FOREST RESTORATION PLAN

FOR

PSE&G's Susquehanna-Roseland 500 kV Transmission Line Project

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SECTION

1.0 INTRODUCTION

This Forest Restoration Plan (FRP) has been prepared as a component of the Comprehensive Mitigation Plan for the Susquehanna-Roseland 500kV transmission line project (Project). These components will provide an implementation mechanism for identifying the specific environmental resource issues, the means to avoid, reduce and minimize the specific impact and to define ways that would help to mitigate unavoidable environmental impacts. This FRP will illustrate methods and techniques to reduce and minimize the impacts of the Susquehanna-Roseland Transmission Line Project (the "Project") on forest resources through the New Jersey Highlands Region. This plan addresses impacts on forest resources from the construction of temporary access roads and for the permanent construction of the Hopatcong switching station.

The purpose of this FRP is to demonstrate that the Project is designed to reduce and minimize the loss of forest habitat and is supportive of a no net loss of forest habitat values goal. The purpose will be achieved by:

- Describing potential forest impacts resulting from project construction related activities;
- Proposing construction techniques to avoid and minimize impacts on forest resources;
- Identifying impact restoration and mitigation measures;
- Defining success criteria; and
- Outlining a post-construction monitoring program to evaluate success.

2.0 EXISTING CONDITIONS

Transmission line access roads

The submitted site plans show the number of linear access roads that are necessary for the purpose of reaching a tower location for either the removal of an existing tower and installation of a new tower or both. Once the tower work is completed, there will be no further need for construction access and so therefore any newly constructed access roads would be able to be restored upon completion of the work.

In many locations, these construction access roads are proposed to be within existing cleared dirt paths, existing logging roads, existing gravel roads, extended residential driveways or through existing cleared fields. Many of these existing access points now wind through the forest, and transcend up slopes and down gradients, across boulder fields and over fallen tree trunks. Many are very rough to travel and are rutted by tire tracks, erosion wash-outs and maneuver between trees, yet are used by hunting clubs, forest fire fighters, loggers and other outdoors persons in four-wheeled drive vehicles. The levels of improvements to each of these access points will vary based on the existing conditions in the field, but the construction of new access roads involving clearing a new road through an existing forest have been limited to the extent practicable. Appendix 9 provides a listing of the proposed access roads in relation to the transmission structure locations. {**LISTING TO BE FINALIZED- JUNE 2011**}

The proposed access roads will generally be required to be sixteen (16) feet wide and will be constructed so as to avoid mature trees to the maximum extent practicable. Many existing trails and paths now measure at least twelve (12) feet wide and may only require the select removal of specific trees, the movement of obstructions like significant boulders, fallen trees and/or the cutting back of existing limbs. Gravel or wooden mats may be required to be placed within the access roads depending upon site conditions. To the maximum extent practical, these access roads would be designed and sited along forest edges or within disturbed portions of forest land. In many areas, the forest canopy of adjacent trees extends across these existing access roads. However, even in these locations, careful attention to design details will be required to maintain forest habitat continuity for many species of wildlife, including reptiles and amphibians and to avoid any further forest fragmentation. Appendix C shows the photographs of several typical forest roads that will be used to provide construction access to the Project site. Photograph 1 below is representative of the conditions as well.

The most common tree species are hickory (*Carya* spp), northern red oak (*Quercus rubra*), black birch (*Betula lenta*), red maple (*Acer rubrum*), and sugar maple (*Acer saccharum*). The forest structure is predominantly closed canopy, i.e. the tops of the trees are virtually touching, which

limits the amount of sunlight that reaches the ground and restricts the underlying shrub and ground cover. Tree diameters at breast height (DBH) range from 4 inches up to 20 inches indicating a fairly well distributed size range. Snags (i.e. standing dead trees) are fairly well distributed in these plots. There are some shrub species represented in the plots but in many location there are no dominant shrub species, in part, because of extensive deer browse.

Hopatcong Switching Station

Preliminary site investigations have been conducted at the Hopatcong Switching Station forest restoration site. Foresters and other technical specialists evaluated these locations, identified representative plots, and recorded preliminary information on tree species, diameter and height, shrub species, and ground cover species as well as other habitat information.

A detailed tree inventory and survey of the trees within the proposed Hopatcong switching station location has been completed and a summary of this data is shown in the spreadsheet in Appendix 8. Photograph 2 is representative of the conditions at the Hopatcong Switching Station. The site is dominated by forest vegetation and the most common species are white oak (*Quercus alba)*, chestnut oak (*Quercus prinus*), northern red oak, black birch, and sugar maple. Similar to the road system forests, the site is dominated by closed canopy forest with small amounts of shrub and ground cover. Tree diameters at breast height (DBH) range from about 4 inches up to 24 inches, and a few trees reaching 30" DBH indicating a fairly well distributed size range. Snags (i.e. standing dead trees) are also well distributed in these plots. There are a variety of shrub species represented in the plots but there are no dominant shrub species. Common shrub species include yellow birch (*Betula alleghaniensis*), serviceberry (*Amelanchier* spp), and witch-hazel (*Hamamelis virginiana*). The ground cover is sparse and includes sedges and ferns. Invasive species are present in low numbers, of which Japanese barberry was the most prevalent. Efforts to control the spread of invasive species have been incorporated into this plan and are applicable for the construction of the Hopatcong switching station.

Photograph 1: Representative forest conditions along the access roads.

Photograph 2: Forest condition in the area around the Hopatcong Switch

3.0 CALCULATING IMPACTS OF TEMPORARY ACCESS ROADS ON FOREST RESOURCES

As part of the Project, construction equipment will need to gain access through some lands that are forested to reach the Susquehanna-Roseland transmission line right-of way using a variety of construction access roads. Access road alignments have been designed to minimize earth disturbance and tree removal. Two roadway widths are required for this Project: 10 feet for light construction vehicles such as pick-up trucks and 16 feet for heavy equipment such as cranes, cement trucks and material handling trucks. Where needed, timber mats and temporary bridges will be employed, including unavoidable stream and wetlands crossings. These mats will minimize soil disturbance and loss of natural seed banks and root structure.

One of the goals of this FRP is to limit the amount of tree clearing necessary for the Project. To do so, it was decided that it would be premature to precisely inventory the trees to be removed until such time as a general contractor has specifically identified those trees that would actually be required to be removed as part of the access road construction. To facilitate this effort, the contactor will be required to mark all trees to be removed during the construction of access roads at least 2 weeks prior to construction. This activity will also be provided in the 2-week look ahead for scheduling purposes.

Trees to be removed will be clearly identified in the field prior to the start of work as those trees necessary to provide vehicle clearance for a particular Project access road. Prior to the start of construction on a particular access road, a forester will inventory the size (DBH), species and number of trees within each proposed access road. PSE&G will maintain a log of each tree removed, recording DBH and species for forest restoration purposes. The data sheet within **Appendix 3** shall be used to create the tree inventory for each access road and to calculate the number of replacement trees and shrubs to be provided and the costs associated with the forest restoration efforts. The cost of tree replacement is based on the rule of three used by landscape companies to purchase the replacement tree, to plant it and to insure its survival with a warranty.

Non-native trees considered to be invasive species will be inventoried as part of the trees to be removed along an access road, however these trees will not be factored into the tree replacement ratio calculations described in Section 5.0 below, unless the restoration area would be lacking a sufficient number of replacement trees to be certain to close any gaps in the forest canopy. Invasive tree species include Norway maple *(Acer platanoides)*, Tree of Heaven *(Ailanthus altissima)*, and Black locust (*Robinia pseudoacacia)*. These trees will be removed when located along the temporary access road route and replaced with a native tree as part of the restoration efforts.

Any tree that has more than 50% of its crown overlapping the anticipated limit of disturbance will be considered "in" the Project area, unless the root structure of the tree can be protected during construction from soil compaction. For trees greater than 18 inches DBH, the forester will record the DBH and species of the tree, affix a numbered

aluminum metal tag to the tree, and record the GPS coordinates of the tree to a 5-meter level of accuracy. For trees 18 inches DBH or less the forester will record a tally of the trees to be removed by size, species and road segment. The inventory will be stratified by riparian and upland zones. The field inventory will be field verified by PSE&G prior to tree removal.

In selecting trees to be removed, the contractor and PSE&G shall prioritize their efforts to preserve existing trees to the extent practicable using the following parameters:

- Crown height and width. Trees that have tall/spreading canopies will have a higher priority level for preservation than trees with low and/or narrow canopies;
- Overall health/condition/structure of tree. Trees in good health and condition will have a higher priority level for preservation than trees that are diseased, have poor structure or are leaning;
- Cavity trees. Trees with cavities that are in otherwise good overall health will have a higher priority level for preservation than trees lacking cavities;
- Diameter. Trees with greater diameter will have a higher priority level for preservation than trees with lesser diameter;
- Mast production. Trees that produce mast edible by multiple species of wildlife will have a higher priority level for preservation than trees that do not produce mast or trees that produce mast used by a lesser number of wildlife species. The publication *American Wildlife & Plants: A Guide to Wildlife Food Habits* (Martin *et al* 1961) will be used to determine the number of wildlife species that utilize each tree species.
- As required by the US Fish & Wildlife Service, dead or dying trees with dead limbs and exfoliating bark will also be evaluated in the field as to their suitability to remain as snags or roosting trees for species such as the Indiana bat providing they safely can be worked around;
- In accordance with this concern for Indiana bat habitat, PSE&G will flag and preserve high-suitability roost trees to the maximum extent practical, including:
  - live shagbark hickories (*Carya ovata*) over 9"DBH;
  - lightning-struck trees over 9"dbh;
  - dead, dying, or damaged trees of any species over 9"dbh with at least 10% exfoliating bark;
  - den trees, broken trees, or stumps over 9"dbh and over 9 feet in height
- Live trees of any species over 26 inches DBH.
- In these same areas, when practical, PSE&G will girdle trees over 9 inches DBH when such trees would otherwise be cut.

4.0 ACCESS ROAD OPERATION AND MAINTENANCE

Construction on the site shall adhere to the requirements of the regulatory approvals granted for the Project, and the "CONSTRUCTION AND RESTORATION STANDARDS" prepared by PSE&G for the Project, last revised on June 18, 2010.

PSE&G will incorporate invasive plant prevention and control into the project layout, design, and implementation as well as into post construction monitoring and maintenance. This FRP incorporates practices consistent with the guidelines set forth in the United States Department of Agriculture – Forest Service's *Guide to Noxious Weed Prevention Practices* to accomplish the following goals:

- Avoid or remove sources of invasive plant seed and propagules to prevent their spread;
- Prevent the introduction of invasive plants caused by moving/importing weed contaminated materials;
- Retain closed canopies and shade to suppress establishment of invasive plants in forested areas;
- Minimize soil disturbance to reduce opportunities for establishment of new populations of invasive plants;
- Provide education and training to contractors and PSE&G personnel regarding the identification of and control techniques for invasive plants.
- Train staff to recognize invasive plants, monitor the transmission line access road system for invasive plants, and implement control measures before significant populations become established.

Prior to the start of work:

- All limits of clearing and other disturbance (e.g. cuts/fills) will be clearly marked in the field and verified by PSEG;
- All required soil erosion and sediment control measures will be in place prior to soil disturbance;
- Key contractor personnel will have knowledge or will receive training in the ecological functions of Highland forests, proposed construction practices and identification of invasive plants;
- Identifiable populations of invasive plants will be removed and properly disposed of away from the work area to the extent practicable;
- As directed by the environmental compliance officers in the field, construction vehicles and equipment may be required to be cleaned to remove any foreign soil and plant propagules before entering the work areas and after passing through known populations of invasive plants. Equipment cleaning will follow the techniques outlined in the United States Department of Agriculture Forest Service publication *Vehicle Cleaning Technology for Controlling the Spread of Noxious Weeds and Invasive Species* (2005).

During road construction:

- Soil disturbance will be limited to the minimum necessary to construct the road. Topsoil removed for road construction will be stockpiled locally in a invasive weed free location for reuse during road decommissioning.
- All trees and shrubs that are cut (slash) to provide road access shall be left to the side of the road where cut to be used for tree seedling protection during access road planting unless the landowner requires removal of the slash;
- To the extent practicable, stumps will be cut or ground flush to the ground rather than excavated;
- The contractor shall exercise due care to avoid bringing soil or plant materials that would introduce invasive weeds or non-native plants into the work area.
- All soil erosion and sediment control measures will be inspected daily and cleaned and repaired as necessary;
- Any soil erosion potentially resulting in sedimentation outside the work area will be immediately corrected;
- Any equipment leaving the work area or passing through any known populations of invasive plants will be cleaned to remove soil and plant propagules before re-entering the work areas;
- Measures such as gates or other barriers at road entrances and intersections with trails/other roads will be installed to reduce unauthorized vehicle use of the roads.

During transmission line construction:

- All soil erosion and sediment control measures will be inspected weekly and cleaned and repaired as necessary;
- Any soil erosion potentially resulting in sedimentation outside the work area will be immediately corrected;
- Any equipment using the roads shall be first cleaned to remove soil and plant propagules and any vehicles passing through known populations of invasive plants will be re-cleaned prior to using the road;
- Measures such as gates or other barriers at road entrances and intersections with trails/other roads will be installed to reduce unauthorized vehicle use of the roads.

5.0 ACCESS ROAD DECOMMISSIONING AND RESTORATION

The goal of access road decommissioning and restoration is to restore existing roads to their original preconstruction width and canopy closure and to restore areas occupied by new roads to their pre-construction contours and canopy closure to the extent practicable. To the extent practicable, only topsoil removed during road construction or topsoil that has been screened to limit the introduction of invasive plant propagules will be used for road decommissioning. Decommissioned roads will be replanted with indigenous non-invasive species and monitored seasonally for a period of three years to determine the success of the restoration techniques and invasive plant control measures. Replanting of access roads shall include native tree species identified from within the tree inventory for each access road as well as the planting of tree species conducive to Indiana bat roosts, particularly those from the table below:

Red maple (*Acer rubrum*)	Shagbark hickory* (*Carya ovata*)	White oak* (*Quercus alba*)
Silver maple* (*Acer saccharinum*)	Other hickories (*Carya* spp.)	Pin oak (*Quercus palustris*)
Sugar maple* (*Acer saccharum*)	White ash (*Fraxinus americana*)	Post oak (*Quercus stellata*)
Yellow birch (*Betula alleghaniensis*)	Green ash* (*Fraxinus pennsylvanica*)	Red oak (*Quercus rubra*)
Gray birch (*Betula populifolia*)	White pine (*Pinus strobus*)	Slippery elm (*Ulmus rubra*)
Bitternut hickory (*Carya cordiformis*)	Eastern cottonwood* (*Populus deltoides*)	
Sweet pignut hickory (*Carya ovalis*)	American elm* (*Ulmus americana*)	

[*denotes the more commonly used roost tree species]:

6.0 ACCESS ROAD TREE REPLACEMENT RATIOS

The intent of access road planting is to reestablish native tree species that can fully utilize the sites, such as white oak, northern red oak, yellow poplar (*Liriodendron tulipifera*), and black cherry (*Prunus serotina*). The preliminary inventory plots established from a sample of access roads as detailed in Appendix 7, have 21 overstory tree species with no more than 7 to 8 species on any given plot. Yellow poplar, Sugar maple, northern red oak, hickory, and black birch are the most common tree species.

Common understory shrub species include witch-hazel, highbush blueberry, and spice bush (*Lindera benzoin*). The composition of the vegetation varies, however, with slope aspect, soil characteristics and previous/current forest management practices. To mimic existing patterns of vegetation, the species composition observed in the pre-construction vegetation inventory in combination with nursery availability will be used to develop lists of proposed plant materials specific to soils mapping units and upland/riparian habitat zones. The plant materials list for each habitat will consist of at least four different tree species and three shrub species extant in that habitat and will be supplemented with other appropriate indigenous trees, shrubs, grasses and forbs, including seedlings and seed mixes prepared by ERNST Conservation Seeds of Meadville PA and found within Appendix 6 and within the "Construction and Restoration Standards For The Susquehanna-Roseland 500kV Transmission Project," dated April 20, 2010 and last revised June 18, 2010. Plant specifications will include a variety of nursery stock including containerized stock, bare root stock and seed.

In non-riparian zones, seedlings (approximately 300 seedlings per acre) as well as stratified or otherwise pretreated seed (if necessary) will be the primary mechanism for re-establishment of tree seedlings, shrubs, grasses and forb cover. The rate of seed application will vary with the size of the seed, purity and germination rate but will provide a minimum of 2,000 pure live seeds per acre in accordance with the CR Standards, last revised June 18, 2010. Stratification/pretreatment will be used to break seed dormancy of acorns (or other seeds if necessary).

Plant tree seedlings and acorns on 10 x 10 foot spacing

- Only where suitable soil depth occurs (includes roadbed and any spoil material)
- Use tree shelters for all seedlings to protect from deer browse
- After seedlings planted – cut up available fallen trees and shrubs and place around seedlings as additional deer browse protection
- Goal is species diversity so planting crews should sequentially cycle through available seedling and acorn species
- Plant Ernst Seed Mixtures in accordance with **Appendix 6** for upland conditions
- Plant white oak, N. red oak, yellow poplar, black cherry, white ash

Native trees larger than 6 inches DBH that are to be removed for construction will be replaced with native nursery stock based on the following dimensions and ratios:

- Greater than 6 inches to 10 inches DBH – plant container size 3 tree with minimum 1 ½ inch caliper at a 1:1 ratio;
- Greater than 10 inches to 18 inches DBH – plant container size 4 tree with minimum 1 ½ inch caliper at a 2:1 ratio plus at least one well branched shrub at least 24 inches in height per tree planted;
- Greater than 18 inches DBH to 24 inches DBH – plant minimum 2 ½ inch caliper tree at a 2:1 ratio plus at least one well branched shrub at least 24 inches in height per tree planted; and
- Greater than 24 inches DBH – plant minimum 2 ½ inch caliper tree at a 3:1 ratio plus at least one well branched shrub at least 24 inches in height per tree planted.

