Conservation Enhancements for a Living Landscape

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2012 Conservation Activities
E.L. Rose Conservancy

2012 Overview

In 2012, cooperative conservation and monitoring efforts involving the Cornell Conservation Education and Research Program and the E.L. Rose Conservancy focused on five overarching issues including: 1) continued expansion of biological monitoring and inventory efforts, 2) research on the effects of natural gas pipeline development on forest amphibians, 3) hemlock woolly adelgid monitoring, education, and research, 4) Geographic Information Systems (GIS) modeling of potential watershed impacts and high priority water quality monitoring sites, and 5) education and outreach. Through biological inventories, we continue to elevate the knowledge of biological communities on the Conservancy's fee-owned properties and surrounding areas. Four Cornell undergraduate students were formally incorporated into inventory activities through summer undergraduate internships funded by Cornell's Arnot Forest Internship Program and other sources of grant funding. In addition to biological inventories, interns also assisted with a water quality monitoring workshop for the public. In addition, students from a Cornell Applied Conservation Ecology class used Geographic Information Systems (GIS) to conduct a group project in the spring, looking at gas well locations in relation to topography and streams to predict ideal water monitoring locations.

Biological Inventories

Biological inventories are important for establishing baseline information, and for detecting environmental change over time. Both the location and the ecological characteristics of the Conservancy's three fee-owned properties make them ideal sites for biological monitoring. These sites can serve as indicators of overall landscape-level forest health in the area.

Odonate Inventory at Greenwood and Silver Lake

Odonates, or dragonflies and damselflies, are an attractive group for biological monitoring. They occur in a variety of habitats along streams and rivers, at the edges of ponds and forests, in wet meadows, and in fields. They require aquatic habitats for larval development, and are often the top predators in both their aquatic larval and adult stages. Dragonfly and damselfly larvae are sensitive to environmental change and can be used as indicators of water quality and habitat change. Susquehanna County is home to over 80 species of dragonflies and damselflies, several of which are rare. The rich diversity of species provides an excellent tool for characterizing habitats and monitoring for environmental change.

A pair of variable dancers at Greenwood Sanctuary

In our initial surveys during 2012, we documented 10 different species at Greenwood Sanctuary and 10 species at Highpoint Preserve/Silver Lake. While there was some overlap between the sites, we recorded 16 species in all (Table 1). Notably, two species, the emerald spreadwing (*Lestes dryas*) and the slender bluet (*Enallagma traviatum*), were not previously listed as occurring in Susquehanna County (Odonates of Pennsylvania by County 2003).

Table 1. Dragonfly and damselfly species detected at Highpoint Preserve/Silver Lake and Greenwood Sanctuary in 2012.

Scientific Name	Common Name	Greenwood	Silver Lake
Argia fumipennis violacea	Variable dancer	x	x
Argia moesta	Powdered dancer		x
Calopteryx maculata	Ebony jewelwing	x	
Celithemis elisa	Calico pennant	x	
Enallagma geminatum	Skimming bluet		x
Enallagma signatum	Orange bluet	x	
Enallagma traviatum	Slender bluet		x
Epitheca cynosura	Common baskettail	x	
Erythemis simplicicollis	Eastern pondhawk	x	x
Ischnura verticalis	Eastern forktail	x	
Lestes dryas	Emerald spreadwing	x	
Libellula incesta	Slaty skimmer		x
Libellula luctuosa	Widow skimmer		x
Libellula pulchella	Twelve-spotted skimmer	x	x
Perithemis tenera	Eastern amberwing	x	x
Plathemis lydia	Common whitetail		x

Permanent Forest Inventory Plots at Greenwood Sanctuary and Highpoint Preserve

Our natural environment is facing many different pressures today, including climate change, invasive plants and insects, emerging diseases, and forest fragmentation. By establishing Permanent Forest Inventory (PFI) plots, valuable information can be gathered on species composition, species distribution, presence of invasive pests, and other forest health indicators, for both current analyses and future comparisons.

<u>*Methodology*</u>

To enhance the level and quality of information about plant species composition and habitat condition at Greenwood Sanctuary, two additional PFI plots were established and sampled in 2012, bringing the total number of plots to 12 at that site (Figure 1). At Highpoint Preserve, three new plots were sampled bringing the total number of plots to 15, and three previously established plots were re-sampled (Figure 1). This year, we intentionally selected plots containing eastern hemlock. While conducting other research this summer, hemlock woolly adelgid (*Adelges tsugae*) was found at Greenwood. As such, the emphasis of our forest inventory this summer shifted slightly, and focused on documenting the current condition of hemlock trees, so that we can monitor their long-term health and survival. The PFI plot methodology (Appendix A)

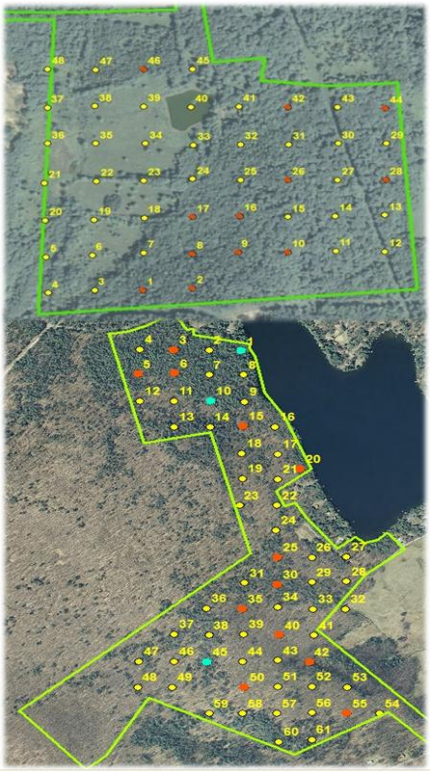


Figure 1. Three additional PFI plots were established at Greenwood Preserve in 2012 (top, red). At Highpoint Preserve, three new plots were sampled (bottom, red), and three plots were sampled for a second time (bottom, blue). Additional plots designated for future sampling appear in yellow.

is based on protocols we developed and implemented at Cornell University's Arnot Teaching and Research Forest. In addition to providing information on the current conditions, PFI plots will be used to monitor short- and long-term changes in forest health and composition.

Each quarter-acre PFI plot consists of a circular central plot (58.9' radius) and two subplots (11.8'). The center of the plot is marked with white pvc pipe for visibility to act as a long-term marker. The pipe has a numbered tag attached at the top, and the plot number is also written on the pipe in permanent marker for easy identification. Within the central plot, all the living trees with a diameter at breast height (dbh) of at least 4" are marked one foot off the ground with small, round aluminum tags. The tags provide a permanent reference for future tree measurements. For each tagged tree, the species, dbh, presence/absence of cavities, and crown class are recorded. At the north and south ends of each plot, subplots are marked at the center with short wooden stakes. The subplots are used to sample the number of seedlings and saplings present, as well as other key understory characteristics. Additional information recorded for the PFI plots included: geography (elevation, aspect, etc.); measures of coarse woody debris; presence/absence of water, rocks and tree cavities; number of dead standing trees (snags); species and number of salamanders found; and signs of other wildlife (Appendix A).

