ISSN 0198-7356

BARTONIA

JOURNAL OF THE PHILADELPHIA BOTANICAL CLUB

philbotclub.org

No. 64

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PUBLISHED BY THE CLUB
ACADEMY OF NATURAL SCIENCES, 1900 BENJAMIN FRANKLIN PARKWAY
PHILADELPHIA, PENNSYLVANIA 19103-1195
ISSUED 30 JANUARY 2009

BARTONIA

Journal of the Philadelphia Botanical Club

Since its founding in 1891, the Philadelphia Botanical Club has offered outstanding programs, field trips, and other opportunities for those with an interest in plants to meet and exchange information. Monthly meetings (www.acnatsci.org/hosted/botany_club/meeting.html) feature speakers from various botanical backgrounds. They are held at 7:30 p.m. on the fourth Thursday of the month in September, October, and January through May and the third Thursday in November and December, usually at the Marvin Comisky Conference Center, One Logan Square (one block east of the Academy of Natural Sciences of Philadelphia). From April to October, expert field botanists lead field trips in the mid-Atlantic region and occasionally elsewhere in North America or overseas (www.acnatsci.org/hosted/botany_club/field_trips.html).

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A subscription to *Bartonia* comes with Club membership (annual dues are $20.00 for regular members, $12.00 for full-time students) and the cost is $25.00 per issue for non-members and institutions. The membership year is from 1 October through the following 30 September. The Club is exempt from federal income tax under section 501(c)(3) of the Internal Revenue Code; contributions above the subscription cost are tax-deductible.

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Bartonia No. 64: 1-18, 2009

Distribution Trends of Rare Plants at the Warren Grove Gunnery Range

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ABSTRACT. We conducted a comprehensive rare plant survey at the Warren Grove Gunnery Range (WGR), Burlington County, New Jersey from July 2004 through August 2006. Although areas outside the Range boundary have a long history of botanical exploration, little information on rare plant occurrences, habitats and distribution exists for WGR. The landscape at WGR is a mosaic of upland and lowland habitats that include sections of the East Pine Plains and the Oswego River Lowlands (ORL). Frequent anthropogenic disturbance (mechanical and prescribed burning) in military target zones provides suitable habitat for several early successional species, while less disturbed buffer zones support habitat for late successional species. Temporal and spatial habitat heterogeneity influences diverse plant assemblages at WGR, where we have documented the occurrences of 32 rare species including large, previously unreported populations of *Calamovilfa brevipilis, Corema conradii, Gentiana autumnalis, Lobelia canbyi, Muhlenbergia torreyana, Narthecium americanum, Panicum wrightianum, Rhynchospora knieskernii* and small pockets of *Calamagrostis pickeringii.* Although the greatest density of plant populations occurred in the ORL, 60% of the populations throughout WGR were associated with some level of anthropogenic disturbance. Natural resource management at WGR appears to successfully protect, promote and conserve habitat for rare plants concurrent with the military mission.

INTRODUCTION

The New Jersey Pine Barrens has an extensive history of botanical exploration (Britton 1889; Stone 1911; Harshberger 1916). However, few comprehensive plant surveys are reported for the East Pine Plains (Harshberger 1916; Lutz 1934) and fewer still for the East Pine Plains section known as the Warren Grove Gunnery Range (WGR; NJANG 2005). The WGR is located in Burlington and Ocean Counties, New Jersey. It occupies 3,810 hectares within the 450,000 ha Pinelands National Reserve. The landscape is a mosaic of upland (87.8%) and lowland habitats (12.2%; NJANG 2007). Uplands are dominated by dwarf pine plains and pitch pine-scrub oak barrens, whereas lowlands include herbaceous savannas, Atlantic white cedar swamps, pitch pine lowlands, hardwood swamps and shrub thickets (sensu McCormick 1979).

The WGR has been in continuous operation as a weapons range since 1942 and is currently owned by the U.S. Department of Defense and operated by the New Jersey Air National Guard 177th Fighter Wing. The WGR can be divided into two general areas, a Facilities Operation Zone (FOZ) and a Buffer Zone (BZ). Most military operations take place in the FOZ (938 ha), while very few military operations take place in the BZ (2872 ha). The FOZ is subdivided into a Target Zone (TZ) and Fire Management Zone (FMZ). The Target

Zone (360 ha) is an open anthropogenically disturbed area located within the East Pine Plains where the forest has been cleared for tactical and conventional air-to-ground gunnery training (Figure 1). Anthropogenic disturbance in the TZ includes maintenance activities (e.g., target renovation), mission operations (e.g., strafing, bombing) and prescribed burning. The FMZ (578 ha) is composed of intact upland forest surrounding the TZ. There is less disturbance from military activity in the FMZ; however, several "fire blocks" adjacent to the TZ are sequentially burned every four to seven years to reduce hazardous fuel loads, create

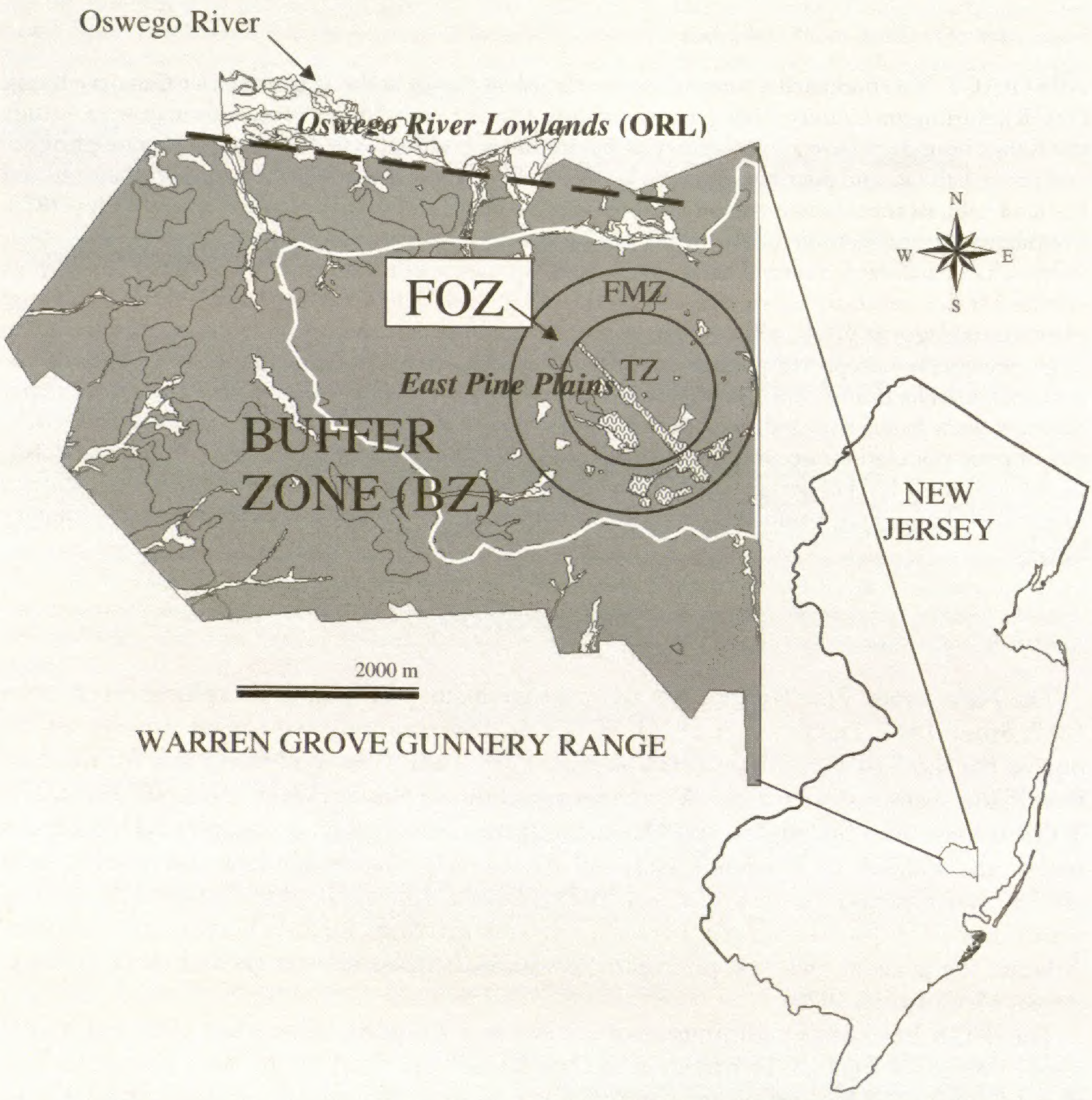

Figure 1. Location of Warren Grove Gunnery Range. The Facilities Operations Zone (FOZ) includes the Target Zone (TZ) and Fire Management Zone (FMZ). The Buffer Zone (BZ) includes sections of the East Pine Plains and the Oswego River Lowlands (ORL). The FOZ is within the East Pine Plains and is made up of dwarf pine plains habitat (light gray stipple). The BZ is made up of dwarf pine plains and pitch pine-scrub oak barrens (dark gray) as well as wetland habitats (white). The dashed line demarcates the Buffer Zone from the Oswego River Lowlands, which extends to the Oswego River.

