Conservation Strategy

for the

New England Cottontail

(*Sylvilagus transitionalis*)

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and

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with input from the

New England Cottontail Technical Committee

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Adopted by the Executive Committee

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List of Abbreviations and Acronyms

ESA	Endangered Species Act of 1973
CTDEEP	Connecticut Department of Energy and Environmental Protection
CSWG	Competitive State Wildlife Grant
EC	Eastern Cottontail
ESF	State University of New York Environmental Scholl of Forestry
LPWG	Land Protection Working Group
MEIFW	Maine Department of Inland Fish and Wildlife
MMR	Massachusetts Military Reservation
NALCC	North Atlantic Landscape Conservation Cooperative
NEFO	U.S. Fish and Wildlife, New England Field Office
NEC	New England Cottontail
NECLMT	NEC England Cottontail Land Management Teams
NERR	National Estuarine Research Reserve
NEZCC	New England Zoo Conservation Collaborative
NFWF	National Fish and Wildlife Foundation
NGO	Non-governmental Organization
NHFGD	New Hampshire Fish and Game Department
NWR	National Wildlife Refuge
NRCS	USDA, Natural Resources Conservation Service
NYDEC	New York Department of Environmental Conservation
OWG	Outreach Working Group
PFW	Partners for Fish and Wildlife
PMWG	Population Management Working Group
RCN	Regional Conservation Needs Program
RIDEM	Rhode Island Department of Environmental Management
RMWG	Research and Monitoring Working Group
RWPZ	Roger Williams Park Zoo
SNEP	U.S. Fish and Wildlife, Southern New England/ New York Bight Coastal Program
SWG	State Wildlife Grant
UNH	University of New Hampshire
UNHCE	University of New Hampshire Cooperative Extension
URI	University of Rhode Island
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAP	Wildlife Action Plan
WCS	Wildlife Conservation Society
WMI	Wildlife Management Institute

1.0 Executive Summary

The New England cottontail rabbit (*Sylvilagus transitionalis*), abbreviated as NEC, is the only rabbit native to the northeastern United States from the Hudson River Valley of New York eastward. The NEC is currently threatened by the loss of its habitat through development and forest succession. It may also be imperiled by encroachment into its range by the introduced eastern cottontail (*Sylvilagus floridanus*), which may compete with NEC and seems more able to use diverse and fragmented habitats and avoid predators.

Biologists do not believe that NEC interbreed with the eastern cottontail; NEC and eastern cottontail hybrids, if born, apparently do not survive. Taxonomists have recognized the New England cottontail as a separate species since the 1990s, when it was split off from the Appalachian cottontail (*Sylvilagus obscurus*) on the basis of chromosomal differences, morphology, and geographic separation.

In 2006 the U.S. Fish and Wildlife Service responded to conservationists concerned that the population of NEC was declining. The Service reviewed the status of the species and the factors threatening it, and designated NEC as a "candidate" for listing under the federal Endangered Species Act.

This Conservation Strategy sets forth actions to address threats to NEC and show how conservation partners are implementing those actions to ensure the presence of NEC into the future as well as precluding the need to place the species on the Endangered Species List.

To conserve NEC, the Fish and Wildlife Service set a regional habitat restoration goal of 27,000 acres to support 13,500 rabbits. The six states where NEC are currently found set combined habitat restoration goals totaling 42,440 acres to support 21,650 rabbits. And the NEC Technical Committee, a group of wildlife biologists from all of the states in the species' range, set a goal of 60,625 acres of habitat and 32,720 rabbits. (At each level, the sum of goals exceeds the preceding level to account for localized uncertainties in the feasibility of conserving the species.)

The NEC Technical Committee delineated 47 focus areas for NEC conservation, each having 11 or more habitat patches, with a combined capacity to support 80 metapopulations of NEC. Conservationists plan to manage 31 focus areas between 2012 and 2020, with a target level of 35,987 acres of habitat, including 15,595 on private land, 1,290 on municipal land, 18,555 on state land (to include 10,475 acres managed through controlled burning), 525 on federal land, and 25 acres on Native American Tribal land. Approximately 473 areas of habitat have been identified as feasible for creating habitat patches greater than 25 acres, and 470 areas feasible for creating habitat patches under 25 acres in size, projecting a total of 943 distinct habitat-management operations.

The estimated cost to provide planning and oversight for the 943 operations by 2030 exceeds $4 million. Conservation partners recognize that the long-term cost of maintaining habitat for NEC may be substantial, but due to uncertainty regarding the potential use of self-sustaining natural habitats, this Strategy does not attempt to estimate that cost.

The estimated cost to recruit private landowners to create habitat for NEC, and to complete eligibility, enrollment, and project planning, is estimated at a minimum of $6.5 million for 15,595 acres. Another $27 million will be needed to actually manage habitat on those acres, for a total of over $33 million.

Managing habitat on 9,895 acres of public land will cost over $17 million; an additional 10,475 acres of state land are slated for management through controlled burning at an additional cost of $2 million.

According to parcel analyses, over 145,268 acres of public land are highly suitable as potential NEC habitat. Increasing management on public land would lead to substantial savings by (1) letting managers increase patch size, reducing the number of necessary operations and their accompanying planning and oversight; (2) reducing or eliminating the cost of recruiting and enrolling private landowners; (3) creating efficiencies of scale; (4) increasing the opportunity to use controlled burning as a management tool, at a savings of $1,500 per acre; and (5) generating income from the sale of timber products.

With few exceptions, managing public land is much cheaper than managing private land or acquiring land for NEC habitat. Conservation partners believe that managing public land will generate a quicker response at an estimated 30 to 90 percent savings compared to focusing management on private lands. Parcel analyses identified 145,268 acres of public lands with good potential for management, but due to perceived barriers, the NEC Technical Committee lowered this figure to 23,812 acres. Evaluating and removing the barriers to managing public land must be a high priority.

The NEC Technical Committee identified almost 30,000 acres of naturally self-sustaining shrub habitat in the NEC range, mainly on Massachusetts' Cape Cod and in New York state, and biologists have increasingly documented NEC on those lands. While enough naturally self-sustaining acres of habitat are not available in all states, some swamps, pitch-pine and scrub-oak barrens, Appalachian oak forest types could potentially contribute to the Cape Cod and New York acreages to meet habitat objectives with a minimal need for managing vegetation, at an enormous savings. Clearly, conservation partners must assess these lands for the presence of NEC and evaluate their potential to increase and support NEC populations.

Throughout the southern New England range of the introduced eastern cottontail, conservation partners are uncertain whether habitat availability or competition between NEC and eastern cottontails is the major factor limiting the NEC population. Biologists have begun research on interaction between the two species; information from these studies will let conservationists address the cost effectiveness of selective trapping and relocation of eastern cottontails as an alternative to habitat management.

The NEC Technical Committee has overseen the development of a zoo-based captive breeding program that shows promise to produce large numbers of NEC that can be put back in the wild. Research is underway to discover the best ways of introducing captive-bred animals to natural habitats and wild populations.

There are many uncertainties in the effort to make sure that the New England cottontail remains a part of its native landscape. How do NEC interact with eastern cottontails? What is the best way to make habitat that NEC populations need to sustain themselves? Can we enlist and manage enough private land to create an effective habitat network? What is the best way to link fragmented populations so that gene flow continues and the NEC population as a whole remains robust and healthy?

Conservationists are addressing these and other uncertainties through scientific adaptive management. This Conservation Strategy should be considered a living document. As monitoring, research, and information-sharing give rise to new knowledge about the New England cottontail, we will change the Strategy as needed to make certain that New England's native rabbit remains a part of our fauna in the future.

2.0 Introduction

2.1 Purpose

The New England cottontail (*Sylvilagus transitionalis*), hereafter referred to as NEC, is the only cottontail rabbit native to areas east of New York's Hudson River Valley, including New England. Primarily owing to habitat loss, this species' range has shrunk by an estimated 86 percent since 1960. In 2004 the NEC was listed as a priority species in every Wildlife Action Plan (WAP) for the states in which it occurs. Conservationists concerned with its decline submitted a petition requesting that the U.S. Fish and Wildlife Service (hereafter the Service) list the species as either endangered or threatened under the federal Endangered Species Act (ESA) of 1973, as amended (64 FR 57533). In 2006, in response to this petition, the Service concluded a review of the status of NEC and the threats facing the species. The Service determined that listing the NEC was warranted but that this action was precluded by higher-priority listing actions; therefore, the Service designated the NEC a "candidate" for listing (71 FR 53756 Sept. 12, 2006).

In executing their charge under the Region 5 State Wildlife Grant (SWG) Regional Conservation Needs Program (RCN), the Northeast Fish and Wildlife Diversity Technical Committee in 2007 named NEC as the top-priority Species of Greatest Conservation Need (SGCN) for regional landscape-scale habitat conservation. The Committee then began a cooperative effort to secure Competitive SWG funding for a multistate conservation effort, with the goal of averting the need for the Service to list the NEC as threatened or endangered.

Conservation efforts such as those proposed by the states can be considered by the Service during its listing decision process. Specifically, Section 4 (b)(1)(A) of the ESA requires that the Service take into account "those efforts, if any, being made by any State or foreign nation, or any political subdivision of a State or foreign nation, to protect such species, whether by predator control, protection of habitat and food supply, or other conservation practices, within any area under its jurisdiction . . ." To help guide the evaluation of such conservation efforts, the Service has prepared a Policy for the Evaluation of Conservation Efforts (PECE) (68 FR 15100, March 28, 2003). The PECE policy explains that in order to determine that a conservation effort has contributed to making the listing of a species unnecessary, the Service must find that the conservation effort is sufficiently certain to be implemented and to be effective. The PECE policy lists several criteria that the Service must use in making this determination. For example, all laws and regulations necessary to implement the conservation effort must be in place, and the parties intending to undertake the conservation effort must provide a high level of certainty that they will obtain the funding needed to carry out the conservation actions identified.

Beginning in 2008, state and federal wildlife biologists convened to organize the conservation effort for NEC. A governance structure was formalized in 2011 when the Maine Department of Inland Fish and Wildlife, the New Hampshire Fish and Game Department, the Massachusetts Division of Fisheries and Wildlife, the Rhode Island Department of Environmental Management, the Connecticut Department of Energy and Environmental Protection, the New York Department of Environmental Conservation, the

U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS), and the U.S. Fish and Wildlife Service, facilitated by the Wildlife Management Institute, convened an Executive Committee and adopted bylaws. The bylaws set forth guidelines to coordinate efforts among the participating agencies "to promote recovery, restoration, and conservation of the NEC and their associated habitats so that listing is not necessary" (Appendix A). Critical to this effort was the commitment to produce a conservation strategy to effectively conserve the NEC.

This Conservation Strategy for the New England Cottontail, hereafter referred to as the Strategy, describes: (1) our assessment of the conservation status of and threats facing the NEC; (2) the process used to develop a conservation design that includes those landscapes where conservation actions will be taken to achieve a series of explicit conservation goals; (3) the objectives related to achieving those goals; (4) important conservation actions needed to protect and manage habitat; (5) communications needed to ensure implementation; (6) research needed to improve our understanding of the ecology of NEC; (7) monitoring techniques to evaluate the effectiveness of the implemented actions and identify any changes needed to increase their effectiveness; (8) the commitment of the participating agencies to carry out the conservation effort; and (9) the process for modifying the strategy in the future, if necessary, in light of any new and relevant information.

2.2 Legal Status and Agency Authority

Because the NEC is a non-migratory game animal, the states have clear authority for managing the species. Currently Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, and New York are actively managing NEC. Maine and New Hampshire list the NEC as an endangered species; in both states, take is illegal and there is no open hunting season for NEC. In Massachusetts, Rhode Island, Connecticut, and New York, the NEC is a legal game species that may be taken during the regulated hunting season.

The states have the jurisdictional authority to regulate the harvesting of both NEC and the similar-appearing eastern cottontail (*Sylvilagus floridanus*), a closely related species that was imported to and released in parts of the NEC range during the twentieth century. Eastern cottontails are not present in Maine. In New Hampshire, the cottontail hunting season is closed in areas where eastern cottontails might live alongside NEC; because the latter are so scarce, conservationists believe that any additional mortality could have significant effects on the population. Massachusetts, Rhode Island, Connecticut, and New York permit hunting of both species within regulated hunting seasons, but because hunting pressure is low relative to the overall abundance of cottontails, and believed not to be significant compared to other mortality factors, biologists postulate that hunting has a minimal impact on the NEC population in those states. Eastern cottontails greatly outnumber NEC in Rhode Island; on Patience Island, where a NEC breeding colony has been established, small-game hunting is prohibited by state hunting regulations.

The states have not limited hunting of the snowshoe hare (*Lepus americanus*) in areas where the snowshoe's range overlaps that of the NEC. Incidental taking of NEC by snowshoe hare hunters is not believed to be a significant risk, because the pelage of the snowshoe hare is white during the legal season (winter) and the pelage of the NEC is brown, letting hunters tell the two apart and avoid accidentally taking NEC. While there is some overlap in the type of habitat that the two species use during winter, behavioral use of the habitat differentiates the two species with regard to hunting vulnerability. NEC have relatively small hind feet unsuited for walking or running on snow, are poorly camouflaged against a snowy background, and prefer to stay hidden in the thickest cover available throughout the winter. Snowshoe hares, on the other hand, are camouflaged on snow by their white coats and have large hind feet that let them forage more openly and escape danger by running across the top of the snowpack.

As a candidate for listing under the ESA, the NEC is in a transitional phase during which further listing actions pursuant to the ESA could lead to the assumption of management authority by the U.S. Fish and Wildlife Service. Both the Service and the states have certain accountabilities for candidate species, which provide a basis for mutual collaboration in developing and carrying out conservation actions aimed at preventing the listing of beleaguered species. These accountabilities and authorities include:

1. Authority for candidate species rests within the states' broad trustee and police powers over fish and wildlife within state borders, including on federal land, absent a clear expression of Congressional intent to the contrary. Where Congress has given certain federal agencies conservation responsibilities, such as for migratory birds or species listed under the ESA, the states in most cases have cooperative management authority.
2. When a species is listed under the ESA, Congress charges to the Service certain authorities and responsibilities for the species. However, until actual listing occurs, authority remains vested in the states.
3. There are four phases defining the transition to full protection under the ESA for a species, such as the NEC, that is thought to be at risk: petitioned, candidate, proposed, and listed.
4. For the purposes of intra-Service coordination, the Service treats candidate species as if they have been proposed for listing, so that no action undertaken by the Service will result in jeopardy to the species (ESA Consultation Handbook).
5. The Service has Section 4 statutory responsibilities for administering the ESA, including those which pertain to candidate species:

   A. processing of petitions to list, delist, or reclassify a species under the ESA;
   B. publishing a 90-day finding of "substantial" or "not substantial" for listing;
   C. reviewing the status of candidate species on an annual basis ;
   D. evaluating the candidate's Listing Priority, its "warranted but precluded" finding, and modifying these as appropriate ;
   E. publishing an annual "Candidate Notice of Review" to update the status of candidate species ;
   F. publishing a 12-month finding;
   G. publishing a Proposed Rule for listing in the Federal Register, if listing is found to be "warranted"; and
   H. publishing a final rule or withdrawal of the proposed rule after public notice and comment.

6. The candidate designation may be changed via a “change in status designation” (5.iii. above) that is substantiated by a review of the best scientific and commercial information available that the magnitudes or imminence of threats to the species are not significant. Related to this threats assessment, Section 4(b)(1)(A) of the ESA requires the Service to take into account state and local conservation efforts when making listing determinations.

7. The Policy for Evaluation of Conservation Efforts When Making Listing Decisions (50 CFR IV), also known as the PECE Policy, guides the Service in determining whether a conservation effort is adequate in fulfilling Section 4(b)(1)(A). When reviewing such conservation efforts, the Service considers several criteria to determine whether the conservation effort provides certainty that the:

    A. Conservation effort will be implemented; and that:
        - I. the parties to implement the plan/agreement, staffing, funding, and resources are identified;
        - II. legal authority is described;
        - III. legal procedural requirements are identified and do not preclude implementation;
        - IV. necessary authorizations are identified and will be obtained;
        - V. type and level of voluntary participation is identified and demonstrated to be attainable;
        - VI. necessary regulatory mechanisms are in place;
        - VII. funding sources are identified and secure;
        - VIII. an implementation schedule is provided; and
        - IX. the agreement/plan is approved by all implementing parties.

    B. Conservation effort will be effective, including whether:
        - i. the extent of threats and a strategy to address them are described;
        - ii. explicit incremental objectives and timelines are stated;
        - iii. the steps that must be implemented are identified in detail;
        - iv. quantifiable performance goals and measures are identified;
        - v. provisions for monitoring and performance reporting are identified; and
        - vi. adaptive management is incorporated.

8. In regard to species listed under the ESA, the Service has clear authority and a mandate to draft a recovery plan unless such a plan would not provide a conservation benefit to the species. Without management jurisdiction, the Service lacks a clear parallel authority to draft a conservation strategy for a candidate species. The Service does have the authority to help in developing and implementing voluntary conservation efforts to conserve candidate species, including the development of conservation strategies.

9. States are not mandated to produce a recovery plan to conserve a candidate species; however, the states do have the prerogative to develop and implement such a plan.

10. Recognizing that the states, the NRCS, and the Service share a charge to collaborate in efforts to preempt the need to list Species of Greatest Conservation Need (Appendix B), it is in the best interest of the states to work in partnership with the Service to plan and carry out pre-emptive conservation for candidate species. Furthermore, it is in the best interest of all the agencies to

work closely with the Service to ensure that their efforts meet PECE criteria, so that the states put forth a conservation effort adequate to be considered in the Service's decision regarding whether or not to list a candidate species.

11. Recognizing that the Service is charged with annually reviewing the status of candidate species, and recognizing that multistate biological surveys need substantial coordination, consistent methodology, and a data management commitment, it is in the states' best interest to seek the Service's assistance in coordinating surveys and maintaining regional data on the status and distribution of candidate species, along with developing conservation efforts. The Service through its various programs also can help in implementing appropriate conservation actions.

12. Recognizing the authorities of the states with respect to candidate species, all population- and habitat-management activities implemented by federal agencies and non-governmental organizations should be conducted in coordination and cooperation with those states.

2.3 Species Information

Description

The New England cottontail (*Sylvilagus transitionalis*) is the only cottontail rabbit native to the Northeast from the Hudson River Valley of New York eastward. A medium-sized rabbit that can reach a length of approximately 16 inches and a weight of 2.2 pounds, it is sometimes called a gray rabbit, brush rabbit, woods hare, or coney. It usually can be distinguished from the closely related eastern cottontail (*Sylvilagus floridanus*) by its shorter ears, the presence of a black spot between the ears, the absence of a white spot on the forehead, and a black line on the anterior edge of the ears (Litvaitis *et al.* 1991, p. 11). However, it can often be difficult to tell a New England from an eastern cottontail by using external characteristics alone (Chapman and Ceballos 1990, p. 106). Cranial differences – specifically the length of the supra-orbital process and the pattern of the nasal frontal suture – provide a more reliable means of distinguishing the two species (Johnston 1972, p. 6-11). The NEC shares part of its range with the snowshoe hare (*Lepus americanus*), from which it can be distinguished by its smaller body size and lack of seasonal variation in pelage coloration.

Taxonomy

"No one definition has as yet satisfied all naturalists; yet every naturalist knows vaguely what he means when he speaks of a species."

Charles Darwin (1859)

Chapman *et al.* (1992, p. 841-866) were the first to formally propose that *Sylvilagus transitionalis* east of the Hudson River comprise a distinct and separate species. Evaluating data to make taxonomic decisions can be challenging to taxonomists and other biologists because the very nature and interpretation of phylogenetic data is rapidly evolving. To appreciate the context of the determination made by Chapman *et al.* (1992, pp. 841-866) and later genetic challenges described below, consider the scientific discourse on cottontail, human, and guinea pig systematics during the latter part of the twentieth century. In a protein electrophoretic study of cottontail systematics, Chapman and Morgan (1973, pp. 1-53) identified proteins that were similar to those found in humans. Also studying protein sequences, Grauer *et al.* (1996, pp. 333-335) proposed a new phylogenetic position for lagomorphs (members of Order Lagomorpha, which includes the rabbits and hares), placing them closer to primates than to rodents.

Halyanch (1998, p. 139) refuted Grauer by analyzing the same dataset using a different technique, and cautioned against placing too much emphasis on molecular data. Frye and Hedges (1995, pp. 168) refuted an earlier proposal to place guinea pigs in an independent evolutionary lineage by examining DNA for many more proteins than Grauer had (1991, p. 496). Based largely on conflicting reports resulting from new genetic applications during the preceding decade, Sites (2004, p. 199) reviewed operational standards for empirically delimiting species and concluded that "all methods will sometimes fail to delimit species boundaries properly or will give conflicting results, and that virtually all methods require researchers to make qualitative judgments."

Before 1992, wildlife biologists believed that the New England cottontail occurred in a mosaic of populations stretching from southern New England south through the Appalachian Mountains to Alabama (Hall 1981, p. 305). Ruedas *et al.* (1989, p. 863) questioned the taxonomic status of *S. transitionalis* based on the presence of two distinct chromosomal races: Individuals north and east of the Hudson River had diploid counts of 52, while individuals west and south of the Hudson had diploid counts of 46. Ruedas *et al.* (1989, p. 863) suggested that the two forms of *S. transitionalis* should be considered distinct species, corroborating Wilson's conclusion that the two species have maintained genetic distinction (Wilson 1981, p. 99).

Chapman *et al.* (1992, pp. 841-866) reviewed the systematics and biogeography of the species and proposed a new classification. Based on morphological variation and earlier karyotypic studies, Chapman *et al.* (1992, p. 848) reported clear evidence for two distinct taxa within what had been regarded as a single species. Accordingly, Chapman *et al.* (1992, p. 858) defined a new species, the Appalachian cottontail (*Sylvilagus obscurus*), with a range west and south of the Hudson River. The NEC (*S. transitionalis*) was defined as that species occurring east of the Hudson River through New England. This taxonomic classification is currently supported by the American Society of Mammalogists. No subspecies of the NEC are currently recognized (Chapman and Ceballos 1990, p. 106).

Litvaitis *et al.* (1997, pp. 595-605) studied variation of mitochondrial DNA (mtDNA) in the *Sylvilagus* complex in the northeastern United States. While their mtDNA sample did not show support for reclassifying the Appalachian cottontail (*S. obscurus*) as a species distinct from the NEC (a reasonable conclusion in the context of mtDNA applications at that time), Litvaitis *et al.* (1997, p. 595) also acknowledged the importance of morphological variation and karyotypic differences in specimens.

Current science urges caution in interpreting results of earlier mtDNA-based studies. Litvaitis *et al.* (1997, p. 597) sampled 25 individual *S. transitionalis*/*obscurus* across 15 locations in a geographic area extending from southern Maine to Kentucky. The number of individuals sampled ranged from 1 to 7 per location, with a mean sample size of 1.7 per location (Litvaitis *et al.* 1997, p. 598). Allendorf and Luikart

(2006, p. 391) warn that “many early studies that used mtDNA analysis included only a few individuals per geographic location, which could lead to erroneous phylogeny inferences.” In the Litvaitis study, genetic analysis concentrated on the “proline tRNA and the first 300 base pairs of the control region” (Litvaitis *et al.* 1997, p. 599). Similar taxonomic re-evaluations that have been based on relatively small fragments of mtDNA have been found to warrant further verification (King *et al.* 2006, p. 4332). For example, it required 2,645 base pairs (Frye and Hedges 1995, p. 168) representing three complete RNA genes to re-establish what was previously known from guinea pig morphology: that they are monophyletic with other rodents. Strict adherence to the requirement of reciprocal monophyly in mtDNA as the sole delineating criterion for making taxonomic decisions often ignores important phenotypic, adaptive, and behavioral differences (Allendorf and Luikart 2006, p. 392; Knowles and Carstens 2007, pp. 887-895; Hickerson *et al.* 2006, pp. 729-739).

The best available science is consistent with a pattern of allopatric speciation in the NEC, whose chromosomes and morphology reflect the isolating effects of both land elevation and the Hudson River. Molecular data have not refuted Chapman *et al.* (1992, p. 848). New England cottontails are accepted as a distinct and separate species by the scientific community, and appear as a distinct species in the authoritative global guide to mammalian taxonomy, *Mammal Species of the World* (Wilson and Reeder 2005, pp. 210-211). The U.S. Fish and Wildlife Service includes the recognized taxonomic reclassification as provided by Chapman *et al.* (1992, p. 848) in their Species Assessment and Listing Priority Assignment Form for the NEC: (http://ecos.fws.gov/docs/candidate/assessments/2012/r5/A09B_V01.pdf).

Interbreeding and Hybridization

Is it possible for New England cottontails to interbreed with eastern cottontails?

Reports presenting evidence regarding the interbreeding of NEC and eastern cottontails cannot be considered substantive without confirmation of the identity of allegedly paired subjects through examining their cranial characteristics or DNA. No such reports exist. According to Eabry (1983, p. 26), a frequently cited compilation of cottontail project reports (Hosley 1942) is often incorrectly credited to Dalke (1942). Eabry (p. 26) quoted Hosley (1942) regarding the compilation: “The present publication should be considered a progress report more than a completed study,” further noting that species distinctions were inaccurate or not made at all in Dalke’s studies (Eabry 1983, pp. 14-26). According to Chapman (1975, p. 3), Dalke (in Hosley 1942) reported no difference in the breeding behaviors of NEC and eastern cottontail, and although his observations appear to refer to both species, only one hybrid litter was reported, with other breeding attempts thwarted by aggressive behavior.

Based on the Hosley (1942) references to interbreeding between captive NEC and eastern cottontails, Fay and Chandler (1955, p. 422) inferred that such interbreeding took place in the wild in Massachusetts. In making this inference, Fay and Chandler (1955, p. 422) provided neither corroborating data nor specimens; instead, they drew a parallel between anecdotal reports of early eastern cottontail pregnancy and the progressive replacement of the mountain hare (*Lepus timidus*), a European species, through impregnation by the earlier-breeding European hare (*L. europaeus*), in wild european populations.

It is true that eastern cottontails and NEC were deliberately mixed and possibly confused during early game-stocking and breeding programs, contributing to uncertainty in their reproductive relationship (Wilson 1981, pp. 99-101; Litvaitis 2007, pp. 167-185). More recently, Probert and Litvaitis (1996, p. 290) and Smith and Litvaitis (2000, p. 2135) conducted behavioral trials on captive NEC and eastern cottontails; they did not report interbreeding, although observation of breeding was not their research objective, and their studies only briefly overlapped the breeding season.

Is the current NEC gene pool threatened by NEC-eastern cottontail hybrids surviving and propagating in the wild?

There is no substantive evidence showing that any such hybrids survive and propagate in the wild. Holden and Earby (1970, p. 167) reported diploid numbers of 52 and 42 chromosomes for NEC and eastern cottontail, respectively. While such karyotypic differences are not an absolute barrier to hybridization, they are a fair indicator of poor F1 generation viability. Hybrid specimens reported as *transitionalis* by Bangs (1895, p. 411) and by Chapman and Morgan (in Chapman 1975, p. 55) should not be considered examples of adult NEC hybrids: They originated from west and south of the Hudson River and before the distinction of *S. obscurus* from *S. transitionalis* by Chapman *et al.* (1992, p. 858). To date, no adult hybrid specimen has been confirmed east of the Hudson. Fay and Chandler (1955, p. 422) note that "The scarcity of [intergraded specimens] suggests that crossbreeding does not normally proceed beyond the F1 generation." In their mtDNA analysis, Litvaitis *et al.* (1997, p. 595-605) found no evidence that hybridization is occurring between NEC and eastern cottontails. Recently, nuclear DNA was examined in an unpublished University of New Hampshire study (Kovach, pers. com.) corroborating Litvaitis *et al.* (1997). Allele frequency distributions from allopatric eastern cottontails (n=30) were highly overlapping with those of sympatric eastern cottontails (n=30), and the alleles of both allopatric and sympatric eastern cottontails were distinct from alleles of sympatric New England cottontails (n=75), providing no indication of nuclear introgression of NEC alleles into eastern cottontails. To detect hybridization, current genetic techniques depend on the survival of hybrids long enough for a morphological or genetic specimen to be detected and evaluated. Until substantive data are presented to the contrary, Fay and Chandler's observation (1955, p. 422) may be applied to the genetic data: If interbreeding occurs at all, hybrids have not been observed beyond the F1 generation, and there is little or no likelihood that the NEC is threatened by hybridization with the eastern cottontail.

Even if hybrids don't survive, are NEC threatened by interbreeding?

If interbreeding is taking place, it could interfere with NEC reproduction and adversely affect the NEC population. However, there is no direct and substantive evidence to either confirm or refute the possibility that NEC and eastern cottontails even attempt to reproduce in the wild – there is only the consistent lack of evidence that hybrids survive if they are produced. Studying neonate nuclear DNA and skull specimens could provide evidence of non-surviving F1 hybrids. Research (currently proposed and approved) by scientists with the University of Rhode Island (Husband *et al.* in litt. 2010) and the U.S. Geological Survey (King and Tur in litt. 2011) will use microsatellite markers and next-generation DNA sequencing to delimit the possible threat of hybridization between sympatric NEC and eastern cottontails. However, at present scientists do not believe interbreeding threatens the NEC.

Life History

As with other cottontail rabbits, a New England cottontail is unlikely to survive more than two to three years in the wild. The species compensates for this high mortality with a high reproductive rate. Individuals mature quickly: Approximately 40 days elapse from the time of conception, through birth, to the juveniles dispersing from the nest (Chapman and Ceballos 1990, p. 108). NEC tend to reproduce at a young age, with some individuals probably breeding during their first year. Litter size ranges from three to eight (typically five), and females may have two or three litters per year. Females breed again soon after they have given birth. Cottontails demonstrate density-independent breeding: If adequate food resources are present, they will breed even when a given habitat area is already fully populated with individuals. This kind of reproductive capacity allows a species to thrive in spite of a high predation rate (Chapman, Hockman and Edwards 1982, p. 105).

Habitat

New England cottontails live in dense areas of shrubs and young forests where trees are growing back following disturbances caused by factors such as logging, fire, flooding, mortality from disease or insects, and high winds. NEC are “habitat specialists,” which means they depend on a specific kind of habitat – in this case, early successional or “thicket” habitat (Litvaitis 2001, p. 466). Many biologists agree that “If you can walk through it, it isn’t thick enough” to be good NEC habitat (and, indeed, successful surveys to detect NEC often entail crawling through nearly impenetrable thorn patches). The plant species that make up this sort of habitat can vary. Barbour and Litvaitis (1993, p. 324) quantified NEC habitat and demonstrated that winter survival of NEC is closely tied to patches containing more than 20,234 stems per acre. (Throughout this document, we refer to discrete but contiguous expanses of similarly dense habitat as “patches,” and use the term interchangeably for both natural and human-created habitats. We use the term “site” to refer to any location where conservationists may decide to manage habitat.)

NEC generally do not venture far from heavy cover (Smith and Litvaitis 2000, p. 2134). Smith and Litvaitis (2000, p. 2136) found that when food was not available within the cover of thickets, NEC were reluctant to forage in the open: They lost a greater proportion of body mass and suffered higher rates of mortality from predation than did eastern cottontails held in the same experimental enclosure. Thicket habitats and their NEC populations decline steadily as the vegetative understory thins out during the process of forest stand maturation (Litvaitis 2001, p. 467): As trees grow taller and their canopies knit together, they cast shade on the ground that causes low-growing vegetation to become sparse or die out.

NEC feed on a variety of grasses and herbaceous plants during spring and summer, and on the bark, twigs, and buds of woody plants during winter. In a study conducted in southeastern New Hampshire, Barbour and Litvaitis (1993, p. 325) suggested that the winter diet of NEC is related to the size of the habitat patch. During winter, forage quality will decline in smaller habitat patches sooner than it will in larger patches, making the smaller habitat patches less able to sustain healthy NEC populations. The researchers concluded that patches less than 6.2 acres in area were “sink habitats,” because mortality in the patches was expected to exceed recruitment from reproduction and immigration of individuals from neighboring populations (Barbour and Litvaitis 1993, p. 326). Subsequent research found that rabbits in smaller patches generally had lower body weights and were presumably less fit than rabbits in larger patches (Villafuerte *et al.* 1997, p. 148). NEC living in smaller patches also tended to experience higher rates of predation (Villafuerte *et al.* 1997, p. 148) because, lacking sufficient forage, they were forced to venture out of protective cover in search of food.

2.4 Historic Distribution and Current Status

The NEC is the only cottontail native to New England (Probert and Litvaitis 1995, p. 289). The historic range of the species likely extended from southeastern New York, east of the Hudson River and including Long Island, north through the Champlain Valley and into southern Vermont, the southern half of New Hampshire, and southern Maine, and was statewide in Massachusetts, Connecticut, and Rhode Island (Nelson 1909, Litvaitis and Litvaitis 1996, p. 725). As of 1960, the occupied range of the NEC covered an estimated 34,750 square miles (Litvaitis *et al.* 2006, p. 1191).

In the past, thicket-dependent species like NEC may have persisted in core habitats associated with frost pockets, barrens, and the shrubby interface between wetlands and upland forests (Litvaitis 2003, p. 120). Soil conditions, fire, or other disturbances likely limited forest canopy closure in many such shrublands (Lorimer and White 2003, p. 41, Latham 2003, p. 34, Brooks 2003, p. 65). From those relatively static core habitats, NEC would have dispersed to occupy more-ephemeral disturbance-generated patches elsewhere on the land (Litvaitis 2003, p. 120).

Although the amount of shrubland and early successional habitat in the pre-Columbian landscape of the Northeast is not well known, it is generally accepted that those habitats were not naturally abundant before European settlement (Brooks 2003, p. 65). At times, Native Americans set fires to burn off forests and create areas of good game-hunting habitat (Bromley 1935, p. 64, Cronon 1983, p. 49). In addition, periodic wildfires and coastal storms, including hurricanes, resulted in an estimated 10 to 31 percent of coastal pine-oak forests existing in the seedling-sapling stage (ages 1 to 15 years), a stage that provides good habitat for NEC (Lorimer and White 2003, pp. 45 - 46). In inland forests, where fires were less frequent, beaver activity and cyclical insect outbreaks killed trees and yielded areas of dense, re-growing woodland. In inland forests, at any given time around 6 percent of the landscape is estimated to have been in an early successional stage that could have supported cottontails (Litvaitis 2003, p. 117). Another model examining inland forests suggests that stand-regenerating disturbances were very rare, and that most early successional forest patches resulted from tree-falls (gap-phase replacement) in an otherwise broadly distributed climax forest (Lorimer 1977 in Brooks 2003, p. 70).

Since 1960, the NEC range has shrunk substantially, with smaller populations becoming increasingly separated from one another. In comparison to the estimated 34,750-square-mile range of 1960, the current range is estimated at 4,701 square miles (Litvaitis *et al.* 2006, pp. 1192-93), a reduction of approximately 86 percent during the last 50 years.

The current NEC range contains habitat that apparently remains usable, with the vegetation in a shrubby or thicket state. However, this habitat may not be suitable for long term occupancy by cottontails. A comprehensive multistate survey of NEC (Litvaitis *et al.* 2006, pp. 1190-1197) suggested that the species is absent from 93 percent of approximately 2,300 habitat patches within the recent (1990 to present) historic range (Litvaitis *et al.* 2006, p. 1193). Survey results are summarized below (see also Table 1):

Table 1. Regional Inventory of NEC, 2001-2004. From Litvaitis *et al.* (2003a, pp. 48-59) and Litvaitis and Tash, unpublished data.

State	Total Number Sites Searched	Sites with NEC	% of Sites Occupied
CT	538	22	4.1
MA	374	26	7
RI	94	11	11.7
NY	294	14	4.8
VT	73	0	0
NH	554	23	4.2
ME	406	58	14.3
Totals	2333	154	6.6

In Connecticut, where NEC were found in 22 of 544 habitat patches searched, occupied areas are in the western and southeastern portions of the state (Litvaitis *et al.* 2003, unpublished data and Litvaitis *et al.* 2006, p. 1190-1197). Through 2004, NEC were recorded in 22 of 106 towns (20.8 percent) statewide (Goodie, Gregonis and Kilpatrick 2004, p. 2), and, more recently, in 42 towns and 65 locations (H. Kilpatrick, personal communication 2012).

In Massachusetts, where the range was once statewide, including the islands of Martha's Vineyard and Nantucket, NEC currently are restricted to two widely separated population clusters, one on Cape Cod in the east and the other in the Berkshire Mountains in the west (Cardoza in litt. 1999; Litvaitis *et al.* 2003, unpublished data; Litvaitis *et al.* 2006, p. 1190-1197).

In Rhode Island the species had been confirmed in 11 sites in 8 towns in three counties, primarily in the southern half of the state (Tefft in litt. 2005; Litvaitis *et al.* 2003, unpublished data). However, recent DNA analysis of over 1,000 fecal pellet samples revealed the presence of only one individual NEC (T. Husband, pers. comm. 2011), suggesting that the species' population has declined sharply within the state.

In New York the species occurs in Putnam, Dutchess, Columbia, and Westchester counties but appears to have vanished from Long Island and from areas north of Columbia County in the east-central part of the state (Litvaitis *et al.* 2003, unpublished data; M. Clark and A. Hicks, in litt. 2005).

In Vermont the species has not been documented since 1971 and is believed to be extirpated (Litvaitis *et al.* 2003, unpublished data; Litvaitis *et al.* 2006, p. 1190-1197; S. Parren pers. comm. 2012).

In New Hampshire the remaining population appears to be limited to two separate areas in the southeastern corner of the state: one in Strafford County and the other in the Merrimack River Valley south of Concord (Litvaitis *et al.* 2003, unpublished data; Litvaitis *et al.* 2006, p. 1190-1197).

In Maine, Litvaitis *et al* (2003, p. 881) reported NEC in 53 of 376 habitat sites surveyed. The current range of approximately 620 square miles represents an 83 percent reduction in the species' historic range in the state (Litvaitis *et al.* 2003, p. 881).

Rangewide Overview

Current NEC distribution (figure 1) is believed to be fragmented into five core regions or population clusters (Litvaitis et al 2006, p. 1193; Fenderson *et al.* 2010, p. 943):

1. the seacoast region of southern Maine and New Hampshire (1,190 square miles);
2. the Merrimack River Valley in southern New Hampshire (490 square miles);
3. part of upper Cape Cod, Massachusetts (376 square miles);
4. eastern Connecticut and Rhode Island (920 square miles); and
5. parts of western Connecticut, eastern New York, and southwestern Massachusetts (1,840 square miles).

