A Review of Feral Cat Eradication on Islands

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Abstract: *Feral cats are directly responsible for a large percentage of global extinctions, particularly on islands. We reviewed feral cat eradication programs with the intent of providing information for future island conservation actions. Most insular cat introductions date from the nineteenth and twentieth centuries, whereas successful eradication programs have been carried out in the last 30 years, most in the last decade. Globally, feral cats have been removed from at least 48 islands: 16 in Baja California (Mexico), 10 in New Zealand, 5 in Australia, 4 in the Pacific Ocean, 4 in Seychelles, 3 in the sub-Antarctic, 3 in Macaronesia (Atlantic Ocean), 2 in Mauritius, and 1 in the Caribbean. The majority of these islands (75%;* n = *36) are small (≤5 km^2). The largest successful eradication campaign took place on Marion Island (290 km^2), but cats have been successfully removed from only 10 islands (21%) of ≥10 km^2. On Cousine Island (Seychelles) cat density reached 243 cats/km^2, but on most islands densities did not exceed 79.2 cats/km^2 (*n = *22; 81%). The most common methods in successful eradication programs were trapping and hunting (often with dogs; 91% from a total of 43 islands). Frequently, these methods were used together. Other methods included poisoning (1080; monofluoracetate in fish baits;* n = *13; 31%), secondary poisoning from poisoned rats (*n = *4; 10%), and introduction of viral disease (feline panleucopaenia;* n = *2; 5%). Impacts from cat predation and, more recently, the benefits of cat eradications have been increasingly documented. These impacts and benefits, combined with the continued success of eradication campaigns on larger islands, show the value and role of feral cat eradications in biodiversity conservation. However, new and more efficient techniques used in combination with current techniques will likely be needed for success on larger islands.*

Key Words: eradication, *Felis catus*, feral cat, islands, predation effect

Revisión de la Erradicación de Gatos Asilvestrados en Islas

Resumen: *Los gatos asilvestrados han sido responsables directos de un gran número de extinciones, particularmente en islas. En este estudio, se revisan los programas de erradicación de este felino con el fin de ofrecer información de utilidad en futuras acciones de conservación en islas. La mayor parte de las introducciones datan de los siglos diecinueve y veinte, mientras que las erradicaciones han sido realizadas básicamente durante los últimos 30 años, y sobre todo en la última década. Los gatos asilvestrados han sido erradicados de al menos 48 islas: 16 de ellas en Baja California (México), 10 en Nueva Zelanda, 5 en Australia, 4 en el Océano Pacífico, 4 en Seychelles, 3 en la Región Subantártica, 3 en Macaronesia (Océano Atlántico), 2 en Mauricio, y una en el Caribe. La mayoría de éstas (75%;* n = *36) son de reducidas dimensiones (≤5 km^2), mientras que la más extensa es Marion Island (290 km^2). En tan sólo 10 islas (21%) ≥ 10 km^2 se ha podido erradicar este depredador. En Cousine Island (Seychelles) la densidad de gatos alcanzó 243 individuos/km^2; sin embargo, en la mayoría de las islas, las densidades no excedieron los 79,2 individuos/km^2 (*n = *22; 81%). Los métodos más comúnmente empleados fueron el trampeo y la caza, a menudo con perros (91% de un total de 43 islas). Con frecuencia dichas prácticas fueron empleadas conjuntamente. Otros métodos incluyeron venenos (1080, monofluoracetato*

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Paper submitted October 16, 2002; revised manuscript accepted June 5, 2003.

de sodio en cebos de pescado: n = *13; 31%), envenenamiento secundario con ratas envenenadas (*n = *4; 10%) y el virus de la leucemia felina (*n = *2; 5%). La información sobre el efecto negativo de los gatos en islas y, más recientemente, el beneficio de su erradicación, se ha ido dando a conocer paulatinamente, poniendo de manifiesto su importancia en la conservación de la biodiversidad insular. No obstante, la combinación de técnicas nuevas y más eficientes junto con las habituales, será necesaria para el éxito de la erradicación de los gatos en islas de grandes dimensiones.*

