CASE STUDY: How to Manage Eastern Cottontail Competition to Recover the New England Cottontail in the Northeast
Structured Decision Making Workshop
National Conservation Training Center
February 6-10, 2012

Decision Problem: How do we strategically manipulate both New England cottontails and Eastern cottontails to favor New England cottontail and avoid their federal listing.

Eastern cottontail is present within focus areas designated for the recovery of the New England cottontail. Competition between the two species may limit the recovery of New England cottontail. Removal of eastern cottontails from locations where habitat management or reintroductions of New England cottontail may occur could improve restoration success. State managers need to determine the most effective course of action to succeed in increasing New England cottontail abundance within focus areas. Currently state managers are deciding actions at a patch scale, and habitat management is the only action that has been implemented to date.

Background

New England cottontail (*Sylvilagus transitionalis*) is native to the northeastern United States, but the species population has been in decline and is now a candidate species for federal listing, with a ruling scheduled for 2014. While the mechanistic relationship between New England cottontail and eastern cottontail (*Sylvilagus floridundus*) is unknown, it is believed that the interaction of the two species is contributing to the decline of New England cottontail. The eastern cottontail was introduced as a game species in late 1800's in the Northeast, reaching a high of translocations in the 1930's. The intensity of stocking was greatest in the southern New England states, with no stocking documented in Maine or Vermont, although it is uncertain if private fish and game clubs may have done some stocking on their own (Johnston 1971, Jackson 1973). By the 1970's eastern cottontails occupied a continuous range in southern New England with the exception of some areas of high elevation and northern counties of Massachusetts east of the Merrimack River (Johnston 1971).

Eastern cottontails were repeatedly documented in the coastal towns of New Hampshire, and towns inland adjacent to the Massachusetts line (Jackson 1973). Concurrently, the native New England cottontail has showed substantial declines, occupying less than 14% of its historic range within five isolated regions in the Northeast (Litvitais et al. 2006).

Numerous studies conducted at the University of New Hampshire have revealed behavioral (Probert and Litvitais 1996; Smith and Litvaitis 2000) and morphological (Smith and Litvaitis 1999) adaptations that have enabled eastern cottontails to exploit smaller habitat patches in a more fragmented landscape. Over time this can result in eastern cottontail becoming more dominant in patches where the two species are sympatric (CT, MA, and NY). Surveys from 2010-2011 indicate the eastern cottontail may be the only species left in Rhode Island.

Differentiation between the two species can be challenging. The two species were historically identified by skull sutures following harvest or collection from road kills. In the 1990's a discriminant function analysis was developed using field measurements of morphological characteristics with a 94% success rate (Litvaitis et al. 1991). In more recent years, fecal DNA analysis has been used to monitor the species during winter (Kovach et al. 2003).

This background material played an important role in the development of our decision structure. To evaluate the strategies to increase New England cottontail numbers in the Northeast we felt it was important design to include the uncertain relationship between New England and eastern cottontail and its impact on the outcome of the management strategies. We had to consider the impact that the similarity of the two species, and the subsequent difficulty of discriminating between species, in the development of effective strategies.

Decision Structure

Objectives

The three overarching, or fundamental objectives that we identified are achieving a sustainable population of New England cottontails, minimize opposition, and minimizing cost. We identified a number of means objectives necessary for the achievement of these fundamental objectives. The objectives were organized in an objectives hierarchy showing the linkages between the objectives (Figure 1).

The means objectives to achieving a sustainable population include the threats to New England cottontails, such as predation and the effects of limited habitat and low quality habitat as a result of Eastern cottontail. They also include potential means towards boosting New England cottontail numbers and distribution, such as releasing New England cottontails in a manner to maximize the probability of successful releases.