NEC have not been found outside of those five core regions (Fig. 1), suggesting that the five remaining disjunct population clusters do not represent a stable condition for the species' long-term survival (Litvaitis *et al.* 2006, p. 1190)

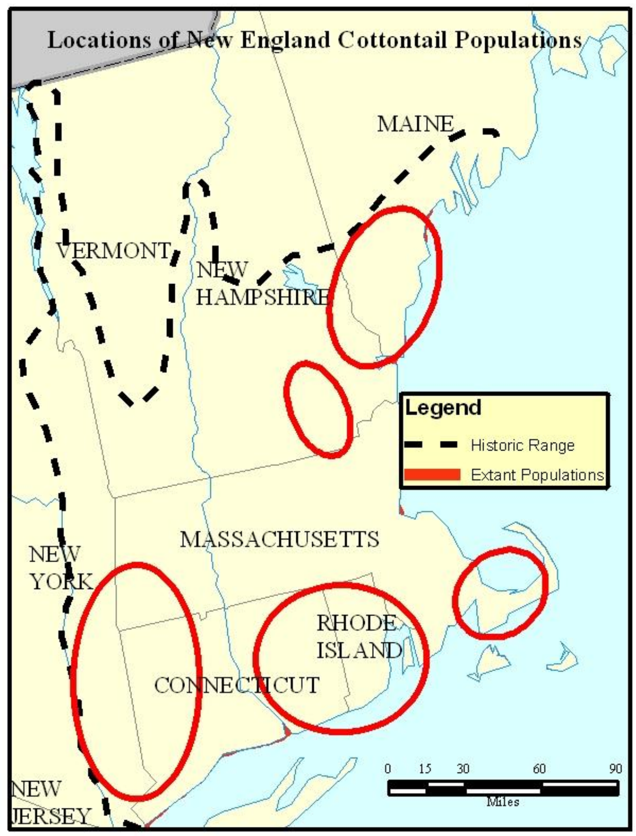


Figure 1. Distribution of Five Extant NEC Populations within the Species' Historical Range (adapted from Nelson 1909; Litvaitis and Litvaitis 1996, p. 725).

Based on site visits to most areas currently occupied by NEC, U.S. Fish and Wildlife Service biologists estimate that less than one-third of the occupied sites occur on lands in conservation status, such as federal, state, municipal, or land trust properties, and less than 10 percent of the lands in conservation status are currently being managed to provide the early successional or thicket habitat that NEC need. (http://ecos.fws.gov/docs/candidate/assessments/2012/r5/A09B_V01.pdf)

Of the remaining sites occupied by NEC, many are small, support few cottontails, and may actually be "population sinks" where local rabbits do not produce enough offspring to maintain their numbers in the absence of individuals migrating in from other populations. For example, two-thirds of the occupied habitat patches in Maine are less than 6.2 acres and are considered population sinks (Barbour and Litvaitis 1993, p. 326; Litvaitis and Jakubas 2004, p. 41). In New Hampshire more than half of the 23 sites occupied by NEC in the early 2000s were less than 7.4 acres (Litvaitis *et al.* 2006, p. 1194). Sampled patches in eastern Massachusetts, as well as most of those in the largest remaining population cluster – centered on western Massachusetts, southeastern New York, and western Connecticut – covered less than 7.4 acres and probably supported no more than three or four rabbits each (Litvaitis *et al.* 2006, p. 1194).

Population

Accounts from the late nineteenth century describe native cottontails as "common," and one observer (Fisher 1898; cited in Eabry 1983, p. 17) noted that even though hundreds of rabbits were killed every winter, cottontail numbers appeared to remain as high as they had been 20 years earlier. Robust rabbit populations apparently persisted into the mid-twentieth century, as Litvaitis (1984, p. 632) found that the NEC was the major prey species of bobcats harvested in New Hampshire in the early 1950s.

Accurate estimates are not available for the historic or current rangewide population, or for the five core populations described above. Due to the difficulty of detecting NEC in the field, reliable estimates of population size for NEC are scarce. The areas that they occupy are difficult to verify, and the number of rabbits in habitat patches may vary greatly throughout the year. In Maine, the current statewide mid-winter population has been estimated at around 250 animals (Litvaitis and Jakubas 2004, p. 33). Although wildlife biologists have not developed population estimates for states other than Maine, they believe the NEC population status can be inferred from the amount and quality of its habitat. Barbour and Litvaitis (1993) estimated NEC density in many habitat patches in New Hampshire; based on their estimates, the NEC Technical Committee adopted 0.5 NEC per acre as a conservative approximation of the average winter density of NEC in occupied patches.

As stated earlier, the amount of suitable habitat available to the species has dwindled by around 86 percent in the last 50 years, with extant NEC populations becoming increasingly separated by areas of unsuitable habitat in the form of older even-aged forests (Litvaitis 1993, p. 871) and developed landscapes (Patterson 2003; Noss and Peters 1995, p. 57; Litvaitis *et al.* 1999, p. 102).

Discussion of Population Viability, Genetics, and Spatial Structure

In the past, NEC were probably distributed along a continuous band of habitats ranging from east of the Hudson River in New York through southern New England to southern Maine. As a consequence of habitat loss and fragmentation due to forest maturation and land use conversion, the species distribution has been fragmented and now, the NEC occurs in five separate geographic areas (Figure 1) (Litvaitis and Litvaitis 1996, p. 725). As the NEC range has contracted, that of the eastern cottontail has expanded, so that the latter is, by far, the more common rabbit in much of the historic NEC range (Johnston 1972, pp. 1-70, Tracy 1993, pp. 1-49, Cardoza in litt. 1999). This range expansion by the eastern cottontail appears to have been at the expense of the native NEC; however, the presence of sympatric populations suggests that the two species can coexist (H. Kilpatrick, pers. comm.). Nevertheless, the long term viability of remaining NEC populations is uncertain without active intervention by conservationists (Litvaitis *et al.* 2007, p. 168).

When habitat critical to an animal's existence is lost or fragmented, reduced connectivity among wildlife populations can lead to the rise of new species or, more often, can cause populations to go extinct (Reed 2004). A recent study used microsatellite genotyping to discern patterns of population structure, genetic variability, and demographic history of the NEC, and explored whether the observed patterns are a consequence of habitat loss and fragmentation (Fenderson *et al.* 2011). The study focused on DNA obtained from body tissue samples and fecal pellets of known NEC. The researchers found historic genetic signatures of connectivity within the overall NEC population. They concluded that habitat loss and fragmentation have shaped the genetic structure of remaining NEC populations, and that some remnant populations exhibit limited gene flow and low effective population size, with several populations possessing comparatively reduced genetic diversity (Fenderson *et al.* 2011, p.955). The researchers stated that "human intervention will be required to mitigate and reverse continued population declines" so that disjunct populations of NEC do not "become differentiated due to lack of genetic exchange and the rapid effects of genetic drift" (Fenderson *et al.* 2011, p. 955).

To date, no genetic, morphological, or biological evidence exists to suggest that there are biogeographically discrete populations of NEC. Fenderson *et al.* (2011) recommended that once geographically separated populations are made sustainable through the creation of ample suitable habitat, "reestablishing connectivity among populations and eventually reintroducing cottontails to historically occupied parts of the range (e.g., Vermont) will help ensure the persistence of this species" (Fenderson *et al.* 2011, p. 955).

Based on the best currently available information, wildlife biologists believe it is imperative to manage the NEC as a single species by creating habitat critically needed by each of the five remaining core populations while determining the best ways of restoring gene flow between them. Gene flow may be restored by increasing habitat connectivity, thereby allowing dispersal and exchange of individuals among populations of the New England, or by conservationists translocating animals between populations.

Population Subdivisions

As previously described, the range of the NEC has become increasingly fragmented and remnant populations appear to be restricted to five areas that are distributed from east of the Hudson River in New York, through southern New England to southern Maine. No population of NEC is currently known to occur outside this area. Following a recent rangewide genetic analysis of NEC populations, evidence of genetic differentiation has sparked speculation on whether separated populations of NEC may meet the "distinct population segment," or DPS, criterion under the Endangered Species Act. The ESA requires the Secretary of the Interior or the Secretary of Commerce (depending on jurisdiction) to determine whether species are endangered or threatened. The ESA, as originally passed, included in the definition of “species”: “any subspecies of fish or wildlife or plants and any other group of fish or wildlife of the same species or smaller taxa in common spatial arrangement that interbreed when mature.” In 1978 the ESA was amended so that the definition read “. . . any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature.” The authority to list a “species” as endangered or threatened is thus not restricted to species as recognized in formal taxonomic terms, but extends to subspecies and, for vertebrates, to distinct population segments. Congress has instructed the Secretary to exercise this authority with regard to distinct population segments “sparingly and only when the biological evidence indicates that such action is warranted” (Senate Report 151, 96th Congress, 1st Session).

Interpretation of the phrase “distinct population segment of any species of vertebrate fish or wildlife” for the purpose of listing, delisting, and reclassifying species under the ESA is guided by the “Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the ESA (61 FR 4722, February 7, 1996).” In determining if listing a Distinct Population Segment under the ESA is warranted, three elements are considered:

I. Discreteness of the population segment in relation to the remainder of the species to which it belongs;
II. The significance of the population segment to the species to which it belongs; and
III. The population segment's conservation status in relation to the ESA standards for listing (i.e., is the population segment, when treated as if it were a species, endangered or threatened?).

According to the Distinct Population Segments (DPS) Policy, a population segment of a vertebrate species may be considered discrete if it satisfies either one of the following conditions:

I. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Genetics can also indicate marked separation.
II. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the ESA.

The range of the NEC does not cross an international government boundary. As a result, a DPS determination cannot be made on the basis of international differences in exploitation, habitat management, conservation status, or regulatory mechanisms.

Further analysis is required to determine if marked separation exists across the species’ range using the “physical, physiological, ecological, or behavioral factors” consideration:

The NEC range is fragmented, and current populations appear to be restricted to five areas from east of the Hudson River in New York through southern New England to southern Maine. However, populations that are disjunct because of human-caused habitat fragmentation are not in and of themselves markedly separate, and therefore discrete, under DPS policy.

Identification of a DPS is determined, in part, on the basis of marked separation of populations, as indicated by physical, ecological, or behavioral factors. No clear indication of marked separation of NEC based on these factors exists, even though some of these factors have been evaluated through research studies. For example, scientists analyzed the morphology of NEC to develop a field technique for differentiating them from eastern cottontails on the basis of ear length, body mass, hind foot length, and pelage characteristics (Litvaitis *et al.* 1991). Other studies have evaluated pelage and body measurements, along with skull morphology, to distinguish NEC and eastern cottontail specimens (Fay and Chandler 1955; Johnston 1972). While studies have found morphological differences between NEC and eastern cottontails, they have not shown differences among NEC from geographically separated populations.

Several authors have also conducted habitat assessments (as measured by stem density) and food-preference studies involving NEC in various parts of the species' range (e.g., Earby 1968; Linkalia 1971; Pringle 1960). Still other studies have noted behavioral responses of captive NEC, including food consumption, defecation rates, vocalizations, and response to handling by humans (Chandler 1952 in Earby 1968; Pringle 1960). Although most of these studies were conducted in relatively limited areas within the NEC range, no author has suggested any differences exist among current NEC populations.

Ecological differentiation has not been reported. The NEC is known to occupy several habitat types throughout its range, including scrub-oak and pitch-pine barrens, coastal shrubland, young forests, and shrub wetlands (Bangs 1894, p. 412; Fay and Chandler 1955, p. 418-421). NEC use of these different habitat types is most likely a result of the vegetation's physical structure, especially shrub height and density, rather than the specific plant species represented in the ecological community (Earby 1968, p. 18; Litvaitis *et al.* 2007, p. 167).

Based on the best available data, there is no visually observable evidence of marked separation of NEC populations based on morphological, ecological, or behavioral factors. However, genetic information can provide another type of evidence for differentiation within a species.

Fenderson *et al.* (2011, pg. 951) conducted a genetic analysis of extant NEC populations. The authors used microsatellite genotyping to discern patterns of population structure, genetic variability, and demographic history across the species' range. They also assessed whether the observed patterns stemmed from recent habitat loss and fragmentation. Fenderson *et al.* (2011) demonstrated that habitat loss and fragmentation have shaped the genetic structure of remaining NEC populations by limiting gene flow between populations, with several populations having reduced genetic diversity when compared with larger NEC populations that enjoy less restricted gene flow, such as those in western Connecticut and eastern New York (Fenderson *et al.* 2011, p. 951).

As a consequence of habitat loss and fragmentation, the current NEC genetic structure has been shaped by genetic drift (Fenderson *et al.* 2011, p. 953). Genetic drift is the random change in allelic frequencies due to chance events rather than through evolutionarily adaptive processes. Smaller populations are more likely to lose important genetic material through stochastic processes than are larger populations, in which the loss of genetic material due to chance events is less likely. The random nature of genetic drift means that the resulting genetic distance among populations does not reflect environmental adaptation and fitness of local populations. In fact, considering today's disjunct NEC populations to be Distinct Population Segments could reinforce the current unnatural separation of these populations, heightening the danger to the species from fragmentation and isolation.

The best available scientific data indicate that today's NEC populations do not meet the DPS criteria and, therefore, DPS designations are not appropriate. Genetic structuring within the NEC is a recent phenomenon, owing, in large part, to recent habitat fragmentation and genetic drift. It does not indicate discreteness as defined by DPS policy. Forest maturation, altered disturbance regimes, and development are the factors driving habitat fragmentation and the isolation of remaining NEC populations. The goal of NEC conservation is to manage this habitat loss and fragmentation. Effective conservation efforts should address the adverse impacts to the populations.

2.5 Threats

In its Species Assessment and Listing Priority Assignment Form, used to prioritize species for inclusion on the federal Endangered Species List, the U.S. Fish and Wildlife Service evaluated potential threats to the NEC. A summary of those threats, categorized under the ESA factors, follows. For detailed information, see http://ecos.fws.gov/docs/candidate/assessments/2012/r5/A09B_V01.pdf

Present or Threatened Destruction, Modification, or Curtailment of NEC Habitat or Range

NEC need young re-growing forest, dense shrubs, or thickets in which to find food, reproduce, shelter from bad weather, and escape predators. Barbour and Litvaitis (1993, p. 324) found that NEC thrive in habitats containing greater than 20,234 stem-cover units per acre. The amount of such dense habitat (often called "early successional habitat") is limited in the states and regions where NEC now exist, in part because this type of habitat is short-lived. It is formed by the response of vegetation to changing human uses of the land and by shifting ecological processes, and it can be created, expanded, or maintained through forestry practices and management activities. Permanent destruction of habitat caused by human population growth and land development has reduced or wiped out some NEC populations, and it remains a threat to existing populations. Yet the habitat of NEC is not permanent anywhere, and development amounts to a highly localized and temporary factor that can be addressed by creating and expanding habitats elsewhere on the surrounding landscape. However, overall trends in the pattern of humans' land-use and land-management practices have limited the distribution and amount of early successional habitat (Litvaitis 1993, p. 870, 113). The many factors contributing to the modification of early successional habitats, if they continue unabated, will prevent the creation, regeneration, and expansion of habitat, making it hard to conserve the NEC. In the final analysis, the primary threat to NEC is modification of its habitat, including:

1. Natural forest maturation associated with land-use change, such as the progressive abandonment of farming and a decrease in logging (Litvaitis 1993, p. 870). Following land-clearing for agriculture, the minimum forest cover in northern New England was reached around 1875, with early successional habitat peaking before 1950 and sharply declining since then

(Litvaitis 1993, p. 867). Relatively abundant early successional habitat remaining in the Hudson River Valley region, according to local observations and supported by remote assessment using satellite imagery (Fuller *et al.* 2011), may reflect a much later shift in land use there compared to New England. **Forest management practices can be used on both public and private lands to reverse forest maturation and restore areas of young forest that provide habitat for NEC.**

2. Loss of shrubland habitat capable of supporting NEC has occurred as a result of interrupted or abated natural processes that once maintained a shifting mix of shrub communities and understory structure on the natural landscape. Factors include a present-day dearth of fire in pine barrens (Litvaitis 2003, p. 113); flood-control structures that limit natural flooding, and fewer beaver impoundments (Litvaitis 2003, p. 113; Earby 1968, p. 7); deer browsing that limits understory growth (Latham *et al.* 2005, pp. 66-69, p. 104; Martin *et al.* 1961, pp. 241-242, 268-270); and a lack of fire in Appalachian oak forests to promote oak and enhance mountain laurel thickets (Earby 1968, p. 7; Dey *et al.* 2010, p. 201; Hooper, 1969, pp. 1-6). Based on an assessment of land-cover data provided by the Northeast Terrestrial Habitat Classification (Anderson and Ferree, in litt. 2011), Fuller *et al.* (2011, p. 6) estimated that 41 percent of the 60-meter neighborhood surrounding recent NEC records consists of floodplain swamps and marshes, dry oak-pine forests, pine barrens, and coastal marshes, dunes, and forests. Restoring large-scale natural processes is made difficult by land parcelization (fragmented ownership patterns and reduced parcel size) that would require extensive landowner cooperation and coordination. However, using maps and local knowledge of habitat, the NEC Technical Committee identified over 30,000 acres of protected habitat where ecological processes could be restored, and over 20,000 acres of conserved land that may be available to actively manage for NEC (see Chapter 5.0). The greatest opportunity to manage conserved land is in southern New England, where large state properties in NEC focus areas total more than 100,000 acres of potential habitat. **On public lands, a combination of silvicultural manipulations and restoration practices may minimize the cost of sustaining habitat by taking advantage of ecological processes and large-scale forest economics, thereby collectively and substantially lessening the threat of NEC habitat modification and fragmentation.**
3. In some areas, eastern cottontails seem to be gradually displacing NEC in otherwise suitable habitat. Johnston (1972, p. 17), in summarizing the history of eastern cottontail introductions, reported that the occupation of new areas by eastern cottontails may be at the expense of NEC. Probert and Litvaitis (1996, p. 289) found that eastern cottontails, although larger in body size, were not physically dominant over NEC. Smith and Litvaitis (1999) reported that the eastern cottontail has a larger exposed surface area of the eye, with individuals showing a greater reaction distance to a simulated owl than did NEC; for this reason, eastern cottontails can use a wider range of habitats, including relatively open areas such as meadows and residential back yards, compared to NEC. Through "prior rights," eastern cottontails may exploit newly created habitats sooner than NEC (Litvaitis *et al.* 2007). Once established in a given area, the highly fecund eastern cottontails are not readily displaced by NEC (Probert and Litvaitis 1996, p. 292, Litvaitis *et al.* 2007). **Resolving the uncertainty about the best approaches to managing eastern cottontails is a top-priority research need. We do not know which species in sympatric populations will benefit more from habitat-management activities, but we conclude that**

successful management of sympatric eastern cottontail populations could let NEC expand into formerly occupied habitats.

4. NEC habitat, especially in coastal New England, has seen significant modification, fragmentation, and destruction as a result of human population growth and accompanying development. Between 1950 and 2005, the human population increased by 44 percent in southern New England (Brooks 2003, p. 70). Even though the acreage of potential habitat on currently protected lands far exceeds rangewide habitat goals, local circumstances often prevent using those lands for NEC restoration. Continued human population expansion, accompanied by unchecked development and/or insufficient management of public lands, will likely limit the security of habitat voluntarily restored on private lands and further fragment habitats now used by NEC unless management and/or protection of those habitats can be assured. **The impact of development will be mitigated by increasing the management of land already under state, federal, and municipal authority; establishing populations on such protected lands; enlisting private landowners to conduct voluntary land management; and, in the long term, targeting important habitats for acquisition.**

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The NEC is difficult to distinguish from the much more common eastern cottontail with which it sometimes shares brushy habitats (Litvaitis et al. 199). Cottontail rabbits are considered small game animals and are legally hunted in four of the six states that NEC inhabits. The states have the jurisdictional authority to regulate eastern cottontail and NEC harvest and the ability to adopt regulations to maintain healthy populations according to local circumstances.

Maine (where only the NEC has been found) recently closed its cottontail hunting season, and New Hampshire has prohibited taking cottontail rabbits in those parts of the state where NEC are known to live. Massachusetts, Connecticut, Rhode Island, and New York permit taking both species during regulated hunting seasons, but because hunting pressure is low relative to the overall abundance of cottontails and not considered significant compared to other mortality factors, its impact on the NEC population is believed to be minimal. Eastern cottontails greatly outnumber NEC in Rhode Island; however, Patience Island, where a breeding colony has been established for NEC, is legally closed to shotgun small game hunting through state regulations. Evidence suggests that habitat loss caused by forest maturation and human development, rather than hunting, is the primary reason for the dramatic population decline of NEC during the second half of the twentieth century (Jackson 1973, p. 21; Brooks and Birch 1988, p. 85; and Litvaitis *et al.* 1999, p. 101). On the basis of the best available information, the U.S. Fish and Wildlife Service concluded that hunting by humans does not appear to significantly threaten NEC. However, if the species' population continues to fall, hunting may be reconsidered as a potential threat.

Disease and Predation

Cottontail rabbits are known to contract a number of different diseases, such as tularemia, and are afflicted with ectoparasites such as ticks, mites and fleas, and endoparasites such as tapeworms and nematodes (Eabry 1968, pp. 14-15). However, there is little evidence to suggest disease is a limiting factor for NEC. DeVos, Manville, and VanGelder (1956) in Eabry (1983, p. 15) stated that eastern cottontails introduced onto the Massachusetts islands of Nantucket and Martha's Vineyard probably competed with the native NEC and that the eastern cottontails introduced tularemia to the islands. It is not known whether tularemia played a role in the disappearance of NEC from the islands. Chapman and Ceballos (1990, p. 96) do not identify disease as an important factor in the dynamics of cottontail populations. Rather, they identify quality of habitat as the key to cottontail abundance and state that populations are regulated through mortality and dispersal. They note that escape cover is an essential habitat requirement, suggesting that mortality from predation is an important mechanism regulating local populations.

Brown and Litvaitis (1995, p. 1007) found that mammalian predators accounted for the loss of 17 of 40 NECs in their study. Barbour and Litvaitis (1995, p. 325) determined that the coyote (*Canis latrans*) and red fox (*Vulpes vulpes*) are the primary predators of NEC in New Hampshire. Litvaitis et al. (1984, p. 632) noted that cottontails were a major prey item of bobcats (*Felis rufus*) in New Hampshire during the 1950s, recorded in the stomachs of 43 percent of the bobcats examined; more recently, researchers determined that the cottontails found in the bobcat study were all NEC (Litvaitis, in litt. 2005). In recent decades, bobcat populations have declined in some northeastern states (Litvaitis 1993, p. 869), but at the same time, a new predator became established: the coyote. Coyotes first appeared in New Hampshire and Maine in the 1930s, in Vermont in the 1940s and in southern New England in the 1950s (DeGraaf and Yamasaki 2001, p. 341). Since then, coyote populations have increased throughout the Northeast (Litvaitis and Harrison 1989, p. 1180; Smith and Litvaitis 1999, p. 59) and even occur on many offshore islands. Coyotes have become especially abundant in human-dominated landscapes (Oehler and Litvaitis 1996, p. 2070). Other mammalian predators of cottontail rabbits in New England include the gray fox (*Urocyon cinereoargenteus*), weasels (*Mustela* sp.), and fisher (*Martes pennanti*). Avian predation is also considered a significant cause of mortality for NEC (Smith and Litvaitis 1999, p. 2136): Both barred owls (*Strix varia*) and great horned owls (*Bubo virginianus*) took cottontails in a New Hampshire study where an enclosure prevented entry by mammalian predators. The abundance of above-ground hunting perches is believed to reduce the quality of cottontail habitat along powerlines, because the perches make it easier for red-tailed hawks (*Buteo jamaicensis*) and other raptors (Litvaitis et al. 2007, p. 180) to locate and catch prey, including rabbits.

NEC are also killed by domestic dogs (*Canis familiaris*) and cats (*Felis catus*) (Walter et al. 2001, p. 17, Litvaitis and Jakubas 2004, p. 15, Kays and DeWan, p. 4). The significance of the domestic cat as a predator on numerous species is well known (Coleman et al. 1997, pg 1-8). The domestic cat has been identified as a major predator of the endangered Lower Keys marsh rabbit (*Sylvilagus palustris hefneri*) and is thought to be the single greatest threat to that species' recovery (Forys and Humphreys 1999, p. 251). According to the American Veterinary Medical Association (2002), cats occur in 31.6 percent of homes in the United States, and the average number of cats per household is 2.1. Although we do not have direct evidence regarding the role of domestic cats in influencing NEC populations, given the high human population and housing densities throughout most of the NEC range, domestic cats may be important predators of NEC.

Predation is a natural source of mortality for rabbits, and where habitat is ample it would not threaten species' survival. However, most thicket habitats supporting NEC today are not large enough to provide enough cover and food to sustain rabbit populations amid high predation rates by what is now a more diverse set of midsized carnivores (Brown and Litvaitis 1995, pp. 1005-1011; Villafuerte et al. 1997, pp. 148-149).

Available evidence suggests that land use influences predation rates and NEC survival in several ways. Brown and Litvaitis (1995, pp. 1005-1011) compared the fate of transmitter-equipped NEC with habitat features that surrounded habitat patches. They found that the extent of developed lands, presence or absence of coniferous cover, and lack of surface-water features were associated with an increase in predation rates. Oehler and Litvaitis (1996, pp. 2070-2079) examined the effects of contemporary land uses on coyote and fox numbers and concluded that the abundance of these generalist predators doubled as forest cover decreased and agricultural land use increased. Thus, the populations of creatures that prey on NEC have increased substantially in recent decades.

The abundance of food and risk of predation are very influential in determining the persistence of small- and medium-sized vertebrates such as the NEC. Barbour and Litvaitis (1993, pp. 321-327) found that as food in the most-secure habitat areas was depleted, rabbits were forced to turn to lower-quality forage, or to feed farther from cover where the risk of predation was greater. As a result, NEC occupying small habitat patches were killed at twice the rate, and were killed sooner, than rabbits living in larger habitat patches. Further study found that rabbits in small patches were "on the lowest nutritional plane" (Villafuerte et al. 1997, pp. 150). Villafuerte et al. (1997, pp. 151) concluded that poorer forage in the wake of habitat fragmentation determined the viability of local NEC populations by making individuals more vulnerable to predation.

As landscapes become increasingly fragmented, NEC become more vulnerable to predation, not only because there are more predators but also because cottontail habitat quantity and quality (forage and escape cover) are reduced (Smith and Litvaitis 2000,pp. 2134-2140). Rabbits on larger patches were less vulnerable to predation; therefore, large patches of habitat may be essential to sustain populations of this species in a human-altered landscape. Smith and Litvaitis (2000, pp. 2134-2140) report that because eastern cottontails appear able to forage farther from cover and to detect predators sooner than NECs, eastern cottontails will likely persist while populations of NECs will continue to decline.

In summary, disease does not appear to be an important factor affecting NEC populations. Numerous studies suggest that mortality from predation is very important and is linked to habitat destruction and degradation. Predation is a routine aspect of the life history of most species, and under natural conditions – such as those that existed before Europeans settled in the Northeast and substantially changed the landscape – predation probably was not a threat to the persistence of NEC. Today, however, the diversity of types of predators has increased, the amount of suitable cottontail habitat has decreased, the remaining habitat is highly fragmented, and many habitat patches are quite small. The available evidence strongly suggests that predation is the reason why most small-thicket habitat patches are unoccupied by NEC. Mortality to predation is the fate awaiting most cottontails that now occupy small habitat patches, as few rabbits that disperse into those areas or which are born there live long enough to breed. Since predation is strongly influenced by habitat quantity and quality, we conclude that the primary risk factor is the present destruction, modification, and curtailment of NEC habitat and range, and that predation has become an important risk factor due to current habitat conditions.

Inadequacy of Existing Regulatory Mechanisms

Limited regulatory mechanisms exist to directly prevent the destruction or modification of wildlife habitat. Today, habitat impacts occur mainly on private lands. Existing zoning ordinances appear to provide inadequate protection of NEC habitat, since much habitat destruction and modification has already occurred under zoning ordinances designed to regulate development. The destruction of NEC habitat could be lessened by persuading conservation commissions or other municipal permitting authorities to more actively limit development of habitats used by NEC.

The states have jurisdictional authority to manage both eastern cottontail and NEC populations and the ability to adapt regulations to local circumstances. For example, in Maine and New Hampshire the taking of NEC is prohibited under state endangered species laws, so that potential impacts on NEC from development are minimized, avoided, and/or mitigated. Regulatory activity under state endangered species laws in both states has preserved habitat for NEC on utility rights-of-way, protected habitat patches through deed restrictions and voluntary easements, and secured mitigation funding to help restore habitat. Rangewide, NEC benefits from state and federal regulatory mechanisms protecting other wildlife that share their habitats, including migratory birds, the bog turtle (*Glyptemys muhlenbergii*), and the eastern box turtle (*Terrapene carolina carolina*); these species' ranges substantially overlap that of NEC in southern New England. Both state and federal agencies currently have authority to manage land that is suitable for NEC, which could collectively and substantially lessen the threat to the population from continued habitat modification and fragmentation.

Other Natural or Human-Caused Factors Affecting the Continued Existence of NEC

Eastern Cottontail. The eastern cottontail was released into much of the NEC range, and some wildlife scientists believe the success of this species is a factor in the NEC's decline. The historical range of the eastern cottontail extended northeast only as far as the lower Hudson Valley and possibly extreme western Connecticut (Nelson 1909, pp. 20-25, 160-161, 170-171, 194-199; Goodwin 1935 in Chapman and Stauffer 1981, p. 980). Beginning with an introduction on Nantucket Island, Massachusetts, in 1899 (Johnston 1972, p. 3), state wildlife agencies and private hunting clubs introduced into the Northeast tens of thousands of eastern cottontails of four or five different subspecies. Large-scale introductions took place in Connecticut (Nelson 1909, and Dalke 1942 in Chapman and Stauffer 1981, p. 980), New Hampshire (Silver 1957), Rhode Island (Johnston 1972, p. 6), Massachusetts (Johnston 1972, pp. 4-5), and possibly Vermont (C. M. Kilpatrick, in litt. 2002). Today the eastern cottontail is firmly established in all the New England states except Maine.

The eastern cottontail is both larger (2.9 pounds versus 2.2 pounds) and more fecund than the NEC. In states where researchers and state wildlife agencies reported the NEC as the predominant or the only cottontail during the early to mid-1900s, by the latter half of the century the eastern cottontail had become by far the more common rabbit (Johnston 1972, pp. 1-70; Tracy 1995, pp. 1-49; Cardoza in litt. 1999). Maine, where the eastern cottontail is not known to occur, is the only exception to this pattern.

The precise mechanisms that may explain the gradual replacement of NEC by the eastern cottontail are not known. Biologists hypothesize that it may be some combination of the eastern cottontail's better ability to evade predators or disperse into and use the available habitat, reproductive interference, or some other factor. Likely, the increase in eastern cottontails results from several subtle factors that, working together, in some way let this non-native rabbit gradually displace NEC from otherwise suitable habitat. A better understanding of the factors related to the relationship between the two species is one of the top priorities to reduce uncertainty and increase the effectiveness of this conservation Strategy. The NEC Technical Committee believes that the most effective way to gain an understanding of and devise a solution to this problem lies in experimental manipulations of habitat and of eastern cottontail populations. Preliminary studies have begun to measure the response of both species to habitat management designed to benefit NEC, and to measure the response of both species to the removal of individual eastern cottontails from co-occupied habitats.

Weather and Climate

Winter severity, measured by the persistence of snow cover, affects NEC survival, because snow cover increases the rabbits' vulnerability to predation, particularly in poor-quality habitat patches (Brown and Litvaitis 1995, pp. 1005-1011). Rabbits are not highly evolved to survive in snow. In comparison with snowshoe hares, cottontails have proportionately smaller hind feet and cannot run on top of the snowpack. Also, they do not turn white in winter, so they stand out sharply against a white background.

Villafuerte *et al.* (1997, p. 151) found that snow cover reduces the availability of high-quality foods, which likely results in rabbits becoming weakened and more likely to be caught by predators. Brown and Litvaitis (1995, pp. 1005-1011) noted that during winters with prolonged snow cover, a greater proportion of the cottontails they studied were killed by predators. Litvaitis and Johnson (2002, p. 21) speculated that differences in snow cover and duration may explain the largely coastal distribution of NEC because, during most winters, less snow usually falls in coastal areas, and there are fewer days with snow cover. Snow may be important factor defining the northern limit of the NEC range: 85 percent of documented NEC occurrences are within 50 miles of the coast and 100 percent are within 75 miles of the coast (S. Fuller, unpublished data). The preceding studies suggest that a winter or a series of winters with unusually persistent snowfall could cause NEC populations to decline sharply and the species' range to contract. Such events would have the most severe results in areas where populations are the most depressed, because those populations tend to be highly fragmented, with individuals living in smaller habitat patches.

Based on the relationship of NEC survival to winter severity, we surmise that climate change may have important implications in conserving NEC. Climate-change models predict decreasing snow cover within the NEC range (Hayhoe *et al.* 2007), which presumably would increase winter survival. However, the potential implications of climate change extend beyond changes in snow cover. For example, Tracy

(1993, p. 68) compared the metabolic physiology of NEC with that of eastern cottontails and found that, at lower temperatures, energy demands in eastern cottontails are significantly higher than in NEC. This difference may explain slight variations in habitat use between the species. Specifically, NEC may have an advantage in habitats where plant nutrition levels are insufficient to support the higher energy demands of eastern cottontails (Tracy 1993, p. 69). Elevated levels of carbon dioxide (CO_2), the primary gas that is contributing to climate change, are anticipated to change plant communities by abetting the invasion of certain plant species and altering plant succession and ecological processes, including fire regimes (Weltzin et al. 2003). At present, the overall impacts of climate change on wildlife are not well understood, and scientists are uncertain how changes resulting from elevated CO_2 will levels will affect NEC. Some impacts may benefit the species, while others may harm it.

When Populations Dwindle

Since the seminal work of Allee *et al* (1949), many scientists have studied the problems that crop up when populations of animals dwindle and small populations become isolated from larger, healthier ones. These problems include inbreeding and difficulty in finding mates. The extensive loss of habitat in southern New England (Jackson 1973, p. 21; Brooks and Birch 1988, p. 85; and Litvaitis *et al.* 1999, p. 101) has both diminished and isolated many NEC populations, which may limit essential population functions, such as breeding, within the remaining fragmented habitat patches. It is possible that habitat restoration in itself may not be enough to restore some populations, and bringing in NEC from other areas may be needed.

3.0 Species Population and Habitat Goals

3.1 Rangewide Summary of Population and Habitat Goals

This Strategy outlines goals to be reached by year 2030 that the NEC Technical Committee believes will best ensure longterm conservation of NEC. Table 3.1.1 shows the three levels of habitat and population goals developed prior to, and as a part of, this conservation effort for different but related purposes. The three levels, described in futher detail below, represent rangewide goals developed by the U.S. Fish and Wildlife Service (USFWS); individual state goals; and sub-goals for the focus areas within each state.

USFWS rangewide goals were developed for the 2011 New Hampshire Candidate Conservation Agreement with Assurances (CCAA) program, a voluntary conservation tool promoting the participation of non-federal landowners in NEC conservation in New Hampshire. In developing CCAAs, the USFWS is required to evaluate rangewide habitat and population goals necessary for precluding the need to place the NEC on the endangered species list, if all similarly situated landowners were to implement the practices covered in the CCAA across the species' range and not just in New Hampshire. USFWS rangewide goals were subject to public comment and were reported in the Federal Register (75 FR 66122 66123).

Table 3.1.1. Summary of NEC Recovery Goals. As discussed in section 4.5, habitat goals may be met by 2030 through creating new habitat; enhancing or managing existing habitat; documenting NEC use of self-sustaining natural habitat; and documenting NEC use of formerly unoccupied habitat.

RECOVERY GOALS		
Goal Level	**Habitat (acres)**	**Population (N)**
USFWS* Range-wide Goals	27,000	13,500
Connecticut	19,000	9,500
Massachusetts	6,800	4,500
Maine	5,140	2,570
New Hampshire	2,000	1,000
New York	10,000	5,000
Rhode Island	1,000	500
Total All State Goals	43,940	23,070
Total All Focus Area Sub-Goals	51,665	28,100

*Per NH CCAA (Federal Register: 75 FR 66122 66123)

The NEC Technical Committee and conservation professionals representing the states in the NEC range refined the USFWS rangewide goals by using an eight-step landscape-analysis process to ensure: (1) representation of population diversity across the historic range; (2) resiliency of populations by making sure enough individuals exist to buffer environmental and genetic uncertainty; and (3) a redundancy of populations, because multiple populations will help guard against unexpected catastrophes such as disease outbreaks (Shaffer *et al.*, 2002, p. 138). In 2012, the NEC Technical Committee finished delineating focus areas and established habitat and population goals for each that exceeded the goals identified by the USFWS. The approach is described more fully below, and in technical detail by Fuller *et al.* (2011):

1. Apply habitat models of capability and habitat suitability across the species' range;
2. Use models, landscape and connectivity metrics, and species occurrence data to evaluate and prioritize parcels of land for their management and conservation potential;
3. Use ranked parcels to delineate preliminary focus areas based on the density of clusters of habitat, conservation land, and parcels suitable for management;
4. Identify patches of habitat within preliminary focus areas, and extrapolate maximum density, or carrying capacity, of NEC that can be supported by those patches;
5. Evaluate the predicted configuration of potential habitat and NEC carrying capacity in preliminary focus areas;
6. Refine focus area boundaries based on local knowledge, complementary datasets, and alternative models (for example, Tash and Litvaitis 2007);
7. Set population and habitat goals within the bounds of predicted potential habitat and NEC carrying capacity;
8. Consider the rangewide representation, resiliency, and redundancy of populations delineated by focus areas and projected by the population and habitat goals in seeking to answer the question: Are the individual "parts" and the collective "whole" together capable of conserving the species?

In coordination with the NEC Technical Committee, the states provided an additional feasibility check and selected focus areas with the clearest likelihood of restoration success. The state goals account for reality, acknowledging that opportunities will change, implementation may not be practical in some areas, and the predictions made by our landscape analysis may not be correct for all locations. For these reasons, state goals exceed the sum of goals for all the focus areas in each state. (We refer to the goals set for individual focus areas as "sub-goals," and point out that sub-goals have not yet been set for all focus areas due to insufficient data or the inability to assess opportunities for restoration.)

In summary, the goal of this Strategy is to ensure healthy NEC populations into the future, beyond the short-term goal of making sure the NEC does not need to be placed on the endangered species list. Therefore, the state goals exceed the USFWS goals, and the focus area sub-goals exceed both the state and USFWS goals to assure that the overall rangewide goals are exceeded and to overcome uncertainty regarding the viability of any specific focus area across the species' range.

Intended Use of Focus Areas

The methods used to delineate focus areas are described below and in greater detail in Fuller *et al.* (2011). The delineation of focus areas was rooted in habitat models and an analysis of land parcels across New England, and was intended to guide the design of a landscape for conservation on the broadest scale: to map a landscape that will conserve NEC. The focus areas provide general direction for programs to regions with promising opportunities. Decisions about on-the-ground management and the spending of conservation funding should be driven by site-specific assessments and not solely through remote analysis or focus area boundaries.

Revision of Focus Area Goals and Boundaries

The Technical Committee recognizes that new information may suggest that we change our original focus area goals and boundaries. As such information becomes available; we will review potential changes or new focus areas annually. For example, in areas that also support populations of eastern cottontails, the prescribed goals may prove to be unrealistic unless research shows management can effectively address sympatry; or, certain habitat types may be shown to favor NEC, which may indicate a need to adjust the boundaries of a given focus area.

Allocation of Recovery Goals Across States

As shown in Table 3.1.1, recovery goals are not evenly allocated across the states. According to Fuller *et al.* (2011), across four modeling approaches and many model iterations, snow depth and forest canopy cover were consistently among the top 4 of 16 habitat variables considered. The models demonstrate that a favorable lesser snow depth and protective canopy cover within the species range occur most abundantly in southern New England. The modeled habitat pattern is consistent with the pattern of existing NEC populations; it reflects recent declines in NEC populations in Maine and New Hampshire, following severe winter weather; it overlays large expanses of well-documented existing habitat; and it reflects the history of land use in southern New England relative to that in northern New England. Wildlife biologists familiar with habitats in Maine and New Hampshire expressed strong reservations about the feasibility of goals higher than those proposed; accordingly, goals were set higher in southern New England.