fire breaks and discourage potential wildfires from escaping from the TZ (NJANG 2005). The BZ surrounds the FOZ. It consists of intact uplands and lowlands that include sections of the East Pine Plains and Oswego River Lowlands (149 ha), two areas that the New Jersey Natural Heritage Program recognizes as Priority Sites for Biodiversity Conservation within the New Jersey Pine Barrens. The East Pine Plains is a fire-maintained ecosystem where plant and animal species are well adapted to the high frequency of forest fires common to the region. It is one of several dwarf pine plains communities in the New Jersey Pine Barrens. The dwarf pine plains forest type is dominated by diminutive or stunted pitch pine (*Pinus rigida*) that is typically less than 3.4 meters high (Lutz 1934) and by two shrub oaks, the blackjack oak (*Quercus marilandica*) and scrub or bear oak (*Quercus ilicifolia*). The dwarf pine plains is a globally imperiled community type (G2; Breden et al. 2001) and critically imperiled community type at the State level (S1; Breden et al. 2001). The WGR is underlain by three major upland soil series: Lakewood, Lakehurst and Woodmansie (NJANG 2007). The Woodmansie soil series is the dominant soil type within the FOZ including areas where the dwarf pine plains forest type has been cleared for major buildings, headquarters, target zone and maintenance roads. Tedrow (1986) sampled the Woodmansie soil series several miles north of WGR near Coyle Field in the West Pine Plains and characterized the series as unconsolidated sandy deposits (A horizon) overlying an iron-rich clay layer (B horizon). Chemically, the soil series is nutrient poor and has a low pH. Typically, there is little surface organic matter as a result of the frequent fires common to dwarf pine plains regions (Tedrow 1986).

The WGR is a restricted access facility that supports large tracts of wetland and upland habitats including potential habitat for rare plants. As a result of variation in disturbance intensity, vegetation communities at WGR are in various stages of succession ranging from those frequently disturbed (anthropogenic) in active military zones to those less disturbed in buffer zones. A frequent disturbance regime in the Target Zone maintains open areas that are suitable for early successional species, whereas less disturbance (anthropogenic and/or natural) in the buffer zone maintains late successional species. We investigated the influence of anthropogenic disturbance intensity on the rare plant flora at WGR.

Scope of Study

Passed by Congress in the 1960s, the SIKES Act and as amended by the National Defense Authorization Act of 2004 (Public Law 108-136) requires the Department of Defense to implement conservation and rehabilitation programs on its land. The Act as amended requires each military base to develop a state- and federally-approved Integrated Natural Resources Management Plan (INRMP), which is a guide for environmental stewardship and biodiversity conservation. In July 2002 Drexel University and the Air National Guard signed a cooperative agreement to perform a series of ecological studies at WGR. This agreement included a Comprehensive Floral Survey (CFS) that was conducted from July 2002 through 2004 (NJANG 2005). The purpose of the CFS was to provide detailed information on the occurrence of native and non-native plant species. The CFS determined that WGR supports a rich and diverse flora. The current rare plant survey was an extension of the CFS. It focused on identifying additional rare plants and their habitats at WGR. These data will assist natural resource managers to better protect, manage and conserve rare plants.

Survey Objectives

1. Continue a Range-wide survey over an additional two years (2004-2006).
2. Develop a rare plant inventory that provides baseline data for field monitoring and delineating of rare plant populations and rare plant habitats.
3. Determine GPS coordinates of rare plant populations and provide Range personnel with GPS data for entry into the Range GIS database.
4. Evaluate the impact of mission activities on rare plants and habitats.
5. Make recommendations for managing and protecting rare plants and habitats.

Survey Methods

Definition of Rare and Endangered Plant Species

We use the term "rare plants" to include the following: federally-listed endangered or threatened species; species proposed for federal candidate listing; state-listed endangered species; all species listed in the New Jersey Pinelands Comprehensive Management Plan (Pinelands Commission 1980 and as amended in 2007); and all Plant Species of Concern listed by the New Jersey Natural Heritage Program (New Jersey Natural Heritage Program 2005).

Rare Plant Locations

Rare plant habitat in the Pine Barrens is often associated with edaphic conditions (e.g., wetland soils), seasonal wetlands (e.g., spongs), modified landscapes (e.g., logged cedar bogs, roadsides, etc.), small-scale landscape features (e.g., habitat patches), microhabitats (e.g., old cedar stumps), successional habitats (e.g., abandoned fields and meadows), atypical landscape features (e.g., abandoned cranberry bogs) and habitat transition zones (Fairbrothers 1979). We used high resolution aerial maps to identify landscape features, habitats (uplands and lowlands) and search units (SUs) where there was a high potential for rare plant occurrences. We maximized our search per-unit-effort within potential rare plant SUs and at locations where rare plants were previously identified during the CFS (NJANG 2005). We used a random-meander-search (RMS) within each SU and resurveyed each SU approximately every 2-3 weeks throughout the growing season to maximize the potential for identifying additional species.

We defined a "plant occurrence" to mean the occurrence of either a single plant or group of plants living together (patch). When we identified a plant occurrence we recorded the GPS coordinates (UTMs), habitat type, number of individuals (abundance), phenology and associate species. We considered all plant occurrences (individuals and patches) within one kilometer (≈0.62 miles) to be part of the same population. One kilometer is the separation distance recommended by the Natural Heritage Program to delimit different Element Occurrences (EOs; NatureServe 2004). It is assumed that EOs with a separation distance greater than 1 kilometer have a lower probability of interacting with one another and therefore are treated as a separate fundamental unit (EO). Although gene flow declines over distance and at different rates for different species, the minimum default EO separation distance of 1 km is the accepted metric for most situations (NatureServe 2004).

Definition of Habitat Affinity and Anthropogenic Disturbance Association

In an ecological context, habitat selection is the density of a species in a particular habitat, compared with the availability of that habitat (Railsback et al. 2003). Habitat selection concepts are mainly applied to mobile animals (Rosenweig 1991) and are inappropriately applied to immobile plants (Bazzaz 1991). Although there is no equally developed habitat selection theory for plants, plants have "choice habitats" that supply required resources (i.e. water, light, nutrients, mates, pollinators, etc.; Bazzaz 1996). Theoretically, a plant's choice habitat is located somewhere along a dry-to-wet continuum (gradient). Therefore, we defined "habitat affinity" to mean the propensity for a rare plant to occur under wet, dry, or seasonally wet-dry (hydroxeric) soil conditions. This approach allowed us to standardize plant occurrences whether they occurred in small microhabitats (e.g., plants growing in a wet tire depression) or in larger habitats (e.g., wetlands, upland forests, open fields, etc.). Because wet microhabitats are too small to be considered wetlands under jurisdictional wetland standards, we adopted the habitat affinity model to categorize a plant's choice habitat (i.e., wet, dry, seasonal wet-dry) regardless of its size.

Although natural disturbance is an important part of the ecology of the New Jersey Pine Barrens, we focused on the influence of disturbance from management practices on rare plant occurrences. For example, *Schizaea pusilla* may benefit from natural disturbance that maintains an open habitat (e.g., tree blowdowns) whereas *Rhynchospora knieskernii* may benefit from anthropogenic disturbance that creates small wet depressions (e.g., tire tracks). Therefore, we defined "anthropogenic disturbance association" to mean the propensity for a rare plant to occur in disturbed habitats as evidenced by a casual relationship between occurrence and man-made disturbances. We were careful to limit our survey to disturbed sites where the soil pH ranged from 3.6 to 5.5 (NJANG 2007), which is the average pH range for pine barrens soils (Tedrow 1986). Soils at WGR greater than a 5.5 pH indicate disturbed sites where the soil has been enriched by fertilizers or other soil amendments (NJANG 2007). We defined anthropogenic disturbance to mean sites that were mechanically disturbed (i.e., soil scraping and bulldozing, vegetation mowing, tree cutting, detonation of ordnance, etc.) or prescribed burned.

