Establishing a Population of New England Cottontail (*Sylvilagus transitionalis*) on Nomans Land Island National Wildlife Refuge

U. S. Fish and Wildlife Service
Eastern Massachusetts National Wildlife Refuge Complex
Sudbury, MA

Draft
Environmental Assessment

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Chapter 1 - Introduction

Executive Summary

The New England cottontail (*Sylvilagus transitionalis*) was designated as a candidate species under the Endangered Species Act from 2006 through September 2015. Considered a habitat specialist, the New England cottontail occupies thicket habitat which can be found in early successional habitats, regenerating forests, and coastal barrens. Habitat loss to succession, fragmentation and development is thought to be the main threat to New England cottontails. Today, New England cottontails can be found in five distinct populations and have had a range reduction of approximately 86 percent since 1960 (Litvaitis et al. 2006). Technical and executive committees made up of representatives from each of the states with New England cottontail, the U.S. Fish and Wildlife Service (USFWS, Service), National Resources Conservation Service, and the Wildlife Management Institute formed to coordinate conservation efforts for the species across the range and developed the Conservation Strategy for the New England Cottontail (Conservation Strategy) which was approved in 2012. Implementation of the Conservation Strategy including habitat management and creation, captive breeding, population augmentation, and reintroduction of New England cottontails within its historic range has benefitted the New England cottontail. In September of 2015, the Service removed the species from the candidate list, determining that it no longer met the criteria to be considered a threatened or endangered species and issued a "not warranted" finding (USFWS 2015). This decision was based on the conservation actions that had already occurred and a commitment from partners to continue with the conservation actions identified in the Conservation Strategy.

Purpose and Need for Action

The New England cottontail, the only native cottontail rabbit to New England, is considered a species of greatest conservation need. Though no longer protected by the Endangered Species Act, continued conservation actions are critical to the recovery of the species. Habitat loss is still considered the primary threat to New England cottontails, affecting the species ability to find shelter, find food, and breed. The resulting small patches of habitat that remain amplify the effects of predation, competition with eastern cottontails (*Sylvilagus floridanus*), and viability due to small population sizes (USFWS 2015). Most New England cottontails now occur on small parcels, where food quality is low and winter mortality from predation is unsustainably high (Barbour and Litvaitis 1993, Brown and Litvaitis 1995). Further, the current distribution of the species is discontinuous, being divided by expanses of unsuitable habitat that separate the range into five population clusters. Among the factors contributing to the long term and range wide reduction in habitat, Litvaitis (1993) considered habitat succession to be the most important cause of habitat loss for the species. However, at a local or individual patch scale, loss or modification of habitat due to development is also significant. Studies on other wildlife species that depend on thicket habitat for survival show a similar decline in both number and distribution due to the growing scarcity of this habitat type in the northeastern United States. In general, the range of the New England cottontail has contracted by 86 percent since 1960 (Litvaitis et al. 2006) and current land uses in the region indicate that the rate of change, about two percent range loss per year, will continue (Litvaitis and Johnson 2002). This is supported by results from various State surveys conducted since 2004.

One component of the range wide New England cottontail Conservation Strategy is to create 12 landscapes that are capable of supporting 500 or more individuals. Nomans Land Island National Wildlife Refuge (hereafter "Nomans Land Island NWR, refuge") is expected to be able to support 600 or more cottontails. With the lack of mammalian predators, lack of eastern cottontails, and a habitat that is expected to succeed at a very slow rate due to climatic conditions, Nomans Land Island NWR provides many advantages over other sites in attaining this goal. The island also has the potential to provide a source of New England cottontails to augment mainland populations or to start new populations in appropriate habitat, further contributing to the population targets set out in the Conservation Strategy. The release of New England cottontails onto Nomans Land Island NWR could significantly benefit the species by potentially creating a large, self-sustaining population. While isolation from the mainland would hinder natural immigration and emigration, this population alone would contribute to the overall range wide population goals set forth by the Conservation Strategy (Fuller and Tur 2012) by utilizing 628 acres of federally protected habitat, with the potential to support a population exceeding 600 individuals.

Justification for this Proposal

Nomans Land Island NWR, located in Chilmark, Massachusetts was previously owned by the U.S. Navy and used as an aerial bombardment and gunnery range, and has been managed by the USFWS Eastern Massachusetts National Wildlife Refuge Complex since the late 1990's as a sanctuary for migratory birds. The refuge is closed to the public in part because of the presence of unexploded ordnance. As part of the range wide effort to protect and restore the New England cottontail, Nomans Land Island NWR has been identified as a likely successful release site for New England cottontails to improve the species' status. This is largely based on numerous factors that distinguish Nomans Land Island NWR from other potential release sites, including:

(1) Qualitative visual observations made by biologists with expertise in New England cottontail ecology that concluded the extent and condition of shrubland habitats on Nomans Land Island NWR was extensive and likely to support a substantial population of New England cottontails, projected to exceed 600 animals.

(2) The coastal shrubland habitats on the site are projected to remain stable over time and not experience high rates of vegetation succession, which is considered the most significant threat facing New England cottontail populations today.

(3) The lack of eastern cottontails and mammalian predators that influence persistence of mainland populations.

(4) Though avian predators exist on the island including gulls, crows, and raptors, avian predation is expected to be low.

(5) Federal ownership of Nomans Land Island NWR provides a high degree of certainty regarding future management of the island and prevents land use conversion to other uses, which are a significant threat to New England cottontail populations occurring at mainland locations.

In 2010, the need to further assess the island for its suitability as a release site for New England cottontail was outlined in the refuge's Comprehensive Conservation Plan (CCP). Two objectives are relevant: 1) "perpetuate the biological integrity and diversity of coastal island habitats to

support native wildlife and plant communities, including species of conservation concern" and 2) "within 5 years of CCP approval, refuge managers will explore the possibility of introducing New England cottontail on Nomans Land Island NWR." These objectives support the decision made by the New England Cottontail Technical Committee Population Management Working Group, which includes representatives from all involved states in the range of New England cottontails, the Service, the Roger Williams Park Zoo (where captive breeding of New England cottontails is taking place), and local universities, that Nomans Land Island NWR represented a high priority site for the release of captive bred New England cottontail and/or the translocation of wild New England cottontail and may have the potential to sustain a significant breeding population. The need for a quantitative analysis of the habitat present on the island was also identified in the CCP, and this was achieved in 2011 through collaboration among the Refuge, the USFWS Southern New England-New York Bight Coastal Program, and the University of Rhode Island. Development of this environmental assessment was possible through the New England Field office in Concord, New Hampshire and the Eastern Massachusetts National Wildlife Refuge Complex in Sudbury, MA.

The re-introduction of New England Cottontail, evaluated and outlined in this EA, is in keeping with objective 1.1 in the 2007 CCP. The wilderness review in the 2007 CCP determined the area suitable as wilderness, but has not been formally recommended as wilderness. As such, the re-introduction of NEC does not conflict with Service wilderness policies, or Goal four (Wilderness Character) of the CCP.

It is recognized that activities will need to be consistent with Chapter 2, "Wilderness Administration and Resource Stewardship" of Service policy (610 FW 2), including the re-introduction of New England cottontail, if a formal wilderness recommendation is proposed.

A wilderness review will be conducted in 5 years and will re-evaluate Nomans Land Island with regard to wilderness and achieving New England cottontail and other CCP objectives.

Decision to be made

Based on the information provided in this Environmental Assessment (EA) and after completion of the public comment process, the Service will determine that the action either has no significant impact and will select a preferred alternative or write an Environmental Impact Statement. The decision to be made is whether to authorize the release of New England cottontails on Nomans Land Island NWR over a 5-10 year period with the intent of monitoring the growth, survivorship and movements of the introduced cottontails, as well as whether to augment mainland populations of New England cottontails or start new populations in appropriate habitat on the mainland. Establishment of a reproducing, self-sustaining, viable population on Nomans Land Island NWR and contribute to the population targets on the mainland as set out in the Conservation Strategy is the overall goal.

Chapter 2 - Species of Interest

The New England Cottontail

This summary is intended to familiarize the reader with the New England cottontail and to briefly summarize its general distribution, relevant life history and ecology, habitat needs, movement patterns, and threats to its persistence in New England. For a complete review of literature on the species and a detailed assessment of this species' status, we refer the reader to the USFWS 12-Month Finding on a Petition to List the New England Cottontail as an Endangered or Threatened Species (USFWS 2015) and the Conservation Strategy for the New England Cottontail (*Sylvilagus transitionalis*) (Fuller and Tur 2012).

Description

New England cottontails are the only native cottontail east of the Hudson River Valley (Probert and Litvaitis 1995). They are a medium sized light brown rabbit that weighs approximately 2.2 pounds and reaches approximately 16 inches in length. It can be distinguished from the non-native eastern cottontail by its shorter ears and pelage characteristics including a black spot between the ears, a black line along the anterior edge of the ear, and absence of a white spot on the forehead (Litvaitis et al. 1991). It can be difficult to tell the two species apart based on these characteristics. Cranial differences, specifically differences in the pattern of the nasal suture and the length of the supra-orbital process can be used to tell the species apart more reliably (Johnston 1972). The snowshoe hare (Lepus americanus), another species that shares part of the New England cottontail range, is larger and varies in color based on the season (Fuller and Tur 2012).

Life History

Like other cottontails, New England cottontails are a short-lived species, and an individual is unlikely to survive more than two or three years in the wild. This short life-span is compensated for with a high reproductive rate and with individuals that mature quickly, some breeding during their first year. Females can have two to three litters per year, breeding again soon after giving birth. Litter size ranges from three to eight, with an average size of five. Maturation is fast, taking approximately 40 days from the time of conception to juvenile dispersal from the nest (Chapman and Ceballos 1990). Cottontails will continue to breed as long as food resources are present even when an area is fully populated. This density-independent breeding allows the species to survive high predation rates (Chapman, Hockman and Edwards 1982).

Ecology

New England cottontails occupy thickets associated with sandy soils or wetlands and regenerating forests associated with small scale disturbances that set back forest succession, such as logging, fire, flooding, mortality from disease or insects, and high wind. Today, New England cottontail habitats are typically associated with beaver flowage wetlands, idle agricultural lands, power line corridors, coastal barrens, railroad rights-of-way, and patches of regenerating forests (Litvaitis 1993, Tash and Litvaitis 2007). In contrast, eastern cottontails appear to have relatively

generalized habitat requirements and sometimes co-occur with the New England cottontails, but also can often be found in residential areas where they utilize private lawns and golf courses, and in active agriculture areas where hedge row cover may be insufficient to support New England cottontails (Chapman and Ceballos 1990). New England cottontails are considered habitat specialists, in so far as they are dependent upon these early-successional habitats, frequently described as thickets (Litvaitis 2001). Barbour and Litvaitis (1993) found a positive relationship with microhabitats containing greater than 20,234 stem cover units/acre (50,000 stem-cover units/hectare). In addition to New England cottontails demonstrating a strong affinity for large patches of heavy cover, they generally do not venture far from it (Smith and Litvaitis 2000). Smith and Litvaitis (2000) found that when food was not available within the cover of thickets, New England cottontails were reluctant to forage in the open and lost a greater proportion of body mass and succumbed to higher rates of predation than did eastern cottontails in the same enclosure. Thicket habitats and their New England cottontail populations decline rapidly as understories thin during the natural processes of stand maturation (Litvaitis 2001).

New England cottontails are herbivorous and feed on a wide variety of grasses and herbs during spring and summer, and the bark, twigs and buds of woody plants during winter. Barbour and Litvaitis (1993) suggested that the winter diet of New England cottontails is related to the size of the habitat patch and that patch size influences forage availability and quality. In smaller habitat patches less than 6.2 acres (l2.5 hectares), the density of cottontails is higher and results in less available forage per individual. As a consequence, forage quality declined in smaller habitat patches sooner during winter than did forage quality in larger patches. For these reasons, Barbour and Litvaitis (1993) considered patches less than 6.2 acres (2.5 hectares) in size to be "sink habitats" where mortality exceeds recruitment (i.e., reproduction and immigration). Subsequent research found that cottontails in smaller patches generally have lower body weights, are presumably less fit, and tend to experience greater predation rates (Villafuerte et al. 1997).

Distribution

Historically, New England cottontails likely ranged east of the Hudson River in New York including Long Island, through the Champlain Valley and into southern Vermont, southern New Hampshire, southern Maine, and throughout Massachusetts, Rhode Island and Connecticut (Nelson 1909, Litvaitis and Litvaitis 1996). In 1960, the occupied range of New England cottontails was considered to be approximately 34,750 square miles. Since 1960, the range has decreased by 86 percent and is now considered to be 4,701 square miles (Litvaitis et al. 2006). As the range decreased, populations became smaller and increasingly isolated and resulted in the five distinct populations we have today (Litvaitis et al. 2006).

In Massachusetts, where the range was once statewide, including the islands of Martha's Vineyard and Nantucket, New England cottontails are currently restricted to two widely separated population clusters, one on Cape Cod in the east and the other in the Berkshire mountains in the west (figure 1; Cardoza in lit 1999; Litvaitis et al. 2003, unpublished data; Litvaitis et al. 2006). Recently, a population of New England cottontail was confirmed to still be on Nantucket through sampling conducted in 2011, 2013, and 2015 (Beattie personal communication 2015).

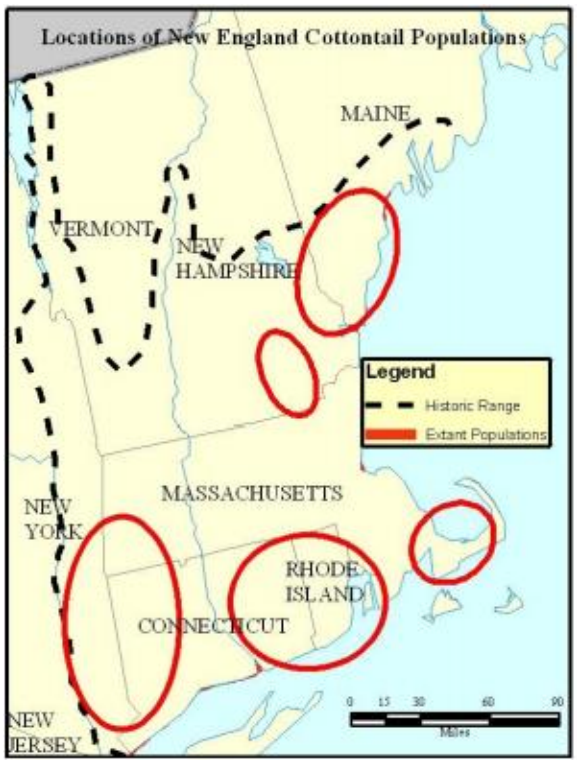

Figure 1. Current and historic distribution of New England cottontail (Fuller and Tur 2012; adapted from Nelson 1909; Litvaitis and Litvaitis 1996).

Chapter 3 - Affected Environments

The national wildlife refuge proposed for involvement in this project, Nomans Land Island NWR, is a 628-acre island located in Dukes County, Massachusetts, approximately three miles southwest of Martha's Vineyard in the Atlantic Ocean. See figure 2.

Figure 2. Location of Nomans Land Island NWR.

Mission and Refuge Purpose

The mission of the National Wildlife Refuge System (and therefore a mission for all refuges) is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans. Nomans Land Island NWR's primary purpose is "for use as an inviolate sanctuary, or for any other management purpose, for migratory birds" (16 U.S.C. § 715d Migratory Bird Conservation Act).

In addition, the refuge's CCP (2010) refines the focus to prioritize focal species and habitats including evaluating the release of New England cottontail on the refuge.

Description

Nomans Land Island NWR (figure 3) is a maritime island that is included within the Martha's Vineyard Island watershed, the Atlantic Flyway, and has been classified as a priority within The Nature Conservancy's North Atlantic Coast ecoregion. This ecoregion is characterized by flat topography, low elevations, scattered moraines, large rivers draining into estuaries and bays, and a mild, humid climate (USFWS 2010).

Figure 3. Aerial photo of Nomans Land Island NWR.

History

Nomans Land Island was likely attached to Martha's Vineyard until recent geological time, within the past 1,000 years. Oral traditions of the Wampanoag Tribe of Gay Head (Aquinnah) support this theory, describing the separation of Nomans Land Island from Martha's Vineyard occurring when Maushop, the first Indian on the Vineyard, drew a line in the sand with his toes and allowed water to rush in and erode the beach, separating the land mass into two islands (Simmons 1986). LaFarge (1933) also supports the theory that the two islands were once attached; describing a storm that finally removed the spit (Nomans Land Island) from the Vineyard.

