Desecheo Island
National Wildlife Refuge

Rat Eradication to Promote Ecosystem Restoration Final Environmental Assessment








FINAL ENVIRONMENTAL ASSESSMENT

Desecheo National Wildlife Refuge Rat Eradication Project

U.S. Department of the Interior
Fish & Wildlife Service

Prepared by:

Caribbean Islands National Wildlife Refuge Complex,
Puerto Rico

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Executive Summary

Desecheo National Wildlife Refuge is managed by the U.S. Fish & Wildlife Service and was historically known as an important center of biodiversity and species abundance in the Caribbean. Desecheo was a major seabird rookery and formerly home to one of the largest brown booby (*Sula leucogaster*) breeding populations in the world. The extirpation of nesting seabirds has been linked to the presence of invasive mammals including: goats, rats and macaques.

Introduced non-native species are a leading cause of extinctions in island communities worldwide. Increasingly, land managers are removing introduced species to aid in the restoration of native ecosystems. Rats are responsible for 40-60 percent of all recorded island bird and reptile extinctions worldwide. Given their widespread successful colonization on islands and the resulting impact to native species, introduced rats have been identified as key species for eradication.

Removing black rats (*Rattus rattus*) from Desecheo will result in obvious, empirically tested biodiversity benefits for seabirds, plants, reptiles, terrestrial invertebrates and other components of the islands terrestrial ecosystem. Additionally, it is anticipated that the removal of non-native rats from Desecheo will allow the recolonization by nesting seabirds, promote recovery of the island's seabird colonies, increase the abundance of resident landbirds, remove the predation threats to the islands endemic reptiles, increase woodland vegetative cover and abundance, restore ecosystem functioning as a high density seabird island, and improve the overall abundance of the endangered higo chumbo (*Harrisia portoricensis*) cactus.

The action alternatives were developed to focus on the issues identified by resource specialists within the Service, experts in island rodent eradication and government regulatory agencies. All individuals, agencies and organizations that provided substantive input regarding the proposed action are listed in Chapter 5. In order to be retained for consideration, an alternative had to 1) have a high likelihood of success, 2) have an acceptably low probability for adverse effects on the populations of non-target species and the environment, and 3) be permitted under regulations governing Desecheo National Wildlife Refuge ("the Refuge").

The action alternatives would be:

- *Alternative B: Aerial broadcast of brodifacoum, with mitigation actions for endemic reptile taxa*
- *Alternative C: Aerial broadcast of brodifacoum, without proactive risk reduction actions for endemic reptile taxa*
- *Alternative D: Aerial broadcast of diphacinone, with mitigation actions for endemic reptile taxa*
- *Alternative E: Aerial broadcast of diphacinone, without proactive risk reduction actions for endemic reptile taxa*

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List of Acronyms

AZA	Association of Zoos and Aquariums
CEQ	Council on Environmental Quality
CSIRO	Commonwealth Scientific and Industrial Research Organization
CWA	Clean Water Act
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
DEQ	Department of Environmental Quality
DNER	Puerto Rico Department of Natural and Environmental Resources
EQB	Puerto Rico Environmental Quality Board
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
GIS	Geographic Information System
GPS	Global Positioning System
MBTA	Migratory Bird Treaty Act
MLD	Method Limit of Detection
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Area
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NWR	National Wildlife Refuge
NWRS	National Wildlife Refuge System
NWRSAA	National Wildlife Refuge System Administration Act
NWRSIA	National Wildlife Refuge System Improvement Act
PPE	Personal Protective Equipment
SHPO	State Historic Preservation Office
SUP	Special Use Permit
USDA/APHIS	U.S. Department of Agriculture/Animal and Plant Health Inspection Service
USVI	United States Virgin Islands
UXO	Unexploded Ordnances

Glossary of Terms

Active ingredient	A chemical integrated into bait used to kill rodents. Typically expressed as a concentration (e.g. parts per million, or ppm).
Aerial broadcast	A method developed to disperse rodent bait on land from the air. Typically this has been used for animal eradication programs where the terrain prevents successful ground operations. Bait is typically dispersed by helicopter.
Anticoagulant	A substance that prevents blood coagulation, i.e. it stops blood from clotting. Anticoagulants used in rodent bait are typically grouped into "first generation" and "second generation" compounds. These terms were introduced to contrast anticoagulants for which rodent populations had developed a genetic resistance("first generation" compounds) with anticoagulants that could kill resistant individuals ("second generation").
Commensal	A relationship between two organisms where one benefits but the other is neutral. Typically, brown rats are referred to as commensal with humans, where brown rats benefit but people do not.
Hand broadcast	A method used to manually disperse rodent bait on land. Typically bait is dispersed in a systematic way at a standardized rate so that even coverage is achieved.
Introduced species	A species occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) (IUCN 2000). Note: not all introduced species are invasive.
Invasive Species	A species occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and which becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity (IUCN 2000). Also referred to as Invasive Alien Species.
LD_{50}	Median lethal dose. A statistically estimated oral dose expected to be lethal to 50 percent of test animals. The LD_{50} is expressed in mg of active ingredient per kg of body weight of animal.
LC_{50}	Median lethal concentration. A statistically estimated dietary concentration expected to be lethal to 50 percent of test animals. LC_{50} is expressed in ppm.

Migratory species	A bird that is in the Caribbean region for only part of the year, either during the winter or summer. The over-wintering migration period for Neotropical migrants to the Caribbean is typically September to April, and the summer migration period for species that breed in the Caribbean is typically March to October. Some species are only transient in Puerto Rico during these periods on route to another country.
Non-native species	A species occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) (IUCN 2000). Note: not all non-native species are invasive.
Non-target species	An organism unintentionally at risk to adverse effects of rodent bait.
Placebo bait	A bait product without the active ingredient, used for field trials.
Primary **r**isk	Risk to target or non-target organisms that consume bait.
Resident species	A species found year-round and which breeds in Puerto Rico. A resident of Desecheo Island is a species found year-round on the island and which breeds there.
Rodent	Common name used for the taxonomic order of mammals Rodentia. Common rodents include rats, mice, squirrels, gerbils, voles and chipmunks.
Rodenticide	A term applied to any chemical used to kill rodents.
Rodent bait	A commercial or non-commercial product that contains a chemical used to kill rodents. Typically the product is manufactured to be a food substitute (comprising a grain-based matrix) palatable and attractive to rodents. Bait products are available in several forms such as waxed or unwaxed blocks, cereal, meals, pellets, liquid or tracking powders.
Rodent eradication	Complete and permanent removal of every individual rodent. Typically this can only be achieved where immigration of rodents into the area after eradication is not possible, e.g. on an isolated island.
Rodent control	Management of a rodent population to achieve an abundance and/or density that is lower than the typical carrying capacity of the environment and maintained through control at a population level where rodent impacts are reduced (e.g. for biodiversity, health or agricultural purposes). This method is typically used where there is constant immigration (reinvasion) into the area of concern.

Secondary risk:	Risk to predatory or scavenging organisms that feed on other organisms that ate bait.
Toxicant	A chemical used to kill rodents, typically integrated into rodent bait.

1 PURPOSE AND NEED

1.1 Introduction

The U.S. Fish and Wildlife Service (or "the Service") proposes to undertake the following actions on Desecheo Island, which is managed as the Desecheo National Wildlife Refuge ("the Refuge"):

- Eradication of the invasive black rat (*Rattus rattus*); and
- Prevention and emergency response plan for responding to re-introduction of rats, other invasive rodents, and other non-native animals to the islands.

In accordance with the National Environmental Policy Act of 1969 (NEPA) (42 USC 4321 *et seq.*, as amended) and the Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 CFR 1500 *et seq.*), Federal agencies must consider the environmental impacts of actions, projects, programs, policies, or plans that are implemented, funded, permitted, or controlled by a federal agency or agencies they propose to undertake. Specifically, Federal agencies must consider the environmental impacts of a reasonable range of alternatives for implementing an action, and make the public aware of the environmental impacts of each of the alternatives presented. If adverse environmental impacts are identified, NEPA requires an agency to show evidence of its efforts to reduce these adverse impacts through mitigation. An environmental analysis, such as this Environmental Assessment (EA), documents that an agency has considered and addressed these impacts.

This EA will be used by the Service to solicit public involvement and to determine whether the implementation of any of the action alternatives presented within would have a significant impact on the quality of the human environment.

1.2 Purpose of the Proposed Action

The purpose of the proposed action is to meet the Service's management goal of protecting and restoring the ecosystem of Desecheo Island, particularly seabirds, reptiles and native plants, through the eradication of invasive rats.

1.3 Need for Action

1.3.1 Summary of Suspected and Potential Rat Impacts to Desecheo Island, and Anticipated Benefits from Rat Eradication

Rodents were introduced to Desecheo National Wildlife Refuge in the early 1900s and, together with the introduction of rhesus macaques (*Macaca mulatta*), have decimated the large seabird populations that once bred on the island (Evans 1989, Meier et al. 1989). Historically, Desecheo Island was a major seabird rookery. In the early 1900s, tens of

thousands of seabirds of eight species were nesting on the island, including 8-10,000 brown boobies (*Sula leucogaster*), 2,000 red-footed boobies (*Sula sula*) and 1,500 bridled terns (*Onychoprion anaethetus*) (Bowdish 1900, Wetmore 1918, Struthers 1927, Meier et al. 1989). Subsequently, Meier and colleagues (1989) report on a general decline through the 1970s and 1980s in the number of breeding birds (Morrison and Menzel 1972, Kepler 1978, Raffaele 1989) such that in 1986 and 1987 between ten and a few hundred pairs of five species were reported from the island, some of which did not nest. In 1998, Breckon (1998) reported seeing only a single individual American oystercatcher (*Haematopus palliates*). In 2010 (after significant reduction of non-native introduced macaques and complete removal of introduced feral goats), less than 100 brown boobies were known to roost at two or three sites on the island, one pair of brown noddy (*Anous stolidus*) was found nesting on the island and 17 pairs of bridled terns were recorded as nesting onshore and on islets just offshore of Desecheo (Island Conservation 2010b).

Historically, Desecheo Island has been subject to a range of human impacts. Feral goats were introduced in 1788, and in the 1920s the island was temporarily farmed and forest was cleared for cropland. The former cultivated area reverted to grassland that was burned by visiting fishermen to maintain land crab habitat. Between 1940 and 1952, Desecheo was used by the U.S. War Department as a bombing and gunnery training range during World War II, and continued as a survival training site for the U.S. Air Force until 1960 (Woodbury et al. 1971). These activities together with harvesting by fishermen through to the 1980s would have had some impact to the island's seabird colonies. However, up to 1,500 brown and 1,000 red-footed boobies still occupied the island in the 1970s (Noble and Meier 1989), a much reduced population but which are not present today. The introduction of rhesus macaques in 1966 appears to have halted all reproduction of seabirds on the island and led to their final extirpation (Struthers 1927, Evans 1989, Meier et al. 1989, Noble and Meier 1989). Re-establishment of the seabird colonies on Desecheo is likely to be impacted by the ongoing presence of rats, even in the absence of macaques. In particular, the smaller ground-nesting seabirds, including those nesting on cliffs less accessible to humans and macaques, are likely to have suffered the greatest impact from rat predation of eggs, chicks and adults (Atkinson 1985, Towns et al. 2006, Jones et al. 2008).

Landbird species such as the zenaida dove (*Zenaida aurita*) and pearly-eyed thrasher (*Margarops fuscatus*) probably nested in significant numbers on the island (Wetmore 1918). Today, their abundance appears much reduced. In 2009 and 2010, 10-27 percent of 30 point-count stations were occupied by pearly-eyed thrasher and 0-3 percent by zenaida dove (Island Conservation unpubl. data). Macaque and rat predation have also likely led to the extirpation of the mangrove cuckoo (*Coccyzus minor*) from the island. In 2003, the poor state of the land birds was demonstrated when only two pearly-eyed thrashers were captured in 256 hours of mist netting (Earsom 2003a). It is likely that predation by macaques has masked the full impact of rat predation, which is well known for island-nesting seabird species elsewhere (Taylor et al. 2000, Jouventin et al. 2003).

Macaques and rats are likely impacting the native and endemic reptile species on Desecheo. Evidence exists to indicate that rats are affecting the abundance and recruitment of endemic reptiles from other regions (Cree et al. 1995) and removal of rats from offshore

islands has been a strategy proven to protect threatened reptile species (Towns 1991, 1994, Daltry et al. 2001, Towns et al. 2001, Towns et al. 2007). Desecheo supports three endemic reptile species: Desecheo ameiva (*Ameiva desechensis*); Desecheo anole (*Anolis desechensis*); Desecheo dwarf gecko (*Sphaerodactylus levinsi*) and two native species: Puerto Rico racer (*Borikenophis portoricensis*) and slippery-backed skink (*Mabuya sloani*). The few studies carried out on the endemic reptiles suggest that the Desecheo ameiva, Desecheo anole and Desecheo dwarf gecko are relatively abundant (Meier and Noble 1990a, 1991, Island Conservation unpubl. data), but the Puerto Rico racer and slippery-backed skink are uncommonly encountered. However, direct predation of Desecheo anoles by rats has been observed (Island Conservation 2010c) and tail scars observed on the racer are believed to be injuries caused by rats, suggesting that predation and attempted predation might be occurring.

Finally, the three endemic invertebrates (the Desecheo whip scorpion *Schizomus desecheo* and two endemic spiders, *Clubiona desecheonis* and *Camillina desecheonis*) are probably directly preyed upon by rats, and indirectly impacted by habitat alteration from rats. The whip scorpion has been found in, and is believed to be restricted to, the west and central valleys of the island due to a lack of suitable vegetation and leaf litter elsewhere (Camilo and Cokendolpher 1988, Island Conservation unpubl. data). Feral goats (*Capra hircus*), the last of which were removed in 2008, likely restricted available habitat for the whip scorpion and other invertebrates through over-grazing and subsequent habitat modification. Rats may also indirectly impact the abundance and species richness of invertebrate and soil inhabiting micro-invertebrate fauna through the alteration of soil nutrients and associated vegetation communities from the depletion of seabirds and their nutrient transfer role from sea to land (Towns et al. 2009).

On Desecheo, invasive rats likely have the biggest impact on nesting birds by preying upon eggs and chicks. They also predate seeds of native and endemic plants, reducing natural regeneration, and predate the smaller reptiles and endemic invertebrates. It is anticipated that rat eradication on Desecheo would allow recolonization by nesting seabirds, promote recovery of the island's seabird colonies, increase the abundance of resident landbirds, remove the predation threats to the island's endemic reptiles, increase woodland vegetative cover and abundance, restore ecosystem functioning as a high density seabird island and improve the overall abundance of the island's biodiversity. Furthermore, rat eradication is expected to allow the recovery, over the long-term, of the large nesting populations of brown and red-footed boobies, and increase the abundance of the endangered higo chumbo (*Harrisia portoricensis*) cactus.

1.4 Background: The Problem of Invasive Rats on Islands

1.4.1 The Importance of Island Ecosystems

It is widely accepted that the natural world is currently facing a particularly high rate of species extinction (Raup 1988), that most recent extinctions can be directly attributed to human activity (Diamond 1989) and that for ethical, cultural, aesthetic and economic reasons, this current rate of extinction is cause for considerable concern (Ehrlich 1988,

Ledec and Goodland 1988). One of the major worldwide causes of anthropogenic extinctions is the introduction of invasive species. Introduced species are responsible for 39 percent of all recorded animal extinctions since 1600 for which a cause could be attributed (World Conservation Monitoring Centre 1992).

Island ecosystems are key areas for biodiversity conservation. While islands make up only about three percent of the earth's surface, they are home to 15-20 percent of all plant, reptile and bird species (Whittaker 1998). However, small population sizes and limited habitat availability make species endemic to islands especially vulnerable to extinction, and their adaptation to isolated environments makes them especially vulnerable to aggressive introduced species (Elton 1958, Diamond 1985, 1989, Olson 1989). Of the 484 recorded animal species extinctions since 1600, 75 percent were species endemic to islands (World Conservation Monitoring Centre 1992).

Islands are high-value targets for conserving biodiversity because:

- A large percentage of their biota is endemic species and subspecies with small populations, which makes them particularly extinction-prone.
- They are important habitat for animals such as seabirds and turtles, which feed over thousands of square kilometers of ocean but are dependent on small isolated islands for safe breeding. Protection of these animals at their island breeding sites is easier and more cost-effective than protecting them from threats at sea (such as plastics pollution and accidental or deliberate entanglement in fishing tackle), which could affect them anywhere along their travels (Wilcox and Donlan 2007).
- Many smaller islands are sparsely inhabited or uninhabited by humans, keeping the socioeconomic costs of protection low.

In summary, by restoring and protecting islands, functioning ecosystems can be maintained without large expenditures for land acquisition or management, or significant conflict with local human populations.

1.4.1.1 Impacts of Rats on Island Ecosystems

The impacts of introduced predatory mammals are one of the leading causes of species extinction on islands (Blackburn et al. 2004, Duncan and Blackburn 2007). Rats living in close association, or commensally, with humans (the Norway rat *Rattus norvegicus*, black rat and Polynesian rat *R. exulans*) have been introduced to about 90 percent of the world's islands and have a pronounced impact on island ecosystems (Towns et al. 2006). In addition, the extinction of many island mammals, birds, reptiles and invertebrates have been attributed to the impacts of invasive rats (Andrews 1909, Daniel and Williams 1984, Meads et al. 1984, Atkinson 1985, Tomich 1986, Hutton et al. 2007) and estimates of 40-60 percent of all recorded bird and reptile extinctions globally were caused by invasive rats (Atkinson 1985).

Even if species are not extirpated, rats can have negative direct and indirect effects on native species and ecosystem function. For example, comparisons of rat-infested and rat-

free islands, and pre- and post-rat rat eradication experiments, have shown that rats depressed the population size and recruitment of birds (Campbell 1991, Thibault 1995, Jouventin et al. 2003), reptiles (Whitaker 1973, Bullock 1986, Towns 1991, Cree et al. 1995), plants (Pye et al. 1999) and terrestrial invertebrates (Bremner et al. 1984, Campbell et al. 1984). In particular, rats have significant impacts on seabirds, depredating eggs, chicks and adults and causing population declines, with the most severe impacts on burrow-nesting seabirds (Atkinson 1985, Towns et al. 2006, Jones et al. 2008).

In addition to preying on local seabird colonies, rats feed opportunistically on plants and alter the floral communities of island ecosystems (Campbell and Atkinson 2002), in some cases degrading the quality of nesting habitat for birds that depend on the vegetation. On Tiritiri Matangi Island, New Zealand, ripe fruits, seeds and understory vegetation cover underwent significant increases after rats were eradicated from the island, indicating their previous impacts on the vegetation (Graham and Veitch 2002).

Rats have been documented affecting the abundance and age structure of intertidal invertebrates (Navarrete and Castilla 1993), directly and indirectly affecting species richness and abundance of a range of invertebrates (Towns et al. 2009) and contributing to the decline of endemic land snails in Hawaii (Hadfield et al. 1993), Japan (Chiba 2010) and American Samoa (Cowie 2001).

There is also increasing evidence that rats alter key ecosystem properties. For example, total soil carbon, nitrogen, phosphorous, mineral nitrogen, marine-derived nitrogen and pH are lower on rat-invaded islands relative to rat-free controls (Fukami et al. 2006). In rocky inter-tidal habitats, invasive rats have affected invertebrate and marine algal abundance, changing intertidal community structure from an algae to an invertebrate dominated system (Kurle et al. 2008). Such changes are a result of indirect negative effects of rats causing a reduction in seabird populations; rat predation often drives seabird colonies to near-extirpation (Moller 1983, Atkinson 1985, McChesney and Tershy 1998), resulting in the loss of seabird-derived nutrients on islands (Fukami et al. 2006). Where rats co-exist with other predators (such as cats or predatory birds), the collective direct impact of introduced predators on seabirds is greater than the sum of the individual impacts because rats also act as a food resource to higher level predators when seabirds are absent from the islands (Moors and Atkinson 1984, Atkinson 1985).

Given the widespread successful colonization of rats on islands and their impact on native species, rats are identified as key species for eradication (Howald et al. 2007).

1.4.1.2 Eradication of Rodents from Islands

The first successful rodent eradication was in 1951 on Rouzic Island in France (Lorvelec and Pascal 2005). Subsequently, through the 1970s and 1980s, New Zealand biologists developed the methodology for systematic rodent eradication techniques and successfully eradicated rats from several small islands (Moors 1985, Thomas and Taylor 2002). Building on these successes, and with the application of new strategies and research to

monitor the campaigns, rats were eradicated from increasingly larger islands culminating on Campbell Island in 2002 (11,300 ha), the largest island to date from which rats have been completely eradicated (Taylor and Thomas 1989, Taylor and Thomas 1993, Cromarty et al. 2002, Morris 2002, Clout and Russell 2006).

To date, successful rodent eradications have been achieved on at least 304 islands in 20 different countries, including 284 islands from which *Rattus* sp. have been eradicated and 153 islands from which *Rattus rattus* have been eradicated (Howald et al. 2007, Island Conservation reanalysis of data) (see also Parkes and Fisher 2011 for an updated evaluation of eradication attempts worldwide). Rodent eradication on Desecheo Island NWR continues the efforts to create rat-free wildlife refuges within the region; currently rodent eradications on 13 islands have been successful in Puerto Rico and the U.S. Virgin Islands (See Appendix XII). The fundamental methodology used in all but one of the known successful eradications was the delivery of bait containing a rodenticide into every potential rodent territory on the island. Bait was typically delivered during a time of year when rats were relatively food deprived, as indicated by annual resource-dependent population declines. Depending on island topography and size, climate, native species assemblages, operational logistics and other factors, these eradication projects applied bait using either bait stations or broadcast, or both. Bait stations were typically laid out on a grid pattern. Bait broadcast could be by hand or using spreaders suspended under a helicopter (Howald et al. 2007).

1.4.1.3 Benefits of Rat Eradication

The conservation benefits of these global rat eradications have extended from increases in abundance and population parameters of a variety of taxa including seabirds, landbirds, reptiles, mammals, plants and overall ecosystem recovery. Owing to the well-documented impact of rats on seabirds (Jones et al. 2008), removal of rats almost automatically provides protection for existing seabird colonies. In Western Mexico, the eradication of black rats from five islands resulted in the protection of 46 seabird populations (Aguirre-Munoz et al. 2008). Direct benefits to breeding seabirds have also been reported, including an increase in nest site occupancy, nesting attempts, hatching success and reduced nest depredation (Jouventin et al. 2003, Whitworth et al. 2005, Smith et al. 2006, Amaral et al. 2010). Increases in native landbirds after rat eradication have also been reported. In New Zealand the abundance of four species of native landbirds increased between 10 percent and 178 percent during three years after rat eradication (Graham and Veitch 2002) and endemic species have even re-colonized islands after local extirpation by rats (Barker et al. 2005, Ortiz-Catedral et al. 2009). Also in New Zealand, rodent eradication has been used to restore endemic and native reptile populations. By 1998, rodents had been removed from 25 islands providing measurable or potential benefits for tuatara (*Sphenodon* sp.), two species of *Naultinus* geckos, six species of *Hoplodactylus* geckos, five species of *Cyclodina* skinks and seven species of *Oligosoma* skinks (Towns 1994, Cree et al. 1995, Towns et al. 2007). Island-dwelling mammals have also benefited from rodent eradication, including an endemic deer mouse in California (Howald et al. 2010) and two species of shrew in France (Pascal et al. 2005). At the ecosystem-level, indigenous forest restoration has been

documented as a result of substantial increase in the number of shrub and tree seedlings after Norway rat eradication (Allen et al. 1994).
In addition to direct biodiversity benefits, rat eradications have been carried out to create rat-free refuges for native and endemic fauna and flora that are at risk from rat impacts elsewhere in their range. By 2003, rodents had been eradicated from more than 90 offshore islands in New Zealand, releasing the potential to translocate native birds, reptiles, amphibians and invertebrates to these predator-free refuges (Towns and Broome 2003).

1.5 Authority and Responsibility to Act

The eradication of invasive rats from Desecheo Island is authorized, and in many cases mandated, by several federal laws requiring land managers to conserve and restore wildlife and habitats under their jurisdiction.

The U.S. Fish and Wildlife Service's mission is to work with others to "conserve, protect and enhance fish, wildlife and plants and their habitats for the continuing benefit of the American people." The threat that invasive species pose to habitat and native wildlife makes addressing their impacts one of the Service's top management priorities. Lessening or eliminating the impacts of introduced species on Desecheo is essential to the Service's management goals for the island.

The Fish and Wildlife Act of 1956 (16 U.S.C. 742a-742j, not including 742 d-l, 70 Stat. 1119), as amended, gives general guidance that can be construed to include invasive species control, that requires the Secretary of the Interior to take steps "required for the development, management, advancement, conservation and protection of fish and wildlife resources."

The National Wildlife Refuge System Administration Act of 1966 (NWRSAA) (16 USC 668dd) established the National Wildlife Refuge System, to be managed by the Service. Among other mandates, the NWRSAA requires the Service to provide for the conservation of fish, wildlife and plants and their habitats within the System, and to ensure that the biological integrity, diversity and environmental health of the System are maintained.

The Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531-1544, 87 Stat. 884), as amended, directs the Service to conserve ecosystems upon which threatened and endangered species depend.

The National Wildlife Refuge System Improvement Act of 1997 (NWRSIA), which amends the NWRSAA, provides comprehensive legislation on how the Refuge System should be managed and used by the public. The NWRSIA clearly establishes that wildlife conservation is the singular Refuge System mission, provides guidance to the Secretary of the Interior for management of the System, provides a mechanism for refuge planning and gives refuge managers uniform direction and procedures for making decisions regarding wildlife conservation and uses of the System.

The U.S. Fish and Wildlife Service policy for maintaining biological integrity and diversity and environmental health (601 FW 3, 2001), directs Refuges to "prevent the introduction of invasive species, detect and control populations of invasive species and provide for restoration of native species and habitat conditions in invaded ecosystems." 601 FW 3 further directs refuge managers to "develop integrated pest management strategies that incorporate the most effective combination of mechanical, chemical, biological and cultural controls while considering the effects on environmental health."

Presidential Executive Order 13112 on Invasive Species (February 3, 1999): Section 2(a)(2), on Federal agency duties, states: "Each Federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law, subject to the availability of appropriations and within Administration budgetary limits, use relevant programs and authorities to: (i) prevent the introduction of invasive species; (ii) detect and respond rapidly to and control populations of such species in a cost-effective and environmentally sound manner; (iii) monitor invasive species populations accurately and reliably; (iv) provide for restoration of native species and habitat conditions in ecosystems that have been invaded; (v) conduct research on invasive species and develop technologies to prevent introduction and provide for environmentally sound control of invasive species; and (vi) promote public education on invasive species and the means to address them." Executive Order 13112 defines "invasive species" as "an alien species [a species that is not native with respect to a particular ecosystem] whose introduction does or is likely to cause economic or environmental harm or harm to human health."

1.6 Regulatory Framework of the Alternatives

1.6.1 Federal Laws

- National Environmental Policy Act
- Endangered Species Act
- Marine Mammal Protection Act
- Migratory Bird Treaty Act
- Clean Water Act (CWA), as amended (formally, the Water Pollution Control Act, USC 33 1251 et seq.)
- National Historic Preservation Act (NHPA) of 1966, as amended)
- Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1947, as amended
- Archaeological Resources Protection Act of 1979, as amended, 16 USC 470
- Archaeological Resources Protection Act, 16 U.S.C. 460, et seq.
- Native American Graves Protection and Repatriation Act of 1990 (25 USC 3000-3013, as amended)
- Curation of Federally Owned and Administered Archeological Collections (36 CFR 79)
- Executive Memorandum – Government-to-Government Relations with Native American Tribal Governments (59 FR 85, April 29, 1994)
- Executive Order 13007 – Indian Sacred Sites (61 FR 104, May 24, 1996)

- Executive Order 13175 – Consultation and Coordination with Indian Tribal Governments (65 FR 218, November 9, 2000).

1.7 Scope of the Proposed Action

The Proposed Action is focused on methods for the eradication of invasive rats from Desecheo Island. Other actions that may occur in the future that are not a result of the Proposed Action will not be analyzed in detail in this document. The potential implications of the Proposed Action in relation to past, present and future actions will be discussed in the Cumulative Impacts sections of the Environmental Consequences chapter (Section 4.13.1). This analysis will not focus on restoration actions on Desecheo other than the eradication of invasive rats.

1.8 Environmental Issues (Impact Topics) Identified

1.8.1 Summary of Scoping

Section 1501.7 of the CEQ regulations for implementing NEPA requires that agencies implement a process, referred to as "scoping", to determine the scope of issues to be addressed in an environmental impacts analysis and identify the major environmental issues related to a proposed action that need to be analyzed.

The NEPA scoping process [40CFR 1501.7] was used to determine the scope of the analysis and to identify potential issues and opportunities related to the Proposed Action. The scoping process for the eradication of black rats from Desecheo Island involved both internal and external scoping. The internal scoping process included an extensive review of the biological, physical and social issues associated with eradicating rats from Desecheo Island. The Service and Island Conservation have conducted field research to identify the ecological factors that are being affected by the presence of rats as well as the potential benefits to ecological services, including species recovery, from rat removal. The external scoping process involved consultation with cooperative and regulatory agencies that have a stake in the outcome of the project; a summary of these procedures conducted during the development of the Draft EA is presented below.

Beginning in early 2009, the Service began internal scoping exercises, consulting with island experts and experts in rodent eradication techniques. In March 2010, the Service sent a letter to potential stakeholder agencies requesting input on the environmental issues that should be addressed in this EA (see Appendix VIII). Recipients of this scoping letter included:

- Puerto Rico Department of Natural and Environmental Resources (DNER)
- Puerto Rico Environmental Quality Board (EQB)
- Puerto Rico Planning Board
- Puerto Rico Department of Agriculture
- United States Department of Agriculture / Animal and Plant Health Inspection Service – Wildlife Services (USDA/APHIS-WS)
- U.S. Fish and Wildlife Service Regional Archaeologist

The letter was also received by the following intra-agency departments:

- U.S. Fish and Wildlife Service Caribbean Islands, Ecological Services
- U.S. Fish and Wildlife Service Southeast Region, Regional Historic Preservation Officer and Regional Archaeologist

The Service received a response from DNER that supported the development of alternatives which afforded protection to sensitive reptile taxa on the island (Appendix VIII). Additionally, the Service contacted the Regional Archaeologist for an informal consultation regarding potential impacts to sensitive historical and cultural resources found on Desecheo. The Regional Archaeologist indicated that "Desecheo rat eradication project does not possess the potential to impact historical properties" and "consultation with PR SHPO (Puerto Rico State Historic Preservation Office) pursuant to Section 106 of the National Historic Preservation Act is not required." (See Appendix VIII).

In addition, a Section 7 consultation was held with the U.S. Fish and Wildlife Service Caribbean Islands, Ecological Services (Appendix VIII), an informal consultation was held with the NOAA National Marine Fisheries Service with regards to the activities and potential impact of the project, and several consultations about the project were made to Service officers at the Southeast regional office.

In October 2010, a two-day workshop was held by the U.S. Fish & Wildlife Service Caribbean Islands NWR Complex to assess the risk to non-target reptile species from toxicant use and to make recommendations to manage that risk. The workshop was attended by representatives from the U.S. Fish & Wildlife Service NWR and Ecological Services divisions, the Puerto Rico Government DNER, Mayaguez Zoo, Forth Worth Zoo (Texas), Wildlife Vets International (United Kingdom) and Island Conservation. During the workshop, information was presented with discussion on: Desecheo NWR and the proposed rat eradication; overview of rat eradication methodologies; results from field trials on Desecheo reptiles using a non-toxic placebo bait; overview of rat eradication projects worldwide with relevance to reptile conservation; overview of documented toxicant risk to reptiles, summary of ongoing USDA-APHIS laboratory trials; population status and distribution of Desecheo reptiles; captive reptile holding, reptile capture and transport from Desecheo, and; disease risks of holding reptiles in captivity and re-releasing animals to Desecheo.

During the scoping process, the Service identified the major environmental issues, or "impact topics," that are described below. These issues were central in structuring the development of appropriate action alternatives and the scope and content of the environmental impacts analysis for each alternative found in Chapter 4.

1.8.2 Impact Topic: Physical Resources

Sub-topic: Impacts to Water Resources

Because the proposed action includes the introduction of a toxicant into the Desecheo environment, the potential impact of the toxicant to local water quality (i.e. the marine environment) was identified as an important environmental issue.

Sub-topic: Impacts to Geology and Soils

Because the proposed action includes introduction of a toxicant into the Desecheo environment, the potential for transfer and persistence of the toxicant in soils was identified as an important environmental issue.

1.8.3 Impact Topic: Biological Resources

Sub-topic: Birds and Reptiles

Rat eradication would include the use of a toxicant that is lethal to rats. Toxicants should only be used in the environment if the behavior of that toxicant can be predicted with some accuracy. The impact of the toxicant to species other than rats and the persistence of the toxicant in the environment are important environmental issues related to impacts of the action to biological resources because animals other than rats, including reptiles and birds, could ingest the toxicant either directly or indirectly. The impact of rat eradication on reptiles is of particular concern on Desecheo because three reptile species are only found on Desecheo (single-island endemic species) and one native species has been assessed as locally vulnerable by DNER (García et al. 2005). The impact to birds is also of concern because many birds are known to be physiologically sensitive to anticoagulant rodenticides (Erickson and Urban 2004).

1.8.4 Impact Topic: Social and Economic Environment

Sub-topic: Impacts to Refuge Visitors and Recreation

Desecheo Island is closed to the public to protect the Refuge's sensitive biological resources and to limit public access in areas with unexploded ordnance. Currently only one or two permitted tour companies visit the near shore environment for recreational snorkeling and diving.

Sub-topic: Impacts to Historical and Cultural Resources

There are no known historical or cultural resources on Desecheo.

2 ALTERNATIVES

2.1 Introduction

As part of the analytical process mandated by the National Environmental Policy Act (NEPA), section 102(2)(E) requires all Federal agencies to "study, develop and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources." Based upon the existing site conditions, need for action, constraints and concerns identified during the initial scoping process, five alternatives were identified: four action alternatives (Alternatives B - E) and the alternative of no action (Alternative A), which is included in the NEPA analysis to provide a benchmark with which to compare the magnitude of environmental effects of the action alternatives. The no action alternative will describe the U.S. Fish and Wildlife Service's current management regime on Desecheo Island with regard to the black rat (*Rattus rattus*) population and its impacts to the island ecosystem.

The action alternatives were developed to focus on the issues identified by resource specialists within the Service, experts in island rodent eradication and government regulatory agencies. All individuals, agencies and organizations that provided substantive input regarding the proposed action are listed in Chapter 5. In order to be retained for consideration, an alternative had to 1) have a high likelihood of success, 2) have an acceptably low probability for adverse effects on the populations of non-target species and the environment, and 3) be permitted under regulations governing Desecheo National Wildlife Refuge ("the Refuge").

The action alternatives would be:

- *Alternative B: Aerial broadcast of brodifacoum, with mitigation actions for endemic reptile taxa*
- *Alternative C: Aerial broadcast of brodifacoum, without proactive risk reduction actions for endemic reptile taxa*
- *Alternative D: Aerial broadcast of diphacinone, with mitigation actions for endemic reptile taxa*
- *Alternative E: Aerial broadcast of diphacinone, without proactive risk reduction actions for endemic reptile taxa*

A number of action alternatives that were dismissed from detailed consideration are also described, with rationale for their dismissal (Section 2.8).

2.2 Alternative A: No Action

Analysis of the no action alternative is required under NEPA. Under the no action alternative, the island's rat population would not be subject to any targeted management actions. There are currently no other activities taking place on Desecheo with respect to rat

control or the prevention of new rodent introductions. Other ongoing invasive species management programs on Desecheo, including eradication of introduced rhesus macaques (*Macaca mulatta*) and introduced feral goats (*Capra hircus*), would continue based on previous agency decisions. Furthermore, any other related programs or projects decided and implemented under different authority, now or in the future, would also continue.

Taking no action to address the effects of rats would be contrary to the purpose of the Refuge, which is to restore and protect the historic seabird colonies and natural island ecosystem of Desecheo. It would also be contrary to the purpose of the National Wildlife Refuge System, which is dedicated to the conservation, management, and restoration of wildlife and plant resources and their habitat, and the maintenance of biological integrity, diversity and environmental health for the benefit of present and future generations of Americans. Additionally, removal of introduced rhesus macaques and feral goats will have only limited benefit as long as rats remain.

2.3 Features Common to All Action Alternatives

The purpose of eradicating rats from Desecheo Island is to conserve, protect and enhance habitat for native wildlife species, especially nesting habitat for seabirds and to restore the biotic integrity of the island. The overarching goal in a successful rodent eradication operation is to ensure the delivery of a lethal dose of toxicant to every rodent on the island. This Proposed Action presents a detailed analysis of a rodenticide, delivered by aerial broadcast, as the primary method for eradicating rats from Desecheo Island.

2.3.1 Rodent Bait

Pressed-grain bait pellets (1 – 3 g) containing a rodenticide would be applied at a rate necessary to achieve rat eradication and according to the U.S. Environmental Protection Agency (EPA) approved pesticide label instructions set forth in the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). All bait application activities would be conducted under the supervision of a Pesticide Applicator certified by the Government of Puerto Rico.

2.3.2 A Comparison of Two Bait Products Registered for Conservation Purposes: Brodifacoum-25D (Alternatives B and C) and Diphacinone-50 (Alternatives D and E)

2.3.2.1 Introduction

Brodifacoum (3-[3-(4'–bromobiphenyl-4-yl)-1,2,3,4-tetrahydro-1-naphthyl]-4 hydroxycoumarin) and *diphacinone* (2-[diphenylacetyl]-1,3-indandione) are both anticoagulant rodenticides. Anticoagulant rodenticides are the most widely used toxicant for control of small mammals worldwide (Eason et al. 2002, Hoare and Hare 2006, Howald et al. 2007). They act by inhibiting the synthesis of vitamin-K-dependent clotting agents in the liver, thereby interfering with the blood's ability to form clots and causing sites of even

minor tissue damage to bleed continuously (Hadler and Shadbolt 1975, Eason and Ogilvie 2009). Mortality from anticoagulant rodenticides is caused by internal hemorrhaging, typically within 3-10 days of initial consumption (Buckle and Smith 1994, Howald et al. 2007, Eason and Ogilvie 2009).

Anticoagulants are grouped into first- or second-generation compounds. These terms were introduced to contrast anticoagulants for which rodent populations had developed a genetic resistance ("first generation" compounds) with anticoagulants that could kill resistant individuals ("second generation"). First-generation anticoagulants, which include diphacinone, generally appear to be most effective at achieving mortality in rodents when consumed over several consecutive days, although a single high dose may cause mortality in some animals (Eason and Ogilvie 2009). Second-generation anticoagulants have a greater toxicity than first-generation, with lower LD_{50} (median lethal dose, or the amount required to kill 50 percent of a test population) values and are typically 'single feed' poisons when administered in high enough concentrations (Hone and Mulligan 1982) *in* (Eason and Ogilvie 2009). The generally lower toxicity of first-generation anticoagulants compared to second-generation products is attributed to their poorer binding affinity to sites in the liver. Second-generation anticoagulants have a greater binding affinity than first-generation anticoagulants (Parmar et al. 1987) and, depending on the concentration in the bait and amount of bait consumed, require only one feeding to be effective. In order for either toxicant to have physiological effects, levels in the liver must reach a critical threshold; this level can vary widely between species and even between individuals within a species. However, any rodenticide can kill an entire rat population if the animals consume enough bait and/or animals are exposed to rodenticide pathways over an appropriate amount of time.

There are currently two anticoagulant rodenticide products being considered for use on Desecheo that are registered for aerial broadcast for eradication of rodents from islands in the United States and in U.S. territories where EPA has local authority:

- Brodifacoum-25D Conservation (Bell Laboratories, Madison, WI, EPA Reg. No. 56228-37)
- Diphacinone-50 (Hacco, Randolph, WI, EPA Reg. No. 56228-35)

Each bait product is designed to be highly attractive to rodents, such that rodents on the island are highly likely to choose the bait over natural food sources. The predominant inactive ingredients in these bait products are non-germinating grains (either sterile or crushed) (Table 2.1).

Table 2.1. The composition of two bait products registered for conservation use in the U.S.

Bait product name	Bait pellet size	Active ingredient		Inert ingredients		Optimal environmental conditions
		Rodenticide name	Conc^{n} (ppm)	Description	Conc^{n} (%)	
Brodifacoum-25D Conservation	~2.3 g[1]	Brodifacoum	25	Sweet, cereal flavor.	99.998	Dry climates[2]
Diphacinone-50	~1.08 g[1]	Diphacinone	50	Fish flavor[2].	99.995	Weather resistant[2]

Notes: [1]Island Conservation unpubl. data ; [2]as described on the EPA bait product label.

Both products are "restricted use pesticides" according to the EPA-approved pesticide label for each product:

- The products may only be used on islands or vessels [marine is implied]
- The products may only be used for the control or eradication of invasive rodents.
- The products are only available for sale to three federal government agencies: U.S. Department of Agriculture/ Animal and Plant Health Inspection Service (USDA/APHIS, Wildlife Services), U.S. Fish and Wildlife Service and U.S. National Park Service, although these agencies can make the bait available to other agencies or private parties under their oversight.
- The products may only be applied by Certified Pesticide Applicators (a certification generally provided by the state or territory in which the bait is to be applied) or persons under their direct supervision.

2.3.2.2 Brodifacoum and Brodifacoum-25D bait product

Brodifacoum is the most frequently used rodenticide for rodent eradication from islands. Of 277 successful island rodent eradication events worldwide (where the toxicant applied was known), 196 (71 percent) used brodifacoum as the primary rodenticide (Howald et al. 2007, Island Conservation unpubl. data). In 92 (47 percent) occasions bait stations were the primary technique used to deliver brodifacoum, 58 (29 percent) occasions used aerial broadcast as the primary technique and 42 (21 percent) occasions used hand-broadcast as the primary technique. Of these, in 33 (17 percent) occasions, a combination of bait stations, hand-broadcast, aerial broadcast and/or traps were used, the most common of which was aerial broadcast as the primary technique supplemented with hand-broadcast (14, or 7 percent of occasions) (Howald et al. 2007, Island Conservation unpubl. data).

Brodifacoum is highly toxic to rats; consumption of no more than a few bait pellets as a single feed or spread across multiple feeding events, would result in mortality (Erickson and Urban 2004, Eason and Ogilvie 2009). The LD_{50} dose has been achieved in Norway rats (*Rattus norvegicus*) ingesting 1.5 g (0.052 oz) of brodifacoum bait product in a single feeding (0.3 mg/kg at 50 ppm brodifacoum) (Buckle and Smith 1994), but within and between *Rattus* species variation also occurs (see Table 2.3). The toxicity of brodifacoum to

rats makes it desirable as a tool for rat eradication because it reduces the need to make bait consistently available to rats for an extended period of time.

Brodifacoum-25D Conservation (hereafter referred to as Brodifacoum-25D) is an unwaxed cereal bait product with 25 ppm brodifacoum, available in 2 - 3g pellets with a sweet, grain flavor. The product is manufactured specifically for conservation purposes; Brodifacoum-25D is for use in dry climates and is designed to break down rapidly on exposure to moisture, including both dew and rainfall.

Brodifacoum-25 ppm products (Bell Laboratories, Madison, WI) have been used to successfully eradicate rats from at least five islands using aerial broadcast as the primary technique (Samaniego-Herrera et al. 2009, Buckelew et al. 2010, Howald et al. 2010) and from one island using hand-broadcast (Hall et al. 2006). In addition, the bait product has been tested for efficacy and palatability under laboratory conditions, prior to its use in eradication operations. To successfully eradicate rats from an island, every rodent must be exposed to sufficient quantities of rodenticide, by either consuming bait or eating other animals that have consumed bait, to acquire a lethal dose of brodifacoum. A bait trial must similarly demonstrate that 100 percent of the rodents in the trial area were lethally exposed to bait. Brodifacoum-25 products have also been trialed with favorable results in at least three field sites: the Aleutian Islands in Alaska (Buckelew et al. 2006), Palmyra Atoll in the equatorial Pacific (Buckelew et al. 2005) and Pohnpei, Micronesia in the Western Pacific (Wegmann et al. 2007).

During field trials, Brodifacoum-25D has been shown to be more palatable to rats in comparison to naturally-available food sources (Buckelew et al. 2005, Howald et al. 2005a, Buckelew et al. 2006, Island Conservation 2010a). The palatability of Brodifacoum-25D to rats makes it a desirable tool for rat eradication because it increases the probability that every rat on the island will consume bait.

While high toxicity and high palatability are desirable bait characteristics from the perspective of successfully eradicating rats, these same characteristics can be undesirable from the perspective of minimizing non-target impacts (Hoare and Hare 2006). Brodifacoum is highly toxic to many birds (Erickson and Urban 2004) and can be toxic to secondary consumers that prey on primary bait consumers (Rammell et al. 1984, Dowding et al. 1999, Stone et al. 1999). Furthermore, because brodifacoum can persist in body tissues of vertebrate and invertebrate species, potential non-target impacts from brodifacoum through secondary exposure of predators has been shown to be extended beyond the period of time that bait pellets themselves are available in the environment (Eason et al. 2002, Fisher et al. 2004). The pellets are manufactured with a grain base to be attractive as a food item to rodents, but the pellets are also likely attractive to other granivorous and opportunistic omnivorous animals. However, other species such as insectivores (some landbirds, shorebirds, reptiles), herbivores (e.g. fruit-eating pigeons) and carnivores (e.g. fish-eating seabirds) would be unlikely to identify the pellets as a food item, would not be as attracted to the pellets as food and thus would be unlikely to intentionally consume them as food. Additionally, pellets would be dyed blue or green which has been shown to make pellets less attractive to some birds and reptiles (Pank

1976, Tershy et al. 1992, Tershy and Breese 1994). Despite this, mortality in individual non-target birds during several rat eradication operations has been attributed to brodifacoum bait products used for eradications (Eason and Spurr 1995, Eason et al. 2002, Howald et al. 2005a, Buckelew et al. 2010).

In an effort to reduce risks to wildlife and people but allow rodenticide products to remain available, the EPA recently limited the use of brodifacoum and nine other rodenticides; brodifacoum is currently restricted to agricultural applications, professional pest control operations and ecosystem restoration efforts on islands (Environmental Protection Agency 2008). However, the EPA does not discourage the use of brodifacoum for rodent eradication from islands. On the contrary, the EPA's recent decision to restrict brodifacoum use explicitly exempted island use from this decision (Environmental Protection Agency 2008). In addition, the New Zealand Department of Conservation identifies brodifacoum as the preferred toxicant for island rodent eradication (Eason and Ogilvie 2009). These explicit exemptions are logical in light of the fact that island rodent eradication operations are fundamentally different from rodent control operations. The potential risks from using brodifacoum for eradication can be avoided or reduced more effectively on an isolated island, with a finite time period of bait availability, than for rodent control operations on mainland or larger-island sites where rodenticide is available in the environment chronically. Furthermore, the generally high cost and logistical complexity of conducting a whole-island rodent eradication necessitate techniques and tools that maximize the probability of successful eradication on the first attempt.

2.3.2.3 Diphacinone and Diphacinone-50 bait product

At least 32 successful island rodent eradications have been reported using diphacinone as the primary toxicant (Table 2.2)(Howald et al. 2007, Island Conservation unpubl. data). Additional eradications have been completed but either there was no information available on the outcome or insufficient time has passed to declare the eradication successful. Of these successful eradications, eight used bait stations as the primary delivery technique, 22 used hand broadcast and one used aerial broadcast. Fifteen eradications using diphacinone are reported to have failed; (Pierce 2003, Hall et al. 2006, Dunlevy and Scharf 2007, Dunlevy et al. 2008, Dunlevy and Swift 2010, Harrison 2010). Although diphacinone has a lower record of success for island rodent eradication in comparison to the use of brodifacoum bait products, some success has been achieved. It is often a preferred rodenticide because of the reduced environmental risk in comparison to brodifacoum (Fisher et al. 2003, Eason and Ogilvie 2009). Additional successful island rodent eradications are needed to adequately demonstrate that diphacinone can compete with proven anticoagulants in efficacy, cost-efficiency and on a larger scale.

Diphacinone-50 is a cereal bait product, available in 1-2g kibble, with an added fish flavor. The bait contains 50 ppm diphacinone. Pellets are dyed dark green, which has been shown to make pellets less attractive to some birds and reptiles (Pank 1976, Tershy et al. 1992, Tershy and Breese 1994). Diphacinone-50 bait product is comparable to commercially available Ramik® Green bait products.

Table 2.2. Known rat eradication attempts worldwide using diphacinone bait products. Country codes: JPN = Japan, MEX = Mexico, UK = United Kingdom, USA = United States of America, USVI = United States Virgin Islands. [1]Warfarin was the primary bait used, supplemented with diphacinone. [2]Reinvaded 2010. [3]Also used spot-baiting. [4]Brodifacoum baits were used in bait stations. [5]No sowing bucket was used in Japanese operations; the baits were simply broadcast by hand from a helicopter. unknown = outcome unknown because no information or insufficient time has passed since operation completed.

Island name	Country	Species	Area (ha)	Year eradicated	Primary delivery	Outcome	Reference
Nonsuch, Bermuda	UK	*R. rattus* *R. norvegicus*	5.8	< 1985	bait stations[1]	successful	Wingate 1985
Canna Island	UK	*R. norvegicus*	1,130	2006	bait stations	successful	Anon, Natl. Trust Scotland
Chain Island, Falkland Islands	UK	*R. norvegicus*	4	2007	hand broadcast	successful	Poncet 2011 pers. comm.
Chain Islet, Falkland Islands	UK	*R. norvegicus*	2	2007	hand broadcast	successful	Poncet 2011 pers. comm.
Channel Islands SE, Falkland Islands	UK	*R. norvegicus*	25	2007	hand broadcast	successful	Poncet 2011 pers. comm.
Channel Islands NW, Falkland Islands	UK	*R. norvegicus*	26	2007	hand broadcast	successful	Poncet 2011 pers. comm.
Skull Bay Island, Falkland Islands	UK	*R. norvegicus*	7	2007	hand broadcast	successful	Poncet 2011 pers. comm.
Green Island, Falkland Islands	UK	*R. norvegicus*	24	2007	hand broadcast	successful	Poncet 2011 pers. comm.
Little Coffin Island, Falkland Islands	UK	*R. norvegicus*	24	2007	hand broadcast	successful	Poncet 2011 pers. comm.
Little Coffin Islet, Falkland Islands	UK	*R. norvegicus*	0.5	2007	hand broadcast	successful	Poncet 2011 pers. comm.
Stick-in-the-Mud Island, Falkland Islands	UK	*R. norvegicus*	3	2007	hand broadcast	reinvaded[2]	Poncet 2011 pers. comm.
Letterbox Island, Falkland Islands	UK	*R. norvegicus*	3	2007	hand broadcast	successful	Poncet 2011 pers. comm.
Governor Island, Falkland Islands	UK	*R. norvegicus*	250	2008	hand broadcast	successful	Poncet 2011 pers. comm.
Big Samuel Island, Falkland Islands	UK	*R. norvegicus*	50	2009	hand broadcast	successful	Poncet 2011 pers. comm.
Big Samuel West islets, Falkland Islands	UK	*R. norvegicus*	3	2009	hand broadcast	successful	Poncet 2011 pers. comm.
Big Samuel SW islet, Falkland Islands	UK	*R. norvegicus*	0.4	2009	hand broadcast	successful	Poncet 2011 pers. comm.
Big Samuel South islet, Falkland Islands	UK	*R. norvegicus*	0.1	2009	hand broadcast	successful	Poncet 2011 pers. comm.
Little Samuel Island, Falkland Islands	UK	*R. norvegicus*	25	2009	hand broadcast	successful	Poncet 2011 pers. comm.
Northwest Islands inner, Falkland Islands	UK	*R. norvegicus*	35	2009	hand broadcast	successful	Poncet 2011 pers. comm.
Northwest Islands islet, Falkland Islands	UK	*R. norvegicus*	1.5	2010	hand broadcast	successful	Poncet 2011 pers. comm.
Tea Island, Falkland Islands	UK	*R. norvegicus*	320	2009	hand broadcast	successful	Poncet 2011
Pitt Island, Falkland Islands	UK	*R. norvegicus*	42	2009	hand broadcast	successful	Poncet 2011
Sniper Island, Falkland Islands	UK	*R. norvegicus*	3.4	2009	hand broadcast	unknown	Poncet 2011
The Knobs, Falkland Islands	UK	*R. norvegicus*	1.3	2009	hand broadcast	unknown	Poncet 2011
The Knobs islet, Falkland Islands	UK	*R. norvegicus*	0.2	2009	hand broadcast	unknown	Poncet 2011
Amy Island, Falkland Islands	UK	*R. norvegicus*	3.6	2009	hand broadcast	unknown	Poncet 2011
Kalkun Cay, USVI	USA	*R. rattus*	1	1982	hand broadcast	successful	Parkes and Fisher 2011
Steven Cay, USVI	USA	*R. rattus*	1	1983	hand broadcast	successful	Parkes and Fisher 2011
Dog Cay, USVI	USA	*R. rattus*	5	1983	hand broadcast	successful	Parkes and Fisher 2011
Buck Island Reef NM, USVI	USA	*R. rattus*	80	2000	bait stations	successful	Witmer et al. 2007
Mokoli'i, Hawaii	USA	*R. rattus*	2	2002	bait stations traps	successful	Smith et al. 2006
Dutchcap Cay, USVI	USA	*R. norvegicus*	13	2003	bait stations	successful	Pierce 2003
Congo Cay, USVI	USA	*R. rattus*	11	2003	bait stations	failed	Pierce 2003
Saba Cay, USVI	USA	*R. norvegicus* *R. rattus*	12	2003	bait stations	successful	Pierce 2003
Cormorant (Bay of Islands, Alaska)	USA	*R. norvegicus*	2	2003	bait stations[3]	failed	Dunlevy & Scharf 2007
South (Bay of Islands, Alaska)	USA	*R. norvegicus*	11	2003	bait stations[3]	failed	Dunlevy & Scharf 2007
Green (Bay of Islands, Alaska)	USA	*R. norvegicus*	22	2003	bait stations[3]	failed	Dunlevy & Scharf 2007

Table 2.2 (continued)

Island name	Country	Species	Area (ha)	Year eradicated	Primary delivery	Outcome	Reference
Camouflage (Bay of Islands, Alaska)	USA	*R. norvegicus*	4	2004	bait stations	failed	Dunlevy & Scharf 2007
Black (Bay of Islands, Alaska)	USA	*R. norvegicus*	1	2004	bait stations	failed	Dunlevy & Scharf 2007
Sweet (Bay of Islands, Alaska)	USA	*R. norvegicus*	1	2004	bait stations	successful?	Dunlevy & Scharf 2007
Ina (Bay of Islands, Alaska)	USA	*R. norvegicus*	5	2004	bait stations	failed	Dunlevy & Scharf 2007
Aureola (Bay of Islands, Alaska)	USA	*R. norvegicus*	0	2004	bait stations	failed	Dunlevy & Scharf 2007
Duh (Bay of Islands, Alaska)	USA	*R. norvegicus*	0	2004	bait stations	failed	Dunlevy & Scharf 2007
Earl (Bay of Islands, Alaska)	USA	*R. norvegicus*	6	2004	bait stations	failed	Dunlevy & Scharf 2007
Bubba (Bay of Islands, Alaska)	USA	*R. norvegicus*	1	2004	bait stations	successful?	Dunlevy & Scharf 2007
North Rocks (Bay of Islands, Alaska)	USA	*R. norvegicus*	1	2004	bait stations	successful?	Dunlevy & Scharf 2007
Channel (Bay of Islands, Alaska)	USA	*R. norvegicus*	3	2004	bait stations	successful?	Dunlevy & Scharf 2007
Capella Island, USVI	USA	*R. norvegicus* *R. rattus*	9	2005	bait stations	successful	Pierce 2005
Buck Island NWR, USVI	USA	*R. norvegicus* *R. rattus*	17	2005	bait stations	successful	Pierce 2007
Mokapu, Hawaii	USA	*R. rattus*	4	2008	aerial	successful	Swenson & Duvall 2008
Lehua, Hawaii	USA	*R. rattus*	117	2008	aerial	failed	Dunlevy & Swift 2010
Egmont Key, Florida	USA	*R. rattus*	112	2009	bait stations hand broadcast	successful?	Witmer et al. 2010
Cocos Island, Guam	USA	*R. exulans* *M. musculus*	34	2009	hand broadcast bait stations[4] trapping	successful?	Parkes and Fisher 2011
San Jorge East, Gulf of Mexico	MEX	*R. rattus*	5	2000	bait stations	successful	Donlan et al. 2003
Nishijima, Ogasawara	JPN	*R. rattus*	49	2007	bait stations	failed	Hashimoto 2010
	JPN	*R. rattus*	49	2010	aerial[5]	unknown	Harrison 2010
Hagashijima, Ogasawara	JPN	*R. rattus*	28	2008	aerial	failed	Hashimoto 2010
	JPN	*R. rattus*	28	2010	aerial	unknown	Harrison 2010
Mukojima, Ogasawara	JPN	*R. rattus*	268	2008	aerial	failed	Hashimoto 2010
	JPN	*R. rattus*	268	2010	aerial	unknown	Harrison 2010
Torishima, Ogasawara	JPN	*R. rattus*	11	2008	aerial	failed	Hashimoto 2010
	JPN	*R. rattus*	11	2010	aerial	unknown	Harrison 2010
Anijima, Ogasawara	JPN	*R. rattus*	785	2010	aerial	unknown	Harrison 2010
Otoutojima, Ogasawara	JPN	*R. rattus*	530	2010	aerial	unknown	Harrison 2010

Ramik® Green has been trialed for rodent eradication with at least partially favorable results in the Aleutian Islands in Alaska; rats were apparently successfully eradicated from some islets (mostly < 0.5 ha in size), but not all trial islets (Dunlevy and Spitler 2008). While diphacinone has been trialed or used with favorable results in a number of landscape-scale rodent control efforts (Dunlevy et al. 2000, Spurr et al. 2003a, Spurr et al. 2003b), the success of these control efforts is not relevant to the potential success of diphacinone as a tool for rodent eradication. The goal of a rodent control operation is to reduce a rodent population to an acceptably small size and maintain low density populations, whereas the goal of an eradication operation is to permanently remove every rodent. This fundamental difference is sometimes overlooked in discussions of the relative merits of different bait products; a bait product that is available for use, attractive to

rodents, but has a lower efficacy may be an excellent tool for a control operation but is inadequate for an eradication operation.

Although diphacinone can be lethal to some rats when administered in a single, large dose, it is relatively more potent in small doses administered over several days (Buckle and Smith 1994, Timm 1994). Single lethal doses of 1.93 - 43.3 mg/kg have been reported for laboratory rats, but doses of < 1 mg/kg over five successive days are more effective (Hone and Mulligan 1982, Jackson and Ashton 1992). Laboratory studies demonstrate that both single-dose and multiple-dose LD_{50} values for rats exposed to diphacinone are higher than for brodifacoum (Table 2.3) and that for mortality to occur, diphacinone generally must be ingested regularly over a period of days (Buckle and Smith 1994, Erickson and Urban 2004). Jackson and Ashton (1992) reported LD_{50} values over a five-day period of 0.21 and 0.35 mg/kg/day in domestic and wild Norway rats respectively. Tobin (1992) demonstrated that for mortality to occur, black and Polynesian rats required a mean of 8.6 mg/kg (11.8 - 28.4 g of pellet) and Norway rats required a mean of 10 mg/kg (34.6 g pellet) ingested over an average of six to seven days, with a range of between four and 12 days. Thus, to ensure 100 percent mortality to a rat population, bait needs to be available and attractive to rats and consumed for at least 12 days.

Table 2.3 LD_{50} values for *Rattus* sp. exposed to brodifacoum and diphacinone. Data from Hone & Mulligan (1982); Buckle (1994); Erickson & Urban (2004).

Species	**LD_{50}** mg/kg **brodifacoum**	**LD_{50}** mg/kg **diphacinone**
Laboratory rat	0.41 (0.35 – 0.50)	2.5 (1.3 - 3.4)
	0.56 (0.47 – 0.66)	2.1 (1.5 – 2.9)
		7.0 (5.2 – 9.5)
		5-day dose @ 0.21/day=1.05
		1.9
Norway rat (wild)		5-day dose @ 0.35/day=1.75
Rat (unspecified)		3.0 (< 1 over 5 days)
Norway rat		10 (40% mortality)
Black rat		8.6 (90% mortality)
Polynesian rat		8.6 (90% mortality)
Rat (unspecified)	0.39	
Norway rat	0.3	3
Norway rat-male	0.4 (0.35-0.46)	
Norway rat-female	0.49 (0.43-0.56)	
Norway rat-male	0.42 (0.37-0.48)	
Norway rat-female	0.56 (0.46 – 0.73)	
Norway rat-male	0.98 (0.78 – 1.2)	
Norway rat-female	1.3 (1.0 – 1.6)	
Norway rat-male	0.81 (0.7 – 0.95)	
Norway rat-female	1.0 (0.4 – 2.1)	
Norway rat	0.22-0.27	
Black rat	0.65-0.73	

The primary advantage of diphacinone as a rodenticide for conservation purposes is the low risk it poses to non-target organisms in comparison to brodifacoum. Diphacinone has comparatively low persistence in animal tissues, which makes toxicity to non-target species through secondary exposure less likely than for brodifacoum (Fisher 2009).

Furthermore, laboratory trials have indicated that diphacinone has low toxicity to birds when compared with brodifacoum (Erickson and Urban 2004, Eisemann and Swift 2006). However, recent research suggests that the toxicity of diphacinone to some birds may be considerably higher than previously thought (Rattner et al. 2010), although overall the toxicity of diphacinone still remains low compared with brodifacoum. From the perspective of non-target risk, diphacinone is the optimum choice. However, when balanced against efficacy, the long exposure requirement decreases the probability of success as all rats may not select the bait over natural foods over the required time period.

The physiological action of diphacinone is the same as for brodifacoum; diphacinone interferes with the blood's clotting ability and causes profuse bleeding. However, diphacinone and other first-generation anticoagulants have a poorer affinity for the enzyme that produces vitamin-K-dependent clotting agents (in comparison to brodifacoum and other second-generation anticoagulants) resulting in a slower depletion time of these clotting agents in the bloodstream (Eason and Ogilvie 2009). Also, diphacinone in rats is more actively metabolized and excreted than brodifacoum; in one trial, after a single dose of diphacinone, 80 percent was eliminated in feces and urine within eight days (Yu et al. 1982). These properties indicate that diphacinone generally takes longer than brodifacoum to accumulate in a rodent to achieve a lethal dose.

In an effort to reduce risks to wildlife and people but allow rodenticide products to remain commercially available, the EPA recently employed measures to limit the allowable application methods of diphacinone, along with nine other rodenticides. Diphacinone is still available for residential users, but only in enclosed bait stations (Environmental Protection Agency 2008). These new regulations are less strict than those imposed on second-generation anticoagulants, including brodifacoum, which are no longer available for purchase by residential users and permitted for use only in agricultural applications, professional pest control operations and ecosystem restoration efforts on islands.

2.3.3 Comparative Likelihood of Success

All of the action alternatives in this EA include the use of one of the following bait products:

- Brodifacoum-25D; or
- Diphacinone-50

The Environmental Consequences section (Chapter 4) will analyze the comparative impacts of each bait product on the biological and physical resources of Desecheo. In this section, we primarily address a separate issue: the comparative likelihood of a successful eradication using each different bait product. The efficacy of a bait product is a combination of the toxicity of the rodenticide, the relative palatability to the target species

under field conditions, the method of bait application, and other factors. It is critical to recognize that the differences in toxicity and palatability between the two products available result in different likelihoods of successful rat eradication.

At a basic level, from the perspective of operational efficacy, brodifacoum is a better choice for rat eradication than diphacinone because the higher toxicity and efficacy of brodifacoum means there is a greater probability of eradication success. In addition, a greater efficacy is more important for bait broadcast delivery than for bait station delivery where bait can be made available for long periods of time. Rat eradication using brodifacoum has been proven to be successful using either one or two aerial bait applications. For diphacinone, only a few eradication projects have used aerial application (Table 2.2), meaning a strategy for aerial application has not yet been extensively tested. Given the knowledge that diphacinone is physiologically more effective at low repeated doses and that successful eradications using bait stations have required diphacinone bait to be consistently available for long periods, aerial application of diphacinone would require multiple applications. Therefore, a brodifacoum eradication using aerial techniques would be more cost-efficient and more effort-efficient than a diphacinone broadcast, which might demand up to four broadcast applications over a period of 30 days or more in order to make bait consistently available for the required period. The higher toxicity of brodifacoum also renders the eradication at less risk of failure. Diphacinone delivered by aerial broadcast has successfully eradicated rats only once and failed five times, although the outcome of six other aerial application projects is currently unknown (see Table 2.2, Section 2.3.2.3). The multiple-feed requirement of diphacinone as a contributor to operational failure for aerial applications cannot be ruled out. On Lehua Island, Hawaii, where aerial broadcast of diphacinone in 2009 failed to eradicate rats, island managers believed that the success of the operation was compromised by unanticipated regulatory actions that prevented implementers from conducting more than two broadcast applications as well as limited bait broadcast around the coastline. In comparison brodifacoum delivered by aerial-broadcast has been used successfully for rodent eradication on at least 58 occasions (Howald et al. 2007, Island Conservation unpubl. data).

Recent rat eradications in the Falkland Islands using a diphacinone product (Ditrac®) have demonstrated that under some conditions, hand broadcast application of diphacinone can achieve success (Table 2.2). In the Falkland Islands, it is likely that the combined effect of a simple ecosystem type (largely tussock grass and sand dunes), a maritime sub-arctic climate and a high bait application rate (10-20kg/ha depending on the size of the island) contributed to the success of these eradications. The bait application provided an abundance of wax blocks for caching and effectively acted as a second bait application; due to the cold climate, bait was available over a period of months (Poncet pers. comm.). Many treated islands were relatively small (mean for 22 islands, 13 ha - although two islands were 250 ha and 320 ha in size), and could be easily accessed on foot. While densities of brown rats on these islands were not determined, seasonal breeding patterns, winter mortality and reduced food resources in comparison to tropical ecosystems would also likely have contributed to the successes.