Sampling Blocks and Analyses

We divided WGR into three major landscape sampling blocks: 1) Facilities Operation Zone (FOZ; 938 ha), 2) Buffer Zone (BZ; 2723 ha) and 3) Oswego River Lowlands (ORL; 149 ha). The FOZ sampling block included the Target Zone (TZ) and Fire Management Zone (FMZ; see introduction). We designated Upper Cabin Road as the demarcation line between the ORL and BZ sampling blocks (Figure 1). Upper Cabin Road runs along a ridge that separates upland forest habitat from the ORL, an extensive tract of wetland habitats that eventually drains into the Oswego River (Figure 1). We compared differences among sampling blocks for rare species, EO density, species habitat affinity (wetland or upland) and anthropogenic disturbance association. Three significant environmental gradients occur at WGR: 1) topographical, 2) moisture and 3) anthropogenic disturbance intensity. A topographical sequence from uplands to lowlands follows from the TZ to the BZ. Thus surface water level increases with increased distance from the TZ. Several drainages that begin in the TZ flow though the BZ before emptying into the ORL. In contrast, anthropogenic disturbance intensity decreases with increased distance from the TZ. Because sampling blocks were unequal in size, we first calculated EO density per unit area before making comparisons among sampling blocks for species richness, habitat affinity and anthropogenic disturbance association. In addition, we used the Sorenson similarity coefficient to compare species richness similarity among sampling blocks (Krebs 1999).

Spatial Analyses

We used ArcView GIS Version 3.2a (ESRI) to develop EO distribution maps, measure distances between EO occurrences and correlate EOs with habitat features and distribution patterns. These data were used to assess potential impacts from military operations and to make recommendations for protecting rare plant species and habitat.

Plant Identification and Nomenclature

Nomenclature for vascular plants followed that in the *Manual of Vascular Plants of Northeastern United States and Adjacent Canada* (Gleason and Cronquist 1991) or, in matters pertaining to varieties and forms not recognized therein, the digital listing by Kartesz and Meachem (1999) and/or Fernald (1950). Nomenclature for *Sphagnum* followed that in *Flora of North America* (McQueen and Andrus 2007).

Results

Inventory and Distribution

We inventoried 32 rare plant taxa that included 27 vascular plants and five *Sphagnum* species (Table 1). Inventoried species included 1 federally-listed species, 1 federal-candidate species, six state endangered species, 20 CMP-listed species and 28 Plant Species of Concern (NJNHD 2005). Twenty-seven of 32 species had a wet habitat affinity (84.38%) while 13 of the 32 species (40.63%) were associated with some level of anthropogenic disturbance (Table 2). We recorded 131 EOs: 31 in the FOZ, 37 in the ORL and 63 in the BZ (Table 2). The ORL had the greatest EO density per unit area (0.248 ha) compared to the FOZ (0.033 ha) and BZ (0.023 ha; Table 2). Although the ORL was the smallest sampling block (149 ha), it had the greatest species richness (n=20) and species richness per unit area (0.134 ha) compared to species richness per unit area for the FOZ (0.015 ha.) and BZ (0.0007 ha). One-hundred nineteen of 131 EOs had a wet habitat affinity (90.84%) while 79 of 131 EOs (60.31%) were associated with some level of anthropogenic disturbance (Table 3). The ORL was more similar in species richness to the BZ (62%) than to the FOZ (24%; Table 4). In contrast, the BZ was more similar to the FOZ (48%) than to the ORL (Table 4). The trend of greater similarity between sympatric sampling blocks was probably more related to moisture regimes than to differences in disturbance intensity among sampling blocks. Three species occurred in all three sampling blocks: *Agalinis fasciculata*, *Calamovilfa brevipilis* and *Muhlenbergia torreyana* (Table 2). *Calamovilfa brevipilis* had the highest number of EOs (n=19) followed by *M. torreyana* (n=17) and *R. knieskernii* (n=9; Table 2). In contrast, several species had limited distribution among sampling blocks. Two species only occurred in the BZ (*Ludwigia linearis, Scleria reticularis*), whereas five species only occurred in the FOZ (*Aristida dichotoma* var. *curtissii*, *Aristida purpurascens* var. *virgata*, *Corema conradii*, *Solidago stricta*, *Spiranthes tuberosa*). Seven species only occurred in the Oswego River Lowlands (*Arethusa bulbosa*, *Narthecium americanum*, *Rhynchospora pallida*, *Schizaea pusilla*, *Sphagnum macrophyllum*, *Triantha racemosa*, *Utricularia purpurea*).

Table 1. Inventory and status of rare plants surveyed at Warren Grove Range (2002-2006).

	Scientific Name	Federal status	State status	CMP	NJNHP	Rank
1	*Agalinis fasciculata* (Ell.) Raf.				Yes	G5S3
2	*Arethusa bulbosa* L.				Yes	G4S2
3	*Aristida dichotoma* var. *curtissii* A.Gray ex S. Wats. & Coult.				Yes	G5S2
4	*Aristida purpurascens* var. *virgata* (Trin.) Allred				Yes	G5T4T5S2
5	*Calamagrostis pickeringii* A.Gray		E	LP	Yes	G4S1
6	*Calamovilfa brevipilis* (Torr.) Scribn.			LP		G4S4
7	*Carex barrattii* Schwein. & Torr.			LP		G4S4
8	*Corema conradii* (Torr.) Torr. ex Loud		E	LP	Yes	G4S1
9	*Gentiana autumnalis* L.			LP	Yes	G3S3
10	*Juncus caesariensis* Coville		E	LP	Yes	G2S2
11	*Lobelia canbyi* A.Gray			LP	Yes	G4S3
12	*Ludwigia linearis* Walt.			LP	Yes	G5S2
13	*Muhlenbergia torreyana* (Schultes) A. Hitchc.			LP	Yes	G3S3
14	*Narthecium americanum* Ker-Gawl.	C	E	LP	Yes	G2S2
15	*Panicum wrightianum* Scribn.				Yes	G4S2
16	*Platanthera cristata* (Michx.) Lindl.			LP	Yes	G5S3
17	*Rhynchospora cephalantha* A.Gray			LP	Yes	G5S3
18	*Rhynchospora knieskernii* Carey	LT	E	LP	Yes	G2S2
19	*Rhynchospora pallida* M.A. Curtis				Yes	G3S3
20	*Schizaea pusilla* Pursh			LP	Yes	G3S3
21	*Scleria minor* W. Stone			LP		G4S4
22	*Scleria pauciflora caroliniana* (Willd.) Wood				Yes	G5TNRS1
23	*Scleria reticularis* Michx.			LP		G3S4
24	*Solidago stricta* Ait.			LP	Yes	G5S3
25	*Sphagnum carolinianum* Andrus				Yes	G3S2
26	*Sphagnum cyclophyllum* Sull. & Lesq. ex Sull.				Yes	G3S2
27	*Sphagnum macrophyllum* Bernh. ex Brid.				Yes	G3S2
28	*Sphagnum perichaetiale* Hampe				Yes	G5S2
29	*Sphagnum portoricense* Hampe				Yes	G5S2
30	*Spiranthes tuberosa* Raf.			LP	Yes	G5S3
31	*Triantha racemosa* (Walt.) Small		E	LP	Yes	G5S1
32	*Utricularia purpurea* Walt.			LP	Yes	G5S3

Note: *Agalinis fasciculata* = *Agalinis purpurea* var. *racemulosa* (Pennell) Boivin; Triantha racemosa (Walt.) Small = Tofieldia racemosa (Walt.) BSP Panicum wrightianum Scribn.=Dichanthilium wrightianum (Scribner.) Freckmann

Notable Occurrences within the Facilities Management Zone and Target Zone

We identified four SUs (1, 4, 5 and 8) in the TZ with high rare plant species richness and/or abundance (Figure 2). These areas are adjacent to the runway and were mowed and/or prescribed burned every 2 to 7 years. They supported significant occurrences of *Agalinis fasciculate, Calamovilfa brevipilis, Gentiana autumnalis, Muhlenbergia torreyana, Scleria minor, Rhynchospora knieskernii, Solidago stricta* and *Spiranthes tuberosa. Rhynchospora knieskernii* occurred at SU1 and *G. autumnalis* occurred at SU4, including the white and green form (*G. autumnalis* f. *albescens)* and the white and blue form (*G. autumnalis* f. *albocaerulea)*. The authors believe that these two sites possibly support the largest contiguous populations of *R. knieskernii* (>10,000 plants) and *G. autumnalis* (>10,000 plants) in the

Table 2. Number in sampling blocks signifies frequency of element occurrences (EO). FOZ = Facilities Operations Zone, BZ = Buffer Zone, and ORL = Oswego River Lowlands. EO density per unit area and species richness density per unit area are listed at the bottom of each sampling block column. Species' habitat preference and anthropogenic disturbance affinity are based on observations by the authors. * = complex hydroxeric habitat (hx*) near runway target area that supports wetland, non-wetland and facultative species; see text.