Greenwood Sanctuary Overstory and Understory Characteristics

In 2012, 146 overstory trees were recorded, measured, classified and tagged in two plots at Greenwood. Eleven tree species were present within the new plots, bringing the total recorded number of species to 20. Species present include American basswood (*Tilia americana*), American beech (*Fagus grandifolia*), eastern hemlock (*Tsuga canadensis*), red maple (*Acer rubrum*), sugar maple (*Acer saccharum*), black birch (*Betula lenta*), gray birch (*Betula populifolia*), yellow birch (*Betula alleghaniensis*), white birch (*Betula papyrifera*), black cherry (*Prunus serotina*), white ash (*Fraxinus americana*), northern red oak (*Quercus rubra*), northern white oak (*Quercus alba*), eastern hophornbeam (*Ostraya virginiana*), American hornbeam (*Carpinus caroliniana*), big tooth aspen (*Populus grandidentata*), quaking aspen (*Populus tremuloides*), white pine (*Pinus strobus*), bitternut hickory (*Carya cordiformis*), and shagbark hickory (*Carya ovata*). Dominant species comprising 30% or more of the trees in one or more plots include eastern hemlock (5 plots), black birch (3 plots), quaking aspen (1 plot), red maple (1 plot), and sugar maple (1 plot) (Table 2). The number of trees per ¼-acre plot ranged from 30 to 86.

At Greenwood, 16 different tree and shrub species have been recorded in the understory (Table 3). Thirteen of the 16 species growing in the understory were also observed growing in the overstory. American beech (11 of 12 plots) and white ash (9 of 12 plots) were most prevalent in the understory. Bitternut hickory, hop hornbeam, red maple, and sugar maple were also common and were documented in at least 40% of the plots. The number of seedlings present in the plots varied and, although quite a few seedlings were present in some of the plots, very few (58 total) have grown to sapling size in the plots sampled. With relatively little sunlight reaching the forest floor due to a closed forest canopy, it is not surprising that the understory is not well-developed. Several herbaceous species of note were found in the understory plots including maidenhair fern, Christmas fern, trillium, blue cohosh, and jack-in-the-pulpit.

Table 2. Overstory tree composition of PFI plots at Greenwood Sanctuary; species comprising 30 percent or more of overstory trees in the plot are highlighted.

	PFI Plot Number											
Overstory trees	**1**	**2**	**8**	**9**	**10**	**16**	**17**	**26**	**28**	**42**	**44**	**46**
American basswood	0.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
American beech	6.67	4.84	3.33	5.08	5.56	7.94	1.16	0.00	20.00	0.00	0.00	0.00
American hornbeam	0.00	0.00	0.00	0.00	0.00	0.00	2.33	0.00	0.00	10.81	0.00	0.00
Big tooth aspen	0.00	0.00	0.00	0.00	0.00	0.00	2.33	0.00	0.00	0.00	0.00	0.00
Bitternut hickory	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.71	6.67	0.00	3.51	0.00
Black birch	35.00	11.29	3.33	6.78	0.00	23.81	67.44	0.00	3.33	8.11	73.68	0.00
Black cherry	0.00	0.00	0.00	1.69	0.00	0.00	1.16	5.71	0.00	2.70	0.00	0.00
Eastern hemlock	45.00	69.35	88.33	55.93	0.00	28.57	4.65	0.00	43.33	2.70	1.75	0.00
Gray birch	0.00	0	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	7.89
Hop hornbeam	1.67	0.00	0.00	0.00	25.00	0.00	1.16	14.29	0.00	0.00	0.00	0.00
North. red oak	1.67	0.00	0.00	6.78	2.78	3.17	1.16	11.43	0.00	10.81	0.00	0.00
North. white oak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.86	0.00	0.00	0.00	0.00
Quaking aspen	1.67	0.00	0.00	0.00	0.00	3.17	0.00	0.00	0.00	2.70	1.75	92.11
Red maple	5.00	6.45	1.67	13.56	19.44	12.70	7.95	0.00	0.00	32.43	3.51	0.00
Shagbark hickory	0.00	0.00	0.00	0.00	0.00	3.17	9.3	17.14	0.00	0.00	0.00	0.00
Sugar maple	0.00	3.23	0.00	0.00	30.56	0.00	0.00	5.71	16.67	8.11	5.26	0.00
White ash	1.67	0.00	0.00	10.17	16.67	15.87	1.16	17.14	10.00	18.92	7.02	0.00
White birch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.51	0.00
White pine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.70	0.00	0.00
Yellow birch	1.67	3.23	3.33	0.00	0.00	1.59	0.00	0.00	0.00	0.00	0.00	0.00

Table 3. Number of seedlings and saplings by species in each plot at Greenwood Sanctuary.

Plot	American basswood	American beech	American hornbeam	Bitternut hickory	Black birch	Black cherry	Dogwood sp.	Eastern hemlock	Hop hornbeam	Ironwood	Maple-leaved viburnum	Northern red oak	Red maple	Sugar maple	Shagbark hickory	White ash
1	0	6	0	0	0	0	0	1	0	0	0	1	0	0	0	2
2	0	30	0	0	0	0	0	1	0	0	0	0	0	0	0	0
8	0	6	0	0	27	0	0	0	0	0	0	1	32	0	0	15
9	0	24	0	0	0	0	0	0	0	0	0	0	61	0	0	0
10	2	3	0	1	0	3	0	0	22	0	0	0	5	8	0	3
16	0	3	0	0	5	0	0	0	4	0	20	0	0	0	0	21
17	0	6	2	0	11	0	0	0	0	0	0	0	3	0	8	0
26	4	4	0	20	0	0	0	0	74	0	0	16	4	36	5	4
28	0	4	0	16	0	0	0	0	20	0	0	4	0	80	0	24
42	0	6	0	21	0	0	4	0	46	0	0	0	13	0	15	8
44	0	9	0	28	0	0	8	0	0	8	0	0	0	24	0	15
46	0	0	0	0	0	0	0	0	0	18	0	0	0	8	4	38

Highpoint Preserve Overstory and Understory Characteristics

At Highpoint Preserve in 2012, 198 new overstory trees were recorded, measured, classified and tagged in three plots, and 163 trees in three previously established plots were re-measured. Nine tree species were present within the new plots, bringing the total recorded number of species to 14. Species include American basswood (*Tilia americana*), American beech (*Fagus grandifolia*), eastern hemlock (*Tsuga canadensis*), red maple (*Acer rubrum*), sugar maple (*Acer saccharum*), striped maple (*Acer pennsylvanica*), black birch (*Betula lenta*), yellow birch (*Betula alleghaniensis*), black cherry (*Prunus serotina*), white ash (*Fraxinus americana*), eastern hophornbeam (*Ostraya virginiana*), American hornbeam (*Carpinus caroliniana*), white pine (*Pinus strobus*), and hickory (*Carya sp.*). Dominant species comprising 30% or more of the trees in one or more plots included eastern hemlock (8 plots), American beech (1 plot), red maple (2 plot), and sugar maple (6 plots), and white pine (1 plot) (Table 4).