In riparian zones, seedlings (approximately 400 seedlings per acre) as well as stratified or otherwise pretreated seed (if necessary) will also be used as a mechanism for re-establishment of seedlings, shrubs, grasses, and forb cover. The rate of seed application will vary with the size of the seed, purity and germination rate but will provide a minimum of 2,000 pure live seeds per acre in accordance with the CR Standards, last revised June 18, 2010. . Stratification/pretreatment will be used to break seed dormancy of acorns (or other seeds if necessary).

Plant tree seedlings and acorns on 10 x 10 foot spacing

- Only where suitable soil depth occurs (includes roadbed and any spoil material)
- Use tree shelters for all seedlings to protect from deer browse
- After seedlings planted – cut up available fallen trees and shrubs and place around seedlings – additional deer browse protection
- Goal is species diversity so planting crews should sequentially cycle through available seedling and acorn species
- Plant Ernst Seed Mixtures from **Appendix 6** for riparian zones

Replacement trees in riparian zones and wetlands, however, will be provided at a larger size and greater planting ratio than for uplands. Replacement tree sizes and ratios for the riparian zones will be:

- Greater than 6 inches to 10 inches DBH – plant container size 3 tree with minimum 1 ½ inch caliper at a 1.5:1 ratio;
- Greater than 10 inches to 18 inches DBH – plant container size 4 tree with minimum 1 ½ inch caliper at a 2.5:1 ratio plus at least one well branched shrub at least 24 inches in height per tree planted;
- Greater than 18 inches DBH to 24 inches DBH – plant minimum 2 ½ inch caliper tree at a 3:1 ratio plus at least one well branched shrub at least 24 inches in height per tree planted; and
- Greater than 24 inches DBH – plant minimum 2 ½ inch caliper tree at a 3.5:1 ratio plus at least one well branched shrub at least 24 inches in height per tree planted.

Trees/shrubs planted in the uplands will not be planted on standard grid spacing but rather in random clusters of up to 25 plants consisting of at least three species. Within the clusters, the planting density should be between 1 plant per 9 square feet to 1 plant per 25 square feet for shrubs and 1 plant per 25 square feet to 1 plant per 100 square feet for trees. The spacing of the clusters will be dependent on the number of required replacement trees and the area available for planting. If the overall planting density exceeds the maximum target density (i.e., 1 shrub per 9 square feet or 1 tree per 25 square feet) in the available planting area the number of plants will be reduced, beginning with the smallest stock until the maximum target density is met. **Seeding of plant material shall be in accordance with Appendix 4.** All stock will be planted in accordance with standard nursery specifications and in accordance with **Appendix 5 - PSE&G Tree Planting Specifications**. At least 40 percent of the stock will be protected from animal browsing with appropriately sized tree protector tubes. At least 20 percent of the nursery stock will be planted in exclosures designed to prevent deer browsing,

which will be determined in the field by the restoration contractor and PSE&G at the time of the planting.

The above approach is intended to provide a methodology for tree restoration, which accounts for the presence or absence of actual existing trees within the construction envelope. Another approach as used under the New Jersey No Net Loss Reforestation Act Program Guidelines uses a Tree Replacement Factor (TRF) that calculates the tree replacement values based on quantifying acres of impacts associated with tree removal. The values as part of the TRF have been standardized for ease of application.

These values are: 204 (2" - 2 1/2") caliper trees per acre
408 whip/container (4' - 6) trees per acre
1210 tree seedlings per acre

The above numbers will be used as a baseline for adjusting or comparing the total trees to be planted relative to seedling, caliper and whip/container trees. Where tree replacement ratios exceed the above TRF, then the numbers of trees to be replanted may be adjusted accordingly. However, the TRF is not intended to increase the amount of trees to be replaced.

7.0 Success Criteria and Monitoring

The goal of the road decommissioning activities is to establish a seedling forest (as defined under the New Jersey No Net Loss Reforestation Act Program Guidelines) on the decommissioned portions of the access roads, with invasive plant populations equal to or less than current levels at the end of the third growing season following completion of planting. Alternatively, road decommissioning will be considered successful if the average canopy closure above the decommissioned road is equal to or greater than pre-construction conditions and invasive plant populations are equal to or less than current levels at the end of the fifth growing season following completion of planting. If this standard is not reached or practical then an alternate standard of at least 75% survival of the planted trees shall apply. PSE&G will use GPS to identify and establish baseline representative sampling plots or transects to document the progress of the road decommissioning tree restoration efforts. All restoration areas will be monitored for planting success or failures with on site seasonal field inspections of the plantings. To the extent practical, efforts to regularly water the newly planted stock will be undertaken through the use of a water truck, tree bladder bags and contour grading; however due to the remoteness of some areas, this may not be feasible in every restoration area. There will be at least one plot or transect located at least every fourth restoration area outside of the ROW, where more detailed sampling of success rates will be able to be recorded in order to compare to baseline tree inventories. Monitoring and vegetation sampling of these restoration areas will be conducted in the Spring and fall and a final baseline vegetation surveys will also be conducted at the end of the

monitoring period. The results of these efforts will be summarized within the annual reports.

8.0 HOPATCONG SWITCHING STATION FOREST ENHANCEMENT SITE

Existing land area adjacent to the proposed Hopatcong Switching station will be used as a forest enhancement area that will implement various forest management techniques including the installation of deer exclusion fencing. The goal of the enhancement activities in the Hopatcong Switching Station forest restoration site is to develop a more complex vertical stand forest structure as well as improving the growth rates of existing trees. This will also improve habitat values for various wildlife species and in particular for migratory song birds and the Indiana bat. To achieve this, several prescriptions (treatments) will be implemented that are designed to:

- Increase light penetration to the understory by creating openings in the current nearly closed canopy forest with ecological thinning; while also recognizing that attention to detail is essential so to not induce or encourage invasive species;
- Provide supplemental seed sources; and understory planting;
- Reduce pressure from deer browsing to enhance shrub and groundcover survival by installing deer resistant fencing;
- Reduce competition from undesirable plants by implementing a invasive plant control program.

Fenced forestry plots that exclude white-tailed deer are an important component of the enhancement plan for the Hopatcong Switch site. Deer are a well-documented threat to forest structure in the northeast. High deer population numbers have significantly altered forest structure, function, and appearance. Deer browsing affects regeneration, abundance, and distribution of species, particularly in regenerating stands or those in early stages of succession, where the forest floor is open to sunlight. Minimizing the impact of deer requires either reducing the size of the deer herd or restricting its access to forest areas being regenerated.

FOREST ENHANCEMENT AREAS

The land area that is part of the forest enhancement site is approximately 60 acres excluding the proposed Hopatcong switch station and the existing and proposed transmission right of ways. There are four (4) forest enhancement locations that have been identified totaling 12-acres or 20% of the site as shown on the map on Appendix 1.

- **Area A** is approximately 3 acres. The site is located on a topographic rise with steep slopes that drop off the site. This is an oak dominated forest with mature Chestnut oak, Red oak and Scarlet oak as well as various oak, birch and hickory

saplings. Except for Black huckleberry, Mountain Laurel and Pennsylvania sedge, the understory is sparse and contains a very limited shrub layer.

- **Area B** is also approximately 3 acres. It contains Chestnut oak, Red Oak and Scarlet oak but the presence of these species in the understory is absent. A defined shrub and herbaceous layer is also absent from this site.

- **Area C** is largest of the restoration areas at approximately 4.5 acres. It contains mature larger trees of White, Red and Chestnut oak and a dense understory of Black birch, but a limited shrub layer. The site would also incorporate a small wetland and an ephemeral stream with Red maple and Sweet gum as the dominant trees.

- **Area D** is approximately 2.5 acres and contains mature Scarlet and Red oak and contains an existing seedling forest of Scarlet and Red oak with Serviceberry and Black huckleberry shrub layer. This area will be used as a control plot.

WETLANDS HABITAT MANAGEMENT AREA

- **Area E** is forested wetlands where the existing trees will be cleared since the trees will be located under the proposed conductors that will extend to the Hopatcong switch. Under the BPU rules, trees are not allowed to grow in this area since they could pose a threat to the conductors. Instead this area will be managed as a palustrine shrub/scrub and palustrine herbaceous wetland system. The proposed tree removal in forested wetlands will be conducted in accordance with the Freshwater Wetlands Protection Act Rules at N.J.A.C. 7:7A-1.1 et. Seq.

  The required clearing provides an opportunity to create numerous snags, a transient, but important wildlife habitat element. In this area, the trees will be topped at a height of 10 – 15 feet (providing the required clearance to the conductor is met). Following topping, the trees will be girdled and monitored to avoid sucker sprouts, in order to create standing snags to provide habitat for insects, bats, woodpeckers and bats and cavity nesting birds. Eventually the trees will collapse, or would be knocked down if they became a physical threat to the conductors. In this interim period, the proposed snags will create needed habitat elements compared to simply felling the trees at the base. The tops of these trees will also be arranged on the ground for other habitat needs such as cover for amphibians.

FOREST ENHANCEMENT TECHNIQUES

8.1 Prescription 1 - Ecological Thinning

Creating openings in the forest canopy should provide sufficient light and site preparation to establish a more diverse species mix, increase the age and size class distribution and improve forest habitat over time. Approximately 40 trees live per acre spaced approximately 33 feet apart will be selected for retention and a certain number of identified remaining trees will be felled or girdled. Selection of trees for retention will be prioritized in the following order:

- Crown height and width. Trees that have tall/spreading canopies will have a higher priority level for retention than trees with low and/or narrow canopies;
- Crown class. Dominant or codominant trees will be selected for retention over sub-dominant trees.
- Overall health/condition/structure of tree. Trees in good health and condition will have a higher priority level for retention than trees that are diseased, have poor structure or are leaning; unless these trees are also supportive of Indiana bats or would support other wildlife objectives.
- Vigor. Trees with no evidence of epicormic branching or other signs of stress will have a higher priority level for retention than trees that display evidence of stress;
- Cavity trees. Trees with cavities that are in otherwise good overall health will have a higher priority level for retention than trees lacking cavities;
- Diameter. Trees with greater diameter will have a higher priority level for retention than trees with lesser diameter;
- Spacing. Trees appropriately spaced will have a higher priority level for retention than trees closely spaced.
- Mast production. Trees that produce mast edible by multiple wildlife species will have a higher priority level for retention than trees that do not produce mast or trees that produce mast used by a lesser number of wildlife species. The publication *American Wildlife & Plants: A Guide to Wildlife Food Habits* (Martin *et al* 1961) will be used to determine the number of wildlife species that utilize each tree species.

All existing snags will be left in place. The existing shrub layer will be left intact except for invasive plants which will be cut to the base and the stumps treated with an appropriate herbicide. All logs and tops from tree falling will be retained in the treatment area to create habitat (brush piles or large woody debris) and return nutrients to the soil. All trees will be felled in a manner that avoids or minimizes damage to trees selected for retention. Approximately 75% of the trees to be removed will be felled and the remaining 25% of the trees to be removed will be girdled to provide standing snags and stagger the release of nutrients and organic matter contained in the standing biomass. Trees to be girdled will be selected to minimize potential impacts to trees selected for retention when they eventually fall. Trees to be girdled will be clearly marked in the field.

In locations with existing oak trees, it may be necessary to create a site disturbance to provide a mixed mineral-organic seedbed for oak forest canopy seedlings. This site disturbance can be created with rakes or a small tractor with a disking attachment, if appropriate. No soil disturbance will occur in areas containing invasive plants or where the forester indicates there is a likelihood that soil disturbance could allow the establishment of invasive plants. All equipment will be cleaned to remove any foreign soil and plant propagules before entering the work areas and after passing through known populations of invasive plants. Equipment cleaning will follow the techniques outlined in the United States Department of Agriculture Forest Service publication *Vehicle Cleaning Technology for Controlling the Spread of Noxious Weeds and Invasive Species* (2005).

The final boundaries of the treatment area will be verified in the field and will avoid freshwater wetlands, freshwater wetlands transition areas, riparian zones required under the Flood Hazard Area Control Act Rules. The layout of the treatment areas should be approximately square to minimize the amount of fencing needed (VerCauteren et al. 2006). However, the perimeter will be adjusted based on the ability to install fence posts around rocky sites, and if possible to avoid small topographic dips where fencing material would not be flush with the ground. The treatment perimeter will be clearly marked in the field before selecting trees for retention. All trees to be retained will be clearly marked in the field and tallied by DBH and species.

8.2 Prescription 2 – Provide Supplemental Seed Source

The potential for natural regeneration is limited by the availability of seed sources, the species composition of the treatment area and adjacent areas, site preparation, and microsite conditions. Many species of hardwoods will sprout and natural regeneration is expected in the treatment areas. Additional information regarding forest regeneration is available in Brose et al. (2009), Jacobs (2003), Miller et al. (1995), Morrissey et al. (2007), Pijut (2003) and Vodak (No Date). Accordingly, the goal of the supplemental seeding is to increase tree and shrub species diversity. Only indigenous non-invasive tree and shrub species will be used for supplemental planting. In support of Indiana bat habitat enhancement efforts, the trees from the table above under Section 5.0 shall be selected for planting. In addition, species to be planted will include white oak, northern red oak, yellow poplar, black cherry, flowering dogwood (*Cornus florida*), black gum (*Nyssa sylvatica*) and white ash (*Fraxinus americana*), persimmon (*Diospyros virginiana*), hickories (*Carya* spp), American beech (*Fagus grandifolia*) and other tree and shrub species which are adapted for site conditions, have relatively high wildlife value but may be currently in low abundance and/or had been suppressed by deer browsing. The final selection species for supplemental planting will be based also on existing species composition after ecological thinning, site conditions (e.g. amount of shade, slope, soils and aspect) and nursery availability.

A minimum of 222 seedlings, seeds or live acorns per acre will be planted. No more than 60 percent of the plantings will be acorns or other seeds (e.g. hickory nuts) and the remaining plantings will be seedlings obtained from the New Jersey State Forest

Nursery. At least 2 percent of the plantings will be conifers. All seeds will be stratified or otherwise pretreated to allow germination during the first growing season. Acorns/seedlings will be planted on a grid of approximately 14 feet by 14 feet and only where suitable sites (e.g. sufficient soil depth) are available. Seeds will be buried just below the soil and surface organics or duff. All seedlings shall be placed within seedling protectors or shelters. The bottom of the protectors or shelters should be below the soil surface to protect from voles or other small animals. Individual species will be distributed throughout the planting area to provide maximum diversity.

Seeding of plant material shall be in accordance with Appendix 4 and 6. Trees shall be planted in accordance with Appendix 5 - PSE&G Tree Planting Specifications.

Seedling, Acorn and Container Availability - Among other sources, bare root stock seedlings and acorns are available from the New Jersey Forest Service State Forest Nursery:

New Jersey State Forest Nursery
370 East Veterans Highway
Jackson, NJ 08527
732-928-0029 phone
732-928-4925 fax
www.ForestNursery.org

Their catalog and order form with prices (New Jersey State Forest Nursery 2009) is available at
www.state.nj.us/dep/parksandforests/forest/bw_2010_nursery_catalog.pdf.

For large seedling orders (approximately greater than 10,000 of an individual species) advance notification to the nursery is appropriate. Stratified acorns (i.e. acorns that have been kept in a cold, moist environment so that they are ready to sprout when planted) need about three months of cold storage; therefore, to be available for the spring or summer planting three or more months notice to the nursery is appropriate. Available acorns are anticipated to be northern red oak and white oak. However, white oak acorns will likely not be used because they sprout in the fall. After sprouting the acorns are susceptible to attack by various fungi and their success rate the following spring is very low (Joe Battersby, New Jersey State Forest Nursery, personal communication). Nursery orders are delivered to individual New Jersey Forest Service offices for pickup. The appropriate delivery office for this project is:

New Jersey Forest Service
240 Main St (Route 206 North)
Andover, Sussex County, NJ
973-786-5035

Container trees are available from several nurseries including:
Octoraro Native Plant Nursery
6126 Street Road

Kirkwood, PA 17536
717-529-3160
www.octoraro.com/

Conservation Seed is available from: See Appendix 6

Ernest Conservation Seed
9006 Mercer Pike, Meadville PA 16335
(800) 873-3321

8.3 Prescription 3 – Install Deer Resistant Fencing

Deer resistant fencing will be constructed around treatment areas A through D (see Appendix 2) and will be 8 feet high. A separate wire will be strung 2 feet above the top of the deer fencing to protect to a height of 10 feet. However, if available, deer fencing can be purchased in four foot rolls which are less expensive than 8 foot rolls. Crews can place the first four foot roll at the bottom and then the second four foot roll above the first. This can be easier, faster and less expensive to accomplish than trying to string 8 foot rolls. However, regardless which method is used, the total wire deer fence height will include a two foot wire so that the total height will be 10 feet at the completion as discussed above.

The bottom of the fencing will be installed flush against the ground so that deer cannot get under it. This will require weighting with logs or staking to keep the fence on the ground. The fencing perimeter will be located so that topographic dips that prevent the fence being flush with the ground are avoided.

Fence posts will be placed at least 1 foot into the ground and spaced approximately every 10 feet.

Fencing material will be of sufficient durability and hexagonal wire or equivalent so that deer cannot break through it, vandals cannot cut it with a knife, and it will last for a 10 to 15 year time period for the treatment areas with moderate monitoring and maintenance.

A gate with lock will be installed at each treatment area for human access.

Interpretive educational signage will be affixed to the fence every 100 feet alerting the reader that this fencing is in place to allow the development of more complex forest and ecosystem structure by excluding deer to prevent their killing young trees and shrubs. **See Appendix 6.**

Additional details on fencing installation are provided within Appendix 2. See also DeerFacts.org.

