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Surveying the Forest Biodiversity of Evansburg State Park: Plant Community Classification and Species Diversity Assessment

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Abstract: A field study was conducted in Evansburg State Park, Collegeville, Pennsylvania, in order to assess the impact of humans on the natural succession of forests and the diversity of plant species therein. Vascular vegetative growth was surveyed and the data collected was used to calculate Relative Importance Values (RIV) of the plants found in the study site. Using the RIV, the plant community type was determined according to the classifications outlined in the Evansburg State Park Resource Management Plan (Jean, 1999) by the US Department of Conservation and Natural Resources. The plant community type in the study site was determined to be that of a sugar maple/ basswood community. The change of this sugar maple/ basswood community over centuries of human involvement is considered. Human induced factors, such as the effect of invasive species, the creation of edge effects and agricultural use of land, are discussed with reference to the sugar maple/ basswood community.

Key words: Biodiversity, conservation, deer overabundance, invasive species, Relative Importance Value (RIV), successional

INTRODUCTION

Ecological diversity is indisputably one of science's hot topics. Diversity provides even the casual observer a feeling of satisfaction in the natural world. In many fields of science, diversity has often been considered to be a measure of the health of an ecosystem (McGrady-Steed and Morin, 2000). Furthermore, species relationships and richness patterns can only be analyzed when biodiversity is measured. The loss of diversity is often attributed, directly or indirectly, to anthropogenic effects such as fossil fuel burning, deforestation and the introduction of invasive species (Hobbs and Huenneke, 1992). The study of diversity is therefore imperative if society aims at preserving and understanding dynamic ecosystems.

Diversity is comprised of two components: the variety of species present and the relative abundance of those species. Greater species richness and an even relative abundance are indicative of good community diversity (Magurran, 1988). A comprehensive survey of species diversity should include these two components to be considered useful.

Evaluation of forest vegetation diversity is desirable not only for its intrinsic value of noting plant populations, but also because vegetation is the most basic trophic level in a forest. All other organisms in a forest-detrivores, herbivores and predators-rely foremost on the primary production of plants. When one considers the bottom-up control model of trophic levels, it is evident that a change in the diversity of plant population will propagate changes in the diversity of all other resident organisms (Pimm, 1982).

Maintaining the balance between industrialization and conservatism has constantly been a struggle for the Department of Conservation and Natural Resources (DCNR), as the goal is to keep the natural resources of state parks undisturbed and thereby promote healthy opportunities of outdoor recreational activities and education. Located in southcentral Montgomery County, Evansburg State Park offers a peaceful environment of green space and solitude in an urbanized area. Contrasting the communities surrounding the park that gradually expand and become more highly developed, Evansburg State Park retains its natural beauty and continues to teach the importance of ecology and appreciation of nature.

The following study describes the forestry and plant layer of the surveyed area and its relation to compositions observed in other studies. This report aims to explore the different forest types currently present in Evansburg State Park. In addition, a look into the management of state parks is observed, its difficulty and challenges as well as the goals for the future.

MATERIALS AND METHODS

Study site: Pennsylvania is host to approximately 3400 plant species (Rhoads and Block, 2000). DCNR classified

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105 different types of plant communities in the state. The study site in question lies in south-central Montgomery County, which falls in a physiographic region called the Piedmont Province, which stretches from Virginia northwards to southeastern Pennsylvania. Montgomery County lies in the Piedmont Upland. The Piedmont Province is significantly devoid of primary forest vegetation. Proximity to major cities has caused the old-growth forests of the Piedmont Province to be repeatedly cleared for timber, to be used agriculturally and to be used for grazing animals. The variety of secondary/ successional communities is quite large as a result of this continual disruption (Braun, 1950).

A field study was conducted in Evansburg State Park, Collegeville, Pennsylvania, with the aim of documenting the state of plant diversity and classifying community type. Research was conducted in October and November of 2005. Evansburg State Park is a public state park consisting of 3,349 acres of cropland, meadows, successional forests and old forests (DiBerardinis, 2003). The site studied was roughly bordered to the north by Skippack Creek and was bordered to the south by an early successional forest, previously an abandoned agricultural field. The study site was above the normal flood plain of Skippack Creek and contained bedrock of Brunswick Formation.