At Highpoint Preserve, 8 tree species have been recorded in the understory (Table 5). Seven of the 8 species growing in the understory were also observed growing in the overstory. American beech (3 of 14 plots) and white ash (9 of 14 plots) were most prevalent in the understory. The number of seedlings present in the plots varied, and very few have grown to sapling size in the plots sampled. Although quite a few seedlings were present in some of the plots, only 77 saplings were documented in the plots sampled, and a majority of saplings were of only two species, beech and sweet birch. With relatively little sunlight reaching the forest floor due to a closed forest canopy, it is not surprising that the understory is not well-developed. Several herbaceous species of note were found in the understory plots including maidenhair fern, Christmas fern, trillium, sensitive fern, blue cohosh, and jack-in-the-pulpit.

Table 4. Overstory tree composition of PFI plots at Highpoint Preserve; species comprising 30 percent or more of overstory trees in the plot are highlighted.

	PFI Plot Number														
Overstory Trees	**1**	**3**	**5**	**6**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**42**	**45**	**50**	**55**
Am. beech	13.11	3.77	3.15	15.38	0.00	9.52	5.56	21.95	9.72	3.33	27.78	5.71	32.65	11.00	2.27
Am. basswood	0.00	0.00	0.00	0.00	0.00	3.17	0.00	0.00	6.94	0.00	0.00	0.00	0.00	0.00	2.27
Am. hornbeam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.86	0.00	0.00	0.00
Black birch	11.48	1.89	14.96	12.50	0.00	0.00	13.33	0.00	4.17	3.33	18.52	8.57	4.08	0.00	0.00
Black cherry	13.11	0.00	0.00	0.00	1.96	4.76	0.00	2.44	1.39	0.00	1.85	0.00	0.00	0.00	6.82
E. hemlock	47.54	24.53	43.31	44.23	39.22	20.63	53.33	41.46	33.33	1.67	1.85	11.43	42.86	0.00	2.27
Hickory sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.41	4.55
Hop hornbeam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00
Red maple	6.58	24.53	33.86	20.19	33.33	3.17	5.56	7.32	8.33	10	5.56	0.00	10.2	14.81	2.27
Striped maple	0.00	1.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	0.00
Sugar maple	0.00	0.00	0.00	0.00	0.00	39.68	0.00	24.39	23.61	73.33	37.04	62.86	4.08	62.96	65.91
White ash	0.00	0.00	0.00	0.00	0.00	4.76	0.00	2.44	12.5	6.67	7.41	0.00	2.04	0.00	13.6
White pine	0.00	43.40	2.36	5.77	1.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.08	0.00	0.00
Yellow birch	8.20	0.00	2.36	1.92	23.53	14.29	22.22	0.00	0.00	0.00	0.00	8.57	0.00	0.00	0.00

Table 5. Number of seedlings and saplings by species in each plot at Highpoint Preserve.

Plot	American beech	Black cherry	Red maple	Shagbark hickory	Sugar maple	Striped maple	Sweet birch	White pine
1	10	51	16	0	0	0	0	2
3	11	1	0	0	0	0	0	0
5	6	10	0	0	0	0	0	0
6	1	1	0	0	0	0	0	0
10	5	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
20	2	0	0	0	19	0	0	0
25	10	0	5	0	10	1	0	0
30	1	0	0	0	4	4	0	0
35	2	0	0	0	80	0	0	0
40	5	0	0	0	13	302	0	0
42	5	0	0	1	9	2	0	0
45	42	1	10	0	8	39	46	0
50	25	0	20	0	75	6	0	0
55	0	0	100	0	100	0	0	0

New and Ongoing Research

Longford Lake Deer Exclosure

The white-tailed deer is both a charismatic and influential member of our biological community. Through extensive browsing, deer can affect the kinds and numbers of plants present in an area, impair the ability to grow new trees, and shape the overall structure of the forest, both present and future. The changes brought about by deer can affect the quality of the forest, and reduce available food and habitat for other wildlife species.

As selective browsers, deer prefer certain plant species over other less desirable species. Many of the tree species deer prefer are valued for timber or as wildlife food trees (e.g., oak, maple). Deer also eat many wildflower and understory plants like trillium and lady slipper, but tend to avoid ferns and some other plants. By feeding on certain species and leaving others behind, deer can actually change the plant species and community composition in a forest.

Deer can reduce the abundance of wildflowers such as trillium.

In addition to changing the types of plants, deer can also cause changes in the vertical structure of the

forest. For example, over-browsing of tree seedlings and shrubs creates open, park-like stands with few preferred food species near the ground and little or no forest understory. Loss of forest understory affects other wildlife too, particularly those songbirds that rely on the forest understory for nesting and feeding. In fact, some animal species may become less abundant in heavily browsed areas, while others may disappear completely where deer have done there damage.

To determine and demonstrate the severity of impacts deer are having on vegetation and potential forest regrowth in Susquehanna County, Conservancy members and volunteers from Rockwell Collins constructed a deer exclosure at Longford Lake in 2006. Following an experimental design created by the Cornell Conservation Education and Research team, black cherry and red oak seedlings were planted both inside and outside of the exclosure, situated in an open area near a woodland edge.

After six years, the results have been striking. Based on data collected this year, 98% of the black cherry seedlings planted inside the exclosure have survived, while only 72% have survived outside the exclosure. In contrast, the black cherry seedlings outside of the exclosure have only grown to an average of 11 inches tall, while those within the exclosure have grown to an average of 5 ½ feet tall.

Inside the fence, the planted seedlings are thriving and many are over 5 or 6 feet tall.

Browsing effects on the northern red oak seedlings was even more pronounced. Eighty percent of the red oak seedlings within the exclosure have survived, while only 30% have survived outside of the exclosure. The seedlings inside the exclosure average about 4 feet in height, compared to survivors on the outside which average only 9 inches. So, overall, most black cherry seedlings were able to withstand multiple years of deer browsing, but their height was stunted greatly and their chances of ever growing beyond the reach of deer are probably minimal. Red oak seedlings were much more sensitive to browsing early on and suffered a higher rate of mortality in the first six years, and even slower growth when browsed repeatedly.

From this straightforward experiment, it is clear that deer are having a substantial effect on the vegetation in the area, and likely are delaying, or even preventing, natural forest regeneration. After six growing seasons, the planted seedlings within the exclosure have reached a height sufficient enough to guarantee their escape from the pressures of deer browsing (5-6 feet).

After six years, the few red oak seedlings that survived outside of the fence have been browsed multiple times and are still very small.

Additionally, many trees including red maple, black birch, aspen and apple have seeded into the exclosure on their own and have grown to heights of five feet or more. In the absence of reduced deer populations, landowners in the region hoping to reforest an open area, or grow young trees (regenerate) within existing forest, will need to provide protection around seedlings for them to survive and grow.

Inside the deer exclosure (pictured right) the tree seedlings have thrived. Outside the deer exclosure (pictured left within red circle) seedling mortality has been high and few seedlings have grown taller than 11 inches high.

