FINAL REPORT

for

Habitat Evaluation and Monitoring of Working Lands for Wildlife:

Assessment of Habitats Managed for New England Cottontails

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Executive Summary

This project evaluated management actions supported by the *Working Lands for Wildlife Program* of the Natural Resources Conservation Services (NRCS). Efforts supported by NRCS are addressing the habitat needs of species dependent on young forests and shrub-dominated lands, with special emphasis on New England cottontails (NEC, *Sylvilagus floridanus*). **Objective I** sought to develop a rapid, field-based method for monitoring suitability of managed parcels. The resulting protocol largely relies on visual obstruction provided by understory vegetation rather than plot-based stem counts and should help determine if a managed site is or is not developing toward suitability for NEC. **Objective II** included visits to 55 sites located in Connecticut, Maine, Massachusetts, New Hampshire, and New York. Conditions among visited sites ranged from "rabbit ready" (capable of supporting NEC, n=11), "moving toward suitability" (n=12), "too soon to predict future suitability"(n=18), "unlikely to develop essential features required by NEC" (especially the needed dense understory vegetation, n=13), and varied condition (n=1). These mixed results suggest there may be a need to re-emphasize the need for larger, productive source habitats. Although small or low-quality sites (relative to NEC suitability) may have some positive influences on metapopulation dynamics, they are probably not cost effective. Conversations with landowners during field visits also revealed that there is a need for greater engagement with them. This may be especially important for retaining landowners and their acreage in the NEC restoration initiative. **Objective III** was an evaluation of habitat conditions in comparison to management action, local conditions, and regional forest type. General patterns indicated that development of dense understory vegetation seemed most responsive to aspects of the management action (e.g., size and configuration of clearcut), soil fertility, prior land use (e.g., re-forested farmland versus mature forest), and forest type. Restoration goals that rely on a standard estimate of NEC density within available habitat and do not consider inherent differences in carrying capacity among forest types or the presence of sympatric eastern cottontails are probably too optimistic and should be re-evaluated. **Objective IV** provides recommendations that could enhance suitability of parcels that are not yet capable of supporting NEC. These actions include methods that increase cover (e.g., regularly spaced brush piles or mowing to stimulate increased stem density via sprout growth), promote areas with herbaceous forage in close proximity to cover, and reduce vulnerability to predators (e.g., remove potential raptor perch trees). Responding to invasive shrubs will be challenging because invasive shrubs were often most abundant on productive soils that were moving toward "rabbit

ready" and these shrubs do provide dense understory cover. Beyond concerns for establishing a seed source that further spreads invasive shrubs, there may be unexpected and potentially detrimental consequences to NEC that colonize these sites (e.g., higher ectoparasite loads that may reduce rabbit fitness). **OBJECTIVE V** provided an introduction of the rapid assessment protocol to biologists engaged in NEC restoration efforts during site visits and an overview was provided at the annual meeting of the New England Cottontail Technical Committee.

OBJECTIVE I - Develop a rapid-assessment protocol of habitat suitability that facilitates periodic monitoring of parcels managed for New England cottontails.

Introduction

Habitats occupied by New England cottontails (*Sylvilagus transitionalis*, NEC) are largely characterized by features that provide escape cover from mammalian and avian predators (dense understory vegetation) and an abundance of summer (grass and forbs) and winter (woody browse) forage (Arbuthnot 2008). To aid the range-wide recovery plan (Fuller and Tur 2012), Warren et al. (2016) developed a method to assess the suitability of managed parcels. That approach included plot-based sampling across the parcels to inventory density and height of understory woody stems and delineation of herbaceous forage in close proximity to escape cover. Although such an inventory can provide a rigorous evaluation of habitat suitability, a quick assessment of the major features (specifically the abundance of dense understory cover) would likely facilitate periodic monitoring of managed parcels and aid in identifying when a parcel is capable of supporting NRC (Fig. 1). Regular monitoring also can enable proactive interventions (e.g., follow-up mowing) should they be needed as habitats develop. In addition to understory vegetation, the prevalence of invasive shrubs and intensity of browsing pressure by white-tailed deer (*Odocoileus virginianus*) or moose (*Alces alces*) can affect regeneration of native vegetation. These features should be included in the assessment of how well a parcel is developing the features needed by NEC. It is important to acknowledge that a rapid approach is not intended to be a replacement for the comprehensive assessment of suitability constructed by Warren et al. (2016).

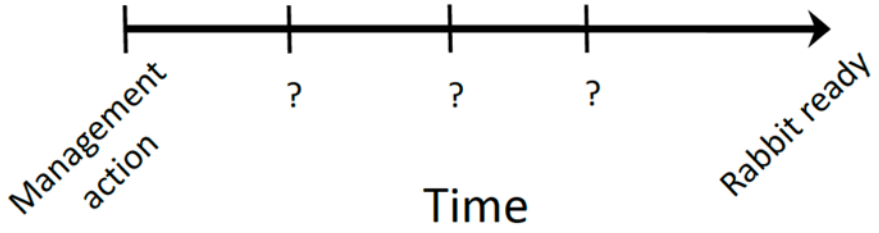

Figure 1. *Understanding how a managed parcel of land is progressing toward suitability for New England cottontails will likely require several visits. These visits will include an assessment of regeneration of woody plants, prevalence of invasive shrubs, relative impact of deer or moose foraging on regenerating vegetation, and other factors that may affect rabbit use of the managed habitat.*

Developing an Index of Understory Cover

I considered several protocols that rely on application of digital photography and subsequent computer-based analysis. These included methods based on light penetration (e.g., Goodenough and Goodenough 2012) where a white board is placed behind the understory vegetation to assess visual obstruction. Although this can reduce variation among observers, an obvious limitation of this approach is that it does not differentiate between living vegetation and standing dead vegetation. For example, dead stalks and floral clusters of dense patches of annuals like asters (*Asters* spp.) and goldenrods (*Solidago* spp.) can provide substantial visual obstruction early in the dormant season (November/December, Fig. 2), but these plants are subsequently knocked to ground level with accumulated snow (January/February). As a result, applications of this method would likely result in

Figure 2. *Visual obstruction provided by understory shrubs, young, trees, and standing, dead asters and goldenrod stems. Photographs illustrate cover from different perspectives relative to ground level. The problematic nature of the ephemeral cover provided by standing, dead vegetation is most apparent at ground level to 1 meter above ground level.*

different measures depending on when sampling occurred. Other photographic approaches to inventory living vegetation rely on light transmission in the photosynthetic-active radiation wavelengths (e.g., Chen et al. 2010). But this approach cannot be used in the leaf-off season when measures of cover are most relevant to NEC (Barbour and Litvaitis 1993). Based on these considerations and the notion that any approach should be relatively simple and quick, I turned to an evaluation that relies on a simple estimate of visual obstruction. Specifically, relying on multiple samples of visual obstruction of a 2-meter range pole (painted red and white, Fig. 3). This method can be applied by one person, does not require analysis of digital photographs, and provides information on vegetation height (the pole is delineated in 0.5 meter increments) and relative density (based on visual obstruction).