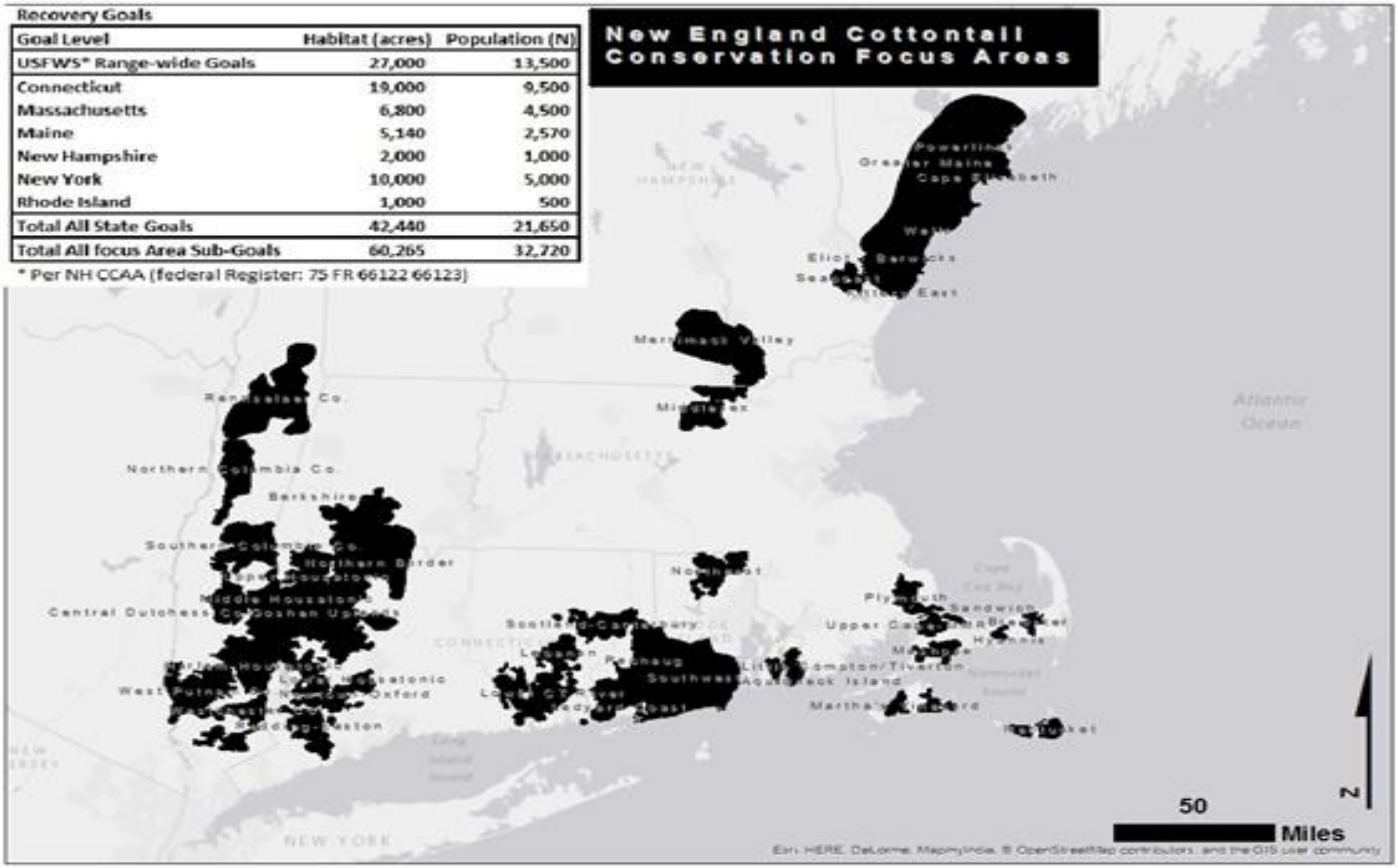
The NEC is believed to have vanished in Vermont. At present there are no plans to reintroduce the species there. We believe that the geographic scope of the existing Strategy, with its associated goals and objectives, is adequate to conserve the NEC. Should NEC be rediscovered in Vermont, or a reintroduction effort be undertaken there, we will evaluate the need to develop goals and objectives for the state in partnership with the Vermont Fish and Wildlife Department.

Table 3.1.2. Summary of NEC Focus Area Sub-Goals. Minimum sub-goals were required by the NEC Technical Committee for all focus areas. Some states developed Upper Goals to take into account local

				Habitat Sub-Goals		Population Sub-Goals	
State	Focus Area	Subunit		Lower	Upper	Lower	Upper
CT	Goshen uplar	Goshen uplands		5000	-	2500	-
CT	Lebanon	Lebanon		1500	-	750	-
CT	Ledyard-coas	Ledyard-coast		2000	-	1000	-
CT	Lower CT Rive	Lower CT River		1500	-	750	-
CT	Lower Housa	Lower Housa	*	1000	-	500	-
CT	Middle Housa	Middle Housatonic		4000	-	2000	-
CT	Newtown-Ox	Newtown-Ox	*	1000	-	500	-
CT	Northern Bor	Northern Bor	*	1000	-	500	-
CT	Pachaug	Pachaug		4000	-	2000	-
CT	Redding-East	Redding-East	*	1000	-	500	-
CT	Scotland-Can	Scotland-Canterbury		1000	-	500	-
CT	Upper Housa	Upper Housa	*	1000		500	
MA	Harwich-Brev	Harwich-Brewster		1000	3000	250	-
MA	Hyannis/Yarn	Hyannis/Yarmouth		500	750	100	-
MA	Martha's Vin	Martha's Vin	*	1000	-	1000	-
MA	Mashpee	Mashpee		1300	3880	1000	-
MA	Nantucket	Nantucket	*	1000	-	2000	-
MA	Middlesex Co	Middlesex Co	*	1000	-	400	-
MA	Plymouth Co.	Plymouth Co.		1000	1250	500	-
MA	Sandwich	Sandwich		1000	1500	150	-
MA	Southern Ber	Southern Berkshire		1000	-	500	-
MA	Upper Cape-I	Upper Cape-MMR		1000	6000	2000	-
ME	Cape Elizabet	Cape Elizabeth/Scarb.		-	1000	-	500
ME	Elliot/The Ber	Elliot/The Berwicks		-	1800	-	900
ME	Kittery	Kittery		-	350	-	175
ME	N-S Corridor	N-S Corridor		-	1015	-	508
ME	Wells East	Wells East		-	350	-	175
ME	Greater Main	Greater Maine		-	625	-	312
NH	Merrimack Va	Merrimack North		500	-	250	-
NH	Merrimack Va	Merrimack Sc	*	-	-	-	-
NH	Seacoast	(sum of subunits)		1500	-	750	-
NH	Seacoast	Bellamy		750	-	375	-
NH	Seacoast	Crommet Creek		100	-	50	-
NH	Seacoast	Dover West		200	-	100	-
NH	Seacoast	Dover-WOKQ		200	-	100	-
NH	Seacoast	Oyster River		250	-	125	-
NH	Seacoast	Rollinsford		-	-	-	-
NY	Central Dutch	Central Dutchess		1000	6000	500	-
NY	Harlem-Hous	Harlem-Housatonic		4000	24000	2000	-
NY	Northern Col	Northern Col	*	-	-	-	-
NY	Rensselaer Co	Rensselaer Co	*	-	-	-	-
NY	Southern Col	Southern Columbia Co.		1000	6000	500	-
NY	West Putnam	West Putnam		3000	6000	1500	-
NY	Westchester	Westchester Co.		1000	6000	500	-
RI	Aquidneck	Aquidneck	*	200	-	100	-
RI	Little Compto	Little Compto	*	200	-	100	-
RI	Northeast RI	Northeast RI	*	200	-	100	-
RI	Southwest RI	Southwest RI		1000	-	500	-
TOTAL (lower end of range)				47400		26700	

* Focus area is not currently managed due to high uncertainty in population status or conservation feasibility.

Figure 3.1.1. Rangewide map of NEC focus areas approved by NEC Executive Committee October 18, 2011. Sub-goals for focus areas with high management uncertainty as noted in table 3.1.2 are not included in state recovery goals. Habitat goals may be met by 2030 via creating new habitat, enhancing or managing existing habitat, documenting NEC use of self-sustaining natural habitat, and documenting NEC use of formerly unoccupied habitat.



Recovery Goals

Goal Level	Habitat (acres)	Population (N)
USFWS* Range-wide Goals	27,000	13,500
Connecticut	19,000	9,500
Massachusetts	6,800	4,500
Maine	5,140	2,570
New Hampshire	2,000	1,000
New York	10,000	5,000
Rhode Island	1,000	500
Total All State Goals	42,440	21,650
Total All focus Area Sub-Goals	60,265	32,720

* Per NH CCAA (federal Register: 75 FR 66122 66123)

3.2 Designing a Landscape to Conserve NEC

Which parts of the remaining range of an at-risk species remain secure? How much habitat is needed to maintain existing populations? How should we configure the habitat on the landscape to protect those populations? In planning to conserve a species, wildlife biologists must first ask many questions about the animal's current distribution and how to preserve and manage essential habitat in the face of human and environmental pressures. In delineating and designing focus areas for NEC conservation, we used models of NEC distribution and habitat, made coarse extrapolations of the land's population-carrying capacity, and performed complex analyses of the New England landscape. Here, we briefly describe some of the science behind our landscape design, which provides a configuration of focus areas for NEC across the species' range. (In section 3.3, we provide guidelines for designing NEC reserves in the absence of the fine-scale data required for viability models.)

We established a landscape design and conservation goals based on principles of population viability and biogeography that would: (1) keep or return NEC to most of its historic range; (2) protect existing populations by ensuring that enough individuals are present to overcome environmental and genetic uncertainty; and (3) provide multiple populations to guard against unexpected events such as disease outbreaks (Shaffer *et al.*, 2002, p. 138). These principles have been translated into numbers that represent population goals for conserving the species.

Sophisticated habitat models helped us identify landscapes potentially able to support persistent populations of NEC (Appendix C). Different habitat models were considered to delimit focus areas and establish habitat and population goals for each. Following model development, biologists used both models and local knowledge to fine-tune focus area boundaries and estimate the collective effort needed to conserve NEC.

Habitat Model Development

A dataset of 637 recent (2000 to 2010) NEC occurrence records from throughout the species' range provided a sound basis for developing two models to predict habitat capability and habitat suitability (Fuller *et al.*, 2011). The habitat capability index was used to identify habitats with abiotic (non-living) factors such as soils, hydrology, topography, and terrain similar to those of habitats currently being used by NEC, and thereby be able to predict which sites would be suitable for growing dense forest stands and shrub thickets, regardless of the current vegetation and suitability of the habitat for NEC (Fuller *et al.* 2011, pp. 4-5).

For modeling both habitat capability and habitat suitability, the initial selection of habitat variables was guided by prior published data (Tash and Litvaitis 2007). For the habitat capability index, coarse- and fine-scale continuous habitat variables were screened through iterative multivariate logistic regression analyses and further refined by comparing frequency distributions of NEC across levels of the candidate variables (Fuller *et al.* 2011, pp. 5-6). Geographic variation was addressed by constructing minimum convex polygons around occurrence data points identified as significant through cluster analysis.

Statistically rigorous habitat suitability modeling can be challenging when only presence data (i.e., simply the presence of NEC in a habitat) are available. We considered several standard techniques to work with presence-only data, including maximum entropy and niche modeling. Niche modeling was dismissed because the model did not allow for classification variables, such as land-cover, landform, or soil-texture class, which have been shown to be important predictors of NEC presence. We decided to develop a flexible modeling approach that could account for the varied ecological and historical land-use pathways capable of yielding suitable NEC habitat. Ensemble classification is a technique that applies many models to each point on the landscape, and measures their consensus. Since early successional and shrub habitats may result from very different landscape patterns and processes, many different models can be true, while only a few might apply to a single location.

To apply ensemble classification to habitat suitability, Fuller et al. (2011) compared NEC presence points against a set of randomly generated null points that served as surrogate absence data for modeling purposes. Several ensemble classification techniques were tested to classify the presence and null absence data for NEC and thereby model habitat suitability: (1) a single classification tree with pruning, (2) bagging, (3) random forests, and (4) boosting (Fuller *et al.* 2011, p. 10). After substantial review, validation, and testing, we determined that the boosting algorithm provided the best predictive power for determining areas where NEC habitat is likely to exist. The model was then used to evaluate the range of the NEC for the presence of important habitat variables contained within a 100-meter raster grid overlay. Each cell was evaluated and ranked on a scale of 0 to 1, representing the proportion of an entire ensemble of models positively predicting the suitability of a habitat for NEC. The two models, habitat suitability and capability, provide complementary tools for assessing where habitat might currently be, and where it might be created.

Extrapolating Carrying Capacity to Habitat Models

The carrying capacity of a wild animal in its environment is the maximum population of the species that the environment can sustain indefinitely with its available food, cover, water, and other factors. Fuller *et al.* (2011) derived a rough estimate of carrying capacity based on NEC densities discovered by other researchers:

> "We applied standardized density data to our habitat models for the purpose of projecting upper limits of restoration in geographies where limited information is available to inform the scope and feasibility of species restoration. The resulting data were intended to inform decision-making, and should be interpreted cautiously because their validity are highly uncertain . . . . The analysis was performed in 2 steps, the first yielding a continuous surface of projected maximum NEC densities constrained to discrete patches of potential habitat derived from the habitat capability index (patches 10 ha or larger where the habitat capability index raster score is >70), and the second step summarizing results for discrete geographies, e.g., within the focus areas delineated . . . further

> constrained by the average predicted capability of habitat and arbitrary constants defining upper and lower limits variability in NEC utilization of habitat."

The resulting data were used as a scaling factor in considering population goals for focus areas. Extrapolated carrying capacities were weighed with carrying capacities from published viability simulations (Litvaitis and Villafuerte 1996), local knowledge, and other factors such as potential competition with eastern cottontails.

Habitat Model Uncertainty

No model provides certain information about our environment; direct observation must ultimately be used to affirm the accuracy of predictions. Allocating funding to additional habitat modeling is not justified at this time: The habitat suitability model that we used achieved cross-validation misclassification error of 4 to 8 percent, which is exceptionally low, and more than 80 percent of new observations of NEC have been made on parcels identified through using habitat models in concert with other landscape-screening factors. While other methods could yield comparable performance, the most suitable occupied and unoccupied landscapes have already been predicted and validated in the NEC range.

Monitoring and research efforts (sections 4.2 and 4.6) have been designed and will be used to integrate empirical data in an adaptive management framework (section 6.0) to detect trends in patch occupancy and measure rangewide population response to management. Since both management and monitoring will be conducted within a framework that provides for testing assumptions, we believe empirical measurement of responses will be more effective than additional habitat or metapopulation modeling in predicting the effectiveness of management.

In habitat suitability models for distressed populations developed using presence-only data, the presence of populations does not necessarily indicate that the habitat being occupied is the most suitable for the species. In an intact landscape, where would the best habitat be? Unfortunately, no such landscape exists today in the NEC range. Underlying habitat model uncertainty is amplified in extrapolations of carrying capacity – the "best" habitat is unknown, the true distribution of population densities is unknown, and the true relationship of densities to habitat models is unknown. Fuller *et al.* (2011) summarized the uncertainties associated with extrapolated carrying capacities:

> "Obvious uncertainty arises from 1) the assumption that density estimates provided by Barbour and Litvaitis (1993) from NH apply to the species range, and 2) our highly speculative formulation of the relationship between our habitat models and NEC density. Lower depth and duration of snow cover in the southern portion of the species range may indicate higher possible densities, and the relative density of NEC vs. eastern cottontail is poorly documented where they co-occur south of the NH study area."

Delineating Focus Areas

While the habitat models generated useful information that could be used to describe the potential distribution of NEC during the period from 2000 to 2010, additional analysis was needed to identify important landscapes where conservation actions should take place. Changes in land use have destroyed and fragmented much NEC habitat, and areas with extremely altered habitats are unlikely to support persistent populations of NEC. In addition, most southern New England forest is privately owned, ranging from 85 percent in Rhode Island to 69 percent in Massachusetts (Butler *et al.* 2011, p. 12). Further, 90 percent of private landowners hold relatively small tracts of forest land, ranging between 1 and 9 acres (Butler *et al.* 2011, p. 12). This fragmentation of forest ownership has imposed social and logistical restrictions on forest management options (Brooks 2003, p. 65).

Given this challenge, the habitat model results were compared against land-ownership patterns to identify landscapes containing larger privately owned parcels and areas with substantial amounts of secured lands such as state forests, state wildlife management areas, and National Wildlife Refuges. Identifying existing conservation landscapes was judged to be extremely important, because trying to create and maintain enough good NEC habitat on privately owned land is likely to be less efficient and may not be feasible as part of a strategy designed to support persistent populations of NEC.

Focus areas were developed by analyzing parcel data from town tax maps. Parcels smaller than 5 acres were removed from the data set (Fuller *et al.* 2011, p. 17). Parcels were then ranked according to their size, distance from the nearest recent (since 2003) NEC occurrence record, habitat capability score, habitat capability index score, maximum and mean predicted suitability, and distance to nearest conservation land (Fuller *et al.* 2011, p. 18). Parcels falling within the 94th percentile were considered high-value parcels and were targeted for site-specific assessments to validate our predictions and to learn whether landowners were receptive to conservation actions such as forestry management aimed at creating NEC habitat (Fuller *et al.* 2011, p. 17).

We developed preliminary focus area boundaries by creating two fixed-kernel density rasters in ArcGIS from polygon centroids of the 90th and 94th percentiles of ranked parcels across the range (Fuller *et al.* 2011, pp. 22-23) – put simply, our analysis identified regions with the highest density of land parcels suited to making and maintaining NEC habitat. With regard to creating focus areas, Fuller *et al.* (2011) noted:

> "Since parcel ranking integrates multiple sources of information, the parcel dataset is more powerful than individual data sources or models. Decisions about on the-ground expenditure of conservation funding should be driven by site-specific assessments, and not our remote analysis. The data provide coarse scale information to help direct programs to regions with fitting opportunities; for example, certain landscapes present few opportunities on private lands and abundant opportunity on public lands, and relevant programs should be directed accordingly."

Final selection and delineation of focus areas involved state-level management teams refining the boundaries and selecting specific areas where conservation actions would take place.

Developing Goals for Focus Areas

In developing population goals, the NEC Technical Committee adopted an index of 0.5 individual NEC per acre, a figure derived through computer simulations (Litvaitis and Villafuerte 1996) that correlated habitat degradation and loss (based on forest maturation) with periods when the ground is covered with snow (when cottontails are extremely vulnerable to predation) – factors that, when combined, could "cause a rapid decline in rabbit populations or local extinctions" (Litvaitis and Villafuerte 1996). The researchers concluded that those negative effects could be countered by a management program that maintained a network of suitable early successional habitat patches of 37 to 185 acres through a regime of periodic disturbances such as burning, cutting, or mowing vegetation. The NEC Technical Committee evaluated population and habitat carrying capacity estimates for each focus area. Fuller *et al.* (2011, pp. 19-21) advocated cautious interpretations of the estimates with regard to local conditions, stating:

> "Presence of eastern cottontail rabbits should be taken into consideration. Although the habitat models should provide some discrimination between the habitat of the two species, sympatric occurrences are well documented, and reducing the estimated carrying capacity by as much 50 percent to account for habitat utilization by eastern cottontail may be prescribed."

In summary, the goal-setting process was informed by simulations (Litvaitis and Villafuerte 1996) and carrying-capacity extrapolations, but the final goals were determined by conservative local judgments that took into account the feasibility of carrying out management activities, habitat conditions, and potential competition from eastern cottontails.

Revising Focus Area Goals and Boundaries

The Technical Committee recognizes that new information will likely lead us to change our original focus area goals and boundaries. As reliable new information emerges, we will review proposed changes or new focus areas on a yearly basis, and modify focus areas as needed (see objective 005). For example, in areas with sympatric eastern cottontail populations, the prescribed goals may prove unrealistic unless research shows that management can effectively address sympatry, or that certain habitat types favor NEC.

3.3 Designing Reserves for the New England Cottontail

While state summaries (Section 5.0) provide statistics to describe features important for designing reserves in each focus area, explicit reserve design for the 47 individual focus areas is not within the scope of this strategy. On a local scale – the scale at which animals interact with one another and move between habitat patches – metapopulation modeling and other population viability analyses may be used to develop and test spatially explicit reserve designs. The demographic and habitat patch occupancy data needed to perform spatially explicit population viability analyses and to test specific reserve designs are largely unavailable across the NEC range.

We advocate for the future implementation of spatially explicit reserve designs (see objective 309) for each focus area identified in our larger-scale landscape design, recognizing that it may not be feasible to support viable populations of NEC in some of those areas. When designing reserves for wildlife, biologists must consider species-specific life-history traits. These traits can include morphological, developmental, or behavioral characteristics such as body size, growth patterns, size and age at maturity, reproductive capacity, mating success, the number, size, and sex of offspring, and the rate of senescence (Ronce and Olivieri 2004, p. 227).

Given the life history of the NEC, we believe that the key to an effective Strategy is to ensure that the species is provided with ample resources. In addressing the resource needs of NEC, we considered factors that affect habitat quality and quantity. In addition, we also recognize that the landscape-level habitat alterations that have occurred throughout the species' range have fragmented NEC populations. As a result, NEC populations are believed to function as metapopulations; that is, a set of local populations that may interact when individuals move between them (Hanski and Gilpin 1991, p. 7; Litvaitis and Villafuerte 1996, p. 686). Litvaitis and Villafuerte (1996, p. 686) characterized the population structure of fragmented NEC populations as "induced metapopulations."

In the real world, the spatial structure of the NEC population varies widely depending on the degree of habitat fragmentation and the extent and availability of suitable habitat; some populations are highly fragmented, while others occupy thousands of acres of nearly contiguous habitat. In this Strategy, we use the term "metapopulation" loosely to describe the varying population structures that result from the diverse patterns of ephemeral habitat in a changing landscape. We intend that spatial population structure be directly addressed in reserve designs for each NEC focus area. It is essential that spatial population structure be considered in concert with the species' life history characteristics in order to design management systems that ensure the species' viability (Hanski 1998, p. 41).

Life History Considerations

The NEC, like all cottontails, can reproduce at an early age, with some juveniles probably breeding in their first year. Litter size is typically five young (range, three to eight), and females, who provide little parental care, may produce two or three litters per year. Females have a high incidence of postpartum breeding, demonstrate density-independent breeding response, and mature quickly (approximately 40 days from conception to parental freedom) (Chapman and Ceballos 1990, p. 108). Such characteristics allow a species to thrive in spite of a high predation rate, provided ample resources are available (Chapman, Hockman and Edwards 1982, p. 105). In the case of cottontail rabbits, these resources include ample nutritious food, and habitat that is free from interspecific competition and that offers protection against excessive predation (Chapman, Hockman and Edwards 1982, p. 106). We believe that a focused effort to increase food, cover, and shelter for NEC will insure the species' long term viability.

NEC are considered habitat specialists dependent on early successional habitats, often described as "thickets" (Litvaitis 2001, p. 466). Barbour and Litvaitis (1993, p. 324) found that individuals could survive winter conditions when they inhabited areas that contained greater than 20,234 stem cover units per acre. They determined that NEC occupying habitat patches of around 6 or fewer acres were predominantly males, had lower body mass, consumed lower-quality forage, and had to feed farther away from protective cover than rabbits in larger patches covering 12 or more acres (Barbour and Litvaitis 1993, p. 321). Their study also demonstrated that, owing to mortality from predation, NEC in the smaller patches had a survival rate only half that of NEC in the larger patches.

Environmental conditions are known to impact survival. Winter severity, measured by the persistence of snow cover, increases NEC vulnerability to predation, particularly in low-quality habitat such as small patches having a low stem density (Brown and Litvaitis 1995, pp. 1005-1011). Barbour and Litvaitis (1993, p. 321) state that the skewed sex ratios (sometimes only a single occupant) and low survival rates among rabbits in small patches may effectively prevent reproduction from taking place. The presence of NEC in small patches relies on individuals migrating in from nearby source populations (Barbour and Litvaitis 1993, p. 326). Litvaitis *et al.* (2007, p. 179) and Barbour and Litvaitis (1993, p. 321) view such small patches as "sink habitats," in which reproduction is insufficient to balance mortality.

Demographic and Environmental Stochasticity

In metapopulations, population extinction and colonization at the patch-specific scale are recurrent rather than unique events (Hanksi 1998, p. 42). As with many metapopulations, local extinctions of NEC likely result from demographic, environmental, and genetic stochasticity ("stochasticity" is defined as involving chance and lacking any predictable order or plan.) While there are no known examples of genetic stochasticity that have led to inbreeding depression or other adverse effects in NEC, there are indications that demographic and environmental stochasticity play a role in the persistence of NEC populations. For example, small patch size affects survivability and sex ratios in NEC, resulting in demographic stochasticity and local extinctions. Winter snow depth and persistence is another example of a stochastic environmental factor that could cause a local population to go extinct. We recognize that winter severity operates on a regional scale and, therefore, addressing the effects of such environmental processes at the patch-specific scale will be difficult. To guard against the risk of local extinctions caused by environmental stochasticity, conservation efforts should be distributed across the species' range. In addition, although there are no published studies regarding genetic stochasticity that inform our conservation approach for conserving NEC, preserving all genetic heterozygosity within the species is clearly the best strategy.

Extrapolating Patch-Specific Considerations to a Regional Scale

The two familiar forms of stochasticity affecting local populations, demographic and environmental stochasticity, have exact counterparts at the metapopulation level in extinction-colonization (also called immigration-extinction) and regional stochasticity's (Hanski 1991, p. 31). Extinction-colonization dynamics in metapopulations consisting of small extinction-prone habitat patches are prone to regional extinction when extinction exceeds colonization (Hanski 1998, p. 43). When localized extinction occurs, an area may be re-occupied by individuals dispersing from other source habitats. Reoccupation depends on the strength and distribution of source populations and the species' dispersal capability. With small patch sizes, a declining habitat base, and a relatively limited dispersal range, the NEC is considered vulnerable to continued reductions in its numbers and distribution (Dalke 1937, p. 542, Litvaitis and Jakubas 2004, p. 41).

We need better information on colonization by NEC to fully understand the species' dispersal ability and the persistence of regional populations; unfortunately, this information remains unknown. Researchers considered the colonization ability of NEC in creating one computer simulation model of NEC metapopulations (Litvaitis and Villafuerte 1996, p. 689). In this model, the authors relied on information extrapolated from other mammals, especially the snowshoe hare. Based on their analysis, they determined that dispersal of NEC fit a geometric distribution, with a maximum dispersal distance of 1.8 mile (3 km).

Reserve Design Standards for the Conservation Strategy

The metapopulation framework recognizes and provides a conceptual model for evaluating the interactions of within-population processes (for example, birth, death, and competition) and among-population processes (dispersal, gene flow, colonization, and extinction) (Thrall *et al.* 2000, pg. 75). In practical terms, metapopulation extinction is a function of the number, size, quality, and connectivity of habitat patches within the system (Drechsler and Wissel 1998). This approach has been useful in formulating other management strategies, such as the one developed for the northern spotted owl (Thrall *et al.* 2000, pg. 87). A metapopulation approach may prove useful for developing a management strategy for the NEC because it addresses genetic, demographic, and environmental effects of fragmentation (Thrall *et al.* 2000, pg. 75).

Using a computer simulation model, Litvaitis and Villafuerte (1996, p. 686-693) analyzed various population scenarios and developed management guidelines for NEC. They suggest that a network of suitable habitat patches, each 38 to 185 acres and totaling approximately 370 acres, may be enough to sustain local populations, where the carrying capacity of a patch equals one rabbit per acre. A conservation network of this size would be expected to result in a maximum local population of 150 rabbits. Following conservation biology studies in recent years, wildlife scientists now recommend population thresholds of 500 individuals at the local level and 5,000 individuals in an overall population to ensure viability (Traill *et al.* 2010, p. 33), with 15 to 20 habitat patches considered desirable to reduce the likelihood of metapopulation extinction (Hanski 1998, p. 48).

The NEC Technical Committee recommended at least 500 NEC and 1,000 acres per focus area, representing a sum total of the various configurations of habitat patch sizes and populations, and allowing for one large metapopulation or several smaller ones, recognizing that some focus areas have a lower capacity and will require intensive management and/or augmentation to achieve those numbers. The Technical Committee did not specify the size and number of individual habitat patches within each focus area; instead, each focus area was evaluated to set a target number of patches in three size classes: greater than 50 acres, 25 to 50 acres, and smaller than 25 acres (see section 5.0, State Conservation Summaries). The Committee recommends a minimum patch size of greater than 25 acres but acknowledges that smaller patches may be a necessary component of reserve design in most landscapes.

Summary

The NEC Strategy and conservation goals are based on the best available data, including general conservation biology principles, NEC life-history information, and local habitat and management knowledge. We acknowledge that substantive new information may require us to re-evaluate our goals. In the meantime, uncertainty regarding our conservation targets should not distract or delay efforts to help NEC. To conserve the species, we plan to:

1. **Implement conservation actions in focus areas throughout the range** to establish:
    - A. 1 overall NEC landscape capable of supporting 2,500 or more individuals;
    - B. 5 smaller landscapes each capable of supporting 1,000 or more individuals; and
    - C. 12 smaller landscapes each capable of supporting 500 or more individuals;
2. **Develop a reserve design for every focus area** to provide clear local guidance on patch quality, quantity, and connectivity to ensure that large source populations remain viable and have enough suitable habitat;
3. **Convene land-management teams in each state** to provide certainty that management will be implemented and that reserve designs for each focus area minimize further loss and fragmentation of existing populations;
4. **Increase management on state and federal lands,** especially those currently under the authority of wildlife agencies, to offset development and other forms of habitat destruction and modification, recognizing that for most of the focus areas the acreage of state and federal lands biologically suitable for management exceeds the minimum habitat goals identified in this Strategy;
5. **Develop management agreements** with municipalities and other conservation-land owners to offset development and other forms of habitat destruction and modification, recognizing that in most focus areas the acreage of these lands in combination with similarly suitable state and federal lands substantially exceeds the minimum habitat goals identified in this Strategy;
6. **Increase capacity and funding to manage public land,** recognizing that in most cases, the potential of currently secured lands to support NEC is limited by the resources available to manage them and not by the number of acres that are biologically suitable for management;

7. **Engage private landowners to participate in voluntary management** actions, recognizing that the opportunity to manage currently secure and biologically suitable public lands to benefit NEC may be limited by factors beyond our control;
8. **Increase the security of management on private lands** by implementing a long term land-protection plan;
9. **Develop a captive breeding program** to bolster depressed populations and counter the destabilizing effects of fragmentation, isolation, and small population size;
10. **Evaluate the role of eastern cottontails** as a non-native competitor and take conservation actions to address this threat, as appropriate.

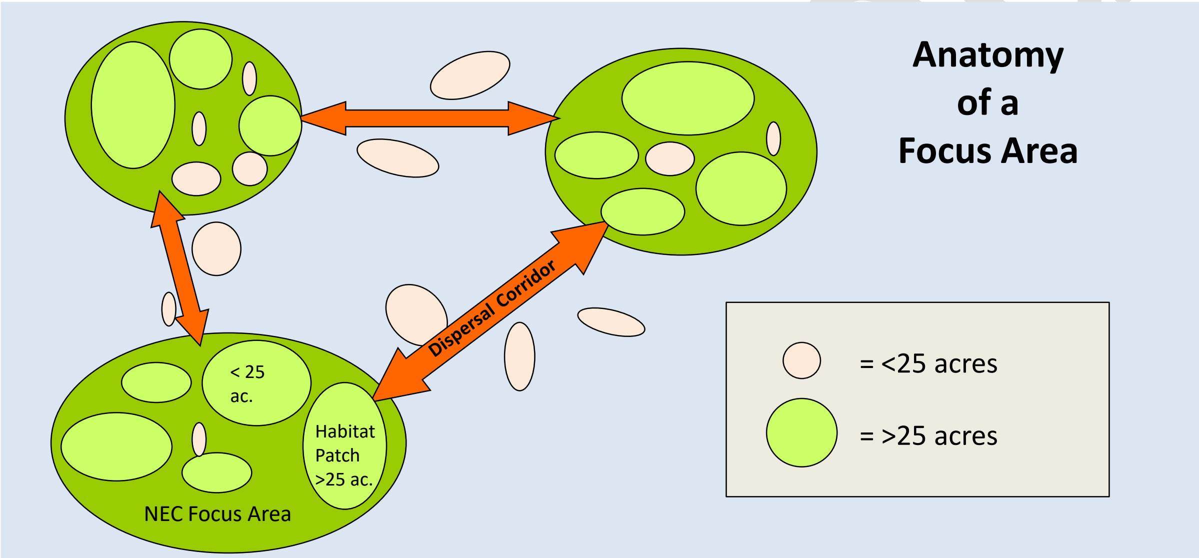
Table 3.3.1. Summary Reserve Design for All Focus Areas. In each focus area, the NEC Technical Committee evaluated all candidate parcels, habitat models, species occurrence data, aerial photography, conservation land, and ongoing habitat-management efforts and estimated the feasibility of conserving a network of habitat capable of supporting a metapopulation of NEC. Aside from the U.S. Fish and Wildlife Service's rangewide goals, the statistics reported summarize the contribution of all focus areas toward the 2030 focus area sub-goals set by the Technical Committee (see Section 5.0: State Conservation Summaries).

USFWS Range-wide Habitat Goals (acres)*	27,000
USFWS Range-wide Population Goals*	13,500
Focus Areas delineated:	47
Managed Focus Areas:	31
Metapopulations:	80
Habitat patches per metapopulation:	>11
2020 Target Patches > 50 acres (N):	473
2020 Target Patches < 25 acres (N):	470
2020 Target Managed Habitat Acres:	35,590
Estimated natural secure[1] habitat:	29,875
Secure[2] habitat available for management:	23,232
Estimated private land[3] available for mgmt.:	13,448
Secure[4] BP[5] Federal (acres):	7,119
Secure BP State (acres):	118,773
Secure BP Local (acres):	19,376
Secure BP Other (acres):	49,252
Not Secure BP Local (acres):	574,671

*Per NH CCAA (Federal Register: 75 FR 66122 66123)

1. Protected habitat acreage sustained as shrub/early successional habitat by natural process.
2. Protected habitat acreage to be maintained as shrub/early successional by management the purpose of wildlife.
3. Private or other voluntary land acreage to be maintained as shrub/early successional habitat.
4. Any federal, state, local (municipal), or other private land secured from development by fee or easement.
5. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011). *Per NH CCAA (Federal Register: 75 FR 66122 66123)

NEC focus areas (Figure 2) should contain at least 1,000 acres of habitat and support one or more metapopulations of NEC. Each metapopulation should be comprised of a network of 15 or more habitat patches (fewer if the patches exceed 50 acres, more if they are smaller than 25 acres). Within metapopulations, habitat patches should be 25 acres or greater in size, and situated within dispersal distance (less than 0.6 miles) of other habitat patches. Within focus areas, metapopulations should be separated by less than 3 miles. Landscape planning should take into account whether areas have manmade features or substantial natural barriers likely to increase habitat fragmentation and thwart the dispersal of individual NEC from one habitat patch to another. Where targeted landscapes are highly fragmented, focus areas may need to be larger or support more individual NEC. Landscapes that fall short of these recommendations will require special consideration for intensive management and translocation of captive-bred NEC to augment populations.



Each Focus Area should:
-Contain at least 1000 acres of habitat to support 500 NEC;
- Consist of one or more metapopulations separated by less than 3 miles (5 km), each containing 15 or more habitat patches (fewer when patches are greater than 50 acres), several of which should be 25 acres or greater in size; and
-Have each habitat patch within 1 mile or less of one or more other patches (within reasonable dispersal distance for individual NEC).

It is best, although not necessary, for connectivity to exist or be established between metapopulations and focus areas, although that may not be feasible within the five geographic areas currently known to have NEC.

Figure 2. Conceptual Model for the Conservation of the New England Cottontail. This diagram depicts one possible configuration of habitat networks or metapopulations. Alternative configurations or exceptions to the recommended reserve design features may be recognized by the NEC Technical Committee.

4.0 Species Conservation

This chapter describes the strategies developed to conserve the New England cottontail (NEC). Each section gives a brief overview of important relationships to the adaptive management process as described in chapter 6.0. Following the overview, each objective is described in text. A table concludes each section, presenting the objectives, their desired outcomes, performance measures, target levels, timing and duration, and other factors relating to the adaptive management process and how it will guide conservation of the NEC.

Section 4.0 Administration

Overview

Representatives of many state and federal agencies and nongovernmental organizations worked together to develop this Strategy. The objectives described below set forth the coordination for the governing committees to administer an adaptive management effort. Adaptive management allows for flexibility in making management decisions to resolve uncertainties and reach a goal or goals.

To ensure that this Strategy is implemented and that it reaches the goals identified, we established a framework to provide oversight of the achievement of objectives and the continual and ongoing adaptation that will lead to NEC recovery. This section provides an explicit plan to implement adaptive management (see section 6.0). We differentiate monitoring from performance evaluation and research. Together, three critical kinds of information provide feedback for adaptive management. Monitoring (section 4.2) involves collecting biological data within a sampling design. Performance evaluation (embedded in this section, 4.0) entails tracking implementation metrics (objective 004) or biological status derived from monitoring (objective 003). Research (section 4.6) tests specific management assumptions or uncertainties within an experimental, theoretical, or modeling framework.

We describe specific mechanics of reporting progress and modifying the conservation strategy so that: (1) the strategy can be adapted to reflect substantive new information; (2) procedures and timelines for accomplishment reporting are established and documented; (3) the efforts of the various working groups concentrating on different tasks are coordinated; and (4) agency leadership is kept aware of the overall effort and understands any needs so that resources can be allocated to important tasks.

Objective 001: Convene NEC Executive Committee
The NEC Executive Committee (Appendix D) oversees the decision-making element of the Adaptive Management Framework. It charges the NEC Technical Committee with tasks such as developing and carrying out habitat and population plans and tracking accomplishments. The Executive Committee also plays an important role in obtaining funds to accomplish conservation tasks. The Executive Committee has established bylaws that outline procedures for communication among its members (Appendix A).

Objective 002: Convene NEC Technical Committee
The NEC Executive Committee established the NEC Technical Committee (Appendix D) to develop a conservation strategy (the Strategy) and prioritize and implement actions needed to conserve the NEC (objectives 003, 004, 005, and 006). Work Groups (Appendix E) help the Technical Committee carry out various tasks. Work Groups are composed of experts in fields important to developing and implementing the Strategy. The Technical Committee coordinates the Work Groups to ensure that they meet their individual charges in carrying out the Strategy (objectives 006 through 011).

Objective 003: Review Species Status
The NEC Technical Committee helps the U.S. Fish and Wildlife Service (the Service) carry out a key evaluative element of the Adaptive Management Framework as described in Section 2.2 and as required by the federal Endangered Species Act: the annual review of the status of NEC, currently considered a candidate species for listing. The Technical committee also makes sure that all partners in the conservation effort receive complete and accurate information concerning NEC so that they and the Service can work together and fulfill their duties.