Effect of Gas Pipeline Development on Amphibians

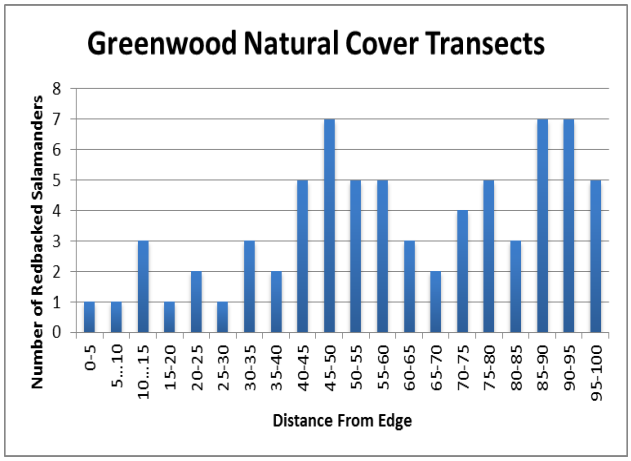
In 2012, we initiated a research project to study to the effects of Marcellus Shale gas exploration and development on forest amphibians in northern Pennsylvania, using Greenwood Sanctuary as one of our study sites. Amphibians reach their highest diversity within eastern forests and are highly sensitive to changes in forest cover and increased road densities making understanding effects of Marcellus activity on this group extremely critical. Direct loss of forest habitat, as well as changes in remaining forest due to forest fragmentation, may have a substantial effect on forest salamander populations. When sizable openings in the forest tree canopy are created, forest floor temperatures may rise, and soil moisture maydecrease considerably. Salamanders are sensitive to heat, and prone to desiccation when soil moisture is low.

To measure the effects of gas pipeline openings on adjacent populations of forest salamanders, we established both natural cover and artificial cover transects along which to measure the relative abundance of salamanders from pipeline openings into the adjacent forest. We established five natural cover transects and four artificial cover transects at Greenwood Sanctuary. These transects are located a minimum of 30 m apart. Each natural cover transect begins at the forest edge (0 m) and extends perpendicularly into the forest for a distance of 100 m (Figure 2). Artificial cover transects are 50 m in length. We placed a pair of coverboards, constructed from rough-cut lumber, at 10-m intervals (from 0 to 50 m into the forest) along each

transect. At each 10-m interval one board was placed 0.5 m to the left of the transect, and another was placed 0.5 m to the right of the transect (Figure 2).

Figure 2. Natural cover transects (yellow) begin at the pipeline edge and extend 100 m into the forest. Artificial cover transects (orange) begin at the edge and extend 50 m

Natural cover surveys were conducted by walking slowly along each transect, recording all amphibians found on the surface or under cover objects. All amphibians seen on the surface or under cover (rocks, logs) within a 3-m wide strip centered on each transect were recorded. Artificial cover surveys were conducted by turning over all cover boards along each transect, and recording the number and species of salamanders found under each board. Natural cover searches were conducted three times from July to September 2012, and artificial cover searches were conducted five times from June to October. Results from each of the methods show a general increase in the number of redbacked salamanders from the edge of the pipeline into the interior of the forest (Figure 3). Very few red-backed salamanders were present within the first 15 m from the edge.



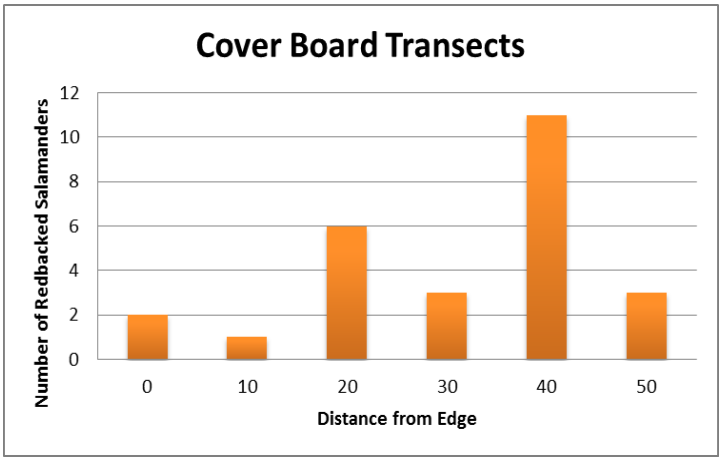


Figure 3. The number of redbacked salamanders increased with distance from edge. Few salamanders were found within the first 10 m from the pipeline opening.

To determine the effects of pipeline creation on temperature and light from the edge of the opening into the forest, Hobo temperature and light data loggers were installed along one of the artificial cover transects at the Susquehanna County site. Each data logger measured and archived temperature and light readings every two hours, from the end of July through the beginning of October. Temperature was higher nearer the pipeline edge, and cooler deeper into

the forest. Data collection will continue at this and other sites throughout the state in the upcoming year.

Hemlock Woolly Adelgid Monitoring, Research and Control

This summer, we discovered an infestation of hemlock woolly adelgid (HWA) at Greenwood Sanctuary, and subsequently conducted a property-wide survey for HWA at both Greenwood Sanctuary and Highpoint Preserve. The adelgid is a destructive, non-native insect pest which presents a serious danger to eastern hemlock trees. Once infested, untreated hemlock trees often die within 4-10 years. The level of infestation is moderate and widespread at Greenwood Sanctuary. At Highpoint Preserve, there is some evidence of HWA, but it appears to be a new, localized infestation.

Hemlock trees help maintain cool water temperatures for fish and other aquatic organisms and provide important and unique habitat and food resources for wildlife. Therefore, the loss of hemlocks could have far-reaching effects beyond just the trees. Sudden and widespread death of hemlock trees at Silver Lake and Greenwood could further lead to soil erosion on steep slopes. The cooling shade which hemlock trees now provide along the water's edge would be lost, and could contribute to warmer water temperatures in Silver Lake.

A long-term plan is needed to address the potential impacts of HWA and determine appropriate treatment options. Researchers have been investigating the use of natural adelgid predators (beetles) as biological controls to manage HWA at the landscape scale. These beetles have been released in a number of locations in Pennsylvania and show some promise. However, it may be years before populations of these beetles reach the levels needed to provide widespread protection. Therefore, for the time being, chemical insecticides are the only effective option for controlling this pest. We conducted extensive research on current HWA treatment options, which included interviews with leading experts from Cornell University and the National Park Service. We attended a Stewardship Committee meeting at the Nature Conservancy's Woodbourne Preserve to explore future, long-term collaborative treatment options with the Nature Conservancy. In the short term, in an effort to safeguard some individual hemlock trees at Greenwood Sanctuary, we selected, measured and marked 23 hemlock trees for basal bark treatment with Dinotefuran, and coordinated treatment with a local applicator. Dinotefuran provides immediate protection to the treated trees – protection that lasts for up to 2 years.

Water Quality Monitoring

In support of Conservancy efforts to engage citizens in water quality monitoring, undergraduate students from Cornell's Applied Conservation Ecology class undertook a group project focused on industrial gas development and water quality in Susquehanna County. They looked at gas well locations in relation to topography and streams to develop a predictive risk assessment model to target water quality monitoring locations with the greatest likelihood of detecting impacts resulting from natural gas drilling activities. Using GIS, students assembled a number of different spatial data layers. The layers included streams, watersheds, a digital elevation model, roads and bridges, and active and permitted gas wells. They modeled the flow of water over the landscape relative to gas well locations to pinpoint downstream locations most likely to receive water flow from areas with gas wells (Figure 4). Bridge locations closest to those downstream locations were then designated as potential water sampling sites, and labeled according to the number of gas wells within the watershed draining to that location (Figure 5). Bridges with the highest numbers are the sites at which water quality impacts are most likely to be captured.

