Chapter 8

Biota of the Lehigh Gap Wildlife Refuge – Plants

LGWR Biota – Plants

Follow-up to the Plant Community Studies of the Ecological Assessment Part I

A main focus of Part I of the Ecological Assessment of the LGWR (finished in July 2007) was to inventory the plant species on the Refuge and identify and characterize the biotic or ecological communities. These communities are classified by the dominant plant species which, in turn, are highly influenced by the abiotic features such as bedrock, water supply, and exposure to sun. From the surveys done, 374 vascular plants were identified, of which 57% (214 species) are herbaceous perennials and 29% (110 species) are non-native. Sixteen species (4%) are rare or very rare. Based on the total number of plant species, one might conclude that there is great biodiversity on the Refuge; however, 73% of the species were rated as scarce. Only 12 species or 3% of the plants were considered abundant.

Since Part I of the LGWR Ecological Assessment was completed, four species of plants have been found that were not previously recorded. These include purple-leaved willow-herb (*Epilobium coloratum*), daisy fleabane (*Erigeron annuus*), sweetfern (*Comptonia peregrina*), and mountain mint (*Pycnanthemum tenuifolium*). Also, one species discovered during the previous study, bristly greenbrier (*Smilax hispida*) was noted in the text on page 21, but was not included in the full listing of the vascular flora.[1] A number of native species have been introduced in the habitat gardens and in test plots in the grasslands (see below and Appendix F-1) since Part I of the assessment was completed.

Of the abundant species identified in the earlier assessment, some were early successional trees such as sweet birch (*Betula lenta*) and gray birch (*Betula populifolia*). Since then, the number of these birch saplings has increased dramatically in the grassland areas especially starting about one-third of the way up the mountain between the LNE and the Charcoal Trails. Many of these birch trees that are growing along either side of the LNE trail on the steep slopes of the ridge north of the Osprey House show signs of stress including leaf margin chlorosis, small leaf size and leaf curling, early leaf drop, and stunted growth.

[1] See Appendix A, Lehigh Gap Wildlife Refuge Ecological Assessment, 2007 available at http://lgnc.org/wp/wp-content/uploads/2009/06/lgnc-ecological-assessment.pdf.
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A young gray birch along the LNE Trail in July showing signs of stress

Studies summarized in Appendix G and discussed in Chapter 9 determined that gray birch takes up zinc from the soil and accumulates it in leaf tissue to levels around 1000 ppm. This is consistent with the findings of BBL [2]; those studies showed that sweet birch also takes up metals from the soil. The leaf marginal chlorosis shown in the image below could likely be due to direct metal toxicity and/or damage caused by the formation of reactive oxygen species formed in the presence of the zinc and other heavy metals.[3]

Leaf marginal chlorosis in Gray Birch from the LGWR

The trees are also likely stressed from a lack of nutrients, especially nitrogen, due to the poor quality of the soil and from water deficits since there is little organic matter in the ground to retain water. The latter becomes a particular problem in mid-summer in Pennsylvania where short-term droughts are common.

Evidence of stress in sweet birch leaves at the LGWR

Two other trees that were described as abundant include sassafras (*Sassafras albidum*) and black gum or tupelo (*Nyssa sylvatica*). Stunted remnants of both of these trees were evident in what is now the grassland, even when the area was essentially denuded of most vegetation. Both

[2] Preliminary Human Health and Ecological Risk Evaluation and Data Summary Report – Warm Season Grass Remediation Area, 2004. Prepared for Viacom International, Inc. by BBL (now Arcadis).

[3] A. Schützendübel and A. Polle, 2002. Plant Responses to Abiotic Stresses: Heavy Metal-Induced Oxidative Stress and Protection by Mycorrhization, *J. Expt. Bot*. 53: 1351-1365; Michalak, A. 2006 Phenolic Compounds and Their Antioxidant Activity in Plants Growing under Heavy Metal Stress, *Polish J. of Environ. Stud.*, Vol. 15, No. 4 (2006), 523-530.

tree species are capable of vegetative (asexual) progagation; sassafras can readily form pure stands through suckering and black gum stumps sprout readily and larger stumps sprout and develop root suckers. Thus, it is believed that with the soil amendments added at the time of the grass seed planting, conditions improved enough so that the remaining stumps of these species were able to re-propagate more readily that trees that can only reproduce sexually. The high metal levels remaining in the ground are toxic to young seedlings and reproductive success was most likely hampered further by the acidic soil conditions, and the lack of cover exposing seeds to harsh winds, temperature extremes and strong sunlight.

Photo of the grasslands in October 2008 showing sassafras and black gum trees

Both types of birch have been shown to take up significant amounts of zinc. Sassafras trees, on the other hand, accumulate zinc at only about one-tenth of the levels of the birch (see Appendix G and BBL report[4]). The reason for this is unknown, but it helps to explain why the sassafras trees do not show the same types of metal toxicity signs that the birch do. Metal uptake by black gum trees has not been tested at the LGWR site to date.

Another abundant species noted in Part I of the assessment is hay-scented fern (*Dennstaedtia punctilbula*). Large patches of this fern are typically indicative of over-browsing by white-tailed deer (*Odocoileus virginianus*). From the preliminary herbivory studies at the Refuge, the large number of tracks evident after a snowfall and the number of deer that have been photographed from the fall 2010 trail camera study (Chapter 3), there is clear evidence of a significant deer population on the site.

In Part I of the LGWR Ecological Assessment, it was noted that wild bleeding heart (*Dicentra eximia*) which is endangered in the state is surprisingly prevalent at the Refuge (and throughout the Palmerton area). In fact, it was noted that this may comprise the largest indigenous population of the species in Pennsylvania.[5] The population is still thriving at the LGWR along the mountain slopes, especially in ravines and erosion areas along the railroad rights-of-way (both the D&L and LNE Trails).

[4] Preliminary Human Health and Ecological Risk Evaluation and Data Summary Report – Warm Season Grass Remediation Area, 2004. Prepared for Viacom International, Inc. by BBL (now Arcadis).

[5] See page 8 of the LGWR Ecological Assessment – Part I, 2007.