Figure 3. *Range pole positioned 10 meters from observer and the percentage of each 0.5 meter segment that are covered by vegetation is used to index cover for New England cottontails. Height of dominant vegetation within 10 meters of the pole is also estimated.*

The most important feature of affecting the suitability of a site for NEC is understory cover. According to the suitability model developed by Warren et al. (2016), two variables describe understory cover: proportion of the site covered by dense woody vegetation and average understory height (Fig. 4). For the rapid assessment protocol, I have modified how this information is collected. Rather than rely on plot-based counts of understory stems, I recommend using an index of visual obstruction (measured with a range pole) in those portions of the site that are recognized (by walking through the area or using recent aerial photography) as having the densest vegetation.

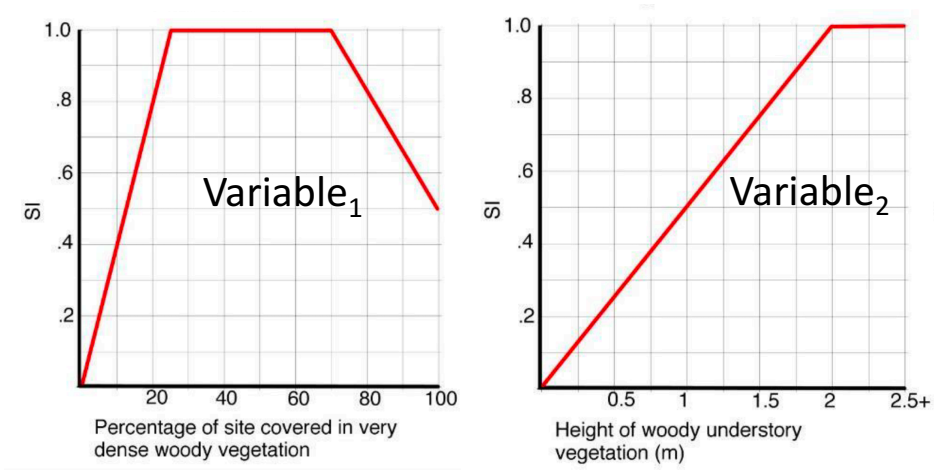

Figure 4. *Two variables used in rapid assessment of sites managed for New England cottontails focus on understory characteristics (adapted from Warren et al. 2016). The suitability index (SI) of each variable can vary from 0 (not suitable) to 1.0 (optimal suitability). Very dense understory (V_1) refers to woody understory vegetation >0.5-m tall that provides ≥75% visual obstruction of a range pole and is measured within the average height of vegetation (V_2) at the sampling point. For example, if the average understory height (visual estimation) is 1.5 m, then the observer evaluates visual obstruction of the portion of the range pole that is 0.5 – 2.0 m above ground level from a distance of 10 m from the range pole. Cover at ground level to 0.5 m above is not a reliable measure because of the presence of (ephemeral) standing dead vegetation.*

To develop an easily-understood index of cover, I relied on the relationship between stem density and visual obstruction reported by Litvaitis et al. (1985) during an investigation of snowshoe hare habitat preferences. In that study, visual obstruction (concealment of a vegetation profile board) was compared to the density of hardwood stems that were >0.5 m tall and a ≤7.5 cm diameter-at-breast height (Fig. 5). I recommend using 75% visual obstruction, equivalent to approximately 40,000 hardwood stems/ha, as a threshold value for very dense vegetation in NEC habitats. This approach is illustrated below (Fig. 6). The method described by Litvaitis et al. (1985)

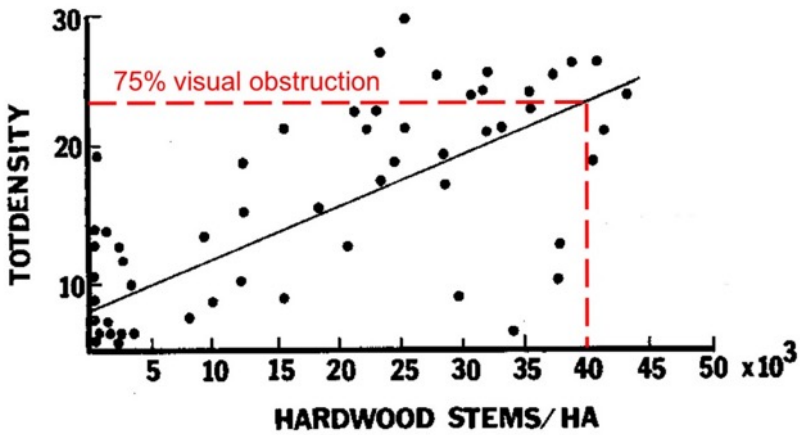

Figure 5. *The relationship between visual obstruction and understory-stem density was based on samples collected by Litvaitis et al (1985) in eastern Maine, where a vegetation profile board was positioned 15 m from an observer who recorded the amount of the board that was hidden (= visual obstruction). That value (TOTDENSITY) ranged from 0 – 30, where 30 is equivalent to 100% of 2-m board covered by vegetation. These samples were collected during the leaf-off season and sites with ≥75% visual obstruction (circa >40,000 hardwood stems/ha) were considered "very dense".*

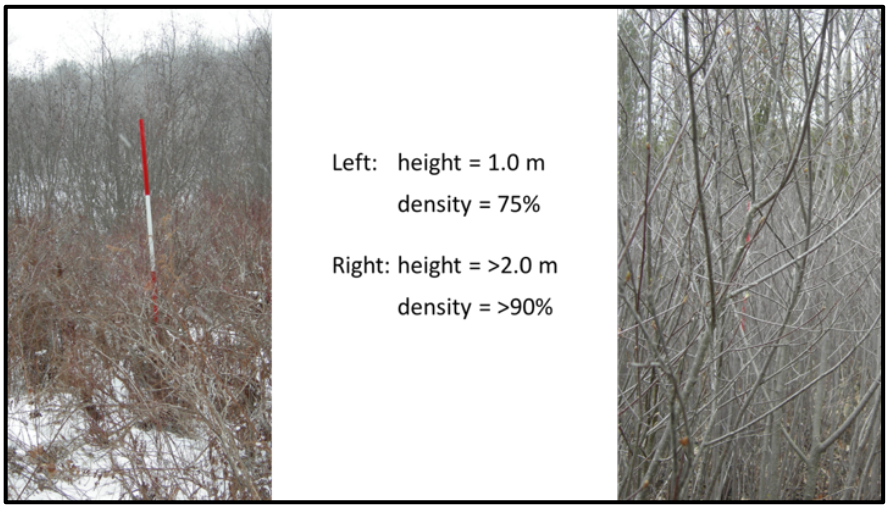

Figure 6. *Examples of visual obstruction recorded at two sites. On the left, average height of vegetation within the sample plot was 1 m and 75% of the range pole 0.5-1 m above ground level was concealed by vegetation. On the right, vegetation was >2.0 tall and >90% of the range pole at 0.5-2 m above ground level was concealed by vegetation.*

utilized a vegetation profile board (2-m tall and 0.33-m wide, painted red and white at 0.5 m intervals) that required two field technicians to execute. So, I compared the patterns of visual obstruction provided by profile boards and range poles because poles can be easily used by one person. I found that cover estimates made using range poles were generally comparable to those made using a board at the same site, especially when the pole was positioned 10 m from the observer and the profile board was 15 m away. Not surprising, the narrow range pole was hidden by less vegetation (Fig. 7). This distinction is not critical but may aid in more efficient field surveys.