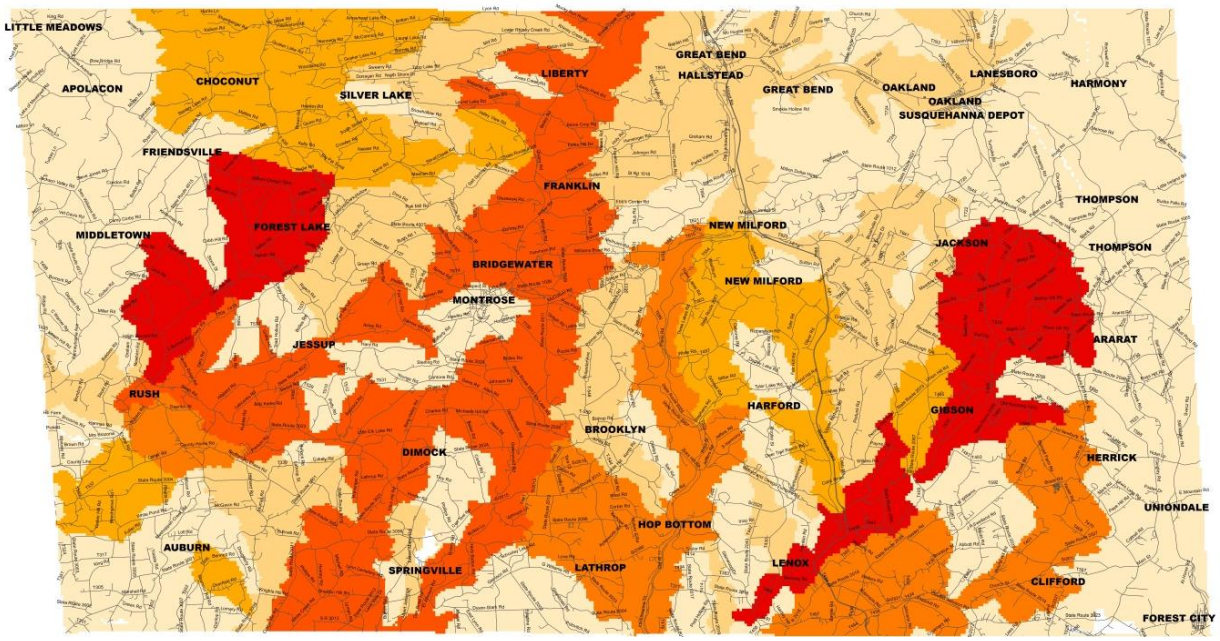


Figure 4. Watersheds shown in red and orange had the greatest number of permitted gas wells as of June 2012, and therefore the greatest risk for water quality impacts.

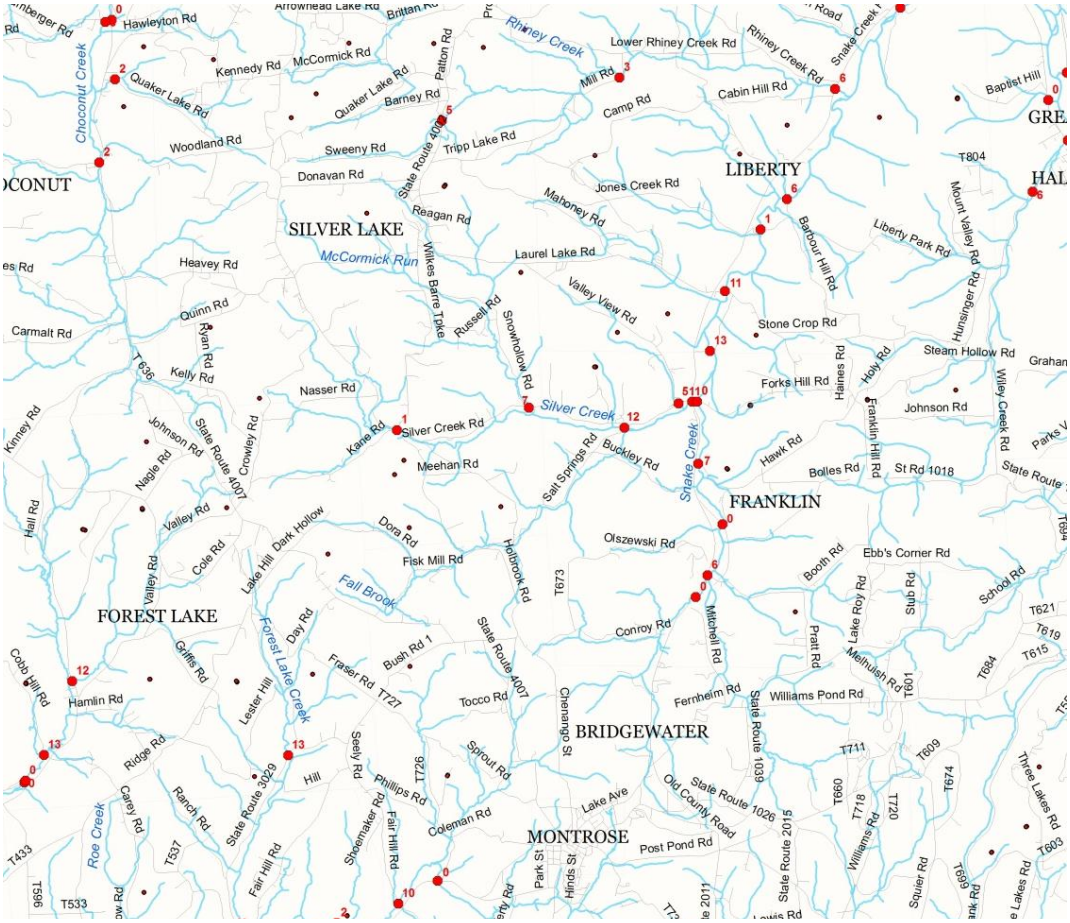


Figure 5. Sample of GIS map showing bridge locations that could be used as water monitoring sites, and labeled according to the number of gas wells within the watershed draining to that location.

Education and Outreach

This year we, along with several undergraduate students, were involved in several educational outreach efforts. We delivered a presentation at the water quality monitoring workshop in June, and provided one-on-one consultation with workshop participants using the GIS maps developed with students as a focus of discussion. Other outreach efforts included writing an article about the Longford Lake deer exclosure research results for inclusion in the summer newsletter, a letter to Silver Lake residents regarding monitoring and treatment of hemlock woolly adelgid, and two fact sheets and checklists of dragonflies and damselflies of Silver Lake and Greenwood Preserve (Appendix B).

Summary

Through our collaborative efforts in 2012, we continued to expand and enhance our collective knowledge about the ecology of the Conservancy's fee-owned properties, as well as their respective roles within the overall landscape. We expanded biological survey, inventory, research and monitoring efforts, and addressed critical issues of water quality and the spread of invasive species. We incorporated Cornell undergraduate students into all aspects of our work with the Conservancy, in an effort both to provide them with hands-on experience and to bring their skills and knowledge to bear on Conservancy-related issues.

