# DRAFT ENVIRONMENTAL ASSESSMENT

for

## RESTORATION OF HABITAT ON THE DESECHEO NATIONAL WILDLIFE REFUGE THROUGH THE ERADICATION OF NON-NATIVE RATS

Desecheo, Puerto Rico

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## Introduction

The U.S. Fish and Wildlife Service (or "the Service") proposes to eradicate the invasive black rat (*Rattus rattus*) on the Desecheo National Wildlife Refuge ("the Refuge"). The proposed action also includes pre and post eradication monitoring for success and possible effects of the eradication methodology.

A first attempt at the eradication of the black rat from the Refuge took place in March of 2012. This attempt involved the aerial application of brodifacoum-25D, with captive holding of endemic reptiles as a precautionary measure. An Environmental Assessment (EA) was prepared for this action and is referred to in numerous sections of the current EA (U.S. Fish and Wildlife Service, 2011). While it was thought that the eradication was successful, several months later cameras revealed that rats remained on the island. It was determined via genetic studies that the rats were not a result of reintroduction, but instead were rats that were not eliminated by the initial eradication attempt. A review was conducted to evaluate the possible reasons for the incomplete eradication (Brown and Tershey 2013). A summary of the reasons for the lack of success and the review's recommendations will be provided in a subsequent section. The current EA will discuss action alternatives for a second attempt at eradication and their potential impacts.

Federal agencies must consider the environmental impacts of actions, projects, programs, policies, or plans that they propose to implement, fund, or permit. The agency must consider the environmental impacts of a reasonable range of alternatives for implementing an action. If adverse environmental impacts are identified, NEPA requires an agency to show evidence of its efforts to reduce these adverse impacts. An environmental analysis, such as this EA, documents that an agency has considered and addressed these impacts.

This EA will be used by the Service to determine whether the implementation of the action alternatives would have a significant impact on the quality of the human environment.

## 1.0 PURPOSE OF AND NEED FOR ACTION

### 1.1 Purpose of 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 native seabirds, reptiles and plants, through the eradication of invasive rats.

### 1.2 Need(s) for Action

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 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 five species were reported to occur on the island in densities of only ten to a few hundred pairs, some of which did not nest. In 1998, Breckon (1998) reported seeing only a single American oystercatcher (*Haematopus palliates*). In 2010 (after significant reductions 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, 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 into the 1980s, would have had some impact to the island's seabird colonies. While up to 1,500 brown and 1,000 red-footed boobies still occupied the island in the 1970s (Noble and Meier 1989), this represented a much reduced population; one that is 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 to 27 percent of 30 point-count stations were occupied by the pearly-eyed thrasher and zero to three percent by the 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 these 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 affecting island-nesting seabird species (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*), and 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 these 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 island's three endemic invertebrates [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 by the Service 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 invertebrates and soil inhabiting micro-invertebrate fauna through the alteration of soil nutrients and associated vegetation communities resulting 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 smaller reptiles, endemic invertebrates, and seeds of native and endemic plants the last of which reduces natural regeneration It is anticipated that rat eradication on Desecheo would  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 functions as a high density seabird island, and improve the overall biodiversity of the island.   It is also expected to assist in the recovery of the threatened higo chumbo cactus (*Harrisia portoricensis*).

## 1.3 Summary of previous eradication attempt

In March of 2012, following the completion of the 2011 EA and the receipt of the required permits, two aerial applications of brodifacoum 25D were conducted.  These treatments were spaced 10 days apart from one another.   This was implemented in accordance with Alternative B presented in the 2011 EA.   The target application rate was 18kg/ha on the first application and 9kg/ha on the second.    Supplemental baiting was done on the ridges through the use of rodenticide at bait stations.  All three endemic reptiles were retained for 35 days within captive holding structures on the island  as a precaution in the event of a severe population decline.

Post-application monitoring included searches for rat carcasses and both systematic (transects) and opportunistic searches for non-target species' carcasses.  No bird carcasses that could be attributed to the application were encountered following the treatment.  Documentation of the operational aspect of the eradication is included in Island Conservation (2013).

## 1.4 Decision(s) to be Made

The U. S. Fish and Wildlife Service must, through this document, evaluate the proposed action and determine whether it will result in the preparation of a Finding of No Significant Impact (FONSI) or identify the need for an Environmental Impact Statement.

## 1.5 Scoping Process

The scoping process for the eradication of black rats from Desecheo Island has involved both internal and external scoping. This scoping process began in 2009 and contributed to the first EA which was completed in 2011. Following the unsuccessful eradication in 2012, an extensive review process was conducted that evaluated the reasons for failure and made recommendations for changes in the methodology to improve the probability of success (Brown and Tershy 2013).

The initial internal scoping process included a review of the biological, physical and social issues associated with eradicating rats from Desecheo Island. The Service, along with Island Conservation, conducted field research to identify the ecological factors that are being affected by the presence of rats, as well as the potential benefits of rat removal to ecological services , including species recovery.

The external scoping process involved consultation with cooperative and regulatory agencies that have a stake in the outcome of the project. These included, but were not limited to, the Puerto Rico Department of Natural and Environmental Resources (DNER), Puerto Rico Planning Board (PRPB), Environmental Protection Agency (EPA), and National Marine Fisheries Service (NMFS). 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.

All necessary permits and authorizations were obtained for the 2011 eradication attempt, including PRDNER, PRPB, USDA, and EPA. No authorization was needed from SHPO since Desecheo is not known to possess historic or cultural resources. A Section 7 consultation was conducted with the Service's Caribbean Ecological Services Office and with the National Marine Fisheries Service in preparation for the first attempt at eradication and for the current proposal.

An independent review of the unsuccessful 2012 eradication was conducted (Brown and Tershy 2013). It was considered that the project's lack of success was not the result of a single factor but rather a result of several overlapping issues. These included: inadequate overall and localized bait rates or availability; non-uniformity of bait distribution in particular during the first of the two applications; unusually wet weather that resulted in an abundance of alternative natural foods and rat breeding that resulted in unavailability of bait to emerging juveniles. The review specified that despite these issues, the eradication came very close to succeeding. Recommendations for future eradications, which have been incorporated into the action alternative B, included incorporating sufficient flexibility into the project to delay if climatic conditions (increased rainfall) make the potential for alternative food sources and increased breeding possible; as well as increased bait application rate, uniformity of bait application rates, and increase time between applications as needed.

## 1.6 Issues and Concerns

- *Impacts to the Marine Environment from the presence of the toxicant.*
- *Impacts to Geology and Soils from the presence of the toxicant.*
- *Impacts to Birds and Reptiles*
  Rat eradication would include the use of a toxicant that is lethal to rats. 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).
- *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.
- *Impacts to Historical and Cultural Resources.*
- There are no known historical or cultural resources on Desecheo.

## 2.0 Alternatives

The National Environmental Policy Act (NEPA requires that Federal agencies study, develop and describe appropriate alternatives to recommended courses of action. Based upon the existing site conditions, the results of the 2012 eradication, the need for action, constraints and concerns identified during the initial scoping process, three alternatives were identified: two action alternatives (Alternatives B - C) 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.

## 2.1 Alternative A - No Action Alternative

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 and only limited actions concerning 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 not contribute to fulfilling the purpose of the Refuge, which is to restore and protect the historic seabird colonies and the 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. Additionally, removal of introduced rhesus macaques and feral goats will have only limited benefit as long as rats remain.

## 2.2 Action Alternatives: Common Features

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.

### 2.2.1 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 and supplemental 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.

### 2.2.2 A Comparison of Two Bait Products Registered for Conservation Purposes: Brodifacoum-25D (Alternative B) and Diphacinone-50 (Alternative C)

#### 2.2.2.1 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.

#### 2.2.2.2 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.

#### 2.2.2.3 Diphacinone and Diphacinone-50 bait product

At least 32 successful island rodent eradications have been reported using diphacinone as the primary toxicant (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; (Hall et al. 2006, 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.

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 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.

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.

### 2.2.3 Comparative Likelihood of Success

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.

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, 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. 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. 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. 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 on the Aleutian Islands. 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 need 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, acknowledges 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 are positive. 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.

### 2.2.4 Bait Trials Conducted on Desecheo Island

Prior to project implementation in 2012, 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.

#### 2.2.4.1 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).

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 of the 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 being 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 kestrels (*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.