Figure 7. *Comparison of estimates of visual obstruction using a vegetation profile board and range pole. At 10 m from both devices, the range pole is completely hidden by vegetation (100% cover) whereas approximately 80% of the board is covered.*

To efficiently assess the relative suitability a specific parcel, I used a Google Earth® image in conjunction with a tablet computer while visiting the parcel (Fig. 8). This approach provides a method of partitioning the parcel into relatively homogenous units or stands. Additionally, information on the status of homogenous units (blue polygons in Fig. 8) obtained during the field assessment can inform managers of specific actions that could enhance suitability (e.g., construction of brush piles or removal of potential raptor-perching trees). To illustrate this approach, consider a 37-acre parcel managed for NEC. Using a recent Google Earth image of the site, I initially partitioned it into 3 units based on overstory density (Fig. 9). A subsequent field visit confirmed that division and that the units also described relative understory densities at the site.

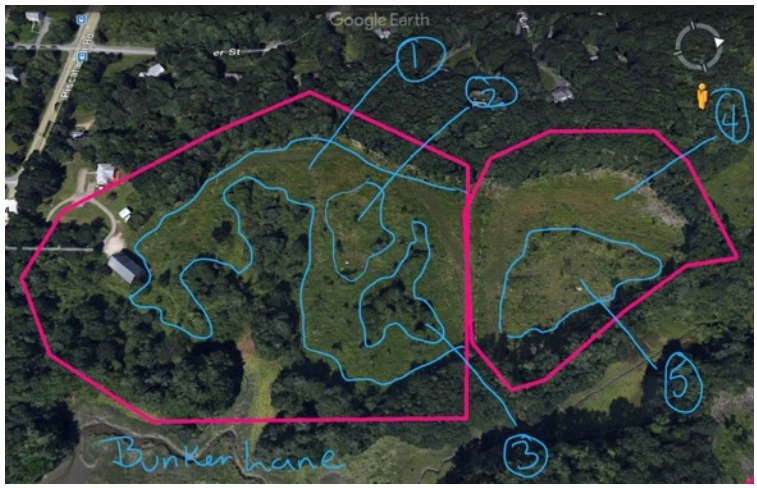

Figure 8. *Recent aerial photograph of habitat managed for New England cottontails. Red lines are the parcel boundary and blue polygons represent units of relatively homogenous vegetation and are used to characterize understory density and height of the entire parcel.*

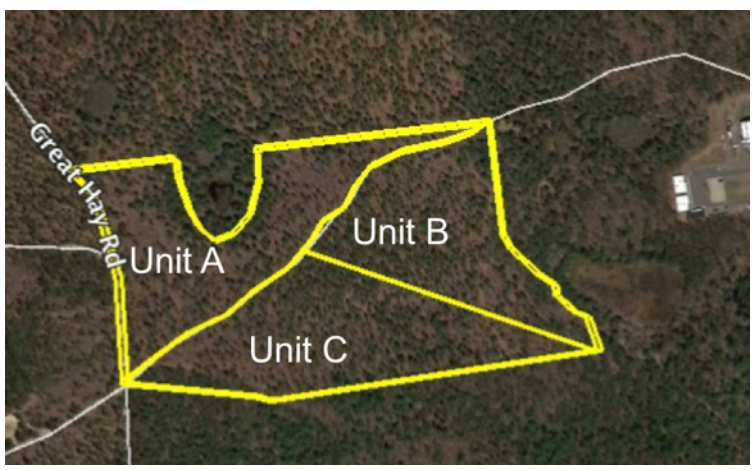

Figure 9. *Google Earth® image of a 37-acre parcel managed for New England cottontails. Unit A seems to have a more open canopy than either Units B and C. This was supported by direct observation of denser understory in Unit A during a walk through the area.*

To determine if the parcel is "on track" relative to developing suitable understory density, I collected samples of understory density and height using a range pole (Fig. 10). Understory vegetation in Unit A was sufficiently dense and that unit represented 36% of the entire parcel, so the suitability index for portion of the site that is covered by very dense vegetation ($Variable_1$) was 1.0 (see Fig. 4). However, mean understory height was only 1.1 or a suitability index of ~0.56 for $Variable_2$ (see Fig. 4). Combining these two indices (1 x 0.56 = 0.56), I concluded the parcel was not

ready for rabbits (understory needs to grow), but seemed "on track" for generating a sufficient amount of dense understory vegetation. Additionally, there was no evidence of that deer browsing or invasive shrubs were limiting regeneration of native shrubs and trees. Although I used the values of suitability indices developed by Warren et al. (2016) in this example, the rapid assessment approach is intended to be qualitative rather than quantitative. Index values, therefore, are intended to guide initial applications of this approach, not to provide a "suitability score".

Figure 10. *Assessing development of dense understory vegetation at a 37-acre parcel that was partition into 3 units (A, B, and C) based on relative overstory and understory densities. In Unit A, visual obstruction at the average height of understory vegetation (mean = 1.1 m tall) was 92%. Understory vegetation in Units B and C was <0.5 m tall, so it was not evaluated in those units.*

Need for Multiple Site Visits as a Parcel Develops

After visits to managed parcels in Connecticut, Rhode Island, and New Hampshire, it became apparent that "*time since management action*" (number of elapsed growing seasons) should be considered during site assessments. For example, evaluating understory density isn't realistic after only 1 or 2 growing seasons (Fig. 11). Likewise, waiting until 5 or 6 years to evaluate the response of invasive shrubs may be too long to effectively reduce the dominance of these shrubs via

herbicides or mechanical removal (Fig. 12). To incorporate time since management, I modified the assessment protocol to highlight specific habitat features and the best time to evaluate them. It is important to acknowledge that development of a parcel toward suitability for cottontails is along a continuum and not in discrete steps. Additionally, development of specific features will vary according to parcel-specific conditions (e.g., soil quality and aspect). As a result, benchmark time periods I have used are only an approximation. Although multiple site visits may be counter to

Figure 11. *Twelve-acre parcel in Connecticut after 1 or 2 growing seasons since being cut. Understory vegetation is dominated by raspberry brambles, young hardwoods, and stump sprouts. It is difficult to determine if understory vegetation will develop to a sufficient density, but it is possible to determine if regeneration is dominated by trees or shrubs and the relative abundance of invasive vegetation.*

Figure 12. *Dense pocket of invasive honeysuckle can provide good cover for cottontails, but removal or reduction of this plant at this stage will be difficult in comparison to confronting it several years earlier.*

the notion of rapid assessment, information obtained during these visits is qualitative rather than quantitative and meant to address the status of a managed parcel and whether it is "on track" or "off track" relative to suitability to New England cottontails. Each visit should span approximately 1-3 hours depending on size and location.

