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Principles of Natural Resource Management

12/5/12

Invasive Species Management by Native Species in Canopy Gaps

Abstract

The broad goal of this proposal is to create a stratified forest ecosystem in the section of the RUEP Kilmer Woods which currently lacks an understory. We want to observe the various factors that threaten forest understory layers. The three factors we are observing for are the role of canopy disturbance, invasive species, and deer browse. The specific goal is to determine the best method for restoration of a native understory by taking advantage of habitat made available by canopy disturbance from Hurricane Sandy of October 2012. This method will consist of a plan for understory restoration, and for preventing obstacles to restoration: the management of invasive species and deer browse.

Background (Literature Synthesis)

Natural disturbance regimes undoubtedly play a vital role in the development of a dynamic forest composition. Flooding, fires, treefall, and other natural disturbances create heterogeneous forest stands by manipulating geology, hydrology, and resource availability. Disturbance has been proposed as a driving factor in overall species diversity in various papers by authors including, but not limited to, J. Philip Grime, Joseph Connell, and Michael Huston (Denslow, 1980). In a synthesis by Dr. Judie Sloan Denslow of University of Wisconsin Botany, natural disturbance is touted as a necessary source of mortality and source of establishment for plant communities. Thus when these disturbance regimes are missing or repressed, rates of establishment and mortality will be skewed. Within canopy gaps caused by disturbance, early successional species are found to colonize, providing variability and seed sources for an otherwise mature forest (Denslow, 1980).

However, canopy gaps also create the opportunity for invasive species to propagate. Invasive species are those species, either native or non-native, that hinder the previous mechanisms of an ecosystem in a deleterious manner. In a meta-analysis on invasive plant control experiments by Karin M. Kettenring, it was concluded that invasive plants significantly reduce biodiversity and alter ecosystem functions. The mechanisms for why invasives prevail have been studied, yet is inconclusive and is most likely on the per species basis (Kettenring & Adams, 2011).

Therefore, controlling for invasive species has proven to be difficult, and often the propagation of these species will outcompete native species. Methods employed by the studies in the meta-analysis included the use of herbicide (55%; 42% using glyphosate), cutting techniques (34%), and burning techniques (24%). The meta-analysis also indicated that although various invasive control experiments were successful in immediately removing invasive species, little was done to control for native species growth afterwards. The authors noted that few studies focused on active revegetation which lead to reinvasion (Kettenring & Adams, 2011). In order to prevent reinvasion, the Kettenring & Adams suggested jumpstarting native plants (pre-growing and planting) into invasive plant managed areas. They indicated that as per various studies, jumpstarting native plants will have weed control benefits and help give the native plant community a foothold. The authors suggest that as a consequence, native plant propagation can act as a long-term invasive management plan.

Although there is little literature on controlling invasive species in a forested habitat by native jumpstarting, there have been studies on jumpstarting in field grass ecosystems (Bakker & Wilson, 2004). Results similar to the suggestion of Kettenring & Adams were found. It was found that an invasive grass, *Agropyron cristatum*, invaded 1/3 fewer restored plots than unrestored plots; and that *A. cristatum* cover decreased with increasing native grass planting on restored plots. Thus, the authors conclude that active native plant restoration can act as "filter, constraining invasive species while allowing colonization by native species" (Bakker & Wilson, 2004). While the filter in the Bakker & Wilson study is that of colonization space by grass on fields, it is still acting upon light availability - analogued by the canopy gaps in forests.

While invasive species cause profoundly negative effects on Northeastern forests, the pressure of the white-tailed deer (*Odocoileus virginianus)* is more profound. The white-tailed deer is a forest browser that is known to cause extreme understory and herbaceous destruction through herbivory. In addition, there is currently an overabundance of these deer as a result of human development and its creation of small, patchy forests with large edge habitat (Knight, Caswell, & Kalisz, 2009). It has been found in a various number of studies that white-tailed deer have a direct, negative effect on the survival rates and species richness of seedlings, saplings, and herbaceous plants (Knight, Caswell, & Kalisz, 2009). It has been proposed that by changing the composition and amount of understory plants, profound effects can be seen in the production and nutrient cycling of an ecosystem (Knight, Caswell, & Kalisz, 2009). Thus, in this study, we are using deer exclosures to protect jumpstarted native species from deer herbivory.