Appendix A. Permanent Forest Inventory Plot Methodology

Permanent Forest Inventory Plot Methodology

(Adapted in 2008 from methodology developed for Cornell's Arnot Forest)

Objective: Establish permanent plot samples throughout the forest to measure the change in various forest characteristics through time. Be able to describe changes in forest species composition, structure, health and habitat availability that result from natural forest dynamics and management practices.
Assumptions/Constraints: Plots will be established annually. Each point will be re-sampled every 5 to 8 years and allow an analysis of change through time. Some plots may be sampled more frequently to assess short-term forest dynamics.
Methods: Establish 10-15 plots per year, distributed among properties owned or managed by the E.L. Rose Conservancy in Susquehanna County, Pennsylvania. Plots will be numbered sequentially. Plot center is marked with a white 2.5" PVC pipe 5' long. A GPS unit will be used to record UTM coordinates. A "Permanent Plot Location Sheet" will be completed for each plot. This sheet will include written directions/map to the plot, a general description, and information about deer impact. Each plot will include:

- A fixed radius overstory plot (0.25 acres, 58.9 ft. radius) where all live trees $\geq$ 4" dbh will be tagged with aluminum numbered tags and aluminum nails at 12" above ground, and tallied by species, dbh, presence of cavities > 1" diameter, and crown class. DBH will be measured to the nearest 0.1 inch using a diameter tape located at the top of a 3.5' stick placed on the nail. Nails should face plot center. All dead trees will be tallied and diameter will be recorded.
- Within each overstory plot record elevation, aspect, % slope, slope shape, percent fern cover, and presence or absence of grass, seeps or wet areas, trails or roads, logs in water, perches, soft or hard mast species, rock piles, rock crevices, caves, and cavities in living or dead trees. Also make note of the presence or absence of accumulate litter on the forest floor, and note the presence or absence of forest pests including beech blight, hemlock woolly adelgid, and emerald ash borer.
- Within each plot, N/S and E/W lines transecting the diameter of the plot will be established to record the percent cover of coarse woody debris > 3" diameter at the point of their intersection with the transect. Record diameter at the intersection, condition, and whether bark is present.
- At the north and south cardinal directions on the edge of the overstory plot, establish sapling/ground layer plots having an 11.8' radius to equal 0.01 acres each. Subplot centers should be marked with a 30" wooden stake and flagged. Record the number of woody stems by species in the ground layer (height of 4" – 54") and sapling/shrub layer (height > 54" up to 3.99" dbh) using decadal increments (1-10 by one; 11 to 100 by tens; 101+ by hundreds).
- Within each sapling subplot (11.8' radius), record presence or absence of the following herbs: sensitive fern, maiden-hair fern, Christmas fern, true ginseng,

dwarf ginseng, blue cohosh, jack-in-the-pulpit, or trillium. Also record presence or absence of invasive species including garlic mustard, barberry, multi-flora rose, honeysuckle, or autumn olive, and the percent of inhibiting fern cover, percent of other fern cover, and percent grass and sedge cover.

List of Equipment Needed

1. PVC Pipe: preferably white 2.5" PVC pipe 5' long
2. Short wooden stakes
3. Blue spray paint (for the top of the PVC)
4. Tags for the pipe (the soft etch-able aluminum one work)
5. Round aluminum tree tags from Forestry Suppliers Co.
6. Multiple tape measures
7. Data sheets, pencils, and permanent marker
8. DBH tape
9. Hammer
10. Aluminum nails (aluminum makes it safe for loggers)
11. Small sledge hammer (to pound in stakes)
12. Flagging
13. Field guides if necessary

Definitions of Variables Recorded at Permanent Forest Inventory (PFI) Plots at Greenwood

Deer Impact: An estimate of the browsing pressure that deer are having on tree seedlings in the area of the sample plot. Code is as follows:
1= low pressure; 2= low/medium; 3= medium; 4=medium/high; 5= high
Travel Description: A narrative description of travel from the nearest permanent location or landmark.
Map: A hand sketch of the travel description.
Overstory Plot Size: The length of the plot's radius in feet. Typically 58.9' unless otherwise noted.
Sapling Plot Size: The length of the subplot's radius in feet. Typically 11.8' unless otherwise noted.
Seedling Plot Size: The length of the subplot's radius in feet. Typically 11.8' unless otherwise noted.
Aspect: The direction of the downward slope coded as: North, Northeast, East, Southeast, South, Southwest, West, or Northwest.
Slope: The calculated percent slope. Can be calculated in the field or from a topographic map.
Slope Shape: An visual estimation coded as: 1=convex; 2=linear; 3=concave

Topographic Position: Coded as: 1=Upland Plateau; 2=Upland Bottom; 3=Ridge Top; 4=Upper Slope or Shoulder; 5=Mid-slope; 6=Bench; 7=Lower Slope; 8=Bottomland/Flatland.
Riparian %: The percentage of the plot that characterized by stream channels, wetlands, floodplains, and immediately adjacent terrestrial ecosystems.
Seep: Enter either "present" or "absent" as to the presence of seeps or springs within or adjacent to the plot. A seep is a source of surface ground water without a well-defined point of origin. A spring has a well-defined point of origin. Seeps and springs may or may not have vegetation around them.
Streams: Enter "present" if perennial streams are within the stand or immediately adjacent to the stand.
Temporary Ponds: Enter "present" if any temporary or vernal pools are within or adjacent to the plot. Temporary ponds must be greater than 6 inches deep and greater than 1 square yard; water must be present for at least two months during the growing season. The exact month differs for each species that uses temporary ponds. Areas covered by a fine layer of silt and depressions filled with blackened leaves me serve as dry season indicators of temporary ponds.
Permanent Ponds: Enter "present" if any permanent ponds of lakes are within or adjacent to the plot. Permanent ponds are any size of depth, but larger is generally better; water must be present year-round, although the top layer can freeze.
Logs in water: Enter "present" if any downed logs are partially or wholly in a permanent water source.
High Perch: Enter "present" if any high exposed perches occur in the plot. A high perch is any live or dead tree that clearly towers above the canopy such as a supracanopy white pine, or a single tree or group of trees standing above ground vegetation such as a lone elm in a pasture or a snag in a clearcut.
Hard mast: Enter "present" if there are any plant species in or near the plot that provide hard mast such as acorns or hickory.
Loose soils: Enter "present" if there is soil that can be easily burrowed into.
Rock Piles: Enter "present" if there are any natural or man-made piles (rock walls), as long as they provide hiding places for small mammals, amphibians, or reptiles.
Rock crevices: Enter "present" if there are openings in the rocks that lead below the frost line.
Caves: Enter "present" if there are any caves or larger rock openings that lead below the frost line.
Live cavities: Enter "present" if there are any live trees in or near the plot with cavities at least 1" in diameter. This is collected in the overstory plot and may be determined from field data.
Dead cavities: Enter "present" if there are any dead trees in or near the plot with cavities at least 1" in diameter. This is collected in the overstory plot and may be determined from field data.

Coarse Woody Debris: Any fallen logs or trees that are longer than three feet and greater than three inches in diameter.

Condition: Coded as: 1=solid/good; 2=rotten/ poor

Species: For every tallied tree, enter the tree species using either the 3-digit forest survey code or the mnemonic abbreviation.

