APPENDIX B: BAIT APPLICATION STRATEGY, DESECHEO NATIONAL WILDLIFE REFUGE RAT ERADICATION. PROPOSED TARGET DATE: MARCH 15 – APRIL 08, 2016

Background

In February of 2012, the USFWS in partnership with Island Conservation implemented a project to remove invasive rats from Desecheo Island National Wildlife Refuge. The initiative was part of a wider effort to restore Desecheo's natural ecosystems, increase security for three endemic reptiles, promote recovery of the island's once abundant seabird breeding colonies, and protect the federally-listed higo chumbo cactus (Harrisia portoricensis). Rats were not detected during fieldwork in October 2012, but in March 2013 biologists working on the island observed and captured rats. Genetic testing indicated the operation was not successful and the presence of rats was not a result of a reintroduction.

To determine reasons why the operation may have failed, an independent review of the project was commissioned in 2013 (Brown and Tershy 2013). The most likely contributors to the failure to eradicate rats from Desecheo Island included: (1) higher than average rainfall with an assumed subsequent increase in the availability of natural food resources for rats, which may have reduced the competition for rodent bait and/or stimulated rat breeding leading to higher densities of rats and/or young rats in the nest that were not exposed to bait; (2) insufficient bait availability to rats due to competition for bait by invertebrates such as terrestrial hermit crabs and/or because some areas during the first bait application operation received bait at a lower application rate than prescribed. This review and the subsequent review of rodent eradications on tropical islands resulted in several peer reviewed manuscripts that recommend guidelines for conducting rodent eradications on tropical islands (Russell and Holmes 2015). These recommendations were used to inform the bait application strategy for a proposed second attempt on Desecheo Island (Island Conservation 2014).

An amendment to the 2012 final Environmental Assessment for rat eradication from Desecheo will be prepared in compliance with the National Environmental Policy Act (NEPA) to address the proposed revised bait application strategy for Desecheo Island for 2016.

Island Area

Area calculations for Desecheo Island. Data was derived from High Resolution Orthoimagery at 1 ft. GSD, 4 Band (Natural Color and CIR), for Puerto Rico and US Virgin Islands.

Type	Land Area (ha)	Surface Area (ha)
Desecheo (main landmass)	116	132.9
Islets	1.1	1.1
TOTAL AREA	117.1	134

2016 Project Approach

The 2016 bait application strategy incorporates information from the independent review of the 2012 operation (Brown and Tershy 2013) and the recommended guidelines from a review of rodent eradications on tropical islands (Russell and Holmes 2015) to increase the likelihood of success. The key changes to the 2012 bait application strategy are summarized below:

1. Monitor environmental conditions preceding the operation to inform the implementation schedule. The eradication will target the seasonal dry period between January and April 2016. Develop a strategy to delay or postpone the eradication operation (either the same year or following year) if environmental conditions indicate unfavorable climatic conditions for a successful operation.
2. Increase the application rate (kg/ha) from the rate used in 2012.
3. Increase the application rate for the second bait broadcast so that it is the same as the first application rate.
4. Increase the interval between the two bait applications to a target of 24 days, but allow for the interval to be 17-66 days, dependent on weather and logistical considerations.
5. Increase the amount of contingency bait allowed in order to reduce the risk of bait gaps at swath interfaces, and smooth out inconsistencies in bait application rates on the ground (i.e., where lower bait application rate exists).

Justification for Bait Application Strategy Changes

1. Monitoring environmental conditions to inform the bait application schedule

The ideal biological window for a successful eradication has been identified as the Caribbean tropical dry season (which typically occurs between January and April). Natural food availability is believed to be more limited for rats than at other times of the year and rat breeding is reduced. If the environmental conditions are consistent with historical patterns, the target month for bait application is March 2016, which is expected to be a period of low primary productivity (plant growth) due to low precipitation, high soil-water discharge, and high rates of leaf litter fall (Lugo 1978). If conditions are not ideal in this period, a later bait application could occur if conditions became favorable (e.g., May, June, and July, when soil moisture is typically also in deficit). Rainfall and soil moisture content are key drivers of resource availability on Desecheo Island, typical of Puerto Rican subtropical dry forests. Environmental conditions on Desecheo Island between January and April can be variable and highly dependent on the amount of soil water recharge generated from successive rainfall events in the previous year's wet season (July-December) and the timing and amount of rain from near term rainfall events.

