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Increasing Climate Resilience: Hoffman Evergreen Preserve

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OVERVIEW

Hoffman Evergreen Preserve is a 198 acre coniferous and deciduous temperate forest located in Stonington, Connecticut. The Preserve recently underwent patch cuts and thinning due to an unhealthy overcrowding of trees. The deforested areas of the property provide a unique opportunity to regrow a healthier forest: specifically, one that is more resilient to impending climate change impacts. Furthermore, this is a chance to develop more understory, soften edges, and nurture a young forest. There are currently five distinct patch cuts amassing 67 acres, as well as an extensive amount of thinned forest, resulting from wide skid trails. Patch 1, 2, 3, and 5 are categorized as canton and charlton soils, extensively stony, and minimal inclines (≤15% slope). Patch 4 is categorized as partially hydric soil and inland wetland, extensively stony, and moderate inclines (≈30% slope).

GOALS

1. Create areas of forest within Hoffman resilient to anticipated temperature, precipitation, and extreme weather events projected to 2050
2. Implement flora that are compatible with the current and anticipated environmental changes in the region in order to project the kinds of plantings that would best respond to changing climate
3. Develop understory, soft edges, and young forest

Current and Projected Climate Changes

Impending climate change will increase average temperature and precipitation, as well as increase the frequency, duration, and intensity of extreme weather events such as droughts and downpours and possibly more intense coastal storms. The annual mean temperature of Connecticut has increased 3 °F (1.7 °C) since 1895, faster than the rise in global mean temperature (UMass). Climate models predict that Connecticut average temperatures could increase 4 to 7.5 °F by the end of the century. Such projections also suggest that the frequency of days over 90 and 100 °F will increase along with heatwaves and droughts (DEEP). Average annual precipitation in the Northeast has increased 36% from 1895 to 2011 and heavy downpours have increased 55% since 1958 (EPA; Scott 2019). DEEP suggests that annual precipitation may increase by 5 to 10% by the end of the century, with severe storm events and flooding likely to occur more often. EPA predicts that above average precipitation and flood events are most likely to increase in the winter and spring, whereas increased evaporation in the spring will contribute to dry soils and droughts in the summer and fall. Hoffman Preserve will likely be subject to all of these aspects of climate change.

Managed Translocation

The proposed managed translocation of plant species into Hoffman Preserve is likely the most optimal solution for creating a resilient environment in the face of climate change. Corlett and Westcott (2013) state, "managed translocation (also called assisted migration or assisted colonization) is the deliberate establishment of populations outside their natural range for conservation purposes." This appears to be a viable way to combat climate change as it prevents the further degradation of current ecosystems by establishing species better adapted to deal with the imminent changes, while also securing the colonization of species in what will become a changing, but healthy optimal habitat. The global mean velocity of mean annual temperature and precipitation change outpaces the migration of many tree species. Mid and late-successional tree species are likely to be left behind due to their typically longer generation times and shorter dispersal distances. The result would see future forests dominated by smaller trees, lower density wood, and less carbon storage. Due to current climate projections, it's plausible Hoffman Preserve could lose some current species and undergo such a change. However, implementing managed translocation could mitigate such effects by introducing populations better adapted to acclimate to future conditions and facilitate gene flow within the current population to increase the amount of favorable genotypes within the population.

To implement managed translocation, one should consider the current and designated ecosystem of the plant to be translocated, as well as the physiological and genomic features of the plant. This requires, first, to evaluate the climate trends and exposures of the plant and site. From there, one has a foundation to select species. McPherson et al. (2018) suggest searching for plants that are present in areas that have similar and different climates, rainfall, and soils. This would indicate how durable a plant is in a range of conditions: the greater the range, the better a candidate. However, there is a limit to this as well. Relocating a new species that borders the site's range decreases the chance of introducing an invasive, as the environment is likely to be relatively similar to it's current one. But, one can also introduce seeds or trees of a native species that occur in a somewhat different environment to facilitate advantageous traits. Aitken and Bemmels (2015), suggest that the individuals should, "span at least five degrees of latitude or 50% of the species distribution to ensure clines reflect broadscale species-level patterns." Then, one can rank the species based on habitat suitability (temperature, precipitation, soil type, etc.), physiology (drought, flood heat, cold tolerance), and other biotic or abiotic interactions. Upon selection, one can then plan the methods of implementation and analysis of the outcome.