Objective 004: Review Performance
Based on input from the Work Groups, the NEC Technical Committee will review performance to ensure that priority conservation objectives are adequately funded and that funding shortfalls are identified; that habitat- and population-management measures to conserve NEC are effective; and that implementing the Strategy proceeds as scheduled.

Objective 005: Review Strategy Adaptations
The Technical Committee will review status and performance reports and propose new or modified objectives to the Executive Committee if and when they are needed. Incorporating new information into the Strategy is an important part of the adaptive management process, because it will increase the effectiveness of conservation measures over time (see chapter 6.0).

Objective 006: Coordinate Information and Adaptive Management Work Group
The Technical Committee coordinates efforts on the part of the Information and Adaptive Management Work Group (IAMWG). The scientists in this Work Group provide the integrative reporting and information oversight element of the Adaptive Management Framework by consistently collecting and sharing data on NEC occurrence, habitat management, and other science-based aspects of the conservation effort (see objectives for section 4.1; objective 005; and chapter 6.0).

Objective 007: Coordinate Research and Monitoring Work Group (RMWG)
This objective provides oversight for the monitoring and research performance element of the Adaptive Management Framework, the associated measures, and progress toward explicit habitat and population targets. Coordination of the RMWG (Appendix E) will ensure consistent delivery of monitoring and research objectives (see objectives for sections 4.2 and 4.6).

Objective 008: Coordinate NEC Land Management Teams (NECLMT) in Each State
This objective provides oversight for the land management performance element of the Adaptive Management Framework, the associated measures, and progress toward explicit targets. Coordination of this Work Group by the State Technical Committee representative (Appendix E) is needed to ensure consistent recruiting of landowners and achievement of habitat management objectives (see objectives for sections 4.3 and 4.5).

Objective 009: Coordinate Population Management Work Group (PMWG)
This objective provides oversight for the population management performance element of the Adaptive Management Framework, the associated measures, and progress toward explicit targets. Coordination of the PMWG by an appointed coordinator (Appendix E) is needed to ensure consistent delivery and coordination of population management objectives (see objectives for sections 4.4).

Objective 010: Coordinate Outreach Work Group (OWG)
This objective provides oversight for the outreach performance element of the Adaptive Management Framework, the associated measures, and progress toward explicit targets. Coordination of this Work Group by an appointed coordinator (Appendix E) is needed to ensure consistent delivery and coordination of outreach objectives (see Objectives for Strategies 4.7).

Objective 011: Coordinate Land Protection Work Group (LPWG)
This objective provides oversight for the land protection performance element of the Adaptive Management Framework, the associated measures, and progress toward explicit targets. Coordination of this Work Group (Appendix E) is needed to ensure consistent delivery and coordination of outreach objectives (see objectives for sections 4.8).

Objective 012: Coordinate Habitat Work Group (HWG)
This objective provides oversight for the development and updating of BMP's for the creation of NEC habitat, and to provide administrative technical support for managing contracting and vendors to conduct on the ground management activities.

Table 4.0.1. Coordination and Administration Objectives, Performance Measures, Scope, and Implementation Status (continued next page).

Objective	Desired Outcome	Performance Measure	Target Level	Structured Reporting	Adaptive Management	Scope (states)	Priority	Timing	Duration (years)	Status
001: Convene Executive Committee (ExCom)	Conservation Strategy implemented contingent on funding availability	Conduct at least 1 face-to-face meeting annually to review performance and recommended Conservation Strategy adaptations	Listing is not necessary	no	no	6	High	2012	8	On Schedule
002: Convene Technical Committee (TechCom)	Coordinate TechCom and workgroups to provide oversight for plan implementation and adaptive management	1 annual meeting and monthly calls	6 out of 8 in attendance	yes	yes	6	High	2012	8	On Schedule
003: TechCom annual review of species status	Review biological status of NEC and assess progress toward Population and Habitat Goals	Complete review at January Annual meeting	1 request to ExCom for approval	yes	yes	6	High	2012	8	Complete
004: TechCom annual review of performance	Review performance indicators and research results to assess efficacy of implemented actions	Complete review at January Annual meeting	1 request to ExCom for approval	yes	yes	6	High	2012	8	On Schedule
005: TechCom annual review of strategy adaptations	Utilize substantive new information to adapt conservation strategies and refine landscape design (focus areas) to ensure recovery	Complete review at January Annual meeting	1 request to ExCom for approval	yes	yes	6	High	2012	8	On Schedule
006: Coordinate Information & Adaptive Management Work Group (IAMWG)	Work group ensures consistent delivery of information management objectives, and organizes information to support adaptive management (see also "Adaptive Management " column)	achieve performance as defined under strategy 100	1 annual report	yes	yes	6	High	2012	8	On Schedule
007: Coordinate Research and Monitoring Work Group (RMWG)	Work group ensures consistent delivery and coordination of monitoring and research objectives	achieve performance as defined under strategy 200 and 600	1 annual report	yes	yes	6	High	2012	8	On Schedule

Table 4.0.1. (continued) Coordination and Administration Objectives, Performance Measures, Scope, and Implementation Status.

Objective	Desired Outcome	Performance Measure	Target Level	Structured Reporting	Adaptive Management	Scope (states)	Priority	Timing	Duration (years)	Status
008: Coordinate NEC Land Management Team in each state (NECLMT)	NECLMTs in each state ensure consistent delivery of recruitment and habitat management objectives	achieve performance as defined under strategy 300 and 500	1 annual report	yes	yes	6	High	2012	8	On Schedule
009: Coordinate Population Management Work Group (PMWG)	Work group ensures consistent delivery and coordination of population management objectives	achieve performance as defined under strategy 400	1 annual report	yes	yes	6	High	2012	8	On Schedule
010: Coordinate Outreach Work Group (OWG)	Work group ensures consistent delivery and coordination of outreach objectives	achieve performance as defined under strategy 700	1 annual report	yes	yes	6	High	2012	8	On Schedule
011: Coordinate Land Protection Work Group (LPWG)	Work group ensures consistent delivery and coordination of land protection objectives	achieve performance as defined under strategy 800	1 annual report	yes	yes	6	High	2012	8	Complete
012: Coordinate Habitat Work Group (HWG)	Work group ensures consistent delivery and coordination of habitat management objectives	achieve performance as defined under objectives 511 & 512	1 annual report	yes	yes	6	High	2016	4	On Schedule

Section 4.1 Information Management

Overview

To conserve the NEC, a diverse group of partners must work together on many tasks. Good communication is vital: Partners must share information to promote awareness and understanding of the Strategy, track habitat management efforts and changes in NEC populations, and recognize improvements in our scientific understanding of the species that may lead to changing the Strategy. To be most effective, we must exchange information in a clear, concise, accurate, and well-planned way.

Objective 101: Assess Data Management Needs
Conservation partners must identify and assess data and information from multiple sources to track the conservation effort so that its progress can be reliably determined. This information is important for ranking the priority of different conservation actions.

Objective 102: Develop and Integrate Data Management Tools
Partners must develop tools to combine and integrate data from multiple sources to track progress in the conservation effort. Automating the reporting and synthesis of data will save time and make the adaptive management effort more effective. The Wildlife Management Institute uses a land management database that will be valuable in tracking habitat management projects; however, this database has yet to be adopted by the NEC partnership because of sensitivities involving data exchange, such as the need to protect personally identifiable information on private landowners.

Objective 103: Maintain and Manage Spatial Data
Partners and/or staff must develop a system to manage spatial data. To conserve NEC, we need to identify landscapes where management efforts will be most effective. New information on the occurrence of NEC populations and the importance of different habitat types may require us to periodically re-evaluate those landscapes, including the boundaries of focus areas. Maintaining and sharing spatial data is complicated by a lack of staff whose time is dedicated solely to NEC conservation, as well as the absence of a protocol to assure the timely distribution of data.

Objective 104: Maintain and Manage Planning Data
Partners will design and develop an effective system of habitat reserves (see Section 3.3) through the timely review of data by local teams implementing habitat-management projects. Conservationists must develop a system for tracking incremental progress at the local, or focus area, scale to further cooperation among conservation professionals responsible for identifying and carrying out such projects.

Objective 105: Maintain and Manage NEC Status Data
Conservationists must manage spatial data on the occurrence and numbers of NEC at different sampling locations. Such information helps in assessing the effectiveness of management projects and can inform changes in conservation design and delivery. Small populations of NEC are highly ephemeral, and the

timely sharing of information on the species' presence on specific tracts will help scientists incorporate protective measures to reduce adverse impacts on resident NEC in areas where habitat management takes place.

Objective 106: Maintain and Manage Management Performance Data
Partners must develop a process for collecting performance data to better conduct management actions identified in the conservation design.

Objective 107: Acquire Necessary Data and Permissions
Conservationists must develop data-sharing protocols and agreements to ensure that sensitive information is protected. Data exchange among partners can be complicated by the need to avoid making public information on precise locations of NEC or personally identifiable information such as the names and addresses of private landowners involved in conservation activities.

Objective 108: Provide Technical Assistance to Managers
Conservation professionals may need guidance in implementing this Conservation Strategy. Technical Committee and Working Group coordinators will provide this guidance effective coordination and consistent delivery of this Conservation Strategy. (See also 104)

Objective 109: Provide Technical Assistance with Data Backlog
As data on species occurrence, habitat management, species response, etc. accumulates, from time to time there will be data backlogs that need to be addressed and resolved. Technical Committee and Working Group coordinators will provide this guidance effective coordination to resolve these data backlogs.

Objective 110: Create and Share Status and Performance Reports
Conservationists must regularly create and share status and performance reports showing the progress of the NEC conservation effort, both to describe specific projects and actions being undertaken and to demonstrate the effort's overall effectiveness in conserving NEC. This information will be critical to the U.S. Fish and Wildlife Service's listing decision process, which takes into account the effectiveness of partners' efforts to conserve the species.

Objective 111: Respond to Requests for Data
Partners must develop data-sharing agreements, protocols, and management systems that will promote timely and accurate responses to requests for data and information explaining the progress of the conservation effort and for guiding future management actions.

Table 4.1.1. Information Management Objectives, Performance Measures, Scope, and Implementation Status (continued next page).

Objective	Desired Outcome	Performance Measure	Target Level	Structured Reporting	Adaptive Management	Scope (states)	Priority	Timing	Duration (years)	Status
101: Assess data management needs	Strategy drafted to manage data in an adaptive management framework	Strategy specifies reporting templates for work groups	1 document	no	yes	6	High	2012	1	On Schedule
102: Develop/integrate data management tools	Integrative platform for 103-106; including data interface, query, report template & schedules for 202, 204, 305, 306, 409, 502, 505-510	performance and status reports satisfy TechCom and ExCom	Approval of 1 annual status and performance report	yes	yes	6	High	2012	1	On Schedule
103: Maintain/manage spatial data	A populated platform to manage & access changing spatial data, such as focus areas	Data transferred to platform & updated	1 annual update	no	yes	6	Med.	2012	8	On Schedule
104: Maintain/manage planning data	A populated platform to manage & access changing planning data, such as goals, objectives, & maps	Data transferred to platform & updated	1 annual update	no	yes	6	Med.	2012	8	On Schedule
105:Maintain/manage NEC status data	A populated platform to manage & access species population data	Data transferred to platform & updated for 200	1 annual update on target levels	yes	yes	6	High	2012	8	Needs Improvement
106: Maintain/manage management performance data	A populated platform for performance data, such as habitat treatments and outreach events	Data transferred to platform & updated for 300, 400, 500, 700, 800	Annual report – Data provided by Techcom by Oct. 15, draft report delivered by Dec. 1	yes	yes	6	High	2012	8	On Schedule

Table 4.1.1. (continued) Information Management Objectives, Performance Measures, Scope, and Implementation Status.

Objective	Desired Outcome	Performance Measure	Target Level	Structured Reporting	Adaptive Management	Scope (states)	Priority	Timing	Duration (years)	Status
107: Acquire required data and permissions	Agreements in place to share restricted data at appropriate levels	Signed agreement between NRCS, USFWS, and WMI	1 agreement	no	no	6	High	2012	8	Inactive
108: Provide technical assistance to managers	Technical assistance to TechCom on information management to support adaptive management	# of trainings provided to managers	1 workshop, 4 webinars	no	yes	6	Med.	2012	2	On Schedule
109: Provide technical assistance with data backlog	Data backlog is eliminated	data backlog is addressed	perf. data from 2009; NEC from 2003	no	no	6	High	2012	1	Complete
110: Create and share status and performance reports	Prepare annual status and performance report by January 1	Proportion of target levels measured and proportion of FASSTs updated; report complete by January 1	100% of target levels measured annually; all A1 and C! ranked focus areas updated annually; report complete by January 1	no	yes	6	High	2012	8	On Schedule
111: Respond to requests for data	Managers competent to upload and query integrated database	# of requests resolved by technical support staff or automated system	All requests fulfilled	yes	no	6	Med.	2012	8	On Schedule

Section 4.2 Monitoring

Overview

Monitoring NEC populations provides information on the status of the species, helps in evaluating the effectiveness of the conservation effort, and can guide any changes that may need to be made in the Strategy. Monitoring helps reduce the uncertainty of management outcomes over time. We differentiate monitoring from performance evaluation and research. Together, these three kinds of information provide feedback for adaptive management when they are integrated in a decision-making framework. Monitoring involves collecting biological data within a sampling design; performance evaluation (section 4.0) entails tracking implementation (objective 004) or species' biological status (objective 003) derived from monitoring; and research (section 4.6) tests management assumptions or uncertainties within an experimental, theoretical, or modeling framework.

This section describes the collecting of biological data needed to drive some of the key feedback mechanisms that address management uncertainties identified as critical to successful adaptive management (see chapter 6.0):

1. Vital rates and abundance
2. Habitat quality
3. Population viability
4. Establishing new populations
5. Captive breeding success
6. Pathogen effects

Conservationists must monitor the response of vegetation following habitat-management projects. At present, vegetation is being monitored on a set of index sites on managed lands. This type of monitoring helps ensure that our management decisions produce the kind of habitat NEC need, and that an increase in and improvement of habitat boosts NEC populations. Developing protocols to define feedback loops and to address these information needs will help streamline information collection and analysis.

Total enumeration, or conducting a census, of NEC to obtain estimates of population size or density across the species' range is not feasible, because this method is not likely to be accurate and would be prohibitively expensive. Like most small mammals, the NEC is subject to large swings in population numbers due to high mortality and a high reproductive capacity. From a practical standpoint, the cryptic coloration of rabbits lets them blend in with their habitat, making it hard to locate them in the thickets where they live. Currently the most cost-effective approach to determining the presence of NEC is to collect fecal pellets (droppings) from habitat patches in accordance with protocols developed by scientists (Kovach *et al.*, in litt. 2012) and then identify the species from DNA extracted from the pellets.

NEC pellet surveys continue to generate a growing dataset that will help researchers monitor the locations and genetic health of populations. Specific genetic monitoring applications are incorporated in the captive breeding program to manage the risk of inbreeding and outbreeding in both captive-bred source populations and in wild populations that may be augmented through the release of captive-born NEC (objective 403). In the future, microsatellite markers may be used to derive mark-recapture estimates of NEC abundance (Kovach *et al.*, in litt. 2012).

Choosing the best method of obtaining usable estimates of NEC abundance depends on several criteria, which include:

1. the circumstances and the question that is being asked;
2. the precision and accuracy of the data needed to answer the question;
3. biological and statistical methods needed;
4. the cost of the technique;
5. financial resources available to conduct the field work and analysis; and
6. the priority of the information needed.

To resolve these considerations, conservation partners formed a Research and Monitoring Work Group (RMWG) to prioritize monitoring objectives and ensure that appropriate protocols are developed and implemented.

Objective 201: Quantify Extent of Habitat

Conservation partners must develop a standardized definition of NEC habitat, along with monitoring methods to establish baseline habitat levels. Clear nomenclature and monitoring protocols will let conservationists periodically evaluate the quantity and location of potential habitat, including at the landscape level. They will help managers identify trends in habitat availability, such as a loss of habitat to development, which may limit the effectiveness of this Strategy.

Objective 202: Develop Regional Monitoring Protocol

To determine habitat occupancy rates by NEC based on data from collecting fecal pellets, conservationists must develop protocols that lead to accurate surveys. Pellet survey detection protocols are being developed and refined by researchers at the University of New Hampshire. The next step, anticipated to be completed by scientists with the U.S. Geological Survey, is to incorporate the detection protocols in a rangewide survey design to ensure high quality presence/absence data at a patch-scale resolution that may be used to assess our landscape design and detect landscape-scale population trends.

Objective 203: Measure Habitat Occupancy Rates

In the future, intensive pellet sampling may be used to derive a population index. NEC pellet surveys generate a growing dataset useful in monitoring the genetic health of populations. Genetic monitoring is also incorporated in the zoo captive-breeding program (objective 403) to manage the risk of inbreeding and outbreeding in wild populations that may be augmented through the release of captive-born NEC.

Objective 204: Presence/Absence Distribution Surveys
Although the current distribution of the NEC is well documented (Litvaitis *et al.* 2006), wildlife biologists need to conduct ongoing research to determine any changes in the distribution of the species. Confirming the presence of NEC in given habitat areas may signal that the conservation effort is working; conversely, decreases in NEC presence may raise additional concerns that need to be addressed.

Objective 205: Measure Vegetation Response to Management
Assessing the response of vegetation to management is critical to determine the effectiveness of management techniques in generating habitat suitable for NEC. Such vegetation monitoring will also let researchers and managers asses the condition of the habitat in targeted stands so that they can efficiently plan future management actions.

Objective 206: Monitor Effectiveness of Vegetation Management
The work group will conduct quality control activities to determine the effectiveness of vegetation management and recommend any necessary modifications to the vegetation management protocol.

Objective 207: Monitor Disease and Parasitism
Conservationists must evaluate both captured individual NEC and populations of NEC to determine the presence of diseases and parasites and, if needed, judge their possible impacts on NEC populations. There is little evidence to suggest that disease or parasites have been or are a limiting factor for NEC; therefore, no conservation measures to manage these factors have been proposed.

Objective 208: Monitor Genetic Health of Small Populations
To effectively manage small populations, and to inform decision-making on the identity of founders for captive breeding, it is necessary to monitor the genetic health of small populations of NEC. The Techcom and work groups will coordinate this monitoring on an on-going basis, as needed.

Table 4.2.1. Monitoring Objectives, Performance Measures, Scope, and Implementation Status.

Objective	Desired Outcome	Performance Measure	Target Level	Structured Reporting	Adaptive Management	Scope	Priority	Start Year	Duration (years)	Status
201: Quantify extent of habitat	Develop a standardized definition of habitat and monitoring methods to establish a baseline habitat level and evaluate habitat extent every 10 years.	Percentage of NEC range mapped.	10% of range mapped after baseline is established	no	no	6	High	2017	1	Needs Improvement
202: Develop regional detection protocol	Finalize detection sampling protocol to develop regional survey design, including estimation of minimum detectable trends, number of surveys, and sites.	Regional survey design updated annually as needed with an acceptable balance of statistical power and available resources.	Update annually.	no	yes	6	Urgent	2012	1	On Schedule
203: Measure Habitat Occupancy Rates	Apply regional survey design on managed land as prescribed at varying intensity to measure trends in occupancy (lowest), density, and abundance (highest).	Create baseline densities for potential and actively managed sites; re-measure presence/absence annually; density and/or abundance every 5 years	Prescribed surveys implemented for 10 years, occupancy of managed sites ↑, occupancy natural habitats stable or ↑	no	yes	6	High	2013	6	Needs Improvement
204: Presence/ Absence distribution surveys	Test current understanding of the present distribution of NEC by evaluating samples from locations inside or outside established Focus Areas.	Evaluate sites in areas that are considered under surveyed, but have potential for supporting unknown populations of NEC.	Investigate 2 or more sites per state per year.	no	yes	6	Low	2014	6	On Schedule
205: Measure vegetation response to management	Implement stem density protocol & refine sampling intensity to test efficacy of treatments	Change in woody stem density over 3-year intervals	>50,000 stem–cover units per hectare	no	yes	6	Med.	2012	6	Needs Improvement
206: Monitor effectiveness of vegetation management	Quality control/rapid assessment to confirm response.	Ratio of project success to projects checked	0.9	no	yes	6	Med.	2012	7	Needs Improvement
207: Monitor disease	Detect epidemics	Cooperators are aware of carcass collection or disease monitoring efforts.	Opportunistic mortality surveillance	no	no	<1	Low	2012	8	On Schedule
208: Monitor genetic health of small populations	Genetic characteristics of small populations are understood	Small populations are identified and sampling protocols developed	Cooperators collect and analyze genetic samples as needed.	no	yes	6	Med.	2016	4	On Schedule

Section 4.3 Landowner Recruitment

Overview

To effectively conserve NEC, planning suggests that voluntary habitat creation and management must take place on 7,000 to 15,000 acres of privately owned land. (The rest of the rangewide habitat goals will be met on public land.) The greatest limiting factor to conducting management on private lands is enlisting landowners and completing eligibility, enrollment, planning, contracting, and compliance procedures. When the sale of wood products offsets management expenditures on private land, revenues benefit the landowner and do not defray the cost to conservationists of recruiting and enrolling landowners. At the beginning of 2012, prior to the commencement of the Working Lands for Wildlife Initiative (a program sponsored by the Natural Resource Conservation Service, or NRCS, an arm of the U.S. Department of Agriculture), performance reports indicated that approximately 2,500 acres of private land had already been assessed, and management activities had been planned or begun on around 1,250 of those acres. As the NRCS Working Lands for Wildlife Initiative gets underway, it will likely provide enough funding to carry out most of the remaining habitat management needed on private lands, although continued recruitment of landowners and planning of projects may require additional outside support (see objective 303).

Estimated Need for Voluntary Conservation

Here, we discuss the need for voluntary participation in land-management programs. To estimate the need for voluntary participation, the NEC Technical Committee used three complementary approaches (see tables in section 5.0). First, land managers were asked to estimate the amount of habitat that they expected to manage through the private-lands programs under their purview: Their total explicit objective through 2020 is 15,595 acres. Next, the Technical Committee reviewed maps, parcel data, and prior management on public and private lands in each focus area, and estimated the need for voluntary participation, which totaled 13,898 acres rangewide. To check the capacity of the land to meet the estimated need for voluntary participation, the Technical Committee compared the explicit objectives and the need for participation with remote assessments, based on spatial data, of habitat potential on private parcels. The "best parcels" for managing were found to contain over 574,671 acres (Fuller *et al.* 2011, p. 16). Thus, the need is within the scope of what land managers believe is feasible, and the current landscape appears to provide ample opportunity to meet that need.

Management opportunities on other lands may offset the anticipated need for voluntary management on private land. Roughly 145,000 acres of public land were identified as "best parcels" by Fuller *et al.* (2011) (chapter 5), but due to perceived barriers, the Technical Committee estimated that fewer than 24,000 acres of public land are available for actual habitat management to benefit NEC. Land managers scheduled explicit objectives through 2020 exceeding 20,000 acres on public land, including over 10,000 acres slated for controlled burning. While the actual ability to carry out controlled burning on these lands is somewhat uncertain, if these objectives are met, then the need for private landowners to voluntarily manage for NEC may fall to 7,000 acres or less, since the U.S. Fish and Wildlife Service's rangewide habitat goal is 27,000 acres.
When the Technical Committee reviewed maps, parcel data, and prior management patterns on public and private lands in each focus area, we estimated that the protected habitat acreage now being kept in shrub/early

successional habitat by natural processes (such as fire, drought, flooding, and exposure to windblown salt in coastal areas) may exceed 30,000 acres. To evaluate this estimate, we need to assess NEC occupancy on such sites, recognizing that because not all areas have sustainable habitat, habitat management in some locations will be needed. Based on an assessment of land cover data provided by the Northeast Terrestrial Habitat Classification (Anderson and Ferree, in litt. 2011), Fuller *et al.* (2011, p. 6) estimated that 41 percent of the 60-meter neighborhood surrounding recent NEC records is composed of floodplain swamps and marshes, dry oak-pine forests, pine barrens, and coastal marshes, dunes, and forests. Each of these ecological systems contains shrubs that are sustained or periodically regenerated through natural processes. The relationship between natural processes and the need for management is ambiguous, yet we feel fairly certain that in many locations, especially parts of southern New England, the need to manage habitat on both public and private lands may be substantially lessened by ongoing natural processes.

Evaluating and removing barriers to managing public land for NEC is a real priority: Unless state and federal partners resolve factors limiting management on these lands (such as obtaining funding and getting management activities approved by agencies and accepted by the public), successfully carrying out this Strategy may depend on voluntary participation of landowners. Also, local circumstances and reserve-design issues, such as connecting NEC populations, will clearly call for conservationists to enlist many private landowners in the conservation effort. Recruiting landowners is costly and time-consuming, but we have improved the efficiency of that process by using spatial analysis of natural resource data and parcels to target important parcels (Tash and Litvaitis, 2007; Fuller *et al.* 2011, p. 16), and have already shown significant progress toward signing up enough private land to further NEC conservation.

Objective 301: Convene NEC Land Management Team for Each State

Conservation partners must create local management groups, including state and federal agencies and nongovernmental organizations, to identify habitat management priorities, develop habitat-creation projects, and identify resources to be used in carrying out those tasks. Such efforts will help ensure the timely creation of high-quality NEC habitat. NEC Land Management Teams will be charged with adopting, revising, and sharing Best Management Practices (BMPs) already drafted by the BMP Working Group (now inactive).

Objective 302: Develop and Deliver Incentives

Conservationists must develop and deliver incentives to attract private landowners to participate in the conservation effort. Incentives may include regulatory assurances such as Candidate Conservation Agreements with Assurances (CCAAs), which let private landowners continue to use their land and gain income from it while voluntarily creating habitat for NEC. (CCAAs provide legal guarantees that no additional regulatory burdens will be placed on cooperating landowners should the New England cottontail formally be listed as threatened or endangered under the federal Endangered Species Act.)

Objective 303: Hire a Recruitment Coordinator

At least one recruitment coordinator in each State should approach owners of lands that are highly suited to habitat management benefiting NEC (see also Section 4.7). To date, conservationists have made steady progress in signing up landowners willing to create NEC habitat, but such efforts require considerable time and resources. The cost of time spent developing personal relationships with landowners, educating them regarding NEC, and negotiating with them to set up habitat projects is considerable and can be a key limiting factor. The Working Lands for Wildlife Initiative by NRCS may significantly lower costs as NRCS staff who have not yet been involved in habitat projects for NEC begin advising their clients on how to manage land to help the species. However, there is a need to identify additional funding sources to increase recruitment capacity.

Objective 304: Contact Landowners

Conservation partners must reach out to private landowners to increase their awareness of NEC and the need to create and manage habitat for this dwindling species. Mailings, telephone calls, and workshops are potential tools for contacting and enlisting landowners.

Objective 305: Conduct Site Assessments

Conservation partners must assess properties owned by landowners interested in joining the NEC conservation effort to determine their suitability for management or land protection, identify landowners' objectives before management or protection takes place, and develop effective management or land protection plans.

Objective 306: Draft Applications, Preliminary Plans, and Cost Estimates

Conservation professionals must help in planning specific habitat work, estimating its cost, and drafting applications to programs that help landowners pay for creating and managing habitat on their lands.

Objective 307: Draft and Review Land Management Ranking and Eligibility Criteria

To ensure that Farm Bill and other private-land-management resources are directed to projects that maximize benefit to NEC, conservationists should develop ranking criteria for private lands. Program eligibility criteria may pre-empt the award of some funding; thereby, necessitating the need to find alternative funds through other programs. Recommendations on revision of rules directing eligibility should be collected and submitted through appropriate channels.

Objective 308: Manage Parcel Information and Landowner Status

Use decision support tools and NEC data to identify key parcels, and track efforts to recruit landowners willing to manage those tracts.

Objective 309: Evaluate Information in Each Focus Area Status Screening Template (FASST)

Focus Area Status Screening Templates were developed and completed for each Focus Area as part of the Fish and Wildlife Service's listing decision-making process. Those FASST documents contain the most up to date information regarding the status of NEC, the species' habitat, threats to local populations, and conservation efforts planned and implemented on the species behalf. Annual review and updating, as necessary, is the best way to keep those documents and the status of the species rangewide current and accurate.

Table 4.3.1. Landowner Recruitment Objectives, Performance Measures, Scope, and Implementation Status.

Objective	Desired Outcome	Performance Measure	Target Level	Structured Reporting	Adaptive Management	Scope	Priority	timing	Duration (years)	Status
301: Convene NEC Land Management Teams for each state (NECLMTs)	Operational state partnership to recruit landowners, review, develop, and coordinate land management projects	Regular meetings include field and office information exchange.	1 or more per year per state	no	no	6	High	2012	8	Needs Improvement
302: Create/apply incentives	Increase enrollment incentives (walking trails, views, economic, hunting opportunities, berry picking)	Acres enrolled/cost of incentives	undefined	no	no	6	Med.	2012	8	On Schedule
303: Support recruitment coordinator	Build capacity to recruit landowners and apply decision tools to ensure recruitment results in effective reserve design	positions filled	1-2 per state	no	no	6	Urgent	2013	5	Needs Improvement
304: Contact landowners via mail, phone, workshops	Reach out to priority landowners and garner interest in managing habitat.	State Specific Metrics	State Specific Metrics	no	no	6	Low	2012	5	On Schedule/ Needs Improvement
305: Conduct site assessments	Assess existing habitat conditions for management or land protection	Number of sites assessed for management or land protection	20 per state annually	no	yes	6	High	2012	5	Needs Improvement
306: Draft application/preliminary plan/cost estimates	Develop preliminary plans that are feasible, eligible, and acceptable for permitting and vendor contracting	Ease of implementation and lack of modification	n/a	no	yes	6	Urgent	2012	8	On Schedule
307: Draft/review land management ranking and eligibility criteria	All ranking criteria ensure that funds are not allocated to low priority parcels in focus areas or satisfy exception to focus area boundaries	Alignment of funded projects with NEC priorities	75% in Best Parcels	no	no	6	High	2012	8	On Schedule
308: Manage parcel information/landowner status	Use decision support tools and NEC data to identify key parcels, and track efforts to recruit them	Develop GIS layer of priority parcels	One map per focus area	no	yes	6	Med.	2012	8	On Schedule
309: Evaluate information in each Focus Area Status Screening Template (FASST)	Review each FASST to ensure the information represents the best scientific information available.	Each SLMT will annually review, and if necessary, revise FASST documents for their state.	1 for each Focus Area	no	yes	6	Urgent	2012	8	On Schedule

Section 4.4 Population Management

Overview

Population management objectives described here are intended primarily to address the threats of small population size and possible encroachment by the eastern cottontail (see section 2.5). The population status of NEC varies across the species' range. In some locales, NEC are fairly common; in others, their numbers are very low or the species is absent, likely caused by the loss of suitable habitat. In areas where populations are low, creating and managing habitat may offer limited benefits unless populations are augmented by bringing in additional NEC. Even as habitats are restored, conservationists may need to release rabbits to overcome problems such as population fragmentation or isolation, skewed sex ratios, and other limitations on population growth caused by a history of persisting in a grossly altered landscape.

In severely depressed NEC populations, local populations may be so small that any further loss of individuals can have significant impacts. Reproduction may not be sufficient to overcome losses from otherwise normal mortality processes such as predation. Natural environmental events can endanger small populations that have been severely suppressed: For example, long and snowy winters are thought to affect NEC survival by increasing their vulnerability to predation, particularly in low-quality habitat patches (Brown and Litvaitis 1995, pp. 1005-1011). Such winters may cause local extinctions; some wildlife biologists believe that the deep, persistent snow cover that occurred throughout New Hampshire and Maine during the winters of 2008 and 2009 may have led to several such extinctions.

Environmental factors are not the only threat to small populations. Recent rangewide genetic information indicates that all remnant NEC populations have relatively low genetic diversity and small effective population sizes (Fenderson *et al.* 2011, p. 954). Because these populations may be more susceptible to extinction resulting from reduced genetic diversity and increased inbreeding, several management interventions have been recommended (Fenderson *et al.* 2011, p. 954). For example, Fenderson *et al.* (2011, p. 943) suggested that conservation efforts should focus on within-population sustainability and eventually restoring connectivity among isolated populations. They further suggested that without immediate human intervention, the short-term persistence of NEC populations in Maine, New Hampshire, and Cape Cod is at great risk. Rhode Island populations are also of concern, as a recent analysis of over 1,000 fecal pellets collected in the state revealed the presence of only one NEC (T. Husband, pers. comm. 2011). To address these needs, researchers recommend that conservation measures include population augmentation to promote genetic exchange at the same time that habitat is being renewed and created (Fenderson *et al.* 2011, p. 954).

In helping other threatened or endangered species, biologists have translocated, or moved, individual animals to remnant populations to improve their genetic health and boost their numbers. Translocation efforts for rabbits require releasing large numbers of individuals to overcome high mortality rates (Cabezas *et al.* 2011, p. 666; Hamilton *et al.* 2010, p. 999; Zeoli, Sayler and Wielgus 2008). Because all current NEC populations have relatively low genetic diversity and small effective population sizes

(Fenderson *et al.* 2011, p. 954), directly moving large numbers of individual rabbits from one wild population to another can cause additional losses of genetic diversity in the source population, something that biologists consider unacceptable. As a result, it seems prudent that we take measures to preserve important genetic diversity and that we promote genetic exchange among populations by propagating NEC to: (1) provide a source of individuals for reintroduction to restored habitat to establish new, self-sustaining populations; (2) augment existing populations where needed; and (3) prevent the extinction of NEC populations in the wild.

In 2010, conservationists in Massachusetts, New Hampshire, and Connecticut, and the Roger Williams Park Zoo (RWPZ) in Providence, Rhode Island, submitted a Competitive State Wildlife Grant (CSWG) to help fund a captive breeding program for NEC. In parallel, Rhode Island, Connecticut, RWPZ, and the U.S. Fish and Wildlife Service began a pilot study to test captive breeding methods. The NEC Technical Committee convened a Captive Breeding Work Group (CBWG) with an initial charge of developing a captive breeding protocol; starting a pilot project to troubleshoot problems; and screening NEC populations for potential sources of breeding stock and to receive captive-bred individuals in the future. In the fall of 2010, biologists captured six NEC (four females and two males) from a wild population in Connecticut and transported them to the RWPZ. Soon thereafter, one male died; a necropsy showed that this rabbit had an empty gastrointestinal tract, suggesting death due to starvation. The five remaining animals adjusted well to captivity and were still alive after one year.

From November 2010 to February 2011, RWPZ refined husbandry techniques to ensure the health of captive animals. Male NEC bred with females, and during the summer of 2011 four litters with a total of 18 young were born. Soon after birth, one litter of six perished, apparently as a result of the dam being introduced to a new enclosure and not building the normal hair-lined nest, or form, for birthing. One other newborn died soon after birth from unknown causes. Despite these early setbacks, all 11 remaining captive-bred young were successfully weaned. In November 2011 they were released into a 1-acre enclosed pen at Ninigret National Wildlife Refuge in southern Rhode Island. Over the winter, two animals died after they forced their way into closed wooden box traps kept in the enclosure for monitoring purposes. Again, these initial setbacks were followed by success, and on March 28, 2012, six of the surviving nine were successfully transferred to Patience Island, in Narragansett Bay, Rhode Island, where the Captive Breeding Work Group is working to establish a breeding colony. Biologists believe that island colonies, enclosure-based facilities, and/or commercial rabbit-breeding operations could reduce the costs of large-scale captive breeding in the future.

The grant proposal submitted to the CSWG program was awarded in 2011 to expand the captive breeding program at RWPZ. The expanded effort is expected to increase production to more than 60 rabbits per year for three years, increasing genetic diversity of the offspring and providing animals to test releases in multiple locations. Funding will also support trapping NEC in the wild to provide more breeding stock, and the construction of an outdoor enclosed breeding pen at Great Bay National Wildlife Refuge in New Hampshire. The draft captive breeding protocol will not be finished and distributed for review until the pilot study begun in 2011 is completed.

Key Uncertainties (updated in 2023)

1. Vital rates and abundance

What are typical NEC reproductive rates, mortality rates and population densities? Approximately how many NEC are in each focus area? What are the current trends in NEC numbers and distribution range-wide? Where populations are declining or disappearing, what proximate factors are contributing most to the decline? Is removing animals for captive breeding or translocation having a negative effect on the source populations?

2. Population viability

Do all of our focus areas have the capacity (in terms of habitat abundance and connectivity) to sustain a viable metapopulation, and do any of them currently do so? In nonviable populations, is the lack of viability demographic, genetic, or both? What extent of exchange with other populations would be needed to achieve genetic viability? Is translocation of individuals among wild populations a feasible way to accomplish this exchange? How widespread is hybridization with EC? To what extent does the presence of EC affect population viability of NEC?

3. Establishing new populations

What reintroduction/translocation parameters (e.g. number of released animals per year that survive to breed, number of years of releases, acreage of protected habitat, connectivity of habitat etc.) would have to be achieved to create a viable metapopulation in an unoccupied area, and what factors (e.g. availability of land, availability of animals to release, survival of released animals, competition from EC etc.) interfere with our ability to achieve them? Can shortcomings in some aspects (such as availability of land) be overcome by maximizing other aspects (such as number of animals released)? What modifications to our release procedures would improve survival and reproduction?

4. Captive breeding success

How can we improve pregnancy rates and neonatal survival in the zoo breeding program? What effects would incorporating some zoo-born rabbits in the breeding program have on productivity of the zoo program and survival, reproduction and genetic diversity of offspring that are released? Are fecundity and neonatal survival higher among rabbits housed in pens in suitable NEC habitat than they are in the zoos? How many rabbits would we need to have in zoos and pens and on islands to produce the number of animals needed to create viable populations through reintroduction?

5. Pathogen effects

Are diseases or parasites having population-level effects? Does the presence of EC affect pathogen prevalence in NEC? How much of a reduction in abundance would we expect from a RHDV2 outbreak? How would an *in situ* vaccination program need to be structured (e.g. percentage of individuals, distribution on the landscape, etc.) to preserve population viability through such an outbreak?

[Note: Uncertainties are more fully discussed in chapter 6.0, Adaptive Management

Objective 401: Obtain NEC for Captive Breeding

Conservationists must capture wild NEC suitable for use in captive breeding. Fenderson *et al.* (2011, p. 955) recommended that population augmentation and reintroduction efforts should avoid moving NEC between geographically separated populations unless inbreeding depression of populations makes it necessary to do so. However, it can be very hard to trap individuals in small populations, and removing them from the wild can harm those populations, which may be in great need of augmentation with captive-bred rabbits. With this in mind, the NEC Technical Committee recommended capturing breeding stock from nearby source populations, recognizing the likely need for limited geographic mixing. Scientists will evaluate the health and general condition of captured wild individuals to make sure they do not bring disease into breeding populations. Captive-breeding sites for wild-caught animals may include island-based colonies and enclosed outdoor pens at places such as Ninigret and Great Bay National Wildlife Refuges and Roger Williams Park Zoo.

Objective 402: Evaluate Sources of NEC for Captive Breeding

Conservationists will review the need for wild NEC as founders for the captive breeding program and when necessary identify additional sites for capture of NEC for the captive breeding program. Additional sites will be identified based on sound genetic principles to maintain or improve genetic fitness of captive bred NEC for release into the wild.