In comparison to broadcast delivery, bait station delivery allows implementers to deliver bait into every potential rat territory, over a longer period of time and with more opportunity to adapt to the changing dynamics of a decreasing rat population. However, effective bait station delivery requires the majority of the rat population on the island to enter a bait station to consume bait, a behavioral requirement that leaves the operation potentially vulnerable to failure if some rats are hesitant to enter stations. While this behavioral requirement can compromise the success of rat eradication regardless of the toxicant used, it is a greater risk when using diphacinone because of the multiple-feeding requirement; rats would need to enter bait stations repeatedly on multiple consecutive days. However, diphacinone delivered in bait stations has been used to successfully eradicate rats from at least eight islands (Table 2.2). But in comparison, brodifacoum delivered in bait stations has been used successfully on at least 92 occasions (Howald et al. 2007, Island Conservation unpubl. data).

Bait palatability is another important aspect of the likelihood of successful rat eradication. In field trials, the products Brodifacoum-25D and Ramik® Green (comparable to Diphacinone-50) have both been shown to be preferred by most rats over locally available natural food sources. Brodifacoum-25 bait products have been used to successfully eradicate rats on at least five islands and have shown favorable results in at least three other eradication trials (see Section 2.3.2.2). The bait product Diphacinone-50 has not yet been proven to successfully eradicate rats, but a comparable product (Ramik® Green) was successfully used on Mokapu Island, Hawaii. Ramik® Green has also shown at least partially favorable results in trials the Aleutian Islands (Table 2.2). However, in a recent laboratory free-choice food trial designed to determine the efficacy of different rodent baits, the percentage palatability (bait consumption / total food consumption) of Ramik® Green diphacinone product was only 60 to 70 percent in black rats and 50 to 54 percent in Polynesian rats (*Rattus exulans*) in a 3-day test (Pitt et al. 2011). In addition, the Ramik® Green product achieved only 40 percent mortality in black rats and 20 percent mortality in Polynesian rats. Overall, this diphacinone formulation was the only product tested that did not achieve at least 80 percent mortality for a single rodent species in both 3-day and 7-day trials. The low efficacy of this product was likely the result of low overall product toxicity, limited exposure times, and low palatability compared to other products (Pitt et al. 2011).

While bait product choice is an important component of eradication efficacy, the most important component is the methodology used for bait delivery. Bait delivery methodology can vary significantly due to the specific bait product used, the equipment and supplies available for implementation and most importantly, characteristics of the local environment. There is no single “recipe” for successful rat eradication beyond the basic principle of ensuring that every rat on the island is exposed to a lethal dose, which varies by species and toxicant. Implementers must approach each new project with a strategy that is customized for the parameters of the project. This being said, implementers can and should adopt and adapt strategies from other successful eradications. For Desecheo Island, the proven record of successful eradications using aerially-broadcast brodifacoum – at least 58 operations – provides a comprehensive set of tested methodologies from which to design a strategy.

From an operational perspective, the essential difference between application of Diphacinone-50 and Brodifacoum-25D to eradicate rats from Desecheo would be that quantities of diphacinone would be needed to remain relatively consistent across a period of up to 12 days. With a brodifacoum operation, a rat that ingests bait on day one will likely not need to ingest bait again because brodifacoum has a high binding affinity and is metabolized slowly. However, with a diphacinone operation, bait needs to be available to all rats for 10 - 12 days; this requires that (a) the bait is highly attractive to rats to ensure that rats prefer it above natural food items, (b) that sufficient bait is available daily to ensure rats frequently encounter bait within their environment, (c) that the consistent bait uptake in the environment through ingestion by rats, crabs and other animals, and degradation by invertebrate, microbial and other environmental action does not diminish the amount of bait available to the level at which sufficient bait is no longer daily available for ingestion by rats. More generally, it seems that the tested double-baiting strategy proven for aerial application of brodifacoum baits cannot be simply copied for diphacinone aerial baiting (Parkes and Fisher 2011).

In conclusion, from the perspective of the likelihood of eradication success, Brodifacoum-25D is a better choice than Diphacinone-50, due to its higher toxicity and extensive proven record. This conclusion does not eliminate Diphacinone-50 from full consideration for the proposed action, because Diphacinone-50 has also been used successfully to eradicate rats from an island. Furthermore, as outlined in this section and discussed in detail in the Environmental Consequences (Chapter 4), use of diphacinone imparts a considerably lower risk to non-target species than brodifacoum. Regardless, the difference in the predicted likelihood of success of Brodifacoum-25D in comparison to Diphacinone-50 should be an important consideration when deciding between the alternatives presented here and should not be overshadowed by concern for potential non-target impacts, especially non-target impacts that would not affect species at a population level; the need to ensure eradication success is critical. A failed eradication attempt would provide no conservation returns in the long term, since rats would quickly re-establish throughout the island (Howald et al. 2005b). The most cost-effective conservation returns on rat eradication investment is through a successful eradication on the first attempt.

Conservation practitioners seek to avoid causing harm to biological resources. However, impact to individual animals or plants that is incidental to a conservation action can arise. The Service's policy, and other government regulations, acknowledge that circumstances exist in which the responsible management of Refuge lands may necessitate actions that might incidentally harm individual animals or plants. For example, a recent clarification of the Migratory Bird Treaty Act (MBTA) (U.S. Fish and Wildlife Service 2010b) has allowed for the issuance of a special-purpose permit during invasive species eradication actions where *take* of listed migratory birds is possible when the overall effects to migratory birds is positive (see Section 3.5.2). Therefore, potential incidental harm to individual animals during rat eradication operations on Desecheo may be acceptable as long as any individual impacts are outweighed by the expected beneficial effects of rat eradication to the ecosystem.

2.3.4 Bait Trials Conducted on Desecheo Island

Prior to project implementation, representatives from Island Conservation conducted trials on Desecheo Island as part of the detailed operational planning process; this included a determination of an appropriate bait application rate for rat eradication and bait degradation trials. The studies focused on the need to maximize the probability of eradication success while minimizing the risk to non-target individuals through exposure to rodent bait.

2.3.4.1 Rat Eradication Feasibility Study, February 2009

Field surveys were implemented on Desecheo island, Puerto Rico, as a preliminary measure to developing a feasibility plan for eradication of rodents from the island (Island Conservation 2009a, 2010c). Six Island Conservation personnel visited Desecheo between February 12 and 26, 2009 and accompanied staff from the Service's Caribbean Islands NWR Complex.

The main goals of the study were to:

- evaluate a generalized feasibility of rodent eradication
- gain a preliminary understanding of rodents on the island through application of a rodent survey and biomarker study
- obtain pre-eradication baseline status for island fauna and vegetation components
- obtain information about native species potentially at risk from an eradication operation

Trapping surveys confirmed that black rats were the only rodent species detected. A trial survey using a placebo bait (with the same grain matrix of Brodifacoum-25D but without the toxicant) impregnated with fluorescent biomarker determined that after a bait application rate of 18 kg/ha (the maximum allowable), 100 percent rats were positive for biomarker up to seven days post bait application. No young weanling rats were detected and no active breeding was observed. In the placebo bait uptake trials at 18 kg/ha, 20 percent of bait pellets remained on the ground four days post-application suggesting that the application rate was sufficient to allow rats full access to bait (Island Conservation 2009).

Biological surveys across the island revealed generally poor diversity and abundance of bird species and no evidence of any seabird colonies within the island's interior. However, seven potentially active seabird rookeries were observed, including two of reasonable size, one on the southeast coastline which had up to 50 roosting brown booby (*Sula leucogaster*) and one on the northeast coastline. In addition, large numbers of brown boobies were seen at sea, offshore, in rafts along with red-footed boobies (*Sula sula*) and masked boobies (*Sula dactylatra*) suggesting that there may at least be source populations from which the Desecheo seabird colonies could be re-established.

Four of the five native and endemic reptiles known from Desecheo were observed, with the exception of the slippery-backed skink, which was not seen on visits in 2009 (but observed in Febuary 2010). All reptiles may be at risk of exposure to rodenticide in rat bait, mostly through secondary pathways (consuming invertebrates, scavenging) although the Desecheo ameiva might eat bait directly. The assessment demonstrated that further research would be needed to understand whether or not reptiles are at risk of bait exposure during a rat eradication operation.

Of the passerine bird species observed on the island, pearly-eyed thrasher (*Margarops fuscatus*) was identified as at potential risk of both primary and secondary bait exposure (through eating *Anolis* lizards), and the zenaida dove (*Zenaida aurita*) would be at risk of primary exposure because of its ground-foraging granivorous habits. American kestrel (*Falco sparverius)* and peregrine falcons (*Falco peregrinus*) might be at risk of secondary and tertiary exposure through ingestion of *Anolis* and *Ameiva* lizards; kestrels were observed feeding on *Anolis* lizards and a female peregrine falcon was observed carrying an *Ameiva* lizard.

2.3.4.2 Bait Uptake Field Trials, February - March 2010

A second series of field surveys were conducted on Desecheo Island to develop ongoing operational planning needs for the proposed eradication of rodents from Desecheo (Island Conservation 2010c). Seven representatives from Island Conservation, four research biologists from University of California Santa Cruz and two biologists from the Government Department of Environment and Natural Resources visited Desecheo between February 26 and March 11, 2010, supported by the Service's Law Enforcement officers.

The objectives were:

- Monitor placebo bait uptake in two habitats (woodland and shrubland)
- Determine consumption of placebo bait amongst trapped rats
- Identify reproductive stage of rats
- Quantify hermit crab density in two habitats (woodland and shrubland)
- Determine consumption of placebo bait by hermit crabs
- Test ambient environmental placebo bait degradation
- Field test eradication efficacy tools (collection of DNA samples, test rat chew indicators)

Two bait uptake trials were conducted: the first in woodland habitat using placebo bait impregnated with a biomarker, the second in shrubland habitat using placebo bait with no biomarker. Bait was applied by hand to 2.1 ha of woodland and 1.3 ha of shrubland at 18 kg/ha followed by a second application of 9 kg/ha five days later.

Overall, bait remained on the ground across a five-day period after the first application and for four days after the second application, with no bait remaining on the ground 10 days after the initial application (Figs. 2.1 A-C). This decline in bait availability across time was

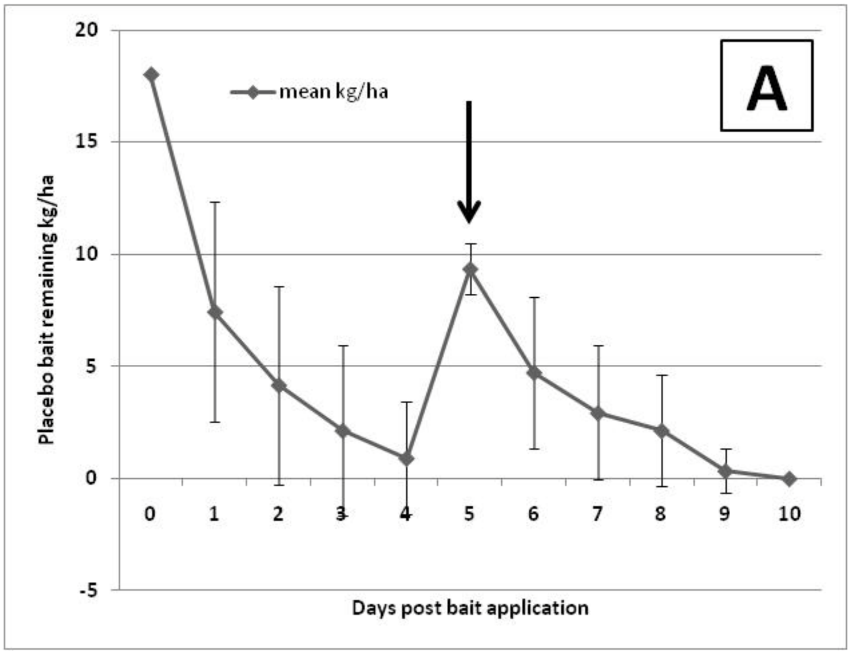
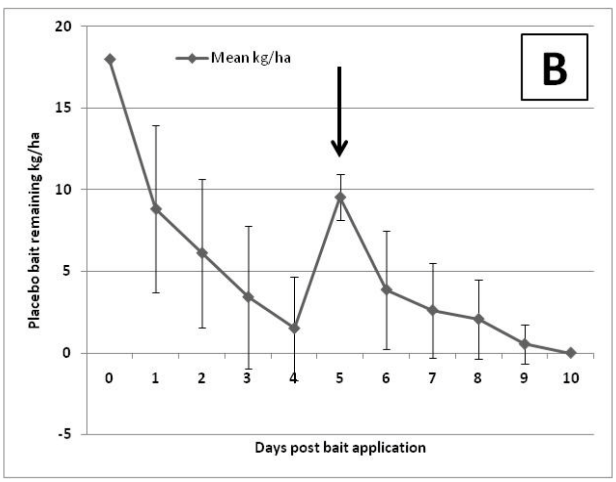
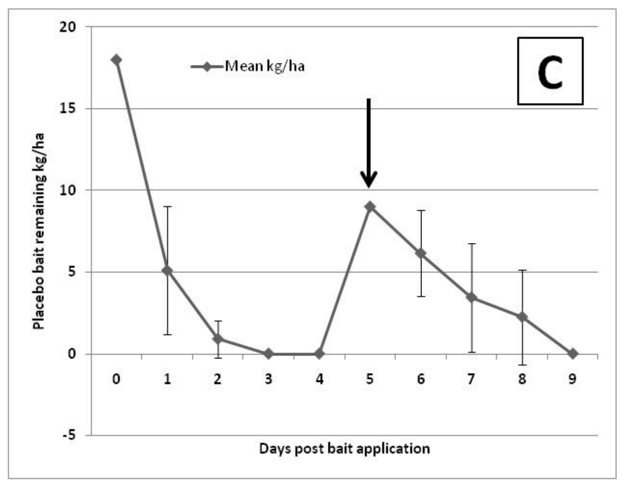


Figure 2.1 Placebo bait uptake field trials on Desecheo NWR, Feb-Mar 2010. Chart shows mean uptake values with standard deviations. **A**: bait uptake in both woodland and shrubland; **B**: bait uptake in woodland (n=10); **C**: bait uptake in shrubland (n=6). Note: First bait application=18 kg/ha, second bait application (vertical arrow) = 9 kg/ha.





considered sufficient to ensure that all rats had access to bait, but also that surplus bait did not persist on the ground for an extended period. After the first application, bait disappeared more quickly in shrubland habitat than in the woodland habitat, but after the second application the rate of bait disappearance was more equal across the two habitats.

All rats trapped (70 individuals) tested positive for signs of biomarker for seven days after each bait application, indicating that 100 percent of rats examined had ingested bait. No weanling rats were observed and no females caught showed signs of fetal development or lactation, indicating that rats were either not breeding or breeding at undetectable levels during the study period.

Two species of landcrab are present on Desecheo, the purple land crab (*Gecarcinus ruricola*) and tropical hermit crab (*Coenobita clypeatus*). In other field trials, high densities

of land and hermit crabs taking large quantities of rodent bait has resulted is less bait being available for rats (Buckelew et al. 2005). On Desecheo, a higher abundance of hermit crabs were detected in the woodland habitat than in shrubland areas. The mean hermit crab density was 696 crabs/ha but densities were higher in woodland sites (833 crabs/ha) than in shrubland sites (61 crabs/ha). All hermit crabs in woodland sites tested positive for the presence of biomarker; this, together with high densities of crabs, indicates that hermit crabs would be a significant consumer of rodent bait.

Pellets of placebo bait were observed to retain their hardness and shape for up to four days of exposure to natural environmental influences such as weather, invertebrate and microbial action (excluding the effects of rats and hermit crabs). After an additional two days when several light to medium rainfall events occurred, the pellets softened and retained most of their structure, but fell apart when handled. After rainfall therefore, it would be unlikely that crabs, rats, or other vertebrates, could pick up and ingest whole pellets as they would crumble when animals attempted to eat them.

During the field trials, a new chew-tag indicator was tested and rat DNA samples were collected from across the island and archived; subsequent genetic analysis of tissue from a subsample of rats demonstrated that the collection, storage and analysis techniques were appropriate. The chew-tag indicator tool can be used to detect and monitor rodent presence for up to two years post bait application. Similarly, in the event of a project failure where rats are detected, DNA samples can be used to understand whether the failure was due to the re-establishment of a small remnant rat population that wasn't entirely eradicated, or to the re-invasion of rats from an outside source.

2.3.4.3 Bait degradation trials, June 2010

Field trials were carried out on Desecheo in June 2010 to test the degradation of placebo dry and wet rodent bait pellet formulations in woodland and grassland habitats, and in the marine near-shore environment using placebo bait (Island Conservation 2010b). The objectives were to evaluate the most appropriate formulation for application on Desecheo, and to measure the rate of degradation from natural environmental causes. The "wet" pellet formulation includes sorbitol (not included in the dry pellet formulation), a gumming agent that makes the pellets more resistant to weathering particularly in a damp or wet environment. Previous field trials on Desecheo used dry formulation pellets, but following the trials in February 2010 when high consumption rates of pellets by ants (*Solenopsis* sp.) was observed, we proposed that wet formulation pellets might better resist ants. However, wet formulation pellets can persist longer in the environment because of the sorbitol content which can increase risk to non-target species.

Bait degradation in grassland and woodland: rat exclosure cages
Eight scenarios were tested: wet bait formulation with and without crabs and dry bait formulation with and without crabs in two different habitats, grassland and woodland. Bait pellets were placed in rat exclosure cages which allowed pellet exposure to environmental factors as well as invertebrates, but prevented access by rats, land and hermit crabs. Two

equally-sized hermit crabs (about 5 cm in diameter) and 20 equally-sized (about 2 cm in length) pellets were placed in each compartment under a different treatment. Pellets were monitored at 24 hour intervals for four days for the presence of invertebrates on or close to pellets, disappearance of pellets and overall condition of pellets in each habitat.

In the grassland habitat, ants crawled onto the pellets almost immediately they were placed in the enclosure. However, on subsequent days, only few ants on or close the pellets were observed in both habitats. By day four in the grassland habitat, a similar number of dry (nine) and wet (seven) pellets remained in the no-crab enclosures, but far fewer dry (five) and wet (one) pellets remained in the enclosures with crabs, and all remaining pellets were only 50 percent of their original size. However, in enclosures with crabs, by day two more wet formulation pellets (three pellets remaining in grassland, four pellets in woodland) had disappeared than the dry formulation (13 pellets remaining). Unfortunately by day two crabs had dug into the woodland habitat enclosure (that had no original crabs) and eaten all the pellets.

While the observations of pellet degradation were largely subjective, there was no consistent difference in the environmental degradation of dry or wet formulation pellets without crabs. Although this was a small informal study, it was suspected crabs may have been more attracted to the wet formulation pellets than the dry formulation because of the sweetened flavor due to the sorbitol content. Because of the greater non-target species risk associated with the wet formulation pellet, the dry formulation was considered sufficient for the purpose of rat eradication.

Bait degradation in the marine environment
A simple experiment was undertaken evaluate how two different bait formulations (wet and dry) degraded underwater in the marine environment around Desecheo. Trials were conducted at two locations about ten meters apart at Puerto de los Botes. A variety of fish were seen foraging at both locations prior to releasing any bait into the water. Two handfuls of each bait formulation were dropped from just above the surface into the water. Fish behavior was monitored immediately on introducing bait, and 10 and 30 minutes after the introduction of bait. Pellets were also tested for consistency 10 and 30 minutes after the introduction of bait.

Dry bait: Pellets sank almost immediately to the sea floor. Fish did not immediately seize upon bait when it was dropped into the water. After 10 minutes, a few cleaner wrasses were observed “investigating” pellets, but not eating or biting them. After 10 minutes, some pellet flaking occurred when manually compressed, but the core remained hard and intact. Large trigger fish present did not show any interest in pellets lying on the sea floor. After 30 minutes, the majority of pellets had either been flushed from the environment, had been eaten, or had broken down into small particles, and only the remnants of five pellets and small fragments were visible on the sea floor. A few cleaner wrasses were seen nibbling at small bait particles. When manually compressed, pellets broke apart and particles readily dispersed in the water.

Wet bait: Pellets sank almost immediately to the sea floor. Fish did not immediately react to the introduction of bait into the environment. After 10 minutes, a few cleaner wrasses were seen "kissing" or nibbling pellets. A few larger fish swimming in the immediate vicinity did not appear interested in bait. Pellets remained wholly intact after being submersed for 10 minutes in sea water. After 30 minutes, all pellets were still on the sea floor and had not broken down significantly nor dispersed by the motion of the water. A few wrasses were seen nibbling pellets. When tested manually, pellets became slimy and mushy, did not break down into particles but did lose their shape and structure. Within each pellet, a small, hard core of bait remained unaffected by the activity of the sea water.

Fish did not react immediately to the introduction of bait to the environment, as was expected, and large fish were not observed to eat pellets. It is possible that fish were intimidated or distracted by the presence of observers in the water and altered their normal foraging behavior. However, these results are comparable with similar tests conducted on Palmyra atoll when 20 fish species initially showed no interest in bait pellets dropped into the water column, and only after the first three trials did fish (of six species) show a response by 'mouthing', grabbing or eating bait pellets (Island Conservation 2010a). This might suggest that increasing exposure to pellets might increase a response in fish, but during a bait application for rat eradication the potential for bait pellets to drift into the marine environment should only happen once or twice.

2.3.5 Aerial Broadcast

Aerial bait broadcast by helicopter is a bait delivery technique that has been commonly used for successful rodent eradications from islands worldwide (Howald et al. 2007). Common to these rat eradications, a whole island application of bait is required to ensure bait is available in every potential rat territory. Aerial bait broadcast is often the only way to deliver bait to inaccessible or unsafe terrain, such as steep cliffs or areas with unexploded ordnances (UXO), while maintaining personnel safety. Employing aerial bait broadcast as the primary bait application method would minimize risk to personnel, and would also minimize disturbance to Desecheo's sensitive terrestrial habitat by allowing the Service to deliver bait to all potential rat habitat on the island without setting foot on much of the island. More details on the specific techniques that would be employed for bait broadcast can be found in Section 2.3.

2.3.6 Timing Considerations

The seasonal timing for the action alternatives is an important factor for determining both the likelihood of implementing successful rat eradication and the risk of negative impacts from operational activities to the biological resources of Desecheo Island. The likelihood of success is influenced by three seasonally-dependent factors: 1) the demographic patterns of the local rat population; 2) the availability of alternative food sources for rats; and 3) local weather conditions and seasonal patterns that would affect the feasibility of conducting operations. The risk of negative impacts to biological resources depends on the

seasonal breeding and migratory patterns of species other than rats that may be vulnerable to rodenticide exposure and disturbance caused by the bait application process.

The time period for bait application under each alternative would be defined by:

- Rat biology
- Weather patterns
- Plant productivity
- Bird breeding season
- Bird migratory patterns
- Reptile breeding season

2.3.7 Biology of Rats & Timing of Eradication Operation

Rat eradication from an island is more likely to be successful if intensive baiting takes place when the rat population is declining in response to annual food shortages. At this time, rats are typically more food stressed and therefore more likely to eat the bait presented (Macdonald et al. 1999). The probability of eradication success is also increased if the bait application takes place when rats are not breeding. During the rat breeding season, there is a possibility that juvenile rats could still be in the nest at the time of bait application. These juvenile rats could first emerge from the nest to forage after all the bait nearby has been consumed, and could therefore re-populate the island. Breeding is likely driven by increased food availability, which is in turn driven by climatic factors. Productivity of invertebrates, reptiles, and plants begins to increase on Desecheo as rainfall increases and soil moisture is replenished. Field surveys in February and March 2009 and 2010 (during the dry season) have indicated that breeding activity in rats is very low in these months.

From the perspective of rat population biology on Desecheo, the ideal time period for rat eradication would be from January through April, when the island is comparatively dry and plant productivity is low (see Section 3.2.3).

2.3.8 Seasonal Patterns of Native Wildlife

Effects of the operational activities associated with rat eradication (e.g. exposure to toxicants, helicopter operations) on the native wildlife could be reduced by avoiding seasons in which large numbers of animals are present, such as bird migration and breeding. Currently, the size of the resident, migratory and breeding bird populations on Desecheo are much reduced, with only small numbers of individuals present (Meier et al. 1989, Earsom 2003a, b). Field surveys in 2009 and 2010 reported only 17 pairs of bridled tern and one pair of brown noddy (*Anous stolidus*) as breeding in 2010 either on the island or on offshore rocks (Island Conservation 2010b). Therefore, to determine a time of year when birds have the potential to breed on the island (and might unexpectedly arrive on the island), general information from mainland Puerto Rico and its other offshore islands has been used. In tropical habitats, seasonality of bird breeding is often extended, in comparison to temperate systems (Nelson 1983)(see Section 3.4.2.5). On adjacent Mona

and Monito islands, variable seabird breeding seasons have been reported between years, with some years demonstrating a bi-modal pattern of peaks in spring and fall seasons (Saliva 2009). Bait broadcast operations would aim to occur during months when seabird and land bird breeding activity is likely to be reduced, but some variability in those months may exist between years and would be difficult to accurately predict.

Specific timing considerations for birds include the following:

Seabird breeding seasons: seabird reproductive activity across nine species has been reported from other islands in Puerto Rico in every month of the year (see Table 3.1, Section 3.4.2.5). However, peak breeding season for the two species known to breed on Desecheo (bridled tern and brown noddy) is between June and August. In the event that other species arrive to breed on Desecheo, because of the current absence of established colonies the total number of breeding birds would likely be low.

Summer migrant breeding period: typically April-September; a few summer migrant land birds may attempt to breed on Desecheo.

Resident species breeding period: generally, the abundance of resident bird species on Desecheo is low, and only five resident species have been confirmed as breeding on the island in recent surveys.

See Section 3.4.2 for a more detailed analysis of bird abundance and seasonal patterns.

2.3.8.1 Weather Considerations

Weather conditions must be fairly calm to effectively broadcast bait by helicopter, with average wind speeds lower than 30 knots (35 mph). It is important to the success of the eradication that the entire island area is treated with a bait broadcast within a minimum time frame, rather than in partial-island treatments separated by multiple days or weeks. A rapid and continuous bait application prevents potential reinvasion of rats from untreated areas into areas of the island previously treated with bait. Furthermore, the bait used would not withstand a significant rainfall event, so it would be important that the bait application is implemented on a day with no anticipated precipitation, and none anticipated in the near-term forecast. The Caribbean region hurricane season typically begins in May and ends in November, with peak activity between June and November with an overall peak in September (Taylor and Alfaro 2005). During this period, tropical storms and hurricanes can result in extreme rainfall and wind events. It would therefore, not be advisable to plan a rodent eradication operation during the typical hurricane season owing to the risk of high rainfall and high winds, and the logistical contingencies that would be required to operate within this period.

2.3.9 Project Staging and Support Operations

The bait application operation would be staged at a pre-designated site, which would function as the operational base for the bait application activities. All helicopter activity, fuel, bait, equipment and personnel required for the bait application would work from the operational base. Bait, fuel and all equipment would be delivered and stored at the operational base prior to the commencement of bait application activities, which would be up to five days prior to bait application. Helicopters would land at designated landing zones situated at the operational base where personnel would re-fill the bait bucket, re-fuel the helicopter, and conduct other necessary maintenance. The operational base would be adequately stocked with fuel, safety equipment and other supplies and equipment to support the helicopter operations and personnel for the entire bait application process. The operational base would also require a central place for radio communications with the helicopter pilot and with support and emergency personnel and for geographic information system (GIS) and technological support for the bait application activities.

A field camp would be installed on the island to support up to eight personnel for up to two months, across the period before and after bait application. Personnel would be responsible for conducting pre- and post-bait application monitoring activities, and for preparing and managing the site leading up to and immediately after the bait application. Site preparation would include staging bait, fuel, equipment and supplies, as well as the transfer of additional personnel needed for the bait application. Installation of the camp would require temporary infrastructure including radio communications and a living and working space. The camp would need to be re-supplied at intervals, and all personnel, supplies and equipment would be subject to strict biosecurity practices.

Helicopters would be used to transport equipment and personnel to the island for the purpose of project activities, including pre- and post-eradication monitoring and bait applications. These helicopter operations would be localized to discrete flight paths and landing sites that would be routed to avoid or minimize helicopter disturbance to sensitive wildlife. Helicopters may hover for brief periods over land, and land at designated landing zones on the island to drop off personnel and equipment.

Small boats would also be used to transport personnel, equipment and to re-supply the field camp. Boats would land or moor at pre-authorized landing areas and mooring sites. All helicopters, boats and personnel would have the necessary permits to land on the Refuge.

The bait application operation may be staged from the island, from a boat offshore of the island, or from a mainland location adjacent to the island. The safest, most efficient and cost-effective staging site would be from Desecheo Island. In this scenario, the operational base would be the water catchment area (aka helipad) located near the coast in the southwest of the island. However, due to potential changes in operational strategy that may occur under recommendation from project reviewers, the options to base operations from a ship offshore of Desecheo or from an adjacent location on the mainland would remain available. In the event that the operational base would be located on a boat offshore of

Desecheo, or from the adjacent mainland, all bait loading and refueling would be conducted offshore of Desecheo, and a designated helicopter landing site on the island would only be required for an unscheduled, emergency landing.

2.3.10 Reducing Wildlife Disturbance during Operations

Before eradication operations begin, wildlife-sensitive areas would be identified and personnel would be briefed on strategies and techniques for avoiding wildlife disturbance whenever possible. These techniques would be implemented during actual eradication operations.

Requirements would include personnel to:

- Move slowly and deliberately to avoid frightening birds.
- Travel carefully by foot avoiding sensitive areas when possible to reduce unnecessary impact.
- Be given a map detailing wildlife-sensitive areas.

2.3.11 Protecting Cultural Resources

There are no known cultural or historical resources present on Desecheo NWR.

2.3.12 Monitoring Eradication Efficacy

Rats on Desecheo would be monitored to initially determine effectiveness of the bait application in the short-term, during and immediately after bait application. Subsequently, Desecheo would be monitored in the long-term for up to two years after the eradication operation to ensure eradication success.

Examples of short-term monitoring activities would include some or all of the following:

- Radio transmitters attached to individual rats prior to bait application would allow project personnel to track a sample of rats on the island and confirm mortality during and immediately after bait application, as a measure of operational progress.
- Rodent detection devices such as traps, chew indicators, remote cameras and special tracking surfaces would allow personnel to monitor rat activity during and immediately after bait application, and make comparisons with activity levels prior to bait application. These rodent detection devices would also be used at discrete periods for up to two years post bait application to confirm complete rodent eradication.

2.3.13 Monitoring Ecosystem Response

The Service would work with others to conduct biological monitoring both before and after rat eradication in order to detect any positive or negative changes to native biodiversity.

Monitoring activities would largely consist of observational counts of native taxa including birds and reptiles, and would continue periodically for five years post-eradication. Supplemental monitoring activities that require animal handling or alteration of the physical environment may be conducted as well. These supplemental activities may be subject to additional permitting if required.

2.3.14 Public Information

Access by the general public onto Desecheo is restricted, but the waters surrounding the islands provide diving and snorkeling opportunities from nearby ports in Puerto Rico including, but not limited to, Rincon, Mayaguez and Cabo Rojo. Outreach activities describing the eradication action taking place on Desecheo would be conducted with tour operators that visit the islands. Tour operators would also be provided with informational materials including handouts and posters to distribute to clients as appropriate, to ensure public safety and as an opportunity for education. Local researchers with an interest in Desecheo would also be directly informed about eradication activities and timing.

All Service-approved island users, including Service personnel, research biologists and technicians, contractors and volunteers would be given written materials stating that rodent bait containing a rodenticide would be present on the island, describing its appearance and its intended purpose.

Approved pesticide warning signs would be placed along the coastline, visible at typical island access points, and in accordance with the EPA label and Government of Puerto Rico pesticide regulations. Signs would be posted in at least two languages (Spanish and English). Adequate signage would be installed to ensure that even unauthorized visitors to the island are aware of the temporary presence of a toxicant.

Rodent re-introduction prevention and response to post-bait application rodent reintroductions are a primary concern of the Service. The intended biodiversity benefits of successful rat eradication could be lost with the re-introduction of even one pregnant female rodent. Rodents can be accidentally transported to islands and escape from:

- Cargo such as food boxes, personal gear and construction or other bulk materials
- Watercraft pulled up onshore, or anchored/moored nearby
- Debris washed ashore from the mainland
- Sinking or disabled vessels
- Aircraft that land on the island

2.3.15 Re-introduction Prevention

The Service would obligate personnel, partners and contractors traveling to the island to abide by a rodent exclusionary plan which would include the following measures:

- Ensuring through physical inspection that all materials and equipment transported to the island are free of rodents.
- Managing any mainland areas commonly used for storing or staging gear intended for the island so as not to attract rodents.
- Using only new materials for any future construction projects on the island.
- Transporting materials to the island only in rodent-proof containers.

The implementation of these measures would be thoroughly reviewed and enforced before the rat eradication operation is implemented. Full compliance among all island users would be necessary.

The Service would include, as part of its public information campaign, a request (not enforceable) for tour operators in the water immediately surrounding Desecheo to maintain rodent-free status on their vessels as well. This request would be made in an effort to allow tour operators to make their contribution to protect the island ecosystem.

2.3.16 Detection & Response

After the Service has determined that the eradication operation has concluded, personnel would monitor the island for up to two years post-bait application in order to confirm eradication efficacy. A combination of chew indicators, rodent traps and specialized detection surfaces would be used to monitor for rat detection. Chew indicators could be maintained year-round at likely re-introduction entry routes including the main helipad and landing beaches located on the southwest of the island. In the event that rodents are detected after bait application operations have been completed, a review of the situation would be needed to determine the appropriate course of action, but which could include re-baiting and/or spot-baiting using aerial broadcast, hand-broadcast, or bait station techniques.

2.4 Alternatives B and C: Aerial Broadcast as Primary Delivery Technique of Brodifacoum-25D Bait Product

2.4.1 Rationale

Brodifacoum-25D is a bait product intended specifically for use in conservation projects, which contains the rodenticide brodifacoum at a concentration of 25 ppm. Brodifacoum is the most commonly used rodenticide for eradication of rodents from islands (Howald et al. 2007). More details on brodifacoum and the bait product Brodifacoum-25D can be found in Section 2.3.2.2.

2.4.2 Summary of Bait Delivery Methods

Bait pellets containing the rodenticide would be systematically applied by helicopter to all land areas above the mean high tide mark on Desecheo Island. In areas that cannot be

baited by helicopter, for example caves and offshore rocks, personnel would distribute bait pellets by hand. If residual rodent activity was observed post-treatment (up to 10 days), the bait registration label would allow for tamper-resistant bait stations or direct application of bait into burrows to be carried out in areas where rodents remained active. Localized treatments would be maintained for as long as rodent activity is evident in the given area and rodents appeared to be accepting bait. If rodent activity did not respond to baiting, baiting would cease and the situation reviewed to determine the appropriate course of action, which could include re-baiting and/or spot-baiting using aerial broadcast, hand-broadcast, or bait station techniques.

Lessons learned from the Rat Island, Alaska, eradication project such as minimizing risks to non-target species while maintaining a high probability of eradication success, have been taken into consideration in this EA. Additional needs such as comprehensive logistical planning, structured communications, recording keeping, and documentation of impacts will be incorporated into the operational planning.

2.4.3 Timing

Aerial broadcast operations would occur between January and April.

Bait broadcast would be completed within a 30-day window, a range that would allow for two bait applications, each separated typically by between five and seven days, with additional contingency time included to allow for weather delays and additional localized bait application if signs of rats persist.

Bait broadcast would only be initiated if local weather predictions indicate that precipitation would be unlikely for at least seven days.

2.4.4 Equipment and Materials

2.4.4.1 Bait

Under Alternatives B and C, the bait product used would be Brodifacoum-25D. A detailed description of Brodifacoum-25D can be found in Section 2.3.2.2.

2.4.4.2 Aerial Broadcast Equipment

Aerial bait broadcast would be conducted using a single primary-rotor/single tail-rotor helicopter. Helicopter models considered for use in the operations would include the Bell 206B Jet Ranger, Bell 206L4 Long Ranger, or other small- to medium-sized aircraft.

Bait would be applied from a specialized bait bucket slung beneath the helicopter. The bait bucket comprises a bait storage compartment, a remotely-triggered adjustable gate to regulate bait flow out of the storage compartment, and a motor-driven broadcast device that can be turned on (to broadcast bait over a wide swath) or off remotely and

independently of the outflow gate. The broadcast device would include a deflector that can be installed when directional (rather than 360°) broadcast is necessary, such as along the coastline to prevent bait drift into the marine environment.

2.4.4.3 Bait Stations

Bait stations are box-like enclosures with small entryways designed to be attractive to rodents, but difficult to enter for other species such as birds. Bait stations reduce the risk of rodenticide exposure in non-target species by making bait more difficult to access and reducing the total amount of bait introduced into the ecosystem. The bait station design for Desecheo would need to include the following characteristics:

- An entryway small enough to make entry by birds difficult, but large enough to allow for easy passage by rats.
- An interior bait placement scheme that makes it difficult for birds or large reptiles to access the bait inside, but provides minimal difficulty for rats. This can be accomplished by placing the bait behind a baffle near the entryway that would block access to the bait without entering the station completely.
- A "lockable" access panel that resists tampering but is easy to open by personnel for station re-filling and maintenance.

A number of commercially-available bait stations fit these criteria and would be assessed for the best choice prior to implementation. Alternatively, bait stations could be fabricated specifically for this project, in accordance with the requirements described on the bait label.

2.4.5 Bait Application Operations

2.4.5.1 Aerial Broadcast

Bait broadcast by helicopter would consist of multiple low-altitude overflights of Desecheo and adjacent islets. The baiting regime would follow common practices based on successful island rodent eradications elsewhere in the U.S. and globally (Howald et al. 2007), in which overlapping flight swaths are flown across the interior island area, and overlapping flight swaths with a deflector attached to the bait bucket (to prevent bait spread into the marine environment) flown around the coastal perimeter. The width of a flight swath would be determined beforehand in helicopter bait calibration trials. Previous operations have demonstrated that a range of 164 – 264 ft (50 – 75 m) would be effective. Each flight swath would overlap the previous by approximately 25 – 50 percent to ensure no gaps in bait coverage.

The bait would be applied according to a flight plan that would take into account:

- The need to apply bait relatively evenly and to prevent any gaps in coverage or excessive overlap

- Island topography
- Current and forecast weather conditions
- The need to avoid bait broadcast into the marine environment
- The need to minimize disturbance to native wildlife
- The need to minimize the substantial costs associated with helicopter flight time

The helicopter would fly:

- at speeds ranging from 25 - 50 knots (29 - 35 mph or 46 - 56 km/hr)
- at an average altitude of approximately 164 ft (50 m) above the ground
- with the bait bucket on a long-line 49 – 66 ft (15 - 20 m) below the helicopter

During one island-wide application all points on Desecheo would be subject to at least one helicopter pass to apply bait, possibly more. However, the helicopter would also be required to travel across the island between the bait loading site and bait application site, to do reconnaissance, and to support ground-personnel. Thus, it is likely that many points on the island would be subject to several helicopter passes.

In order to ensure rat eradication it would be necessary to conduct two island-wide bait applications. Each application would typically occur between five and seven days apart to minimize the likelihood of competitively inferior adult rats or juveniles surviving the initial bait broadcast because they were not given an opportunity to feed on bait. For each island-wide bait application, there would likely be no more than three consecutive operating days.

Bait would be applied strictly according to the limitations set by the EPA's pesticide regulations (FIFRA). The precise bait application rate would not exceed the rate set by the EPA. Field trials using a non-toxic placebo bait replica conducted on Desecheo in 2009 and 2010 have demonstrated bait uptake rates (including both consumption and degradation) indicating an appropriate bait application rate for rat eradication on Desecheo Island (see Section 2.3.4).

Soon after application, bait pellets would be consumed or cached by rats and may be consumed by other animals as well. Bait pellets exposed to heavy moisture would degrade faster than pellets that fall in more protected locations. The application rate would be calculated so that an adequate amount of bait is available for consumption by rats for a period of at least three days.

Before bait application, calibration between the pilot, helicopter and bait bucket that would be used in the application would be conducted to ensure consistency and accuracy of application using a placebo bait broadcast. The calibration would occur over a test site off-island in atmospheric conditions similar to those on Desecheo Island.

To ensure complete and uniform bait application:

- The actual application path would be monitored and digitally recorded onboard the helicopter using an onboard global positioning system (GPS) and a navigation bar to

precisely guide the application in order to avoid gaps and prevent unintended overlaps in application coverage.

- The application rate would be calculated using the known rate of bait flow from the bucket, the helicopter's reported velocity, and overlaps in the bait swath reported by the helicopter's onboard GPS tracking system.
- By combining the GPS data for the application path and the application rate, the application coverage would be reviewed throughout the operation using GIS and a computer to identify gaps and areas of sub-optimal bait application.

Adjustments in bait flow rates, helicopter speed and flight lines would be made as necessary to meet the optimal application rate, staying within the limits legally required by the EPA.

2.4.6 Preventing Bait Spread into the Marine Environment

Rodent bait would not be distributed deliberately into the marine environment. However, during bait application in the coastal areas, some bait drift may occur. Every reasonable effort would be made to minimize the risk of bait drift into the marine ecosystem. The broadcast deflector would be attached to the bucket for all flight swath treatment passes of the coastline including bluffs and coastal cliffs. The deflector would broadcast bait within approximately 120 degrees of the onshore side of the helicopter, to minimize the risk of bait entering the ocean on the opposite, or seaward, side. Additionally, the bucket may be used with the broadcast motor off to trickle bait in precise points directly underneath the helicopter, along the coastal perimeter of the island and offshore islets. Additional information about bait operations with relevance to the marine environment can be found in Appendix XIV.

2.4.7 Coverage of Baiting Gaps

As a result of the need for caution in spreading bait near the marine environment, the island's coastline and offshore islets, which are potential rat habitat, may not receive the optimal bait coverage with helicopter broadcast alone. Additionally, areas within caves and under overhangs may be shielded from aerial broadcast.

In cases where it is evident or suspected that any land area did not receive full coverage, there would be supplemental systematic broadcast either by foot, boat, helicopter, or any combination of the above. Helicopters may hover for brief periods over land during bait application to bait offshore islets, either by hand or from the bucket with the broadcast motor off to trickle bait at a precise point directly underneath.

All personnel who may participate in supplemental hand broadcasts would be trained and tested in systematic bait application at a target application rate (Buckelew et al. 2005).

Bait stations may also be installed in limited circumstances, including:

- Within and surrounding camp(s)
- In discrete areas in which bait stations would reduce bait exposure risk to a potentially vulnerable wildlife population
- At island arrival sites such as the helicopter landing pad, harbors and beaches

The bait used in bait stations would be identical to the bait pellets used for broadcast.

All personnel that handle bait or monitor bait application in the field would meet all requirements for personal protective equipment (PPE) required by the EPA. All bait application activities (aerial broadcast, hand broadcast and bait station filling) would be conducted under the supervision of certified pesticide applicators licensed by the Government of Puerto Rico.

2.5 Alternatives D and E: Aerial Broadcast as Primary Delivery Technique of Diphacinone-50 Bait Product

2.5.1 Rationale

Diphacinone-50 is a bait product intended specifically for use in conservation projects, which contains the rodenticide diphacinone at a concentration of 50 ppm. Diphacinone rodenticide has been used for urban and agricultural rodent control for many decades, and was recently used to successfully eradicate rats from Mokapu Island using an aerial delivery technique (Swenson and Duvall 2007, Dunlevy et al. 2008). Diphacinone is a potential alternative rodenticide to brodifacoum for island rodent eradications, and exposes non-target birds to comparatively less risk than brodifacoum (Erickson and Urban 2004), but its proven record of eradication success using aerial broadcast technique is extremely limited. More details on diphacinone and the bait product Diphacinone-50 can be found in Section 2.3.2.3.

2.5.2 Summary of Bait Delivery Methods

The Diphacinone-50 bait product has not yet been successfully used to eradicate rats from an island. However, Ramik® Green, a comparable product, has been used on one occasion to successfully eradicate rats using aerial broadcast delivery (U.S. Fish and Widlife Service 2005, Swenson and Duvall 2007, Dunlevy et al. 2008, Dunlevy and Swift 2010). The specific techniques and considerations for successful aerial broadcast of Diphacinone-50 are largely untested (but the specific bait product distributed aerially on two islands in Japan (Hashimoto 2010) is unknown). Other 50 ppm diphacinone bait products (e.g., Ditrac® Blox; J. T. Eaton™ Bait Block®) have been used successfully to eradicate rats when delivered in bait stations and hand broadcast, either as the sole toxicant or applied in combination with a second toxicant.

Safety concerns on Desecheo Island resulting from UXO presence and the rugged terrain dictate that hand broadcast and the use of bait stations as the primary delivery method is not achievable. Therefore, bait pellets containing diphacinone would be systematically

applied by helicopter to all land areas above the mean high tide mark on Desecheo Island. In areas that cannot be baited by helicopter, such as caves, personnel would distribute bait pellets manually. Personnel would also install bait stations at a limited number of sites.

If residual rodent activity was observed post-treatment (up to 10 days), the bait registration label would allow for tamper-resistant bait stations or direct application of bait into burrows to be carried out in areas where rodents remained active. Localized treatments would be maintained for as long as rodent activity is evident in the given area and rodents appeared to be accepting bait. If rodent activity did not respond to baiting, baiting would cease and the situation reviewed to determine the appropriate course of action, which could include re-baiting and/or spot-baiting using aerial broadcast, hand-broadcast, or bait station techniques.

2.5.3 Timing

Aerial broadcast operations would occur between January and April. To maximize the availability of bait to rats, repeated aerial applications would be required across an extended period, with each application scheduled typically between five and seven days apart (see Section 2.3.5). The total bait broadcast would be completed within a four month window between January and April as this is the optimal biological and climatic window on Desecheo (see Section 2.3.6). Additional contingency time would be needed to account for weather delays and additional bait application, if signs of rats persisted after the last application.

Bait broadcast would only be initiated if local weather predictions indicate that precipitation would be unlikely for at least seven days.

2.5.4 Equipment and Materials

2.5.4.1 Bait

Under Alternatives D and E, the bait product used would be Diphacinone-50. A detailed description of Diphacinone-50 can be found in Section 2.3.2.3.

2.5.4.2 Aerial Broadcast Equipment

The equipment needed to aerially broadcast Diphacinone-50 would not be different to that needed for Brodifacoum-25D (see Section 2.4.4).

2.5.4.3 Bait Stations

Bait station design used to apply Diphacinone-50 would not be different to those used for Brodifacoum-25D (see Section 2.4.4.3).

2.5.5 Bait Application Operations

The standard methodologies for diphacinone use in successful ground-based rat eradications has been either hand broadcast or regular application of a diphacinone bait product in bait stations over a period of several months to years. In Mexico, Donlan and colleagues (2003) applied bait daily for five to 10 days, then weekly, across a two month period. Bait was subsequently replenished five times over the subsequent two years, at an average application rate of 11.8 kg/ha. In the U.S. Virgin Islands (USVI), Witmer and colleagues (2007) conducted a rat eradication applying bait five times over a period of one year; the initial bait operation lasted six weeks, followed by three operations of two weeks each, and the final operation lasting four weeks. During each baiting operation, bait was replenished every one to three days. In total about 546 kg of bait was applied on the island, equivalent to about 0.027 kg (27 g) of active diphacinone. In Hawaii, rat eradication on Mokolii Island (1.6 ha) was achieved using 11.3 lbs/ac (12.7 kg/ha) diphacinone applied in bait stations over a period of six months, with bait being replenished about every two weeks (Smith et al. 2006). In both USVI and Hawaii bait operations were supplemented with rat traps. Replicating these application regimes has not been tested in an aerial broadcast operation.

In the Falkland Islands, the standard methodology was hand broadcast of diphacinone bait (Ditrac® bait blocks). The high bait application (10-20 kg/ha) provided an abundance of wax blocks for caching and effectively acted as a second bait application; due to the cold climate, bait was available over a period of months (Poncet pers. comm.).

2.5.5.1 Aerial Broadcast

The measures for aerial bait broadcast are the same as those for brodifacoum. Please see Section 2.3.5 for aerial broadcast protocol.

In order to ensure successful rat eradication using diphacinone, it would be necessary to conduct three or more island-wide applications to ensure that sufficient quantities of bait remained on the ground to guarantee that all rats ingested small amounts of bait consistently over a period up to 12 days (see Section 2.3.2). In addition, multiple applications would be needed to minimize the likelihood of competitively inferior adult rats or juveniles surviving the initial broadcast because they were not given an opportunity to feed on bait.

Application of Diphacinone-50 is directed by the EPA’s pesticide regulations (FIFRA). The directions for use dictate that bait would be applied at a maximum of 12.5 lbs/ac (13.8 kg/ha) followed by a second application of 12.5 lbs/ac (13.8 kg/ha) between five and seven days after the initial application. If rat activity persisted after broadcast application, tamper-resistant bait stations would be maintained, or bait would be broadcast in burrows where rat activity was evident. If difficult terrain restricted the use of bait stations or burrow baiting, then continued broadcast baiting would be maintained in areas where rat activity persisted for as long as activity was evident. For each aerial bait application, there would likely be no more than three consecutive operating days.

Given that bait pellet trials using brodifacoum pellets of similar size and matrix applied at the maximum allowable rate of 16 lbs/ac (18 kg/ha) followed by 8 lbs/ac (9 kg/ha) five days later demonstrated that bait remained on the ground for a maximum of five days (see Section 2.3.4.2), it would be anticipated that the maximum broadcast application rate of Diphacinone-50 of 12.5 lbs/ac (13.8 kg/ha) followed by a second application of 12.5 lbs/ac (13.8 kg/ha) between five and seven days later would also be required to ensure that enough pellets remained on the ground for all rats to be exposed over a minimum period of five days.

However, given that rats need to be exposed to diphacinone for up to 12 days in order to achieve 100 percent mortality, the bait application rate required to achieve this would need to be determined from bait uptake field trials on Desecheo Island prior to the eradication. These trials would use a non-toxic placebo bait replica with a biomarker to measure an approximate rate of bait uptake (including both consumption and breakdown) within the environment on Desecheo Island, and to demonstrate the percentage of rats that ingested bait (see Section 2.3.4.2 for comparable trials with Brodifacoum-25D).

Soon after application, bait pellets would be consumed or cached by rats, and may be consumed by other animals as well. Bait pellets exposed to heavy moisture would degrade faster than pellets that fall in more protected locations. Field trials of Diphacinone-50 on Palmyra Atoll indicated that the bait pellets are not as weather resistant as Brodifacoum-25W (Island Conservation 2010a) and would degrade more quickly after a rainfall event. Therefore, bait would only be applied if it could be anticipated that rainfall events were not expected for the duration of the operation (up to 21 days).

Before bait application, calibration between the pilot, helicopter and bait bucket would be conducted to ensure consistency and accuracy of application using a placebo bait broadcast. The calibration would occur over a test site off-island in atmospheric conditions similar to those on Desecheo Island.

To ensure complete and uniform application:

- The actual application path would be monitored and digitally recorded onboard the helicopter using an onboard GPS and a navigation bar to precisely guide the application in order to avoid gaps and prevent unintended overlaps in application coverage.
- The application rate would be calculated using the known rate of bait flow from the bucket, the helicopter's reported velocity, and overlaps in the bait swath reported by the helicopter's onboard GPS tracking system.
- By combining the GPS data for the application path and the application rate, the application coverage would be reviewed throughout the operation using GIS and a computer to identify gaps and areas of sub-optimal bait application.

Adjustments in bait flow rates, helicopter speed and flight lines would be made as necessary to meet the optimal application rate, staying within the limits legally required by the EPA.

2.5.6 Preventing Bait Spread into the Marine Environment

The measures to prevent bait spread into the marine environment are the same as those used for the application of brodifacoum. Please see Section 2.4.7 for details.

2.5.7 Coverage of Baiting Gaps

The measures to ensure full coverage of baiting gaps are the same as those used for the application of brodifacoum. Please see Section 2.4.7 for details.

The aerial application of bait following EPA regulations has only been tested successfully once, on a 10 ha island, with the proposed nominal application rate of 10 lbs/ac (11.25 kg/ha) applied twice separated by five days (Swenson and Duvall 2007). The second aerial application attempt on Lehua Island (117 ha) failed using an application rate of 12.5 lbs/ac (11.2 kg/ha) applied twice between five and seven days apart (U.S. Fish and Widlife Service 2005).

Given that only one rat eradication operation using aerial bait application of diphacinone has been successful (and on a very small island) and given the general understanding of the mechanism of action of diphacinone as an anticoagulant (small doses across consecutive multiple days), further aerial application operations using diphacinone that have a greater chance of success may require an operational strategy that is outside of the limitations dictated by the existing EPA regulations for the Diphacinone-50 bait product. For example, it may be necessary to apply multiple (more than two) applications across several weeks. Such a strategy would require further trials, and if trials were successful, would require changes to the EPA bait label before an operation could be implemented.

2.6 Alternatives B and D: Captive Holding of Endemic Reptile Taxa

Captive holding of endemic reptile taxa is intended as a safeguard against negative impacts to reptiles resulting from exposure to, and mortality from, rodent bait during an eradication operation.

In October 2010, a two-day workshop was held by the U.S. Fish & Wildlife Service Caribbean Islands NWR Complex to assess the risk to non-target reptile species from toxicant use, and to make recommendations to manage that risk. The workshop generated a set of agreed principles and recommendations from participants for managing the risk to reptiles from toxicant use on Desecheo, including:

- The information available on Desecheo reptiles, toxicant risk, and other case-studies worldwide is sufficient to make recommendations.
- The densities of reptiles on Desecheo are large enough to consider temporary captive holding, but do appear reduced suggesting that reptiles are suffering from ongoing negative impacts from rats.
- Temporarily holding reptiles in captivity for the duration of the rat eradication operation is an appropriate strategy. The duration in captivity would depend on

the strategy adopted and toxicant residues detected on Desecheo after bait application.

- To re-establish a species on Desecheo in the event of a population-level decline, about 20-30 pairs of the three Desecheo endemic species would be sufficient for captive holding; animals would be held in captivity on mainland Puerto Rico. Further discussion may re-evaluate whether all three species would be required. If no impact was detected in Desecheo's reptiles as a result of bait application, captive animals would not be re-released due to the potential risk of introducing a novel reptile disease or pathogen onto Desecheo. In this scenario, captive reptiles would be re-distributed to AZA-approved animal institutions, museums or other facilities, and any surplus animals that could not be re-homed would be euthanized. Public perception was recognized as important when re-distributing the animals.
- A survey would be needed to evaluate disease and pathogen presence in reptiles on Desecheo and at the mainland captive reptile facility location. This survey would help to inform a reintroduction strategy for reptiles back to Desecheo, if it was needed.
- Alternatively, animals could be held in captivity on Desecheo. This would eliminate the disease risk to reptiles, would allow for outdoor enclosures and access to sunlight, and would be less costly. In this scenario, reptiles would be re-released to Desecheo when appropriate. However, it was recognized that the remoteness and ruggedness of the island, and ongoing law enforcement issues, would make the management of reptiles and personnel safety more difficult than an off-island captive facility.
- A captive-holding operation would require the appropriate wildlife collection and holding permits from DNER, the U.S. Fish & Wildlife Service and other U.S. Federal or Puerto Rico Government agencies.
- Reptiles would need to be monitored on Desecheo, post-bait application.
- Consultation with individuals experienced in captive holding and management of reptiles is needed, and a mainland captive program should be contracted to an experienced zoological institution.
- The participants generally considered that population-level impact to Desecheo reptiles was unlikely, but that the captive holding measures options were appropriate strategies to manage the uncertainty of the outcome of toxicant use to non-target reptiles on Desecheo.

Within Alternatives B and D, two different strategies for captive-holding reptiles are proposed:

Alternatives B(i) and D(i) would recommend the following strategy:

Strategy (i): reptiles would be removed from Desecheo to a biosecure captive facility on Puerto Rico, and the captive population would be utilized to re-stock the island post-eradication in the event of a population-level decline in any of the three endemic species. This strategy would:

- Allow for retention of sufficient genetic diversity needed to successfully re-establish a wild population.
- Promote optimal animal management and captive care.
- Allow a long time period (up to three months) after completion of the bait application operation to detect a population-level decline.
- Not allow the captive animals to be returned to Desecheo, in the event that no population-level impact to reptiles is recorded.

Alternatives B(ii) and D(ii) would recommend the following strategy:

Strategy (ii): reptiles would be held in captivity on Desecheo, in small outdoor enclosures, and released back into the wild when appropriate. This strategy would:

- Quarantine animals from potential toxicant impacts on Desecheo.
- Allow captive animals to be re-released on Desecheo when toxicant residues are negligible.
- Not guarantee sufficient genetic diversity to ensure long-term population survival, if captive animals were needed to re-establish a wild population on Desecheo, because insufficient numbers of animals would be held on the island. However if a population decline on-island was detected, additional wild animals could be collected for a captive-breeding program, which would increase the genetic diversity of the existing captive stock.
- Allow only a short time period (up to one month) after completion of the bait application operation to detect a population-level decline.
- Increase the risk of mortality and injury, and escapes, to captive animals because the remoteness and ruggedness of the island would not allow for optimal animal care.
- Introduce personnel safety risks while living on Desecheo to support the captive reptiles.

It should be acknowledged that bringing wild individuals into captivity, either to Puerto Rico or on Desecheo, holding them for the required period and releasing animals back onto the island also presents risks, including injury, deterioration in body condition, mortality of individuals, behavioral changes, disease outbreak in a captive-holding facility and disease introduction to the island.

2.6.1 Taxa

The Desecheo ameiva, Desecheo anole and Desecheo dwarf gecko would be the target species for captive-holding because they are endemic to Desecheo, they do not exist in captivity or elsewhere other than Desecheo and therefore, population-level impacts would be deleterious to the species' long-term survival. In addition, field trials in 2010 using placebo bait with biomarker demonstrated that rodenticide exposure pathways for the ameiva and anole exist (Island Conservation 2010c). Exposure pathways are likely either primary (eating bait or bait fragments directly) or secondary (eating invertebrates, other reptiles, or scavenging dead rats or reptiles that had eaten bait). The Desecheo dwarf gecko

was not tested during these trials. Captive holding is not required for the slippery-backed skink and Puerto Rico racer on the basis of endemicity and restricted range because both of these species are native to the Puerto Rico mainland and other offshore islands. Should population-level impacts occur, Desecheo could be re-stocked with the same species collected from mainland Puerto Rico. In addition, a rat eradication using Klerat® (50 ppm brodifacoum) from offshore islands in Antigua demonstrated no negative impacts to the Antiguan racer (*Alsophis antiguae*), and in fact by 18 months post-rat eradication, the racer population had more than doubled in size (Daltry et al. 2001).

2.6.2 Alternatives B(i) and D(i)

Alternatives B(i) and D(i) would require individuals of three endemic reptile species to be captured and transferred to a specialist reptile facility on mainland Puerto Rico. Animals would be held in captivity until survey results indicated whether wild populations had been impacted by the bait application operation. If no population-level impact was recorded, captive animals would not be re-released onto Desecheo due to the risk of introducing a novel disease that could impact wild populations. Instead, captive animals would be distributed to AZA-approved animal institutions, museums or other facilities, and any surplus animals that could not be re-homed would be euthanized. If population-level impact was recorded in one or more of the endemic species, a captive-breeding program would be established with the existing captive animals to produce offspring that would be used to re-establish a population on Desecheo. Breeding pairs would be selected and bred to maintain sufficient genetic heterozygosity in the offspring to ensure long-term population survival (see Section 2.6.2.1). Using an off-island captive-breeding program to re-establish a species in the wild was carried out to restore the critically endangered tuatara (*Sphenodon punctatus*) in New Zealand following rat eradication operations on at least four islands (Keall et al. 2001, Towns 2001). The entire known population of tuatara was collected between 1990-1992 prior to rat eradication and removed to several institutions where they were subsequently captively bred; reintroduction of offspring to rat-free islands is currently ongoing.

2.6.2.1 Number of Captive Animals

Population management theory, for conservation purposes, proposes that a captive population should retain (among the individuals) at least 90 percent of the wild population's genetic diversity for 100 years to ensure long-term survival and the continuation of natural evolutionary processes (Frankham et al. 2002). For example, for the endangered Aruba Island rattlesnake (*Crotalus durissus unicolor*) recovery strategy, experts recommended that 150 individuals (about 15-30 percent of the known wild population size) be maintained in captivity in order to retain 98 percent of the average heterozygosity for an indefinite period (Captive Breeding Specialist Group 1992). However, some species are being maintained in captivity with smaller numbers due to finite resources; the cost of this compromise may be increased inbreeding and reduced reproductive fitness (e.g. Keall et al. 2001). For the reptiles on Desecheo, consultation with zoo population biologists resulted in a recommendation that 20-30 breeding pairs of each species should be held in

captivity, which is sufficient to capture the populations' genetic diversity if animals are subsequently selectively bred to produce offspring for release. This means, should there be a significant population decline as a result of the rat eradication operations, pairs of captive reptiles would be established to maximize the genetic diversity of the captive population, and offspring produced would be released onto Desecheo once toxicant residue levels were negligible. This strategy (to maintain breeding pairs) means that fewer individuals are required in captivity. This reduces the impact from the captive operation on the wild population, and makes more efficient use of resources. The alternative strategy (to captively-hold a representative proportion of the population) would require a much larger number of animals, a larger captive facility and, by removing a larger number of animals from the wild, have a greater impact on the wild population.

2.6.2.2 Capture and Transfer to Captive-Holding Facility

Reptiles would be captured using standard reptile surveying and capturing techniques including, but not limited to: capture by hand, with capture nets and/or nooses, drift fences with pitfall and funnel traps and the use of cover-boards (Blomberg and Shine 1996). Animals would be held in cloth bags for transfer to a temporary staging area on Desecheo prior to removal to the captive facility. The staging area would likely be located close to the concrete helipad on the southwest tip of the island. The optimal time to capture animals would be in the early morning from dawn and late afternoon to sunset. The Service would attempt to capture an equal number of adult males and females; however, any animals that appeared unhealthy or in poor body condition would be released back onto Desecheo. Animals would be transported on foot from their site of capture to the temporary staging area, and held at the staging area prior to transfer off-island. Any animals captured late in the day would be held overnight at the staging area, before transfer to the mainland captive facility. The temporary staging area would need to be shaded (e.g. shade tents might be needed) to prevent animals from overheating, and stocked with sufficient supplies (e.g. water, generator) to support captive animals and personnel. Due to potential weather or other delays in transferring animals off the island, sufficient supplies would be needed to support captured animals for a few days. A small camp would be needed at the staging area for biologists capturing, managing and transferring the animals. Some small temporary wire cages may be required at the staging area in which to place animals to prevent predation by rats and crabs at night.

Animals would be captured and transferred to the mainland captive holding facility between two and four weeks before the initiation of bait application operations. Ideally, animals would be transported by helicopter in the mornings, allowing sufficient daylight for personnel to establish animals in their captive enclosures on the mainland. Animals would be transported in cloth bags or zip-top plastic bags filled with air, inside a rigid box with sufficient ventilation or a cooling mechanism to prevent over-heating. Ideally, animals would be transferred daily from a temporary holding area on Desecheo to the mainland captive facility, but a regular daily schedule may suffer from weather or other delays.

2.6.2.3 Disease Monitoring

A significant risk of a captive-holding strategy is the introduction of a novel pathogen or disease into the wild reptile population on Desecheo through the reintroduction of the captive animals. While it is unlikely that the wild reptile population on Desecheo is pathogen-free, reptiles native to mainland Puerto Rico are likely to have a higher diversity of pathogens than those found in reptiles on Desecheo, and to which Desecheo reptiles may not be immune. In order to monitor and manage pathogens in captive animals and to understand potential constraints to re-stocking the island post-eradication, a disease survey of Desecheo reptiles and reptiles found wild at the site of the captive facility would likely be conducted. Subsequently, any unusual pathogens found while managing the captive animals, that are not typically found in the Desecheo wild populations, would be monitored while the animals are in captivity.

2.6.2.4 Aspects of Captive-holding Facility

A captive holding facility would need to: be furnished with standard reptile holding cages, boxes, or enclosures; have access to clean water, natural and artificial light and heat; has a regular power source. Holding cages and enclosures would need to exclude invasive predators such as rats, mice and feral cats, as well as other native reptiles (especially snakes) and minimize the risk of Desecheo reptiles escaping into the natural environment of Puerto Rico. Depending on the species' behavior animals would be maintained singly or in groups. Animal care would need to be supervised by specialist personnel with expertise in captive management of reptiles and daily animal keepers would need to be trained. Daily management would include regular provision of fresh and artificial reptile-specific foods. Commercially available live invertebrate food (e.g. crickets, mealworms, waxworms) would be needed that would either be shipped to Puerto Rico from the U.S. mainland, or if imported food is not available, produced on-site at the captive facility. The facility would require a food-preparation and storage area, an animal clinic area to manage health issues and access to veterinary advice in the event that an individual would require veterinary support. Strict quarantine and biosecurity measures would need to be implemented to reduce the risk of disease introduction into the facility, and hygiene standards would need to be maintained to reduce any potential disease outbreak or disease transmission among animals.

2.6.2.5 Considerations for Captive-holding Facility Location

The need for reduced travel time from Desecheo Island to the captive-holding facility and for an environment where daylight, diurnal rhythms, temperature and humidity are similar to Desecheo Island dictate that the holding facility should be on mainland Puerto Rico, and would preferably be located in the climatically drier west coast. The captive-holding facility location should also take advantage of local expertise in captive reptile management, be accessible to personnel recruited to manage the facility (keepers, maintenance personnel, security and visiting experts) and be situated on a secure site. The facility location would need regular access to clean water and power, fresh animal food, as well as email access

and phones for remote support from veterinary and reptile expertise. Participants at the reptile workshop held in October 2010 determined that Cabo Rojo NWR was an appropriate location for the captive facility.