Visit #1 - Features to consider after ≤2 growing seasons

- Is regeneration tree or shrub-dominated?
- What is the status of invasive shrubs?
- Is treatment of invasive shrubs needed?
- How intense is deer browsing?
- Will browsing affect species composition or density of understory cover?
- Should pockets of native shrubs be fenced to protect them from deer or moose?

Addressing the above list should provide information on a number of features that were not or could not be evaluated prior to management activity. For example, was there a substantial invasive-shrub seedbed and how will local deer respond to young and re-sprouting vegetation (Fig. 13)? Deer browsing may be problematic on several fronts. First, it may slow down or limit the density of regeneration that is desired understory cover. Browsing may also be selective toward to native trees and shrubs, potentially exacerbating the prominence of invasive shrubs. As a result, some cooperators fence pockets of native shrubs until they are established (Fig. 14).

Figure 13. *Intense deer browsing within a 19-acre parcel. Anecdotal observations suggest that browsing intensity may be greatest in areas close to forest cover along edges of the cut.*

Figure 14. *Native ground juniper surrounded by a deer-proof fence in a western Connecticut parcel managed for New England cottontails. Notice an abundance of invasive honeysuckle (with green foliage) in the background.*

Visit #2 - Features to consider after 2-4 growing seasons

- Consider stratification of managed habitat into sub units based on understory density to identify pockets of dense cover and those that may be lagging in their development of that feature.
- Initial identification of other features that may affect future suitability.

By this time, it may be possible to stratify portions of the managed parcel into relatively homogenous units that will facilitate subsequent evaluations (Fig. 15).

Figure 15. *Recent aerial photography can be obtained using Google Earth and used in the field to stratify homogenous units and identify potential features of possible concern (e.g.,, snags or seed trees that may subsequently functions as perches for raptors hunting cottontails).*

Visit #3 - Features to consider after 4-6 growing seasons

- Construct or bolster brush piles if needed in pockets of marginal cover.
- Consider removing potential raptor perches if they seem problematic.

By this stage, it should be apparent if understory density is progressing toward a level that will provide adequate cover for cottontails. If not, consider brush piles (at least 2/acre). If these are already in place, consider enhancing them to assure they are above the height of expected snow accumulation. Likewise, even if adequate understory cover is developing, there may be residual trees or snags that will pose potential problems. Residual trees are left behind for a number of reasons: seed trees to assure regeneration, prominent mast tree that can be attractive to local deer and turkey populations, legacy trees that maintain structural diversity of the stand and are used by roosting bats and a variety of primary and secondary cavity-nesting species, and preference of the landowner to lessen the visual effects of timber harvest. However, once cottontails are established at a site, such trees may provide raptors with an ambush perch for hunting rabbits and removal may be necessary (see Objective IV).

Visit #4 - Features to consider after ~8 growing seasons – is it ready?

- Consider site visits by a team that includes NRCS and state biologist involved with habitat restoration and conduct a complete habitat audit with special attention to the proportion of the site that provides dense cover.
- Resolve any shortcomings with specific recommendations (e.g., additional brush piles, increasing cover/grass interface, etc.

At this stage of development, understory density should be evaluated to determine relative habitat suitability. Rather than using plot-based stem counts, visual obstruction may still be an efficient alternative (Fig. 16). Preliminary application of this technique suggests that it may be a suitable alternative for estimating the proportion of the site that provides essential cover from terrestrial and aerial predators. However, I will emphasize that this approach is not meant to replace the HSI approach developed by Warren et al. (2016). If there is an intention to evaluate cottontail fitness (including survival and subsequent reproduction) among a group of habitats, the rapid assessment approach may not be sufficient in describing quantitative features of a site that are needed for such rigorous comparisons.

Figure 16. *Understory density (up to 2 meters tall) is perhaps the most influential parameter in gauging the suitability of a site for New England cottontails. Measuring visual obstruction of a 2-meter range pole can provide an efficient approach for indexing understory density. The site on the left was dominated by raspberry and blackberry canes in the foreground and understory density was insufficient. Contrast that to the site on the right where dense buckthorn stems completely concealed the range pole. In both photos, the observer is 10 meters from the pole.*

Conclusions

Utilizing the rapid assessment field protocol described here can provide an opportunity to effectively gauge progress toward suitability of parcels managed for NEC. I have suggested that regular visits should occur so that supplemental management actions may be taken if deficiencies are identified. Such visits also provide an opportunity to engage with the landowner (see additional comments in summary of Objective II). Additionally, after visiting sites in several forest types, it became apparent that the optimum values for some habitat features (e.g., understory height) may differ throughout the range of NEC. This topic is explored in greater detail in Objective III. As a result, the rapid assessment protocol should be considered as a guide to understanding suitability of managed habitats. It is not intended to provide a rigorous evaluation of management actions nor should it be used to measure or index such attributes as carrying capacity. Future application of this protocol should result in modifications that enhance its usefulness.

OBJECTIVE II – Survey managed parcels in Connecticut, Maine, Massachusetts, New York, and Rhode Island and focus on conditions of each parcel relative to suitability for New England cottontails.

Introduction

Habitat features associated with sites occupied by New England cottontails (NEC) include dense understory vegetation for cover from mammalian and avian predators and access to forage (Barbour and Litvaitis 1993). Litvaitis (2001) suggested that disturbance-generated habitats (e.g., resulting from clearcuts, prescribed burns, or abandoned farmlands) may require up to 10 years to develop the features that are suitable for NEC. This lag period is largely a consequence of time required for regeneration of sufficient woody understory vegetation. Relying on this and other features, Warren et al. (2016) developed a habitat suitability index that provides a quantitative assessment of how suitable a site may be for NEC. This approach is dependent on a comprehensive inventory of features that can then be used to rank relative suitability of a parcel. Although this approach is useful in comparing sites for such events as releasing captive-reared NEC, it may be too involved and time consuming for gauging early progress of a recently managed habitats.

I visited a group of habitats that were managed to enhance their suitability for NEC. Most of these sites had been manipulated less than 5 growing seasons ago as part of the NRCS *Working Lands for Wildlife* initiative. My intent was to provide a qualitative assessment of how well these parcels were progressing toward suitability and to consider possible steps that could be taken to increase future suitability.