Palabras Clave: efecto de depredación, erradicación, *Felis catus*, gato asilvestrado, islas

Introduction

Since domestication from the African wildcat (*Felys silvestris libyca*) some 4000 years ago (Randi & Ragni 1991; Serpell 2000), cats (*Felis catus*) have traveled widely as human commensals, often establishing feral populations (Todd 1977). Effects of predation on native species by feral cat populations are widespread and significant, particularly on islands (Whittaker 1998). In these insular environments, feral cats are directly responsible for a number of extinctions and extirpations worldwide and across multiple taxa (Iverson 1978; Moors 1985; Kirkpatrick & Rauzon 1986; Cruz & Cruz 1987; Towns et al. 1990; Donlan et al. 2000; Veitch 2001). Due to high levels of species, behavioral, and genetic diversity on islands, these effects contribute significantly to the reduction of biological diversity (Stone et al. 1994; Groombridge & Jenkins 2000; Atkinson 2001; McNeely et al. 2001). These negative effects and their wide distribution have resulted in the cat being included in the list of the 100 worst invasive species (Lowe et al. 2001).

In response to the problem of feral cats, techniques have been developed to remove populations from islands (Veitch 1985; Wood et al. 2002). Over the past two decades, these conservation techniques have prevented the extinction of insular species and restored many island ecosystems (Forsell 1982; Rauzon 1985; Doom & Messersmith 1990; Cooper et al. 1995; Bester et al. 2000; Veitch 2001; Mitchell et al. 2002; Wood et al. 2002). Although the removal of introduced mammals, such as feral cats, from islands is a powerful conservation tool, many of these conservation successes remain unpublished or are found only in internal reports and are thus relatively inaccessible. This lack of readily available information likely inhibits progress in eradication techniques and more generally contributes to the low level of importance placed on eradication of invasive species in many conservation circles (Simberloff 2001).

We reviewed feral cat eradication campaigns on islands with the primary intent of assessing the approaches, successes, and challenges of these conservation actions to help facilitate future island conservation programs. We reviewed documented impacts of feral cat populations on island ecosystems and the recovery of native populations after cat removal. We then analyzed key aspects of these eradication campaigns to identify future directions and challenges of cat eradication. We compiled data from published and gray literature and personally communicated with over 60 researchers and conservation practitioners, covering most of the world's insular regions.

Effects of Feral Cats on Insular Systems

Cats are extremely adaptable (Coman & Brunner 1972; Van Aarde 1986; Konecny 1987) and are found on most major island groups worldwide, including many islands inhospitable (e.g., arid, with no water) and uninhabited (Tabor 1983; Atkinson 1989). Many cat introductions were made to control rodent or rabbit populations (Flux 1993; Lever 1994). The majority of introductions took place in the nineteenth and early twentieth centuries or before; however, introductions have occurred more recently (e.g., Asunción, Coronado Norte, San Roque and Socorro islands, Baja California, Mexico). Due to the naïveté of island organisms to predation, the consequent lack of antipredator behavioral, morphological, and life-history responses (Stone et al. 1994), and the catholic diet of cats (Fitzgerald 1988), the impact of cat predation on island fauna has been devastating.

The cat is an opportunistic predator. On islands its diet includes a variety of mammals, reptiles, birds, and insects (Kirkpatrick & Rauzon 1986; Konecny 1987; Fitzgerald 1988; Nogales et al. 1988; Fitzgerald & Turner 2000). Often, primary prey is determined by relative abundance (Van Aarde 1980; Veitch 1985). Predation by cats has been directly responsible for numerous island extinctions of mammals (Mellink 1992; Tershy et al. 2002), reptiles (Iverson 1978; Mitchell et al. 2002), and birds (Jehl & Parks 1983; Lever 1994; Dowding & Murphy 2001; Veitch 2001).