2.6.2.6 Holding Animals and Restocking Desecheo

With bait application anticipated between January and April (the ideal biological window), all animals would need to be established in captivity at least two weeks prior to the operation. Capturing and establishing animals in captivity could take up to one month. Animals would be held in captivity for up to three months to ensure that captive animals are available for restocking should any population declines be detected on Desecheo. If no population-level impacts in the wild are detected, animals would not be released onto the island due to the risk of introducing a novel pathogen or disease to Desecheo reptiles. Instead, animals would be distributed to zoological institutions, museums, universities, or other facilities. In the event that all captive animals could not be re-housed, any surplus animals remaining would be euthanized using standard approved techniques. If population-level impacts were recorded in any one of the three endemic species on Desecheo, scheduling for re-stocking animals would depend on when offspring were available to release, as well as when toxicant residue levels in the environment were below a minimum threshold for potential long-term impacts to reptile populations. Bait residue levels would be monitored during bait application operations. Delays in releasing animals back to Desecheo could be expected during hurricane season from June to November.

If population-level impacts were recorded in wild reptiles, captive animals would be managed to maximize genetic diversity in the offspring, which would be used to restock wild populations on Desecheo. This would result in a shift of the captive reptile operation from being a temporary safety population during rat eradication operations to a captive-breeding and reintroduction program. Should this be necessary, supplemental NEPA documentation as well as other permits may be required.

2.6.3 Alternatives B(ii) and D(ii)

Alternatives B(ii) and D(ii) would require reptiles to be captured and temporarily held in outdoor enclosures on Desecheo island. Animals would be held in captivity until survey results indicated no population-level impact to wild populations as a result of the bait application operation or until toxicant residues remaining in the ecosystem were at sufficiently low levels to have negligible impact on the released animals. If no impact was detected, captive animals would be re-released onto Desecheo. Quarantine of native species during rat eradication operations has been the more frequently-selected technique (e.g. Merton et al. 2002, Butler 2005, Cuthbert 2009). If population-level impacts were detected in one or more of the endemic species, a captive population could be subsequently established to produce offspring that would be used to re-establish a population on Desecheo. Under this scenario, an off-island captive-breeding program would need to be established, as for Alternatives B(i) and D(i) (see Section 2.6.2).

2.6.3.1 Number of Captive Animals

The number of animals of each species held on Desecheo would be determined by the size and number of enclosures that would be practical to establish and maintain without additional irreversible impact to the Refuge from construction and reptile management activities. Because of their smaller size, it is anticipated that larger numbers of Desecheo dwarf gecko and Desecheo anole could be kept, whereas fewer numbers of Desecheo ameiva would likely be kept because of their larger size, strong territoriality, aggressive behavior to conspecifics, and their larger natural home range. It is anticipated that up to 30-40 individuals of Desecheo dwarf geckos, 30-40 individuals of Desecheo anoles and 20-30 individuals of Desecheo ameiva (comprising males, females and juveniles) could be maintained.

Population management theory, for conservation purposes, proposes that a captive population should retain (among the individuals) at least 90 percent of the wild population's genetic diversity for 100 years to ensure long-term survival and the continuation of natural evolutionary processes (Frankham et al. 2002). However, some species are being maintained in captivity with smaller numbers due to finite resources; the cost of this compromise may be increased inbreeding and reduced reproductive fitness (e.g. Keall et al. 2001). For Alternatives B(ii) and D(ii), the number of reptiles kept in enclosures on Desecheo would not be sufficient to address the theoretical genetic needs for population re-establishment. However, should a dramatic population-level decline be detected immediately after the bait application operation, additional animals could be captured from the wild to form a captive-breeding population together with the existing captive animals.

2.6.3.2 Capture and Transfer to Enclosures

Reptiles would be captured using standard reptile surveying and capturing techniques including, but not limited to: capture by hand, with capture nets and/or nooses, drift fences with pitfall and funnel traps and the use of cover-boards (Blomberg and Shine 1996). Animals would be held in cloth bags for transfer to their respective enclosure. The optimal time to capture animals would be in the early morning from dawn and late afternoon to sunset. The Service would attempt to capture an equal number of adult males and females; however, any animals that appeared unhealthy or in poor body condition would be released. Animals would be transported on foot from their site of capture to the enclosures. Animals would be captured and transferred to the enclosures between one and two weeks before the initiation of bait application operations.

2.6.3.3 Disease Monitoring

Disease monitoring would not be required.

2.6.3.4 Aspects of Enclosure Construction and Reptile Management

The enclosures would be constructed on Desecheo. Because of the UXO regulations, no digging could be used in construction, so enclosures would need to be self-standing. Enclosures would need to be constructed on the valley floor under trees to reduce the risk to reptiles from overheating in the sun, and in a location that could be effectively managed on a daily basis by personnel. Additional shade would be provided artificially for each enclosure. The enclosures would be constructed to represent semi-natural conditions and furnished with soil, leaf-litter, live and dead branches, and rocks. Enclosures would need to exclude rats, fire ants (*Solenopsis* sp.), the Puerto Rico racer, Desecheo ameiva, pearly-eyed thrasher, American kestrel and other potential predators. The enclosures should also ensure that captive animals cannot escape. In addition, enclosures should attempt to exclude invertebrates that might have fed on rodent bait. Captive reptiles would be kept in groups comprising males, females and juveniles depending on their behavioral traits.

Animal care would need to be carried out by specialist personnel with expertise in captive management of reptiles and animal keepers would need to be trained. Daily management would include regular provision fresh and artificial reptile-specific foods, and water. Access to veterinary advice would be needed in the event that an individual might require veterinary support. Standard hygiene practices would need to be implemented to reduce the risk of disease transmission between enclosures.

Reptile personnel would need to live on Desecheo for the duration of the captive program. A camp would be required to support a sufficient number of reptile keepers. Staff and reptiles would need to be provisioned with drinking water and food supplies from the mainland on a regular basis.

2.6.3.5 Holding Animals and Restocking Desecheo

Animals would be collected about one week prior to bait application and held in captivity for up to one month immediately after the bait application operation has been completed. If no population-level impacts in the wild were detected, animals would be re-released onto the island when toxicant residue levels in the environment were considered negligible to reptiles. Bait residue levels would be monitored during bait application operations.

If population-level impacts were detected immediately following bait application, a captive-breeding population could be established using the existing captive animals as well as additional wild animals that could be captured on the island. A captive-breeding population would follow the program description provided in Section 2.6.2. This would result in a shift of the captive reptile operation from being a temporary safety population during rat eradication operations to a captive-breeding and reintroduction program. Should this be necessary, supplemental NEPA documentation as well as other permits may be required.

2.7 Alternatives C and E: No Captive Holding of Reptiles

Prior to project implementation, the Service conducted trials on Desecheo as part of detailed operational planning, including site-specific examination of the potential for non-target exposure to bait, especially in reptiles. In 2010, placebo bait trials indicated that exposure pathways for the Desecheo anole and Desecheo ameiva existed, indicating that both of these species would be at risk from non-target exposure to rodenticide (Island Conservation 2010c). In addition, laboratory trials to evaluate the effect of brodifacoum and diphacinone anticoagulants on reptiles are ongoing (USDA-APHIS) and may help to inform potential non-target risk assessment to reptiles. Regardless, non-target risk to reptiles could be substantially higher than estimated in this EA. Should the service decide not to hold reptiles in captivity as a mitigation action, the Service would either a) design mitigation actions to reduce non-target exposure; or b) determine that the predicted level of non-target exposure is within acceptable limits. The Service would conduct supplemental NEPA analysis to address these new findings if appropriate.

Table 2.4. Comparative Summary of Actions by Alternative.

Action attribute	ALTERNATIVE B:	ALTERNATIVE C:	ALTERNATIVE D:	ALTERNATIVE E:
	Aerial broadcast of brodifacoum with active reptile mitigation actions	Aerial broadcast of brodifacoum	Aerial broadcast of diphacinone with active reptile mitigation actions	Aerial broadcast of diphacinone
Primary bait delivery method	Aerial broadcast	Aerial broadcast	Aerial broadcast	Aerial broadcast
Secondary bait delivery methods	Hand broadcast; bait stations	Hand broadcast; bait stations	Hand broadcast; bait stations	Hand broadcast; bait stations
Bait type	Brodifacoum-25D	Brodifacoum-25D	Diphacinone-50	Diphacinone-50
Actions to reduce risk to reptiles	(i) Captive holding on Puerto Rico (ii) Captive holding on Desecheo	None	(i) Captive holding on Puerto Rico (ii) Captive holding on Desecheo	None
Seasonal timing	January to April	January to April	January to April	January to April

2.8 Alternatives Dismissed from Detailed Analysis

2.8.1 Bait Stations and Hand-broadcast

The island's size, rugged terrain, steep slopes, deep valleys and UXO status dictate that much of the island is difficult to access on foot, and a ground-based operation would present logistical difficulties and a serious danger to operators.

2.8.2 Use of Other Toxicants

The use of other rodenticides registered with the EPA was dismissed from further consideration, for one or more of the following reasons: 1) no other bait products are currently registered for aerial application for conservation purposes, 2) lack of proven effectiveness in island rat eradications; 3) potential for development of bait shyness in the

rat population; and 4) the lack of an effective antidote in case of human exposure. Each of these issues and the associated rodenticides are discussed below.

Most successful documented island-wide rodent eradication programs that used a toxicant as the primary technique have used “second-generation” anticoagulants such as brodifacoum and bromadiolone (230/270, or 85 percent). A total of 38 successful eradications have used “first-generation” anticoagulants such as diphacinone and pindone. Seven eradications are known where non-anticoagulant toxicants were used including strychnine, sodium monofluoroacetate and cholecalciferol (Howald et al. 2007, Island Conservation unpubl. data). Acute rodenticides, such as strychnine, have the ability to kill rats quickly after a single feeding. However, because poisoning symptoms appear rapidly, acute rodenticides can induce learned bait avoidance if animals consume a sub-lethal dose. Studies with zinc phosphide have demonstrated that rodents associate toxicity symptoms with bait they had consumed earlier if the onset of symptoms occurs as long as six or seven hours after consumption (Lund 1988). Thus, any individual that consumes a sub-lethal dose is likely to avoid the bait in the future (Record and Marsh 1988). Also, acute rodenticides are often extremely toxic to humans and effective antidotes are not always available. The combination of these factors disqualifies the acute rodenticides from detailed consideration.

Cholecalciferol, which is classified as a “subacute” rodenticide, has the ability to kill rats more quickly than the anticoagulant rodenticides, but most often more slowly than the acute rodenticides. Cholecalciferol has a lower level of toxicity to birds. It has been used successfully to eradicate rats from very small islands (Donlan et al. 2003). These characteristics give cholecalciferol potential as a candidate toxicant for eradications, but it has not been extensively tested for eradication efficacy (Howald et al. 2007) or impacts to non-target species. Thus, its use on Desecheo would be largely experimental in nature. The presence of unique taxa on Desecheo, and the need for a high probability of successful eradication on the first attempt disqualifies cholecalciferol from detailed consideration. In addition, no EPA approved bait product (except Brodifacoum-25D and Diphacinone-50) is currently available for aerial dispersal for conservation purposes.

2.8.3 Use of Disease

While there is ongoing research focused on the development of taxon-specific diseases that can control populations of invasive species (such as by the Commonwealth Scientific and Industrial Research Organization (CSIRO), www.cse.csiro.au/research/rodents/publications.htm), there are no pathogens with proven efficacy at eradicating rodents (Howald et al. 2007). Even a highly lethal rat-specific pathogen would be ineffective at eradicating rats from Desecheo, because if the rat population rapidly declined, transmission rates of the introduced pathogen would also decline so as to be ineffective in eradicating the last few remaining individuals. Furthermore, the introduction of novel pathogens into the environment carries tremendous potential risks to non-target species. Therefore, the use of pathogens is disqualified from detailed consideration.

2.8.4 Trapping

This alternative would call for the use of live traps and/or lethal ("snap") traps to eradicate rats. This action is highly unlikely to succeed on Desecheo. The use of live traps and/or lethal traps to remove rats from an area is a strong selection agent in favor of rats that are "trap-shy". Thus, after extensive trapping the only rats that would remain would be those that are behaviorally less likely to enter a trap, and those rats would be very difficult to remove without the introduction of alternate methods such as toxicants. Furthermore, a ground-based operation would be under the same constraints as those detailed for bait station and hand-broadcast; the island's size, rugged terrain, steep slopes, deep valleys and UXO status dictate that much of the island is difficult to access on foot, and widespread use of traps would present logistical difficulties and a serious danger to operators. Therefore, this alternative is disqualified from detailed consideration.

2.8.5 Introduction of a Predator

The introduction of predators on rats, such as snakes and cats, was dismissed because biological control most often only reduces, rather than fully eliminates the target species and thus fails to achieve the desired ecological benefit gained through complete rat removal. There is no known effective biological control agent for rats on islands, and some forms of biological control would result in unreasonable damage to the environment. The introduction of cats to islands in order to control invasive rodents has been attempted numerous times since European explorers began crossing the Atlantic and Pacific oceans, and has generally resulted in a greater combined impact on birds than if one or the other were present alone. When seabirds are present, cats have been shown to prey upon them heavily (Atkinson 1985), consuming fewer rodents during these times. When seabirds leave the islands following the end of the breeding season, cats switch prey to rodents, which allow the island cat population to remain stable at a higher level than if no rodents were present on the island (Atkinson 1985, Courchamp et al. 1999, 2000). Thus, birds are impacted not only by rodents but also the larger number of cats that are sustained by rodent presence on the island. Introduction of another species onto an island can have severe and permanent consequences to the ecosystem (Quammen 1996). Therefore, this alternative is disqualified from detailed consideration.

2.8.6 Fertility Control

Reproductive inhibition appears to be a useful method of reducing rodent populations, particularly on islands that have a greater potential to negatively impact non-target species with other eradication techniques. Reproductive inhibition is a non-lethal alternative that has the potential to provide long-lasting control. There are no products currently registered in the United States for fertility management in rodents and little is known about the impacts that anti-fertility treatments have on rodents at the population level (Jacobs et al. 2008). The effective control of free-ranging wildlife populations would require oral delivery or species-specific systems, which typically are infectious viruses that deliver reproductive inhibitors to a sufficiently high proportion of animals to effect population

control (Jacobs et al. 2008). The ultimate development of reproductive inhibitors for controlling free-ranging wildlife populations requires the resolution of many complex legal, biological, economic and ethical issues (Guynn 1997), and may be practical only for long-lived animals with lower reproductive capacities, like horses (Tobin and Fall 2004). Ensuring that non-target species are not susceptible to fertility control agents is just as important as with the use of toxicants. Many rodent species breed year-round, so oral contraceptives would have to be fed periodically during the year to reduce reproductive rates (Fagerstone et al. 2006). Furthermore, the only practical delivery system for sterilants would be via baiting. The same non-target organisms that may eat anticoagulant bait could eat bait formulated with other agents. Fertility control agents could sterilize organisms that consume bait and possibly organisms that eat primary consumers, depending upon the nature and specificity of the reproductive inhibitor. Sterilants have not been used much in the field to eradicate rodents and are not currently available for use in the United States. In fact, sterilants are only thought to be useful to obtain partial population reduction not full eradication.

2.8.7 Rat Removal with the Goal of "Control"

The net conservation gain achieved by successful rat control (i.e. reducing and maintaining rat populations at extremely low levels) compared to complete eradication could be similar. However, the risks to non-target wildlife from control operations are greater than the risks from an eradication operation due to the indefinite timeline for which a control operation must be continued; long-term bait presence and repeated disturbances from control operations puts non-target wildlife at constant risk. In addition, should scheduled control operations be interrupted, rats can quickly reproduce and rapidly re-populate the island achieving former population sizes, requiring an intensification of control operations once more. The constant maintenance of an ecologically beneficial rat control program (i.e. control of island-wide rat populations to levels low enough to eliminate them as an ecosystem threat) is far less cost-effective, increases personnel safety risks, and does not result in the permanent conservation benefits of entire-island eradication. It is therefore disqualified from detailed consideration.

3 AFFECTED ENVIRONMENT

3.1 Introduction

This chapter focuses on portions of the environment that are directly related to conditions addressed in the alternatives. The description of the affected environment is not meant to be a complete description of the project area. Rather, it is intended to portray the relevant conditions and trends of the resources that may be affected by the proposed action. The descriptions of Desecheo's resources presented in this chapter will be referenced in the analysis of potential impacts to these resources in the following chapter (Ch. 4 Environmental Consequences).

3.2 General Description of Desecheo

3.2.1 Geographical Setting

Desecheo is located approximately 13 mi (21 km) west of Punta Higüero, Puerto Rico, and about 62 mi (100 km) east of Hispaniola. Desecheo sits atop a submarine ridge in the northeastern part of the Mona Passage, a broad shallow strait connecting the Caribbean Sea with the Atlantic Ocean. The only other islands of significant size in the strait, Mona Island (13,633 ac/5,517 ha) and Monito Island (37 ac/15 ha), lie about 33 mi (53 km) to the southwest (Seiders et al. 1972).

3.2.2 Topography

Desecheo is a small, mountainous island of 301 acres (122 ha) (Figs. 3.1 A and B). Three sides of the island are defined by steep slopes, ranging from 20 to 35 degrees. The southwestern portion of the island has three valleys with ridges rising northward (Seiders et al. 1972). The island's high point (slightly less than 700 ft / 213 m) occurs on the northern ridge of the island (Morrison and Menzel 1972). Most of the coastline is rocky, although there are three small sand beaches. Several unvegetated islets lie off the coast of Desecheo.

3.2.3 Climate

Desecheo's local climate is tropical. Average temperatures in the region range between 66 and 90 degrees Fahrenheit (Figure 3.2) (Southeast Regional Climate Center 2010). Annual rainfall on Desecheo has been reported at between 750 mm and 1,039 mm (Morrison and Menzel 1972, Seiders et al. 1972). Rainfall data from the west coast of mainland Puerto Rico suggest some seasonality, with a dry period from January to March, rainfall increasing in April and May, and higher rainfall period between July and October - generally coinciding with the Caribbean's hurricane season. However, between-year variation (as indicated by the error bars) can result in small temporal shifts in the months when the dry and wet

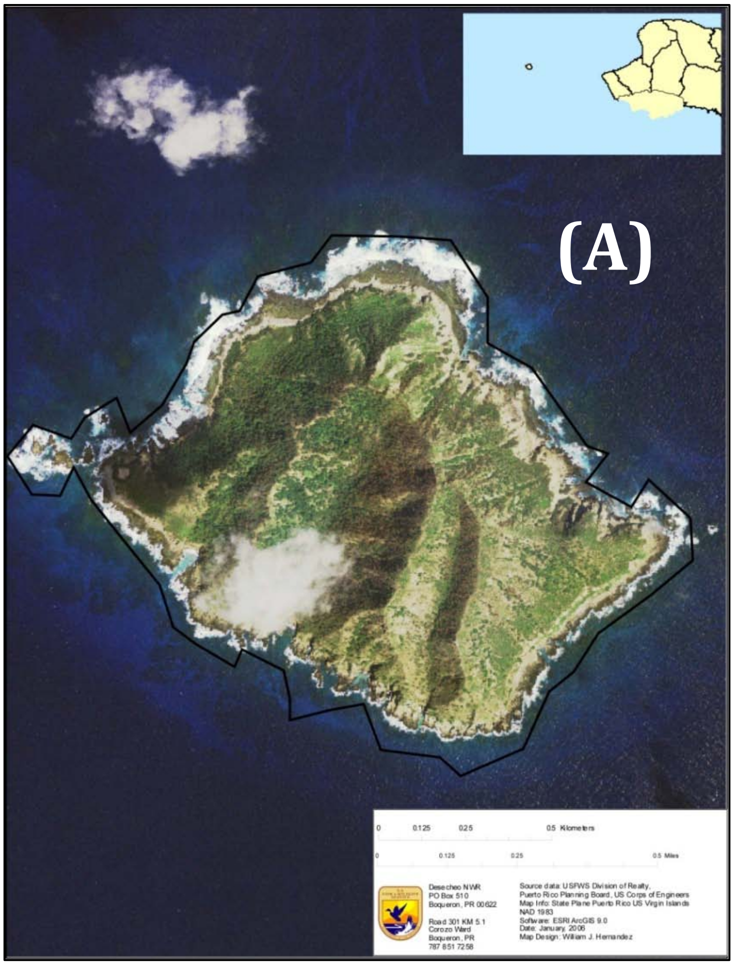
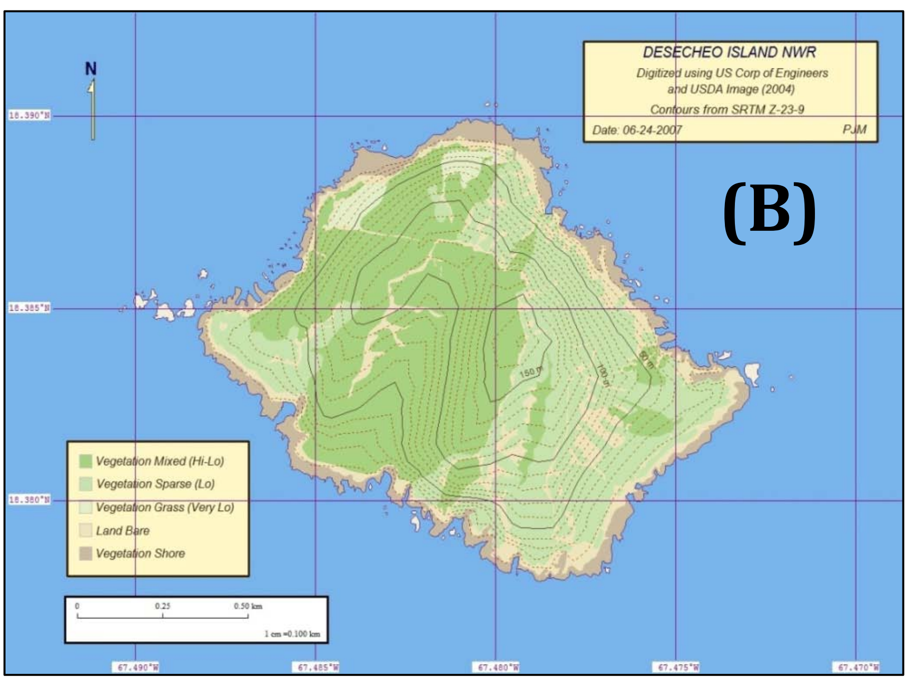


Figure 3.1. (A) Aerial map of Desecheo Island NWR showing location to Puerto Rico; **(B)** Topographical map of Desecheo NWR.



seasons begin and end. In addition, on Desecheo high evaporation rates combined with rapid runoff from the steep topography can result in chronic aridity on the island (Seiders et al. 1972). Winds on Desecheo prevail from the northeast.

The following climate data (Figure 3.2) summarizes the average temperature and precipitation by month for Rincon power plant, Puerto Rico, between 1968 and 2010. Rincon power plant is located on the mainland coast of Puerto Rico, approximately 13 miles (21 km) to the east of Desecheo, and is climatically similar.

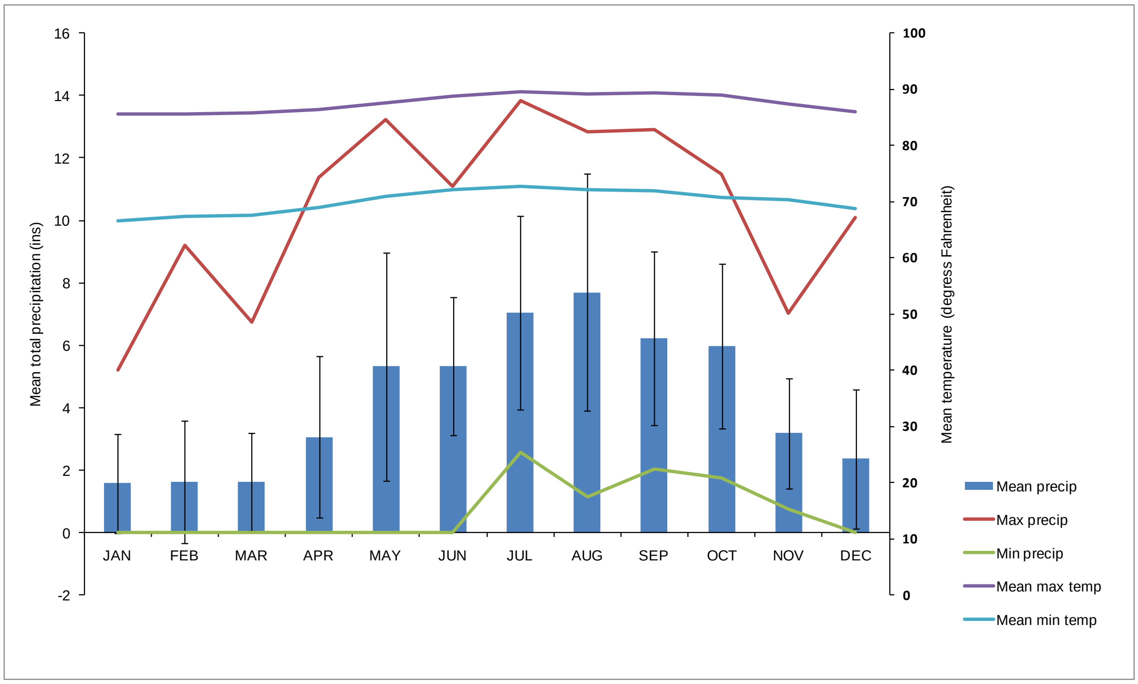


Figure 3.2. Average monthly climate data near Desecheo Island (Rincon Power Plant, northwest Puerto Rico), between 1968 and 2010 with standard deviations (error bars) (Southeast Regional Climate Center 2011). On the primary axis, mean monthly precipitation (blue bars) with monthly standard deviations, monthly maximum (red line) and minimum (green line) precipitation (inches). On the secondary axis, mean monthly maximum (purple line) and minimum (turquoise line) temperatures recorded (degrees Fahrenheit).

3.3 Physical Resources

3.3.1 Water Resources

There are no permanent sources of freshwater on Desecheo (Evans 1989). Ephemeral surface water may be present during and after rainfall events. There are no data available on the quality of the coastal waters near the island. However, it is unlikely that there is more than a negligible quantity of pollutants in Desecheo's coastal waters, given the island's distance from any significant sources of pollutants. Local sources of water pollution

are likely negligible to minor and likely include pollution from boat traffic and soil erosion from the island.

The marine waters around Desecheo are managed by the Government of Puerto Rico as a no-take Marine Reserve.

3.3.2 Geology and Soils

Geologically, Desecheo Island is not considered part of the Puerto Rican Bank (Seiders et al. 1972), but part of the Río Culebrinas Formation indicating that the islands of Puerto Rico and Desecheo were likely connected at one time (Breckon 2000). However, Desecheo is believed to have become isolated from Puerto Rico during or before the Pliocene (Heatwole et al. 1981). Desecheo is composed primarily of early Tertiary volcanic sandstones, with volcanic breccia and mudstone, as well as calcareous sandstones and mudstones. There is a discontinuous bench of assumed Pleistocene marine colluvium, part of which is phosphate-cemented, at 8 – 12 m above sea level. Portions of this bench above Puerto Canoas and Puerto de los Botes have recently collapsed. There is a lower bench of more recent Holocene beach deposits in protected coves and beaches (Seiders et al. 1972).

3.3.3 Air Quality

There are no data on air quality on or immediately surrounding Desecheo. There are no current activities on the island that would affect air quality. It is unlikely that there is more than a negligible quantity of air pollutants at Desecheo, given the island's distance from any significant sources of pollutants. Local sources of air pollution are likely negligible to minor, and likely include pollution from boat and air traffic and occasional mineral dust transported from Africa (Kellogg and Griffin 2006).

3.4 Biological Resources

3.4.1 Introduction

Historically, Desecheo Island was a major seabird rookery. At the turn of the 20th century, a biologist observing Desecheo Island through a telescope from Puerto Rico saw "a maze of birds winding and circling in the haze with which the island was enveloped" (Bowdish 1900). Desecheo may have had the largest breeding colony of brown boobies in the world with estimates of up to 15,000 breeding birds (Meier et al. 1989). However, this historical breeding ground has now been completely abandoned; surveys in 2009 revealed no breeding seabirds at all (Island Conservation 2009a) and only a small number birds nesting on the coastline and offshore islets in 2010 (Island Conservation 2010b). The extirpation of nesting seabirds has been linked to the presence of invasive mammals including: goats, macaques and rats (Evans 1989, Breckon 1998, Island Conservation 2010d).

Although Desecheo's biological resources have been detrimentally affected by invasive mammals, as well as numerous high-impact human use patterns in the past, the island is

still home to a high number of single-island endemic species for its small size. Five endemic species (three lizards and three arachnids) have been identified from the island. In addition, the island supports a semi-deciduous subtropical lowland dry forest and woodland/shrubland habitat types, of which only about 3,000 ha is protected on mainland Puerto Rico (Helmer et al. 2002), and the endangered higo chumbo.

The biological resources of Desecheo are protected in perpetuity as a National Wildlife Refuge, and the surrounding waters are protected as a Marine Reserve by the Government of Puerto Rico DNER, making them especially valuable as targets for lasting ecological restoration projects.

3.4.2 Birds on Desecheo

3.4.2.1 Historical and Current Status

Historically, eight or nine species of seabird were reported as breeding on Desecheo Island. Brown boobies were the most abundant species, with estimates numbering between 8,000 – 15,000 breeding individuals per year (Wetmore 1918, Noble and Meier 1989) making it one of the largest colonies in the Caribbean region. In addition, about 2,000 individuals of red-footed boobies were reported in the early 1900s (Wetmore 1918), a species which was still relatively common in the late 1970s (Kepler 1978) but which has declined dramatically on Desecheo since (Meier et al. 1989, Noble and Meier 1989). Wetmore (1918) also reported more than 2,000 brown noddy and 1,500 bridled terns nesting on offshore islets and in cliffs on Desecheo proper (some of which may have been sooty terns (*Onychoprion fuscata*)—identification of the two species can be difficult). There were also a few hundred each of magnificent frigatebirds (*Fregata magnificens*) and laughing gulls (*Leucophaeus atricilla*) nesting on the island (Wetmore 1918, Struthers 1927).

However, biological surveys over the successive decades have documented the disappearance of all of these colonies. Meier and colleagues (1989) reported on an increasing decline in all breeding seabirds between the late 1970s and late 1980s, such that between 1987 and 1996, only 120 individuals of six species of seabird on or around the island could be accounted for (Breckon 1998). During field surveys in 2009, no nesting seabirds were observed. However in 2010, 17 pairs of nesting bridled terns and one nesting pair of brown noddy were found breeding on the coastal rocks and offshore islets (Island Conservation 2010b).

The introduction of rhesus macaques in 1966 appears to be the greatest contributor to the disappearance of seabirds on Desecheo (Evans 1989, Meier et al. 1989, Noble and Meier 1989). For the larger seabird species, unsustainable harvesting by humans may also have contributed to seabird declines (Struthers 1927). Smaller species, including those attempting to nest on cliffs, have likely been depredated by rats (Towns et al. 2006). Furthermore, predation by macaques may be masking the impacts of rat predation, a phenomenon that has been documented for other island-nesting seabird species (Taylor et al. 2000, Jouventin et al. 2003).

Most terrestrial land birds reported from the island are probably migratory species or vagrants, and only remain on the island for short periods. Of Puerto Rico's 354 recorded bird species, about 133 are known to breed and over 200 species occur as wintering Neotropical migrants, transients, or vagrants (Wege and Anadon-Irizarry 2008). More than 45 exotic bird species have been recorded from Puerto Rico, and more than 35 are either well-established or breeding. Over-wintering migrants typically occur in Puerto Rico from September through to April, but can occur as early as August and as late as June (Raffaele 1989). A total of 26 species of over-wintering migrants have been reported from Desecheo, although not all species may all be seen in the same year.

Historically, three species have been considered resident to Desecheo, and breeding has been recorded or suspected: the mangrove cuckoo, belted kingfisher (*Megaceryle alcyon*) and pearly-eyed thrasher (Meier et al. 1989). However, in Puerto Rico the belted kingfisher is not known as a breeding bird but as a winter migrant with some individuals possibly remaining throughout the summer. Meier and colleagues (1989) reported individuals on Desecheo in the summer months of June 1986 and July 1987, and the species was observed on Desecheo in June in 2009 and June 2010 (Island Conservation 2009b, 2010d) but with no evidence of breeding. The pearly-eyed thrasher is the most common breeding resident on the island. This species is an 'avian supertramp' species that has increased its range in the Caribbean in recent times and in Puerto Rico since the 1920s. These birds are voracious predators of a range of vertebrates, birds, eggs and chicks. While most nest predation events recorded have been on passerines (Arendt 2006), they are known to impact the endangered Puerto Rican parrot (*Amazona vittata*) (Snyder et al. 1987), Puerto Rican sharp-shinned hawk (*Accipiter striatus*) (Delannoy 1997), and have been implicated in the disappearance of the endangered white-necked crow (*Corvus leucognaphalus*) from Puerto Rico (Wiley 2006). Other species, such as the zenaida dove probably nested in significant numbers on the island historically (Wetmore 1918), and some individuals may still be resident. In 2009 and 2010, island-wide surveys and behavioral observations also confirmed breeding of American kestrel (*Falco sparverius*), grey kingbird (*Tyrannus dominicensis*), American oystercatcher (*Haematopus palliates*) and possible breeding by black-whiskered vireo (*Vireo altiloquus*) and red-tailed hawk (*Buteo jamaicensis*). However, since the 1960s, Desecheo's land bird fauna has suffered a fate similar to the seabirds; macaque and rat predation have likely led to low densities of pearly-eyed thrasher and the extirpation of the mangrove cuckoo which has not been seen in the last few years.

3.4.2.2 Species Records

At least 67 bird species have been recorded from Desecheo Island since the year 1900 (Appendix I). This includes 31 species that are resident year-round in Puerto Rico and 30 migratory species that either over-winter in Puerto Rico (26 species) or are spring migrants that remain in Puerto Rico through the summer to breed and depart in the fall (four species). Three seabird species (sooty tern, bridled tern, brown noddy) breed in Puerto Rico in the summer but mostly remain out at sea for the remainder of the year, while the laughing gull also breeds in the summer but remains around coastlines during the rest of the year, sometimes venturing out to sea and moving between islands (see

Table 3.1). Four species (great blue heron (*Ardea herodias*), green heron (*Butorides virescens*), yellow-crowned night-heron (*Nyctanassa violacea*) and killdeer (*Charadrius vociferus*)) have bird populations that are permanently resident in Puerto Rico year-round; however, they may be augmented by additional migratory birds in the winter. One species, the black-whiskered vireo, is largely a spring migrant that breeds in Puerto Rico in the summer, but some birds are also known to remain in Puerto Rico through the winter too. Four species (upland sandpiper (*Bartramia longicauda*), bank swallow (*Riparia riparia*), barn swallow (*Hirundo rustica*), blackpoll warbler (*Dendroica striata*)) are transient visitors to Puerto Rico, passing through the island during the migration periods either in the spring or fall, or both. The passage of transient migrants is often unpredictable, and large flocks can appear and depart quite suddenly (see Section 3.4.2.3). One additional species, the yellow-billed cuckoo (*Coccyzus americanus*), has a summer breeding population in Puerto Rico which may also be augmented by transient spring and/or fall migrants. Finally, sightings of three species (Common Potoo (*Nyctibius griseus*), cedar waxwing (*Bombycilla cedrorum*), alpine swift (*Apus melba*) on Desecheo have only been recorded once and are either accidentals or vagrants to the region, occurring outside of their normal distribution.

Of the 67 species recorded from Desecheo, 41 have been sighted in the last 10 years since 2000, and seven species were first recorded from the island in 2009 and 2010 (Appendix I). The recent addition of these seven records suggests that new sightings are likely to be recorded regularly and that the list of species reported from Desecheo island is (and always will be) incomplete. This is particularly relevant to migratory species, where the annual pattern of dispersal can be influenced by climatic and other environmental factors elsewhere within their migratory routes. Of the seven new records, five were migratory species to Puerto Rico. Of the remaining 26 species that have not been sighted on Desecheo in the last 10 years, all records except one (sooty tern) were recorded for the first time in 1987 by Meier and colleagues (1989). This included eight species that are known to be permanently resident on Puerto Rico (including three introduced species, orange-cheeked waxbill (*Estrilda melpoda*), bronze manikin (*Lonchura cucullata*), Hispaniolan parakeet (*Aratinga chloroptera*)), and 18 species that are winter, summer, or transient migrants to Puerto Rico. Of particular note is the current absence of the mangrove cuckoo which was seen frequently on all three field surveys in 1987 by Meier and colleagues (1989); the last observations for this species on the island was of a single individual in 2001 and in 2003.

Four seabird species (white-tailed tropicbird (*Phaeton lepturus*), masked booby (*Sula dactylatra*), royal tern (*Thalasseus maximus*) and sandwich tern (*Thalasseus sandvicensis*)) have never been reported from Desecheo Island but have been observed offshore. A few masked boobies were seen in 2009 offshore of Desecheo in large rafts of red-footed boobies and other seabirds (Island Conservation unpubl. data). Bowdish (1902) reported tropicbirds around the island, but was unable to identify the birds to species. All four species are common within Puerto Rico and currently breed on Mona and Monito islands, 33 miles (53 kms) to the southwest, with the exception of the royal tern, which breeds on islands off the east coast of Puerto Rico (Saliva 2009).

3.4.2.3 Avian Seasonal Patterns

Bait broadcast operations, as described in Chapter 2, would be scheduled to occur during months when bird presence and breeding activity is likely to be low. Of the seabirds, in the last 10 years since 2000 only 17 pairs of bridled terns and one pair of brown noddy have been reported as breeding on Desecheo (see Appendix I). In addition, the few species of land bird reported as fully resident on Desecheo (see above) are apparently present at low densities, and thus the number of breeding pairs is also likely to be low. In 2003, the poor state of the land birds was demonstrated when only two pearly-eyed thrashers were captured in 256 hours of mist netting (Earsom 2003a). Similarly, in 2009 and 2010, an average of only 9.6 of 30 (32 percent) point-count stations were occupied by eight species of landbird; the most common of which were pearly-eyed thrasher (18 percent), American kestrel (8 percent) and peregrine falcon (4 percent) (Island Conservation unpubl. data).

Therefore, for operational scheduling, to determine any potential breeding patterns that might have gone unreported in previous years, we must use data on bird breeding and residency patterns from elsewhere in the region.

3.4.2.4 Landbirds and Waterbirds

The over-wintering migration period for Neotropical migrants to the Caribbean region is typically September to April. Of the 59 land bird and waterbird species (excluding seabirds) reported for Desecheo, 26 are migrants to the Caribbean region remaining in Puerto Rico for the duration of the winter (Appendix I). Of these, five species also have year-round resident populations, and 14 have been reported from Desecheo in the last 10 years. An operational schedule between January and April might overlap with part of the seasonal winter residency period for some of these species. Some species such as upland sandpiper and barn swallow are transient migrants, passing through Puerto Rico either in the spring (Apr-May), or fall (Aug-Oct), or both spring and fall, and are rarely seen in the winter months. For these species, large concentrations of birds have been reported passing through during their migration. If such a concentration were to occur through Desecheo during the rodent operation, larger numbers of birds than anticipated could be at risk from eradication operations. This was demonstrated by Meier and colleagues (1989) who reported numerous sightings of blackpoll warbler from October 15 – 26, 1987, including more than 100 individuals on October 21 and 22, but which had disappeared from the island by October 26. A few species such as black-necked stilt (*Himantopus mexicanus*), black-whiskered vireo and Caribbean martin (*Progne dominicensis*) are summer migrants (Mar-Oct) that arrive in Puerto Rico to breed, but which winter in other regions. For these species, an operational schedule of January to April might overlap with the very early part of a breeding season. Finally, some species recorded from Puerto Rico are considered vagrant or accidentals, birds that are rarely seen in the central Caribbean region and that are outside of their normal distributional range. These species may appear randomly, usually during the spring or fall migration periods, and their presence on Desecheo between January and April is unpredictable.

Of the 59 land bird and waterbird species (excluding seabirds) reported for Desecheo, 30 (including four summer-breeding migrants) are breeding residents in Puerto Rico, of which 21 species have been reported from Desecheo in the last 10 years. However, breeding is only suspected in eight species. An operational schedule between January and April is likely to overlap with part of the breeding season for these species. Despite the diversity of bird species reported from Desecheo since the early 1900s, the total number of individual migratory and resident land birds and waterbirds present on the island at any one time is estimated to be small, and for resident species breeding density is estimated to be low.

3.4.2.5 Seabirds

In temperate seasonal latitudes, seabird breeding occurs in a defined annual cycle marked by changes in photoperiod and temperature, and annual laying dates of island or regional populations of temperate seabirds are very consistent. By contrast, all tropical birds in the order Pelecaniformes show a wide spread of laying times and the breeding cycle, which is often only loosely seasonal (Nelson 1983). In some cases, egg-laying seems entirely aseasonal, although each species in any given population may have a detectable broad peak(s). In addition, some tropical seabirds will breed more than once per year, resulting in an extension of the breeding cycle across the year. Other species breed less than once per year. In some areas, brown and blue-footed booby (*Sula nebouxii*) fit more than one breeding cycle into a calendar year, while the frigatebirds normally breed only once every two years. In addition, the same species can be an annual seasonal breeder in one locality (e.g. red-footed boobies on Christmas Island, Indian Ocean) but breed aseasonally and less than once per year in another locality (red-footed boobies in the Galapagos islands). Tropical seabird breeding can also be extended by subsequent nesting attempts if failure occurs in the first. The timing of replacement egg-laying can be variable and ill-defined as it is often in response to fluctuations in food supply. Replacement laying within two or three weeks of egg loss may occur in all three pan-tropical boobies, but also failed breeding attempts may be abandoned and a variable period may ensue before a replacement clutch is laid (Nelson 1983). In conclusion, tropical seabirds are less constrained in their seasonal breeding cycles and breeding strategies than temperate species, resulting in less predictable fluctuations of seabirds in a breeding colony.

Little is known about potential breeding cycles of seabirds on Desecheo Island. No breeding has been reported for the majority of the seabirds since the late 1980s, and no in-depth studies of seabird breeding cycles have been conducted. Therefore, to anticipate potential impact to seabirds on Desecheo as a result of the rodent eradication operation, we need to extract information of the same species breeding on nearby adjacent islands. Mona and Monito islands are about 50 miles (80 km) from the western coast of Puerto Rico, and about 33 miles (53 km) southwest of Desecheo. Seven seabird species nest on the two islands, all of which were known to nest historically on Desecheo, with the exception of the brown pelican which does not nest on Mona or Monito islands (Table 3.1).

On nearby Mona and Monito islands, variable seabird breeding seasons have been reported between years with some years demonstrating a bi-modal pattern of peaks in spring and

fall seasons (Kepler 1978). Sulids, such as brown and red-footed booby, may be resident and/or breeding on the islands throughout the year. Brown boobies have a flexible breeding season, some colonies breed seasonally while others breed aseasonally, and nests at any stage of development can be found year-round. Breeding peaks can be variable as some colonies show prolonged breeding seasons or temporally different peaks in different years. Saliva (2009) report peak breeding season for brown boobies between December and March, whereas Kepler (1978) on Monito Island reported annual breeding cycles but with variation between years in timing of the main breeding effort; in March-April in 1969 and Sept-Oct in 1973. Similarly, red-footed boobies may nest throughout the year, but with a peak between February and June (Saliva 2009). Kepler (1978) reported variable nesting seasons for red-footed boobies, which could lay up to twice a year, the first season occurring in March and April and the second season spanning from August to November. The laughing gull is typically more synchronous in breeding effort, arriving around mid-April to pair and establish territories in mid-May, peak breeding seen in May, June and July and some nesting through to August. Similarly, magnificent frigatebirds are also synchronous, on Monito Island nesting in greatest numbers from December to May (Saliva 2009) and late October to early December (Kepler 1978), although eggs and chicks at various stages can be found throughout the year.

Table 3.1. Seabird breeding seasonality in Puerto Rico islands, from Saliva (2009) and Kepler (1978). Note: light gray = breeding reported, dark gray = peak breeding.

Species	Island	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
White-tailed tropic bird	Mona & Monito												
Brown booby	Mona & Monito												
Red-footed booby	Mona & Monito												
Magnificent Frigatebird	Monito												
Laughing Gull	Mona & Monito												
Brown Noddy	Mona & Monito												
Sooty tern	Mona												
Bridled tern	Mona & Monito												
Brown pelican	Puerto Rico-general												

3.5 Special Legal Protection for Birds on Desecheo

3.5.1 Endangered Species Act

There are no known birds protected by the ESA from Desecheo. The brown pelican (*Pelecanus occidentalis*), which is a regional resident, was removed from the ESA list in November 2009.

3.5.2 Migratory Bird Treaty Act

Most of the birds listed above are protected under the Migratory Bird Treaty Act, which generally prohibits the take of migratory birds without a permit. In January 2010, the FWS authorized the use of a special-purpose permit for the incidental take of migratory birds for "eradication or control of invasive species" (U.S. Fish and Wildlife Service 2010b). The Special Purpose Miscellaneous permit will allow for unintentional take of migratory birds for projects intended to benefit migratory birds. The Service intends to apply for a Special Purpose Miscellaneous permit under the MBTA for the proposed action.

3.6 Terrestrial Wildlife on Desecheo

3.6.1 Reptiles

The endemic reptiles include the Desecheo dwarf gecko (*Sphaerodactylus levinsi*), the Desecheo anole (*Anolis desechensis*) and the Desecheo ameiva (*Ameiva desechensis*). In addition to the endemic species, two native species, the slippery-back skink (*Mabuya sloanii*) and the Puerto Rican racer (*Borikenophis portoricensis*), also inhabit the island. The taxonomic status of the racer is in question, it may be the same species found on Mona Island (*Borikenophis variegatus*), or it may be an endemic subspecies unique to Desecheo, although no genetic or taxonomic work has been completed (Henderson and Powell 2009) (M. Evans and J. Schwagerl pers. comm. 2007). Desecheo has no known introduced herpetofauna.

The Puerto Rican racer primarily feeds on other reptiles, small birds and amphibians (Meier and Noble 1991, Rodríguez-Robles 1992, Rodríguez-Robles and Leal 1993, Leal and Thomas 1994, Henderson and Sajdak 1996). It is typically found under rocks, in open pastures, in forests, in coastal areas and under termite nests (Pérez-Rivera and Vélez Jr. 1978, Schwartz and Henderson 1991, Rivero 1998, Rodríguez-Robles 2005, Barun et al. 2007). The species' primary breeding season is between March and April with clutch sizes of approximately four to 10 eggs (Schwartz and Henderson 1991, Rivero 1998).

The Desecheo ameiva feeds primarily on insects, ground snails, *Anolis* eggs and dwarf geckos (Lewis 1989). It is found in coastal areas, in cactus scrub, in grassy areas, or in areas with maximum sun exposure (Evans et al. 1991). The species breeds in the summer months between June and August while the day length is long, and rarely breeds in the winter or fall. There is a direct correlation in the timing and onset of breeding with the length of day. Typical clutch sizes range from two to three eggs per nest, and several females may contribute eggs to the nest making it difficult to determine the number of eggs individual females lay in a season (Rodríguez-Ramirez and Lewis 1991, Rivero 1998).

The Desecheo anole has a structural niche and general ecology similar to that of Puerto Rican crested anole (*Anolis cristatellus*) on mainland Puerto Rico, and both are considered to be "ground-trunk" anoles "sit and wait" foragers (Gorman and Stamm 1975, Meier and Noble 1991). Incidental observations collected during bird surveys by Meier and Noble (1991) suggested that the species was found typically in the forest canopy, in deciduous

woodlands, and near the shore at the vegetation line. Individuals were rarely found in the thorny cactus scrub, on upper slopes, or ridge tops. They observed the species to eat berries, flies on the beach, grasshoppers, moths and other anole eggs. Although there are no data on the timing of the Desecheo anole breeding season, where they likely breed, or the average clutch size, we can deduce some information from the ecology of *Anolis cristatellus*, a similar species found on mainland Puerto Rico. Henderson and Powell (2009) state that in Puerto Rican crested anole, male reproductive activity is at its highest from March-August and that females are non-reproductive during the winter dry season. The average clutch size is one; however communal deposition of eggs has been reported on a number of occasions, with eggs laid under logs, stones, or rock piles, or in debris at the base of trees.

While there is limited information on the Desecheo dwarf gecko, in general, geckos in the genus *Sphaerodactylus* feed primarily on mites, spiders, isopods, ants, gastropods and small frogs (Thomas and Kessler 1996). Typical habitat for the dwarf geckos, and for the Desecheo dwarf gecko, is under stones or dead wood, on low slopes, in forested and shaded areas and in leaf litter (Heatwole 1968, Meier and Noble 1990a, Schwartz and Henderson 1991, Herrera-Giraldo 2009). The timing and onset of the breeding season for dwarf geckos is directly linked to the length of day; therefore, reproduction typically is during the summer from June through August and rarely if ever occurs in January (Lopez-Ortiz and Lewis 2002).

The slippery-backed skink typically feeds on cricket nymphs, frogs, cockroaches and isopods (Currat 1980, Schwartz and Henderson 1991, Rivero and Segui-Crespo 1992). Skinks are primarily found at the base of trees, secondary scrub, coconut palms, under rocks, around ground bromeliad and in thorny cactus scrub (Schmidt 1928, Thomas and Thomas 1977, Meier and Noble 1990b, Schwartz and Henderson 1991, Rivero 1998). The timing of the breeding season is not clear; however, the typical clutch size ranges from three to five eggs (Schwartz and Henderson 1991).

Information about Desecheo reptile ecology, population abundance and distribution across the island is limited. Only one study of the endemic dwarf gecko exists, from 1987, which reported densities of 3-19 animals in 125 m^2 forest plot and suggested that the gecko is probably a forest-obligate species (Meier and Noble 1990a). The slippery-back skink was only first recorded from Desecheo Island in 1987, where it was observed primarily in the thorny cactus scrub community (Meier and Noble 1990b). Previous field observations suggested that the endemic anole and *Amieva* were abundant (Earsom 2002, Island Conservation 2009a).

Field surveys conducted in 2009 and 2010 provided preliminary data on the population density and abundance of the Desecheo anole, dwarf gecko, *Ameiva* and racer. Using several different but standardized survey techniques, total population estimates for *Ameiva desechensis* was 7,469 individuals (1,800 – 13,137, 95 percent confidence limits), for *Anolis desechensis* was 52,111 individuals (31,464 – 72,758, 95 percent confidence limits), and for *Sphaerodactylus levinsi* was 13,261 individuals (8,796 – 19,991, 95 percent confidence limits). However, population estimates for the Desecheo dwarf gecko varied between

habitat types with estimates much lower in grassland habitats (1,179 individuals: 464 – 2,998, 95 percent confidence limits) than in forest habitats (7,328 individuals: 4,535 – 11,840, 95 percent confidence limits). Density estimates for the Desecheo anole and *Ameiva* were also influenced by habitat type with higher densities in forest and shrub habitats than in grassland and rocky shore habitats (Island Conservation, unpubl. data). The Puerto Rico racer density was generally low across the island, with only an average of seven individuals recorded per hectare.

3.6.2 Bats

The status of native terrestrial bats on Desecheo is unknown. Wetmore (1918) reported "a few bats" on the island in 1912, which Breckon (1998) later speculated to be the fish-eating bat *Noctilo leporinus*. In June 2010 during field surveys, several micro-bats were observed in the evenings around the helicopter landing-pad, but were not identified. A total of 13 species of bats occur in Puerto Rico, including six endemic subspecies: greater bulldog bat (*Noctilio leporinus*), Antillean ghost-faced bat (*Mormoops blainvillii*), Parnell's mustached bat (*Pteronotus parnellii*), sooty mustached bait (*Pteronotus quadridens*), Jamaican fruit bat (*Artibeus jamaicensis*), Antillean fruit bat (*Brachyphylla cavernarum*), brown flower bat (*Erophylla sezekoni bombifrons*), Leach's single leaf bat (*Monophyllus redmani*), red fruit bat (*Stenoderma rufum*), big brown bat (*Eptesicus fuscus*), Eastern red bat (*Lasiurus borealis*), velvety free-tailed bat (*Molossus molossus*) and Brazilian free-tailed bat (*Tadarida brasiliensis*) (Baker and Genoways 1979, García et al. 2005).

3.6.3 Invertebrates

Three endemic invertebrates are known to occur on Desecheo, two spiders (*Clubiona desecheonis* [Clubionidae] and *Camillina desecheonis* [Gnaphosidae; previously *Zelotes desecheonis*]) and a whip scorpion (*Schizomus desecheo* [Schizomidae]) (Platnick and Shadab 1982, Camilo and Cokendolpher 1988). The whip scorpion is believed to be restricted to the central valley of island due to a lack of suitable vegetation and leaf litter elsewhere (Camilo and Cokendolpher 1988). It is probably preyed upon by rats, while goats have also restricted its available habitat by altering vegetation. Little is known about the invertebrate fauna of the island and other island endemics may remain undiscovered.

Hermit crabs (*Coenobita clypeatus*) and land crabs (*Gecarcinus ruricola*) are present on the island, with hermit crabs being more abundant. Regional populations of both species are declining, probably as a result of over-harvesting for human consumption and fish bait (Nieves-Rivera and Williams Jr. 2003). Crab harvesting is prohibited on Desecheo, and unauthorized harvesting is unlikely.

3.6.4 Introduced Non-native and Invasive Mammals

Feral goats (*Capra hircus*) were present on the island in 1788, but by 1912 may have disappeared (Wetmore 1918) because no other authors reported their presence until the

late 1960s (Woodbury et al. 1971). However, by the 1990s goat presence was on the rise and there were obvious signs of impact including decimation of vegetation and significant erosion. An eradication campaign began in 1998 (Earsom 2003b) and goats were completely removed by 2010 (K. Campbell pers. comm.).

Feral cats (*Felis silvestris catus*) were reported from Desecheo in 1966 (Morrison and Menzel 1972). Between 1985 and 1987, nine male cats were removed from the island, which at the time were believed to be a recent introduction (Morrison and Menzel 1972, Evans 1989). No cats have been reported since the last cat was removed in 1987.

In 1966, 56 rhesus macaques were introduced to Desecheo as part of a research program initiated by the National Institutes for Health, U.S. Department of Health, Education and Welfare. Because of their impact on seabird colonies (Noble and Meier 1989), several attempts were made to remove them from the island but without success (Herbert 1987, Evans 1989). Since 2009, the Service and Island Conservation have conducted another macaque eradication effort and greatly reduced their population; at this time only one animal is known to remain. Personnel will continue the effort until complete removal has been confirmed.

3.6.4.1 Black Rats

Black rats (*Rattus rattus*) were first reported and collected from Desecheo in 1912, at which time they were abundant (Wetmore 1918). Black rats are native to the Indian subcontinent, but are now widespread as an invasive species around the world. They are more arboreal-living than brown rats (*R. norvegicus*) or Polynesian rats (*R. exulans*), but equally spend much time on the ground.

Rats are omnivorous generalists, adapting their feeding habits constantly to exploit the most nutrient-rich and easiest to obtain food items in their environment. However, they are also considered "neophobic," or wary of novel objects in their environment including potential food items. Rats will often avoid novel food items completely at first, then sample small amounts, and only wholly consume new food items after multiple exposure events. Rats on Desecheo have been documented eating juvenile anoles and many mature racers show scarring on their tails, thought to be caused by rodents (Island Conservation 2010c).

Populations of rats in temperate regions undergo winter seasonal declines due to the depletion of natural food resources and lack of breeding. Because of milder climates, and availability of year-round food resources, abundance of rats in tropical climates is generally higher than in colder, temperate regions. In contrast to temperate regions, high densities of rats are more common in the wetter tropical winter months, and a decline in rat abundance and reproductive status occurs in the drier summer months, though this may also be driven by day-length as well as seasonal climate changes (Tamarin and Malecha 1971, 1972, Madsen and Shine 1999). On Desecheo therefore, the rat population is likely higher than on an island of comparable size in a temperate region and likely breeds throughout most of the year with no clearly definable breeding season. However, during two, two-week field

surveys in February and March 2009 and 2010 (the dry season), no signs of fetal development or obvious lactation were observed in trapped female rats. Although no population studies of black rats have been carried out on Desecheo, other studies have similarly demonstrated year-round breeding of black rats in tropical climates (Strecker et al. 1962, Brooks et al. 1994, Tobin et al. 1994).

3.7 Intertidal and Nearshore Ecosystems on Desecheo

Puerto Rico has one of the largest contiguous coral reef systems in the US Caribbean region; and comprises the archipelago and nine nautical miles surrounding the islands (Aguilar-Perera et al. 2006). The waters surrounding Desecheo support a diversity of habitats including coral, rock reefs, and sponge-encrusted walls that stretches to depths of 500 m to 3,000 m (Schärer 2004). Desecheo is adjacent to one of the deepest coral reefs in the archipelago, reaching depths of up to 131 ft (40 m) (García-Sais et al. 2004, referenced in García-Sais et al. 2008a). The northern section of the island has a narrow insular platform due to the strong wave action, limiting the area where coral reefs can develop. Conversely, the southern section of the island has a wider platform where a vast reef has developed (García-Sais et al. 2008a). The coral reefs located off the southern shores of the island are considered some of the best formations in the Puerto Rico archipelago, but the reefs cover a relatively small proportion of the insular shelf of the island; most reefs are at depths greater than 15 m (Schärer 2004) and are best developed in the areas between 20 and 25 m depth (García-Sais 2010). In general, the reefs are comprised of approximately 44 percent hard coral, 25 percent algae, 4 percent soft coral and 11 percent other organisms. The remaining 16 percent of the bottom cover is comprised of sand and rock (ReefKeeper International and Comité ProFondo Marino de Desecheo 1997) (see map of benthic habitat in Appendix IX (c)).

The southwest wall reef of Desecheo is found at depths between 30-40 m and is dominated by benthic macroalgae (mostly *Lobophora variegata*), sand, sponges and massive scleractinian corals (García-Sais et al. 2008a). Sponges comprise a significant proportion of surface cover and grow mostly as large erect and branching forms that provide substantial topographic relief and protective habitat for fishes and invertebrates. In many instances, sponges grow attached to stony corals forming sponge-coral associations of considerable size. A total of 25 scleractinian corals, three hydrocorals and two black coral species were identified from the southwest wall reef at Isla Desecheo. Great star corals (*M. cavernosa*, *M. annularis* complex) were the dominant species of scleractinian corals at the site. Rhodolith reefs have developed along gently sloping terraces below depths of 40 m at Desecheo. Agelas reef off Desecheo is an area of very low topographic relief and supports a crustose algal rhodolith formation colonized by encrusting brown algae (*Lobophora variegata*), large erect and branching sponges (*Agelas* spp., *Aplysina* spp.) and lettuce corals (*Agaricia* spp) found at depths of 40-70 m (García-Sais et al. 2008a). The sessile-benthic biota, including corals, grows attached to a vast deposit of rhodolite nodules that are loosely anchored to the bottom. Reef substrate cover by live biota is over 95 percent. A total of 18 species of scleractinian corals, two hydrozoans (*Millepora alcicornis* and *Stylaster roseus*) and the black wire coral (*Stichopathes lutkeni*) have been reported from Agelas reef (García-Sais et

al. 2008a). This reef provides important residential and foraging habitats for large, commercially exploited reef fish populations and serve as recruitment habitats for a variety of shallow reef fish populations.

The dominant coral species surrounding the island include the boulder star coral (*Montastrea annularis*), finger coral (*Porites porites*), lettuce coral (*Agaricia agaricites*), mustard-hill coral (*P. astreodes*) and great star coral (*M. cavernosa*) (García-Sais et al. 2008b). Additionally, the federally listed threatened staghorn coral (*Acropora cervicornis*) (NOAA 2011e) can be found on the Candyland Reef off the southwestern coast of Desecheo. Elkhorn coral (*Acropora palmata*) is also federally listed as threatened and is likely present in the shallow waters around Desecheo (National Marine Fisheries Service, pers. comm.); however, no studies confirm this. NMFS designated waters around Puerto Rico and associated islands as Designated Critical Habitat for elkhorn and staghorn corals; this includes all waters in the depths of 98 ft (30 m) and shallower to the mean low water line (NOAA 2010). Three additional coral species found or suspected to be present at Desecheo are now considered "Candidate Species" for ESA listing: *Montastraea annularis*, *M. faveolata*, *M. franksi* (Federal Register 2010). A final determination as to whether any of these species warrant listing as threatened or endangered will be made in the near future (NOAA 2011a).

The Government of Puerto Rico has designated the coral reef surrounding Desecheo as a Marine Protected Area (MPA) with the legal designation as a Marine Reserve and a no-take zone (Law 57, 2000) (Valdés-Pizzini et al. 2011)(Appendix IX). Furthermore, the Desecheo Island Marine Reserve managed by the Puerto Rico DNER is considered a "high-priority monitoring site" (García-Sais et al. 2008a). In the late 1990s, the reef was considered to be in pristine condition (ReefKeeper International and Comité ProFondo Marino de Desecheo 1997), and during several surveys in the early 2000s, the reefs surrounding Desecheo were found to be very healthy with only 1–10 percent coral sickness and 1–5 percent coral bleaching depending on the season. García-Sais et al. (2001) stated that if live coral cover is used as the main criteria, the coral reef system off Puerto de los Botes and Puerto Canoas at Desecheo rank among the best developed of Puerto Rico. However, although some corals in the Desecheo Marine Reserve have shown higher growth rate in comparison to other localities in Puerto Rico (García-Ureña 2004 *in* Valdés-Pizzini et al. 2011), recent studies have documented a massive loss of some species. In 1998, the coral cover in the Marine Reserve was between 38 percent and 52 percent, and most of the colonies (93 – 98 percent) were free of disease and bleaching (Reefkeeper International, 1998). But between 2000 and 2008, 95 percent of the live coverage of *Montastraea annularis* complex was lost. Most of this loss is due to the yellow band disease, documented since 1999, and the white plague which increased after a mass bleaching event in 2005. On average, a loss of 32 percent of the *Montastraea annularis* complex colonies was reported at three sites off Desecheo; *Montastrea annularis* and *M. faveolata* now comprise about 19 percent of all corals off Desecheo (Garcia-Sais et al. 2008a, Bruckner and Hill 2009). However, all other species showed minimal declines or slight increases, with a net reduction of only 1.5 percent in colonies 10 cm or larger.

The dominant fish species surrounding Desecheo include: blue chromis (*Chromis cyanea*), brown chromis (*Chromis multilineata*), fairy basslet (*Gramma loreto*), masked goby (*Coryphopterus personatus*), peppermint goby (*Coryphopterus lipernes*), creole wrasse (*Clepticus parrae*), bluehead wrasse (*Thalassoma bifasciatum*), yellow-head wrasse (*Halichoeres garnoti*), clown wrasse (*Halichoeres maculipinna*), bicolor damselfish (*Stegastes partitus*) and the sharknose goby (*Gobiosoma evelynae*) (García-Sais et al. 2008b). Fish populations have also showed a general declining trend in abundance and species diversity at survey sites off Desecheo; it is uncertain if the decline in reef fish species is associated with the massive coral mortality in the reef systems (Garcia-Sais et al 2008a).

The federally listed green sea turtle (*Chelonia mydas*) (Threatened) and hawksbill sea turtle (*Eretmochelys imbricata*) (Endangered) have been observed in the marine environment immediately adjacent to Desecheo. While the marine environment around Desecheo does not support the sea grass beds that are typical foraging habitat of green turtles, individuals were observed relatively frequently during tagging surveys between 1999 and 2009; 12 animals captured measured 27.7 - 50 cms in size indicating animals could have been between five and 10 years of age (Zug and Glor 1998, Diez et al. 2010).

Hawksbill turtle is the more common visitor to Desecheo feeding on sponges on the island's reefs. While Desecheo does not support typical sandy-beach nesting habitat for marine turtles (Schärer 2004), apparent signs of nesting by hawksbill turtle on a gravel beach was observed in 1986 and 1987 (Evans 1989), and incidental nesting has been documented on the small beach close to the helipad in the southwest of the island. During surveys between 1999 and 2009, a total of 146 individual hawksbill turtles were captured and tagged; most individuals were captured off the southeast and southwest shores (see Appendix IX (d)). Smaller individuals were more frequently caught suggesting that Desecheo Island is a developmental habitat for hawksbill turtles; only once was an adult male hawksbill observed in the area (Diez et al. 2010). Recaptures and resightings of some of the same individuals at Desecheo suggested that some juveniles have a limited home range. However, 85 percent of juveniles at Mona Island disperse or die (Diez and Van Dam 2000 cited in Diez et al. 2010) and dispersal of one juvenile from Mona to Desecheo Island (a distance of 53 kms) indicates that migration to other habitats does occur (Diez et al. 2010).

The federally listed leatherback turtle (*Dermochelys coriacea*) (Endangered) is known to nest within the U.S. Caribbean Region, in the U.S. Virgin Islands (St. Croix, St. Thomas, St. John), and on Culebra, Vieques and Mona islands, and on mainland Puerto Rico. Leatherback turtles have not been reported in waters offshore of Desecheo Island, and it is considered an unlikely nesting site as the island does not support the appropriate beach-nesting habitat.