Identifying Candidate Sites and Categorizing Current Status

For each state within the NEC recovery region, I contacted the representative of the New England Cottontail Technical Committee. This group is charged with the recovery of NEC and their habitats. Representatives were agency biologists or biologists contracted by NRCS. Within a state, representatives were asked to identify up to 15 parcels that had been managed for NEC and to describe the methods used to alter vegetation (e.g., cut and remove overstory vegetation, "chop-and-drop – where trees are cut but left on site, or mowing) and when those actions occurred. Representatives were also asked to provide a simple rank of priority for site visits, where: 1 = high

priority, 2 = intermediate priority, and 3 = low priority to aid in selecting which sites to visit. Once parcels were identified, I or the state representative contacted the landowners to invite them to participate in the field assessment.

State representatives provided approximate boundary maps of the managed habitats using Google Earth images. These maps were used in the field to identify specific features of interest and partition habitats into logical subunits or areas that were similar in vegetation composition. During each visit, I focused the density and height of regenerating woody vegetation because this is the most influential feature affecting suitability for NRC (Warren al. 2016, see Objective I). I also noted to what extent deer or moose browsing may be limiting understory development and the abundance of non-native (invasive) shrubs. Each parcel was evaluated during a 1 to 3 hour walk and subsequently assigned a qualitative rank as: **rabbit ready** (resources sufficient to support NEC), **moving toward suitability** (e.g., where density of vegetation seemed to be sufficient but was too short to provide cover during periods of deep snow), **too soon to predict future suitability** (insufficient regeneration time and not possible to predict future suitability), or **unlikely to develop essential features needed by NEC** (this was largely based on understory stem density and factors that may limit it). Additionally, factors that could detract from the suitability of a site (e.g., potential perches for hunting raptors) or could enhance suitability (e.g., construction of brush piles) were also recorded. Finally, landowners or land-trust members that participated in the field assessment were asked about their impressions of the management actions and what other goals or aspirations they had for their land. As more and more sites were visited, this approach was formalized into a "rapid assessment" that is described in Objective I.

Fifty-five sites were visited within the management focus areas (Fig. 17). Of these, 11 were considered **rabbit ready,** 12 were **moving toward suitability**, 18 were **too soon to project suitability,** 13 **were unlikely to develop essential features required by NEC**, and one was **not designated because of varied conditions.** These mixed results suggest a need for some re-evaluation of the approaches being used to recruit private lands into the program. Specifically, there may be a need to re-emphasize the need to establish source habitats rather than include small or low quality sites. Such parcels may function as stepping stones between source habitats (Litvaitis and Villafuerte 1996); but creation and maintenance of small or low quality habitats may be too costly to include in an NEC restoration program and these stepping stones may be incidentally generated by other land uses (e.g., powerline rights-of-way and transportation corridors; Litvaitis 2001). It is important to acknowledge that the inclusion of small or low quality parcels is, at least partly, a

consequence of the difficulty of recruiting private landowners into the program. Appendix A provides a Google Earth map where road names and other identify features have been redacted, photographs, and a brief summary of each parcel that was visited.

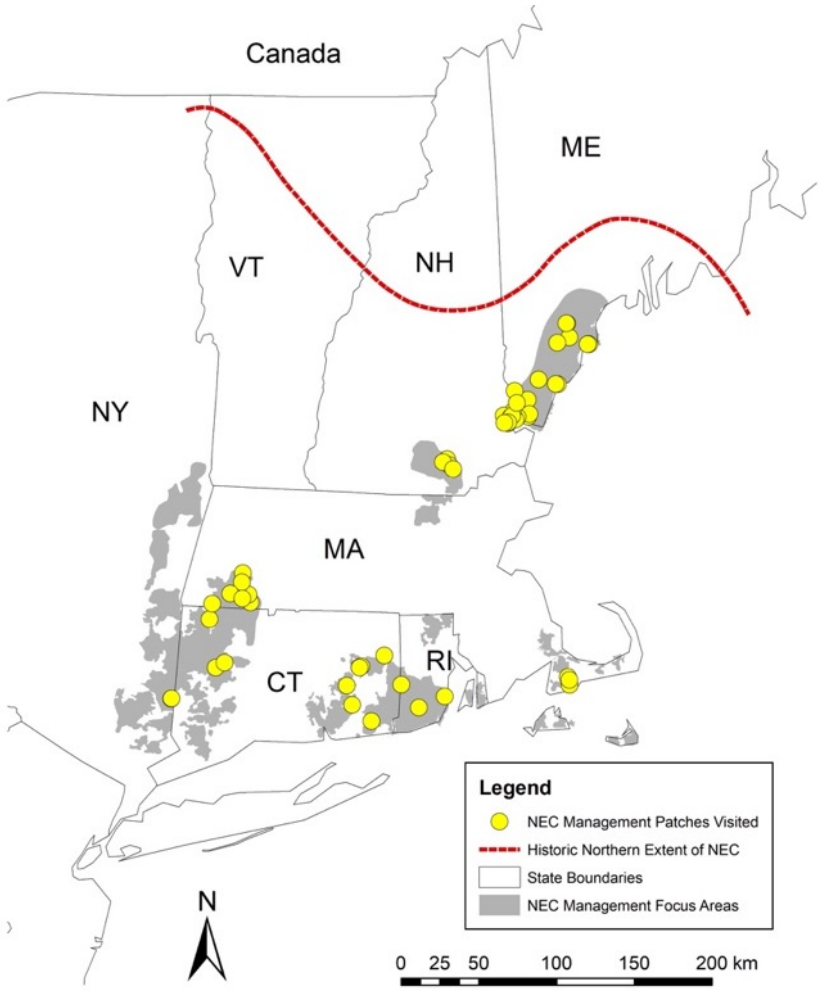

Figure 17. *Distribution of 55 parcels assessed for current and future suitability for New England cottontails during 2017 and 2018.*

Is There Need for Additional Engagement With Landowners?

During site visits that landowners or land-trust members (including members local rod and gun clubs) participated in, I explored several topics with them that included how they became involved in the NRCS program, the aspirations they had for their land, and how well they believe the NRCS was helping them achieve those aspirations (Fig. 18). These conversations were informal

but quite informative. The major impression I gained from these talks was that land owners and land-trust members did appreciate the opportunities provided by the NRCS but often they did not feel as engaged or informed on their specific project as they had hope to.