Dicentra eximia

Also noted in Part I of the assessment, the Lehigh Gap area is the sole known location in Pennsylvania for Pitcher's stitchwort or glade sandwort (*Minuartia patula;* syn. *Arenaria*). This plant is known to be in a group of metal "hyper-accumulators". From studies described in Appendix G, sandwort samples taken from along the LNE trail within the Refuge had levels of more than 3000 ppm zinc in the vegetative tissue which is three times higher than was has been observed in birch leaves. Earlier studies by Marilyn Jordan at Rutgers found specimens with levels of zinc as high as 15,000 ppm[6].

It has likely thrived on the contaminated slopes, in part, because of its ability to tolerate high levels of metals. For decades, it had little competition, and in observations since 2005, we have seen no evidence of insect herbivory on this plant.

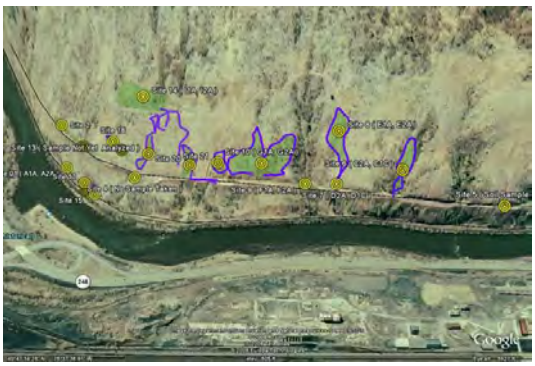
Minuartia patula

Sandwort in bloom in the LGWR grassland. Light patches seen on the ground along the slopes in the image below are sandwort plants in bloom in early June. The Bobolink Trail runs along the diagonal boulder line on the left side of the photo and the D&L Trail can be seen along the bottom of the photo.

In 2008 and 2009, Sarabeth Brockley and Diane Husic from Moravian College began documenting the location through GPS coordinates and size of sandwort populations at the Refuge and in the Palmerton region.

[6] Jordan, M.J. 1975. Effects of zinc smelter emissions and fire on a chestnut-oak woodland. *Ecology* 56: 78-91.

Some of the major patches of sandwort that were sampled for the 2008 metal uptake studies are shown in the map below. Large patches of sandwort have not been observed above approximately 800 feet on the ridge.



Map of sandwort populations studied

The photo below shows this area of the grassland with the sandwort in bloom (the light patches in the middle of the slope). Above the sandwort, the tree line can be seen; sandwort has not found above this point on the slope.

Interestingly, as one heads west along the LNE trail past the original West Plant smelter site (upwind from the direction the pollution traveled) both the number of sandwort plants and the size of the patches of growth diminish. The ravine (Smilax Hollow) in this region has much greater plant diversity and a significant patch of Canada wild-rye (*Elymus canadensis*) which may be out-competing the sandwort. Presumably, the soil metal levels are lower in this region as well.

Smilax Hollow

Likewise, while sandwort grows extensively along the lower slopes of

the Kittatinny Ridge and Stoney Ridge (the next ridge north of the Kittatinny Ridge) in the areas close to the two smelter sites, by the time you reach the Carbon County Fairground area along Little Gap Road (3.2 miles from the east plant), sandwort plants are no longer found. This may be due to changing habitat as you approach the wetlands surrounding the Aquashicola Creek in the Little Gap area just to the west of Blue Mountain Ski Area. But the metal contamination is likely much less significant this far downwind from the eastern-most smelter that was in Palmerton. The hypothesis is that as metals become less bio-available and other plants in the restoration area become more abundant, *Minuartia* will eventually be out-competed. Thus, this plant may serve as a bio-indicator of recovery in the contaminated areas.

Sandwort in bloom. Light colored areas are the sandwort flowers; photo taken at the base of the Kittatinny Ridge downwind from the East Plant smelter.

Invasive Plant Species

A list of the non-native and invasive species (approximately 20) were provided in Part I of the LGWR Ecological Assessment and management of invasive plants was one of the key stewardship issues discussed in the recommendations section of that report.

In 2008 East Penn Township significantly cleared the brush along the D&L Trail to widen the space for future improvements to the trail. In doing so, they removed a significant amount of shrubs, much of which was invasive, especially some of the large Butterfly-bush (*Buddleja davidii*) plants. Without management, these plants will all grow back. *Buddleja* continues to be a problem on the Refuge propagating freely along the rail beds and in the grassland. Thousands of plants have been pulled by volunteers, but if any root remained in the ground, bushier shrubs came back immediately. The LGNC now routinely employs trained interns to eradicate this plant in sensitive areas using backpack sprayers and the herbicide Crossbow which contains 2,4-D and Triclopyr. This kills broad leaved plants but not grasses.

Buddleja davidii

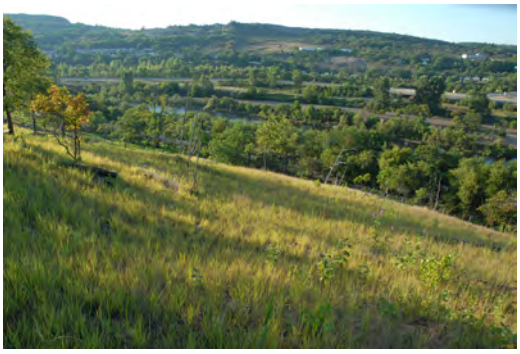
Over the past few years, there have been a number of disturbances due to road work and construction. These sites are prime areas for invasion by garlic mustard (*Alliaria petiolata*). Diligent monitoring and control (hand-pulling) will be needed. Significant spreading of other invasive species has not been noticed. A significant amount of the *Phragmites australis* was removed during pond restoration work (Fall 2010) and in work to establish a new boat launch on the Lehigh River to the immediate south of the Refuge (to the east of the entrance road). This may help to slow the spread of this reed.

One exceptionally aggressive invasive species is oriental bittersweet (*Celastrus orbiculatus*) which grows along the D&L Trail. It is not known if this plant has taken advantage of the brush clearing that was done or if weather conditions have been ideal for its growth.

Status of the grasslands

Visitors to the Refuge—including hikers and botanical experts—routinely comment about the progress of the restoration. The grasses have filled in large areas along the slopes of the mountain; although bare rock areas still remain. Arcadis staff, along with students from various schools and local colleges and universities, continues to monitor percent vegetative cover and succession studies are being conducted (see Chapter 9).