#### 2.2.4.2 Bait Uptake Field Trials, February - March 2010

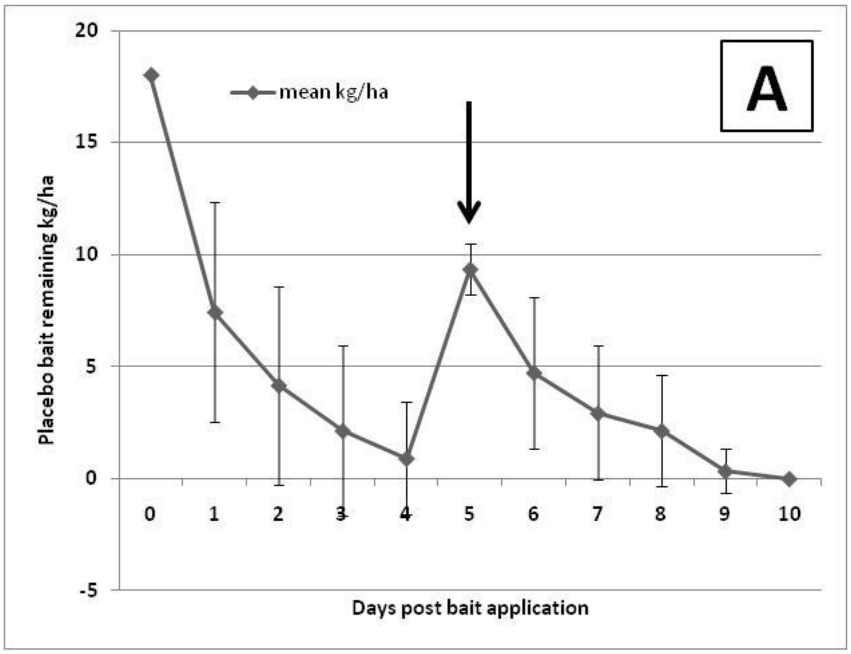
A second series of field surveys were conducted on Desecheo Island to develop ongoing operational planning needs for the proposed eradication of rodents from Desecheo (Island Conservation 2010c).

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



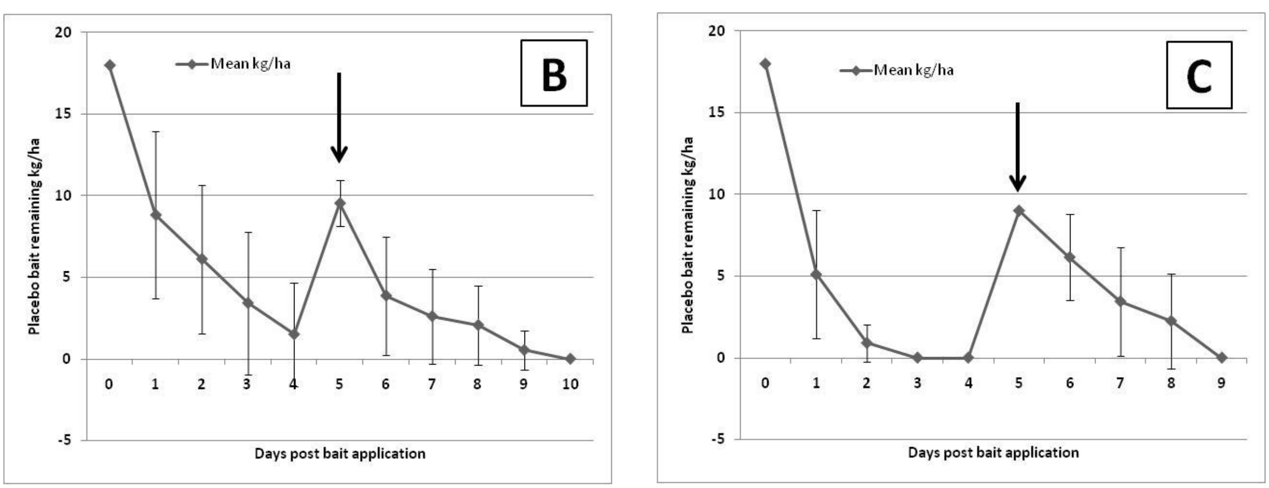




**Figure 2.1** Placebo bait uptake field trials on Desecheo NWR, Feb-Mar 2010. Chart shows mean uptake values with standard deviations. **A**: bait uptake in both woodland and shrubland; **B**: bait uptake in woodland (n=10); **C**: bait uptake in shrubland (n=6). Note: First bait application=18 kg/ha,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

#### 2.2.4.3 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.

While the observations of pellet degradation were largely subjective, there was no consistently observed difference in the environmental degradation of dry or wet formulation pellets when crabs were not present. 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 sweet flavor of the sorbitol. 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.

A simple experiment was completed to 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 at zero, 10, and 30 minutes following the introduction of bait into the environment.

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 infrequently.

Results of these studies are included in the 2011 EA (Fish and Wildlife Service 2011)

### 2.2.5 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 ordnance (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 habitats by allowing the Service and cooperators to deliver bait to all potential rat habitat on the island without setting foot on much of the island.

### 2.2.6 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

### 2.2.7 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. In 2009 and 2010, field surveys in the dry season of February and March 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.

### 2.2.8 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, information from mainland Puerto Rico and its other offshore islands has been used to determine a time of year when birds have the potential to breed on the island (and might unexpectedly arrive on the island). In tropical habitats, seasonality of bird breeding is often extended in comparison to temperate systems (Nelson 1983). 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. However, 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). However, the 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, the total number of breeding birds would likely be low because of the current absence of established colonies.

*Summer migrant breeding period*: This is typically between April and September, although summer migrant land birds that attempt to breed on Desecheo are few.

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

#### 2.2.8.1 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.

### 2.2.9 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 require a central place for radio communications with the helicopter pilot, support and emergency personnel; the 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, spanning 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 set down at designated landing zones on the island to drop off personnel and equipment.

Small boats would also be used to transport personnel, equipment, and  fresh supplies for 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 on the southwest end 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.

### 2.2.10 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 and avoiding sensitive areas when possible to reduce unnecessary impact.
- Be given a map detailing wildlife-sensitive areas.

### 2.2.11 Protecting Cultural Resources

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

### 2.2.12 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 following bait application to confirm complete rodent eradication.

### 2.2.13 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, animal collection, or alteration of the physical environment may be conducted as well. These supplemental activities may be subject to additional permitting if required.

### 2.2.14 Public Information

Access by the general public to 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 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

#### 2.2.15 Re-introduction Prevention

The Service would require personnel, partners and contractors traveling to the island to abide by a Biosecurity 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 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 Alternative B: Aerial Broadcast as Primary Delivery Technique of Brodifacoum-25D Bait Product

### 2.3.1 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).

### 2.3.2 Difference between Alternative B and Brodifcoum 25D alternative of 2012

Brodifacoum 25D was utilized in the 2012 eradication attempt at a target rate of 18kg/ha on the first application and 9kg/ha on the second. Applications were separated by a period of 10 days.

While it was anticipated that this rate would be sufficient to allow access to bait for each and every rat, a review of the unsuccessful eradication recommended an increase in the application rate and an increase in the time between applications. At present, the recommended application rate is 31kg/ha for both applications. This amount was derived from data collected during the 2012 application. The bait availability goal in 2012 was to have bait available for four nights; but during monitoring it was found to be present only for 2-3 nights and in some transects it was only available for 1-2 nights. The consumption rate can be used to predict a revised application rate that would ensure adequate bait availability for a minimum of four nights. Using this method, an application rate of 29.5kg/ha is predicted to be required. When adjusted to the steep terrain the target is 31kg/ha. Because bait consumption rates were similar between the first and second applications, it is recommended that the application rate in the two be the same. The time period will be extended to 21 days to allow for bait to be available to emerging juvenile rats. This application rate requires a Supplemental Label from EPA.

### 2.3.3 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 (e.g., 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 remain 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.

### 2.3.4 Timing

Aerial broadcast operations would occur between January and April, typically the driest part of the year. Bait broadcast would only be initiated if local weather predictions indicate that precipitation would be unlikely for at least seven days.

The bait broadcast would be completed within a 30-day window, a range that would allow for two bait applications with additional localized bait application if signs of rats persist. Bait applications would be ideally be separated by approximately 21 days, with additional contingency time included to allow for weather delays.

### 2.3.5 Equipment and Materials

#### 2.3.5.1 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.

#### 2.3.5.2 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 non-target rodenticide exposure by making bait more difficult to access and reducing the total amount of bait introduced into the ecosystem.

### 2.3.6 Bait Application Operations

#### 2.3.6.1 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) are flown around the coastal perimeter. The width of a flight swath would be determined 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 forecasted 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.

Bait would be applied strictly according to the limitations set by the EPA's pesticide regulations and any Supplemental Label obtained (FIFRA). The precise bait application rate would not exceed the rate set by the EPA.

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 four 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 GPS and a navigation bar to precisely guide the application.
- 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.
- The application coverage would be reviewed throughout the operation using GIS to identify gaps and areas of sub-optimal bait application by combining the GPS data for the application path and the application rate,.

### 2.3.7 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.

### 2.3.8 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.

## 2.4 Alternative C: Aerial Broadcast as Primary Delivery Technique of Diphacinone-50 Bait Product

### 2.4.1 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 less risk than brodifacoum (Erickson and Urban 2004), but its proven record of eradication success using aerial broadcast technique is extremely limited.

### 2.4.2 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.

### 2.4.3 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. 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. 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.

### 2.4.4 Equipment and Materials

#### 2.4.4.1 Bait

Under Alternative C, the bait product used would be Diphacinone-50.

#### 2.4.4.2 Aerial Broadcast Equipment

The equipment needed to aerially broadcast Diphacinone-50 would not be different to that needed for Brodifacoum-25D.

