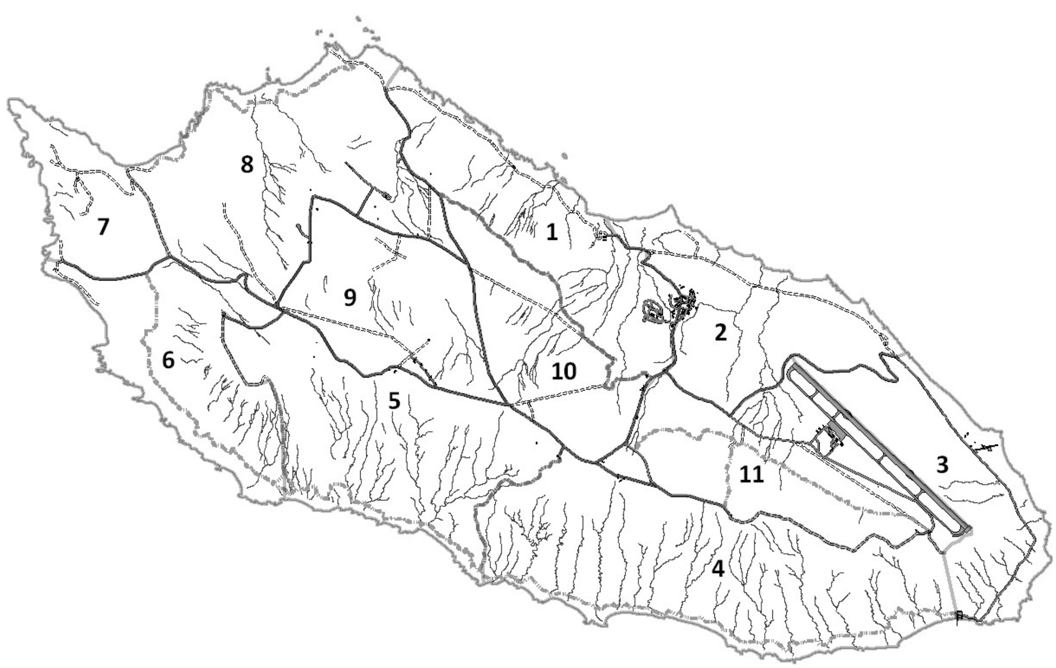

Figure 3. Map of San Nicolas Island showing work zones, roads, drainages, and ATV trails.

capturing the last remaining cats (Wood et al. 2002). Key features where traps were placed included latrine sites, animal trails, drainage bottoms, beach edges, ridges, and old roads. Targeting only locations with evidence of cat activity was a key component of minimizing captures of foxes. In areas where substrate did not allow for prints to be detected, trappers used their knowledge of cat behavior to select trap sites.

Trapping efforts progressed on a "rolling front", sweeping around the island beginning with zone 1, and then progressing through zones 2, 3, 10, 11, 4, 5, 9, 8, 6, and 7. Accommodating for extended closures on the western end of the island, island wide coverage took 69 days. Advancing with a rolling front of traps allowed personnel to keep up with the high number of non-target captures associated with newly opened trap locations. After fox captures decreased to a level manageable by staff in an area (foxes became trap shy), trapping would progress into a new zone. Advancing in structured waves proved advantageous, as it facilitated an adaptive management approach.

Trapping was conducted with the use of Oneida Victor® #1 Soft Catch® padded-jaw traps. Bullet Point Super Stakes (Schmitt Enterprises, New Ulm, MN) were used exclusively as trap anchors. Anchors were used to secure traps away from green vegetation that could bind swivels and were driven to a depth that allowed the lower swivel to remain just above ground level. Originally, anchors utilized galvanized steel aircraft cable, connected to the lower swivel and ground anchor on opposite ends by aluminum ferrules. After 5 weeks of deployment, anchor assemblies began to show signs of corrosion, and on several occasions the cable sheared in half. The combination of incompatible metals, coupled with the moist marine environment, provided ideal conditions for galvanic corrosion. This phenomenon was not apparent in past trapping efforts, either due to their short duration and/or dissimilar substrate conditions. In searching for a solution to this issue, we discovered commercial fur trappers often use copper ferrules in combination with stainless steel aircraft cable when operating in salt marshes (N. Sterling, pers. commun., 2009). All sets on SNI were modified to use these components, and to date the copper and stainless materials show no signs of corrosion or deterioration after being deployed for >6 months.

Wood (2002) described a successful trap set for targeting cats. On SNI, all sets were built in accordance with this description and made as 'walk-through' sets utilizing narrow 'pinches' on existing animal trails. When cats were thought to be avoiding the standard set type, 'cubby sets' were used as an alternative. Cubby sets were constructed of local materials, utilizing terrain features that facilitated limiting the animal to a single entrance (Algar and Burrows 2004, Veitch 2001, Wood et al. 2002). All sets were constructed in the same manner with a similar appearance, regardless of its placement (walk-through or cubby), to facilitate identification of trap sets by previously captured foxes.

