

Accomplishments and impact of the NGO, Island Conservation, over 15 years (1994–2009)

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Abstract Improvements in biodiversity conservation are hampered by the lack of reporting on the effectiveness of conservation techniques and the organizations that implement them. Here we summarize the accomplishments and potential impact of the non-governmental organization, Island Conservation, which eradicates damaging invasive vertebrates from islands. Island Conservation has removed 54 populations of 10 invasive vertebrates from 35 islands totaling over 520 km². These actions helped protect 233 populations of 181 insular endemic species and subspecies of plants and vertebrates and 258 populations of 54 species and subspecies of seabirds from the threat of local and global extinction. There were no reinvasions. One eradication attempt failed. These conservation actions and their apparent biodiversity impact demonstrate the potential of private organizations to protect biodiversity by eradicating invasive species from islands.

Keywords Eradication · Island Conservation · Invasive species · Insular endemic species · Threatened seabirds

Abbreviations

NGO Non-governmental organization

IUCN International Union for Conservation of Nature

Introduction

It is now widely accepted that we are in the midst of an extinction crisis brought about by land conversion, overexploitation, pollution and invasive species (Pimm et al. 2006; Wake and Vredenburg 2008). For well-studied taxa, current extinction rates are two to three orders of magnitude greater than background rates and equally above rates at which new

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species evolve (Dirzo and Raven 2003). This loss of species has negative economic, ethical, and aesthetic impacts and is essentially permanent over time scales relevant to humans. Consequently, efforts to prevent extinctions have been extensive, but the efficacy of such efforts is often not evaluated (Sutherland et al. 2004; Ferraro and Pattanayak 2006).

Here we report on the accomplishments and resulting biodiversity impacts of an international conservation organization that specializes in the prioritization, planning and implementation of invasive vertebrate eradications from islands. Island Conservation is a US-headquartered non-government conservation organization founded in 1994 whose mission is “to prevent extinctions”. Island Conservation started as an entirely volunteer organization with offices in the US and Mexico and now has 30 paid employees and programs in North America, South America, the Caribbean and the Tropical Pacific. The Mexican branch of Island Conservation, Conservación de Islas, has experienced similar growth and in 2009 the two organizations became formally independent. In this paper we examine accomplishments between 1994 and 2009.

Methods

To quantify Island Conservation’s accomplishments, we compiled a database of plant and vertebrate biodiversity, area and location for all islands where they attempted to eradicate one or more invasive mammal species. We used the IUCN Redlist (<http://iucnredlist.org>, 2004) to determine if an endemic vertebrate species was threatened (classified as Critically Endangered, Endangered or Vulnerable). We did not determine the threatened status of plants as the IUCN Redlist coverage of plant taxa was not adequate. We did not independently evaluate the success or failure of attempted eradications, but instead relied on the assessments of Island Conservation staff, the organizations that manage the islands, and island users. Two of the authors of this paper (Tershy and Croll) founded Island Conservation but are no longer affiliated with the organization. However, their lab at the University of California, Santa Cruz, receives funding to assist Island Conservation in its selection of islands for invasive vertebrate eradication and to monitor the biodiversity impact of those eradications.

In this analysis we documented terrestrial species and subspecies that occur only on islands and seabirds that breed primarily or exclusively on islands. We considered a species or subspecies an island endemic if it bred on ≤ 5 islands. We counted an island endemic or seabird species or subspecies as “protected from extinction” if it occurred on an island where a potentially damaging invasive mammal (either via direct or indirect impacts) was eradicated. Endemic vertebrates and seabirds were considered protected by the eradication of invasive herbivores, omnivores and carnivores. Endemic plants were considered protected by the eradication of invasive herbivores and omnivores, but not of invasive carnivores.

Our logic for assigning impacts of invasive vertebrates on island species is as follows. Invasive herbivores directly impact plants (Ali 2004) and indirectly impact native species dependent on vegetation and soil (Donlan et al. 2007). Invasive omnivores directly impact plants and animals via herbivory and predation. They indirectly impact animals that feed on plants via herbivory. Invasive herbivores and omnivores impact seabirds directly by trampling and competition for burrows, or indirectly via grazing of plants used for nesting or compaction and erosion of soil used for nesting holes. Invasive omnivores also impact seabirds directly through predation (Howell and Webb 1989). Invasive carnivores directly impact native animals via predation. Although they can indirectly impact native plants via

disruption of seed dispersal (Kaiser-Bunbury et al. 2010), disturbance processes (Pinter and Vestal 2005), biogeochemical cycles (Hannon et al. 2001), and seabird-derived nutrient subsidies (Croll et al. 2005), these impacts are less well documented for many project islands and we did not include them in this analysis.