3.8 Marine Mammals

A total of 17 species of whale and dolphin have been recorded from the waters around Puerto Rico, the U.S. Virgin Islands and the British Virgin Islands. While some species are

seen year-round, sightings generally increase in December, peak in February, and decrease in March (Mignucci-Giannoni 1998). The most common species is the humpback whale (*Megaptera novaeangliae*), which comprised 79 percent of all sightings between 1952 – 1989 (Mignucci-Giannoni 1998). In the western Atlantic, humpback whales breed mainly along the Antillean chain, but concentrate in the north-central and northeastern Caribbean in areas less than 200 m deep. Here the main breeding and calving grounds are restricted to two small banks north of the Dominican Republic. Humpback whales are usually sighted in small groups averaging two individuals and are considered a largely transient population with individuals staying no longer than two weeks, with the exception of mother-calf aggregations which are seen more repeatedly. A major concentration of humpback whales has been recorded along the northwestern coast of Puerto Rico where animals aggregate off Punta Higüero in Rincón and off Punta Agujereada in Aguadilla. Whales have also been observed near Mona and Desecheo islands. In the northeastern Caribbean, humpback whales have a marked seasonality between November and May, with the peak of the season from the first two weeks of February through to the middle of March.

Other records of whales and dolphins seen offshore of Desecheo Island include shortfin pilot whales (*Globicephala macrorhyncus*), spinner dolphins (*Stenella longirostris*) and minke whales (*Balaenoptera acutorostrata*). The other 13 species seen within the region, including offshore of Mona Island, include common dolphin (*Delphinus spp.*), Risso's dolphin (*Grampus griseus*), killer whale (*Orcinus orca*), false killer whale (*Pseudorca crassidens*), Atlantic spotted dolphin (*Stenella frontalis*), roughtooth dolphin (*Steno bredanensis*), bottlenose dolphin (*Tursiops truncates*), pygmy sperm whale (*Kogia breviceps*) (from strandings only), sperm whale (*Physeter macrocephalus*), Cuvier's beaked whale (*Ziphius cavirostris*), sei whale (*Balaenoptera borealis*) and fin whale (*B. physalus*). One additional species, the striped dolphin (*Stenella coeruleoalba*), is only known from a skull found in St. Croix.

The West Indian (Antillean) manatee population in Puerto Rico is very small, with just over 100 animals recorded, and widely distributed (Powell et al. 1981, Mignucci-Giannoni et al. 2000). They are most common along coastlines with a wide coastline shelf and numerous bays that provide calm seas, extensive seagrass beds and freshwater. However, the manatee is the marine mammal most commonly found dead in Puerto Rico waters accounting for 44 percent of all marine mammal stranding records in Puerto Rico since 1980 (Mignucci-Giannoni et al. 2000). Causes of mortality have been attributed to hunting, accidental nest entanglement, watercraft collision, capture and other human-related interactions.

3.9 Terrestrial Vegetation

Desecheo Island falls within the subtropical dry forest life zone, and is dominated by seasonal deciduous woodlands in the valleys and lower slopes, with shrubs, grass and cactus communities that dominate the ridges and exposed slopes (Breckon 2000, Helmer et al. 2002).

Woodbury et al. (1971) described the vegetation of Desecheo as a mosaic of grassy patches, shrubland, woodland with candelabra cacti and semi-deciduous forest. The semi-deciduous forest is dominated by *Bursera simaruba*, and is found mostly in the more mesic valleys and ravines. Much of the vegetation senesces during the dry season (November - March). The floristic diversity of the island has been dramatically reduced by the impacts of goats, macaques, rats, and to a lesser extent, man (Breckon 2000). In a revision of the flora of the island, Breckon (Breckon 2000) documents 64 suspected extirpations from an original flora of 166 plant species. However, since the significant reduction in the numbers of goats on the island, vegetation biomass has increased (J. Schwagerl pers. comm. 2007), but plant diversity post-recovery has yet to be documented. Desecheo has no endemic plants, but is home to seven species endemic to the Greater Antilles and adjacent islands, as well as the federally listed higo chumbo (Threatened), a night-flowering cactus (Breckon 2000). This species has been extirpated from mainland Puerto Rico and is restricted to Mona, Monito and Desecheo islands.

3.10 Threatened and Endangered Species listed under ESA

The higo chumbo (Threatened) is found on Desecheo, Mona and Monito islands. It was once relatively common in southwest Puerto Rico. Populations on Desecheo Island are much reduced with only nine individuals accounted for in 2003 (U.S. Fish and Wildlife Service 2010a). Recent surveys in 2010 and 2011 have located 39 known individuals or clusters of plants, and morphological traits of the plants suggested recent growth had occurred since the reduction in the numbers of feral goats and introduced macaques (Island Conservation unpubl. data). Goats and macaques have been reported as feeding on the cactus.

The hawksbill sea turtle (Endangered) is frequently observed in the waters around Desecheo, which provide excellent foraging grounds, although the island does not appear to provide appropriate nesting habitat.

The green sea turtle (Threatened) may occasionally be found in the waters around Desecheo, although the nearshore habitat does not provide extensive seagrass beds preferred by foraging green turtles. The very limited beaches on Desecheo Island are unlikely to provide nesting habitat for this species.

The leatherback turtle (Endangered) has not been reported in waters offshore of Desecheo, and the island does not support the appropriate beach-nesting habitat. However, the species is pelagic, and known to nest on Mona Island, located 33 miles (53 km) to the southwest of Desecheo, so occasional sightings of animals offshore of Desecheo would not be unusual.

The staghorn coral (*Acropora cervicornis*) (Threatened) is known from Candyland Reef, approximately a quarter mile to the southwest of Desecheo. Elkhorn coral (*Acropora palmata*) (Threatened) is also likely to occur in the Desecheo reefs but has not yet been recorded.

The humpback whale (Endangered) has been frequently reported offshore of Desecheo, especially in the winter period December to March.

The endangered fin whale, sei whale, killer whale and sperm whale have not been reported offshore of Desecheo but have been observed within the region including offshore of Mona Island 33 miles (53 km) to the southwest of Desecheo.

The brown pelican, which is a regional resident, was delisted in November 2009.

3.11 Social and Economic Environment

3.11.1 History

In 1912, 14 years after Spain ceded control of Puerto Rico to the United States, President Taft designated Desecheo as a reserve for nesting and breeding seabird populations. In 1940, President Franklin Roosevelt transferred ownership to the War Department, which used the island as a bombing range until 1952. From 1952 until 1960 the US Air Force used the island as a center for survival training. In 1966, the island was transferred to the National Institutes of Health, who introduced 56 rhesus macaques to the island for medical research. Finally, in 1976 Desecheo was transferred to the Service and was designated as a National Wildlife Refuge for the purpose of the protection and restoration of seabirds.

Historically, Desecheo has been used for a number of human activities. Both before and after the island was granted protected status in 1912, farmers and fishermen attempted to introduce cattle and clear forests for crops, and harvested eggs and birds from the seabird rookeries. Upon the outbreak of World War II the island was used as a bombing and gunnery range, and then as a survival training site. In 1965 it was declared surplus property by the military, and in July 1966 it was acquired by the U.S. Department of Health, Education and Welfare, under whose direction a rhesus macaque colony was established in 1966 (Morrison and Menzel 1972).

Desecheo has two bombing range areas that were established during World War II. Bombing Range East and Bombing Range West are each 649 acres and were intended for high-level radar bombing and gunnery exercises that used small arms of 100 lb or less. In addition, there is a large water catchment pad located on the western side of the island, which now allows access to the island by helicopter.

3.11.2 Ownership, Management and Major Stakeholders

The Desecheo Island NWR is administered as part of the Caribbean Islands NWR Complex. The NWR includes the terrestrial environment of Desecheo Island and surrounding offshore islets. The waters surrounding Desecheo are managed by the Puerto Rico Department of Natural and Environmental Resources as a 677 ha no-take Marine Reserve

(Aguilar-Perera et al. 2006, Valdés-Pizzini et al 2011). This reserve is one of two legally recognized marine reserves in Puerto Rico, although 35 other marine protected areas exist.

3.11.3 Recreational and Aesthetic Uses

Desecheo is not open to the public without a Special Use Permit (SUP) and does not support any regular recreational activities or provide any services to the general public.

The marine environment surrounding Desecheo is regularly used for recreational diving and snorkeling. Additionally, fishing boats may occasionally land on the island to wait out severe storms. Access to Desecheo is difficult because of extremely strong currents, a limited number of landing sites, and large offshore rocks. When conditions are favorable, there are three beaches that small boats could generally land on in the morning (Breckon 1998).

3.11.4 Unauthorized Uses

Desecheo is occasionally used as a stopover point for illegal drug traffickers, and immigrants attempting to enter the United States illegally. During the 1990s there was an average of three reported boat landings on Desecheo by illegal immigrants per year with an estimated 125 individuals apprehended yearly in the waters nearby. In the last three years, there have been five reported landings onto Desecheo and an average of 60 individuals apprehended each year from the island. The majority of apprehended individuals are from Cuba and the Dominican Republic (U.S. Fish and Wildlife Service, unpubl. data).

Recreational boaters and fishermen may also occasionally land on Desecheo to explore, or to harvest marine resources (such as the West Indian topshell, *Cittarum pica*) from the nearby reefs (in violation of Marine Reserve regulations). This use pattern is considered uncommon (U.S. Fish and Wildlife Service pers. comm.).

3.11.5 Historical and Cultural Resources and Values

There are no known historical or cultural resources on Desecheo, and no pre-Columbian era artifacts known from the island.

4 ENVIRONMENTAL CONSEQUENCES

4.1 Purpose and Structure of Environmental Consequences

Chapter 4 analyzes the environmental consequences of the alternatives as presented in Chapter 2. For comparative purposes, Chapter 4 also includes a similar analysis of the consequences of taking no action to address the problem of invasive black rats on Desecheo Island. The purpose of the impacts analysis in this chapter is to determine whether or not any of the environmental consequences identified may be significant.

The concept of significance, according to CEQ regulations (40 CFR 1508.27), is composed of both the *context* in which an action will occur and the *intensity* of that action on the aspect of the environment being analyzed. "Context" is the setting within which an impact is analyzed, such as a particular locality, the affected region, or society as a whole. "Intensity" is a measure of the severity of an impact. Determining the intensity of an impact requires consideration of the appropriate context of that impact as well as a number of other considerations, including the following:

- The degree to which an action affects *public health or safety*.
- *Unique characteristics of the geographic area* (e.g. historical or cultural significance, specially protected lands, ecologically critical areas).
- The degree to which the impacts of an action are likely to be *highly controversial*. The degree to which the possible impacts of an action are *highly uncertain, or involve unique or unknown risks*.
- The degree to which an action may i) *establish a precedent* for future actions with significant effects; and/or ii) *represent a decision in principle* about a future consideration.
- Whether an action is related to other actions with individually insignificant but *cumulatively significant impacts*. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment.
- The degree to which an action may adversely affect properties listed in or eligible for listing in the National Register of Historic Places, or may cause *loss or destruction of significant scientific, cultural, or historical resources*.
- The degree to which an action may *adversely affect an endangered or threatened species or critical habitat as listed under the ESA*.
- Whether the action *threatens a violation of Federal, State, or local law* or requirements imposed for the protection of the environment.
- Environmental Issues Addressed

Impacts may be both *beneficial* and *adverse*. A significant effect may exist even if on balance the effect will be beneficial.

4.2 Scope for Environmental Issue

The Service compiled a list of major environmental issues, or impact topics that warranted specific consideration in this analysis. This list of issues was compiled through a scoping process that included informal discussions with representatives from government agencies and individuals with relevant expertise or a stake in Desecheo Island (see Section 1.8).

In the analysis below, the potential significance of effects of each action alternative and the no action alternative will be discussed on a case-by-case basis for each environmental issue considered.

4.3 Impact Topic

The impact topics analyzed in this document include:

- Impacts to physical resources
- Water resources
- Geology and soils
- Impacts to biological resources
- Impacts to species vulnerable to toxicant use
- Terrestrial and intertidal foragers
- Impacts to species vulnerable to disturbance
- Indirect effects to biological resources
- Impacts to the social and economic environment
- Impacts to refuge visitors and recreation
- Impacts to historical and cultural resources
- Cumulative impacts
- Irreversible or irretrievable commitment of resources
- Relationship of short-term uses to long-term productivity

Brief descriptions of many of these topics can be found in Section 1.8.

4.4 Aspects of the Environment Excluded from Detailed Analysis (with Rationale)

4.4.1 Air Quality

Impacts of the action alternatives on air quality at Desecheo Island will not be analyzed in detail because there are no activities proposed that would represent a measurable change from the background levels of air pollution caused by nearby water- and aircraft. The brief, localized helicopter operations that would occur as part of each action alternative would have no more than a negligible contribution to local or regional changes in air quality.

4.4.2 Environmental Justice

The impacts of the action alternatives on environmental justice, mandated by Executive Order 12898 of 1994 to identify and address the potential for disproportionate placement of adverse environmental, economic, social, or health impacts on minority and low-income populations, will not be analyzed in detail because there are no minority or low-income populations that would be affected by any of the action alternatives.

4.4.3 Marine Mammals

Potential impacts of rat eradication activities to cetaceans in the waters surrounding Desecheo will not be analyzed in this EA, except to establish the threshold for significance to federally listed and MMPA species. The likelihood of cetacean exposure to brodifacoum or diphacinone would be negligible. Both brodifacoum and diphacinone have low solubility in water (brodifacoum 0.24 mg/L at pH 7.4, (Environmental Protection Agency 1998); diphacinone 0.3 mg/L (Extoxnet 1996)), and their large masses would require marine mammals to consume enormous quantities of bait to manifest even a sublethal response from the rodenticide.

There is potential to physically disturb cetaceans with the use of boats around the island of Desecheo as apart of the eradication operations. NOAA (2008) has established protocols for mariners to avoid vessel collisions with marine life (Appendix X). Small boats will be used during the eradication operations and boat operators will be briefed on NOAA protocols. Additional information on the issue of bait operations and relevance to marine mammals can be found in Appendix XIV.

4.4.4 Marine Fish

Potential impacts of rat eradication activities to marine fish in the waters surrounding Desecheo will not be analyzed in this EA because the likelihood of any of the action alternatives having measurable impacts on fish populations is negligible:

- The number of bait pellets that would enter the marine environment as a result of aerial bait broadcast, would be low as a result of the mitigation measures described in the Alternatives chapter (Chapter 2) for avoiding bait application into the ocean.
- In bait disintegration trials on Desecheo, placebo Brodifacoum-25D test baits had either disintegrated or been flushed from the immediate environment within 30 minutes, and fish were largely uninterested (Island Conservation 2010b).
- In bait disintegration trials in New Zealand, non-toxic test baits distributed in the sea disintegrated within 15 minutes (Empson and Miskelly 1999).
- In tests in southern California, Alaska, Hawaii and the equatorial Pacific, marine fish species have mostly demonstrated no interest in placebo bait pellets that entered the water nearby (Howald et al. 2005a, Buckelew et al. 2006, Island Conservation unpubl. data).
- In tests on Palmyra atoll, 20 fish species showed no interest in bait pellets dropped into the water column during the first three trials. However, in subsequent trials, six

fish species 'mouthed', grabbed or ate bait pellets, indicating that increasing exposure might increase a response in fish (Island Conservation 2010a).

- The waters immediately surrounding Desecheo are extremely deep with depths up to 130 feet. For this reason, most fish would have to consume bait as it is dropping through the water column.
- Surveys of marine fish after rat eradication on Kapiti Island (New Zealand) showed no evidence that fish densities were affected by the operation (Empson and Miskelly 1999).
- After an accidental spill of 20 tones of brodifacoum bait into marine waters in New Zealand in 2001, measureable concentrations of brodifacoum were detected in the water 36 hours after the spill, but which were below MLD (< 0.02 ppm) by day nine. Residues in fish samples collected 14-16 days after the spill were below MLD.
- Both brodifacoum and diphacinone have low solubility in water (brodifacoum 0.24 mg/L at pH 7.4, (Environmental Protection Agency 1998); diphacinone 0.3 mg/L (Extoxnet 1996)).
- After two aerial rat eradication operations in Hawaii in 2008 and 2009, no detectable levels of diphacinone were detected in samples of several fish species (Gale et al. 2008, Orazio et al. 2009).
- During a rat eradication on Anacapa Island divers observed fish behavior in relation to bait that accidentally entered the marine environment; no fish were observed consuming bait. All fish and seawater samples tested negative for brodifacoum concentration post application (Howald et al. 2010).

Additional information on the issue of bait operations and relevance to the marine enviroment can be found in Appendix XIV.

4.4.5 Staghorn and Elkhorn Coral

Potential impacts of rat eradication activities to the federally listed staghorn and elkhorn coral in the waters surrounding Desecheo will not be analyzed in this EA, except to establish the threshold for significance to the listed species. The likelihood of coral exposure to brodifacoum or diphacinone would be negligible. Staghorn coral is known to be located at the Puerto de los Botes and Puerto Canoas reefs approximately one quarter mile from the coast of Desecheo at depths of 15 – 23 m (García-Sais et al. 2001); however, researchers believe that staghorn and elkhorn corals may be found closer to Desecheo and at shallower depths. To our knowledge, no studies have addressed the affects of rodenticides on coral species; however, data suggests that invertebrates are largely not affected (see Section 4.6.3.5). Therefore, the likelihood of coral exposure to any toxicants that may enter the water is negligible due to the distance the corals are from Desecheo, the rapid wave action that would likely disperse the toxicants and the low likelihood the toxicants would affect the invertebrates. In addition, both brodifacoum and diphacinone have low solubility in water (brodifacoum 0.24 mg/L at pH 7.4, (Environmental Protection Agency 1998); diphacinone 0.3 mg/L (Extoxnet 1996))

There is potential to physically disturb and/or damage corals with the use of boats around the island of Desecheo as apart of the eradication operations. NOAA (2008) has established

protocols for mariners to avoid vessel collisions with marine life (Appendix X). Small boats will be used during the eradication operations and boat operators will be briefed on NOAA protocols as well as advised on the location of mooring buoys and how and where to avoid shallow reef areas around Desecheo (Appendix IX). Additional information on the issue of bait operations and relevance to threatened corals can be found in Appendix XIV.

4.5 Consequences: Physical Resources

4.5.1 Water Resources

4.5.1.1 Analysis Framework for Water Resources

Significant water quality impacts were analyzed for the identified action alternatives with respect to potentially adverse physical and biological impacts from bait application on Desecheo Island. Water quality in the Puerto Rico is regulated by the Environmental Quality Board, which requires state waters to meet minimum criteria for a number of designated uses.

Rats on Desecheo are frequently found on and around the shoreline. For this reason, it is essential that managers apply the rodenticide on and around the shoreline to ensure the elimination of invasive rats from the island, but with a minimal amount of bait drift into the surrounding water. At this time, additional permitting for aerial pesticide use around the shoreline would be required to comply with EPA's current CWA guidelines because bait drift into any waterway of the United States including oceans and seas requires an NPDES permit.

While the federal Clean Water Act (CWA) prohibits the discharge of "pollutants" into waters of the United States, in 2007 the EPA clarified its interpretation of the term "pollutant" to exclude pesticides that may unavoidably enter the water while being applied to control pests that occur "over, including near" water bodies (71 CFR 227 pp. 68483-68492). This ruling was vacated by the 6th Circuit Court of Appeals in 2009; subsequently EPA was granted a stay until April 9, 2011. Concurrence with the Clean Water Act NPDES permitting requirements for this EA will be adhered to; it is anticipated that some bait would accidentally drift into the waters surrounding Desecheo during rat eradication activities in 2012.

There are no natural sources of freshwater or drinking water on Desecheo.

4.5.1.2 Alternative A: No Action

Under the No Action alternative, there would be no bait drift into the nearshore marine waters.

4.5.1.3 Alternatives B and C

Some bait pellets would likely drift into the nearshore marine waters surrounding Desecheo during aerial bait application operations. However, the bait application techniques described would include mitigation measures to limit bait entry into water bodies to a level well under the target bait application rate for the adjacent shoreline.

Even if bait does enter water bodies around Desecheo at the maximum application rate, it would be very unlikely to contribute to detectable levels of brodifacoum in the water column. The low water solubility and strong chemical affinity of brodifacoum to the grain matrix of the bait pellets largely prevents the rodenticide from entering aquatic environments, either directly or via run-off.

Environmental testing during rodent eradications and eradication trials in the California Current marine system and elsewhere have failed to detect brodifacoum in any seawater samples taken after bait application (Howald et al. 2005a, Buckelew et al. 2006, Buckelew et al. 2009, Island Conservation unpubl. data). However, during a rat eradication operation on Rat Island in the Aleutians, Alaska, in 2008, brodifaoum residue levels above MLD were detected in two (out of 22) freshwater samples collected from two inland freshwater lakes. Because direct bait application to the freshwater lakes was prevented through aerial application exclusion zones around the lakes which were baited by hand, it was concluded that the residue detections could have arisen from: (a) sample contamination by the collector, (b) wind-blown bait drift into the lakes from hand-baiting operations, or (c) run-off from streams (which were not excluded from baiting) into lake systems. Modeling the number of bait pellets required to achieve the residue levels detected, a bait fragment one percent the size of a bait pellet (2 g) would result in a residue concentration > 20 times greater than those detected. Therefore, contamination from a minute bait particle from a hand or clothing during sample collection could have been sufficient to result in the residue detected (Buckelew et al. 2009).

Water supplies for personnel on Desecheo would be brought to the island in enclosed water containers and protected from bait entry during bait application activities. In summary, it is estimated that aerial bait application would result in a negligible risk to the marine water column or the drinking water supply.

4.5.1.4 Alternatives D and E

Some bait pellets would likely drift into the nearshore marine waters surrounding Desecheo during aerial bait application operations. However, the bait application techniques described would include mitigation measures to limit bait entry into water bodies to a level well under the target bait application rate to the adjacent shoreline.

Even if bait does enter water bodies around Desecheo at the maximum application rate, it would be very unlikely to contribute to detectable levels of diphacinone in the water column. The low water solubility and strong chemical affinity of diphacinone to the grain matrix of the bait pellets largely prevents the rodenticide from entering aquatic environments, either directly or via run-off.

After the aerial application of 7,800 lbs of diphacinone (Ramik® Green rodent bait pellets) for rat eradication from Lehua Island, Hawaii, in January 2009, no diphacinone was detected in the seawater surrounding Lehua (Orazio et al. 2009). Similarly, after the aerial application of the same product in February 2008 on Mokapu Island, Hawaii, applied at a nominal rate of 10 lbs/acre in two separate applications with coastlines and steep areas treated with twice the bait amount for each application, the concentrations of diphacinone in seawater were below the MLD (90 ng/L) (Gale et al. 2008).

Water supplies for personnel on Desecheo would be brought to the island in enclosed water containers and protected from bait entry during bait application activities. In summary, it is estimated that aerial bait application would result in a negligible risk to the marine water column or the drinking water supply.

4.5.2 Geology and Soils

4.5.2.1 Analysis Framework for Geology and Soils

The major issues of concern for the geology and soil resources of Desecheo are 1) permanent damage to fragmented volcanic rocks, 2) increases in soil erosion, 3) reduction in soil fertility, and 4) contamination of soils.

4.5.2.2 Alternative A: No Action

Under the no action alternative, rats would remain on the island and would continue to burrow in areas with a substantial soil layer. Through comparisons of rat-invaded and rat-free islands, rats have been shown to reduce soil fertility, and the diversity and abundance of soil fauna through the predation of seabirds and consequent disruption of sea-to-land nutrient transfer by seabirds (Fukami et al. 2006, Towns et al. 2009). Consequently, under the no action alternative, soil fertility and invertebrate diversity would remain reduced.

4.5.2.3 Alternatives B and C

The operational activities in Alternatives B and C would not have a noticeable impact on soil erosion, rock formations, or soil contamination. The installation and maintenance of bait stations in limited circumstances may have highly localized impacts to soil and rock but these impacts would not be significant and would primarily be on the shoreline and around the helipad. The extremely low concentration of brodifacoum in bait pellets would not lead to measurable soil contamination. In environmental monitoring after rat eradication on Anacapa Island using brodifacoum pellets, all soil samples collected tested negative for brodifacoum residue (Howald et al. 2010). However, soil tests on Palmyra Atoll in 2010 demonstrated very low concentrations of brodifacoum residue in soil collected directly beneath an individual bait pellet (soil sampled up to 20 cm deep) for up to 50 days, but in only two out of 48 samples tested were concentrations of the toxicant high enough to be quantified, all other samples yielded a zero (undetectable) value (Island Conservation 2010a).

4.5.2.4 Alternatives D and E

The operational activities in Alternatives D and E would not have a noticeable impact on soil erosion, rock formations, or soil contamination. The installation and maintenance of bait stations in limited circumstances may have highly localized impacts to soil and rock but these impacts would not be significant and would primarily be on beaches and around the helipad. The extremely low concentration of diphacinone in bait pellets would not lead to measurable soil contamination. Soil samples collected after diphacinone aerial bait application on Lehua Island in Hawaii resulted in little to no detectable concentrations of diphacinone (Orazio et al. 2009). However, soil tests on Palmyra Atoll in 2010 demonstrated very low concentrations of diphacinone residue in soil collected directly beneath an individual bait pellet (soil sampled up to 20 cms deep) for up to 28 days, but in only two out of 48 samples tested were concentrations of the toxicant high enough to be quantified, all other samples yielded a zero (undetectable) or 'trace' value (Island Conservation 2010a).

4.6 Consequences: Biological Resources

4.6.1 Introduction

In order for this project to be considered a restoration success, the long-term benefits of rat eradication must outweigh any potential ecosystem impact associated with project implementation. The eradication of rats is expected to have benefits for a number of animals and plants that are currently being negatively affected by rat presence. However, it is also critical to identify the potential biological impacts of the eradication operations, including mortality and injury to sensitive wildlife species as a result of ingestion of rodenticide and/or disturbance from project operations. Furthermore, it is important to identify any biological resources that are currently dependent on the invasive rat in some capacity and may be negatively affected once rats are removed. This document's analysis of impacts to biological resources will identify both the benefits (positive effects) and the costs (negative effects) of toxicant use and activities that would be used to distribute the bait in order to achieve rat eradication.

While the impacts to the biological resources of each alternative will be examined with respect to individuals of a range of species, the primary focus will be to analyze whether impacts to a particular resource (species or taxonomic group) could be considered significant according to the general significance criteria described in Section 4.6.2. The concept of significance will be defined separately for each topic analyzed. In some cases, impacts at the individual level (i.e. mortality or modified behavior) must be considered significant if the individual is a species of concern (listed as threatened or endangered on the ESA) unless the impacts to that individual can be mitigated to below significant levels. One example of this scenario is the impact that project implementation has on ESA listed species. In the majority of cases on Desecheo, impacts to individual organisms, however major, may not qualify as a significant impact to the population. In other words, species with relatively large populations are unlikely to be negatively harmed from project implementation because they typically have a large range and are capable of quickly

recovering from impacts. Results from species specific risk analyses will contribute to the overall analysis of significance for each species but should not be considered interchangeable with the significance determination for each impact topic. Significance for non-listed species is any action that will likely impact the regional or global population of the given species.

While the impacts of each alternative can be analyzed with considerable confidence over the short term, it is more difficult to accurately predict specific long-term responses to rat eradication. While the overall determination of the ecosystem response to rat eradication on Desecheo includes too many variables to analyze with precision in this document, data from other island rat eradications can be used to predict long-term ecosystem responses. Whenever possible, these data will be used to help determine long-term effects in the analysis sections below. Additionally, the four action alternatives will analyze for both direct and indirect effects from toxicant exposure, toxicological risk, disturbance risk, and the extent of risk from either the toxicant or disturbance to biological resources. Finally, cumulative impacts will be analyzed by identifying all of the past, present, and future projects that will likely contribute to the overall impact of the alternatives, and determine the extent of the impact from the combined effects of every identified project to the biological and physical resources on Desecheo.

4.6.2 Assessing Significance of Impacts to Biological Resources

4.6.2.1 Introduction

As described in Section 4.1, the concept of significance is shaped by both the context of an action and the intensity of the action's effects. In the case of the action alternatives analyzed here, the action itself has a very limited, site-specific context. However, many of the species that utilize Desecheo have large global and regional distributional ranges or interact, at a population level, with other individuals that may be distributed over an area much larger than Desecheo. In addition, successful invasive species eradications have demonstrated significant recovery of island populations of various taxa post-eradication, despite some mortality to individuals during or shortly after an eradication operation (see Section 1.4.1.3). Therefore, the most appropriate context within which to consider impacts to biological resources is at the population level rather than the individual level. The intensity of effects is dependent on a multitude of variables that are different for each taxon. This analysis will highlight additional legal protection (ESA listing and Marine Mammal Protection Act (MMPA) listing) to determine the intensity of an impact to a species. In other words, impacts to species that have been assigned specific legal protection under the ESA or MMPA will be considered as "more intense" than similar impacts to unlisted species.

For all biological resources analyzed, except those identified in the "special considerations" section below, the potential for significance will be determined using the following guidelines:

- Is there a high likelihood that the global breeding population of an organism would experience noticeable changes that will not be counteracted by migration?

- Is there a high likelihood that impacts to organisms on Desecheo would be measurable elsewhere in the Insular Caribbean region?

4.6.2.2 Special Significance Considerations for ESA Listed Species

The higo chumbo cactus is the only federally listed endangered species that occurs on Desecheo. There are five additional federally listed species that occur in the marine environment around Desecheo: the endangered hawksbill sea turtle; the endangered leatherback turtle; the threatened green sea turtle; the endangered humpback whale; and the staghorn coral. In addition, the endangered killer whale, sperm whale, fin whale and sei whale have been reported off Mona Island, 30 miles to the southwest of Desecheo. Listing under ESA provides a context for impacts analysis which lowers the threshold of significance. This analysis will identify any ESA-listed species and any ESA-designated critical habitat that may be affected by the alternatives. The Marine Reserve surrounding Desecheo has been classified by National Marine Fisheries Service (NMFS) as critical habitat for the staghorn coral, which will require eradication personnel to mitigate any actions around the coastline during the eradication operation to minimize any potential impacts to designated Critical Habitat. The significance of these impacts will be determined separately, but the ESA-listed status of the species affected will be given special weight. Informal Section 7 ESA consultation indicated that all of the listed species and critical habitat on or near Desecheo are either “not likely to be adversely affected” or “no effect” is anticipated from rat eradication activities.

- For the higo chumbo cactus, the significance threshold for effects will be set at an action that adversely impacts one or more individual cacti.

- For hawksbill, green and leatherback sea turtles, the significance threshold for effects will be set at an action that is likely to cause the mortality of one or more turtle.

- For the staghorn coral the significance threshold for effects will be set at an action that is likely to cause the mortality of one or more coral colonies.

- For humpback, sei, fin, killer and sperm whales, the significance threshold will be set according to the MMPA’s definition of Level A Harassment: “any act which injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild” (MMPA 515.18(A)).

Endangered Species Act (ESA) regulations also oblige Federal agencies to ensure that the actions they take are not likely to “jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat” (ESA Section 7(a)2 1973). If a Federal action is likely to adversely affect an ESA-listed species or

its designated critical habitat, the action agency must initiate a formal process of consultation with either the Service or NMFS to determine whether or not the action will put the potentially affected species in jeopardy of continued survival.

4.6.2.3 Special Significance Considerations for MMPA Listed Species

Listing under MMPA provides a context for impacts analysis which lowers the threshold of significance. The MMPA regulations generally prohibit the killing, injury or disturbance of marine mammals, but permits can be granted allowing exceptions to this prohibition for actions that may impact a marine mammal if the impact is incidental to rather than the intention of the action. This analysis will identify the potential for impacts to marine mammals that may require additional permits under MMPA.

The MMPA listed species that are found near or around Desecheo will be given special significance thresholds to minimize negative impacts to listed marine mammals. Therefore, the significance threshold for impacts to marine mammals will be set at an action that causes the mortality of an individual animal. MMPA regulations prohibit “disturbance” of marine mammals, which is a lower threshold of impact than mortality. Disturbance according to the MMPA definition will not alone constitute a significant impact in this analysis, but other potential circumstances (including cumulative impacts analysis) may nevertheless contribute to an overall determination of significant impacts.

- For all marine mammals found around Desecheo (see Section 3.8 for complete list) the significance threshold will be set according to the MMPA’s definition of Level A Harassment: “any act which injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild” (MMPA 515.18(A)).

4.6.2.4 Special Significance Considerations for Birds Listed under the Migratory Bird Treaty Act (MBTA)

Listing under the Migratory Bird Treaty Act (MBTA) provides a context for impacts analysis which lowers the threshold of significance for this analysis. Take under the MBTA includes the unlawful pursuit, hunt, take, capture, or kill, of any migratory bird, nest, or egg of any such bird. MBTA listed species that are found near or around Desecheo will be given special significance thresholds to minimize negative impacts to listed birds. All of the birds found on Desecheo Island are listed for protection under the MBTA. Therefore, the significance threshold for impacts to birds will be set at an action that causes the mortality of an individual animal.

Under certain circumstances where the goal is eradicating or controlling invasive species, the FWS will provide practitioners with a Special Purpose Permit under the MBTA that allows for the take of listed individuals for “projects where the applicant demonstrates expected benefits to migratory birds. These projects support the Service’s bird conservation mandate and mission and are consistent with the Administration’s emphasis on control of invasive species” (U.S. Fish and Wildlife Service 2010b). The Service will

comply fully with all MBTA requirements prior to the implementation of any of the four action alternatives.

4.6.3 Direct Impacts of Alternative A (No Action) on Biological Resources

4.6.3.1 Introduction

If no action is taken regarding invasive black rats on Desecheo, the impacts that rats are having to the islands' biological resources would continue. This section summarizes the known and suspected impacts from black rats on Desecheo Island's biological resources.

The most pronounced impact of invasive rodents on island ecosystems is the extinction of endemic species. Invasive rats (*Rattus* sp.) are responsible for an estimated 40 – 60percent of all bird and reptile extinctions (Island Conservation analysis of World Conservation Monitoring Centre data)(Atkinson 1985), and have caused the extinction of endemic mammals, birds and invertebrates on islands throughout the world's oceans (Andrews 1909, Hindwood 1940, Daniel and Williams 1984, Meads et al. 1984, Atkinson 1985, Tomich 1986).

4.6.3.2 Impacts to Reptiles

Rats are known to directly depredate smaller reptile species, and there are reported benefits to reptiles from rat eradication (Towns et al. 2001, Bellingham et al. 2009). Pacific rats have been reported to affect the density, demographic structure, recruitment, and body condition of the endemic New Zealand tuatara through direct predation and competition for food (Cree et al. 1995, Towns et al. 2007), and when rats were removed the proportion of juvenile tuatara increased up to 17 fold, and the body condition of adult males and females also improved. Following black rat eradication on offshore islands in Antigua, the endemic population of Antiguan racer (*Alsophis antiguae*) doubled within 18 months (Daltry 2006). In addition, rats consume insects and other invertebrates that many reptiles rely on as a primary food source (Towns et al. 2009, St. Clair et al. 2011)(see Section 1.4.1.1). Rats may also alter the vegetation communities of the landscape by depredating seeds, depressing seedling recruitment and dispersing weed seeds, which likely impact the suitable available habitat for reptiles (Allen et al. 1994, Williams et al. 2000, Campbell and Atkinson 2002). The persistence of rats on the island is likely to continue to negatively impact reptile species and could possibly drive some endemic populations to extinction. The following is a breakdown of the perceived impacts that rats have on reptile species at Desecheo.

<u>Puerto Rico racer</u>
Rat Impacts: Rats alter the floral makeup of the island, which may impact racer habitat. Rats likely prey on juvenile racers and are known elsewhere to cause physical injury to adult *Alsophis* sp. by attacking them (Daltry et al. 2001). Similar evidence of injury from rats has been observed on Desecheo (Figure 4.1). Racer and rat diets overlap in that they both prey upon anoles, geckos and juvenile ameivas, which could act as a source of

competition for resources potentially impacting the racer population on Desecheo. Rat impacts were also been inferred by the doubling of the Antiguan racer population after rat eradication over 18 months (Daltry et al. 2001).

Desecheo ameiva
Rat Impacts: Rats alter the floral makeup of the island, which may impact ameiva habitat. Rats are considered a potential source of competition for resources because ameivas and rats both consume terrestrial invertebrates, juvenile anoles and juvenile geckos. Additionally, rats may impact the demographic structure of the ameiva population through direct predation and indirect competition. It is also likely that rats consume amieva eggs.

Figure 4.1. Scars seen on Puerto Rico racer believed to be a result of rats attacking the racers, Desecheo 2010.

Desecheo anole
Rat Impacts: Rats alter the floral makeup of the island, which may impact anole habitat. Rats are considered a potential source of competition for resources because anoles and rats both consume terrestrial invertebrates. Additionally, rats may impact the demographic structure of the anole population through direct predation and indirect competition. On Desecheo, an observation of a rat attempting to predate a juvenile anole suggests that rats are direct predators of anoles (Island Conservation 2010c). It is also likely that rats consume anole eggs.

Slippery-backed skink
Rat Impacts: Rats alter the floral makeup of the island, which may impact skink habitat. Rats are considered a potential source of competition for resources because skinks and rats both consume terrestrial invertebrates. Additionally, rats may impact the demographic structure of the skink population through direct predation of young skinks and indirect competition.

Desecheo gecko
Rat Impacts: Rats alter the floral makeup of the island, which may impact gecko habitat. Rats are considered a potential source of competition for resources because geckos and rats both consume terrestrial invertebrates. Additionally, rats may impact the demographic

structure of the gecko population through direct predation and indirect competition. It is also likely that rats consume gecko eggs.

Hawksbill turtle
Rat Impacts: Rats are known to impact hawksbill sea turtles elsewhere, depredating turtle eggs and hatchlings and harassing adult females attempting to nest (Witmer et al. 1998). On Desecheo nesting attempts have been incidental (Evans 1989) and the island does not have an abundance of suitable beaches for turtles to haul out onto, so the potential for rat impacts to turtles is low. Turtles are often seen foraging in the marine environment surrounding the island.

Green sea turtle
Rat Impacts: Rats are not known to impact green sea turtles on Desecheo because the island has limited suitable habitat for turtles to haul out onto, turtles are not known to breed on Desecheo, and they are only seen in the marine environment surrounding the island.

Leatherback turtle
Rat Impacts: Rats are not known to impact leatherback sea turtles on Desecheo because the island has limited suitable habitat for turtles to haul out onto, turtles are not known to breed on Desecheo, and they are only seen in the marine environment surrounding the island.

4.6.3.3 Impacts to Breeding Seabirds

Rats are known to significantly impact seabirds, depredating eggs, chicks and adults, resulting in failed breeding attempts and causing population declines (Atkinson 1985, Towns et al. 2006, Jones et al. 2008). While the overall impact of rats on seabirds is detrimental to all families of seabirds, some are more susceptible than others, depending on life-history traits, morphology and behavior. For example, burrow-nesting and crevice-nesting seabirds suffer the greatest impact, while larger species and gulls are more resilient. Smaller species are impacted more than larger species, and seabirds that experience rat predation across all life stages (eggs, chicks, adults) have the highest mean impact from rats (Jones et al. 2008). Where rats co-exist with other predators (such as predatory birds) the collective direct impact of introduced predators on seabirds is greater than the sum of the individual impacts because rats also act as a food resource to higher level predators when seabirds are absent from the islands (Moors and Atkinson 1984, Atkinson 1985). Given the extensive knowledge-base of rat impacts on seabirds worldwide, the following analyses are the anticipated impacts of rats on the seabird species at Desecheo. Birds are grouped by similar nesting habits. Masked booby, royal tern and sandwich tern are not included in the analysis below because: they have only been observed offshore from Desecheo; they have never been reported from the island; Desecheo has limited suitable nesting habitat for masked booby; and sandwich tern is a vagrant to the region. While the white-tailed tropicbird has also only been reported from

offshore of the island, it is included in this analysis because it is considered likely to inhabit Desecheo in the absence of rats.

Large ground-nesting seabirds – *brown booby, brown pelican*
Rat Impacts: Rats impact large ground-nesting seabirds by preying upon eggs and chicks.

Small ground-nesting seabirds – *bridled tern, sooty tern, laughing gull*
Rat Impacts: Rats impact small ground-nesting seabirds preying upon eggs and chicks, and may prey upon adult birds causing injury and mortality.

Tree-nesting seabirds – *magnificent frigatebird, red-footed booby*
Rat Impacts: Rats impact tree-nesting seabirds by preying upon eggs and chicks. In addition, rats may indirectly impact tree-nesting seabirds through alteration of nesting habitat as a result of seed and sapling predation.

Small ground/tree-nesting seabirds – *brown noddy, white-tailed tropicbird*
Rat Impacts: brown noddy will nest on the ground, or in vegetation such as tree branches or crotches, base of palm fronds, cacti and leaves. White-tailed tropicbird will nest under overhangs and in crevices on the ground, or in large holes in tree trunks or branches. Rats impact small ground/tree-nesting seabirds preying upon eggs and chicks, and may prey upon adult birds causing injury and mortality. Rats may also impact white-tailed tropicbirds by competing for nest holes in trees. In addition, rats may indirectly impact ground/tree-nesting seabirds through alteration of nesting habitat as a result of seed and sapling predation.

4.6.3.4 Impacts to Terrestrial Birds

Rats often compete with terrestrial birds for food resources, and may directly prey upon eggs, chicks and adults of smaller species. Desecheo's land bird fauna is impoverished, and rat predation has likely led to the local extirpation of at least one species, the mangrove cuckoo, and reduced the resident population of pearly-eyed thrasher. In 2003, the poor state of the land birds was demonstrated when only two pearly-eyed thrashers were captured in 256 hours of mist netting (Earsom 2002). Similarly, in 2009 and 2010, a mean of only 9.6 of 30 (32 percent) point-count stations were occupied by eight species of land bird (Island Conservation unpubl. data). If rats persist on the island, terrestrial bird populations are expected to remain low and could result in the complete extirpation of the remaining resident species. The following analyses are the anticipated impacts that rats have on the terrestrial bird species at Desecheo. Birds are grouped by similar foraging, breeding, and migratory habits (see Section 3.4.2.3 for description of bird migratory patterns in Puerto Rico). Descriptions of the habitat and diet of the different species indicates those parameters that are likely representative for the species on Desecheo, not in their worldwide distribution.

Permanent and Summer Resident Breeding Birds in Puerto Rico

Raptors – *red-tailed hawk, American kestrel*
Rat Impacts: Rats impact resident breeding raptors by preying upon eggs and chicks. Additionally, the diet of rats and resident raptors may overlap as they both prey upon the native and endemic herpetofauna at Desecheo. For example, anoles are a primary food source for American kestrels in the Caribbean (Cruz 1976), and on Desecheo, American kestrels and rats have both been documented consuming anoles (Island Conservation 2010b, a). Red-tailed hawks are known to feed on *Anolis*, *Ameiva* and *Borikenophis* (*Alsophis*) species on mainland Puerto Rico (Santana and Temple 1988). Therefore, the continued presence of rats may be a source of food competition for these birds that would potentially impact their abundance on Desecheo.

Aquatic coastal foragers – *ruddy turnstone, American oystercatcher, black-necked stilt, belted kingfisher, yellow-crowned night heron, green heron, great egret and great blue heron*
Rat Impacts: Rats impact breeding aquatic coastal foragers by preying upon eggs and chicks. During breeding, rats may also cause physical disturbance by flushing birds from nests. Rats may also impact coastal foragers through diet overlap; both rats and coastal foragers eat invertebrates and small fish. All coastal aquatic foragers listed above feed on aquatic invertebrates to some degree, with American oystercatchers being bivalve specialists, and yellow-crowned night herons being crustacean specialists. In addition, belted kingfisher, green heron and great egret also eat fish, and will prey on reptiles. Therefore, the continued presence of rats may be a source of food competition for these birds that would potentially impact their abundance on Desecheo. The impact of rats on black-necked stilt is likely to be minimal as this species primarily inhabits freshwater or brackish water habitats, and rarely uses marine shores; it has only been reported from Desecheo on one occasion in 2010, and its presence on the island is likely accidental. Rats likely have limited impact on belted kingfisher as there is little dietary overlap.

Ground insectivores - *killdeer, smooth-billed ani*
Rat Impacts: Rats impact breeding ground insectivores by preying upon eggs and chicks. During breeding, rats may also cause physical disturbance by flushing birds from nests. Additionally, the diet of rats and terrestrial insectivores overlap; both killdeer and smooth-billed ani forage on large invertebrates, and smooth-billed ani may prey upon reptiles. Therefore, the continued presence of rats may be a source of food competition for these birds that would potentially impact their abundance on Desecheo. In addition, rats may impact the abundance and diversity of invertebrate fauna available to ground insectivores through changes in vegetation communities as a result of seed predation, weed seed dispersal, and disruption of nutrient cycles caused by the reduced activities of seabirds on Desecheo.

Aerial insectivores – *Caribbean martin, cave swallow*
Rat Impacts: It is highly unlikely that rats impact breeding Caribbean martins or cave swallows as their nests would be very inaccessible to rats. However, both species feed on flying insects, and rat predation of insects on Desecheo may result in a reduced food source for these species. Therefore, the continued presence of rats may be a source of food

competition for these birds that would potentially impact their abundance on Desecheo. In addition, rats may impact the abundance and diversity of invertebrate fauna available to aerial insectivores through changes in vegetation communities as a result of seed predation, weed seed dispersal, and disruption of nutrient cycles caused by the reduced activities of seabirds on Desecheo.

Canopy foragers – *black-whiskered vireo, gray kingbird*
Rat Impacts: Rats impact breeding canopy foragers by preying upon eggs and chicks. During breeding, rats may also cause physical disturbance by flushing birds from nests. Additionally, the diet of rats and canopy foragers may overlap; both black-whiskered vireo and gray kingbird forage in the canopy on large terrestrial invertebrates, including beetles, Lepidoptera, dragonflies, and invertebrate eggs and larvae. Therefore, the continued presence of rats may be a source of food competition for these birds that would potentially impact their populations on Desecheo. In addition, rats may impact the abundance and diversity of invertebrate fauna available to canopy foragers through changes in vegetation communities as a result of seed predation, weed seed dispersal, and disruption of nutrient cycles caused by the reduced activities of seabirds on Desecheo.

Canopy/ground forager – *yellow-billed cuckoo, mangrove cuckoo*
Rat Impacts: Rats impact breeding canopy/ground foragers by preying upon eggs and chicks. During breeding, rats may also cause physical disturbance by flushing birds from nests. Additionally, the diet of rats and canopy/ground foragers may overlap; as both rats and these canopy/ground foraging species feed on large insects and small lizards. The yellow-billed cuckoo primarily feeds on large insects such as caterpillars, katydids, grasshoppers and crickets. While yellow-billed cuckoos primarily hunt prey within the canopy and along tree limbs, birds may occasionally pursue lizards on the ground through the vegetation. The mangrove cuckoo relies heavily on insect eggs, larvae and adults, and has a preference for hairy caterpillars and other slow moving insects. In Grenada, the mangrove cuckoo consumes many *Anolis* lizards particularly during the dry season when they are more visible (Wunderle 1981). Therefore, the continued presence of rats may be a source of food competition for these birds that would potentially impact their abundance on Desecheo. In addition, rats may impact the abundance and diversity of invertebrate fauna available to canopy/ground foragers through changes in vegetation communities as a result of seed predation, weed seed dispersal, and disruption of nutrient cycles caused by the reduced activities of seabirds on Desecheo.

Omnivores – *Northern mockingbird, shiny cowbird, cattle egret, pearly-eyed thrasher*
Rat Impacts: Rats impact breeding omnivorous species by preying upon eggs and chicks. During breeding, rats may also cause physical disturbance by flushing birds from nests. Additionally, the diet of rats and omnivorous species may overlap. All four species listed above may forage in the canopy or on the ground, and prey upon terrestrial invertebrates and arthropods, such as grasshoppers, spiders, and small reptiles such as lizards and geckos. The shiny cowbird also eats seeds and grain, and the Northern mockingbird will eat fruit. The cattle egret is particularly opportunistic, eating a wide range of invertebrates and vertebrates, including ticks (Acarina), earthworms (Oligochaeta), crayfish (Decapoda), millipedes (Diplopoda), centipedes (Chilopoda), fish, frogs and birds (including eggs and

nestlings). Therefore, the continued presence of rats may be a source of food competition for these birds that would potentially impact their abundance on Desecheo. In addition, rats may impact the abundance and diversity of invertebrate fauna available to omnivorous species through changes in vegetation communities as a result of seed predation, weed seed dispersal, and disruption of nutrient cycles caused by the reduced activities of seabirds on Desecheo.

Frugivores – *white-crowned pigeon, scaly-naped pigeon*.
Rat Impacts: Rats impact breeding frugivorous species by preying upon eggs and chicks. During breeding, rats may also cause physical disturbance by flushing birds from nests. Additionally, the diet of rats and frugivorous species may overlap, as both rats and frugivorous species forage on fruits. In addition, white-crowned pigeons will also eat seeds, and some small invertebrates such as wasps and land snails. Therefore, the continued presence of rats may be a source of food competition for these birds that would potentially impact their abundance on Desecheo.

Frugivores/granivores: introduced species –*Hispaniolan parakeet*.
Rat Impacts: It is highly unlikely that rats would impact breeding of Hispaniolan parakeet. It is a non-native species introduced to Puerto Rico, and only a single vagrant individual has been reported once from Desecheo. Should additional individuals arrive on Desecheo, their diet may overlap with rats as both rats and parakeets forage on fruits, seeds, leaf buds and flowers. Therefore, the continued presence of rats may be a source of food competition for these birds that would potentially impact their abundance on Desecheo. However, as this is a non-native introduced species, their long-term persistence of a population on Desecheo would not be encouraged.

Granivores – *zenaida dove, common ground-dove*
Rat Impacts: Rats impact breeding granivorous species by preying upon eggs and chicks. During breeding, rats may also cause physical disturbance by flushing birds from nests. Additionally, the diet of rats and granivorous species may overlap, as both forage on seeds and grain. In particular, zenaida doves and common ground-doves forage primarily on the ground and so may be in direct competition with rats. While they are primarily granivorous, both species will also feed on small invertebrates, such as snails. The continued presence of rats may be a source of food competition for zenaida dove and common ground-dove, and may impact their abundance on Desecheo.

Granivores: non-native introduced species - *house sparrow, bronze mannikin, orange-cheeked waxbill*
Rat Impacts: Rats impact breeding granivorous species by preying upon eggs and chicks. During breeding, rats may also cause physical disturbance by flushing birds from nests, and may depredate adult birds while roosting or sitting on a nest. Additionally, the diet of rats and these granivorous species may overlap, as both rats and these species forage on seeds and grain. House sparrow, bronze mannikin and orange-cheecked waxbill are all non-native species introduced to Puerto Rico. They feed primarily on small seeds of grasses, herbaceous plants and weeds, but seasonally will also feed on small invertebrates. The continued presence of rats may be a source of food competition and may impact the

abundance of these species on Desecheo, but as these species are introduced, their long-term persistence of populations on Desecheo would not be encouraged.

Nectarivores – *Antillean mango*
Rat Impacts: Rats impact breeding Antillean mango by preying upon eggs and chicks. During breeding, rats may also cause physical disturbance by flushing birds from nests, and may depredate adult birds. Additionally, the diet of rats and the Antillean mango might overlap as both species feed on flowers and small invertebrates. The continued presence of rats may be a source of food competition for the Antillean mango, and may impact their abundance on Desecheo.

Winter Migratory Birds in Puerto Rico

Raptors – *peregrine falcon, osprey, northern harrier, merlin*
Rat Impacts: As wintering migrants, these raptor species are not known to breed on Desecheo. Part of the diet of rats and peregrine falcons may overlap on Desecheo as peregrines have been observed to prey upon the endemic *Ameiva* (Island Conservation 2010c) but for the most part the diet of rats and these raptors are not similar. Overall, therefore, the continued presence of rats would be unlikely to impact the abundance of migratory raptors on Desecheo. However, as seabirds and shorebirds are a significant food source for peregrine falcons, the impacts of rats on the abundance of seabirds and shorebirds on Desecheo may indirectly affect the density of peregrine falcons on Desecheo by reducing the prey base for these birds.

Aquatic coastal foragers – *spotted sandpiper*
Rat Impacts: As a wintering migrant, spotted sandpipers are not known to breed on Desecheo. Rats may impact spotted sandpiper through diet overlap, as both rats and spotted sandpiper eat small invertebrates. While spotted sandpipers feed primarily along shorelines, they will feed on a diverse range of aquatic and terrestrial invertebrates including, midges (Diptera), mayflies (Ephemeroptera), house and stable flies (Diptera), grasshoppers, crickets and mole crickets (Orthoptera), beetles (Coleoptera), caterpillars (Lepidoptera), worms (Annelida), mollusks and crustaceans, fish and spiders (Araneae). Therefore, the continued presence of rats may be a source of food competition for sandpipers that would potentially impact their abundance on Desecheo.

Ground insectivores - *upland sandpiper, ovenbird, northern waterthrush*
Rat Impacts: As wintering migrants, these species are not known to breed on Desecheo. Rats may impact terrestrial insectivores through overlapping diet, as rats and all three species listed feed on large and small insects. Therefore, the continued presence of rats may be a source of food competition for these birds that would potentially impact their abundance on Desecheo. In addition, rats may impact the abundance and diversity of invertebrate fauna available to ground insectivores through changes in vegetation communities as a result of seed predation, weed seed dispersal, and disruption of nutrient cycles caused by the reduced activities of seabirds on Desecheo.

Aerial insectivores – *Barn swallow, bank swallow, tree swallow, alpine swift, common potoo, chuck-will's widow*
Rat Impacts: As wintering migrants, these passerines are not known to breed on Desecheo. Rats may impact aerial-feeding insectivores through predation of insects on Desecheo resulting in a reduced food source for these species. Therefore, the continued presence of rats may be a source of food competition for these birds that would potentially impact their abundance on Desecheo. In addition, rats may impact the abundance and diversity of invertebrate fauna available to aerial insectivores through changes in vegetation communities as a result of seed predation, weed seed dispersal, and disruption of nutrient cycles caused by the reduced activities of seabirds on Desecheo. However, the common potoo and alpine swift are vagrant species to the Caribbean region, and only a single individual of each species has been reported on Desecheo. Therefore, the continued presence of rats is unlikely to have a measurable impact on the abundance of these two species on Desecheo.

Canopy foragers – *white-eyed vireo, black-throated blue warbler, yellow-rumped warbler, palm warbler, prairie warbler, bay-breasted warbler, blackpoll warbler, yellow-throated warbler, Cape May warbler, common yellowthroat, hooded warbler, northern parula*
Rat Impacts: As wintering migrants, these passerines are not known to breed on Desecheo. Rats may impact canopy foragers through diet overlap, as both rats and canopy foragers feed on a range of small insects, including beetles, Lepidoptera larvae and flies. Therefore, the continued presence of rats may be a source of food competition for these birds that would potentially impact their populations on Desecheo. In addition, rats may impact the abundance and diversity of invertebrate fauna available to canopy foragers through changes in vegetation communities as a result of seed predation, weed seed dispersal, and disruption of nutrient cycles caused by the reduced activities of seabirds on Desecheo.

Frugivores – *cedar waxwing*
Rat Impacts: The cedar waxwing is a vagrant to the Caribbean, and has been reported from the region very rarely; only a single individual has been reported from Desecheo. Therefore the presence of rats would be unlikely to have a measureable impact to cedar waxwing abundance on Desecheo. However, should an increasing number of birds appear on Desecheo in the future, there may be some diet competition between rats and waxwings as both species consume fruit. Therefore, the continued presence of rats may be a source of food competition for these birds that could potentially impact their abundance on Desecheo.

Frugivores/granivores – *indigo bunting*
Rat Impacts: As a wintering migrant, indigo bunting is not known to breed on Desecheo. Rats may impact indigo bunting through diet overlap, as both rats and indigo bunting feed on fruits, seeds, small invertebrates and insects. Therefore, the continued presence of rats may be a source of food competition for these birds that would potentially impact their populations on Desecheo. In addition, rats may impact the abundance and diversity of invertebrate fauna available to canopy foragers through changes in vegetation communities as a result of seed predation, weed seed dispersal, and disruption of nutrient cycles caused by the reduced activities of seabirds on Desecheo.

4.6.3.5 Impacts to Invertebrates

While the direct impact of rats on invertebrates is poorly known and difficult to demonstrate, some case studies have been reported, including direct rat predation of mollusks (Parisi and Gandolfi 1974), rat-associated declines of land snails in Hawaii, American Samoa and Japan (Hadfield et al. 1993, Cowie 2001, Chiba 2010), and negative effects on the abundance and age structure of intertidal invertebrates (Navarrete and Castilla 1993). Terrestrial crabs have been known to shift from nocturnal behavior to diurnal behavior in the presence of invasive rats, and with the removal of rats, crabs have returned to their nocturnal habits (Burggren and McMahon 1988). This shift in behavior is likely due to the competition for food and other resources between crabs and rats.

Rats are not known to negatively impact coral species.

Given the limited knowledge-base of direct impacts of rats to invertebrates, the following are the anticipated impacts of rats on known invertebrate species on Desecheo:

<u>Arachnids</u> – endemic spider (*Clubiona desecheonis)*, endemic spider (*Camillina desecheonis)*, endemic whip-tail scorpion (*Schizomus desecheo*).
Rat Impacts: Rats may impact the arachnids and the whip scorpion by preying upon eggs, juveniles and adults. However, as there is little information in the literature about these and other arachnids on Desecheo, we cannot fully evaluate the impacts that rats have on arachnids or their habitat on the island.

<u>Purple landcrab</u>
Rat Impacts: Terrestrial crabs have been known to shift from nocturnal behavior to diurnal behavior in the presence of invasive rats, and with the removal of rats, crabs have been known to return to their nocturnal habits (Burggren and McMahon 1988). This shift in behavior is likely the result of competition for food and other resources between crabs and rats. Specifically rats are a potential source of competition for food because both rats and crabs consume invertebrates, fruit, seeds and carrion. Additionally, rats and crabs also have the potential to compete for burrows. Furthermore, rats have been documented to depredate purple landcrabs at Palmyra Atoll (Wegmann 2008).

<u>Hermit crab</u>
Rat Impacts: Rats impact hermit crabs by competing with them for resources because they both consume invertebrates, fruit, seeds and carrion.

4.6.3.6 Impacts to Vegetation

Invasive rats feed opportunistically on plants, and alter the floral communities of ecosystems in which they are inhabiting (Campbell and Atkinson 2002), in some cases degrading the quality of nesting habitat for birds and reptiles that depend on the vegetation. Rat impacts can contribute to the extinction of rare plants (Meyer and Butaud 2009), predate native plant seeds (Sheils and Drake 2011), promote weed seed dispersal (Williams et al. 2000, Sheils 2011) and depress seedling recruitment; their impact is

implicated by improved forest regeneration once rats are removed (Allen et al. 1994). It is anticipated that if rats persist on Desecheo they would continue to alter the floral communities on the island, as well as negatively impact bird, reptile and invertebrate populations through habitat degradation and alteration. Given the knowledge-base of rat impacts to vegetation communities worldwide, the following are the anticipated impacts that rats may have on the vegetation on Desecheo:

Higo Chumbo
Rat Impacts: Rats are omnivorous, and feed on both animal and plant matter, including fruits, seeds, flower and leaf buds, seedlings and leaves. It is likely, therefore, that rats feed on higo chumbo fruits and seeds. Rats therefore may inhibit cactus recruitment by depredating the seeds and seedlings. Furthermore, rats have been documented on nearby Mona Island foraging on fruits of an adult cactus (Fig. 4.2) (Rojas-Sandoval and Meléndez-Ackerman 2009). If rats persist on Desecheo they have the potential to prevent recruitment of young plants, and contribute to a depressed cactus population size on the island.

Figure 4.2 (a) Black rat foraging on higo chumbo fruit, Mona Island, Puerto Rico (photo: J. Rojas-Sandoval in Rojas-Sandoval and Meléndez-Ackerman 2009), (b) Damage by black rat foraging on *Bursera simaruba*, Desecheo NWR March 2011.

Other Vegetation/Flora
Rat Impacts: Rats likely depredate seeds, fruit, flowers and seedlings of native plant species on Desecheo, depressing natural rates of recruitment (Sheils and Drake 2011). In addition, rats are known to spread invasive weed seeds (Williams et al. 2000, Sheils 2011). Through both predation and seed dispersal, rats could potentially cause a shift in the floral community assemblages of the island if rats are not removed.

4.6.4 Impacts of Action Alternatives to Biological Resources

4.6.4.1 Analysis Framework for Impacts to Biological Resources Vulnerable to Toxicant Use

The risk of impact from brodifacoum or diphacinone rodenticide to an individual animal is determined by two factors (Erickson and Urban 2004):

- the likelihood that an individual would be exposed to the toxicant, and
- the toxicity of the toxicant to that individual

From the perspective of risks from the rodenticide, the action alternatives differ in the different toxicity of the two different compounds, and the different toxicity of each toxicant between species and sometimes even within species.

4.6.4.2 Exposure

Exposure to the toxicant is primarily dependent on two factors:

- Foraging habits, diet preferences, behavior patterns, and other specific characteristics that increase or decrease an animal's exposure to the rodenticide;
- The availability of rodenticide in the local environment.

For rodent eradication, brodifacoum and diphacinone are delivered through oral ingestion; pest animals ingest the toxicant directly, by consuming bait pellets (primary exposure), or indirectly through consumption of contaminated animal tissue (secondary exposure). Brodifacoum and diphacinone molecules adhere strongly to the grain matrix of the bait pellets, and both have a low solubility in water (brodifacoum 0.24 mg/L pH 7.4, (Environmental Protection Agency 1998); diphacinone 0.3 mg/L, (Extoxnet 1996)). As a bait pellet disintegrates, the molecules do not appear to leach into soils or vegetation through moisture or precipitation. Once the pellets disintegrate into particles that are too small for most foraging animals to consume, the toxicant is essentially no longer available for primary consumption. Eventually, the molecules remaining from a fully disintegrated pellet break down into non-toxic compounds including carbon dioxide and water.

Primary Exposure

Granivorous and omnivorous species, particularly omnivorous scavengers, are more likely to directly consume bait than carnivorous, herbivorous, or insectivorous species, because the bait pellet matrix is composed primarily of grain. It is unlikely that carnivorous and insectivorous species on Desecheo would consume bait pellets intentionally as food.

Secondary Exposure

The active ingredient (the rodenticide) in rodent bait can be stored temporarily in the body tissues of primary consumers (rats or other animals feeding on bait), and other animals can acquire the active ingredient by eating or scavenging primary consumers (secondary exposure). Different taxa show variation in the amount of time that they retain anticoagulant toxicant in their bodies (Erickson and Urban 2004). In laboratory rats dosed

sub-lethally, brodifacoum concentration in the liver took between 80 and 350 days to be reduced by 50 percent (Erickson and Urban 2004).

Yu et al. (1982) showed that in rats given a single oral dose of diphacinone at either 0.18 or 0.4 mg ai/kg, about 70 percent of the dose was eliminated in feces and 10 percent in urine within 8 days, whereas about 20 percent of the dose was retained in body tissues. Mice given a single dose of 0.6 mg ai/kg eliminated most diphacinone within four days, and only seven percent was retained in body tissues (Erickson and Urban 2004).

For invertebrates, the exact mechanisms of brodifacoum and diphacinone retention are unclear but the general understanding is that most invertebrates only retain toxicants briefly in their digestive system and not in body tissues (Booth et al. 2001).

4.6.4.3 Toxicity

The toxicity of a particular compound to an individual animal is often expressed in a value known as the "LD_{50}" – the dosage (D) of a toxicant that is lethal (L) to 50 percent of animals in a laboratory test. LD_{50} values are useful for comparing toxicity sensitivity between taxa, but have less value as an absolute measure of toxicity to a species or to an individual. The EPA provides laboratory data on the LD_{50} values of brodifacoum and diphacinone for a number of species (Erickson and Urban 2004). However, due to the difficulty and expense of obtaining extensive laboratory data, the LD_{50} values for many species, including most species on Desecheo, are unknown. Besides lethal toxicity, there are other physiological effects from ingestion of anticoagulants. Erickson and Urban (2004) report that individual birds and mammals that are exposed to anticoagulants and survive may nevertheless experience internal hemorrhaging, external bleeding, and other clinical signs of anticoagulant toxicity. Fortunately, researchers have estimated the LD_{50} of brodifacoum for species with unknown LD_{50} values to be 0.56 with a confidence of 95 percent (Howald et al. 1999). For this reason we assume that the risk of mortality from the toxicant level for brodifacoum to be high, and since we assume that diphacinone is likely to be less toxic than brodifacoum we have assumed that the risk of mortality from the toxicant level is moderate.

4.6.4.3.1 Toxicity to Birds

The EPA has determined that the overall toxicity of brodifacoum to birds is high, and only requires one average dose to be lethal, while the toxicity of diphacinone is considered moderate and requires multiple feedings to be lethal (Erickson and Urban 2004, Rattner et al. 2010) (see Section 2.3.2). For example, LD_{50} values of brodifacoum in birds have been reported between 0.26 mg/kg for mallard (*Anas platyrhynchos*) and >20 mg/kg for paradise shelduck (*Tadorna variegata*) and can be achieved after a single feeding. By comparison, an LD_{50} value of 906 mg/kg diphacinone in mallard has been reported (Eason et al. 2002, Erickson and Urban 2004). Erickson and Urban (2004) reviewed a series of laboratory studies on the effect of rodenticides on birds; in eight species (seven raptors and the laughing gull) exposed to brodifacoum-poisoned prey, 42 percent of 149 individuals

died, while some test survivors showed sub-lethal effects of toxicity. In contrast, in five species of birds (all raptors) exposed to diphacinone-poisoned prey, only nine percent of 34 individuals died.