For this proposal, an upland Piedmont forest in the Rutgers University Ecopreserve (RUEP) of Middlesex County, NJ was the subject of native plant restoration following invasive removal in a canopy gap. Various studies conducted in the RUEP in the past provided vast knowledge on the composition of the forest understory. All of the articles (Davison & Forman, 1982; Pickett & Kempf, 1980; Nicola & Pickett, 1983) referenced an upland forest dominated by *Viburnum acerifolium,V. dentatum, and V. prunifolium* (maple-leaf viburnum, arrowwood viburnum, and blackhaw), and riparian zones dominated by *Lindera benzoin* (spicebush) . In addition, information about the light preferences of dominant understory shrubs was found to determine the best plants for planting in semi-shaded canopy gaps. *V. acerifolium* and *L. benzoin* were both classified as shade-tolerant species. *Viburnum dentatum* and *prunifolium* were also mentioned as a transitional species between areas of open sunlight and shade - thus possibly indicating other species that would be seen colonizing a canopy gap (Nicola & Pickett, 1983).

Materials & Methods

Experimental Design

Three plots were used in this proposal. All plots were surrounded with deer fencing. The first plot - the control - received only deer fencing. The second plot (experimental plot #1) received native species planting without invasive species removal. And the third plot (experimental plot #2) received both native species planting and invasive species removal.

Site Determination

The three plots are located on one site in the Rutgers University Ecopreserve with a slope between the Buell Brook riparian zone and an upland section. This site is found while heading southward from the intersection of the yellow and red trails (red circle in figure I), on the north side of the trail (figure I, figure II). This area was

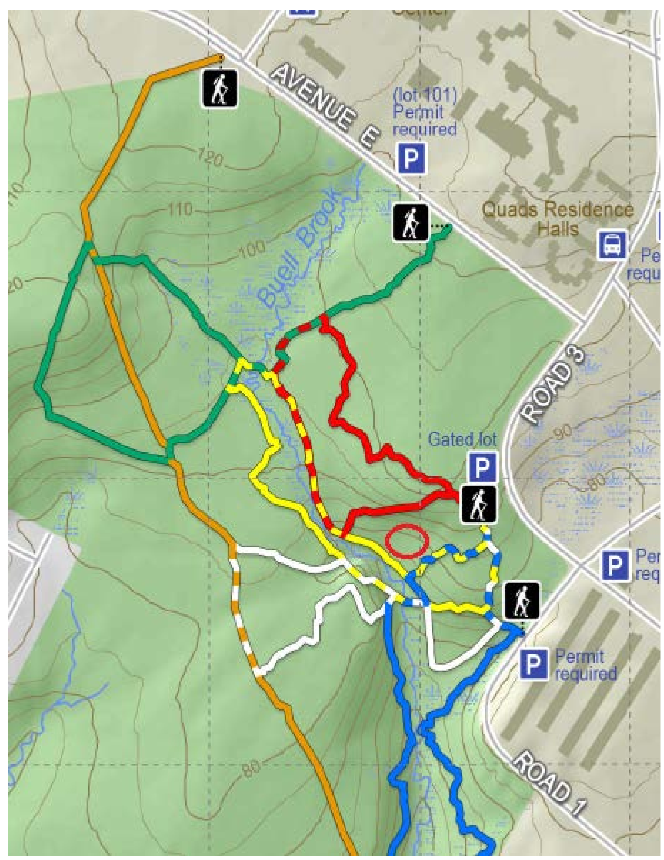

Figure I - Map of RUEP trails and location of the study site (red circle) chosen in able to use both species (*L. benzoin* and *V. dentatum*), each of which utilize a different part of the gradient between upland areas and riparian zones. The experimental method for each plot was determined by random after randomly staking out the three plots.