The island has a fishing history, was purchased for use as a private game reserve in the 1920's, and was a U.S. Navy training facility for about 50 years. Nomans Land Island NWR was established in 1970 as an overlay refuge on the eastern third of the island, and in 1998 ownership of the entire island was transferred to the USFWS from the U.S. Navy.

Management

Nomans Land Island NWR is managed to perpetuate the biological integrity and diversity of coastal island habitats to support native wildlife and plant communities, including species of conservation concern. Approximately 400 acres of the island is maritime shrubland and provides habitat for migrating, breeding and over-wintering landbirds, raptors, butterflies and other species of high conservation concern. This habitat would also provide New England cottontails with a dense native shrub and vine understory with at least 20,000 stems per acre. In addition to the maritime shrubland, Nomans Land Island NWR also provides approximately 15 acres of vegetated dune habitat to support rare plants and nesting shorebirds and terns. Marine mammals, migrating shorebirds and nesting waterbirds benefit from the 100 acres of marine intertidal beach and rocky shore that the island offers. Several freshwater wetland types also exist on the refuge including ponds and marshes that make up 100 to 150 acres of the island's interior. These wetlands support a variety of species including waterfowl, marshbirds, herons, muskrat and turtles. Several species of conservation concern are known to occur on the refuge including plants, invertebrates, reptiles, fish, and birds. Due to the presence of unexploded ordnance throughout the island, including its wetlands and ponds, little is known about the fish and invertebrates inhabiting these areas. Refuge staff maintains two mowed trails to facilitate refuge management, including the replacement of warning signs which notify the public that the refuge is closed to all public use. The U.S. Navy conducts unexploded ordnance assessment and remediation every five years on the mowed trails.

Potential management actions identified in the CCP include but are not limited to exploring the possibility of introducing New England cottontails on the refuge, mapping and control of invasive species, and implementing a biologically-based fire regime for management of native shrub communities. Other management actions exist for environmental education, interpretation, outreach, partnerships, archaeological and cultural resources.

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It is recognized that activities will need to be consistent with Chapter 2, "Wilderness Administration and Resource Stewardship" of Service policy (610 FW 2), including the re-introduction of New England cottontail, if a formal wilderness recommendation is proposed.

A wilderness review will be conducted in 5 years and will re-evaluate Nomans Land Island with regard to wilderness and achieving New England cottontail and other CCP objectives.

Likelihood of New England cottontail being present at Nomans Land Island NWR

Confirmed historical records of New England cottontails on Martha's Vineyard, combined with the geological evidence that suggests Nomans Land Island was once connected to Martha's Vineyard, implies that New England cottontails were also once present on Nomans Land Island NWR. Currently, there is no evidence to support the presence of any terrestrial mammalian species on Nomans Land Island NWR except muskrat (*Ondatra zibethicus*). At one time, several mammal species such as Belgian hare (*Oryctolagus cuniculus*) and muskrat were imported to the island for hunting and trapping, but a small mammal survey conducted in 1974 revealed evidence of only muskrat (USFWS 1974).

Potential Donor Sites on Cape Cod

The following is a list of potential donor sites that have been identified to date, several of which are Massachusetts Division of Fisheries and Wildlife properties. Additional sites may still be identified as more information becomes available on New England cottontail distribution and genetics. Sites will be chosen based on considerations of density of New England cottontail, connectivity to other occupied sites, size, and genetic diversity / integrity. If biologists working on New England cottontail genetics determine the genetic viability would be improved by utilizing cottontails from other sites on Cape Cod or even throughout the Northeast, the potential exists to translocate cottontails from other state, federal or town lands.

Mashpee National Wildlife Refuge (Mashpee NWR)

Location and Size

Mashpee NWR is located 65 miles from the City of Boston, Massachusetts, on Upper Cape Cod. The refuge falls within the boundaries of two towns, Mashpee and Falmouth in Barnstable County. The refuge itself extends from the Sandwich town line and Mashpee Pond in the north, to Popponessett Bay on the east, to South Cape Beach State Park and Waquoit Bay in the south and to the State's Crane Wildlife Reserve and the Hatchville area of Falmouth in the west. The Congressionally approved acquisition boundary for Mashpee NWR includes 6,444 (GIS) acres (4,685 acres in Mashpee and 1,759 acres in Falmouth); the Service has 341.65 acres within this area (USFWS 2014).

Description

The Mashpee NWR is currently managed through a partnership with the U.S. Fish and Wildlife Service, Waquoit Bay National Estuarine Research Reserve, Massachusetts Department of Conservation and Recreation, Massachusetts Division of Fisheries and Wildlife, Town of Mashpee, Town of Falmouth, Orenda Wildlife Land Trust, Falmouth Rod and Gun Club, and the Mashpee Wampanoag Indian Tribal Council, Inc. (USFWS 2014). The refuge was established in 1995 to preserve and protect natural resources associated with Waquoit Bay and for the protection of waterfowl and wildlife. The official establishing purposes are as follows:
... for the development, advancement, management, conservation, and protection of fish and wildlife resources ... 16 U.S.C. § 742f(a)(4)

... for the benefit of the United States Fish and Wildlife Service, in performing its activities and services. Such acceptance may be subject to the terms of any restrictive or affirmative covenant, or condition of servitude ..." 16 U.S.C. § 742f(b)(1) (Fish and Wildlife Act of 1956).

Mashpee NWR consists of pine-oak forest, pitch pine-scrub oak forest, forested wetlands, scrub-shrub wetlands, emergent marsh, grassland, and cranberry bog. The Massachusetts Natural Heritage and Endangered Species program considers coastal Atlantic white cedar swamp, pitch pine-scrub oak forest, and saltmarsh to be priority habitats. Several vernal pools have also been certified on the refuge and provide habitat for a variety of rare species. The Northern long-eared bat, a federally threatened species, and New England cottontail, a species of greatest conservation need, have been confirmed on the refuge. Several state listed species occur on the refuge as well including pied-billed grebe, American bittern, least bittern, upland sandpiper, sedge wren, grasshopper sparrow, northern parula, northern harrier, bald eagle, short-eared owl, peregrine falcon, little brown bat, eastern spade-foot toad, wood turtle, diamondback terrapin, eastern box turtle, water-willow stem borer moth, pine barrens bluet, scarlet bluet, three spine stickleback, and American brook lamprey.

Management

Mashpee NWR is managed collectively and collaboratively through a Memorandum of Understanding between the Service and other partner landowners within the refuge. The Service has no direct authority over work accomplished on partner lands. Partners retain the right to manage their lands within the boundary according to their individual mandates. Development of a CCP for Mashpee NWR is underway that will, when complete, guide management on the refuge for the next 15 years as well as summarize management occurring on partner lands.

We anticipate that future management of Mashpee NWR will focus on maintaining and enhancing the biological integrity, diversity, and environmental health of the coastal, wetland, riverine and upland habitats by conserving and promoting native fish, wildlife and plant communities, with an emphasis on species and habitats of conservation concern through cooperative management efforts. Specifically, we will propose to manage up to 295 acres of pitch pine mixed oak habitat on Service owned lands to improve the health, vigor and resiliency by creating variable age and size structure, increased shrub density and structure to benefit New England cottontails, bats, and migratory songbirds. Prescribed burns and mechanical methods would be used to create these conditions. A one hundred foot buffer would be created around vernal pools to maintain canopy cover and ensure undisturbed upland habitat for vernal pool dependent amphibians. Potential roost trees would be maintained or created for tree roosting bat species. Approximately 45 acres of saltmarsh and stream habitat would be managed for the benefit of species of conservation concern.

Partners would continue to manage lands as directed by their agency or organization’s mission. Their work supports the goal of the Service to maintain and enhance biological integrity, diversity and environmental health of the habitats within the refuge. Partners are already managing to benefit New England cottontails, migratory birds, Lepidoptera, and other species of concern within pitch pine-scrub oak habitat as well as pitch pine-mixed oak habitat. Grassland and shrublands are also being managed for early successional species and several streams and tributaries are managed to benefit alewife, American eel, Sea run brook trout and other

anadromous and diadromous fish. As with Service owned lands, prescribed fire and mechanical treatments is being used to manage many of the upland habitats (USFWS 2014).

New England Cottontail Research

Research on New England cottontail and eastern cottontail occupancy, home range, and habitat use was conducted at Mashpee NWR between the fall of 2010 and 2012. We identified areas on Mashpee NWR and surrounding lands that were occupied by New England cottontail through live trapping, estimate New England and eastern cottontail home ranges, and document habitat use. Live trapping efforts focused on areas thought to be good New England cottontail habitat through GIS mapping and local knowledge of the area (USFWS unpublished report 2013).

Over the course of two winters of trapping, a total of 36 cottontails were caught. Three escaped during processing and no DNA was collected. Of the 33 cottontails sampled, 14 (42 percent) were eastern cottontails and 19 (58 percent) were New England cottontails. Of the 33 cottontails processed, 28 were affixed with radio collars. Each cottontail was tracked from the time of trapping until the collar came off, the battery in the collar stopped working, or the cottontail died. Tracking times were focused around dusk and dawn. However, it was not always possible to track at these times, so daytime tracking also was conducted. There was no tracking between the hours of 10:30pm and 4:30am (USFWS unpublished report 2013).

The home range for New England cottontails is considered to be between one-half and eight acres (*http://www.fws.gov/northeast/pdf/necotton.fs.pdf*; accessed January 2016). All year round home ranges for New England cottontails in Mashpee NWR were larger than that (Table 1). Home ranges of both eastern and New England cottontails at Mashpee NWR were similar for all seasons compared to home range data from Connecticut (Kilpatrick, personal communication 2016). Most of the telemetry locations for the Mashpee NWR cottontails are for diurnal or crepuscular activity, while the Connecticut data represents a 24-hour period. Cottontails on the Massachusetts Military Reservation were most active and had the largest home ranges between the hours of 10:00pm and 3:00am, for which there is no tracking data from Mashpee NWR (Curtis 2016 personal communication). Therefore home range calculations for cottontails on Mashpee NWR may represent minimal home range sizes (Table 1 and Table 2).

Table 1.Home Range Summary for New England Cottontails at Mashpee NWR 2010-2012 (USFWS unpublished report 2013)

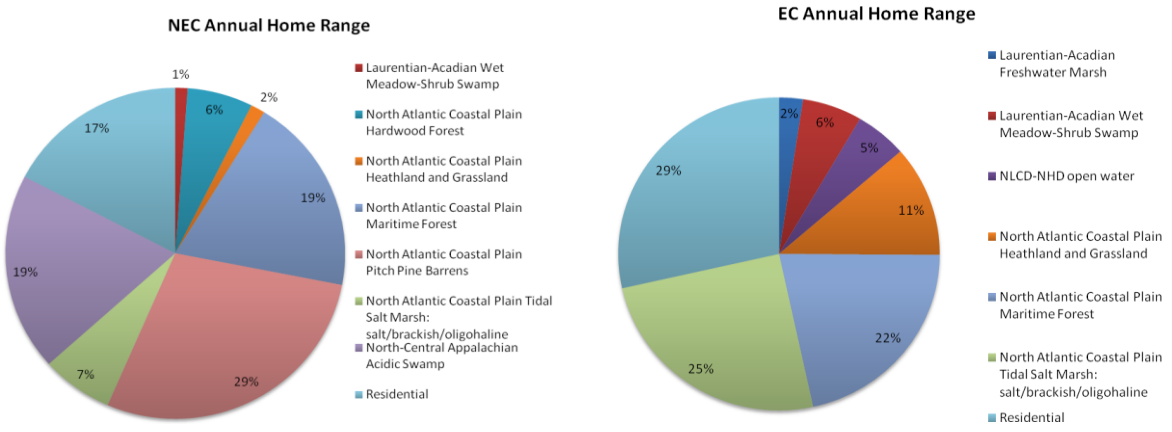
Cottontail	**Year Round**	**April 1-October 31**	**November 1-March 31**
NEC 5		4.9 acres (2.0 hectares)	9.6 acres (3.9 hectares)
NEC8		10.0 acres (4.1 hectares)	
NEC 10	16.2 acres (6.6 hectares)	18.6 acres (7.5 hectares)	
NEC 53			8.3 acres (3.4 hectares)
NEC 57		30.0 acres (12.1 hectares)	
NEC 58	21.9 acres (8.9 hectares)	23.7 acres (9.6 hectares)	8.8 acres (3.6 hectares)
NEC 59	60.1 acres (24.3 hectares)	58.2 acres (23.6 hectares)	48.1 acres (19.5 hectares)
NEC 70	17.0 acres (6.9 hectares)	14.6 acres (6.0 hectares)	
Average	**28.8 acres (11.7 hectares)**	**22.8 acres (9.2 hectares)**	**18.7 acres (7.6 hectares)**

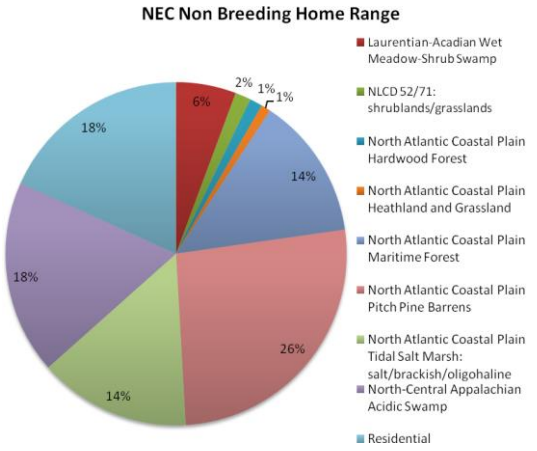
Table 2. Home Range Summary for Eastern Cottontails at Mashpee NWR 2010-2012 (USFWS unpublished report 2013)

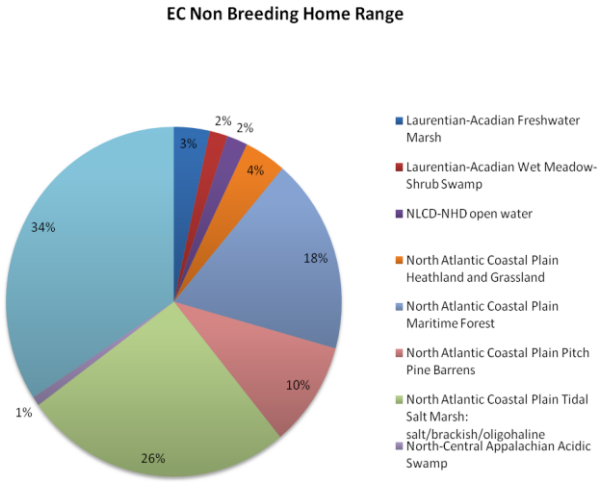
Cottontail	Year Round	April 1-October 31	November 1 - March 31
EC 3			7.2 acres (2.9 hectares)
EC55	49.5 acres (20.0 hectares)	44.6 acres (18.1 hectares)	
EC 60			9.2 acres (3.7 hectares)
EC61	62.4 acres (25.3 hectares)	62.8 acres (25.4 hectares)	56.6 acres (23.0 hectares)
EC 68		5.8 acres (2.4 hectares)	4.2 acres (1.7 hectares)
Average	**56.0 acres (22.7 hectares)**	**37.7acres (15.3 hectares)**	**19.3 acres (7.8 hectares)**

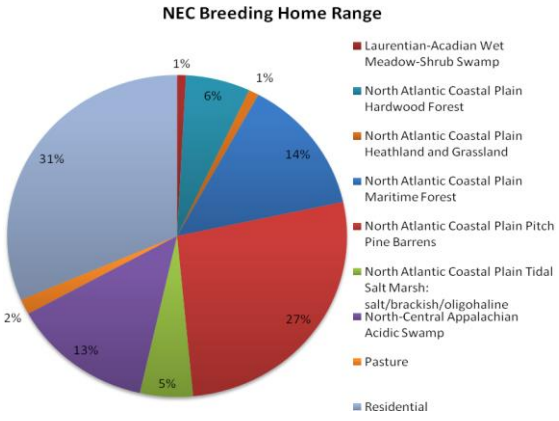
Once home ranges were determined they were overlaid on a cover type map using the Northeast Terrestrial Wildlife Habitat Classification System and general habitat use was examined. Both eastern and New England cottontails occupied various habitat types including residential, North Atlantic coastal plain tidal salt marsh, North Atlantic coastal plain maritime forest, North Atlantic coastal plain pitch pine barrens, North Atlantic coastal plain heathland and grassland, Laurentian-Acadian wet meadow-shrub swamp, and North-central Appalachian acidic swamp according to home range data. Habitat use varied among the year round, breeding and non-breeding home range data (USFWS, unpublished report 2013), as depicted in Figure 4.