We identified two means objectives that influence public opposition, hunter opportunity and trust. The public trust objective is influenced by the transparency of management and decision making

Alternatives

We identified four categories of actions to manipulate the status of New England cottontails (Table 1): release New England cottontails from a captive breeding facility, conduct site work to improve available habitat for New England cottontails, regulate the cottontail hunting season, and manipulation of eastern cottontail. There are a number of actions available for each category. We then grouped the actions into coherent strategies for evaluation (Tables 2 and 3).

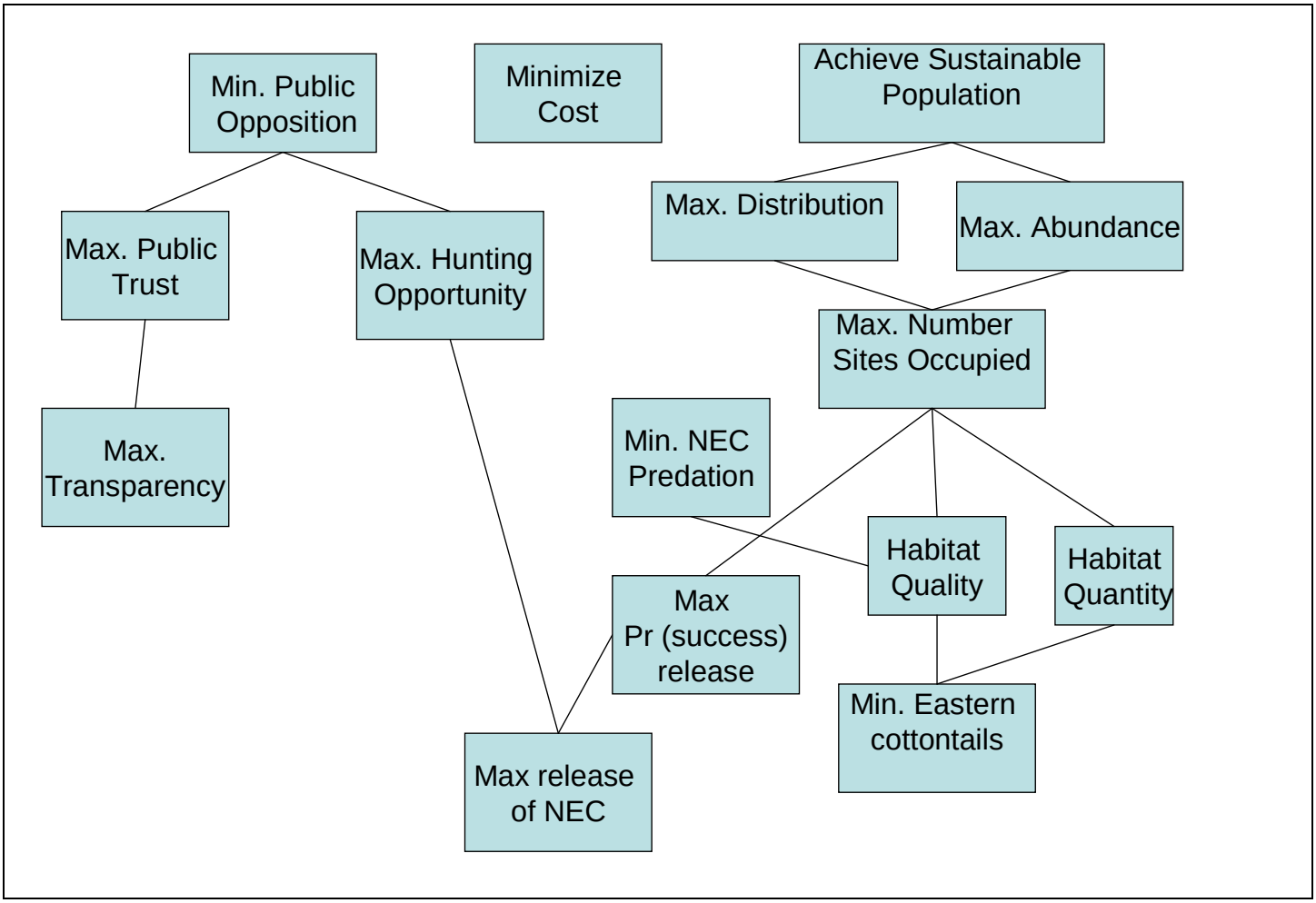

Table 1. Actions grouped by Category.