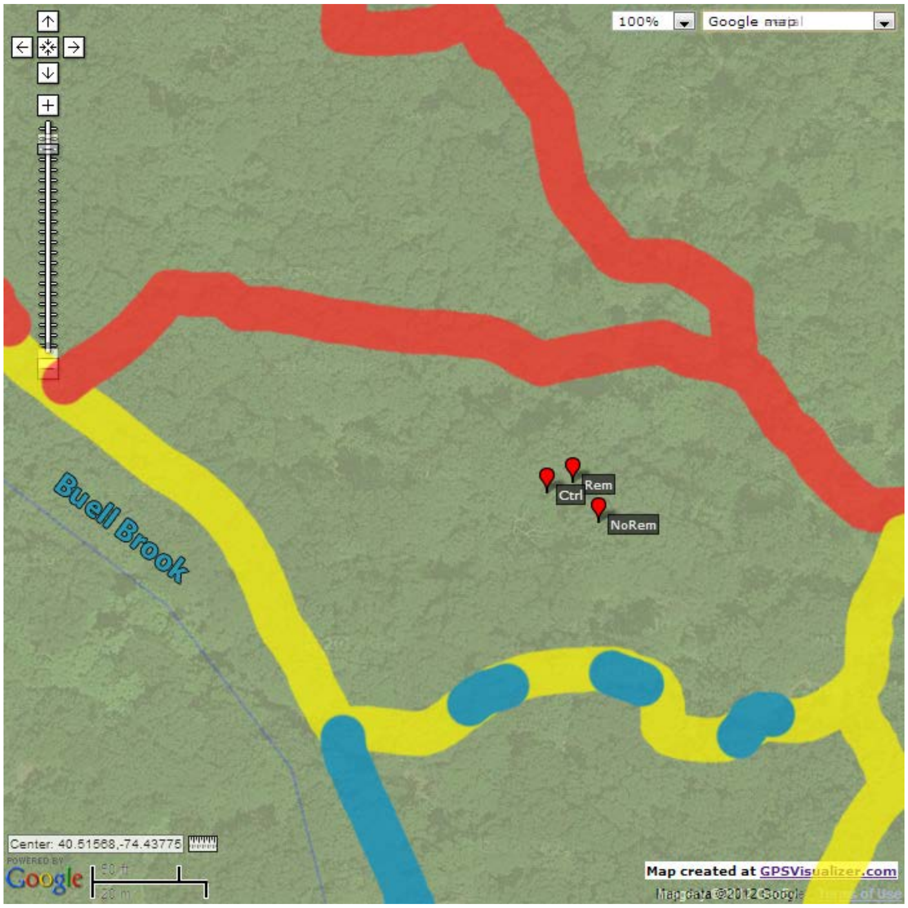

Figure II - Composite map of sites and trails, plotted by GPS coordinates (Google Maps, GPS Visualizer)

GPS coordinates of overall site location: 509502.763686583 easting, 612764.130244414 northing. The GPS locations of each individual plot is seen below in table I.

Table I - GPS locations of the study site and each individual plot

	Easting	Northing
Overall Site	509502.8	612764.1
Control Plot	509486.6	612743.6
No Removal Plot	509516.1	612726.5
Removal Plot	509501.1	612749.7

Invasive Species Control

Invasive species were dealt with on a per species basis as per the invasive species control guidelines on the USDA Forest Invasive Plants Resource Center website, as seen below:

Rosa multiflora (multiflora rose)

Manual: repeated cutting/digging/moving

Chemical: cut stump application, foliar application, basal bark *

Alliaria petiolata (garlic mustard)

Manual: digging up roots, hand pulling flowering plants, propane torch new seedlings, prescribed burning, cut when flowering

Chemical: foliar application

Microstegium vimineum (Japanese stiltgrass)