Objective 403: Conduct Zoo-Based Husbandry

Conservationists will develop a program to maximize the efficiency of zoo-based captive breeding. Biologists and captive-breeding specialists will coordinate their efforts so that captive breeding needs can be quantified, reintroduction sites prioritized, and a schedule for implementation developed. The Captive Breeding Work Group (CBWG) has been charged with drafting a captive breeding protocol and is working on a document, *Captive Propagation and Reintroduction Manual for the New England Cottontail*, to be released after the pilot captive-breeding study is finished. The manual will describe health checks on captive rabbits (adults and young) and will include a list of diseases of rabbits. It will present husbandry protocols, including all aspects of trapping, transporting, and housing animals, record keeping, veterinary care, sanitation, breeding, population genetic management, and release and monitoring of captive-bred animals. It will identify candidate sites for releasing captive-bred rabbits. The manual will address uncertainties and refine the overall captive-breeding effort. The CBWG will review the protocol for compliance with state and federal regulations and appropriate permitting, and after it is approved RWPZ will implement the plan in coordination with the states, the CBWG, and researchers at the University of New Hampshire and the University of Rhode Island. RWPZ has designated a building for NEC captive breeding and husbandry and is currently refining and developing the facility as it carries out the pilot study. The genetics of candidate source and recipient populations will be used to guide the establishment and management of the captive population. Surviving offspring will either be designated for augmenting wild populations in coordination with the CBWG and the recipient state, or held in captivity for breeding.

Objective 404: Construct and Manage Hardening Pens for Zoo-Based Captive Bred NEC

Conservationists will construct and manage hardening pens to smooth the transition from zoo-based rearing to release in the wild. Management will consist of regular maintenance of fencing, feeding and care of captive bred animals and logistic support for moving animals from the zoos to the pens, and from the pens to the wild release sites.

Objective 405: Evaluate Enclosure-Based Husbandry

Captive-breeding specialists will explore enclosure-based husbandry of NEC as an alternative to husbandry in a zoo setting. Meeting all population-augmentation and reintroduction needs through a zoo-based facility may not be feasible because of limitations on the size of the captive population that can be maintained. A 1-acre pen was completed and tested at Ninigret National Wildlife Refuge, southern Rhode Island, during the RWPZ pilot study. The pen successfully excluded land and avian predators, and most NEC in the pen over-wintered and were live-trapped and released on Patience Island, in Narragansett Bay, to establish an island colony. Conservationists will test a similar enclosure design at Great Bay National Wildlife Refuge in southern New Hampshire. In northern New England, aerial predators have been known to take NEC held in outdoor pens (Smith and Litvaitis 2000, p. 2136).

Objective 406: Manage Island Colonies

Captive-breeding specialists will manage and monitor the population of NEC composed of offspring from the captive-breeding pilot project at Roger Williams Park Zoo that were released in spring 2012 on 200-acre Patience Island in Rhode Island's Narragansett Bay. If the Patience Island population thrives, conservationists will capture NEC there and translocate them to other areas to augment depressed populations or to establish new populations. Depending on the success of the Patience Island project, scientists may look for other offshore islands where similar breeding populations could be established. As of this writing (2025) a large population (estimated at 400 rabbits) has been established on Noman's Land Island off of Nantucket, and other islands in Narraganset Bay are under consideration or development.

Objective 407: Release NEC to Augment or Establish Populations

Conservation partners will release captive-bred or wild-caught NEC to boost wild populations or to establish new populations in suitable habitat. Animals for augmenting or establishing populations may come from several sources: captive breeding conducted in zoos; animals born in outdoor enclosures; animals from island-based or large, healthy populations; and animals produced by commercial breeders. Rabbits from zoo-based or commercial facilities will be held in temporary hardening pens (such as the one at Ninigret National Wildlife Refuge) prior to full release to better acclimate them to life in the wild. Animals from outdoor enclosures or wild populations will not be held in a temporary acclimation facility and can immediately be released into the wild. Conservationists may build "soft release" enclosures 100 to 200 square feet in size that will temporarily hold (for one to two weeks) individuals prior to their release, a technique that has increased success for other rabbit reintroduction efforts (Cabezas, Calvete and Moreno, 2011). Using radio-telemetry, scientists will monitor selected released NEC to determine the effectiveness of various release methods and to improve them as needed (Hamilton *et al.* 2010).

Objective 408: Manage Eastern Cottontails

Conservationists will use an adaptive management approach to learn whether managing eastern cottontails will help conserve NEC and manage populations, as necessary. The Adaptive Management Work Group (AMWG) attended a Structure Decision Making workshop to develop an approach for testing hypotheses related to managing eastern cottontails. The AMWG decided to develop an adaptive management framework to implement management actions and to conduct scientific monitoring studies to gauge the feasibility and effects of managing eastern cottontails in NEC focus areas. AMWG plans to request proposals for putting the adaptive management framework into practice.

Objective 409: Manage Predators

Small populations of NEC (less than a few dozen individuals) are particularly vulnerable to dying out; such low numbers usually signal a lack of adequate habitat, particularly in winter. The effects of predators killing NEC in those situations may further suppress populations and hasten their extinction. In such settings, controlling predators may be important. Currently, conservationists are making no efforts to suppress predator numbers to increase NEC survival, although the practice has been considered. Several issues confront efforts to reduce predator numbers. The effectiveness of predator control is uncertain, because mammalian predators are often numerous, wary, and hard to locate and kill. Predator control can be costly. Control of some predators, such as hawks, will likely be opposed by the public as well as prohibited by regulations protecting these migratory birds. Many scientists believe that suppressing predator numbers, except in limited localized situations, may not be feasible or desirable.

Objective 410: Manage Disease

Cottontails are susceptible to diseases, such as tularemia, and are afflicted with ectoparasites, including ticks, mites, and fleas, and endoparasites such as tapeworms and nematodes (Eabry 1968, pp. 14-15). However, there is little evidence to suggest that disease or parasites have been or are a limiting factor for NEC. Monitoring natural populations and screening the health of wild NEC brought into captivity should let scientists detect any potential problems from diseases and parasites. Should such problems arise, conservationists will take appropriate measures to address them.

Objective 411: Manage hunting

Similar to the effects of predation, hunting of cottontails may be unsustainable in areas where there are few NEC. In such areas, it may be prudent to forbid rabbit hunting to prevent the loss of individual NEC which are extremely valuable to the survival of small populations. This practice has been used in Maine and New Hampshire, where there currently is no open hunting season for any cottontails in areas where NEC occur.

Objective 412: Reduce Predation

An alternative, or complementary, approach to managing predators may be to take steps to reduce the effects of predation of NEC. For example, workers, including volunteers, can build brush piles that provide hiding places where NEC can escape or remain shielded from predators. Another way of reducing predation is to alter NEC foraging behavior by providing supplemental food to keep undernourished individuals from leaving escape cover and exposing themselves to predators (Weidman 2010). Conservationists can put out prepared rabbit foods or cut down trees and shrubs in parts of NEC-occupied patches to create new dense vegetation that cottontails can feed on.

Table 4.4.1. Population Management Objectives, Performance Measures, Scope, and Implementation Status.

Objective	Desired Outcome	Performance Measure	Target Level	Structured Reporting	Adaptive Management	Scope	Priority	Start Year	Duration	Status
401: Extract NEC for captive propagation	Trap individuals for breeding while preserving genetic diversity	number of rabbits available for captive breeding from representative genetic strains	30/year	no	yes	6	Urgent	2012	8	Needs Improvement
402: Evaluate sources of NEC for captive breeding	Increase number of focus areas approved as sources as needed via interagency agreement for geographic mixing	Number of source focus areas	6 focus areas	no	yes	6	Urgent	2012	1	On Schedule
403: Zoo-based husbandry	document basic biological/physiological characteristics of NEC, preserve genetic integrity, conservative approach to production, individuals for release	rate of survival to weaning	6/female/year	no	yes	6	Urgent	2012	6	Needs Improvement
404: Construct and Manage Hardening Pens	Construct and manage hardening pens to acclimate captive-bred offspring and promote breeding before release	pens constructed	6 pens @ 40/pen/year	no	yes	6	Urgent	2012	8	On Schedule
405:Construct and manage breeding pens	Construct and manage large pens to propagate young for release into the wild	Number of young produced/pen	3/female/year	no	yes	6	Urgent	2023	8	Needs Improvement
406: Manage island colonies	To establish breeding colonies requiring minimal handling	Number of rabbits released from Island	.25 rabbit/acre of productive habitat/year	no	yes	3	Urgent	2012	8	Needs Improvement
407: Release NEC to augment population(s)	Establish self sustaining populations of NEC, rescue populations/ patches/ individuals from extirpation, maintain genetic diversity	# populations steady or increasing and number of new populations established or augmented from captive breeding program	500 individuals released annually	no	yes	3	Urgent	2023	7	On Schedule
408: Manage EC	Removal of individuals to prevent EC from establishing in focus areas without sympatric populations and where released animals are establishing	percent EC	100%	no	no	5	High	TBD	TBD	Needs Improvement
409: Manage predators	Increase annual survival in suburban and source patches, increase success of release	Change in density of NEC	Increase	no	no	6	Med.	TBD	TBD	Inactive
410: Manage disease	Disease detected in captive populations or in the wild (see 207) will trigger response to minimize impacts	documentation of spike in disease	No outbreaks	no	no	6	Low	TBD	TBD	On Schedule

411: Manage hunting	To preserve hunting as a traditional sustained activity, prevent eradication of NEC, modify season and bag limit to "take" and preserve sustainability of population NEC	Hunting continues in region	Applicable in 4 states	no	no	5	Low	2012	8	On Schedule
412: Reduce predation	Predation is reduced through the use of innovative and effective strategies	The need for alternative methods to reduce predation are identified and acted on	Applicable in 6 states	no	yes	6	Med.	2012	8	Inactive
413: Maximize output of the captive breeding program to meet objectives in the conservation strategy	Maximize the number of young available for release from all breeding facilities and islands	Number of rabbits released from all breeding facilities and islands	Up to 250/year	no	yes	6	Urgent	2023	7	Needs Improvement

Section 4.5 Habitat Management

Overview

While permanent destruction of habitat as a result of human population growth and conversion of land to development has reduced or extirpated some NEC populations and remains a threat to other extant populations, the habitat of NEC is not permanent anywhere. Development can therefore be considered a highly localized concern that will be addressed most effectively by creating and expanding habitat for NEC in other, more secure parts of the landscape—not by curtailing development. Modification of habitat is the primary threat to NEC (see section 2.5). The Landowner Recruitment strategy (section 2.3) was developed to recruit and engage landowners of all kinds in a targeted effort to reverse trends in land management and land use that have driven the modification of NEC habitat during the last century. The habitat management objectives described in this section are intended to enhance and leverage land management partnerships and define specific parameters for on-the-ground implementation of management.

Specific modes of habitat modification include: (1) natural forest maturation arising from changes in land use, such as the abandonment of agriculture and forestry (Litvaitis 1993, p. 870); (2) humans' interruption or suppression of natural processes that once maintained a shifting mix of shrub communities and dense understory growth, such as a lack of fire in pine barrens (Litvaitis 2003, p. 113); and (3) fragmentation of habitat as a result of human population growth and accompanying development (Litvaitis and Villafuerte 1996, p. 686-693). To evaluate habitat management alternatives, we must learn which areas still support NEC and recognize that since not all areas have sustainable habitat, we need to manage habitat in some locations. The primary focus of this Strategy – considered in the context of effectiveness of approach and certainty of implementation – is to increase the amount and distribution of early successional habitat on the New England landscape to ensure that healthy populations of NEC persist and, secondarily, so that the NEC does not need to be placed on the Endangered Species list.

Evaluating Effectiveness of Approach (see also section 5.0)

Here, we discuss the anticipated effectiveness of our primary strategy of habitat management, creation, and expansion. (In section 4.3 we more fully discuss voluntary participation, and in 7.0 we discuss certainty of implementation.) Regarding the effectiveness of our approach, the foremost consideration is whether prescribed management generates the desired population response. Based on prior management experience, we have a sound basis to observe that the land-management tools applied in the past to benefit early successional species such as American woodcock, songbirds, and ruffed grouse have already benefited NEC. For example, NEC currently persist in regenerating shrub and aspen stands first nurtured for early successional species over a decade ago at Bellamy River Wildlife Management Area in New Hampshire. There are many other examples of diverse and successful management approaches across the NEC range, including fire management conducted on the Massachusetts Military Reserve on Cape Cod and silvicultural applications at Patchogue State Forest in Connecticut. While biologists have no doubt that well-tested habitat-management prescriptions will continue to create the thick habitat needed by NEC, occasional failures must be acknowledged as we work to improve the ways in which we create and renew habitat. Confidence in management methods notwithstanding, we designed and implemented a monitoring protocol to scientifically assess vegetation response to habitat management (see objective 204) and to confirm NEC population response (objective 202) before implementing large-scale management. In the future, careful monitoring will let make changes and adapt management practices as necessary to conserve NEC.

Another way to manage habitat more effectively is to target the right locations – places capable of generating the desired response to management, both in terms of the type of vegetation and the extent of habitat for NEC. Scientists have carefully analyzed the landscape across the NEC range (Tash and Litvaitis 2007; Fuller *et al.* 2011) to identify specific locations and parcels of land having high potential to support habitat and become colonized by NEC. Recent surveys revealed that the vast majority of new locations of NEC have been found on parcels we identified as being among the best opportunities: "Best Parcels" (BP), as explained in Fuller *et al.* 2011. The collective configuration of best parcels (BP) and the focus areas delineated around them provide a science-based landscape design that identifies areas of maximum concurrence of large parcels, large patches of existing habitat, protected land, and populations of NEC. The landscape-design approach avoids the most highly developed areas and maximizes opportunities for habitat connectivity. Conservationists are already directing management activities to sites that have been screened for ecological potential and that are near remnant NEC populations in need of expanded habitat. Model results help target the right locations; the suitability of prospective sites is then carefully evaluated in the field by a team of managers to ensure both the site and the prescribed management are appropriate (see objective 301). Such preliminary modeling and landscape analysis translates to fewer sites being evaluated on the ground, and finding sites that more often are a good fit for actual habitat management.

Finding the best way to effectively manage habitat requires assessing the level of voluntary participation needed to achieve our goals and involves understanding the demographics, economics, and culture of both public and private landowners. The New England landscape is complex, and the cost of recruiting lands and developing projects is significant. It is a waste of time and money to recruit landowners who are ineligible for available habitat-creation programs. Targeting industrialized landscapes with programs constrained by income caps is not effective, nor is targeting a few private landowners in areas where there are many opportunities to create NEC habitat less expensively on secure public lands. To avoid misdirected effort, we analyzed the distribution of ownership types within each focus area and have begun developing partnerships with key landowners in advance of implementing this Strategy. The combination of careful analysis of parcels and effective work by land management teams lets us match prospective landowners with the right expertise and programs available to guide and carry out habitat management.

The NEC Technical Committee has focused the initial 2012-2020 habitat effort on aggressive management in 31 focus areas believed to present the best opportunities for private landowner recruitment, public land management, and NEC population response. As described in section 4.3, the Technical Committee used three complementary approaches to assess habitat management objectives (see detailed tables in chapter 5.0). First, the Committee asked land managers to develop explicit measureable objectives toward implementing land management for NEC by the programs under their purview; in many cases, objectives were developed for specific parcels of land.

Land managers set a target level of 35,990 acres of habitat to be managed by 2020, exceeding the 27,000 acre rangewide goal developed by the U.S. Fish and Wildlife Service. The 35,990 acres include 15,595 acres of private land, 1,290 acres of municipal land, 18,555 acres on state land (with 10,475 of those acres to be managed through controlled burning), 525 acres of federal land, and 25 acres of Native American tribal land. These figures represent what the Technical Committee estimates to be realistic based on current and historic funding levels, perceived limitations to management of public land, and recent trends in private-landowner recruitment. The acreage figures were reviewed and approved by the NEC Executive Committee to ensure administrative support for the scope of the intended management effort. While the Executive Committee does not have the ability to make long term commitments of funding, substantial support has already been demonstrated for NEC conservation, including, but not limited to, the NRCS's Working Lands for Wildlife Initiative, the USFWS Science Support Partnership with the U.S. Geological Survey and two previous Competitive State Wildlife Grants.

Next, the NEC Technical Committee reviewed maps, parcel data, and prior management patterns on public and private lands in each focus area, and estimated approximately 23,812 acres were available to manage for NEC on public land, suggesting that 13,898 acres are needed on private land. To check the ecological capacity of different tracts to meet the estimated availability and need, the Technical Committee compared the explicit objectives and the estimated availability with remote-sensing assessments of habitat potential. They found that the "best parcels" (Fuller *et al.* 2011, p. 16) represent 199,996 acres of secured conservation land and 574,671 acres of private land. The availability of land for management is within the scope of what land managers believe is feasible, and the current landscape appears amply able to meet the overall management goals. Further, the Technical Committee estimated that over 30,000 acres of naturally self-sustaining shrub habitat now exists, mainly on Cape Cod and in New York, and wildlife biologists have increasingly documented NEC using those habitats. While sufficient acres of self-sustaining habitat are not present in all states within the NEC range, it is possible that some habitat types elsewhere could help meet habitat objectives with minimal management of vegetation (discussed more fully in section 4.3). Field research to document and map the population status of NEC in natural shrub habitats must be a top priority.

Habitat Model Uncertainty

Funding additional habitat modeling is not justified at this time, because the habitat suitability model achieved cross-validation misclassification error of 4 to 8 percent, which is exceptionally low, and more than 80 percent of new observations of NEC have been made on parcels indicated by using habitat suitability as one screening factor. While other methods could yield comparable performance, the most suitable occupied and unoccupied landscapes have already been predicted and validated in the species' range. It makes more sense to work on monitoring and mapping the responses of managed habitats and populations. In the future, better population and habitat data may be applied to reduce the uncertainty inherent to habitat-suitability models that depend on presence-only data for distressed populations: specifically, that the presence of a population does not necessarily mean it occupies the most suitable habitat. In an intact landscape, where would the best habitat be? Unfortunately, no such landscape is available. This underlying uncertainty is amplified in extrapolations of carrying capacity – the "best" habitat is unknown, the true distribution of population densities is unknown, and the true relationship of densities to habitat models is unknown.

Other Key Uncertainty (updated in 2023)

1. Habitat quality

What habitat characteristics contribute to high levels of NEC reproduction and survival, resulting in population persistence and growth, even in the presence of EC? How much habitat with these characteristics currently exists within NEC range? How successful have our management efforts been at creating such habitat, and what changes to our management approaches would increase success? What factors interfere with our ability to create, maintain and restore such habitat?

(Note: Uncertainties are more fully discussed in chapter 6.0, Adaptive Management)

Objective 501: Create Demonstration Areas

Creating habitat demonstration areas across the NEC range will increase the amount of shrubland, regrowing forest, and other habitat capable of supporting NEC populations. Demonstration areas will be useful places where landowners can see and learn about NEC habitat when considering whether they would like to join the conservation effort by creating habitat on lands that they own or manage (see also Section 4.3).

Objective 502: Develop Site-Specific Management Plans

The NEC Technical Committee estimates that more than 900 patches of habitat need to be created in order to achieve rangewide habitat goals. Development of management plans will be coordinated by New England Cottontail Land Management Teams in each State (see objective 301). Each plan should identify practices to be implemented, monitoring expectations, number of acres targeted, and numbers of acres managed. Planning each land-management project to ensure compliance with environmental regulations, successful implementation, and a positive response by NEC is time consuming and requires significant experience and expertise. It is therefore a significant limiting factor and reflects the most costly aspect of this Strategy. The new Working Lands for Wildlife Initiative by the Natural Resources Conservation Service may significantly defray the cost to other partners as previously unengaged NRCS staff in each state become involved. The number of site-specific management plans will be used to track the number of projects for which habitat-management plans are developed. Ultimately, management plans should translate into the number of acres of habitat management implemented.

Objective 503: Coordinate with National Wildlife Refuges

Several National Wildlife Refuges, managed by the U.S. Fish and Wildlife Service, are located in NEC focus areas and actively conduct cooperative land management and acquisition. Existing partnerships between refuges and other land protection partners (i.e., State agencies, nongovernmental organization, land trusts, etc.) present high-value opportunities to help conserve NEC. Such partnerships should be expanded or initiated in anticipation of approval of the recently submitted rangewide NWR Preliminary Project Proposal to expand refuge acquisition boundaries. If approved, the Preliminary Project Proposal will trigger a formal planning process, during which partners will be engaged to identify potential properties for future acquisition and additional properties to enlist for NWR land-management assistance.

Objective 504: Coordinate with National Estuarine Research Reserves

Partners will further NEC conservation on National Estuarine Research Reserves (NERRs) and monitor achievements on these reserves, four of which are in focus areas identified for NEC conservation: Great Bay NERR in southern New Hampshire; Wells NERR in southern Maine; Waquoit Bay NERR on Cape Cod in Massachusetts; and Narragansett Bay NERR in Rhode Island. Lands held in these partnership efforts involving the National Oceanic and Atmospheric Administration (NOAA) and coastal states offer valuable conservation opportunities. For example, Patience Island, in the Narragansett Bay NERR, was selected as a site for release of captive-born animals from the Roger Williams Park Zoo. At Wells River NERR, habitat management that benefits NEC is already underway.

Objective 505: Create Habitat on Private Land through Farm Bill Funding

The Natural Resources Conservation Service and other partners will help implement this management under Farm Bill program funding and the Working Lands for Wildlife Initiative. To help assess the effectiveness of the rangewide effort to conserve NEC, conservation partners will track management that benefits NEC on private lands.

Objective 506: Create Habitat on Private Lands Not Funded by Farm Bill Funding

In addition to the Natural Resources Conservation Service, other partners and programs, such as the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program and habitat projects designed and funded by the Wildlife Management Institute (WMI), focus on private lands not eligible for funding through Farm Bill programs, including projects on industrial lands or those by landowners and projects that have reached Farm Bill funding limits. To help assess the effectiveness of the rangewide effort to conserve NEC, conservation partners must track management that benefits NEC on private lands.

Objective 507: Create Habitat on Municipal Land

Throughout the range of the NEC, partners and programs such as the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program and the Wildlife Management Institute should focus on making NEC habitat on municipally owned lands. Accomplishments achieved through these efforts will be tracked to help assess the effectiveness of the conservation effort.

Objective 508: Create Habitat on State Land

State natural resource agencies oversee numerous properties containing many acres and have committed to managing habitat to benefit NEC. Management actions on these properties will be tracked to help measure progress of the conservation effort.

Objective 509: Create Habitat on Federal Land

The U.S. Fish and Wildlife Service (USFWS) and other federal agencies, including the Department of Defense and the Forest Service, have management authority over potentially important habitats for NEC and may implement management to benefit the species. Specifically, USFWS has authority over national wildlife refuges, many of which actively manage habitat for wildlife, including NEC. Such management will be tracked to assess the effectiveness of the conservation effort.

Objective 510: Manage Habitat Through Prescribed Burning

Conservation partners believe that prescribed fire (also called "controlled burning") will be an effective tool for creating and renewing important NEC habitats, providing substantial savings over other land-management techniques. Using prescribed fire is difficult because numerous logistical and liability considerations must be addressed. Overcoming these barriers is critical to creating NEC habitat in important landscapes such as pitch-pine scrub-oak ecosystems on Cape Cod and elsewhere in the NEC range.

Objective 511: Refine Best Management Practices for Making NEC Habitat

Best Management Practices (BMPs) to create and maintain NEC habitat were developed by the currently inactive Best Management Practices Work Group. Conservation partners will refine BMPs and review them for their compatibility with Natural Resources Conservation Service practices prior to the commencement of the NRCS's Working Lands for Wildlife Initiative. New England Cottontail Land Management Teams will handle the adoption, revision, and dissemination of BMPs (see objective 301). Publishing and distributing BMPs will help land managers learn and understand these measures so that they can incorporate them into site-specific habitat management plans.

Objective 512: Manage Contracts and Vendors

Conservation partners will manage contracts and providers of habitat-management actions to insure that NEC habitat is created in a timely and effective way.

Objective 513: Implement Restoration (Acres) on Tribal Lands

Several federally recognized Native American tribes own lands in identified focus areas. These tribal lands may provide significant opportunities for managing habitat to benefit NEC.

Table 4.5.1. Habitat Manage ment Objectives, Performance Measures, Scope, and Implementation Status (continued next page).

Objective	Desired Outcome	Performance Measure	Target Level	Structured Reporting	Adaptive Management	Scope	Priority	Start Year	Duration (years)	Status
501: Create Demonstration Sites	Show diversity of habitats; beneficial to NEC; available to public; showcase BMP techniques; etc.	Completed projects, signage, and marketing.	at least two per state	no	no	6	Med.	2014	5	On Schedule
502: Draft site-specific management plans	Comprehensive planning documents that meet agency compliance, permitting, logistic, and contracting constraints	projects implemented	1 per management site	no	yes	6	Urgent	2012	8	On Schedule
503: Coordinate with National Wildlife Refuge partnerships	Implementation on NWR lands and adjacent properties	Completed projects	Support for Focal area goals & objectives	no	no	6	Urgent	2012	8	On Schedule
504: Coordinate with Estuarine Research Reserves	Implementation on Research Reserves and adjacent properties	Completed projects	Support for Focal area goals & objectives	no	no	4	Med.	2012	8	On Schedule
505: Create Habitat on Private Land through Farm Bill Funding	Sufficient suitable habitat to meet species state and rangewide goals.	Best Parcel (BP) acres treated by 2020 in focus areas	75% BP & total 10470 acres	no	yes	6	High	2012	8	On Schedule
506: Create Habitat on Private Lands Not Funded by Farm Bill Funding	Sufficient suitable habitat to meet species state and rangewide goals.	BP acres treated by 2020 in focus areas	75% BP & total 5125 acres	no	yes	6	High	2012	8	On Schedule
507: Create Habitat on Municipal Land	Sufficient suitable habitat to meet species state and rangewide goals.	BP acres treated by 2020 in focus areas	75% BP & total 1290 acres	no	yes	6	Urgent	2012	8	On Schedule
508: Create Habitat on State Land	Sufficient suitable habitat to meet species state and rangewide goals.	BP acres treated by 2020 in focus areas	75% BP & total 8080 acres	no	yes	6	Urgent	2012	8	On Schedule
509: Create Habitat on Federal Land	Sufficient suitable habitat to meet species state and rangewide goals.	BP acres treated by 2020 in focus areas	75% BP & total 525 acres	no	yes	6	Urgent	2012	8	On Schedule

4.5.1. (continued) Habitat Management Objectives, Performance Measures, Scope, and Implementation Status.

Objective	Desired Outcome	Performance Measure	Target Level	Structured Reporting	Adaptive Management	Scope	Priority	Start Year	Duration (years)	Status
510: Implement prescribed fire (acres)	Sufficient suitable habitat to meet species state and rangewide goals.	BP acres treated by 2020 in focus areas	75% BP & total 10475 acres	no	yes	4	High	201 2	8	On Schedule
511: Refine Best Management Practices for Making NEC Habitat	Completed document that can modified for individual states.	Comprehensive document	Meet annually to review new information and recommend adaptations as appropriate.	no	yes	6	Low	201 3	5	On Schedule
512: Administrative technical support to manage contracting & vendors	Complete projects cost-efficiently assuring efficacy, delivery, and compliance	Projects completed	na	no	yes	6	High	201 2	8	On Schedule
513: Implement restoration (acres) on Tribal Land	Sufficient suitable habitat to meet species state and rangewide goals.	BP acres treated by 2020 in focus areas	75% BP & total 25 acres	no	no	6	High	201 2	8	Inactive

Section 4.6 Research

Overview

In 2008, wildlife biologists concerned with the status of the New England cottontail met to identify and prioritize research and information needs. Since then, scientists have conducted several research projects and addressed many of those research needs. Information obtained from the studies has been used to develop this Conservation Strategy and to begin efforts to conserve the NEC. Recently, the Research and Monitoring Work Group updated the list of research needs and priorities. The group is also discussing procedures for exchanging and disseminating information, including NEC occurrence across the species' range.

Key Uncertainties

1. <u>Vital rates and abundance</u>
   What are typical NEC reproductive rates, mortality rates and population densities? Approximately how many NEC are in each focus area? What are the current trends in NEC numbers and distribution range-wide? Where populations are declining or disappearing, what proximate factors are contributing most to the decline? Is removing animals for captive breeding or translocation having a negative effect on the source populations?

2. <u>Habitat quality</u>
   What habitat characteristics contribute to high levels of NEC reproduction and survival, resulting in population persistence and growth, even in the presence of EC? How much habitat with these characteristics currently exists within NEC range? How successful have our management efforts been at creating such habitat, and what changes to our management approaches would increase success? What factors interfere with our ability to create, maintain and restore such habitat?

3. <u>Population viability</u>
   Do all of our focus areas have the capacity (in terms of habitat abundance and connectivity) to sustain a viable metapopulation, and do any of them currently do so? In nonviable populations, is the lack of viability demographic, genetic, or both? What extent of exchange with other populations would be needed to achieve genetic viability? Is translocation of individuals among wild populations a feasible way to accomplish this exchange? How widespread is hybridization with EC? To what extent does the presence of EC affect population viability of NEC?

4. <u>Establishing new populations</u>
   What reintroduction/translocation parameters (e.g. number of released animals per year that survive to breed, number of years of releases, acreage of protected habitat, connectivity of habitat etc.) would have to be achieved to create a viable metapopulation in an unoccupied area, and what factors (e.g. availability of land, availability of animals to release, survival of

released animals, competition from EC etc.) interfere with our ability to achieve them? Can shortcomings in some aspects (such as availability of land) be overcome by maximizing other aspects (such as number of animals released)? What modifications to our release procedures would improve survival and reproduction?

5. <u>Captive breeding success</u>
   How can we improve pregnancy rates and neonatal survival in the zoo breeding program? What effects would incorporating some zoo-born rabbits in the breeding program have on productivity of the zoo program and survival, reproduction and genetic diversity of offspring that are released? Are fecundity and neonatal survival higher among rabbits housed in pens in suitable NEC habitat than they are in the zoos? How many rabbits would we need to have in zoos and pens and on islands to produce the number of animals needed to create viable populations through reintroduction?

6. <u>Pathogen effects</u>
   Are diseases or parasites having population-level effects? Does the presence of EC affect pathogen prevalence in NEC? How much of a reduction in abundance would we expect from a RHDV2 outbreak? How would an *in situ* vaccination program need to be structured (e.g. percentage of individuals, distribution on the landscape, etc.) to preserve population viability through such an outbreak?

Objective 601: Determine NEC Demography
Scientists must learn more about the life history and demography of NEC. (Demography is the study of population characteristics such as size, growth, density, and distribution.) Although scientists have researched the survival rates of adult NEC during winter, very little is known about other life stages. Information regarding these other life stages may influence management actions. Scientists may research factors that may: (1) increase NEC fecundity, such as nutrition; (2) increase survival of nestlings; and (3) increase recruitment of juveniles into the adult population. For example, several studies involving other rabbit species suggest that more-fertile soil can lead to an increase in litter size and growth rates of juvenile rabbits because the soil supports healthy browse habitat (Hill 1972; Williams and Caskey 1965).

Objective 602: Determine NEC Abundance
While preliminary documentation of the estimated abundance of NEC has taken place (Litvaitis *et al.* 2006), this subject is still under study. Wildlife biologists should conduct research to determine changes in the abundance of the species, showing whether rangewide conservation efforts are proving effective.

Objective 603: Study NEC/Eastern Cottontail Interaction
Habitat partitioning in sympatric populations of eastern cottontails and NEC has been investigated in Connecticut. More research is needed to ensure that eastern cottontails are not benefiting from habitat management at the expense of NEC. Scientists should study the mechanisms of competition between

the two species: Do eastern cottontails interfere with NEC reproductive behavior, physiology, or development? Conservation departments in New York and Connecticut have committed funding to help answer these questions. (See objective 408 for additional information on eastern cottontails.)

Objective 604: Investigate Habitat Ecology

Scientists must conduct research to improve our understanding of: (1) the relationship of habitat type to NEC population density; (2) the amount of habitat available at a landscape scale; and (3) the relationship between NEC, eastern cottontails, and non-native invasive plants, which are prominent species in many shrub communities in the NEC range. Successfully restoring habitat for NEC in areas that support both NEC and eastern cottontails depends on knowing how each species benefits from different management approaches.

Objective 605: Investigate Survival Rates in Burned and Unburned Habitat

Conservationists will investigate the survival of NEC in burned and unburned habitat using radio telemetry to quantify the quality of burned habitat as it relates to survival of NEC. This is important as fire is being used more frequently as a management tool, particularly in southeast Massachusetts where extensive areas are harboring low densities of NEC.

Objective 606: Study NEC Taxonomy and Genetics

Continue research to refine and lower the cost of techniques that use genetic material obtained from rabbit fecal samples to distinguish NEC from eastern cottontails. Although genetic data indicate that NEC and eastern cottontails are not interbreeding, the potentially serious effects of hybridization may warrant study to test for hybridization in focus areas where restoration efforts will be concentrated.

Objective 607: Test Management Assumptions

Conservationists should conduct research to determine if habitat-management actions taken to increase populations of NEC are effective. Are habitat-creation measures increasing NEC abundance and distribution? Are habitat-maintenance measures minimizing harmful impacts on resident rabbits while still providing stable habitat conditions? Such questions should be explored for all habitat-management techniques, including prescribed fire, timber harvesting, controlling invasive plants, and others. If performance measures lag below target levels for objective 203 (NEC habitat occupancy rate) and 505-510 (habitat acres created), population research may be needed to determine if the focus areas and reserve design considerations presented in section 3.3 are effectively creating persistent local populations of NEC. Initial emphasis will be placed on testing whether the removal of eastern cottontails will increase survival and reproduction of NEC.

Objective 608: Monitor Public Opinions of Management Actions

Scientists will perform various habitat and population management actions to determine their impact on NEC populations. To understand the true feasibility of those responses (regardless of the efficacy on NEC), it is important to understand the acceptability of those actions to the public, so that long term support for restoration efforts are maintained. Initial emphasis will be placed on understanding public and hunter opinions to the removal of predators and eastern cottontails via hunting and trapping.

Table 4.6.1. Research Objectives, Performance Measures, Scope, and Implementation Status.

Objective	Desired Outcome	Performance Measure	Target Level	Structured Reporting	Adaptive Management	Scope	Priority	Start Year	Duration (years)	Status
601: Determine NEC demography	Measure NEC vital rates in captivity	litter size, growth rate, age at weaning, and mortality are documented	3 litters for 20 females/year	no	no	6	High	2012	8	Needs Improvement
602: Determine NEC abundance	Develop a protocol to measure NEC abundance at local scales (i.e. state or patch level).	The number of investigations implemented by partners to understand factors related to NEC abundance	Implemented in 2 or more states by 2020	no	no	6	Low	na	2	On Schedule
603: Study NEC/EC interaction	Measure response of NEC/EC to management in co-occupied habitats	Reduce uncertainty that NEC ↑	TBD	no	yes	5	Urgent	2012	4	On Schedule
604: Investigate habitat ecology	Measurement of NEC/EC habitat use, nutrition, and parasite loads in native vs. non-native vegetation	Reduce uncertainty that native vs. non-native vegetation benefit NEC	TBD	no	no	6	High	2012	3	On Schedule
605: Investigate Survival Rates in Burned and Unburned Habitat	Obtain survival rates via telemetry in burned and unburned habitat	Statistically valid survival rates	As needed	no	no	<1	Med.	2012	2	On Schedule
606: Study NEC taxonomy/genetics	Refine taxonomy/species markers	na	na	no	no	6	Low	na	5	On Schedule
607: Test management assumptions	Measure response of NEC to removal of eastern cottontails via trapping	Reduce uncertainty that NEC ↑ & that trapping is selective	TBD	no	yes	6	Urgent	2012	4	On Schedule
608: Monitor Public Opinions of Management Actions	Measure public/hunter opinion about removal of predators & EC via hunting/trapping	na	na	no	yes	6	High	2013	4	Inactive

4.7 Outreach and Education

Overview

Some of the habitat- and population-management techniques used to help New England cottontails will arouse controversy, such as logging to create young forest, prescribed burning to renew shrubland habitat, managing eastern cottontails to reduce competition between this introduced species and the native NEC, and buying land to expand wildlife refuges. Conservationists must address potential communication and education problems in a proactive way to inform all stakeholders and minimize opposition. Communications and educational activities should be rangewide and involve many participants across the conservation effort. An Outreach Work Group consisting of wildlife biologists and communications specialists will identify social barriers to NEC restoration and determine how best to overcome them. The group will create and distribute a range of communications and outreach products to explain why we as a society must conserve NEC and how we can best fulfill this responsibility.

An effective outreach strategy is a high priority need because:

1. Success of the conservation effort depends on participation by and cooperation between private landowners, nonprofit organizations, and state and federal agencies;
2. Public opposition to forest and shrubland management that create prime early successional habitats for NEC can hamper conservationists' efforts to create such habitat;
3. Political support for NEC conservation is vital; and
4. Public understanding of all aspects of the conservation effort will make it much more likely to succeed.

Objective 701: Develop an Outreach Strategy

Wildlife biologists and professional communicators must cooperate in creating an outreach strategy that identifies barriers to restoring NEC. They must develop products to directly address those barriers and deliver messages to different audiences. The outreach strategy must provide cost estimates for developing and distributing those products. In October 2012, the Outreach Work Group presented an outreach plan for the NEC Technical Committee to evaluate.

Objective 702: Develop and Maintain a Website

Partners should build and support a website to educate and inform the public about NEC conservation. The website will describe and explain management actions and document increasing state, federal, municipal, nongovernmental organization, and private-landowner participation in the conservation effort. A website supported by the Wildlife Management Institute was launched in March 2012 and can be accessed at www.newenglandcottontail.org.

Objective 703: Develop Communications Products to Explain and Further NEC Conservation
Wildlife biologists, habitat managers, and communications specialists must cooperate to develop a range of products that accurately and persuasively tell the story of NEC conservation. Products may include print publications, scripts and illustrations for use in presentations to live audiences, workshops for prospective conservation partners, digital documents, and videos. Such products will increase awareness of the NEC's plight and encourage landowners to create NEC habitat. Conservation partners already have created a number of products, including *A Landowners Guide to New England Cottontail Habitat Management* (www.edf.org/sites/default/files/8828_New-England-Cottontail-Guide_0.pdf), a short video (accessible through www.newenglandcottontail.org) and a New Hampshire Cooperative Extension brochure (http://extension.unh.edu/resources/files/resource001135_rep1417.pdf).

Objective 704: Direct Outreach Efforts to NEC Focus Areas
Communications specialists should work with wildlife biologists and habitat managers to deliver outreach products to landowners and other potential partners who may decide to make NEC habitat in focus areas throughout the species' range.

~~**Objective 705: Target Recruitment of Key Landowners**~~
~~Conservation partners should hire a recruitment specialist who can coordinate all aspects of outreach prescribed in the outreach strategy. An NEC recruitment specialist would develop and present outreach products to agencies, municipalities, nongovernmental organizations, tribes, and the public.~~
Objective 705 was deleted in 2025 as it was determined to be overlapping with Objective 303.

Table 4.7.1. Outreach and Education Objectives, Performance Measures, Scope, and Implementation Status.