During the rat eradication operation birds are more likely to be exposed to anticoagulant rodenticide through secondary sources, i.e. feeding on contaminated prey. While the risk of mortality is generally understood to be higher with exposure to brodifacoum than to diphacinone, the impact appears variable between species and taxa; this may be partly due to inherent species-specific resistance and partly due to the different exposure pathways. Eason et al. (2002) reports on variable responses in New Zealand bird species to the application of brodifacoum-based bait products for invasive species eradication or control; for example about 80 – 90 percent of weka (*Gallirallus australis*) (a ground-feeding omnivorous woodhen) were killed on Ulva Island after a brodifacoum bait was used in bait stations; 98 percent of weka were killed after aerial broadcast of brodifacoum bait on Inner Chetwode Island, and 90 percent of pukeko (a ground feeding herbivore) were killed on Tiri Tiri Matangi Island also after the aerial broadcast of brodifacoum bait. By contrast neither kiwi (*Apteryx* sp.)(a ground-feeding insectivore) nor North Island robin (*Petroica longipes*) (a small ground/tree-feeding insectivorous landbird) were affected after the aerial broadcast of brodifacoum bait on two different islands. Omnivorous and granivorous ground-feeding birds are at the greatest risk of poisoning, as demonstrated during rat eradication on four islands in the Republic of Seychelles when mortality occurred in 25 – 90 percent (72 individuals) of turnstone (*Arenaria interpres*), 10 - 80 percent (320 individuals) of Madagascar turtle-dove, 40 – 80 percent (545 individuals) of barred ground dove (*Geopelia striata*), 40 – 70 percent (350 individuals) of Madagascar fody (*Foudia madagascariensis*), five cattle egrets (*Bubulcus ibis*) and two Asiatic whimbrel (*Numenius phaeopus*) (Merton et al. 2002). Bowie and Ross (2006) demonstrated that non-target risk through secondary sources depended on the prey item mass and the body mass of the bird in relation to the birds' daily food intake; none of the bird species tested could physically consume a LD_{50} dose of contaminated prey in a single day's feeding for the smaller prey items (a hedge sparrow (*Prunella modularis*)) would need to feed continuously on contaminated prey for four days to achieve a LD_{50} dose), but four bird species could achieve a LD_{50} dose by eating the larger-bodied prey items.

Eason et al. (2002) also reports on the detection of brodifacoum residues in birds after bait application activities for invasive species eradication and control; 63 percent (66 of 105) of birds found dead and 40 percent (33 of 82) of birds found alive had detectable brodifacoum residues. None of the birds found alive showed any signs of intoxication, including six of six common blackbirds (*Turdus merula*), weka, North Island robin and Australian magpie (*Cracticus tibicen*).

There is little comparable field information available for the non-target risks posed by diphacinone exposure. Of the 64 eradication attempts documented, 25 applied bait in bait stations (Table 2.2) making it less accessible to potential non-target species; the largest of these programs (Canna Island 1,130 ha) reported no non-target losses (see Section 2.3.2.3). However, 28 operations applied bait by hand broadcast; no non-target losses were reported.

Overall, it is difficult to accurately predict risk to an individual bird, and to different species of birds based on known toxicity data. For this reason, this risk analysis for bird estimates risk from the toxicant using the species' perceived risk of exposure, and the difference in toxicity of the two bait products.

4.6.4.3.2 Toxicity to Mammals

The EPA has determined that the toxicity of brodifacoum to all mammals is generally high and only requires one dose to be lethal, while diphacinone's toxicity is considered moderate but requires multiple feedings to be lethal (Erickson and Urban 2004). Furthermore, animals that have a large body mass, such as pinnipeds or cetaceans, would generally need to ingest more of the compound in order to reach an LD_{50} threshold. In general, brodifacoum has an average LD_{50} value of 0.2mg/kg for small mammals, while diphacinone has an average LD_{50} value of 2.3mg/kg for small mammals.

While the concentration of each toxicant in bait pellets would be consistent, the number of bait pellets that individual animals would be likely to consume would vary considerably and unpredictably. Furthermore, predators and scavengers can also be exposed to a toxicant through secondary pathways by consuming individuals that were previously exposed to the toxicant. It is even more difficult to predict the amount of toxicant that would be present in these prey animals, and consequently difficult to predict how much a particular predator or scavenger would need to consume to reach a toxic threshold.

Overall, it is difficult to accurately predict risk to mammals based on toxicity data. Instead, risks from the toxicant will be estimated primarily using an animal's risk of exposure.

4.6.4.3.3 Toxicity to Reptiles

There are, to our knowledge, no published studies on the laboratory testing of anticoagulants to reptiles. Major references listing the LD_{50} values for anticoagulants (Timm 1994, Tasheva 1995) do not list any values for reptiles. Brooks et al. (1998) found that warfarin was lethal to brown tree snakes (*Boiga irregularis*) when orally administered in ethanol (but not propylene glycol) at 40 mg/kg, but elicited no signs of discomfort or internal hemorrhaging upon necropsy. In the same study, diphacinone delivered orally to brown tree snakes was consistently lethal at dosages of 40 – 80 mg/kg, but snakes displayed no apparent clinical signs prior to death or evidence of internal hemorrhaging upon necropsy. Gopher snakes (*Pituophis catenifer*) fed with mice poisoned with lethal quantities of the anticoagulants Prolin® (0.05 percent warfarin, 0.05 percent sulfaquinoxaline), Diphacin® and warfarin showed no observable behavioral or physiological reaction (Brock 1965). Snakes fed brodifacoum-killed house mice (R. Marsh pers. comm.) and lizards (*Uta* sp.) force fed 50 ppm brodifacoum (Tershy et al. 1992, Tershy unpubl. data) survived for at least several weeks.

Similarly, to our knowledge, there are no published studies on the toxicity of brodifacoum to reptiles. Brodifacoum inhibits Vitamin K dependent pathways in mammals and birds.

Because reptiles are poikilothermic (cold-blooded), their blood chemistry and physiology is different from that of mammals and birds (homiothermic or warm-blooded animals) (Merton 1987), and blood coagulation mechanisms in reptiles are slower than those of mammals (Frost et al. 1999, Kubalek et al. 2002). Reptiles have an active extrinsic clotting pathway (Spurling 1981) but, for example in spectacled caimans, several factors (Factors V, VIII, IX and XI, and possibly XII) in the Vitamin K dependent (intrinsic) clotting pathway are missing in the blood (Arocha-Pinango et al. 1982). In the puff adder (*Bitis arietans*), other clotting activation factors, such as prothrombin, α_2-antiplasmin (fibrinogen system) and kallikrein (kallikrein system) have significantly reduced activity when compared with humans (Frost et al. 1999).

There are reports of larger skinks consuming baits containing brodifacoum during island rat and rabbit eradication efforts in the Seychelles (Thorsen et al. 2000, Merton et al. 2002) and Mauritius (Merton 1987). In brodifacoum baiting operations on two South Pacific islands, two gecko species, *Hoplodactylus duvaucelii* and *H. maculatus*, showed some evidence of having consumed brodifacoum baits in bait boxes (Christmas 1995, Hoare and Hare 2006). In a laboratory study, 17 McCann's skinks (*Leiolopisma maccannii*) were offered both wet and dry AgTech® pindone (0.025 percent active ingredient) rabbit pellets in a no choice feeding study (Freeman et al. 1997). Skinks preferred wet pellets and consumed an average of 8 g/kg body weight. No mortality was observed following the two day test.

Reports of reptile mortality associated with brodifacoum bait consumption are uncommon. In two separate observations, single dead moko skinks (*Oligosoma moco*) were found near baiting stations at two locations in New Zealand. On analysis, one skink had a brodifacoum residue (probably whole body) of 0.82 µg/g, while analysis of stomach contents in the second lizard showed consumption of 19 µg/g of pindone. Necropsy of the second skink found blood clots ventral and caudal to the heart (Tocher 2008) (though clotting signs are not normally associated with anticoagulant effects). A single Northland green gecko (*Naultinus grayii*) was found dead after pindone baiting operations near Boundary Stream, New Zealand, and contained 0.52 µg/g pindone residues. This level of pindone was similar to the concentration found in the baits (Tocher 2008). During a two month-long rabbit eradication program on Round Island, Mauritius, using Talon 20P® pelleted baits (20 ppm brodifacoum), Merton (1987) noted that out of several species of skinks and geckos, only Telfair's skinks (*Leiolopisma telfairii*) routinely consumed bait pellets. After three weeks of bait exposure, dead Telfairs's skinks began to be found, with increasing mortality for a further five weeks, when lizard mortality abruptly ceased. In all, over 100 dead Telfair's skinks (out of an estimated 5,000 individuals) were found, primarily during the hottest parts of the day and on the hottest days. However, because of the subsequent eradication of invasive rabbits, populations of Telfair's skink (and other endemic species) on Round Island expanded rapidly following anticoagulant baiting and skinks are now being translocated to other islands which were part of the species' historic range (ARKive.org 2011). Analysis of bulked livers (n = 10) from intoxicated Telfair's skinks yielded brodifacoum residues of 0.6 mg/kg, but only one lizard showed signs of internal hemorrhaging. Merton (1987) speculated that since dead lizards were only found during the hottest portion of the day, anticoagulant intoxication may have interfered with

thermoregulatory mechanisms rather than inhibition of blood coagulation. The extent of the mortality may also have been due to the overly long exposure time.

During a rat eradication campaign in the Montebello Islands Conservation Park, Australia, Bungarras (*Varanus gouldii*) were observed scavenging dead or dying rats poisoned with Talon G® (50 ppm brodifacoum) to the extent that some rat droppings contained the green dye from the bait, but no dead or moribund Bungarras were found, and the following year, Bungarra tracks were plentiful (Burbridge 2004). During a rat eradication campaign on Seymour Island in the Galapagos Islands, six of 134 Galapagos land iguanas (*Conolophus subcristatus*) were found dead two to three months after the bait application at least one of which was directly attributable to bait consumption (Harper pers. comm.). On Isabel Island, México, brown iguanas (*Ctenosaura pectinata*) were observed eating rodent bait pellets directly and 19 were found dead after an aerial bait application of brodifacoum bait in 2009 (M. Rodriguez Malagón pers. comm.).

In 1986, plans to eradicate rats from Monito Island, Puerto Rico, were stopped owing to concerns over the potential mortality of *Sphaerodactylus macrolepsis* from 0.005percent brodifacoum (Talon-G®) deduced from a laboratory experiment (Gaa 1986, García 1994, both unpublished reports to Puerto Rico Department of Natural Resources). A rat eradication campaign was eventually implemented on Monito Island (García et al. 2002), but in order to address the earlier concern, a second captive experiment was conducted in 1994 to test the effect of the second-generation anticoagulant 0.005 percent bromadiolone (Maki® mini blocks) on a surrogate species, the Mona Island gecko *Sphaerodactylus monensis* (justification for using bromadiolone in the test and brodifacoum in the actual Monito island eradication is described in García *et al*. 2002[1]). No mortality or change in behavior was observed. Prior to the Monito program, successful rat eradications had also been achieved on Cayo Ratones (Puerto Rico) and Steven Cay (U.S. Virgin Islands), with no apparent effect on non-target reptiles including native *Sphaerodactylus* species.

Despite reports of individual reptile mortality from anticoagulant rodenticides, experience from large-scale rodent eradication campaigns on islands with native and endemic reptiles suggests that reptile populations increase dramatically after rodent eradication, and to our knowledge no rodent eradication campaign has extirpated a local population of a native reptile. There are many examples of reptile population increases after rodent eradication programs (Towns 1991, Newman 1994, North et al. 1994, Towns 1994, Towns et al. 2001, Parrish 2005, Daltry 2006). Although lethal toxicity in reptiles on Desecheo is possible, little impact to species at the population-level is expected and in fact population increases are anticipated, in particular of the *Borikenophis* and *Sphaerodactylus* species.

Little is known about the effect that brodifacoum or diphacinone has on marine turtles. Experiments to investigate the effect of rodenticides have not been conducted for marine turtles and therefore the LD_{50} values are unknown for all species of marine turtle present

[1] In García *et al*. 2002, both Maki® mini blocks and Talon-G® were stated as 0.05 percent concentrations, however, commercial bait are both available in 0.005percent concentrations and it is assumed that the projects used bait with a 0.005 percent or 50 ppm concentration.

in the waters surrounding Desecheo. However, an initial assessment from preliminary findings of a USDA National Wildlife Research Center (NWRC) turtle-anticoagulant hazards study indicates that terrestrial ornate wood turtles (*Rhinoclemmys pulcherrima*) were not negatively affected by brodifacoum or diphacinone consumption (Witmer 2010). Wood turtles that were fed high doses of diphacinone (1.7mg/kg in two doses one week apart) showed no physical or behavioral changes during the two-week exposure period before euthanasia. The mean concentration for the high dose turtle livers detected at necropsy was 1.30 µg/g with a range of 1.19 µg/g-1.40 µg/g. Wood turtles that were fed high brodifacoum doses received 1.6 mg/kg of brodifacoum (0.79 mg/kg in two doses one week apart), and none died or showed signs of ill health during the two-week exposure period before the animals were euthanized. The wood turtle with the highest liver brodifacoum residue level (2.02 ppm) detected at necropsy weighed 319 g, indicating that it received about 0.5 mg (500 ppm) of brodifacoum. Since a Brodifacoum-25D pellet contains 25 ppm, the wood turtle received the equivalent of about 20 pellets (G. Witmer APHIS USDA, pers. comm). Adult marine green turtles weigh on average 325 lbs. (147 kg) (NOAA 2011b), thus, using similar metrics, one adult green turtle would have to consume approximately 9,200 pellets or 40.5 lbs. (18.4 kg) of pellets to receive a comparable exposure to the ornate wood turtle (which did not cause death or signs of ill health). Adult hawksbill turtles weigh on average 125 lbs. (57 kg) (NOAA 2011c), thus one turtle would have to consume approximately 3,500 pellets or 15.4 lbs. (7.0 kg) of pellets to receive a comparable exposure to the ornate wood turtle. Adult leatherback turtles weigh almost 2,000 lbs. (900 kg) (NOAA 2011d), thus one turtle would have to consume approximately 56,400 pellets or 248.7 lbs. (112.8 kg) of pellets to receive a comparable exposure to the ornate wood turtle.

4.6.4.3.4 Toxicity to Invertebrates

Arthropods are not thought to be susceptible to brodifacoum or diphacinone toxicity (Booth et al. 2001). Soft-bodied invertebrates such as mollusks may be affected, but the evidence for this is still inconclusive (Booth et al. 2001) and recent field studies suggest that at least some species of terrestrial mollusks are not affected by brodifacoum (Brooke et al. 2010). Morgan et al. (1996) found that orally dosing large-headed weta (*Hemideina crassidens*) with brodifacoum had no significant effect. Fisher et al. (2007) found no mortality in tree weta (*Hemideina thoracica*) when they fed on Ditrac® bait blocks (50 ppm diphacinone) for up to 64 days.

Invertebrates may function as short-term intermediate carriers of rodenticides that could be ingested by their predators. While not affected themselves, land crabs on Palmyra atoll have been documented to retain brodifacoum in their system for up to 56 days (USDA 2006). Captive tree weta fed on Ditrac® bait blocks had detectable levels of diphacinone residue in their bodies but did not accumulate diphacinone, i.e. whole-body concentrations did not increase with the amount of diphacinone bait eaten over time, and in fact there was a small but significant temporal decrease in residual concentrations (Fisher et al. 2007). However, after rat eradication from Lady Alice Island (New Zealand), no brodifacoum residues were detected in randomly sampled tree weta, cockroaches (Blattidae), or black beetles (Coleoptera) found on baits, but some brodifacoum residue (4.3 $\mu g\ g^{-1}$) was found

in cave weta (*Gymnoplectron* spp.) on baits (Ogilvie et al. 1997). Similarly, after the Anacapa Island rat eradication, no brodifacoum residue was detected in any of the intertidal invertebrates tested (Howald et al. 2005a) and no diphacinone residue in tissues of several invertebrate species were detected after rat eradication on Mokapu and Lehua islands in Hawaii (Gale et al. 2008, Orazio et al. 2009).

After an accidental spill of 20 tonnes of brodifacoum rodent bait into the marine environment in New Zealand in 2001,brodifacoum residues peaked in mussels (*Mytilus edulis*, *Perna canaliculus*) one day after the spill and averaged just above detectable levels by day 29, while detectable residues in limpet (*Cellana ornata*) tissue persisted for approximately 80 days. Low levels of residue (< 0.001 ppm) were detectable for up to 796 days in mussels and 471 days for paua (Haliotidae abalone). The greatest exposure of marine invertebrates occurred within 100 m of the bait spill location, and only minor exposure was detected between 100-300 m (Primus et al. 2005, Primus et al. 2006).

While invertebrates may function as secondary sources of rodenticide for some taxa, the likelihood of an individual eating sufficient numbers of contaminated invertebrates to achieve a toxic dose may depend on the size of the invertebrate; during trials to evaluate the risk of secondary poisoning to birds from brodifacoum-contaminated weta (*Hemiandrus* sp., *Pleioplectron simplex*, *Hemideina ricta*), Bowie and Ross (2006) concluded that none of the 17 bird species evaluated could physically consume a LD_{50} dose of smaller contaminated weta in the equivalent of a single day of feeding. However, by consuming the larger-bodied tree weta, four bird species (common blackbird (*Turdus merula*), hedge sparrow (*Prunella modularis*), southern black-backed gull (*Larus dominicanus*), pukeko (*Porphyrio melanotus*)) could consume an LD_{50} dose in a single day of feeding.

4.6.4.3.5 Toxicity to Plants

Plants are not known to be susceptible to toxic effects from brodifacoum or diphacinone.

4.6.5 Impacts to Species Vulnerable to Disturbance

4.6.5.1 Analysis Framework for Impacts from Disturbance

The risk of impacts from disturbance to individual animals is determined by two factors:

- the exposure of species to disturbance from ground operations; and
- the exposure of species to disturbance from aerial operations

From the perspective of risks from the disturbance, the action alternatives differ primarily in the level of exposure to either ground or aerial operations. The following section describes the anticipated disturbance issues on Desecheo, and the methods for analysis of disturbance to individual species.

4.6.5.2 Helicopter Operations

The operation of low-flying aircraft throughout Desecheo would likely result in disturbance to wildlife from noise, the sudden appearance of an aircraft, changes in air movement, or a combination of all (Efroymson et al. 2001). Wildlife would be exposed to noise that exceeds normal background levels. Due to the relatively low altitude at which helicopters would fly, most noise would be focused in a narrow cone directly underneath each machine, thereby reducing the area of disturbance at each helicopter pass (Richardson et al. 1995). Terrestrial animals would likely be exposed to higher-decibel noise than animals underwater.

Potential disturbance from helicopter operations would occur during pre- and post-bait application activities (e.g. research personnel support, staging operations, demobilization), and during bait application. Helicopter activities to stage personnel and operational equipment and supplies on Desecheo would be largely limited to the area around the helipad located on the coastline in southwest of the island, with some additional activity at the upper camp site near the highest point on the island. Potential disturbance from helicopter operations during bait application activities would be through helicopter travel across the island. During one island-wide bait application, all points on Desecheo Island would most likely be subject to two helicopter passes, and operations would require no more than three consecutive operating days. Over the course of all bait application operations; there would likely be fewer than 10 days during which the helicopter would operate. The responses of animals to aircraft disturbance, and the adverse effects of this disturbance, would be localized to the area directly below or immediately adjacent to the helicopter pass, and would vary between species and different seasons. In addition, animals that flush as a result of the disturbance would have alternative habitat to utilize.

4.6.5.3 Personnel Activities

Additional wildlife disturbance could result from personnel activities through: pre- and post-bait application research and monitoring; reptile mitigation activities; bait application activities; and post-bait application efficacy monitoring. Wildlife disturbance could result from personnel traveling by foot across the island (e.g., when hand-broadcasting bait, surveying for non-target mortality, and collecting rat carcasses), or traveling in small boats in the nearshore waters. The responses of animals to ground disturbance, and the adverse effects of this disturbance, would be localized to the immediate area in which individual personnel are operating, and would vary between species and different seasons. In addition, animals that flush as a result of the disturbance would have alternative habitat to utilize.

Personnel dedicated to rat and non-target monitoring would be based on Desecheo for a total time of about six weeks, preceding and following bait application activities, under Alternatives B, C, D and E. Personnel engaged in bait application activities would be on Desecheo for no more than three consecutive days for each bait application, and likely less than a total of 10 days for the entire bait application. Under Alternatives B and D, personnel engaged in reptile mitigation activities would be operating on Desecheo over a period of

about six weeks prior to bait application activities, and for a total time of about two weeks for up to four months post bait application activities.

Following completion of bait application activities, there would be several monitoring visits to the island for at least two years to monitor native species recovery and to determine the success of the rat eradication. Personnel on Desecheo would conduct research and monitoring activities in pre-selected seasonal windows. Most current monitoring activities take place at previously selected individual survey points, and personnel are required to travel throughout the island to access them. Bait application and reptile mitigation operations may also require personnel to travel throughout island, but to sites that are additional to currently monitored survey stations. Personnel would be briefed on strategies and techniques to reduce wildlife disturbance, but disturbance events would likely still occur.

4.6.6 Species Impact Assessment

Since the introduction of non-native invasive rats, goats and macaques, Desecheo has lacked a large diversity and abundance of native species, particularly of terrestrial birds. Many of the bird species that were identified in the above analysis (Alternative A) are either seasonal migrants, vagrant species, or have only been documented a few times on Desecheo since the early 1900s. In addition, most bird species recorded have been represented by only a few individuals. For these reasons, in the following descriptive analysis, we have only included species that are considered at a higher risk than others due to their probability of exposure (likely presence and exposure pathway). This includes species known to be resident in Puerto Rico, have been recorded from Desecheo in the last 10 years (since 2000), and have a foraging habit that would lead to greater exposure risk (for example granivorous, omnivorous and carnivorous species (mostly raptors)). We also include species of concern including all seabirds. The remaining species were analyzed in a similar manner, but included as an appendix (see Appendix II and III) to this document as a good faith effort to maintain a high level of transparency; we decided to exclude the complete descriptive evaluation for all species in this Environmental Consequences analysis section because of the large number of species that have been reported only rarely on Desecheo and/or in small numbers, and because the analysis indicated that there was no more than a negligible to low level of risk from all of the action alternatives to all of these species. The primary information sources used to inform the risk evaluation presented in Appendix II and III were Raffaele (1989) and relevant accounts in the Birds of North America online http://bna.birds.cornell.edu/bna with additional information gathered from Goldwasser and Roughgarden (1993), Woodall 1975 (in Avery 1980), Pérez-Rivera and Vélez Jr. (1978) (in Rivera-Milán 1995) and Carlier and Lefebvre (1996).

The risk of brodifacoum or diphacinone poisoning is a function of both exposure and toxicity (see Section 4.6.4). While lethal effects of anticoagulants are known, there is little comparable data on sub-lethal effects on wildlife, and it is therefore not possible to precisely predict the likelihood or characteristics of these effects. Furthermore, it is even more difficult to predict whether or not sub-lethal effects would lead to a measurable

decrease in the fitness of individual animals. In order to compensate for the lack of data on the sub-lethal effects of brodifacoum and diphacinone, the risk level of lethal exposure to these toxicants will be estimated liberally in this document.

Usually, the likelihood of detecting carcasses of all individuals of non-target species, whose death may be attributable to the use of brodifacoum or diphacinone, is very small. In most instances, the Service could not be expected to recover a precise number of dead or sub-lethally affected animals that could be attributed to the toxicant. However, the Service could still estimate the likelihood and severity of toxicant impacts to most of the species on Desecheo based on evidence from other similar island restoration projects, an understanding of the likelihood of exposure to the toxicants in different taxa, and the ability of populations of different species to recover.

4.6.7 Methods for Impacts Analysis to Biological Resources

4.6.7.1 Impact Indices

The following impacts analysis identifies the level of risk from the perspective of bait availability (the amount of time bait would be available through either primary or secondary exposure pathways), toxicant exposure (the number of exposure pathways available to individual species based on feeding ecology and toxicant fate), risk of mortality from toxicant use (the toxicity of the toxicant to different species based on toxicological properties), disturbance risk (the sensitivity to disturbance and the amount of disturbance risk that individuals may be exposed to during operations), extent of the risk (the number of individuals that may be impacted from eradication operations and the impact that would have to the global or regional breeding population), and the duration of the risk (the period of time that individuals would be exposed to the toxicant or disturbance). For the purposes of this analysis and to facilitate a clear comparison between uses of the two anticoagulants, the risk from brodifacoum has been assigned a high index and the risk from diphacinone has been assigned a moderate index. The following indices illustrate the methodology employed to analyze the impacts to each of the identified species for the five action alternatives:

Toxicant exposure risk level

- None: No exposure pathway
- Low: Possible exposure pathway
- Medium: One exposure pathway
- High: Multiple exposure pathways and/or dietary overlap with bait

Risk of mortality from toxicant use

- None: No toxicological sensitivity
- Low: Minor toxicological sensitivity
- Medium: Moderate toxicological sensitivity
- High: Severe toxicological sensitivity

Disturbance risk

- None: No disturbance pathway

- Low: Low sensitivity to disturbance
- Medium: Moderate sensitivity to disturbance
- High: Severe sensitivity to disturbance

Extent of toxicant /disturbance risk within a population

- Individuals: Few individuals affected, no affect on resident breeding population
- Island population: resident breeding population affected, no affect on regional or global population
- Global or regional population: regional or global population affected

Duration of risk: toxicant exposure

- Short: Impacts for up to 2 months
- Medium: Impacts for 2 to 6 months
- Long: Impacts for more than 6 months

Duration of risk: disturbance

- Short: Impacts for up to 2 months
- Medium: Impacts for 2 to 6 months
- Long: Impacts for more than 6 months
- Permanent: Impacts are permanent (animals removed from wild population).

4.7 Impacts of Alternative B (aerial brodifacoum broadcast with reptile captive hold)

4.7.1 Impacts on Birds

There are no bird species on Desecheo Island that would suffer long term population-level impacts from rat eradication activities. The numbers of birds on Desecheo are relatively low, all resident and migratory bird species are common species found regionally or globally, and any localized extirpation of a resident species would likely be short-term as birds would recolonize the island from the nearby mainland. However, individual birds present on Desecheo at the time of the aerial bait application may be at risk of bait exposure during or shortly after the bait application (approximately two weeks).

The risk of mortality from the toxicological effects of brodifacoum has been described in Section 2.3.2.2, and is generally considered high. However, this risk is dependent on the different toxicant exposure pathways between different species. Therefore, in the analyses below, the risk of brodifacoum exposure is the primary criteria used to evaluate risk of impact from toxicant use to different species.

Generally, the species at high risk of primary exposure to brodifacoum (by eating bait directly) would include granivorous birds that primarily eat seeds and grains, and some omnivorous scavengers. Birds at high risk of secondary exposure would include predators and scavengers, in particular animals that feed on rats, carrion, or large ground-dwelling invertebrates such as beetles. Birds that have a broad, omnivorous diet would initially be at high risk for both primary and secondary exposure.

Birds at lower risk of primary exposure include species foraging in the intertidal zone because the mitigation procedures for applying bait along the coastline would reduce the likelihood of pellets entering the marine environment, and because any bait pellets that do drift into the water would disintegrate and become unavailable within a few hours. Similarly, birds that specialize in intertidal invertebrates would be at low risk of secondary exposure for similar reasons.

Birds that feed on terrestrial invertebrates would be at risk of secondary exposure only where the prey items are themselves feeding directly on bait; on Desecheo, ants (Formicidae) have been most frequently observed directly eating bait pellets, but land crabs, beetles (Coleoptera), cockroaches (Blattidae) and New Zealand weta have been observed feeding on bait pellets elsewhere (Ogilvie et al. 1997, Island Conservation unpubl. data). Birds that feed primarily on flying and canopy insects and terrestrial micro-invertebrates would be at a low risk of secondary exposure due to the low likelihood that these invertebrate taxa would acquire brodifacoum by ingesting bait pellets directly.

The risk of secondary and tertiary exposure in birds that feed on terrestrial and canopy invertebrates would decline to negligible within a few months of the bait application. The likelihood of exposure in intertidal specialists would likely be negligible by about 30 days of the final bait application.

The following sections present an analysis of the toxicant and disturbance impacts to each of the identified bird species that are residents of Desecheo or have been documented on Desecheo in the last ten years (since 2000). Additionally, we have estimated the number of individuals per species that are likely to be adversely impacted by Alternative B (we have assumed the worst case scenario and consider any individuals that may be present on the island during the bait application operations to be vulnerable to adverse impacts from the action alternative).

Species Risk Evaluation

4.7.1.1 Permanent Resident Species in Puerto Rico

All species evaluated below, with the exception of ruddy turnstone, common ground-dove, and turkey vulture, have been frequently observed on Desecheo in February and March 2009 and 2010, and are considered resident on the island. While ruddy turnstone and common ground-dove have been reported infrequently in the last ten years, they are included in the analysis in this section because they are common species and permanent residents in Puerto Rico, and could therefore also be permanently resident on Desecheo, but at low densities. Turkey vultures have never been recorded from Desecheo but because they are permanent residents in Puerto Rico and would be at high risk of toxicant exposure because of their scavenging feeding ecology, they are given some consideration here.

Turkey vulture: In Puerto Rico, turkey vultures are primarily restricted to an area of about 60 x 12 miles (100 km x 20 km) in the southern and southwestern region of the island

(Santana et al. 1986a). This region is characterized by subtropical dry forest, cattle pastures, rolling hills of pasture or shrubland, rugged karst hills and mangroves, and it is believed that vultures are more common in this area due to the availability of range cattle (Santana et al. 1986b). However, individual birds have been recorded outside of this region (Williams and Bunckley-Williams 1995), and the bird atlas of Puerto Rico documents seven records for turkey vultures from Añasco to Isabela in the west and northwest, to Matojillo, Camuy, about 12 mils east of Isabela. http://www.aosbirds.org/prbba/SpeciesTUVU.html However, given that the minimum home range of a turkey vulture can be 458 km^2 (Santana et al. 1986a) these sightings could be of wandering birds typically resident further south.

Turkey vultures are unlikely to be exposed to brodifacoum because they are not expected to be on Desecheo where they have never been recorded, the main population of vultures in Puerto Rico is concentrated in the south and southwest of the island and Desecheo is about 23 miles from the nearest recorded observation of a single turkey vulture. In addition, the likelihood that a turkey vulture could detect carrion (i.e. dead rats) on Desecheo Island by sight or smell is also low given that the prevailing winds are from the northwest to southeast (away from Puerto Rico). Also, vultures require updrafts of warm air on which to soar and glide and typically use escarpments, hills and mountains which provide these. While migratory turkey vultures from North America are known to fly across open water, they are generally hesitant to make water crossings and evidence of exhausted birds only 13 kms from land suggest that water crossings may be risky (Kirk and Mossman 1998).

If turkey vultures were present on Desecheo during the operation, they would be likely exposed to brodifacoum through secondary exposure pathways by consuming dead or moribund rats that have consumed bait. Rats found in the open, such as in grassland and shrubland areas, would be more easily located and accessed than rats under the forest canopy which would take longer to find (Kirk and Mossman 1998). Generally the risk to turkey vultures from toxicant exposure is considered negligible given the considerations described above, and this species is not included in the detailed risk analyses.

The species listed below are likely to be present on Desecheo during the bait application operations and would likely be present on the island for all or part of the time during which brodifacoum may be available within the environment.

Predatory birds – ***red-tailed hawk, American kestrel***

Toxicant Exposure Risk

American kestrels and red-tailed hawks would be likely exposed to brodifacoum through secondary exposure pathways by consuming rats, passerines, reptiles, carrion and large terrestrial invertebrates that consume bait; the exposure risk would be high because of the range of exposure pathways to these raptors. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway. The extent of the impact would be to the island population.

Disturbance Risk
American kestrels and red-tailed hawks would likely be exposed to disturbance from aerial operations, which would likely cause them to flush from their immediate location to an alternative site, and may temporarily change breeding behavior. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

- 0-10 red-tailed hawks would likely be impacted from Alternative B.
- 5-25 American kestrels would likely be impacted from Alternative B.

<u>Omnivores</u> – *pearly-eyed thrasher, Northern mockingbird, smooth-billed ani, shiny cowbird*

Toxicant Exposure Risk
These omnivorous species would likely be exposed to brodifacoum through secondary exposure pathways by consuming terrestrial invertebrates and anoles that consume bait. In addition shiny cowbird would also be exposed through a primary exposure pathway as this species also eats grain. The exposure risk for all omnivorous species would be high because of the range of exposure pathways. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to passerines. For pearly-eyed thrashers, the extent of the impact would be to the island population. For Northern mockingbird, smooth-billed ani and shiny cowbird the extent of the impact would be to individuals because these species are uncommon on Desecheo.

Disturbance Risk
Omnivorous species would likely be exposed to disturbance from aerial operations, would likely cause them to flush from their immediate location to alternative habitat, and may temporarily change breeding behavior. For pearly-eyed thrasher the impacts associated with disturbance risks for this alternative would be medium, and the duration of the risk would be for the medium term because this species is a permanent breeding resident on Desecheo. For Northern mockingbird, smooth-billed ani and shiny cowbird the disturbance risks would be low and the duration of the risk would be for the short term because these species are only known as visitors to the island. The extent of the risk to all species would be to individuals.

- 25-50 pearly-eyed thrashers would likely be impacted from Alternative B.
- 0-10 Northern mockingbirds would likely be impacted from Alternative B.
- 0-10 smooth-billed ani would likely be impacted from Alternative B.
- 0-10 shiny cowbird would likely be impacted from Alternative B.

<u>Granivores</u> – *zenaida dove, common ground-dove*

Toxicant Exposure Risk
Doves would be likely exposed to brodifacoum through primary exposure pathways. Doves are granivorous species that most commonly consume seeds and grains. Since brodifacoum- 25D is a grain based pellet, and the doves are ground-feeding granivorous

species, doves would likely eat bait pellets directly and the exposure risk would be high. The mortality risk would be high and the duration of the risk would be for the short term. The extent of the impact to zenaida doves would be to the island population, and to common ground doves would be to individuals because ground doves are uncommon on Desecheo.

Disturbance Risk
Doves would likely be exposed to disturbance from both aerial and ground operations, which would likely cause them to flush their immediate location into alternative habitat, and may temporarily change breeding behavior. The impacts associated with disturbance risks for this alternative would be medium. The duration of the risk would be for the medium term. The extent of the risk for zenaida dove would be to the island population, but for common ground-dove to individuals because the species is uncommon on Desecheo.

- 25-50 zenaida doves would likely be impacted from Alternative B.
- 0-5 common ground-doves would likely be impacted from Alternative B.

<u>Canopy foragers</u> – *black-whiskered vireo, gray kingbird*

Toxicant Exposure Risk
Canopy foragers would be likely exposed to brodifacoum through secondary exposure pathways by consuming terrestrial invertebrates that consume bait; the exposure risk would be medium because of the single exposure pathway. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to individuals. The extent of the impact would be to the island population.

Disturbance Risk
Canopy foragers would likely be exposed to disturbance from aerial operations, which would likely cause them to flush their immediate location into alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

- 0-50 black-whiskered vireos would likely be impacted from Alternative B.
- 0-50 gray kingbirds would likely be impacted from Alternative B.

<u>Canopy/Ground foragers</u> – *mangrove cuckoo*

Toxicant Exposure Risk
Mangrove cuckoos would be likely exposed to brodifacoum through secondary exposure pathways by consuming terrestrial invertebrates and small lizards that consume bait; the exposure risk would be high because of the range of exposure pathways. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to individuals. The extent of the impact would be to individuals because mangrove cuckoos are uncommon on Desecheo.

Disturbance Risk
Mangrove cuckoos would likely be exposed to disturbance from aerial operations, which would likely cause them to flush their immediate location into alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

- 0-5 mangrove cuckoos would likely be impacted from Alternative B.

Aquatic coastal foragers – ***ruddy turnstone, American oystercatcher, great blue heron, great egret, green heron, belted kingfisher***

Toxicant Exposure Risk
American oystercatchers would likely be exposed to brodifacoum through secondary exposure pathways by consuming bivalves that might be exposed to brodifacoum through bait drift into the marine environment. The exposure risk would be low because of the single exposure pathway and the coastal mitigation measures designed to reduce bait drift into the environment. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of inter-tidal species that provide a secondary exposure pathway to oystercatchers. The extent of the impact would be to the island population because this species is known to breed on Desecheo.

Ruddy turnstones would likely be exposed to brodifacoum through both primary and secondary exposure pathways, whereas great blue herons, green herons and great egrets would likely be exposed through secondary pathways only. Generally, turnstones forage in the intertidal zone for aquatic invertebrates and insects but will consume carrion, while great blue herons, green herons and great egrets also consume carrion and intertidal invertebrates as well as fish, rats and small reptiles. The primary exposure pathway would probably be limited to individual turnstones that might consume softened bait pellets, whereas the secondary exposure pathways for turnstones, great blue herons, green herons and great egrets would include consumption of rats, intertidal invertebrates including crabs and carrion. Thus the exposure risk would be high because of the range of toxicant exposure pathways for these species. The mortality risk would be high and the duration of the risk would likely be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway. The extent of the impact would be to individuals because these species are uncommon on Desecheo and are not known to breed.

Belted kingfishers would likely be exposed to brodifacoum through secondary exposure pathways by consuming rats that consume bait; the exposure risk would be medium because of the single exposure pathway. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to kingfishers. The extent of the impact would be to individuals because kingfishers are uncommon on Desecheo and are not known to breed.

Disturbance Risk
Aquatic coastal foragers would likely be exposed to disturbance from both aerial and ground operations, which would likely cause them to flush from their immediate location into alternative habitat. For American oystercatchers, the impacts associated with disturbance risks for this alternative would be medium, the duration of the risk would be for the medium term, and the impact would be to the island population because this species is known to breed on Desecheo. For the remaining species, the impacts associated with disturbance risks would be low, the duration of the risk would be for the short term, and the extent of the risk would be to individuals because the species are uncommon on Desecheo, and not known to breed.

- 0-25 ruddy turnstones would likely be impacted from Alternative B.
- 0-25 American oystercatchers would likely be impacted from Alternative B.
- 0-5 great blue herons would likely be impacted from Alternative B.
- 0-5 green herons would likely be impacted from Alternative B.
- 0-5 great egrets would likely be impacted from Alternative B.
- 0-5 belted kingfishers would likely be impacted from Alternative B.

Granivores: non-native terrestrial species – *house sparrow, bronze mannikin, orange-cheeked waxbill*

Toxicant Exposure Risk
Non-native terrestrial granivores would likely be exposed to brodifacoum through primary exposure pathways. These terrestrial birds are granivorous species that most commonly consume seeds. Since Brodifacoum-25D is a grain based pellet, and these species frequently forage on the ground, they would likely eat bait pellets directly and the exposure risk would be high. The mortality risk would be high and the duration of the risk would be for the short term and the extent of the impact would be to individuals since these species are uncommon on Desecheo.

Disturbance Risk
Non-native terrestrial birds would likely be exposed to disturbance from aerial operations, which would likely cause them to flush from their immediate location into alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals since these are uncommon species on Desecheo.

- 0-50 house sparrows would likely be impacted from Alternative B.
- 0-50 bronze mannikins would likely be impacted from Alternative B.
- 0-50 orange-cheeked waxbills would likely be impacted from Alternative B.

4.7.1.2 Winter Migratory Birds in Puerto Rico

The following species are winter migrants, typically present in Puerto Rico between November and February. However, the departure dates from Puerto Rico for their summer breeding grounds may vary between species, and for some individuals may be as late as

May. Therefore, because the operational window would be within this migratory transitional period, we have evaluated the following species with the expectation that individuals would be present on Desecheo during bait application activities.

Predatory birds – *peregrine falcon, Northern harrier, merlin*

Toxicant Exposure Risk
Peregrine falcons would likely be exposed to brodifacoum through secondary exposure pathways by consuming shorebirds and laughing gulls that consume bait, and through tertiary pathways by consuming birds and reptiles that have scavenged carcasses or fed on invertebrates exposed to brodifacoum. The exposure risk is high because of the range of exposure pathways to falcons. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary and tertiary exposure pathway to falcons. The extent of the impact would be to individuals.

Northern harriers would likely be exposed to brodifacoum through secondary exposure pathways by consuming rats and passerines that consume bait. The exposure risk would be high because of the range of exposure pathways to harriers. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to harriers. The extent of the impact would be to individuals.

Merlins would likely be exposed to brodifacoum through secondary exposure pathways by consuming passerines that consume bait. The exposure risk would be medium because of the single exposure pathway to merlins. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to merlins. The extent of the impact would be to individuals.

Disturbance Risk
Raptors would likely be exposed to disturbance from aerial operations, which would cause them to flush from their immediate location to an alternative site. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals because these species are uncommon on Desecheo.

- 0-10 peregrine falcons would likely be impacted from Alternative B.
- 0-5 Northern harriers would likely be impacted from Alternative B.
- 0-5 merlins would likely be impacted from Alternative B.

4.7.1.3 Seabirds

Few seabirds have been reported on or around Desecheo Island in recent years, and there was no known nesting on Desecheo for 50 years until 2010 when a handful of bridled terns and one pair of brown noddy nested on the island and on offshore rocks (Breckon 1998,

Island Conservation 2010b). Therefore, to evaluate the potential risk to breeding seabirds (because of limited information for seabirds on Desecheo) information on the breeding seasons for seabirds on adjacent islands was used. The egg-laying period for species previously reported as breeding on Desecheo is primarily between March and July, with some species showing bi-modal patterns and a winter peak between August and December (see Section 3.4.2.5, Table 3.1). The only species currently recorded on Desecheo with any consistency is the brown booby, but only roosting birds are known. On nearby islands, peak egg-laying for brown boobies occurs between March and April. The aerial bait application is recommended to occur between January and April, a period that coincides with some seabird breeding activity on adjacent islands. Any potential disturbance to known seabird roosts can be minimized by manipulating the helicopter flight plan to avoid working in areas of high density birds for extended periods of time.

The only seabird known historically from Desecheo that is potentially at risk of primary exposure to the rodenticide is the laughing gull *Larus atricilla*. In 1970, C. Kepler reported up to 700 adult laughing gulls and 71 nests on cays offshore of Desecheo Island, but only one lone laughing gull was reported during four visits in 1986 and 1987 (Meier et al. 1989). Gulls are at primary risk of exposure to rodenticide due to their more omnivorous feeding habits and inquisitive behavior. During a placebo bait acceptability trial on Macquarie Island (Australia) in 2005, kelp gulls *Larus dominicanus* fed on accidentally spilled bait around the helicopter pad as demonstrated by green feces (the placebo-bait color) found in the area (K. Springer pers. comm.). After an attempted rabbit and rat eradication operation that applied brodifacoum to Macquarie Island in 2010, 356 kelp gulls were found dead, along with 377 giant petrels (*Macronectes* sp.) and subantarctic skuas (*Catharacta lonbergi*)(the latter two species of which are scavengers) (Australian Department of Sustainability 2010). During rat eradication on the island of San Pedro Martír (Gulf of California) in 2007, green feces from yellow-footed gulls *Larus livens* were observed along the coastline and one dead adult bird was found. Nearly eight months after an aerial bait application on Rat Island, Alaska, to remove brown rats, carcasses of 320 glaucous-winged gulls *Larus glaucescens* were found; toxicology tests implicated brodifacoum in 24 of the 34 tested (Salmon and Paul 2010).

Laughing gull

Toxicant Exposure Risk

Generally, laughing gulls are at low risk of exposure to brodifacoum because the species is a summer breeding migrant to the region and is unlikely to be on Desecheo during the bait application window. However, many birds remain coastal inhabitants during the winter period, sometimes traveling out to sea and between islands. In addition, a dead laughing gull was found on the beach on Desecheo in February 2009 (Island Conservation unpubl. data), suggesting that some individuals either arrive early to the region or are present year-round. If laughing gulls were on the island at the time of bait application, individuals would likely be exposed to brodifacoum through both primary and secondary exposure pathways. Laughing gulls are omnivorous and are often found foraging in the intertidal zone for aquatic and terrestrial invertebrates, eating seeds and plants, or feeding on carrion. The primary exposure pathway is significant because gulls are known to consume rodenticide pellets (see Section 4.6.3.3). Additionally, the secondary exposure pathways include

consumption of carrion and terrestrial invertebrates that have consumed the toxicant. For individual birds that appear on the island, the exposure risk would be high because of the range of toxicant exposure pathways, the mortality risk would be high and the duration of the risk would likely be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to gulls. The extent of the impact would be to individuals because gulls are uncommon as breeding birds on Desecheo.

Disturbance Risk
There is a low risk of disturbance to laughing gulls from aerial or ground operations because the species is a summer breeding migrant to the region, and their presence on the island during the operational period would be unlikely. However, in the event that some gulls are present year-round or arrive to breed in the area earlier, aerial and ground operations would likely cause any birds roosting on the island to flush from their immediate location to an alternative site. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals because laughing gulls are uncommon on Desecheo.

- 0-25 laughing gulls would likely be impacted from Alternative B.

Brown booby and brown pelican
Toxicant Exposure Risk
Less than 100 individuals of brown booby and small numbers of brown pelican are known to roost on Desecheo, but no breeding has been reported in recent years. Therefore, individuals of both species would be present during the bait application window. However, neither species would be considered at risk of toxicant exposure because they rarely if ever feed on anything other than marine fish and squid; therefore, the extent of the impact is insignificant and does not require further evaluation.

Disturbance Risk
Roosting brown booby and brown pelican would be exposed to disturbance from both aerial and ground operations, which would likely cause birds to flush from their immediate location to an alternative site. Although neither species has been reported as breeding on Desecheo in recent years, because both are known to roost on the island, both have extended breeding seasons throughout the year which would overlap with the operational window, and brown booby breeds on Mona and Monito islands, the potential exists for nesting birds on Desecheo during the bait application window. Physical disturbance may cause nesting birds to temporarily leave their nest but they would likely return once the disturbance has passed. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals because both species are uncommon on Desecheo.

- 20-50 brown boobies would likely be impacted from Alternative B.
- 0-5 brown pelican would likely be impacted from Alternative B.

Magnificent frigatebird and red-footed booby

Toxicant Exposure Risk

Magnificent frigatebirds have been observed flying over the island and there is therefore the potential for birds to be roosting on the island during the operational window. Red-footed boobies have not been observed on Desecheo in recent years. However, as both species are year-round residents in the region, there is the potential for both birds to be on Desecheo during the operational window. However, they would not be considered at risk of toxicant exposure because they rarely if ever feed on anything other than marine fish and squid. Therefore, the extent of the impact is insignificant and does not require further scrutiny.

Disturbance Risk

If present on the island, both species would likely be exposed to disturbance from both aerial and ground operations, which may cause roosting birds to flush from their immediate location to an alternative site; the impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals because these species are uncommon on Desecheo.

- 0-5 magnificent frigatebirds would likely be impacted from Alternative B.
- 0-5 red-footed boobies would likely be impacted from Alternative B.

Bridled tern, sooty tern, brown noddy

Toxicant Exposure Risk

Bridled terns, sooty terns and brown noddy are spring/summer migrants to the region and their presence on Desecheo during the operational window would be unlikely; nests of 17 bridled tern pairs and one brown noddy pair were found with eggs in June 2010. In addition, they would not be considered at risk of toxicant exposure because they rarely if ever feed on anything other than marine fish and squid; therefore, the extent of the impact is insignificant and does not require further scrutiny.

Disturbance Risk

There is negligible disturbance risk to these small ground-nesting seabirds from aerial or ground operations because they are spring/summer migrants to the region, and their presence on the island during the operational period would be unlikely. In the event that birds arrive in the area earlier than anticipated, aerial and ground operations would likely cause any birds roosting on the island to flush from their immediate location to an alternative site. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals because these species are uncommon on Desecheo.

- 0-5 bridled terns would likely be impacted from Alternative B.
- 0-5 sooty terns would likely be impacted from Alternative B.
- 0-5 brown noddies would likely be impacted from Alternative B.

White-tailed tropicbird
Toxicant Exposure Risk
There would be no risk of toxicant exposure to white-tailed tropicbirds because they have never been reported on Desecheo, and they rarely if ever feed on anything other than marine fish and squid. Therefore, the extent of the impact is insignificant and does not require further scrutiny.

Disturbance Risk
White-tailed tropicbirds are summer breeding residents on nearby Mona and Monito islands between February and August (Table 3.1). Tropicbirds have been reported flying close to Desecheo, but have never been reported as breeding. If birds were to appear on the island during the operational window, they may be impacted by localized aerial and ground disturbance causing individuals to flush from their immediate location to an alternative site. However, because of the very low likelihood that white-tailed tropicbirds would roost or breed on Desecheo, the impacts associated with disturbance risk would be very low, the extent of the risk would be to individuals and the duration of the risk would be short.

- 0-5 white-tailed tropicbirds would likely be impacted from Alternative B.

4.7.2 Impacts on Reptiles

Toxicant exposure risk to reptiles on Desecheo would be primary (by ingesting the bait) or secondary (by ingesting contaminated prey). In either case, the time window of risk is relatively short, beginning with the date of application and lasting until the brodifacoum has disappeared from the environment. The three lizard species and the dwarf gecko on Desecheo are primarily insectivores that hunt using visual cues (moving prey), with the exception of the *Amieva* which is also a predator of anolis lizards. Therefore, direct ingestion of the bait would be unlikely. However, in field trials using a placebo biomarker bait, about 20 percent of Desecheo anoles tested positive for biomarker, but the pathway of contamination could not be confirmed (Island Conservation 2010c). Most exposure would likely be secondary via ingestion of contaminated invertebrates, contaminated anoles, or scavenging on dead rats by *Ameiva*. A captive experiment on *Sphaerodactylus* geckos demonstrated no affect of direct exposure to bait pellets (reported in García 1994). Terrestrial invertebrates are known to consume bait pellets and secondary poisoning of insectivorous birds has been reported (Eason and Spurr 1995). Similarly, exposure risk to the Puerto Rican racer is likely to be secondary via ingestion of contaminated anoles and geckos, its preferred prey (Henderson and Sajdak 1996). However, a successful rat eradication on the island of Antigua resulted in no detectable mortality of the endangered Antiguan racer *Alsophis antiguae*, and in fact the racer population doubled in size in 18 months post-rat eradication (Daltry 2006).

The toxicity of brodifacoum to reptiles is discussed in Section 4.6.3.2. Because of the limited laboratory and field knowledge on the toxicity of rodenticides to reptiles, this analysis presents the most cautious approach, anticipating a high risk of brodifacoum toxicity on exposure.

Because the reptile fauna of Desecheo Island comprises three single-island endemic species with an associated restricted range and population size (see Section 3.6.1), significant reptile mortality during the bait application has the potential for population-level impacts. In addition, even though the slippery-backed skink and the Puerto Rican racer are native species with populations elsewhere in Puerto Rico, the sub-specific status of the racer is in question, and the slippery-backed skink is classified as locally vulnerable based on reported limited distribution and sightings (García et al. 2005). Information about the species' ecology, population abundance and distribution across the island is limited, particularly from recent years. Only one study of the endemic dwarf gecko exists, from 1987, which reported densities of 3 – 19 animals in 125 m^2 forest plot and suggested that the gecko is probably a forest-obligate species. In addition, more animals were found during the wetter months when their activity levels increased (Meier and Noble 1990a).

The slippery-backed skink was only first recorded from Desecheo Island in 1987, where it was observed primarily in the thorny cactus scrub community (Meier and Noble 1990b). Based on observations, the endemic anole and *Amieva* are believed to be abundant (Earsom 2002, Island Conservation 2009a).

Field surveys conducted in 2009 and 2010 provided further information on the population density and abundance of the Desecheo anole, dwarf gecko, *Ameiva* and racer (see Section 3.6.1). Total population estimates for *Ameiva desechensis* was calculated as 7,469 individuals (1,800 – 13,137, 95 percent confidence limits), for *Anolis desechensis* was 52,111 individuals (31,464 – 72,758, 95 percent confidence limits), and for *Sphaerodactylus levinsi* was 13,261 individuals (8,796 – 19,991, 95 percent confidence limits). Population estimates for each of these species varied between habitats, and estimates were generally lower in grassland habitats than in shrub and forest habitats. The Puerto Rico racer's density was generally low across the island, with only an average of seven individuals recorded per hectare. Densities of the four reptile populations monitored were generally considered low in comparison to mainland populations of similar species, which suggests that there are some ongoing impacts from rats on reptile densities.

Desecheo gecko

Toxicant Exposure Risk

A sub-set of Desecheo geckos removed to captivity prior to bait application would not be at risk of impacts from the toxicant.

Desecheo geckos remaining in the wild on the island after animals had been removed to captivity would be exposed to brodifacoum through secondary exposure pathways by consuming micro-invertebrates that consume bait. The toxicant exposure risk would be medium because of the single exposure pathway. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to geckos. The extent of the impact would be to the remaining island population.

Disturbance Risk
Desecheo geckos that remain in the wild on Desecheo would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals remaining on the island.

Individual geckos that are taken into captivity prior to the bait application are at high level of disturbance risk from being captured, and from being held for an extended period of time. Capture operations could potentially cause injury or death to individuals prior to bringing them into captivity, while captive individuals could be at risk of injury, disease, and poor nutrition that could cause mortality. The extent of the risk would be to individuals captured and held in captivity.

Alternative B(i): 20-30 pairs of Desecheo geckos would be permanently removed from the wild population to captivity and not returned to Desecheo.

Alternative B(ii): 30-40 individual Desecheo geckos would be temporarily held in captivity on Desecheo. The duration of the risk to captive individuals would be medium.

Desecheo ameiva
Toxicant Exposure Risk
A sub-set of Desecheo amieva removed to captivity prior to bait application would not be at risk of impacts from the toxicant.

Desecheo ameiva remaining in the wild on the island would be exposed to brodifacoum through secondary exposure pathways by consuming carrion, juvenile anoles, juvenile geckos, and terrestrial invertebrates that consume bait. The toxicant exposure risk would be high because of the range of exposure pathways. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to ameivas. The extent of the impact would be to the population remaining on the island.

Disturbance Risk
Desecheo ameivas that remain in the wild on Desecheo would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals remaining on the island.

Individual ameivas that are taken into captivity prior to the implementation of the bait application are at high level of disturbance risk from being captured, and from being held in captivity for an extended period of time. Capture operations could potentially cause injury or death to individuals prior to bringing them into captivity, while captive individuals could be at risk of injury, disease, and poor nutrition that could cause mortality. The extent of this risk would be to individuals captured and held in captivity.

Alternative B(i): 20 - 30 pairs of Desecheo ameiva would be permanently removed from the wild population to captivity and not returned to Desecheo.

Alternative B(ii): 20-30 individual Desecheo ameiva would be temporarily held in captivity on Desecheo. The duration of the risk to captive individuals would be medium.

Desecheo anole

Toxicant Exposure Risk

A sub-set of Desecheo anoles removed to captivity prior to bait application would not be at risk of impacts from the toxicant.

Desecheo anoles remaining in the wild on Desecheo would be exposed to brodifacoum through both primary and secondary exposure pathways. Generally, anoles consume terrestrial invertebrates. The primary exposure pathway would be limited to anoles who consume bait pellets whereas the secondary exposure pathways would include consumption of terrestrial invertebrates. The toxicant exposure risk would be high because of the range of toxicant exposure pathways, the mortality risk would be high, and the duration of the risk would likely be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to anoles. The extent of the impact would be to the entire island population remaining after a sub-set of animals has been removed to captivity prior to bait application.

Disturbance Risk

Desecheo anoles that remain in the wild on Desecheo would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals remaining on the island after a sub-set has been removed to captivity prior to bait application.

Individual anoles that are taken into captivity prior to the implementation of the rat eradication would be at high level of disturbance risk from ground operations, as well as from being captured and held for an extended period of time. Capture operations could potentially cause injury or death to individuals prior to bringing them into captivity, while captured individuals could be at risk of injury, disease, poor management that could cause mortality. The extent of the risk would be to individuals captured and held in captivity.

Alternative B(i): 20 - 30 pairs of Desecheo anoles would be permanently removed from the wild population to captivity and not returned to Desecheo.

Alternative B(ii): 30-40 individual Desecheo anoles would be temporarily held in captivity on Desecheo. The duration of the risk to captive individuals would be medium.

Puerto Rico racer

Toxicant Exposure Risk

The Puerto Rican racer would be exposed to brodifacoum through secondary exposure pathways by consuming anoles, geckos and juvenile ameivas that consume bait. The toxicant exposure risk would be high because of the range of exposure pathways. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to racers. The extent of the impact would be to the entire island population.

Disturbance Risk

Puerto Rican racers would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. However, racers are rarely seen and would likely experience little if any impact from disturbance. Therefore, the impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

Slippery-backed skink

Toxicant Exposure Risk

Slippery-backed skinks would be exposed to brodifacoum through both primary and secondary exposure pathways. Generally, skinks consume terrestrial invertebrates, and may prey upon small lizards. The primary exposure pathway would be by direct feeding on bait, whereas the secondary exposure pathways would include consumption of terrestrial invertebrates and small lizards that consume bait. The toxicant exposure risk would be high because of the range of exposure pathways, the mortality risk would be high, and the duration of the risk would likely be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to skinks. The extent of the impact would be to the entire island population.

Disturbance Risk

Slippery-backed skinks would be exposed to disturbance from ground operations, which may cause them to flee their immediate location into alternative habitat. However, skinks are rarely seen and would likely experience little if any impact from disturbance. Therefore, the impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

Hawksbill, green and leatherback sea turtles

Toxicant Exposure Risk

Turtles may face a primary risk of exposure to brodifacoum through eating bait directly as it drops through the water column. These turtles' common foraging behaviors make exposure unlikely, but juvenile green turtles in particular are known to be comparatively opportunistic feeders, and marine turtles have been documented ingesting marine debris elsewhere (Carr 1987, Meylan 1988, Bjorndal et al. 1994, Coyne 1994, Bugoni et al. 2001, NOAA Fisheries pers. comm.). By applying bait only above the high tide line and limiting the spread of bait into the marine environment through use of a deflector on the bait

bucket, bait would only enter the marine environment through bait drift from the bucket during aerial application. Any bait pellets that do enter the water will only be ingestible by turtles for a few hours prior to embedding in the sediment and breaking down to tiny fragments (Empson and Miskelly 1999, Howald et al. 2010). Thus, the duration of risk to turtles is for the very short term. Hawksbill turtles are almost exclusive sponge feeders in the Caribbean and are known to feed on sponges within the Desecheo Marine Reserve. Sponges present a possible incidental pathway of toxicant to individuals. However, brodifacoum is very poorly soluble in water and binds tightly to the grain matrix of the bait pellet (Section 4.5.1.3); it is considered unlikely that the brodifacoum molecule could bind to the sponge independently. Thus the pathway through sponges would require a bait pellet or pellet fragment to lodge on the surface or inside the sponge and which might be ingested by the turtle together with pieces of sponge. The extent of risk is essentially negligible. The risk of turtle mortality, given the extremely low likelihood of exposure to the toxicant, is unknown but suspected to be negligible.

Disturbance Risk
Hawksbill, green and leatherback sea turtles could be exposed to disturbances from boat operations, which will likely cause turtles to flee from the immediate area. However, boat operations in association with the rat eradication would not exceed normal levels of boat use during the recreational season, and would be limited to small boats, and all boat operators would be briefed on NOAA protocols to avoid vessel collisions and disturbance associated with marine life (NOAA 2008) (Appendix X). Turtles would not be at risk from disturbance impacts on the island because they are not known to haul onto Desecheo during the implementation period of this project. Green and leatherback turtles are not known to breed on the island, and only incidental records of hawksbill turtles nesting on Desecheo have been reported. The predominant nesting months for hawksbill turtles in Puerto Rico and the U.S. Virgin Islands is June to November (although some nesting can be documented for every month of the year), which is outside of the operational window. The impacts associated with disturbance risks for this alternative are low, the duration of the disturbance will be for the short-term, and the extent of the effect will be on the individual level.

4.7.3 Impacts on Invertebrates

Invertebrates rely on a circulatory system which is different from systems found in birds, reptiles and mammals. For this reason, invertebrates are not thought to be at risk of mortality from brodifacoum poisoning. However, few laboratory-based studies have been conducted to validate this statement. A study by Morgan et al. (1996) found that while a species of New Zealand orthoptera readily consumed brodifacoum bait, there was no mortality when individuals were dosed orally with brodifacoum. Other studies have demonstrated a range of invertebrates found at bait stations that consume bait (Bowie and Ross 2006), brodifacoum residues found in land crabs during planning for rodent eradication (Pain et al. 2000), and brodifacoum residues found in live invertebrates following an eradication attempt (Ogilvie et al. 1997). It is anticipated that land crabs

would be the biggest consumer of bait pellets (Island Conservation 2010a), while a variety of insects may also feed on the grain-based pellets (Spurr and Drew 1999).

Arachnids – (Spider *Clubiona desecheonis*, Spider *Camillina desecheonis* and Whip Scorpion *Schizomus desecheo*)

Toxicant Exposure Risk
Arachnids would be likely exposed to brodifacoum through secondary exposure pathways by consuming terrestrial invertebrates that consume bait. No risk of toxicity is considered because arachnids have a different circulatory system to mammals, birds and reptiles, and no negative impacts from brodifacoum use have been reported. The toxicant exposure risk would be low because of the single exposure pathway; however, there would be no risk of mortality. The duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to arachnids. The extent of the impact would be to the entire global population because these are single-island endemic species.

Disturbance Risk
Arachnids would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

Purple landcrab
Toxicant Exposure Risk
Purple land crabs would be exposed to brodifacoum through both primary and secondary exposure pathways. Generally, land crabs are omnivorous and consume terrestrial invertebrates, carrion and seeds. The primary exposure pathway would be limited to land crabs who consume bait pellets, whereas the secondary exposure pathways would include consumption of terrestrial invertebrates and carrion. There would be no risk of mortality from the toxicant because land crabs have a different circulatory system to mammals, birds and reptiles, and because studies have demonstrated no mortality from brodifacoum toxicity (Pain et al. 2000, Island Conservation 2010a). The exposure risk would be high because of the range of toxicant exposure pathways. The duration of the risk would likely be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to land crabs. The extent of the impact would be to the island population.

Disturbance Risk
Purple land crabs would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. However, land crabs are largely nocturnal and would be unlikely to experience any impacts from disturbance. Therefore, the disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

Hermit crab

Toxicant Exposure Risk

Hermit crabs would be exposed to brodifacoum through both primary and secondary exposure pathways. Generally, hermit crabs are omnivorous and consume terrestrial invertebrates, carrion and seeds. The primary exposure pathway would be limited to crabs who consume bait pellets, whereas the secondary exposure pathways would include consumption of terrestrial invertebrates and carrion. There would be no mortality risk from the toxicant because hermit crabs have a different circulatory system to mammals, birds and reptiles, and because studies on land crabs and hermit crabs have demonstrated no mortality from brodifacoum toxicity (Pain et al. 2000, Island Conservation 2010a). The exposure risk would be high because of the range of toxicant exposure pathways. The duration of the risk would likely be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to crabs. The extent of the impact would be to the island population.

Disturbance Risk

Hermit crabs would be exposed to disturbance from ground operations from reptile capture and shoreline baiting, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be medium. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

4.7.4 Impacts on Bats

Toxicant Exposure Risk

Because the specific bat species on Desecheo are unknown, the toxicant exposure risk can only be evaluated in general terms. Both insectivorous and frugivorous bats are native to Puerto Rico. Insectivorous bats would be exposed to brodifacoum through secondary pathways, consuming aerial insects that had consumed bait. The risk of brodifacoum causing mortality in bats would likely be high, but the toxicant exposure risk to insectivorous bats would be low, as only a secondary pathway is available, and there is unlikely to be an exposure pathway to frugivorous/nectivorous bats. The duration of the risk to insectivorous bats would likely be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to bats. The extent of the impact would likely be to individuals as few observations of bats have been reported.

Disturbance risk

It is unlikely that bats would be exposed to disturbance from either aerial or ground operations as the bats observed on Desecheo are crepuscular and nocturnal.

4.7.5 Impacts on Vegetation

Higo chumbo

Toxicant Exposure Risk

Higo chumbo cacti would not be at risk from toxicant exposure therefore the extent of the impact is insignificant and does not require further scrutiny.

Disturbance Risk

Higo chumbo would be exposed to disturbance from ground operations, which would be mitigated for by providing ground personnel with photographs and identification keys for cacti, a map with the approximate location of known plants, and GPS coordinates indicating the exact location of known individuals on Desecheo. Additionally, ground personnel would be advised to avoid disturbing cacti while conducting ground operations. The impacts associated with disturbance risks for this alternative would be low because of the range of mitigation measures that would be implemented during ground operations. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

Other Vegetation/Flora

Toxicant Exposure Risk

Vegetation would not be at risk of toxicant exposure therefore the extent of the impact is insignificant and does not require further scrutiny.

Disturbance Risk

Vegetation would be exposed to disturbance from ground operations. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individual plants or limited to the immediate area of activity.

4.7.6 Impacts Table for Alternative B: Biological Resources

Table 4.1. Impacts of Alternative B (aerial brodifacoum broadcast with reptile captive hold) on biological resources. Species are listed in the order in which they are discussed in the text.