Manual: pulled by hand during growing season when plants are taller and more branched; if in fruiting stage, plants should be bagged and disposed of offsite; Can also be mowed

Chemical: glyphosate

Eleagnus umbellata (autumn olive)

Manual: seedlings can be pulled by hand or dug; ensure whole root is removed; cutting, mowing and burning cause prolific resprouting so it is NOT recommended

Chemical: basal bark treatment with triclopyr

Lonicera japonica (Japanese honeysuckle)

Manual: hand pull or dig seedlings and prescribed burning

Chemical: foliar application

*- Chemical control and controlled burns will most likely not be used; however, they are included in the event of future management plans.

Restoration Jumpstart Planting

The species chosen to be planted were spicebush (*Lindera benzoin*) and arrowwood viburnum (*Viburnum dentatum*). Spicebushes were planted on the lower, riparian part of the slope; and arrowwood viburnums were planted on the further upland part of the slope. These species were chosen in part due to the absence of both spicebush and arrowwood viburnum from the present understory of the RUEP, but also due to the available inventory of the Pinelands Nursey in Columbus, NJ, from which the plants were purchased. Each experimental plot contained 2 spicebushes and 4 arrowwood viburnums. The design of the planted plots is as seen in figure II.

Planting of shrubs took place in early December. The shrubs were planted by hand-digging by shovel, retention/replacement of mother soil after placement of shrub, watering sufficient to soak the soil (in this case, rain was present), and reintroduction of leaves removed during planting. Shrubs were in 6” diameter and 7” length pots, and thus the holes dug were at least 8” diameter and 9” deep. The site was planted homogeneously with *L. benzoin* and *Viburnum spp. L. benzoin* will be preferred on the side of the site furthest downslope, while *Viburnum* spp. will be preferred more upland. (The original design called for heterogeneous planting; however, due to budget constraints on fencing, space within the plot had to be maximized. See also Section: *Deer Exclosure Construction*).

Since *V. dentatum* grows 4’-6’ tall with a 4’-6’ spread (Brand, 2001), plants were planted no closer than 3’ to each other or 1.5’ additional to half the spread of adjacent heterospecifics. Since *L. benzoin* grow up to 8’-12’ tall with a spread of 8’-12’ (Brand, 2001), plants were planted no closer than 6’ to each other or 3’ additional to half the spread of adjacent heterospecifics (figure III).

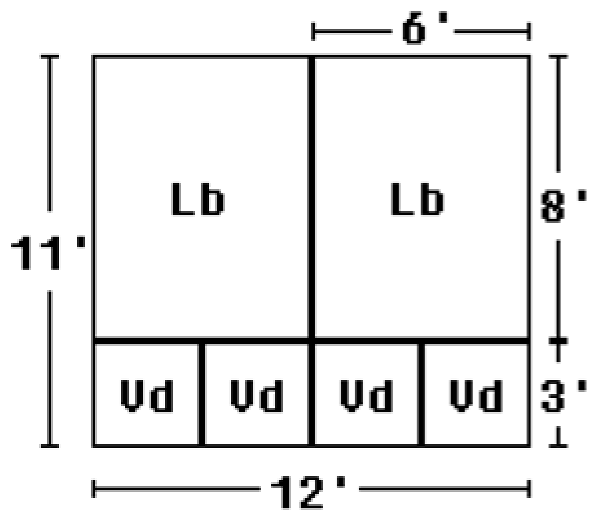

Figure III - Arrangement of plants on both experimental plots. Lb = *L. benzoin*; Vd = *V. dentatum*. The top of the plot design is towards the riparian zone, while the bottom of the plot design is towards the upland area.