Under the revised bating strategy, the operational team will conduct monitoring of environmental conditions in the months preceding the operational window to assess if the target month (March 2016) is optimal. A strategy has been developed that allows a delay of operations by weeks or months within the same year, or to postpone implementation to the following year if monitoring suggests that environmental conditions are not suitable. Additional research was conducted to define what environmental criteria will be used to inform the implementation schedule. These criteria are described in **Appendix U:** Monitoring Environmental Conditions.

2. *Increase application rate*

The Desecheo Island rat eradication review identified "inadequate overall or [inadequate] localized bait rates" as one of the potential causes of failure to eradicate rats, and that a more conservative interpretation of the field trials data and a higher minimum bait application rate is warranted (Brown and Tershy 2013).

Bait should be available to rats for at least four consecutive 24 hour periods to maximize the probability that all individual rats in the population will be exposed to a lethal dose of bait and to account for individual heterogeneity in vulnerability of rats to bait due to age, behavior, body size, alternative food supply, and home range size (Cromarty *et al.* 2002).

Using recent guidelines (Pott *et al.* 2014) and bait monitoring data from the 2012 eradication attempt (Figure 1), we estimated that bait disappeared from the island at a rate of 5.97 kg/ha per day in the 2012 eradication attempt (Figure 2). This daily disappearance rate computes to a **target bait density on the ground of 30 kg/ha,** which is anticipated to ensure that bait is available to rats for approximately 5 consecutive days after each application.

Figure 1. The mean bait availability from the five bait availability plots set in the woodlands during the 2012 eradication attempt. The error bars represent the 99% lower limit from a one-tailed t-statistic. Day 0 represents the broadcast date and Day 1 represents the first 24 hour period during which bait is available to bait consumers (ie. Day 1 ends 24 hours after the end of bait application).

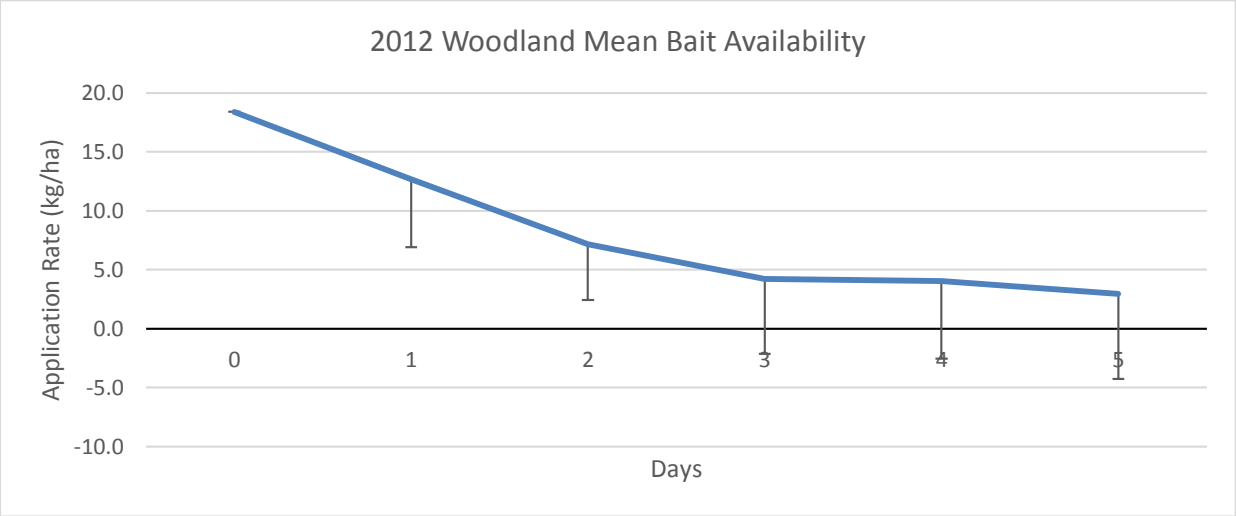
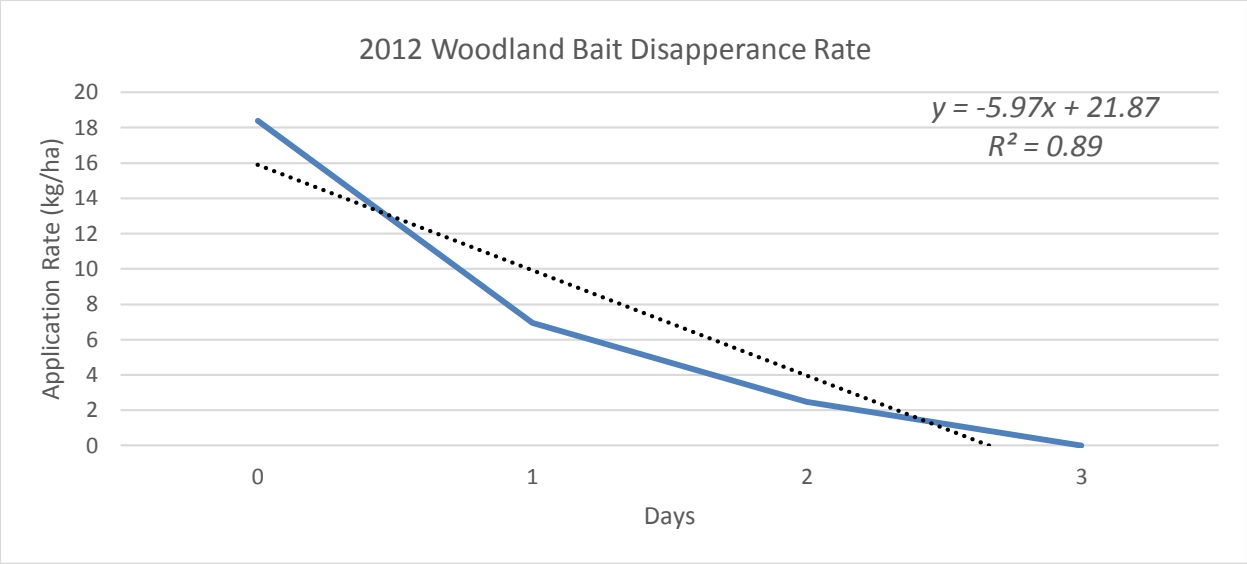