		Sampling Block					
	Scientific Name	FOZ 938 ha	ORL 149 ha	BZ 2723 ha	EO	Habitat Preference	Anthropogenic Disturbance Affinity
1	*Agalinis fasciculata*	1*	1	1	3	hx*/wetland	yes
2	*Arethusa bulbosa*		1		1	wetland	no
3	*Aristida dichotoma* var. *curtissii*	1			1	non-wetland	yes
4	*Aristida purpurascens* var.*virgata*	1			1	facultative	yes
5	*Calamagrostis pickeringii*		2	1	3	wetland	no
6	*Calamovilfa brevipilis*	2*/1	2	14	19	hx*/wetland	yes
7	*Carex barrattii*		1	1	2	wetland	no
8	*Corema conradii*	4			4	non-wetland	yes
9	*Gentiana autumnalis*	2*		5	7	hx*/wetland	yes
10	*Juncus caesariensis*		2	2	4	wetland	no
11	*Lobelia canbyi*		1	3	4	wetland	no
12	*Ludwigia linearis*			1	1	wetland	no
13	*Muhlenbergia torreyana*	2	4	11	17	wetland	yes
14	*Narthecium americanum*		3		3	wetland	no
15	*Panicum wrightianum*	1*		2	3	hx*/wetland	yes
16	*Platanthera cristata*	1	1		2	wetland	no
17	*Rhynchospora cephalantha*		1	3	4	wetland	no
18	*Rhynchospora knieskernii*	4*/1		4	9	hx*/wetland	yes
19	*Rhynchospora pallida*		1		1	wetland	no
20	*Schizaea pusilla*		3		3	wetland	no
21	*Scleria minor*	3*		2	5	hx*/wetland	yes
22	*Scleria pauciflora caroliniana*	3*		1	4	hx*/non-wetland	yes
23	*Scleria reticularis*			5	5	wetland	no
24	*Solidago stricta*	2*			2	hx*	yes
25	*Sphagnum carolinianum*		2	2	4	wetland	no
26	*Sphagnum cyclophyllum*		2	3	5	wetland	no
27	*Sphagnum macrophyllum*		2		2	wetland	no
28	*Sphagnum perichaetiale*		1	1	2	wetland	no
29	*Sphagnum portoricense*		3	1	4	wetland	no
30	*Spiranthes tuberosa*	2*			2	hx*	yes
31	*Triantha racemosa*		2		2	wetland	no
32	*Utricularia purpurea*		2		2	wetland	no
	EO	31	37	63	131		
	EO density per unit area (ha)	0.033	0.248	0.023	0.034		
	Species richness	14	20	19	32		
	Species richness per unit area (ha)	0.015	0.134	0.007			

New Jersey Pine Barrens. *Rhynchospora knieskernii* was frequently observed at other disturbed sites, and it is probable that many more occurrences of *R. knieskernii* will be discovered at WGR. In addition, we identified several occurrences of *Corema conradii* in dwarf pine plains habitat where the canopy had been opened as a result of management practices, as well as scattered occurrences in areas with greater canopy closure throughout the FOZ.

Table 3. Distribution of element occurrences (EOs) and species richness (SR) in sampling blocks for habitat preference and affinity for anthropogenic disturbance. FOZ = Facilities Operations Zone, BZ = Buffer Zone, and ORL = Oswego River Lowlands.

Sampling Block	Habitat Preference						Anthropogenic Disturbance Affinity			
	Wetland		Non-wetland		Facultative		Yes		No	
	EO	SR	EO	SR	EO	SR	EO	SR	EO	SR
FOZ	5	4	5	2	21	10	30	13	1	1
ORL	37	20	0	0	0	0	10	4	27	16
BZ	57	17	1	1	5	1	42	8	21	11
Total	99		6		26		82		49	

Soil habitat conditions at SU1 and SU4 (Figure 2) are somewhat of an anomaly in that they supported a mix of upland (non-wetland) and wetland plants. We attributed this atypical mixture to: 1) the presence of a pit-mound relief that resulted from past and current management practices and 2) the presence of a semi-permeable clay fragipan that maintained a capillary fringe that provided enough moisture to support the unusual constellation of species. It was not unusual for wetland species to occur in shallow pits (i.e. bomb craters) and for upland species to occur immediately adjacent to these wetland species but at a slightly higher elevation. Even on patches of terrain with only the slightest variability in relief, this mixture of species prevailed. For example, "wetland affinity species" such as *Calamovilfa brevipilis, G. autumnalis* and *R. knieskernii* were growing side-by-side with "upland affinity species" such as *Eurybia compacta* (=*Aster gracilis*), *Hudsonia ericoides*, *Quercus ilicifolia*, *Quercus marilandica* and *Solidago odora*. We describe this landscape in a non-jurisdictional context because mosaic landscapes with ridge-swale topography or those with pit-mound relief are difficult to designate as either a wetland or non-wetland (Tiner 1999). Therefore, we have categorized this highly diversiform landscape as a "complex hydroxeric habitat" where past and current anthropogenic disturbance has facilitated conditions congenial for supporting an atypical assemblage of species with dramatically different moisture requirements ranging from xeric to mesic to hydric.

Notable Occurrences within the Buffer Zone

On 13 March 2004, the New Jersey Forest Fire Service (NJFFS) prescribed burned approximately 454 hectares at WGR for hazardous fuel reduction and ecological fire management. Several pockets of pitch pine lowlands and seasonally flooded palustrine grasslands

Table 4. Sorensen similarity coefficient matrix for comparing species richness among sampling blocks: FOZ = Facilities Operations Zone, BZ = Buffer Zone, and ORL = Oswego River Lowlands. Percentages represent how similar one sampling block is to another.

	FOZ	BZ	ORL
FOZ	100%		
BZ	48%	100%	
ORL	24%	62%	100%

Figure 2. Polygons delimit search units (SUs) in the Target Zone. A significant diversity of rare plants occurred in SUs 1, 4, 5 and 8. An estimated 10,000 plants of *Rhynchospora knieskernii* occurred in SU 1 and approximately 10,000 *Gentiana autumnalis* occurred in SU 4.

occurred in the fuel block, parts of which were last burned by a wildfire in 1954 (NJANG 2005). Prior to the prescribed burn only small populations of *Lobelia canbyi*, *Muhlenbergia torreyana* and *Calamovilfa brevipilis* occurred in these closed-canopy wetlands (Bien, unpublished observation). The intense burn reduced canopy cover creating clearings suitable for several herbaceous species that favor pioneer conditions. A luxuriant post-fire growth of the three above mentioned species occurred in several of the treated areas. The intense burn facilitated competitive release and stimulated flowering and vegetative expansion for these CMP-protected species. We estimate that these populations exceeded 10,000 plants for *M. torreyana* and *C. brevipilis*.

In an open herbaceous savanna in the northwest section of the installation we discovered a large populations of *Lobelia canbyi* (>2,000 plants), *Muhlenbergia torreyana* (>100,000 plants) and *Panicum wrightianum* (>1,000 plants). We recorded two occurrences of *Calamagrostis pickeringii* in a savanna drainage on the west side of Old Allen Road.