Deer *Exclosure Construction*

Deer exclosures were constructed by fencing in each entire plot. Each plot on the site was enclosed by a 12' x 11' fence (figure III). Fenceposts were driven into the ground using a fencepost driver. A mixture of plastic and steel fenceposts, as well as a mixture of plastic webbed fencing 1.5 meters tall, and 10 gauge, 15.25-cm mesh concrete reinforcing wire, 1.5 meters tall, were used due to budget constraints. (The original proposal called for metal fenceposts and fencing.) The wire fence was secured to the fenceposts using the frayed ends of the fencing, the slots on the fenceposts, and/or plastic twist-ties. From the fencepost, the fencing was fully drawn to adjacent poles and attached, ultimately creating a rectangle of fence surrounding the plot.

Analysis Methods

Number of stems were counted for each invasive shrub/herbs/vines found on each plot. (*L. japonica* and *R. multiflora* were the only two shrub species observed; however, if others are present in future surveys, similar protocol is to be used.) The main stem in *L. japonica* was determined as the central point from which runners emanated, and where the taproot was located. Percentage cover was determined for all species on each plot using percentage cover guidelines as shown below (figure IV).

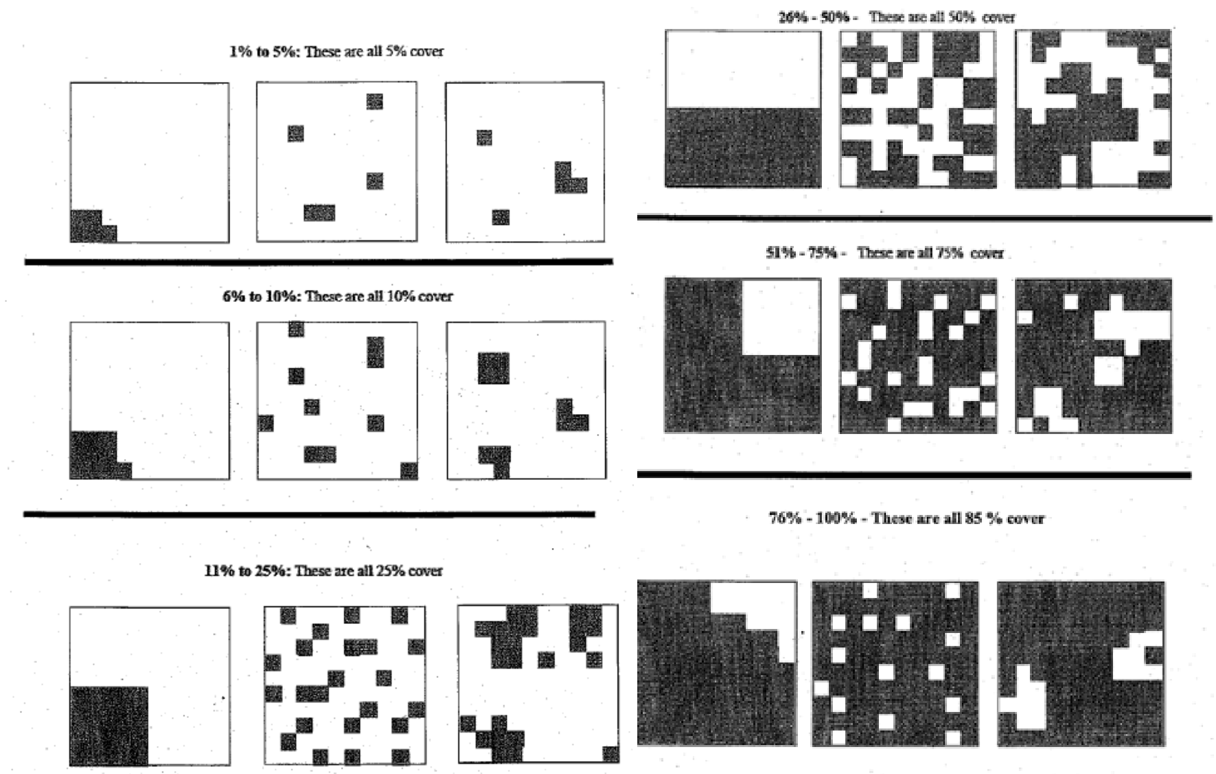

Figure IV - Visual representations of percentage cover, used as basis for determining percentage cover of shrubs/herbs/vines/grasses

Using the guidelines, percentage cover is broken into a variety of cover classes as pictured in figure III. These classes are as follows: 0 (<1%); 1 (1-5%); 2 (6-10%); 3 (11-25%); 4 (26-50%); 5 (51-75%); 6 (76-100%).