Species		Toxicant exposure risk level[1]	Risk mortality - toxicant use[2]	Disturbance risk[3]	Extent of risk within a population[4]		Duration of risk[5]	
					toxicant	disturbance	toxicant	disturbance
Red-tailed Hawk & American Kestrel		High	High	Low	Island	Individ.	Medium	Short
Pearly-eyed Thrasher		High	High	Medium	Island	Individ.	Medium	Medium
Northern Mockingbird, Smooth-billed Ani, Shiny Cowbird		High	High	Low	Individ.	Individ.	Medium	Short
Zenaida Dove & Common Ground-dove		High	High	Medium	Island/ Individ.[6]	Individ.	Short	Medium
Black-whiskered Vireo & Gray Kingbird		Medium	High	Low	Island	Individ.	Medium	Short
Mangrove Cuckoo		High	High	Low	Individ.	Individ.	Medium	Short
American Oystercatcher		Low	High	Medium	Island	Individ.	Medium	Short
Ruddy Turnstone, Great Blue Heron, Green Heron, Great Egret		High	High	Low	Individ.	Individ.	Medium	Short
Belted Kingfisher		Medium	High	Low	Individ.	Individ.	Medium	Short
House Sparrow, Bronze Mannikin, & Orange-cheeked Waxbill		High	High	Low	Individ.	Individ.	Short	Short
Peregrine Falcon & Northern Harrier		High	High	Low	Individ.	Individ.	Medium	Short
Merlin		Medium	High	Low	Individ.	Individ.	Medium	Short
Laughing Gull		High	High	Low	Individ.	Individ.	Medium	Short
Brown Booby & Brown Pelican		None	None	Low	None	Individ.	None	Short
Magnificent Frigatebird & Red-footed Booby		None	None	Low	None	Individ.	None	Short
Bridled Tern, Sooty Tern & Brown Noddy		None	None	Low	None	Individ.	None	Short
White-tailed Tropicbird		None	None	Low	None	Individ.	None	Short
Desecheo Gecko	wild	Medium	High	Low	Island	Individ.	Medium	Short
	[7]captive (i)	None	None	High	None	Individ.	None	Perm.[8]
	captive (ii)	None	None	High	None	Individ.	None	Medium
Desecheo Ameiva	wild	High	High	Low	Island	Individ.	Medium	Short
	captive (i)	None	None	High	None	Individ.	None	Perm.
	captive (ii)	None	None	High	None	Individ.	None	Medium
Desecheo Anole	wild	High	High	Low	Island	Individ.	Medium	Short
	captive (i)	None	None	High	None	Individ.	None	Perm.
	captive (ii)	None	None	High	None	Individ.	None	Medium
Puerto Rico Racer		High	High	Low	Island	Individ.	Medium	Short
Slippery-backed Skink		High	High	Low	Island	Individ.	Medium	Short
Hawksbill, Green & Leatherback Sea Turtles		Low	Low	Low	Individ.	Individ.	Short	Short
Arachnids [9]		Low	None	Low	Global	Individ.	Medium	Short
Purple Landcrab		High	None	Low	Island	Individ.	Medium	Short
Hermit Crab		High	None	Medium	Island	Individ.	Medium	Short
Bats (insectivores)		Low	High	None	Individ.	None	Medium	None
Higo Chumbo		None	None	Low	None	Individ.	None	Short
Other Vegetation/Flora		None	None	Low	None	Individ.	None	Short

NOTES TO TABLE 4.1

[1]None: No exposure pathway; Low: Possible exposure pathway; Medium: One exposure pathway; High: Multiple exposure pathways.

[2] None: No toxicological sensitivity; Low: Minor toxicological sensitivity; Medium: Moderate toxicological sensitivity; High: Severe toxicological sensitivity.

[3]None: No disturbance pathway; Low: Low sensitivity to disturbance; Medium: Moderate sensitivity to disturbance; High: Severe sensitivity to disturbance.

[4]Individual (Individ.): Few individuals affected, no affect on resident breeding population; Island population (Island): Resident breeding population affected, no affect on regional or global population; Global or regional population (Global): Regional or global population affected.

[5]Short: Impacts for up to two months; Medium: Impacts for two to six months; Long: Impacts for more than six months.

[6]Extent of risk within a population for both toxicant and disturbance is: Island for zenaida dove and Individual for common ground-dove.

[7] captive (i) and (ii) represents Alternatives B(i) and B(ii).

[8] Permanent (Perm.). Individuals are permanently removed from the population.

[9]Arachnids: *Clubiona desecheonis*, *Camillina desecheonis* and *Schizomus desecheo*.

4.8 Impacts of Alternative C on Biological Resources: (aerial brodifacoum broadcast)

4.8.1 Impacts on Birds

The impacts to birds on Desecheo that are associated with toxicity and exposure to Brodifacoum-25D and to disturbance from implementing the eradication operation in Alternative C are the same as those in Alternative B. For a full analysis of the impacts to birds from Alternative C please refer to Section 4.7.1.

4.8.2 Impacts on Reptiles

Toxicant exposure risk to reptiles on Desecheo would be primary (by ingesting the bait) or secondary (by ingesting contaminated prey). In either case, the time window of risk is relatively short, beginning with the date of application and lasting until the brodifacoum has disappeared from the environment. The three lizard species and the dwarf gecko on Desecheo are primarily insectivores that hunt using visual cues (moving prey), with the exception of the *Amieva* which is also a predator of anolis lizards. Therefore, direct ingestion of the bait would be unlikely. However, in field trials using a placebo biomarker bait, about 20 percent of Desecheo anoles tested positive for biomarker, but the pathway of contamination could not be confirmed (Island Conservation 2010c). Most exposure would likely be secondary via ingestion of contaminated invertebrates, contaminated anoles, or scavenging on dead rats by *Ameiva*. A captive experiment on *Sphaerodactylus* geckos demonstrated no affect of direct exposure to bait pellets (García 1994). Terrestrial invertebrates are known to consume bait pellets and secondary poisoning of insectivorous birds has been reported (Eason and Spurr 1995). Similarly, exposure risk to the Puerto Rican racer is likely to be secondary via ingestion of contaminated anoles and geckos, its

preferred prey (Henderson and Sajdak 1996). However, a successful rat eradication on the island of Antigua resulted in no detectable mortality of the endangered Antiguan racer *Alsophis antiguae*, and in fact the racer population doubled in size in 18 months post-rat eradication (Daltry 2006).

The toxicity of brodifacoum to reptiles is discussed in Section 3.6.1. Because of the limited laboratory and field knowledge on the toxicity of rodenticides to reptiles, this analysis presents the most cautious approach, anticipating a high risk of brodifacoum toxicity on exposure.

Because the reptile fauna of Desecheo Island comprises three single-island endemic species with an associated restricted range and population size (see Section 3.6.1), significant reptile mortality during the bait application has the potential for population-level impacts. In addition, even though the slippery-backed skink and the Puerto Rican racer are native species with populations elsewhere in Puerto Rico, the sub-specific status of the racer is in question, and the slippery-backed skink is classified as locally vulnerable based on reported limited distribution and sightings (García et al. 2005). Information about the species' ecology, population abundance and distribution across the island is limited, particularly from recent years. Only one study of the endemic dwarf gecko exists, from 1987, which reported densities of 3 – 19 animals in 125m^2 forest plot and suggested that the gecko is probably a forest-obligate species. In addition, more animals were found during the wetter months when their activity levels increased (Meier and Noble 1990a). The slippery-backed skink was only first recorded from Desecheo Island in 1987, where it was observed primarily in the thorny cactus scrub community (Meier and Noble 1990b). Based on observations, the endemic anole and *Amieva* are believed to be abundant (Earsom 2002, Island Conservation 2009a).

Field surveys conducted in 2009 and 2010 provided further information on the population density and abundance of the Desecheo anole, dwarf gecko, *Ameiva* and racer (see Section 3.6.1). Total population estimates for *Ameiva desechensis* was calculated as 7,469 individuals (1,800 – 13,137, 95 percent confidence limits), for *Anolis desechensis* was 52,111 individuals (31,464 – 72,758, 95 percent confidence limits), and for *Sphaerodactylus levinsi* was 13,261 individuals (8,796 – 19,991, 95 percent confidence limits). Population estimates for each of these species varied between habitats, and estimates were generally lower in grassland habitats than in shrub and forest habitats. The Puerto Rico racer's density was generally low across the island, with only an average of seven individuals recorded per hectare. Densities of the four reptile populations monitored were generally considered low in comparison to mainland populations of similar species, which suggests that there are some ongoing impacts from rats on reptile densities.

The impacts to reptiles that are associated with toxicity and exposure to brodifacoum-25D and to disturbance from implementing the eradication operation in Alternative C are largely the same as those presented in Alternative B. However, because Alternative C does not propose removal of a sub-set of animals to captivity, any impacts anticipated as a result of this alternative would affect the entire island population of the three single-island endemic species; this may be the global population or individuals within that population.

Desecheo gecko

Toxicant Exposure Risk

Desecheo geckos would be exposed to brodifacoum through secondary exposure pathways by consuming micro-invertebrates that consume bait. The toxicant exposure risk would be medium because of the single exposure pathway. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to geckos. The extent of the impact would be to the global population.

Disturbance Risk

Desecheo geckos that remain on Desecheo would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals.

Desecheo ameiva

Toxicant Exposure Risk

Desecheo ameiva would be exposed to brodifacoum through secondary exposure pathways by consuming carrion, juvenile anoles, juvenile geckos, and terrestrial invertebrates that consume bait. The toxicant exposure risk would be high because of the range of exposure pathways. The mortality risk would be high and the duration of the risk would be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to ameivas. The extent of the impact would be to the global population.

Disturbance Risk

Desecheo ameivas would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals.

Desecheo anole

Toxicant Exposure Risk

Desecheo anoles would be exposed to brodifacoum through both primary and secondary exposure pathways. Generally, anoles consume terrestrial invertebrates. The primary exposure pathway would be limited to anoles who consume bait pellets whereas the secondary exposure pathways would include consumption of terrestrial invertebrates. The toxicant exposure risk would be high because of the range of toxicant exposure pathways, mortality risk would be high, and the duration of the risk would likely be for the medium term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to anoles. The extent of the impact would be to the global population.

Disturbance Risk
Desecheo anoles would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals.

Puerto Rico racer
The impacts to Puerto Rico racer that are associated with toxicity and exposure to Brodifacoum-25D and to disturbance from implementing the eradication operation in Alternative C are the same as those in Alternative B. For a full analysis of the impacts to racers from Alternative B please refer to Section 4.7.2.

Slippery-backed skink
The impacts to the slippery-backed skink that are associated with toxicity and exposure to Brodifacoum-25D and to disturbance from implementing the eradication operation in Alternative C are the same as those in Alternative B. For a full analysis of the impacts to skinks from Alternative B please refer to Section 4.7.2.

Hawksbill, green and leatherback sea turtles
The impacts to hawksbill, green and leatherback sea turtles that are associated with toxicity and exposure to Brodifacoum-25D and to disturbance from implementing the eradication operation in Alternative C are the same as those in Alternative B. For a full analysis of the impacts to turtles from Alternative B please refer to Section 4.7.2.

4.8.3 Impacts on Invertebrates

The impacts to invertebrates, including the three arachnids (*Clubiona desecheonis*, *Camillina desecheonis* and *Schizomus desecheo*), purple landcrab and hermit crab, that are associated with toxicity and exposure to Brodifacoum-25D and to disturbance from implementing the eradication operation in Alternative C are the same as those in Alternative B. For a full analysis of the impacts to invertebrates from Alternative B please refer to Section 4.7.3.

4.8.4 Impacts on Bats

The impacts to bats that are associated with toxicity and exposure to Brodifacoum-25D and to disturbance from implementing the eradication operation in Alternative C are the same as those in Alternative B. For a full analysis of the impacts to bats from Alternative B please refer to Section 4.7.4.

4.8.5 Impacts on Vegetation

The impacts to vegetation including the higo chumbo cactus that are associated with toxicity and exposure to Brodifacoum-25D and to disturbance from implementing the eradication operation in Alternative C are the same as those in Alternative B. For a full analysis of the impacts to vegetation from Alternative B please refer to Section 4.7.5.

4.8.6 Impacts Table for Alternative C: Biological Resources

Table 4.2. Impacts of Alternative C (aerial brodifacoum broadcast) on biological resources.

Species	Toxicant exposure risk level[1]	Risk mortality - toxicant use[2]	Disturbance risk[3]	Extent of risk within a population[4]		Duration of risk[5]	
				toxicant	disturbance	toxicant	disturbance
Red-tailed Hawk & American Kestrel	High	High	Low	Island	Individ.	Medium	Short
Pearly-eyed Thrasher	High	High	Medium	Island	Individ.	Medium	Medium
Northern Mockingbird, Smooth-billed Ani, Shiny Cowbird	High	High	Low	Individ.	Individ.	Medium	Short
Zenaida Dove & Common Ground-dove	High	High	Medium	Island/ Individ.[6]	Individ.	Short	Medium
Black-whiskered Vireo & Gray Kingbird	Medium	High	Low	Island	Individ.	Medium	Short
Mangrove Cuckoo	High	High	Low	Individ.	Individ.	Medium	Short
American Oystercatcher	Low	High	Medium	Island	Individ.	Medium	Short
Ruddy Turnstone, Great Blue Heron, Green Heron, Great Egret	High	High	Low	Individ.	Individ.	Medium	Short
Belted Kingfisher	Medium	High	Low	Individ.	Individ.	Medium	Short
House Sparrow, Bronze Mannikin, & Orange-cheeked Waxbill	High	High	Low	Individ.	Individ.	Short	Short
Peregrine Falcon & Northern Harrier	High	High	Low	Individ.	Individ.	Medium	Short
Merlin	Medium	High	Low	Individ.	Individ.	Medium	Short
Laughing Gull	High	High	Low	Individ.	Individ.	Medium	Short
Brown Booby & Brown Pelican	None	None	Low	None	Individ.	None	Short
Magnificent Frigatebird & Red-footed Booby	None	None	Low	None	Individ.	None	Short
Bridled Tern, Sooty Tern & Brown Noddy	None	None	Low	None	Individ.	None	Short
White-tailed Tropicbird	None	None	Low	None	Individ.	None	Short
Desecheo Gecko	Medium	High	Low	Global	Individ.	Medium	Short
Desecheo Ameiva	High	High	Low	Global	Individ.	Medium	Short
Desecheo Anole	High	High	Low	Global	Individ.	Medium	Short
Puerto Rico Racer	High	High	Low	Island	Individ.	Medium	Short
Slippery-backed Skink	High	High	Low	Island	Individ.	Medium	Short
Hawksbill, Green & Leatherback Sea Turtles	Low	Low	Low	Individ.	Individ.	Short	Short
Arachnids[7]	Low	None	Low	Global	Individ.	Medium	Short
Purple Landcrab	High	None	Low	Island	Individ.	Medium	Short
Hermit Crab	High	None	Medium	Island	Individ.	Medium	Short
Bats (insectivores)	Low	High	None	Individ.	None	Medium	None
Higo Chumbo	None	None	Low	None	Individ.	None	Short
Other Vegetation/Flora	None	None	Low	None	Individ.	None	Short

NOTES TO TABLE 4.2

[1]None: No exposure pathway; Low: Possible exposure pathway; Medium: One exposure pathway; High: Multiple exposure pathways.

[2] None: No toxicological sensitivity; Low: Minor toxicological sensitivity; Medium: Moderate toxicological sensitivity; High: Severe toxicological sensitivity.

[3] None: No disturbance pathway; Low: Low sensitivity to disturbance; Medium: Moderate sensitivity to disturbance; High: Severe sensitivity to disturbance.

[4] Individual (Individ.): Few individuals affected, no affect on resident breeding population; Island population (Island): Resident breeding population affected, no affect on regional or global population; Global or regional population (Global): Regional or global population affected.
[5] Short: Impacts for up to two months; Medium: Impacts for two to six months; Long: Impacts for more than 6 months.
[6] Extent of risk within a population for both toxicant and disturbance is: Island for zenaida dove and Individual for common ground-dove.
[7] Arachnids: *Clubiona desecheonis*, *Camillina desecheonis* and *Schizomus desecheo*.

4.9 Impacts of Alternative D (aerial diphacinone broadcast with reptile captive hold)

4.9.1 Impacts on Birds

There are no bird species on Desecheo Island that would suffer long term population-level impacts from rat eradication activities. The numbers of birds on Desecheo are relatively low, all resident and migratory bird species are common species found regionally or globally, and any localized extirpation of a resident species would likely be short-term as birds would recolonize the island from the nearby mainland. However, individual birds present on Desecheo at the time of the aerial bait application may be at risk of bait exposure during or shortly after the bait application (approximately two weeks).

The risk of mortality from the toxicological effects of diphacinone has been described in Section 2.3.2.3, and is generally considered lower in comparison to brodifacoum. However, this risk is dependent on the different toxicant exposure pathways between different species. Therefore, in the following analyses, the risk of diphacinone exposure is the primary criteria used to evaluate risk of impact from toxicant use to different species. Also, we have represented the reduced toxicity of diphacinone by assuming a moderate impact to birds from diphacinone, in comparison a severe impact assumed from the use of brodifacoum, and we have represented the duration of the risk to be short in comparison to a medium duration risk for brodifacoum (see Section 4.6.4.1).

Generally, the species at high risk of primary exposure to diphacinone (by eating bait directly) would include granivorous birds that primarily eat seeds and grains, and some omnivorous scavengers. Birds at high risk of secondary exposure would include predators and scavengers, in particular animals that feed on rats, carrion, or large ground-dwelling invertebrates such as beetles. Birds that have a broad, omnivorous diet would initially be at high risk for both primary and secondary exposure.

Birds at lower risk of primary exposure include species foraging in the intertidal zone because the mitigation procedures for applying bait along the coastline would reduce the likelihood of pellets entering the marine environment, and because any bait pellets that do drift into the water would disintegrate and become unavailable within a few hours.

Similarly, birds that specialize in intertidal invertebrates would be at low risk of secondary exposure for similar reasons.

Birds that feed on terrestrial invertebrates would be at risk of secondary exposure only where the prey items are themselves feeding directly on bait; on Desecheo, ants (Formicidae) have been most frequently observed directly eating bait pellets, but land crabs, beetles (Coleoptera), cockroaches (Blattidae) and New Zealand weta have been observed feeding on bait pellets elsewhere (Ogilvie et al. 1997, Island Conservation unpubl. data). Birds that feed primarily on flying and canopy insects and terrestrial micro-invertebrates would be at a low risk of secondary exposure due to the low likelihood that these invertebrate taxa would acquire diphacinone by ingesting bait pellets directly.

The risk of secondary and tertiary exposure in birds that feed on terrestrial and canopy invertebrates would decline to negligible within a few months of the bait application. The likelihood of exposure in intertidal specialists would likely be negligible by 30 days of the final bait application.

The following sections present an analysis of the toxicant and disturbance impacts to each of the identified bird species that are residents of Desecheo or have been documented on Desecheo in the last ten years (since 2000). Additionally, we have estimated the number of individuals per species that are likely to be adversely impacted by Alternative D (we have assumed the worst case scenario and consider any individuals that may be present on the island during the bait application operations to be vulnerable to adverse impacts from the action alternative).

<u>Species Risk Evaluation</u>

4.9.1.1 Permanent Resident Species in Puerto Rico

All species evaluated below, with the exception of ruddy turnstone, common ground-dove, and turkey vulture have been frequently observed on Desecheo in February and March 2009 and 2010, and are considered resident on the island. While ruddy turnstone and common ground-dove have been reported infrequently in the last ten years, they are included in the analysis in this section because they are common species and permanent residents in Puerto Rico, and could therefore also be permanently resident on Desecheo, but at low densities. Turkey vultures have never been recorded from Desecheo but because they are permanent residents in Puerto Rico and would be at high risk of toxicant exposure because of their scavenging feeding ecology, they are given some consideration here.

Turkey vulture: In Puerto Rico, turkey vultures are primarily restricted to an area of about 60 x 12 miles (100 km x 20 km) in the southern and southwestern region of the island (Santana et al. 1986a). This region is characterized by subtropical dry forest, cattle pastures, rolling hills of pasture or shrubland, rugged karst hills and mangroves, and it is believed that vultures are more common in this area due to the availability of range cattle (Santana et al. 1986b). However, individual birds have been recorded outside of this region

(Williams and Bunckley-Williams 1995), and the bird atlas of Puerto Rico documents seven records for turkey vultures from Añasco to Isabela in the west and northwest, to Matojillo, Camuy, about 12 mils east of Isabela. http://www.aosbirds.org/prbba/SpeciesTUVU.html However, given that the minimum home range of a turkey vulture can be 458 km^2 (Santana et al. 1986a) these sightings could be of wandering birds typically resident further south.

Turkey vultures are unlikely to be exposed to diphacinone because they are not expected to be on Desecheo where they have never been recorded, the main population of vultures in Puerto Rico is concentrated in the south and southwest of the island and Desecheo is about 23 miles from the nearest recorded observation of a single turkey vulture. In addition, the likelihood that a turkey vulture could detect carrion (i.e. dead rats) on Desecheo Island by sight or smell is also low given that the prevailing winds are from the northwest to southeast (away from Puerto Rico). Also, vultures require updrafts of warm air on which to soar and glide and typically use escarpments, hills and mountains which provide these. While migratory turkey vultures from North America are known to fly across open water, they are generally hesitant to make water crossings and evidence of exhausted birds only 13 kms from land suggest that water crossings may be risky (Kirk and Mossman 1998).

If turkey vultures were present on Desecheo during the operation, they would be likely exposed to diphacinone through secondary exposure pathways by consuming dead or moribund rats that have consumed bait. Rats found in the open, such as in grassland and shrubland areas, would be more easily located and accessed than rats under the forest canopy which would take longer to find (Kirk and Mossman 1998). Generally the risk to turkey vultures from toxicant exposure is considered negligible given the considerations described above, and this species is not included in the detailed risk analyses.

The species listed below are likely to be present on Desecheo during the bait application operations and would likely be present on the island for all or part of the time during which diphacinone may be available within the environment.

Predatory birds – *red-tailed hawk, American kestrel*

Toxicant Exposure Risk

American kestrels and red-tailed hawks would be likely exposed to diphacinone through secondary exposure pathways by consuming rats, passerines, reptiles, carrion and large terrestrial invertebrates that consume bait; the exposure risk would be high because of the range of exposure pathways to these raptors. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway. The extent of the impact would be to the island population.

Disturbance Risk

American kestrels and red-tailed hawks would likely be exposed to disturbance from aerial operations, which would likely cause them to flush from their immediate location to an alternative site, and may temporarily change breeding behavior. The impacts associated

with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

- 0-10 red-tailed hawks would likely be impacted from Alternative D.
- 5-25 American kestrels would likely be impacted from Alternative D.

<u>Omnivores</u> – *pearly-eyed thrasher, Northern mockingbird, smooth-billed ani, shiny cowbird*

Toxicant Exposure Risk
These omnivorous species would likely be exposed to diphacinone through secondary exposure pathways by consuming terrestrial invertebrates and anoles that consume bait, in addition shiny cowbird would also be exposed through a primary exposure pathway as this species also eats grain. The exposure risk for all omnivorous species would be high because of the range of exposure pathways. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to passerines. For pearly-eyed thrashers, the extent of the impact would be to the island population. For Northern mockingbird, smooth-billed ani and shiny cowbird the extent of the impact would be to individuals because these species are uncommon on Desecheo.

Disturbance Risk
Omnivorous species would likely be exposed to disturbance from aerial operations, would likely cause them to flush from their immediate location to alternative habitat, and may temporarily change breeding behavior. For pearly-eyed thrasher, the impacts associated with disturbance risks for this alternative would be medium and the duration of the risk would be for the medium term because this species is a permanent breeding resident on the island. For Northern mockingbird, smooth-billed ani and shiny cowbird the impacts associated with disturbance risks would be short and the duration of the risk would be short because these species are only known as visitors to the island. The extent of the risk would be to individuals for all species.

- 25-50 pearly-eyed thrashers would likely be impacted from Alternative D.
- 0-10 Northern mockingbirds would likely be impacted from Alternative D.
- 0-10 smooth-billed ani would likely be impacted from Alternative D.
- 0-10 shiny cowbird would likely be impacted from Alternative D.

<u>Granivores</u> – *zenaida dove, common ground-dove*

Toxicant Exposure Risk
Doves would be likely exposed to diphacinone through primary exposure pathways. Doves are granivorous species that most commonly consume seeds and grains. Since Diphacinone-50 is a grain based pellet, and the doves are ground-feeding granivorous species, doves would likely eat bait pellets directly and the exposure risk would be high. The mortality risk would be medium and the duration of the risk would be for the short term. The extent of the impact to zenaida doves would be to the island population, and to

common ground doves would be to individuals because ground doves are uncommon on Desecheo.

Disturbance Risk
Doves would likely be exposed to disturbance from both aerial and ground operations, which would likely cause them to flush their immediate location into alternative habitat, and may temporarily change breeding behavior. The impacts associated with disturbance risks for this alternative would be medium. The duration of the risk would be for the medium term. The extent of the risk for zenaida dove would be to the island population, but for common ground-dove to individuals because the species is uncommon on Desecheo.

- 25-50 zenaida doves would likely be impacted from Alternative D.
- 0-5 common ground-doves would likely be impacted from Alternative D.

Canopy foragers – *black-whiskered vireo, gray kingbird*

Toxicant Exposure Risk
Canopy foragers would be likely exposed to diphacinone through secondary exposure pathways by consuming terrestrial invertebrates that consume bait; the exposure risk would be medium because of the single exposure pathway. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to individuals. The extent of the impact would be to the island population.

Disturbance Risk
Canopy foragers would likely be exposed to disturbance from aerial operations, which would likely cause them to flush their immediate location into alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

- 0-50 black-whiskered vireos would likely be impacted from Alternative D.
- 0-50 gray kingbirds would likely be impacted from Alternative D.

Canopy/Ground foragers – *mangrove cuckoo*

Toxicant Exposure Risk
Mangrove cuckoos would be likely exposed to diphacinone through secondary exposure pathways by consuming terrestrial invertebrates and small lizards that consume bait; the exposure risk would be high because of the range of exposure pathways. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to individuals. The extent of the impact would be to individuals because mangrove cuckoos are uncommon on Desecheo.

Disturbance Risk
Mangrove cuckoos would likely be exposed to disturbance from aerial operations, which would likely cause them to flush their immediate location into alternative habitat. The

impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

- 0-5 mangrove cuckoos would likely be impacted from Alternative D.

Aquatic coastal foragers – ***ruddy turnstone, American oystercatcher, great blue heron, great egret, green heron, belted kingfisher***

Toxicant Exposure Risk
American oystercatchers would likely be exposed to diphacinone through secondary exposure pathways by consuming bivalves that might be exposed to diphacinone through bait drift into the marine environment. The exposure risk would be low because of the single exposure pathway and the coastal mitigation measures designed to reduce bait drift into the environment. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of inter-tidal species that provide a secondary exposure pathway to oystercatchers. The extent of the impact would be to the island population because this species is known to breed on Desecheo.

Ruddy turnstones would likely be exposed to diphacinone through both primary and secondary exposure pathways, whereas great blue herons, green herons and great egrets would likely be exposed through secondary pathways only. Generally, turnstones forage in the intertidal zone for aquatic invertebrates and insects but will consume carrion, while great blue herons, green herons and great egrets also consume carrion and intertidal invertebrates as well as fish, rats and small reptiles. The primary exposure pathway would probably be limited to individual turnstones that might consume softened bait pellets, whereas the secondary exposure pathways for turnstones, great blue herons, green herons and great egrets would include consumption of rats, intertidal invertebrates including crabs and carrion. Thus the exposure risk would be high because of the range of toxicant exposure pathways for these species. The mortality risk would be medium and the duration of the risk would likely be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway. The extent of the impact would be to individuals because these species are uncommon on Desecheo and are not known to breed.

Belted kingfishers would likely be exposed to diphacinone through secondary exposure pathways by consuming rats that consume bait; the exposure risk would be medium because of the single exposure pathway. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to kingfishers. The extent of the impact would be to individuals because kingfishers are uncommon on Desecheo and are not known to breed.

Disturbance Risk
Aquatic coastal foragers would likely be exposed to disturbance from both aerial and ground operations, which would likely cause them to flush from their immediate location into alternative habitat. For American oystercatchers, the impacts associated with

disturbance risks for this alternative would be medium, the duration of the risk would be for the medium term, and the impact would be to the island population because this species is known to breed on Desecheo. For the remaining species, the impacts associated with disturbance risks would be low, the duration of the risk would be for the short term, and the extent of the risk would be to individuals because the species are uncommon on Desecheo, and not known to breed.

- 0-25 ruddy turnstones would likely be impacted from Alternative D.
- 0-25 American oystercatchers would likely be impacted from Alternative D.
- 0-5 great blue herons would likely be impacted from Alternative D.
- 0-5 green herons would likely be impacted from Alternative D.
- 0-5 great egrets would likely be impacted from Alternative D.
- 0-5 belted kingfishers would likely be impacted from Alternative D.

<u>Granivores: non-native species</u> – *house sparrow, bronze mannikin, orange-cheeked waxbill*

Toxicant Exposure Risk
Non-native terrestrial granivores would likely be exposed to diphacinone through primary exposure pathways. These terrestrial birds are granivorous species that most commonly consume seeds. Since Diphacinone-50 is a grain based pellet, and these species frequently forage on the ground, they would likely eat bait pellets directly and the exposure risk would be high. The mortality risk would be medium, the duration of the risk would be for the short term, and the extent of the impact would be to individuals since these species are uncommon on Desecheo.

Disturbance Risk
Non-native terrestrial birds would likely be exposed to disturbance from aerial operations, which would likely cause them to flush from their immediate location into alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals since these are uncommon species on Desecheo.

- 0-50 house sparrows would likely be impacted from Alternative D.
- 0-50 bronze mannikins would likely be impacted from Alternative D.
- 0-50 orange-cheeked waxbills would likely be impacted from Alternative D.

4.9.1.2 Winter Migratory Birds in Puerto Rico

The following species are winter migrants, typically present in Puerto Rico between November and February. However, the departure dates from Puerto Rico for their summer breeding grounds may vary between species, and for some individuals may be as late as May. Therefore, because the operational window would be within this migratory transitional period, we have evaluated the following species with the expectation that individuals would be present on Desecheo during bait application activities.

<u>Predatory birds</u> – *peregrine falcon, Northern harrier, merlin*

Toxicant Exposure Risk

Peregrine falcons would likely be exposed to diphacinone through secondary exposure pathways by consuming shorebirds and laughing gulls that consume bait and through tertiary pathways by consuming birds and reptiles that have scavenged carcasses or fed on invertebrates exposed to diphacinone. The exposure risk is high because of the range of exposure pathways to falcons. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary and tertiary exposure pathway to falcons. The extent of the impact would be to individuals.

Northern harriers would likely be exposed to diphacinone through secondary exposure pathways by consuming rats and passerines that consume bait. The exposure risk would be high because of the range of exposure pathways to harriers. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to harriers. The extent of the impact would be to individuals.

Merlins would likely be exposed to diphacinone through secondary exposure pathways by consuming passerines that consume bait. The exposure risk would be medium because of the single exposure pathway to merlins. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to merlins. The extent of the impact would be to individuals.

Disturbance Risk

Raptors would likely be exposed to disturbance from aerial operations, which would cause them to flush from their immediate location to an alternative site. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals because these species are uncommon on Desecheo.

- 0-10 peregrine falcons would likely be impacted from Alternative D.
- 0-5 Northern harriers would likely be impacted from Alternative D.
- 0-5 merlins would likely be impacted from Alternative D.

4.9.1.3 Seabirds

Few seabirds have been reported on or around Desecheo Island in recent years, and there was no known nesting on Desecheo for 50 years until 2010 when a handful of bridled terns and one pair of brown noddy nested on the island and on offshore rocks (Breckon 1998, Island Conservation 2010b). Therefore, to evaluate the potential risk to breeding seabirds (because of limited information for seabirds on Desecheo) information on the breeding seasons for seabirds on adjacent islands was used. The egg-laying period for species previously reported as breeding on Desecheo is primarily between March and July, with

some species showing bi-modal patterns and a winter peak between August and December (see Section 3.4.2.5, Table 3.1). The only species currently recorded on Desecheo with any consistency is the brown booby, but only roosting birds are known. On nearby islands, peak egg-laying for brown boobies occurs between March and April. The aerial bait application is recommended to occur between January and April, a period that coincides with some seabird breeding activity on adjacent islands. Any potential disturbance to known seabird roosts can be minimized by manipulating the helicopter flight plan to avoid any areas of high density birds, and avoid working for extended periods of time in their vicinity.

The only seabird known historically from Desecheo that is potentially at risk of primary exposure to the rodenticide is the laughing gull *Larus atricilla*. In 1970, C. Kepler reported up to 700 adult laughing gulls and 71 nests on cays offshore of Desecheo Island, but only one lone laughing gull was reported during four visits in 1986 and 1987 (Meier et al. 1989). Gulls are at primary risk of exposure to rodenticide due to their more omnivorous feeding habits and inquisitive behavior. During a placebo bait acceptability trial on Macquarie Island (Australia) in 2005, kelp gulls *Larus dominicanus* fed on accidentally spilled bait around the helicopter pad as demonstrated by green feces (the placebo-bait color) found in the area (K. Springer pers. comm.). After an attempted rabbit and rat eradication operation that applied bait pellets to Macquarie Island in 2010, 356 kelp gulls were found dead (Australian Department of Sustainability 2010). During rat eradication on the island of San Pedro Martír (Gulf of California) in 2007, green feces from yellow-footed gulls *Larus livens* were observed along the coastline and one dead adult bird was found. Nearly eight months after an aerial bait application on Rat Island, Alaska, to remove brown rats, carcasses of 320 glaucous-winged gulls *Larus glaucescens* were found (Salmon and Paul 2010). While the brodifacoum toxicant was implicated in these mortalities, they demonstrate that many gulls will readily eat bait pellets (although some birds may have scavenged other dead animals).

Laughing gull

Toxicant Exposure Risk

Generally, laughing gulls are at low risk of exposure to diphacinone because the species is a summer breeding migrant to the region and is unlikely to be on Desecheo during the bait application window. However, some birds may remain coastal inhabitants year-round, but often flying out to sea and between islands. In addition, a dead laughing gull was found on the beach on Desecheo in February 2009 (Island Conservation unpubl. data), suggesting that some individuals either arrive early to the region or are present year-round. If laughing gulls were on the island at the time of bait application, individuals would likely be exposed to diphacinone through both primary and secondary exposure pathways. Laughing gulls are omnivorous and are often found foraging in the intertidal zone for aquatic and terrestrial invertebrates, eating seeds and plants, or feeding on carrion. The primary exposure pathway would be significant because gulls are known to consume rodent bait pellets (see Section 4.6.4.3.1). Additionally, the secondary exposure pathways include consumption of carrion and terrestrial invertebrates that have consumed the toxicant. For individual birds that appear on the island, the exposure risk would be high because of the range of toxicant exposure pathways, the mortality risk would be medium, and the duration of the risk would likely be for the short term due to the retention time of

the toxicant in the tissue of species that provide a secondary exposure pathway to gulls. The extent of the impact would be to individuals because gulls are uncommon as breeding birds on Desecheo.

Disturbance Risk
There is negligible disturbance risk to laughing gulls from aerial or ground operations because the species is a summer breeding migrant to the region, and their presence on the island during the operational period would be unlikely. However, in the event that gulls are present year-round or arrive in the area earlier, aerial and ground operations would likely cause any birds roosting on the island to flush from their immediate location to an alternative site. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals because laughing gulls are uncommon on Desecheo.

- 0-25 laughing gulls would likely be impacted from Alternative D.

Brown booby and brown pelican
Toxicant Exposure Risk
Less than 100 individuals of brown booby and small numbers of brown pelican are known to roost on Desecheo, but no breeding has been reported in recent years. Therefore, individuals of both species would be present during the bait application window. However, neither species would be considered at risk of toxicant exposure because they rarely if ever feed on anything other than marine fish and squid; therefore, the extent of the impact is insignificant and does not require further evaluation.

Disturbance Risk
Roosting brown booby and brown pelican would be exposed to disturbance from both aerial and ground operations, which would likely cause birds to flush from their immediate location to an alternative site. Although neither species has been reported as breeding on Desecheo in recent years, because both are known to roost on the island, both have extended breeding seasons throughout the year which would overlap with the operational window, and brown booby breeds on Mona and Monito islands, the potential exists for nesting birds on Desecheo during the bait application window. Physical disturbance may cause nesting birds to temporarily leave their nest but they would likely return once the disturbance has passed. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals because both species are uncommon on Desecheo.

- 20-50 brown boobies would likely be impacted from Alternative D.
- 0-5 brown pelicans would likely be impacted from Alternative D.

Magnificent frigatebird and red-footed booby
Toxicant Exposure Risk
Magnificent frigatebirds have been observed flying over the island and there is therefore the potential for birds to be roosting on the island during the operational window. Red-footed boobies have not been observed on Desecheo in recent years. However, as both species are year-round residents in the region, there is the potential for both birds to be on

Desecheo during the operational window. However, they would not be considered at risk of toxicant exposure because they rarely if ever feed on anything other than marine fish and squid. Therefore, the extent of the impact is insignificant and does not require further scrutiny.

Disturbance Risk
If present on the island, both species would likely be exposed to disturbance from both aerial and ground operations, which may cause roosting birds to flush from their immediate location to an alternative site; the impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals because these species are uncommon on Desecheo.

- 0-5 magnificent frigatebirds would likely be impacted from Alternative D.
- 0-5 red-footed boobies would likely be impacted from Alternative D.

Bridled tern, sooty tern, brown noddy
Toxicant Exposure Risk
Bridled terns, sooty terns and brown noddy are spring/summer migrants to the region and their presence on Desecheo during the operational window would be unlikely; nests of 17 bridled tern pairs and one brown noddy pair were found with eggs in June 2010. In addition, they would not be considered at risk of toxicant exposure because they rarely if ever feed on anything other than marine fish and squid; therefore, the extent of the impact is insignificant and does not require further scrutiny.

Disturbance Risk
There is negligible disturbance risk to these small ground-nesting seabirds from aerial or ground operations because they are spring/summer migrants to the region, and their presence on the island during the operational period would be unlikely. In the event that birds arrive in the area earlier than anticipated, aerial and ground operations would likely cause any birds roosting on the island to flush from their immediate location to an alternative site. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals because these species are uncommon on Desecheo.

- 0-5 bridled terns would likely be impacted from Alternative D.
- 0-5 sooty terns would likely be impacted from Alternative D.
- 0-5 brown noddies would likely be impacted from Alternative D.

White-tailed tropicbird
Toxicant Exposure Risk
There would be no risk of toxicant exposure to white-tailed tropicbirds because they have never been reported on Desecheo, and they rarely if ever feed on anything other than marine fish and squid. Therefore, the extent of the impact is insignificant and does not require further scrutiny.

Disturbance Risk
White-tailed tropicbirds are summer breeding residents on nearby Mona and Monito islands between February and August (Table 3.1). Tropicbirds have been reported flying close to Desecheo, but have never been reported as breeding. If birds were to appear on the island during the operational window, they may be impacted by localized aerial and ground disturbance causing individuals to flush from their immediate location to an alternative site. However, because of the very low likelihood that white-tailed tropicbirds would roost or breed on Desecheo, the impacts associated with disturbance risk would be very low, the extent of the risk would be to individuals and the duration of the risk would be short.

- 0-5 white-tailed tropicbirds would likely be impacted from Alternative D.

4.9.2 Impacts on Reptiles

Toxicant exposure risk to reptiles on Desecheo would be primary (by ingesting the bait) or secondary (by ingesting contaminated prey). In either case, the time window of risk is relatively short, beginning with the date of application and lasting until the diphacinone has disappeared from the environment. The three lizard species and the dwarf gecko on Desecheo are primarily insectivores that hunt using visual cues (moving prey), with the exception of the *Amieva*, direct ingestion of the bait would be unlikely. However, in field trials using a placebo biomarker bait, about 20 percent of Desecheo anoles tested positive for biomarker, but the pathway of contamination could not be confirmed (Island Conservation 2010c). Most exposure would likely be secondary via ingestion of contaminated invertebrates, contaminated anoles, or scavenging on dead rats by *Ameiva*. A captive experiment on *Sphaerodactylus* geckos demonstrated no affect of direct exposure to bait pellets (García 1994). Terrestrial invertebrates are known to consume bait pellets and secondary poisoning of insectivorous birds has been reported (Eason and Spurr 1995). Similarly, exposure risk to the Puerto Rican racer is likely to be secondary via ingestion of contaminated anoles and geckos, its preferred prey (Henderson and Sajdak 1996). However, a successful rat eradication on the island of Antigua resulted in no detectable mortality of the endangered Antiguan racer *Alsophis antiguae*, and in fact the racer population doubled in size in 18 months post-rat eradication (Daltry 2006).

The toxicity of diphacinone to reptiles is discussed in Section 4.6.4.3.3. Because of the limited laboratory and field knowledge on the toxicity of rodenticides to reptiles, this analysis presents the most cautious approach, anticipating a high risk of diphacinone toxicity on exposure.

Because the reptile fauna of Desecheo Island comprises three single-island endemic species with an associated restricted range and population size (see Section 3.6.1), significant reptile mortality during the bait application has the potential for population-level impacts. In addition, even though the slippery-backed skink and the Puerto Rican racer are native species with populations elsewhere in Puerto Rico, the sub-specific status of the racer is in question, and the slippery-backed skink is classified as locally vulnerable based on reported limited distribution and sightings (García et al. 2005). Information about the species' ecology, population abundance and distribution across the island is limited,

particularly from recent years. Only one study of the endemic dwarf gecko exists, from 1987, which reported densities of 3 – 19 animals in 125 m^2 forest plot and suggested that the gecko is probably a forest-obligate species. In addition, more animals were found during the wetter months when their activity levels increased (Meier and Noble 1990a). The slippery-backed skink was only first recorded from Desecheo Island in 1987, where it was observed primarily in the thorny cactus scrub community (Meier and Noble 1990b). Based on observations, the endemic anole and *Amieva* are believed to be abundant (Earsom 2002, Island Conservation 2009a).

Field surveys conducted in 2009 and 2010 provided further information on the population density and abundance of the Desecheo anole, dwarf gecko, *Ameiva* and racer (see Section 3.6.1). Total population estimates for *Ameiva desechensis* was calculated as 7,469 individuals (1,800 – 13,137, 95 percent confidence limits), for *Anolis desechensis* was 52,111 individuals (31,464 – 72,758, 95 percent confidence limits), and for *Sphaerodactylus levinsi* was 13,261 individuals (8,796 – 19,991, 95 percent confidence limits). Population estimates for each of these species varied between habitats, and estimates were generally lower in grassland habitats than in shrub and forest habitats. The Puerto Rico racer's density was generally low across the island, with only an average of seven individuals recorded per hectare. Densities of the four reptile populations monitored were generally considered low in comparison to mainland populations of similar species, which suggests that there are some ongoing impacts from rats on reptile densities.

Desecheo gecko

Toxicant Exposure Risk

A sub-set of Desecheo geckos removed to captivity prior to bait application would not be at risk of impacts from the toxicant.

Desecheo geckos remaining in the wild on the island after animals had been removed to captivity would be exposed to diphacinone through secondary exposure pathways by consuming micro-invertebrates that consume bait. The toxicant exposure risk would be medium because of the single exposure pathway. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to geckos. The extent of the impact would be to the remaining island population.

Disturbance Risk

Desecheo geckos that remain in the wild on Desecheo would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals remaining on the island.

Individual geckos that are taken into captivity prior to the bait application are at high level of disturbance risk from being captured, and from being held in captivity for an extended period of time. Capture operations could potentially cause injury or death to individuals prior to bringing them into captivity, while captive individuals could be at risk of injury,

disease, and poor nutrition that could cause mortality. The extent of the risk would be to individuals captured and held in captivity.

Alternative D(i): 20 - 30 pairs of Desecheo geckos would be permanently removed from the wild population to captivity and not returned to Desecheo.

Alternative D(ii): 30-40 individual Desecheo geckos would be temporarily held in captivity on Desecheo. The duration of the risk to captive individuals would be medium.

Desecheo ameiva

Toxicant Exposure Risk

A sub-set of Desecheo ameiva removed to captivity prior to bait application would not be at risk of impacts from the toxicant.

The Desecheo ameiva remaining in the wild on the island would be exposed to diphacinone through secondary exposure pathways by consuming carrion, juvenile anoles, juvenile geckos, and terrestrial invertebrates that consume bait. The toxicant exposure risk would be high because of the range of exposure pathways. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to ameivas. The extent of the impact would be to the population remaining on the island.

Disturbance Risk

Desecheo ameivas that remain in the wild on Desecheo would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals remaining on the island.

Individual ameivas that are taken into captivity prior to the implementation of the bait application are at high level of disturbance risk from being captured, and from being held in captivity for an extended period of time. Capture operations could potentially cause injury or death to individuals prior to bringing them into captivity, while captive individuals could be at risk of injury, disease, and poor nutrition that could cause mortality. The extent of this risk would be to individuals captured and held in captivity.

Alternative D(i): 20 - 30 pairs of Desecheo ameivas would be permanently removed from the wild population to captivity and not returned to Desecheo.
Alternative D(ii): 20-30 individual Desecheo ameivas would be temporarily held in captivity on Desecheo. The duration of the risk to captive individuals would be medium.

Desecheo anole

Toxicant Exposure Risk

A sub-set of Desecheo anoles removed to captivity prior to bait application would not be at risk of impacts from the toxicant.

Desecheo anoles remaining in the wild on the island would be exposed to diphacinone through both primary and secondary exposure pathways. Generally, anoles consume terrestrial invertebrates. The primary exposure pathway would be limited to anoles who consume bait pellets whereas the secondary exposure pathways would include consumption of terrestrial invertebrates. The toxicant exposure risk would be high because of the range of toxicant exposure pathways, the mortality risk would be medium, and the duration of the risk would likely be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to anoles. The extent of the impact would be to the remaining island population.

Disturbance Risk
Desecheo anoles that remain in the wild on Desecheo would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals remaining on the island after a sub-set has been removed to captivity prior to bait application.

Individual anoles that are taken into captivity prior to the implementation of the rat eradication would be at high level of disturbance risk from ground operations, as well as from being captured and held for an extended period of time. Capture operations could potentially cause injury or death to individuals prior to bringing them into captivity, while captured individuals could be at risk of injury, disease, poor management that could cause mortality. The extent of the risk would be to individuals captured and held in captivity.

Alternative D(i): 20 - 30 pairs of Desecheo anoles would be permanently removed from the wild population to captivity and not returned to Desecheo.

Alternative D(ii): 30-40 individual Desecheo anoles would be temporarily held in captivity on Desecheo. The duration of the risk to captive individuals would be medium.

Puerto Rico racer
Toxicant Exposure Risk
The Puerto Rican racer would be exposed to diphacinone through secondary exposure pathways by consuming anoles, geckos and juvenile ameivas that consume bait. The toxicant exposure risk would be high because of the range of exposure pathways. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to racers. The extent of the impact would be to the island population.

Disturbance Risk
Puerto Rican racers would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. However, racers are rarely seen and would likely experience little if any impact from disturbance. Therefore, the impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

Slippery-backed skink

Toxicant Exposure Risk

Slippery-backed skinks would be exposed to diphacinone through both primary and secondary exposure pathways. Generally, skinks consume terrestrial invertebrates and may prey upon small lizards. The primary exposure pathway would be by direct feeding on bait, whereas the secondary exposure pathways would include consumption of terrestrial invertebrates and small lizards that consume bait. The toxicant exposure risk would be high because of the range of exposure pathways, the mortality risk would be medium, and the duration of the risk would likely be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to skinks. The extent of the impact would be to the island population.

Disturbance Risk

Slippery-backed skinks would be exposed to disturbance from ground operations, which may cause them to flee their immediate location into alternative habitat. However, skinks are rarely seen and would likely experience little if any impact from disturbance. Therefore, the impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

Hawksbill, green and leatherback sea turtles

Toxicant Exposure Risk

Turtles may face a primary risk of exposure to diphacinone through eating bait directly as it drops through the water column. These turtles' common foraging behaviors make exposure unlikely, but juvenile green turtles in particular are known to be comparatively opportunistic feeders, and marine turtles have been documented ingesting marine debris elsewhere (Carr 1987, Meylan 1988, Bjorndal et al. 1994, Coyne 1994, Bugoni et al. 2001, NOAA Fisheries pers. comm.). By applying bait only above the high tide line and limiting the spread of bait into the marine environment through use of a deflector on the bait bucket, bait would only enter the marine environment through bait drift from the bucket during aerial application. Any bait pellets that do enter the water will only be ingestible by turtles for a few hours prior to embedding in the sediment and breaking down to tiny fragments (Empson and Miskelly 1999, Howald et al. 2010). Thus, the duration of risk to turtles is for the very short term. Hawksbill turtles are almost exclusive sponge feeders in the Caribbean and are known to feed on sponges within the Desecheo Marine Reserve. Sponges present a possible incidental pathway of toxicant to individuals. However, diphacinone is very poorly soluble in water and binds tightly to the grain matrix of the bait pellet (Section 4.5.1.4); it is considered unlikely that the diphacinone molecule could bind to the sponge independently. Thus the pathway through sponges would require a bait pellet or pellet fragment to lodge on the surface or inside the sponge and which might be ingested by the turtle together with pieces of sponge. The extent of risk is essentially negligible. The risk of turtle mortality, given the extremely low likelihood of exposure to the toxicant, is unknown but suspected to be negligible.

Disturbance Risk
Hawksbill, green and leatherback sea turtles could be exposed to disturbances from boat operations, which will likely cause turtles to flee from the immediate area. However, boat operations in association with the rat eradication would not exceed normal levels of boat use during the recreational season, and would be limited to small boats, and all boat operators would be briefed on NOAA protocols to avoid vessel collisions and disturbance associated with marine life (NOAA 2008) (Appendix X). Turtles would not be at risk from disturbance impacts on the island because they are not known to haul onto Desecheo during the implementation period of this project. Green and leatherback turtles are not known to breed on the island, and only incidental records of hawksbill turtles nesting on Desecheo have been reported. The predominant nesting months for hawksbill turtles in Puerto Rico and the U.S. Virgin Islands is June to November (although some nesting can be documented for every month of the year), which is outside of the operational window. The impacts associated with disturbance risks for this alternative are low, the duration of the disturbance will be for the short-term, and the extent of the effect will be on the individual level.

4.9.3 Impacts on Invertebrates

Invertebrates rely on a circulatory system which is different from systems found in birds, reptiles and mammals. For this reason, invertebrates are not thought to be at risk of mortality from diphacinone poisoning. However, few laboratory-based studies have been conducted to validate this statement. A study by Fisher et al. (2007) demonstrated that captive weta fed on Ditrac® wax blocks retained diphacinone residues in their body, but residues did not accumulate over time and weta did not suffer mortality. A study by Primus et al. (2006) found that snails and slugs exposed to diphacinone bait (0.005 percent) accumulated residues that were higher than LD_{50} values for ground squirrels (*Otospermophilus beecheyi*), house mice (*Mus musculus*) and pocket gophers (Geomyidae), and comparable to black rats, but effects on mortality were unknown since the animals were euthanized for the study. It is anticipated that land crabs would be the biggest consumer of bait pellets (Island Conservation 2010a), while a variety of insects may also feed on the grain-based pellets (Spurr and Drew 1999).

Arachnids – (spider *Clubiona desecheonis*, spider *Camillina desecheonis* and whip scorpion *Schizomus desecheo*)
Toxicant Exposure Risk
Arachnids would be likely exposed to diphacinone through secondary exposure pathways by consuming terrestrial invertebrates that consume bait. No risk of toxicity is considered because arachnids have a different circulatory system to mammals, birds and reptiles, and no negative impacts from diphacinone use have been reported. The toxicant exposure risk would be low because of the single exposure pathway; however, there would be no risk of mortality. The duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to arachnids. The extent of the impact would be to the global population because these are single-island endemic species.

Disturbance Risk
Arachnids would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

Purple Landcrab
Toxicant Exposure Risk
Purple land crabs would be exposed to diphacinone through both primary and secondary exposure pathways. Generally, land crabs are omnivorous and consume terrestrial invertebrates, carrion and seeds. The primary exposure pathway would be limited to land crabs who consume bait pellets, whereas the secondary exposure pathways would include consumption of terrestrial invertebrates and carrion. There would be no mortality risk from the toxicant because land crabs have a different circulatory system to mammals, birds and reptiles. The exposure risk would be high because of the range of toxicant exposure pathways. The duration of the risk would likely be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to land crabs. The extent of the impact would be to the island population.

Disturbance Risk
Purple land crabs would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. However, land crabs are largely nocturnal and would be unlikely to experience any impacts from disturbance. Therefore, the disturbance risks for this alternative would be low. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

Hermit Crab
Toxicant Exposure Risk
Hermit crabs would be exposed to diphacinone through both primary and secondary exposure pathways. Generally, hermit crabs are omnivorous and consume terrestrial invertebrates, carrion and seeds. The primary exposure pathway would be limited to crabs who consume bait pellets, whereas the secondary exposure pathways would include consumption of terrestrial invertebrates and carrion. There would be no mortality risk from the toxicant because hermit crabs have a different circulatory system to mammals, birds and reptiles. The exposure risk would be high because of the range of toxicant exposure pathways. The duration of the risk would likely be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to crabs. The extent of the impact would be to the island population.

Disturbance Risk
Hermit crabs would be exposed to disturbance from ground operations from reptile capture and shoreline baiting, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be medium. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

4.9.4 Impacts on Bats

Toxicant Exposure Risk

Because the specific bat species on Desecheo are unknown, the toxicant exposure can only be evaluated in general terms. Both insectivorous and frugivorous bats are native to Puerto Rico. Insectivorous bats would be exposed to diphacinone through secondary pathways; consuming aerial insects that had consumed bait. The risk of diphacinone causing mortality in bats would likely be medium, but the toxicant exposure risk to insectivorous bats would be low, as only a secondary pathway is available, and there is unlikely to be an exposure pathway to frugivorous/nectivorous bats. The duration of the risk to insectivorous species would likely be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to bats. The extent of the impact would likely be to individuals as few observations of bats have been reported.

Disturbance risk

It is unlikely that bats would be exposed to disturbance from either aerial or ground operations as the bats observed on Desecheo are crepuscular and nocturnal.

4.9.5 Impacts on Vegetation

Higo Chumbo

Toxicant Exposure Risk

Higo chumbo cacti would not be at risk of toxicant exposure therefore the extent of the impact is insignificant and does not require further scrutiny.

Disturbance Risk

Higo chumbo would be exposed to disturbance from ground operations, which would be mitigated for by providing ground personnel with photographs and identification keys for cacti, a map with the approximate location of known plants, and GPS coordinates indicating the exact location of known individuals on Desecheo. Additionally, ground personnel would be advised to avoid disturbing cacti while conducting ground operations. The impacts associated with disturbance risks for this alternative would be low because of the range of mitigation measures that would be implemented during ground operations. The duration of the risk would be for the short term, the extent of the risk would be to individuals.

Other Vegetation/Flora

Toxicant Exposure Risk

Vegetation would be not at risk of toxicant exposure therefore the extent of the impact is insignificant and does not require further scrutiny.

Disturbance Risk

Vegetation would be exposed to disturbance from ground operations. The impacts associated with disturbance risks for this alternative are low. The duration of the risk is for the short term, the extent of the risk would be to individual plants or limited to the immediate area of activity.

4.9.6 Impacts Table for Alternative D: Biological Resources

Table 4.3. Impacts of Alternative D (aerial diphacinone broadcast with reptile captive hold) on biological resources.

Species	Toxicant exposure risk level[1]	Risk mortality - toxicant use[2]	Disturbance risk[3]	Extent of risk within a population[4]		Duration of risk[5]	
				toxicant	disturbance	toxicant	disturbance
Red-tailed Hawk & American Kestrel	High	Medium	Low	Island	Individ.	Short	Short
Pearly-eyed Thrasher	High	Medium	Medium	Island	Individ.	Short	Medium
Northern Mockingbird, Smooth-billed Ani, Shiny Cowbird	High	Medium	Low	Individ.	Individ.	Short	Short
Zenaida Dove & Common Ground-dove	High	Medium	Medium	Island/ Individ.[6]	Individ.	Short	Medium
Black-whiskered Vireo & Gray Kingbird	Medium	Medium	Low	Island	Individ.	Short	Short
Mangrove Cuckoo	High	Medium	Low	Individ.	Individ.	Short	Short
American Oystercatcher	Low	Medium	Medium	Island	Individ.	Short	Short
Ruddy Turnstone, Great Blue Heron, Green Heron, Great Egret	High	Medium	Low	Individ.	Individ.	Short	Short
Belted Kingfisher	Medium	Medium	Low	Individ.	Individ.	Short	Short
House Sparrow, Bronze Mannikin, & Orange-cheeked Waxbill	High	Medium	Low	Individ.	Individ.	Short	Short
Peregrine Falcon & Northern Harrier	High	Medium	Low	Individ.	Individ.	Short	Short
Merlin	Medium	Medium	Low	Individ.	Individ.	Short	Short
Laughing Gull	High	Medium	Low	Individ.	Individ.	Short	Short
Brown Booby & Brown Pelican	None	None	Low	None	Individ.	None	Short
Magnificent Frigatebird & Red-footed Booby	None	None	Low	None	Individ.	None	Short
Bridled Tern, Sooty Tern & Brown Noddy	None	None	Low	None	Individ.	None	Short
White-tailed Tropicbird	None	None	Low	None	Individ.	None	Short
Desecheo Gecko wild	Medium	Medium	Low	Island	Individ.	Short	Short
[7]captive (i)	None	None	High	None	Individ.	None	Perm.[8]
captive (ii)	None	None	High	None	Individ.	None	Medium
Desecheo Ameiva wild	High	Medium	Low	Island	Individ.	Short	Short
captive (i)	None	None	High	None	Individ.	None	Perm.
captive (ii)	None	None	High	None	Individ.	None	Medium
Desecheo Anole wild	High	Medium	Low	Island	Individ.	Short	Short
captive (i)	None	None	High	None	Individ.	None	Perm.
captive (ii)	None	None	High	None	Individ.	None	Medium
Puerto Rico Racer	High	Medium	Low	Island	Individ.	Short	Short
Slippery-backed Skink	High	Medium	Low	Island	Individ.	Short	Short
Hawksbill, Green & Leatherback Sea Turtles	Low	Low	Low	Individ.	Individ.	Short	Short
Arachnids [9]	Low	None	Low	Global	Individ.	Short	Short
Purple Landcrab	High	None	Low	Island	Individ.	Short	Short
Hermit Crab	High	None	Medium	Island	Individ.	Short	Short
Bats (insectivores)	Low	High	None	Individ.	None	Short	None
Higo Chumbo	None	None	Low	None	Individ.	None	Short
Other Vegetation/Flora	None	None	Low	None	Individ.	None	Short

NOTES TO TABLE 4.3

[1]None: No exposure pathway; Low: Possible exposure pathway; Medium: One exposure pathway; High: Multiple exposure pathways.

[2] None: No toxicological sensitivity; Low: Minor toxicological sensitivity; Medium: Moderate toxicological sensitivity; High: Severe toxicological sensitivity.

[3] None: No disturbance pathway; Low: Low sensitivity to disturbance; Medium: Moderate sensitivity to disturbance; High: Severe sensitivity to disturbance.

[4] Individual (Individ.): Few individuals affected, no affect on resident breeding population; Island population (Island): Resident breeding population affected, no affect on regional or global population; Global or regional population (Global): Regional or global population affected.

[5] Short: Impacts for up to two months; Medium: Impacts for two to six months; Long: Impacts for more than 6 months.

[6] Extent of risk within a population for both toxicant and disturbance is: Island for zenaida dove and Individual for common ground-dove.

[7] captive (i) and (ii) represents Alternatives D(i) and D(ii).

[8] Permanent (Perm.). Individuals are permanently removed from the population.

[9]Arachnids: *Clubiona desecheonis*, *Camillina desecheonis* and *Schizomus desecheo*.

4.10 Impacts of Alternative E (aerial diphacinone broadcast)

4.10.1 Impacts on Birds

The impacts to birds on Desecheo that are associated with toxicity and exposure to Diphacinone-50 and to disturbance from implementing the eradication operation in Alternative E are the same as those in Alternative D. For a full analysis of the impacts to birds from Alternative E please refer to Section 4.9.1.

4.10.2 Impacts on Reptiles

Toxicant exposure risk to reptiles on Desecheo would be primary (by ingesting the bait) or secondary (by ingesting contaminated prey). In either case, the time window of risk is relatively short, beginning with the date of application and lasting until the diphacinone has disappeared from the environment. The three lizard species and the dwarf gecko on Desecheo are primarily insectivorous, with the exception of the *Amieva* which is also a predator of anolis lizards. Therefore, direct ingestion of the bait would be unlikely. However, in field trials using a placebo biomarker bait, about 20percent of Desecheo anoles tested positive for biomarker, but the pathway of contamination could not be confirmed (Island Conservation 2010c). Most exposure would likely be secondary via ingestion of contaminated invertebrates, contaminated anoles, or scavenging on dead rats by *Ameiva*. Two captive experiments on *Sphaerodactylus* geckos only tested the effect of direct exposure to bait pellets and, at least in the second experiment, captive animals were fed with termites that were unlikely to have been exposed to the bait (García 1994). Terrestrial invertebrates are known to consume bait pellets and secondary poisoning of insectivorous birds has been reported (Eason and Spurr 1995). Similarly, exposure risk to the Puerto

Rican racer is likely to be secondary via ingestion of contaminated anoles and geckos, its preferred prey (Henderson and Sajdak 1996). However, a successful rat eradication on the island of Antigua resulted in no detectable mortality of the endangered Antiguan racer *Alsophis antiguae*, and in fact the racer population doubled in population size in 18 months post-rat eradication (Daltry 2006).

The toxicity of diphacinone to reptiles is discussed in Section 4.6.4.3.3. Because of the limited laboratory and field knowledge on the toxicity of rodenticides to reptiles, this analysis presents the most cautious approach, anticipating a high risk of diphacinone toxicity on exposure.

Because the reptile fauna of Desecheo Island comprises three single-island endemic species with an associated restricted range and population size (see Section 3.6.1), significant reptile mortality during the bait application has the potential for population-level impacts. In addition, even though the slippery-backed skink and the Puerto Rican racer are native species with populations elsewhere in Puerto Rico, the sub-specific status of the racer is in question, and the slippery-backed skink is classified as locally vulnerable based on reported limited distribution and sightings (García et al. 2005). Information about the species' ecology, population abundance and distribution across the island is limited, particularly from recent years. Only one study of the endemic dwarf gecko exists, from 1987, which reported densities of 3 – 19 animals in 125 m^2 forest plot and suggested that the gecko is probably a forest-obligate species. In addition, more animals were found during the wetter months when their activity levels increased (Meier and Noble 1990a). The slippery-backed skink was first recorded from Desecheo Island in 1987, where it was observed primarily in the thorny cactus scrub community (Meier and Noble 1990b). Based on observations, the endemic anole and *Amieva* are believed to be abundant (Earsom 2002, Island Conservation 2009a).

The impacts to reptiles that are associated with toxicity and exposure to Diphacinone-50 and to disturbance from implementing the eradication operation in Alternative E are largely the same as those presented in Alternative D. However, because Alternative E does not propose removal of a sub-set of animals to captivity, any impacts anticipated as a result of this alternative would affect the entire island population of the three single-island endemic species; this may be the global population or individuals within that population.

Desecheo gecko

Toxicant Exposure Risk

Desecheo geckos would be exposed to diphacinone through secondary exposure pathways by consuming micro-invertebrates that consume bait. The toxicant exposure risk would be medium because of the single exposure pathway. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to geckos. The extent of the impact would be to the global population.

Disturbance Risk
Desecheo geckos would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals.

Desecheo ameiva
Toxicant Exposure Risk
The Desecheo ameiva would be exposed to diphacinone through secondary exposure pathways by consuming carrion, juvenile anoles, juvenile geckos, and terrestrial invertebrates that consume bait. The toxicant exposure risk would be high because of the range of exposure pathways. The mortality risk would be medium and the duration of the risk would be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to ameivas. The extent of the impact would be to the global population.

Disturbance Risk
Desecheo ameivas would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals.

Desecheo anole
Toxicant Exposure Risk
Desecheo anoles would be exposed to diphacinone through both primary and secondary exposure pathways. Generally, anoles consume terrestrial invertebrates. The primary exposure pathway would be limited to anoles who consume bait pellets whereas the secondary exposure pathways would include consumption of terrestrial invertebrates. The toxicant exposure risk would be high because of the range of toxicant exposure pathways, the mortality risk would be medium, and the duration of the risk would likely be for the short term due to the retention time of the toxicant in the tissue of species that provide a secondary exposure pathway to anoles. The extent of the impact would be to the global population.

Disturbance Risk
Desecheo anoles would be exposed to disturbance from ground operations, which may cause them to flee their immediate location to alternative habitat. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be for the short term, and the extent of the risk would be to individuals.

Puerto Rico racer
The impacts to Puerto Rico racer that are associated with toxicity and exposure to Diphacinone-50 and to disturbance from implementing the eradication operation in Alternative E are the same as those in Alternative D. For a full analysis of the impacts to the racer from Alternative D please refer to Section 4.9.2.

Slippery-backed skink
The impacts to slippery-backed skinks on Desecheo that are associated with toxicity and exposure to Diphacinone-50 and to disturbance from implementing the eradication operation in Alternative E are the same as those in Alternative D. For a full analysis of the impacts to the skink from Alternative D please refer to Section 4.9.2.

Hawksbill, green and leatherback sea turtles
The impacts to hawksbill, green and leatherback sea turtles that are associated with toxicity and exposure to diphacinone and to disturbance from implementing the eradication operation in Alternative E are the same as those in Alternative D. For a full analysis of the impacts to turtles from Alternative D please refer to Section 4.9.2.

4.10.3 Impacts on Invertebrates

The impacts to invertebrates, including the three arachnids (*Clubiona desecheonis*, *Camillina desecheonis* and *Schizomus desecheo*), purple landcrab and hermit crab, that are associated with toxicity and exposure to Diphacinone-50 and to disturbance from implementing the eradication operation in Alternative E are the same as those in Alternative D. For a full analysis of the impacts to invertebrates from Alternative D please refer to Section 4.9.3.

4.10.4 Impacts on Bats

The impacts to bats on Desecheo that are associated with toxicity and exposure to Diphacinone-50 and to disturbance from implementing the eradication operation in Alternative E are the same as those in Alternative D. For a full analysis of the impacts to bats from Alternative D please refer to Section 4.9.4.

4.10.5 Impacts on Vegetation

The impacts on vegetation, including the higo chumbo cactus, that are associated with toxicity and exposure to Diphacinone-50 and to disturbance from implementing the eradication operation in Alternative E are the same as those in Alternative D. For a full analysis of the impacts to vegetation from Alternative D please refer to Section 4.9.5.

4.10.6 Impacts Table for Alternative E: Biological Resources

Table 4.4. Impacts of Alternative E (aerial diphacinone broadcast) on biological resources.