Objective	Desired Outcome	Performance Measure	Target Level	Structured Reporting	Adaptive Management	Scope	Priority	Start Year	Duration (years)	Status
701: Develop outreach strategy	A completed outreach strategy which identifies critical target audiences & prioritizes outreach tactics and tools.	Annual Review	1	no	no	6	high	na	1	On Schedule
702: Develop/maintain website	Website featuring info on NEC biology, ongoing projects/programs, contacts and how to get involved.	Content added and updated	5 per year	no	Yes	6	high	na	8	On Schedule
703: Develop Communications Products to Explain and Further NEC Conservation	Media/messages available for use in NEC outreach, targeted to audiences defined in strategy	Develop and distribute products	Distribute new publications or links to digital materials as developed	no	no	6	high	2012	1	On Schedule
704: Direct Outreach Efforts to NEC Focus Areas	Public support for managing NEC is established within focus areas	Number of private landowners receiving media or attending workshop	10,000 landowners	Yes	Yes	6	Urgent	2012	3	On Schedule
~~705: Target recruitment of key landowners~~	~~A dedicated outreach specialist in each state will promote implementation or restoration, including prescribed fire--by agencies, Tribes, towns and NGOs, and Inter-state~~	~~increase in habitat management acreage objectives for 507, 508, 509, 510, 513~~	~~10,000 acres~~	~~Yes~~	~~Yes~~	~~6~~	~~Urgent~~	~~2013~~	~~3~~	~~Ongoing~~

Objective 705 was deleted in 2025 as it was determined to be overlapping with objective 303.

Section 4.8 Land Protection

Overview

Our assessments indicate that voluntary habitat management to conserve the New England cottontail must take place on 7,000 to 15,000 acres of privately owned land (see section 4.3), with the remaining rangewide habitat goals to be met on public land. The estimated need for voluntary participation provides a context for planning the scope of permanent land protection. Both land-management experts and the NEC Technical Committee project over 20,000 acres of public lands available for potential management, requiring only another 7,000 acres of private lands to meet the rangewide U.S. Fish and Wildlife Service goal of 27,000 acres. Except within the few NEC focus areas that lack ample public lands, land protection is not a short-term priority to successfully conserve NEC. Land protection is a long-term strategy to be used when key habitats need permanent protection to ensure continued access for management and is not a requirement for successful NEC conservation on private land.

Based on carefully delineating focus areas and thoroughly assessing the lands within them, we believe we will achieve our goals to create, maintain, or expand the rangewide habitat for NEC to 27,000 acres before 2020. By design, and confirmed by subsequent evaluations, NEC focus areas are characterized by ample amounts of public land, minimal parcelization of the landscape surrounding those public holdings, and the presence of wetlands already protected by state and federal regulations. Because NEC habitat is short-lived, our strategy is not to prevent development by purchasing and protecting large amounts of land but rather to build partnerships to manage landscapes that are largely secure from development. Nevertheless, the voluntary recruitment of landowners is uncertain, and reserve design necessities – such as maintaining connectivity between NEC populations – will undoubtedly mean that some lands will need to be acquired.

The cost of buying land to protect NEC habitat in coastal New England is a serious obstacle, and therefore our aim is to explore every alternative to minimize the need for it. Section 5.0 provides information that can be used to compare the need for land protection in each focus area. A more immediate and cost effective way to ensure access to land for future management is to reverse trends limiting management of public lands that have already been secured. It may be feasible to exceed the scheduled habitat management objectives because not all public land managers were initially solicited to schedule management objectives: for instance, only 525 acres of management were scheduled on federal land. Managing more acres of public land could lower the need for voluntary conservation on private land to below 7,000 acres, with the caveat that some of the objectives already scheduled may not be met. Further, the need for management on both public and private land may be offset by habitats sustained by natural processes, should research prove that such habitats support NEC.

In spite of the foregoing admonitions about the difficulty of land protection, we are making progress in protecting habitat for NEC. To date, approximately 400 acres have been placed in easement for NEC in Maine and New Hampshire through funding from the National Fish and Wildlife Foundation, the Open Space Institute, the Wildlife Conservation Society, and the Natural Resources Conservation Service's

Wetlands Reserve Program. NRCS collaborated with the Wildlife Management Institute in New Hampshire to reassess Geographic Area Rate Caps in accordance with a localized real estate market assessment, so that easement rates would be competitive with the real market. The NEC Land Protection Work Group (LPWG) was established to develop partnerships for conserving land and to manage the development and implementation of tools to rank and prioritize land for protection. The most significant accomplishment has been the completion of a Preliminary Project Proposal (PPP) to initiate a planning analysis on the possible expansion of National Wildlife Refuge (NWR) acquisition boundaries across the six-state NEC range (see objective 801). If approved, the PPP will trigger a formal planning process, during which partners will identify properties for potential future acquisition and additional properties to enlist as candidates eligible for NWR land-management assistance. When complete, the NWR contribution could provide new resources to increase management on public lands and new funding to protect land for NEC where necessary.

Objective 801: Expand National Wildlife Refuge Partnerships and Land Protection Efforts
Collaborating with the LPWG and the NEC Technical Committee, the managers of National Wildlife Refuges throughout the range of the NEC have developed a Preliminary Project Proposal (PPP) that presents a concept for expanding National Wildlife Refuge System land-protection efforts to acquire important habitats for NEC, either through fee acquisition, purchasing easements, leasing. Upon regional approval, the PPP will be forwarded to the U.S. Fish and Wildlife Service's Washington, D.C., office for consideration. Should the USFWS director approve the PPP, individual refuges will begin working on a detailed Land Protection Plan (LPP) that will provide information to partners and the public outlining resource protection needs, an implementation schedule and priorities, and the dimensions of Service's preservation proposal. The LPP will include maps, a priority acquisition table identifying specific tracts, and additional properties to enlist as candidates eligible for NWR land management assistance.

Objective 802: Develop Local and Regional Land Protection Partnerships
Different kinds of land protection efforts are currently underway in many NEC focus areas. Communication and collaboration between the groups guiding these efforts will help in determining if the lands being protected are suitable and available for managing to benefit NEC. In addition, communicating and collaborating with groups engaged in protecting land can help develop local support for NEC conservation and garner resources for land protection efforts to be used for in-kind match purposes to leverage additional land-protection funds. NEC conservationists should work to identify groups such as nongovernmental organizations, land trusts, and municipalities that are active in the focus areas.

Objective 803: Develop Projects
Conservation partners should identify land-protection opportunities in those NEC focus areas identified as high-priority areas for this type of activity. They should develop a strategy to streamline land protection, including title searches, boundary surveys, appraisals, etc., culminating in final land transactions.

Objective 804: Raise Funds

Conservation partners will need to find ways to increase the amount of funding available to protect land in NEC focus areas. One important approach will be securing grants, which requires writing clear proposals and demonstrating a diverse partnership that offers pooled resources to help conservation efforts succeed.

Objective 805: Develop Land Protection Ranking Criteria

Because resources for protecting important NEC habitat will be limited, conservationists should develop ranking criteria for lands that may become available. Criteria may include land protection needs within focus areas, parcel-specific habitat potential, proximity to known NEC occurrences, and how the parcel may contribute to the landscape being designed to conserve NEC.

Table 4.8.1. Land Protection Objectives, Performance Measures, Scope, and Implementation Status.

Objective	Desired Outcome	Performance Measure	Target Level	Structured Reporting	Adaptive Management	Scope	Priority	Start Year	Duration (years)	Status
801: Expand NWR partnerships & land protection efforts	Completion and implementation of a Land Protection Plan (LPP).	Plan approved	N/A	no	no	All States	High	2012	3	Complete
802: Develop local and regional land protection partnerships	Organizations agree to prioritize land protection to benefit NEC and adopt Ranking Criteria	organizations adopting ranking criteria	1 land trust per focus area	no	no	All States	Med.	2013	2	On Schedule
803: Develop projects	Transactions to protect NEC habitat are negotiated by buyer/seller on highest priority NEC parcels in focus areas in need	Alignment of parcels negotiated with NEC priorities	TBD by SLMT	no	yes	All States	Med.	2012	5	Needs Improvement
804: Raise funds	Negotiated transactions are funded and completed on highest priority NEC parcels in need	Alignment of funded transactions with NEC priorities	TBD by SLMT	no	yes	All States	High	2012	5	Needs Improvement
805: Development of Land Protection Ranking Criteria	Regional criteria ensure that funds are not allocated to focus areas with a secure land base for NEC or to low priority parcels in focus areas in need	Screening factors filter focus areas of need and select high-ranking or connecting parcels	fully developed ranking criteria	no	no	All States	Urgent	2012	1	On Schedule

5.0 State Conservation Summaries

This chapter assesses the capability of the land and the feasibility of our strategy to conserve the New England cottontail in the six states that make up today's NEC range. Conservation professionals have identified target levels for specific elements of reserve design in each focus area in their state, including the distance between habitat patches, and have characterized the sizes of parcels, including both naturally occurring and managed patches, that offer the best opportunities to manage habitat for NEC. Detailed spatially explicit reserve design is not within the scope of this Strategy. (The need to develop a spatially explicit reserve design and corresponding business plan is described under objective 309.)

We recognize that not all focus areas provide good opportunities to restore populations of NEC. We assume in our planning that restoration will not succeed in all focus areas: Our regional goals do not require uniform success across each and every focus area. We recognize that at the local focus-area scale, some goals are not realistic. While we have provided objective statistics in the state summaries to help managers weigh their priorities, we understand that the decision to forgo restoring any particular NEC population must be a local one. In the future, areas with relatively low human population densities may offer the best opportunities for restoring NEC habitat; however, we believe that the feasibility of safeguarding and restoring existing NEC populations needs further on-the-ground evaluation before shifting our efforts to areas not currently occupied by NEC. The NEC Technical Committee recognizes that new information will likely cause us to change our original focus area boundaries. As new information emerges, we will review proposed changes or new focus areas on an annual basis and modify existing focus areas as needed (see objective 005).

As shown in Table 3.1.1, recovery goals are not evenly allocated across the six states. According to Fuller *et al.* (2011), across four modeling approaches and many model iterations, snow depth and canopy cover were consistently among the most important 4 out of 16 habitat variables considered. According to the models, appropriate snow depth and forest canopy cover occur most abundantly in southern New England. The modeled habitat pattern is consistent with the pattern of extant NEC populations, recent NEC declines in Maine and New Hampshire, large expanses of well-documented habitat, and the history of land use in southern New England compared to northern New England. Accordingly, habitat and population goals are higher for states in southern New England.

The NEC is presumed to be extirpated from Vermont. At this time there are no plans to reintroduce the species the state, so no conservation actions are proposed. We believe that the geographic scope of the existing Strategy and its goals and objectives will sufficiently improve the conservation status of the NEC. Nevertheless, if NEC should be rediscovered in Vermont or a reintroduction effort be initiated there, we will evaluate the need to develop goals and objectives in partnership with that state's wildlife agency.

Intended Function of Focus Areas

The delineation of focus areas is rooted in habitat models and an analysis of land parcels across New England. It guides the design of a landscape for conserving NEC on the broadest scale: a map of the configuration of landscapes that may conserve the species. Focus areas provide general direction for conservation actions to regions with fitting opportunities. Decisions about on-the-ground expenditures of conservation funding should be driven by site-specific assessments and not simply by remote-analysis data or focus area boundaries. The information in the following state summaries is not intended to be used for comparing or establishing a priority ranking of the focus areas or state-based conservation efforts.

Interpreting Tables

Tables for each state were developed in concert with conservation professionals, including a Land Management Work Group convened by the NEC Technical Committee for each state. Tables provide statistics and a means of evaluating the general feasibility of creating NEC habitat in different focus areas within each state. When considering the numbers in the tables, please refer to Figure 3.2, Conceptual Model for the Conservation of the New England Cottontail, entitled “Anatomy of a Focus Area,” which shows how focus areas and habitat patches relate and connect to each other.

5.1 State Conservation Summary: MAINE

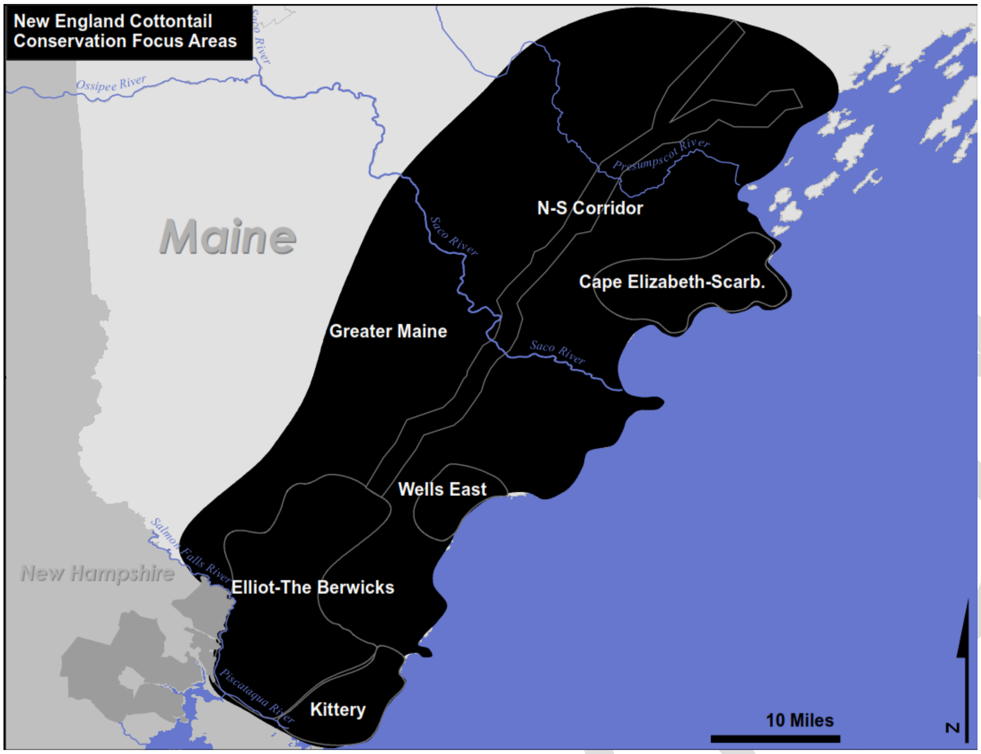


Figure 5.1. Maine Focus Areas (approved 10/17/2011).

State Habitat Goal: 5,140 acres (2,080 hectares)

State Population Goal: 2,570 NEC

General Notes: The sum of focus area goals reported in the following tables for Maine may exceed the statewide goals reported above and in chapter 3.0 due to the uncertainty of success or insufficient information regarding some focus areas. The tables provide a means for comparing and prioritizing focus areas within the state, and DO NOT represent all of the relevant metrics or data for making management decisions. Best Parcel (BP) acreages may be skewed by a few large parcels; therefore, check the BP Count in the first column of the first table before interpreting other tables. Local knowledge is strongly recommended to accurately interpret the reported BP acres.

A Maine Working Group, which pre-existed and was not convened by the NEC Technical Committee, has developed an alternative analysis of parcels for the state, which should be used under the direction of the Maine Working Group for planning and decision-making. The Maine Working Group recognizes the limitations to restoring viable NEC populations in several focus areas and has established a broad-scale focus area known as the Greater Maine Focus Area (see the map above) to accommodate opportunities to expand NEC populations into currently unoccupied landscapes.

Table 5.1.1. Reserve Design Target Levels and Features. The NEC Technical Committee used maps and local knowledge to estimate feasible target levels for the size, number, and configuration of habitat patches needed to support NEC in each focus area.

Focus Area*	Count Best Parcels[1] (BP)	Natural or Managed Patches >50 ac	25-50 ac	10-25 ac	Max. dist. Inter-patch (mi)	Major Barriers	Meta-populations
Cape Elizabeth-Scarb.	31	> 3	>8	>6	3	no	1
Elliot-The Berwicks	15	8	20	35	3	no	1
Kittery	8	3	5	10	3	no	1
N-S Corridor	4	1	-	-	3	no	1
Wells East	29	2	6	7	3	no	1

*Data are currently not available for Greater Maine Focus Area

1. Best Parcels (BP), subset of parcels in focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).

Table 5.1.2. Potential Effectiveness of Conservation Focus Areas. This table provides a way to check on the feasibility and benefit of achieving habitat goals in focus areas. The ideal feasibility and benefit scenario exists where Habitat Goals are far lower than Best Parcel (BP) acres, and a poorer feasibility and benefit scenario exists where Habitat Goals approach or exceed BP acres. (Best Parcels make up only 6 percent of all rangewide parcels, but they are concentrated in closer proximity to remaining NEC populations than other parcels and have a higher potential to support habitat.) Low suitability scores compared to other focus areas are a good indicator of poorer current habitat condition caused by forest succession or other factors such as humans' development of the landscape.

Focus Area*	Capability[1] Avg.	Suitability[2] Avg. Prob.	Total Acreage Best Parcels[3] (BP)	Habitat Goal[4] (acres)	Pop. Goal (N)
Cape Elizabeth-Scarb.	70	0.56	9,775	1,000	500
Elliot-The Berwicks	74	0.22	10,928	1,800	900
Kittery	71	0.15	2,228	350	175
N-S Corridor	73	0.17	1,353	1,015	508
Wells East	72	0.30	1,772	350	175

*Only Goals are available for Greater Maine Focus Area (Habitat=625; Population=250-565)

1. Best Parcel average capability (Fuller et al. 2011), index of abiotic potential for habitat, maximum=100.

2. Best Parcel average suitability (Fuller et al. 2011), index of current habitat suitability, maximum=1.

3. Best Parcels (BP), subset of parcels in focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).

4. Habitat and population goals for species recovery by approximately 2030.

Table 5.1.3. Estimated Need for Voluntary Participation. In the three columns at left, NEC Technical Committee members used detailed parcel maps and consulted with local land managers to estimate the proportion of habitat likely to be contributed toward NEC conservation goals by natural processes and conditions on protected land; by habitat management on protected land; and voluntarily on other (private) land. Under the columns labeled Secure, th e Best Parcel (BP) ownership pattern was analyzed as a way to check on the estimated need for voluntary participation and to help identify the types of ownership and land management programs needed to carry out management.

Focus Area*	**Protected Natural[1]**	**Protected Managed[2]**	**Other Managed[3]**	**Secure[4] BP[5] Fed.**	**Secure BP State**	**Secure BP Local**	**Secure BP Other**	**EC[6] Threat**
Cape Elizabeth-Scarb.	355	195	290	227	1,065	0	237	None
Elliot-The Berwicks	0	625	775	0	344	0	858	None
Kittery	20	162	93	231	0	0	88	None
N-S Corridor	0	100	915	0	78	0	54	None
Wells East	50	100	100	931	0	146	88	None

*Data are currently not available for Greater Maine Focus Area

1. Protected habitat acreage sustained as shrub/early successional habitat by natural process.
2. Protected habitat acreage to be maintained as shrub/early successional by management the purpose of wildlife.
3. Private or other voluntary land acreage to be maintained as shrub/early successional habitat.
4. Any federal, state, local (municipal), or other private land secured from development by fee or easement.
5. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
6. Eastern cottontail, where present, is assumed to present greater threat in fragmented landscapes .

Table 5.1.4. Security of Habitat. This table provides another way to check on the security of habitat compared to the habitat goals. If the Minimum Goal is much less than the Secure Best Parcel (BP) Total (<<30 percent), habitat goals may be attainable on secure land, and assumptions about natural habitats, managing public land, and/or land acquisition should be rigorously tested. Where Secure BP acres exceed Not Secure BP acres, pressure for habitat loss from development is expected to be high. As Not Secure BP acres increase, alternative sites for voluntary management are expected to be available in the face of development or failed efforts to recruit private landowners.

Focus Area*	Secure[1] BP[2] Total	Not Secure BP Total	Goal (acres)
Cape Elizabeth-Scarb.	1,529	8,246	1,000
Elliot-The Berwicks	1,202	9,726	1,800
Kittery	319	1,909	350
N-S Corridor	132	1,220	1,015
Wells East	1,165	607	350

*Only Goals are available for Greater Maine Focus Area (Habitat=625; Population=250-565)

1. Any federal, state, local (municipal), or other private lands secured from development by fee or easement.

2. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).

Table 5.1.5. Habitat Management Implementers and Schedule. The NEC Technical Committee asked state and federal land managers to estimate the schedule of habitat management implementation for NEC based on trends in funding, agency capacity, prior implementation success, and likelihood of future implementation. While the partnering programs do not have direct control over all factors contributing to the certainty of implementation, this table demonstrates the collective intent and readiness of partners to aggressively take actions to conserve the species.

	Habitat Management Schedule (acres)		
Maine Habitat Program Objectives*	**2011-2015**	**2016-2020**	**2011-2030**
Private Land (Farm Bill programs)	449	898	1795
Private Land (including SWG, WMI, PFW, other)	388	775	1550
Municipal Land (including PFW)	155	310	620
State land (including ERR)	88	175	350
Federal land (including NWR)	142	284	567

* ME reported habitat objectives totaling 4882 acres for 2011-2030 , but not interim figures for 2015 and 2020. Table 4 shows 2015 objectives for ME assuming 25% implementation of the 2011-2030 objectives by 2015 and the 2020 objectives assume an additional 50% by 2020.

5.2 State Conservation Summary: NEW HAMPSHIRE

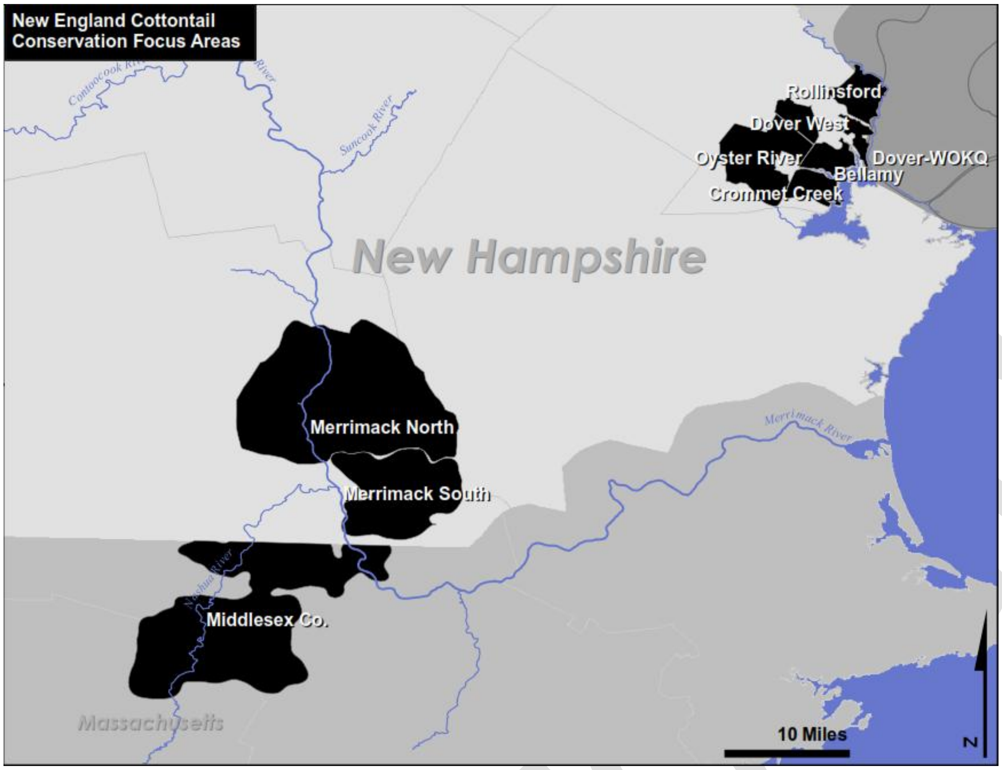


Figure 5.2. New Hampshire Focus Areas (approved 10/17/2011).

State Habitat Goal: 2,000 acres (809 hectares)

State Population Goal: 1,000 NEC

General Notes: The sum of focus area goals reported in the following tables for New Hampshire may exceed the statewide goals reported above and in chapter 3.0 due to the uncertainty of success or insufficient information regarding some focus areas. The tables provide a means for comparing and prioritizing of focus areas within the state, and DO NOT represent all of the relevant metrics or data for making management decisions. Best Parcel (BP) acres may be skewed by a few large parcels; therefore, check the BP Count in the first column of the first table before interpreting other tables. Local knowledge is strongly recommended to accurately interpret the reported BP acres.

Table 5.2.1. Reserve Design Target Levels and Features. The Technical Committee used maps and local knowledge to estimate feasible target levels for the size, number, and configuration of habitat patches needed to support NEC in each focus area.

Focus Area*	Count Best Parcels[1] (BP)	Natural or Managed Patches >50 ac	25-50 ac	10-25 ac	Max. dist. Inter-patch (mi)	Major Barriers	Meta-populations
Merrimack North	18	1	1	4	1.0	no	1
Seacoast (sub-units):							
Bellamy	11	2	2	6	1.0	no	2
Crommet Creek	9			5	1.0	no	1
Dover West	2	2	3	5	0.5	no	1
Dover-WOKQ	2	2	2	5	1.0	no	1
Oyster River	50	1	3	4	1.0	Rte. 4	3

*Data are currently not available for Rollinsford (Seacoast sub-unit) and Merrimack South Focua Area

1. Best Parcels (BP), subset of parcels in focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).

Table 5.2.2. Potential Effectiveness of Conservation Focus Areas. This table provides a way to check on the feasibility and benefit of achieving habitat goals in focus areas. The ideal feasibility and benefit scenario exists where Habitat Goals are far lower than Best Parcel (BP) acres, and a poorer feasibility and benefit scenario exists where Habitat Goals approach or exceed BP acres. (Best Parcels make up only 6 percent of all rangewide parcels, but they are concentrated in closer proximity to remaining NEC populations than other parcels and have a higher potential to support habitat.) Low suitability scores relative to other focus areas are a good indicator of poorer current habitat condition, caused by forest succession or other factors such as humans' development of the landscape.

Focus Area*	Capability[1] Ave.	Suitability[2] Ave. Prob.	Total Acreage Best Parcels[3] (BP)	Habitat Goal[4] (acres)	Pop. Goal (N)
Merrimack North	71	0.26	12,035	500	250
Seacoast (sub-units):					
Bellamy	74	0.28	1,941	750	375
Crommet Creek	71	0.18	1,389	100	50
Dover West	70	0.31	658	200	100
Dover-WOKQ	71	0.30	732	200	100
Oyster River	69	0.25	5,657	250	125

*Data are currently not available for Rollinsford (Seacoast sub-unit) and Merrimack South Focua Area

1. Best Parcel average capability (Fuller et al. 2011), index of abiotic potential for habitat, maximum=100.
2. Best Parcel average suitability (Fuller et al. 2011), index of current habitat suitability, maximum=1.
3. Best Parcels (BP), subset of parcels in focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
4. Habitat and population goals for species recovery by approximately 2030.

Table 5.2.3. Estimated Need for Voluntary Participation. In the three columns at left, NEC Technical Committee members used detailed parcel maps and consulted with local land managers to estimate the proportion of habitat likely to be contributed toward NEC conservation goals by natural processes on protected land; by habitat management on protected land; and voluntarily on other (private) land. Under the columns labeled Secure, the Best Parcel (BP) ownership pattern was analyzed to check on the estimated need for voluntary participation and to help identify the types of ownership and land management programs needed to carry out management.

Focus Area*	Protected Natural[1]	Protected Managed[2]	Other Managed[3]	Secure[4] BP[5] Fed.	Secure BP State	Secure BP Local	Secure BP Other	EC[6] Threat
Merrimack North	100	75	50	0	78	1,792	1,061	high
Seacoast (sub-units):								
Bellamy	50	250	50	0	478	155	124	low
Crommet Creek	50	50	25	0	311	51	298	low
Dover West	50	25	100	0	0	0	110	low
Dover-WOKQ	25	25	50	0	0	0	57	none
Oyster River	75	75	50	0	1,541	128	466	low

*Data are currently not available for Rollinsford (Seacoast sub-unit) and Merrimack South Focua Area

1. Protected habitat acreage sustained as shrub/early successional habitat by natural process.
2. Protected habitat acreage to be maintained as shrub/early successional by management the purpose of wildlife.
3. Private or other voluntary land acreage to be maintained as shrub/early successional habitat.
4. Any federal, state, local (municipal), or other private land secured from development by fee or easement.
5. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
6. Eastern cottontail, where present, is assumed to present greater threat in fragmented landscapes .

Table 5.2.4. Security of Habitat. This table provides another way to check on the estimated need for voluntary participation in managing habitat for NEC. If the Minimum Goal is 25 percent of the Secure Best Parcel (BP) total or less, management should be targeted toward secure land and assumptions about managing public land and/or land acquisition should be tested. Where Secure BP acres exceed acres that are Not Secure, habitat loss from development is expected to be high. As Not Secure BP acres increase, alternative sites for voluntary management are expected to be available in the face of development or failed recruitment efforts.

Focus Area*	Secure[1] BP[2] Total	Not Secure BP Total	Minimum[3] Goal (acres)
Merrimack North	2,931	9,103	500
Seacoast (sub-units):			
Bellamy	757	1,184	750
Crommet Creek	659	729	100
Dover West	110	548	200
Dover-WOKQ	57	674	200
Oyster River	2,135	3,522	250

*Data are currently not available for Rollinsford (Seacoast sub-unit) and Merrimack South Focua Area

1. Any federal, state, local (municipal), or other private lands secured from development by fee or easement.

2. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).

3. Minimum habitat goal (some states reported a range) for species recovery by approximately 2030.

Table 5.2.5. Habitat Management Implementers and Schedule. The NEC Technical Committee asked state and federal land managers to estimate the schedule of habitat management implementation for NEC based on trends in funding, agency capacity, prior implementation success, and likelihood of future implementation. While the partnering programs do not have direct control over all factors contributing to the certainty of implementation, this table demonstrates the collective intent and readiness of partners to aggressively take actions to conserve the species.

	Habitat Management Schedule (acres)		
New Hampshire Habitat Program Objectives	**2011-2015**	**2016-2020**	**2011-2030**
Private Land (Farm Bill programs)*	384	250	884
Private Land (including SWG, WMI, PFW, other)	49	362	774
Municipal Land (including PFW)	100		100
State land (including ERR)	215		215

* NH NRCS included additional acres for the 2011-2030 period.

5. 3 State Conservation Summary: MASSACHUSETTS

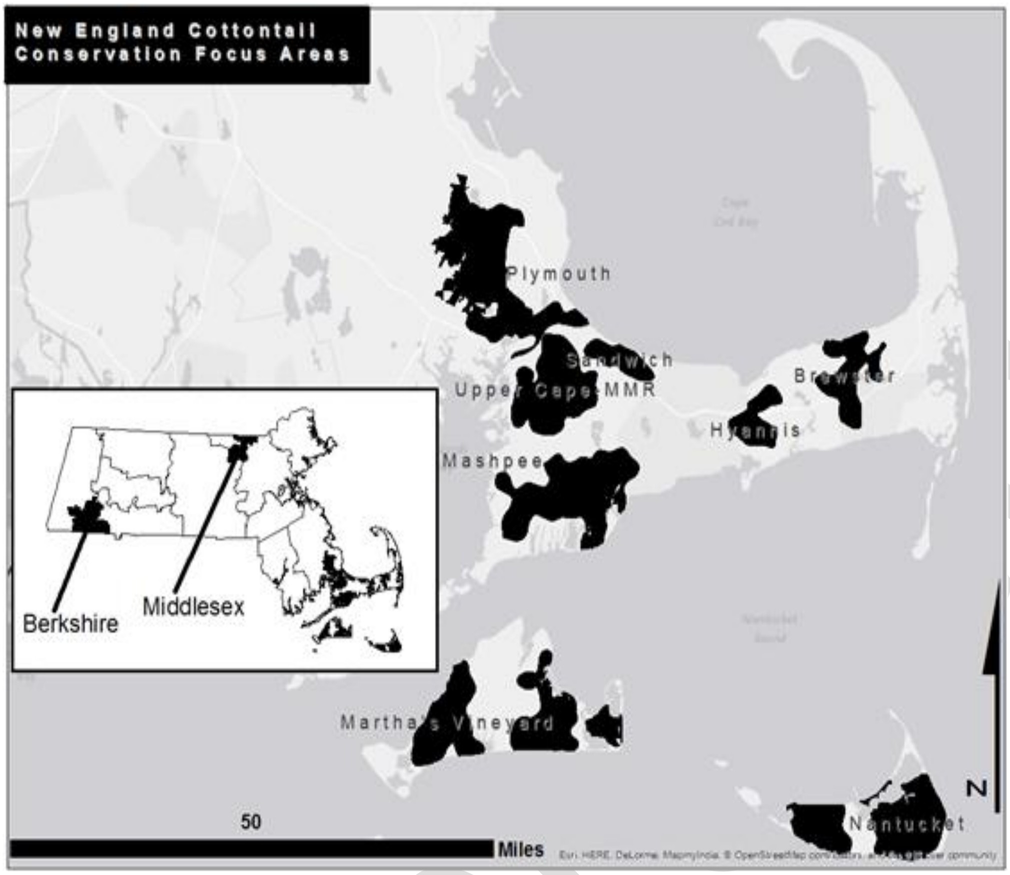


Figure 5.3. Massachusetts Focus Areas (updated 2/25/2015).

State Habitat Goal: 6,800 acres (2,751 hectares)

State Population Goal: 4,500 NEC

General Notes: The sum of focus area goals reported in the following tables may exceed the statewide goals reported above and in chapter 3.0 due to the uncertainty of success or insufficient information regarding some focus areas. The tables provide a means for comparing and prioritizing focus areas within the state, and DO NOT represent all of the relevant metrics or data for making management decisions. Best Parcel (BP) acres may be skewed by a few large parcels; therefore, check the BP Count in the first column of the first table before interpreting other tables. Local knowledge is strongly recommended to accurately interpret the reported BP acres.

Table 5.3.1. Reserve Design Target Levels and Features. The NEC Technical Committee used maps and local knowledge to estimate feasible target levels for the size, number, and configuration of habitat patches needed to support NEC in each focus area.

Focus Area*	Count Best Parcels[1] (BP)	Natural or Managed Patches >50 ac	25-50 ac	10-25 ac	Max. dist. Inter-patch (mi)	Major Barriers	Meta-populations
Harwich-Brewster	35	1	4	12	1.0	Rt. 6/conrail RR	3
Hyannis-Yarmouth	17	3	4	10	1.0	Rt. 6/airport	3
Mashpee-Falmouth	76	2	4	6	1.0	waquoit/rt. 28	4
Plymouth Co.	79	12	10	6	1.0	none	5
Sandwich	6	0	4	12	1.0	6a/saltmarsh	4
Southern Berkshire Co.	176	5	8	40	1.0	mature forest	4
Upper Cape-MMR	157	8	6	0	1.0	none	4

*Data are currently not available for Middlesex Co., Martha's Vineyard, Nantucket

1. Best Parcels (BP), subset of parcels in focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).

Table 5.3.2. Potential Effectiveness of Conservation Focus Areas. This table provides a way to check on the feasibility and benefit of achieving habitat goals in focus areas. The ideal feasibility and benefit scenario exists where Habitat Goals are far lower than Best Parcel (BP) acres, and a poorer feasibility and benefit scenario exists where Habitat Goals approach or exceed BP acres. (Best Parcels make up only 6 percent of all parcels, but they are concentrated in closer proximity to remaining NEC populations than other parcels and have a higher potential to support habitat.) Low suitability scores relative to other focus areas are a good indicator of poorer current habitat condition caused by forest succession or other factors such as human's development of the landscape.

Focus Area*	Capability[1] Ave.	Suitability[2] Ave. Prob.	Total Acreage Best Parcels[3] (BP)	Habitat Goal[4] (acres)	Pop. Goal (N)
Harwich-Brewster	65	0.27	4,532	1,000	250
Hyannis-Yarmouth	62	0.28	5,857	500	100
Mashpee-Falmouth	63	0.30	10,050	1,300	1,000
Plymouth Co.	65	0.31	13,876	1,000	500
Sandwich	65	0.29	1,814	1,000	150
Southern Berkshire Co.	63	0.32	53,235	1,000	500
Upper Cape-MMR	64	0.36	9,655	1,000	2,000

*Data are currently not available for Middlesex Co., Martha's Vineyard, Nantucket

1. Best Parcel average capability (Fuller et al. 2011), index of abiotic potential for habitat, maximum=100.
2. Best Parcel average suitability (Fuller et al. 2011), index of current habitat suitability, maximum=1.
3. Best Parcels (BP), subset of parcels in focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
4. Habitat and population goals for species recovery by approximately 2030.

Table 5.3.3. Estimated Need for Voluntary Participation. In the three columns at left, NEC Technical Committee members used detailed parcel maps and consulted with local land managers to estimate the proportion of habitat likely to be contributed toward NEC conservation goals by natural processes on protected land; by habitat management on protected land; and voluntarily on other (private) land. Under the columns labeled Secure, the Best Parcel (BP) ownership pattern was analyzed to provide a check on the estimated need for voluntary participation and to help identify the types of ownership and land management programs needed to carry out management.

Focus Area*	Protected Natural[1]	Protected Managed[2]	Other Managed[3]	Secure[4] BP[5] Fed.	Secure BP State	Secure BP Local	Secure BP Other	EC[6] Threat
Harwich-Brewster	100	1,000	na	0	0	1,263	286	high
Hyannis-Yarmouth	150	700	100	0	636	566	221	high
Mashpee-Falmouth	500	1,500	500	197	1,904	1,616	818	low
Plymouth Co.	500	1,000	100	0	2,844	428	1,197	high
Sandwich	150	300	100	0	168	33	31	high
Southern Berkshire Co.	100	900	na	0	16,234	1,458	4,157	med
Upper Cape-MMR	2,000	3,500	na	326	5,957	448	250	low

*Data are currently not available for Middlesex Co., Martha's Vineyard, Nantucket

1. Protected habitat acreage sustained as shrub/early successional habitat by natural process.
2. Protected habitat acreage to be maintained as shrub/early successional by management the purpose of wildlife.
3. Private or other voluntary land acreage to be maintained as shrub/early successional habitat.
4. Any federal, state, local (municipal), or other private land secured from development by fee or easement.
5. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
6. Eastern cottontail, where present, is assumed to present greater threat in fragmented landscapes .

Table 5.3.4. Security of Habitat. This table provides another way to check on the estimated need for voluntary participation in managing habitat for NEC. If the Minimum Goal is 25 percent or less of the Secure Best Parcel (BP) total, management should be targeted toward secure land and assumptions about managing public land and/or land acquisition should be tested. Where Secure BP acres exceed acres that are Not Secure, habitat loss from development is expected to be high. As Not Secure BP acres increase, alternative sites for voluntary management are expected to be available in the face of development or failed recruitment efforts.

Focus Area*	Secure[1] BP[2] Total	Not Secure BP Total	Minimum[3] Goal (acres)
Harwich-Brewster	1,549	2,983	1,000
Hyannis-Yarmouth	1,423	4,434	500
Mashpee-Falmouth	4,535	5,516	1,300
Plymouth Co.	4,469	9,407	1,000
Sandwich	232	1,582	1,000
Southern Berkshire Co.	21,849	31,386	1,000
Upper Cape-MMR	6,981	2,673	1,000

*Data are currently not available for Middlesex Co., Martha's Vineyard, Nantucket

1. Any federal, state, local (municipal), or other private lands secured from development by fee or easement.
2. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
3. Minimum habitat goal (some states reported a range) for species recovery by approximately 2030.

Table 5.3.5. Habitat Management Implementers and Schedule. The NEC Technical Committee asked state and federal land managers to estimate the schedule of habitat management implementation for NEC based on trends in funding, agency capacity, prior implementation success, and likelihood of future implementation. While the partnering programs do not have direct control over all factors contributing to the certainty of implementation, this table demonstrates the collective intent and readiness of partners to aggressively take actions to conserve the species.