Trap sites, track pads, and cat sign were recorded in a geo-database on field computers with GPS capabilities (Archer PDA, Juniper Systems, Logan, UT). Each trapper carried an Archer PDA and recorded data into the geo-database via drop-down menus. The system allowed for efficient standardized data collection and gave managers the ability to adaptively manage the project with near-real time data when coupled with GIS. This system had several advantages over traditional data collection methods, and these are discussed by Will et al. (2010).

Pongo (cat urine, faeces, glycerine) and catnip (*Nepeta cataria*) oil were combined and used as a lure on all trap locations. The majority of cats were captured in traps utilizing this lure. Faeces was removed after ~5 weeks of trapping in each zone, and the amount of catnip was reduced progressively after this time to counteract any avoidance that may have been occurring by individual cats. Although most cats are attracted to catnip, some are not (Clapperton et al. 1994). By the fourth month of trapping, all trap sites were scented with lure consisting of only cat urine and glycerine. Scent at the trap sites was refreshed after any capture, or every 10 days in conjunction with scheduled site checks. Anal gland secretion was collected from several cats as an alternative olfactory lure. This was only used on one occasion, when a cat was thought to be avoiding the standard set type and scent combination. In addition to olfactory lures, Felid Attracting Phonics (FAPs), a digital audio lure mimicking a cat's meow, were utilized in conjunction with the 'cubby' set type (Algar and Burrows 2004).

In order to minimize the time animals were restrained in a trap, a monitoring system was developed (Will et al. 2010), allowing managers to remotely detect sprung traps. In addition, the ability to remotely monitor the status of traps allowed a small number of personnel to operate more traps than could have been physically visited in a single day. The trap monitor system increased the efficiency of trap checking by field staff 10-fold (Will et al. 2010). Each individual trap was connected to a monitor unit placed near the trap set and activated when the trap was opened. Monitor units were each assigned a unique identification code and activated when personnel opened the associated trap. Further details about the design of the monitoring system are described in Will et al. (2010).

Trap sets were revisited the following day after activation, ideally by a different trapper, to ensure all components of the trap set and monitoring system were installed and functioning properly. Additionally, visual checks were performed every 5 days so that trappers could adjust any aspects of the set that would reduce the likelihood of captures, including environmental damage, and determine that the monitor units were still functioning properly.

Captured cats were removed from traps and transferred to an on-island holding facility operated by the Institute for Wildlife Studies (IWS, Arcata, CA). Each cat was sexed, aged, vaccinated, inspected for injury, and tagged with a passive integrated transponder (PIT) by IWS staff. IWS personnel also collected DNA samples from each animal and noted its reproductive status. In conjunction with The Humane Society of the United States (HSUS), all cats captured in traps were transported to a permanent holding sanctuary on mainland California, where they would live out the rest of their natural lives.

All island foxes removed from traps were processed on site by IC trappers. Trappers were trained in fox handling techniques to ensure safe removal and processing, including the identification of potential injuries. PIT tags were administered to all untagged foxes. Animals with suspected injuries including fractures, dislocations, major cuts, or body temperature related conditions were transferred to an on-island fox medical clinic staffed by IWS personnel. All other animals were released on site.

Foxes trapped during the day were susceptible to hyperthermia (overheating). Elevated fox core temperatures could occur as quickly as 20 minutes post-capture, which is one reason why the trap monitoring system and good radio communication were so critical. Trappers immediately treated hyperthermic foxes in the field, employing several methods for cooling by evaporation, while rapidly transferring the foxes to on-site veterinary staff. Hypothermia (low body temperature) was also a concern on cold evenings and when rain was likely. Protocols were established to mitigate for rain events: traps in difficult to access areas were closed when rain was forecasted, and staff were available to respond to sprung traps 24 hours a day. Additionally, trappers routinely carried instant heat packs and dry towels to begin treatment of affected animals in the field before transferring them to veterinary staff.

Detection Dogs

Specialized feline detection dogs were utilized during the cat eradication campaign on SNI for 3 months (Figure 1). Dogs were used as a tool to determine trap sites by indicating the location of scent trails, and were also used to track cats that were avoiding traps. Quarantine measures developed in conjunction with the Island Fox Working Group were designed to minimize the risk of potential introduction of diseases or parasites that could impact the SNI endemic fox. Because the goal of the project was to trap as many of the cats as possible to allow them to be removed alive from the island, hunting with dogs was used only in areas that had already been trapped for a period of time. Dogs were not as effective at detecting cat sign on SNI as we had anticipated. We feel there were several reasons for this; dogs were provided aversion training for foxes using training collars, and thus foxes, which they encountered frequently, were likely seen by the dogs as negative reinforcement for their efforts, making them less eager to work. Additionally, the extended quarantine period (7 weeks) where the dogs could not work, and the low numbers of cats in the areas they were worked on SNI, meant there were few opportunities to positively reinforce their effort. After 3 months, dogs were removed from SNI and no longer used.