Species	Toxicant exposure risk level[1]	Risk mortality - toxicant use[2]	Disturbance risk[3]	Extent of risk within a population[4]		Duration of risk[5]	
				toxicant	disturbance	toxicant	disturbance
Red-tailed Hawk & American Kestrel	High	Medium	Low	Island	Individ.	Short	Short
Pearly-eyed Thrasher	High	Medium	Medium	Island	Individ.	Short	Medium
Northern Mockingbird, Smooth-billed Ani, Shiny Cowbird	High	Medium	Low	Individ.	Individ.	Short	Short
Zenaida Dove & Common Ground-dove	High	Medium	Medium	Island/ Individ.[6]	Individ.	Short	Medium
Black-whiskered Vireo & Gray Kingbird	Medium	Medium	Low	Island	Individ.	Short	Short
Mangrove Cuckoo	High	Medium	Low	Individ.	Individ.	Short	Short
American Oystercatcher	Low	Medium	Medium	Island	Individ.	Short	Short
Ruddy Turnstone, Great Blue Heron, Green heron, Great Egret	High	Medium	Low	Individ.	Individ.	Short	Short
Belted Kingfisher	Medium	Medium	Low	Individ.	Individ.	Short	Short
House Sparrow, Bronze Mannikin, & Orange-cheeked Waxbill	High	Medium	Low	Individ.	Individ.	Short	Short
Peregrine Falcon & Northern Harrier	High	Medium	Low	Individ.	Individ.	Short	Short
Merlin	Medium	Medium	Low	Individ.	Individ.	Short	Short
Laughing Gull	High	Medium	Low	Individ.	Individ.	Short	Short
Brown Booby & Brown Pelican	None	None	Low	None	Individ.	None	Short
Magnificent Frigatebird & Red-footed Booby	None	None	Low	None	Individ.	None	Short
Bridled Tern, Sooty Tern & Brown Noddy	None	None	Low	None	Individ.	None	Short
White-tailed Tropicbird	None	None	Low	None	Individ.	None	Short
Desecheo Gecko	Medium	Medium	Low	Global	Individ.	Short	Short
Desecheo Ameiva	High	Medium	Low	Global	Individ.	Short	Short
Desecheo Anole	High	Medium	Low	Global	Individ.	Short	Short
Puerto Rico Racer	High	Medium	Low	Island	Individ.	Short	Short
Slippery-backed Skink	High	Medium	Low	Island	Individ.	Short	Short
Hawksbill, Green & Leatherback Sea Turtles	Low	Low	Low	Individ.	Individ.	Short	Short
Arachnids[7]	Low	None	Low	Global	Individ.	Short	Short
Purple Landcrab	High	None	Low	Island	Individ.	Short	Short
Hermit Crab	High	None	Medium	Island	Individ.	Short	Short
Bats	Low	High	None	Individ.	None	Short	None
Higo Chumbo	None	None	Low	None	Individ.	None	Short
Other Vegetation/Flora	None	None	Low	None	Individ.	None	Short

NOTES TO TABLE 4.4

[1]None: No exposure pathway; Low: Possible exposure pathway; Medium: One exposure pathway; High: Multiple exposure pathways.

[2] None: No toxicological sensitivity; Low: Minor toxicological sensitivity; Medium: Moderate toxicological sensitivity; High: Severe toxicological sensitivity.

[3] None: No disturbance pathway; Low: Low sensitivity to disturbance; Medium: Moderate sensitivity to disturbance; High: Severe sensitivity to disturbance.

[4] Individual (Individ.): Few individuals affected, no affect on resident breeding population; Island population (Island): Resident breeding population affected, no affect on regional or global population; Global or regional population (Global): Regional or global population affected.

[5] Short: Impacts for up to two months; Medium: Impacts for two to six months; Long: Impacts for more than 6 months.
[6] Extent of risk within a population for both toxicant and disturbance is: Island for zenaida dove and Individual for common ground-dove.
[7] Arachnids: *Clubiona desecheonis*, *Camillina desecheonis* and *Schizomus desecheo*.

4.11 Indirect Impacts to Biological Resources

4.11.1 Indirect Effects under Alternative A

Alternative A, the no action alternative, would leave rats on Desecheo, which will continue to impact the island by altering vegetation communities, impact the breeding success of seabirds, and impact the overall food web of the island. Specifically, rats will likely prevent the threatened higo chumbo from recovery by eating the seeds, young shoots and adult cacti. The continued presence of rats would likely prevent extirpated breeding seabirds from re-establishing on Desecheo, depress the abundance of terrestrial birds, depress the abundance of the Desecheo dwarf gecko, and contribute to habitat alteration, potentially leading to the extirpation of resident terrestrial birds from the island.

4.11.2 Indirect Effects under All Action Alternatives

Rats may currently play a strong role in the terrestrial ecosystem of Desecheo. As a result, their removal would likely have indirect impacts to other species. The Service anticipates that the majority of these impacts would be positive. The benefits of rat eradication from islands worldwide have been outlined in Section 1.4.1.3, and the impacts of rats to native wildlife on Desecheo have been discussed in Section 4.6.3. Indirect benefits from rat eradication have been extensively reported for seabirds, terrestrial land birds, reptiles, invertebrates, rare plants, forest regeneration, inter-tidal communities, and whole ecosystem transformation.

The most immediate positive impacts expected on Desecheo from the removal of rats would be to the smaller nesting seabirds, such as bridled and sooty terns and brown noddies. Early accounts from Desecheo suggested that these species nested in their thousands on and around Desecheo. In the Azores archipelago, eradication of black rats resulted in the re-establishment of breeding roseate terns (*Sterna dougalli*) and common terns (*S. hirundo*) (Amaral et al. 2010). Following black rat eradication on Anacapa Island, California, Xantus' murrelet (*Synthliboramphus hypoleucus*) nest occupancy increased from 36 to 51 percent, and hatching success from 42 to 80 percent (Whitworth et al. 2005).

In addition, rat eradication would likely have a positive indirect impact to terrestrial resident birds through reduced depredation on eggs, chicks and adults, and through reduced competition for food resources. Early accounts from Desecheo suggest that a number of land birds haven't been seen on the island in recent years, including the mangrove cuckoo that Wetmore (1918) considered resident and was commonly observed by Meier and colleagues in 1987. Overall habitat recovery through reduced seed and

seedling predation by rats would also provide higher quality foraging grounds for wintering neotropical migrants. The Service would anticipate an increase in abundance and distribution of the Desecheo dwarf gecko; currently rats likely impact this species by direct predation of eggs, young and adults, and competition for shared food resources.

On other islands from which rats have been eradicated, terrestrial invertebrate populations are some of the best-documented beneficiaries of rat eradication (Newman 1994, Ruscoe 2001, Jones and Golightly 2006) and overall invertebrate abundance on Desecheo, especially populations of terrestrial invertebrates that rats currently depend on for food, would be anticipated to increase. In addition, it is likely that rats impact the two endemic spiders and the endemic whip scorpion, and rat removal would be anticipated to improve the long-term population survival of these species (see Section 4.6.3.5).

Elsewhere, rats have impacted rare plants and tree regeneration through seed, seedling and fruit predation, and consequently contribute to the alteration of native vegetation communities. Specifically, rat removal would be anticipated to have indirect positive impact of the recovery of the higo chumbo cactus on Desecheo, as rats are known predators of higo chumbo fruit on nearby Mona Island (see Section 4.6.3.6).

The removal of rats might also have an indirect negative impact to some ecosystem components, given their currently perceived role in the Desecheo ecosystem. Given that a large proportion of rat diet is likely to be invertebrates and seeds on Desecheo, these prey items would be released from rat predation pressure once rats are eradicated. It is anticipated that this release would be compensated by the subsequent predation of the same prey items by native terrestrial wildlife (predatory invertebrates, reptiles, land birds), and in fact that the removal of food competition between rats and native species would be beneficial to Desecheo's native wildlife populations. However, there is the possibility that some prey items would not be consumed by native species and thus, being under no predation pressure, could result in a population increase. If a species detrimental to the ecology of Desecheo (such as an invasive plant or predatory invertebrate) increases in abundance after rat removal, this could result in a negative indirect impact. Of particular concern is the presence of fire ants (Formicidae: possibly *Solenopsis* sp.), but it is unknown whether the species on Desecheo are native or invasive, or if rats play a role on controlling ant abundance.

The presence of red-tailed hawks and Northern harrier on Desecheo could decline as a result of rat eradication because small mammals comprise a large part of these species' diet. However, on mainland Puerto Rico, the diet of red-tailed hawks in lowland forests comprised largely of small mammals, but in upland rainforest comprised mostly reptiles, birds and amphibians (Santana and Temple 1988) suggesting that the species has the ability to adapt to a non-mammal diet when needed. Additionally, Northern harrier has been rarely recorded on Desecheo; the island does not provide optimal habitat and it is likely a temporary resident or vagrant to the island.

The numbers of pearly-eyed thrasher and shiny cowbird could increase on the island as a result of reduced depredation of eggs and chicks, and increased food abundance. The shiny

cowbird is a brood parasite that, since 1900, has been increasing its range from South America (where it is native) through the Caribbean to mainland North America. It is currently documented as impacting 232 species that have received cowbird eggs, and 74 species that have reared cowbird young. The pearly-eyed thrasher is an 'avian supertramp' species that has increased its range in Puerto Rico since the 1920s. These birds are voracious predators of a range of vertebrates, bird eggs and chicks. While most nest predation events recorded have been on passerines (Arendt 2006), there would be the possibility that pearly-eyes would prey upon seabird eggs and chicks, particularly those of the smaller species such as terns. An increased abundance of both cowbird and thrasher on Desecheo could have an impact on nesting success of resident breeding bird species.

The numbers of the non-native house sparrow, bronze manikin and orange-cheeked waxbill could increase as a result of decreased rat predation on eggs, young and adult birds and increased food resources. These three species are introduced to Puerto Rico and the impact of an increased abundance on Desecheo would be unknown.

4.12 Consequences: Social and Economic Environment

The CEQ guidelines at 40 CFR 1508.14 include the human relationship with the natural environment as a category of potential impacts that must be considered in a NEPA analysis. This is interpreted to mean that a NEPA analysis needs to examine the potential effects of an action on any economic and/or social values that are related to the natural environment.

4.12.1 Refuge Visitors and Recreation

4.12.1.1 Analysis Framework for Refuge Visitors and Recreation

Although access to Desecheo by the public is prohibited without a permit, the waters surrounding the islands are utilized for limited recreational activities, such as wildlife viewing, snorkeling and scuba diving, by permitted tour agencies and individuals. This analysis will examine the likely changes to visitor experience as a result of all the action alternatives. The Service would consider any major, long-term changes to the visitor experience to be significant.

4.12.1.2 Alternative A – No Action

The direct impacts that rats will continue to have on seabird populations on Desecheo will be perceptible to boaters near the islands. Overall, taking no action with regard to removing invasive rats from the island will be unlikely to result in any direct impacts to the current value of the Desecheo NWR for nearshore visitors. However, by not removing rats from Desecheo, nearshore visitors will likely continue to experience decreased bird viewing since several extirpated bird species are expected to continue to be absent from the island.

4.12.1.3 Alternative B

The area immediately surrounding Desecheo Island would be closed to boater access during aerial bait application operations, which would be a minor short-term inconvenience to refuge visitors. If flocks of roosting seabirds, particularly gulls or pelicans, are flushed during helicopter operations the flocks would be visible to boaters offshore, but only during the short period of actual helicopter operations. The expected recovery of the Desecheo ecosystem after rat eradication would likely not be perceptible to boaters near the islands. However, by removing rats from Desecheo nearshore visitors would likely have greater bird viewing opportunities since several extirpated bird species are expected to return to the island post rat eradication.

4.12.1.4 Alternative C

The area immediately surrounding Desecheo Island would be closed to boater access during aerial bait application operations, which would be a minor short-term inconvenience to refuge visitors. If flocks of roosting seabirds, particularly gulls or pelicans, are flushed during helicopter operations the flocks would be visible to boaters offshore, but only during the short period of actual helicopter operations. The expected recovery of the Desecheo ecosystem after rat eradication would likely not be perceptible to boaters near the islands. However, by removing rats from Desecheo nearshore visitors would likely have greater bird viewing opportunities since several extirpated bird species are expected to return to the island post rat eradication.

4.12.1.5 Alternative D

The area immediately surrounding Desecheo Island would be closed to boater access during aerial bait application operations, which would be a minor short-term inconvenience to refuge visitors. If flocks of roosting seabirds, particularly gulls or pelicans, are flushed during helicopter operations the flocks would be visible to boaters offshore, but only during the short period of actual helicopter operations. The expected recovery of the Desecheo ecosystem after rat eradication would likely not be perceptible to boaters near the islands. However, by removing rats from Desecheo nearshore visitors would likely have greater bird viewing opportunities since several extirpated bird species are expected to return to the island post rat eradication.

4.12.1.6 Alternative E

The area immediately surrounding Desecheo Island would be closed to boater access during aerial bait application operations, which would be a minor short-term inconvenience to refuge visitors. If flocks of roosting seabirds, particularly gulls or pelicans, are flushed during helicopter operations the flocks would be visible to boaters offshore, but only during the short period of actual helicopter operations. The expected recovery of the Desecheo ecosystem after rat eradication would likely not be perceptible to boaters near the islands. However, by removing rats from Desecheo nearshore visitors would likely have greater bird viewing opportunities since several extirpated bird species are expected to return to the island post rat eradication.

4.12.2 Historical and Cultural Resources

4.12.2.1 Analysis Framework for Historical and Cultural Resources

The National Historic Preservation Act (NHPA) defines the concept of an "adverse impact" to historical resources, but the regulations make clear that "a finding of adverse effect on a historic property does not necessarily require an EIS [Environmental Impact Statement] under NEPA" (36 CFR 800.8(a)(1)). Section 106 of the NHPA requires agencies to consult with the appointed regional Historic Preservation Officer(s) if adverse impacts to historical or cultural resources are possible. Desecheo has no known historical or cultural resources. In addition, an informal consultation with the Service's Regional Archeologist indicated that eradicating rats on Desecheo would not result in any negative impacts to historical or cultural resources, and therefore, does not require a formal consultation with the Puerto Rico State Historic Preservation Office (SHPO) (See Appendix VIII). However, in the event that historical or cultural resources remain undetected on Desecheo, this analysis will evaluate any potential impacts as a reference for the appropriate Historic Preservation Officers.

4.12.2.2 Alternative A – No Action

The Service has no evidence that rat activities would affect any undetected historical and cultural resources on the island. Rats are burrowing animals, a behavior that has the potential to damage buried artifacts, but there are numerous seabird species that burrow on the island as well, which makes the preservation of buried artifacts on Desecheo difficult, whether or not rats are present.

4.12.2.3 Alternative B

Alternative B would not involve activities that would require soil disruption or any other actions that would affect any undetected historical or cultural resources on Desecheo.

4.12.2.4 Alternative C

Alternative C would not involve activities that would require soil disruption or any other actions that would affect any undetected historical or cultural resources on Desecheo.

4.12.2.5 Alternative D

Alternative D would not involve activities that would require soil disruption or any other actions that would affect any undetected historical or cultural resources on Desecheo.

4.12.2.6 Alternative E

Alternative E would not involve activities that would require soil disruption or any other actions that would affect any undetected historical or cultural resources on Desecheo.

4.13 Consequences: Cumulative Impacts

4.13.1 Assessing Cumulative Impacts

The NEPA regulations require Federal agencies to consider not just the direct and indirect impacts of an action but also the cumulative impacts to which an action would contribute. Analyzing cumulative impacts on Desecheo Island requires consideration of other, unrelated impacts that are occurring simultaneously to those resources, impacts that have occurred in the past, or impacts that are likely to occur in the foreseeable future. The continued presence of rats is likely impacting many of the species on the island, but there are no other clear localized impacts known to be occurring today. Furthermore, there are no foreseeable future human actions on the island that are likely to negatively affect the island's environment, because the land is being managed in perpetuity as a National Wildlife Refuge. However, many of the species on Desecheo are still recovering from severe past impacts. Also, many of the species that use Desecheo Island have large ranges. These far-ranging populations may have been affected in the past, may be currently experiencing unrelated impacts, or may be at risk of impacts from reasonably foreseeable consequences in the future, elsewhere in their ranges.

The following is a breakdown of the past, present and reasonably foreseeable future actions that would likely cumulatively contribute to the impacts associated with the five identified alternatives. Direct and indirect impacts from each alternative will be analyzed with the following list of activities to determine the cumulative impacts for the given alternative.

Past Actions – actions that occurred in the past but have lasting impacts, and that would contribute to the impacts from the proposed action.

Historically, Desecheo Island has been subjected to a number of human impacts. In the 1920s farming was attempted. Cattle were pastured in Long Valley and the mouths of both West and Long Valleys were dammed to trap water. The forest in the southwest of the island near Puerto de los Botes was cleared for cropland and the red-footed booby rookery was displaced about 500 feet to the east. The former cultivated area reverted to grassland that was maintained by visiting fishermen who burned it periodically to maintain land crab habitat; the burning prevented the reestablishment of trees in the area.

- Desecheo military range and removal of Unexploded Ordnances - Between 1940 and 1952, Desecheo was used by the U.S. War Department as a bombing and gunnery training range during World War II and as a survival training site for the U.S. Air Force up to 1960 (Woodbury et al. 1971). It remained under Federal jurisdiction until 1964 when it was declared surplus property. Evidence of this bombardment can be seen in in the shattered pulverized rock on the eastern ridges and cliffs. Segments and fragments of shells were still being reported in the 1970s (Woodbury et al. 1971) and site assessments carried out by the Department of Defense in 1991, 2002 and 2007 detected ordnance remnants and high levels of zinc in the soil at two of the known bombing ranges; the entire island is considered at risk for ordnance

remnants. As a U.S. military range, the natural ecosystem of Desecheo would have been severely impacted by bombing activities and heavy foot and vehicle impact throughout the island. A small concrete building and large concrete water catchment pad was constructed along the southwest coastline. The assessments conducted in 1991, 2002 and 2007 included short site visits to Desecheo by military personnel across the island on foot causing some disturbance along trails

- Feral Cat Eradication – Nine male cats were removed from Desecheo between 1985 and 1987. The removal of feral cats has likely had some minor short term impacts to Desecheo from operational activities; however, the long term impacts are primarily positive because of the negative impacts that feral cats are known to have on island species. Feral cats have been documented to prey upon birds, bird eggs, reptiles, and other island species (Nogales et al. 2004). By removing feral cats, island species have had the opportunity to recover; however, full recovery will not be realized until rats have been removed from Desecheo since they impact the same species as cats do.

- Goat removal - Goats were present on Desecheo as early as 1788. Breckon (2000) proposes that the increasing visual impact of feral goats on Desecheo in the 1990s was a result of the cessation of illegal hunting of goats in the late 1980s. Feral goats have had a negative impact on the island's ecosystem through overgrazing, soil impaction, erosion, loss of plant diversity, and disturbance of seabird nesting areas. Between 1996 and 1999, 390 goats were removed (Breckon 2000), and during seven field visits by Service personnel between March 2001 and December 2002, a further 291 goats were removed. In 2008 the last few goats were removed and complete eradication was confirmed in 2010. While the immediate negative impacts of removing feral goats from the island, including increased foot traffic, soil impaction and vegetation disturbance by hunters traveling across the island, would have occurred, the result of the activities will be very positive effects on the island's ecosystem including: increased seedling recruitment, reduced browsing and grazing on native plants, increased survival of threatened and low density plant species, and possibly an increase in overall plant diversity due to recruitment from dormant seeds. In addition, general habitat recovery will benefit native reptiles and birds, and soil erosion and impaction will decrease. Already, the number of endangered higo chumbo cactus on Desecheo has increased from only five known plants in 2003 to more than 39 individuals in 2010, with obvious signs of rapid growth in many individuals.

- Macaque removal - Rhesus macaques were introduced to Desecheo in 1966 as part of a primate behavioral study by the National Institutes of Health. The colony was abandoned in about 1971 when the study was finished (Evans 1989). Almost immediately after introduction, the macaques were implicated in the dramatic decline of nesting populations of brown booby and red-footed booby, to the point that less than 20 pairs of only two seabird species (of the nine species historically documented) are known to breed on the island today. Previous efforts at trapping

and removing rhesus macaques were carried out in 1977, 1979 and 1981 (Evans 1989). Between 1985 and 1988, a more intensive removal effort was undertaken by the U.S. Fish and Wildlife Service as an effort to restore the National Wildlife Refuge's historical biodiversity. This attempt was unsuccessful at complete removal but the significant reduction in macaque density would have allowed some recovery of native species on the island. Beginning in 2009, a further attempt to completely remove the remaining animals was initiated and is ongoing. While the negative effects of these removal programs, including terrain impaction and vegetation disturbance from hunters living temporarily and working on the island would have occurred, the positive benefits on the island's ecosystem from the reduced densities of animals in the interim and the complete removal of animals in the long-term greatly exceeds the short-term impacts of the management activities.

- Biological Monitoring - The Service conducts regular biological surveys on Desecheo NWR to monitor ecosystem health. Surveys are conducted by Service biologists at permanent survey stations across the island. Typically, up to four Service personnel visit the island for between two and four days, and travel on foot across the island to access survey sites. Impacts from these activities is limited to foot traffic and associated soil impaction and vegetation disturbance along regular hiking paths (often old goat trails) to gain access to the island's interior. Temporary camps to support the survey personnel have been located on the old concrete water catchment in the southwest of the island; all equipment and supplies are removed from the island on completion of the field trip.

- Law Enforcement - Desecheo Island and the surrounding waters have been known to be used for illegal activities including illegal landings of illegal immigrants from elsewhere in the Caribbean Region (typically Dominican Republic, Cuba), and illegal drugs trafficking. These activities have required frequent law enforcement within the area and on the island, by U.S. Federal and Puerto Rico Government agents. Law enforcement activities have involved regular policing of the area by aircraft, ship and officers on the island. Any impact to the island from these activities is minimal and generally infrequent.

Current Actions – actions that are occurring within the same timeframe as the proposed action or within the planning and compliance phase of the proposed action and contribute to the impacts from the proposed action.

- Biological Monitoring - Further biological surveying is being conducted within this timeframe to document the specific recovery of native and endangered species as a result of the rat eradication management proposal, and to carry out field trials in preparation of the rat eradication. Monitoring occurred three times in 2009 (February, June, December) and twice in 2010 (February, June). Field personnel were temporarily based on Desecheo for between five days and two weeks. The impacts associated with these activities include increased foot traffic and vegetation

disturbance through access to the island's interior and coastal areas, trapping and euthanizing rats, and hand-capturing reptiles. At the end of each field trip, all equipment and supplies are permanently removed from the island.

- Seismic Station Maintenance – The University of Puerto Rico annually travels to Desecheo to check and maintain the seismic station that is located on Top Ridge. Maintenance personnel travel by boat or helicopter to the island and will only stay on the island to check and perform any required maintenance on the station. The short term impacts from such actions are likely negligible with no known long term impacts.

Future Actions – actions that are reasonably foreseeable in the future that may contribute to the cumulative impacts from the proposed action.

- Biological Monitoring - Surveys by the Service to monitor ecosystem health and recovery of threatened and native biodiversity, as described above, will continue. It is anticipated that surveys to document ecosystem recovery in particular will finish five years after implementation of the rat eradication efforts.

- Law enforcement – Law enforcement activities will remain an activity as required, but are not expected to create any short or long term impacts to the island.

4.13.1.1 Cumulative Impacts under Alternative A – No Action

Under the no action alternative, the negative impacts that rats are having to Desecheo Island, particularly on the island's biological resources, would continue in perpetuity. These impacts could be additive to other unrelated impacts on these resources in the future. However, the minor impacts that the listed past, present and future projects would have on the biological resources of Desecheo are not likely to contribute any additional impacts. However, if the presence of rats persists on the island without any eradication efforts, the biological resources of the island are likely to continue to be negatively affected and could potentially cause the extirpation of more seabird species from Desecheo. In addition, if rats persist on the island, the ecosystem benefits from the feral goats, cats and macaque removal would not be fully realized and the costs of those operations would not have achieved maximum benefit.

4.13.1.2 Cumulative Impacts under Alternative B

There would be no major negative impacts to the biological, physical and cultural resources of Desecheo Island under Alternative B. The minor negative impacts to biological resources on the island as a result of Alternative B would not be likely to contribute additively to the negative impacts of any ongoing unrelated projects. However, the expected positive impacts of Alternative B to the island's biological resources would likely contribute additively to the cumulative positive impacts of the combined eradications of feral goats, cats and macaques.

4.13.1.3 Cumulative Impacts under Alternative C

There would be no major negative impacts to the biological, physical and cultural resources of Desecheo Island under Alternative C. The minor negative impacts to biological resources on the island as a result of Alternative C would not be likely to contribute additively to the negative impacts of any ongoing unrelated projects. However, the expected positive impacts of Alternative C to the island's biological resources would likely contribute additively to the cumulative positive impacts of the combined eradications of feral goats, cats and macaques.

4.13.1.4 Cumulative Impacts under Alternative D

There would be no major negative impacts to the biological, physical and cultural resources of Desecheo Island under Alternative D. The minor negative impacts to biological resources on the island as a result of Alternative D would not be likely to contribute additively to the negative impacts of any ongoing unrelated projects. However, the expected positive impacts of Alternative D to the island's biological resources would likely contribute additively to the cumulative positive impacts of the combined eradications of feral goats, cats and macaques.

4.13.1.5 Cumulative Impacts under Alternative E

There would be no major negative impacts to the biological, physical and cultural resources of Desecheo Island under Alternative E. The minor negative impacts to biological resources on the island as a result of Alternative E would not be likely to contribute additively to the negative impacts of any ongoing unrelated projects. However, the expected positive impacts of Alternative E to the island's biological resources would likely contribute additively to the positive cumulative impacts of the combined eradications of feral goats, cats and macaques.

4.14 Irreversible and Irretrievable Impacts

4.14.1 Alternative A – No Action

The no action alternative does not require the commitment of any resources that are considered to be irreversible or irretrievable. The majority of the impacts associated with this alternative will only result in short term impacts and do not require the use of any non-renewable resources.

4.14.2 Alternative B

This alternative does not require the commitment of any resources that are considered to be irreversible or irretrievable. The majority of the impacts associated with this alternative would only result in short term impacts and do not require the use of any non-renewable resources. Furthermore, there would be no construction or development of any permanent structures, divergence of any waterways, or extraction of gas or oil resources during the project implementation period.

Project activities would require a commitment of funds that would then be unavailable for use on other Service projects. At some point, commitment of funds (for purchase of supplies, payments to contractors, etc.) would be irreversible; once used, these funds would be irretrievable. Non-renewable or non-recyclable resources committed to the project (such as helicopter fuel, bait and bait stations) would also represent an irreversible or irretrievable commitment of resources.

4.14.3 Alternative C

This alternative does not require the commitment of any resources that are considered to be irreversible or irretrievable. The majority of the impacts associated with this alternative would only result in short term impacts and do not require the use of any non-renewable resources. Furthermore, there would be no construction or development of any permanent structures, divergence of any waterways, or extraction of gas or oil resources during the project implementation period.

Project activities would require a commitment of funds that would then be unavailable for use on other Service projects. At some point, commitment of funds (for purchase of supplies, payments to contractors, etc.) would be irreversible; once used, these funds would be irretrievable. Non-renewable or non-recyclable resources committed to the project (such as helicopter fuel, bait and bait stations) would also represent an irreversible or irretrievable commitment of resources.

4.14.4 Alternative D

This alternative does not require the commitment of any resources that are considered to be irreversible or irretrievable. The majority of the impacts associated with this alternative would only result in short term impacts and do not require the use of any non-renewable resources. Furthermore, there would be no construction or development of any permanent structures, divergence of any waterways, or extraction of gas or oil resources during the project implementation period.

Project activities would require a commitment of funds that would then be unavailable for use on other Service projects. At some point, commitment of funds (for purchase of supplies, payments to contractors, etc.) would be irreversible; once used, these funds would be irretrievable. Non-renewable or non-recyclable resources committed to the project (such as helicopter fuel, bait and bait stations) would also represent an irreversible or irretrievable commitment of resources.

4.14.5 Alternative E

This alternative does not require the commitment of any resources that are considered to be irreversible or irretrievable. The majority of the impacts associated with this alternative would only result in short term impacts and do not require the use of any non-renewable resources. Furthermore, there would be no construction or development of any permanent structures, divergence of any waterways, or extraction of gas or oil resources during the project implementation period.

Project activities would require a commitment of funds that would then be unavailable for use on other Service projects. At some point, commitment of funds (for purchase of supplies, payments to contractors, etc.) would be irreversible; once used, these funds would be irretrievable. Non-renewable or non-recyclable resources committed to the project (such as helicopter fuel, bait and bait stations) would also represent an irreversible or irretrievable commitment of resources.

4.15 Short-term Uses and Long-term Productivity

An important goal of the Service is to maintain the long-term ecological productivity and integrity of the biological resources on the Refuge. The action alternatives are designed to contribute to the long-term ecological productivity of Desecheo Island and would not result in short-term uses of the resources that would counteract this long-term productivity. Any short-term negative impacts to the islands biological resources would be outweighed by the ecosystem's long-term restoration through the eradication of rats.

5 CONSULTATION AND COORDINATION

5.1 Public Scoping and Review

A Draft Environmental Assessment was made available for review and comment by the public for 30 days, from July 29 through August 31, 2011, to allow the public to provide input on the content of the EA. Availability of the Draft EA was advertised in the local media and delivered by mail or email to all interested parties who requested information.

During the public scoping and review, requests were also made to the following agencies to review and comment on the Draft EA:

1. Puerto Rico Department of Natural and Environmental Resources (DNER)
   - Daniel Galań Kercadó - Secretary
   - Miguel Garcia - Director, Wildlife and Fisheries Bureau
   - Robert Matos - Director of Reserves Division
   - Damarys Delgado - Director, Bureau of Reserves and Coastal Zone
2. Javier Rivera Aquino, Secretary, Puerto Rico Department of Agriculture
3. Pedro J. Nieves Miranda, President, Puerto Rico Environmental Quality Board
4. Carl Soderberg, Environmental Protection Agency (EPA), Director, Caribbean Environmental Protection Division.
5. Ing. Hector Morales Vargas, President, Puerto Rico Planning Board
6. United States Department of Agriculture (USDA)
   - John Eisemann, USDA-NWRC, Fort Collins, Colorado.
   - Frank Boyd, State and Caribbean Director, Wildlife Services
   - Charles Brown, Eastern Regional Director, Wildlife Services
8. Lisamarie Carrubba, NOAA – NMFS (Caribbean Field Office, Puerto Rico)
9. U.S. Fish and Wildlife Service
   - David Viker, Chief, National Wildlife Refuges, Region 4.
   - Edwin Muniz, Field Supervisor, Ecological Services Caribbean office
   - Jenny Ericcson, National Invasive Species Program Coordinator, NWRS.
   - Whit Lewis, Regional IPM Coordinator, Department of Environmental Quality (DEQ).
   - Richard Kanaski, Regional Historic Preservation Officer and Regional Archaeologist, southeast region.

In total, 25 external parties contacted the Service during the comment period:

- four government agencies outside of the Service
  - NOAA – Fisheries
  - USDA – Natural Resources Conservation Service
  - Department of Environment, Montserrat
  - DPNR – Division of Fish and Wildlife, U.S. Virgin Islands
- six organizations
- two parties representing academic institutions

- 13 private individuals

The Draft EA was sent to 43 parties:
- 18 representatives of government agencies were initially sent the Draft EA
- The Service received 25 requests for copies of the Draft EA.
- four additional representatives of government agencies were sent the Draft EA upon request
- six organizations were sent the Draft EA upon request
- two representatives of academic institutions were sent the Draft EA upon request
- 13 private individuals were sent the Draft EA upon request

The Service received four substantive comments on the document from external parties:
- two non-governmental organizations specifically expressed support for the project.
- two provided specific suggestions or corrections (one from a government agency, NOAA – Fisheries; one from an academic institution).
- one requested the re-initiation of Section 7 consultation under the ESA (NOAA – Fisheries).
- None expressed opposition to the project.

The Service also received a number of intra-agency comments on the Draft EA. These comments were incorporated into the Final EA.

Summaries of the public and inter-agency comments received, and the Service's responses to these comments, can be found in Appendices XIII and XIV.

5.2 Preparers, Contributors and Reviewers

5.2.1 U.S. Fish and Wildlife Service

- Susan Silander - Project Leader, Caribbean Islands National Wildlife Refuge
- Richard Warner – (Regional office NEPA lead)
- Richard Kanaski - Regional Historic Preservation Officer and Regional Archaeologist
- Whit Lewis - Regional IPM Coordinator
- Chuck Hunter - Chief, Division of Planning and Resource Management
- Félix López - Ecologist, Contaminants Program and Habitat Conservation

5.2.2 Island Conservation

- Gabrielle Feldman – Environmental Compliance Specialist
- Jacob Sheppard – Environmental Compliance Specialist
- Lillie Langlois – Assistant Environmental Compliance Specialist
- Kirsty Swinnerton – Project Manager
- Gregg Howald – North American Regional Director and Ecotoxicologist
- Madeleine Pott – Island Restoration Specialist
- José Luis Herrera Giraldo – Island Restoration Specialist

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7 Appendices

Appendix I. Birds recorded from Desecheo Island, 1900-2010.
Migrant status in Puerto Rico: R = resident, SB = summer breeding migrant, W = winter migrant, T = transient migrant, V = vagrant, * introduced species, ** observed offshore. Arrangement follows the American Ornithologist Union (AOU) Check-list of North American birds. Breeds on Desecheo = confirmed or suspected breeding since 2000.

Common Name	*Scientific Name*	Year of First Sighting	Seen since 2000	Resident in Puerto Rico	Migrant status	Breeds on Desecheo
Procellariformes						
White-tailed Tropicbird**	*Phaethon lepturus*	2009	●	●		
Suliformes						
Magnificent Frigatebird	*Fregata magnificens*	1900	●	●		
Masked Booby**	*Sula dactylatra*	2009	●	●		
Brown Booby	*Sula leucogaster*	1900	●	●		
Red-footed Booby	*Sula sula*	1901	●	●		
Pelecaniformes						
Brown Pelican	*Pelecanus occidentalis*	1987	●	●		
Great Blue Heron	*Ardea herodias*	1971	●	●	W	
Great Egret	*Ardea alba*	1987	●	●		
Cattle Egret	*Bubulcus ibis*	1987		●		
Green Heron	*Butorides virescens*	2009	●	●	W	
Yellow-crowned Night-Heron	*Nyctanassa violacea*	1987		●	W	
Accipitriformes						
Osprey	*Pandion haliaetus*	1987			W	
Northern Harrier	*Circus cyaneus*	1987			W	
Red-Tailed Hawk	*Buteo jamaicensis*	1971	●	●		●
Falconiformes						
American Kestrel	*Falco sparverius*	1987	●	●		●
Merlin	*Falco columbarius*	1987			W	
Peregrine Falcon	*Falco peregrinus*	1971	●		W	
Charadriiformes						
Killdeer	*Charadrius vociferus*	2010	●	●	W	
American Oystercatcher	*Haematopus palliatus*	1901	●	●		●
Black-necked Stilt	*Himantopus mexicanus*	2010	●		SB	
Spotted Sandpiper	*Actitis macularia*	1987			W	
Upland Sandpiper	*Bartramia longicauda*	1987			T	
Ruddy Turnstone	*Arenaria interpres*	1987	●	●		
Laughing Gull	*Leucophaeus atricilla*	1900	●		SB	
Brown Noddy	*Anous stolidus*	1900	●		SB	●
Sooty Tern	*Onychoprion fuscata*	1900			SB	
Bridled Tern	*Onychoprion anaethetus*	1900	●		SB	●
Royal Tern**	*Sterna maxima*	1993		●		
Sandwich Tern**	*Sterna sandvicensis*	2009	●			

Appendix I (continued)

Common Name	*Scientific Name*	Year of First Sighting	Seen since 2000	Resident in Puerto Rico	Migrant status	Breeds on Desecheo
Columbiformes						
Scaly-naped Pigeon	*Patagioenas squamosa*	1987	●	●		
White crowned Pigeon	*Patagioenas leucocephala*	1987		●		
Zenaida Dove	*Zenaida aurita*	1900	●	●		●
Common Ground-dove	*Columbina passerina*	1987	●	●		
Psittaciformes						
Hispaniolan Parakeet	*Aratinga chloroptera*	1987		●		
Cuculiformes						
Yellow-billed Cuckoo	*Coccyzus americanus*	1987			SB+T	
Mangrove Cuckoo	*Coccyzus minor*	1987	●	●		
Smooth-billed Ani	*Crotophaga ani*	1987		●		
Caprimulgiformes						
Chuck-will's-widow	*Caprimulgus carolinensis*	2009	●		W	
Common Potoo	*Nyctibius griseus*	1987			V	
Apodiformes						
Alpine Swift	*Apus melba*	1987			V	
Antillean Mango	*Anthracothorax dominicus*	1987		●		
Coraciiformes						
Belted Kingfisher	*Megaceryle alcyon*	1976	●	●	W	
Passeriformes						
Gray Kingbird	*Tyrannus dominicensis*	1987	●	●		●
White-eyed Vireo	*Vireo griseus*	2001	●		W	
Black-whiskered Vireo	*Vireo altiloquus*	1900	●	●	SB	●
Caribbean Martin	*Progne dominicensis*	1987	●		SB	
Tree Swallow	*Tachycineta bicolor*	1987			W	
Bank Swallow	*Riparia riparia*	1987			T	
Cave Swallow	*Petrochelidon fulva*	1987	●	●		
Barn Swallow	*Hirundo rustica*	1987	●		T	
Northern Mockingbird	*Mimus polyglottos*	2001	●	●		
Pearly-eyed Thrasher	*Margarops fuscata*	1900	●	●		●
Cedar Waxwing	*Bombycilla cedrorum*	2010	●		V	
Northern Parula	*Parula americana*	1987	●		W	
Cape May Warbler	*Dendroica tigrina*	2001	●		W	
Black-throated Blue Warbler	*Dendroica caerulescens*	1987			W	
Yellow-rumped Warbler	*Dendroica coronata*	2003	●		W	
Yellow-throated Warbler	*Dendroica dominia*	2010	●		W	
Prairie Warbler	*Dendroica discolor*	1987	●		W	
Palm Warbler	*Dendroica palmarum*	1987			W	
Bay-breasted Warbler	*Dendroica castanea*	2010	●		W	
Blackpoll Warbler	*Dendroica striata*	1987			T	
Ovenbird	*Seiurus aurocapilla*	1987			W	
Northern Waterthrush	*Seiurus noveboracensis*	1987			W	

Appendix I (continued)

Common Name	*Scientific Name*	Year of First Sighting	Seen since 2000	Resident in Puerto Rico	Migrant status	Breeds on Desecheo
Passeriformes						
Common Yellowthroat	*Geothlypis trichas*	1987			W	
Hooded Warbler	*Wilsonia citrina*	1987			W	
Indigo Bunting	*Passerina cyanea*	2001	●		W	
Shiny Cowbird	*Molothrus bonariensis*	2001	●	●		
House sparrow	*Passer domesticus*	2000	●	●		
Orange-Cheeked Waxbill	*Estrilda melpoda*	1987		●		
Bronze Mannikin	*Lonchura cucullata*	1987		●		

Appendix II. Risk assessment for all birds on Desecheo NWR, Alternatives B and C.
Status in Puerto Rico: R = resident, SB = summer breeding migrant, W = winter migrant, T = transient migrant, V = vagrant, * introduced species, ** observed offshore only. See Section 4.7.1 and 4.8.1 for a descriptive evaluation of species in bold.

Common Name	EXPOSURE & TOXICITY RISK					DISTURBANCE RISK				Status in Puerto Rico
	Brodifacoum		Brodifacoum use hazard	Extent of Risk	Estimated individuals impacted	PHYSICAL DISTURBANCE		Extent of Risk	Estimated individuals impacted	
	Risk mortality - toxicant use	Risk duration				Disturbance pathway	Risk level			
White-tailed Tropicbird**	**None**	**None**	**None**	**None**	0	**aerial / ground**	**Low**	**Individuals**	0-5	**SB**
Magnificent Frigatebird	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R**
Masked Booby**	None	None	None	None	0	aerial / ground	Low	Individuals	0-5	R
Brown Booby	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**20-50**	**R**
Red-footed Booby	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R**
Brown Pelican	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R**
Great Blue Heron	**High**	**Medium**	**High**	**Individuals**	**0-5**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R + W**
Great Egret	**High**	**Medium**	**High**	**Individuals**	**0-5**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R**
Cattle Egret	High	Medium	Medium	Individuals	0-5	aerial / ground	Low	Individuals	0-5	R
Green Heron	**High**	**Medium**	**High**	**Individuals**	**0-5**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R + W**
Yellow-crowned Night-Heron	High	Medium	Medium	Individuals	0-5	aerial / ground	Low	Individuals	0-5	R + W
Osprey	None	None	None	None	0	aerial	Low	Individuals	0-5	W
Northern Harrier	**High**	**Medium**	**High**	**Individuals**	**0-5**	**aerial**	**Low**	**Individuals**	**0-5**	**W**
Red-Tailed Hawk	**High**	**Medium**	**High**	**Whole island**	**0-10**	**aerial**	**Low**	**Individuals**	**0-10**	**R**
American Kestrel	**High**	**Medium**	**High**	**Whole island**	**5-25**	**aerial / ground**	**Low**	**Individuals**	**5-25**	**R**
Merlin	**High**	**Medium**	**Medium**	**Individuals**	**0-5**	**aerial**	**Low**	**Individuals**	**0-5**	**W**
Peregrine Falcon	**High**	**Medium**	**High**	**Individuals**	**0-10**	**aerial**	**Low**	**Individuals**	**0-10**	**W**
Killdeer	High	Medium	Medium	Individuals	0-5	aerial / ground	Low	Individuals	0-5	R + W
American Oystercatcher	**High**	**Medium**	**Medium**	**Whole island**	**0-25**	**aerial / ground**	**Medium**	**Individuals**	**0-25**	**R**
Black-necked Stilt	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	SB
Spotted Sandpiper	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Upland Sandpiper	None	None	None	None	0	None	None	None	0	T
Ruddy Turnstone	**High**	**Medium**	**High**	**Individuals**	**0-25**	**aerial / ground**	**Low**	**Individuals**	**0-25**	**R**
Laughing Gull	**High**	**Medium**	**High**	**Individuals**	**0-25**	**aerial / ground**	**Low**	**Individuals**	**0-25**	**R + SB**
Brown Noddy	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**SB**
Sooty Tern	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**SB**
Bridled Tern	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**SB**
Royal Tern**	None	None	None	None	0	aerial / ground	Low	Individuals	0-5	R
Sandwich Tern**	None	None	None	None	0	aerial / ground	Low	Individuals	0-5	R
Scaly-naped Pigeon	None	None	None	None	0	aerial / ground	Low	Individuals	0-5	R
White-crowned Pigeon	None	None	None	None	0	aerial / ground	Low	Individuals	0-5	R
Zenaida Dove	**High**	**Short**	**High**	**Whole island**	**25-50**	**aerial / ground**	**Medium**	**Individuals**	**25-50**	**R**
Common Ground-dove	**High**	**Short**	**High**	**Individuals**	**0-5**	**aerial / ground**	**Medium**	**Individuals**	**0-5**	**R**
Hispaniolan Parakeet*	None	None	None	None	0	None	None	None	0	R
Yellow-billed Cuckoo	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	SB + T
Mangrove Cuckoo	**High**	**Medium**	**High**	**Individuals**	**0-5**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R**
Smooth billed Ani	**High**	**Medium**	**Low**	**Individuals**	**0-10**	**aerial / ground**	**Low**	**Individuals**	**0-10**	**R**
Chuck-will's-widow	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Common Potoo	None	None	None	None	0	None	None	None	0	V
Alpine Swift	None	None	None	None	0	None	None	None	0	V
Antillean Mango	None	None	None	None	0	None	None	None	0	R

Appendix II (continued)

Common Name	EXPOSURE & TOXICITY RISK					DISTURBANCE RISK				Status in Puerto Rico
	Brodifacoum		Brodifacoum use hazard	Extent of Risk	Estimated individuals impacted	PHYSICAL DISTURBANCE		Extent of Risk	Estimated individuals impacted	
	Risk mortality - toxicant use	Risk duration				Disturbance pathway	Risk level			
Belted Kingfisher	**High**	**Medium**	**Medium**	**Individuals**	**0-5**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**SB**
Gray Kingbird	**High**	**Medium**	**Medium**	**Whole island**	**0-50**	**aerial / ground**	**Low**	**Individuals**	**0-50**	**R**
White-eyed Vireo	High	Medium	Medium	Individuals	0-50	aerial / ground	Low	Individuals	0-50	W
Black-whiskered Vireo	**High**	**Medium**	**Medium**	**Whole island**	**0-50**	**aerial / ground**	**Low**	**Individuals**	**0-50**	**R + SB**
Caribbean Martin	High	Medium	Low	Individuals	0-5	aerial	Low	Individuals	0-5	SB
Tree Swallow	High	Medium	Low	Individuals	0-5	aerial	Low	Individuals	0-5	W
Bank Swallow	None	None	None	None	0	None	None	None	0	T
Cave Swallow	High	Medium	Low	Individuals	0-5	aerial	Low	Individuals	0-5	R
Barn Swallow	None	None	None	None	0	None	None	None	0	T
Northern Mockingbird	**High**	**Medium**	**High**	**Individuals**	**0-10**	**aerial / ground**	**Low**	**Individuals**	**0-10**	**R**
Pearly-eyed Thrasher	**High**	**Medium**	**High**	**Whole island**	**25-50**	**aerial / ground**	**Medium**	**Individuals**	**25-50**	**R**
Cedar Waxwing	None	None	None	None	0	None	None	None	0	V
Northern Parula	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Cape May Warbler	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Black-throated Blue Warbler	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Yellow-rumped Warbler	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Yellow-throated Warbler	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Prairie Warbler	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Palm Warbler	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Bay-breasted Warbler	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Blackpoll Warbler	None	None	None	None	0	None	None	None	0	T
Ovenbird	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Northern Waterthrush	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Common Yellowthroat	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Hooded Warbler	High	Medium	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Indigo Bunting	High	Medium	Medium	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Shiny Cowbird	**High**	**Medium**	**High**	**Individuals**	**0-10**	**aerial / ground**	**Low**	**Individuals**	**0-10**	**R**
House sparrow*	**High**	**Short**	**High**	**Individuals**	**0-50**	**aerial / ground**	**Low**	**Individuals**	**0-50**	**R**
Orange-Cheeked Waxbill*	**High**	**Short**	**High**	**Individuals**	**0-50**	**aerial / ground**	**Low**	**Individuals**	**0-50**	**R**
Bronze Mannikin*	**High**	**Short**	**High**	**Individuals**	**0-50**	**aerial / ground**	**Low**	**Individuals**	**0-50**	**R**

Appendix III. Risk assessment for all birds on Desecheo NWR, Alternatives D and E. Status in Puerto Rico: R = resident, SB=summer breeding migrant, W = winter migrant, T = transient migrant, V = vagrant, * introduced species, ** observed offshore. See Sections 4.9.1 and 4.10.1 for a descriptive evaluation for species in bold.

Common Name	EXPOSURE & TOXICITY RISK					DISTURBANCE RISK				Status in Puerto Rico
	Diphacinone		Diphacinone use hazard	Extent of Risk	Estimated individuals impacted	PHYSICAL DISTURBANCE		Extent of Risk	Estimated individuals impacted	
	Risk mortality - toxicant use	Risk duration				Disturbance pathway	Risk level			
White-tailed Tropicbird**	**None**	**None**	**None**	**None**	0	**aerial / ground**	**Low**	**Individuals**	0-5	**SB**
Magnificent Frigatebird	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R**
Masked Booby**	None	None	None	None	0	aerial / ground	Low	Individuals	0-5	R
Brown Booby	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**20-50**	**R**
Red-footed Booby	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R**
Brown Pelican	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R**
Great Blue Heron	**Medium**	**Short**	**Medium**	**Individuals**	**0-5**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R + W**
Great Egret	**Medium**	**Short**	**Low**	**Individuals**	**0-5**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R**
Cattle Egret	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	R
Green Heron	**Medium**	**Short**	**Low**	**Individuals**	**0-5**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R + W**
Yellow-crowned Night-Heron	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	R + W
Osprey	None	None	None	None	0	aerial	Low	Individuals	0-5	W
Northern Harrier	**Medium**	**Short**	**Medium**	**Individuals**	**0-5**	**aerial**	**Low**	**Individuals**	**0-5**	**W**
Red-Tailed Hawk	**Medium**	**Short**	**Medium**	**Whole island**	**0-10**	**aerial**	**Low**	**Individuals**	**0-10**	**R**
American Kestrel	**Medium**	**Short**	**Medium**	**Whole island**	**5-25**	**aerial / ground**	**Low**	**Individuals**	**5-25**	**R**
Merlin	**Medium**	**Short**	**Low**	**Individuals**	**0-5**	**aerial**	**Low**	**Individuals**	**0-5**	**W**
Peregrine Falcon	**Medium**	**Short**	**Medium**	**Individuals**	**0-10**	**aerial**	**Low**	**Individuals**	**0-10**	**W**
Killdeer	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	R + W
American Oystercatcher	**Medium**	**Short**	**Low**	**Whole island**	**0-25**	**aerial / ground**	**Medium**	**Individuals**	**0-25**	**R**
Black-necked Stilt	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	SB
Spotted Sandpiper	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Upland Sandpiper	None	None	None	None	0	None	None	None	0	T
Ruddy Turnstone	**Medium**	**Short**	**Medium**	**Individuals**	**0-25**	**aerial / ground**	**Low**	**Individuals**	**0-25**	**R**
Laughing Gull	**Medium**	**Short**	**Medium**	**Individuals**	**0-25**	**aerial / ground**	**Low**	**Individuals**	**0-25**	**R + SB**
Brown Noddy	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**SB**
Sooty Tern	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**SB**
Bridled Tern	**None**	**None**	**None**	**None**	**0**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**SB**
Royal Tern**	None	None	None	None	0	aerial / ground	Low	Individuals	0-5	R
Sandwich Tern**	None	None	None	None	0	aerial / ground	Low	Individuals	0-5	R
Scaly-naped Pigeon	None	None	None	None	0	aerial / ground	Low	Individuals	0-5	R
White-crowned Pigeon	None	None	None	None	0	aerial / ground	Low	Individuals	0-5	R
Zenaida Dove	**Medium**	**Short**	**Medium**	**Whole island**	**25-50**	**aerial / ground**	**Medium**	**Individuals**	**25-50**	**R**
Common Ground-dove	**Medium**	**Short**	**Medium**	**Individuals**	**0-5**	**aerial / ground**	**Medium**	**Individuals**	**0-5**	**R**
Hispaniolan Parakeet*	None	None	None	None	0	None	None	None	0	R
Yellow-billed Cuckoo	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	SB + T
Mangrove Cuckoo	**Medium**	**Short**	**Medium**	**Individuals**	**0-5**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**R**
Smooth billed Ani	**Medium**	**Short**	**Low**	**Individuals**	**0-10**	**aerial / ground**	**Low**	**Individuals**	**0-10**	**R**
Chuck-will's-widow	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Common Potoo	None	None	None	None	0	None	None	None	0	V
Alpine Swift	None	None	None	None	0	None	None	None	0	V
Antillean Mango	None	None	None	None	0	None	None	None	0	R

Appendix III (continued)

Common Name	EXPOSURE & TOXICITY RISK					DISTURBANCE RISK				Status in Puerto Rico
	Diphacinone		Diphacinone use hazard	Extent of Risk	Estimated individuals impacted	PHYSICAL DISTURBANCE		Extent of Risk	Estimated individuals impacted	
	Risk mortality - toxicant use	Risk duration				Disturbance pathway	Risk level			
Belted Kingfisher	**Medium**	**Short**	**Low**	**Individuals**	**0-5**	**aerial / ground**	**Low**	**Individuals**	**0-5**	**SB**
Gray Kingbird	**Medium**	**Short**	**Low**	**Whole island**	**0-50**	**aerial / ground**	**Low**	**Individuals**	**0-50**	**R**
White-eyed Vireo	Medium	Short	Low	Individuals	0-50	aerial / ground	Low	Individuals	0-50	W
Black-whiskered Vireo	**Medium**	**Short**	**Low**	**Whole island**	**0-50**	**aerial / ground**	**Low**	**Individuals**	**0-50**	**R + SB**
Caribbean Martin	Medium	Short	Low	Individuals	0-5	aerial	Low	Individuals	0-5	SB
Tree Swallow	Medium	Short	Low	Individuals	0-5	aerial	Low	Individuals	0-5	W
Bank Swallow	None	None	None	None	0	None	None	None	0	T
Cave Swallow	Medium	Short	Low	Individuals	0-5	aerial	Low	Individuals	0-5	R
Barn Swallow	None	None	None	None	0	None	None	None	0	T
Northern Mockingbird	**Medium**	**Short**	**Medium**	**Individuals**	**0-10**	**aerial / ground**	**Low**	**Individuals**	**0-10**	**R**
Pearly-eyed Thrasher	**Medium**	**Short**	**Medium**	**Whole island**	**25-50**	**aerial / ground**	**Medium**	**Individuals**	**25-50**	**R**
Cedar Waxwing	None	None	None	None	0	None	None	None	0	V
Northern Parula	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Cape May Warbler	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Black-throated Blue Warbler	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Yellow-rumped Warbler	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Yellow-throated Warbler	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Prairie Warbler	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Palm Warbler	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Bay-breasted Warbler	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Blackpoll Warbler	None	None	None	None	0	None	None	None	0	T
Ovenbird	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Northern Waterthrush	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Common Yellowthroat	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Hooded Warbler	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Indigo Bunting	Medium	Short	Low	Individuals	0-5	aerial / ground	Low	Individuals	0-5	W
Shiny Cowbird	**Medium**	**Short**	**Medium**	**Individuals**	**0-10**	**aerial / ground**	**Low**	**Individuals**	**0-10**	**R**
House sparrow*	**Medium**	**Short**	**Medium**	**Individuals**	**0-50**	**aerial / ground**	**Low**	**Individuals**	**0-50**	**R**
Orange-Cheeked Waxbill*	**Medium**	**Short**	**Medium**	**Individuals**	**0-50**	**aerial / ground**	**Low**	**Individuals**	**0-50**	**R**
Bronze Mannikin*	**Medium**	**Short**	**Medium**	**Individuals**	**0-50**	**aerial / ground**	**Low**	**Individuals**	**0-50**	**R**

Appendix IV. Feeding ecology and potential toxicant exposure pathways in birds on Desecheo NWR.

Common Name	FEEDING ECOLOGY		
	Prey items	Feeding group	Toxicant exposure pathway
White-tailed Tropicbird	fish	piscivorous	none
Magnificent Frigatebird	fish	piscivorous	none
Masked Booby	fish	piscivorous	none
Brown Booby	fish	piscivorous	none
Red-footed Booby	fish	piscivorous	none
Brown Pelican	fish	piscivorous	none
Great Blue Heron	mostly fish: also amphibians, invertebrates, reptiles, mammals	aquatic/coastal forager	intertidal invertebrates*, reptiles, carrion, rats
Great Egret	fish, invertebrates, reptiles, small rodents	aquatic/coastal forager	intertidal invertebrates*, small reptiles, small rats
Cattle Egret	very opportunistic, large insects, birds, small rodents, reptiles	omnivorous	large insects, small reptiles, carrion
Green Heron	fish, invertebrates, reptiles & small rodents	aquatic/coastal forager	intertidal invertebrates*, reptiles, small rats
Yellow-crowned Night-Heron	crustaceans	aquatic/coastal forager	marine crustaceans**
Osprey	fish	piscivorous	fish
Northern Harrier	small birds, small mammals	predatory	rats, passerines
Red-Tailed Hawk	mammals, carrion	predatory	rats, carrion
American Kestrel	anoles	predatory	mostly anoles, some passerines, large invertebrates
Merlin	small birds	predatory	passerines
Peregrine Falcon	birds	predatory	shorebirds, Ameiva, laughing gulls
Killdeer	earthworms, grasshoppers, beetles	ground insectivore	terrestrial invertebrates
American Oystercatcher	mostly bivalves, some other marine invertebrates	aquatic/coastal forager	marine bivalves, crabs*
Black-necked Stilt	aquatic micro invertebrates	aquatic/coastal forager	intertidal microinvertebrates
Spotted Sandpiper	aquatic micro invertebrates	aquatic/coastal forager	intertidal microinvertebrates
Upland Sandpiper	orthoptera; all insects	ground insectivore	terrestrial invertebrates
Ruddy Turnstone	aquatic invertebrates	aquatic/coastal forager	softened bait pellets, intertidal invertebrates*, carrion
Laughing Gull	opportunistic	aquatic/coastal forager	bait, carrion, intertidal invertebrates*
Brown Noddy	fish	piscivorous	none
Sooty Tern	fish	piscivorous	none
Bridled Tern	fish	piscivorous	none

Appendix IV (continued)

Common Name	FEEDING ECOLOGY		
	Prey items	Feeding group	Toxicant exposure pathway
Royal Tern	fish	piscivorous	none
Sandwich Tern	fish	piscivorous	none
Scaly-naped Pigeon	fruits	frugivorous	none
White-crowned Pigeon	fruits	frugivorous	none
Zenaida Dove	seeds; opportunistic	frugivorous/granivorous	bait
Common Ground-dove	fruits	granivorous	bait
Hispaniolan Parakeet§	fruits	frugivorous/granivorous	none
Yellow-billed Cuckoo	large insects; sometimes lizards	canopy/ground forager	large terrestrial insects, reptiles
Mangrove Cuckoo	orthoptera, insect larvae; also lizards	canopy/ground forager	large terrestrial insects, reptiles
Smooth billed Ani	insects, also lizards	ground insectivore	large terrestrial insects, reptiles
Chuck-will's-widow	flying insects	aerial insectivore	flying insects
Common Potoo	flying insects	aerial insectivore	flying insects
Alpine Swift	flying insects	aerial insectivore	flying insects
Antillean Mango	nectar; insects	nectarivorous	none
Belted Kingfisher	fish, also aquatic invertebrates, reptiles, mammals	aquatic/coastal forager	rats
Gray Kingbird	large flying insects (bettles, bees, dragonflies)	canopy forager	terrestrial invertebrates
White-eyed Vireo	lepidoptera & larvae; flies & beetles	canopy forager	terrestrial invertebrates
Black-whiskered Vireo	fruits & spiders; lepidoptera larvae/eggs	canopy forager	terrestrial invertebrates
Caribbean Martin	flying insects	aerial insectivore	flying insects
Tree Swallow	flying insects	aerial insectivore	flying insects
Bank Swallow	flying insects	aerial insectivore	flying insects
Cave Swallow	flying insects	aerial insectivore	flying insects
Barn Swallow	flying insects	aerial insectivore	flying insects
Northern Mockingbird	arthropods, fruit, lizards	omnivorous	terrestrial invertebrates, anoles
Pearly-eyed Thrasher	large insects, opportunistic, lizards, fruits	omnivorous	terrestrial invertebrates, anoles
Cedar Waxwing	fruits	frugivorous	none
Northern Parula	small insects	canopy forager	small canopy insects

Appendix IV (continued)

Common Name	FEEDING ECOLOGY		
	Prey items	Feeding group	Toxicant exposure pathway
Cape May Warbler	small insects	canopy forager	small canopy insects
Black-throated Blue Warbler	small insects	canopy forager	small canopy insects
Yellow-rumped Warbler	small insects	canopy forager	small canopy insects
Yellow-throated Warbler	small insects	canopy forager	small canopy insects
Prairie Warbler	small insects	canopy forager	small canopy insects
Palm Warbler	small insects	canopy forager	small canopy insects
Bay-breasted Warbler	small insects	canopy forager	small canopy insects
Blackpoll Warbler	small insects	canopy forager	small canopy insects
Ovenbird	small and large insects	ground insectivore	terrestrial invertebrates
Northern Waterthrush	small insects: diptera and coleoptera	ground insectivore	terrestrial invertebrates
Common Yellowthroat	small insects	canopy forager	small canopy insects
Hooded Warbler	small insects	canopy forager	small canopy insects
Indigo Bunting	seeds/fruits, some insects	frugivorous/granivorous	bait
Shiny Cowbird	arthropods, grain	omnivorous	bait, small reptiles (geckos)
House sparrow[§]	seeds, grains, insects	frugivorous/granivorous	bait
Orange-Cheeked Waxbill[§]	seeds, grains	granivorous	bait
Bronze Mannikin[§]	seeds, grains	granivorous	bait

NOTES:

* While no specific records of food items for great blue heron, great egret, green heron, ruddy turnstone and laughing gull are available for Desecheo, dietary information for these species from elsewhere within their range includes various crabs, depending on availability of different crab species in the environment. For example in Boqueron Wildlife Refuge, *Uca* sp. comprised 0.4% of the diet of great egrets (Miranda and Collazo 1997). Green heron and cattle egret are quite opportunistic in their feeding habits and would likely take beach, sand, intertidal and small land crabs, While the primary food item for great blue heron is fish, it is also likely that they might prey on inter-tidal crabs. However, hermit crabs (*Coenobita* sp.) are taken less readily by shorebirds because they are difficult to extract from their shell, but some anecdotal observations of turnstones, plovers and tattlers from the Pacific Ocean indicate that these shorebirds will take juvenile hermit crabs.

** Yellow-crowned night heron is a marine crustacean specialist feeding on land and shallow-water crabs including: land crabs (*Gecarcinu*s spp.), ghost crabs (*Ocypod*e spp.), fiddler crabs (*Uca* spp.), and sand crabs (*Emerita* spp.), although hermit crabs are not well-documented as a food item for this species.

§ Introduced species.

Appendix V. Risk assessment for reptiles on Desecheo NWR, Alternatives B & C.

(i) Alternative B. See Section 4.7.2 for descriptive evaluation.

Common Name	Status	EXPOSURE & MORTALITY RISK						DISTURBANCE RISK			
		EXPOSURE		Brodifacoum		Brodifacoum use hazard	Extent of Risk	PHYSICAL DISTURBANCE		Extent of Risk	Duration of the Risk
		Food web pathway	Presence/ absence probability	Toxicant use mortality risk	Risk duration			Disturbance pathway	Risk level		
Desecheo Gecko	wild	Medium	High	High	Medium	High	Island	Ground	Medium	Individuals	Short
	captive (i)	None	None	None	None	None	None	Ground	High	Individuals	Perm.
	captive (ii)	None	None	None	None	None	None	Ground	High	Individuals	Medium
Desecheo Ameiva	wild	High	High	High	Medium	High	Island	Ground	Medium	Individuals	Short
	captive (i)	None	None	None	None	None	None	Ground	High	Individuals	Perm.
	captive (ii)	None	None	None	None	None	None	Ground	High	Individuals	Medium
Desecheo Anole	wild	High	High	High	Medium	High	Island	Ground	Medium	Individuals	Short
	captive (i)	None	None	None	None	None	None	Ground	Medium	Individuals	Perm.
	captive (ii)	None	None	None	None	None	None	Ground	Medium	Individuals	Medium
Puerto Rican Racer	wild	High	High	High	Medium	High	Island	Ground	Medium	Individuals	Short
Slippery-backed Skink	wild	High	High	High	Medium	High	Island	Ground	Medium	Individuals	Short
Hawksbill Sea Turtle	wild	None	None	None	None	None	None	None	None	None	None
Green Sea Turtle	wild	None	None	None	None	None	None	None	None	None	None
Leatherback Sea Turtle	wild	None	None	None	None	None	None	None	None	None	None

(ii) Alternative C. See Section 4.8.2 for descriptive evaluation**.**

Common Name	Status	EXPOSURE & MORTALITY RISK						DISTURBANCE RISK			
		EXPOSURE		Brodifacoum		Brodifacoum use hazard	Extent of Risk	PHYSICAL DISTURBANCE		Extent of Risk	Duration of the Risk
		Food web pathway	Presence/ absence probability	Toxicant use mortality risk	Risk duration			Disturbance pathway	Risk level		
Desecheo Gecko	wild	Medium	High	High	Medium	High	Global	Ground	Medium	Individuals	Short
Desecheo Ameiva	wild	High	High	High	Medium	High	Global	Ground	Medium	Individuals	Short
Desecheo Anole	wild	High	High	High	Medium	High	Global	Ground	Medium	Individuals	Short
Puerto Rican Racer	wild	High	High	High	Medium	High	Island	Ground	Medium	Individuals	Short
Slippery-backed Skink	wild	High	High	High	Medium	High	Island	Ground	Medium	Individuals	Short
Hawksbill Sea Turtle	wild	None	None	None	None	None	None	None	None	None	None
Green Sea Turtle	wild	None	None	None	None	None	None	None	None	None	None
Leatherback Sea Turtle	wild	None	None	None	None	None	None	None	None	None	None

Appendix VI. Risk assessment for reptiles on Desecheo NWR, Alternatives D & E.

(i) Alternative D. See Section 4.9.2 for descriptive evaluation.

Common Name	Status	EXPOSURE & MORTALITY RISK						DISTURBANCE RISK			
		EXPOSURE		Brodifacoum		Diphacinone use hazard	Extent of Risk	PHYSICAL DISTURBANCE		Extent of Risk	Duration of the Risk
		Food web pathway	Presence/ absence probability	Toxicant use mortality risk	Risk duration			Disturbance pathway	Risk level		
Desecheo Gecko	wild	Medium	High	Medium	Short	Medium	Island	Ground	Medium	Individuals	Short
	captive (i)	None	None	None	None	None	None	Ground	High	Individuals	Perm.
	captive (ii)	None	None	None	None	None	None	Ground	High	Individuals	Medium
Desecheo Ameiva	wild	High	High	Medium	Short	Medium	Island	Ground	Medium	Individuals	Short
	captive (i)	None	None	None	None	None	None	Ground	High	Individuals	Perm.
	captive (ii)	None	None	None	None	None	None	Ground	High	Individuals	Medium
Desecheo Anole	wild	High	High	Medium	Short	Medium	Island	Ground	Medium	Individuals	Short
	captive (i)	None	None	None	None	None	None	Ground	Medium	Individuals	Perm.
	captive (ii)	None	None	None	None	None	None	Ground	Medium	Individuals	Medium
Puerto Rican Racer	wild	High	High	Medium	Short	Medium	Island	Ground	Medium	Individuals	Short
Slippery-backed Skink	wild	High	High	Medium	Short	Medium	Island	Ground	Medium	Individuals	Short
Hawksbill Sea Turtle	wild	None	None	None	None	None	None	None	None	None	None
Green Sea Turtle	wild	None	None	None	None	None	None	None	None	None	None
Leatherback Sea Turtle	wild	None	None	None	None	None	None	None	None	None	None

(ii) Alternative E. See Section 4.10.2 for descriptive evaluation.