Notable Occurrences within the Oswego River Lowlands

We identified three large populations of *Narthecium americanum* within the Oswego River Lowlands. All three were in open savanna habitat. One occurrence was along the

Oswego River, while the other two occurrences were along a single drainage that empties into the Oswego River. *Calamagrostis pickeringii* occurred in two small populations, one along the drainage, the other, along the Oswego River. The latter population was discovered during a Philadelphia Botanical Club field trip on 6 August 2006 (see Gordon trip report this volume). These same two savannas supported significant populations of *Agalinis fasciculata*, *Rhynchospora pallida*, *Scleria reticularis*, and *Triantha racemosa*. The three savannas including several smaller drainages supported large occurrences of *Sphagnum carolinianum*, *S. cyclophyllum*, *S. perichaetiale* and *S. portoricense*.

Discussion

Disturbed (FOZ), less disturbed (BZ) and undisturbed habitats (ORL) at WGR support a significant Pine Barrens flora including extensive occurrences of several rare plant taxa. It was unclear what ecological interactions took place between disturbed and undisturbed areas, but temporal and spatial habitat heterogeneity was an important factor influencing the high diversity of rare plants at WGR. The diversity of rare plant taxa reflects the area's unique ecology, history of disturbance and geographical location.

Range operations that included certain kinds of disturbance regimes, namely mechanical disturbance (e.g., land clearing) and periodic prescribed burning (at intervals of 5-7 years) in burn blocks, were important for creating or maintaining habitat for early successional species and for those species that required some level of disturbance at some stage of their life cycle. The large populations of *Gentiana autumnalis* and *Rhynchospora knieskernii* located in the FOZ, namely in SU1 and SU4, appeared to benefit from past and current disturbance. It is important that these populations and their habitats be monitored to better understand the long-term effect of Range activities on these and other sensitive plant species in the TZ. These populations provide an opportunity for research to examine how disturbance and edaphic factors are linked to facilitate such large stands of these species. In addition, we recommend that wetland habitats in buffer zones that support populations of *Narthecium americanum* be monitored. A better understanding of recruitment, survivorship, longevity and turnover of this species will provide a quantitative assessment of the status of these populations and their habitats over time.

Rhynchospora knieskernii, a member of the Cyperaceae, was listed as a federal-threatened species on 18 July 1991 (USFWS 1993). Most *Rhynchospora* species in North America are confined to the Atlantic coastal plain (Gleason and Cronquist 1991). In New Jersey the genus is represented by 21 species. Although historically the former range of *Rhynchospora knieskernii* included Delaware, today it is restricted to the Pine Barrens of New Jersey, where it has always been considered rare (Knieskern 1857; Stone 1911). When recommended as a species for recovery by the United States Fish and Wildlife Service in 1993, there were only 34 known extant populations in New Jersey (USFWS 1993). Since that time additional stations have been discovered in Atlantic, Burlington, Camden, Monmouth and Ocean Counties. The discovery of additional sites since 1993 (Gordon 1993, 1996b), a better understanding of its habitat requirements (Gordon 1997; Yurlina 1998), seed germination studies (Yurlina 1998) and development of conservation strategies (Obee 1995; Gordon 1996b; Yurlina 1997) are important for the long-term security of *R. knieskernii* in New Jersey. Although these recent studies have helped to elucidate much needed information for this species, little is known about seed bank ecology, seed dispersal, recruitment, or effects of fire on seeds. We have documented 11 new EOs of *R. knieskernii* at WGR including one population with greater than 10,000 plants (Figure 2). This population of *R. knieskernii* represents one of the largest known populations in New Jersey. All of the populations occur within seasonally wet locations, where there has been some level of disturbance (i.e., soil scraping, tire track depressions, mowed roadsides and open fields) and where this early colonizer receives little competition from other species. Because of the disturbance regime, number of extant stations and ideal edaphic requirements, WGR offers an excellent opportunity to study successional trends and demography trajectories. Although a large number of *R. knieskernii* EOs occurs at WGR, it still remains unclear what effect military operations will have on the long-term survival of this ephemeral species. It is recommended that these plant populations be monitored and that a comprehensive study be conducted that examines the effect of fire on seed bank dynamics. Such studies may provide natural resource managers with information that will assist in the development of a management plan for the conservation of this species.

Corema conradii, a member of the *Empetraceae*, is a low cushion shrub. It is a disjunct species with populations documented from Nova Scotia to New Jersey (Obee 1994), its southern limit of range. Although it is apparently secure throughout most of its range (G4; see Appendix A for plant ranking system used throughout text), it is state-endangered (S1). Except for about a dozen small, outlier populations (Gordon 1998) the distribution of *C. conradii* in New Jersey is restricted to dwarf pine plains communities, including large sections of WGR, a significant stronghold for this taxon (Windisch 1998).

Redfield (1884), an authoritative student of *C. conradii* throughout its range, commented that fire is often lethal to old, established plants. On the other hand, there are data to suggest that fire is important for seedling regeneration (Redfield 1889; Good et al., 1979; Dunwiddie 1990). *Corema conradii* is commonly observed in gregarious stands throughout the fire prone dwarf pine plains communities of the New Jersey Pine Barrens, suggesting that seedlings establish as cohorts following a fire (Zaremba 1984). Windisch (1998) studied the distribution of *C. conradii* at WGR and found it to be widely dispersed. He concluded that fires that create forest openings ("open-coremal-physiognomy") are important for the recruitment of *C. conradii* and for protecting established stands from subsequent fires. Although *C. conradii* may show signs of decline from canopy closure in areas where there has been a long period of fire suppression (Sorrie 1987), subsequent fires are important for keeping succession in check around established stands (Windisch 1998). In discussing the occurrence, disappearance and sudden re-occurrence after a long absence of historic populations of *C. conradii*, W. Stone (1911) concluded: "From the variation, in abundance of the species at different times and its apparent disappearance from some stations, it seems to me that it probably dies out or is exterminated by fire in certain spots, while the seed blown freely over this wind swept waste is constantly starting new colonies, so that its actual stations are continually shifting." Near Watering Place Pond east of WGR, Gordon (1989) reported the apparent eradication of an occurrence of *C. conradii* by a July 1983 fire. After a lapse of three years, seedlings appeared at the site, presumably by seed recruitment from an adjacent population not consumed by the fire (Gordon, unpublished observation). Near Munyon Field south of WGR, Gordon observed the permanent eradication by an April 1981 fire of a small occurrence of *C. conradii* growing in a dense shrub thicket beneath a pine canopy (Gordon, unpublished observation). Both of these examples appear to corroborate Stone's conclusion. Although fire can create open spaces necessary for seedling recruitment and protection, extremely hot fires can kill mature, well-established *C. conradii* colonies.

This dynamic may occur with other rare species of the region, as well. Near Whitesbog, Gordon witnessed the extinction of several hundred plants of the state-endangered Pickering's morning glory (*Stylisma pickeringii*) following an intense prescribed burn. Even after repeated surveys, not a single seedling has been observed since the fire in the 1980s (Gordon, unpublished observation). This example helps illustrate that prescribed burning must be used judiciously and with good planning when used in areas that harbor rare plants.

A recent study in dwarf pine plains habitat near WGR by Maritine et al. (2005) suggests that myrmecochory may play a critical role in seed dispersal and germination of *C. conradii.* Harvest ants (*Pheidole davisi* Wheeler) take crowberry seeds underground where some of them may eventually germinate following a fire (Maritine et al. 2005). However, little research has been conducted on the effects of burning, mowing, or soil removal on seedling growth rate, sex ratios and habitat partitioning (Obee 1994). Along with monitoring of existing stands, studies that address demographic and life history questions are needed. Additional data will be important for developing a conservation management plan for this state-endangered species.

Gentiana autumnalis, a member of the *Gentianaceae,* is a showy, perennial herb that is globally rare (G3; New Jersey Natural Heritage Program 2005). *Gentiana autumnalis* ranges locally from New Jersey to South Carolina, occurring in moist pine barrens on the coastal plain (Gleason and Cronquist 1991). While populations in North Carolina and New Jersey appear to be relatively stable (ranked S3 in both states), the species is imperiled (S2) in South Carolina, critically imperiled (S1) in Virginia and extirpated in Delaware (NatureServe Explorer 2007). *Gentiana autumnalis* appears to benefit from some level of disturbance that creates open sunny spaces that are free of competitors and succession. However, certain forms of disturbance that include grading and scraping of roadside populations, mowing regimes during the growing season, herbicide use and fire suppression are detrimental to *G. autumnalis* (Jenkins and Blades 1990). *Gentiana autumnalis* is locally abundant at WGR and apparently benefits from repeated low intensity prescribed burns. Continued monitoring, including studies of long-term fire effects, is important for the management of this species.