Figure 2. The estimated rate at which bait disappeared in the five bait availability plots set in the woodlands ruing the 2012 eradication attempt. The blue line represents the 99% LL of mean bait availability data.



Desecheo Island has a planar area (2-dimensional) of 117.1 ha including the offshore islets (Fig. 1A), and a topographical surface area (3-dimensional) of 134 ha (Fig. 1B); the surface area (3-dimensional) is 13% higher than the planar (2-dimensional) area. Given that bait is aerially applied in a planar (2-dimensional) mode, **bait needs to be sown at a rate of 34 kg/ha** in order to achieve the **target bait density of 30 kg/ha on the ground.** Because of the large area with extreme slopes on Desecheo Island, actual land surface area must be accounted for when determining the bait application rate.

3. Increased application rate for second bait application

Bait application on temperate islands typically targets rats in the late autumn, winter, and early spring period when rodent abundance is generally low, rodent populations are generally not breeding, and there is increased food competition and high natural mortality. Application of bait when a rat population is breeding increases project risk of failure because pregnant and lactating female rats may have different food preferences (Leshner *et al.* 1972), and young rats not yet weaned may be underground in nests and not exposed to bait. However, tropical islands generally support higher rodent abundance than in islands in temperate regions, and rats can potentially breed throughout the year. For the purposes of rat eradication planning, year-round rodent breeding should be assumed on tropical islands. The increased application rate for a second bait application, to the same as for the first drop i.e. 34kg/ha is to address the potential of a generally higher abundance of adult rats on Desecheo Island, and of weanling and juvenile rats emerging after the first bait application.

4. Increase the interval between bait application broadcasts to 24 days, allowing for an interval of 17-66 days dependent on weather conditions or logistical considerations

The target bait application interval should be increased to 24 days. The longest period that a rat has been known to survive after ingesting a lethal dose of bait was 21 days following an eradication effort on Palmyra Atoll; Howald *et al.* 2004). Given that the weaning time of *R. rattus* pups is 21-28 days, there is the potential for a female rat's pups to survive and avoid bait exposure if the second bait application is implemented less than 24 days from the first application. However, allowing a bait application interval

of 17-66 days provides some allowance for unfavorable weather conditions or logistical issues impacting the timing of the second bait application. Only in extreme conditions will a gap of less than 24 days be considered.