Procedure

Point-centered quarter method (Trees): A tape measure was stretched in a straight line for a distance of 50 m from a randomly selected starting point. At points every 10 m along the tape, imaginary perpendicular lines were constructed to produce a series of quadrants. In each quadrant, the closest living tree with a diameter of 12 cm or more was identified. Each tree so located was identified and its diameter measured using a diameter tape (referred often to DBH, or diameter at breast height). This measurement was taken on the trunk of the tree at approximately 1.4 m above the ground. The location, species and diameter were recorded. In the case of multi-stemmed individuals, the measurements of the stems were added together. In low density forests, an individual tree may have been closest in more than one quadrant. In no case should the same tree be measured twice.

Circular (100 m^2) plots (Shrubs): Ropes measuring 5.64 m were used to make circular plots. These plots were located at random along a point-centered quarter transect line. Within each plot, all living plants more than 1 m tall and less than 12 cm in diameter were identified. The percent of the surface covered by each species was estimated.

1 m^2 plots: (Herbaceous): PVC pipe frames were used to make square plots. These plots were located at random within the 100 m^2 plots (nested plots) or along a point-centered quarter transect line. Within each plot all living plants less than 1 m tall were identified and the percent of the surface covered by each species was estimated.

After data was collected from the field, calculations of relative frequency, relative density and relative cover were made. Frequency is the occurrence of a species type related to the total number of collection areas. It is useful to calculate frequency if one wishes to monitor changes in a plant population over time (Bonham, 1989). Frequency was calculated for all plants in the survey. Cover was calculated for trees by using basal area. Cover was calculated for shrub and herb plots by estimating foliage cover. Density is a common measure of species richness. Density is the number of species per specified collection area (Hurlbert, 1971). Density estimates were calculated for the tree plots only.

After frequency, cover and density calculations were made, it was possible to compare calculations among species. Relative Frequency (RF), Cover (RC) and Density (RD) were made for Species 1 (Sp1) according to the formulae in Table 1. Using the relative values, relative importance values (RIVs) were calculated for each species in question. The formula for RIV calculation is also shown in Table 1.

Table 1: Formulae for RIV calculation

Frequency	Cover	Density
$F = \frac{(\#\text{ plots of occurrence Sp1})}{(\#\text{plots})}$	$RC = \frac{(\text{Sum of Sp1's basal area or C})}{(\text{Total basal area or total C})}$	$RD = \frac{(\#\text{ individuals Sp1})}{(\text{Total }\#\text{ individuals})}$
$RF = \frac{(F\text{ of Sp1})}{(\text{Total F})}$	C = estimated foliage cover of Sp1	
	$\text{RIV (trees)} = \frac{(RF+RC+RD)}{3}$	
	$\text{RIV (shrubs and herbs)} = \frac{(RF+RC)}{2}$	

RESULTS

Four canopy-layer plots were made, as well as six shrub-layer plots and 20 herbaceous layer plots. The study site exhibited patchiness in its canopy-layer diversity. The results of the canopy-layer survey are displayed in two ways: by total area (Table 2) and by plot-by-plot (Fig. 1-4). By looking at each of the four plots separately, the patchiness of the plant diversity is evident by the RIVs. The most important canopy-layer plants in Plot 1 are sugar maple (*Acer saccharum*), shagbark hickory (*Carya ovata*) and musclewood (*Carpinus caroliniana*). Plot 2 mostly supports red oak (*Quercus rubra*) and American beech (*Fagus grandiflora*), while Plot 3 is dominated by red elm (*Ulmus rubra*) and red oak. White ash (*Fraxinus americana*) is the chief canopy-layer species in Plot 4. All of the plots were combined so that RIV values could be calculated for the entire site. It was determined that the most important species in the entire site was red oak, followed by white ash, sugar maple and red elm.