DBH: The diameter at breast height (typically four feet above the ground).

Crown Class: Determine the position of the tree crown using the following codes:

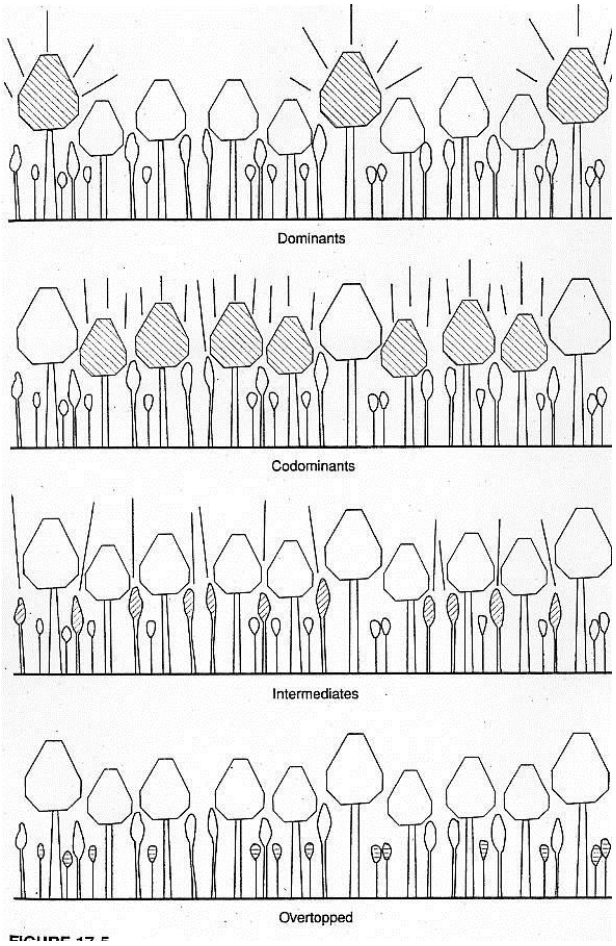
1= open grown- a tree that is free of competition and receives light on top and all sides of the crown as a result of a very heavy thinning or being in an isolated, open-grown position.

2= dominant- a tree with the crown extending above the general level of the main crown canopy and receiving full light from above and partly from the sides.

3=codominant-a tree with a crown forming the general level of the main canopy, receiving full light from above but little from the sides.

4=intermediate- a tree with a crown extending into the lower portions of the main crown canopy, but shorter than the codominants and receiving little direct light from above and none from the sides.

5=suppressed- a tree whose crown is entirely below the general level of the canopy and receives no direct light from either above or the sides.



Data Sheets for Permanent Forest Inventory (PFI) Plots
-PFI Plot Features

Tally date _____/ _____/ _____ Page _____ of _____

PFI Plot Number _____ Tallied by_____

Overstory Plot Size (radius, ft)	58.9
Sapling/ Seedling Plot Size (radius, ft)	11.8

Elevation	
Aspect	
Slope	
Slope Shape	
Topo Position	
UTM Coordinates:	

Trail on Road (y/n)	
Riparian %	
Wetland %	
Adjacent water(y/n)	
Seep (p/a)	
Stream (p/a)	
Temp. Pond (p/a)	
Perm. Pond (p/a)	

Logs in water (p/a)	
High Perch (p/a)	
Low Perch (p/a)	
Soft Mast (p/a)	
Hard Mast (p/a)	
Rock Pile (p/a)	
Rock Crevice (p/a)	
Cave (p/a)	
Live Cavity (p/a)	
Dead Cavity (p/a)	
# of Snags	
Accumulate litter (p/a)	

Comments:

_____

_____

_____

_____

_____

Sapling/Seedling Plot Features

Indicator Species	North	South
Ginseng (p/a)		
Dwarf ginseng (p/a)		
Sensitive fern (p/a)		
Maiden-hair fern (p/a)		
Christmas fern (p/a)		
Trillium (p/a)		
Blue cohosh (p/a)		
Jack-n-the-pulpit (p/a)		
Invasive Exotics		
Garlic mustard (p/a)		
Barberry (p/a)		
Multi-flora rose (p/a)		
Honeysuckle (p/a)		
Autumn Olive (p/a)		
Inhibiting Fern Cover (%)		
Other Fern Cover (%)		
Grass and Sedge Cover (%)		
Soggy Ground (%)		
Surface Stone > 50% (y/n)		

Forest Health

Beech blight (p/a)	
Hemlock woolly adelgid (p/a)	
Emerald ash borer (p/a)	
Other:	

Coarse Woody Material

N-S Transect (117.8ft)			E-W Transect (117.8ft)		
Diam. (ft.)	**Cond. (1/2)**	**Bark (y/n)**	**Diam. (ft.)**	**Cond. (1/2)**	**Bark (y/n)**

-PFI Herp Search Data and Wildlife Sign

PFI Plot Number _____ Tally Date _____/ _____/ _____
Tallied By _____ Page _____ of _____

Time of day	
Days since significant rain	
Litter moisture rating	Dry Moist Wet
Number of turn-overs (minimum 10)	

Species Name **Number Found**

1. _____ _____
2. _____ _____
3. _____ _____
4. _____ _____
5. _____ _____

Wildlife Sign / Special Features

_____
_____
_____
_____
_____
_____
_____
_____

-Greenwood Preserve Permanent Plot Location Sheet

PFI Plot Number _____ Tally date: ____/ ____/ _____
Tallied by _____ Page _____ of _____

Pictures _____ -_____

Plot Habitat Description	
Deer Impact	

Comments/ Travel Description:
_____
_____
_____
_____

Map / Directions

-PFI Seedling-Sapling Sample Data Sheet

PFI Plot Number _____ Tally Date _____/ _____/ _____
Tallied by _____ Page _____ of _____

Subplot : 11.8′ radius
Seedlings: 4″-- 54″ tall
Saplings: 54.1″ tall -- 3.99″ dbh

North Subplot		
SPP	**#SDL**	**#SPL**

North (cont.)		
SPP	**#SDL**	**#SPL**

South Subplot		
SPP	**#SDL**	**#SPL**

South (cont.)		
SPP	**#SDL**	**#SPL**

-PFI Overstory Tree Sample Data Sheet

PFI Plot Number _____ Tally Date _____/ _____/ _____

Tallied By _____

Tree #	Species	dbh	Cavity (y/n)	Crown class

Tree #	Species	dbh	Cavity (y/n)	Crown class

Appendix B. Educational and Outreach Materials

- **Checklists of Odonates of Greenwood Sanctuary and Odonates of Silver Lake**
- **Odonates of Greenwood Sanctuary and Odonates of Silver Lake handouts**
- **Deer exclosure article for newsletter**
- **Letter to Silver Lake residents regarding hemlock woolly adelgid**

Checklist of Odonates at Greenwood Sanctuary

Check Here if Observed	Scientific Name	Common Name
	Argia fumipennis violacea	Variable Dancer
	Calopteryx maculata	Ebony Jewelwing
	Celithemis elisa	Calico Pennant
	Enallagma signatum	Orange Bluet
	Epitheca cynosura	Common Baskettail
	Erythemis simplicicollis	Eastern Pondhawk
	Ischnura verticalis	Eastern Forktail
	Lestes dryas	Emerald Spreadwing
	Libellula pulchella	Twelve-spotted Skimmer
	Perithemis tenera	Eastern Amberwing