5. Increase the amount of contingency bait available to reduce the risk of bait gaps at swath interfaces, and lower than target bait density on the ground.

The independent post-project review noted that the bait application strategy created a risk of bait gaps and/or lower than planned bait rates between coastal and interior zones (Brown and Tershy 2013). It recommended applying the standard methodology of 'safety buffering' with additional bait between coastal and interior swaths. The supplemental label allows for the application of contingency bait (up to 15% by weight of the bait applied to coastal and interior zones, offshore islets, and the coastal/interior zone overlap) to ensure that baiting swaths overlap sufficiently, and to treat areas identified with lower than target application rate. The intention is to not apply all of the contingency bait and for there to be unused bait at the end of each application, but this f contingency bait is available to ensure that all parts of the island achieve the target bait density on the ground.

Several critical habitats were identified in the review as needing reevaluation to ensure that the bait application rate is adequate. Predominant valleys and cliffs run perpendicular to one another, flights that are parallel to one are perpendicular to the other which has an impact on the consistency of bait application on the round (ie. bait shadows, or more bait upslope than downslope). In addition the valleys are known areas of high rat density and represent the largest efficacy risk. To ensure bait coverage and maximize efficacy, additional flights will be flown parallel to the valley or cliff features at a lower application rate, 17 kg/ha.

Bait Application Strategy

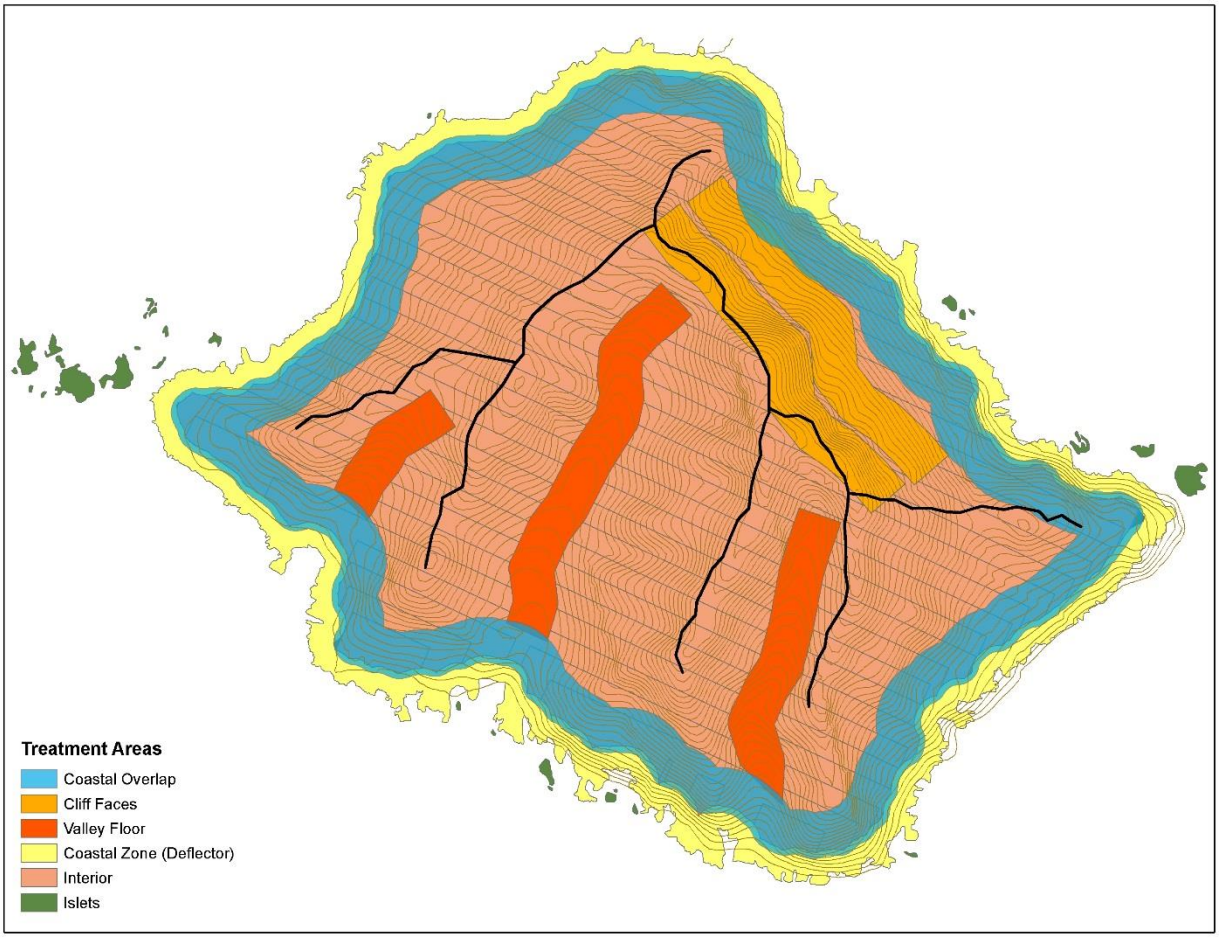
Bait will be applied aerially by helicopter using a spreader bucket slung below the helicopter. To minimize bait application and drift into the marine environment, bait will be applied along the mean high water mark at the coastal zone with directional (deflector) swath bucket fitted to the helicopter, and in the interior without a deflector (Table 1). Bait applied at the interface of the coastal and interior zones will have 'safety buffering' to reduce the risk of bait gaps and areas of lower than target bait density.