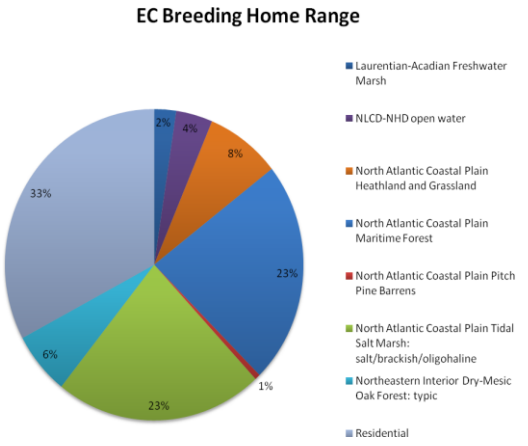
Figure 4. Summary of Habitat Use for New England and Eastern Cottontail at Mashpee NWR (USFWS, unpublished report 2013).











Though more work needs to be done looking at available habitat in relation to home ranges for the cottontails on Mashpee NWR, many of the same habitats found within the New England cottontail home ranges can be found on Nomans Land Island NWR. The majority of habitat on Nomans Land Island NWR is classified as North Atlantic coastal plain maritime forest, North-Central Appalachian acidic swamp, and North Atlantic coastal plain heathland and grassland (Maynard 2013). Both the maritime forest and acidic swamp were habitats that occurred in higher percentages of the New England cottontail's home range on Mashpee NWR (USFWS unpublished report 2013). Other habitats heavily used by New England cottontail at Mashpee NWR but not present on Nomans Land Island NWR include pitch pine barrens and residential areas.

East Sandwich Game Farm

Location and Size

The East Sandwich Game Farm is a 133-acre site located off Route 6A in East Sandwich, MA on Cape Cod in Barnstable County. The Game Farm is bordered by another conservation area called Talbot's Point and together they provide 245 acres of habitat (*http://www.thorntonburgess.org/EastSandwichGameFarm.htm*; accessed December 2015).

Description

The East Sandwich Game Farm consists of fields and forests as well as freshwater ponds and saltmarsh (*http://www.thorntonburgess.org/EastSandwichGameFarm.htm*; accessed December 2015). A majority of the 133-acre site is considered high value habitat for New England cottontail (Scarpitti 2015 personal communication).

Management

The Thornton W. Burgess Society now manages the East Sandwich Game Farm through a cooperative agreement with the Massachusetts Division of Fisheries and Wildlife for educational purposes. However, up until 1987 the game farm was used to raise quail and pheasants for distribution throughout the state. Most of the buildings and pens that were once used to raise game have been removed. The Thornton W. Burgess Society maintains trails throughout the site, mows fields, and has restored 10 acres of salt marsh off Long Creek marsh (*http://www.thorntonburgess.org/EastSandwichGameFarm.htm*; accessed December 2015).

New England Cottontail Research

The East Sandwich Game Farm is considered to be one of the most productive New England cottontail sites in the state. In 1985, New England cottontails were trapped and relocated from this site to Grape Island in Boston Harbor by the Massachusetts Division of Fisheries and Wildlife. Presence was once again confirmed in 2010 through DNA analysis of pellet samples and a specimen identified through skull morphology. In 2015, cottontail trapping was conducted again in order to provide New England cottontails for the captive breeding program. Several New England cottontails were trapped and four were translocated to the Queens Zoo. Trapping efficiency at this site was high, indicating the potential that this is a robust population of New England cottontail (Scarpitti 2015 personal communication).

Sandwich Fish Hatchery

Location and Size

The Sandwich Fish Hatchery is a 35-acre facility off Route 6A in Sandwich, MA on Cape Cod owned by the Massachusetts Division of Fisheries and Wildlife.

Description

The Sandwich Fish Hatchery is one of the oldest state run fish hatcheries in the country. In 1912, the Massachusetts Division of Fisheries and Wildlife purchased the facility which had been in private operation since 1860. Currently the hatchery raises trout; in the past it has also raised salmon. The facility consists of six raceways that hold 52 rearing pools and a hatch house with

14 tanks for egg incubation and rearing. The habitat on the 26-acre site is considered to be of high quality for New England cottontails, containing a scrubby understory of green briar and multiflora rose (*http://www.southcoasttoday.com/article/20120930/Sports/209300314;* accessed January 2016).

Management
The Sandwich Fish Hatchery raises approximately 75,000 brook, brown, tiger, and rainbow trout annually and releases them into rivers, streams, ponds and lakes throughout Southeastern Massachusetts. The facility is open to visitors daily, year-round and encourages the public to see the facility to learn about fish and their habitats (*http://www.southcoasttoday.com/article/20120930/Sports/209300314;* accessed January 2016).

New England Cottontail Research
The Sandwich Fish Hatchery is another site considered to be very productive for New England cottontails. During the range wide survey in 2003, New England cottontails were documented on the site. Presence was confirmed again in 2010 through a hunter- submitted skull which was confirmed by the Massachusetts Division of Fisheries and Wildlife as a New England cottontail. In 2014, cottontail pellet surveys were conducted and eight out of eight samples collected were verified by DNA to be New England cottontail. In 2015, three New England cottontails were trapped and translocated to the Roger Williams Park Zoo for inclusion in the captive breeding program. The trapping efficiency at this site was also considered high, potentially indicating a robust New England cottontail population (Scarpitti 2015 personal communication).

South Cape Beach State Park

Location and Size
South Cape Beach State Park is located in Mashpee, Massachusetts on Cape Cod in Barnstable County. It is a 460-acre park on the edge of Waquoit Bay and Nantucket Sound.

Description
The park contains a variety of habitats including pitch pine-scrub oak forest, kettle ponds, salt marsh, barrier beach, and dunes (*http://www.mass.gov/eea/agencies/dcr/massparks/region-south/south-cape-beach-state-park.html;* accessed December 2015).

Management
The park is managed by the Massachusetts Department of Conservation and Recreation and the National Oceanic and Atmospheric Administration as part of the Waquoit Bay National Estuarine Research Reserve. Several hiking trails and a mile long beach are available for use by the public for fishing, swimming, and hiking. Other recreational opportunities include canoeing, boating, and hunting (*http://www.mass.gov/eea/agencies/dcr/massparks/region-south/south-cape-beach-state-park.html;* accessed December 2015).

New England Cottontail Research
New England cottontail were confirmed at this site through pellet surveys in 2009 and through pellet sampling and trapping in 2011. Eastern cottontails were also confirmed on South Cape Beach in 2011 but all eastern cottontial samples were collected on the north end of the park near the entrance road, whereas samples collected in the interior of the park were New England cottontial (USFWS unpublished report 2013).

Santuit Pond Preserve

Location and Size
Santuit Pond Preserve is 293 acres adjacent to Santuit Pond in Mashpee and Barnstable, Massachusetts on Cape Cod in Barnstable County (Town of Mashpee 2008).

Description
The area includes forested habitat, vernal pools, and cranberry bogs as well as part of the headwaters to the Santuit River (*http://www.mashpeema.gov/Pages/MashpeeMA_Conservation/MapsFolder/Santuit_Pond.pdf;* accessed December 2015).

Management
The property is managed for the conservation of fish and wildlife, habitat protection, and public recreation. Habitats included in this site also support rare species including spotted turtle, Eastern box turtle, spotted salamander, worm-eating warbler, brook trout, herring, American eels, and New England cottontails (*http://www.mashpeema.gov/Pages/MashpeeMA_Conservation/MapsFolder/Santuit_Pond.pdf;* accessed December 2015.). There are approximately 2 miles of trails throughout the parcel that are open to the public (*http://www.townofbarnstable.us/GIS/Maps/santuit-trail.pdf*; accessed December 2015). The land is owned by the towns of Mashpee and Barnstable while the Massachusetts Division of Fisheries and Wildlife holds a conservation restriction (Town of Mashpee 2008).

New England Cottontail Research
Trapping for cottontails was conducted in November 2011 at Santuit Pond. Two cottontails were trapped and identified as New England cottontail through DNA analysis (USFWS unpublished report 2013).

Camp Edwards

Location and Size
Camp Edwards is part of Joint Base Cape Cod. This 14,697-acre property is part of the larger 22,000-acre Joint Base Cape Cod located predominately in Bourne and Sandwich, Massachusetts on Cape Cod in Barnstable County (McCumber 2015 personal communication).

Description

Prior to the establishment of the base the land was used for sheep farming and a state forest. The base was established in 1935 and has been used for military training activities ever since. The northern 15,000 acres of the base is the largest undeveloped tract of land on Cape Cod and includes the largest Pine Barrens north of New Jersey. There are 37 state-listed species on the base which includes seven major plant communities including pitch pine-scrub oak forest, scrub oak barrens, grasslands, wetlands, mixed woods, hardwood forest, and disturbed communities. In addition to the state listed species inhabiting the base, it is considered a stronghold for the New England cottontail (*http://www.thenationsfirst.org/ERC/index.htm;* accessed December 2015). Due to the extensive military training activities on the base, early successional habitats have been created and maintained including scrub oak shrublands which are preferred by New England cottontail (Curtis and Kelly undated). The 2,200-acre Impact Area, an area once used for artillery training is considered to be the best habitat for New England cottontail remaining on Cape Cod (Curtis 2015 personal communication).

Management

There are several management projects ongoing on the base to benefit rare habitats and species. Prescribed fire and mowing are used to maintain early successional habitat including grasslands and shrublands; restoration activities such as native plantings and invasive species control are used to benefit damaged upland areas; and extensive erosion control and trails management are used to maintain soil stability and ensure sustainability of training activities. Conservation activities and training lands management benefit many species of conservation concern including New England cottontail, northern long-eared bat, grasshopper sparrow, American woodcock, brown thrasher, Eastern towhee, prairie warbler, Northern bobwhite, box turtle, and black racer (*http://www.thenationsfirst.org/ERC/index.htm;* accessed December 2015).

New England Cottontail Research

New England cottontail research began in 2006 on the base with an initial baseline survey to provide information on the population status and habitat requirements within the base. Pellet searches have been conducted consistently since 2009 and show that New England cottontails have a preference for the scrub oak shrublands and the pitch pine scrub oak shrublands, but are also found in the pitch pine oak forests. They were not typically found in the hardwood forests. In 2009, a five year study began to look at New England cottontail home range size and to learn more about habitat preferences including vegetation structure and density. Trapping began in 2009 with locations based on the pellet surveys and known historic rabbit locations. Trapped cottontails were fitted with radio collars and were tracked on a rotating 24-hour schedule to determine activity periods and home ranges. Though analysis is not fully complete, preliminary results show the average home range for New England cottontails is very large, roughly 68 acres, and that rabbits prefer habitat dominated by shrubs. Follow-up surveys have continued to use pellet searches, trapping, and radio telemetry to answer additional questions including more specific habitat use, response to management, and interactions with eastern cottontails. Telemetry is now limited to dawn and dusk hours based on the previous studies results (McCumber 2015 personal communication).

Chapter 4 - Review of Translocation and Releases of Rabbits on Islands

Manipulative Population Management

As ecosystems become more and more impacted by human activities, natural processes become increasingly disrupted and the ability of species to compensate for these perturbations diminishes. As a result, species become more vulnerable to local extirpations and even range-wide extinction. Although non-intrusive management approaches such as habitat protection, restoration, and management are critical to maintaining biodiversity and ecosystem function, some species will require more intensive management measures, including population manipulations.

In short, population manipulation requires careful consideration and planning (IUCN 1998, Siegel and Dodd 2000) and should not be undertaken without:

1) understanding of the species' and system's ecology
2) considering the associated ecological, financial, or logistical constraints
3) considering other alternative management techniques in terms of their relative benefits and risks
4) verifying that the threats or causes of the original decline have been abated
5) developing detailed protocols
6) planning subsequent monitoring of affected populations
7) ensuring long-term security & management of habitat/site
8) coordinating with all stake holders

Review of Translocation Literature

Translocations are commonly used in the management of native birds and mammals, although success rates have differed between game (86 percent) and non-game species (46 percent) (Griffith et al. 1989). Variation in success rates has been attributed to number of animals released, habitat quality at the release site, location of the release site within the species' range, and the species' life history (Griffith et al. 1989, Wolf et al. 1996).

Translocations of several species of rabbits to islands have been documented throughout history with varying results. Historical records of releases of the European rabbit (*Oryctolagus cuniculus*), an invasive species in many parts of the world, have revealed devastating impacts on the habitats of those islands where it was introduced (Thompson 1955, Flux and Fullugar 1992). In contrast, none of the historical island releases of cottontails exhibited similar outcomes (Peterson 1966, French 2010 personal communication, Jakubas 2011). On the contrary, island releases of cottontails, New England cottontails in particular, have failed, presumably due to factors such as low recruitment and high levels of depredation.

Record of Introductions of Cottontails (Sylvilagus spp.) on Island Habitats

The oldest recorded experimental release of cottontails was implemented by the Massachusetts Cooperative Wildlife Research Unit in the 1960s (Peterson 1966). To expand knowledge of the

basic biology, population dynamics, and interactions between eastern and New England cottontails, six New England cottontails and five eastern cottontails were released onto a 30-acre (10.5-hectare) island in the Quabbin Reservoir in February and March of 1963. Due to concerns of rabbits traveling back to the mainland during the ice-over of the reservoir, 12 more rabbits (six of each species) were subsequently released in April and May of that year. It is important to note that species identification at this time was based solely on physical characteristics as guided by McDonough and Hames (1953). However, as modern molecular evidence has demonstrated (Sullivan et al. 2013), there is great potential for misidentification using morphological methods of identification. A resident population of snowshoe hares (*Lepus americanus*) was extant on this island, but an effort was made prior to the release of cottontails to trap and remove all hares. Trap censuses were conducted from September 24 to October 3, 1963, and from November 20 to November 25, 1963. Each census included the use of 20 wooden box traps located at 200-foot (61-meter) intervals in addition to observations made by driving through the area. Twelve imprint plots and driving also were used for indirect censusing. Trapping efforts to document the post-release status of cottontails did not result in high enough numbers to estimate a population size, but due to the general low recapture rate of cottontails, it was assumed that the population was larger than the trapping rates indicated. The first trap census in September included 139 trap nights and resulted in 23 captures of five rabbits (one juvenile and two adult eastern cottontails and one juvenile and one adult New England cottontail. The second trap census in October included 100 trap nights and resulted in only nine captures of three juvenile cottontails (one eastern cottontail and two New England cottontails, with only one recapture from the first census). Recruitment was low, with only five juveniles from at least four different litters surviving until the fall census, indicating a ratio below the expected of three or four juveniles to one adult in the fall. By December 31, 1963, no evidence of cottontails was observed (i.e. no tracks or sign could be observed on a nine day old powder snow) and Peterson concluded there were no live cottontails remaining on the island. There are many factors that may have contributed to the low success of this island release of cottontails. First, the ice-over during the winter may have allowed mammalian predators to immigrate to the island or for cottontails to emigrate to the mainland. Additionally, the presence and behavior of a flock of crows observed on the island during the summer of 1963 may support the findings of Kalmbach (1918) and Kirkpatrick (1950) who suggest that crows can efficiently locate and depredate young cottontails. In the final analysis, the reasons for the failure of the cottontail populations introduced to this island remain unknown.

Grape Island is a 54-acre (22-hectare) island located in Boston Harbor (Elliman 2005). Personal communication with Tom French (2010) describes the following history of cottontails on Grape Island. In 1985, 16 New England cottontails were transported from Sandwich, Massachusetts to Grape Island, which had European hares present, but no cottontails. In 1986, 10 New England cottontails were captured during a trapping census, four of which were juveniles. In 1987, a similar census yielded 14 New England cottontails, seven of which were juveniles. Formal trapping censuses did not occur after this, but cottontails were observed during trips to the island in 1989 and 1998. A rabbit skull, identified as a New England cottontail, was recovered during the 1998 visit. During an extensive search of the island in 2009, no pellets or other cottontail sign were observed. A survey of the mammals of the Boston Harbor Islands in 2005 and 2006 resulted in similar findings for Grape Island, with no evidence of any lagomorph species being detected (Trocki et al. 2007).