Insular rodents have been the mammal taxon most vulnerable to cat predation. Hutias (*Geocapromys* spp.), an endemic group of rodents found on islands throughout the Caribbean, have been hard hit by cats and other introduced predators. A number of species are near extinction or already thought to be extinct (Fitzgerald 1988; Berovides & Comas 1991; Nowak 1999). Endemic rodents (*Nesoryzomys* spp. and *Oryzomys* spp.) from the Galapagos Islands have also suffered dramatic declines and extinctions from predation by non-native rats and cats. Only four species remain, three of which are found only on islands free of introduced predators (Patton & Hafner 1983; Dowler et al. 2000). In northwestern Mexico, cats have caused a wave of rodent extinctions on the islands of Baja California, with over 10 taxa extinct or nearly extinct (Mellink 1992; Álvarez & Cortés 1996; Álvarez & Ortega 2002; Mellink et al. 2002).

Cat predation on island reptiles at tropical and subtropical latitudes appears cosmopolitan (Laurie 1983; Konecny 1987; Fitzgerald 1988; Nogales et al. 1990; Arnaud et al. 1993; Nogales & Medina 1996; Rando & López 2001). Cats, along with other introduced predators such as mongooses (*Herpestes javanicus*) and rats (*Rattus* spp.), have played a significant role in driving recent distributions and abundances of island reptiles. These community-level processes have resulted in novel biogeographic patterns (Case & Bolger 1991). For example, the tuatara (*Sphenodon punctatus*) and 40% of New Zealand lizards are now largely confined to offshore islands free of introduced predators (Daugherty et al. 1994; Towns & Daugherty 1994). Other examples of local reptile extinctions due to cat predation are iguanas (*Brachylophus* spp.) and skinks (*Emoia* spp.) in the Fiji Islands (Gibbons 1984) and iguanas (*Cyclura* spp.) on islands in the Caribbean (Iverson 1978; Alberts 2000; Mitchell et al. 2002). Other reptiles, such as the endemic giant lizard (*G. gomerana*) from La Gomera Island (Canary Islands, Spain), are on the verge of extinction, with cat predation suspected as the major cause (Valido et al. 2000; Nogales et al. 2001).

Feral cats are responsible for the extinction of at least 33 bird species (Lever 1994). Insular endemic landbirds are most frequently driven to extinction. The Stephen Island Wren (*Traversia lyalli*; New Zealand) is a noteworthy example because the last population of this species was driven to extinction by one individual cat in 1894 (Fuller 2000). Such examples lend support to the idea that only a few predators can have substantial impacts on prey demography and community-level processes (Estes et al. 1998; Roemer et al. 2001; Roemer et al. 2002). A more recent case of wild extinction occurred in Socorro Island (Mexico), where an endemic species of dove (*Zenaida graysoni*) disappeared in the wild and the population of an endemic passerine (*Mimodes graysoni*) was reduced nearly to extinction after cats were introduced by a military garrison in the late 1950s (Jehl & Parks 1983; Martínez & Curry 1996).

Seabirds are less frequently driven to extinction because they usually breed on more than one island; however, there have been spectacular extirpations and even extinctions caused by cats (Stonehouse 1962; Moors & Atkinson 1984; Fitzgerald & Veitch 1985; Veitch 1985; Fitzgerald 1988). An often-quoted example of a global seabird extinction is that of the Guadalupe Storm Petrel (*Oceanodroma macrodactyla*), which was restricted to Guadalupe Island, Mexico (Jehl 1972). Van Aarde (1980) estimated that on Marion Island (sub-Antarctic island, South Africa) cats preyed on about 455,119 seabirds per year, which constitutes an annual kill rate of more than 200 individuals per cat. Pascal (1980) estimated that on Kerguelen (sub-Antarctic island, France), cats killed approximately 1.2 million seabirds each year during the 1970s. Seabirds are also severely preyed upon by cats on Ascension Island, where the Sooty Tern (*Sterna fuscata*) colony has been reduced from possibly more than one million pairs in the 1940s to the current estimation of about 150,000 breeding pairs (Ashmole et al. 1994).