8.4 Prescription 4 - Invasive Plant Control

Increasing light penetration to the forest floor and limited soil disturbance are critical components to restoring and enhancing forest diversity and productivity. However, these activities also create opportunities for undesirable plants to become established. If left unchecked invasive plants and invasive species threaten the opportunities for project success. Prescribed forest management practices should not contribute to the expansion of invasive plants or be a contributing factor in their establishment. Prescribed practices must be modified or implemented in such a way to help control or prevent their proliferation or not contribute to their establishment.

Methods to prevent, detect and control invasive plants in the treatment areas are outlined below.

Prevention - All equipment and clothing will be cleaned to remove any foreign soil and plant propagules before entering the work areas and after passing through known populations of invasive plants. Equipment cleaning will follow the techniques outlined in the United States Department of Agriculture Forest Service publication *Vehicle Cleaning Technology for Controlling the Spread of Noxious Weeds and Invasive Species* (2005). No topsoil or plant materials containing invasive plant propagules will be permitted to be imported into the treatment areas. Seeds, bare root plant materials and stock grown indoors in sterile conditions will be selected over plant material grown outdoors and/or in soil. Where practicable existing populations of invasive plants will be excluded or removed from the treatment area before initiating treatment activities.

Detection – As described in Section 4.2 PSE&G will conduct baseline vegetation inventories to document existing conditions. Any extant populations of invasive plants will be documented and their status monitored throughout the treatment monitoring period. All treatment areas will be inspected at least once each season to determine the presence of any new invasive plant populations.

Control - Treatment measures will be developed to control any new or expanding invasive plant populations. Depending on the species and size of the population these measures may include hand pulling, covering with a light inhibiting barrier, and cutting and/or the appropriate application of an herbicide.

The following invasive species are the minimum that must be addressed if present.
See also the Central Jersey Invasive Species Strike Team recommendations at:
http://www.cjisst.org/pdf/CJISST_AllFactSheets.pdf

Common Name	Scientific Name	Plant type
Norway maple	*Acer platanoides*	Tree
Tree of Heaven	*Ailanthus altissima*	Tree
Winged spindle tree	*Euonymus alata*	Tree
Japanese barberry	*Berberis thunbergii*	Shrub
Oriental bittersweet	*Celastrus orbiculata*	Shrub
Autumn olive	*Elaeagnus umbellata var. parvifolia*	Shrub
Honeysuckle	*Lonicera spp.*	Shrub
Multiflora rose	*Rosa multiflora*	Shrub
Wineberry	*Rubus phoenicolasius*	Shrub
Common buckthorn	*Rhamnus cathartica*	Shrub
Garlic mustard	*Alliaria petiolata*	Herb
Japanese knotweed	*Polygonum cuspidatum*	Herb
Japanese stiltgrass	*Microstegium vimineum*	Herb
Porcelain berry	*Ampelopsis brevipedunculata*	Herb
Mile-a-minute weed	*Polygonum perfoliatum L*	Herb
Chinese and Japanese wisteria	*Wisteria sinensis; Wisteria floribunda*	Herb
Lesser celandine	*Ranunculus ficaria*	Herb
Purple loosestrife	*Lythrum salicaria*	Herb
Giant hogweed	*Heracleum mantegassianum*	Herb
Common reed	*Phragmites australis*	Herb

8.5 Forest Enhancement Control Table

Forest Restoration Area	1 Prescribed Thinning	2 Supplemental Seeding	3 Deer Fence Exclosure	4 Nox Plant Control	Comments
A	**Yes**	**Yes**	**Yes**	**Yes**	**Topo relief**
B	**Yes**	**Yes**	**Yes**	**Yes**	**Proximity to access road**
C	**Yes**	**Yes**	**Yes**	**Yes**	**Wetlands Habitat Enhancement**
D	**No**	**No**	**Yes**	**No**	**Control Plot**

8.6 Success Criteria and Monitoring

Natural regeneration, seedling survival, and acorn success is expected to be good if the deer fencing is maintained. The criterion for success is the survival of over 50% of the tree seedlings per acre after one year and after 3 years. These tree seedlings may be from planting or natural regeneration. To determine if this goal is met one permanent plot will be established in each of treatment areas A through D. Each permanent plot will be 1/50 of an acre in size which equates to a 16.65 foot radius. The permanent plot location will be randomly chosen within the treatment area. However, once the plot location is randomly determined its center should be moved so that the center is located midway between the two nearest trees selected for retention. In this manner the plot will be located the maximum distance from trees to be retained in areas with the least potential shading. The plot center should be permanently located with rebar or similar permanent stake driven into the ground with its top painted so that it is readily visible. Information on how to find the plot location should also be recorded so it can be readily relocated (e.g. GPS coordinates and/or recording an azimuth and distance from the treatment area gate). The techniques applied to the baseline vegetation inventory should be at a minimum repeated at the end of the treatment period to document changes in forest structure and diversity.

The permanent plot data will be recorded three times: immediately after planting, after year one and after year three. The goal is to have 50% or at least 100 seedlings per acre from planting or natural regeneration living after year one and after year three (as indicated by expanding the plot data to the full treatment area size). If these goals are not met then new planting may be initiated to meet these goals and the specific reasons for not meeting this goal will be documented, such as a prolonged drought. The permanent plots should also be sampled after 5 years to document the condition at that time. Additional planting at this time is not required because sufficient growth of retention trees, planted seedlings and natural regeneration is expected to be such that newly planted seedlings would be outcompeted and have little chance of survival.

Deer fencing should be monitored at least once per season for the first five years and repaired as needed to exclude deer. This monitoring and repair should include areas where the fencing is not flush with the ground and that allow deer entry. Signage should also be monitored and replaced when removed or unreadable to maintain public awareness of the fencing's purpose. Deer fencing may not need to be maintained once the interior planted or natural regeneration trees have reached a height of 10 feet and which will therefore no longer be subject to browsing by deer. It is expected that the interior vegetation will reach these heights in approximately 8 to 10 years.

9.0 REFERENCES

Brose, P.H. and nine others. 2009. Prescribing regeneration treatments for mixed-oak forests in the Mid-Atlantic Region. USDA Forest Service Northern Research Station General Technical Report NRS-33, 100pp. Available at: www.nrs.fs.fed.us/pubs/8561

DeerFacts.org. 2009. Deer exclosures – a comprehensive practical guide. 16pp. Available at http://deerfacts.org/ and http://deerfacts.org/index.php?option=com_content&view=article&id=54:exclosurereport&catid=37:deerexclosures&Itemid=53

Highlands Water Protection and Planning Council. 2008. Regional Master Plan. 463pp. Available at: www.highlands.state.nj.us/njhighlands/master/index.html

Jacobs, D.F. 2003. Nursery production of hardwood seedlings. Northern Research Station USDA Forest Service, Department of Forestry and Natural Resources, Purdue University, FNR-212, 8pp. Available at: www.ces.purdue.edu/extmedia/FNR/FNR-212.pdf

Kochenderfer, J.N., M.B. Adams, G.W. Miller and F. Wood. 2006. Growth and development of planted northern red oak on bulldozed skidroads after clearcutting in Appalachian hardwoods. USDA Forest Service Northeaster Research Station Research Paper NE-730, 16pp.

Miller, G.W., P.H. Wood and J.V. Nichols. 1995. Two-age silviculture – an innovative tool for enhancing species diversity and vertical structure in Appalachian hardwoods. In: L.G. Eskew, comp. Forest health through silviculture: proceedings of the 1995 National Silviculture Workshop, Mescalero, New Mexico, May 8-11, 1995. USDA Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-GTR-267. Pp. 175-182. Available at: www.treesearch.fs.fed.us/pubs/23499

Morrissey, R.C., J. Seifert, N. King and M. Selig. 2007. Enrichment planting of oaks. Planting and Care of Fine Hardwood Seedlings. Northern Research Station USDA Forest Service, Department of Forestry and Natural Resources, Purdue University, FNR-225, 8pp. Available at: www.ces.purdue.edu/extmedia/fnr/fnr-225.pdf

New Jersey Agricultural Extension Service. No Date. Native trees and shrubs for riparian forest buffers. Available at: http://njaes.rutgers.edu/njriparianforestbuffers/nativeHIGHLANDS.htm

New Jersey Bureau of Forest Management. 1995. New Jersey Forestry and Wetlands Best Management Practices Manual. 31pp. Available at: www.state.nj.us/dep/parksandforests/forest/nj_bmp_manual1995.pdf

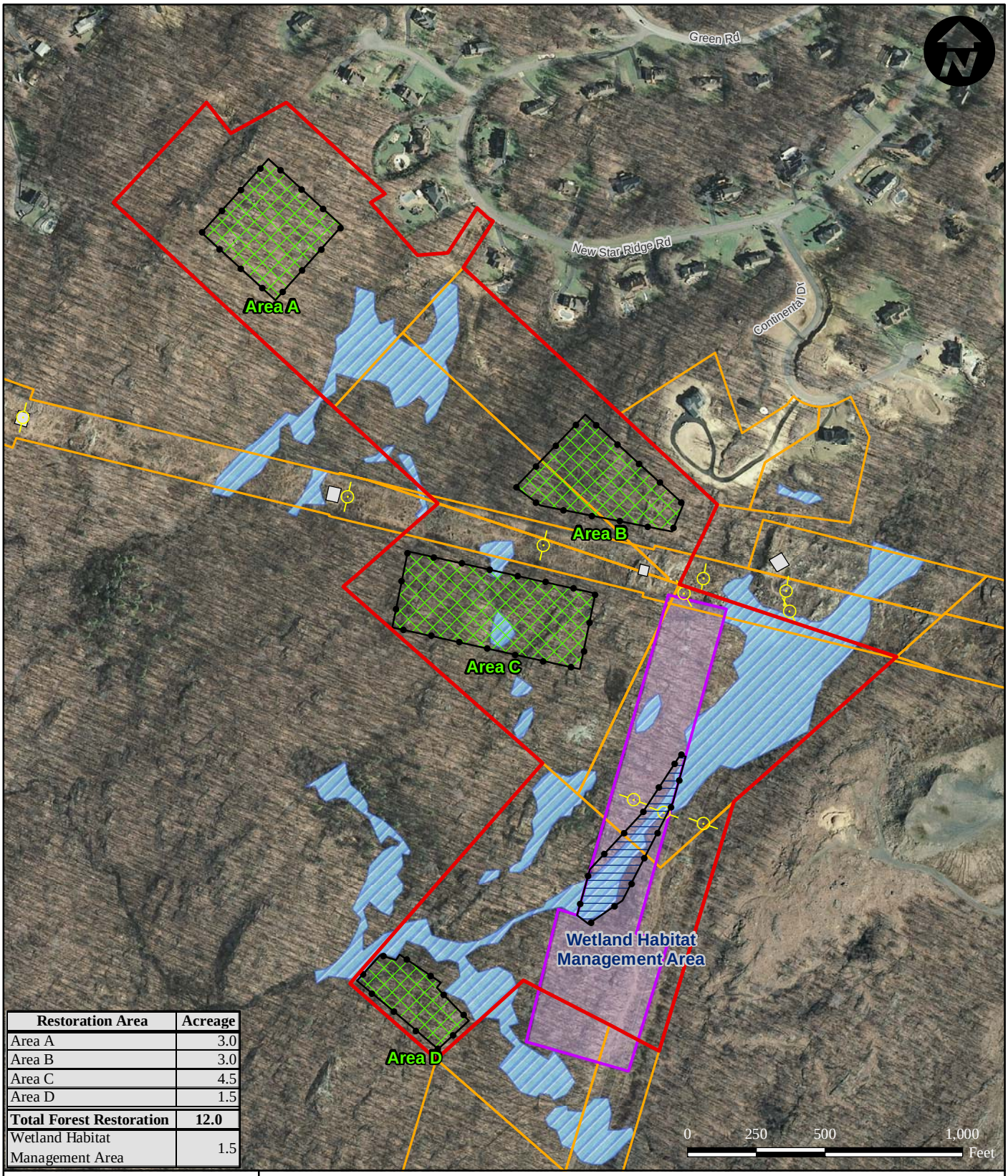
New Jersey State Forest Nursery. 2009. Tree seedling catalog 2010. New Jersey Forest Service, Division of Parks and Forestry, Department of Environmental Conservation, 4pp. Available at: www.state.nj.us/dep/parksandforests/forest/bw_2010_nursery_catalog.pdf

Pijut, P.M. 2003. Planting hardwood seedlings in the central hardwood region. Northern Research Station USDA Forest Service, Department of Forestry and Natural Resources, Purdue University, FNR-210, 8pp. Available at: www.ces.purdue.edu/extmedia/FNR/FNR-210.pdf

VerCauteren, K.C., M.J. Lavelle and S. Hygnstrom. 2006. Fences and deer-damage management: a review of designs and efficiency. Wildlife Society Bulletin v 34, 191-200. Available at: www.deerfacts.org/index.php?option=com_content&view=article&id=55:exclosurerefs&catid=37:deerexclosures&Itemid=53

Vodak, M.C. No Date. Reforestation and Forest Tree Planting: Guidelines for New Jersey. Cooperative Extension Service, Cook College, Rutgers University, 13pp.

Appendix 1: Hopatcong Forest Restoration Areas



Restoration Area	Acreage
Area A	3.0
Area B	3.0
Area C	4.5
Area D	1.5
Total Forest Restoration	**12.0**
Wetland Habitat Management Area	1.5

Legend

- Forest Management Area
- Forest Restoration Areas
- Wetland Habitat Management Area
- Proposed Towers
- Existing Towers
- Existing ROW
- Delineated Wetlands
- Proposed Hopatcong Switch Area

Base map features from PSE&G, 2009-2010.
ESRI StreetMap USA, 2007.
Aerial Imagery from NJOIT, Office of GIS, flown 4/22/07.

FOREST RESTORATION AREAS

Susquehanna-Roseland Comprehensive Mitigation Plan
Hopatcong Borough & Sparta Township,
Sussex County, New Jersey

PSE&G TRANSMISSION ENGINEERING DEPARTMENT

Drawn By: JA	Scale: 1" = 500'	Project No. 01315.071.030
Chk'd By: PD	Date: 8/30/10	Figure No. 1

Map Document: (P:\01315\071\Y\N\Maps\Hopatcong_SwitchingStation\Fig_ForestManagementPlan_082710_01.mxd)
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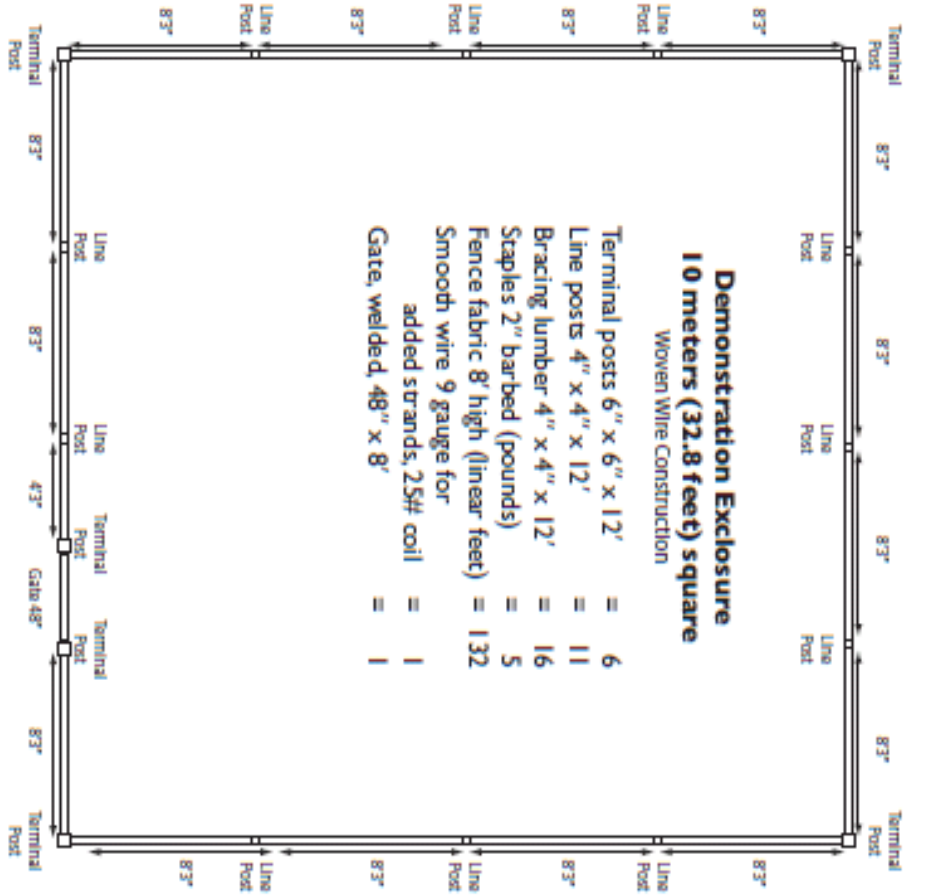
Appendix 2: Representative Deer Fence Exclosure Detail



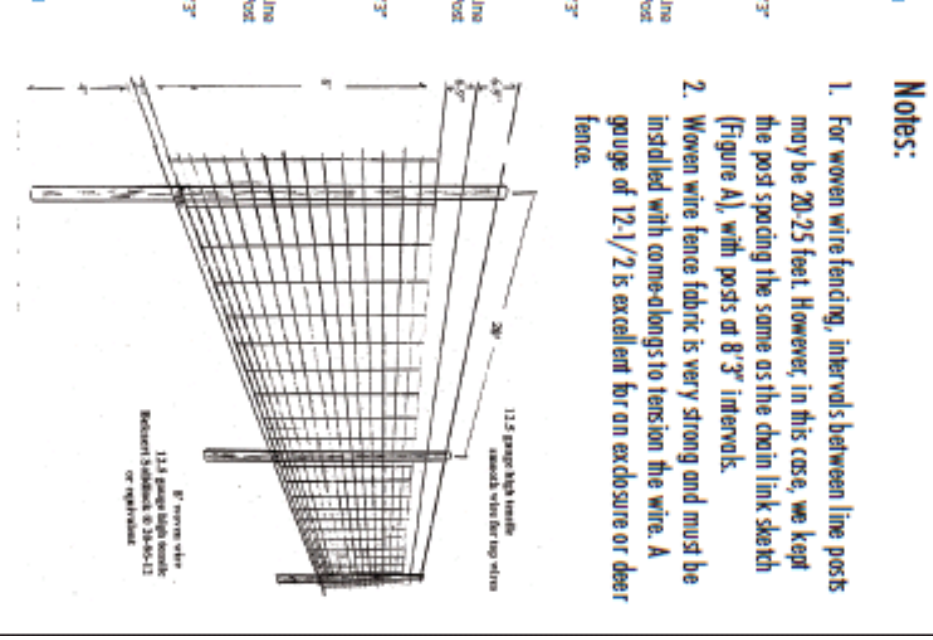


Figure B: Sketch of an exclosure with woven wire construction. Scale approximate. Materials list is for illustration only, and minor items may be omitted. Specifications call for an 8-foot fence fabric height, topped with 2-3 strands of smooth wire, raising the total height to nearly 10 feet. Woven wire construction is relatively expensive compared to other methods, but can be expected to last 20-30 years. Inset diagram is from Minnesota, where guidelines call for posts to be sunk 4 feet into the ground.