Release	Site Work	Hunting	Eastern Cottontail
No Action	No Improvement	Closed	No Action
Min. Viable	Improvement	Open	Trap/Relocate
Site Max			Trap/Dispatch
			Exclusion
			Hunt

Table 2. Strategies developed from combination of actions.

Strategy	Release	Site Work	Hunting	Eastern Cottontail
A	Site Max	Improvement	Closed	Hunt; Trap/Dispatch
B	No Action	Improvement	Open	Trap/Dispatch
C	No Action	No Improvement	Open	Trap/Relocate
D	Site Max	Improvement	Closed	Exclusion
E	Min. Viable	Improvement	Open	Trap/Dispatch

Table 3. Narrative Description of Strategies.

Strategy A (Most effective) Combining targeted hunts and trap/dispatch techniques to remove the greatest number of eastern cottontails from the site. Close regular season hunting, and perform management to improve and/or increase habitat area. Following management activities, the maximum release of captive bred animals will be performed.
Strategy B (Middle of the Road) Trap and dispatch of eastern cottontails will be combined with habitat improvement. Regular hunting season will remain open, and no captive bred cottontails will be released.
Strategy C (Public Best) Trap and relocate eastern cottontails away from the patch. No additional recovery actions will be taken.
Strategy D (Nuclear) Remove current habitat with mowing for 1-2 years forcing resident cottontails to disperse. Allow habitat to return and perform management to improve and/or increase habitat area. Regular season hunting will be closed, and a maximum number of captive bred cottontails will be released at the site.
Strategy E (Max) Trap and dispatch of eastern cottontails will be combined with habitat improvement. Regular hunting season will remain open, and a minimum number of captive bred cottontails will be released.

Decision Analysis

Preliminary Prototype

For the preliminary prototype of this decision analysis we choose to focus on the management of a single habitat patch and to limit our objectives hierarchy to focus only on cost, hunter opportunity, which is influenced by cottontail status, and New England cottontail abundance which is influenced by eastern cottontail status and the associated intermediary processes. During this first iteration these three fundamental objectives were weighed against one another: cost, hunting opportunity, and New England cottontail growth rate. A lack of scientific knowledge, agency liability and feasibility of eastern cottontail control constrained the set of actions available and our ability to predict the outcomes of implementing actions with certainty. The recommendations section of this report offers some insight as to how future prototypes can incorporate the additional means objectives, and evaluate some additional actions and strategies for combining them.

Optimization was used to select the best strategy for the decision problem. To complete the tradeoff analysis, objectives were valued and combined with the predicted consequences for three patch profiles to derive a weighted scored for each management alternative. Maximizing the abundance of New England cottontail was the most valued objective (weight of 0.75), followed by cost (weight of 0.15) and maximizing hunting opportunity (weight of 0.10).

Three patch profiles were evaluated for the five strategies. The most optimal strategy was different depending on the starting condition of the patch. When there were only eastern cottontails present (patch profile 1) strategy A which included intensive removal of eastern cottontails, habitat improvement and maximum New England cottontail reintroduction was the best. When New England cottontails are present, the strategy varied based on the ratio of eastern cottontails to New England cottontails. In the instance that eastern cottontails were the dominant species in the patch (patch profile 2) then strategy E which included eastern cottontail removal, habitat improvement, and minimal New England cottontail release was the best. In the instance that NEC was the

dominant species (patch profile 3), strategy C which included removal of eastern cottontails only was the best.