In early September 2009, Roger Latham hiked through the grasslands to survey the progress and was struck the extent of grass cover along the mid- and upper slopes that were seeded by aerial application. He and others have noted that the Canada wild-rye (*Elymus canadensis*) is of particularly high density at mid-slope. At that time, he suggested that this might be due, in part, to the unusual cooler weather during the summer of 2009. However, this grass continued to thrive in the summer of 2010 which was much warmer. The high density of this cool season (C3) species may have set back the establishment success of the warm-season grasses in that part of the slope. Time will tell whether the wild-rye growth will scale back and the warm-season grasses will begin to burgeon at the higher elevations. Regardless, the establishment of any grass on the steeper slopes provides excellent erosion-control cover and wildlife habitat.



Latham also commented about the eastern part of the ridgetop. He had previously seen low numbers of rough bentgrass (*Agrostis scabra*) over the ridgetop, but not in such large patches. It is interspersed with common hairgrass (*Deschampsia flexuosa*) and one of the minority cool-season grasses that flower and fruit through late summer and fall (like Canada wild-rye).

Latham commented on how interesting it is to observe the changes that plant communities go through during unusual weather conditions and during this restoration process. Because of the experimental nature of this entire project, it is precisely these changes and species interactions that will be important to monitor for years to come.

In the grassland, especially in areas that still have low percentages of vegetative cover, lichens been observed amongst the rocks and remnants of tree logs and in areas of crusty black dirt. These tend to be some of the most highly contaminated areas. Howe and Lendemer describe their May-June 2006 survey of lichen communities at the Lehigh Gap and note the substantial recovery that had occurred since the 1972 Nash study. [7] On September 30, 2010, while doing a walk through of the area between the LNE and D&L Trails just east of the Bobolink Trail, fruiting bodies of lichen were documented for the first time (see photo below).

[7] Appendix E, LGWR Ecological Assessment Part I, 2007.

At the bottom of the photo on the previous page, the green rosettes of sandwort (*Minuarta patula*) that appear in fall are obvious. What was unusual was that some of the sandwort plants were blooming – something that had not been seen previously at this time of year (see photo below).

Another surprise that day was evidence of the old tree logs rotting – an indication that some decomposers have returned to the site.

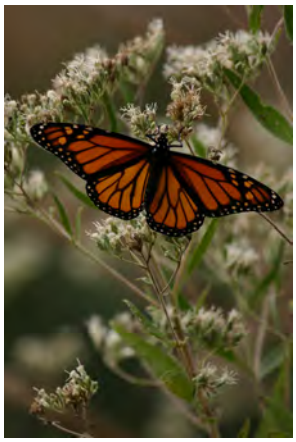
The photo below was taken in summer 2007 when bare patches along the LNE trail edge were still obvious and places where erosion, especially along the trail edge, was possible.

The original grass seed mixture used on these steep slopes included several cool season fescues, which sprouted quickly and shaded out the slower germinating warm-season sprouts, eliminating the warm-season species in this area. The fescues died in ensuing years, leaving behind these barren areas. In retrospect, it was not a good idea to include the fescues in this mix, as places where the fescues were not added are today fully stocked with grasses. These areas have since been reseeded to increase the vegetative cover and minimize the erosion potential, but bare patches still remain. The trees visible in the photo to the right have grown significantly helping to stabilize the steep slope.

Habitat Enhancement

The goals of the EPA's Record of Decision for the Palmerton Superfund Site at the LGWR site are being met: there is revegetation with native species, the erosion has generally been halted, and metals are, for the most part, are only accumulated in the vegetation at low levels deemed safe for wildlife and human receptors. However, warm season grasses alone do not create a healthy biotic community which includes a suite of decomposers, mycorrhizal fungi, and a host of

consumers from insects and small mammals to songbirds and predators. The plant community within the grasslands is diversifying with forbs such as goldenrods (*Solidago* spp.), blue vervain (*Verbena hastata*), and late eupatorium (*Eupatorium serotinum*) becoming notable. Invasive species such as butterfly bush (*Buddleja davidii*) and tree-of-heaven (*Ailanthus altissima*) are invading the site but are being removed as they are found. But, in general, the diversity of the plant community is still low.



LGNC is working to increase the diversity of the restoration area with the introduction of a variety of native forbs that provide pollen, nectar, seeds, and forage for a wider variety of consumers. This increase in plant diversity should not only increase the diversity of other species, but also provide more long-term stability to the ecosystem. (Appendix F-1 is a database of all the plants that have been introduced in various studies at the Refuge.) Invasive species removal will continue as well as we attempt to manage the trajectory of succession with the goal of a diverse prairie ecosystem. As we increase the diversity, we will also need to evaluate uptake of metals by these introduced species to ensure we are not mobilizing the metals to an extent that poses a risk to consumers.

Grassland Perennials:

In 2006, seed from eleven species of plants were spread in the grassland:

Partridge Pea
(*Chamaecrista fasciculata*)
Wild Senna
(*Senna hebecarpa*)
Wild Lupine
(*Lupinus perennis*)
Round-head Lespedeza
(*Lespedeza capitata*)
Butterfly Milkweed
(*Asclepias tuberosa*)
Common Milkweed
(*Asclepias syriaca*)
Ox eye Sunflower
(*Heliopsis helianthoides*)
Black-eyed Susan
(*Rudbeckia hirta*)
Brown-eyed Susan
(*Rudbeckia triloba*)
Smooth Blue Aster
(*Aster laevis = Symphotrichum laevis)*
Dense Blazing Star
(*Liatris spicata*)

It was feared that none had germinated until 2009 when seven of the eleven species were found blooming. The summer milkweed species were first to bloom. The following images were taken in August 2009.