Deer Exclosures

A Comprehensive Practical Guide

prepared for
DeerFacts.org
June 2009

Introduction: This report is intended to give a very complete range of options for anyone who is contemplating the construction of a deer exclosure for demonstration or scientific study purposes. It also may be of value for anyone who is searching for ways to exclude deer from a yard, a field or a forest.

Photo courtesy Natural Resource Consultants, Inc.

Photo 1: View straddling the fence of a large exclosure in Pennsylvania. Healthy and diverse plants are on the right, where the deer cannot browse. On the left is a monoculture of ferns (usually hayscented ferns), found in thousands of acres of Pennsylvania woodlands. Fence is of woven wire fabric. Note the 2 x 4 lumber between the fence material and the tree, center.

I. Definition

A deer exclosure is an area, usually of forest floor, surrounded by fencing that keeps deer out, but allows virtually every other animal to enter. There is no rule about how big an area must be fenced, so some exclosures cover many acres. A small demonstration exclosure can be nominally 10 meters square (33 feet square). An exclosure for scientific study may be slightly larger, at 23 to 25 meters square (75 to 82 feet).

An exclosure *can* show effects in just a year or two, but displays its maximum effect within about six years, depending on local placement and conditions. It may be expected to remain in place for 10 to 30 years.

At some point, the distinction between an exclosure and "fencing" becomes merely semantic, so that farmers, foresters—and homeowners with yards to protect—can all benefit from knowing the techniques of exclosure construction.

II. History

The word "exclosure" has been in the dictionary since 1920, and there are exclosures that were created in 1936 that are still in existence today. In the early days of exclosures, the aim often was to keep grazing animals such as cattle or sheep out of an area so that scientists could study the grasslands. Since the late 1940s, exclosures increasingly have been used to keep out ruminant animals such as deer and elk.

Photo 2: An exclosure fence (chain link) in British Columbia. The deer species is different there (black-tailed deer) but the damage being done to the forest by deer overbrowsing is the same as in the eastern U.S., where the dominant large mammal is the white-tailed deer.

III. Functions and Benefits

A. Demonstration

Even a small deer exclosure serves as a dramatic practical illustration of the effect of deer overbrowsing on a local woodland. "A picture is worth a thousand words." Outside the fence, the full effects of deer overbrowsing remain evident. Within about a year after a deer exclosure is built, numerous herbaceous plants may begin to appear inside. After two to five years, the exclosure begins to show the full range of herbaceous and

CT DEP

Photo 3: A very small exclosure made with cedar posts and woven wire fabric was built by the CT DEP in 1995 at Bluff Point, CT in an area of very high levels of deer overpopulation (more than 100 deer per square mile). The inside and outside look the same—very overbrowsed.

CT DEP

Photo 4: In 2000, the deer had remained overabundant, and the difference inside and outside the exclosure was striking. Shortly after this photo, the deer population was reduced to about 10 deer per square mile (the threshold density to help prevent Lyme disease).

Photo 5: In 2005, the areas inside and outside the exclosure were teeming with plant life. The deer density had been maintained at about 10 per square mile. (Photos courtesy of CT DEP, from "Managing Urban Deer in Connecticut," by Howard Kilpatrick.)

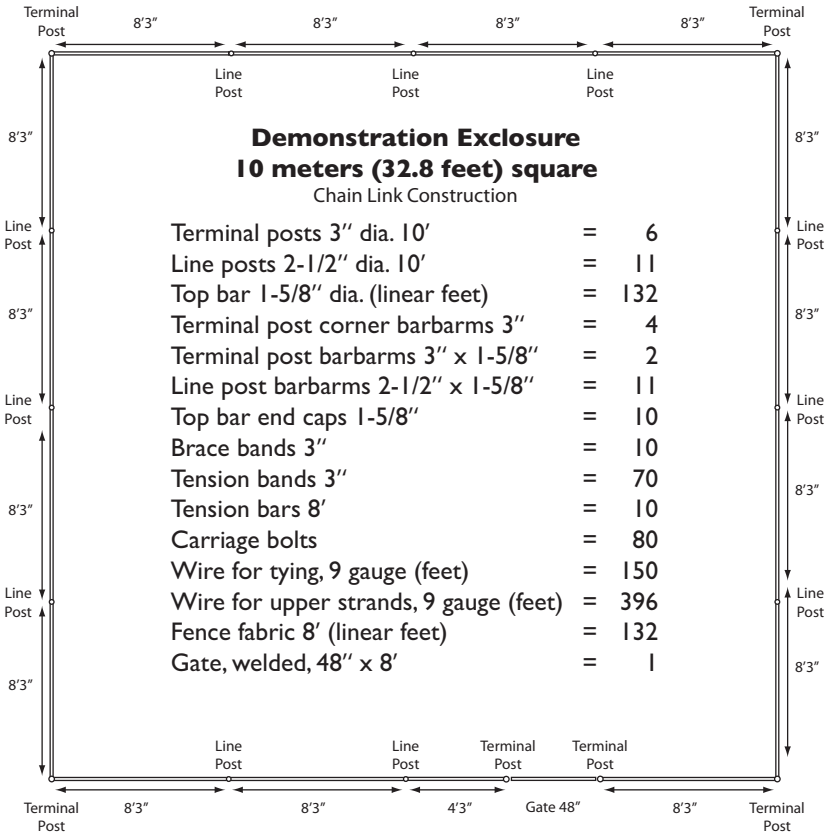
woody plants, along with habitat for small animals and songbirds. There may be seedlings from the taller trees above, clearly indicating that this forest could regenerate, if given the necessary conditions.

B. Ecological Studies

Exclosures offer a large benefit in scientific studies that may be conducted by foresters, botanists, biologists and ecologists, etc. These scientists often take a detailed inventory of all the plant life inside an exclosure, as well as in an equivalent unprotected plot outside the exclosure.

C. Flora Vault

In some locations, deer exclosures are used to provide a safe haven or repository for valued species of native plants, awaiting a time when the deer population might come under control, so that these protected plants can be used to repopulate areas that otherwise would become "deer savannahs." When a forest is overbrowsed for a very long period, it can lose its



Notes:

1. For chain link fencing, the rule of thumb is that line posts should be spaced no greater than 10 feet apart. For esthetics, divide the span into equal parts to determine line post spacing. In this case, three posts at 8′3″ intervals yield a 33-foot span, just slightly over the goal of 32.8 feet (10 meters).
2. Chain link fence fabric for residential use generally comes in gauges from 9 to about 12 (heaviest to lightest). A gauge of 11 or 11-1/2 is excellent for an exclosure or deer fence.
3. Terminal posts of 3″ at the corners and gates, and 2-1/2″ as line posts, are amply strong, as are top rails of 1-5/8″. Some suppliers use a lot lighter materials. For instance, Lowes or Home Depot may only offer posts of 2-3/8″ and top bars- of 1-3/8″. These are acceptable substitutes. However, all of the fittings, such as top bar end caps, loop caps, etc., must be re-specified to conform with these substitutions.
4. Using loop caps with "barb arms," and adding several strands of barbed or smooth wire, the fence height can be extended to 9 or 10 feet.

Figure A: Sketch of an exclosure with chain link construction. Scale approximate. Materials list is for illustration only, and minor items may be omitted. Specifications call for an 8-foot fence fabric height, topped with "barbarms" where strands of smooth wire will the strung, raising the total height to nearly 10 feet. Chain link construction is the most expensive compared to other methods, but can be expected to last at least 30 years.

potential to regenerate, especially since invasive species of plants may cover the forest floor. As the canopy of older trees matures and dies, there is no forest understory to replace it.

Photo 6: Homeowner has combined an ornamental fence and stone wall, with a heavy-duty plastic deer netting fence hung on black steel posts. Fence fabric is nearly invisible from the street.

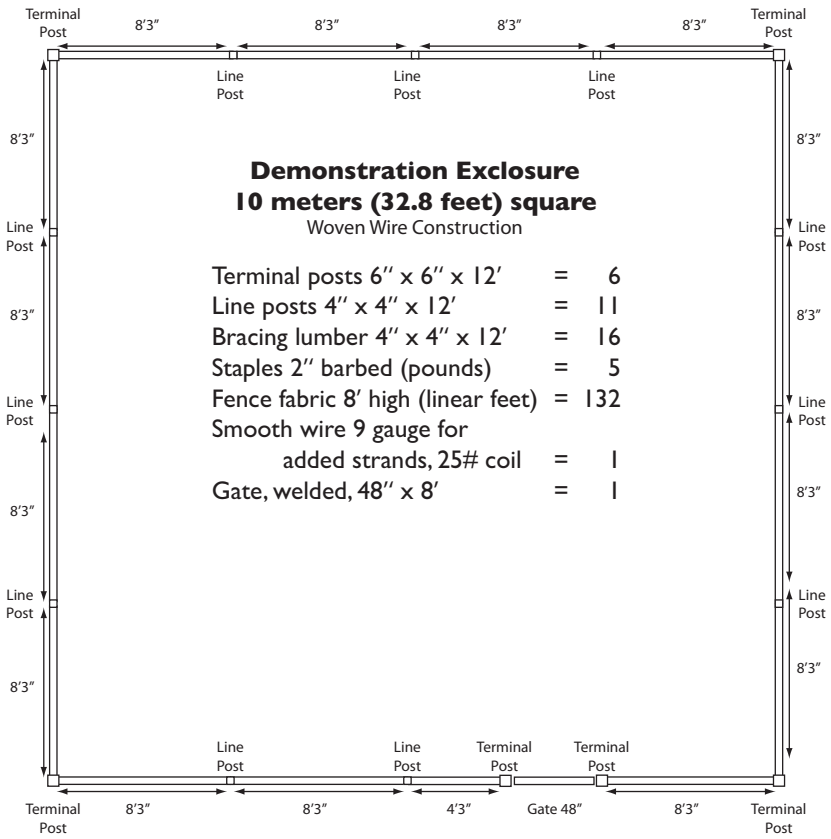
D. Commercial and Open Space Objectives

In large and very large exclosures, so long as the deer are kept out, there is the potential to achieve a fully viable new forest. This may have commercial uses, such as sustainable forestry. It is also a way to preserve an area of woodland such as a municipal or state park. Such a forest can also sustain a smaller population of deer (e.g., at a density of about 5 to 10 deer per square mile) without ill effect, as long as the deer population is not neglected, but managed to prevent uncontrolled growth of the herd.

Photo 7: Side yard treatment (not seen by general public) gives a homeowner access via a simple gate. Heavy-duty plastic deer netting is on left, light duty netting is on gate. Tree at right serves as one post for netting.

E. Gauge of Deer Density

In certain cases, deer exclosures can also be used to assess and estimate deer densities, by comparison of flora with areas of known deer densities. As a mere "litmus test," if the forest floor achieves the same plant mixtures and species inside and outside the exclosure, this is proof of successful deer management. (There may still be deer living in the forest, but they are not at sufficient density so as to significantly damage the understory.)



Notes:

1. For woven wire fencing, intervals between line posts may be 20-25 feet. However, in this case, we kept the post spacing the same as the chain link sketch (Figure A), with posts at 8'3" intervals.
2. Woven wire fence fabric is very strong and must be installed with come-alongs to tension the wire. A gauge of 12-1/2 is excellent for an exclosure or deer fence.

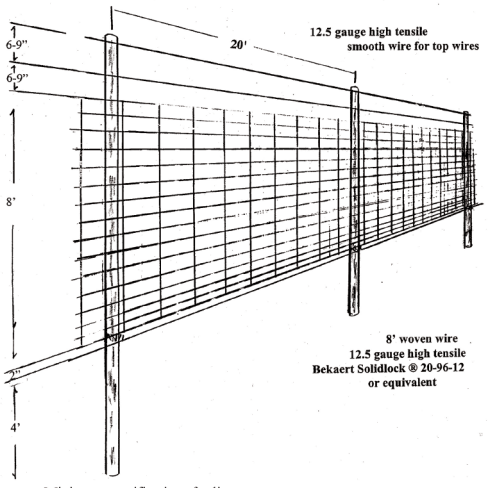


Figure B: Sketch of an exclosure with woven wire construction. Scale approximate. Materials list is for illustration only, and minor items may be omitted. Specifications call for an 8-foot fence fabric height, topped with 2-3 strands of smooth wire, raising the total height to nearly 10 feet. Woven wire construction is relatively expensive compared to other methods, but can be expected to last 20-30 years. Inset diagram is from Minnesota, where guidelines call for posts to be sunk 4 feet into the ground.

F. Habitat for Other Species

An exclosure offers the potential to provide habitat for endangered species of birds, small animals and native flora. The larger the exclosure area, the more songbirds and wildflowers will be seen.

IV. General Specifications

A. Siting

An exclosure for demonstration purposes can be situated on a forest floor, taking care to have the exclosure's space be substantially the same as the surrounding space, so that initially there is no difference between the enclosed area and the surrounding area. The optimum spot may be an area that permits some sunlight on the forest floor (as opposed to a dense unbroken canopy). One rule of thumb is about 25 percent sunlight, but there are no strict standards. The forest may be deciduous, coniferous, or mixed. For study purposes, it is advantageous to mark with stakes an unprotected plot nearby that is exactly equivalent to the protected plot.

Rough Cost Comparison

(10 meter square exclosure with gate)

Light Duty Plastic Netting

Item	No.	Cost	Extension
Line and terminal posts, 9' angle steel	16	$9.95	$159.20
Bracing posts for terminals	8	$9.95	$79.60
Deer netting 7.5' 100-foot rolls	2	$59.95	$119.90
Hog ring pliers	1	$99.95	$99.95
Hog rings (1000)	1	$9.95	$9.95
Monofilament line 11 ga Spool 500'	1	$39.98	$39.98
Top wire tensioning spool	4	$1.95	$7.80
Tensioning spool handle	1	$9.95	$9.95
Ground stakes for bottom edge 12"	30	$0.65	$19.49
Hardware for "gate" (snaps)	5	$4.99	$24.95
TOTAL			**$570.77**

Heavy Duty Plastic Netting

Item	No.	Cost	Extension
Line and terminal posts, 9' angle steel	16	$9.95	$159.20
Bracing posts for terminals	8	$9.95	$79.60
Deer fencing C-flex 7.5' 100-foot rolls	2	$88.35	$176.70
Hog ring pliers	1	$99.95	$99.95
Hog rings (1000)	1	$9.95	$9.95
PVC coated wire 9 gauge, roll	1	$58.25	$58.25
Top wire tensioning spool	4	$1.95	$7.80
Tensioning spool handle	1	$9.95	$9.95
Ground stakes for bottom edge 18"	20	$2.00	$40.00
Hardware for "gate" (snaps)	5	$4.99	$24.95
TOTAL			**$666.35**

Hexagonal Wire Mesh

Item	No.	Cost	Extension
Line and terminal posts, 9' angle steel	16	$9.95	$159.20
Bracing posts for terminals	8	$9.95	$79.60
Vinyl coated hex wire fabric 8' x 100' roll	2	$225.00	$450.00
Hog ring pliers	1	$99.95	$99.95
Hog rings (1000)	1	$9.95	$9.95
PVC coated wire 9 gauge, 25# coil	1	$58.25	$58.25
Top wire tensioning spool	4	$1.95	$7.80
Tensioning spool handle	1	$9.95	$9.95
Ground stakes for bottom edge 18"	20	$2.00	$40.00
Gate 4' x 8'	1	$153.60	$153.60
TOTAL			**$1,068.30**

Woven Wire

Item	No.	Cost	Extension
Terminal posts 6 x 6 x 12' PT	6	$32.97	$197.82
Line posts 4 x 4 x 12' PT	11	$13.97	$153.67
Bracing lumber 4 x 4 x 12' PT	16	$13.97	$223.52
Woven wire 20/96/6 roll 330'	1	$534.95	$534.95
Staples 2" barbed, pounds	5	$1.40	$7.00
PVC coated wire 9 gauge, 25# coil	1	$58.25	$58.25
Gate, welded 48" x 8'	1	$153.60	$153.60
TOTAL			**$1,328.81**

Chain Link

Item	No.	Cost	Extension
Terminal posts 3" dia. 10'	6	$47.52	$285.12
Line posts 2-1/2" dia. 10'	11	$34.95	$384.45
Top bar 1-5/8" dia. swedged, 21' lengths	7	$39.44	$276.08
Terminal post corner barbarms 3"	4	$14.21	$56.84
Terminal post line barbarms 3" x 1-5.8"	2	$12.32	$24.64
Line post barbarms 2-1/2" x 1-5/8	11	$6.62	$72.82
Top bar end cups 1-5/8"	10	$2.09	$20.90
Brace bands 3 "	10	$0.68	$6.80
Brace bands 2 "	22	$0.59	$12.98
Tension bands 3"	70	$0.62	$43.40
Tension bars 8'	10	$5.07	$50.70
Carriage bolts	80	$0.41	$32.80
Tension wire 7-gauge, roll 1,000'	1	$146.11	$146.11
Fence fabric 8' 11-gauge, rolls 50'	3	$213.75	$641.25
Gate, welded, 36" x 8'	1	$153.60	$153.60
TOTAL			**$2,208.49**

Notes:

1. Lists and prices are for illustration only: lists may not be complete; minor parts may have been omitted. Plan your own exclosure and confirm materals lists and prices with your own supplier.
2. No labor is included in any of these estimates.
3. Shipping, handling, taxes are not included in any of these estimates.
4. Materials specified are amply sufficient or even excessive, so substitutions can be made. For instance, line post spacing may be increased in several of the construction methods.