Published studies on the recovery of populations from cat eradication are less common than impact studies; thus, most case studies remain anecdotal or in unpublished reports. Nonetheless, the benefits to biodiversity conservation are clear and significant. On Natividad Island (Mexico), for example, Keitt et al. (2002) showed that a relatively small population of cats could have driven the population of approximately 75,000 Black-vented Shearwaters (*Puffinus opisthomela*) to local extinction in 10–50 years. When cats were present, more than 1000 shearwaters were found dead on the colony every month (Keitt et al. 2002). After cats were eradicated (Wood et al. 2002), fewer than 100 shearwaters were found dead on the colony each month (Keitt & Tershy 2003). On Coronados Islands (Mexico), Cassin's Auklets (*Ptychoramphus aleuticus*) were driven to local extinction by cat predation (Jehl 1977) but recolonized the island within 4 years after cats were eradicated (Wolf 2002). On Marion Island, cat depredation caused the extinction of the Common Diving Petrel (*Pelecanoides urinatrix*) and severely affected some species of hole-nesting petrels (Procellariidae). Following cat eradication, hole-nesting petrels showed signs of recovery (Cooper et al. 1995), and Common Diving Petrels are again breeding on Marion Island (Hänel & Chown 1998).

Eradication on Islands

Feral cat eradication has been carried out on at least 48 islands (Appendix 1). By geographic region, Baja California (Mexico) has had the most successful cat removals, followed by islands of New Zealand, Australia, the South Pacific, Seychelles, sub-Antarctic, Macaronesia (Atlantic Ocean), Mauritius, and the Caribbean (Fig. 1). Island areas range from 0.13 km^2 (San Jerónimo, Baja California, Mexico) to 290 km^2 (Marion Island, sub-Antarctic). However, the majority of islands (75%, $n = 36$) where eradication has been successful are $\leq$5 km^2, and only 10 (21%) are $\geq$10 km^2 (Appendix 1).

The first successful campaign took place on Stephens Island, New Zealand, in 1925 (Baldwin 1981). Between 1925 and 1980, cats were removed from nine islands;

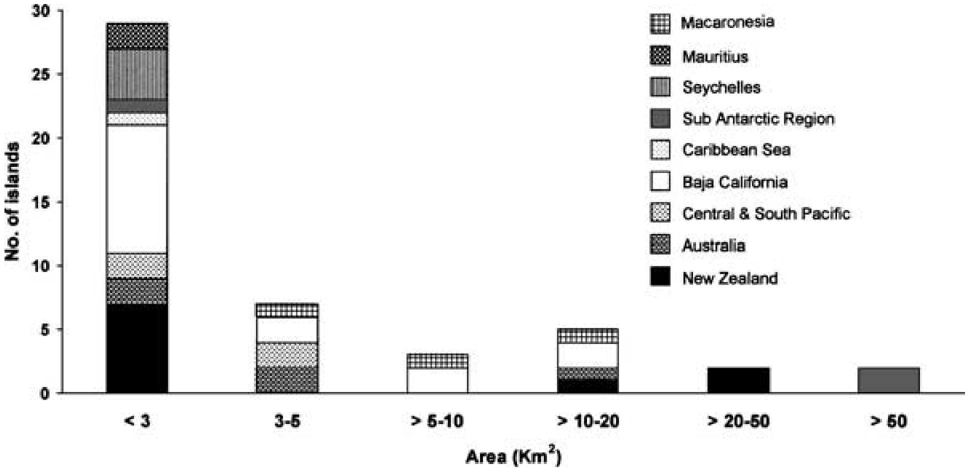

*Figure 1. Location and size of the islands where feral cat (*Felis catus*) eradication campaigns have been successfully carried out.*

most are offshore islands of New Zealand (Veitch 1995). In the last 20 years there have been great successes with removal of island cats: cat populations were removed from 37 islands, 28 of them in the last decade, especially around Baja California.

On 27 islands for which cat densities have been reported, densities varied from 0.15 individuals/km^2 (Partida Sur, Mexico) to 243 individuals/km^2 (Cousine, Seychelles). However, a high number of islands ($n = 22$; 81%) had densities lower than 79.2 individuals/km^2.