Results

Preliminary Data

At this point, the only results are the preliminary, pre-management surveys of the sites. Since the sites have yet to be invaded after the canopy gap disturbance, their compositions vary significantly (table II).

Table II - Invasive species stem counts and percent cover on each plot within the site

12/11/2012	X	Y	L. japonica "stems"	L. japonica % cover	Unknown grass #1 % cover	R. multiflora stems	R. multiflora % cover
Control Plot	509486.6	612743.6	2	0 (<1%)	1 (1-5%)	2	0 (<1%)
No Removal Plot	509516.1	612726.5	53	3 (11-25%)	1 (1-5%)	2	0 (<1%)
Removal Plot	509501.1	612749.7	28	4 (26-50%)	4 (25-50%)	1	0 (<1%)

No results of the management action have been noted, as the composition of the plots have not changed since management was employed.

Possible Results

There may be a decline in the abundance and coverage of the invasive species as hypothesized. In this case, there could be suggestion that the native plants are outcompeting the invasive plants. With this relationship, there may be a declined need in invasive species management through manual removal. Studies on additional plots could confirm these results. There may be no significant change, or an increase in the abundance and coverage of the invasive species. In this case, alternative methods for management may need to be considered.

Discussion/Further Research

There are some inherent design flaws in our proposal that would be good to address in larger scales studies in the future. One flaw is that due to a limited number of sites, the composition of each plot within the site may vary significantly (as seen in our results). In addition, having only one site in our proposal does not allow us to consider the results within the site as a viable management action in an entire forest system (i.e. the results of our management may be specific to the site area). To resolve these issues in future studies, multiple sites can be utilized to grasp a wide breadth of compositions; in addition, plots within the sites can be entirely cleared to ensure that the same initial disturbance is kept constant. Another flaw in our design comes from the utilization of a variety of materials to construct the plots due to budget constraints. Plastic fencing is less resilient than metal fencing, and thus could be vulnerable to disturbance by environmental conditions. In addition, it is not what was proposed originally to keep white-tailed deer out of the plot, and may not be as effective.

We intend on continuing the survey of these plots over the next semester (through June 2013) at the least. I propose that surveys and continued invasive removal should be done at the minimum of 3 month intervals (with increased frequency in growth months - to be determined; late April-June). In addition to the survey of invasive species coverage and abundance, I propose that we monitor the health of the planted native shrubs. This will be done by measuring the height of the plants and giving a visual health assessment (to be determined). These methods (measuring height and visual health) can also be applied to monitor the health of the invasive species. Additionally, maintenance and/or replacement of the existing exclosure fencing may be needed, and will be beneficial.

Ultimately, the success of determining a proper use of native planting in order to combat invasives will come from the continued monitoring of these plots and adapting management strategies to the results accordingly. If the manual invasive removal methods prove to be ineffective, there may need to be a shift in the management of invasives - perhaps to the herbicide management as suggested under section *Invasive Species Control*. The shrubs may not survive initial planting, so maintenance of the plot through additional planting or supplementation may be required. However, when proposing additional management plans, it is to be considered that this proposal is trying to create a management plan in which minimal manual management is needed, and mimicry of natural ecosystem processes.

Annotated Bibliography

Bakker, J. D., & Wilson, S. D. (2004). Using Ecological Restoration to Constrain Biological Invasion. *Journal of Applied Ecology* (41), 1058-1064.