Ox eye Sunflower

Brown eyed Susan

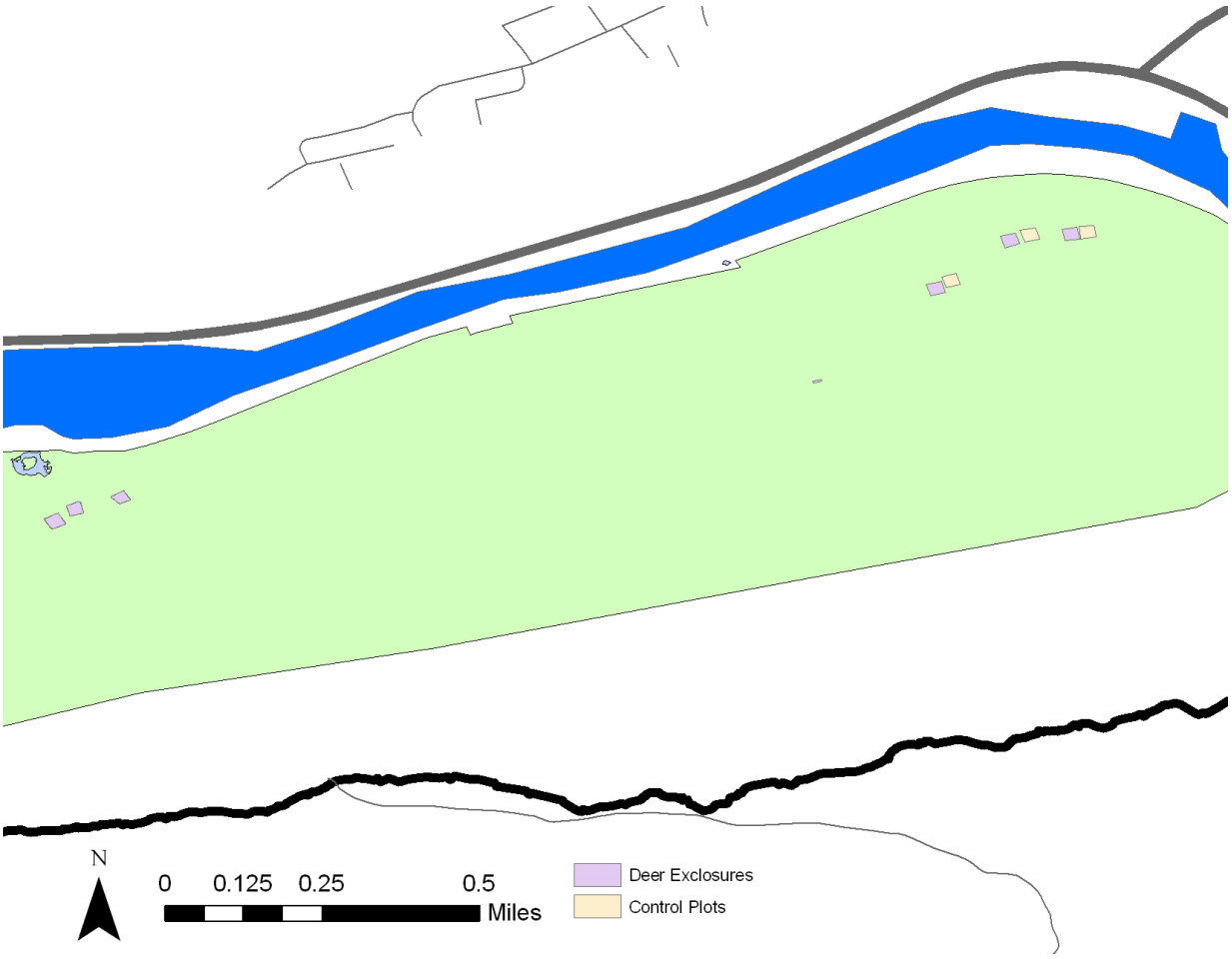
Partridge Pea

Black eyed Susan

Wild Senna

There are two major factors that may limit the type of forbs that can be established and sustained: 1) physical conditions of the site (low nutrient levels, lack of organic soil, and high metal concentrations), and 2) browsing by herbivores, primarily insects, small mammals, and deer. Since it is not known which species will be affected by these factors, and since it is costly to introduce these plants, a controlled experimental planting of a variety of forbs to monitor their success has been designed and implemented.

The details of the ***Habitat Enhancement and Deer Exclosure Studies*** are described in a report included as Appendix F-2. This project, funded by an Audubon *TogetherGreen* Innovation grant, involved the systematic planting of 150 plugs each of nine native species (six in spring and three in fall; see table below on page 8-14 for species used). A number of individuals provided expert advise on the selection of species and design of the experimental plots including Roger Latham, Sue Tantsits, Louise Schaeffer, and Everett Warren. Deer exclosures were installed by Everett Warren and staff from Green Man Enviroscaping (see locations in map on the following page).



Location of the Deer Exclosures and Control Plots at the LGWR

Planting was accomplished with a large corp of LGNC volunteers and students from Moravian College.

The locations of each plant were marked with flags and GPS coordinates. One half of these were planted inside of deer exclosures; the other half in control plots outside of the exclosures. Monitoring commenced in June 2009 for the spring planted species to determine the effects of the physical conditions on the establishment and growth of the forb species, as well as the effects of herbivory. Because each exclosure (fenced) plot is paired with an unfenced control plot, monitoring should be able to separate the effects of herbivory by insects and small mammals from that of deer browsing. Small mammals such as voles may also be significant browsers on herbaceous vegetation both inside and outside of the exclosures. The plan is to also use inked tiles to monitor small mammal presence in the test plot areas in the future.