Common Name	Status	EXPOSURE & MORTALITY RISK						DISTURBANCE RISK			
		EXPOSURE		Brodifacoum		Diphacinone use hazard	Extent of Risk	PHYSICAL DISTURBANCE		Extent of Risk	Duration of the Risk
		Food web pathway	Presence/ absence probability	Toxicant use mortality risk	Risk duration			Disturbance pathway	Risk level		
Desecheo Gecko	wild	Medium	High	Medium	Short	Medium	Global	Ground	Medium	Individuals	Short
Desecheo Ameiva	wild	High	High	Medium	Short	Medium	Global	Ground	Medium	Individuals	Short
Desecheo Anole	wild	High	High	Medium	Short	Medium	Global	Ground	Medium	Individuals	Short
Puerto Rican Racer	wild	High	High	Medium	Short	Medium	Island	Ground	Medium	Individuals	Short
Slippery-backed Skink	wild	High	High	Medium	Short	Medium	Island	Ground	Medium	Individuals	Short
Hawksbill Sea Turtle	wild	None	None	None	None	None	None	None	None	None	None
Green Sea Turtle	wild	None	None	None	None	None	None	None	None	None	None
Leatherback Sea Turtle	wild	None	None	None	None	None	None	None	None	None	None

Appendix VII. Conversion Factors

Multiply	By	To obtain
	Length	
meter (m)	0.3048	feet (ft)
centimeter (cm)	2.54	inch (in)
kilometer (km)	0.621388	mile (mi)
	Volume	
microliter (µL)	0.00003382	ounce, fluid (fl. oz)
milliliter (mL)	0.03382	ounce, fluid (fl. oz)
liter (L)	33.82	ounce, fluid (fl. oz)
	Mass	
kilograms (kg)	2.204	pounds (lbs)
gram (g)	0.03527	ounce, avoirdupois (oz)
microgram (µg)	=	1×10^{-6} grams
nanogram (ng)	=	1×10^{-9} grams
	Concentration	
microgram per gram (µg/g)	=	parts per million (ppm: 10^{-6})
microgram per milliliter (µg/mL)	=	parts per million (ppm: 10^{-6})
microgram per liter (µg/L)	=	parts per billion (ppb: 10^{-9})
nanogram per liter (ng/L)	=	parts per trillion (ppt: 10^{-12})
kilograms per hectare (kg/ha)	0.8888	pounds per acre (lb/acre)
	Area	
hectare (ha)	2.47	acre

Appendix VIII. Inter-agency Scoping Communications

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Caribbean Islands National Wildlife Refuge
P.O. Box 510, Carr. 301, Km. 5.1
Boqueron, Puerto Rico 00622

March 8, 2010

Ing. Hector Morales Vargas
President
Puerto Rico Planning Board
P.O. Box 41119
Santurce, Puerto Rico 00940

Dear Mr. Morales:

We have identified you and/or your agency as a potentially interested party to a proposed action to be conducted by the US Fish & Wildlife Service, Caribbean Islands National Wildlife Refuge Complex ("the Service") on Desecheo National Wildlife Refuge, a small island located 14 miles off the west coast of Puerto Rico. The purpose of the proposed action is to meet the Service's management goal of protecting and restoring the ecosystem of Desecheo Island, particularly seabirds, reptiles, and native plants, by eradicating non-native rats.

The Service is currently conducting an environmental assessment (EA) for the proposed action, as required by the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.), and its associated regulations. We are contacting you 1) to advise you of our intentions; 2) to solicit input from you regarding specific attributes of the proposed action, and/or of Desecheo's environment, that you believe should be included in the EA; and 3) to solicit input from you as to additional compliance requirements or regulations within your jurisdiction that may apply to this project.

A description follows for the need for the proposed action, and the alternatives the Service is currently considering in the EA.

Rats were introduced to Desecheo National Wildlife Refuge in the early 1900s and, together with the introduction of rhesus macaques and feral goats, have drastically altered the island ecosystem. Historically, Desecheo Island was a major seabird rookery. In the early 1900s tens of thousands of seabirds of seven species were nesting on the island. Landbird species such as the Zenaida dove and Pearly-eyed Thrasher also likely nested in significant numbers on the island. Today, no seabirds and few landbirds nest on the island, and less than a dozen seabirds may circle it in a day.

Unsustainable harvesting by humans contributed to these seabird declines, while the introduction of rhesus macaques in 1966 appears to have halted all reproduction of larger seabirds, such as

TAKE PRIDE IN AMERICA

brown and red-footed boobies, on the island. Rats likely continue to depredate eggs, chicks, and adults of any remaining seabirds that attempt to breed, particularly for smaller species, such as tropicbirds and terns, which nest on more inaccessible cliffs. Macaque and rat predation has likely led to the extirpation of the mangrove cuckoo and belted kingfisher from the island, and all but a few pairs of pearly-eyed thrasher remain. Finally, the endemic dwarf gecko, Desecheo whip scorpion, and two endemic spiders are probably preyed upon by rats, while goats have also restricted their available habitat by altering vegetation.

The Service is anticipating that removing the threats that these non-native species pose will facilitate the recovery of the Desecheo ecosystem to a state that more closely resembles the island's previous biodiversity. On other islands, rat eradication has been followed by the recovery of seabirds, landbirds, reptiles, and plants.

The Service is proposing to eradicate rats by broadcasting rodenticide bait pellets onto the island, following commonly practiced techniques that have been implemented successfully to eradicate rats from over 300 islands during the past six decades. Based on the environmental issues unique to Desecheo that were initially identified, the Service is currently considering five alternatives – four action alternatives, and the no action alternative, which is included in the analysis to provide a benchmark with which to compare the magnitude of environmental effects of the action alternatives.

The alternatives are:

- *Alternative A: No action*
- *Alternative B: Aerial broadcast of "Brodifacoum-25 Conservation", with proactive risk reduction actions for vulnerable reptile taxa*
- *Alternative C: Aerial broadcast of "Brodifacoum-25 Conservation", without proactive risk reduction actions for vulnerable reptile taxa*
- *Alternative D: Aerial broadcast of "Diphacinone-50 Conservation", with proactive risk reduction actions for vulnerable reptile taxa*
- *Alternative E: Aerial broadcast of "Diphacinone-50 Conservation", without proactive risk reduction actions for vulnerable reptile taxa*

Aerial broadcast of bait pellets would be the primary distribution method in all action alternatives. Other bait distribution methods would include hand broadcast of bait pellets, and/or placing bait pellets in bait stations. Rat eradication would be followed by biological monitoring to ensure eradication success and to document the response of native biota to rat removal. The Service would also implement protocols to prevent future rodent re-introductions.

The Service is proposing this action pursuant to management authorities including the Refuge Improvement Act of 1997 (16 U.S.C. 668dd et seq.), the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1544), the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. 703-712), and the Fish and Wildlife Act of 1956, as amended (16 U.S.C. 742a-742j, not including 742 d-l).

If you would like to provide input regarding specific attributes of the proposed action, and/or of Desecheo's environment, that you believe should be included in the EA or if you have

information on additional compliance requirements or regulations within your jurisdiction that may apply to this project, please provide this information to us by April 30. If you have any questions, please contact me at 787/851-7258.

Sincerely,

Susan Silander

Susan Silander
Project Leader

Richard Kanaski/R4/FWS/DOI
03/17/2010 10:39 AM

To Susan Silander/R4/FWS/DOI
cc
bcc
Subject Re: Desecheo project

Susan - although technically an undertaking, Desecheo rat eradication project does not possess the potential to impact historic properties. It is similar to other invasive species eradication efforts conducted elsewhere by the FWS, i.e. cut and squirt techniques used to eliminate Brazilian Pepper. Consultation with the PR SHPO pursuant to Section 106 of the National Historic Preservation Act is not required. If you typically notify the PR SHPO as part of the NEPA process for other projects, then I see no reason to change your SOP.

Here's some language that can be edited or revised for use in the EA's cultural resource impact assessment:

Current rat-related impacts on Desecheo's historic properties involve damage caused by burrowing and devegetation. Eradication of this pest species benefits the Key's historic properties and biota. The use of Brodifacoum-25 Conservation or Diphacinone-50 Conservation and the subsequent removal of dying or dead rodents will not impact any historic properties. Due to the nature of the undertaking, the RHPO/RA also determined that historic and/or archaeological investigations are not warranted or recommended.

Hope this helps. Don't hesitate to contact me if you have any questions or I can be of further assistance. Thanks.

Rick

Richard S. Kanaski
Regional Historic Preservation Officer &
Regional Archaeologist
Southeast Region
Savannah Coastal Refuges
694 Beech Hill Lane
Hardeville, South Carolina 29927
O: (843) 784-6310
C: (912) 257-5434
F: (843) 784-7112 or
(843) 784-2465
email: richard_kanaski@fws.gov

Susan Silander/R4/FWS/DOI

Susan Silander/R4/FWS/DOI
03/16/2010 05:36 PM

To Richard Kanaski/R4/FWS/DOI
cc
Subject Desecheo project

We are planning an eradication project for rats on the island of Desecheo involving the aerial application of bait. We are currently working on an Environmental Assessment and have prepared a scoping letter (see attached). There will be no excavating or earth movement. Do we need to send a letter to them, if so should you send it or should we? Thanks for your assistance.

GOVERNMENT OF PUERTO RICO
Department of Natural and Environmental Resources

April 20, 2010

Mrs. Susan Silander
Project Leader
Fish and Wildlife Service
Caribbean Islands National Wildlife Refuge
PO Box 510
Boquerón, PR 00622

Dear Mrs. Silander:

We support the proposed action of initiating a rodent eradication program on Desecheo Island. This management initiative has proven to be very effective in the restoration of native biotas, specifically on island ecosystems. In fact, the Puerto Rico Department of Natural Resources and Environment (DNER) executed a similar project in Monito Island about a decade ago. In relation to the three (3) objectives, stated in your March 8, 2010 letter, these are our comments.

- **Objective 1. Advise DNER of the Proposed Action**
  The intended action has been adequately notified. Please keep us informed about the expected timeline and potential collaborative efforts with our agency.

- **Objective 2. Soliciting Input about the Proposed Action**
  We support alternatives B and D. Both combined the use of highly recommended rodenticides with a risk reduction protocol to minimize impact to vulnerable reptile taxa.

- **Objective 3. Soliciting Input about Additional Compliance Requirement/ Regulation**
  Please be advised that Desecheo wildlife resources are protected under the Government of Puerto Rico laws and regulation and a scientific research permit will be required to conduct inventories or to manipulate (e.g. marking) animals.

We would like to reiterate our commitment and strongly encourage the initiation and fully completion of the aforementioned activity, please feel free to contact, Dr. Miguel A. García, Director of Fisheries and Wildlife Bureau at 787-999-2200, extension 2607, or magarcia@drna.gobierno.pr, if you require any further discussion on this matter.

Cordially,

Daniel J. Galán-Kercadó
Secretary

MAG/mtn

PUERTO RICO VERDE
PO Box 366147, San Juan, PR 00936
Tel. 787.999.2200 • Fax. 787.999.2303

INTRA-SERVICE SECTION 7 BIOLOGICAL EVALUATION FORM

Division/Office: Boquerón Field Office, Coastal Program Project

Project Biologist/Phone#: Beverly Buchanan Yoshioka
787-851-7297 Ext.227

Date: June 16, 2008

I. **Proposed Action:** Island Conservation, a Santa Cruz, California based conservation organization is carrying out a cooperative project with Fish and Wildlife Service to remove Macaque (Rhesus) monkeys, goats, and rats from Desecheo Island National Wildlife Refuge, a 358 acre island off the west coast of Puerto Rico. The project is underway and removed most of the monkeys last year, and left two non-fertile, collared, goats to track any remaining goats during this year. The project is moving into the next phase to remove the remaining monkeys and goats, complete an EA and preliminary work for the rat removal, and complete the rat removal by summer 2011.

II. **Location (County and State/attach project area map):** Desecheo Island NWR (see attached aerial photograph).

II. **Description of proposed action (describe in enough detail to allow proper evaluation of project impacts, attach additional pages as needed):** Desecheo Island lies approximately 10 miles off the west coast of Puerto Rico. It was set aside in 1912 as a preserve and seabird nesting area, had one of the largest brown booby nesting colonies in the world, and hosted a number of other seabird species. Brown pelicans also utilize the island for roosting and feed in the nearshore waters. It has a history of various disturbances detailed in the previous consultation. In addition to the serious wildlife perturbation from introduced monkeys, rat populations are also very high, further affecting bird nesting and vegetation.

At this stage, the project intends to finish the monkey removal this year, and is moving into the rat eradication stage. An Environmental Assessment is being developed by the Refuge and Cooperator to address the rat removal. Island Conservation has accomplished rat removal on a number of islands with highly sensitive species (including one with an endangered rodent species) with success. The EA will determine how they will apply the rodenticide and what measures will be taken to protect potential non-target species. Typically Island Conservation has used aerial broadcasting for islands with terrain similar to Desecheo.

IV. **Species and Habitats Considered:**

A. List all federally endangered, threatened, proposed, and candidate species, and describe any associated critical or proposed critical habitat that may be affected by the proposed action. Make a determination of how the proposed action may affect each:

SPECIES/CRITICAL HABITAT	STATUS[1]	DETERMINATION[2]			RESPONSE REQUESTED[3]
		NE	NA	AA	
Brown pelican (*Pelecanus occidentalis*)	E		X		
Hawksbill sea turtle (*Eretmochelys imbricate*)	E		X		
Green sea turtle (*Chelonia mydas*)	T	X			
"Higo Chumbo" (*Harrisia portoricensis*	T		X		

[1]STATUS: E = endangered, T = threatened, PE = proposed endangered, PT = proposed threatened, CH = critical habitat, PCH = proposed critical habitat, C = candidate species

[2]DETERMINATION:

NE = no effect. This determination is appropriate when the proposed action will not directly, indirectly or cumulatively impact, either positively or negatively, any listed, proposed, candidate species or designated/proposed critical habitat.

NA = not likely to adversely affect. This determination is appropriate when the proposed action is not likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat or there may be beneficial effects to these resources.

AA = likely to adversely affect. This determination is appropriate when the proposed action is likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat.

[3]RESPONSE REQUESTED: conference, concurrence, formal consultation

V. Determination of effects:

A. Explanation of effects of the action: include direct, indirect, interrelated, interdependent, and cumulative effects (attach additional pages as needed):

Definitions for Effects of the Action:

Direct Effects = are those that are an immediate result of the action.

Indirect Effects = are those that are caused by the action and are later in time but are still reasonably certain to occur. They include the effects of future activities that are induced by the action and that occur after the action is completed.

Interrelated = are those that are part of a larger action and depend on the larger action for their justification.

Interdependent = are those that have no significant independent utility apart from the action that is under consideration.

Cumulative Effects = are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area.

The brown pelican feeds in the waters near Desecheo and roosts on the island, but has not been reported nesting on Desecheo. Nevertheless, removal of the invasive pest species (macaques and rats, in particular) would potentially provide habitat suitable for nesting for this species. Therefore, the project would not be likely to adversely affect the brown pelican due to potential future direct beneficial effects.

The hawksbill sea turtle is common in the waters around Desecheo which provide excellent foraging grounds. While nesting on the island may be very limited, removal of the macaques would be likely to benefit hawksbills by reducing potential nest predations. Therefore, the project would not be likely to adversely affect the hawksbill sea turtle due to potential direct beneficial effects.

The green sea turtle may occasionally be found in the waters around Desecheo, although it does not provide extensive seagrass beds used for foraging of this species. The very limited beaches on Desecheo Island are unlikely to provide nesting habitat for this species. Therefore, the project is not likely to affect this species.

The "Higo Chumbo" cactus is found on Desecheo, Mona, Monito, and very limited specimens in southwest Puerto Rico. It was once relatively common in southwest Puerto Rico. Populations on Desecheo Island are very reduced, and possibly have been extirpated. Goats and macaques have been observed feeding on the cactus during previous visits. The project would not be likely to adversely affect the "Higo Chumbo"

cactus due to the potential for direct beneficial effects from the removal of the monkeys, goats and rats.

B. Explanation of actions to be implemented to reduce adverse effects: There is a potential for non-target species impacts to species such as hawks that may predate on rats. The EA will be evaluating the potential for impacts to non-target species, including reptiles found on the island, and means of minimizing or avoiding those impacts. The project is not expected to adversely affect the federally listed species on the island.

VI. Bradf Yoshida 13 July 2009

Project Leader:
Signature Date

VII. Reviewing Ecological Services Office(ESO) Evaluation:

A. Concurrence ✓ **Nonconcurrence** ______ pH 7/13/09

B. Formal Consultation Reguired

C. Conference Required

D. Remarks (attach additional pages if needed):

VIII. Signatory Approval:

ESO Supervisor: Edwin Muñiz 20 July 09
Signature **Date**

Note: The process ends here if the proposed action is "not likely to adversely affect".

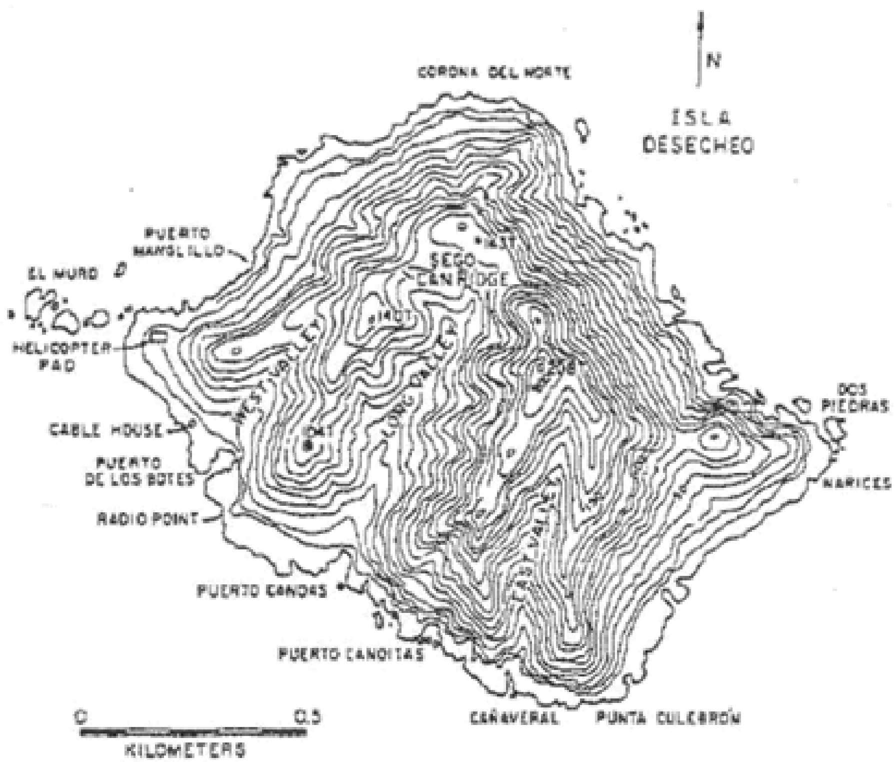
ARD Program: ______________________ _______
Signature **Date**

ARD Ecological Services: ______________________ ________

Signature **Date**

Note: These signatures are required for approval of a conference report or biological opinion.

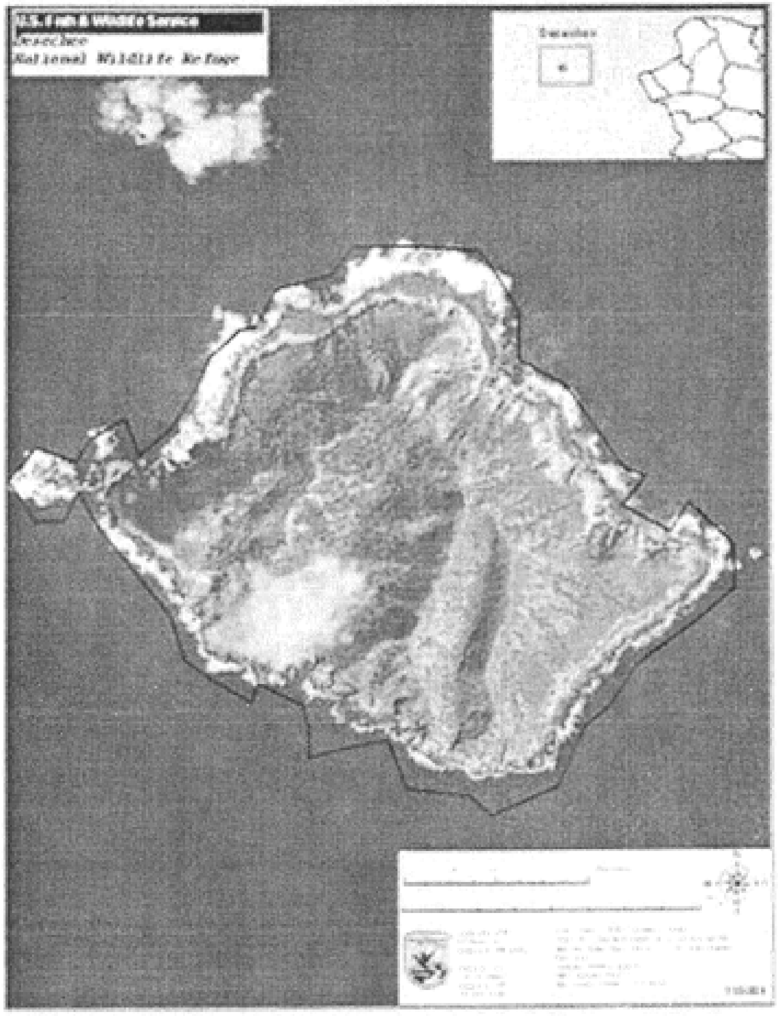
Note: There are no USGS topographic maps for Desecheo, nor was it included in the available vertical aerial photography. It is approximately 10 miles west of Punta Higuero, Puerto Rico.



CONTOUR INTERVAL = 10 METERS

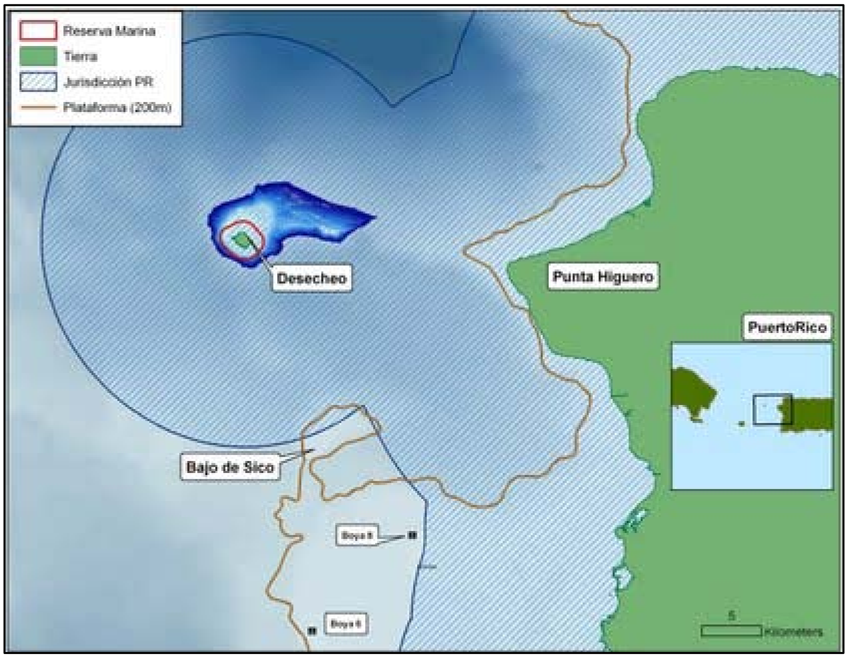
FIG. 1. Desecheo Island, contour intervals and place names. From Morrisonb and Menzel (1972, pg. 14).

Figure 1. Desecheo Island topographic map (from Breckon, 2000, p. 179).

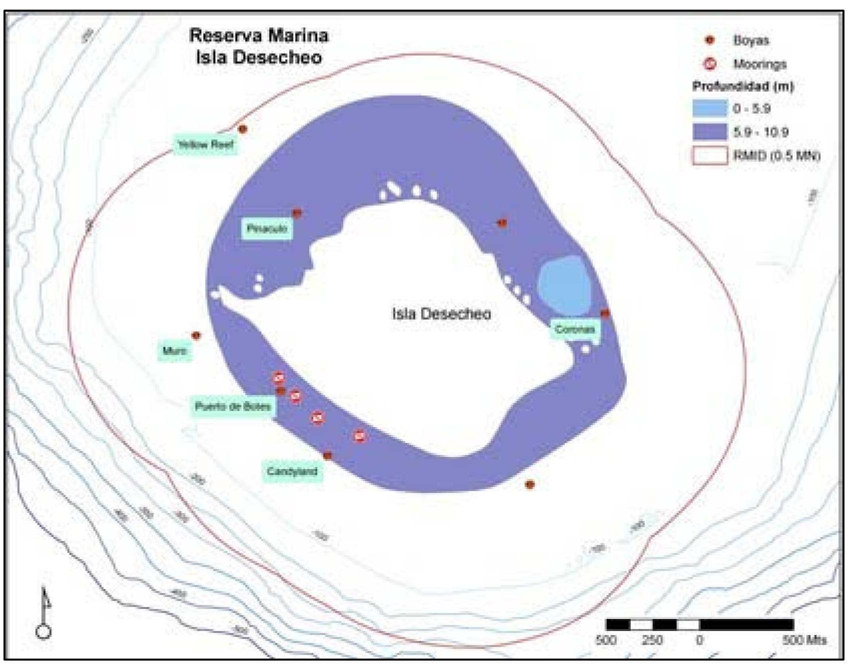


Desecheo Island NWR.

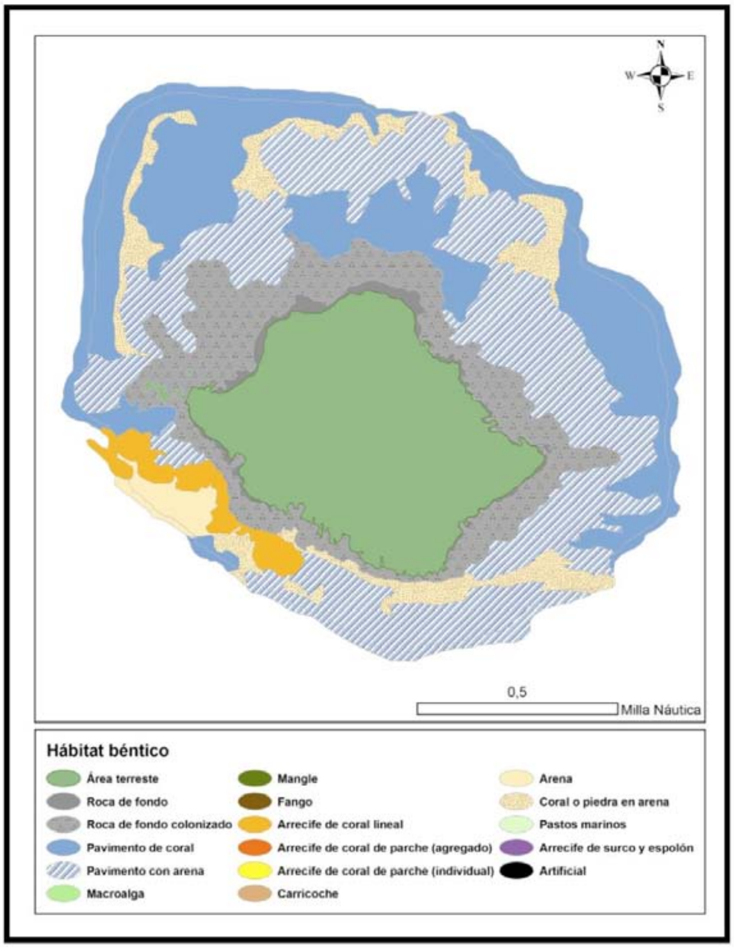
Appendix IX Desecheo Marine Reserve maps (from Valdés-Pizzini et al. 2011).



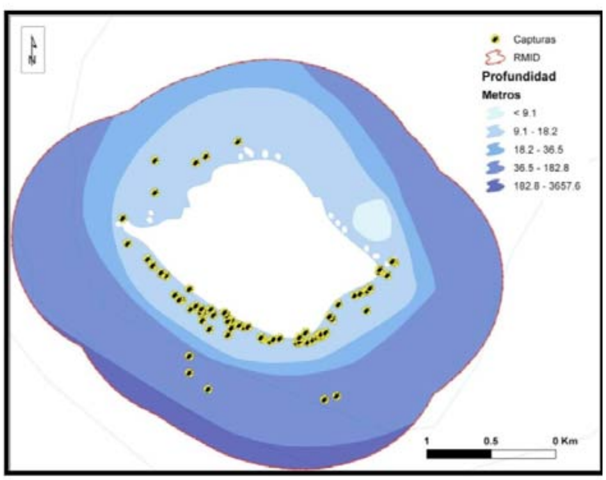
(a) Location of Desecheo Marine Reserve (map: M. Schärer)



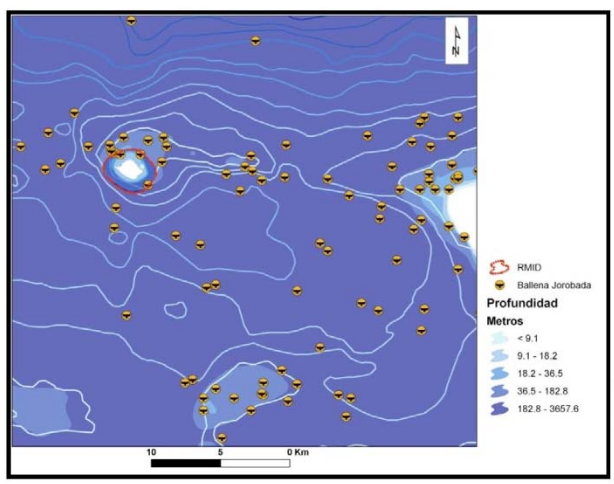
(b) Location of coral reefs, buoys and moorings in Desecheo Marine Reserve (map: M. Schärer)



(c) Map showing distribution of benthic habitats in Desecheo Marine Reserve (map: M. Schärer).



(d) Location of marine turtle captures between 1999 and 2009 in Desecheo Marine Reserve (map: C. Diez).



(e) Location of humpback whale sightings in Desecheo Marine Reserve (map: M. Schärer).

Appendix X. NOAA Vessel Strike Avoidance Measures and Reporting for Mariners: NOAA Fisheriers Service, southeast region.

Background

The National Marine Fisheries Service (NMFS) has determined that collisions with vessels can injure or kill protected species (e.g., endangered and threatened species, and marine mammals). The following standard measures should be implemented to reduce the risk associated with vessel strikes or disturbance of these protected species to discountable levels. NMFS should be contacted to identify any additional conservation and recovery issues of concern, and to assist in the development of measures that may be necessary.

Protected Species Identification Training

Vessel crews should use an Atlantic and Gulf of Mexico reference guide that helps identify protected species that might be encountered in U.S. waters of the Atlantic Ocean, including the Caribbean Sea, and Gulf of Mexico. Additional training should be provided regarding information and resources available regarding federal laws and regulations for protected species, ship strike information, critical habitat, migratory routes and seasonal abundance, and recent sightings of protected species.

Vessel Strike Avoidance

In order to avoid causing injury or death to marine mammals and sea turtles the following measures should be taken when consistent with safe navigation:

1. Vessel operators and crews should maintain a vigilant watch for marine mammals and sea turtles to avoid striking sighted protected species.

2. When whales are sighted, maintain a distance of 100 yards or greater between the whale and the vessel.

3. When sea turtles or small cetaceans are sighted, attempt to maintain a distance of 50 yards or greater between the animal and the vessel whenever possible.

4. When small cetaceans are sighted while a vessel is underway (e.g., bow-riding), attempt to remain parallel to the animal's course. Avoid excessive speed or abrupt changes in direction until the cetacean has left the area.

5. Reduce vessel speed to 10 knots or less when mother/calf pairs, groups, or large assemblages of cetaceans are observed near an underway vessel, when safety permits. A single cetacean at the surface may indicate the presence of submerged animals in the vicinity; therefore, prudent precautionary measures should always be exercised. The vessel should attempt to route around the animals, maintaining a minimum distance of 100 yards whenever possible.

NMFS Southeast Region Vessel Strike Avoidance Measures and Reporting for Mariners; revised February 2008.

6. Whales may surface in unpredictable locations or approach slowly moving vessels. When an animal is sighted in the vessel's path or in close proximity to a moving vessel and when safety permits, reduce speed and shift the engine to neutral. Do not engage the engines until the animals are clear of the area.

Additional Requirements for the North Atlantic Right Whale

1. If a sighted whale is believed to be a North Atlantic right whale, federal regulation requires a minimum distance of 500 yards be maintained from the animal (50 CFR 224.103 (c)).

2. Vessels entering North Atlantic right whale critical habitat are required to report into the Mandatory Ship Reporting System.

3. Mariners should check with various communication media for general information regarding avoiding ship strikes and specific information regarding North Atlantic right whale sighting locations. These include NOAA weather radio, U.S. Coast Guard NAVTEX broadcasts, and Notices to Mariners. Commercial mariners calling on United States ports should view the most recent version of the NOAA/USCG produced training CD entitled "A Prudent Mariner's Guide to Right Whale Protection" (contact the NMFS Southeast Region, Protected Resources Division for more information regarding the CD).

4. Injured, dead, or entangled right whales should be immediately reported to the U.S. Coast Guard via VHF Channel 16.

Injured or Dead Protected Species Reporting
Vessel crews should report sightings of any injured or dead protected species immediately, regardless of whether the injury or death is caused by your vessel.

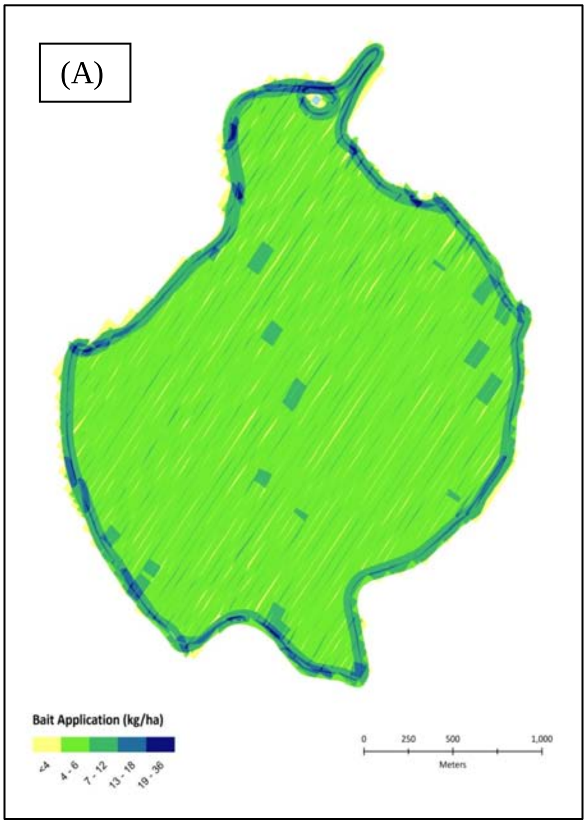
Report marine mammals to the Southeast U.S. Stranding Hotline: 877-433-8299
Report sea turtles to the NMFS Southeast Regional Office: 727-824-5312

If the injury or death of a marine mammal was caused by a collision with your vessel, responsible parties should remain available to assist the respective salvage and stranding network as needed. NMFS' Southeast Regional Office should be immediately notified of the strike by email (takereport.nmfsser@noaa.gov) using the attached vessel strike reporting form.

For additional information, please contact the Protected Resources Division at:
NOAA Fisheries Service
Southeast Regional Office
263 13th Avenue South
St. Petersburg, FL 33701
Tel: (727) 824-5312
Visit us on the web at http://sero.nmfs.noaa.gov

NMFS Southeast Region Vessel Strike Avoidance Measures and Reporting for Mariners; revised February 2008.

Appendix XI. Bait application maps, Rabida Island rat eradication, Galapagos 2010.



Above: Helicopter flight lines and bait swaths applied to Rabida Island, November 2010, showing coastal and interior applications: (A) first bait application, (B) second bait application. *Below*: Google Earth image of Rabida Island. Rabida is 490 ha with a maximum altitude of 367 m and comparable terrain to Desecheo NWR.

Appendix XII. Rodent eradications in Puerto Rico and the U.S. Virgin Islands, 1980 – 2011.

Island Name	Island Group	Island area (ha)	Scientific name	Date eradicated	Eradication Status	Eradication Method	Primary Baiting Method	Primary Toxicant
Cayo Diablo	Puerto Rico	14.2	*R. rattus*	1980	Successful	Poison	Bait station	Unknown
Kalkun Cay	US Virgin Islands (St. Thomas)	1.4	*R. rattus*	1982	Successful	Poison	Bait station	Diphacinone
Dog Cay	US Virgin Islands (St. Thomas)	4.91	*R. rattus*	1983	Successful	Poison	Bait station	Diphacinone
Stevens Cay	US Virgin Islands (St John)	0.8	*R. rattus*	1984	Successful	Poison	Hand broadcast	Diphacinone
Cayo Ratones (La Cordillera)	Puerto Rico	2.81	*R. rattus*	1991	Successful	Unknown	Unknown	Unknown
Isla Monito	Puerto Rico	25.7	*R. rattus*	1993	Failed	Poison	Bait station	Bromadiolone
Isla Monito	Puerto Rico	25.7	*R. rattus*	1999	Successful	Poison	Hand broadcast	Brodifacoum
Buck Island Reef NM	US Virgin Islands (St. Croix)	71	*R. rattus*	2000	Successful	Poison	Bait station	Diphacinone
Green Cay NWR	US Virgin Islands (St Croix)	5.7	*R. rattus*	2000	Reinvaded 2006	Trapping	-	-
Saba	US Virgin Islands (St Thomas)	12.2	*R. rattus* *R. norvegicus*	2003	Successful	Poison	Bait station	Diphacinone
Congo Cay	US Virgin Islands (St. John)	10.6	*R. rattus* *R. norvegicus*	2004	Reinvaded 2006	Poison	Bait station	Diphacinone
Dutchcap Cay	US Virgin Islands (St. Thomas)	12.8	*R. rattus* *R. norvegicus*	2004	Successful	Poison	Bait station	Diphacinone
Buck Island NWR	US Virgin Islands (St. Thomas)	16.8	*R. rattus* *R. norvegicus*	2005	Successful	Poison	Bait station	Diphacinone
Capella Island	US Virgin Islands (St. Thomas)	8.9	*R. rattus*	2005	Successful	Poison	Bait station	Diphacinone
Congo Cay	US Virgin Islands (St. John)	10.6	*R. rattus* *R. norvegicus*	2006	Reinvaded 2007	Poison	Hand broadcast	Brodifacoum
Green Cay NWR	US Virgin Islands (St Croix)	5.7	*R. rattus*	2007	Reinvaded 2007	Trapping	-	-
Ruth Cay	US Virgin Islands (St Croix)	10.9	*R. rattus*	2007	Failed?	Trapping	-	-
Cayo Don Luis	Puerto Rico	-	*R. rattus*	2009	Reinvaded 2011	Poison	Bait station	Unknown
Isla Cardona	Puerto Rico	-	*R. rattus*	2009	Successful	Poison	Bait station	Unknown
Cayo Ratones (Ponce Islands)	Puerto Rico	-	*R. rattus*	2010	Successful	Poison	Bait station	Brodifacoum
La Paguera cays	Puerto Rico	-	*R. rattus*	ongoing	In progress	Poison	Bait station	Unknown

Rattus rattus = black rat, *Rattus norvegicus* = Norway or brown rat

Appendix XIII. Public comments received and responses to comments

Comment Response Matrix

Draft Environmental Assessment: Rat Eradication to Promote Ecosystem Restoration on Desecheo

Commenter	Comment summary	Relevant DEA sections	Service response
William A. Mackin, Society for the Conservation and Study of Caribbean Birds	Supports project: Desecheo is an ideal site for restoration: a large area on which native animals can expand		Comment noted.
"	Recommendations: Careful planning, sticking to plan		See Chapter 2 for detailed descriptions of each alternative. In particular, see Sec. 2.3.4 for a description of site-specific trials & planning.
"	Offers the assistance of "seabird specialists in the Caribbean region"		The Service will continue to engage Caribbean seabird experts as necessary throughout implementation.
Karron James, Environmental Awareness Group	Pleased to hear of planned efforts on Desecheo Island		Comment noted.
Lisamarie Carrubba, NOAA – NMFS	Measures must be taken to ensure that nesting sea turtles and their habitat [on land] are not affected by the proposed project, in consultation with USFWS Ecological Services	App. VIII	See Appendix XIV for detailed response to comments from NOAA-NMFS
Lisamarie Carrubba, NOAA – NMFS	NMFS requests further Section 7 consultation (consultation information may be incorporated into EA)		See Appendix XIV for an informal biological evaluation of species under NMFS's purview

Commenter	Comment summary	Relevant DEA sections	Service response
”	EA should address potential impacts from anchoring of vessels and accidental vessel grounding on:	-	-
“	• Listed whales (some information already included)	4.4.3	See Appendix XIV for detailed response to comments from NOAA-NMFS
“	• Listed sea turtles & their habitat	4.7.2 4.9.2	See Appendix XIV for detailed response to comments from NOAA-NMFS
Lisamarie Carrubba, NOAA – NMFS	• Listed corals (some information already included)	4.4.5	See Appendix XIV for detailed response to comments from NOAA-NMFS
“	EA should address avoidance and minimization measures for impacts from the anchoring of vessels and from accidental vessel grounding	4.4.5 4.7.2 4.9.2	See Appendix XIV for detailed response to comments from NOAA-NMFS
“	EA should address potential impacts from release of bait pellets (including absorption by sponges as turtle food sources) on:	-	-
“	• Listed sea turtles & their habitat	4.6.4.3.3 4.7.2 4.9.2 4.4.4	See Appendix XIV for detailed response to comments from NOAA-NMFS
“	• Listed corals	4.4.5	See Appendix XIV for detailed response to comments from NOAA-NMFS
“	EA should address avoidance and minimization measures for impacts from release of bait pellets, including:	-	-

Commenter	Comment summary	Relevant DEA sections	Service response
"	• Monitoring water and sediment quality in the nearshore environment	2.3.13	See Appendix XIV for detailed response to comments from NOAA-NMFS
"	• Operating procedures to ensure bait application does not occur during storms and bait does not reach the marine environment.	2.3.4.2 2.3.8.1 2.4.3 2.4.4.2 2.4.5.1 2.4.5.1 2.4.6 2.5.6 4.7.2	See Appendix XIV for detailed response to comments from NOAA-NMFS
Lisamarie Carrubba, NOAA – NMFS	DEA does not contain sufficient information regarding:	-	-
"	• Potential amount of bait that could reach the marine environment	4.5.1.3	See Appendix XIV for detailed response to comments from NOAA-NMFS
"	• Potential toxicity of bait to listed species and their habitat	4.6.4.3.3 4.7.2 4.4.5	See Appendix XIV for detailed response to comments from NOAA-NMFS
"	• Monitoring to determine effects of bait application	2.3.13	See Appendix XIV for detailed response to comments from NOAA-NMFS
"	• Detailed measures that will be employed to minimize the potential for bait to be released in the marine environment.	4.7.2	See Appendix XIV for detailed response to comments from NOAA-NMFS
"	Confusion in document regarding which species of whales are listed under ESA vs. protected under MMPA only	3.10 4.6.2.3	See Appendix XIV for detailed response to comments from NOAA-NMFS

Commenter	Comment summary	Relevant DEA sections	Service response
"	Recommendation: Figures indicating proposed pellet application areas in relation to marine environment, habitat of listed species		See Appendix XI for a GIS image of the bait swath pattern from a similar aerial-broadcast rat eradication on Rabida Island in the Galápagos Islands.
Michelle T. Schärer, University of Puerto Rico – Mayagüez	Most relevant eradication project (Monito) not cited in DEA. Nearby location, similar endemic reptile community, similar seabird community. Eradication methods & effectiveness discussed in: García, M.A., C.E. Diez and A. O. Alvarez, 2000. The eradication of *Rattus rattus* from Monito Island, West Indies. In Veitch, C. R. and Clout, M. N. (eds.). *Turning the tide: the eradication of invasive species*. IUCN, Gland, Switzerland and Cambridge, UK.	4.6.4.3.3	Garcia et al. 2002, as well as Garcia 1994, are cited in the EA's discussion of possible impacts to native reptiles (Section 4.6.4.3.3). The Final EA has been amended to include a clarification of the larger context of similar island restoration projects in the past, present, and future in Puerto Rico and the Caribbean (Section 1.4.1.2).
"	Draft Management Plan contains current information regarding local waters and threatened species. Other relevant documents available at http://sites.google.com/site/rmisladesecheo/RM-Isla-Desecheo	3.3.1 3.4.1 3.5 3.7 3.11.2	A Management Plan for the Desecheo Marine Reserve, still in draft form at time of comment response (see Valdés-Pizzini et al. 2011), was not available to the Service when the Draft EA was prepared. Appendix IX in the Final EA contains information on the Marine Reserve's boundaries, habitats, and ecology.

Commenter	**Comment summary**	**Relevant DEA sections**	**Service response**
Michelle T. Schärer, University of Puerto Rico – Mayagüez	Most recent & relevant study on coral reefs within the Marine Reserve (current condition of corals) was not included: Bruckner, A.W. and R.L. Hill, 2009. Ten years of change to coral communities off Mona and Desecheo Islands, Puerto Rico, from disease and bleaching. *Dis Aquat Org* 87: 19–31.	3.7	Bruckner & Hill (2009) describe recent declines in reef health surrounding Desecheo. This project is not expected to negatively impact corals, even cumulative to these recent declines. Section 3.7 of the Final EA has been amended to provide additional information on the status and trend of Desecheo's coral reefs.
"	Marine debris is a significant problem affecting elkhorn coral (*Acropora palmata*), which is an endangered species and should be an important consideration during marine and land based operations at Desecheo. Schärer, M.T., 2004. Mona Channel Marine Debris Removal, Puerto Rico. Final Report to Amigos de Amoná, Inc. 37 pp.		This project will not generate marine debris except in the unlikely event of an accident. Boat operations will not represent an increase from normal levels, and thus the risk from marine debris will not be above the baseline environmental conditions
"	Developmental habitat for hawksbill (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*). Turtles have been tagged & recaptured in littoral zone of Desecheo. Potential impact of aerial, marine, land based operations on juvenile sea turtles should be considered. Diez, C.E., M.T. Schärer, M.I. Nemeth and R.P. van Dam, 2010. Status survey of hawksbill sea turtles (*Eretmochelys imbricata*) at Desecheo Island, Puerto Rico, Summary report for 1999-2009.	3.7 3.10 4.6.3.2	Section 3.7 of the Final EA has been amended to provide additional information on the status and trend of Desecheo's turtles, particular the importance of Desecheo's nearshore waters as habitat for juvenile hawksbill turtles.

Commenter	Comment summary	Relevant DEA sections	Service response
Michelle T. Schärer, University of Puerto Rico – Mayagüez	Marine operations must be in compliance w/ DNER regulations & management plans (fisheries, wildlife, whale encounters, concessions, etc.). The EA fails to mention how the marine operators will be held accountable and prevent violations to DNER regulations. Borrador Plan de Manejo de la Reserva Marina de Isla Desecheo. 2011. Valdés-Pizzini, M., M. Schärer-Umpierre, C.J. Carrero-Morales y M. Fernández-Arribas, eds. Equipo de facilitación del Centro Interdisciplinario de Estudios del Litoral (CIEL), Universidad de Puerto Rico, Mayagüez, Puerto Rico.		The proposed project would be consistent with the objectives of the draft Management Plan for Desecheo Marine Reserve. The Service & its partners would abide by all applicable DNER regulations. DNER has been, and will continue to be, closely involved in project development.

"Will Mackin" <willmackin@gmail.com>
07/28/2011 10:45 AM

To: <caribbeanisland@fws.gov>
cc:
Subject: Public Comment on Desecheo

As a seabird specialist, I write in support of restoring the ecosystem in Desecheo that has been degraded by multiple invasive mammals. This large island make an ideal site for restoration since it has so much area on which seabirds and native reptile populations can expand. The potential dangers to other wildlife should be minimized by using careful planning and sticking to that plan. Seabird specialists in the Caribbean region would be happy to assist this program in any way possible.

Sincerely,

Dr. William A. Mackin
Co-chair of the Seabird Working Group, Society for the Conservation and Study of Caribbean Birds

---

Karron <karronj@yahoo.com>

07/28/2011 01:15 AM
Please respond to Karron

To: "caribbeanisland@fws.gov" <caribbeanisland@fws.gov>
cc: EAG <eag@candw.ag>
Subject: Request for Env Assessment_Desecheo Island

To whom it may concern:
The Offshore Islands Conservation Programme, of which the Environmental Awareness Group in Antigua & Barbuda is a partner, has had great success over the years in removing black rats (*Rattus rattus*) from 12 of Antigua's offshore islands. The effects have been dramatic: increase in populations of our critically endangered Antiguan racer (*Alsophis antiguae*), of breeding seabird colonies, of overall vegetation cover.

We are pleased to hear of the planned efforts on Desecheo Island and would like the opportunity to provide any comments that might be helpful. Please send us a copy of the Environmental Assessment, *Restoring Wildlife Habitat on Desecheo Island, Puerto Rico,* at your convenience.

Regards,
Karron James
President
Environmental Awareness Group

Lisamarie Carrubba
<**Lisamarie.Carrubba@noaa.gov**>

08/23/2011 05:25 PM

Please respond to
Lisamarie.Carrubba@noaa.gov

To "Susan_Silander@fws.gov" <Susan_Silander@fws.gov>

cc

Subject Draft Environmental Assessment for the project entitled, Restoring Wildlife Habitat on Desecheo Island, Puerto Rico

Saludos, Susan:

This is in response to your letter dated July 26, 2011, regarding the Draft Environmental Assessment (DEA) prepared for the project entitled, Restoring Wildlife Habitat on Desecheo Island, Puerto Rico. The U.S. Fish and Wildlife Service (USFWS), in partnership with Island Conservation, proposes the eradication of rats from Desecheo Island using rodenticide as part of efforts to eliminate non-native invasive species from the island. The USFWS has requested comments form the National Marine Fisheries Service (NMFS) Protected Resources Division (PRD) regarding the DEA prepared for the project.

Although the majority of the project will take place on Desecheo Island and not in the marine environment where listed species and their habitat under our purview occur, the project does involve two potential routes of impact to listed species under NMFS' purview: 1.) if access to the island in order to conduct activities associated with the project will be by boat, and 2.) due to the release of rodenticide into the marine environment following application of bait pellets on the island. In addition, because some sea turtle nesting has been reported on the island, measures must be taken to ensure that nesting sea turtles and their habitat are not affected by the proposed project in consultation with USFWS Ecological Services. NMFS recommends that a Section 7 consultation with NMFS pursuant to the requirements of the Endangered Species Act (ESA) be completed for the project. As part of the consultation, the USFWS should address potential impacts to listed whales, sea turtles, and corals and their habitat related to anchoring of vessels being used to transport personnel and gear to the island; accidental grounding of vessels and associated releases of marine debris and petroleum products into the marine environment, which could affect listed sea turtles and corals and their habitat; and release of bait pellets, which may contain substances that are toxic to listed sea turtles and corals and components of sea turtle habitat, such as sponges, including pesticides, binding agents, and other compounds. The USFWS should also address avoidance and minimization measures to address these potential impacts, such as following NMFS' vessel strike avoidance guidelines for sea turtles and marine mammals; monitoring water and sediment quality in the nearshore environment where bait releases will take place or where runoff could transport bait pellets during storms; and operating procedures to ensure bait application does not occur during storms and bait does not reach the marine environment.

The information required for the Section 7 consultation can be

incorporated in the EA. Based on our review of the DEA, there is some information regarding listed whales and corals under NMFS' purview already in the document, as well as reference to the use of NMFS' vessel strike avoidance guidelines during the use of vessels as part of the proposed project to protect listed whales and sea turtles. However, the DEA does not contain information regarding potential impacts to sea turtles in the water and potential impacts to their habitat and there seems to be confusion regarding which species of whales are listed under the ESA versus protected under the Marine Mammal Protection Act only. The DEA also does not contain detailed information regarding the potential amount of bait that could reach the marine environment, potential toxicity of bait to listed species and their habitat, monitoring to determine effects of bait application, or detailed measures that will be employed to minimize the potential for bait to be released in the marine environment. Figures indicating the proposed pellet application areas in relation to the marine environment and habitat of listed species should be added to the document to assist in evaluating the potential impacts of bait application to listed species and their habitat in waters around Desecheo.

Thank you for the opportunity to provide comments on the DEA. Please let me know if you have any questions regarding the Section 7 consultation process or our position regarding this project.

Lee

Dr. Lisamarie Carrubba
NOAA Fisheries
Caribbean Field Office
P.O. Box 1310
Boqueron, PR 00622
787-851-3700
787-851-5588 (fax)

From: Michelle Scharer [m_scharer@hotmail.com]
Sent: 08/31/2011 01:41 AM GMT
To: FWSDBC; Susan Silander; Jose Martinez
Subject: RE: Desecheo Evironmental Assessment

Attached please find my comments and documents that should be cited in the environmental assessment...

Michelle T. Schärer, PhD
http://uprm.academia.edu/MichelleScharer

The proposed environmental impact statement has some misinformation regarding the DNER marine reserve that surrounds the NWR. This marine reserve has a draft management plan with much of the current information regarding the local waters and threatened species that it contains. The following are some flaws in the document that should be considered and

documents are available at the following site: http://sites.google.com/site/rmisladesecheo/RM-Isla-Desecheo (check 'documentos' link on right side)

The most relevant, yet un-cited, rat eradication project was conducted at Monito Island, which is from a nearby location, similar condition of endemic reptile fauna and seabird roosting characteristics. Should include the following work in the analysis of eradication methods and effectiveness: García, M. A., C. E. Diez and A. O. Alvarez, 2000. The eradication of *Rattus rattus* from Monito Island, West Indies. In Veitch, C. R. and Clout, M. N. (eds.). Turning the tide: the eradication of invasive species. IUCN SSC Invasive Species Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

The most recent and relevant study on coral reefs within the Desecheo Island marine reserve was not included; instead past or unpublished reports are cited. The following work should be cited in the discussion of the current condition of corals: Bruckner, A. W. and R. L. Hill, 2009. Ten years of change to coral communities off Mona and Desecheo Islands, Puerto Rico, from disease and bleaching. Dis Aquat Org Vol. 87: 19–31, doi: 10.3354/dao02120

Marine debris is a significant problem affecting the Elkhorn coral (*Acropora palmata*), which is an endangered species and should be an important consideration during marine and land based operations at Desecheo. The following work highlights the impacts of marine debris specifically on this coral at Desecheo Island: Schärer, Michelle T., 2004. Mona Channel Marine Debris Removal, Puerto Rico. Final Report to Amigos de Amoná, Inc. 37 pp.

Several endangered sea turtle species around Desecheo Island use the area as developmental habitat. Several hawksbill (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) have been tagged and recaptured in the littoral zone of Desecheo. The potential impact of the aerial, marine and land based operations should be considered as an important factor that could affect the juvenile sea turtles around the island. This EIS document should include the following work in the discussion of the impacts to endangered sea turtle species: Diez, Carlos E., Michelle T. Schärer, Michael I. Nemeth and Robert P. van Dam, 2010. Status survey of hawksbill sea turtles (*Eretmochelys imbricata*) at Desecheo Island, Puerto Rico, Summary report for 1999-2009.

Special attention should be given to make sure the marine operations are in compliance with the relevant DNER regulations and management plans that apply within the Desecheo Island Marine Reserve (fisheries, wildlife, whale encounters, concessions, etc.) . This document failed to mention how the marine operators will be held accountable and prevent violations to the DNER regulations and conduct activities compatible with the reserve's management plan that was not cited in the document. Borrador Plan de Manejo de la Reserva Marina de Isla Desecheo (2011) Valdés-Pizzini, M., Schärer-Umpierre, M., Carrero-Morales, C. J., y Fernández-Arribas, M., Eds. Equipo de facilitación del Centro Interdisciplinario de Estudios del Litoral (CIEL), Universidad de Puerto Rico, Mayagüez, Puerto Rico.

Appendix XIV Response to public comment from NOAA/NMFS

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Caribbean Islands National Wildlife Refuge
P.O. Box 510, Carr. 301, Km. 5.1
Boqueron, Puerto Rico 00622

October 12, 2011

Dr. Lisamarie Carrubba
NOAA Fisheries
Caribbean Field Office
P.O. Box 1310
Boqueron, Puerto Rico 00622

Dear Dr. Carrubba:

Thank you for your comments on the Fish and Wildlife Service's Draft Environmental Assessment (DEA) "Rat Eradication to Promote Ecosystem Restoration". In that letter National Marine Fisheries Service (NMFS) that the Fish and Wildlife Service (FWS) complete a Section 7 consultation for the project, pursuant to the requirements of the Endangered Species Act (ESA).

Based on the information that we have compiled we understand that there are 9 federally listed threatened or endangered species under NMFS' purview that may occur in the marine habitat immediately surrounding Desecheo Island NWR:

- Hawksbill sea turtle (*Eretmochelys imbricata*) (Endangered)
- Green sea turtle (*Chelonia mydas*) (Threatened)
- Staghorn coral (*Acropora cervicornis*) (Threatened)
- Elkhorn coral (*A. palmata*) (Threatened)
- Humpback whale (*Megaptera novaeangliae*) (Endangered)
- Fin whale (*B. physalus*) (Endangered)
- Sei whale (*Balaenoptera borealis*) (Endangered)
- Killer whale (*Orcinus orca*) (Endangered)
- Sperm whale (*Physeter macrocephalus*) (Endangered)

In addition, there are 3 coral species that are candidates for listing:

- *Montastraea annularis*
- *M. faveolata*
- *M. franksi*

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NMFS is also responsible for the protection of marine mammals under the Marine Mammal Protection Act, which applies to the 17 species of whale and dolphin known from the waters in the region of Desecheo Island:

- Humpback whale (also ESA-listed: Endangered)
- Fin whale (also ESA-listed: Endangered)
- Sei whale (also ESA-listed: Endangered)
- Killer whale (also ESA-listed: Endangered)
- Sperm whale (also ESA-listed: Endangered)
- Shortfin pilot whale (*Globicephala macrorhyncus*)
- Spinner dolphin (*Stenella longirostris*)
- Minke whale (*Balaenoptera acutorostrata*)
- Common dolphin (*Delphinus spp.*)
- Risso's dolphin (*Grampus griseus*)
- False killer whale (*Pseudorca crassidens*)
- Atlantic spotted dolphin (*Stenella frontalis*)
- Roughtooth dolphin (*Steno bredanensis*)
- Bottlenose dolphin (*Tursiops truncates*)
- Pygmy sperm whale (*Kogia breviceps*) (from strandings only)
- Cuvier's beaked whale (*Ziphius cavirostris*)
- Striped dolphin (*Stenella coeruleoalba*) (only known from a skull found in St. Croix)

In your letter you expressed concern about two types of impacts: 1) impacts from boat operations during the course of activities associated with the project; and 2) impacts due to the release of rodenticide into the marine environment. We believe the DEA addressed some of these impacts but we have also made some revisions in the final EA that we believe address these concerns.

Impacts from Boat Operations

The EA discusses the potential impacts of boat operations in Section 4.4.3 (marine mammals, including whales and dolphins); Section 4.4.5 (invertebrates, including corals); and Sections 4.7.2 and 4.9.2 (reptiles, including marine turtles). Boat operations associated with the action alternatives considered in the EA would not be likely to adversely affect any of the species under NMFS's purview. The Service would limit the extent of boat operations for any of the action alternatives to occasional transportation of personnel and equipment to and from the island in a small vessel, using the buoys placed in the area by the Puerto Department of Natural and Environmental Resources and the customary landing zone (Puerto Los Botes) for authorized Service operations on the island. No anchoring would be permitted. A small boat would transport personnel and equipment to and from a larger boat tied to the buoys. Such operations would not represent a substantial increase in boat traffic (or its associated risks including vessel strike, anchoring, and accidental grounding) above the normal baseline of recreational boaters and diving boats around the island. Furthermore, the Service would require all boat operators to understand and follow NOAA's vessel strike avoidance guidelines to reduce the chance of harming protected marine species as referred to in Section 4.4.3 (marine mammals), 4.4.5 (corals), 4.7.2 and 4.9.2 (turtles). Finally, while suitable nesting beaches are not known for

Desecheo, the Service would implement all of the action alternatives outside of the likely nesting season for hawksbill turtles in the event that turtles attempt to use Desecheo as a nest site.

Impacts from Potential Release of Rodenticide

The EA discusses potential impacts to the marine environment due to bait entry into nearshore waters in Section 4.4.3 (risks from the use of rodenticide bait to marine mammals); 4.4.4 (risks to marine fish); Section 4.4.5 (risks to ESA-listed corals); Section 4.6.4.3.3 (toxicity of anticoagulant rodenticides in reptiles, including discussion on marine turtles); and Sections 4.7.2 and 4.9.2 (risk of exposure to bait product in marine turtles). Although the Service knows of no studies of the impact of brodifacoum or diphacinone on corals specifically, the general consensus of conservation practitioners is that neither of these toxicants pose a risk to invertebrates, including any of the listed or candidate coral species, due to the differences in physiology. In addition the broadifacoum bait pellet is composed of compressed grain. Although the Service knows of no studies of the impact of brodifacoum or diphacinone on marine turtles specifically, recent studies on the ornate wood turtle (*Rhinoclemmys pulcherrima*) showed no physical or behavioral impacts from exposure to large amounts of rodenticide bait containing either brodifacoum or diphacinone. Furthermore, it is highly unlikely that a turtle would consume bait either deliberately (e.g. eating pellets descending through the water or resting on the substrate) or accidentally (e.g. eating a sponge upon which a pellet has landed). None of the cetaceans known from the waters surrounding Desecheo would have a greater than negligible likelihood of exposure to the toxicant, and none would be at risk of toxic effects unless exposed to an enormous quantity of bait.

The EA also discusses the general scenario of bait entry into the marine environment in Section 2.3.4.2 and 2.3.4.3 (studies of the environmental fate of bait pellets in both the terrestrial and marine environments); Section 4.4.4 (impact to marine fish, including a general description of toxicant detectability in the water column); and Sections 4.5.1.3 and 4.5.1.4 (impact to marine water resources from the action alternatives). Brodifacoum and diphacinone both have very low solubility in water, and bait pellets that enter the water would break down to small particles within 30 minutes. While some bait may enter the water, the Service would implement numerous specific operational measures that would reduce the amount of bait entering the nearshore waters. However, even if bait were to enter the water at the full application rate, empirical evidence from other island eradication projects (e.g., Anacapa Island, Section 4.4.4) indicates that toxicant would not be detectable in the water column.

The EA discusses operational measures that will be implemented to reduce the amount of bait entering the marine environment surrounding Desecheo Island in Sections 2.4.6 and 2.5.6 (mechanical measures for avoiding bait broadcast into the marine environment); and elsewhere throughout Sections 2.4 and 2.5. Measures to reduce bait entry into the marine environment would include:

- Establishing flight patterns before bait application that reduce the possibility for broadcasting bait over water, including broadcasting only above the high tide line
- Tracking bait application with near-realtime GIS technology to adjust bait application accordingly

- Attaching a broadcast deflector to the bait bucket for bait application near the coastline
- Broadcasting bait with the broadcast motor off in some areas, for smaller and more precise application
- Implementing bait application only if there is no significant rainfall predicted for the next 7 days, to avoid premature bait disintegration or runoff into the marine environment

Your letter also addressed the need for monitoring of the effects of bait application. We have incorporated into the project implementation the monitoring of sea water before and after each application, following U.S.D.A. protocols for water sampling. Sampling would be done from land as well as by boat. The locations of the latter will depend on the swell and wave action on the day of the application.

The Service has made a number of revisions to the Final EA in response to your comments as well as other comments received. These include:

- A revision of the description of hawksbill sea turtles in Chapter 3
- A revision of the description of the coral community surrounding Desecheo in Chapter 3
- A clarification of the special protection status of marine mammals in the waters surrounding Desecheo, and the effect of this status on impacts analysis in the EA, in Sections 4.6.2.2 and 4.6.2.3
- Addition (Appendix IX) of maps to show delimitation of the Desecheo Marine Reserve, location of coral and other marine communities within the reserve, location of mooring buoys within the reserve, and location of marine turtle and whale sightings in the Mona Channel.
- Addition (Appendix XI) of maps to show an example of bait application and GIS tracking on an island treated for rat eradication in 2010 in the Galapagos.
- Addition (Appendix X) of NOAA/NMFS strike avoidance protocols (2008) as a reference source.

We have completed a IntraService Section 7 consultation with the Boqueron Ecological Services Field Office concerning sea turtles and other species. On July 13, 2009, the Ecological Services Office in Boqueron concurred with a biological evaluation determining that the proposed project would not be likely to adversely affect any of the four listed species under the Service's purview in the project area: 1) brown pelican, 2) hawksbill sea turtle, 3) green sea turtle, and 4) "higo chumbo" cactus. This biological evaluation and concurrence is available within Appendix VIII of the Draft EA. In response to the Draft EA, the Ecological Services Office in Boqueron reiterated its opinion that the proposed project would not be likely to adversely affect listed species under FWS jurisdiction.

Based on the information presented above and that available in the Environmental Assessment, we believe that the proposed project for the eradication of rats on the Desecheo National Wildlife

Refuge is not likely to adversely affect species under the jurisdiction of the National Marine Fisheries Service. If you have any questions, please call me at 787/851-7258, ext. 306.

Sincerely,

Susan Silander
Project Leader