The preliminary decision process was carried out on the patch scale, in the absence of landscape context for immigration or emigration. Inclusion of immigration and emigration could have a large impact on the decision process, specifically by influencing the most heavily weighted objective, New England cottontail abundance. The results of the preliminary prototype cued the working group into the potential cost savings that could be had by removing eastern cottontails from existing habitat patches. In addition to the cost savings, the lag time for habitat to become available after vegetation management is reduced to zero. The expediency of recovery was not an objective that was evaluated in this prototype but could be included in the future.

Table 4. Estimated costs for management actions.
[1] Habitat work $1500 per acre
[2] $1000 per rabbit

Action	Cost
Habitat Improvement [1]	$150,000
Site Max (release) [2]	$60,000
Min. Viable (release) [2]	$30,000
Hunt	$0
Trap	$2,000
Exclusion	$1,000
Relocate	$6,000

Patch Profile 1 (100 EC, 0 NEC)

Consequences	A	B	C	D	E
Max. Abundance	100	0	0	100	30
Min Cost ($K)	212	154	6	211	182
Max. Hunting (0-10)	3	10	10	0	10

Trade-Offs	A	B	C	D	E
Max. Abundance (.75)	1	0	0	1	0.33
Min Cost (.15)	0	0.27	0.97	.01	0.14
Max. Hunting (.10)	0.3	1	1	0	1
	0.78	0.14	0.24	0.75	0.34

Patch Profile 2 (75 EC, 25 NEC)

Consequences	A	B	C	D	E
Max. Abundance	100	50	50	100	100
Min Cost ($K)	212	154	6	211	182
Max. Hunting (0-10)	3	10	10	0	10

Trade-Offs	A	B	C	D	E
Max. Abundance (.75)	1	0.5	0.5	1	1
Min Cost (.15)	0	0.27	0.97	,01	0.14
Max. Hunting (.10)	0.3	1	1	0	1
	0.78	0.52	0.62	0.75	0.87

Patch Profile 3 (25 EC, 75 NEC)

Consequences	A	B	C	D	E
Max. Abundance	100	100	100	100	100
Min Cost ($K)	212	154	6	211	182
Max. Hunting (0-10)	3	10	10	0	10

Trade-Offs	A	B	C	D	E
Max. Abundance (.75)	1	1	1	1	1
Min Cost (.15)	0	0.27	0.97	,01	0.14
Max. Hunting (.10)	0.3	1	1	0	1
	0.78	0.89	1	0.75	0.87

Information Analysis: Dealing with Uncertainty

In the formation of the preliminary prototype two key uncertainties were identified: the density dependent relationship between the two species, and the feasibility for removing eastern cottontails. The removal of eastern cottontails from a patch could have either a major or minor impact on the population growth rate of New England cottontail (Figure 2). The preliminary prototype assumes that the removal of eastern cottontails will result in an increase in the number of New England cottontails in an occupied patch without augmenting with captive bred individuals. If this was not the case, the consequences of the strategies would differ greatly. The preliminary prototype also assumed that we could reduce the number of eastern cottontails in a patch to create this response with either trapping or targeted hunting.

A sensitivity analysis was performed to evaluate what type of monitoring would provide the most value of information to our decision process in resolving these uncertainties. The three types of information that were compared included the form of density dependent relationship between the two species, feasibility of successful removal of eastern cottontails with different techniques (i.e. hunting and trapping), and presence/absence of NEC at a site.

The density dependence uncertainty is modeled as two possible relationships representing a case where low densities of eastern cottontails have a large impact on New England cottontails that declines with higher eastern cottontail density (curve 2, Figure 2) and a case where low densities of eastern cottontails has a minor impact on New England cottontails, but the impact increases with increasing eastern cottontail density (curve 3, Figure 2). Successful removal of eastern cottontails is modeled using the percent of eastern cottontails successfully removed using hunting and trapping respectively. For example, 90,70 represents 90% successful removal from hunting and 70% successful removal from trapping. Certainty of NEC occupying the patch was also included in the analysis.