Forb species planted in test plots*

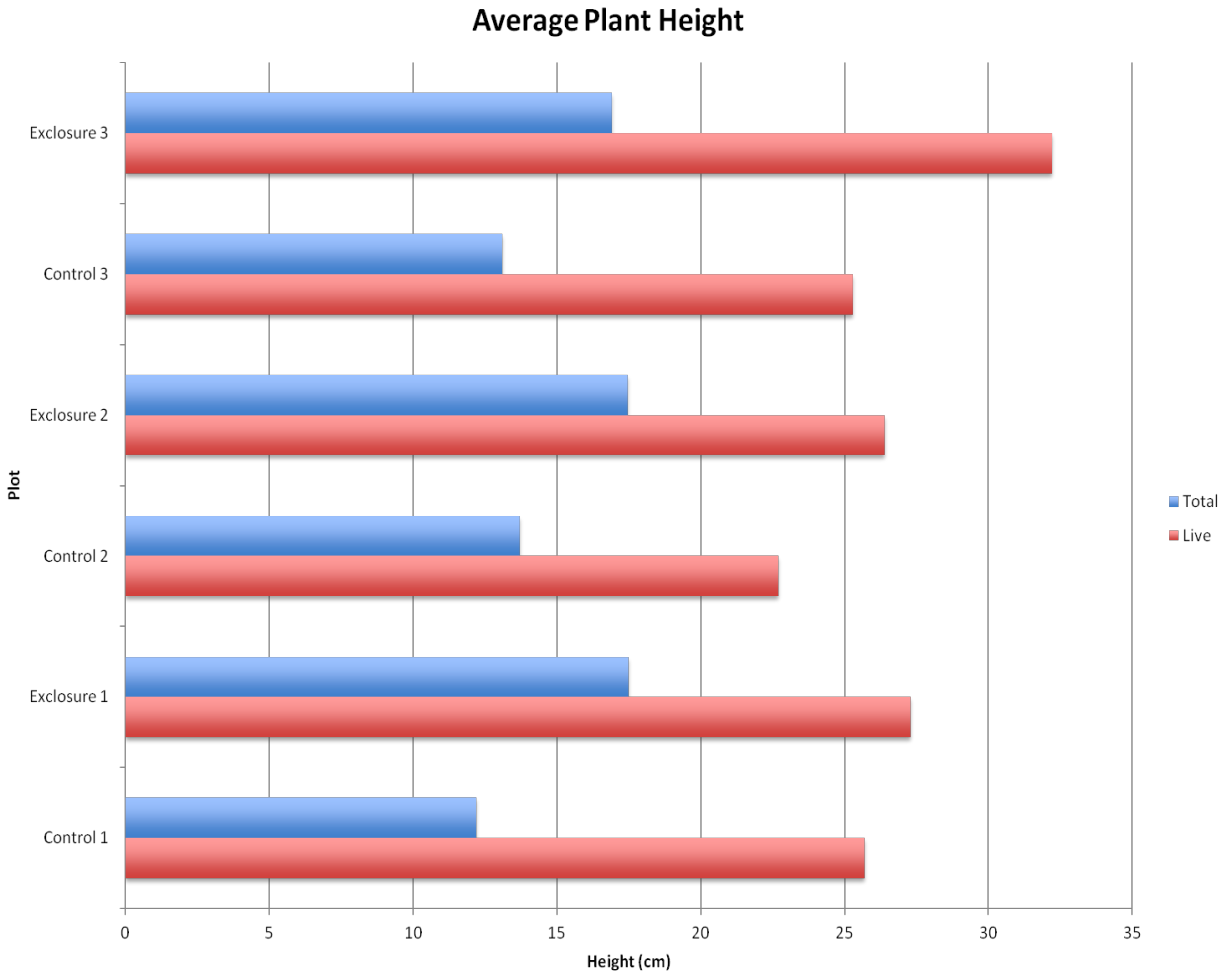
Common Name	Scientific Name	*Spring/Autumn Planting
Butterfly Milkweed	*Asclepias tuberosa*	Spring
Wild Bergamot	*Monarda fistulosa*	Spring
Coreopsis	*Coreopsis tripteris*	Spring
Sundrops	*Oenothera fruticosa*	Spring
Brown-eyed Susan	*Rudbeckia trilobum*	Spring
Three-nerved Joe Pye weed	*Eupatorium dubium*	Spring
False Indigo	*Baptisia australis*	Autumn
Stiff Goldenrod	*Solidago rigida*	Autumn
Smooth Aster	*Aster laevis*	Autumn

* Some violets that may be important for the Regal Fritillary butterfly have also been planted inside the exclosures to determine their viability at the site (See Chapter 6).

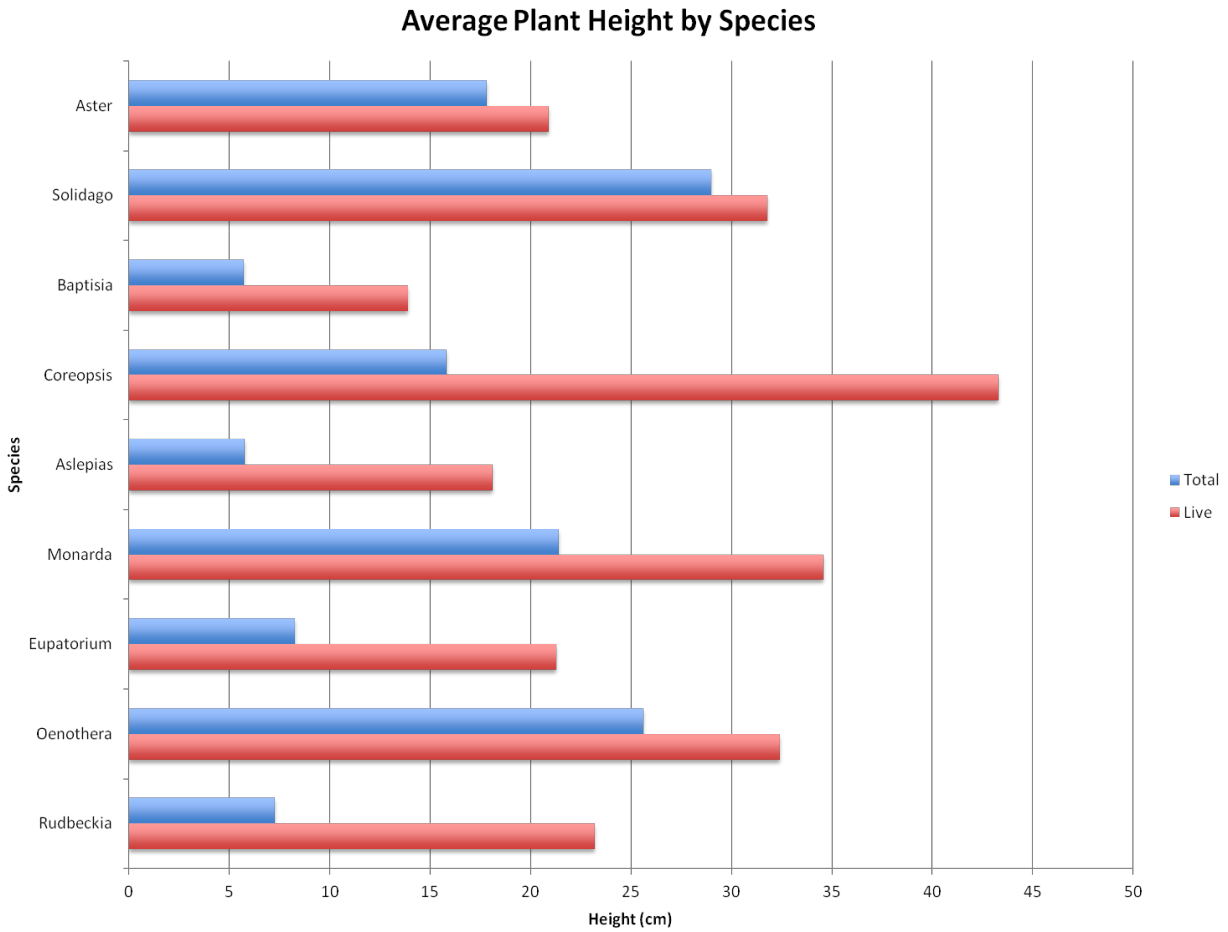
As of August 2009, 66% survival of the plants was recorded with no significant difference between the areas within or outside of exclosures. Survival rates of four species were above 70% (*Oenothera*, *Coreopsis*, *Monarda*, and *Rudbeckia*), while two were under 50% (*Eupatorium* and *Asclepias*). Unfortunately, after the spring planting, the spring weather was unusually hot and dry and many yong plants died. Browsing pressure varied among species with the number of plants showing browsing ranging from 4 to 55% for the six species.