#### 2.4.4.3 Bait Stations

Bait station design used to apply Diphacinone-50 would not be different to those used for Brodifacoum-25D.

### 2.4.5 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.).

#### 2.4.5.1 Aerial Broadcast

The measures for aerial bait broadcast are the same as those for brodifacoum.

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 of 12 days. 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.

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 an off-island test site 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.
- 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.
- The application coverage would be reviewed throughout the operation using GIS, by combining the GPS data for the application path and the application rate,.

### 2.4.6 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.

### 2.4.7 Coverage of Baiting Gaps

The measures to ensure full coverage of baiting gaps are the same as those used for the application of brodifacoum.

## 2.5 Alternatives Dismissed from Detailed Analysis

Bait stations, hand broadcast, and trapping were discarded from consideration due to the island's size, rugged terrain, steep slopes, deep valleys and the presence of unexploded ordnance. This would present logistical difficulties, be costly, and present a serious danger to operators. The use of other toxicants was discarded due to 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 eradications; 3) the potential for development of bait shyness in the rat populations; and 4) the lack of an effective antidote in case of human exposure. Other alternatives dismissed include the use of disease, introduction of predators, fertility control, and rat removal with the "goal" of control. These and other alternatives that were dismissed are discussed in additional detail in the 2011 EA (U.S. Fish and Wildlife Service 2011).

# 3.0 AFFECTED ENVIRONMENT

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 (Chapter 4).

## 3.1 General Description of Desecheo

### 3.1.1 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).

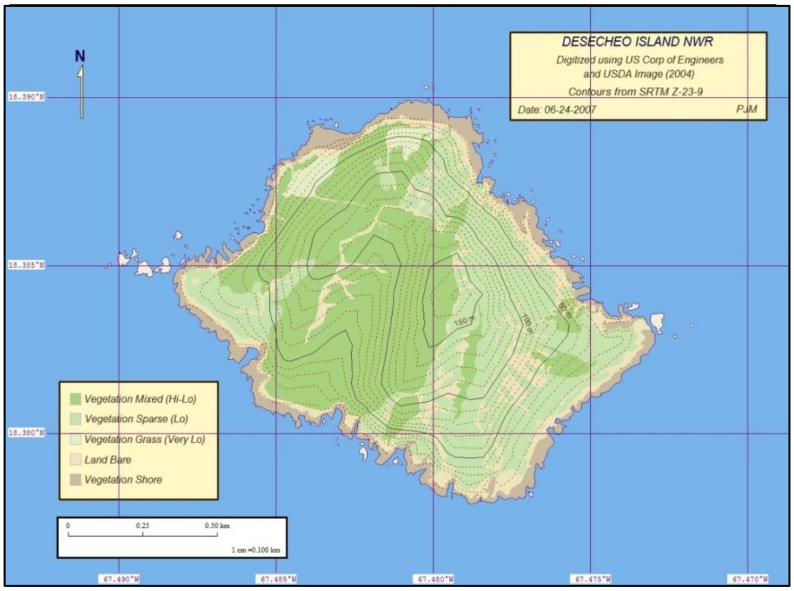
### 3.1.2 Topography

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.

### 3.1.3 Climate

Desecheo's local climate is sub-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 the Rincon power plant, Puerto Rico, between 1968 and 2010. The Rincon power plant is located on the mainland coast of Puerto Rico, approximately 13 miles (21 km) to the east of Desecheo, and the area is climatically similar.

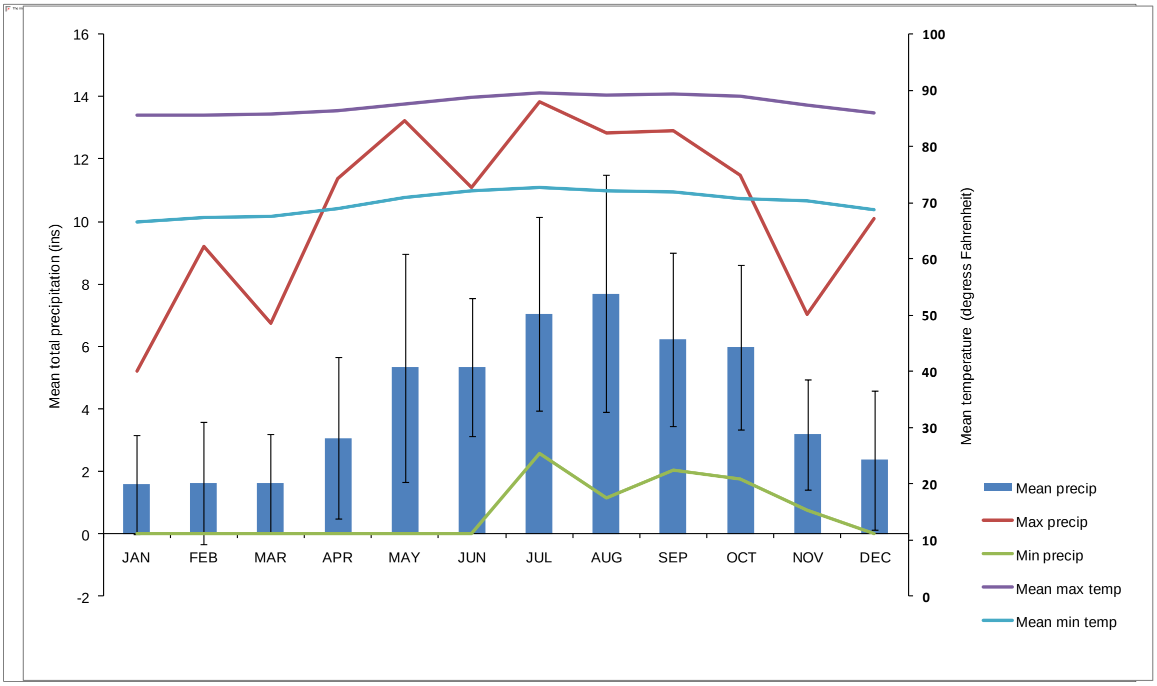



**Figure 3.2**. Average monthly climate data near Desecheo Island (Rincon Power Plant, northwest Puerto Rico), between 1968 and 2010 with standard deviations (error bars) (Southeast Regional Climate Center

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).

## 3.2 Physical Resources

### 3.2.1 Water Resources

There are no permanent sources of freshwater on Desecheo (Evans 1989). Ephemeral surface water may be present during and after rainfall events. The marine waters around Desecheo are managed by the Government of Puerto Rico as a no-take Marine Reserve.
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.

### 3.2.2 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).

### 3.2.3 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).

## 3.3 Biological Resources

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 activities in the past, the island is still home to a high number of single-island endemic species for its small size. Six 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 threatened higo chumbo cactus.

The biological resources of Desecheo are protected as a National Wildlife Refuge, and the surrounding waters are protected as a Marine Reserve by the Commonwealth of Puerto Rico DNER, making both areas particularly valuable as targets for lasting ecological restoration projects.

### 3.3.1 Birds on Desecheo

#### 3.3.1.1 Historical and Current Status

Historically, eight or nine species of seabirds 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 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 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. 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*), and 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.

#### 3.3.1.2 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 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. 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*), and alpine swift (*Apus melba*)] on Desecheo have only been recorded once and are either accidentals or vagrants to the region.

Of the 67 species recorded from Desecheo, 41 have been sighted in the last 10 years since 2000, and seven species were first recorded on 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*), and 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 of this species on the island was a single individual 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 on 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).

### 3.3.1.3 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, only 17 pairs of bridled terns and one pair of brown noddy have been reported as breeding on Desecheo since 2000 (see Appendix I) . In addition, the few species of land birds 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 landbirds; the most common of which were pearly-eyed thrasher (18 percent), American kestrel (eight percent) and peregrine falcon (four 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.

#### 3.3.1.4 Landbirds and Waterbirds

The over-wintering migration period for Neotropical migrants to the Caribbean region is typically September to April. Of the 59 landbird 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 on 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. However, these 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 (March through October) that arrive in Puerto Rico to breed, but 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 those, 21 species have been reported from Desecheo in the last 10 years. However, breeding on Desecheo is only suspected in eight species. An operational schedule between January and April is likely to overlap with part of their breeding season. 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.