Plant Species List

Species Selection Process

Individual trees and shrubs on the list below were selected based on their presumed flexibility and tolerance for a multitude of conditions. A variety of trees and shrubs were selected to ensure that there would be at least one to two species which could be viable in the different settings targeted by this project and representative of the preserve. For example: One might notice there are a high portion of UPL (upland) and OBL (obligate wetland) species, species that obviously have different habitats as one needs dry conditions and another is an obligate wetland species. This is necessary because there will be very dry portions of the preserve (such as central areas of the patch cuts exposed to a lot of sun) while there are also portions of the park that border wetlands and soils are poorly drained. The selection was meant to encompass a range of species that could succeed along overlapping gradients, with the hope that (at the least) a portion of species will succeed.

Categories include the following:

Species: Common Name Scientific Name	Habitat: Native range (southern-northern) Wetland Status Hardiness Status	Attributes: Soil type range Sun/shade range Size Growth rate	Advantages: Genetic diversity Adaptable Tolerant Easy transplant Etc.	Liabilities: Pests Disease Hard transplant Etc.

Connecticut Native Tree Species

Species:	Habitat:	Attributes:	Advantages:	Liabilities:
Red Maple *Acer rubrum*	Florida-Canada FAC Zone 3-9	Moist soil Sun-partial shade 40-70' Fast growth	Easy transplant Adaptable Genetic variation	Storm damage Disease Genetic variation
Persimmon *DIospyros virginiana*	Florida-New York FAC Zone 7-11	Moist-dry soil Sun-partial shade	Soil pH adaptable Wildlife value	Difficult transplant Disease

		~40′		
Shagbark Hickory *Carya ovata*	Texas-Canada FACU Zone 4-8	Moist-dry soil Sun-partial shade Up to 80′ Slow growth	Wildlife value; fruit, caterpillar host	Pests Disease
River Birch *Betula nigra*	Florida-Minnesota FACW Zone 4-9	Moist-wet soil Full sun 50-70′ Medium growth	Soil adaptive (to dry) Heat adaptive Easy transplant Wildlife value	Disease
Silver Maple *Acer saccharinum*	Florida-Canada FACW Zone 3-9	Moist-wet soil Sun-partial shade ~70′ Fast growth	Easy transplant Soil adaptive Genetic variation Drought tolerant Flood tolerant Wildlife value	Genetic variation; not all cold hardy
Black Gum/Black Tupelo *Nyssa sylvatica*	Florida-Canada FAC Zone 3-9	Moist-wet soil Sun-partial shade ~50′ Slow growth	Wildlife value	Hard transplant Disease Pests
Common Sassafras *Sassafras albidum*	Florida-Canada FACU Zone 4-9	Acidic (moist) soil Full sun 40-50′	NA	Hard transplant Disease
Black Cherry *Prunus serotina*	Florida-Canada FACU Zone 2-8	Moist soil Sun-partial shade 60-90′ Fast growth	Drought tolerant	Pests
American Sweetgum *Liquidambar styraciflua*	Florida-New York FAC Zone 5-9	Moist soil Sun-partial shade 60-90′ Medium growth	NA	Young trees lack cold hardiness Disease
Tulip Tree *Liriodendron tulipifera*	Florida-Canada FACU Zone 4-9	Moist soil Full sun 70′-90′	NA	Maladaptive to dry sites
White Oak *Quercus alba*	Florida-Canada FACU Zone 3-9	Acidic (moist) soil Full sun 60-80′	Easy transplant (when small)	Hard transplant (when big) Disease Pests

		Slow growth		
Scarlet Oak *Quercus coccinea*	Georgia-Canada Zone 5-9	Acidic (moist) soil Full sun ~75′	Easy transplant (when young)	Hard transplant (when big)

Connecticut Native Shrub Species

Species:	Habitat:	Attributes:	Advantages:	Liabilities:
Common Ninebark *Physocarpus opulifolius*	Florida-Canada FACW Zone 2-7	Moist-dry soil Sun-partial shade 6-10′ Medium growth	Adaptable Easy transplant Wildlife value	Pests
Silky Dogwood *Cornus amomum*	Florida-Maine FACW Zone 5-8	Moist soil Sun-partial shade 6-10′ Fast growth	Easy transplant Dry soil adaptive Wildlife value	Disease Pests
Spicebush *Lindera benzoin*	Florida-Canada FACW Zone 4-9	Moist soil Sun-partial shade 8-12′ Slow growth	Easy transplant Wildlife value; butterfly larvae attractant	NA
Nannyberry *Viburnum lentago*	Georgia-Canada FAC Zone 2-8	Moist-dry soil Sun-full shade 10-15′	Easy transplant Adaptable Wildlife value; butterfly adult attractant	Disease Pests
Gray Dogwood *Cornus racemosa*	Texas-Canada FAC Zone 3-8	Moist-wet soil Sun-full shade 10-15′	Easy transplant Adaptable Dry soil adaptable Wildlife value	Disease
Fragrant Sumac *Rhus aromatica*	Florida-Canada UPL Zone 3-9	Moist-dry soil Sun-partial shade ~6′ Slow growth	WIldlife value	Disease Pests