Table 2: Results of the caropy layer survey by total area

	Canopy-layer species	
Number	Species	RIV
1	*Liriodendron tulipifera*	0.042587
2	*Fraxinus americana*	0.183461
3	*Acer saccharum*	0.118705
4	*Carya ovata*	0.086194
5	*Carpinus caroliniana*	0.053601
6	*Quercus rubra*	0.23984
7	*Fegus grandiflora*	0.069101
8	*Acer rubrum*	0.018438
9	*Tilia americana*	0.01219
10	*Ulmus rubra*	0.0117473
11	*Carya glabra*	0.011403
12	*Ulmus glabra*	0.011907
13	*Quercus montana*	0.011718
14	*Prunus serotina*	0.023382

Shrub layer is dominated by spicebush (*Lindera benzoin*), young sugar maple and black cherry (*Prunus serotina*) and multiflora rose (*Rosa multiflora*). Plants with high RIVs in the herbaceous layer include black cherry seedlings, various grasses (*Carex* sp.) and Japanese honeysuckle (*Lonicera japonica*).

The collected data fits the classifications according to DCNR adequately enough to classify the study site as a sugar maple-basswood community. All of Pennsylvania, including all sites in Evansburg State Park, fall into the eastern deciduous forest region of the United States. In the pages that follow, graphical representation of sampled plots are shown.

The tree with the largest RIV in Plot 4 was *Fraxinus americana* with a value of 0.376, showing a high relative importance of the white ash (Fig. 4). However, region is not necessarily a predominant sugar maple-basswood forest type due to its low RIV of *Tilia americana* (basswood). Figure 2 shows the basswood to have an RIV of 0.0525, much lower than an RIV of 0.33 by the *Fagus grandiflora*, which is as well not recognized as

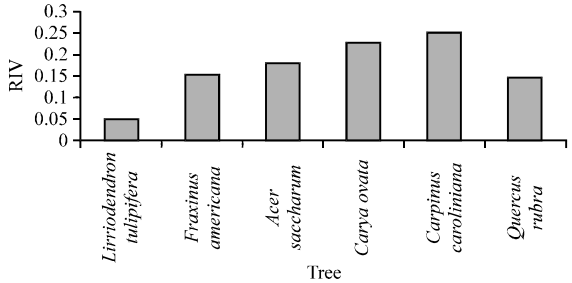

Fig. 1: Tree RIVs of plot 1

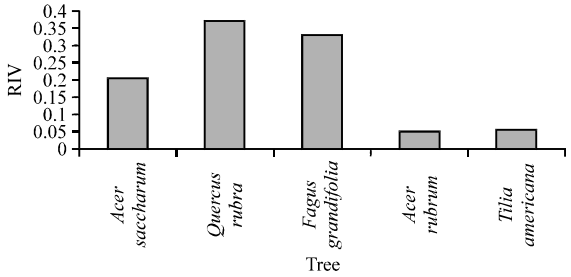

Fig. 2: Tree RIVs of plot 2

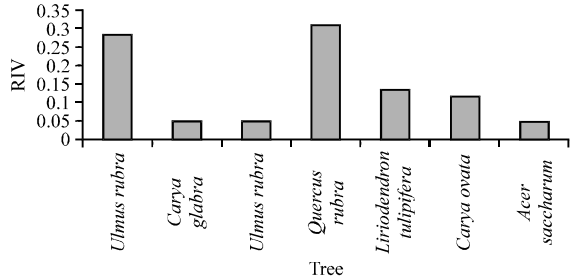

Fig. 3: Tree RIVs of plot 3

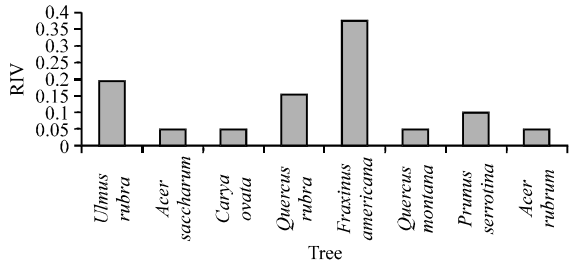

Fig. 4: Tree RIVs of plot 4

a dominant tree in the community. Nonetheless, for the most part the descriptions of these forest types match well with the data pooled.