	Habitat Management Schedule (acres)		
Massachusetts Habitat Program Objectives	**2011-2015**	**2016-2020**	**2011-2030**
Private Land (Farm Bill programs)	625	625	1250
Private Land (including SWG, WMI, PFW, other)	100		100
Municipal Land (including PFW)	325	250	575
State land (including ERR)	625	625	1250
Federal land (including NWR)	50	50	100
Prescribed Fire (not including fuel management)*	5350	5125	10475

*Data are not available for Middlesex Co., Martha's Vineyard, Nantucket

5.4 State Conservation Summary: RHODE ISLAND

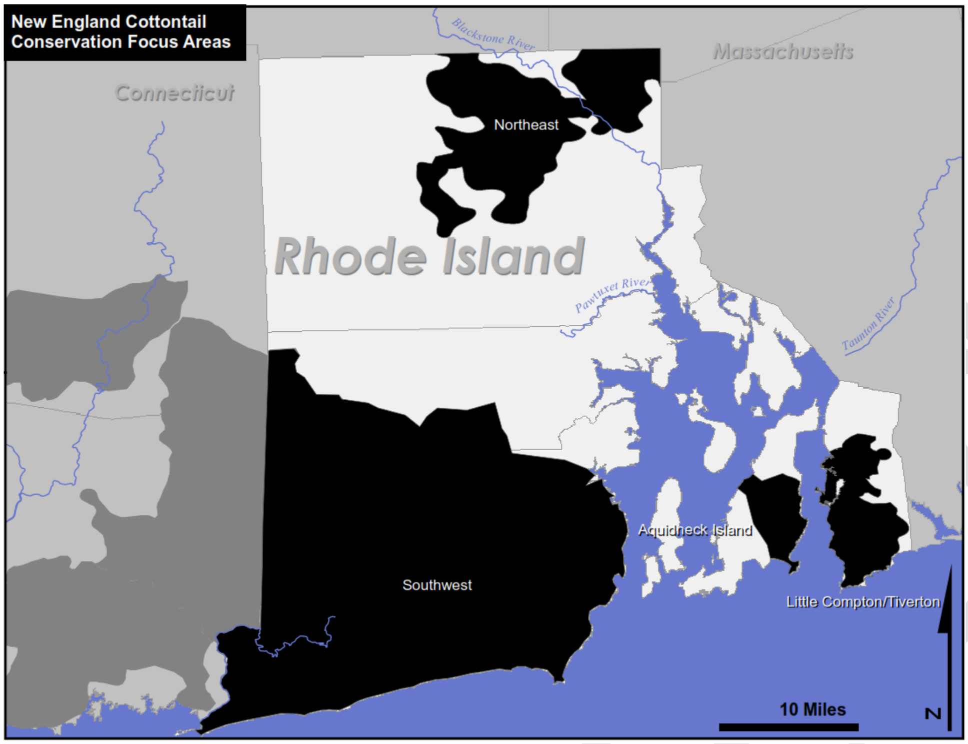


Figure 5.4. Rhode Island Focus Areas (approved 10/17/2011).

State Habitat Goal: 1,000 acres (404 hectares)

State Population Goal: 500 NEC

General Notes: The sum of focus area goals reported in the following tables may exceed the statewide goals reported above and in chapter 3.0 due to the uncertainty of success or insufficient information regarding some focus areas. The tables provide a means for comparing prioritizing focus areas within the state, and DO NOT represent all of the relevant metrics or data for making management decisions. Best Parcel (BP) acres may be skewed by a few large parcels; therefore, check the BP Count in the first column of the first table before interpreting other tables. Local knowledge is strongly recommended to accurately interpret the reported BP acres.

Table 5.4.1. Reserve Design Target Levels and Features. The NEC Technical Committee used maps and local knowledge to estimate feasible target levels for the size, number, and configuration of habitat patches needed to support NEC in each focus area.

Focus Area*	Count Best Parcels[1] (BP)	Natural or Managed Patches >50 ac	25-50 ac	10-25 ac	Max. dist. Inter-patch (mi)	Major Barriers	Meta-populations
Southwest	100	12	40	108	5	Rt. 95	9
Aquidneck Island*	58	0	2	13	<1	develop/farm	2
Little Compton/Tiverton*	51	0	2	13	2	develop/farm	2
Northeast*	101	0	5	10	2	develop/forest	2

*Implementation is highly uncertain.

1. Best Parcels (BP), subset of parcels in focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).

Table 5.4.2. Potential Effectiveness of Conservation Focus Areas. This table provides a way to check on the feasibility and benefit of achieving habitat goals in focus areas. The ideal feasibility and benefit scenario exists where Habitat Goals are far lower than Best Parcel (BP) acres, and a poorer feasibility and benefit scenario exists where Habitat Goals approach or exceed BP acres. (Best Parcels make up only 6 percent of all rangewide parcels, but they are concentrated in closer proximity to remaining NEC populations than other parcels and have a higher potential to support habitat.) Low suitability scores relative to other focus areas are a good indicator of poorer current habitat condition caused by forest succession or other factors such as humans' development of the landscape.

Focus Area*	Capability[1] Ave.	Suitability[2] Ave. Prob.	Total Acreage Best Parcels[3] (BP)	Habitat Goal[4] (acres)	Pop. Goal (N)
Southwest	71	0.20	44,933	1,000	500
Aquidneck Island*	63	0.68	6,229	200	100
Little Compton/Tiverton*	70	0.27	7,185	200	100
Northeast*	67	0.26	19,905	200	100

*Implementation is highly uncertain.

1. Best Parcel average capability (Fuller et al. 2011), index of abiotic potential for habitat, maximum=100.
2. Best Parcel average suitability (Fuller et al. 2011), index of current habitat suitability, maximum=1.
3. Best Parcels (BP), subset of parcels in focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
4. Habitat and population goals for species recovery by approximately 2030.

Table 5.4.3. Estimated Need for Voluntary Participation. In the three columns at left, NEC Technical Committee members used detailed parcel maps and consulted with local land managers to estimate the proportion of habitat likely to be contributed toward NEC conservation goals by natural processes on protected land; by habitat management on protected land; and voluntarily on other (private) land. Under the columns labeled Secure, the Best Parcel (BP) ownership pattern was analyzed to check on the estimated need for voluntary participation and to help identify the types of ownership and land management programs needed to carry out management.

Focus Area*	Protected Natural[1]	Protected Managed[2]	Other Managed[3]	Secure[4] BP[5] Fed.	Secure BP State	Secure BP Local	Secure BP Other	EC[6] Threat
Southwest	3,000	5,000	3,400	1,224	8,491	2,012	4,993	mod
Aquidneck Island*	300	480	300	160	0	669	1,465	high
Little Compton/Tiverton*	100	100	100	0	457	672	1,315	high
Northeast*	<50	<50	50	0	399	3,119	912	mod

*Implementation is highly uncertain.

1. Protected habitat acreage sustained as shrub/early successional habitat by natural process.
2. Protected habitat acreage to be maintained as shrub/early successional by management the purpose of wildlife.
3. Private or other voluntary land acreage to be maintained as shrub/early successional habitat.
4. Any federal, state, local (municipal), or other private land secured from development by fee or easement.
5. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
6. Eastern cottontail, where present, is assumed to present greater threat in fragmented landscapes .

Table 5.4.4. Security of Habitat. This table provides another way to check on the estimated need for voluntary participation in managing habitat for NEC. If the Minimum Goal is 25 percent or less of the Secure Best Parcel (BP) total, management should be targeted toward secure land and assumptions about managing public land and/or land acquisition should be tested. Where Secure BP acres exceed acres that are Not Secure, habitat loss from development is expected to be high. As Not Secure BP acres increase, alternative sites for voluntary management are expected to be available in the face of development or failed recruitment efforts.

Focus Area*	Secure[1] BP[2] Total	Not Secure BP Total	Minimum[3] Goal (acres)
Southwest	16,721	28,212	1,000
Aquidneck Island*	2,295	3,934	200
Little Compton/Tiverton*	2,443	4,742	200
Northeast*	4,430	15,475	200

*Implementation is highly uncertain.

1. Any federal, state, local (municipal), or other private lands secured from development by fee or easement.
2. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
3. Minimum habitat goal (some states reported a range) for species recovery by approximately 2030.

Table 5.4.5. Habitat Management Implementers and Schedule. The NEC Technical Committee asked state and federal land managers to estimate the schedule of habitat management implementation for NEC based on trends in funding, agency capacity, prior implementation success, and likelihood of future implementation. While the partnering programs do not have direct control over all factors contributing to the certainty of implementation, this table demonstrates the collective intent and readiness of partners to aggressively take actions to conserve the species.

	Habitat Management Schedule (acres)		
Rhode Island Habitat Program Objectives	**2011-2015**	**2016-2020**	**2011-2030**
Private Land (Farm Bill programs)	750	2750*	3,500
Private Land (including SWG, WMI, PFW, other)	125		250
Municipal Land (including PFW)	50		50
State land (including ERR)	200	2000	4000

*Assuming 50% implementation of NRCS 2030 goal for RI by 2020.

5.5 State Conservation Summary: CONNECTICUT

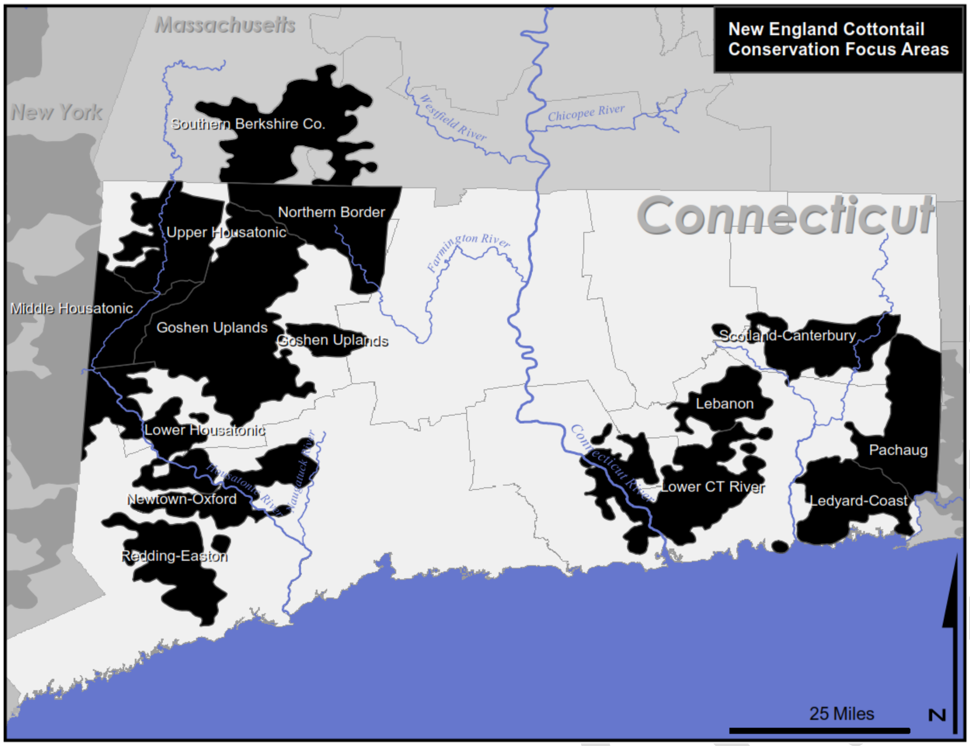


Figure 5.5. Connecticut Focus Areas (approved 10/17/2011).

State Habitat Goal: 19,000 acres (7,689 hectares)

State Population Goal: 9,500 NEC

General Notes: The sum of focus area goals reported in the following table may exceed the statewide goals reported above and in chapter 3.0 due to the uncertainty of success or insufficient information regarding some focus areas. The tables provide a means for comparing and prioritizing focus areas within the state, and DO NOT represent all of the relevant metrics or data for making management decisions. Best Parcel (BP) acres may be skewed by a few large parcels; therefore, check the BP Count in the first column of the first table before interpreting other tables. Local knowledge is strongly recommended to accurately interpret the reported BP acres.

Table 5.5.1. Reserve Design Target Levels and Features. The NEC Technical Committee used maps and local knowledge to estimate feasible target levels for the size, number, and configuration of habitat patches needed to support NEC in each focus area.

Focus Area*	Count Best Parcels[1] (BP)	Natural or Managed Patches >50 ac	25-50 ac	10-25 ac	Max. dist. Inter-patch (mi)	Major Barriers	Meta-populations
Goshen Uplands	166	8	35	50	3	1	2
Ledyard-Coast	51	6	10	10	3	3	4
Lebanon	44	3	3	8	2	1	2
Lower CT River	131	5	5	8	3	1	2
Middle Housatonic	54	4	8	10	5	1	2
Pachaug	78	20	10	20	3	1	2
Scotland-Canterbury	48	3	12	27	2	1	2

*Data are currently not available for Lower Housatonic, Newtown-Oxford, Northern Border, Redding-Easton, Upper Housatonic

1. Best Parcels (BP), subset of parcels in focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).

Table 5.5.2. Potential Effectiveness of Conservation Focus Areas. This table provides a way to check on the feasibility and benefit of achieving habitat goals in focus areas. The ideal feasibility and benefit scenario exists where Habitat Goals are far lower than Best Parcel (BP) acres, and a poorer feasibility and benefit scenario exists where Habitat Goals approach or exceed BP acres. (Best Parcels make up only 6 percent of all rangewide parcels, but they are concentrated in closer proximity to remaining NEC populations than other parcels and have a higher potential to support habitat.) Low suitability scores relative to other focus areas are a good indicator of poorer current habitat condition caused by forest succession or other factors such as humans' development of the landscape.

Focus Area*	Capability[1] Ave.	Suitability[2] Ave. Prob.	Total Acreage Best Parcels[3] (BP)	Habitat Goal[4] (acres)	Pop. Goal (N)
Goshen Uplands	66	0.34	77,587	5,000	2,500
Ledyard-Coast	70	0.30	22,417	2,000	1,000
Lebanon	71	0.33	14,548	1,500	750
Lower CT River	71	0.27	46,092	1,500	750
Middle Housatonic	69	0.32	28,343	4,000	2,000
Pachaug	73	0.20	25,126	4,000	2,000
Scotland-Canterbury	72	0.28	15,962	1,000	500

*Data are currently not available for Lower Housatonic, Newtown-Oxford, Northern Border, Redding-Easton,

1. Best Parcel average capability (Fuller et al. 2011), index of abiotic potential for habitat, maximum=100.
2. Best Parcel average suitability (Fuller et al. 2011), index of current habitat suitability, maximum=1.
3. Best Parcels (BP), subset of parcels in focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
4. Habitat and population goals for species recovery by approximately 2030.

Table 5.5.3. Estimated Need for Voluntary Participation. In the three columns at left, NEC Technical Committee members used detailed parcel maps and consulted with local land managers to estimate the proportion of habitat likely to be contributed toward NEC conservation goals by natural processes on protected land; by habitat management on protected land; and voluntarily on other (private) land. Under the columns labeled Secure, the Best Parcel (BP) ownership pattern was analyzed to check on the estimated need for voluntary participation and to help identify the types of ownership and land management programs needed to carry out management.

Focus Area*	Protected Natural[1]	Protected Managed[2]	Other Managed[3]	Secure[4] BP[5] Fed.	Secure BP State	Secure BP Local	Secure BP Other	EC[6] Threat
Goshen Uplands	1,500	1,750	1,750	0	12,913	1,075	9,550	Mod
Ledyard-Coast	200	800	1,000	0	1,940	1,980	1,314	High
Lebanon	200	500	800	0	1,207	54	3,212	High
Lower CT River	400	700	400	0	10,755	897	7,151	High
Middle Housatonic	1,500	1,500	1,000	1,743	5,689	279	2,526	High
Pachaug	500	2,000	1,500	0	7,553	548	1,558	Mod
Scotland-Canterbury	300	400	300	0	3,640	0	1,475	High

*Data are currently not available for Lower Housatonic, Newtown-Oxford, Northern Border, Redding-Easton, Upper

1. Protected habitat acreage sustained as shrub/early successional habitat by natural process.
2. Protected habitat acreage to be maintained as shrub/early successional by management the purpose of wildlife.
3. Private or other voluntary land acreage to be maintained as shrub/early successional habitat.
4. Any federal, state, local (municipal), or other private land secured from development by fee or easement.
5. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
6. Eastern cottontail, where present, is assumed to present greater threat in fragmented landscapes .

Table 5.5.4. Security of Habitat. This table provides another way to check on the estimated need for voluntary participation in managing habitat for NEC. If the Minimum Goal is 25 percent or less of the Secure Best Parcel (BP) total, management should be targeted toward secure land and assumptions about managing public land and/or land acquisition should be tested. Where Secure BP acres exceed acres that are Not Secure, habitat loss from development is expected to be high. As Not Secure BP acres increase, alternative sites for voluntary management are expected to be available in the face of development or failed recruitment efforts.

Focus Area*	Secure[1] BP[2] Total	Not Secure BP Total	Minimum[3] Goal (acres)
Goshen Uplands	23,538	54,049	5,000
Ledyard-Coast	5,235	17,183	2,000
Lebanon	4,473	10,075	1,500
Lower CT River	18,803	27,289	1,500
Middle Housatonic	10,236	18,107	4,000
Pachaug	9,659	15,467	4,000
Scotland-Canterbury	5,115	10,846	1,000

*Data are currently not available for Lower Housatonic, Newtown-Oxford, Northern Border, Redding-Easton,

1. Any federal, state, local (municipal), or other private lands secured from development by fee or easement.
2. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
3. Minimum habitat goal (some states reported a range) for species recovery by approximately 2030.

Table 5.5.5. Habitat Management Implementers and Schedule. The NEC Technical Committee asked state and federal land managers to estimate the schedule of habitat management implementation for NEC based on trends in funding, agency capacity, prior implementation success, and likelihood of future implementation. While the partnering programs do not have direct control over all factors contributing to the certainty of implementation, this table demonstrates the collective intent and readiness of partners to aggressively take actions to conserve the species.

	Habitat Management Schedule (acres)		
Connecticut Habitat Program Objectives	**2011-2015**	**2016-2020**	**2011-2030**
Private Land (Farm Bill programs)	825	970	3725
Private Land (including SWG, WMI, PFW, other)	575	2600	3175
Municipal Land (including PFW)	100		100
State land (including ERR)	1200	4800	6000

5.6 State Conservation Summary: New York

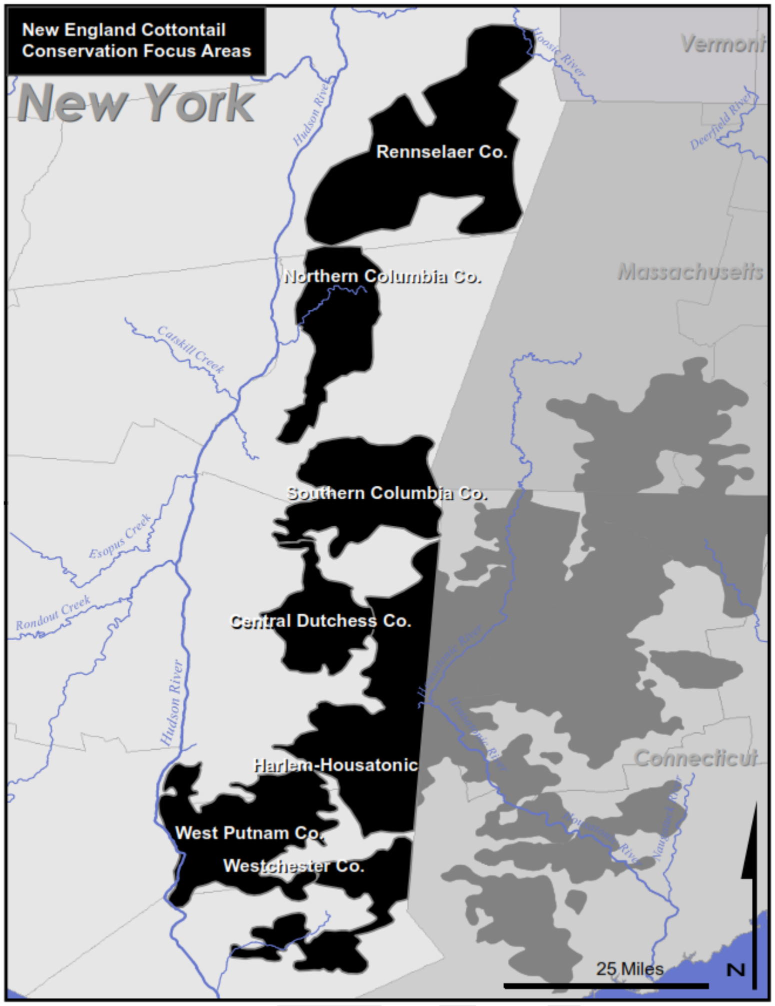


Figure 5.6. New York Focus Areas (approved 10/17/2011).

State Habitat Goal: 10,000 acres (4,046 hectares)

State Population Goal: 5,000 NEC

General Notes: The sum of focus area goals reported in the following tables may exceed the statewide goals reported above and in chapter 3.0 due to the uncertainty of success or insufficient information regarding some focus areas. The tables provide a means for comparing and prioritizing focus areas within the state, and DO NOT represent all of the relevant metrics or data for making management decisions. Best Parcel (BP) acres may be skewed by a few large parcels; therefore, local knowledge is required to accurately interpret the reported BP acres.

Table 5.1.1. Reserve Design Target Levels and Features. The NEC Technical Committee used maps and local knowledge to estimate feasible target levels for the size, number, and configuration of habitat patches needed to support NEC in each focus area.

Focus Area*	Count Best Parcels[1] (BP)	Natural or Managed Patches >50 ac**	25-50 ac	10-25 ac	Max. dist. Inter-patch (mi)	Major Barriers	Meta-populations
Central Dutchess	8	21	2	7	1.5	0	2
Harlem-Housatonic	58	27	10	9	2.5	0	4
Southern Columbia Co.	26	14	11	22	1.5	0	3
West Putnam	191	15	2	9	1.5	0	2
Westchester Co.	17	29	12	9	1.5	2	3

*Data are currently not available for Northern Columbia Co. and Rennselaer Co.

1. Best Parcels (BP), subset of parcels in focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).

Table 5.6.2. Potential Effectiveness of Conservation Focus Areas. This table provides a way to check on the feasibility and benefit of achieving habitat goals in focus areas. The ideal feasibility and benefit scenario exists where Habitat Goals are far lower than Best Parcel (BP) acres, and a poorer feasibility and benefit scenario exists where Habitat Goals approach or exceed BP acres. (Best Parcels make up only 6 percent of all rangewide parcels, but they are concentrated in closer proximity to remaining NEC populations than other parcels and have a higher potential to support habitat.) Low suitability scores relative to other focus areas are a good indicator of poorer current habitat condition caused by forest succession or other factors such as humans' development of the landscape.

Focus Area*	Capability[1] Ave.	Suitability[2] Ave. Prob.	Total Acreage Best Parcels[3] (BP)	Habitat Goal[4] (acres)	Pop. Goal (N)
Central Dutchess	68	0.31	35,144	1000-6000	500
Harlem-Housatonic	69	0.35	99,619	4000-24000	2,000
Southern Columbia Co.	65	0.31	116,246	1000-6000	500
West Putnam	69	0.30	49,168	3000-6000	1,500
Westchester Co.	70	0.22	18,681	1000-6000	500

*Data are currently not available for Northern Columbia Co. and Rennselaer Co.

1. Best Parcel average capability (Fuller et al. 2011), index of abiotic potential for habitat, maximum=100.
2. Best Parcel average suitability (Fuller et al. 2011), index of current habitat suitability, maximum=1.
3. Best Parcels (BP), subset of parcels in focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
4. Habitat and population goals for species recovery by approximately 2030.

Table 5.6.3. Estimated Need for Voluntary Participation. In the three columns at left, NEC Technical Committee members used detailed parcel maps and consulted with local land managers to estimate the proportion of habitat likely to be contributed toward NEC conservation goals by natural processes on protected land; by habitat management on protected land; and voluntarily on other (private) land. Under the columns labeled Secure, the Best Parcel (BP) ownership pattern was analyzed to check on the estimated need for voluntary participation and to help identify the types of ownership and land management programs needed to carry out management.

Focus Area*	Protected Natural[1]	Protected Managed[2]	Other Managed[3]	Secure[4] BP[5] Fed.	Secure BP State	Secure BP Local	Secure BP Other	EC[6] Threat
Central Dutchess	2,000	-	-	0	1,511	1,296	0	high
Harlem-Housatonic	5,000	-	-	1,299	6,715	1,428	2,335	high
Southern Columbia Co.	3,000	-	-	0	11,694	672	0	high
West Putnam	5,000	-	-	941	14,868	477	933	low
Westchester Co.	3,000	-	-	0	160	572	115	high

*Data are currently not available for Northern Columbia Co. and Rennselaer Co.

1. Protected habitat acreage sustained as shrub/early successional habitat by natural process.
2. Protected habitat acreage to be maintained as shrub/early successional by management the purpose of wildlife.
3. Private or other voluntary land acreage to be maintained as shrub/early successional habitat.
4. Any federal, state, local (municipal), or other private land secured from development by fee or easement.
5. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).
6. Eastern cottontail, where present, is assumed to present greater threat in fragmented landscapes .

Table 5.6.4. Security of Habitat. This table provides another way to check on the estimated need for voluntary participation in managing habitat for NEC. If the Minimum Goal is 25 percent of the Secure Best Parcel (BP) total or less, management should be targeted toward secure land and assumptions about managing public land and/or land acquisition should be tested. Where Secure BP acres exceed those acres that are Not Secure, habitat loss from development is expected to be high. As Not Secure BP acres increase, alternative sites for voluntary management are expected to be available in the face of development or failed recruitment efforts.

Focus Area*	Secure[1] BP[2] Total	Not Secure BP Total	Minimum[3] Goal (acres)
Central Dutchess	2,807	32,338	1,000
Harlem-Housatonic	11,776	87,843	4,000
Southern Columbia Co.	12,366	103,879	1,000
West Putnam	17,218	31,950	3,000
Westchester Co.	847	17,833	1,000

*Data are not available for secondary focus areas (Northern Columbia Co., Rennselaer Co.)

1. Any federal, state, local (municipal), or other private lands secured from development by fee or easement.

2. Best Parcels (BP), subset of parcels within focus areas scoring ≥ 94% of parcels in state (Fuller et al. 2011).

3. Minimum habitat goal (some states reported a range) for species recovery by approximately 2030.

Table 5.6.5. Habitat Management Implementers and Schedule. The NEC Technical Committee asked state and federal land managers to estimate the schedule of habitat management implementation for NEC based on trends in funding, agency capacity, prior implementation success, and likelihood of future implementation. While the partnering programs do not have direct control over all factors contributing to the certainty of implementation, this table demonstrates the collective intent and readiness of partners to aggressively take actions to conserve the species.

	Habitat Management Schedule (acres)		
New York Habitat Program Objectives	**2011-2015**	**2016-2020**	**2011-2030**
Private Land (Farm Bill programs)	1200		1200
Private Land (including SWG, WMI, PFW, other)	150		150
Municipal Land (including PFW)	0		0
State land (including ERR)	150		150

6.0 Adaptive Management

Scientific adaptive management is an approach to managing natural resources that can speed up knowledge acquisition, promote information exchange between partners, and accommodate new facts and data as they become available. Carrying through an adaptive management effort is difficult: The environment is complex, the underlying processes that drive population changes are hard to parse out, and observation errors can be large when scientists try to study populations in the wild. As one biologist puts it, "Adaptive management forces us to acknowledge uncertainty, and to follow a plan by which decisions are modified as we learn by doing" (Parma 1998).

Identifying Key Uncertainties

When this Conservation Strategy (CS) was developed in 2012, six aspects of NEC ecology and management were identified as key uncertainties that would need to be resolved as the strategy was implemented (Fuller and Tur, 2012). These were:

1. efficacy of management techniques for creating quality NEC habitat;
2. survival of NEC in augmented and reintroduced populations;
3. competition with the eastern cottontail (EC);
4. productivity of captive breeding;
5. landscape-scale response to the conservation effort; and
6. genetic monitoring and management of NEC populations.

During the subsequent decade, a substantial amount of data was accumulated through implementation of management actions, monitoring and research that sheds light on many of these uncertainties (Kovach et al., 2022). Additionally, some assumptions that were made at the start of the initiative were not borne out by later evidence, pointing to some previously unrecognized uncertainties. In light of these advances in understanding, as well as evidence of the continued decline of NEC populations (Rittenhouse and Kovach, 2020) and the emergence of Rabbit Hemorrhagic Disease Virus 2 (RHDV2) as a new threat to the long-term persistence of NEC, this section of the CS was revised in 2022.

Although much has been learned about NEC habitat in the past decade, substantial uncertainties remain. The species has typically been described as dependent on early successional habitat, but modeling indicates that in some areas NEC are frequently found in sites with moderate levels of overstory tree canopy cover (Buffum et al., 2015), and capture rates in areas of sympatry with EC in New York indicate that early successional shrublands are dominated by the latter species (Cheeseman et al., 2021). Data from radiotracking of sympatric NEC and EC suggest that the presence of EC causes NEC to select shrubland areas with dense canopy closure above one meter in height, because those areas are avoided by EC (Cheeseman et al., 2018). Comparison of vegetation within the home ranges of individuals of the two species revealed that core use areas of NEC had greater canopy closure and basal area coverage than core use areas of EC (Gottfried Mayer et al., 2018). Occupancy modeling conducted for the range-wide conservation initiative has not provided strong evidence that habitat management efforts are having the intended effect of increasing the area occupied by NEC (Rittenhouse, 2021), suggesting that habitat management approaches may need refinement.

Resource selection modeling indicates that NEC habitat use patterns are altered by sympatry with EC, suggesting an effect of interspecific competition (Cheeseman et al., 2018). However, density and survival of NEC appear to be higher than those of EC in naturally self-sustaining forested shrubland habitat types in New York, suggesting that the nature of the competitive relationship varies with habitat type (Cheeseman et al., 2021). Although removal of EC from suitable habitat was originally considered a potentially useful method to expand NEC distribution, experimental removals have proven ineffective at reducing EC density or increasing NEC density (Connecticut Department of Energy and Environmental Protection, unpublished data), and EC distribution continues to expand across NEC range (Rittenhouse, 2021). The evidence indicates that there is little to be gained from further EC removal efforts, except perhaps in highly targeted sites at the edge of EC range.

Determining NEC population trends and tracking the effects of conservation efforts have continued to be challenging to accomplish. Range-wide monitoring has focused on patch occupancy, and the originally implemented methodology didn’t provide enough statistical power to detect meaningful changes in occupancy (Rittenhouse and Kovach, 2020). A revised method that substantially increased the power proved to require more funding and staff time than was available, so the approach was revised again in an effort to maintain adequate power while not exceeding resource limitations (Rittenhouse, 2019). Modeling indicates that occupancy has decreased across the range since implementation of the CS began (Rittenhouse and Kovach, 2020).

Presence/absence information is important, but insufficient for fully evaluating the status of the species and understanding the impacts of management actions. Population density/abundance estimation is more informative, but also even more resource-intensive than occupancy estimation and therefore more difficult to accomplish over large areas. Localized research has indicated that typical NEC densities may be much lower than was assumed when the CS was developed (Kovach and Bauer, 2021), suggesting that the total number of individuals remaining range-wide may be a small fraction of what it has been believed to be (Kovach et al., 2022). Population genetics studies have produced results that seem to support this conclusion, revealing critically low effective population sizes across the range of NEC (Fenderson et al., 2014; Cheeseman et al., 2019; McGreevy et al., 2021).

Although a great deal of effort has been devoted to developing and improving a captive breeding program for NEC, the participating zoos don’t have adequate space to hold large numbers of animals for breeding and haven’t had the resources needed to expand their capacity. Pregnancy rates and neonatal survival have both been persistently low, so production of offspring remains far below the levels anticipated a decade ago and needed to create sustainable populations via reintroduction (Kovach et al., 2022). Annual survival to weaning has averaged 47% over eleven years (New England Cottontail Technical Committee Population Management Work Group, 2021), and in most years the ratio of released offspring to adult females in the breeding program has been approximately 2:1, even though each female is paired with a male for breeding several times each year.

With limited species-specific data available when the CS was developed, the initial assumption was that NEC litter sizes and reproductive rates were similar to those of EC (Fuller and Tur, 2012). The litter sizes observed in the captive breeding program suggest that this assumption may have been incorrect, but litter sizes and reproductive rates of free-ranging NEC have still not been documented. Without knowledge of these basic reproductive parameters, not only is an important benchmark for evaluating captive breeding performance lacking, but potential growth rates of free-ranging populations can't be accurately estimated, so this knowledge gap has implications for multiple aspects of the conservation effort.

Survival of NEC released from the captive breeding program is low overall and highly variable from year to year (New England Cottontail Technical Committee Population Management Work Group, 2017), at least partially due to variation in the severity of winter weather (Bauer et al., 2020). Only 26% of 132 rabbits released from 2012 to 2017 survived their first winter (New England Cottontail Technical Committee Population Management Work Group, 2017). High mortality of released individuals, which has been observed in restoration programs for other rabbit species as well (e.g. Columbia Basin pygmy rabbits, Gallie and Hayes, 2020), appears to be limiting the success of NEC reintroduction efforts (Bauer et al., 2020). Releasing large numbers of individuals could be a way to compensate for high post-release mortality, but if releases continue at current levels, reintroduction efforts may accomplish little for species recovery. Of 42 NEC released at one site in New Hampshire, only six were determined by genetic analyses to have reproduced after release, and after four years of releases, despite documented reproduction by offspring of released animals, the estimated total population size at the release site was only eight individuals (Bauer et al., 2020). Other reintroduction sites in New Hampshire and Maine have shown recent indications of greater success: at one site 25 NEC were detected after 60 individuals had been released over three years (Bauer and Kovach, 2021b), and at another site 26 NEC were detected after 37 individuals had been released over two years (Bauer and Kovach, 2021a).

The continuing overall decline of NEC (Rittenhouse and Kovach, 2020) despite substantial conservation and research efforts by many committed partners suggests that the outlook for the species is poor. Two recently identified threats may increase the obstacles to recovery. The first is RHDV2, which appeared in two wild lagomorph species in New Mexico in spring of 2020 and within months was detected in at least four species in at least seven states (Lankton et al., 2021). RHDV2 is a highly infectious and virulent disease that was able to spread across the continent of Australia in less than two years (Mahar et al., 2018). To date, it has not spread as quickly in North America, but an outbreak in NEC range could devastate the species. In September 2022, RHDV2 was detected for the first time in captive rabbits within NEC range (CT DEEP, September 13, 2022), substantially raising that risk. The second new threat is that multiple instances of NEC-EC hybridization have been documented and fertility of hybrids has been confirmed (New England Cottontail Technical Committee, 2019; 2022), raising the specter of potential genetic swamping.

The failure of species status to improve after 10 years of CS implementation, the lack of information on basic, fundamental aspects of NEC ecology such as reproductive rates and population sizes, and the emergence of new threats to the species all point to the need for a substantial, focused research effort. Below are the important topics and key questions that the Technical Committee feels should be prioritized. Answering these questions will help improve the effectiveness of future conservation efforts and allow resources to be directed where they can address the greatest needs and produce the most meaningful outcomes.

2. Vital rates and abundance

What are typical NEC reproductive rates, mortality rates and population densities? Approximately how many NEC are in each focus area? What are the current trends in NEC numbers and distribution range-wide? Where populations are declining or disappearing, what proximate factors are contributing most to the decline? Is removing animals for captive breeding or translocation having a negative effect on the source populations?

3. Habitat quality

What habitat characteristics contribute to high levels of NEC reproduction and survival, resulting in population persistence and growth, even in the presence of EC? How much habitat with these characteristics currently exists within NEC range? How successful have our management efforts been at creating such habitat, and what changes to our management approaches would increase success? What factors interfere with our ability to create, maintain and restore such habitat?

4. Population viability

Do all of our focus areas have the capacity (in terms of habitat abundance and connectivity) to sustain a viable metapopulation, and do any of them currently do so? In nonviable populations, is the lack of viability demographic, genetic, or both? What extent of exchange with other populations would be needed to achieve genetic viability? Is translocation of individuals among wild populations a feasible way to accomplish this exchange? How widespread is hybridization with EC? To what extent does the presence of EC affect population viability of NEC?

5. Establishing new populations

What reintroduction/translocation parameters (e.g. number of released animals per year that survive to breed, number of years of releases, acreage of protected habitat, connectivity of habitat etc.) would have to be achieved to create a viable metapopulation in an unoccupied area, and what factors (e.g. availability of land, availability of animals to release, survival of released animals, competition from EC etc.) interfere with our ability to achieve them? Can shortcomings in some aspects (such as availability of land) be overcome by maximizing other aspects (such as number of animals released)? What modifications to our release procedures would improve survival and reproduction?

7. Captive breeding success

How can we improve pregnancy rates and neonatal survival in the zoo breeding program? What effects would incorporating some zoo-born rabbits in the breeding program have on productivity of the zoo program and survival, reproduction and genetic diversity of offspring that are released? Are fecundity and neonatal survival higher among rabbits housed in pens in suitable NEC habitat than they are in the zoos? How many rabbits would we need to have in zoos and pens and on islands to produce the number of animals needed to create viable populations through reintroduction?

8. Pathogen effects

Are diseases or parasites having population-level effects? Does the presence of EC affect pathogen prevalence in NEC? How much of a reduction in abundance would we expect from a RHDV2 outbreak? How would an *in situ* vaccination program need to be structured (e.g. percentage of individuals, distribution on the landscape, etc.) to preserve population viability through such an outbreak?

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Organizational Framework

Adaptive management is structured in the objectives described in chapter 4.0. We list desired outcomes, performance measures, and target levels in the objectives table for each part of the overall conservation strategy and indicate whether adaptive management will be used for the different objectives. We expect trouble-shooting problems to be an integral part of fulfilling these defined objectives.

Owing to its scale, evaluating the NEC conservation effort it in its entirety will be complex. The Information Management objectives in section 4.1 provide for continued collecting and organizing of data needed to achieve measurable objectives, evaluate the status of the species, and generate reports estimating the effectiveness of the conservation effort. Partners will use information provided through NEC status monitoring, performance measurement, and scientific research to address uncertainties that may call for changes in the Strategy. In figure 6.1, we show how the conservation framework will incorporate substantive new information. Assessment and adaptation will be needed annually, especially during the Strategy's early years. Reports detailing progress of the conservation effort (see sections 4.1, 4.2, 4.3, 4.4, 4.5, 4.7, and 4.8), as well as new scientific information (section 4.6), will be reviewed each year by the Information and Adaptive Management Work Group, who will evaluate the conservation design and recommend any changes in the Strategy to the NEC Technical and Executive Committees. If approved, such changes will be incorporated into the Strategy. Figure 6.2 provides a calendar of events related to the adaptive management cycle.

The adaptive management process has seven phases (we include specific objectives from chapter 4.0):

1. **Technical coordination**
   Objective 002: Convene NEC Technical Committee to coordinate work groups and all phases of adaptive management and ensure integration of new or modified objectives.

2. **Status monitoring and assumption testing**
   Objective 007: Coordinate Research and Monitoring Work Group (RMWG) to assure collection of new data. Monitoring will provide information to assess species status and overall efficacy of the Strategy. Key uncertainties will be tested via specific research projects.