Virginia Rose *Rosa virginiana*	Georgia-Canada FAC Zone 3-7	Moist-dry soil Sun-partial shade ~6′ Fast growth	Wildlife value	Disease Pests
Eastern Redbud *Cercis canadensis*	Florida-Canada FACU ZOne 4-9	Moist soil Sun-partial shade 20-30′	Soil adaptive	Short lived if stressed Genetic variance in cold hardiness

Southern Native Tree Species

Species:	Habitat:	Attributes:	Advantages:	Liabilities:
Sugarberry *Celtis laevigata*	Florida-Washington FAC-FACW Zone 5-9	Moist-dry soil Full sun 40-60′ Medium growth	Adaptive Soil adaptive Pollutant tolerant Wildlife value	NA
Virginia Pine *Pinus virginiana*	Georgia-New York Zone 4-8	Moist-dry soil Full sun 10-50′ Slow growth	Soil adaptive	Easily damaged Pests
Loblolly Pine *Pinus taeda*	Florida-New Jersey FAC Zone 6b-9b	Acidic (moist) soil Full sun	Easy transplant Soil adaptive	NA
Rocky Mountain Juniper *Juniperus scopulorum*	Texas-Canada Zone 3b-3a	Moist soil Full sun 30-40′ Medium growth	Easy transplant pH adaptive	Possible hardiness limit
Shingle Oak *Quercus imbricaria*	Georgia-New York FACU Zone 4-5	Moist soil Full sun 50-75′	Easy transplant	Possible hardiness limit

Southern Native Shrub Species

Species:	Habitat:	Attributes:	Advantages:	Liabilities:
Silver Buffaloberry *Shepherdia argentea*	California-Canada; New York (closest state) FACU Zone 3-9	Moist-dry soil Sun-partial shade 6-10′ Fast growth	Soil adaptive Easy to grow	Disease
Meadow Holly *Ilex decidua*	Florida-Illinois FAC-FACW Zone ~5	Moist soil Sun-partial shade 3-6′ Slow growth	NA	NA
Holly Leaved Barberry *Mahonia aquifolium*	California-Canada; New York (closest state) UPL	Moist soil Sun-partial shade 3-6′ Slow growth	NA	Hot/dry/cold vulnerable Disease
Common Pawpaw *Asimina triloba*	Florida-Canada; Fairfield County FAC	Moist soil Full sun 15-20′ Medium growth	Container transplant	Hard transplant

Methods of Implementation

Seed, Transplant, and Translocation

The use of both seeds and transplantation is optimal when reforesting a patch cut, as it leads to an uneven-aged, dynamic forest. A multi-aged forest provides a variety of habitats while enabling a forest to remain intact even if thinning is prescribed: this is because trees of differing ages are utilized by different species and require pruning or harvest at different times. However, research suggests that plant biomass may be altered based on its origins of growth. A study compared bell pepper biomass when directly seeded to transplanted plants. The seeded plants had a more balanced biomass partitioning, whereas the translocated plants neglected root growth compared to other tissues. But, transplanted plants exhibited significantly greater and earlier yields when compared to direct seeds (Leskovar & Cantliffe 1993). Thus, translocation and seeding can have drastically different impacts on the physiology of a plant. Aspects critical to the growth of the forest such as mortality rate among species should therefore be investigated and monitored.

Regardless of whether one is buying seeds or a small plant, the selection process for translocation will depend mainly on whether the species is a Connecticut native or a southern native. When selecting Connecticut native species, the seeds or trees which are selected should be five degrees of latitude lower than Connecticut or from the lower half of a plant's natural distribution (Aitken and Bemmels 2015). This ensures that southern genotypes of Connecticut native species will be introduced to Hoffman Preserve's population, with the target of introducing genetic variation that can acclimate to projected changes in climate. Furthermore, it would be beneficial to buy native seeds or plants from regions which reflect the projected temperature and precipitation highlighted in the 'Current and Projected Climate Change' section. For southern native species, it is likely best to buy seeds or plants that are from nearby states or if not available, regions which resemble the current climate of Connecticut. Because there are no natives the southern species can exchange genetic material with at Hoffman Preserve, assisted gene flow does not apply and establishing the species becomes a priority. Thus, selecting seeds and plants from climates similar to Connecticut will increase the likelihood the species has adaptations which allow it to persist at Hoffman Preserve.