The main methods used in eradication campaigns have been (1) trapping, (2) hunting (with dogs, rifles, and guns), (3) poisoning (in fish baits), and (4) disease introduction (mainly virus). The use of baits in traps has been combined on at least on six islands with attractive substances (urine, droppings, or gonad extracts) to improve capture results. Secondary poisoning of feral cats that consumed introduced *Rattus* spp. that had eaten anticoagulants, such as brodifacoum, has played a role in four insular eradication campaigns (Tuhua, Pitcairn, Curieuse, and Flat islands).

Most eradication programs used traps—commonly gin traps (Conibear and Oneida Victor, Lititz, Pennsylvania) and less frequently cage traps (Tomahawk, Tomahawk, Wisconsin—and/or hunting ($n = 39$; 91% of the 43 islands for which information is available; Fig. 2). Hunters have used .22 and .222-caliber rifles and 12-gauge shotguns. Hunting with dogs has been carried out during the day, and at night with the aide of adjustable headlamps. More details on the methods of cat-eradication campaigns on islands have been provided by Veitch (1985, 2001) and Wood et al. (2002).

After hunting and trapping, the most frequently used techniques were direct poisoning ($n = 14$; 33% of the islands), secondary poisoning ($n = 4$; 10%), and disease introduction (5%). To our knowledge, in most cases the only poison used has been 1080 (sodium monofluoroacetate), which has been applied on three islands in Australia, two each in the Seychelles, New Zealand, and sub-Antarctic, and one each in the central Pacific Ocean, Caribbean, and Baja California (Appendix 1). The disease agent was feline panleucopaenia virus, which was used on the islands of Jarvis and Marion (Rauzon 1985; Bester et al. 2000). Recent theoretical models based on virus-vectored immunocontraception may hold promise for future eradication campaigns (Courchamp & Cornell 2000).

In the majority of eradication plans, several simultaneous techniques were used (e.g., Fitzgerald & Veitch 1985; Rauzon 1985; Veitch 1985; Bester et al. 2000; Twyford et al. 2000; Wood et al. 2002). It is difficult to evaluate the relative effectiveness of these techniques because they were used by different individuals in different habitats. However, toxins and biological controls tended to be most effective at the beginning of an eradication operation, whereas hunting and especially trapping appeared to be the only effective techniques to eradicate the few remaining cats.

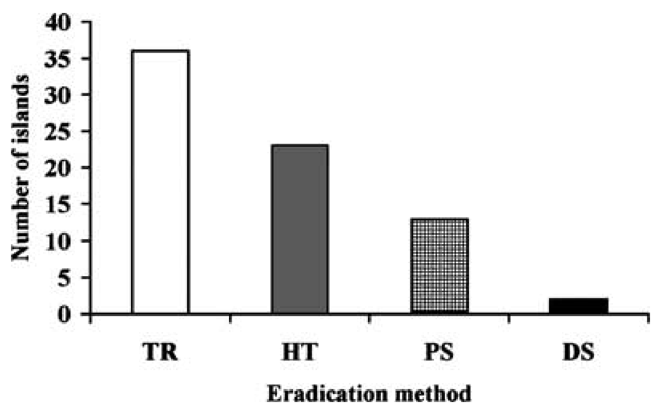

Figure 2. Use of feral cat eradication methods employed on 44 islands: TR, traps; HT, hunting; PS, poison; and DS, disease.

Conclusions and Recommendations

We identified 48 feral cat eradications on islands, most of which were on islands <5 km^2 in size, although a few took place on islands of >15 km^2. Considering the number of island species whose extinctions have been caused by feral cats, it is remarkable that there have been so few documented feral cat eradications. Based on the results of our review, we make the following suggestions. (1) Because of the well-documented extinctions and near extinctions of native island animals caused by feral cats, land managers should routinely eradicate feral cats from islands of <5 km^2. These eradications are particularly beneficial to seabirds, which can form extremely dense nesting colonies on these small islands. (2) With extensive planning and a greater investment of time and effort, land managers should attempt to eradicate feral cats from medium-sized islands (around 10–30 km^2). These programs on medium-sized islands need to be well documented and supported by applied research on cat home ranges, movement patterns, and bait acceptance so that existing techniques can be refined. (3) New techniques should be developed to eradicate cats from larger islands of >50 km^2, where biodiversity and endemism levels are highest.