Penikese Island is a 74-acre (30-hectare) island located in Buzzards Bay which was acquired by the Massachusetts Division of Fisheries and Wildlife in 1924 (French 2010 personal communication). In March 1925, 79 cottontails were released onto the island with the intention of allowing them to breed and provide a source of cottontails that could be trapped and transported back to the mainland to enhance populations at low points or at sites made depauperate by heavy hunting. By early fall, about 200 cottontails were estimated to be on the island, and by 1926 there were "hundreds." Releases continued on Penikese Island from 1925 to 1939, with a total of 369 cottontails from Massachusetts and Vermont being transported to the island during this time period to add vigor to the population. The species of cottontails introduced were not specified, but based on the historic range of New England cottontail in New England it is likely that there were some New England cottontails included in these releases (Litvaitis et al. 2008, Litvaitis et al. 2006). During this same time period, French reports 3,792 cottontails were trapped on Penikese Island and transported to the mainland. In subsequent translocations about 4,300 cottontails were trapped and moved to the mainland. Also, from the 1920s to the 1940s, about 16,200 eastern cottontails were transported to Penikese Island from other states including Kansas, Missouri and other Midwestern states, and a number of cottontails, likely New England cottontails, were transported from Vermont. The population on Penikese Island continues to exist, although rabbits may not be easily observed for two or three years at a time (French 2010 personal communication). Approximately 20 skulls have been collected on the island since 1985 and all have been identified as eastern cottontails.

These case studies give some insight into the potential outcomes of releasing cottontails on coastal islands in the northeast. There is one glaring difference between Penikese Island, which seems to have a self-regulating population of cottontails, and the other islands where cottontails were introduced, which is simply the initial number of rabbits that were released onto the island. Thousands of cottontails were brought to Penikese Island within a 20 to 30 year time period, which likely ensured a genetically robust island population. Penikese Island is also the largest of the islands overviewed here, but is small compared to Nomans Land Island NWR. This indicates that it is possible that a relatively small coastal island can sustain a population of cottontails on a long-term basis. However, it seems likely that the population on Penikese Island is currently only composed of eastern cottontails, so the question of whether or not a population of only New England cottontails would have the same success remains. Another concern that is not addressed in the history of cottontail releases on these islands is the effects, if any, that the cottontails may have had on the habitat. Penikese Island, because of the substantial number of cottontails believed to inhabit the island, was chosen by Maynard (2013) for an assessment of the long-term impact of cottontails on an island habitat, where minimal evidence of cottontail impact was observed.

Outside of New England, another *Sylvilagus* translocation project took place in the Florida Keys. The Lower Keys marsh rabbit (*Sylvilagus palustris hefneri*) is a federally endangered subspecies of marsh rabbit that inhabit the Lower Florida Keys. Similar to the New England cottontail, declines in the Lower Keys marsh rabbit are due to habitat fragmentation and loss (USFWS 1990). One of the recovery strategies identified was to reintroduce the rabbit into unoccupied suitable habitat. According to Faulhaber et al. (2006) wild caught adult and sub adult Lower Keys marsh rabbits were translocated to Little Pine and Water Key during 2002 and 2004.

Rabbits were removed from patches that were connected to other occupied patches and were considered to have moderate to high rabbit density. Rabbits were trapped and within two hours of capture, fit with radio transmitters and hard released into unoccupied sites. Of the 12 rabbits moved to Little Pine Key, 81 percent survived for at least five months while 100 percent of rabbits moved to Water Key survived for at least five months. The Little Pine Key release was comparable to the 79 percent survival rate of the control group. Telemetry data also indicated site fidelity, meaning rabbits set up ranges within the release patch. Reproduction of the translocated rabbits was confirmed through the presence of juvenile pellets and by necropsy of a female found dead from unknown causes. Though rabbits were moved during the height of the breeding season, it is believed that reproduction was delayed by six months. The delay could have been due to stress, a new environment, or lack of detection (Faulhaber et al. 2006). Two years after the release on Little Pine Key, translocated rabbits had occupied additional patches on Little Pine Key and nearby East Water Key (Faulhaber et al. 2007). No negative impacts were noted on the Lower Keys marsh rabbits in areas where adults and sub adults were removed for this project. Surveys done a year or more after the translocation project documented Lower Keys marsh rabbits in these source patches (Faulhaber et al. 2006).

While this study was not with New England cottontails, nor conducted in the northeast, it does provide another study where translocation of a rabbit in the *Sylvilagus* genus was successful. In addition, the study shows that though small numbers of rabbits were released, with high survivorship, the animals were able to successfully breed and disperse. This supports the potential of New England cottontail becoming a self-sustaining population on Nomans Land Island NWR without the need for releasing large numbers of rabbits. While long term monitoring data is not available for the project, translocation is still being considered as a potential management tool for the Lower Keys marsh rabbit (USFWS 2009).

Record of Introductions of New England Cottontails on Island Habitats

According to Jakubas (2011), Stage Island is a 30-acre (12-hectare) island located approximately 0.3 miles (0.5 kilometers) off the coast of Cape Porpoise, Maine and is owned by the Kennebunkport Conservation Trust. Sixteen New England cottontails were transported from Portland and South Portland, Maine to Stage Island in March of 2010 by Maine Department of Inland Fisheries and Wildlife. Eleven of the 16 cottontails were fitted with radio collars. These cottontails were monitored using radio telemetry twice per week. Their documented activity indicated that they spent much of their time on the western side of the island, near where most of the cottontails were released. The mortality rate for these 11 cottontails from March to September 30 was 73 percent, with four cottontails being killed by predators, four with unknown sources of mortality, and three remaining alive. Three of the four predation mortalities were documented to be the result of a long-tailed weasel (*Mustela frenata*), and the fourth was the result of an unidentified predator. Although the habitat on the island seemed to provide good cover (i.e., apparent high stem densities and a thick understory), pellets and tracks were often observed on open shore areas and on a rock pile with no overhead cover, areas where predation may have been a greater factor. A professional trapper was hired to remove any long-tailed weasels after the first mortality was documented, but this effort was unsuccessful. During winter months, some mammalian predators may have taken advantage of the ice-over, or at other times, were able to make the short swim from the mainland. In addition to the long-tailed weasel, other

potential predators present on the island include short-tailed weasel (*Mustela erminea*), mink (*Mustela vison*), red fox (*Vulpes vulpes*), coyote (*Canis latrans*), bald eagle (*Haliaeetus leucocephalus*), northern harrier (*Circus cyaneus*), and various gulls (*Larus* spp.). Trapping in November indicated that only the three known, collared cottontails were present on the island. Twelve cottontails were captured over six days (237 trap nights), with the same three rabbits being repeatedly captured. Images from trail cameras coincided with these findings, with only collared cottontails being detected. These results indicate that there was no evidence of recruitment, however, the two females remaining on the island showed signs of having nursed young. Jakubas (2011) provides two hypotheses to explain the failure of this translocation: 1) "The plants available on the island provided inadequate nutrition making the rabbits and offspring more susceptible to predation"; and 2) "Habitat and environmental differences between the initial capture site and the release site increased the vulnerability of New England cottontails to predation." Strategies such as supplemental feeding and the implementation of artificial, above-ground burrows were employed in an attempt to mitigate these effects, but the effectiveness of these strategies was not evaluated. In the end, they were clearly not adequate to support New England cottontails.

The most recent and most successful, documented release of New England cottontails on an island habitat began in 2012 on Patience Island in Narragansett Bay, Rhode Island. The first attempts at breeding New England cottontails in captivity at Roger Williams Park Zoo in 2011 were successful and produced 11 juveniles; the intention of this effort was to release these offspring onto Patience Island in November 2011. However, due to concerns of harsh weather and monitoring logistics, these juveniles instead spent the winter months in an acclimation pen that was designed and built on a refuge in Charlestown, Rhode Island by the Rhode Island NWR Complex. In March 2012, six penned cottontails were chosen to be released onto Patience Island, and the remaining cottontails were returned to the zoo to continue contributing to the breeding program. On March 28, 2012, six juvenile cottontails, four males and two females, were released on Patience Island. Subsequent releases of nine additional cottontails occurred throughout 2012, with a total of 15 being released during the first year of the program. Using radio telemetry, the cottontails released onto Patience Island were monitored twice a week for the first 10 weeks, and once or twice per week thereafter, weather permitting. New England cottontails are unlikely to live longer than two to three years in the wild (Fuller and Tur 2012) but 80 percent of the cottontails released on Patience Island in 2012 survived at least 10 months. In 2013, this pilot effort continued and the captive breeding program, although still fine-tuning protocols and procedures, produced a total of 90 young, 42 of which survived to weaning. Based on genetic factors, including their relatedness to each other and individuals currently on the landscape, 30 of these young were deemed fit for release in Rhode Island (the others were released at another priority site in New Hampshire). Of these 30 young, seven were released on Patience Island during the summer months of 2013[1]. Monitoring and releases have continued, with 11 cottontails

[1] The numbers reported here are based on the reporting timeline for the captive breeding program, October 1 through September 30. For this reason, cottontails that are born in a given calendar year may not be reported as released until the following reporting year. For example, 30 cottontails were born and deemed for release in RI in 2013, but only seven were released by September 30, 2013. Rabbits born in 2013 but released after September 30th are counted in the 2014 release data.

* These dates represent the last time the radio signal for the individual was detected. The current status and the actual date and cause of mortality cannot be determined due to the loss of radio signal after this date.

being released in 2014 and 26 more in 2015, bringing the total number released to 59 as of September 30, 2015. Five released individuals are confirmed to remain alive, in addition to any offspring that have been produced since releases began, and up to 14 more whose radio signals were lost but mortality was never confirmed. Table 3 summarizes the release program and results at Patience Island. In March of 2015, the Rhode Island Department of Environmental Management and the University of Rhode Island began conducting pellet surveys on the island to determine if and how many new individuals, separate from those that have been released, are present on the island. Microsatellite analysis of the pellets collected during these surveys resulted in the identification of 62 unique individuals, yielding a population estimate of 123 cottontails (McGreevy 2015 personal communication).

Table 3. Summary of results of New England cottontail pilot releases on Patience Island from March 28, 2012 to September 30, 2015.

N	Tag ID	Sex	Release	Mortality	RadioDays	Status	CauseMort
1	1012	M	3/28/2012	6/1/2012	64	Dead	Accident
2	1006	M	3/28/2012	*5/30/2013	425	Lost signal	Battery
3	1007	F	3/28/2012	5/11/2012	44	Dead	Mammalian
4	1009	M	3/28/2012	*5/30/2013	428	Lost signal	Battery
5	1010	M	3/28/2012	5/29/2012	62	Dead	Mammalian
6	1051	F	3/28/2012	*5/30/2013	425	Lost signal	Battery
7	1023	M	7/12/2012	*9/11/2013	426	Lost signal	Battery
8	1026	M	7/12/2012	*9/11/2013	426	Lost signal	Battery
9	1028	M	9/20/2012	*9/11/2013	356	Lost signal	Battery
10	1027	M	9/20/2012	3/13/2013	174	Dead	Avian
11	1033	F	9/20/2012	12/4/2013	440	Lost signal	Radio failure
12	1030	F	9/20/2012	12/4/2013	440	Lost signal	Battery
13	1032	F	9/20/2012	2/7/2013	141	Dead	Avian
14	1036	F	9/20/2012	*12/4/2013	440	Lost signal	Battery
15	1035	F	9/20/2012	2/7/2013	141	Dead	Avian
16	1069	F	7/17/2013	7/30/2013	13	Dead	Unknown
17	1071	F	7/24/2013	*10/9/2014	400	Lost signal	Battery
18	1077	M	7/30/2013	6/2/2014	306	Dead	Unknown
19	1078	M	7/30/2013	1/15/2014	169	Dead	Unknown
20	1068	F	9/11/2013	*12/16/2014	461	Lost signal	Battery
21	1081	F	9/11/2013	10/2/2013	21	Dead	Unknown
22	1084	F	9/11/2013	10/30/2013	49	Dead	Unknown
23	1095	F	10/11/2013	7/30/2014		Dead	Avian
24	1097	F	10/11/2013	10/30/2013	19	Dead	Unknown
25	1100	F	10/11/2013	6/24/2014	255	Dead	Mammalian
26	1096	M	4/17/2014	5/8/2014	21	Dead	Avian-owl
27	1098	F	4/17/2014	6/24/2014	68	Dead	Unknown
28	1099	F	4/17/2014	6/2/2014	46	Dead	Unknown

29	1110	F	4/17/2014	5/8/2014	21	Dead	Avian-owl
30	1111	F	4/17/2014	8/20/2014		Dead	Mammalian
31	1114	F	7/7/2014	5/28/2015		Dead	Avian
32	1116	M	7/30/2014	10/9/2014	71	Dead	Avian
33	1117	M	7/30/2014	*9/3/2015	399	Lost signal	Battery
34	1121	F	10/9/2014	1/21/2015	53	Dead	Avian
35	1123	F	10/9/2014	1/21/2015	53	Dead	Unknown
36	1124	M	10/15/2014	3/11/2015		Dead	Unknown
37	1126	M	10/30/2014	*1/21/2015	82	Lost signal	Radio failure
38	1129	F	10/9/2014	6/17/2015		Dead	Avian
39	1130	F	10/9/2014			Alive	
40	1131	F	10/15/2014	12/16/2014	47	Dead	Avian
41	1136	F	10/30/2014	3/24/2015		Dead	Mammalian
42	1137	F	10/30/2014	12/16/2014	47	Dead	Avian
43	1139	F	10/15/2014	10/30/2014	15	Dead	Unknown
44	1140	F	10/30/2014	12/16/2015	47	Dead	Unknown
45	1143	M	10/30/2014	1/21/2015	82	Dead	Unknown
46	1144	M	10/30/2014	12/16/2015	47	Dead	Unknown
47	1148	F	10/30/2014	12/16/2015	47	Dead	Unknown
48	1149	F	10/30/2014	12/16/2015	47	Dead	Unknown
49	1151	M	10/30/2014	12/16/2015	47	Dead	Unknown
50	1153	M	10/30/2014	12/16/2015	47	Dead	Avian
51	1176	M	7/22/2015	8/6/2015	14	Dead	Unknown
52	1170	M	7/22/2015	8/6/2015	14	Dead	Unknown
53	1172	F	7/22/2015			Alive	
54	1173	F	7/22/2015	8/6/2015	14	Dead	Unknown
55	1178	M	9/3/2015	9/29/2015		Dead	Avian
56	N103	M	9/3/2015			Alive	
57	2010	M	9/3/2015	*9/29/2015		Lost signal	
58	1181	F	9/29/2015			Alive	
59	N101	M	9/29/2015			Alive	

General Findings

The release of New England cottontails on Patience Island, while still in its pilot phase, has proved very successful during the first several years. This pilot study, in combination with the information provided by other historical releases, indicates that a release of New England cottontails on an island such as Nomans Land Island NWR also may be successful. Nomans Land Island NWR and Patience Island are very similar, in that they both have minimal predator presence, no competing cottontail species, and are composed of suitable habitat that is in permanent conservation status. Nomans Land Island NWR differs from Patience Island in that it

is approximately three times larger in size, and therefore could sustain a much larger population of New England cottontails. The other major difference is the complete absence of mammalian predators present on Nomans Land Island NWR, which further reduces the predation risk that would be faced by a population of New England cottontails on the island. The nearest source of mammalian predators would be Martha's Vineyard located 3 miles away, which would make it unlikely that mammalian predators would make it to Nomans Land Island NWR on their own. The status of the population of New England cottontails and the habitat on Patience Island will continue to be monitored closely, and will further inform the decision to release New England cottontails on Nomans Land Island NWR. To date, no major impacts to the habitat on Patience Island have been recorded. Only anecdotal observations of moderately browsed vegetation in areas of concentrated use by the cottontails on the island have been made (Tefft 2014 personal communication).

General Decision-making Tree for Population Manipulations

"This "decision tree" is a series of questions that should be addressed when deciding whether or not translocation or other population manipulations are necessary and appropriate for a particular site. They are presented in roughly the order that they should be considered during the decision making process. At any point in the process, it may be decided that population manipulations should not be pursued, at least under the current conditions. We present only the series of questions here and have presented them in a general framework that is applicable to any number of species and scenarios. An analysis of the decision tree relative to the preferred alternative is provided at the end of Chapter 6.

Decision 1: Is the species secure in the region?

- Yes: No manipulation necessary
- No: Proceed to Decision 2

Decision 2: Is the proposed site within the natural geographic range of the species?