DISCUSSION

Classification of a community should not be taken at face value: in doing so, one neglects the ability to understand the dynamics which create and sustain a community. It is important to understand not only which plant species compose a community, but also the factors which allow specific plant species to survive in that area. Site factors include variables such as topography (physiography, slope), soil (pH, texture, groundwater) and biotic factors (all associated organisms). In a forest community, the site characteristics are more unchanging than the plants that occupy the site; therefore, site classification is imperative for understanding plant community classification (Spurr and Barnes, 1973). For conservation purposes, it is also valuable to understand the factors which cause a plant species' decline in a community. The factors which created, sustain and harm the study sites in the Evansburg State Park community will now be discussed.

Succession plays a large role in this forest composition. For one, given that the site studied was situated within distance of the road indicates evidence of succession and has been affected by the urbanization of its community and by the works of man. The forest area itself is late-successional due to its high RIV of sugar maples, rosa multiflora, tulip-trees, among others. Evansburg State Park was originally covered in mature timber of the oak-chestnut-hickory type. However, in the early 18th century, settlers began to clear the land for agriculture. Since the establishment of the park in the 1970s, many areas of the land have been undergoing succession and reverting to forested areas. Later stages of succession include maples, hickories and ashes, as viewed by the data with higher RIVs. Currently there is little to no oak regeneration. Thus, Tree Plots 1-4 mark late-successional areas with high frequencies, densities and coverage of red and sugar maples, beeches and white ashes.

Proximity to the road is a factor that greatly affected the site studied. Proximity to a road implies an edge effect of habitat fragmentation. Edge effects are many and varied, but some of debilitating factors include the desiccation of plants growing on edges because of contact with direct sunlight, excessive wind damage and propensity for the invasion of non-native species. The creation of edges promotes the growth of an early-successional type forest. Changes of litterfall along the edges of fragmented habitats has been further cited as a reason for plant biomass collapse (Nigelet *et al*., 2000). From surveys of edge effects in southeastern Pennsylvania (Matlack, 1994a), changes in species composition and densities have been documented from the edge to a maximum distance of 40 m into the forest. Although it was determined that none of the species found on the edge could be considered edge specialists because they were found (in smaller numbers) deep in the forest, it was documented that many of these species' growth and reproduction was enhanced by the edges. It is possible that the enhanced success of some species on the edges could lead to the decline of other species. Two types of edges were found in the study site: the edge created by the road to the east and the old field/early successional forest to the south. Possibly as a result of these edges, several edge-loving (but not edge-specialist) species were found in the site. These include *Viburnum prunifolium, Geum* sp. and *Vitis* sp. (Matlack, 1994b).

Speculation on the forest composition 100 to 200 years ago can be made by looking at trends affecting the biodiversity of today's forest. In terrestrial ecosystems, forest fragmentation begins with gap formation or perforation of the vegetative matrix as humans colonize the area and extract resources from the landscape (Meffe *et al*., 1997). Initially the area remains as a natural vegetation; however, as the gaps enlarge and become more numerous, the landscape pattern and species composition change gradually. Fragmentation causes a disruption of continuity in the organization of the forest. Forest fragmentation causes a change in landscape structure that induces many different types of ecological changes. When humans play a role in fragmentation, it is unusual to clear an entire forest. What generally occurs are cuts in patches leaving isolated remnant stands of varying sizes and shapes scattered across the landscape, giving rise to forest edges. Human-generated edges differ from natural edges-larger sizes result that lead to more severe wind turbulence experienced by the clearings than natural canopy gaps, which may damage trees in adjacent forests. The proliferation of forest edges threaten the diversity of many forest communities: wind moves around the forest stand, heats or cools at edges, deposits particulates and occasionally tears down trees (Matlack *et al*., 1999). Forest edges affect plant distributions, giving rise to edge species deep in the forest that are uncommon in the intact forest. The human modification of forests via edges has become a serious problem in the natural biodiversity of the plant community. Radical changes in the forest microclimate at edges lead to dramatic changes in community structure, which may persist for several decades.