Understanding the relationship between motivation, satisfaction, and commitment is necessary for developing a successful retention strategy in any conservation program, especially on private lands where success depends on landowner commitment (Selinske et al. 2015, Briske et al. 2017). For NRCS-funded programs, Lutter et al. (2018) found that landowners that accompanied biologists on monitoring site visits had a higher agency trust and more positive perceptions of

Figure 18. *Interactions with private landowners and land-trust members are important to ensure continued enrollment in habitat management programs.*

program outcomes. Alternatively, if the major interaction was informational mailings rather than in-person meetings, landowner knowledge of the conservation effort did increase but landowner perceptions of the program's outcome or trust in the management agency did not improve (Lutter et al. 2018). Although anecdotal, my observations suggest additional engagement with some landowners might enhance landowner satisfaction and retention. Woods and Ruyle (2015) found

positive responses by enrolling landowners in some form of informal monitoring of their own lands. For NEC cooperators, such an approach might include an annual check list of plants and animals encountered on their property. This could be facilitated by an internet-based "field guide" that includes photos and information on the plants (e.g., Howard and Lee 2003), birds (e.g., DeGraaf and Yamasaki 2003), butterflies (e.g., Wagner et al. 2003), bees (e.g., Milam et al. 2018), and even snakes (e.g., Kjoss and Litvaitis 2001) found in disturbance-generated habitats. Such monitoring would not replace periodic assessments, but the additional information could enhance our understanding of specific management actions and certainly engage the landowner. Given the time and effort required to achieve suitability for cottontails on managed habitat, landowner retention seems to be a critical component for long-term success.

Conclusions

Visits to managed parcels gave a mixed impression of progress to date. There may be need to consider how to respond, especially among managed lands that are not moving toward suitability. Renewed emphasis on managing source parcels (relatively large acreages with suitable habitat features) seems a logical next step in building a viable network of NEC habitats. Such an approach should provide an opportunity to prioritize future efforts. Conversations with landowners during field visits also suggested there is need for greater engagement with them. This may be especially important for retaining private landowners and their acreage in NEC restoration efforts.

OBJECTIVE III - Evaluate suitability of sites in relation to management action, site characteristics, and regional forest type.

Introduction

After visiting sites throughout the NEC-recovery region, it became apparent that the range of local conditions at managed parcels affected their response to management. These conditions include specific management action, soil fertility, and previous land use at the site. Additionally, forest composition varies throughout the range of NEC (Fig. 19) and the inherent differences among forest types (especially understory vegetation) can affect how cottontails respond to different plant communities and regional land uses (Tash and Litvaitis 2007).

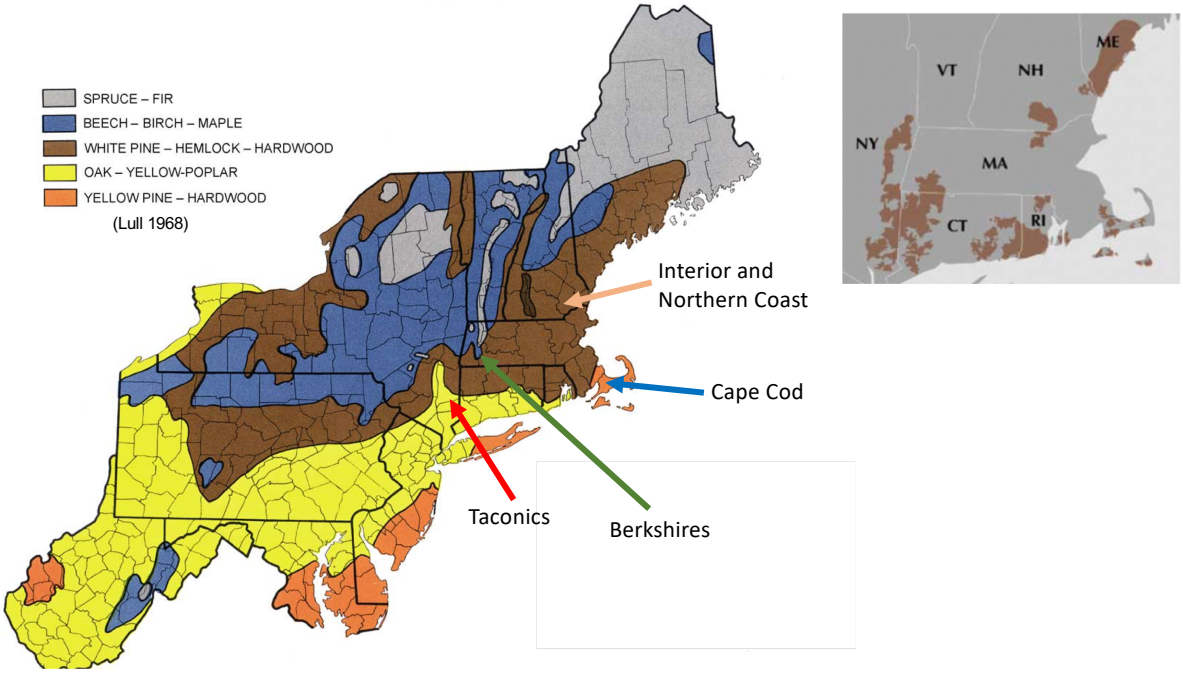

Figure 19. *Although the white pine-hemlock-hardwood forest type dominates the current range of New England cottontails, management focus areas do occur on Cape Cod, the Berkshires, and the Taconic range and southern coast where forest types differ. Insert map illustrates restoration focus areas (insert drawn by Jeff Tash).*

Management Actions and Site Characteristics Affecting Regeneration of Understory Vegetation

A large variety of factors contribute to regeneration of a forest stand after disturbance including, the management action taken (e.g., clearcut, chop-and-drop, or burn) and inherent site-specific characteristics (e.g., soil fertility, previous land use, slope, and aspect). Understanding the influence of management actions and site characteristics should aid in developing effective prescriptions for developing cottontail habitat. However, for this investigation, the influence of a specific actions (e.g., chop-and-drop) on regeneration at a parcel cannot be easily separated from site-specific conditions. Such comparisons would require a large number of sites that could be blocked by such features as soil, forest type, and the time since management occurred. Therefore, I limited my inferences to general circumstances at each site. These included size/configuration of the action, soil fertility, and previous land use. Given the qualitative nature of my observations, my findings should be considered preliminary and are offered as guidelines to consider when recruiting land owners.

Size/configuration of the management action – In general, I found that large and circular or square cuts (or other form of disturbance) were more likely to produce dense regeneration than small and narrow cuts. This may be a consequence of abundant light and high soil temperatures in large openings (that stimulate regeneration) and limited browsing by deer on regenerating vegetation away from disturbance edges in large openings.

Soil fertility – Initial efforts to model NEC restoration focus areas included consideration of soil productivity (Fuller et al. 2011). This relationship was based on a pattern of productive soils being associated with the distribution of remnant populations of NEC and dense understory vegetation. During my field visits, parcels with thin and rocky soils had noticeably modest stem densities and often were dominated by stump sprouts associated with a recent cut. This contrasted with sites having loam soils where regeneration was more vigorous and included a wider variety of plants. However, this pattern is likely confounded by previous land use.