- Yes: Proceed to Decision 3
- No: Population manipulations are not appropriate

Decision 3: Does the proposed target site have a viable, resident population?

- Yes: No manipulation necessary
- No: Proceed to Decision 4

Decision 4: Does the target site have appropriate habitat of sufficient extent to support a resident population?

- Yes: Proceed to Decision 5
- No: Population manipulations are not appropriate at this time. If habitat can be improved through management, population manipulations could be reconsidered once restoration is complete.

Decision 5: Is the site secure, and have potential or historical threats to the species been removed or mitigated?

- Yes: Proceed to Decision 6

- No: Population manipulations are not appropriate at this time and should not be reconsidered until threats have been abated.

Decision 6: What life stage is most appropriate for population manipulations? This decision will be influenced by the life history and ecology of the species, feasibility of working with particular life stages, and potential effects on source population(s).

- Juveniles: If the proposed source population can donate individuals without jeopardizing its own viability, then population manipulations are appropriate.
- Adults: If the proposed source population can donate individuals without jeopardizing its own viability, then population manipulations are appropriate.

The decision to proceed with population manipulations is only the first step. It is crucial that managers and researchers develop protocols detailing the goals of the project, the anticipated duration, number of animals to be used, and the exact methodology for conducting the manipulation, including the collection, handling, care, and release of animals. Most importantly, a commitment must be made to monitor the project to determine its success. In order to evaluate success it will be necessary to have both short-term (e.g., survival) and long-term measures of success (e.g., successful reproduction of offspring born on-site). The indicators selected to measure success will determine the length of monitoring required and the specific type of data that should be collected (USFWS 2007)."

Chapter 5 – Alternatives

Below are proposed alternatives for establishing a population of New England cottontail to Nomans Land Island NWR, including monitoring recommendations for evaluating the effectiveness of each methodology.

Alternatives Considered but Eliminated from Detailed Analysis:

At this time, we are not considering movement of New England cottontails solely from the captive breeding facility or solely from the wild. Though currently the preference is to populate Nomans Land Island NWR with wild caught New England cottontails from Cape Cod, Massachusetts, having the option to supplement wild caught cottontails with captive bred cottontails allows for greater flexibility in ensuring that the appropriate number of animals can be released to the site and that genetic variation is optimized. Both translocation sources have proven to be successful and having the option to utilize both methods will maximize the potential for successfully establishing a reproducing, self-sustaining, viable population of New England cottontails on Nomans Land Island NWR.

Alternative 1: No New Action

Refuge staff will not take any proactive measures towards establishing a population of New England cottontails at Nomans Land Island NWR. Potential habitat would still be protected, but a self-sustaining reproducing population would not be established.

Alternative 2: Direct Translocation of Individuals from Existing Populations and Captive Breeding Facilities

Though there is conflicting information on whether the origin of translocated animals has any impact on the success of a translocation project, several studies have noted that wild caught animals have a higher survivorship rate when translocated (Sokos et al. 2015, Griffith et al. 1989). While the emphasis will be on translocating wild caught cottontails, captive reared cottontails may also be released if sufficient numbers of cottontails cannot be translocated from the wild or if a sufficient number of juvenile cottontails are available for release through the captive rearing program. This will be evaluated on a year by year basis and will be dependent on the number of cottontails that biologists, the Massachusetts Division of Fisheries and Wildlife, and other qualified entities that may include the New England cottontail Technical and Executive Committees, determine can be trapped in the wild, the number of young cottontails propagated through the captive rearing program, and the number of animals that need to be released on the island to support a self-sustaining and genetically diverse population.

Little information exists on the number of cottontails that would need to be released on Nomans Land Island NWR to maximize success of the translocation project. When looking at both avian and mammalian releases, Wolf et al. (1996) released a median number of 50 animals over the course of three years. Important factors contributing to the success of the project included excellent habitat quality in the release site, release of animals into the core of their range, an omnivorous diet, high numbers of animals released, and the animal being a native game species

(Wolf et al. 1996). Variables found not to be important include reproductive rates, number and duration of releases, and the origin of animals (i.e., wild caught verse captive reared; Wolf et al. 1996). In an earlier effort to analyze information on translocation projects, Griffith et al. (1989) showed that reproductive rates were important in determining success of the project and herbivores were more successful than carnivores. Success of the Nomans Land Island NWR translocation project is promising. The habitat quality is high on the release site and it is in the core of the species range. Additional beneficial factors include the lack of mammalian predators and lack of competition from other rabbit species on the island.

Though the number of animals that will be released onto Nomans Land Island NWR is important, there is little information on the number of cottontails that need to be released in order to support a self-sustaining population. Recommendations are to release large numbers of individuals based on the size of the site and site characteristics. The assumption is that a minimum of 10 to 40 animals should be released in a single season (Perrotti and McBride 2014). The program Vortex (Lacy and Pollak. 2014) will be used to run a population viability analysis to guide the number of cottontails that need to be released on the island and over how many years. Because we do not yet have survivorship and reproduction information for cottontails on Nomans Land Island NWR, we will use the best available information from recent releases to populate the model and adapt the information over time as we gain more specific information regarding survivorship and reproduction specific to Nomans Land Island NWR. The number of animals released onto the island in any given year will also be dependent on the number of New England cottontails that can be removed from donor sites or are available from a captive breeding facility. These numbers will be determined by the USFWS, Massachusetts Division of Fisheries and Wildlife, and other qualified entities that may include the New England Cottontail Technical and Executive Committees. Oversight of trapping and removal of New England cottontails from donor sites by these entities will ensure no impacts to the source populations are realized. The Massachusetts Division of Fisheries and Wildlife may facilitate trapping of cottontails towards this effort as staff time and availability warrants.

With the reduced predation pressures due to the lack of mammalian predators on Nomans Land Island NWR, it is likely that survival rates will be greater on the island than at other sites where mammalian predators are abundant. Survivorship of translocated cottontails in 2012 on Patience Island was high, with 80 percent of translocated rabbits surviving at least 10 months (Maynard 2013, Tefft 2013). High survivorship was also noted in the Lower Keys marsh rabbit translocation project with 81 percent surviving on Little Pine and 100 percent of translocated rabbits surviving on Water key (Faulhaber et al. 2006). Mortality rates for rabbits in the wild are typically high and can reach approximately 85 percent during the first year and half but may decrease over the next year, with most rabbits not surviving past their third winter (Petrides 1951).

Both adult and juvenile cottontails would be released on Nomans Land Island NWR as there is little evidence to support success of one age class over another in translocation projects. Letty et al. (2008) suggest that the release of young rabbits during the summer may increase translocation success though this has not been proven. Impacts to donor populations by removing adults is of concern but with mortality rates as high as 85 percent in areas with predators and high mortality rates expected during the winter trapping season, the removal of New England cottontails is not expected to exceed natural mortality rates at a site. The Lower Keys marsh rabbit project moved adults and sub adults that were greater than 800-grams, monitored source populations, and

determined that removal of these animals did not impact the donor populations (Faulhaber et al. 2006). In addition, determining the age of New England cottontails has not been practiced in recent captive rearing studies. An attempt will be made to age New England cottontails that are trapped for translocation as either first year cottontails or adults to determine the validity of age classification based on reproductive organs. Some studies have shown that young rabbits under 4.5 months can be aged by size measurements, but after 4.5 months no measurements seem useful except measurement of reproductive organs (Petrides 1951). It is anticipated that the majority of cottontails trapped for translocation to Nomans Land Island NWR will be greater than 4.5 months old at the time of trapping.

Translocation of cottontails to Nomans Land Island NWR would occur in April or May which is during the breeding season. Reproduction of the Lower Keys marsh rabbits was noted to be delayed in translocated rabbits by about six months even though they were moved at the height of their breeding season (Faulhaber et al. 2006). Monitoring will occur on Nomans Land Island NWR to determine if reproduction occurs during the first season on the island, as all cottontails will be considered of breeding age at the time of release. If there is any delay in reproduction, it may be attributed to the stresses of translocation. Fecundity in cottontails is high as the average reproductive potential is five young per litter and two to three litters per year (DeGraff and Yamasaki 2001). As we gather information specific to the reproductive success of New England cottontails on Nomans Land Island NWR, we will update information in our population viability analysis.

Trapping and Translocation of Individuals

Individual cottontails will be live trapped from the donor populations between November and February using standard wooden or open mesh traps. Trapping will be completed in accordance with established New England cottontail trapping and handling protocols as provided in the Massachusetts Division of Fisheries and Wildlife New England Cottontail Institutional Animal Care and Use Committee (IACUC) documents. Traps will be set in areas most likely to capture New England cottontails, though several sites have both New England and eastern cottontails. Traps will be set in the evening, checked in the morning and baited with apple. Because identification of New England and eastern cottontails needs to be confirmed by DNA analysis, trapped rabbits will be taken to a holding facility at the Bristol County Agricultural High School, Roger Williams Park Zoo, or a similar facility until DNA analysis is complete. Trapping and transportation of cottontails will occur by state permitted or authorized personnel only. The only time a cottontail will be released before DNA analysis is complete, is if there is the presence of an obvious white spot between the ears indicating an eastern cottontail. All trapped cottontails will have a tissue sample taken from the ear, be affixed with an ear tag, weighed, sexed, aged (first year rabbit or adult) and pelage characteristics noted. Cottontails will be transported to the holding facility in the trap or small pet carrier and immediately placed in quarantine. Quarantine will occur in a lab style cage appropriate for cottontails with a small wooden hide box or similar box for cover, hay for substrate material and access to food and water. These guidelines are based off the successful protocol used at the Roger Williams Park Zoo and are approved by the New England Cottontail Technical Committee Population Management Working Group as well as the Massachusetts Division of Fisheries and Wildlife. Time between trapping and placement in quarantine should be as short as possible and access to high quality food should start upon entering quarantine. Calvete et al. (2005) show that stress induced by capture and transport is greater than stress during quarantine. Access to high quality food early in the quarantine period

may also aid in maintaining the cottontails physical condition by reducing weight loss (Calvete et al. 2005). Once DNA analysis is complete, any eastern cottontail in captivity will be returned to the trapping site or other appropriate location determined beneficial by Massachusetts Division of Fisheries and Wildlife.

Once identified by DNA analysis, New England cottontails being held for release on Nomans Land Island NWR will then undergo an intake procedure involving a health screening by a veterinarian. The health screening will include a visual inspection of the animal, weight, blood work for overall health and disease monitoring as well as a topical treatment for fleas. A passive integrated transponder (PIT) tag will be implanted into the rabbit during the health assessment while the animal is under anesthesia. Animals will be kept individually in small lab style cages during quarantine for 30 days and will be released from quarantine if in good physical condition. Cottontails will then be moved from smaller lab style cages to larger pens where they will remain until release on Nomans Land Island NWR. Larger pens will also have small boxes for cover, food, water, and hay for substrate material. Male rabbits will be kept singularly in the pens while females may be kept two to a run unless aggression is noted. An effort will be made to feed cottontails native plant material that would be found on Nomans Land Island NWR including raspberry (*Rubus sp.*), swamp rose (*Rosa palustris*), rugosa rose (*Rosa rugosa*), Virginia rose (*Rosa virginiana*), multiflora rose (*Rosa multiflora*), greenbrier (*Smilax rotundifolia*), red chokeberry (*Aronia arbutifolia*), purple chokeberry (*Aronia floribunda*), black chokeberry (*Pyrus arbutifolia*), common blackberry (*Rubus allegheniensis*), Northern blackberry (*Rubus flagellaris*), Smith's blackberry (*Rubus jaysmithii*), smooth sumac (*Rhus glabra*), staghorn sumac (*Rhus typhina*), winged sumac (*Rhus copallinum*), highbush blueberry (*Vaccinium corymbosum*) and lowbush blueberry (*Vaccinium angustifolium*) to acclimate cottontails to food available on the island. Cottontails will be weighed weekly to monitor their health through the holding period. All animal care, custody, quarantine and genetic testing will conform to current standards documented by the New England Cottontail Technical Committee Population Management Working Group and approved by Massachusetts Division of Fisheries and Wildlife.

Release onto Nomans Land Island NWR would occur in April or May and will be determined by weather conditions. Consultation with the Roger Williams Park Zoo, University of Rhode Island, and the New England Cottontail Technical Committee Population Management Working Group will be needed to determine which cottontails are suitable for release on Nomans Land Island NWR based on health assessments and genetics. New England cottontails that are unsuitable for release onto Nomans Land Island NWR will either be released back to their trap site or relocated to the Roger Williams Park Zoo, Queens Zoo, or other captive breeding facility authorized by the New England Cottontail Technical Committee Population Management Working Group. New England cottontails that are ready for release will be transported to a boat by state permitted or authorized personnel in a pet carrier or box from the enclosure. Refuge staff will then transport cottontails via boat to the island for release.

New England cottontail will be released on Nomans Land Island NWR in areas that offer food and cover. Consideration will also be given to avoid locations that have higher densities of nesting gulls; a potential avian predator for cottontails. To determine if soft release of cottontails on the island will improve survivorship, during the first year, up to half the females will be placed in a temporary pen on the island before final release. All males will be hard released due

to displays of aggression that can occur when males are penned together. Though predation is typically the main cause of mortality after a release, the lack of mammalian predators on Nomans Land Island NWR significantly reduces this concern and therefore a soft release may not increase survivorship. Stress from the translocation process including being housed in a small enclosure, transport, and subsequent release to a new environment is still a concern. A study with wild European rabbits showed that soft release of females increased their survival while a soft release of males reduced survival (Letty et al. 2000). Hard release was successful with both male and female Lower Keys marsh rabbits, with high survivorship, territory creation and reproduction (Faulhaber et al. 2006). The Lower Keys marsh rabbits were not held in captivity long, being released at the translocation site within hours of being trapped. The New England cottontail being released onto Nomans Land Island NWR will have been in captivity for several months before release onto the island. Providing a soft release may reduce stress to the animal and allow it to acclimate to the larger, natural setting before final release. Soft release pens will be approximately six to eight meters in diameter and will include the transport box for additional shelter. Females will be held in the soft release pen for a maximum of three days and then the fencing and transport box will be removed. The need for soft release in future years will be evaluated based on survivorship of the cottontails initially released.

Release of Cottontails through the Captive Rearing Program

Cottontails released through the captive rearing program may include cottontails from the Roger Williams Park Zoo or the Queens Zoo. Individuals recommended for release to Nomans Land Island will have been cleared by the veterinarian for release and their genetic background will be taken into consideration before release to maximize genetic diversity of the Nomans Land Island population. Cottontails may either come from the zoo itself or from holding pens located at Ninigret NWR or Great Bay NWR.

As with the wild caught New England cottontail, animals ready for release will be transported to a boat by state permitted or authorized personnel in a pet carrier or box from the enclosure. Refuge staff will then transport cottontails via boat to the island for release. The timeframe for release of captive reared cottontails will differ from wild caught cottontails and may occur anytime between May and October. Release areas will be in habitat that provides food and cover and have lower densities of potential predators. The same procedure to determine if soft release improves survivorship of translocated wild caught cottontails will occur for captive reared individuals as described above under Trapping and Translocation of Individuals.

Monitoring

New England cottontails translocated to Nomans Land Island NWR will be monitored for survival in the short term and for successful reproduction in the long term. Cottontails will be tagged with a number and monitored through the use of a radio transmitter. Monitoring will occur during the first two weeks after translocation, which is the time period during which the majority of mortality occurred with the Patience Island release (Maynard 2013, Tefft 2013). According to Calvete et al. (2005) increased mortality occurred during the first 22 days of translocation. Monitoring of mortality rates will continue beyond the two weeks if possible and will be dependent on the battery life of the radio transmitter. Information on mortality, dispersal distance, and habitat use will be determined from the data collected. Longer term monitoring may be possible with advances in tracking systems including PIT tags. If it is determined that

more in depth monitoring of the cottontails health is needed, trapping may occur in the fall. Due to the potential for unexploded ordinance on Nomans Land Island NWR, trapping locations will be limited and bait stations may be used to lure cottontails to sites that are accessible by researchers for trapping. Trapped cottontails will be weighed, sexed and pelage characteristics noted. If the cottontail already has an ear tag and a transmitter, the transmitter may be replaced. If the cottontail has never been tagged before, an ear tag will be affixed and a transmitter may be deployed. Long term monitoring will occur through pellet collection. With advances in DNA analysis, individual cottontails can be identified which will allow us to determine if reproduction is occurring. Pellet sampling will be conducted during trips to the island in the spring, summer and/or fall and will be done on an opportunistic basis. Visual observations will also be made on cottontail numbers and age class if possible.