Planting Locations

Currently, there are three big divisions in which planting can occur; non-hydric patches (patch 1, 2, 3, and 5), hydric patches (patch 4), and skidrows. Furthermore, there are subdivisions within these divisions as light availability, soil type, and microenvironment vary greatly. All variables must be factored into plant location for the best possible outcome. The following bullets layout planting guidelines:

Non-hydric patches:

- The central section and northern perimeter of the cut will be exposed to sunlight for the longest period of time, and consequently have dry soils. This location would likely be the best area to implement southern native species due to the lack of competition amongst Connecticut native plants. Plant transplant would also be a viable option due to the open space, but catering to a plant's needs could be necessary.
- The southern, eastern, and western perimeters of the cut will experience less sunlight and maintain a moist soil closer to the perimeter. Southern natives and plant transplant could be viable, however competition from Connecticut native species on the perimeter could be a problem. For this reason, it is recommended to implement Connecticut natives of southern clines to facilitate gene flow between the offspring of such plants.

Hydric patches:

- The central and northern perimeter of the cut will be exposed to sunlight for a long period of time (similar to the non-hydric patch). However, the northern perimeter borders a wetland and likely has moist-to-wet soils. The transplant and establishment of

southern natives would be viable in these conditions when considering a plant's environment.
- The guidelines for this area are similar to that of the non-hydric patches, as the majority of these areas do not border the wetland unless you move further north. The southern, eastern, and western perimeters of the cut will experience less sunlight and maintain a moist soil closer to the perimeter. Southern natives and plant transplant could be viable, however competition from Connecticut native species on the perimeter could be a problem. For this reason, it is recommended to implement Connecticut natives of southern clines to facilitate gene flow between the offspring of such plants.

Skidrows:

- The slim corridors within Hoffman Preserve created to bring in equipment for the patch cuts, as well as areas that have been drastically thinned will be subject to a variety of conditions. However, a unique variable pertaining to skidrows is the competition and proximity to Connecticut natives. For this reason, it would be best to plant Connecticut natives of southern clines to facilitate gene flow throughout these areas of the forest.

Management

Management, under any circumstances, is best performed when treated as an experiment. Treating management as an experiment offers a controlled study system that's capable of analysis, allowing one to further their understanding of the effectiveness of a procedure and how one can improve on the process. With that, here is a layout of essential guidelines to create adaptive management and elaborate on their relevance to Hoffman Preserve specifically:

- Control - A location or locations which do not receive treatment. Without control plots, it's hard to ensure whether management facilitated the outcome or whether it was due to some confounding factor. This would likely mean keeping multiple patch cuts free of any treatment.
- Replication - Increasing the sample size of both experimental and control plots reduces the possibility of the outcome being spurious. With five patch cuts to work with, this would likely mean multiple controls or experimental plots. It's worth considering whether you want to use the same treatment in each plot to increase sample size or sacrifice sample size for different procedures which would confound the study.
- Independent Experimental Units - The isolation of each experiment or control so that the outcome of others or surroundings do not impact that site. This is relatively easy, as the patch cuts are distinct and separated by dense forest. However, it's important to note some of the differences within each section of the forest, specifically that patch 4 and 5 historically had conifers whereas patch 1, 2, and 3 were deciduously dominated.

- Randomization - Ensuring that each plot has the same likelihood to receive treatment decreases the confounding factors of a study as it's not subject to certain biases. Randomizing plots while beneficial for the experimental methods do cause logistical concerns, specifically with patch 4 and 5 being harder to access.
- Interspersing Treatments - To ensure that management outcome isn't due to one general location, it is important to evenly disperse each treatment and control. This might be useful when considering the differences between the coniferous forests in the back of the preserve as opposed to the deciduous cuts in the front.
- Adaptive Management - Previous management plans and outcomes should be considered when devising a new plan, as well as a clear set of goals which can be evaluated and plans to evaluate how effective management actions were.

Conclusion

Hoffman Preserve, like many places, will be increasingly impacted by climate change. The recent patch cuts offer a unique opportunity to create a more resilient, healthy environment. This project proposal offers a plan to implement tree species that are adaptive to the current and anticipated environments, while also developing an understory that softens edges and increases young forest growth. Managed translocation can increase species and genetic diversity of Hoffman Preserve while also strengthening the overall resilience of the land. There are many options for species and implementation. Ultimately, the course of action for management is best understood by the caretakers of the preserve and those who've set the goals, and the most knowledge is gained when treating management as an objective-scientific experiment.

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