Figure C: Rough cost estimates for five methods of exclosure construction. Materials lists and prices are for illustration purposes only. Careful shopping will undoubtedly yield better prices than are listed here. Some figures represent significant over-purchasing. For instance, the woven wire roll at 330 feet is very excessive, but we could not find a supplier who will sell shorter lengths. (A local fence supplier-installer will surely make an adjustment for this.)

B. Area

There is no rule dictating how much area must be enclosed, but a nominal size for a small demonstration deer exclosure is 10 meters square (32.8 feet square). One source recommends that if areas bigger than 70 acres must be fenced, the areas should be split into 70-acre parcels, with unfenced lanes in between that allow the deer to travel through. In the Fairfield County area, an exclosure size of 23 meters square (75 feet square) to 25 meters (82 feet) can be used in scientific studies, if desired. A 25-meter square is about one-seventh of an acre.

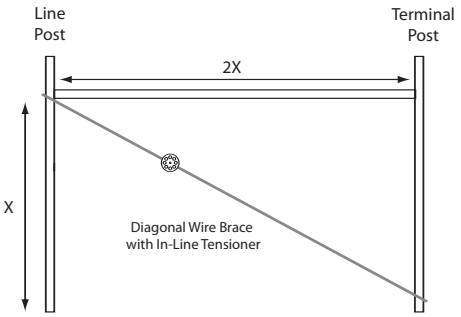


Figure D: The method known as "H-bracing," using a horizontal piece of lumber. A diagonal brace wire with a tensioner device is usually added.

Photo 8: In-line tensioning device known as a "strainer" keeps the diagonal brace wire tight, and allows for later adjustment.

For a number of different types of fencing fabric, such as woven wire or chain link, the standard rolls may be 168 feet or 330 feet in length. This affords a very efficient use of one or two rolls to make a 25-meter exclosure (perimeter of 328 feet), and a single roll of 168 feet is ample for a 10-meter exclosure (perimeter of 132 feet) with material left over.

C. Shape

A rectangle is certainly acceptable as a shape for an exclosure, but a square has the advantage of the shortest perimeter, for any given area. (A circle would yield an even smaller perimeter, but most exclosures gain strength from having corners with extra bracing.)

D. Height

Most experts recommend a fence height of eight feet, and this is surely sufficient for a small exclosure. In large exclosures, some experts recommend a height of 10 feet, and certain subsidies (e.g., U. S. Department of Agriculture) only apply to 10-foot fencing. Deer can jump vertically more than 9 feet, but are very unlikely to try to jump into a 10 x 10 meter exclosure that is at least 8 feet high. Indeed, one study found that they do not jump into very small exclosures (e.g., 3-5 meters square) with only 6-foot fencing. (But mature deer can easily jump a 4- or 5-foot fence from a standstill.)

Photo 9: Light duty plastic deer netting is sold at stores such as Home Depot or Lowes. It may be suitable for residential use, with constant monitoring.

E. Fencing Fabric

Fencing material can be purchased in many gauges and grades, grossly divided into plastics and metals. The least costly is a plastic mesh, and this has sub-levels of quality and strength. Somewhat more expensive is welded-wire, woven wire, or fixed knot fabric. Usually the most expensive is chain link. Plastic fencing is more susceptible to rodent damage and vandalism than the wire or chain link fabrics.

This report will cover a selection of five of these materials, but some of the references will identify more than a dozen levels of quality, strength and durability.

Note: Various forms of smooth-wire fencing, including slant-wire and electric fencing, will only briefly be mentioned in this report. While they may be suitable for some situations, certain drawbacks, such as the risk of electric shock to small children, make them undesirable for demonstration exclosures and most residential fencing situations.

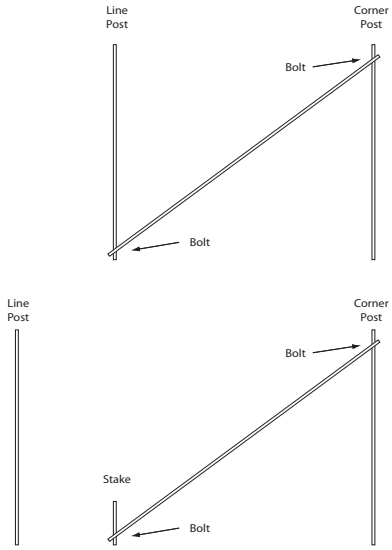


Figure E: Two examples of "N-bracing," or diagonal bracing. In top illustration, the diagonal joins the terminal post and neighboring line post. In bottom illustration, a stake is used at the foot of the diagonal brace.

F. Fence posts

The post materials and specifications will vary with the exclosure and locally available materials. Most small exclosures are free-standing, but larger exclosures may employ existing trees as posts. Some exclosures with plastic mesh fabric may be built with steel bar ("rebar") posts, or stamped metal posts called T-posts or U-posts. More common are wooden posts, usually 6 x 6 and 4 x 4, pressure-treated. It is important that wood posts sunk into the ground be pressure-treated, or be made of a rot-resistant wood

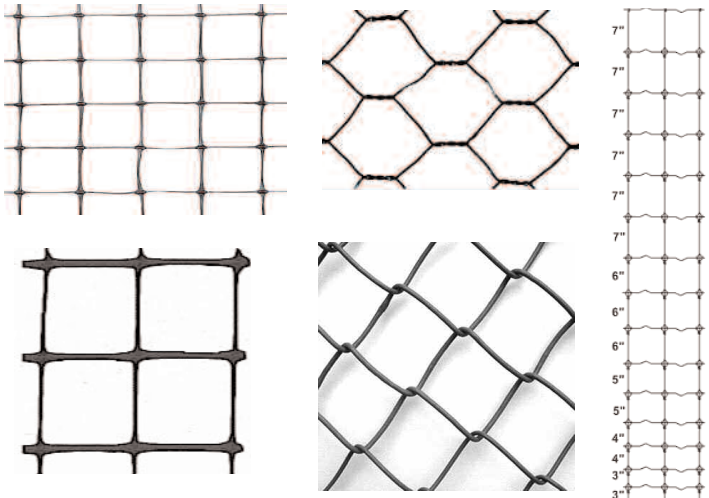


Figure F: A gallery of deer fencing fabric choices. Left column is light-duty plastic netting, top, and heavy-duty plastic netting, bottom. Middle column is hexagonal wire mesh, top, and chain link, bottom. At right is graduated woven wire.

species. For this reason, thick cedar poles are often used in fencing and in exclosures when a rustic-looking post is desired.

For an 8-foot fence height, the posts should be a minimum of 10 feet in length, allowing for about two feet to be sunk into the ground. However, a better design would be 12-foot posts, sunk 30 to 36 inches into the ground. With chain link fencing, it is customary to use steel posts.

There are two general types of posts, depending on whether they are along the line of the fencing ("line posts") or at the corners and gates ("terminal posts"). In chain link construction, for instance, terminal posts are usually 3 inches in diameter, while the line posts may be 2-3/8, 2 or even 1-7/8 inches.

Where lumber is used, the terminal posts may be 6 x 6, while the line posts are 4 x 4. Often, large exclosures may use available trees as posts (healthy trees at least six inches in diameter at breast height), with a 2 x 4 length of lumber sandwiched between the fence material and the tree.

At corners, it is customary to brace the posts in one of several ways. There is horizontal, or "H-bracing," as well as diagonal or "N-bracing." At times cable bracing may be used to substitute for, or supplement, these bracing methods. Chain link fencing is considered to be braced throughout because it usually has a top bar.

G. Foundation

Any of the post materials can be used to set posts into holes dug by a post-hole digger or auger. "Rebar," "T-posts" and "U-posts" can also be driven into the ground. Optionally, any of the post materials may be set into cement or concrete footers. When using concrete, it is customary to dig the hole and then expand its lower part to become wider than the upper, so that the footing makes a firmer base. In practical fence-building, however, the concrete is often omitted. The common method uses a truck- or tractor-mounted device known as a post-pounder. This can drive either wooden or metal posts (even in rocky New England), and no foundation is required. For T-posts, U-posts and angle steel, there is a hand-operated version of the post-pounder.

H. Gate

A gate is optional, but generally, a single-walk (single-leaf) gate of about 3-4 feet in width, and as high as the fencing material, is appropriate. If the exclosure is near heavily trafficked areas, the gate should have a secure and weather-proof lock, such as a padlock and chain. The gate permits periodic counting of the species of plants that may be found inside the exclosure. The fencing posts in the area of the gate need to be braced, with either H-bracing or N-bracing, or with a top brace ("header") crossing above the gate. Gates may be built of wood or steel and typically are covered with the same fence fabric as the rest of the exclosure.

I. Access for Small Animals

The aim of an exclosure is to exclude deer but allow as many small woodland animals as possible to enter. Typically, plastic mesh fencing must be brought down to the ground level (and sometimes held down by logs or metal stakes) in order to keep deer from crawling under, and the typical mesh size may prevent some small animals from going through. Therefore, small "door flaps" may be cut approximately every 20 feet in the bottom edge of the plastic fencing. With woven wire or welded-wire fencing material, there may be graduated meshes or a single mesh size. (With graduated mesh, the small openings should be positioned at the bottom.) Sometimes a bottom tension wire or even barbed wire can be added to keep deer from crawling under the fence. With chain link fencing, there may be a bottom rail for strength, with a gap underneath it of about four inches above the ground.

With all of the metal fabric fencing materials, there is an optional technique, recommended by some experts, for folding the bottom edge outward and even burying it, in order to defeat animals that may try to dig under.

V. Installation (Do-It-Yourself or Professional?)

Installation of most of the plastic and some of the metal fabric fencing is within the capabilities of homeowners, civic groups (such as Boy Scout or Girl Scout troops), or other non-professionals. However, as the fencing material moves upward in weight and strength, it becomes more and more advisable to engage a team of professional installers.

There is a very large difference between the weight of the lighter plastic materials and the heavier metal materials. For instance, rolls of the thinnest, lightest plastic fencing mesh may weigh less than 40 pounds, but rolls of chain link fencing can weigh nearly 400 pounds. The weight of fence posts, rails and other items follows the same upward trend.

Most fence fabric materials, when properly installed, require a substantial amount of tensioning. The lighter materials may require only a top wire to be tensioned with hand tools, but for the heavier fencing fabrics, strong pulling gear may be required, such as hand winches (come-alongs) or powered winches. A woven-wire or chain link fence may need hundreds of pounds of tension.

Photos 10-12: **Specialized equipment helps professional fence installers do a better job, faster. At left, a powered auger digs a post hole. Center, a post-pounder from Beem Fence Company (Lake City, MI) can drive wood or metal posts, 40 per hour. Right, a Beem "StretchMaster" mounts to a loader's bucket arm and can stretch a 330-foot roll of 10-foot fencing fabric in less than a minute.**

Fence posts also follow the trend. At the homeowner level, it is relatively easy to use a hand-held pounder to install T-posts, U-posts or rebar. But to pound in a 4 x 4 wood post or a 3-inch galvanized post 10 or 12 feet long, will likely require a pneumatic or hydraulic "post-pounder" operated from a tractor or backhoe. If the aim is to set a post in cement, a hand-held posthole digger can suffice for some footing holes, but a tractor-mounted auger may be needed for larger, deeper or more numerous ones.

VI. Maintenance and Repair

The advantage of the higher-quality materials is that they require less monitoring and maintenance. The slight disadvantage is that they are somewhat harder to repair.

At the low end of the quality spectrum, thin plastic mesh fencing fabric is the most susceptible to damage. Rodents can chew through it, vandals can easily cut it, and even the deer themselves sometimes "test" this fencing and break it. For this reason, the thinnest fencing, wherever it might be used, should be inspected constantly. For some homeowners, this may be acceptable because they can just look out at their yard to check the integrity of the fencing. Inspection intervals of once a week may be needed.

But where a deer exclosure is going to be unattended, use of welded-wire, woven-wire or chain link materials means that inspection intervals can be monthly, or even several months at a time.

Experts in fencing and exclosures say that the main hazard for the stronger, metal fencing materials is a windstorm that drops large tree limbs or whole trees onto the fence. These experts say they may go for months without visiting the exclosure, but will always go out and check after every major "wind event."

When repairs are needed, the light-duty plastic fencing is very easy to fix by using wire ties (tie-wraps) and it is relatively easy to replace a portion of the fence in this way. A similar technique can be used with welded-wire or woven-wire, but it can become more complicated because of the stronger tensioning requirements of the heavier metal fabrics. Woven-wire splicing requires special equipment. Chain link fencing can be very difficult to repair, requiring an expert.

VII. Deer Behavior vs. Fencing Design

Most fencing serves as a simple barrier, but some fencing also relies on aspects of deer behavior. One concept has to do with "educating" the deer. For instance, it is advantageous to add certain attractants, such as peanut butter, on an electric fence. This brings the deer up to the fence, where it receives a shock. Usually one such "education" session is sufficient to keep that indiviual deer from testing that fence again. (However, another deer that has not been "educated" may run headlong through the same fence.)

The simple barrier effect is important because deer often inadvertently run straight at a fence when they are panicked. Some of the lighter plastic fences cannot withstand this kind of accident, and the deer may break through. With the less

visible fabrics, such as black plastic mesh, tying light-colored strips of cloth at intervals along the fence is somewhat effective.

At times a panicked deer may try to jump over a fence, even eight feet high, and can come down on top of the fence. This not only damages the fence, but also can injure or kill the deer.

Deer also dig under fences (particularly fawns). Fencing professionals have a rule of thumb that a nine-inch hole or gap (the size of a paper plate) is big enough for a deer to get through.

There is an aspect of deer perception that fencing professionals use to advantage. If the deer cannot assess the height of a fence, this tends to discourage them from trying to jump over it. For this reason, an eight-foot woven wire fence, topped with two added strands of barbed wire or smooth wire at one-foot intervals, makes a very effective fence. The two strands at the top confuse the deer's perception of how high the fence actually is. (The same principle is employed with slant-wire fencing, where the deer cannot readily perceive the distance it would require to safely jump over that kind of fence.)

Figure G: **The slant-wire fence design (not covered in detail in this report) is said to confuse a deer's perception of how high and far to jump. A number of other fence designs have this feature.**

VIII. Selected Fencing Designs

There are many decorative designs for fencing that can serve as effective barriers to deer. These have been omitted here in favor of utilitarian designs of plastic and wire. In addition, smooth-wire fencing, such as slant-wire and electric fencing, will only be mentioned here in passing and will not appear in the detailed estimates of costs. These smooth-wire designs can be very cost-effective, but they have other drawbacks that may make them unsuitable for exclosures. However, electric and smooth-wire designs do appear in some of the references cited below.

Below are detailed descriptions and cost estimates for five major categories of practical fencing that might be used for deer exclosures. The same materials can easily be used to fence yards and fields.

For consistency, we have posed a square exclosure, 10 meters on a side (32.8 feet), containing a single gate in one side. Working with a general rule of thumb that line posts should be no more than 10 feet apart, such an exclosure would thus require 11 line posts and six terminal posts. We have therefore made cost estimates of all these fencing categories based on this number of posts.

However, some suppliers may have differing guidelines that allow a smaller number of line posts, and in cases where trees can be used as terminal or line posts, there is an obvious savings in costs. In the case of woven wire, some suppliers advise posts can be 25 feet apart, but we kept the same post spacing for all materials in our estimates. In our woven wire design, we carry the H-bracing rail all the way around the exclosure, making this significantly "over-built" but at only a small added cost (about $200).

A. Plastic Deer Netting with T-posts or U-posts.

1. Light duty plastic netting

Positive: *Low cost, easy to install, easy to repair.* ***Negative:*** *Deer can break through, rodents can chew through, vandals can cut through with a knife. Usually only 7.5 feet high, so deer will attempt to jump it. Easily damaged by falling limbs. Only likely to last about five years, even with constant monitoring and maintenance.*

Netting can be purchased at a home supply store such as Lowes or Home Depot at very low cost. For instance, Home Depot has 100-foot rolls of light duty netting at about $59.

For some homeowners, a second major benefit of the light duty netting, besides low cost, is that it is almost invisible from a distance. It may come in black or green. Combined with black or green light-duty posts, this fence style does no harm to the "curb appeal" of a home.

With constant attention, this material can serve as a reasonably effective deer barrier for a yard. However, it will not be effective if unattended, as

Photo 13: **Light-duty plastic fencing, erected behind a rock wall on black steel posts, is nearly invisible. Deer can run headlong through it, but it is easily repaired if constantly monitored.**

deer that accidentally run into it will often break through. So it doesn't make as much sense for an exclosure as for a yard. When a homeowner sees a break in a fence, he or she can repair it quickly (and rather easily). But an unattended exclosure would not receive the same attention, and the whole purpose of the exclosure would be negated if deer could freely gain access.

The light netting has the advantage of a relatively low tension, so breaks in the fence can be mended by pulling the fabric together and lacing it with wire or polyester string, or joining it with wire ties (tie-wraps).

Typically, the light-duty netting is only 7.5 feet high. It usually requires metal stakes or pins at the bottom edge to keep the deer and other animals from crawling underneath.