Vegetation monitoring will be conducted every five years to ensure that the habitat is still suitable for New England cottontail and to confirm that there is no overall negative impact to the habitats on Nomans Land Island NWR or other species of conservation concern due to the presence of cottontails. Vegetation monitoring will include stem counts, shrub cover, and species composition, and will be compared to the baseline data collected in 2011.

In addition to vegetation monitoring for habitat quality we will also monitor the potential impact cottontails could have to the state listed species on the island including saltmarsh toad rush (*Juncus ambiguus*), sandplain blue-eyed-grass (*Sisyrinchium arenicola*), dragon's mouth (*Arethusa bulbosa*) seaside knotweed (*Polygonum glaucum*), pygmyweed (*Crassula aquatica*), whorled marsh-pennywort (*Hydrocotyle verticillata*), yellow thistle (*Cirsium horridulum*), sickle-leaved golden-aster (*Pityopsis falcate*) and purple needlegrass (*Aristida purpurascens*). If any of these species are negatively impacted by the translocation of cottontail to the island, fencing will be erected around impacted plant populations to prevent further harm.

Habitat Management

Minimal habitat management is expected on Nomans Land Island NWR as the shrub and grassland community succeeds slowly due to climatic conditions. If habitat conditions warrant management over time, prescribed burning may be used to set back succession. Invasive species control may also be implemented through manual or chemical treatments.

Chapter 6 - Environmental Consequences

Introduction

In this section, we analyze and describe the environmental consequences likely to result from each of the alternatives. We consider potential impacts to the proposed donor site, the recipient site and the species in general. This section of the environmental assessment forms the scientific and analytical basis for comparisons of the alternatives.

Both indirect and direct effects are predicted for the foreseeable future. In the following discussion, the terms "positive", "negative", and "neutral" are used frequently as qualitative measures of how an action would likely affect resources of concern. In some of our discussions below, we are not able to quantify the effect. A "positive effect" means that the actions are predicted to enhance or benefit the resources under consideration and work towards accomplishing goals and objectives over the short or long term. A "negative effect" means that the actions are predicted to be detrimental to a resource over the short or long term, and work against achieving goals and objectives. A "neutral effect" means either a) there would be no discernible effect, positive or negative, on the resources under consideration; or B) predicted positive and negative effects cancel each other out.

Alternative 1: No New Action

Under the No New Action Alternative, New England cottontails would not be moved from the donor site to the recipient site, therefore, there would be little or no impact to the biological resources at each site.

Despite neutral impacts to biological resources at the donor and recipient site under the No New Action Alternative, the cumulative impacts to the species as a whole may be negative. Regarded as a species of conservation concern in every New England state in which they occur, the New England cottontail is a species that requires large, unfragmented blocks of early successional habitat in order for viable populations to exist. Such locations are becoming scarcer in human-dominated landscapes, especially in the northeastern United States. The persistence of this species on the landscape may ultimately depend in part on the establishment or reestablishment of populations on large tracts of suitable land already set aside for wildlife conservation. Nomans Land Island NWR provides this type of expansive conserved land with existing suitable habitat. In addition to its potential to host a substantial population of New England cottontails and significantly contribute to overall range-wide goals, the island may also provide a source population of New England cottontails that could allow for individuals to be transferred to other sites where extant populations could be reestablished or existing populations could be enhanced. Given the isolation from nearby populations of New England cottontails, natural colonization at Nomans Land Island NWR is impossible, therefore the large tract of suitable habitat will remain unpopulated and will not contribute to the range-wide population goals set forth in the Conservation Strategy.

Alternative 2: Direct Translocation of Individuals from Existing Populations and Captive Breeding Facilities (Preferred)

Translocation poses the best chance for successfully establishing a reproducing population of New England cottontails at Nomans Land Island NWR because natural colonization would not occur, due to the current geographic isolation of Nomans Land Island NWR from the mainland, and therefore, all remaining New England cottontail populations.

Impacts to biological resources at donor sites on Cape Cod are likely to be neutral. The removal of cottontails from the donor population may represent natural losses due to predation, and will likely not impact the population in a negative way. Removal of cottontails at other sites has shown no long term impacts to the donor site populations. Donor sites will be monitored through trapping and/or pellet surveys to ensure the continued presence of New England cottontail at these sites. If population decreases are noticed at donor sites, determination of the cause will be difficult as there are many variables that may affect cottontail populations. Trapping for translocation purposes will be suspended unless it is deemed that removal of New England cottontails from the site is best for long term survival of the species as determined by Service and Massachusetts Division of Fisheries and Wildlife biologists. Habitat management may also occur to ensure the continuation of quality habitat at donor sites. Translocated cottontails will also be monitored through pellet collection and telemetry to ensure acclimation at the release site.

The goal of the captive rearing program is to provide animals to re-establish populations of New England cottontails throughout its historical range in suitable sites and to augment existing New England cottontail populations. The release of captive reared New England cottontails on Nomans Land Island NWR is expected to have a positive impact on the species by providing a release site that can support over 500 New England cottontails, one of the goals identified in the Conservation Strategy for the New England Cottontail. In addition to the ability to support a large number of cottontails the island also has no mammalian predators and few avian predators, reducing one of the threats to New England cottontail survival. If the project is successful and a self-sustaining population is formed, animals may then be removed from Nomans Land Island NWR to augment other populations in the future.

Impacts to biological resources at Nomans Land Island NWR are likely to be positive in the long term as this alternative provides the best chance of successfully establishing a reproducing population of New England cottontails. Major vegetation disturbance is unlikely, as previous cottontail releases on islands provide no evidence to indicate that New England cottontails have a negative impact on the vegetative structure of the habitats in which they live (Maynard 2013). Several rare plant species can be found on Nomans Land Island NWR and though negative impacts are not anticipated, refuge staff would monitor rare plant populations identified by Massachusetts Natural Heritage and Endangered Species for impacts due to cottontails. If negative impacts are noted, fencing would be put up around rare plant populations for protection. Another rare species, Leach's storm-petrels which are listed as endangered in Massachusetts, nest in the stone walls on Nomans Land Island NWR. It is not believed that New England cottontails will have a negative impact on storm-petrels. If New England cottontails use the stone walls for cover, only very small juveniles would be able to access the small crevices used by the

storm-petrels (French 2015 personal communication.). There is also no evidence to indicate that New England cottontails would have any negative impacts on other species of conservation concern (i.e., migratory birds) inhabiting the island. Visitor use will not be impacted, as Nomans Land Island NWR is not open to public use.

Cumulative impacts to the New England cottontail are also likely to be positive, as establishing another reproducing population in the northeast landscape will help ensure future survival of this species. Regarded as a species of conservation concern in every New England state in which they occur, the New England cottontail is a species that requires large, unfragmented blocks of early successional habitat in order for viable populations to exist. Such locations are becoming scarcer in human-dominated landscapes, especially in the northeastern United States. Most existing New England cottontail sites are likely remnants of once more extensive habitats. Protecting these existing sites and adding to their acreage is critical for the future recovery of this species. The persistence of this species on the landscape may ultimately depend in part on the establishment or reestablishment of populations on large tracts of suitable land already set aside for wildlife conservation. Nomans Land Island NWR provides this type of expansive conserved land with existing suitable habitat, and is also free of mammalian predators and competitor species. Therefore, in addition to its potential to host a substantial population of New England cottontails and significantly contribute to overall range-wide goals, the island may also provide a source population of New England cottontails that could allow for individuals to be transferred to other sites where extant populations could be reestablished or existing populations could be enhanced. This transfer of individuals to mainland sites would also be considered as a means to control the population of New England cottontails on Nomans Land Island NWR if any unforeseen negative impacts to the population or to island resources are observed. While such negative impacts are highly unanticipated, monitoring of the status of the population and the island's resources will take place, and any and all negative impacts will be addressed.

Analysis of Decision-making Tree for Preferred Alternative

In Chapter 4 we presented a series of questions that should be addressed when deciding whether or not translocation or other population manipulations are necessary and appropriate for a particular site. We present the decision-tree here with site and project specific answers to summarize selection of the preferred alternative. Answers to each decision question are denoted in bold text.

Decision 1: Is the species secure in the region?

- Yes: No manipulation necessary
- **No: Proceed to Decision 2**

New England cottontails are regarded as a species of conservation concern in every New England state in which they occur. Increasing concern about populations in New England resulted in the formation of various New England Cottontail Working Groups with state, federal, and academic participation. Protection of individual early successional sites has been difficult enough, but large-scale landscape conservation is even more daunting, especially in the expensive real estate market of the heavily-developed northeastern U.S.

Decision 2: Is the proposed site within the natural geographic range of the species?

- **Yes: Proceed to Decision 3**
- No: Population manipulations are not appropriate

The site is within the historical range of the species. Nomans Land Island was likely attached to Martha's Vineyard until recent geological time, within the past 1,000 years (USFWS 2010). Confirmed historical records of New England cottontails on Martha's Vineyard and Nantucket combined with geological evidence that suggests Nomans Land Island was once connected implies that New England cottontails were also once present on Nomans Land Island NWR. Surveys in 2011, 2013, and 2015 have confirmed the continued existence of New England cottontails on Nantucket (Beattie 2015 personal communication). The last documented New England cottontail on Martha's Vineyard was in 1984 (Scarpitti 2015 personal communication).

Decision 3: Does the proposed target site have a viable, resident population?

- Yes: No manipulation necessary
- **No: Proceed to Decision 4**

Currently, New England cottontails do not occur on Nomans Land Island NWR.

Decision 4: Does the target site have appropriate habitat of sufficient extent to support a resident population?

- **Yes: Proceed to Decision 5**
- No: Population manipulations are not appropriate at this time. If habitat can be improved through management, population manipulations could be reconsidered once restoration is complete.

Appropriate habitat is present based on previous studies and surveys. See Appendix 1 for a detailed analysis and descriptions of the habitats present on the island.

The overall size of Nomans Land Island NWR is 628 acres, and the management goal for the island is to maintain approximately 400 acres of maritime shrubland habitat. In a New Hampshire study, density estimates ranged from 0.1 to 2.8 cottontails per acre (00.3 to 7 cottontails per hectare) (Barbour and Litvaitis 1993). Since shrub density on Nomans Land Island NWR exceeds shrub densities found in the New Hampshire study, predators are absent, and habitat is contiguous, we believe that the habitat quality found on Nomans Land Island NWR exceeds that found in New Hampshire; therefore, we believe that Nomans Land Island NWR will be capable of supporting higher densities of New England cottontail, estimated at 1.5 to 2.8 per acre (Tur 2015 personal communication). Consequently, we estimate that Nomans Land Island NWR is capable of supporting an estimated number of 600 animals or more. This estimate exceeds the minimum focus area population goal of 500 or more individuals (Fuller and Tur 2012), further indicating that population establishment on Nomans Land Island NWR will provide a substantial contribution toward improving the status of the species.

Decision 5: Is the site secure; have potential or historical threats to the species been removed or mitigated?

- **Yes: Proceed to Decision 6**
- No: Population manipulations are not appropriate at this time and should not be reconsidered until threats have been abated.

Presuming New England cottontails were once present on Nomans Land Island NWR, the causes of original disappearance from the site may have included land clearing for the purposes of settlement and agriculture, introduced predators, and more recently, heavy military disturbance. There appears to be appropriate habitat at present and the elimination of human activities may be conducive for a population to become reestablished.

Decision 6: What life stage is most appropriate for population manipulations? This decision will be influenced by the life history and ecology of the species, feasibility of working with particular life stages, and potential effects on source population(s).

- **Juveniles: If the proposed source population can donate individuals without jeopardizing its own viability, then population manipulations are appropriate.**
- **Adults: If the proposed source population can donate individuals without jeopardizing its own viability, then population manipulations are appropriate.**

Translocating both wild caught adult and juvenile cottontails will be beneficial as both age classes are expected to have high mortality rates through the winter. Therefore, we anticipate that removing adults and juveniles from the source population will equally reflect natural mortality rates within the source population, while benefitting the recipient population. Also, juvenile cottontails will be ready to breed by the second summer so removal of first year cottontails will have approximately the same impact on recruitment as removal of adults from the source population. In addition, determining the age of New England cottontails over 4.5 months can be difficult and has not been tested in recent captive breeding studies.

Translocation of captive reared cottontails will primarily be juveniles, though adults may be released if they are no longer considered appropriate for the breeding program. The purpose of the breeding program is to re-establish populations of New England cottontails in suitable sites therefore translocation of captive bred animals is considered beneficial and negative impacts to the source population are not anticipated.

Chapter 7 - Consultation and Coordination with Others

Refuge staff and Service biologists have been coordinating with New England cottontail researchers throughout the range via various working groups for several years. During 2009 and 2010, regional and refuge staff visited Nomans Land Island NWR on two occasions and visually surveyed the habitats present on the refuge. During these visits it was determined that though the habitat on the island looked appropriate for cottontails, more information was needed before cottontails could be released on the island. Information on the historical presence or absence of cottontails on Nomans Land Island NWR was needed, as well as a literature review of previous cottontail releases and their impacts on islands. The Service also needed to conduct statistically sound vegetation surveys to document the current habitat conditions which will serve as a baseline for assessing impacts to the habitat if cottontails are released on the island. Service biologists gathered the information for the preparation of this EA in coordination with the Southern New England-New York Bight Coastal Program in Charlestown, RI and the New England Field Office in Concord, NH. Service staff continues to coordinate with the New England cottontail technical committee, Massachusetts Division of Fisheries and Wildlife and other New England cottontail biologists as well as the New England Cottontail Technical Committee Population Management Working Group, The University of Rhode Island, the Roger Williams Park Zoo, Queens Zoo and Bristol County Agricultural High School.

Chapter 8 – List of Preparers

The following individuals contributed directly to the writing of this EA document:

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APPENDIX A

Habitat Analysis of Nomans Land Island NWR

The following describes the methods and findings of Maynard (2013), who analyzed vegetation on Nomans Land Island (NWR) as part of a larger study that evaluated coastal islands as potential translocation sites for New England cottontails.

Methods

Nomans Land Island NWR was analyzed to assess its suitability as a future release site for New England cottontails August 1 through 8, 2011. The sampling strategy included stratifying the island based on *a priori* vegetation classifications that were created during a 2010 assessment and provided by the Eastern Massachusetts NWR Complex. This assessment resulted in the island's habitat being divided into 17 distinct vegetation classes (Fig. 1). Considering these vegetation classes, a stratified random sampling scheme was developed. A dataset depicting the existing trails on the island was used to create a 5-meter buffer on either side of the trails. The creation of the 5-meter buffer on both sides of the trails was a necessary safety precaution, due to the unexploded ordnance on the island that might be encountered farther off the trail. It is generally considered safe to walk up to 5 meters off of the trails, an area that has been thoroughly swept for ordnance, and on the trails themselves. The trails were mowed prior to my fieldwork, but the 5-meter buffer where sampling took place was not mowed. For the entire 5-meter trail buffer across all vegetation classes, 100 random points were generated using ArcGIS (Fig. 2). The subsequent habitat classifications that were captured in the 5-meter trail buffer and where points were generated were the Maritime Morainal Shrubland (MMS), Northern Tall Maritime Shrubland (TMS), Upland Switchgrass Vegetation (US), Maritime Switchgrass Marsh (MS), and Northern Beachgrass Dune (BD) (Table 1). The Bayberry Shrub Wetland vegetation class is relatively dominant (Fig. 1) but was not one of the five habitat types that were sampled. This habitat type was excluded from the sampling scheme because the sampling was limited to less than 5-meter from the trails and none of the points generated within this trail buffer fell in the Bayberry Shrub Wetland classification. Of these 100 random points, 79 were accessible and independent of other points. A point was not considered independent if its transect overlapped with the transect of another point. In such a case, the point was shifted along the trail to the minimum distance necessary to prevent any overlap with another point's transect. If it was not possible to shift the point along the trail without overlapping the transect of yet another point, the transect was laid on the opposite side of the trail or not used if this strategy still resulted in overlap with another transect. Each of these random points was navigated to using a handheld Garmin GPS Map60Cx and represented the center of a 25-meter transect. The transect was laid out parallel to one side of the trail as determined by a coin flip, and at a randomly-determined distance from the trail of 1, 2, 3, 4, or 5 meters. Along each 25-meter transect, shrub cover was determined using a line-intercept method (Canfield 1941). Species were recorded intersecting a transect at two heights: woody vegetation from 0.5 and less than or equal to 1.0 meter was considered low shrub, whereas woody vegetation greater than 1.0 and less than or equal to 2.0 meter was considered high shrub. Woody vegetation shorter than 0.5 meter was not recorded along the line transect, but was added in the herbaceous vegetation measurements. All vegetation less than 0.5 meter tall, herbaceous cover, and leaf litter encountered along the line transects was

classified as ground cover. In addition, 1-meter square quadrats were placed at the intersection of four randomly chosen locations along a transect and a randomly chosen distance from the trail, at 1, 2, 3, 4, or 5 meters (Fig. 3). Within each of these four quadrats, stem counts were taken for all woody stems greater than or equal to 0.5 meters tall, less than 7.5 centimeters diameter breast height, after the methods of Barbour and Litvaitis (1993), and were only counted if they were rooted in the quadrat (Litvaitis et al. 1985). Herbaceous cover was estimated using the cover classification system described by Daubenmire (1959) for all vegetation less than 0.5 meter tall (Table 2). Woody and herbaceous species present within each quadrat were recorded in order of dominance. All plant identification followed the taxonomy of Gleason and Cronquist (1991). Canopy cover was measured using a convex spherical densitometer and basal area was measured using a 10-factor prism (20 millimeter x 40 millimeter) in one of the four quadrats at each plot.