Checklist of Odonates at Silver Lake and Highpoint Preserve

Check Here if Observed	Scientific Name	Common Name
	Argia fumipennis violacea	Variable Dancer
	Argia moesta	Powdered Dancer
	Enallagma geminatum	Skimming Bluet
	Enallagma traviatum	Slender Bluet
	Erythemis simplicicollis	Eastern Pondhawk
	Libellula incesta	Slaty Skimmer
	Libellula luctuosa	Widow Skimmer
	Libellula pulchella	Twelve-spotted Skimmer
	Perithemis tenera	Eastern Amberwing
	Plathemis lydia	Common Whitetail

Odonates Of Greenwood Preserve

Emerald Spreadwing

Eastern Pondhawk

Calico Pennant

Eastern Forktail

Ebony Jewelwing

Common Baskettail

Twelve-Spotted Skimmer

Variable Dancer

Eastern Amberwing

THE E.L. ROSE CONSERVANCY of SUSQUEHANNA COUNTY

Orange Bluet

Odonates of Silver Lake and Highpoint Preserve

Variable Dancer

Powdered Dancer

Slender Bluet

Skimming Bluet

Widow Skimmer

Slaty Skimmer

Eastern Amberwing

Common Whitetail

Eastern Pondhawk

Oh Deer! The Longford Lake Deer Exclosure Experiment

The white-tailed deer is both a charismatic and influential member of our biological community. Although graceful and stately, deer can greatly impact their own habitat, the resources of other species, and the forest ecosystem overall. Through extensive browsing, deer can affect the kinds and numbers of plants present in an area, impair the ability to grow new trees, and shape the overall structure of the forest, both present and future. The changes brought about by deer can affect the quality of the forest, and reduce available food and habitat for other wildlife species.

As selective browsers, deer prefer certain plant species over other less desirable species. Many of the tree species deer prefer are valued for timber or as wildlife food trees (e.g., oak, maple). Deer also eat many wildflower and understory plants like trillium and lady slipper, but tend to avoid ferns and some other plants. By feeding on certain species and leaving others behind, deer can actually change the plant species and community composition in a forest.

In addition to changing the types of plants, deer can also cause changes in the vertical structure of the forest. For example, over-browsing of tree seedlings and shrubs creates open, park-like stands with few preferred food species near the ground and little or no forest understory. Loss of forest understory affects other wildlife too, particularly those songbirds that rely on the forest understory for nesting and feeding. In fact, some animal species may become less abundant in heavily browsed areas, while others may disappear completely where deer have done there damage.

To determine and demonstrate the severity of impacts deer are having on vegetation and potential forest regrowth in Susquehanna County, Conservancy members and volunteers from Rockwell Collins constructed a deer exclosure at Longford Lake. Following an experimental design created by the Cornell Conservation Education and Research team, black cherry and red oak seedlings were planted both inside and outside of the exclosure, situated in an open area near a woodland edge.

After six years, the results have been striking. Ninety-eight percent of the black cherry seedlings planted inside the exclosure have survived, while only 72% have survived outside the exclosure. But that is not the whole story. The black cherry seedlings outside of the exclosure have only grown to an average of 11 inches tall, while those within the exclosure have grown to an average of 5 ½ feet tall! And browsing effects on the northern red oak seedlings was even more pronounced. Eighty percent of the red oak seedlings within the exclosure have survived, while only 30 percent have survived outside of the exclosure. The seedlings inside the exclosure average about 4 feet in height, compared to survivors on the outside which average only 9 inches. So, overall, most black cherry seedlings were able to withstand multiple years of deer browsing, but their height was stunted greatly and their chances of ever growing beyond the reach of deer are probably minimal. Red oak seedlings were much more sensitive to browsing early on and suffered a higher rate of mortality in the 1st six years, and even slower growth when browsed repeatedly.

Inside the deer exclosure (pictured right) the tree seedlings have thrived. Outside the deer exclosure (pictured left within red circle) seedling mortality has been high and few seedlings have grown taller than 11 inches high.

From this straightforward experiment, it is clear that deer are having a substantial effect on the vegetation in the area, and likely are delaying, or even preventing, natural forest regeneration. After six growing seasons, the planted seedlings within the exclosure have reached a height sufficient enough to guarantee their escape from the pressures of deer browsing (5-6 feet). Additionally, many trees including red maple, black birch, aspen and apple have seeded into the exclosure on their own and have grown to heights of five feet or more. This is good news. Landowners in the region hoping to reforest an open area, or grow young trees (regenerate) within existing forest, can have similar success by protecting young seedlings from browsing and watching them thrive.

Dear (Conservancy member, Lake Association member, neighbor at Silver Lake, etc.),

This summer, our Cornell University partners discovered hemlock woolly adelgid on several hemlock trees in Highpoint Preserve. In addition, two neighboring property owners at either end of the lake reported finding infested trees on their land. The adelgid is a destructive, non-native insect pest which presents a serious danger to the hemlock trees along the lake and in the Preserve, and could pose a threat to the beautiful view enjoyed by all. Quick and decisive action is very important to slowing the spread of this damaging insect. Once infested, untreated hemlock trees often die within 4-10 years. In light of this new and serious problem, we are contacting you and all our neighbors to increase awareness about this pest, and offer assistance.

Hemlock trees help maintain cool water temperatures for fish and other aquatic organisms and provide important and unique habitat and food resources for wildlife. Therefore, the loss of our hemlocks could have far-reaching effects beyond just these trees. Sudden and widespread death of hemlock trees at Silver Lake could further lead to soil erosion on steep slopes. The cooling shade which hemlock trees now provide along the waters' edge would be lost, and could contribute to warmer water temperatures in Silver Lake.

Researchers have been investigating the use of natural adelgid predators (beetles) as biological controls to manage hemlock woolly adelgid at the landscape scale. These beetles have been released in a number of locations in both Pennsylvania and New York and show some promise. However, it may be years before populations of these beetles reach the levels needed to provide widespread protection. Therefore, for the time being, chemical insecticides are the only effective option for controlling this pest.

Some of the chemical products used are providing up to 4 years of protection with a single application. However, application of these products may require professional certification, and some are restricted from use near water. Because of the complexities involved the Edward L. Rose Conservancy, in conjunction with our Cornell partners, is offering to coordinate an adelgid education and control program for property owners in the area.

If you are concerned about the well-being of hemlock trees on your property, and would like to help slow the spread in and around Highpoint Preserve, we recommend the following:

1) **Search each of your hemlock trees** for hemlock woolly adelgid – a brochure with pictures of the adelgid is attached to this email to help you identify the white woolly masses attached to the underside of twigs near the base of the needles.

2) If you suspect you have hemlock woolly adelgid on any of your trees, please **report it by October 15th** by emailing or calling Kristi Sullivan (kls20@cornell.edu, 607-255-5508). Kristi is also available to visit your property to confirm that adelgid is present, answer questions about treatment options, and coordinate treatment for anyone interested.

If we catch this problem early and work together, we may have a chance at beating this destructive pest.