Hunting

Although spotlight hunting was an option in the Final Environmental Assessment, in an attempt to exhaust all non-lethal means of removal, spotlight hunting has not been utilized as a removal method to date. For the removal of remnant feral cats that may be avoiding traps, spotlighting with a precise center-fire rifle and scope may be utilized.

Camera Traps

Infra-red remote cameras set along key travel routes provide images of cats and foxes. Cameras are digital to facilitate field downloads and save expense in developing images. Three different brands of cameras were purchased and trialed: units compared were Cryptic Cams (custom models, Critter Cam, Tasmania), Cuddeback® Capture IR trail camera (Non Typical, Green Bay, WI), and Reconyx Professional Series PC85 (Reconyx, Holmen, WI). This process took longer than expected, as most trialed cameras did not function or perform as advertised. Requirements included a rugged dependable build, weather-proof case, quick trigger, wide field of view, and a battery life and memory enabling them to function in the field over several months. Reconyx PC85 cameras were chosen as the best option, with a lithium ion battery conversion kit and high capacity memory card so that camera traps could function without maintenance for a maximum of 6 months. Twenty-six cameras have been distributed over the island, focusing on areas with high cat captures and sites where significant animal traffic occurs. Photos of detected cats will assist managers in confirming when that cat is removed by matching the image with the animal once captured. Failure to detect cats will assist in confirmation of eradication.

Sign Searches

Sign such as prints, scat, latrines, scratch posts, and predated seabird carcasses were used during the course of the project to detect the presence of cats. Sign searching by trappers occurred both in structured transects across zones, as well as in spot treatments based on GIS data queries. Trappers logged cat sign locations into the Archer handheld computers, allowing for the island-wide mapping of cat sign. Probable home range areas for cats on SNI were identified based on home range estimates from a detailed study of cat home ranges on Santa Catalina Island by Guttilla (2007) and cat sign density from SNI. Staff activity and sign search efforts were heavily influenced by these spatial analyses. In addition, personnel track logs were routinely monitored by managers to direct search activity to areas that had been overlooked.

Track Pads

Track pads were placed where cat presence was suspected or likely. Ideal substrate for tracking was either present or was carried to the locations. Track pads were used throughout the entire campaign, marked with Archer PDAs, and checked regularly. In the initial stages, track pads were used to determine the location of traps by observing sign over several days or weeks and allowing trappers to target the most frequented sites. Rain events and wind disabled track pads, unless they were placed in sheltered areas.

Confirmation of Eradication

Landcare Research have been contracted to develop a detection probability model to determine the probability of eradication, as has been done for other eradication projects (Ramsey et al. 2009). This model will be used to direct the type and amount of effort required to confirm eradication of feral cats from SNI.

RESULTS AND DISCUSSION

Between June 25, 2009 and February 17, 2010, 30,201 trap-nights occurred with up to 236 active trap sets being open at any one time. During this time, 57 feral cats were removed from the island (of which 52 were transferred to HSUS), and 1,013 captures of the endemic fox occurred. Of the captured foxes, 94 (<10%) were admitted for revision by IWS staff; of those, 74 cases (~7%) were treated for minor or major injuries, and 3 fatalities occurred. Monitoring of the fox population by IWS before or during trapping efforts indicated no detectable change in the fox population.

The last cat capture occurred in November 2009. Since that time, no cat sign was detected until camera traps were deployed in December 2009. Since cameras were deployed, a cat has been detected by camera traps on 7 separate occasions, from sign (scat) on one occasion, and from a sighting by Navy personnel. Detections have been spread over approximately one-third of the island. Trapping staff believe, due to coat pattern and appearance, that it may be a single individual.

We anticipate removal of the last cat in 2010. Confirmation of the absence of cats is likely to extend into 2011. The completion of this project will make SNI the largest cat eradication completed without the use of toxins, and the fifth largest island eradicated of feral cats (Campbell et al. 2010). SNI will also be the first cat eradication that has occurred on an island with a similar sized native carnivore, which presented significant challenges. Eradication methods were restricted for this project due to the native fox presence, as methods chosen for cat removal could not pose significant risk to the fox population. Additionally, detection methods were also limited by fox presence and environmental factors. The similarity of fox tracks to cat tracks, coupled with a large fox population, often made deciphering sign challenging. High winds are common on SNI and routinely removed or degraded tracks to an unreadable level. The combination of limited removal and detection methods for implementation of a project of this nature proved challenging. Other challenges included working around closures of parts of (or the entire) island, and having a limited time in which eradication methods could be employed.

ACKNOWLEDGEMENTS

This campaign would not have been possible without the efforts of David Garcelon (IWS), IWS staff, and other IC staff that worked on this project: Larry Bennett, Chace Bergman, Nathan Fowler, Tommy Hall, Wesley Jolley, Erik Oberg, Rory Stansbury, and David Will. Bill Wood and Jeff Davis provided advice throughout the project and its development. This project was funded by the Montrose Settlements Restoration Program.

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