Table 1. Bait bucket configuration and sowage rates for Desecheo.

Bucket configuration	Swath width*	Sow rate	Flight speed
Directional swath bucket	35	34 kg/ha	35 knots
Full swath bucket (with 50% overlap)	80	17 kg/ha	50 knots
Narrow Swath Bucket	5 m	34 kg/ha	25 knots

*Swath width to be confirmed during bucket calibration.

Figure 3. A 2-dimensional representation of Desecheo Island showing the ideal bait application strategy: coastal zone flight swath (yellow), interior zone flight swaths (orange), coastal/interior overlap zone (blue shaded), and theoretical flight transects (crosshatched lines).



1. Immediately adjacent to the coastline, bait will be sowed in 35 m swaths using a deflector fitted to the spreader bucket which will deflect bait spread away from the coastline and reduce bait drift into the marine environment. Bait along the coastline will be applied only above the observed mean High Water Mark.

2. Bait will be spread in 70m swaths across the interior of the island, and swaths will overlap by 50% (Figure 1). Bait will be sowed at half the bait density required on-the-ground (17 kg/ha) so that after overlapping swaths, the full bait density will have been achieved (34 kg/ha).

3. A second full coastal swath (70m diameter) without the deflector will be sowed by flying approximately 60m inland from the coast so that it overlaps both the interior and first coastal swaths by at least 25%. This overlap is needed to minimize the risk of low bait density and gaps in bait availability on the ground and will be sowed at 17 kg/ha.

4. A single full swath (70 m diameter) will be sowed up the bottom of the three valleys on Desecheo at a rate of 17 kg/ha.

5. Two non-overlapping swaths (70 m diameter) will be sowed along the length of the predominant NW-SE cliff at a rate of 17 kg/ha. These swaths will occur at different elevations (one near the top and one near the middle) to ensure there is sufficient coverage on the steep slopes.

1. Amount of Bait needed for Aerial Application

To calculate the total amount of bait needed, the following criteria have been considered:

1. Bait application target density on-the-ground (the island's 3-dimensional surface area).
2. Bait application sow rate (the island's 2-dimensional planar area)
3. Contingency bait to provide safety buffering between the coastal and interior bait swaths, and to fill other potential bait gaps (areas of low bait density) identified across the island.

Table 2. Total amount of bait required for aerial application on Desecheo Island. Bait is sowed from the helicopter at in order to achieve 30 kg/ha target bait density on-the-ground (a 3-dimensional surface area). The maximum total amount of bait applied in the first and second application periods (5,444 kg) is the same.