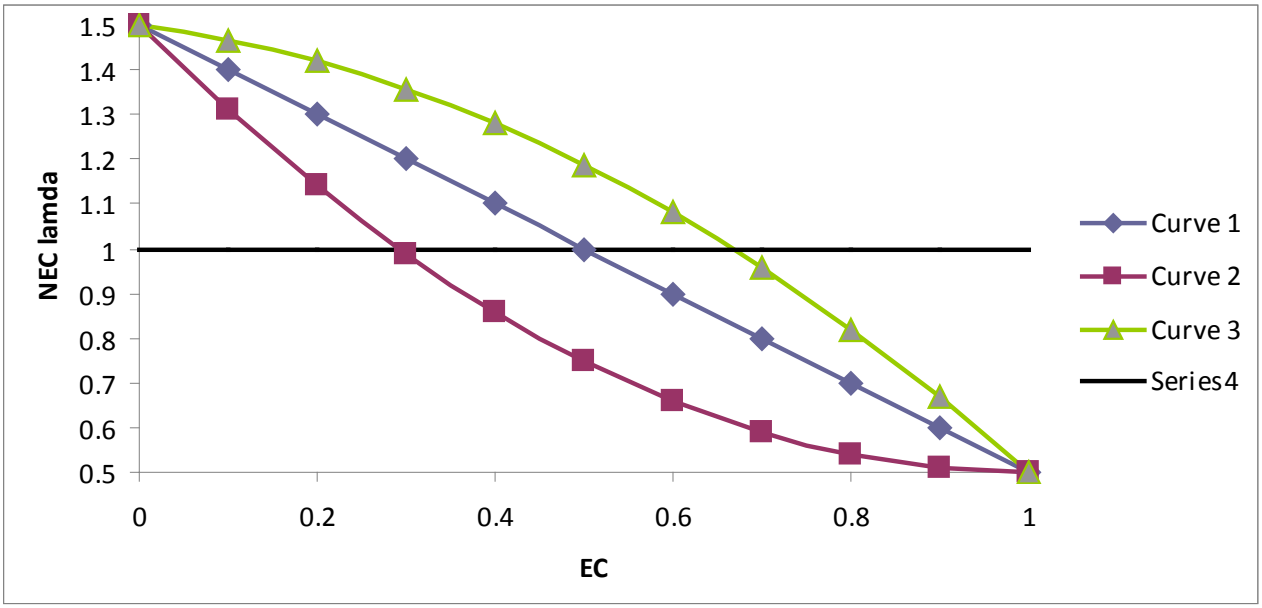

Figure 2. A key uncertainty: Possible density-dependent curves describing relationship between Eastern cottontails and New England cottontails within a patch.

Eight models were created combining the possible outcomes for each of the three types of information (Curve, Effect, NEC occupancy). Due to the lack of information about the effectiveness of either removal techniques and the density dependent curve all models were set at an equal probability. The patch profile used included the presence of New England cottontail (100 EC, 1 NEC). Presence of NEC in a patch was given a higher weight (0.80) than the cost of management (0.20).

Based on the analysis, information regarding the presence of New England cottontail in a patch is more important for determining management actions than knowing the density dependence relationship between the two species. Although hunting would be most cost effective, our risk tolerance is very low for take of NEC, so it is not an acceptable action in patches where there is a high likelihood of occupancy by NEC. If the relationship between the two species is better understood, the risk that each stakeholder faces is reduced, allowing for a better informed decision. If we knew that removal of EC had a greater impact on the population growth rate of NEC, managers may be willing to increase their risk tolerance of NEC being present in a patch while using hunting as a means of removal.

Discussion

Through the SDM process evaluating potential strategies for increasing New England cottontails on the landscape, it was identified that removal of eastern cottontails from existing habitat may be more cost effective than habitat management, and reduce the time-lag between habitat management actions and availability of habitat for New England cottontails. A reduction in time for accomplishment of recovery goals will result in additional cost savings at an administrative level not identified in this analysis.