3. **Performance monitoring**
   The performance evaluation phase collects information on implemented actions from each of the management objectives through specialized management work groups:
   Objective 008: Coordinate NEC Land Management Team in Each State (NECLMT)
   Objective 009: Coordinate Population Management Work Group (PMWG)
   Objective 010: Coordinate Outreach Work Group (OWG)
   Objective 011: Coordinate Land Protection Work Group (LPWG)

4. **Integrative reporting and synthesis**
   Objective 006: Coordinate Information and Adaptive Management Work Group (IAMWG) to collect and share information and data.

5. **Evaluative**
   Convene the NEC Technical Committee to review reports and data.
   Objective 004: Review Performance
   Objective 003: Review Species Status

6. **Adaptive**
   Convene NEC Technical Committee to propose adaptation of objectives, review input from the work groups, and make recommendations to the NEC Executive Committee.
   Objective 005: Review Strategy Adaptations

7. **Decision-making**
   Objective 001: Convene Executive Committee to review and decide on proposed modifications and new objectives.

Figure 6.1. Adaptive Management Framework for the NEC.

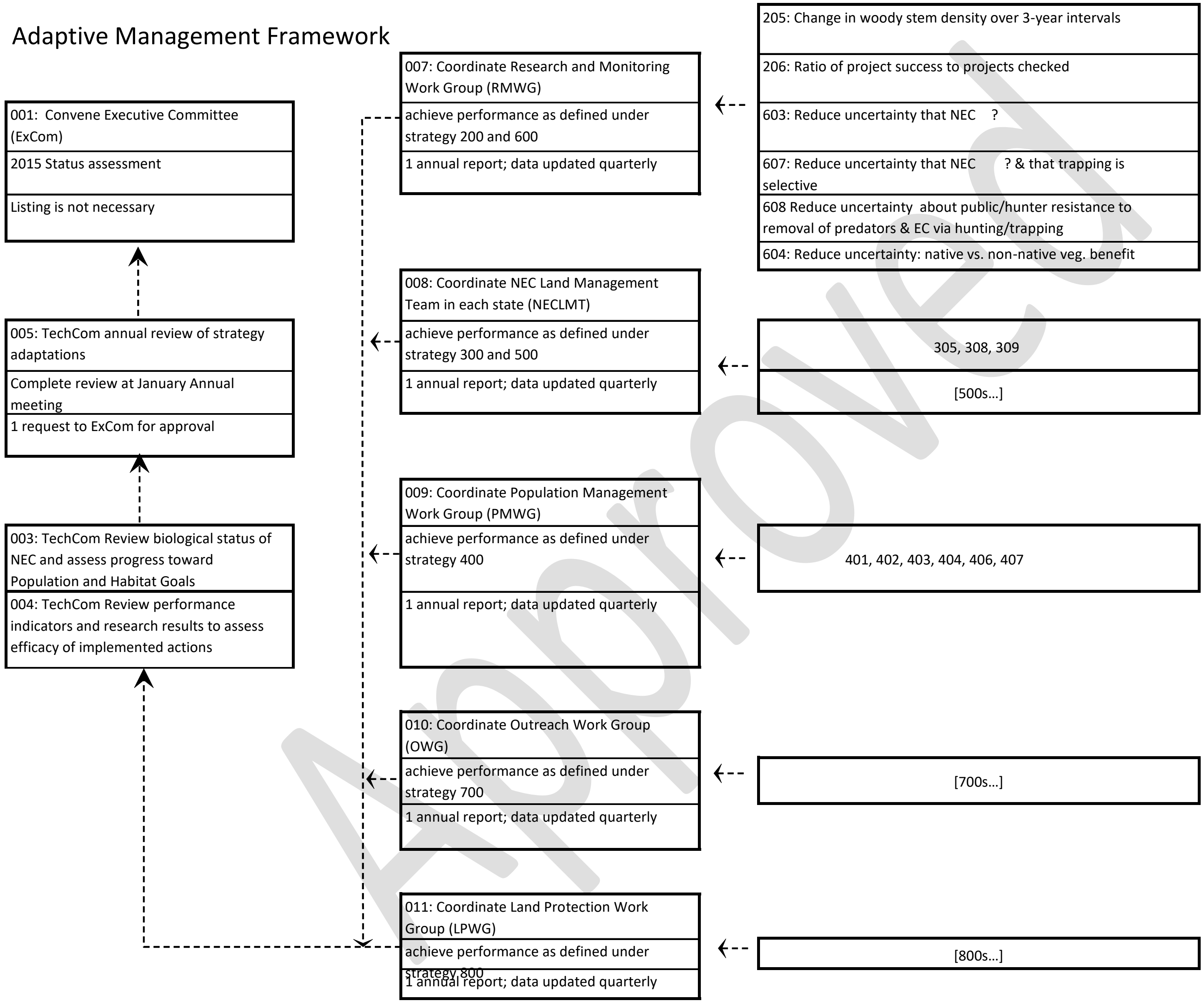
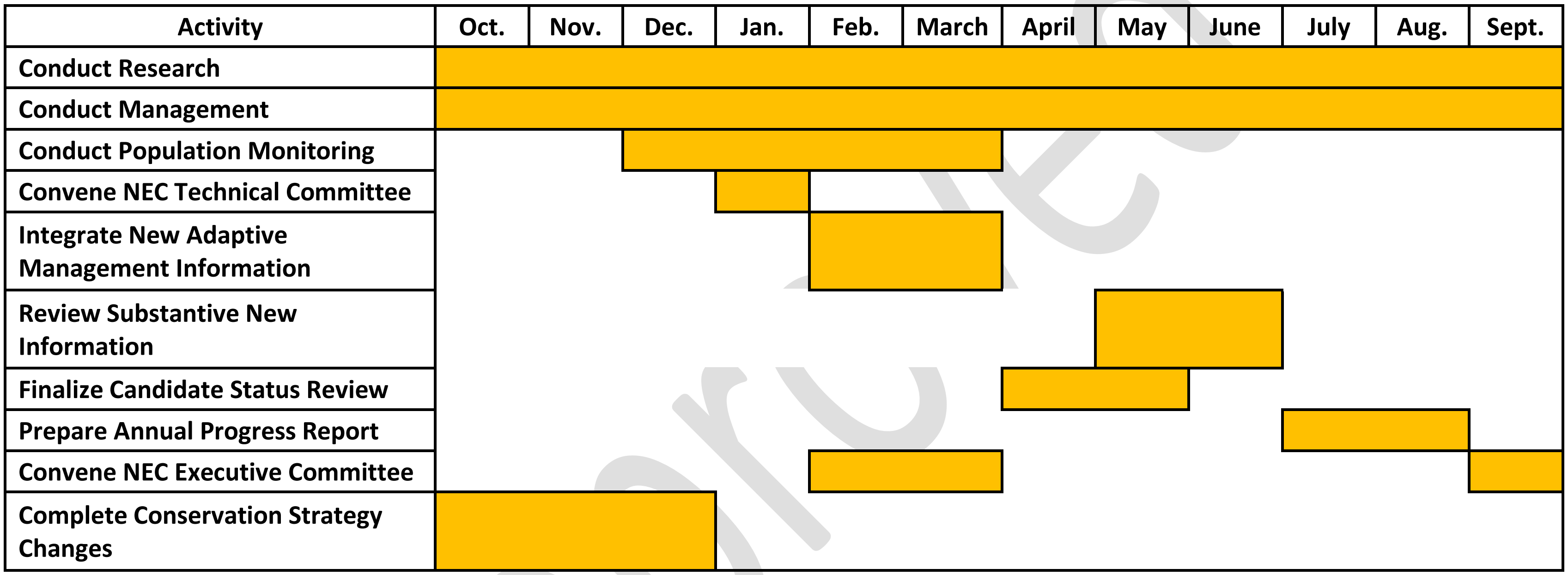


Figure 6.2. Yearly Calendar for Adaptive Management Cycle



7.0 Implementation Schedule and Budget Summary

This section has not been updated since the Strategy was created in 2012

Overview

This section estimates the cost and current status of each objective described in the Strategy. Conserving the New England cottontail is an ongoing, existing effort, not a proposed future project. As shown in the tables below, the objectives have been reviewed and approved by the NEC Executive Committee and are largely underway if not yet completed. We provide cost figures more as a way of assessing and improving the feasibility of NEC conservation rather than as a budget.

It is not possible to completely insure the certainty of carrying out this Strategy, as future funding circumstances and political environments may change. But our system of planning, organizing, and governing have in a short time led to many conservation actions that both help NEC and show the level of partners' commitment to conserve the species. Future constraints may limit the ability of any partner, including federal, state, and local governments, to carry out the conservation actions that have been planned. Nonetheless, we have conservatively estimated funds needed to achieve near-term objectives, $26 million to date, and believe that funding can be acquired to reach longer-term objectives as well. Conservation partners are already pursuing longer-term funding. We also believe that our estimated total cost can be reduced, and that both long-term and short-term objectives are feasible and attainable.

Major Costs

The expense of managing habitat across the NEC range is by far the highest cost identified in this Strategy. It consists mainly of silvicultural practices (such as cutting or mowing down trees that are not commercially valuable) by forestry professionals. Managing habitat for NEC and monitoring populations are both long-term commitments given the ephemeral nature of NEC habitat, whose suitability declines as shrublands inexorably mature into forests, which means habitat management must be ongoing. The long-term recovery of NEC, especially in areas with significant development pressures, may require the commitment of funds for habitat management and monitoring well into the future. Predicting these long-term costs (Table 7.2) is difficult, since many site-specific details are not yet known. Further research will determine which techniques and site conditions lead to efficient management of shrubland habitat communities; however, maintaining such habitat should cost less than creating it. Costs of the personnel capacity needed to recruit landowners, plan projects, and oversee habitat work are significant and necessary. Finally, the costs of managing eastern cottontail populations are largely unknown and will depend on whether and to what extent research shows that controlling eastern cottontails helps increase NEC range and numbers.

The data below (also presented in chapter 1.0, the Executive Summary) come from measurable objectives scheduled by land managers, an evaluation of habitat needs in each focus area by the NEC Technical Committee, costs reported in the tables that follow, and summaries of parcel data included in chapter 5.0, State Conservation Summaries.

1. Conservationists have identified approximately 473 areas with potential for creating habitat patches for NEC larger than 25 acres, and another 470 areas with potential for creating habitat patches smaller than 25 acres, for a total of 943 projected management operations.
2. The estimated cost of planning and overseeing the 943 operations estimated to achieve our goals by 2030 is more than $4 million. (The long-term cost of habitat maintenance is not included here or elsewhere in the Strategy.)
3. The estimated cost to recruit landowners and complete eligibility, enrollment, and cost-estimation procedures exceeded $1,000 per acre during 2009 to 2011. Assuming that those costs will be reduced through partners' cooperative efforts, we estimate the recruitment and enrollment process for 15,595 acres on private land will cost a minimum of $6.5 million.
4. In addition to the cost of recruiting and enrolling landowners, the actual management of 15,595 acres will be around $1,750 per acre, or over $27 million, for a total exceeding $33 million for creating and managing NEC habitat on private lands. Even when the sale of timber products offsets management costs, revenues will benefit the landowner and will not defray recruitment and enrollment expenses.
5. Managing 9,895 acres at $1,750 per acre on public land will cost more than $17 million; another 10,475 acres of state land are slated for controlled burning at $200 per acre, for an additional $2 million.
6. According to parcel analyses, over 145,268 acres of public land are highly suitable for NEC. Increasing management on public land would create substantial savings through: (1) increasing patch size to reduce the number of operations and the amount of planning and oversight; (2) reducing or eliminating landowner recruitment and enrollment costs; (3) creating efficiencies of scale; 4) increasing the opportunity to use controlled burning at a savings of $1,500 per acre over other habitat-creation and -maintenance techniques; and 5) bringing in revenue through the sale of timber products.
7. With few exceptions, managing public land is far cheaper than managing private land or buying new land. Recruitment, outreach, and planning funds allocated to public land will generate a quicker response at 30 to 90 percent less cost than the same actions applied to private land.
8. Modeling data suggest that 145,268 acres of public land are suitable for management, but due to perceived barriers (i.e., conflicting natural resource objectives, habitat management constraints, etc.) the NEC Technical Committee reduced the target level to 23,812 acres. Conservation partners should consider it a high priority to invest time and money in evaluating and removing the barriers to managing public land to benefit NEC.
9. The NEC Technical Committee identified almost 30,000 acres of naturally self-sustaining shrub habitat, predominantly in focus areas on Cape Cod, Massachusetts, and in New York; biologists have increasingly documented NEC use of those habitats. Although sufficient natural acreage is not available in all states, those areas on Cape Cod, in New York, and possibly in other pitch-pine scrub-oak barrens or Appalachian oak forest types could potentially meet habitat objectives with the need for minimal vegetation management, and at an enormous savings. Research to document and map the population status of NEC in naturally self-sustaining shrub habitats must be a top priority. Throughout the southern New England range of the eastern cottontail, we do not know whether habitat availability or competition with the eastern cottontail is the major limiting factor for NEC. If such competition is found to be important, trapping and removing eastern cottontails may cost 70 to 80 percent less than managing habitat. Research to understand potential NEC-eastern cottontail competition should be started immediately to learn whether removing eastern cottontails may be an effective management tool.

Reducing Costs to Increase the Feasibility and Certainty of Conserving the New England Cottontail

Removing barriers to managing public land is the most direct way to ensure long-term security of NEC populations, avoid the considerable expense of recruiting private landowners to manage land for NEC, and minimize the need to buy land (a potential expense that has not been included in this assessment). Conservation partners may save money by: (1) upping the size of NEC habitat patches to reduce the number of habitat-management operations needed, as well as accompanying planning and oversight; (2) reducing or eliminating the cost of recruiting and enrolling landowners; (3) creating efficiencies of scale; (4) increasing the opportunity to manage habitat through controlled burning; and (5) using commercial timber practices, such as rotational clear-cutting, to return income to agencies. A significant paradox exists: Managing privately owned lands may not be limited by funding if the Natural Resources Conservation Service (NRCS) continues to allocate Farm Bill funding to the Working Lands for Wildlife Initiative, but funding is limited for managing public land. However, if Working Lands for Wildlife Initiative funding continues to exceed projected private lands objectives, it will not address long-term security of NEC habitat without a commensurate allocation of NRCS Wetland Reserve Program (WRP) funds to secure easement access for NEC conservation.

Three strategies could reduce the overall need to use habitat management as a way of achieving habitat goals. First, NEC use of habitats sustained by natural processes is poorly documented, but survey efforts and telemetry studies suggest that NEC may be allopatric (i.e., existing without the presence of eastern cottontails) in such habitats, indicating that eastern cottontails may be unable to exist in these habitats. Documenting the extent of NEC use of naturally self-sustaining habitats could potentially minimize the need for both habitat management and eastern cottontail management. Second, NEC may be excluded from poor habitat (small patches that may not support suitable vegetative cover) by eastern cottontails, especially in southern New England. If NEC populations respond positively to the removal of eastern cottontails, then in areas where there is little risk of rabbit mortality from hunting, large landscapes composed mainly of lesser-quality habitat may be opened up to NEC without the need for habitat management. Third, even in better-quality habitat, trapping and removing eastern cottontails may be far cheaper than habitat management.

In conclusion, management of existing public lands may be the most efficient means for creating habitat for the NEC. However, funds to implement habitat management on these properties are limited by existing budgets and eligibility restrictions that prevent some programs from expending funds on these projects (e.g., Working Lands for Wildlife funds cannot be spent on State owned properties). For example, with the commencement of the NRCS Working Lands for Wildlife Initiative, previously unengaged NRCS staff may devote more time toward meeting habitat objectives and contributing to the NEC conservation effort. Capacity costs could be further reduced by establishing relationships to leverage additional land management capacity, such as with state foresters, town foresters, and forestry nongovernmental organizations.

Note: In the tables below, all cost estimates are approximate and are intended for estimation purposes only. Figures presented in any table do not represent a commitment of funding by any party.

Table 7.1. Summary of Habitat Objectives.

A. Sum of habitat objectives by jurisdiction

Partner	Sum of Habitat Objectives (acres) 2012-2015	Habitat Objective (cumulative acres) 2012-2020
Connecticut	2300	12425
Massachusetts	7075	13750
Maine	1221	3665
New Hampshire	748	1360
New York	1500	1500
Rhode Island	515	3265
Total All States	13359	35965
Tribal	25	25

Note: Objectives are estimated targets for management, to be measured as progress toward range-wide Recovery Goals.

B. Sum of habitat objectives by ownership

Ownership	Habitat Objective (cumulative acres) 2012-2020
private land (Farm Bill)	15595.0
municipal land	1290.0
state land	8080.0
federal land	525.0
prescribed fire (acres)	10475.0
tribal	25.0
All	35990

Table 7.2. Budget Summary for Urgent/High Priority Objectives

Budget Summary For Urgent/High Priority Objectives
SUBTOTALS: Conservation Strategies

Objective	Annual Cost	Cost 2012-2020	Funding Identified
000 Adaptive Management	$ 210,090	$ 1,680,720	$ 164,100
100 Information Management	$ 46,417	$ 473,937	$ 172,600
200 Monitoring	$ 176,997	$ 1,049,689	$ 142,299
300 Landowner Recruitment	$ 1,237,858	$ 7,819,239	$ 2,318,925
400 Population Management	$ 227,435	$ 1,735,037	$ 918,349
500 Habitat Management	$ 6,422,531	$ 51,380,248	$ 21,653,800
600 Research	$ 188,600	$ 804,400	$ 646,400
700 Outreach	$ 83,455	$ 275,365	$ -
800 Land Protection	$ 313,764	$ 1,051,719	$ 20,000
Estimated Total	$ 8,907,148	$ 66,270,353	$ 26,036,473

Table 7.3. Budget Summary for Urgent/High Priorities

A. SUBTOTALS: Governance Committees

Partner/Org.	Estimated Cost[1]	Estimate of Funds Identified[2]	Estimated Annual Cost[3]	Unmet Need[4]	Annualized Partner Share[5]
ExCom	$ 519,750	$ 6,000	$ 64,969	$ 513,750	$ 8,027
TechCom	$ 824,877	$ 3,100	$ 103,110	$ 821,777	$ 12,840
LPWG	$ 313,764	$ 20,000	$ 67,780	$ 293,764	$ 4,590
PMWG	$ 355,927	$ 96,000	$ 52,546	$ 259,927	$ 4,061
OWG	$ 213,968	$ -	$ 71,323	$ 213,968	$ 3,343
RMWG	$ 1,687,390	$ 430,000	$ 322,898	$ 1,257,390	$ 19,647
NECLMTs	$ 17,766,458	$ 3,402,484	$ 2,243,565	$ 14,363,974	$ 224,437
SUBTOTAL	$ 21,682,134	$ 3,957,584	$ 2,926,190	$ 17,724,550	$ 276,946

B. SUBTOTALS: Management Objectives by Program

States	$ 17,074,987	$ 2,224,987	$ 2,178,673	$ 14,850,000	$ 232,031
FWS (NALCC)	$ 74,700	$ 49,700	$ -	$ 25,000	$ 3,125
FWS (NWR)	$ 2,354,327	$ 440,861	$ 429,119	$ 1,913,466	$ 239,183
FWS (NEFO)	$ 94,251	$ -	$ 11,781	$ 94,251	$ 11,781
FWS (PFW)	$ 2,257,500	$ -	$ 282,188	$ 2,257,500	$ 282,188
NRCS	$ 18,322,500	$ 18,322,500	$ 2,290,313	$ -	$ -
USGS	$ 4,100	$ 4,100	$ -	$ -	$ -
WMI	$ 4,405,855	$ 1,036,741	$ 788,885	$ 3,369,113	$ 421,139
SUBTOTAL	$ 44,588,220	$ 22,078,889	$ 5,980,958	$ 22,509,330	$ 1,189,448

C. TOTALS: Governance Committees and Management Objectives by Partner

States (each)	$ 33,336,587	$ 5,193,175	$ 4,373,316	$ 28,143,412	$ 508,977
FWS	$ 7,491,045	$ 985,259	$ 1,088,861	$ 6,505,786	$ 813,223
NRCS	$ 21,032,767	$ 18,817,198	$ 2,656,086	$ 2,215,569	$ 276,946
USGS	$ 4,100	$ 4,100	$ -	$ -	$ -
WMI	$ 4,405,855	$ 1,036,741	$ 788,885	$ 3,369,113	$ 421,139
Estimated Total	$ 66,270,353	$ 26,036,473	$ 8,907,148	$ 40,233,880	$ 2,020,286

1 Estimated cost 2012-2020, including supplies, contracts, salaries and 37.5% overhead, including fringe benefits, pay increases, and inflation through 2020.

2 Estimated funds currently granted or expected, generally through 2015.

3 Estimated annual cost, for each of 8 years 2012-2020.

4 Estimated Cost less Estimate of Funds Identified.

5 Annual cost for Partner/Program or each of 8 Executive Partners: FWS, NRCS, ME, NH, MA, RI, CT, NY. Annualized cost shown is evenly distributed, but will be lower through 2015 and higher after.

Table 7.4. Coordination and Administration

Objective	Status	Limitations	Lead Program	Scope (states)	Priority	Timing	Duration (years)	Resources/ units	Annual Cost	Cost 2012-2020	Funding Identified	Funding Source
001: Convene Executive Committee (ExCom)	Initiated (2012)	none	ExCom, WMI	6	High	2012	8	.4 FTE @ GS-14	$64,969	$519,750	$6,000	CSWG2
002: Convene Technical Committee (TechCom)	Initiated (2011)	none	TechCom, WMI	6	High	2012	8	.15 FTE @ GS-13 (Coord.); .5 FTE @ GS-9 (tech.)	$57,720	$461,762	$155,000	NFWF, C-SWG 1&2
003: TechCom annual review of species status	Initiated (2011)	none	TechCom	6	High	2012	8	.02 FTE @ GS-9; travel	$5,571	$44,567	$3,100	-
004: TechCom annual review of performance	Initiated (2011)	none	TechCom	6	High	2012	8	.02 FTE @ GS-9	$5,571	$44,567	-	-
005: TechCom annual review of strategy adaptations	Initiated (2011)	none	TechCom	6	High	2012	8	.02 FTE @ GS-9	$5,571	$44,567	-	-
006: Coordinate Information & Adaptive Management Work Group (IAMWG)	Initiated (2011)	none	TechCom	6	High	2012	8	.15 FTE @ GS-9 (2 TechCom)	$11,781	$94,251	-	-
007: Coordinate Research and Monitoring Work Group (RMWG)	Initiated (2011)	none	TechCom	6	High	2012	8	.15 FTE @ GS-9 (2 TechCom)	$11,781	$94,251	-	-
008: Coordinate NEC Land Management Team in each state (NECLMT)	Initiated (2011)	none	TechCom	6	High	2012	8	.15 FTE @ GS-9 (2 TechCom)	$11,781	$94,251	-	-
009: Coordinate Population Management Work Group (PMWG)	Initiated (2011)	none	TechCom	6	High	2012	8	.15 FTE @ GS-9 (2 TechCom)	$11,781	$94,251	-	-
010: Coordinate Outreach Work Group (OWG)	Initiated (2011)	none	TechCom	6	High	2012	8	.15 FTE @ GS-9 (2 TechCom)	$11,781	$94,251	-	-
011: Coordinate Land Protection Work Group (LPWG)	Initiated (2011)	none	TechCom	6	High	2012	8	.15 FTE @ GS-9 (2 TechCom)	$11,781	$94,251	-	-
012: Coordinate Habitat Work Group (HWG)	Initiated (2016)	none	TechCom	6	High	2016	4	.15 FTE @ GS-9 (2 TechCom)	$11,781	$47,124	Funding not added to Tables 7.2 & 7.3.	

Table 7.5. Information Management

Objective	Status	Limitations	Lead Program	Scope (states)	Priority	Timing	Duration (years)	Resources/ units	Annual Cost	Cost 2012-2020	Funding Identified	Funding Source
101: Assess data management needs	Initiated (2012)	na	NALCC	6	High	2012	1	Input from TechCom	-	$45,600	$45,600	NALCC
102: Develop/integrate data management tools	Initiated (2011)	na	NALCC, WMI	6	High	2012	1	contracts (to develop data management tool	-	$50,000	-	-
103: Maintain/manage spatial data	Inactive	No platform	NALCC	6	Med.	2012	8	.05 FTE @ GS-10	$3,927	$31,417	-	-
104: Maintain/manage planning data	Inactive	No platform	TechCom	6	Med.	2012	8	.05 FTE @ GS-10	$3,927	$31,417	-	-
105: Maintain/manage NEC status data	Inactive	No platform, inefficiency	NEFO	6	High	2012	8	.1 FTE @ GS-10	$7,854	$62,834	-	-
106: Maintain/manage management performance data	Initiated w/ barriers (2011)	Data restrictions	TechCom	6	High	2012	8	.2 FTE @ GS-10 (TechCom); WMI system maintenance contract	$30,709	$245,668	$120,000	WMI
107: Acquire required data and permissions	Initiated w/ barriers (2011)	Data restrictions	ExCom	6	High	2012	8	legal fees etc.	-	-	-	WMI
108 Provide technical assistance to managers	Inactive	Undefined program roles	NALCC, WMI	6	Med.	2012	2	.1 FTE @ GS-13	$12,299	$24,598	-	-
109 Provide technical assistance with data backlog	Initiated w/ barriers (2011)	Data restrictions	WMI, TechCom	6	High	2012	1	contract for WMI system	-	$7,000	$7,000	WMI
110: Create and share status/performance reports	Inactive	No platform, inefficiency	NEFO, WMI	6	High	2012	8	.1 FTE @ GS-10	$7,854	$62,834	-	-
111: Respond to requests for data	Inactive	No platform, inefficiency	NALCC, WMI	6	Med.	2012	8	.1 FTE @ GS-10	$7,854	$62,834	-	-

Table 7.6. Monitoring

Objective	Status	Limitations	Lead Program	Scope (states)	Priority	Timing	Duration (years)	Resources/ units	Annual Cost	Cost 2012-2020	Funding Identified	Funding Source
201: Quantify extent of habitat	Inactive	High cost, but short shelf-life for early successional habitat	RMWG	6	low	2017	1	TBD	-	-	-	-
202: Develop regional detection protocol	Inactive	Complete UNH study	USGS, NWR I&M, NALCC	6	Urgent	2012	1	.1 FTE @ GS-13	$12,299	$12,299	-	NWR I&M
203: Measure habitat occupancy rates	Inactive	May require many staff on few days to desired survey intensity	RMWG	6	High	2013	6	2FTE @ GS-8 to coordinate staff & volunteers; $43,750 DNA; fewer managed sites initially	172,898	$1,037,390	$130,000	CSWG2, RIDEM (PR)
204: Presence/ Absence distribution surveys	Substantial Progress (2003)	Higher priority monitoring tasks consume resources	RMWG	6	Low	2014	6	2 FTE volunteer	-	-	-	-
205: Measure vegetation response to management	Initiated (2009)	none	States and NWRs	6	Med.	2012	6	.5 FTE @ GS-8	$32,287	$193,722	$40,000	CSWG2
206: Monitor effectiveness of vegetation management	Inactive	none	NRCS	6	Med.	2012	7	contract (CEAP)	$50,000	$350,000	$350,000	NRCS CEAP
207: Monitor disease	opportunistic	none	States	<1	Low	2012	8	opportunistic	-	-	-	-
208: Monitor health of small populations.	Initiated (2016)	none	States	6	Med.	2016	4	opportunistic	-	-	-	-

Table 7.7. Landowner Recruitment

Objective	Status	Limitations	Lead Program	Scope (states)	Priority	Timing	Duration (years)	Resources/ units	Annual Cost	Cost 2012-2020	Funding Identified	Funding Source
301: Convene Land Management Teams for each state (NECLMTs)	Initiated (2011)	Staff workload	NECLMTs	6	High	2012	8	1.5 FTE @ GS-9	$142,645	$1,141,162	-	-
302: Create/apply incentives	Initiated (2011)	Administrative rules	NECLMTs	6	Med.	2012	8	No direct cost, for incidental incurred benefits	-	-	-	-
303: Support recruitment coordinator	Initiated, Significant Barriers.	Hiring w/ experience & local ties/roots	WMI	6	Urgent	2013	5	10 FTEs @GS-8 (5 positions are now funded by NRCS/NFWF)	$645,741	$3,228,706	$645,741	NFWF/ NRCS
304: Contact landowners via mail/phone/ workshops	Substantial Progress (2009)	none	NECLMTs	6	Low	2012	5	see 303	-	-	-	-
305: Conduct site assessments	Substantial Progress (2009)	none	NECLMTs	6	High	2012	5	see 303 &306	-	-	-	-
306: Draft applications, preliminary plans and cost estimates	Substantial Progress (2009)	none	NECLMTs	6	Urgent	2012	8	2 FTE @ GS-12 (NRCS) &3 FTE @ GS-9 (PFW)	$420,828	$3,366,627	$1,654,884	NRCS
307: Draft/review land management ranking and eligibility criteria	Initiated (2010)	none	NECLMTs	6	High	2012	8	.1 FTE @ GS-9	$10,343	$82,744	-	-
308: Manage parcel information/landowner status	Substantial Progress (2009)	none	NECLMTs	6	Med.	2012	8	see 303	-	-	-	-
309: Develop/evaluate business plan incorporating parcel ranking & reserve design principles	Inactive	none	NECLMTs	6	Urgent	2012	8	.2568 FTE @ GS-9	$18,300	-	$18,300	CSWG2

Table 7.8. Population Management

Objective	Status	Limitations	Lead Program	Scope (states)	Priority	Timing	Duration (years)	Resources/ units	Annual Cost	Cost 2012-2020	Funding Identified	Funding Source
401: Extract NEC for captive propagation	Initiated (2011)	Low trapping success, source depletion	PMWG	6	Urgent	2012	8	Contract: 50 rabbits/ year	$25,000	$200,000	$11,000	CSWG2
402: Evaluate sources of NEC for captive breeding	2012	Administrative, uncertain outbreeding risks	PMWG	6	Urgent	2012	1	.05 FTE @ GS-13	$6,150	$6,150	-	-
403: Zoo-based husbandry	Initiated (2011)	Zoo facilities, low trapping success, source depletion	RWPZ	6	Urgent	2012	6	Contract: max 100 rabbits/ year	$100,000	$600,000	$300,000	CSWG2
404: Construct and manage outdoor hardening pens	Initiated (2011)	Zoo facilities, low trapping success, source depletion	NWR	6	Urgent	2012	8	6 pens @ $30,000 each, .15 FTE @ GS-9 each pen	$64,190	$693,523	$336,761	Ninigret NWR,CSWG2
405: Evaluate enclosure-based husbandry	Initiated (2011)	Availability of sites, cost of construction and operation	NWR	6	Urgent	2012	8	.15 FTE @ GS-9 each pen	$64,190	$385,140	-	-
406: Manage island colonies	Initiated (2011)	Island logistics	RIDEM, MADFW	3	Urgent	2012	8	.15 FTE @ GS-9 (1 trap & 1 release/year (w/ telemetry)	$10,698	$85,587	$85,587	RIDEM (PR)
407: Release NEC to augment population(s)	Initiated (2011)	Limited propagation yield	PMWG	3	Urgent	2013	7	.3 FTE @ GS-9 (4 releases/year (w/ telemetry), 2 sites	$21,397	$149,778	$85,000	CSWG2, SNEP
408: Manage EC	Inactive	Uncertain opinion/ bio uncertainty	PMWG	5	High	TBD	TBD	$500/acre	-	-	-	-

Table 7.8. Population Management (Continued)

Objective	Status	Limitations	Lead Program	Scope (states)	Priority	Timing	Duration (years)	Resources/ units	Annual Cost	Cost 2012-2020	Funding Identified	Funding Source
409: Manage predators	Inactive	Uncertain opinion/ bio uncertainty	PMWG	6	Med.	TBD	TBD	unknown	-	-	-	-
410: Manage disease	Inactive	na	PMWG	6	Low	TBD	TBD	na	-	-	-	-
411: Manage hunting	Initiated (2008)	na	PMWG	5	Low	2012	8	na	-	-	-	-
412. Reduce Predation	Initiated	none	MEIFW, NHFGD	2	High	2010	TBD	.3 FTE @ GS-9	$21,397	-	-	-

Table 7.9. Habitat Management

Objective	Status	Limitations	Lead Program	Scope (states)	Priority	Timing	Duration (years)	Resources/ units	Annual Cost	Cost 2012-2020	Funding Identified	Funding Source
501: Create Demonstration Sites	Initiated (2011)	Eligibility of WHIP on state land	NECLMTs	6	Med.	2014	5	$2000/acre (2 per state at 10 acres) see 505	-	-	-	see 505
502: Draft site-specific management plans	Significant barriers	Hiring freezes, lack of experienced professionals for 943 plans	NECLMTs	6	Urgent	2012	8	6 FTE @ GS-11; met by contract, allocation of agency staff, or TSPs	$517,754	$4,142,028	$1,209,300	WHIP/ EQIP plans; CSWG2
503: Coordinate with National Wildlife Refuge partnerships	Initiated (2009)	Communicating allowances for NWR off-site contributions	NECLMTs	6	Urgent	2012	8	see 301	-	-	-	-
504: Coordinate with National Estuarine Research Reserves	Initiated (2009)	Coastal Zone Management act restrictions	NECLMTs	4	Med.	2012	8	see 301	-	-	-	-
505: Create Habitat on Private Land through Farm Bill Funding	Initiated (2009)	Small patch size, $750-$1250/acre for recruitment	NRCS	6	High	2012	8	ave. $1750/acre	$2,290,313	$18,322,500	$18,322,500	NRCS WHIP EQIP
506: Create Habitat on Private Lands Not Eligible for Farm Bill Funding	Initiated (2009)	Small patch size, $750-$1250/ acre for recruitment	NECLMTs	6	High	2012	8	ave. $1750/acre	$1,121,094	$8,968,750	$350,000	NFWF, PFW, WCS, SNEP
507: Create Habitat on Municipal Land	Initiated (2009)	none	PFW	6	Urgent	2012	8	ave. $1750/acre	$282,188	$2,257,500	-	-

Table 7.9. Habitat Management (Continued)

Objective	Status	Limitations	Lead Program	Scope (states)	Priority	Timing	Duration (years)	Resources/ units	Annual Cost	Cost 2012-2020	Funding Identified	Funding Source
508: Create Habitat on State Land	Initiated (2009)	Scarce land managers	States	6	Urgent	2012	8	ave. $1750/acre	$1,767,500	$14,140,000	$1,345,000	CSWG
509: Create Habitat on Federal Land	Initiated (2009)	none	USFWS	6	Urgent	2012	8	ave. $1750/acre	$114,844	$918,750	-	-
510: Implement prescribed fire (acres)	Initiated w/ barriers (2011)	Public perception	MDFW	4	High	2012	8	$200/acre	$261,875	$2,095,000	$40,000	SNEP
511: Refine Best Management Practices for Making NEC Habitat	Substantial Progress (2011)	none	NECLMTs	6	Low	2013	5	see 502	-	-		
512: Administrative technical support to manage contracting & vendors	Substantial Progress (2009)	none	WMI	6	High	2012	8	.5 FTE@ GS-13	$61,496	$491,970	$217,000	NFWF, CSWG2, WCS
513: Implement restoration (acres) on Tribal Land	Initiated (2010)	none	NECLMTs	6	High	2012	8		$5,469	$43,750	$170,000	Tribal Wildlife Grant

Table 7.10. Research

Objective	Status	Limitations	Lead Program	Scope (states)	Priority	Timing	Duration (years)	Resources/ units	Annual Cost	Cost 2012-2020	Funding Identified	Funding Source
601: Determine NEC demography	Initiated (2011)	none	RWPZ	6	Med.	2012	8	contract, see 403	-	-	-	-
602: Determine NEC distribution/ abundance	Complete (2012)	none	UNH, URI	6	Low	na	2	na	-	-	-	-
603: Study NEC/EC interaction	Initiated (2011)	none	CTDEP	5	Urgent	2012	4	CTDEP seasonals $26000; ESF, see also 604 and 605	$26,000	$104,000	-	CTDEP (PR)
604: Investigate habitat ecology	Initiated (2011)	none	ESF	6	High	2012	3	grant ESF, EC/NEC habitat interactions	$200,000	$800,000	$800,000	NYSDEC (SWG)
605: Investigate survival rates in burned and unburned habitat	Substantial Progress (2009)	none	MMR	<1	Med.	2012	2	.2 FTE @ GS 9	$14,265	$28,529	$28,529	MMR
606: Study NEC taxonomy/genetics	Initiated (2011)	none	RWPZ	6	Low	na	5	grants	-	$635,498	$635,498	USGS RIDEM (PR)
607: Test management assumptions	Initiated (2012)	none	CTDEP, UNH	6	Urgent	2012	4	grant, seasonal staff, supplies	$112,600	$450,400	$450,400	CTDEP (PR)
608: Monitor public opinion of management actions	TBD	none	TBD	6	High	2013	4	grant (estimate)	$50,000	$50,000	-	-

Table 7.11. Outreach

Objective	Status	Limitations	Lead Program	Scope (states)	Priority	Timing	Duration (years)	Resources/ units	Annual Cost	Cost 2012-2020	Funding Identified	Funding Source
701: Develop outreach strategy	Complete (2012)	none	OWG	6	high	na	1	na	-	-	-	-
702: Develop/maintain website	Complete (2012)	none	WMI	6	high	na	8	maintenance contract	$5,000	$40,000	-	-
703: Develop Communications Products to Explain and Further NEC Conservation	Initiated (2010)	none	OWG	6	high	2012	1	see 705	-	-	-	-
704: Direct Outreach Efforts to NEC Focus Areas	Initiated (2010)	none	NECLMTs	6	Urgent	2012	3	.1FTE @ GS-9	$7,132	$21,397	-	-
~~705: Target Recruitment of Key Landowners~~	~~Initiated (2010)~~	~~none~~	~~NECLMTs~~	~~6~~	~~Urgent~~	~~2013~~	~~3~~	~~1 FTE @ GS-10~~	~~$71,323~~	~~$213,968~~	-	-

Objective 705 was deleted in 2025 as it was determined to be overlapping with Objective 303.

Table 7.12. Land Protection

Objective	Status	Limitations	Lead Program	Scope (states)	Priority	Timing	Duration (years)	Resources/ units	Annual Cost	Cost 2012-2020	Funding Identified	Funding Source
801: Expand NWR partnerships and land protection efforts	Substantial progress	PPP aproval, LPP consensus	USFWS	All States	High	2012	3	2 FTE @ GS-13	$245,985	$737,954	-	-
802: Develop local land protection partnerships	Initiated	Mission not compatible with "single species" management	LPWG	All States	Med.	2013	2	.25 FTE@ GS-13 (contract?)	$30,748	$61,496	-	-
803: Develop projects	Significant barriers	none	LPWG	All States	Med.	2012	5	.25 FTE@ GS-13 (contract?)	$30,748	$153,740	$20,000	OSI, NFWF, WCS
804: Raise funds	Significant barriers	National economy and politics	LPWG	All States	High	2012	5	.5 FTE@ GS-13 (contract?)	$61,496	$307,481	$20,000	OSI, NFWF
805: Development of Land Protection Ranking Criteria	Substantial progress	none	LPWG	All States	Urgent	2012	1	.01 FTE @ GS-10	$6,283	$6,283	-	-

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