Three species (*Baptisia australis*, *Solidago rigida*, and *Aster laevis*) were planted in late August 2009, completing the planting in the experimental plots. Monitoring continued in 2010 and will be ongoing. In July of 2010, heights of surviving plants were measured. Average plant height divided by the total number of specimens planted was plotted (blue bars) as was average plant height divided by the number of surviving (live) plants (red bars). The first plot represents all species combined and the second represents results by individual species. The comparison between the red and blue bars gives a sense of survival rate of the plants.

It is anticipated that the results of this study will allow the LGNC to implement full-scale enhancement of the grassland in a cost-effective way with those species that are best able to survive here. This will also provide easily located plants for metal uptake studies in the future since it is important to know whether introduced plants take up the heavy metals from the soil.



July 2010 Total Plant Growth and Survival Assessment
LGWR Habitat Enhancement Study



July 2010 Growth and Survival Assessment by Species Type
LGWR Habitat Enhancement Study

Three experimental 30 meter square exclosures were also installed on the forested part of the Refuge. Two of these plots were heavily covered with Hay-scented Fern. Herbicide was used to kill the ferns inside half the exclosure and in a similar–sized area outside the exclosure in the adjoining control plots. Monitoring of these plots will help determine what is inhibiting herbaceous, shrub, and understory vegetation and tree regeneration in these areas of the Refuge. Hypotheses include metal contamination, deer browsing pressure, and the abundance of ferns preventing normal habitat development in these forests.

Tree Planting Field Trials

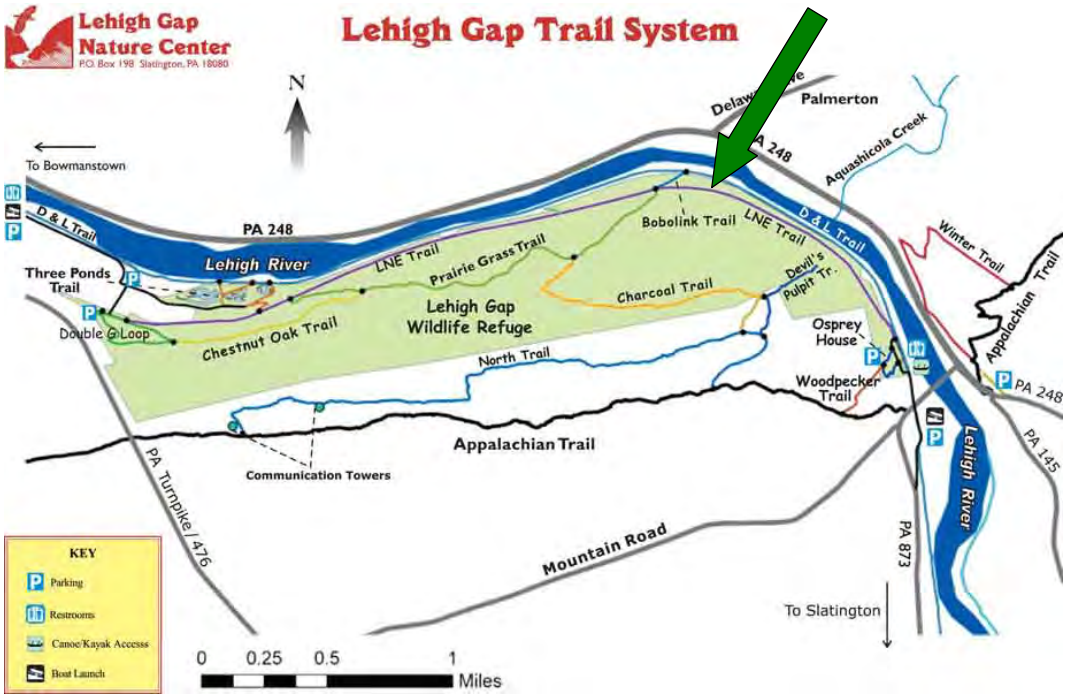
In 2007, Abel Boyer, a resident of the region wanted to conduct a Boy Scout project at the LGWR. His father provided fourth-generation backcross Chestnut Tree hybrids from the American Chestnut Foundation which Abel planted in an area between the D&L and LNE Trails just to the east of the Bobolink Trail. The trees are protected by tree tubes to minimize deer browsing and provide shading from sun. Abel frequently watered these during the first year. As of fall 2010, most are doing quite well and most have now grown taller than the tree tubes.

Chestnut sapling

In order to test the viability of the Superfund Site for supporting growth of trees, a trial planting of 126 acorns or seedlings was initiated in 2007 with advice from Dave Henry, the forester for the PA Game Commission, Ken Beard of the PA Department of Environmental Protection, and Jim Frank, the environmental engineer from Frank and West, Inc. The planting was done by a large number of LGNC volunteers in the test area between the D&L and LNE Trails just to the east of the Bobolink Trail (see green arrow on the map on the following page). About ten each of the following acorns and about seven seedlings were planted:

White Oak (*Quercus alba*)
Chestnut Oak (*Quercus prinus;* syn. *Q. montana*)
Black Oak (*Quercus velutina*)
Red Oak (*Quercus rubra*)
Bur Oak (*Quercus macrocarpa*)
Scrub Oak (*Quercus ilicifolia*)

In addition, some Post (*Quercus stellata*) and Blackjack Oak (*Quercus marilandica*) acorns and seedlings, provided by Ken Beard, were planted in lesser numbers. A map of the specific planting locations and a spreadsheet of observations (survival and growth) from May 15, 2008 are included in Appendix F-3.