In this journal paper a jumpstarted, restoration field was compared to one without restoration to observe the effects of jumpstarting on non-native invasion. It was found that the invasion of a non-native grass, Agropyron cristatum was 33% less on the restored field than the unrestored field. The synthesis made by the authors suggests that "restoration [with native species] can act as a filter, constraining invasive species while allowing colonization by native species." This suggests that restoring an area before invasive propagation will reduce the overall propagation of invasives. Although this study concentrates on grass cover, it is an analogue to our study's concentration on shade provided by native plants; it is a matter of competition for limited resources (ground cover vs. sunlight).

Brand, M. H. (2001). UConn Plant Database. Retrieved 11 5, 2012, from *University of Connecticut Horticulture*: http://www.hort.uconn.edu/plants/index.html

This website provides life history and growing information for various tree and shrub species of the Northeast.

Davison, S. E., & Forman, R. T. (1982). Herb and Shrub Dynamics in a Mature Oak Forest: A Thirty-year Study. *Bulletin of the Torrey Botanical Club*, 109 (1), 64-73.

This journal paper was based off a 30 year forest composition study in the Hutchenson Memorial Forest, an upland, mixed-oak forest in Franklin Township, NJ. This study concentrated on forests indicative of the ideal composition for the site we have chosen at the RUEP. At the time of the study, the dominant understory tree was *Cornus florida* (flowering dogwood); the dominant shrub was *Viburnum acerifolium* (maple-leaf viburnum); and the dominant herb was *Podopyllum peltatum* (mayapple). Of importance is the shrub, as we will be attempting to jumpstart shrubs in order to restore canopy gaps. In addition, the authors suggest that this study (unknowingly) found a correlation between a changing forest understory and canopy gaps. It is visible in the data that the changing forest understory is through the propagation of invasives (loss of species diversity in herbaceous layer to increasing herbaceous cover of invasives). This is directly what we will be trying to prevent through our study.

Denslow, J. S. (1980). Patterns of Plant Species Diversity During Succession Under Different Disturbance Regimes. *Oecologia* (46), 18-21.

This journal paper underscores the importance of natural disturbance regimes in both reduction of species populations and propagation of species populations. It suggests that not only the occurrence of the disturbances is important, but also the life history of the species willing to invade the disturbed area. Thus, it is important to consider that in our management plan. In regards to the Eastern United States, this journal paper mentions that it is important to consider that this area was once agricultural, the soil has been modified, and the end-state ecosystem may be alternative, or differ in species diversity and composition. In addition, the author suggests that (old world) invasives are more virulent because they have coevolved with humans longer than the native (new world) species.

Kettenring, K. M., & Adams, C. R. (2011). Lessons Learned from Invasive Plant Control. *Journal of Applied Ecology* (48), 970-979.

This journal article was a meta-analysis of invasive plant control research looking to determine the most successful control method in terms of restoration. The authors found that most of the studies concentrated on removing invasive species, however many lacked revegetation afterwards. Most of the studies without revegetation were prone to reinvasion by invasives. However, in most of the studies in which revegetation was implemented they found that invasives were controlled (or gains were found in native species). The authors propose that this is because once invasives propagate, they alter ecosystem functions and reduce biodiversity. This is the main point on which our study takes place; we are revegetating an area of disturbance before invasive propagation, as well as actively managing it.

Knight, T.M., Caswell, H., & Kalisz, S. (2009). Population Growth Rate of a Common Understory Herb Decreases Non-linearly Across a Gradient of Deer Herbivory. *Forest Ecology and Management* (257), 1095-1103.

This journal article was a meta-analysis of studies looking at the effects of white-tailed deer (*Odocoileus virginianus*) on plant populations and communities. Many of the studies that were looked at indicated that browsing by white-tailed deer caused a significant reduction in herbaceous and shrub layer survival rates. They also found that many studies saw that plant communities and

ecosystem dynamics were significantly altered by deer browse; overall, damage was seen from the nutrient level up to the primary production of forests.