We did not attempt to assess the magnitude of benefit to a given island endemic or seabird species/subspecies. These benefits ranged from minor (when only a small portion of the population received benefit) to saved from extinction (when the entire species/subspecies was contained on the island). For example, global populations of boobies, *Sula* spp., likely received only a minor benefit from invasive *Rattus rattus* eradication (Jones et al. 2008), while seven single-island endemic plant species thought to be globally extinct returned from the seed bank following an invasive herbivore eradication on Guadalupe Island (Aguirre-Munoz et al. 2008; Donlan et al. 2002; Garcillan et al. 2008).

Some of Island Conservation's project islands contain endemic invertebrates that likely benefited from invasive animal eradications (Otte and Cowper 2007; Weissman et al. 1980). However, we were unable to compile a sufficiently uniform dataset on invertebrate fauna to conduct a meaningful analysis.

Results

Between 1994 and 2009 Island Conservation eradicated 54 invasive vertebrate populations from 35 islands with a total area of 523.87 km² (Table 1; Fig. 1). These actions afforded protection for 233 populations of 181 endemic species and subspecies (15 of which are globally threatened) and 258 populations of 54 seabird species and subspecies (11 of which are globally threatened) (Table 1; Fig. 2).

One attempted eradication failed: the removal of rabbits from 29.28 km² Clarion Island, Mexico (Aguirre-Munoz et al. 2008). However, successful pig and sheep eradications from this island did provide some protection for the island's seven endemic vertebrates and 13 endemic plants.

None of the 35 project islands have been successfully re-invaded by the eradication target species. However, at least two may have suffered subsequent new invasions: (1) San Benito West Island, Mexico was invaded by *Peromyscus maniculatus* (a deer mouse native to the adjacent mainland) ≤ 10 years after invasive rabbits, goats and donkeys were removed, and (2) Coronado South Island, Mexico appears to have been invaded by *Mus musculus* ≤ 5 years after cats, dogs and goats were eradicated. It is possible that *Mus musculus* had previously invaded Coronado South Island but was not detected due to an abundant and similarly-sized endemic deer mouse *Peromyscus maniculatus assimilis* on the island.

Discussion

The two main weaknesses of our analysis are: (1) that we were unable to quantify the absolute benefit (i.e. change in population biology) for each native species affected and, (2) we did not quantify the financial cost of Island Conservation's efforts. Ideally, we would have data to calculate a change in population viability for each endemic and seabird protected (e.g. Keitt et al. 2002; Keitt and Tershy 2003), however sufficient monitoring data were not available for most of the >200 species and subspecies protected. In the future, Island Conservation and other organizations interested in measuring impact, should

Table 1 Island Conservation’s invasive mammal eradications and the insular endemics and seabirds protected

Island	Project				Non-native mammals		Endemic species/subspecies (new populations)							Threatened Seabirds
	Year	Latitude	Longitude	Area (km ²)	Eradicated	Present	Mammals	Reptiles	Birds	Plants	Total	Threatened	Seabirds ^a	
Asuncion	1994	27.105°N	114.293°W	0.68	C		1				1		9	1
San Roque	1994	27.148°N	114.379°W	0.79	R, C								2 (10)	(1)
Coronado North	1995	32.439°N	117.296°W	0.79	C		1	1	2		4		3 (6)	2
Isabela ^b	1996	21.858°N	105.884°W	2.74	R, C								10 (1)	
San Benito Middle	1998	28.312°N	115.574°W	1.05	Rab				3	1	4		2 (10)	1 (2)
San Benito West	1998	28.308°N	115.564°W	5.48	G, Rab, D ^c	M ^d			(3)	5	5 (8)		(11)	(3)
Todos Santos South	1998	31.802°N	116.792°W	1.27	C, Rab		1	1	1	1	4		(6)	(1)
Coronados ^b	1999	26.104°N	111.281°W	10.03	C		2	1			3	1	1	
Estanque	1999	29.067°N	114.125°W	1.05	C								(2)	(1)
Natividad	1999	27.877°N	115.177°W	10.29	C, G ^c , S ^c , DG ^c	SQ ^e	1			3	4		(10)	(1)
Todos Santos North	1999	31.809°N	116.805°W	0.62	C, Rab, D ^c , DG ^c	(1)			(1)	(1)	(3)		(6)	(1)
Guadalupe	2000	29.039°N	118.285°W	264.7	G, Rab ^c , H ^c , DG ^c	C, D			7	34	41	1	4 (5)	3 (1)
San Francisquito	2000	24.842°N	110.582°W	4.65	C, G		2	2		1	5		(1)	
San Jeronimo	2000	29.791°N	115.795°W	0.67	C		1				1		(6)	(1)
San Jorge	2000	31.012°N	113.257°W	0.41	R								(11)	(1)
San Jorge Islet—E	2000	31.23°N	113.264°W	0.09	R								(9)	(1)