An example of a successful cat eradication took place on the uninhabited, large island of Marion. It took about 15 years of intense effort to eradicate the cats, combining several methods such as trapping, hunting, poisoning, and disease introduction (Bloomer & Bester 1992; Bester et al. 2000). The use of disease agents or targeted poisoning campaigns hold promise for an initial population reduction in eradication programs on large islands—such an approach may save effort, time, and money. However, such approaches should minimize nontarget effects (see cautions given by the World Conservation Union [2000]).

Large islands are often inhabited by humans; therefore, eradication programs become more complicated by island area and because the cat has been linked to humans since historical times. Cat eradication is currently being carried out on Ascencion Island (area of 97 km^2 and a human population of around 1000), one of the most important breeding places for seabirds in the tropical Atlantic (Ashmole & Ashmole 2000).

With every eradication program on islands, the prevention of reintroduction is as important as eradication itself. Therefore, effective quarantine plans, including policies prohibiting the presence of potentially invasive pets, should be a major component of conservation plans in insular environments (especially on smaller islands). Furthermore, environmental education programs in conjunction with the eradication program are often a requisite for conservation success (e.g., Donlan & Keitt 1999). Despite the lack of attention that non-native species eradications from islands have received from the overall conservation community, these eradication programs have been successful in stopping extinctions and in preserving biodiversity as well as ecological and evolutionary processes (Donlan et al. 2003). The recent successes on larger islands are encouraging for future island conservation.

Acknowledgments

This review would not have been possible without the collaboration of many researchers who shared all sorts of information with us, sometimes unpublished. We are especially indebted to D. Merton and B. Bell (New Zealand); A. Burbidge, P. Copley, and G. Copson (Australia); P. Oliveira (Madeira, Portugal); M. Bester, and M. Cohen (South Africa); F. Courchamp, M. Pascal, and J.-L. Chapuis (France); K. Campbell and F. Cruz (Galápagos, Ecuador); S. Roy (Mauritius); M. Rauzon, D. Goltz, E. Campbell, and D. Forsell (Hawaii, U.S.A.); N. Mitchell, M. Naughton, and R. Clapp (U.S.A.); and J. Á. Sánchez, M. Á. Hermosillo, and G. Arnaud (México). J. Berger, E. Main, D. Wenny, and two anonymous referees offered valuable comments to improve the manuscript. Basic research for this paper was conducted as part of a natural resource restoration project supported by the LIFE project (99 NAT/E/006392) of the European Union and the Cabildo Insular de Lanzarote (Canary Islands, Spain).

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Appendix 1. Characteristics of the islands from which feral cats (*Felis catus*) have been eradicated.