Treatment Area Description	Per Application Period		
	2-Dimensional Area (ha) sowed	Sow Rate (kg/ha)	Maximum bait applied (kg)
Coastal zone	16.5	34.0	561
Coastal/interior overlap zone ('safety buffering')	28.4	17.0	483
Interior zone	100.1	34.0	3,403
Offshore islets	1.1	34.0	37
SUBTOTAL			4,484
Contingency bait (additional application of up to 15% of the maximum bait applied to the above treatment areas, as needed)	19.8	34.0	674
Valley bottoms and cliff faces (additional application)	16.8	17.0	286
TOTAL BAIT ALLOWED IN EACH APPLICATION PERIOD			**5,444**
TOTAL BAIT ALLOWED IN TWO APPLICATION PERIODS			**10,888**

2. Preventing bait drift into the marine environment

Every reasonable effort will be made to minimize the risk of bait drift into the marine environment. A directional deflector will be attached to the spreader bucket for treatment of areas along the coastline where the use of a full swath bucket might result in bait drift into the marine environment or a lower than desired bait rate. The deflector will broadcast bait to the onshore side of the helicopter to minimize the risk of bait drift into the ocean on the opposite, or seaward, side.

3. Coverage of gaps in bait application

In cases where it is evident that a portion of the treatment area greater than 100 m^2 and wider than 20m did not receive the required application rate, there will be supplemental, systematic broadcast by hand or helicopter to fill in the gaps. Bait will be applied to gaps in coverage in accordance with the Supplemental Bait Label.

4. Baiting offshore islets

Three large and several smaller islets located offshore of the helipad on the west coast of Desecheo will be baited independently. Due to the risk of bait drift into the marine environment, the islets will be baited using the narrow swath bucket.

A list/ map of all islets will be made and they will be crossed off as they are done for each application. This will be the responsibility of Operations Section Chief.

5. Buildings

Only one very small (c. 6 ft x 8 ft x 6 ft) building exists on Desecheo on the west coast beach next to the helipad, a concrete above-ground bunker remaining from the island's military occupation. Bait will be applied inside the building by placing and loading a single bait stations at 30 kg/ha. Once treated, the building will be marked with flagging or spray paint and recorded with a GPS location. The bait station will be armed with bait on the same day as the first and second bait application. The Operations Section Chief is responsible for ensuring this is completed for both applications.

6. Resuming baiting after unplanned stops

If baiting is interrupted before completion, "back-baiting" of previously treated swaths will ensure that bait will be available to rats that may have reinvaded treated areas. When baiting resumes, the rules stated on the supplemental label will be used to determine the extent of back-baiting.

Table 3. Bait application strategy after an unplanned interruption in aerial baiting.

Time delay	Strategy to resume baiting
1 day	At drop boundary
2 – 3 days	2-4 swath widths behind drop boundary
>3 days	4-6 swath widths behind drop boundary

7. Pesticide hazard warnings

In compliance with FIFRA guidelines and the Puerto Rico Department of Agriculture, Pesticide Authority, pesticide hazard warning signs will be placed above the high water mark at Puerto de los Bôtes and along the shoreline to the west as far as the helipad. While access to Desecheo NWR is strictly controlled by the U.S. Fish and Wildlife Service and only authorized by permit, these two areas are the main access sites used by authorized and unauthorized individuals landing on the island by boat. In

addition, pesticide warning signs will be placed around the helipad in the event that authorized personnel from other agencies (e.g. law enforcement) need to land there. Pesticide warning signs will be placed by the Bait Station Leader as soon as bait is applied at the location described.

The notice of application signs must be water resistant and measure at least 20 inches in height and 15 inches in width. Warning signs will be in both English and Spanish languages and will have contact details for the USFWS.

The sign must contain the following information in Red/Black lettering and symbols:

- The word WARNING, at least 2 inches in size.
- The words PESTICIDE APPLIED, in at least 2 inches bold type size.
- The symbol of a circle at least 8 inches in diameter with a diagonal slash over an adult, child, and dog.
- The words DATE APPLIED in size ½ inches bold type size.
- The words NAME OF THE APPLICATOR AGENCY, TELEPHONE NUMBER which made the application, in at least ½-inch bold type size.

Deployment of the specified signage is the responsibility of the Operations Section Chief. A register of when the signs are erected and subsequently checked will be maintained by the Operations Section Chief.