The data collected on Nomans Land Island NWR were analyzed using a variety of techniques. First, to ensure sufficient sampling, the variability of each measurement unit (i.e. each 25-meter transect and each 1-meter square quadrat) was contemporaneously monitored during data collection by calculating the mean, standard deviation, and standard error of the shrub cover data. For each variable measured, the standard error was plotted after each sampling episode and examined for plateauing, a sign that sampling error had reached a constant and that an adequate level of sampling had been approached. Obvious plateauing occurred in sampling the MMS habitat type and slightly in the TMS habitat type for all measurements. The other three communities were much smaller and were not sampled sufficiently to plateau the measures of variability; the MS habitat type only had one sampling point.

For the line intercept data, totals were calculated for each species, in each height category. These totals were used to evaluate the relative dominance of each plant species in each height category. Stem densities were calculated by multiplying the average number of stems per square meter by 10,000 to extrapolate to the number of stems per hectare. Herbaceous cover was characterized by determining the most frequently occurring cover class among all plots and by calculating the mean (plus or minus standard error) for the midpoints of the range of each cover class reported.

Woody and herbaceous species composition was determined by calculating dominance values for all species present by using the frequency of occurrence and the number of times the species ranked first in dominance within the quadrat. An overall dominance value was calculated by dividing the number of times the species ranked first in dominance in each quadrat by the total number of quadrats sampled on the island. A dominance value for when the species was present was obtained by dividing the number of times the species ranked first in dominance by the number of times it occurred. This “dominance when present value” gives some insight into the distribution of the species when it was present at a plot. That is, a high “dominance when present” value indicates a plant species that was not necessarily encountered frequently, but occurred in high abundance when it was present. Canopy cover was calculated by averaging the four densiometer measurements taken at each plot, and the overall average canopy cover for the entire island was estimated by averaging these plot averages. This analysis was applied to each habitat type individually and combined for the island. Basal area was not calculated, as no trees were close enough to any plots to be counted; trees were relatively few in number on the island.

Results

The dominant shrub species, for both the low and high shrub categories along the transects on Nomans Land Island NWR were northern bayberry (*Myrica pensylvanica*; 44 percent), winged sumac (*Rhus copallinum*; 30 percent), blackberry and raspberry (10 percent), staghorn sumac (*Rhus typhina*; 5 percent), and arrowwood (4 percent). The most frequently occurring dominant shrub in both height classes among all habitat types was northern bayberry (Table 3). The average overall shrub cover in this habitat type, regardless of height, was 28 percent (Fig. 4). The total low shrub cover in the dominant MMS habitat type was 40 percent and the total high shrub cover was 17 percent (Fig. 5a and 5b; Table 4). The Beachgrass Dune habitat type is the only exception to the definition of the ground cover category, as these areas would be more accurately described as bare ground, but no special designation was made for this category. Species comprising less than 1 percent of the total shrub cover were pooled and classified as other. In the MMS habitat type, the mean stem density was almost double the highest estimate of required stem density for New England cottontails of 50,000 stems/hectare (Barbour and Litvaitis 1993) (Table 5). Variability among plots was high for all habitat types except MMS. The five woody species with the overall highest dominant values observed during the stem counts in the MMS habitat type were northern bayberry, winged sumac, *Rubus* spp., native roses (*Rosa* spp.), and arrowwood (Table 3). The five woody species with the highest dominance values when present were northern bayberry, rugosa rose (*Rosa rugosa)*, staghorn sumac, winged sumac, and multiflora rose (*Rosa multiflora*) (Table 3). Although the percent cover of herbaceous plants was not captured in the line-intercept method, measurements of herbaceous cover within the quadrats indicated that there was a substantial amount of herbaceous vegetation in most habitat types on the island (Table 6). The variability among quadrats for the MMS habitat type (n=212) indicated that an adequate number of samples were taken for all variables. The most frequently occurring cover class in the MMS habitat type was two and the mean of the midpoints of the cover class ranges was 56.3 plus or minus 0.4 percent. However, the most frequently occurring cover class for the entire island (all habitat types combined) is six, but at 57.9 plus or minus 2.0 percent, the midpoint mean was very close the midpoint mean for the MMS habitat type. The five herbaceous species with the highest overall dominance values in this habitat type that were identified were switchgrass (*Panicum* spp.), meadowsweet (*Filipendula ulmaria*), goldenrod (*Solidago* spp.), various unidentified species, and poison ivy (Table 7). Canopy cover estimates indicate a very low percentage of canopy cover on Nomans Land Island NWR. Habitat types were pooled for this measurement because the variability among all plots, regardless of habitat type, was low. The average canopy cover for all habitat types combined was 2.8 plus or minus 1.3 percent; trees were relatively few in number on the island.

Discussion

The analysis of vegetation on Nomans Land Island NWR showed that the habitat has the potential to support a population of New England cottontails. The estimated stem densities on the island far surpass all of the minimum suggested requirements described in other New England cottontail habitat studies, and this measurement is often viewed as one of the most important characteristics in New England cottontail habitat (Barbour and Litvaitis 1993, Litvaitis et al. 2003, Tash and Litvaitis 2007). To guide their searches for New England cottontail, Litvaitis and

Tash (2006) consider patches of habitat dense enough to be suitable for New England cottontail if they had greater than 9,000 stems/hectare of primarily deciduous understory cover. Probert and Litvaitis (1995) created dense patches of habitat of greater than or equal to18,000 stems/hectare to determine any difference(s) in microhabitat use between New England cottontails and eastern cottontails. Although their results are inconclusive, they indicate some evidence that eastern cottontails are more likely to use areas with a lower understory density, and discuss the eastern cottontail's general ability to exploit a wider range of habitats, further supporting the idea that dense understory cover is particularly important for New England cottontail. Barbour and Litvaitis (1993) report that rabbits used sites with at least 50,000 stems/hectare more than sites with sparse understory density in relation to availability. The stem density estimates calculated for Nomans Land Island NWR are often more than double the highest minimum stem density that is indicated in the literature as necessary to support New England cottontail. In addition, various sites known to be occupied by eastern cottontails, New England cottontails, or both in eastern Massachusetts by the U.S. Fish and Wildlife Service Eastern Massachusetts NWR Complex have exhibited stem densities similar to or below those on Nomans Land Island NWR (Table 8).

In addition to the high stem density measurements, Nomans Land Island NWR boasts a variety of plant species that are suggested to be suitable components of New England cottontail habitat, both for structural and nutritional purposes (Dalke and Sime 1941, Reynolds 1975, Litvaitis *et al*. 2006). Although there is not much literature available on the importance of species composition, the structure provided by the dominant shrubs on Nomans Land Island NWR indicates that there is sufficient cover available on the island. On Nomans Land Island NWR, the dominant shrub species are also native to the region, and while the role that invasive species play in the context of New England cottontail survival is unknown, it is more likely that New England cottontails will be well supported by habitats that reflect the historical landscape in which they once thrived and to which they are likely adapted. Although a nutritional analysis of the plants present on the island was not conducted in this study, communication with professionals in the field and previous studies indicate that the variety of shrub species present on the island would provide adequate forage in the winter. During a study in Connecticut, Dalke and Sime (1941) report that blackberry (*Rubus allegheniensis*) is one of the most important sources of winter food for cottontails (eastern cottontails and New England cottontails; results were pooled because food habits observed in this study were nearly identical), in addition to its provision of thick cover. *Rubus* spp. (*R. allegheniensis* and *R. idaeus*) accounted for one of the three shrub species observed in my line-intercept analysis that composed greater than 1 percent of the cover and occurred in 34 percent of the plots in the dominant habitat type. *Rubus* spp. were also considered as important forage species by Litvaitis *et al*. (2006), where *Rubus* spp. were among the species used to help guide New England cottontail pellet surveys in New Hampshire. Reynolds (1975) also mentions *Rubus* spp. as dominant in his trapping study of New England cottontail and eastern cottontail, and states that several of the dominant woody species in his study are known to be food items of both cottontail species. Dalke and Sime (1941) also found that sumacs, which are prevalent on Nomans Land Island NWR, provide a great deal of food for cottontails during the winter. On Nomans Land Island NWR, *Rubus* spp. composed 10 percent and sumacs (*Rhus typhina* and *Rhus copallinum*) 35 percent of the shrub cover, as measured by the line transects.

Table 1. Number of sampling points assigned to each of the habitat classification types on Nomans Land Island NWR during a 2011 vegetation survey to assess the suitability of the island as a release site for New England cottontail. The area of each habitat type is given for the entire island and within the 5-meter buffer in which sampling took place. The five habitat types captured in my sampling account for 67 percent of the island's total area of 255 hectares.

	A	B	C	D	E
Habitat Type	Area (ha)	% of Island (=A/255)	Area in Buffer (ha)	% of Sampling Area (=C/7.0)	% of Sampling Points (= n/79)
Maritime Morainal Shrubland (n=53)	101.7	40%	4.6	65%	67%
Tall Maritime Shrubland (n=13)	54.3	21%	1.1	15%	16%
Upland Switchgrass (n=9)	7.2	3%	1.0	14%	9%
Beachgrass Dune (n=3)	4.7	2%	0.2	3%	4%
Maritime Switchgrass (n=1)	3.5	1%	0.2	3%	1%
Total (n=79)	171.4	67%	7.0	97%	97%

Table 2. Cover classes (after Daubenmire 1959) used to estimate herbaceous cover within 1-meter square quadrats during a vegetation survey on Nomans Land Island NWR during August of 2011. Midpoints of each range were used to estimate mean herbaceous cover.

Cover Class	% Cover Range	Midpoint
1	0-5%	2.5
2	6-25%	15.5
3	26-50%	38
4	51-75%	63
5	76-95%	85.5
6	>95%	98

Table 3. Woody species observed during stems counts in 212 1-meter square quadrats in the Maritime Morainal Shrubland habitat on Nomans Land Island NWR during a vegetation survey conducted in August 2011.

A	B	C	D	E	F
Species	No. Occurrences	Frequency (=B/212)	No. times Ranked #1	Dominance Value When Present (=D/B)	Overall Dominance Value (=D/212)
Myrica pensylvanica	138	0.65	94	0.68	0.44
Rhus copallinum	92	0.43	49	0.53	0.23
Rubus spp.	73	0.34	25	0.34	0.12
Rosa spp.	50	0.24	14	0.28	0.07
Viburnum dentatum	9	0.04	4	0.44	0.02
Rhus typhina	7	0.03	4	0.57	0.02
Toxicodendron radicans	6	0.03	2	0.33	0.01
Rosa rugosa	3	0.01	2	0.67	0.01
Rosa multiflora	2	0.01	1	0.50	0.01
All Unknown	5	0.02	0	0.00	0.00
Smilax spp.	1	0.01	0	0.00	0.00
Gaylussacia baccata	1	0.01	0	0.00	0.00

Table 4. Total percent shrub cover along all transects in each habitat classification type sampled using the line-intercept method on Nomans Land Island NWR in August 2011. Measurements of cover at each plot within each habitat type were totaled and divided by the total possible cover in the habitat type (i.e. length of transect multiplied by the number of plots sampled) to obtain the total percent cover.

Habitat Type (# of plots sampled)	Low Shrub Cover	High Shrub Cover	Cover (All Heights)	Ground Cover
Maritime Morainal Shrubland (n=53)	40%	17%	28%	72%
Tall Maritime Shrubland (n=13)	44%	40%	41%	59%
Upland Switchgrass (n=9)	34%	3%	19%	81%
Beachgrass Dune (n=3)	25%	0%	13%	87%
Maritime Switchgrass (n=1)	77%	17%	47%	53%

Table 5. Average stem density (± standard error) in each vegetation community type on Nomans Land Island NWR in August 2011.

Vegetation Community	Mean stems/ha ± SE
Maritime Morainal Shrubland (n=53)	96,038 ± 5,367
Northern Tall Maritime Shrubland (n=13)	180,000 ± 21,544
Upland Switchgrass Vegetation (n=9)	72,500 ± 10,338
Northern Beachgrass Dune (n=1)	106,667 ± 38,145
Maritime Switchgrass Marsh (n=3)	177,500 ± 30,652
Combined (n=79)	107,931 ± 5,634

Table 6. Average and most frequently occurring herbaceous cover classes present in each vegetation classification type on Nomans Land Island NWR in August 2011.

Habitat Type (# quadrats sampled)	Midpoint Mean ± SE	Mode Cover Class
Maritime Morainal Shrubland (n=212)	56.3 ± 0.4%	2
Tall Maritime Shrubland (n=52)	57.5 ± 1.9%	6
Upland Switchgrass (n=40)	79.7 ± 3.6%	6
Beachgrass Dune (n=12)	27.4 ± 8.0%	1
Maritime Switchgrass (n=4)	21.1 ± 5.6%	2
Combined (n=320)	57.9 ± 2.0%	6

Table 7. Herbaceous species observed in 212 1-meter square quadrats in the Maritime Morainal Shrubland habitat on Nomans Land Island NWR during a vegetation survey conducted in August 2011.

A	B	C	D	E	F
Species	No. Occurrences	Frequency (=B/212)	No. Times Ranked #1	Dominance Value When Present (=D/B)	Overall Dominance Value (=C/212)
Panicum spp.	159	0.75	103	0.65	0.49
Filipendula ulmaria	110	0.52	38	0.35	0.18
Solidago spp.	120	0.57	22	0.18	0.10
All Unknown	70	0.33	8	0.11	0.04
Toxicodendron radicans	37	0.18	8	0.22	0.04
Achillia millefolium	38	0.18	7	0.18	0.03
Grass spp.	12	0.06	4	0.33	0.02
Rubus spp.	28	0.13	3	0.11	0.01
Parthenocissus quinquefolia	19	0.09	3	0.16	0.01
Rubus hispidus	17	0.08	3	0.18	0.01
Lonicera japonica	11	0.05	3	0.27	0.01
Phragmites australis	4	0.02	3	0.75	0.01
Potentilla recta	12	0.06	1	0.08	0.01
Rhus copallinum	1	0.01	1	1.00	0.01
Unknown fern	1	0.01	1	1.00	0.01
Osmunda cinnamomea	1	0.01	1	1.00	0.01
Cirsium spp.	6	0.03	0	0.00	0.00
Rosa spp.	5	0.02	0	0.00	0.00
Triadenum spp.	2	0.01	0	0.00	0.00
Rumex acetosella	2	0.01	0	0.00	0.00
Trifolium spp.	2	0.01	0	0.00	0.00
Pteridium aquilinum	1	0.01	0	0.00	0.00
Eupatorium perfoliatum	1	0.01	0	0.00	0.00
Viburnum dentatum	1	0.01	0	0.00	0.00
Verbascum thapsus	1	0.01	0	0.00	0.00

Asclepias spp.	1	0.01	0	0.00	0.00

Table 8. Stem density estimates on Nomans Land Island NWR measured in August 2011 compared to stem densities estimated by the Eastern Massachusetts NWR Complex at various New England cottontail occupied mainland sites in 2012.