Previous land use – Establishing a dense shrub-dominated parcel seemed to occur most often among old fields or young forests on were previously cropland or pasture. Here again, such sites are likely to include more productive soils and also have a seed bed that will produce a greater diversity of plants, including native shrubs. Attempting to generate NEC habitat by cutting a mature forest stand will be more challenging, given the tendency for such sites to be dominated by modest

understory vegetation (often young trees) and few shrubs because of their limited presence and lack of seed bed. As a result, stump sprouts often dominate these sites and do not provide adequate cover, with aspen (*Populus tremuloides*) stands being a notable exception.

Influence of Regional Variation in Forest Composition

Variation in forest types throughout the range of NEC (Fig. 19) suggests that there may be a need to modify some of the assumptions associated with suitability model developed by Warren et al. (2016). For example, dense pitch pine-scrub oak (*Pinus rigida-Quercus ilicifolia*) stands on Cape Cod may develop adequate cover and be occupied by NEC well before the average height of the understory reaches 2-m tall (Fig. 20c and see Fig.10). Modifying how suitability is described in that region should rely on information of habitat-use patterns by cottontails from pitch pine-scrub oak habitats. In the Berkshires, aspen stands regenerate quickly and may achieve suitability sooner but also grow-out-of-suitability quicker than other forest types (Fig. 20b). On the other hand, oak forests with mountain laurel (*Kalmia latifolia*) and blueberry (*Vaccinium* spp.) understories found in the Taconic Range in southeastern New York and elsewhere (Fig. 20d) may be a fairly stable type that does not require frequent disturbance to maintain sufficient cover. In those forests, understory vegetation occupied by NEC is associated with moderate tree canopy closure (Cheeseman et al. 2018). As a result, conventional methods of generating early-successional habitats in oak-laurel forests (e.g., clearcuts) may benefit sympatric eastern cottontails (*Sylvilagus floridanus*) rather than provide suitable habitat for NEC (Cheeseman et al. 2018).

It should also be noted that densities of NEC likely vary among forest types. This attribute will affect how recovery of NEC is evaluated. For example, the "standard estimate" of NEC density in available habitats (~1 rabbit/2 acres of habitat, extrapolated from Barbour and Litvaitis 1993) was based on samples largely gathered among old-field habitats that did not have sympatric eastern cottontails. As a result, the standard estimate is probably too large when applied to the expansive acreage of oak-laurel forest in the southern portion of the recovery area (A. Cheeseman, SUNY, Syracuse, personal communication). Because available habitat is used as a proxy for estimates of NEC abundance in the recovery plan (Fuller and Tur 2012), it is essential that more effort be directed toward understanding how densities vary by habitat types and with the presence of eastern cottontails.

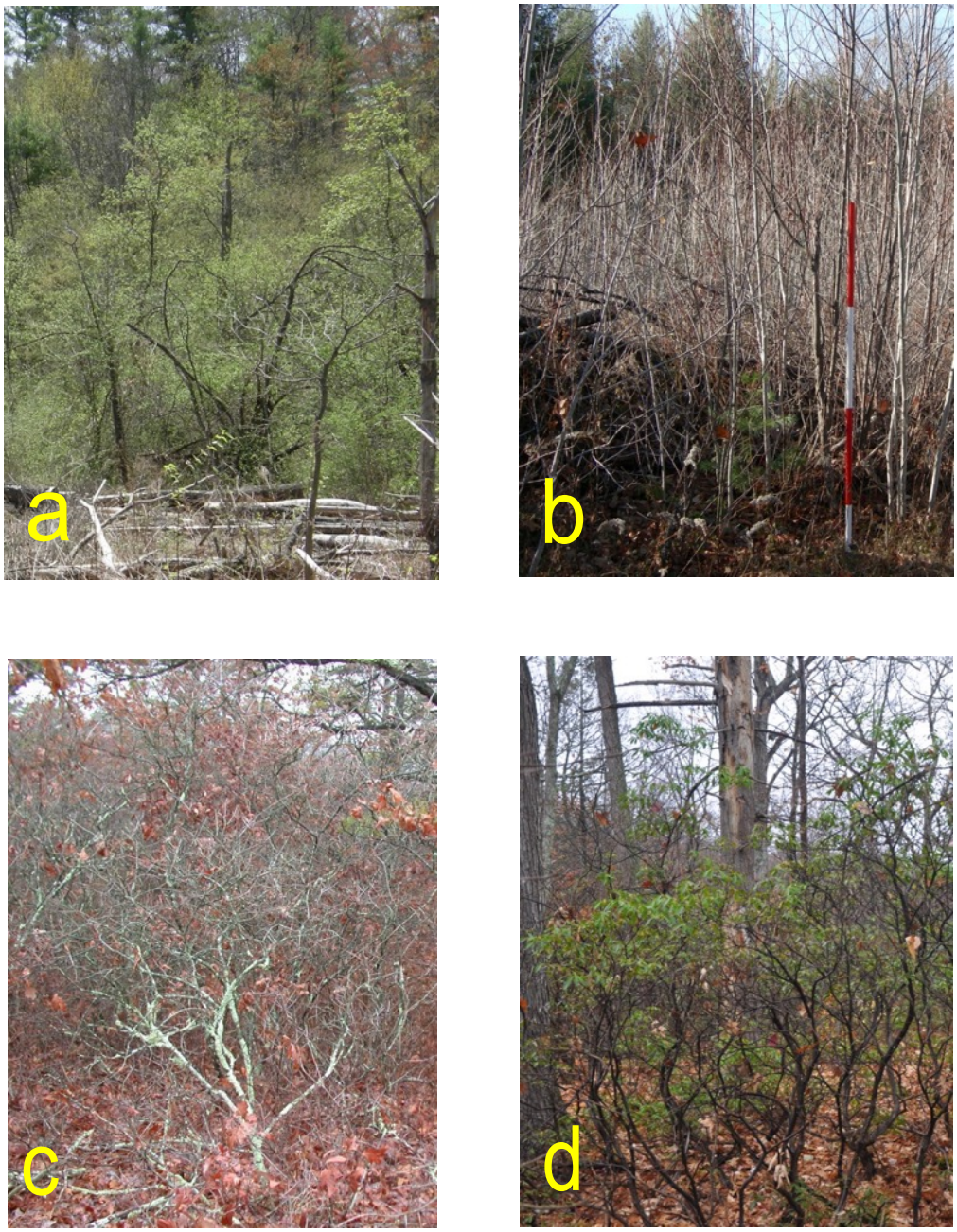

Figure 20. *Understory vegetation among four forest types within the range of New England cottontails includes (a) white pine-hemlock-hardwoods in New Hampshire, (b) aspen in the Berkshires of western Massachusetts, (c) pitch pine-scrub oak on Cape Cod, and (d) mountain laurel in the Taconics of southeastern New York. Management actions and "time to suitability" may differ among these forest types.*

Conclusions

Although specific guidelines for generating dense understory vegetation in managed NEC habitats were not developed, general patterns indicated that such vegetation seemed most responsive to aspects of the management actions that included large and regularly-shaped disturbances, fertile soils, and prior land use that encourages colonization or regeneration of native shrubs. Managers of habitats for NEC should also consider regional differences in forest composition and how sympatric populations of eastern cottontails may affect habitat-use patterns of NEC on those sites. Finally, restoration goals that rely on a standard estimate of NEC density within available habitat (as a proxy for population estimates) and do not consider the inherent differences in carrying capacity among forest types or the effects sympatric eastern cottontails on carrying capacity may be too optimistic and should be re-evaluated.