Table 1 continued

Island	Project		Endemic species/subspecies (new populations)																				
	Year	Latitude	Longitude	Area (km ²)	Non-native mammals		Mammals			Reptiles			Birds		Plants		Total	Threatened	Seabirds ^a	Threatened Seabirds			
					Eradicated	Present	Mammals	Reptiles	Birds	Plants	Total	Threatened	Threatened	Threatened	Threatened	Threatened	Threatened	Threatened	Threatened	Threatened			
San Jorge Islet—W	2000	31.015°N	113.264°W	0.07	R																(9)	(1)	
San Martin	2000	30.486°N	116.117°W	2.98	C		1	1			2										(6)	(1)	
Anacapa East	2001	34.16°N	119.369°W	0.66	R		1		8	9	18										1	(6)	(2)
La Partida	2001	24.558°N	110.391°W	20.29	C		6	2			8										(1)		
Mejia	2001	29.557°N	113.571°W	3.28	C		2	1			3			1							(4)	(2)	
Monserrate	2001	25.678°N	111.051°W	18.84	C		2	2			4			1							(2)		
San Benito East	2001	28.768°N	115.569°W	1.95	Rab						(6)										(12)	(3)	
Anacapa Middle	2002	34.004°N	119.395°W	0.8	R		(1)				(18)										(9)	(2)	
Anacapa West	2002	34.011°N	119.413°W	1.6	R		(1)				(18)										(8)	(2)	
Clarion	2002	18.364°N	114.729°W	29.28	P, S	Rab ^f , I		2	5	13	20	4									3	(5)	1 (2)
Coronado South	2003	32.404°N	117.244°W	2.27	C, G, D ^c	M ^g	(1)	1 (1)	(2)	4	5 (9)										(6)	(1)	
Santa Catalina (Mexico)	2004	25.643°N	110.816°W	30.8	C		1	8			9	3									(2)		
Lehua	2005	22.021°N	160.096°W	1.15	Rab	R				26	26										11 (8)	2 (2)	
Farallon de San Ignacio	2007	25.436°N	109.378°W	0.04	R																(8)	(1)	
San Pedro Martir	2007	28.385°N	112.334°W	1.9	R			2			2	2									(10)	(1)	
Rat Island	2008	51.801°N	178.295°E	28	R																5 (1)		
Desecheo ^b	2009	18.382°N	67.479°W	1.52	G, Mac	R		3		1	4										1 (6)		
Isla de la Plata ^b	2009	1.273°S	81.063°W	14.2	G	R, C, M ^g			2		2	1									2 (5)	1	
San Nicolas ^b	2009	33.251°N	119.505°W	58.93	C		2	1	3		6	1									(2)		

Table 1 continued

Island	Project		Endemic species/subspecies (new populations)							Threatened Seabirds ^a	Threatened Seabirds	
	Year	Latitude Longitude Area (km ²)	Non-native mammals	Present	Mammals	Reptiles	Birds	Plants	Total			Threatened
Total: 35 islands		523.87	54		24 (28)	28 (29)	31 (56)	98 (120)	181 (233)	15	54 (258)	11 (45)

R rat, C cat, Rab rabbit, D donkey, G goat, S sheep, H horse, P pig, DG dog, M mouse, SQ squirrel, I iguana, Mac macaque

^a Seabirds that are found on ≤5 islands globally ($n = 3$) are included in both the endemic bird column and the seabird column

^b Cat eradications on Isabela and Coronados were led by UNAM IE and CIBNOR, respectively and IC played only a supporting role