Island	*Country**	*Size (km^2)*	*Population estimated*	*Population density (cats/km^2)*	*Introduction year*	*Eradication period*	*Eradication methods*	*Reference*
Macquarie I. (sub-Antarctic island)	AUS	120	2450	20.4	1810–1820	1975–2000, to be confirmed	trapping, hunting, Poison 1080	Copson & Whinam 2001; G. Copson, personal communication
Hermite (Montebello I.)	AUS	10.2	≈20	2	c. 1880	1999 (8 weeks)	Poison 1080 in kangaroo meat, trapping	Algar et al. 2002
Great Dog Island (Tasmania)	AUS	3.7	194	52.4	unknown	1991–1992	trapping, hunting	I. Skira, unpublished data
Reevesby	AUS	3.4	4	1.2	end of 1800s or early 1900s	1984–1990	trapping	Pedler & Copley 1993
Gabo (southern-east Victoria)	AUS	1.54	at least 30		first recorded in 1846	1987–1991	hunting, trapping, 1080 poison-baiting program	Twyford et al. 2000
North West I. (Capricornia section)	AUS	1.05	≈105	100	c. 1800s	1984–1985	hunting, trapping, poison 1080 on fish bait	Doom & Messersmith 1990
Guillou (Kerguelen, sub-Antarctic island)	FRA	1.45	≈15	10.3	unknown	1994–1995	hunting	Chapuis & Frenot 1996
Pitcairn (central Pacific Ocean)	GBR	5.0	>70		unknown	1997	cage and gin traps, secondary poisoning from poisoned rats, hunting	Bell & Bell 1997
Long Cay (Caicos Bank, Caribe)	GBR	1.11	<10		unknown	8–12 July 1999	Poison 1080 in fish baits	Mitchell et al. 2002
Partida Sur (Gulf of California)	MEX	20.0	3	0.15	unknown	2001	removed alive by fishers	Donlan et al. 2000; Wood et al. 2002
Monserrate (Gulf of California)	MEX	19.4	15	0.8	unknown	2000–2001	trapping, hunting	Donlan et al. 2000; Wood et al. 2002
Coronados (Gulf of California)	MEX	8.5	8	0.9	unknown	November 1998–April 1999	trapping	Arnaud et al. 2000
Natividad (Pacific Ocean, Baja California)	MEX	7.2	40	5.6	more than 30 years ago	1999–2000, to be confirmed	trapping, hunting	Donlan et al. 2000; Wood et al. 2002
Danzante (Gulf of California)	MEX	4.9	2	0.4	unknown	2000	trapping	G. Arnaud, personal communication
San Martín (Pacific Ocean, Baja California)	MEX	3.2	21	6.6	≈ more than 20 years ago	1999	trapping, hunting	Donlan et al. 2000; Wood et al. 2002
Todos Santos Sur (Pacific Ocean, California)	MEX	1.0	31	31	1910–1923	November 1997–July 1998	trapping, hunting	Donlan et al. 2000; Wood et al. 2002
Asunción (Pacific Ocean, Baja California)	MEX	0.92	1–3		beginning 1970	1994–1995	traps baited with canned food, urine, droppings	Donlan et al. 2000; Wood et al. 2002
Coronado Norte (Pacific Ocean, Baja California)	MEX	0.48	38	79.2	end of 1987–1980	1996–1997	traps baited with urine, droppings, and food	Donlan et al. 2000; Wood et al. 2002
San Roque (Pacific Ocean, Baja California)	MEX	0.38	23	60.5	beginning 1970	end of 1980–1996	hunting, traps baited with canned food, urine, droppings	Donlan et al. 2000; Wood et al. 2002
Todos Santos Norte (Pacific Ocean, Baja California)	MEX	0.23	3	13	1910–1923	July-August 1999	traps baited with urine, droppings, and food	Donlan et al. 2000; Wood et al. 2002
San Jerónimo (Pacific Ocean, Baja California)	MEX	0.13	14	107.7	≈ more than 30 years ago	1999	trapping, hunting	Donlan et al. 2000, Wood et al. 2002
Mejía (Gulf of California)	MEX	3.0	3	1	unknown	2001	trapping, hunting	Donlan et al. 2000; Wood et al. 2002
San Francisquito (Gulf of California)	MEX	2.6	3	1.2	unknown	2000	trapping, hunting	Donlan et al. 2000, Wood et al. 2002
Isabela (Gulf of California)	MEX	1.0	>25		unknown	1996	Poison 1080, trapping, hunting	Wood et al. 2002; C. Rodríguez, personal communication
Estanque (Gulf of California)	MEX	0.5	1	2	unknown	1999	trapping, hunting	Donlan et al. 2000; Wood et al. 2002
Flat	MRI	2.5	5	2	probably recent releases by campers	1998	secondary poisoning from rat eradication, gin traps	Bell & Lomax 1998
Ile aux Aigrettes	MRI	0.25	<10		probably in the twentieth century	1994	modified box traps	S. Roy, personal communication
Little Barrier	NZL	28.2	unknown		<1870	1977–1980	gin traps, hunting, Poison 1080	Veitch 2001
Kapiti	NZL	19.6	never numerous		c. 1900	1934	unknown	Wilkinson & late Amy 1952
Tuhua (Mayor)	NZL	13.0	unknown		unknown	September 2000, to be confirmed	secondary poison from brodifacoum used for rats and possibly starvation	C. R. Veitch, personal observation
Cuvier	NZL	1.9	12	6.3	c. 1889	1960–1964	gin traps, hunting	Merton 1970
Motuihe	NZL	1.8	50	27.8	c. nineteenth century	1978–c. 1981	hunting	Veitch 1995

continued

Appendix 1. (continued)