This type of fencing usually employs light duty steel posts known as T-posts or U-posts. An alternative is angle steel, which can be obtained in 9-foot and 10-foot sizes. Terminal posts usually are not different from line posts. They are the same in every way, the only difference being that bracing is added, usually diagonally, to a corner post.

A top "wire" is strung between the posts and the fence fabric is hung from this top wire. The "wire" can be real wire, or a nylon monofilament cord (like very thick fishing line, but black in color).

Sometimes hanging the mesh is accomplished by lacing the top wire through the fabric, and other times metal rings, known as "hog rings," are used to fasten the fabric. Installing hog rings goes best with a tool made for the purpose, a pair of hog ring pliers.

A gate can be built of wood or metal framing and covered with the same fabric, or alternatively, a mere flap of the fabric itself can be the "gate," secured with simple hardware such as snaps or carabiners.

2. Heavy duty plastic netting

Positive: *Moderate cost, easy to install, easy to repair. Deer cannot break through. Should last 10 years with regular monitoring and maintenance.* ***Negative:*** *Rodents can chew through, vandals can cut through with a knife. Some brands may be only 7.5 feet high, so deer may attempt to jump it. Easily damaged by falling limbs.*

There are several brands of plastic (polypropylene) deer netting that are much stronger than the light-duty kind sold in home supply stores. This stronger netting is usually sold by specialty companies, and often these companies also install deer fences.

One brand of this material is called Tenax C-Flex™, or Cintoflex™ and it is widely sold. One company sells Millennium™ fabric, said to be even stronger.

Like other netting, the heavy-duty plastic mesh is usually hung from a top wire that is strung between posts. This top wire may be a nylon monofilament cord, or a vinyl-coated wire. It is under significant tension, so the terminal posts must be well-braced in order to withstand the load. The netting is attached using "hog rings." Sometimes a bottom wire is also installed and the netting is again attached by hog rings. Other times, the bottom edge of the netting is held to the ground by stakes or metal pins, to prevent animals from crawling underneath.

Photo 14: Cintoflex™ (Tenax™) heavy-duty plastic deer fencing, installed in Redding, CT by Britain Fence LLC, Monroe, CT.

Posts can be light-duty T-posts, U-posts or angle steel, or heavier ones, such as 4 x 4 pressure-treated lumber, steel tubing, galvanized pipe, or cedar posts. One manufacturer uses a system where a short length of tubing is pounded into the ground using a special pounding cap. The tubular steel fence post is inserted into this casing.

Some installers suggest combining a heavy duty plastic deer fence with a 24-inch strip of wire mesh, such as hexagonal wire, at the bottom. For a residence, this is appropriate because it defeats rodents such as rabbits or woodchucks. However, an exclosure should actually have a means to admit any animals except deer.

B. Wire Fencing

1. Hexagonal wire

Positive: *Moderate cost, easy to install, moderately easy to repair. Deer cannot break through. Rodents cannot chew through, vandals cannot cut*

through with a knife. Should last 15 to 20 years with regular monitoring and maintenance. ***Negative:*** *Slightly more difficult to repair than plastic fencing. Easily damaged by falling limbs.*

As a fencing fabric, hexagonal wire mesh is substantially stronger than plastic mesh, and has a distinct advantage in defeating rodents and vandals. In agriculture, the mesh would be called "chicken wire," but fencing suppliers say they could not sell it by that name in Fairfield County, so they use the term "hexagonal wire." The material is significantly better than ordinary galvanized chicken wire, however, because it has been coated with black or green vinyl. It therefore lasts longer and is more esthetically pleasing.

Photo 15: Hexagonal wire mesh with a vinyl coating is hung on bracing wires with hog rings. Posts are steel, painted black with ornamental caps. Fence installed by Specialty Agricultural Products, Orange, CT.

Although posts can be almost any type from T-posts on up, the investment in a higher grade of posts makes sense because the hexagonal material is very durable and thus the fence could last up to 20 years. Terminal posts made of pressure-treated lumber (e.g. 4 x 4s) or cedar posts are appropriate, and the terminal posts should be braced.

It's again appropriate to string a "top wire" and attach the hexagonal fabric to it with hog rings (see above section on plastic fencing). In this case, the wire should be approximately 9-gauge steel wire, which can be obtained with a black vinyl coating. A bottom wire optionally may be installed.

With hex wire and other metal fabrics, it's effective to fold out the bottom six inches of the fabric onto the ground in order to deter deer from digging underneath the fence.

2. Welded Wire/Woven Wire (Fixed Knot)

Positive: *Very strong and deer-proof, very long-lasting (20 to 30 years), very low maintenance.* ***Negative:*** *Relatively high cost, difficult to repair.*

Very strong fencing fabric is made of steel wire that is at least 14 gauge or thicker. (Some of the common thicker gauges are 12.5 or 11.) Some wire fabric in this category is a grid of vertical and horizontal wires, welded together at each crossing. It may be galvanized (zinc coated) for durability, or may be vinyl-coated in colors like green and black. Welded-wire fabric is very strong and is deer-proof.

However, a quantum level above welded wire is woven wire fabric, also often known as fixed-knot. This material is very much in favor with ranchers and farmers, and often is specified under government-subsidized fencing programs.

In woven wire fabric, the crossings of the vertical and horizontal strands are actually tied, like a knot. Further, there are bends in the horizontal strands that permit stretching and tensioning of the fabric. The strands are often a higher-carbon, high-tensile steel. The fabric is so strong that it can be installed between posts without any tension wires, top or bottom.

However, the tensioning of the fabric requires somewhat specialized equipment and therefore woven wire installation is best handled by professional installers. The rolls of fabric also weigh hundreds of pounds and the installers may have specialized equipment just to unroll it under tension.

Photo 16: Woven wire fence, 8 feet high, in a residential setting, on wooden posts. Note doubled corner H-bracing. Fence installed by Specialty Agricultural Products, Orange, CT.

Due to the high tension needed, the posts for a woven wire fence need to be strong and the terminal posts must be well braced. For an 8-foot or 10-foot woven wire fence, terminal posts of 6 x 6 lumber and line posts of 4 x 4 lumber are appropriate. Alternatively, cedar posts of 6 inches and 5 inches in diameter, respectively, may be used.

Some woven wire fabric is made with mesh that is graduated. The distance between horizontal strands may be a few inches at the bottom of the fabric, increasing to about six or seven inches at the top. For 8-foot deer fencing, an optimal configuration includes 20 horizontal wires, graduated from gaps of 3 inches up to 7 inches, with the vertical wires spaced at 6 inches. This is specified as 20/96/6 by fencing suppliers.

The effective height of the fence can be enhanced by making the posts taller by one or two feet than the woven wire mesh itself, then adding

strands of smooth wire or barbed wire at one-foot intervals. This has the benefit of confusing the deer's perception of the height of the fence, deterring attempts to jump it.

The corner bracing for woven wire fencing has two special features. The H-bracing lumber should be twice the height of the fence, as a rule of thumb. Then a strong diagonal bracing wire is installed and tensioned to keep the entire assembly square and rigid.

3. Chain Link

Positive: *Very strong and deer-proof, very long-lasting (30 years), very low maintenance.* ***Negative:*** *Highest cost, difficult to repair.*

Chain link is the arguably the strongest and most durable of fencing materials used to exclude animals. When installed according to generally accepted standards, it can be expected to last at least 30 years. It requires almost no maintenance and the only time it tends to suffer damage is when windstorms bring down large limbs or whole trees on it.

Photo 17: Chain link fencing is expensive but lasts at least 30 years. With federal programs, airports have been upgrading their fences to 10 feet, from 6 or 8 previously.

However, it also is considerably more expensive than most other materials and it almost always requires professional installation.

Traditionally, chain link fence is mounted on galvanized steel pipes as posts. Commonly, these may be 3 inches in diameter for the terminal posts and 2-5/8 or 2 inches for the line posts. Typically, a top rail runs all the way around the fence line, constituting the bracing system. The fence fabric is hung on this top rail using strong wire or straps. While being installed, the fence fabric is pulled to a substantial amount of tension with pulling gear (e.g., come-alongs). The sheer weight of the roll of fencing fabric, combined with the required amount of tension that must be drawn, makes the job very difficult for non-professionals.

With chain link construction there are a lot of ancillary fittings, such as rail end caps or bracing bands, etc. This makes the list of parts for a chain link fencing installation longer than the list for other fencing materials. However, it also makes for a great degree of standardization, so that the fittings can be purchased from many different suppliers and still be compatible.

The fence posts can be pounded into the ground using a hand-operated or hydraulic post-pounder. Alternatively, holes for the posts can be dug using a post-hole digger or auger, and then back-filled with dirt, or filled with concrete. When concrete is used, it is good practice to widen the holes at the bottom to provide a better anchor.

The fencing can be enhanced by topping the posts with barbed-wire arms, or "barbarms." These allow several strands of wire (which may be smooth wire or barbed) to be strung above the chain link mesh, creating a fence that is effectively taller by 1-1/2 to 2 feet. This is particularly effective for deer as it takes advantage of a deer's reluctance to jump over an obstacle when it cannot gauge the height clearly.

IX. Subsidized Fencing Programs

As mentioned before, some exclosures can be very large. In certain states, such as Pennsylvania, hundreds of acres of forest at a time may be set aside behind deer fencing, for forestry and agricultural purposes. There is a Pennsylvania law that allows the state to reimburse farmers and foresters for the costs of fencing. The Pennsylvania method typically uses two passes of 48-inch woven wire to make an 8-foot fence, stapled to 2 x 4 lumber that is nailed to trees as posts.

Elsewhere, airports and farm fields are two common situations where the federal government may provide subsidies for deer fencing.

Wildlife on airports has long been recognized as a threat to safe aircraft operation. The most common wildlife hazard to airplanes is birds, but deer (as well as elk, antelope, etc. in western states) have also been recognized as a serious threat, and therefore the Federal Aviation Administration (FAA) for many years has allowed funds for fencing improvements at many airports. In the wake of 9/11, some airports have made even further upgrades, such as raising the height of their fences, or adding barbed-wire above the existing fence fabric.

Chain link is the most common material for airport fencing, not only because it is strong and secure, but because it lasts a long time with very little maintenance. The FAA has upgraded its guidelines for airport fencing and the latest advisory

(CertAlert 04-16, issued 12/13/04) suggests a 10 to 12-foot chain link fence, although an 8-foot fence is acceptable in some cases. Further, the FAA suggests burying an additional 4 feet of the fencing material in the ground at a 45-degree outward angle, to discourage burrowing under the fence. Chain link fence per FAA standards is expected to last 30 years with very little maintenance.

Fencing in agriculture is sometimes subsidized by both state and federal programs, but in some states these are usually of limited scope.

For instance, the U.S. Department of Agriculture, through its Natural Resources Conservation Service, operates a program that subsidizes fencing in Connecticut each year, but only about $255,000 is allotted. Thus, only about 11 agricultural operations get into the program each year, but they do gain a significant benefit, as up to 75 percent of a deer fencing project is subsidized, up to a maximum of $50,000. The program is called Agricultural Management Assistance (AMA).

The AMA program has a number of requirements of proof that an agricultural enterprise is engaged in serious commerce. The sign-up period is quite brief. For instance, in 2009, the sign-up announcement was posted on January 14 and the deadline for submission of the required paperwork was February 27. For this reason, a sensible strategy is to prepare the paperwork in coordination with the USDA-NRCS, so as to be able to file the application within the next window of eligibility. See http://www.ct.nrcs.usda.gov/programs/ama/ama.html.

Contact: Joyce Purcell, Acting State Resource Conservationist, U.S. Department of Agriculture, Natural Resources Conservation Service, 344 Merrow Road, Suite A, Tolland, CT 06084; phone: (860) 871-4018; website: www.ct.nrcs.usda.gov.

Under the USDA AMA program, the guidelines tend to favor a 10-foot fence, usually with eight feet of woven wire topped with two strands of smooth wire at one-foot intervals. Posts may be 4 x 4s or round cedar posts. The result is an excellent deer fence that can last 20 to 30 years.

The USDA program involves federal funds. In some states, there have been state funds applied to helping with deer fencing. A notable program operated in New Jersey for more than 10 years. It involved major purchases of the deer fencing material (800,000 feet in 1998 and 400,000 more feet in 2005).

The program was operated by the New Jersey Department of Agriculture, Division of Agricultural & Natural Resources, through the Rutgers Extension Service facilities in Hunterdon and Cumberland counties. The fencing material was woven wire, 6.5 feet high, enhanced with two strands of wire above the mesh at one-foot intervals (thus, an 8.5-foot fence). Each farmer was offered up to 5,000 feet of the fencing fabric and 30 percent of the necessary posts. There were training sessions for farmers that intended to install the fence themselves.

However, the New Jersey program is running out of funds and materials. In February 2009, the state's agriculture secretary announced that sufficient material for only about eight farmers was still available, and no new funds or materials were expected.

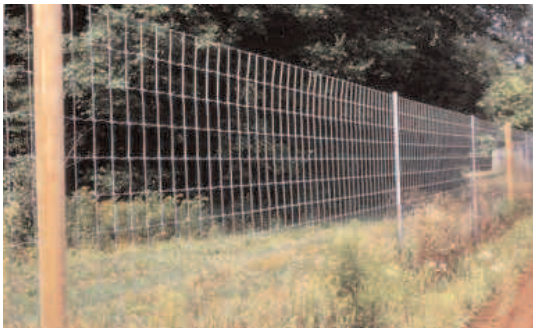


Photo 18: **The Cecarelli Farm fence uses a combination of wood and steel line posts. This 8-foot deer fence restored an unusable 45-acre field to viability and it now grows organic vegetables.**

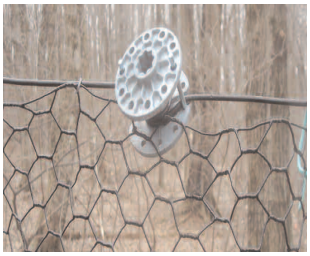
Special mention is due one Connecticut farmer, Nelson Cecarelli of Northford, who set up a web page with photos so as to share his experience with fencing a field for organic farming: http://www.hort.uconn.edu/Ipm/veg/htms/deerfence.htm. In 2001, Cecarelli wanted to rescue a field that had lain fallow since 1988. It had become so overwhelmed by large herds of deer that it couldn't be safely plowed because the antlers were ruining too many tractor tires. His very informative photos and description shows a strong woven wire fence surrounding a 45-acre field. The fencing, 6,250 feet in length and 8 feet high, cost a total of $17,700. It used a combination of lumber and steel posts. Cecarelli estimates that the profits on his crops have already repaid his investment in the fence. He said, "In 20:20 hindsight, the only mistake I made was not building the fence years ago!"

X. Exclosures Already Constructed in Fairfield County

What follows are descriptions and photos of selected exclosures that already have been constructed in Fairfield County. This is by no means a complete listing, and we would welcome additions, updates and photos. Some of these exclosures can be visited freely, while others may be viewed by appointment.

A. Highstead Arboretum

Highstead Arboretum (127 Lonetown Road, Redding, CT) is probably the leader in deer exclosures in Fairfield County, with some exclosures that have been in place for decades, and a growing number of exclosures under study. Some of these are on the Highstead property, and others are situated in about nine towns. Studies are being conducted by forestry ecologist Edward Faison of Highstead, along with David K. Foster, director of Harvard Forest, Harvard University and chair of Highstead's board.



©Russ Kinne Inc

Photo 20: An in-line tensioning device called a "strainer" allows for adjustments to the top wire tension at Highstead Arboretum. Fence fabric is vinyl-coated hexagonal wire.

©Russ Kinne Inc

Photo 22: The bottom six inches of fence fabric is turned outward, to defeat digging. Deer and other animals tend to burrow under a fence if they can.

Towns, land conservators, civic organizations, etc., may wish to build exclosures that increase this network of scientific study plots. To align with the Highstead studies of forestry and ecology, it is suggested that an exclosure be built at about 23 to 25 meters square (75 to 82 feet). This is intended to enclose a plot of 20 x 20 meters, with space around all the edges that allows researchers access and keeps the plant life from being nibbled through the fence.

©Russ Kinne Inc

Photo 19: Corner treatment at Highstead, with H-bracing. Fence fabric is hung from a tightly tensioned top wire with hog rings.

©Russ Kinne Inc

Photo 21: Exclosure at Highstead combines wood and steel materials. Gate is welded steel, while posts are pressure-treated lumber.

Some of Highstead's exclosures are much bigger, sometimes up to an acre. The most recently installed exclosure at Highstead is about 30 x 60 meters and the fencing fabric is vinyl-coated hexagonal wire. The posts are 4 x 4 pressure-treated lumber at the terminals and H-braces, then steel U-posts for the line posts. A top and bottom tension wire were installed and then the fabric was fastened with hog rings. At the bottom about six inches of the fabric was turned outward to discourage digging by deer or other animals, so the fence is about 7.5 feet tall. A custom-welded gate was made of steel pipe and was covered with the same hexagonal fencing fabric. The cost (ballpark figure) was about $7,000 installed, according to the Highstead staff. The exclosure was built by Specialty Agricultural Products of Orange, CT.

Highstead welcomes visitors and will conduct tours of the exclosures as well as other features at the Arboretum. However, Highstead director Bill Toomey suggested that group tours would be the most efficient use of staff time. Visiting hours are by appointment 8:30 a.m. to 4:00 p.m. Monday through Friday.

B. Connecticut Agricultural Experiment Station

There are 22 state-built exclosures throughout the state, mostly in Fairfield and New Haven counties, according to Scott C. Williams of the Department of Forestry and Horticulture, Connecticut Agricultural Experiment Station [123 Huntington Street New Haven, Connecticut 06504; (203) 974-8609; http://www.ct.gov/caes]. Of these, some 16 are 10 meters square and are being studied for general regeneration effects, while 6 are being devoted to a study of what vegetation may return after Japanese barberry is removed. (When deer overbrowse, they leave the invasive barberry, which then tends to dominate a forest floor and is very difficult to remove.)