#### 3.3.1.5 Seabirds

In contrast to temperate areas, all tropical birds in the order Pelecaniformes have breeding cycles and egg laying times that vary widely. and are often only loosely seasonal (Nelson 1983). In some cases, egg-laying seems entirely aseasonal, although each species in any given population may have one or more detectable, broad peak. In some areas, brown and blue-footed booby (*Sula nebouxii*) fit more than one breeding cycle into a calendar year, while 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 when nest failure prompts renesting attempts. 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 this behavior may also 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 these 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, occurrences of the same species breeding on nearby adjacent islands has been utilized. 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(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 the brown and red-footed booby, may be resident and/or breeding on the islands throughout the year. Brown boobies have a flexible breeding season, where 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) reports a peak breeding season for brown boobies between December and March, whereas Kepler (1978) reported annual breeding cycles with variation between years in timing of the main breeding effort on Monitor Island. (March and April in 1969 and Sept and 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. They could lay up to twice a year, with 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, with peak breeding observed in May, June and July and some nesting extending through 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). However, 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 | | light gray | dark gray | dark gray | dark gray | dark gray | dark gray | light gray | | | | |
| Brown booby | Mona & Monito | dark gray | dark gray | dark gray | light gray | light gray | | light gray | light gray | light gray | light gray | light gray | dark gray |
| Red-footed booby | Mona & Monito | | dark gray | dark gray | dark gray | dark gray | dark gray | light gray | dark gray | dark gray | light gray | light gray | light gray |
| Magnificent Frigatebird | Monito | light gray | light gray | light gray | light gray | light gray | | | | | dark gray | dark gray | dark gray |
| Laughing Gull | Mona & Monito | | | | light gray | dark gray | dark gray | dark gray | light gray | | | | |
| Brown Noddy | Mona & Monito | | | | light gray | light gray | light gray | light gray | light gray | | | | |
| Sooty tern | Mona | | | | | light gray | light gray | light gray | | | | | |
| Bridled tern | Mona & Monito | | | | | light gray | light gray | light gray | light gray | | | | |
| Brown pelican | Puerto Rico-general | light gray | light gray | light gray | light gray | light gray | light gray | light gray | | | light gray | light gray | light gray |

## 3.4 Special Legal Protection for Birds on Desecheo

### 3.4.1 Endangered Species Act

There are no known birds protected by the ESA on Desecheo.

### 3.4.2 Migratory Bird Treaty Act

Most of the birds listed above are protected under the Migratory Bird Treaty Act (MBTA), 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). This 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.

## 3.5 Terrestrial Wildlife on Desecheo

### 3.5.1 Reptiles

The endemic reptiles include the Desecheo dwarf gecko (*Sphaerodactylus levinsi*), Desecheo anole (*Anolis desechensis*), and Desecheo ameiva (*Ameiva desechensis*). In addition to these three 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, as it may be the same species found on Mona Island (*Borikenophis variegatus*) or it may be an endemic subspecies unique to Desecheo. No genetic or taxonomic work has been completed to answer this question (Henderson and Powell 2009) (M. Evans and J. Schwagerl pers. comm. 2007). The introduced green iguana (*Iguana iguana*) has been observed sporadically on cameras placed on the island to document macaque and rat presence.

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 size ranges from two to three eggs per nest. Several females may contribute eggs to the same 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 the Puerto Rican crested anole (*Anolis cristatellus*) on mainland Puerto Rico, and both are considered to be "ground-trunk" anoles and "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, 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 eating berries, flies on the beach, grasshoppers, moths and other anole eggs. Although there are no data on the timing of the Desecheo anole's breeding season, breeding locations, 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 the Puerto Rican crested anole, male reproductive activity is at its highest from March toAugust and 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 occurs 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 three to 19 animals in a 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 various standardized survey techniques, total population estimates were 7,469 individuals (1,800 – 13,137; 95 percent confidence limits) for *Ameiva desechensis*, 52,111 individuals (31,464 – 72,758, 95 percent confidence limits) for *Anolis desechensis,* and 13,261 individuals (8,796 – 19,991, 95 percent confidence limits) for *Sphaerodactylus levinsi*. 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.

Mark and recapture studies for the Desecheo Anole and the Desecheo Ameiva were conducted in 2012 on Desecheo as part of the 2012 eradication attempt and its monitoring plan. A total of 453 anoles and 57 ameivas were captured and marked prior to and after the aerial application of bait in 2012. No significant change in survival rate was found across the sampling period, indicating that the application of brodifacoum did not result in detectable mortality (Island Conservation, pers. Com.)

### 3.5.2 Bats

The status of native 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 (Baker and Genoways 1979, García et al. 2005).

### 3.5.3 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 (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.

### 3.5.4 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 on 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 unsuccessful attempts were made to remove them from the island(Herbert 1987, Evans 1989). Since 2009, the Service and Island Conservation have conducted a macaque eradication effort which has greatly reduced their population. At this time only two animals are known to remain. Personnel will continue the effort until complete removal has been confirmed.

#### 3.5.4.1 Black Rats

Black rats (*Rattus rattus*) were first reported and collected on 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, the 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 (Tamarin and Malecha 1971, 1972, Madsen and Shine 1999). Therefore , the rat population on Desecheo is likely higher than on an island of comparable size in a temperate region, and breeding likely occurs throughout most of the year with no clearly definable breeding season. However, during two separate 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).

### 3.6 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. 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)

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).

The 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. 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.

### 3.7 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.

### 3.8 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 removal 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.

### 3.9 Threatened and Endangered Species listed under ESA

The threatened higo chumbo cactus is found on Desecheo, Mona and Monito islands but was also once known from southwest Puerto Rico. Populations on Desecheo Island are much reduced with only nine individuals known in 2003 (U.S. Fish and Wildlife Service 2010a). Recent surveys between 2010 and 2013 have located 72 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.

## 3.10 Social and Economic Environment

### 3.10.1 History

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). 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.

### 3.10.2 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).

### 3.10.3 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.

### 3.10.4 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. Between 2010 and March 2015 there were 14 documented illegal landings on Desecheo with a total of 471 migrants apprehended. The majority of these landing have occurred since September 2013 with 421 migrants apprehended in nine landings. Additionally, some migrant traffickers use Desecheo as a stopover point before proceeding to Puerto Rico; these landings would be undocumented and difficult to quantify (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 Calibri (Body) 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.).

### 3.10.5 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.

# 4.0 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.

## 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.

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

### 4.3.1 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 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.

### 4.3.2 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.

### 4.3.3 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 . Small boats will be used during the eradication operations and boat operators will be briefed on NOAA protocols.

### 4.3.4 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 due to the following:

- 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).

### 4.3.5 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. 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 effects of rodenticides on coral species; however, data suggests that invertebrates are largely not affected. 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 . 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 .

## 4.4 Consequences: Physical Resources

### 4.4.1 Water Resources

#### 4.4.1.1 Analysis Framework for Water Resources

Potentially adverse physical and biological water quality impacts from bait application on Desecheo Island were analyzed. 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.

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

#### 4.4.1.2 Alternative A: No Action

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

#### 4.4.1.3 Alternative B: Aerial Broadcast as Primary Delivery Technique of Brodifacoum-25D Bait Product

Under Alternatives B, some brodifacoum 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 under either alternative, 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).

Samples of seawater were collected during the 2012 Desecheo rat eradication, both nearshore and offshore, two days before the first application, one day after the first application, one day after the second application, and 8 days after the second application. All samples were negative for brodifacoum residues (above the reporting limite of 100 ppb) (Island Conservation, 2013).

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.

#### 4.4.1.4 Alternative C: Aerial Broadcast as Primary Delivery Technique of Diphacinone-50 Bait Product

Some bait pellets of diphacinone 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.

### 4.4.2 Geology and Soils

#### 4.4.2.1 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.

#### 4.4.2.2 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.

#### 4.4.2.3 Alternative B: Aerial Broadcast as Primary Delivery Technique of Brodifacoum 25D Bait Product

The operational activities in Alternative B 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, on Palmyra Atoll in 2010 in two out of 48 samples tested had concentrations of the brodifacoum high enough to be quantified (soil collected directly under a pellet), all other samples yielded a zero (undetectable) value (Island Conservation 2010a).

#### 4.4.2.4 Alternative C: Aerial Broadcast as Primary Delivery Technique of Diphacinone-50 Bait Product

The operational activities in Alternative 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 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, on Palmyra Atoll in 2010 two out of 48 samples tested had concentrations of the diphacinone high enough to be quantified (soil collected directly under a pellet), all other samples yielded a zero (undetectable) or 'trace' value (Island Conservation 2010a).

## 4.5 Consequences: Biological Resources

### 4.5.1 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 positive and negative effects of toxicant use and bait dispersal activities used to achieve rat eradication.

While the impacts to the biological resources of each alternative will be examined with respect to a range of species, the primary focus will be to analyze whether impacts to a particular biotic resource could be considered significant according to the general significance criteria described in Section 4.5.2. 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 (i.e. listed as threatened or endangered) unless the impacts can be mitigated to reduce impacts below significant levels.

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. The two action alternatives will be analyzed for both direct and indirect effects resulting from toxicant exposure and disturbance during application. Analysis will also evaluate 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.

### 4.5.2 Assessing Significance of Impacts to Biological Resources

#### 4.5.2.1 Introduction

As described previously, 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 with other individuals that may be distributed over an area much larger than Desecheo. In addition, successful invasive species eradications have demonstrated significant post-eradication recovery of island populations of various taxa, despite some mortality to individuals during or shortly after an eradication operation. 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.I Impacts to species that have been assigned specific legal protection under the ESA or Marine Mammal Protection Act (MMPA) will be considered "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 extend beyond the island to other areas in the Insular Caribbean region?