Island	*Country**	*Size (km^2)*	*Population estimated*	*Population density ($cats/km^2$)*	*Introduction year*	*Eradication period*	*Eradication methods*	*Reference*
Stephens	NZL	1.5	unknown		c. 1892	c. 1910–1925	unknown	Baldwin 1981
Putauhinu	NZL	1.4	scarce number		unknown	unknown	unknown	Veitch 1995
Mangere (Chathams I.)	NZL	1.3	unknown		end of 1800	c. 1950	none, unknown causes of disappearance	Tennyson & Millener 1994
Matakohe	NZL	0.37	3–5		c. 1832–1848	July-August 1991	Timms and gin traps, Poison 1080	Clapperton et al. 1992
Herekopare	NZL	0.3	33	110	c. 1925	1970	gin traps, hunting	Fitzgerald & Veitch 1985
Deserta Grande (Madeira)	POR	10	scarce but unknown		unknown	unknown; one individual dead on 1984 (M. Jones, personal observation)	none, unknown causes of disappearance	P. Oliveira, personal communication
Marion (sub-Antarctic island)	RSA	290	3405	11.7	1949	1977–1991	feline panleucopaenia virus, dogs, hunting, gin traps, attractive substances, Poison 1080	Van Aarde 1978; Van Aarde & Skinner 1981; Bester et al. 2000
Curieuse (inner group)	SEY	2.9	<50		unknown	2000	primary and secondary poisoning from brodifacoum used in rat eradication, trapping	Parr et al. 2000; Merton et al. 2002
Fregate (inner group)	SEY	2.2	<100		unknown	1980–1982	Poison 1080, trapping	Parr et al. 2000
Denis (inner group)	SEY	1.5	<100		unknown	2000	Poison 1080, trapping	Parr et al. 2000; Merton et al. 2002
Cousine (inner group)	SEY	0.3	73	243.3	unknown	1985–1990	Trapping	Laboudallon 1987; Parr et al. 2000
Alegranza (Canaries)	SPA	10.2	at least two in the 1990s, but probably more abundant in the past		possibly in the twentieth century	1997–2001, one individual killed in 1998 and unknown causes of disappearance	gin traps, cage traps baited with canned fish, lures	Martín et al. 2002*a*
Lobos (Canaries)	SPA	4.38	20–30		unknown	1992–2002, to be confirmed	gin traps, cage traps baited with fish, poison, lures	Ardura & Calabuig 1993; Rodríguez Luengo & Calabuig 1993; Martín et al. 2002*b*
Jarvis (central Pacific Ocean)	USA	4.1	<200		1885?	1957–1990	feline panleucopaenia virus, cage and gin traps, hunting, poison	Rauzon 1985; Rauzon et al. 2002
Howland (central Pacific Ocean)	USA	1.66	8	4.8	1966	9–12 May 1979	hunting, trapping (conibear and tomahawk traps)	Kirkpatrick & Rauzon 1986; Rauzon et al. 2002
Baker (central Pacific Ocean)	USA	1.45	possibly hundreds		1930s	1964?	cats removed by running them down and hitting them with sticks	Forsell 1982; D. Forsell and M. Rauzon, personal communication

**Country abbreviations: AUS, Australia; FRA, France; GBR, United Kingdom; MEX, Mexico; MRI, Republic of Mauritius; NZL, New Zealand; POR, Portugal; RSA, Republic of South Africa; SEY, Republic of Seychelles; SPA, Spain; USA, United States of America.*