There has been some preliminary research on the interaction of the two species, but we do not understand how abundance of eastern cottontails in a patch impacts the abundance of NEC in a patch. This uncertainty is resulting in a different decision by each state on how to manage eastern cottontails due to the risk tolerance for opposition (negative public opinion, reduced hunting opportunities). By implementing removal in some patches where risk tolerance for opposition in less, we are creating an opportunity to learn about the effect of eastern cottontail removal on New Engalnd cottontail abundance and the feasibility of removing eastern cottontails from a patch. The resulting information will feed into a new iteration of the preliminary prototype to evaluate future decisions. This process reduces the risk for state decision makers and provides transparency for decision making in the event that the removal of eastern cottontail is not a useful management action.

Research Needs: Priority research needs identified during this process include feasibility of removing eastern cottontails from a patch using trapping and/or targeted hunting; and the effects to New England cottontail population growth rate following removal of eastern cottontails from a patch.

Recommendations

The information provided from resolving key uncertainties will help identify relevant triggers for management actions regarding eastern cottontail removal from a site. In the future the preliminary prototype should be modified to include other identified means objectives such as habitat improvement, creation of new habitat, and predator control; and potential actions for achieving them. Future prototypes should also strive to incorporate each of these actions in various combinations (strategies) relevant to the profile of a larger landscape (metapopulation, focus area). A spatial context will also provide the ability to incorporate movement between patches (immigration and emigration) into the analysis.

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Expected Value of Partial Information Analysis

	Model							
	1	2	3	4	5	6	7	8
Curve	3	2	3	2	3	2	3	2
Effect % (Hunting, Trapping)	90,70	90,70	70, 50	70, 50	90,70	90,70	70, 50	70, 50
NEC Occupancy	Yes	Yes	Yes	Yes	No	No	No	No

Model Probs	0.1250	0.1250	0.1250	0.1250	0.1250	0.1250	0.1250	0.1250	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Expected Value
Trap & Relocate	0.724	0.528	0.533	0.633	0.528	0.640	0.633	0.400	**0.578**
Trap & Kill	0.764	0.568	0.573	0.673	0.568	0.680	0.673	0.440	**0.618**
Hunt	0.180	0.180	0.180	0.180	0.879	0.927	0.904	0.708	**0.517**
Max (Perfect Info)	0.764	0.568	0.573	0.673	0.879	0.927	0.904	0.708	**0.750**