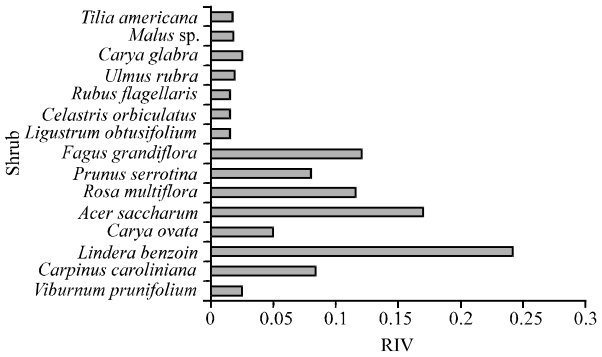

Fig. 5: RIVs of shrub plots

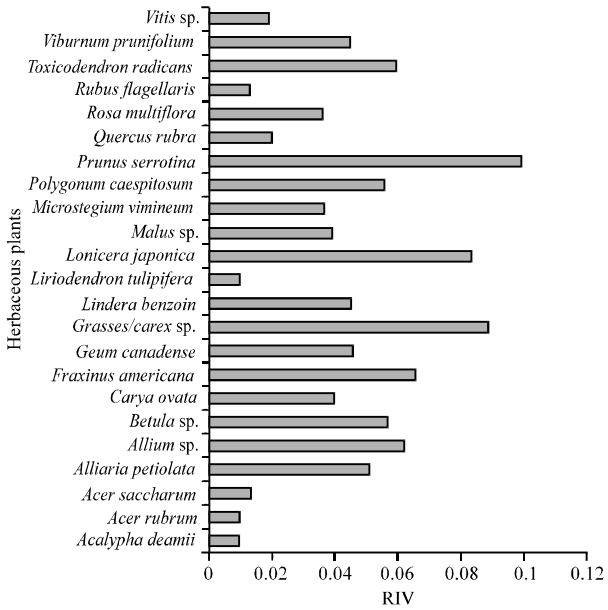

Fig. 6: RIVs of herbaceous layer

Invasive species may also be the result of edge effects. A few scenarios are possible upon a non-native species' arrival in a new habitat: the species may not survive, the species may establish itself without a consequent altering in the numbers of native species (naturalization), or the species may establish and increase its numbers, accompanied by a decreased fitness of native species (invasion). Apart from those plants specifically introduced by humans for agricultural or ornamental purposes, the type of habitat invaded by foreign species is often one that has undergone a recent stress or long-term fundamental change. In a disturbed habitat, the native plant types are not represented in their usual proportions because of an environmental disruption, such as human interference. It is in the aftermath of environmental disruptions that invasive species most easily find a niche (Dukes and Mooney, 1999). Although previous research mentioned earlier determined that invasive species were not positively correlated with edge effects any more than native species, edges of fragmented habitats have been cited as prime grounds for the establishment of invasive species (Vitousek *et al*., 1996). Edges of fragmented habitats represent disturbances or stressed environments. The invasive species found in our study may be attributable to edge effects, though further study would be needed to be certain of causation. Invasive species found in the site include garlic mustard (*Allaria petiolata*), oriental bittersweet (*Celastrus orbiculatus*), multiflora rose, crab apple (*Malus* sp.), privit hedge (*Lingustrum* sp.) and oriental ladysthumb (*Polygonum caespitosum*) (Fig. 5 and 6). These invasive species, along with many others, constitute between 5 to 25% of the vascular plants in the country.

An example of a non-native pathogen which has devastated the eastern deciduous forest is the American chestnut blight fungus, *Cryphonectria parasitica*. *C. parasitica* exists non-lethally on Japanese chestnut (*Castanea crenata*), a species introduced to New York in 1876. The Chinese chestnut tree (*Castanea mollissima*) was also imported around the turn of the century. Both of these exotic trees, in addition to other varieties of Asian chestnuts, could have been the vectors of *C. parasitica*. In any case, this introduction of non-native chestnuts has almost completely eradicated American chestnuts (Anagnostakis and Hillman, 1992). The previous range of American chestnuts is now occupied largely by oaks, which do not experience mortality upon contact with *C. parasitica*.