#### 4.5.2.2 Special Significance Considerations for ESA Listed Species

The higo chumbo cactus is the only federally listed endangered species that occurs on Desecheo. There are also five federally listed species that occur in the marine environment around Desecheo: the hawksbill sea turtle (endangered); the leatherback turtle (endangered); the green sea turtle (threatened); the humpback whale (endangered); and staghorn coral (threatened). In addition, the endangered killer whale, sperm whale, fin whale and sei whale (*Balaenoptera borealis*) have been reported off of 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 the National Marine Fisheries Service (NMFS) as critical habitat for the staghorn coral. 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 in 2012 indicated that all of the listed species and critical habitat on or near Desecheo are either "not likely to be adversely affected" or would experience "no effect" 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 turtles.

- 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)).

#### 4.5.2.3 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. However, permits can be granted allowing exceptions to this MMPA prohibition 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, 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)).

#### 4.5.2.4 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, hunting, taking, capture, or killing, 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 Service 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 two action alternatives.

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

#### 4.5.3.1 Introduction

If no action is taken regarding invasive black rats on Desecheo, the impacts that rats are having on the island's 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 to 60 percent of all bird and reptile extinctions worldwide (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(Andrews 1909, Hindwood 1940, Daniel and Williams 1984, Meads et al. 1984, Atkinson 1985, Tomich 1986).

#### 4.5.3.2 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). Rats also consume insects and other invertebrates that many reptiles rely on as a primary food source (Towns et al. 2009, St. Clair et al. 2011). 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).

For example, 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). When rats were removed from the tuatara's habitat, the proportion of juvenile tuatara increased up to 17 fold and the body condition of adult males and females improved. Following black rat eradication on offshore islands in Antigua, the endemic population of the Antiguan racer (*Alsophis antiguae*) doubled within 18 months (Daltry 2006). Similarly, the persistence of rats on Desecheo 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>
Rats alter the vegetative communities 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.

<u>Desecheo ameiva/Desecheo anole/Desecheo gecko</u>
Rats alter the island's vegetative communities, which may impact ameiva habitat. Rats are considered a potential source of competition for resources because ameivas, anoles, geckos, and rats both consume terrestrial invertebrates. Additionally, rats may impact the demographic

structure of all three of these species' populations through direct predation and indirect competition. It is also likely that rats consume eggs of all three species.  On Desecheo, an observation of a rat attempting to predate a juvenile anole suggests that rats are direct predators of anoles (Island Conservation 2010c).

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

Slippery-backed skink

Rats alter the island's vegetative communities, 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.

Hawksbill, green, and leatherback sea turtles

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.  Rats are not known to impact green or leatherback sea turtles on Desecheo because the island does not have suitable nesting habitat for either species.

#### 4.5.3.3 Impacts to Breeding Seabirds

Rats are known to significantly impact seabirds by depredating eggs, chicks, and adults which results in failed breeding attempts and causes population declines (Atkinson 1985, Towns et al. 2006, Jones et al. 2008). While the overall impact of rats is detrimental to all families of seabirds, some are more susceptible than others. This largely  depends on life-history traits, morphology, and behavior. For example, smaller, burrow-nesting and crevice-nesting seabirds suffer the greatest impacts, while larger species and gulls are more resilient. The highest mean impacts from rats are seen in seabirds that experience rat predation across all life stages (eggs, chicks, adults)(Jones et al. 2008). Where rats co-exist with other predators (such as raptors), 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 on the island; Desecheo has limited suitable nesting habitat for masked booby; and sandwich terns are 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.

<u>Large ground-nesting seabirds</u> (*brown booby, brown pelican)*
Rats impact large ground-nesting seabirds by preying upon eggs and chicks.

<u>Small ground-nesting seabirds</u> (*bridled tern, sooty tern, laughing gull)*
Rats impact small ground-nesting seabirds preying upon eggs and chicks and may prey upon adult birds, causing injury and mortality.

<u>Tree-nesting seabirds</u> (*magnificent frigatebird, red-footed booby)*
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.

<u>Small ground/tree-nesting seabirds</u> (*brown noddy, white-tailed tropicbird)*
Brown noddy will nest on the groundin vegetation such as tree branches or crotches, or in the base of palm fronds, cacti and leaves. White-tailed tropicbirds will nest under overhangs, in crevices on the ground, in large holes in tree trunks, or branches. Rats impact small ground and tree-nesting seabirds by 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 and tree-nesting seabirds through alteration of nesting habitat as a result of seed and sapling predation.

#### 4.5.3.4 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 the pearly-eyed thrasher. This is discussed in Section 3.3.1.3. If rats persist on the island, terrestrial bird populations are expected to remain low and could continue to decline, resulting 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.

**Permanent and Summer Resident Breeding Birds in Puerto Rico**

<u>Raptors</u> (*red-tailed hawk, American kestrel)*

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 compete for limited food resources that could potentially impact raptor abundance on Desecheo.

<u>Aquatic coastal foragers</u> (*ruddy turnstone, American oystercatcher, black-necked stilt, belted kingfisher, yellow-crowned night heron, green heron, great egret and great blue heron)*
Rats impact breeding aquatic coastal foraging birds by preying upon eggs and chicks. During breeding, rats may also cause physical disturbance by flushing birds from nests. Rats may also impact these birds through diet overlap; both rats and coastal foragers eat invertebrates and small fish. All of the 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 kingfishers, green herons, and great egrets 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; rarely uses marine shores; has only been reported from Desecheo on one occasion in 2010; and its presence on the island was likely accidental. Rats also likely have limited impact on belted kingfishers as there is little dietary overlap.

<u>Ground insectivores</u> (*killdeer, smooth-billed ani)*
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 presence of seabirds on Desecheo.

<u>Aerial insectivores</u> (*Caribbean martin, cave swallow)*
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, potentially impacting 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.

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

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 the 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.

<u>Canopy/ground forager</u> (*yellow-billed cuckoo, mangrove cuckoo)*
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 bird 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 typically hunt prey within the canopy and along tree limbs, birds may occasionally pursue lizards on the ground through 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.

<u>Omnivores</u> – (*Northern mockingbird, shiny cowbird, cattle egret, pearly-eyed thrasher)*
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.

<u>Frugivores</u> (*white-crowned pigeon, scaly-naped pigeon*)

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. 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 and could potentially impact their abundance on Desecheo.

Frugivores/granivores: introduced species (*Hispaniolan parakeet*)
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 on 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, the persistence of this species on Desecheo is not encouraged.

Granivores (*zenaida dove, common ground-dove)*
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 the 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)*
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, the persistence on Desecheo would not be encouraged.

Nectarivores (*Antillean mango)*
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)*
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,, 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*)
As a wintering migrant, spotted sandpipers are not known to breed on Desecheo. Rats may impact spotted sandpipers through diet overlap, as both 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, 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)*
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)*
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 the island. 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)*

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.

<u>Frugivores</u> (*cedar waxwing)*

The cedar waxwing is a vagrant to the Caribbean, and has very rarely been reported in the region; only a single individual has been reported from Desecheo. Therefore the presence of rats would be unlikely to have a measureable impact on cedar waxwing abundance on Desecheo. However, should an increasing number of birds appear on the island 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.

<u>Frugivores/granivores</u> (*indigo bunting)*

As a wintering migrant, indigo bunting is not known to breed on Desecheo. Rats may impact indigo buntings through diet overlap, as both rats and indigo buntings 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.

#### 4.5.3.5 Impacts to Terrestrial 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 such as the purple landcrab have been known to shift from nocturnal to diurnal behavior in the presence of invasive rats. 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. Specifically rats are a potential source of competition for food because both rats and crabs consume invertebrates, fruit, seeds and carrion.
Rats and crabs also have the potential to compete for burrows. Rats have been documented depredating purple landcrabs at Palmyra Atoll (Wegmann 2008).

The endemic spiders *Clubiona desecheonis* and *Camillina desecheonis* and the whip scorpion may be impacted by rats through their predation of 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 invertebrates or their habitat on the island.

### 4.5.3.6 Impacts to Vegetation

Invasive rats feed opportunistically on plants and alter the floral communities of the ecosystems which they inhabit (Campbell and Atkinson 2002). In some cases they degrade 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 (Federally listed as Threatened)
Rats are omnivorous and feed on both animal and plant matter, including fruits, seeds, flower and leaf buds, seedlings, and leaves. It is likely 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
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). If not removed, rats could potentially cause a shift in the floral community assemblages of the island through both predation and seed dispersal.

### 4.5.4 Impacts of Action Alternatives to Biological Resources

#### 4.5.4.1 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.

#### 4.5.4.2 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).

#### 4.5.4.3 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.

##### 4.5.4.3.1 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). 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 to 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 to 90 percent (72 individuals) of turnstone (*Arenaria interpres*), 10 to 80 percent (320 individuals) of Madagascar turtle-dove, 40 to 80 percent (545 individuals) of barred ground dove (*Geopelia striata*), 40 to 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. For example, 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. Sixty-three percent (66 of 105) of birds that were found dead and 40 percent (33 of 82) of birds that were 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 the documented eradication attempts using bait stations (Canna Island 1,130 ha) reported no non-target losses. Of the 28 operations that applied bait by hand broadcast, no non-target losses were document.