EC in Patch	100
NEC in Patch	1
Weight NEC	0.8
Weight cost	0.2
Max NEC λ	1.5

All Uncertainty	
Perfect	0.750
Under Uncertainty	0.618
EVPI	0.132

Trapping and relocate - $10,000 = $500/acre

Trapping and kill - $8000 = $400/acre

Focal Hunting - $1000 = $50/acre

Outline of Expanded Decision Making Framework for NEC Recovery in the Northeast

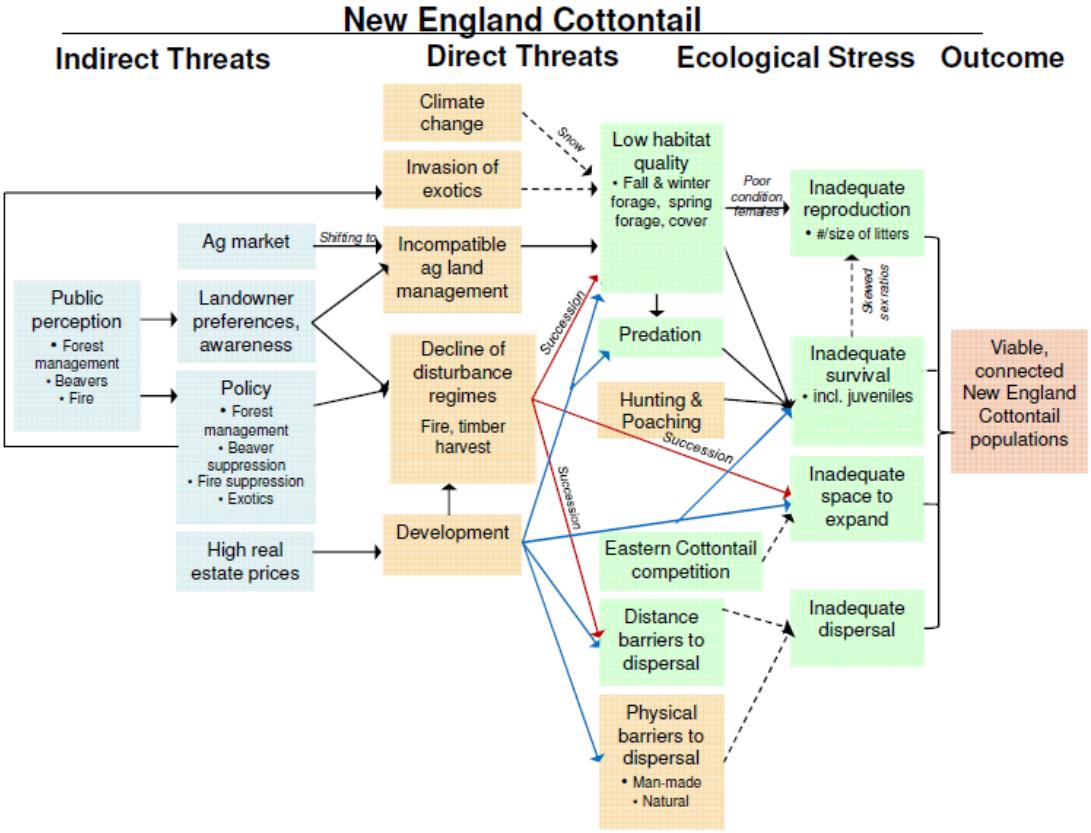

Figure x. Example Influence Diagram for New England cottontail ecology. A refined and widely accepted version could be used as a base for a Bayesian Network Analysis that includes additional actions for recovery such as habitat management. *NFWF business plan 2008.*

Node Classification	Node Title	Node States	Node measurement technique
Human Land Use	Forestry Practices	Clearcut	Patch cuts greater than 5 acres in an given landscape area
		Select Cut	No openings greater than 1 acres are occurring
		None	No timber harvesting is taking place
		no removal	active beaver dams
	Beaver Suppression	removal	non beaver dams
		High	shrub patched present over 5 years
	Abandonment of Agric. lands	Low	annual mowing
		None	no agricultural lands in the area
		High	
	Human development	Low	
		High	
	Road Density	Low	
Environmental Inputs	Predators	High	
		Low	
	Size of Nearby Population	Small	Pop. Estimate/density of pop within 2km is between x-x
		Fair	Pop. Estimate/density of pop within 2km is between x-x
		Large	Pop. Estimate/density of pop within 2km is between x-x
	Avg. annual snowfall	Low	xxx No. days snow
		High	xxx No. days snow
Key Ecological Correlates	Stem density	Low	
		Med	
		High	
	Eastern cottontails present	None	
		Low	
		High	
	Barriers to dispersal	Present	A road or other development greater than xx in between
		Absent	A barrier is absent
Biological Effects (Population Parameters)	Number of Adults	Absent	
		Present	
		Abundant	
	Possibility for immigration	Low	
		High	
Management Outcome	5 year population response	Local Extirpation	
		Decline	
		Stable	
		Growth	

Table x. Potential Nodes and Discreet States for Bayesian Network Analysis.