Location of Tree Planting Field Trials (in area of green arrow)

On October 9, 2008, Maria Tranguch surveyed the field trial area and found 30 living oaks: 25 that had been planted as seedlings and five as acorns. Some of the surviving looked healthy; others looked stressed. Survival by species was as follows:

Red Oak acorns	4
Chestnut Oak acorns	1
Black Oak seedlings	2
Red Oak seedlings	2
White Oak seedlings	2
Bur Oak seedlings	5
Chestnut Oak seedlings	8
Blackjack Oak seedlings	5
Post Oak seedlings	1

Conclusions from this field test include:

1. Planted acorns did not do well. Red oak acorns seem to have done the best, but this is a small sample size.
2. Chestnut and Blackjack Oak seedlings did well.
3. Just over half the seedlings have survived one year; only about 7% of acorns germinated and survived.

Blackjack Oak (*Quercus marilandica*), a small oak of the red oak group is not native to the region, but is found in the southern and central United States, in parts of the coastal plain of New Jersey, and in the State Line Serpentine Barrens that straddle the Pennsylvania-Maryland border. This tree grows in poor, thin, dry, rocky or sandy soils where few other woody plants can thrive, usually on low ground, from sea level up to 900 m altitude. It often occurs near Scarlet (*Quercus coccinea*) and Post Oaks (*Quercus stellata*) as well as Pitch Pine (*Pinus rigida*); understory companions include winged sumac (*Rhus copallinum*), bracken fern (*Pteridium aquilinum*), and sweetfern (*Comptonia peregrina*).

Blackjack Oak Seedling

Prairie Warbler Trail Shrub Habitat Enhancement

Adjacent to the Osprey House Visitor and Education Center at Lehigh Gap is a 100' power line right-of-way (ROW) that must be kept clear of tree species that would grow up and potential damage the 512KV power lines. The result of utility management on the metal contaminated hillside under the power line is a scrub habitat dominated by meadowsweet (*Spirea latifolia*), several sumacs (*Rhus typhina* and *Rhus copalina*), and pioneering gray birch (*Betula populifolia*) and sassafras (*Sassafras alba*) trees. Every few years, the utility company (PPL Corporation) would cut the sassafras and any other tree species that could reach the lines overhead.

The very first spring at the site in 2003, it was immediately noticed that the scrub area was home to nesting Prairie Warblers and Indigo Buntings. The LGNC quickly became interested

in managing this unique early successional (scrub) habitat. Such habitat in Pennsylvania is by nature temporary, since it will continue through succession to become a forest if left alone. In pre-colonial times, disturbances such as beaver activity and fire (both natural and intentionally set by Indians) ensured that there was always an ample supply of scrub habitat. Few beavers and the suppression of fire for more than a century have resulted in a dearth of early successional habitat in the East. Power line rights-of-way present an opportunity for management of early successional habitats.

Spiraea latifolia

A suite of plants, invertebrates and vertebrates depend on scrub habitat for survival. This habitat is critical breeding habitat for Prairie Warblers, but is also favored by a host of other bird species such as Field Sparrows and Indigo Buntings. The addition of nest boxes quickly resulted in breeding Tree Swallows, Eastern Bluebirds, and House Wrens. The first Blue Grosbeak reportedly seen at Lehigh Gap Wildlife Refuge was in this area (2005) and more recently, the first reported breeding Blue Grosbeaks in Carbon County have been observed in scrub habitat in a ravine (Grosbeak Gulch) within the grasslands (Chapter 5). Butterflies and native bees also benefit from early successional habitat. Both rely on nectar sources, such as the *Spirea* blossoms, and the bees find nesting habitat in the soil among the shrubs. The LGNC Naturalist Club bee trapping project found numerous species of native bees in the transects through this habitat.

In 2006, the LGNC began the first habitat gardens project on the south side of the original Osprey House building. The plan included the power line ROW, which was to be enhanced with a variety of native wildflowers and shrubs. Girl Scout Marci Barr approached the LGNC at that time about a Gold Award project (equivalent to the Boy Scout's Eagle Scout award). Together with LGNC staff, Barr chose ecological enhancement of the power line area as part of her project. The other part was to create an interpretive brochure and self-guided nature trail (the Prairie Warbler Trail) through this habitat. The trail itself was built by Doug Beam as part of his Eagle Scout project.

Barr researched the native plants of the area that would be appropriate in the climate and soil conditions of the Prairie Warbler Trail area and consulted with Linda Frederick

(originator of the habitat gardens plan) and Sue Tantsits and Louise Schaeffer at Edge of the Woods Native Plant Nursery. Barr selected a variety of plants and introduced them to areas along the trail. These species included:

Wild Lupine
(*Lupinus perennis*)
Summersweet
(*Clethra alnifolia*)
Silky Dogwood
(*Cornus amomum*)
Elderberry
(*Sambucus canadensis*)
American Hazelnut
(*Corylus Americana*)
Low bush blueberry
(*Vaccinium angustifolium*)
Pasture Rose
(*Rosa Carolina*)
American Cranberry Viburnum
(*Viburnum trilobum*)

Barr also spread seeds of the following species:

Ox-eye (False) sunflower
(*Heliopsis helianthoides*)
Blazing star
(*Liatris spicata*)
Partridge Pea
(*Chamaecrista fasciculate*)
Wild Senna
(*Cassia hebecarpa*)

A very intense short-term drought occurred before the plants were well established and many of them died. Deer browsing also eliminated some of these plants and few survived.

In 2009, Naturalist Club member, Brandon Everett, received a Naturalist Fellowship for his project to continue the enhancement of the power line ROW and to manage the habitat as a high quality scrub habitat. He and

LGNC Director Dan Kunkle met with representatives of PPL at the site and Everett gained permission to manage the area, with the provision that if he failed to keep trees from growing into the lines, PPL would resume management. That summer, Everett and LGNC volunteers cut all the tree species that had grown up since PPL's most recent maintenance, and began planting appropriate native species on the site. They also removed all invasive species from the area.