Narthecium americanum, a member of the Liliaceae, is a federal-candidate species that occurs in moist to wet savanna habitat associated with periodic flooding (Schuyler 1990; Gordon 1996a). This perennial herb has a recorded range that includes New Jersey, Delaware, North Carolina and South Carolina (Schuyler 1990). Extirpated from the latter three states, *N. americanum* is currently restricted to the Pine Barrens of New Jersey (Schuyler 1990), where it is ranked by the Heritage Program as imperiled both globally and in the state (G2, S2). We identified three EOs of *N. americanum* at WGR all within the Oswego River Lowlands (Figure 1). These populations appeared to be ecologically secure provided that canopy closure is held in check and the current stable hydrology is maintained (Gordon 1996a). *Narthecium americanum* cannot survive constant inundation or long periods of drought (Schuyler 1990; Gordon 1996a). The number of flowering plants at WGR appears to fluctuate as a result of year-to-year changes in water level (Bien, unpublished observation). During wet years flowering can be locally abundant, in contrast to drought years when there are fewer flowering plants. During drought periods there is less seed set and higher rates of seed abortion (Bien, unpublished observation). Flowering is also negatively impacted by shading due to succession of shrubs and trees (Schuyler 1990; Gordon 1996a).

The Integrated Natural Resources Management Plan (2001) suggested that a recovery program be conducted for *Narthecium americanum* at WGR. This recommendation was made prior to the discovery of *N. americanum* at WGR. As a result of the CFS, we do not believe a reintroduction program is warranted; however, we do recommend that existing populations of *N. americanum* be monitored for population changes, water level changes and number of flowering plants. In addition, *N. americanum* sites should be evaluated for post fire impacts and potential threats from succession.

The current natural resource management program at WGR appears to be maintaining a natural Pine Barrens ecology and landscape mosaic on a scale that is positive for common and rare plant communities. The habitat heterogeneity of disturbed and relatively undisturbed buffer zones supports a significant diversity of Pine Barrens flora. The current military operations do not appear to be negatively impacting rare plants and the current disturbance regime in the TZ appears to be beneficial to those species that require some level of disturbance for survival.

Recommendations to Protect T/E Species and Habitat at WGR:

1. Develop conservation easements for T/E species with fewer than five EOs.
2. Monitor T/E sites and rare species habitat.
3. Apply adaptive management at the population level if rare species habitat or T/E species are declining. (Threats may include space competition, small effective size, loss of genetic exchange, etc.).
4. Eradicate non-native species.
5. Maintain seed dispersal corridors (immigration and emigration) for genetic exchange between T/E populations when planning prescribed burns.
6. Maintain patches and protect existing T/E seed banks.
7. Use disturbance regimes (mechanical and prescribed burning) that vary at landscape scales (large and small) and time of year (e.g., occasional summer prescribed burns). (This will encourage early successional species that appear to require some level of disturbance in their life cycle).
8. Protect rare plant pollinators. [Do not use herbicides and other biocides that may kill pollinators necessary for pollination (Jenkins and Blades 1990).]
9. Monitor and inventory T/E populations and their habitat every five years.
10. Mow fields at the end of growing season (late October-early November) when plants have completed seed dispersal and life cycles. (This is especially important for rare plant populations in open fields in the target area, along road shoulders and along the runway.)

Acknowledgments

Special thanks are extended to the staff of the 177th Fighter Wing at WGR and to the New Jersey Air National Guard for granting access to field sites. Appreciation is also extended to Michael Zolkewitz, Alicia Buchanan and the many Drexel University students who helped with field work. This project was sponsored through the U.S. Army Medical Research Acquisition Activity (Award #DAMD17-02-2-0045), with funding provided by the Air National Guard Readiness Center. We gratefully acknowledge the comments and insights provided by two anonymous reviewers that have helped improve this paper measurably.

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APPENDIX

Heritage Database symbols used throughout text and in Table 1.

Federal Status Codes

C Taxa for which the U.S. Fish and Wildlife Service currently has on file sufficient information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened species.

LT Taxa formally listed as threatened.

State Status Codes

E Endangered species—one whose prospects for survival within the state are in immediate danger due to one or many factors—a loss of habitat, over exploitation, predation, competition, disease. An endangered species requires immediate assistance or extinction will probably follow.

Other Status (Regional)

LP Taxa listed by the Pinelands Commission as endangered or threatened within their legal jurisdiction. Not all species currently tracked by the Pinelands Commission are tracked by the Natural Heritage Program.

Heritage Listed

Yes indicates species is listed in the data base of the New Jersey Natural Heritage Program

Global Element Ranks

G2 Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it vulnerable to extinction throughout its range.

G3 Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range; with the number of occurrences 21 to 100.

G4 Apparently secure globally; although it may be quite rare in parts of its range especially at the periphery.

G5 Demonstrably secure globally although it may be quite rare in parts of its range especially at the periphery.

T Element ranks containing a "T" indicate that the infraspecific taxon is being ranked differently than the full species.

State Element Ranks

S1 Critically imperiled in New Jersey because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres). Elements so ranked are often restricted to very specialized conditions or habitats and/or restricted to an extremely small geographical area of the state. Also included are elements which were formerly more abundant, but because of habitat destruction or some other critical factor of its biology, they have been demonstrably reduced in abundance. In essence, these are elements for which, even with intensive searching, sizable additional occurrences are unlikely to be discovered.

S2 Imperiled in New Jersey because of rarity (6 to 20 occurrences). Historically many of these elements may have been more frequent but are now known from very few extant occurrences, primarily because of habitat destruction. Diligent searching may yield additional occurrences.

S3 Rare in the state with 21to 50 occurrences. Includes elements which are widely distributed in the state but with small populations/acreage or elements with restricted distribution, but locally abundant. Not yet imperiled in state but may soon be if current trends continue. Searching often yields additional occurrences.

S4 Apparently secure in state with many occurrences.

Bartonia No. 64: 19-35, 2009

Riparian Plant Communities as Predictors of Instream Condition

A Case Study in the Upper Penns Creek Watershed, Pennsylvania

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ABSTRACT. Although riparian and stream habitats are closely linked systems, the ability of the riparian plant community to serve as a consistent and strong predictor of the health of the adjacent instream community has not been empirically explored. We evaluated the efficacy of the Floristic Quality Assessment Index (FQAI) to predict the condition of both mainstem and headwater aquatic sites along Penns Creek, a high gradient coldwater stream in the Ridge and Valley Physiographic Province of central Pennsylvania. We also used Classification and Regression Tree (CART) analysis to evaluate the use of the FQAI in combination with additional landscape and local metrics to determine broad categories of condition for aquatic habitat. Riparian and instream data were collected at 17 sites throughout the upper Penns Creek watershed. Sites were selected to incorporate a range of land uses from forested to agricultural lands and urban/suburban cover, as well as a range of potential chemical properties. Riparian condition followed a pattern predictable for sites in the Ridge and Valley with high quality sites occurring in forested watersheds and low quality sites within agricultural and urban settings. This pattern was mirrored by aquatic insect metrics for headwater streams, but not for sites within the mainstem portion of Penns Creek. Along the mainstem of the creek, floristic quality increased as the stream flowed from the agriculturally-dominated Penns Valley into Bald Eagle State Forest; however, taxonomic richness and EPT diversity were low at Penns Valley sites and remained low over this same distance despite improvement in the riparian corridor. The lack of a consistent relationship between FQAI and aquatic metrics indicated that response is scale-dependent: floristic quality is more sensitive to localized changes in riparian condition, while instream metrics are responsive to changes in the watershed as a whole. Both landscape and local metrics were useful in partitioning sites into broad condition categories. Using % forest, FQAI, and Habitat Assessment scores as predictor variables, CART defined four condition categories for the upper Penns Creek watershed, corresponding to superior, high, moderate, and low quality sites. Since streams are systems that operate over a range of spatial scales, this approach, which uses multiple metrics representing different hierarchical levels, may be more tenable. The use of both landscape-level and local metrics appears necessary to ensure a comprehensive assessment of stream condition and supports EPA's vision of a watershed approach for the protection and management of surface and groundwater resources.

Manuscript Submitted: 11 June 2007; revised 19 September 2008.