Of the state's 10-meter exclosures, four are situated in Devil's Den (a Nature Conservancy preserve in Weston/Redding), and one on Centennial Watershed land in Redding. Williams said the exclosures in some cases are up to eight years old, but many were built in 2005 and only have been under study for three to four years. He said many of the exclosures are in deeply shaded woods, and therefore they do not reveal as much of a difference compared to surrounding woodlands.

The exclosures are built of black plastic mesh 7.5 feet high using some existing trees as posts and some 4 x 4 lumber posts. The plastic mesh requires frequent inspection, Williams said. Because the mesh is hard to see, the exclosures are rarely noticed and would be difficult to find without a guide.

C. Selleck's Woods, Darien

A relatively low-cost exclosure was built in Darien at Selleck's Woods, a 50-acre nature preserve that is owned by the Town of Darien and the Darien Land Trust, and is administered by the non-profit organization Friends of Selleck's Woods (www.sellecks woods.com). Chris Filmer, president of the group, provided a description of the exclosure along with photos.

It has been in place almost three years and has already exhibited very clear signs of flourishing vegetation inside. In fact, the trend was very clear after the first year, Filmer said: "It was a bit of a no-brainer."

Chris Filmer

Photo 23: At Selleck's Woods in Darien, existing trees are used for some posts, and heavy-duty plastic mesh is the fencing fabric, hung from a top wire under tension.

Chris Filmer

Photo 24: Deer mesh at Selleck's Woods is a strong polypropylene material from Tenax™. A combination of trees and wooden poles serves as the posts for this low-cost exclosure.

He said their budget included a number of plantings that were made inside the exclosure and in an equivalent plot nearby. In the unprotected plot, the deer ate all of the plantings, but inside the exclosure, they flourished, along with an estimated 23 other species of vegetation.

Filmer said the exclosure is "about tennis court sized" and the fabric is Tenax, heavy-duty deer netting. (Two 168-foot rolls of netting were used.) The corner posts are trees, and the line posts are 2 x 2 wood poles that merely rests on the ground (not pounded in). The fencing was hung from a galvanized wire that was tensioned with a come-along. The fabric was hung using hog rings and was pinned to the ground at the bottom. The exclosure can be accessed by a simple "door" cut into the fabric, held shut by carabiners.

"During the first couple of weeks, the deer charged into the fence and backed off. We inspected it often and saw that it was pushed in. We were advised to put little orange flags in the fence material. Once we did that, the deer seemed to have learned," Filmer said.

The entire exclosure project cost about $1,500 and that included about $400 worth of plantings.

D. Quarry Head, Wilton

A first-class exclosure was constructed in 2003 at Quarry Head State Park, a 33-acre preserve tucked alongside Route 33 about 3.6 miles north of Wilton Center. Quarry Head is owned by the state but managed by the Town of Wilton. (The exclosure can be found by going to the map kiosk and turning right to follow the Red Trail a few hundred feet.)

©Russ Kinne Inc

Photo 25: Cedar posts with N-bracing is used at Quarry Head for corner bracing. Fence is 8-foot woven wire, with a graduated mesh from 3 to 7 inches.

©Russ Kinne Inc

Photo 26: Gate at Quarry Head is made of cedar post lumber. Note strong header above the gate.

The woven-wire exclosure is built on strong cedar posts and is still in excellent condition after six years. It was sponsored by Wilton's deer management committee and much of the actual work was done by David Lynch, then a member of the committee.

The exclosure is approximately 400 feet in perimeter. Lynch, who is a woodworking craftsman, was able to obtain the cedar posts at a deep discount from a local sawmill, and the cost was only $800. Lynch then hand-dug the holes and set all the fence posts, as well as constructed the corner bracing. He also constructed the strong gate, also made of cedar.

A fencing contractor then installed the 8-foot graduated woven wire fencing fabric and tensioned it. This cost approximately $500 for the fabric and $1,350 for the labor. Thus, the costs for the exclosure came to about $2,650, a considerable savings for the town due to Lynch's donated labor.

©Russ Kinne Inc

Photo 27: Exclosure at Quarry Head was built by the Wilton deer management committee in 2003 and is still in excellent shape. The fence fabric is 8-foot woven wire. It is expected to last 20 to 30 years.

Appendix A: Fencing Suppliers and Installers

Following are suppliers of fencing materials. In many cases, they will also install exclosures or fences.

Inclusion in this list does not constitute an endorsement of any kind. Each of these suppliers is responsible for its own guarantees and warrantees, and inclusion in this list does not constitute any express or implied warranty. Suppliers and installers not listed are welcome to request inclusion.

Academy Fence Company
119 North Day Street
Orange, NJ 07050
Phone: (800) 427-0854
Fax (973) 674-0400
www.academyfence.com

Benner's Gardens
1100 Schell Lane
Phoenixville, PA 19460
Phone: (800) 244-3337
www.bennersgardens.com
info@bennersgardens.com

Britain Fence
560 Main Street
Monroe, CT 06468
Phone: (203) 261-8366
Email: estimates@britainfence.com

Critterfence
PO BOX 220
Pleasant Valley, CT 06063
Phone: (860) 921-7900
Fax: (860) 238-3299
E-mail: info@critterfence.com
Note: offers rolls of medium and heavy duty plastic fence fabric

D-Fence
12 Main Street
Brewster, NY 10509
Phone in Connecticut:
Phone: (203) 792-6300
E-mail: dfence@bestweb.net

DeerBusters.com
Division of Trident Enterprises International
9735A Bethel Road
Frederick, MD 21702-2017
Phone: (888) 422-3337
Fax: (301) 694-9254
www.deerbusters.com
E-mail: customerservice@deerbusters.com
Note: Offers high-strength plastic mesh 8-feet, post system using sleeves in ground and 9-foot and 10-foot posts.

Deer DeFence
Peter C. Aquilina
260 Stillwater Ave. #2
Stamford, CT 06902
Phone: (203) 550-8350
www.deerdefence.com
DeerDeFence@yahoo.com

Deer Guard Fence Systems
Pawling, NY 12564
Phone: (914) 234-6222

Discount Fence LLC
2 Broad Street
Milford, CT 06460
Phone: (203) 877-3100
discountfencect@yahoo.com

Fence Factory Inc.
22 Dyke Lane
Stamford, CT 06902
Phone: (800) 336-2371
(203) 324-3654
www.fence-factory.com
E-mail: info@fence-factory.com

Kencove Farm Fence, Inc.
344 Kendall Rd
Blairsville, PA 15717
Phone: (800) 536-2683
(724) 459-8991
www.kencove.com

Louis E. Page, Inc.
30 Taylor Street
P.O. Box 2405
Littleton, MA 01460
Phone: (800) 225-0508
Fax: (978) 486-8337
www.louispage.com
E-mail: page_wire@comcast.net

The McGregor Fence Company
93 Route 6A
Sandwich , MA 02563
Tel. 508-888-8305
Fax 508-888-1114
www.invisible-deer-fence.com
support@mcgregorfence.com

Orange Fence & Supply Co., Inc.
205 Boston Post Road
Orange, CT
Phone: (800) 772-3828
(203) 795-1321
orangefence@optonline.net

Pleasant Valley Fence Co
77 Route 181
Pleasant Valley, CT
(860) 379-0088
www.pleasantvalleyfence.com
Note: Source for cedar posts

Riverside Fence
84 Danbury Road (Route 7)
Wilton, CT 06897
Phone: (203) 210-7447
www.riversidefence.net

Specialty Agricultural Products LLC
628 Chestnut Ridge Road
Orange, CT 06477
Phone: (800) 483-8889
(203) 387-3458
Note: Supplier of fencing materials and kits, also does installations.

Stay-Tuff Fence Mfg Inc
1409 FM 1101
New Braunfels, Texas 78130
Phone: (888) 223-8322
Fax: (800) 608-5114
www.staytuff.com
Note: Has excellent instructions on woven wire fence construction.

Your Fence Store
P.O. Box 6263
North Logan, Utah 84341
Phone (435) 563-0259
Fax (435) 563-0260
Toll Free 1-866-563-3623
www.yourfencestore.com
Note: Very good page explaining chain link fence construction: http://www.yourfencestore.com/cl/clinstall/index.htm

Selected Conversion Factors

1 meter = 3.28 feet

10 meters = 32.8 feet

20 meters = 65.6 feet

23 meters = 74.5 feet

25 meters = 82.0 feet

XI. References

1. ***Fences and Deer-Damage Management: A Review of Designs and Efficacy***, Kurt C. VerCauteren, et al, *Wildlife Society Bulletin*, 34(1):191-200;2006

2. ***The Role of Deer in Determining the Abundance and Diversity of Native Plants in Oak Forests of Southwestern CT***, Edward K. Faison and David R. Foster, Highstead, Redding, CT. A Proposal to Sample Vegetation on Lands Owned by William Hill, the Connecticut Department of Environmental Protection, Aquarion Water Company, the Towns of Redding, Wilton, Ridgefield, and Bethel, and the Nature Conservancy, 2007

3. ***Deer Exclosure Study 2005-2008 Survey Results***, Drs. Scott C. Williams & Jeffery S. Ward, Department of Forestry and Horticulture, The Connecticut Agricultural Experiment Station, New Haven, CT 06504

4. ***Effects of Key deer herbivory on forest communities in the lower Florida Keys***, Mark A. Barrett, Peter Stiling, Department of Biology, University of South Florida, Tampa, FL, *Biological Conservation*, Volume 129, Issue 1, April 2006, Pages 100-108

5. ***Deer Herbivory at the Nature Park: A Cause for Concern?*** Vanessa Artman, Assistant Professor, Biology Department, DePauw University and Depauw Nature Park Program Coordinator, March 2008 **(https://www.depauw.edu/univ/naturepark/deer%20exclosure%20report%20-%20March%202008.doc)**

6. ***Woven Wire Fencing Installation Guidelines for Deer Exclusion***, Natural Resources Conservation Service, U.S. Department of Agriculture

7. ***High-Tensile Woven Wire Fences for Reducing Wildlife Damage, Fact Sheet 889***, Rutgers Cooperative Research & Extension, New Jersey Agricultural Experiment Station **(http://njaes.rutgers.edu/pubs/publication.asp?pid=FS889)**.

8. ***Can small deer exclosures work?*** Karl Martin, PhD, forest research scientist, Wisconsin Department of Natural Resources, *Woodland Management*, Summer 2006 **(www.deerandforests.org/resources/Can%20small%20deer%20enclosures%20work.pdf)**

9. ***Installation Instructions, Chain Link Fence and Gate***, Hoover Fence Co. **(http://www.hooverfence.com/catalog/chain-link-installation.pdf)**

10. ***Chain-Link Fence and Gate Installation Instructions, Master Halco™*** **(http://www.fencingandawning.com/fencing/chainlinkfencesgates.pdf)**

11. ***A Simulation Model for Determining Cost-Effectiveness of Fences for Reducing Deer Damage***, Kurt C. VerCauteren, et al, *Wildlife Society Bulletin*, 34(1):16-22;2006

12. ***White-Tailed Deer Impact on the Vegetation Dynamics of a Northern Hardwood Forest***, Stephen B. Horsley, et al, USDA Forest Service Northeastern Research Station, Warren, PA; *Ecological Applications* 13(1) 2003, pp. 98-118

13. ***Missouri Standard MO-161 Woven Wire Fence With Steel Posts***, rev. 11/01/04 **(www.modot.gov/doc/othertransportation/MO-161_Wire_Fence_with_Steel_Posts.doc)**

14. ***Deer Exclosure Guidelines, Pennsylvania Department of Conservation & Natural Resources, Bureau of Forestry***, Chris Nicholas, et al; unpublished draft 2007

15. ***Deer Damage Prevention and Control Methods***, Scott R. Craven and Scott E. Hygnstrom, Cooperative Extension Division, Institute of Agriculture and Natural Resources, University of Nebraska - Lincoln; United States Department of Agriculture, Animal and Plant Health Inspection Service, Animal Damage Control; Great Plains Agricultural Council Wildlife Committee, 1994

16. ***Fencing Handbook for 10' Woven Wire Deer Exclusion Fence***, Minnesota Department of Natural Resources Wildlife Damage Management Program **(http://files.dnr.state.mn.us/outdoor_activities/hunting/deer/bovine-tb/fencing_guide.pdf)**

Appendix 3: FOREST INVENTORY DATASHEET TEMPLATE

Project Name: ______________________________
Site Location: ______________________________
Prepaired By: ______________________________

Access Road # __________
Tower Location # __________

Log # ______
Date ______

Forest Restoration Inventory

Tree Species		Tree Location		Tree Size														Tree Replacement										Total Cost				
				Uplands / Transition Areas							Riparian / Wetlands							Uplands / Transition Areas					Riparian / Wetlands									
Common Name	***Scientific Name***	**Uplands**	**Riparian**	**6" ≥10" DBH**	**10" ≥ 18" DBH**	**18" ≥ 24" DBH**	**≥ 24" DBH**	**≥ 18" / Tag #**			**6" ≥10" D**	**10" ≥ 18"**	**18" ≥ 24"**	**≥ 24" DB**	**≥ 18" / Tag #**			**1 1/2 " Rep to 6" ≥10" DBH**	**1 1/2 " Rep to 10" ≥18" DBH**	**2 1/2 " Rep to 18" ≥24" DBH**	**2 1/2 " Rep ≥24" DBH**	**24" Shrub**	**1 1/2 " Rep to 6" ≥10" DBH**	**1 1/2 " Rep to 10" ≥18" DBH**	**2 1/2 " Rep to 18" ≥24" DBH**	**2 1/2 " Rep ≥24" DBH**	**24" Shrub**	**1 1/2 " Rep to 6" ≥10" DBH**	**1 1/2 " Rep to 10" ≥18" DBH**	**2 1/2 " Rep to 18" ≥24" DBH**	**2 1/2 " Rep ≥24" DBH**	**24" Shrub**
Natives								**Tag ID#**	**GPS coord. (lat)**	**GPS coord. (long)**					**Tag ID#**	**GPS coord. (lat)**	**GPS coord. (long)**															
Ash, Green	*Fraxinus pennsylvanica*																											$0	$0	$0	$0	$0
Ash, White	*Fraxinus americana*																											$0	$0	$0	$0	$0
Basswood	*Tilia americana*																											$0	$0	$0	$0	$0
Beech, American	*Fagus grandifolia*																											$0	$0	$0	$0	$0
Birch, Black	*Betula lenta*																											$0	$0	$0	$0	$0
Birch, Gray	*Betula populifolia*																											$0	$0	$0	$0	$0
Birch, Yellow	*Betula alleghauiensis*																											$0	$0	$0	$0	$0
Cherry, Black	*Prunus serontina*																											$0	$0	$0	$0	$0
Cottonwood	*Populas deltoides*																											$0	$0	$0	$0	$0
Cottonwood, Eastern	*Populus deltoides*																											$0	$0	$0	$0	$0
Elm, American	*Ulmus americana*																											$0	$0	$0	$0	$0
Elm, Slippery	*Ulmus rubra*																											$0	$0	$0	$0	$0
Hemlock, Eastern	*Tsuga canadensis*																											$0	$0	$0	$0	$0
Hickories, Other	*Carya spp*																											$0	$0	$0	$0	$0
Hickory, Bitternut	*Carya cordiformis*																											$0	$0	$0	$0	$0
Hickory, Shagbark	*Carya ovata*																											$0	$0	$0	$0	$0
Hickory, Sweet Pignut	*Carya ovalis*																											$0	$0	$0	$0	$0
Maple, Red	*Acer rubrum*																											$0	$0	$0	$0	$0
Maple, Silver	*Acer saccharinum*																											$0	$0	$0	$0	$0
Maple, Sugar	*Acer saccharum*																											$0	$0	$0	$0	$0
Oak, Chestnut	*Quercus prinus*																											$0	$0	$0	$0	$0
Oak, Pin	*Quercus palustris*																											$0	$0	$0	$0	$0
Oak, Post	*Quercus stellata*																											$0	$0	$0	$0	$0
Oak, Red	*Quercus rubra*																											$0	$0	$0	$0	$0
Oak, Scarlet	*Quercus coccinea*																											$0	$0	$0	$0	$0
Oak, Swamp White	*Quercus bicolor*																											$0	$0	$0	$0	$0
Oak, White	*Quercus alba*																											$0	$0	$0	$0	$0
Pine, White	*Pinus strobus*																											$0	$0	$0	$0	$0
Tulip Poplar	*Liriodendron tulipifera*																											$0	$0	$0	$0	$0
																												$0	$0	$0	$0	$0
																												$0	$0	$0	$0	$0
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																												$0	$0	$0	$0	$0
																												$0	$0	$0	$0	$0
Total		**0**	**0**	**0**	**0**	**0**	**0**			**0**	**0**	**0**	**0**	**0**			**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		**0**	**$0**	**$0**	**$0**	**$0**	**$0**

I certify that the tree Inventory prepared for this section of the road is accurate and was prepared using the best available information

____
(Signature)

Appendix 4: SITE PREPARATION FOR SEEDING WOODLAND OPENINGS

- These sites generally involve working around trees and shrubs, while minimizing damage to trunks and roots. Undesirable vegetation must be controlled by tilling or direct spraying with glyphosate.

- The soil needs to be loosened in order to establish seed-to-soil contact and dense leaf litter should be broken up. This can be accomplished using a rototiller. Seedlings can emerge from light leaf litter if planted at the proper depth. Light mulch or hydromulch can protect the seeds and soil until germination.

- Seeding and mulching around bioengineering should occur immediately after bioengineering materials are installed. If bioengineering material cannot be installed immediately after grading, mulching and temporary seeding are recommended.

- Habitat: Moderate shade is a general characteristic of these sites. Many species are adapted to moderate shade and the protective habitat of the trees.