Everett's project was funded with money from Kunkle's *TogetherGreen* Fellowship grant. As did Marci Barr, Everett researched the native plants of the area and consulted with the Edge of the Woods staff. He used his Naturalist Fellowship funds to purchase plants at Edge of the Woods, and installed them along the Prairie Warbler Trail. This project is ongoing. Species introduced to the area to date by Everett include a single specimen each of the following, planted in late August, 2009:

Ox-eye (False) Sunflower
(*Heliopsis helianthoides*)
Tall Tickseed
(*Coreopsis tripteris*)
Virginia Rose
(*Rosa virginiana*)
Woodland Sunflower
(*Helianthus divaricatus*)
Tennessee Coneflower
(*Echinacea tennesseensis*)
Prickly Pear Cactus
(*Opuntia cactaceae*)
Giant Coneflower
(*Rudbeckia maxima*)
Butterfly Weed
(*Asclepias tuberosa*)
New York Aster
(*Aster novi-belgii*)
Strawberry Bush
(*Euonymus amaricana*)
Pinxter Azalea
(*Rhododendron periclymenoides*)
Summersweet
(*Clethra alnifolia*)
False Indigo
(*Baptisia australis*)
Highbush Blueberry
(*Vaccinium corymbosum*)
Gooseberry
(*Ribes rotundifolium*)

***Heliopsis* sp.**

Everett also planted ten smooth asters (*Aster laevis*) and ten stiff goldenrods (*Solidago rigida*) that were donated by Edge of the Woods. One month later, Everett planted the following species that were donated by Barbara Malt from her gardens:

Blue Mistflower
(*Eupatorium coelestinum*)
Trumpet Honeysuckle
(*Lonicera sempervirens*)
Eastern Columbine
(*Aquilegia canadensis*)

While Everett's plantings also suffered from short-term drought and deer browsing, his plantings have met with some success and the habitat diversity has increased. Continued maintenance (tree removal) is necessary and additional plantings could continue to increase the value of this habitat to wildlife.

Management of land in gas line easements and under power lines is important given that the disturbance can readily lead to erosion and invasion by non-natives. The trials in the Refuge shrub habitat could provide information for alternative management practices throughout the region. Since the Prairie Warbler Trail goes around and through this habitat, signage and a detailed trail map can help educate the public about valuable habitats and redefine what constitutes a garden.

An Aerial View of the LGWR Shrub Habitat in the area of the PPL Power Line Right-of-Way

Habitat Gardens

In 2006, with an initial donation from Linda Frederick and Michal Kubik, the LGNC began a Habitat Gardens Project at the Osprey House area of the Refuge. Frederick and Diane Husic have been the directors of this project with Bill Mineo, Sue Tantsits, and Louise Schaeffer serving as consulting advisors. The source of the plant materials for the gardens is Edge of the Woods Native Plant Nursery in Orefield, PA. The primary purposes of the garden are: 1) create habitat for native bees, birds, butterflies, and other species; 2) demonstrate to the public the use of native plants and the concept of creating habitat gardens; and 3) create educational teaching areas for classes visiting the Refuge.

In these gardens, native is defined as plants native to the mid-Atlantic region, along with commercially available cultivars of natives. The gardens are also experimental plots allowing the LGNC to determine which plants will survive at this site given the soil, weather, and contamination conditions and the herbivory pressure.

Native Bog Garden at LGWR

Suburban sprawl in southeastern Pennsylvania has led to thousands of housing developments with large homes and yards of mowed lawns (monocultures). Care of these lawns, planted with non-native cool-season grasses, is often accompanied with the use of chemical fertilizers and pesticides, often far in excess of per/acre usage in agricultural settings. These large expanses of mowed grass provide little habitat for wildlife of any kind. In addition, most of the gardens associated with these homes are filled with exotic plants (often invasive species) and mulched with chipped hardwoods. These gardens also provide little in the way of habitat for wildlife and often utilize invasive species that can colonize and degrade nearby natural landscapes.

As so eloquently described in Doug Tallamy's book, Bringing Nature Home[8], minimizing areas of mowed grass and using native plants in gardens would allow suburban areas to provide habitat for a wide variety of wildlife, especially for birds, butterflies, and native pollinators. Native insects need native plants to feed upon, and 96% of our bird species eat insects at least during the nestling period.

Native butterflies also need native plants. While nectar from exotic plants is similar if not identical to nectar in natives, butterflies need larval food plants as well as nectar. Without the proper native plants on which to lay its eggs, you will not support the full life cycle of any butterflies. Native bees also need native plant pollen to provision their young. These invertebrate species can be benefited even by small gardens with native plants.

In addition to the benefits to wildlife of native plant, there are other benefits as well. Once established, native plants need little care, need no fertilizer or pesticides, and require little if any watering. In the long term, this saves money and time for the homeowner.

The First Habitat Garden at LGWR

The LGNC hopes to convince many area suburban residents to add native plants to their landscaping. A big barrier to succeeding with this educational process is tradition. Most gardeners prefer exotic plants with large, showy flowers, and perfect foliage that is not eaten by insects. Native plants are the base of the food chain and get eaten by a variety of insects. However, this herbivory rarely gets out of hand to destroy entire leaves or plants because predatory insects and birds control the populations of the herbivorous insects. Native plant gardeners must understand that imperfect leaves on their plants means the plants are forming the basis of a healthy food web. For a healthier environment, the public needs to be re-educated about gardens (and the ecological role that they can play) and re-define beauty as nature in balance and working properly, rather than showy, perfect plants.

The habitat gardens at the Osprey House now include nearly an acre of planted and mulched beds, rock

[8] Tallamy, Douglas W. 2007. Bringing Nature Home: How Native Plants Sustain Wildlife in Our Gardens. Timber Press, Portland, OR.

gardens, a bog garden, and habitat plantings along our driveway and in the Prairie Warbler Trail area. They range from highly tended gardens that would be acceptable to many suburban gardeners, to relatively unmanaged areas into which we have introduced native plants and removed invasive species.

These habitat garden plantings have been undertaken in an experimental fashion. Native plants that seem appropriate for the soil and climate conditions that exist at the Refuge were selected. There are elevated levels of metals in the soil from the zinc smelters with which the plants must contend. As noted above, these gardens are also field trials of what plants will survive and thrive in the conditions present. A database of all species planted in the gardens has been compiled (See Appendix F-1), and the gardens are being monitored to determine which species do well here over the long term.

Part of the New Habitat Garden Established in Summer 2010