Native species can be just as detrimental to community health as invasive species. Due largely to the suppression of natural predators, white-tailed deer (*Odocoileus virginianus*) have become destructive pests. Evansburg State Park Resource Management Plan states that an appropriate carrying capacity for white-tailed deer is approximately 55 animals (DCNR, 2003). However, deer populations have escalated in the state to densities of 40-120% higher than the originally recommended goals established in 1979. Although deer hunting is encouraged, the situation still needs improvement. Deer over-abundance was evident in the study site by the absence of canopy-layer tree seedlings, such as red oak. The ease by which regeneration of canopy-layer trees will occur in future years is tied to the deer population. In forests overpopulated by deer, ferns often dominate the herbaceous layer. In this study site, ferns were not a significant species. This indicates that although the deer population is threatening the community (by the herbivory of tree-seedlings), as of yet it has not completely altered the community structure. Deer

overabundance has been an extensive problem affecting forest ecology. High deer densities strongly affect the absolute and relative abundance of woody species, depressing the regeneration of several valuable hardwood species. Upon reaching this more degraded successional state, it becomes difficult for the area to return to its original state without significant management effort. Browse surveys show that deer have a high preference for white oak (*Quercus alba*) and low preference for sugar maple (*Acer saccharum*) (Stromayer *et al*., 1997), signifying a degradation of a reproducing oak forest. This evidence coincides with the data presented by Fig. 1 and 2, indicating a greater amount of sugar maple trees present in the late-successional areas of Plots 1 and 2 and little oak regeneration. The impacts of deer herbivory on eastern vegetation communities is not just a simple management challenge on natural resource managers, to be mitigated by graze control or herd reduction. Deer overabundance creates alternate stable states in the forest ecosystems, threatening the natural diversity of species and community assemblages in the region.

The land now known as Evansburg State Park was purchased in 1684 by William Penn, in an effort to study segregated communities of culture and religion and their relationship to the political and economic bonds shared between them. By the early 18th century, habitation of the land rapidly increased and several water mills were constructed on the Skippack Creek in the park to produce resources and improve transportation. With the addition of the lumber industry in this same time period, the Skippack Valley became less agrarian and progressively more susceptible to industrial development.

In years to come, forests such as our study site will likely continue the successional process. In order for species diversity in successional forests to be achieved, successional forests depend upon old-growth forests. As long as destruction of any remaining old-growth forests is kept to a bare minimum, there is good chance that successional forests will achieve appropriate species diversity, provided that no additional disturbances are inflicted. Edge effects can be mitigated with time (Matlack *et al*., 1999). The numbers of sugar maple and beech trees (evidence of late-succession) surveyed in our study site show evidence that the canopy-layer forest is on the right track. However, as a whole, the Piedmont Plateau is said to have species-poor understory flora due to fragmentation.

Managing suburban forests such as Evansburg State Park comes with many tasks and challenges. The idea is to provide opportunities for healthful outdoor recreation and education, making available the natural resources of the parks to its community members and simultaneously conserving the natural, scenic, aesthetic and historical values of the parks. Still, as mentioned earlier many challenges arise in the preservation of natural parks, namely issues such as forest fragmentation and edges, deer overabundance, invasive species and human interference. It thus becomes difficult to maintain a balance between allowing nature to take its course and stepping in to manage nature's course of action in order to preserve the park's original beauty. Choosing the medium is perhaps the most difficult in a park's resource management plan. For example, limiting timber harvesting practices so that not too many trees are cleared in order for the forest to restore its loss, yet enough is cut to provide adequate resources (Baskin, 2005). Forest management practices are imperative for the future of state parks, functioning as regulators in forest activity and conservators of biological diversity. The strategy for forest management is thus a synthesis considered by all levels of participants-the individual who enjoys the forestry, the government with its sphere of authority and legalities, the state park's management team in charge of the land's resources and conservation organizations that fight for the well-being of the ecosystem. The idea behind the synthesis is working together on individual levels, treating the landscape kindly, dealing with threats of biological diversification and fighting for the existence of another few centuries of the forest's natural beauty.

In addition, many suburban forest managers must make their forests profitable (monetarily or otherwise). They must balance the preservation of natural areas with a certain amount of human trampling. The forest must not be seen as merely an unusable piece of land and therefore useless to society (Janzen, 1998). If a forest is perceived as useless, necessity will sadly dictate its destruction, because its existence is a burden to society.

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