- Fertility: Adding organic matter is most important to improve soil fertility. Check your soil pH and select species adapted to that pH. Shade tolerant native grass species, such as Elymus hystrix (Bottlebrush Grass), Panicum clandestinum (Deer Tongue), Cinna arundinacea (Wood Reedgrass), and Elymus riparius (Riverbank Wild Rye), provide early protection for the emerging herbaceous species.

- Seeding Method: Hand seed, broadcast, or hydroseed. Drag or roll the surface to incorporate the seed 1/4″ -1/2″ into the soil. A seed drill can be used when sufficient room exists for operation.

- Infrequent dormant mowing (4″-6″ high) and controlled burning (by experienced professionals) can protect native forb and grass species from woody undergrowth invasion. Spot treat for invasives only.

APPENDIX 5: TREE PLANTING SPECIFICIATIONS

1. GENERAL

The contractor shall be liable for any damages to property caused by their operations and in the event of damages; they shall at their own expense restore all disturbed or damaged areas to their original condition. All materials, equipment, and personnel shall be limited to the work are defined by the project supervisor.

Trees shall be free of damage as the result of handling or transportation. No substitution of plant material is allowed unless written permission is obtained from PSE&G.

All work shall conform to accepted horticultural practices as ultimately determined by the New Jersey Forest Service's Community Forestry Program. All work shall be completed to the satisfaction of PSE&G, herein referenced as "the Company."

2. SCOPE OF WORK

Work shall consist of:
1. Preparation of areas for planting.
2. Furnishing and planting of specified trees.
3. Maintenance of plantings until acceptance by the Company.
4. Clean up and restoration of any disturbed areas to the condition prior to the contractor's arrival

3. SCHEDULING OF WORK

The tree planting contractor shall submit a proposed work schedule to the Company for approval at least seven (7) days prior to beginning operations. After the schedule is accepted, no modifications will be permitted without written authorization. The contractor shall arrange to confine operations to normal working hours for the industry and no work will be permitted on Sundays or holidays without written authorization from the Company.

4. PERSONNEL

All personnel will be properly supervised in a manner that assures that the property is protected from damage; that the safety of all personnel and the public is protected, and that all contract work is done in a professional manner.

5. PROTECTION OF UTILITIES

Prior to any excavation or the driving of stakes into the ground, the contractor shall ascertain and have marked out the location of all underground utilities. The contractor shall take proper precautions not to disturb or damage any sub-surface utilities.

In the event that any sub-surface utilities are uncovered or damaged, the contractor shall immediately notify the Company that the contract work may be relocated or stopped until the damage

can be repaired. The contractor shall be financially responsible for any damage to utilities or structures and shall properly maintain the protection of same.

6. LAYOUT

All trees shall be located by the contractor based upon the specifications in the Forest Restoration Plan (FRP) within the specific restoration area as identified by the Company. Should the contractor encounter obstructions of any nature, they shall notify the Company who will arrange adjustments. All adjustments to the plan must be authorized by the Company. The marking and layout work shall be done sufficiently in advance of planting to avoid delays to the contractor.

No planting holes shall be excavated in advance of planting operations. Each tree shall be planted in an individual hole as specified. All trees shall be planted so the root flare is level to the surrounding grade. See the accompanying planting diagram for details.

7. WATER

Trees shall be thoroughly watered after planting. The Company will notify the contractor if water suitable for irrigation is available on the site. If water is unavailable on the site, it is the responsibility of the contractor to furnish it at the time of the planting of container species to the extent practicable.

8. NURSERY STOCK

Tree species shall conform to those indicated on the restoration tree inventory list and the publication Hortus Third as well as on line sources of information such as USDA.gov

All landscape nursery stock shall conform to the standard specifications of The American Standard for Nursery Stock sponsored by the American association of Nurserymen, Inc. All container trees (as opposed to tree seedlings) shall be grown under climatic conditions similar to the job site for a period of not less than two (2) years immediately prior to this project and have a caliper ranging from one to two and one half inches (1-2 ½") depending upon the trees species identified from the tree inventory. Trees shall be purchased within a 300 mile radius from the designated planting site.

No substitutions shall be permitted in either kind or grade without written authorization from the Company.

Any material and/or work may be rejected, if, in the opinion of the Company, it does not meet the requirements of the specifications. All rejected material shall be promptly removed from the site by the contractor at their own expense.

9. QUALITY

Trees shall have the habit of growth that is normal for the species or cultivar and shall be sound, healthy, vigorous, free from insects, tree diseases, and injuries or damage of any nature. All trees shall be of the grades specified, neither larger nor smaller without written authorization from the Company Forester. No trees shall be pruned, clipped, or trimmed prior to delivery without written authorization from the Company. All landscape stock must be nursery grown.

All trees shall have been root pruned at the nursery at least once during the three year period immediately preceding transplanting and at least one year prior to transplanting.

10. SHIPMENT, DELIVERY, INSPECTION, AND ACCEPTANCE

The Company reserves the right to inspect and select all trees at its point or origin. Acceptance at the nursery where the tree is growing, prior to transplanting, does not preclude rejection at the site for just cause.

Trees are to be delivered to the site in the quantities and on the dates agreed upon by the Company and the contractor. The contractor shall advise the Company of all deliveries at least 48 hours prior to its arrival at the site, so that all trees can be inspected upon delivery. All trees shall be covered with a tarp, protected from weather, and be adequately packed to avoid breakage, sun scald, windburn, desiccation, and other damage during loading and shipment. All measures customary in good trade practices shall be taken to keep the trees in good condition. No trees shall be planted until they have been inspected and approved on the site by the Company representative.

Legible tags shall be attached to each tree. Trees that fail to meet the specifications set forth in Sections 9 and 10 will be rejected. Rejected trees shall be removed from the site immediately. Approved replacement stock that meets the specifications set forth in sections 9 and 10 will be planted in the prescribed manner by the contractor at their expense. Final written acceptance of the trees will be given only after they have been planted, and after the requirements prescribed herein are met.

11. TIME OF PLANTING

Prior to commencement of planting, the contractor shall contact the Company to establish a schedule of planting trees. Trees will be planted from March 1st through June 30th or September 1st through November 30th.

12. PLANTING

Unless otherwise specified within these specifications, all work shall conform to accepted horticultural practices as ultimately determined by the Company. Trees shall be protected upon arrival to the site by being thoroughly watered and properly maintained until properly planted. Unplanted stock shall be "healed-in" a bed of material approved by the Company upon delivery to the site unless they will be planted within eight (8) hours after delivery. At all times workmanlike methods customary in good horticultural practices shall be exercised.

The contractor shall protect all existing features on the site including underground utilities, structures, and existing trees.

All container trees shall be planted in pits that are a minimum of two (2') feet larger than the diameter of the rootball. The depth of the tree pit shall be equal to the height of the rootball. The tree shall be centered in the hole and then back filled half the depth of the rootball with topsoil. The backfill shall be lightly but thoroughly tamped and well watered. The remainder of the hole is then to be backfilled with approved topsoil to a depth that after settling, will assure the root flare will be at the

same grade as the surrounding soil. The tree will be well watered again before mulch is placed over the surface of the rootball.

13. GUYING, STAKING AND WRAPPING

The installation of tree stakes and supporting materials will be provided by the contactor to trees that the Company deems necessary. Stakes shall be made of wood with the appropriate length and size necessary to restrict excessive movement of the tree, as determined by the Company representative. Tie materials shall be plastic chain lock or flat woven webbing designed specifically for securing stakes to trees. For details on proper staking, see the planting detail. Tree trunks shall not be wrapped.

14. PLANTING PREPARATIONS

Wire baskets shall be removed from the rootball by cutting with any tool that does not destroy the integrity of the rootball or injure the tree roots, prior to backfilling the tree pit with soil.

Prior to backfilling, balled and burlapped trees shall have burlap and twine removed from around the trunks, stems, and rootballs. The burlap shall be removed or folded down to the base of the rootball. No burlap shall be pulled out from underneath the rootball.

Backfilling shall be lightly but thoroughly tamped and well watered as described under planting. Only topsoil may be used to backfill the tree pits during planting operations. Unsuitable excavated material, as designated by the Company shall be removed from the site by the contractor at their expense.

15. MULCHING

Uniformly shredded hardwood mulch supplied by the contractor shall be free of debris and shall be placed by the contractor around all plantings at the time of planting to a depth of three (3") inches as shown in the planting diagram. Care shall be exercised to keep mulch three (3") inches away from the bases of all trees. After the mulching operation has been approved by the Company the mulch shall be thoroughly watered.

16. PRUNING

The contractor shall not prune any plant, except at the direction of the Company.

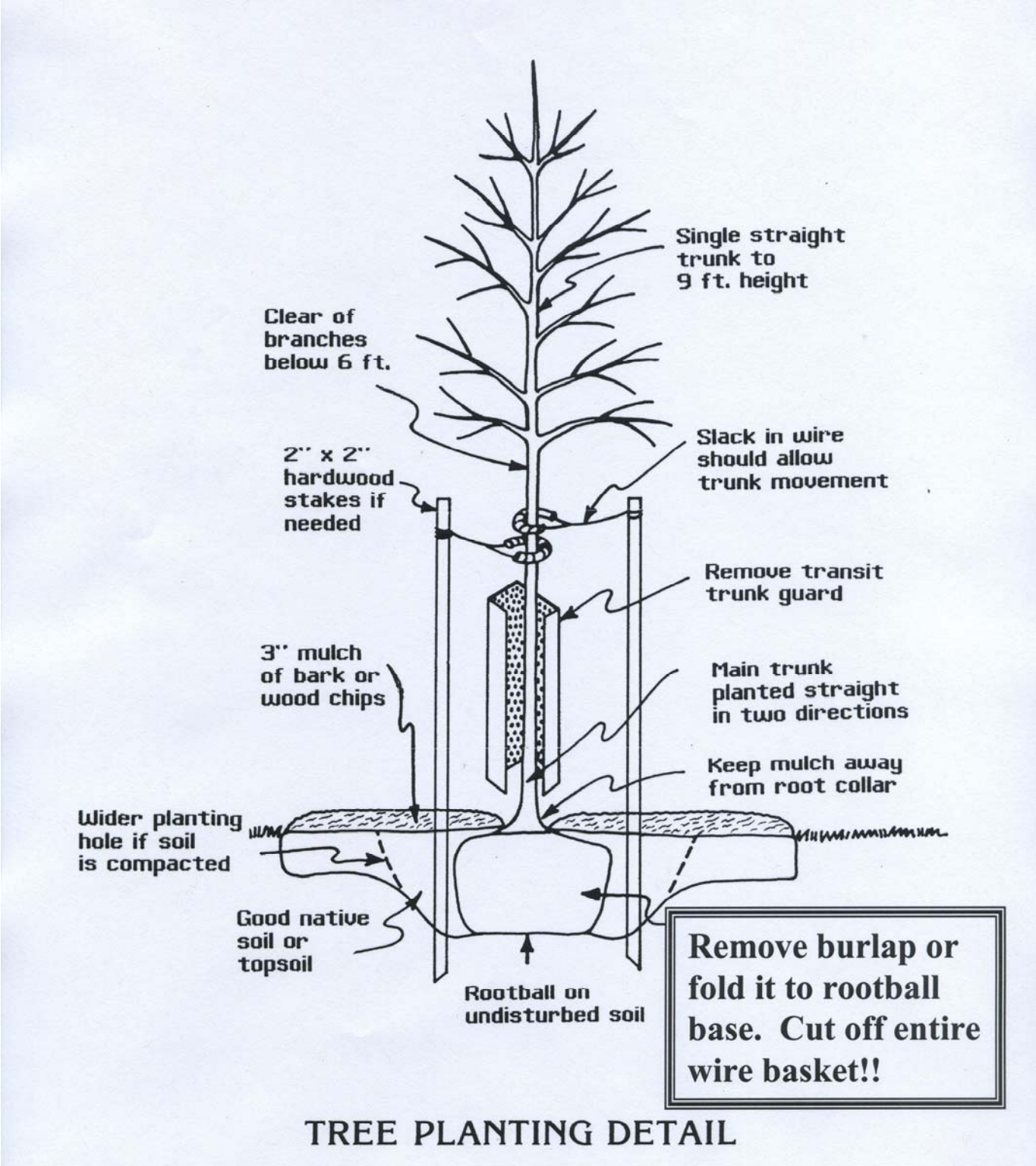
17. CLEAN-UP

During the course of operations, the contractor shall remove from the property at their expense all excess and waste materials.

Any damaged lawn areas or planting areas will be restored to their original condition by the contractor at their expense, if such damage is the result of the contractor's operations.

18. TREE PLANTING DETAIL - See Appendix 5

Appendix 5 – TREE PLANTING DETAIL



Appendix 6: FOREST ROAD RESTORATION SEEDING MIXTURES

PSEG/ERNST 07 Herbaceous Upland Mix For Partial Shade

% of Mix	Latin Name	Common Name
2	Agrostis perennans	Autumn Bentgrass
31	Elymus virginicus	Virginia Wild Rye
2	Juncus tenuis	Path Rush
65	Panicum clandestinum	Deertongue
100	Total	
Seed at 15 bulk lbs per acre. Add 30 lbs grain rye/acre as cover crop.		

PSEG/ERNST 08 Herbaceous FACW Mix for Partial Shade

% of Mix	Latin Name	Common Name
15	Carex scoparia	Blunt Broom Sedge
5	Carex squarrosa	Squarrose Sedge
40	Carex vulpinoidea	Fox Sedge
38	Elymus virginicus	Virginia Wild Rye
2	Juncus tenuis	Path Rush
100	Total	
Seed at 15 bulk lbs/acre.		

PSEG/ERNST 09 Herbaceous/Woody Upland Mix

% of Mix	Latin Name	Common Name
2	Agrostis perennans	Autumn Bentgrass
5	Aronia melanocarpa	Black Chokeberry
25	Cornus florida	Flowering Dogwood
31	Elymus virginicus	Virginia Wild Rye
2	Juncus tenuis	Path Rush
65	Panicum clandestinum	Deertongue
100	Total	
Seed at 20 bulk lbs per acre. Add 30 lbs grain rye/acre as cover crop.		

PSEG/ERNST 10 Herbaceous/Woody FACW Mix Shade

% of Mix	Latin Name	Common Name
10	Carex scoparia	Blunt Broom Sedge
5	Carex squarrosa	Squarrose Sedge
26	Carex vulpinoidea	Fox Sedge
5	Cepthanthus occidentalis	Buttonbush
10	Cornus amomum	Silky Dogwood
10	Cornus racemosa	Gray Dogwood
25	Elymus virginicus	Virginia Wild Rye
2	Ilex verticillata	Winterberry
2	Juncus tenuis	Path Rush
5	Lindera benzoin	Spicebush
100 Seed at 20 bulk lbs/acre	Total	

Appendix 7: Forest Restoration Plan - Sample Tree Inventory

Sample Plot	Lat			Long			Overstory	Understory
1	40	59	47.5N	74	37	50.5W	Yellow -poplar	Chestnut oak
							Yellow birch	Yellow birch
							Chestnut oak	Serviceberry
							N. Red oak	
2	40	59	49.2N	74	38	10.1W	Chestnut oak	Black birch
							White oak	Yellow-poplar
							N. Red oak	Black huckleberry
							Black birch	Lowbush blueberry
							Yellow-poplar	
							Hickory	
3	40	59	26N	74	38	27.W	N. Red oak	Black birch
							Black oak	Serviceberry
							Chestnut oak	Red maple
							Black birch	Mockernut hickory
							White oak	
4	40	59	25.8N	74	38	0.5W	Red maple	Highbush blueberry
							Black birch	Swamp azalea
							Black gum	Witch hazel
							Yellow-poplar	Sweet pepperbush
							Yellow birch	Serviceberry
5	40	59	43.1N	74	38	13.3W	Sugar maple	Black birch
							N. Red oak	Yellow birch
							Green ash	Black cherry
							Yellow-poplar	
							Shagbark hickory	

Appendix 7 (continued)

Sample Plot	Lat			Long			Overstory	Understory
6	40	59	34.7N	74	38	13.3W	Yellow-poplar Green ash Sugar maple American beech Chestnut oak N. Red oak Yellow birch	American beech Spicebush Yellow birch Witch hazel Sugar maple
7	40	59	34N	74	38	11.4W	Sugar maple White oak N. Red oak Chestnut oak Red maple Black birch Mockernut hickory Eastern hemlock	Red maple Service berry Black huckleberry Hornbeam Witch hazel Barberry
8	40	59	52.3N	74	38	18.6W	Yellow birch Green ash Yellow-poplar Red maple	Spicebush Barberry Witch hazel Highbush blueberry Winterberry Ironwood
9	40	59	57.6N	74	28	22.5W	Chestnut oak Hickory Sugar maple	Highbush blueberry American beech Black cherry Green ash

APPENDIX 8

TREE INVENTORY SUMMARY AT THE HOPATCONG SWITCHING STATION

Scientific Name	Common Name
Acer rubrum	Red Maple
Acer saccharum	Sugar Maple
Amelanchier canadensis	Shadblow
Betula alleghaniensis	Yellow Birch
Betula lenta	Black Birch
Carpinus caroliniana	Ironwood
Carya glabra	Pignut Hickory
Carya ovata	Shagbark Hickory
Fagus grandifolia	American Beech
Fraxinus americana	White Ash
Fraxinus pennsylvanica	Green Ash
Liriodendron tulipifera	Yellow Poplar
Nyssa sylvatica	Black Gum
Ostrya virginiana	Hop Hornbeam
Prunus serotina	Wild Black Cherry
Quercus Alba	White Oak
Quercus palustris	Pin Oak
Quercus prinus	Chestnut Oak
Quercus rubra	Red Oak
Quercus velutina	Black Oak
Sassafras albidum	Sassafras
Tilia americana	Basswood
Tsuga canadensis	Hemlock
Ulmus americana	American Elm

DBH	Number
6"- 10"	641
11"-17"	263
18"-24"	173
>24"	38
Multi-trunk	240
Total	1355