Introduction

Riparian habitats are those that are closely associated and influenced by the presence of a perennial or intermittent water source, typically a stream or river (Armantrout 1998). The riparian zone occupies a unique position in the landscape, at the interface between upland and aquatic ecosystems, thus, it is the product of both terrestrial and fluvial processes (Gregory et al. 1991; Naiman and Décamps 1997; Williams et al. 1999). As a result, riparian zones are dynamic and spatially complex systems that often vary in terms of width, elevation, edaphic and hydrologic features, and dominant plant communities (Gregory et al. 1991). Despite this inherent variability, most riparian habitats provide a suite of comparable benefits to the adjacent aquatic habitat. For streams, this includes bank stabilization, flood flow attenuation, cover and shade, and a source of both particulate and dissolved organic matter (Conners and Naiman 1984; Gregory et al. 1991). Riparian habitats also provide a physical buffer between the stream and other land uses, regulating the influx of both sediments (Osborne and Kovacic 1993) and nutrients (Lowrance et al. 1984) from urban and agricultural sources. In turn, riparian vegetation benefits by being hydrologically-connected to the stream.

While the connectivity between terrestrial riparian and aquatic stream habitats has been well established, the link between riparian plant communities and stream condition has not been empirically explored. Historically, plants have been used as indicators of underlying geology, groundwater, soil type, bedrock composition, and minerals (Chikishev 1965) and this close coupling to the physical and chemical environment suggests plant community composition may be an effective indicator of aquatic health. It is not known, however, if riparian plant communities can function as consistent and strong predictors of adjacent stream condition. Although it is easy to envision a scenario where degradation of the adjacent riparian vegetation negatively affects the stream, what about the opposite instance? Does the presence of high quality riparian vegetation imply a high quality stream? Or, is there no clear relationship between riparian plant communities and the adjacent instream environment, with one exhibiting high integrity while the other is impaired? If riparian plant community metrics prove to be successful surrogates for instream metrics, the implications on stream management are potentially significant. Instream metrics typically involve the use of macroinvertebrate indicators, the collection, processing and identification of which can be costly, labor intensive, and may require the use of experts. In these instances, using plant metrics in place of instream metrics would be the more efficient and cost-effective option.

We used both landscape-level and site-specific metrics to explore the relationship between the floristic quality of the adjacent riparian plant community and the condition of upper Penns Creek, a high gradient, coldwater stream in the Ridge and Valley Physiographic Province of central Pennsylvania. The primary stressors to wetland and aquatic systems in the Ridge and Valley are increased sedimentation and nutrient enrichment resulting from both agricultural and urban land uses (Cole et al. 1997). In the upper Penns Creek watershed, agricultural runoff, atmospheric deposition, and industrial discharges are the main pathways by which excess sediments and nutrients enter Penns Creek (Genito and Shervinskie 2002). Sedimentation and eutrophication are chronic disturbances that stress wetland and aquatic habitats by altering light conditions and temperature, introducing sediment-borne pollutants, or changing the depth, permeability, and other features (O_2, moisture) of the substrate (Wardrop 1997).

The link between these kinds of landscape-level anthropogenic disturbances, their resulting stressors, and habitat quality has been explored extensively (Klein 1979; Mangun 1989; Howarth et al. 1991; Grubaugh and Wallace 1995; Lamberti and Berg 1995; Pyle 1995; Malone 1996; Roth et al. 1996; Lopez and Fennessy 2002; Miller et al. 2006). In plants, both species richness (Jurik et al. 1994; Dittmar and Neely 1999; Mahaney et al. 2003) and diversity (Dittmar and Neely 1999) have been shown to decline with increased sediment deposition. Individual species have also been shown to respond differentially to increases in sediment. Jurik et al. (1994) reported a significant reduction in germination for some wetland species exposed to sediment accumulations of as little as 0.5 cm. Wardrop and Brooks (1998) classified plants into tolerance categories based on their response to varying magnitudes of sediment.

Nutrient enrichment also stresses wetland plants by altering nutrient cycles and shifting competitive interactions among species. High nutrient levels generally favor plants that are able to consume excess resources and rapidly increase biomass (Wetzel and van der Valk 1998; Galatowitsch et al. 1999). These species are often non-native (*Lythrum salicaria*) or aggressive native species (*Typha* spp., *Phalaris arundinacea*) that quickly form monotypic stands in nutrient-enriched systems (Hobbs and Huenneke 1992; Galatowitsch et al. 1999, 2000). Grasses are also favored over forbs in enriched habitats (Hobbs and Huenneke 1992).

Likewise, studies of instream macroinvertebrate and algal communities have documented decreased species richness and diversity (Lenat and Crawford 1994; Mangun 1989; Genito and Shervinskie 2002), diminished trophic complexity (Wallace and Gurtz 1986), and shifts in community composition (Mangun 1989; Grubaugh and Wallace 1995; Lamberti and Berg 1995; Kemp and Spotila 1997) with increased sediment and nutrient loading. Increased sediment can fill in interstitial spaces, reducing the amount of habitat for aquatic insects (Waters 1995). Sedimentation also diminishes light penetration, decreasing periphyton abundance and affecting food availability and utilization patterns (Johnson et. al. 1993; Grubaugh and Wallace 1995). Conversely, nutrient enrichment in streams can produce algal blooms that reduce oxygen concentrations and alter substrate conditions adversely affecting stream biota (Genito and Shervinskie 2002).

Since riparian and aquatic communities have been shown to be sensitive to these stressors and the landscape-level changes that cause them, our first objective was to evaluate the efficacy of the riparian plant community to predict aquatic condition at both mainstem and headwater sites along Penns Creek. Streams, however, are systems that operate over a range of spatial scales from micro to macro habitats (Roth et al. 1996). A second objective, therefore, was to use Classification and Regression Tree (CART) analysis to evaluate the utility of using both local and landscape metrics in determining broad categories of condition for aquatic systems. The development of condition categories is fundamental to the monitoring and assessment process and is critical to the long-term protection and enhancement of aquatic resources.

METHODS

Upper Penns Creek Watershed

The upper Penns Creek watershed lies within the Ridge and Valley Physiographic Province, a region characterized by parallel ridges and intervening valleys that traverses the state in a northeasterly direction (Fig. 1) (Rhoads and Klein 1993). The climate is moderate, with an annual average temperature of 10° C and monthly averages ranging from –3° C in January

Figure 1. The Upper Penns Creek Watershed in the Ridge and Valley Physiographic Province of Central Pennsylvania showing Penns Creek, its tributaries, and the 17 sampling locations.

to 22° C in July (U.S. Department of Commerce 1991). Average annual precipitation is 102 cm and is evenly distributed throughout the year. Overall land cover in the Ridge and Valley is 64% forested, 31% agricultural, and 5% developed (Myers et al. 2000). Forested areas are largely confined to the relatively undisturbed ridges, while the valleys support primarily agriculture and urban land uses.

The upper Penns Creek watershed encompasses almost 64,000 ha along the western boundary of the Ridge and Valley (Fig. 1). It is comprised of three major land use types: agriculture, forest, and urban (residential and commercial development). Penns Creek, its primary watercourse, flows in a southeasterly direction from its source at Penns Cave to its confluence with the Susquehanna River some 54 km away. Major tributary streams include Sinking Creek, Muddy Creek, Pine Creek, Elk Creek, Big Poe Creek, Swift Run, Cherry Run, Weikert Run and Laurel Run. Several springs also flow into Penns Creek and some of its tributaries on the valley floor contributing to both a constant water temperature regime and high biological productivity (Genito and Shervinskie 2002).

Although most streams in the Ridge and Valley have their headwaters on the forested ridgetops and flow downstream into valleys dominated by agricultural and urban land uses, in Penns Creek, this pattern is reversed. From above Spring Mills to Coburn, the prevailing land use is open field or residential. From Coburn downstream, forest dominates. Land use as well as the underlying geology, have greatly influenced the stream and its riparian area. In Penns Valley, streams are underlain by calcareous shale and limestone and riparian areas are generally narrow or, in some cases, absent. In contrast, ridgetop streams have extensive riparian buffers and are underlain by sandstones, siltstones, and shales.