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.

#### 4.5.4.3.2 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.

#### 4.5.4.3.3 Toxicity 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 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 to 80 mg/kg, but snakes displayed no apparent clinical signs prior to death or evidence of internal hemorrhaging upon necropsy. Gopher snakes (*Pituophis catenifer*) that were fed 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.

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). For example, 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, spectacled caimans have 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, $\alpha_2$-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 bait 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 et al 2011.). 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. 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. In fact, population increases are anticipated in many reptile species, in particular 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 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. 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.

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[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.

(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.

#### 4.5.4.3.4 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 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 metric tons 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*), and pukeko (*Porphyrio melanotus*)] could consume an $LD_{50}$ dose in a single day of feeding.

#### 4.5.4.3.5 Toxicity to Plants

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

### 4.5.5 Impacts to Species Vulnerable to Disturbance

#### 4.5.5.1 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.

#### 4.5.5.2 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 southwest coastline 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.

#### 4.5.5.3 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 seasons. In addition, animals that flush as a result of the disturbance would have alternative habitat to utilize.

Under alternatives B and C, 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. 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.

Following the 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 during pre-selected seasonal windows. Most current monitoring activities take place at established independent 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  to additional sites throughout island. Personnel would be briefed on strategies and techniques to reduce wildlife disturbance, but disturbance events would likely still occur.

### 4.5.6 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, especially terrestrial birds. Many of the bird species that were identified in the above analysis for 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. 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). We also include species of concern, including all seabirds.

The risk of brodifacoum or diphacinone poisoning is a function of both exposure and toxicity. 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.

### 4.5.7 Methods for Impacts Analysis to Biological Resources

#### 4.5.7.1 Impact Indices

The following impacts analysis identifies the level of risk from the perspective of bait availability, toxicant exposure, risk of mortality from toxicant use, disturbance risk, extent of the risk, and the duration of the risk. 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 two 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 effect on resident breeding population
- Island population: resident breeding population affected, no effect on regional or global population
- Global or regional population: regional or global population affected

Duration of risk: toxicant exposure

- Short: Impacts for up to two months

- Medium: Impacts for two to six months
- Long: Impacts for more than six months

Duration of risk: disturbance

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

## 4.6 Impacts of Alternative B: Aerial Broadcast as Primary Delivery Technique of Brodifacoum-25D Bait Product

### 4.6.1 Impacts on Birds

There are no bird species on Desecheo Island that would suffer long term population-level impacts from rat eradication activities. The number of birds on Desecheo is relatively low. 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). However, 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.

The risk of mortality from the toxicological effects of brodifacoum has been described in Section 2.2.2.2, and is generally considered high. However, this risk is dependent on the different toxicant exposure pathways between different species. 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 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. Birds that specialize in foraging on 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 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 accumulate 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 following 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 since 2000. Additionally, we have estimated the number of individuals per species that are likely to be adversely impacted by Alternative B. For this analysis 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.

#### 4.6.1.1 Permanent Resident Species in Puerto Rico

All species evaluated below, with the exception of the ruddy turnstone and common ground-dove, were 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 in low densities on Desecheo. Turkey vultures have never been recorded from Desecheo and were not observed during the 2012 eradication attempt. Although they were included in the 2011 EA, we have not included the species in this analysis. Information on the species can be found in the 2011 EA (Fish and Wildlife Service 2011)

**Raptors** ***(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 medium due to the retention time of the toxicant in the tissue of s these prey species. 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 might cause them to flush from their immediate location to an alternative site or temporarily change breeding behavior. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be short and the extent of the risk would be to individuals.

**Omnivores** **(*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. The 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 medium 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, which might cause them to flush from their immediate location to alternative habitat or temporarily change breeding behavior. For the pearly-eyed thrasher the impacts associated with disturbance risks for this alternative would be medium, and the duration of the risk would also be medium 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 short because these species are only known to be visitors to the island. The extent of the risk to all species would be to individuals.

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

*Toxicant Exposure Risk*
Doves would likely be 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 short. The extent of the impact to zenaida doves would be to the island population.  Common ground doves would be impacted at the individual level because ground doves are uncommon on Desecheo.

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

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

*Toxicant Exposure Risk*
Canopy foragers would likely be 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 medium due to the retention time of the toxicant in the tissues of prey species. 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 might 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 short and the extent of the risk would be to individuals.

**Canopy/Ground foragers** (***mangrove cuckoo)***

*Toxicant Exposure Risk*
Mangrove cuckoos would likely be 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 medium due to the retention time of the toxicant in the tissues of prey species. 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 might 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 short and the extent of the risk would be to individuals.

**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 medium due to the retention time of the toxicant in the tissues of inter-tidal prey species. 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. 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 could 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 medium due to the retention time of the toxicant in the tissue of prey species. The extent of the impact would be to individuals because these species are uncommon on Desecheo and are not known to breed on the island.

Belted kingfishers might 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 medium due to the retention time of the toxicant in the tissues of prey species. The extent of the impact would be to individuals because kingfishers are uncommon on Desecheo and are not known to breed on the island.

*Disturbance Risk*
Aquatic coastal foragers would likely be exposed to disturbance from both aerial and ground operations, which might 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 medium, 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 short, and the extent of the risk would be to individuals because the species are uncommon on Desecheo and not known to breed on the island.

**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, the duration of the risk would be short, 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 might 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 short and the extent of the risk would be to individuals since these are uncommon species on Desecheo.

### 4.6.1.2 Winter Migratory Birds in Puerto Rico

The following species are winter migrants, typically present in Puerto Rico between November and February. 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. 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.

**Raptors (*peregrine falcon, Northern harrier, merlin)***

*Toxicant Exposure Risk*
Peregrine falcons, Northern harriers, and merlins would likely be exposed to brodifacoum through secondary exposure pathways by consuming shorebirds, laughing gulls, rats, and passerines 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 for

peregrine falcons and Northern harriers is high because of the range of exposure pathways to falcons. The exposure risk for merlins would be medium because of the single exposure pathway to merlins (passerines). The mortality risk for all three species would be high and the duration of the risk would be medium due to the retention time of the toxicant in the tissues of prey species. 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 short and the extent of the risk would be to individuals because these species are uncommon on Desecheo.

#### 4.6.1.3 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 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 (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.

The only seabird historically known to use 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 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 residents 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. 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 medium 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.

***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. 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. Because both are known to roost on the island and both have extended breeding seasons throughout the year which would overlap with the operational window, 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 short and the extent of the risk would be to individuals because both species are uncommon on Desecheo.

***Magnificent frigatebird and red-footed booby***

*Toxicant Exposure Risk*

Magnificent frigatebirds have been observed flying over the island and red-footed boobies have not been observed on Desecheo in recent years. Although neither of these species has been documented using the island, both species are year-round residents in the region and there is the potential for both birds to be on Desecheo during the operational window. They would not be considered at risk of toxicant exposure because they rarely if ever feed on anything other than marine fish and squid.  The extent of the impact is insignificant and does not require further consideration.

*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 short and the extent of the risk would be to individuals because these species are uncommon on Desecheo.

***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. Seventeen brindled tern nests and one brown noddy pair were found with eggs in June 2010. 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 consideration.

*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 short and the extent of the risk would be to individuals because these species are uncommon on Desecheo.

***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 on the island. 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.

### 4.6.2 Impacts on Reptiles

Toxicant exposure risk to reptiles on Desecheo would be primary or secondary. In either case, the time window of risk is relatively short, beginning with the date of application and lasting until brodifacoum has disappeared from the environment. The three lizard species and the dwarf gecko found on Desecheo are primarily insectivores that hunt using visual cues, 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 effect 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 (Daltry 2006).

The toxicity of brodifacoum to reptiles is discussed in Section 4.5.3.2. 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 upon exposure.

Because the reptile fauna of Desecheo Island comprises three single-island endemic species, significant reptile mortality during the bait application has the potential for global 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 its 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, which in 1987 reported densities of 3 – 19 animals in 125 $m^2$ forest plots 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 3.5.1). 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*

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 medium due to the retention time of the toxicant in the tissues of prey species. 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 short 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 medium due to the retention time of the toxicant in the tissues of prey species. 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 short 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, the mortality risk would be high, and the duration of the risk would likely be medium due to the retention time of the toxicant in the tissues of prey species. 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***
*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 medium due to the retention time of the toxicant in the tissues of prey species. 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. The impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be short and 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 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 medium due to the retention time of the toxicant in the tissues of prey species. 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. Therefore, the impacts associated with disturbance risks for this alternative would be low. The duration of the risk would be short and 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 the ingestion of marine debris by marine turtles is well documented (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 drift 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. 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 then 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 and the large quantity that would have to be ingested to present ill effects, the risk to marine turtles is considered to be negligible.

*Disturbance Risk*
Hawksbill, green and leatherback sea turtles could be disturbed by 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. All boat operators would be briefed on NOAA protocols to avoid vessel collisions and disturbance associated with marine life (NOAA 2008) . Turtles would not be at risk from disturbance impacts that occur on the island because green and leatherback turtles are not known to nest 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, which is outside of the operational window. The impacts associated with disturbance risks for this alternative are low, the duration of the disturbance would be short, and the extent of the effect would be on the individual level.