Site	Mean stem density/m^2 (± SE)	Mean stem density extrapolated to a per ha basis
Nomans Land Island NWR (entire island)	10.7 ± 0.6	107,000
Nomans Land Island NWR (Maritime Morainal Shrubland habitat only)	9.6 ± 0.5	96,000
Eastern Massachusetts National Wildlife Refuge Complex Sites:		
Quashnet	1.7 ± 0.3	17,000
Orenda	8.0 ± 0.5	80,000
Greenwood	6.5 ± 0.5	65,000
Gravel Pit (pre-burn)	6.7 ± 0.9	67,000
Gravel Pit (post-burn)	4.0 ± 0.5	40,000

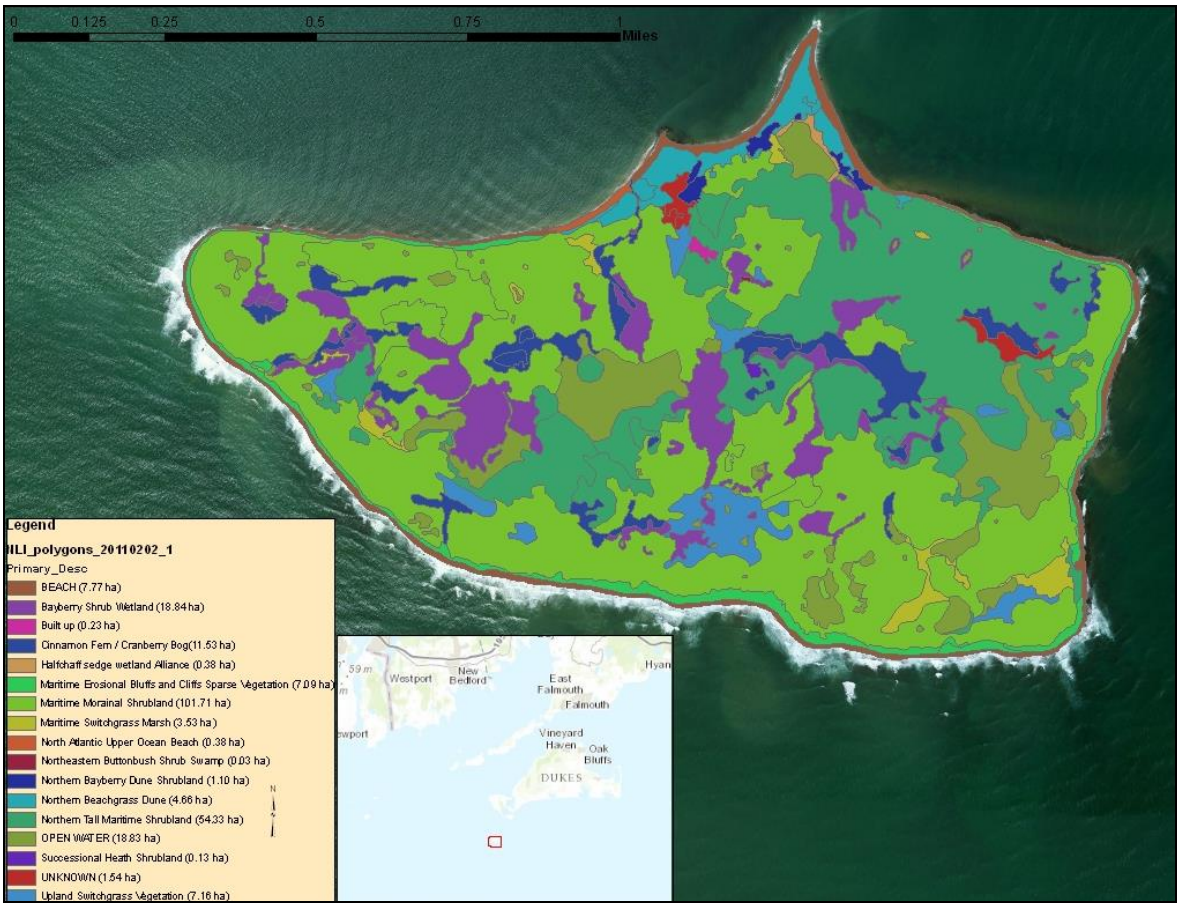


Figure 1. Map of Nomans Land Island NWR showing the 17 habitat classifications provided by the Eastern Massachusetts NWR Complex in 2010.

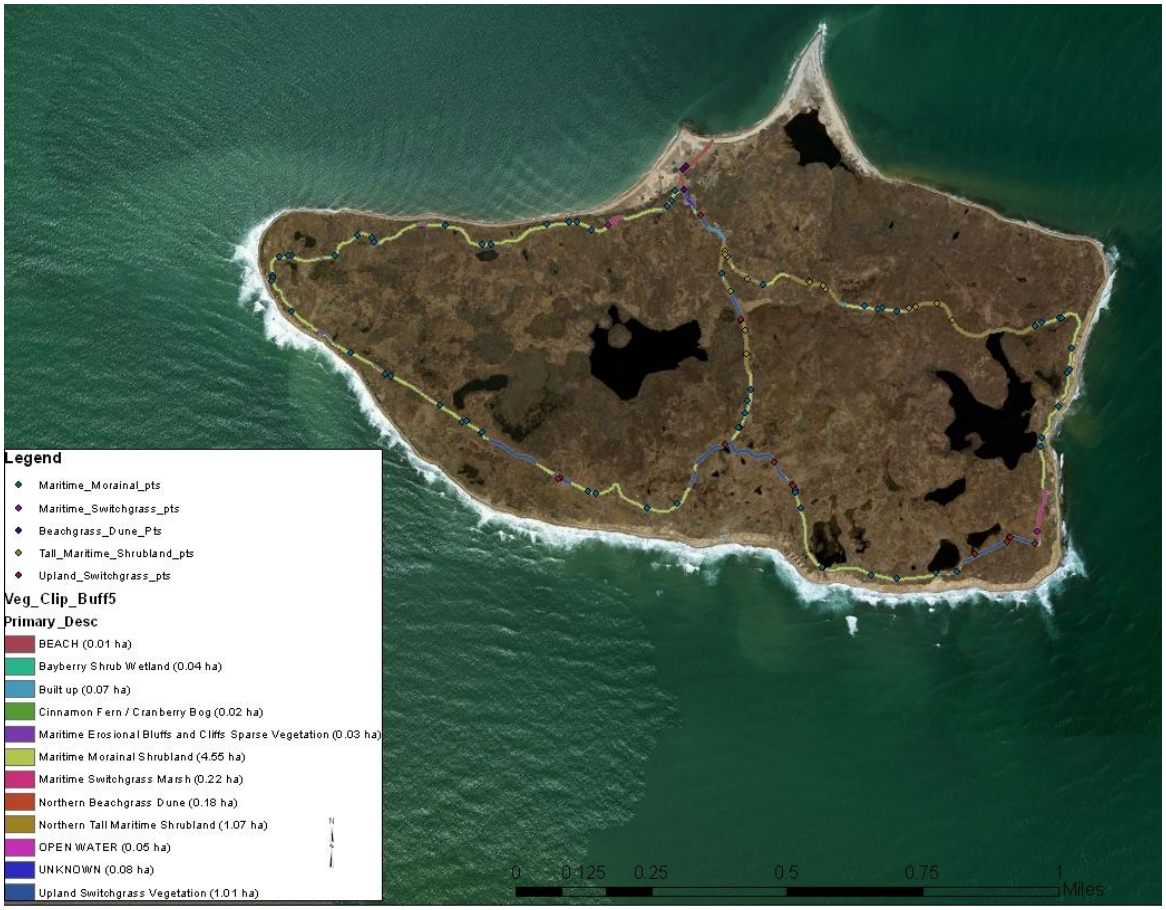


Figure 2. Random sampling points that were generated within the 5-meter buffer around mowed trails for a vegetation survey conducted on Nomans Land Island NWR in August 2011. The 5-meter buffer captured 12 habitat classifications, and randomly generated points fell in five of these 12 classifications.

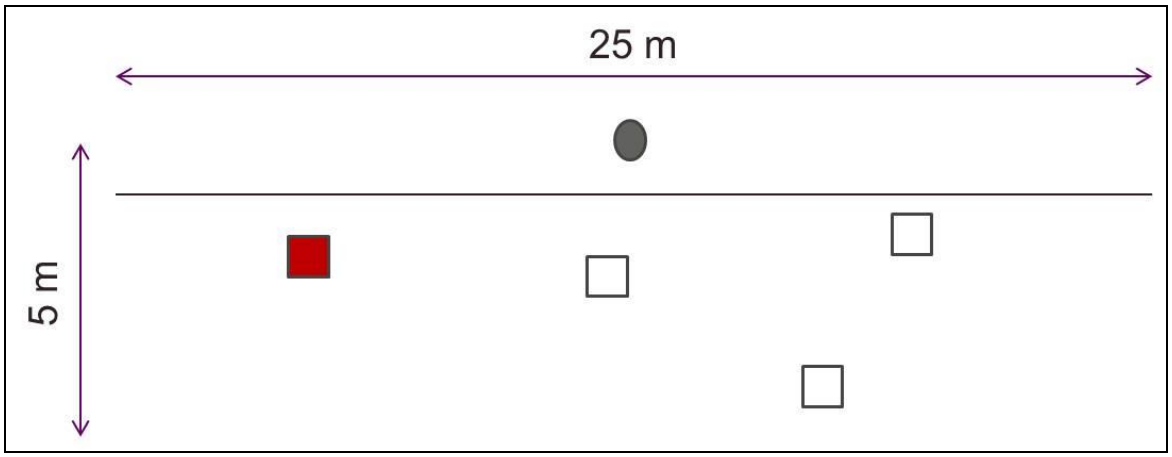


Figure 3. Plot design for the vegetation survey conducted on Nomans Land Island NWR in August 2011. The side of the trail on which the 25-meter line-transect was placed was determined randomly by a coin flip at each plot, and was used to estimate shrub cover with the line-intercept method (Canfield 1941). Herbaceous cover, stem density and species composition were measured in each of the four randomly-placed 1-meter square quadrats. The quadrat shown in red indicates the randomly chosen quadrat where canopy cover and basal area measurements also were taken.

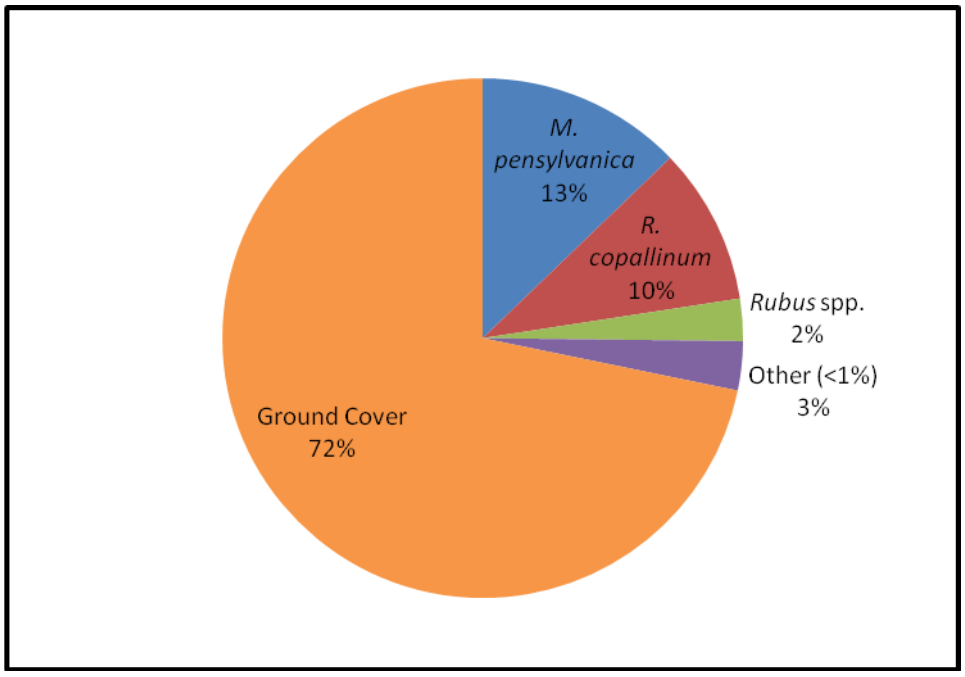
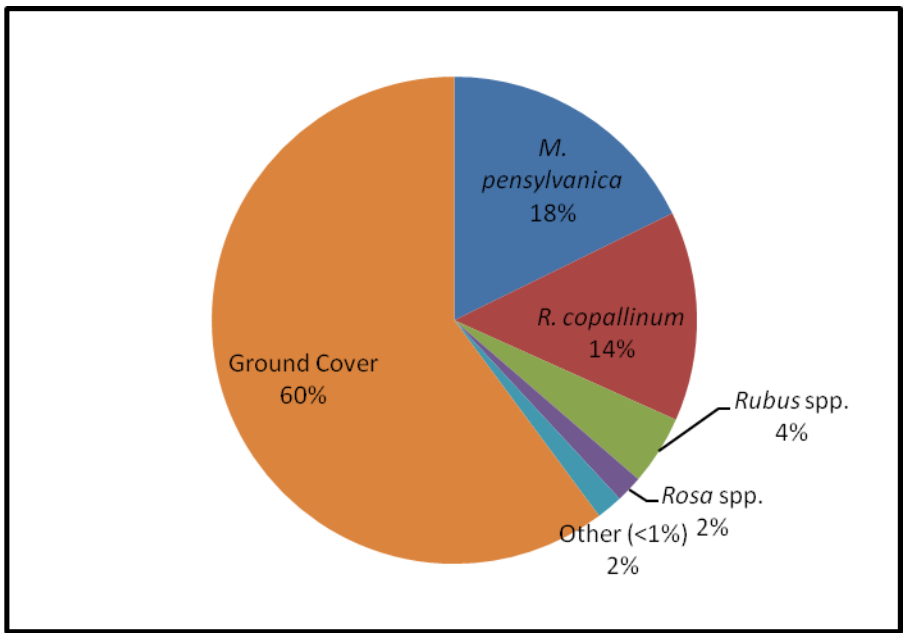


Figure 4. Percent cover of shrubs (0.5 to 2 meters in height) and ground cover (woody vegetation less than 5 meters tall, herbaceous cover, and/or leaf litter) along line transect plots within the Maritime Morainal Shrubland designation on Nomans Land Island NWR in August 2011 (n=53).

a) Low Shrub Cover



b) High Shrub Cover

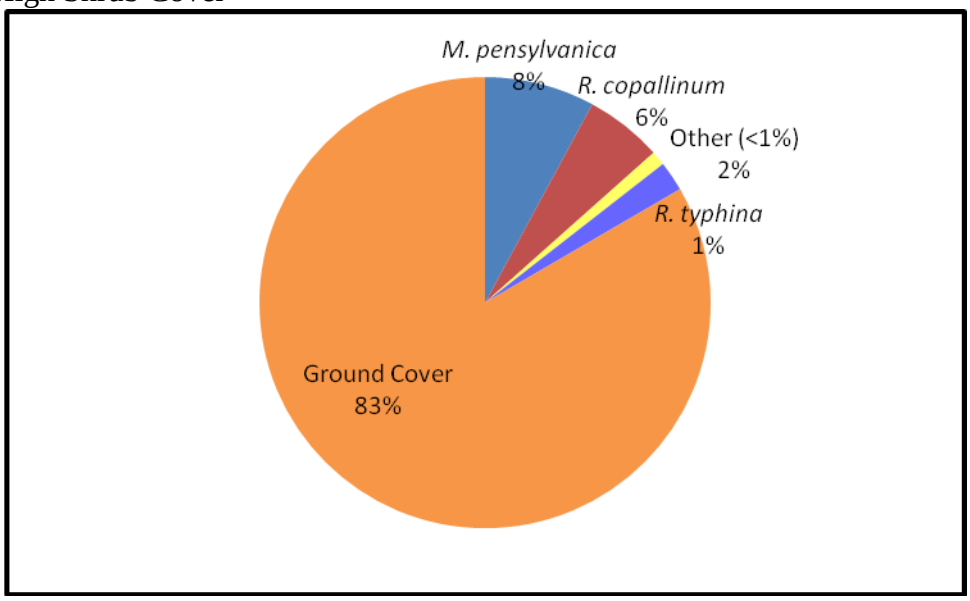


Figure 5. a) Percent cover of low shrubs (0.5 meter to less than or equal to1-meter in height) and b) high shrubs (greater than1 meter to 2 meters in height) and ground cover (woody vegetation less than 5 meters tall, herbaceous cover, and/or leaf litter) along line transect plots within the Maritime Morainal Shrubland designation on Nomans Land Island NWR in August 2011 (n=53).

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