OBJECTIVE IV - Provide recommendations that can enhance suitability of parcels that are not yet capable of supporting New England cottontails.

Introduction

Prior to commenting on my observations at managed habitats, it is important to acknowledge the exceptional publications that have been prepared on creating and maintaining habitats for New England cottontails. Arbuthnot (2008) provides an excellent summary of the habitat needs of NEC whereas the "Best Management Practices for the New England Cottontail" (BMP 2017) provides an overview of many of the technical aspects of actual management actions. Below, I summarize some the actions I encountered on managed habitats and those that could be included to improve suitability of a parcel.

Enhancing Understory Cover

Perhaps the most obvious challenge on marginal sites is providing additional understory cover. Efforts to increase stem density can include direct plantings of native shrubs or promoting vigorous re-sprouting by mowing or burning areas where existing vegetation is not providing adequate cover. It is unlikely that additional disturbances will increase understory cover among sites hindered by poor soils or lacking a seed bed of native shrubs. Where soil fertility is adequate but a seed bed is lacking (e.g., cutting mid-successional forest with a high site index or idle pasture), planting of native shrubs may aid in developing cover.

Supplemental brush piles have been encountered on many of the managed sites. However, there seems to be substantial variation in what is considered a brush pile that can serve as cottontail cover. To provide adequate cover, such structures should be large enough to be accessed during winter when accumulated snowfall may exceed 1 meter (Fig. 21). Brush piles settle with time, so starting with a large, tall pile is appropriate. Additional guidelines for brush piles are provided in the best management practices manual (BMP 2017).

Figure 21. *A well-constructed brush piles should have a base made from the bole of the tree and covered with subsequently smaller limbs. Accumulating snow will depress these piles, so it is better to initially contract a tall pile.*

Reducing Risk to Aerial Predators

In addition to improving cover for cottontails, there should be some consideration of reducing or eliminating features that may facilitate predator success while they are hunting rabbits. Here, the position of residual canopy trees that were left for potentially a number of reasons (e.g., forest legacy tree that enhances vertical structure, cavity tree/snag, or seed tree to promote specific composition of regeneration) may affect vulnerability of rabbits to aerial predators. Specifically, brush piles in close proximity to these trees may provide perches for hunting hawks and owls. Therefore, where supplemental cover is needed, overstory trees should be removed or relegated to areas in the parcel where understory cover is dense (Fig. 22).

Figure 22. *Although the brush pile will provide needed cover, in this instance the snags in the immediate vicinity may provide unwanted opportunities for perching raptors to stalk cottontails. Removing them seems appropriate in this instance.*

Implications of Invasive Shrubs

Invasive shrubs, including autumn olive (*Eleagnus umbellata*), multiflora rose (*Rosa multiflora*), exotic honeysuckles (*Lonicera* ssp.), Japanese barberry (*Berberis thunbergii*), and glossy buckthorn (*Rhamnus frangula*). have become a major concern among land managers in the northeastern United States because of their potential to disrupt ecosystems processes (see review by Johnson et al. 2006). A number of factors have been identified as contributing to the colonization and spread of invasive shrubs, including removal of existing vegetation via timber harvests, mowing, or burning and local soil fertility (Johnson. et al. 2006). As a result, management actions used to increase suitability for NEC can contribute to the spread of invasive shrubs. A problem with this relationship is that invasive shrubs also provide substantial cover for cottontails (Warren et al. 2016), and studies in Maine (Litvaitis et al. 2003) and New York (Cheeseman et al. 2018) have reported that NEC may select habitats with an abundance of invasive shrubs because of the dense cover they provide. As a result, management actions for NEC can potentially result in a quandary where the actions result in an increase in invasive shrubs while providing suitable habitat for rabbits. Litvaitis et al. (2013) have argued that attempting to eliminate or reduce invasive shrubs from habitats occupied by NEC that

are embedded in landscapes with an abundance of invasive shrubs is futile in that any removal of invasive will reduce the habitat suitability for NEC, at least in the short term, and will, most likely, be re-invaded by exotic shrubs simply because of the local seed source. As a result, habitat managers might accept the presence of invasive in some landscapes where they are essentially inevitable and they provide suitable habitat for NEC. A possible exception to this acceptance may be situations where invasive shrubs become monocultures. In those habitats, mowing, burning, pulling, selectively applying herbicides may reduce monocultures and improve available food resources.

New information on the potential detriments of invasive shrubs, however, may add to the difficulty of dealing with invasives. Mello (2018) found that NEC in habitats with an abundance of exotic shrubs had large infestations of ticks. She speculated that large tick infestations were a consequence of the favorable environment for ticks that exotic shrubs provided. An abundance of ticks may reduce rabbit survival, especially among juveniles.

Conclusions

There are opportunities to improve the suitability of managed habitats that are not yet capable of supporting NEC. Such actions include methods that increase cover by stimulating sprout growth via mowing or burning existing understory vegetation, constructing regularly-spaced brush piles, or planting native shrubs where a local seed bed is lacking. Importantly, remaining canopy trees should be viewed in the context of providing perches for raptors. If canopy trees occur where rabbits are likely to congregate, such as brush piles, it may be useful to remove those trees. In forest where rabbits occupy sites with moderate overstory canopies (e.g., oak forests with mountain laurel understories), tree removal may not be needed. Responding to invasive shrubs will be challenging because invasive shrubs may increase after management actions remove or thin existing vegetation in an effort to improve suitability for NEC. Some invasive shrubs provide dense cover and are preferred by NEC. Among sites visited, those with productive soils and were moving toward "rabbit ready" often had a large component of invasive shrubs. Invasive monocultures may be improved by creating opening that provide access to herbaceous forage. NEC occupying sites that are dominated by invasive shrubs can have high numbers of blood-sucking ticks that may reduce survival of rabbits. Additional research on this topic is needed. Although it may not be possible to completely eliminate invasive shrubs, efforts to reduce them prior to cutting, mowing, or burning a site may limit their presence in regenerating habitats.

OBJECTIVE V - Conduct training sessions of the rapid assessment protocol for NRCS staff, state biologists, and other individuals engaged in New England cottontail restoration efforts.

Summary

During site visits, I encouraged individuals to accompany me in the field and discuss application of the rapid assessment approach. Additionally, this protocol was summarized at the annual meeting of the New England Cottontail Technical Committee where all state representatives were present.

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