### 4.6.3 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. Other studies have demonstrated a range of invertebrates found at bait stations that consume bait (Bowie and Ross 2006). Brodifacoum residues have been found in land crabs(Pain et al. 2000) as well as live invertebrates (Ogilvie et al. 1997) in areas with a history of rodent eradication efforts . 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,* whip scorpion)
*Toxicant Exposure Risk*
Arachnids would be likely exposed to brodifacoum through secondary exposure pathways by consuming terrestrial invertebrates that consume bait. There is believed to be no risk of toxicity and no negative impacts from brodifacoum use have been reported. The toxicant exposure risk

would be low because of the single exposure pathway and there would be no risk of mortality. The duration of the risk would be medium due to the retention time of the toxicant in the tissues of prey species. 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 short and the extent of the risk would be to individuals.

***Purple landcrab and hermit crabs***
*Toxicant Exposure Risk*
Purple land crabs and hermit 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. 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 medium due to the retention time of the toxicant in the tissues of prey species. The extent of the impact would be to the island population.

*Disturbance Risk*
Purple land crabs and hermit 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. Hermit crabs, however, are active during the day and would potential be exposed to disturbance from reptile capture and shoreline baiting. Therefore, the disturbance risks for this alternative would be low for purple land crabs and medium for hermit crabs. The duration of the risk for both species would be short and the extent of the risk would be to individuals.

### 4.6.4 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 frugivorous and insectivorous bats are native to Puerto Rico. There is unlikely to be an exposure pathway to frugivorous/nectivorous bats. Insectivorous bats would be exposed to brodifacoum by consuming flying insects that had consumed bait. The risk of brodifacoum causing mortality in insectivorous bats would likely be high, but the toxicant exposure risk to insectivorous bats would be low, as only a secondary pathway is available. . The duration of the risk to insectivorous bats would likely be medium due to the retention time of the toxicant in the tissues of prey species. 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.

### 4.6.5 Impacts on Vegetation

***Higo chumbo (Federally listed as threatened)***

*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 short and 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 short and the extent of the risk would be to individual plants or discrete patches of the plant community.

| 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 |
| Northem Mockingbird, Smooth-billed Ani, Shiny Cowbird | High | High | Low | Individ. | Individ. | Medium | Short |
| Zenaida Dove & Common Ground-dove | High | High | Medium | Island/ Individ.[6] | Island/ Individ. | Short | Short |
| 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 | Island | Medium | Medium |
| 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 & Northem 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 Tem, Sooty Tem & 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[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 |

### 4.6.6 Impacts Table for Alternative B: Biological Resources

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

**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 effect on resident breeding population; Island population (Island): Resident breeding population affected, no effect 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.
[9]Arachnids: *Clubiona desecheonis*, *Camillina desecheonis* and *Schizomus desecheo*.

## 4.7 Impacts of Alternative C: Aerial Broadcast as Primary Delivery Technique of Diphacinone Bait Product

### 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 diphacinone has been described in Section 2.2.2.3, 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 the risk of impact to different species from toxicant use. Also, we have represented the reduced toxicity of diphacinone by assuming a moderate impact to birds from diphacinone in comparison to a high impact assumed from the use of brodifacoum. We have represented the duration of the risk to be short in comparison to a medium duration risk for brodifacoum.

Generally, the species at high risk of primary exposure to diphacinone 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. Also, any bait pellets that do drift into the water would disintegrate and become unavailable within a few hours. 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 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.

#### 4.7.1.1 Permanent Resident Species in Puerto Rico

The discussion of permanent resident species in Puerto Rico is similar to that in Section 4.6.1.1. 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.

**<u>Raptors</u>** ***(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 tissues of prey species. 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 might 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 short and the extent of the risk would be to individuals.

**<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. Shiny cowbirds 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 short due to the retention time of the toxicant in the tissues of prey species. 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, might cause them to flush from their immediate location to alternative habitat, and may temporarily change breeding behavior. For the pearly-eyed thrasher, the impacts associated with disturbance risks for this alternative would be medium and the duration of the risk would be medium because this species is a permanent breeding resident on the island. The impacts associated with disturbance risks for the Northern mockingbird, smooth-billed ani, and shiny cowbird would be low 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.

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

*Toxicant Exposure Risk*
Doves would likely be 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, they would likely directly consume bait pellets and the exposure risk would be high. The mortality risk would be medium and the duration of the risk would be short. The extent of the impact to zenaida doves

would be to the island population, but for common ground doves it 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 might 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 medium. The extent of the risk for zenaida dove would be to the island population, but for common ground-dove it would be to individuals because the species is uncommon on Desecheo.

**<u>Canopy foragers</u> (*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 short due to the retention time of the toxicant in the tissues of prey species. 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 might 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 short and the extent of the risk would be to individuals.

**<u>Canopy/Ground foragers</u> (*mangrove cuckoo)***

*Toxicant Exposure Risk*
Mangrove cuckoos would likely be 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 short due to the retention time of the toxicant in the tissues of prey species. 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 might 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 short and the extent of the risk would be to individuals.

**<u>Aquatic coastal foragers</u> (*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 tissues of prey species. 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 for aquatic invertebrates and insects in the intertidal zone, but they will consume carrion. 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 short due to the retention time of the toxicant in the tissues of prey species. The extent of the impact would be to individuals because these species are uncommon on Desecheo and are not known to breed on the island.

Belted kingfishers might be exposed to diphacinone through secondary exposure pathways by consuming rats that have consumed 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 short 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 might 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 short, 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 short, and the extent of the risk would be to individuals because the species are uncommon on Desecheo, and not known to breed.

**<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 short, 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 might 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 short, and the extent of the risk would be to individuals since these are uncommon species on Desecheo.

#### 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. For some individuals this 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.

**Raptors (*peregrine falcon, Northern harrier, merlin)***

*Toxicant Exposure Risk*
Peregrine falcons, Northern harriers, and merlins would likely be exposed to diphacinone through secondary exposure pathways by consuming shorebirds, laughing gulls, rats, and passerines 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 for the peregrine falcon and northern harrier is high because of the range of exposure pathways to falcons. The exposure risk for merlins would be medium because of the single exposure pathway. The mortality risk for all three species would be medium and the duration of the risk would be short term due to the retention time of the toxicant in the tissues of prey species. 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 short and the extent of the risk would be to individuals because these species are uncommon on Desecheo

#### 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 (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.

The only seabird known historically from Desecheo that is potentially at risk of primary exposure to the rodenticide is the laughing gull. 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 (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 and potential scavenge 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. Some birds may remain coastal residents year-round, but often fly 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 for aquatic and terrestrial vertebrates, eating seeds and plants, or feeding on carrion in the intertidal zone. The primary exposure pathway would be significant because gulls are known to consume rodent bait pellets. 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 short due to the retention time of the toxicant in the tissues of carrion and prey species. 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 during the application window, 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 short and the extent of the risk would be to individuals because laughing gulls are uncommon on Desecheo.

***Brown booby and brown pelican***

*Toxicant Exposure Risk*

Fewer than 100 individuals of brown booby and small numbers of brown pelican are known to roost on Desecheo. Individuals of both species would likely 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. 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. In the unlikely event that birds were nesting, 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 short and the extent of the risk would be to individuals because both species are uncommon on Desecheo.

***Magnificent frigatebird and red-footed booby***

*Toxicant Exposure Risk*

Magnificent frigatebirds have been observed flying over the island and there is 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. 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 short and the extent of the risk would be to individuals because these species are uncommon on Desecheo.

***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. Seventeen bridled tern nests 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. The extent of the impact is insignificant and does not require further consideration.

*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 short and the extent of the risk would be to individuals because these species are uncommon on Desecheo.

***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 consideration.

*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 on the island. If birds were to appear on the island during the operational window, they may be impacted by localized aerial and ground disturbance and 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.

### 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 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 (Daltry 2006).

The toxicity of diphacinone to reptiles has been discussed previously. 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 upon exposure. Information on the island's reptiles is included in Section 4.6.2.

***Desecheo gecko***

*Toxicant Exposure Risk*

Desecheo geckos on the island 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 island (global) population.

*Disturbance Risk*

Desecheo geckos 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*

The Desecheo ameiva 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 island (global) population.

*Disturbance Risk*

Desecheo ameivas 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 anole***

*Toxicant Exposure Risk*

Desecheo anoles 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 island (global) population.

*Disturbance Risk*
Desecheo anoles 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.

***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*
Toxicant exposure risk to sea turtles is similar to that described for Alternative B.

*Disturbance Risk*
Disturbance risk to sea turtles is similar to that described for Alternative B.

### 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 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 )
*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 and Hermit Crab***
*Toxicant Exposure Risk*
Purple land crabs and hermit crabs would be exposed to diphacinone through both primary and secondary exposure pathways. Generally, both 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 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*
Toxicant exposure risk to bats would be similar to that for Alternative B.