Kochenderfer, J. N., & Ford, W. M. (2008, May). Utility of Wire Cages, Tree Shelters, and Repellants to Minimize Herbivory to Oak by White-tailed Deer. Retrieved 11 1, 2012, from *USDA:FS Northern Research Station*: http://www.nrs.fs.fed.us/pubs/rp/rp_nrs5.pdf

This website provided a study publication in which various methods of preventing deer from preying upon tree seedlings were tested. The study used capsaicin repellants, animal protein repellants, and wire cages. All methods were found to provide roughly equal protection; however, the wire caged trees had the largest height and diameter of all methods. The authors propose that the wire cages were the most effective, as well as cost-effective. They are long term and do not require reapplication. This study provided a design for our shrub cages. The cages in the study were made of 10 gauge, 15.25-cm mesh concrete reinforcing wire, 1.5m wide (tall), optionally anchored by either rebar or fence posts.

Pickett, S. T., & Kempf, J. S. (1980). Branching Patterns in Forest Shrubs and Understory Trees in Relation to Habitat. *New Phytologist* , 86 (2), 219-28.

This journal article investigated the branching patterns of forest shrubs and trees in New Jersey. Comparisons were made between the forest understory and respective plants in fields. The study took place on the Rutgers University Ecological Preserve, and thus provides a wealth of information on the forest composition of the area in the 1970s and early 1980s. The authors noted that the dominant tree species were *Quercus alba*, *Q. velutina*, and *Q. rubra* (white, black and red oak, respectively), with other trees such as *Carya ovata*, *C. ovalis*, *Fraxinus americana*, and *Fagus grandifolia* (shagbark and pignut hickory, white ash and American beech, respectively). They noted that the dominant shrub species were *Viburnum acerifolium* (maple-leaf viburnum), *V. dentatum* (arrowwood), *V. prunifolium* (blackhaw), and *Lindera benzoin* (spicebush).

Pickett, S. T., & Nicola, A., (1983). The Adaptive Architecture of Shrub Canopies: Leaf Display and Biomass Allocation in Relation to Light Environment. *New Phytologist , 93* (2), 301-10.

This journal article is a further investigation of the Pickett, S.T., & Kempf, J.S. study. In this study, the authors investigated shrub branching patterns, leaf display, and biomass allocation, and how those related to light environments found in central New Jersey forests. Two sites of the study took place on the Rutgers Ecological Preserve (one of which is a field), and thus it provide information on shrub composition and habits of the area in the 1970s and early 1980s. The forest site was described as oak-hickory, and had the same species' dominance as the previous Pickett, S.T., & Kempf, J.S. study. The field was described as a 50-year-old field south of Kilmer Woods dominated by *Rosa multiflora*, *Rubus spp.*, *V. prunifolium*, *Rhus spp.*, and *Myrica pennsylvanica*. The most notable feature of this study in context of this proposal was the description of elevation, habitat, and light usage for each dominant understory shrub. *V. acerifolium* is dominant in mature, upland forest sites in late succession; and is classified as a highly shade-tolerant species. *V. dentatum* is predominant in poorly-drained and younger forest areas; and is classified as needing partial shade for optimal growth. *V. prunifolium* is abundant in younger forest habitats; and is classified as needing open environments for optimal growth. *Lindera benzoin* is present in rich, moist forest habitats; and is classified as highly shade-tolerant.

USDA Forest Service. (2005, February 6). Forest Invasive Plants Resource Center. Retrieved 11 3, 2012, from USDA Northeastern Area State and Private Forestry: http://na.fs.fed.us/spfo/invasiveplants/factsheets/

This website provided information on invasive reproduction, location, and control methods. We chose the invasives that were most prevalent at the RUEP forest stands: *Rosa multiflora* (multiflora rose), *Alliaria petiolata* (garlic mustard), *Microstegium vimineum* (Japanese stiltgrass), *Elaegnus umbellata* (autumn olive), *Lonicera japonica* (Japanese honeysuckle). The information can be found on the website provided.