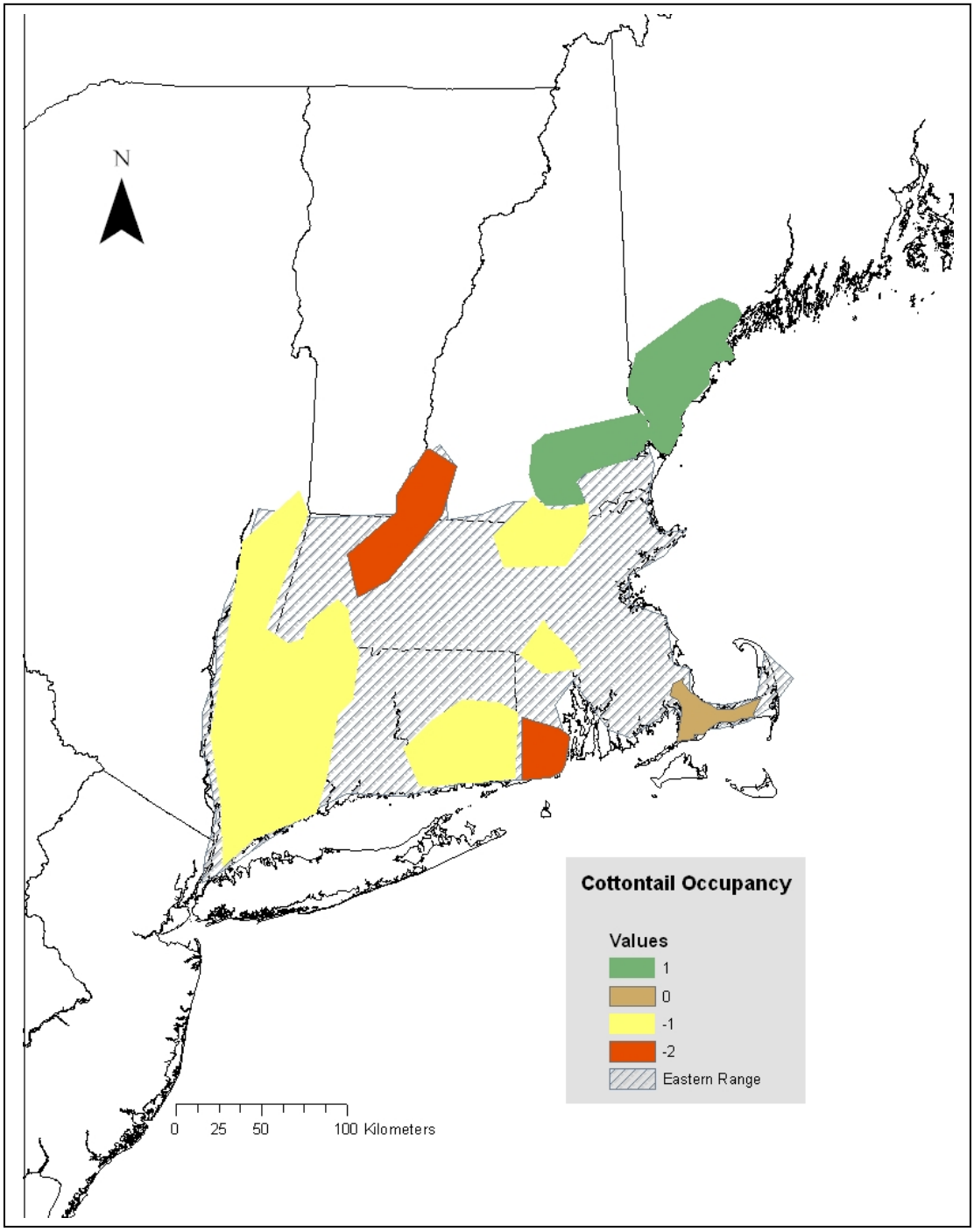

Figure x. Cottontail co-occurrence map in recently occupied focus areas.
1 = NEC only; 0 = NEC>EC; -1 = EC>NEC; -2 = EC only