^c Semi-feral population removed in cooperation with island residents

^d Mouse sp. = *Peromyscus maniculatus*

^e Squirrel sp. = *Ammospermophilus leucurus*

^f A rabbit eradication was attempted in 2000–2002, but was unsuccessful

^g Mouse sp. = *Mus musculus*

^h These islands need eradication confirmation

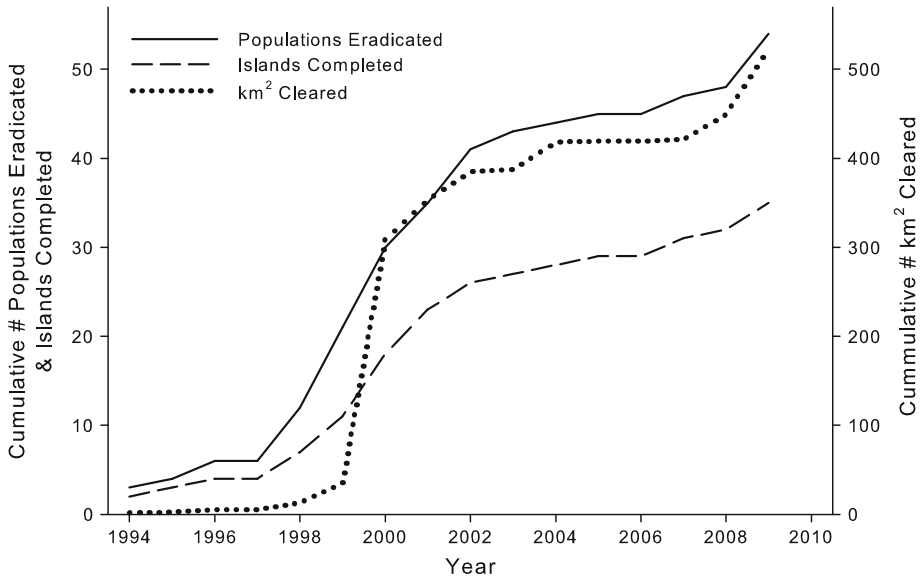


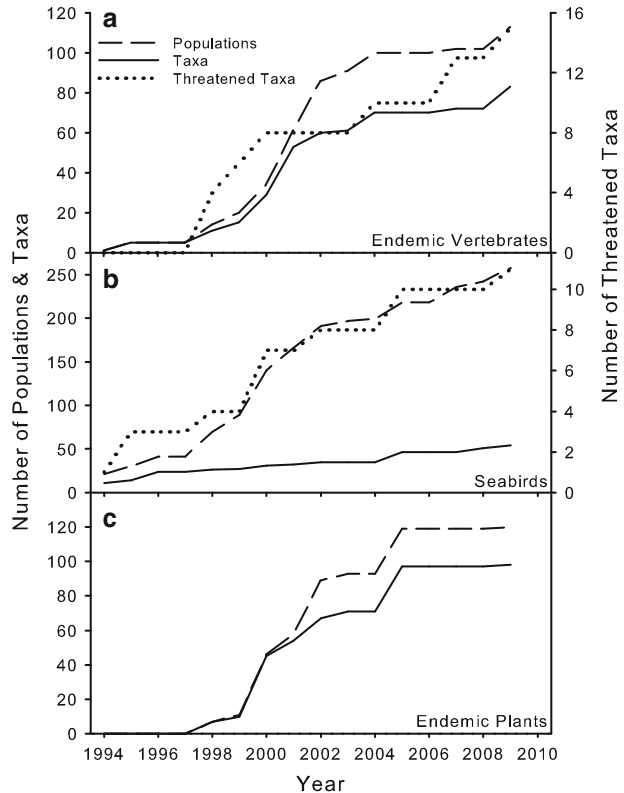
Fig. 1 Island Conservation's actions from 1994 to 2009. Cumulative populations of invasive species populations eradicated (*solid line*); Cumulative number of islands on which one or more invasive species were eradicated (*dashed line*); Cumulative hectares cleared of one or more invasive species (*dotted line*)

collect standardized population data for species anticipated to benefit from the eradication on the project island and a control site before and after the conservation action.

We did not attempt to measure Island Conservation's overall cost effectiveness. An earlier analysis of their work in Mexico measured a cost of <US\$25,000 for each seabird population protected and <US\$50,000 for each endemic species or subspecies protected (Aguirre-Munoz et al. 2008). The average cost for all of Island Conservation's accomplishments is likely higher due to the relatively high costs of conducting conservation actions in the US and the startup costs of developing programs in new regions outside of Mexico and California. However, average long-term costs in other parts of the world may be of the same order of magnitude as those for Mexico because it is a middle-income country with relatively high levels of insular biodiversity (Atkinson and Brandolin 2010; Myers et al. 2000).

Islands are particularly effective habitats in which to prevent extinction. They have an 8–9 fold higher concentration of unique species than continental regions (Kier et al. 2009), more than half of all IUCN-listed extinctions have occurred on islands (Aguirre-Munoz et al. 2008) and the leading cause of extinctions on islands, invasive species, is a problem that can often be solved using existing eradication techniques (Clavero and Garcia-Berthou 2005). Many, if not most, island invasive species eradications have been conducted by government island management agencies on a case-by-case basis. Although this process has resulted in numerous successes, it may be less efficient than the more systematic approach taken by organizations that specialize in prioritizing, designing and implementing eradications. Island Conservation's accomplishments and impacts suggest that other organizations specializing in eradicating invasive species from islands can further stem the loss of biodiversity on the world's ~185,000 marine islands. In particular, new regionally

Fig. 2 Island Conservation's impact from 1994 to 2009. Cumulative number of populations (*dashed lines*), taxa (species and subspecies; *solid lines*), and threatened taxa (*dotted line*) protected of **a** endemic vertebrates, **b** seabirds, and **c** endemic plants



focused eradication organizations (either stand alone or branches of a larger organization like Island Conservation) encompassing the 136 countries with marine islands could significantly decrease global extinction rates.

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