*Disturbance risk*
Disturbance risk to bats would be similar to that for Alternative B.

### 4.7.5 Impacts on Vegetation

***Higo Chumbo (Federally listed as threatened)***
*Toxicant Exposure Risk*
Toxicant exposure risk for higo chumbo would be similar to that for Alternative B.

*Disturbance Risk*
Disturbance risk for higo chumbo would be similar to that for Alternative B.

***Other Vegetation/Flora***
*Toxicant Exposure Risk*
Toxicant exposure risk would be similar to that for Alternative B.

*Disturbance Risk*
Disturbance risk would be similar to that for Alternative B.

### 4.7.6 Impacts Table for Alternative C: Biological Resources

**Table 4.3.** Impacts of Alternative C (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 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Northem 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 & Northem 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 Tem, Sooty Tem & 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[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 effect on resident breeding population; Island population (Island): Resident breeding population affected, no effect 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.

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

## 4.8 Indirect Impacts to Biological Resources

### 4.8.1 Indirect Effects under Alternative A

Alternative A, the no action alternative, would leave rats on Desecheo, which would continue to negatively impact the island by altering vegetation communities, decrease the breeding success of seabirds, and disrupt the overall food web of the island. Specifically, allowing rats to remain on the island would 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 degredation, potentially leading to the extirpation of resident terrestrial birds from the island.

### 4.8.2 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 and the impacts of rats to native wildlife on Desecheo have been discussed previously. Indirect benefits from rat eradication have been extensively reported for seabirds, terrestrial land birds, reptiles, invertebrates, rare plants, forest regeneration, inter-tidal communities, and the ecosystem as a whole.

The most immediate positive response expected on Desecheo from the removal of rats would be seen in the smaller nesting seabirds, such as bridled and sooty terns and brown noddies. Early accounts from Desecheo suggested that these species nested in densities of thousands of breeding pairs 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 increased 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. A comparison of recent and early accounts from Desecheo suggests 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 competition for overlapping food resources and direct predation of eggs, young, and adults.

On other islands where rats have been eradicated, terrestrial invertebrate populations are some of the best-documented beneficiaries of the eradication (Newman 1994, Ruscoe 2001, Jones and Golightly 2006). Overall invertebrate abundance on Desecheo 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 expected to improve the long-term survival of these species.

Elsewhere, rats have impacted rare plant 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.

The removal of rats might also have an indirect negative impact to some ecosystem components, given their currently perceived role in the Desecheo ecosystem. These invertebrates and seeds which constitute a significant proportion of prey items for the Desecheo rats would be released from rat predation pressure once the eradication is successful. It is anticipated that this release would be compensated by the subsequent predation of the same prey items by native terrestrial wildlife (e.g. predatory invertebrates, reptiles, and land birds). and 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 (e.g. invasive plants, predatory invertebrates) increases in abundance after rat removal, this could result in an indirectnegative 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 harriers 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 consists largely of small mammals and their diet in upland rainforest consists mostly of reptiles, birds and amphibians (Santana and Temple 1988). This suggests that the species has the ability to adapt to a non-mammal diet when needed. Additionally, Northern harriers have rarely been recorded on Desecheo as the island does not provide optimal habitat. Therefore, the Northern harrier 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 rat 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 incubated 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, including 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 cowbirds and thrashers on Desecheo could have a negative 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, chicks, and adult birds and increased food resources for these increasing bird populations. These three species are introduced to Puerto Rico and the impact of an increased abundance on Desecheo is unknown.

## 4.9 Consequences: Social and Economic Environment

The CEQ guidelines under 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.

### 4.9.1 Refuge Visitors and Recreation

#### 4.9.1.1 Analysis Framework for Refuge Visitors and Recreation

Although access to Desecheo by the public is prohibited without a permit, the waters surrounding the island 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 the visitor experience as a result of each of the action alternatives. The Service would consider any major, long-term changes to the visitor experience to be significant.

#### 4.9.1.2 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 probably will not 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 continue to experience poor quality bird viewing since several extirpated bird species are expected to continue to be absent from the island.

#### 4.9.1.3 Alternative B: Aerial Broadcast as Primary Delivery Technique of Brodifacoum Bait Product

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 bait application. 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 enhanced bird viewing opportunities since several extirpated bird species are expected to return to the island following the successful rat eradication.

#### 4.9.1.4 Alternative C: Aerial Broadcast as Primary Delivery Technique of Diphacinone Bait Product

Impacts would be similar to those described in Section 4.9.1.3 for Alternative B.

### 4.9.2 Historical and Cultural Resources

#### 4.9.2.1 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). 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.

#### 4.9.2.2 Alternative A – No Action

The Service has no evidence that rat activities would affect any undetected historical and cultural resources on the island, either through burrowing or through potential chewing of artifacts.

#### 4.9.2.3 Alternative B: Aerial Broadcast as Primary Delivery Technique of Brodifacoum Bait Product

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.

#### 4.9.2.4 Alternative C: Aerial Broadcast as Primary Delivery Technique of Diphacinone Bait Product

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.

### 4.10 Consequences: Cumulative Impacts

#### 4.10.1 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 from invasive species. Also, many of the bird and marine 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 three 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 retain water. The forest on the southwest end 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 has since reverted to grassland that was maintained by visiting fishermen who burned it periodically to maintain land crab habitat. This regular burning prevented the reestablishment of trees in the area.  The following are some of the significant actions that have occurred in the past.

- 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 the shattered and 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 still 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 traffic throughout the island. A small concrete building and large concrete water catchment pad was constructed along the southwest coastline. The Department of Defense's previous assessments 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 but the long term impacts are  positive.. 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 negatively impact the same species as cats.

- 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 compaction, erosion, loss of plant diversity, and disturbance of seabird nesting areas. Between 1996 and 1999, 390 goats were removed (Breckon 2000), and  Service personnel removed an additional 291 goats over the course of seven field visits conducted between March 2001 and December 2002. In 2008 the few remaining goats were removed and complete eradication was confirmed in 2010. While there were 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, the result of the activities will be very positive on the island's ecosystem. Benefits are many are include 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 compaction 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 around 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 to trap and remove 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 Service as an effort to restore the National Wildlife Refuge's historical biodiversity. This attempt was not fully successful 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. The negative effects of these removal programs, include terrain compaction and vegetation disturbance from hunters temporarily living and working on the island. However, the positive benefits to the island's ecosystem from the reduced densities of non-native 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 soil compaction and vegetation disturbance associated with foot traffic along regular hiking paths which provide 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 and all equipment and supplies are removed from the island on completion of each field trip.

- Law Enforcement - Desecheo Island and the surrounding waters have been known to be used for illegal activities including unauthorized landings of illegal immigrants from elsewhere in the Caribbean Region (e.g. Dominican Republic, Cuba) and illegal drug 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 infrequent.

- Rat Eradication Attempt in 2012. In March of 2012, following the completion of the 2011 EA and the receipt of the required permits, two aerial applications of brodifacoum 25D were conducted 10 days apart. This was implemented in accordance with Alternative B presented in the 2011 EA. The target application rate was 18kg/ha on the first application and 9kg/ha on the second. Supplemental baiting was done on the ridges through the use of rodenticide in bait stations. All three endemic reptiles were collected and detained on the island as a precaution in the event of a severe population decline. They were held in captivity for 35 days.

  Post application monitoring included searches for rat carcasses and both systematic and opportunistic searches for non-target species carcasses. Systematic searches employed the use of transects. No bird carcasses that could be attributed to the application were encountered during the monitoring period which followed the application. Documentation of the operational aspect of the eradication is included in Island Conservation (2013).

**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 are as follows:

- Biological Monitoring - Further biological surveying is being conducted within this timeframe to document the specific recovery of native and endangered species as a component of the rat eradication management proposal, and to carry out field trials in preparation for 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 periods ranging from five days to 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 the equipment 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 are as follows:

- 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 designed to specifically document ecosystem recovery  will finish five years after implementation of the rat eradication efforts.

- Law Enforcement – Law enforcement will remain an activity as required, but is not expected to create any short or long term impacts to the island.

#### 4.10.1.1 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 previously 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 removal of feral goats, cats and macaque would not be fully realized and the costs of those operations would not have achieved maximum benefit.

#### 4.10.1.2 Cumulative Impacts under Alternative B:  Aerial Broadcast as Primary Delivery Technique of Brodifacoum Bait Product

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.

#### 4.10.1.3 Cumulative Impacts under Alternative C:  Aerial Broadcast as Primary Delivery Technique of Diphacinone Bait Product

Impacts would be similar to those described above in Section 4.10.1.3 for Alternative B.

## 4.11 Irreversible and Irretrievable Impacts

### 4.11.1 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.

### 4.11.2 Alternative B:  Aerial Broadcast as Primary Delivery Technique of Brodifacoum Bait Product

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; meaning, 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.

#### 4.11.3 Alternative C:  Aerial Broadcast as Primary Delivery Technique of Diphacinone Bait Product

Impacts would be similar to those described in Section 4.11.2 for Alternative B.

### 4.12 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 and stability 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.

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