Site Selection, Sampling, and Metrics

Riparian and instream data were collected at 17 sites throughout the upper Penns Creek watershed (Fig. 1). Five sites occurred along the mainstem of Penns Creek with the remaining 12 sites on eight of its tributaries. Sites were selected to incorporate a range of land uses from forested to agricultural lands (croplands or pasture) and urban/suburban cover as well as a range of potential chemical properties (Genito and Shervinskie 2002). Once sites were selected, land use was estimated in a 1-km circle centered on each site and grouped into one of three main categories: forest, agricultural, and urban.

We used the Floristic Quality Assessment Index (FQAI) to relate riparian plant community condition to both land use in the watershed and instream condition. The FQAI is a weighted richness metric that uses conservatism (expressed numerically as a coefficient of conservatism or *C* value) of the plant community to derive an estimate of habitat quality (Swink and Wilhelm 1979, 1994). The *C* value is a measure of an individual plant's fidelity to specific habitat requirements, as well as its tolerance to disturbance. *C* values are assigned *a priori* within a given geographic area and are used to weight species richness.

In our study, we calculated the FQAI as:

$$I' = \left(\frac{\overline{C}}{10} \times \frac{\sqrt{N}}{\sqrt{N+A}} \right) \times 100$$

where $\overline{C}$ is the mean of the *C* values (coefficients of conservatism, see Beatty et al. 2002) of native species, *N* is the number of native species, and *A* is the number of non-native species (Miller and Wardrop 2006). This formula is a modified version of the index that considers the contribution of non-native species and corrects the inherent bias of the index toward species-rich sites. A discussion of this and other iterations of the index can be found in Miller and Wardrop (2006).

The index is rapidly gaining acceptance as a tool for assessing the condition of a variety of habitats including wetland and riparian communities (Fennessy et al. 1998; Lopez and Fennessy 2002; Miller et al. 2006). In central Pennsylvania wetlands, the FQAI was shown to be a reliable assessment tool either as a stand alone technique (Miller and Wardrop 2006) or when incorporated into a plant-based index of biological integrity (IBI) (Miller et al. 2006). It was strongly correlated with disturbance in headwater wetlands in the Ridge and Valley and has demonstrated great potential as a statewide monitoring tool.

To derive FQAI scores, a plant species list was generated for each site by either conducting a complete inventory of plants within a 100 m^2 quadrat positioned parallel to the stream or using the Rapid Assessment Protocol (RAP) developed for wetland assessment in Pennsylvania (Brooks et al. 1999). In this protocol, plant data are collected using a series of nested plots located along an evenly-spaced grid, with 20 m between grid points. Herbaceous and shrub richness are determined within a 3 m radius plot and tree richness within an 11.6 m radius plot. Thus, sites sampled utilizing both techniques provided complete species lists. Sites were sampled between April 2001 and August, 2002. Nomenclature of plant species follows Rhoads and Block (2000).

The Rapid Bioassessment Protocol (RBP) was used to assess stream condition (Genito and Shervinskie 2002). The RBP is a standard and scientifically-accepted method for assessing streams based on the physical, chemical, and biological attributes of the stream channel and streamside vegetation (Plafkin et al. 1989; Barbour et al. 1999). Sampling locations were visually evaluated in November, 2000 and April, 2001 and scored using ten habitat parameters (Table 1). To simplify comparisons, we averaged scores for April and November. Scores were then used to determine if local conditions were reflective of prevailing land uses.

We also selected two aquatic insect metrics, total taxa richness and EPT taxa richness to indicate instream habitat condition. Biological metrics were used because unlike chemical and physical measurements which are point-in-time estimates of stream integrity, biological metrics integrate both past and present stream conditions (Danielson 1998). Aquatic insect metrics, in particular, are the most responsive and easily sampled segment of the aquatic community and their composition, diversity, and abundance can be a direct reflection of stream and watershed quality (Grubaugh and Wallace 1995; Genito and Shervinskie 2002). Furthermore, the decline of aquatic insect communities and the fish species that depend on them hold meaning and relevance to society at large (Barbour et al. 1999).

Aquatic insect sampling was conducted in November 2000 and April 2001 during habitat assessment surveys using a d-frame kick net (approximately 33 cm wide, 600 um mesh). Samples were preserved in 70% ethanol and sorted to a target of 300 organisms. Specimens were identified to genus-level, if possible, using Merritt and Cummins (1996) and Peckarsky et al. (1989). The total number of taxa metric was calculated by summing the total number of aquatic insect species in a sample. The number of EPT taxa metric was determined by summing the number of mayfly, stonefly, and caddisfly species in a sample. These three insect groups were used because they are considered to be the most sensitive of the aquatic insect taxa and typically disappear from aquatic insect communities before other taxa in response to disturbance. Additional details on collection and sorting methods can be found in Genito and Shervinskie (2002).

Statistical Analyses

Because our data violated the necessary assumptions of normality, we used Spearman Rank correlation coefficients to establish the link between landscape and local metrics and to evaluate the relationship between the FQAI and aquatic metrics (total taxa, and EPT) for both mainstem and headwater sites. CART analysis was used to assign broad condition categories based on a combination of landscape and local metrics. CART analysis is a non-parametric alternative to predictive linear discriminant analysis methods and has been

Table 1. Habitat assessment parameters used to assess stream condition as part of EPA's Rapid Bioassessment Protocol for use in Wadeable Streams.

Epifaunal substrate/Available cover
Embeddedness
Velocity/Depth combinations
Sediment deposition
Channel flow status
Channel alteration
Frequency of riffles
Bank stability (condition of banks)
Bank vegetation protection
Riparian vegetative zone width

Poor: 0-59; Marginal: 60-109; Suboptimal: 110-159; Optimal: 160-200.

shown to perform well when data do not meet assumptions of normality or covariance homogeneity (Feldsman 2002), suggesting that CART is an approach well-suited for complex ecological data like those generated by monitoring efforts (De Ath and Fabricius 2000). CART explains the variation in a single response variable (in this case, EPT or total macroinvertebrate taxa) using one or more predictor variables. Response variables can be categorical (classification tree) or numerical (regression tree), and predictor variables can be numerical, ordinal, or categorical. The predictor variable that best explains variation in the response variable is partitioned first. Partitioning continues until the process is stopped based on a set of *a priori* decision rules. The overall goal of the model is to explain the greatest amount of variation while minimizing the number of branches and leaves on the tree.

CART analyses were performed using SAS JMP 5.1.1 (SAS Institute, Inc. 1989-2004), with a stopping rule of 3 cases. Since we were interested in determining whether the FQAI would add significant information to the habitat variables already measured, the following sets of predictor variables were used in separate analyses:

- FQAI and % forest, as a test of the instream condition (total taxa) scores based on the results of a landscape and riparian vegetation assessment only;
- FQAI and % forest, as a test of the instream condition (EPT) scores based on the results of a landscape and riparian vegetation assessment only;
- FQAI, % forest, and Habitat Assessment scores, as a test of the instream condition (total taxa) scores with all possible predictors and indicative of the added value of the FQAI when Habitat Assessment scores are available; and
- FQAI, % forest, and Habitat Assessment scores, as a test of the instream condition (EPT) scores with all possible predictors and indicative of the added value of the FQAI when Habitat Assessment scores are available.

RESULTS

Landcover and Vegetation

Of the five sites sampled along the mainstem of Penns Creek, two were located in Penns Valley, a largely agricultural and urban landscape (sites 8 and 16) and three (sites 1, 3, and 6) within Bald Eagle State Forest, an area of minimal anthropogenic disturbance (Fig. 1). The remaining 12 sites were located along the eight major tributaries of Penns Creek with four occurring in Penns Valley and draining watersheds dominated by agricultural or urban land uses (Elk Creek, Sinking Creek, Muddy Creek and Pine Creek) and four within Bald Eagle State Forest with largely forested headwaters (Weikert Run, Swift Run, Cherry Run and Poe Creek).

Forest was the dominant landcover at most sites, with the exception of some sample locations in Penns Valley which were primarily in agricultural land use (Fig. 2). Urban land use was observed only at sites within Penns Valley and overall accounted for less than one percent of the three land use types described.

Riparian forests within Penns Valley are similar to Fike's Red Oak-Mixed Hardwood Forest type (Fike 1999), although, these sites are typically more species rich than Fike's prototype. Dominant overstory trees include red maple (*Acer rubrum*), sugar maple (*Acer saccharum*), American ash (*Fraxinus americana*), black walnut (*Juglans nigra*), black cherry (*Prunus serotina*), red oak (*Quercus rubra*), basswood (*Tilia americana*), eastern hemlock

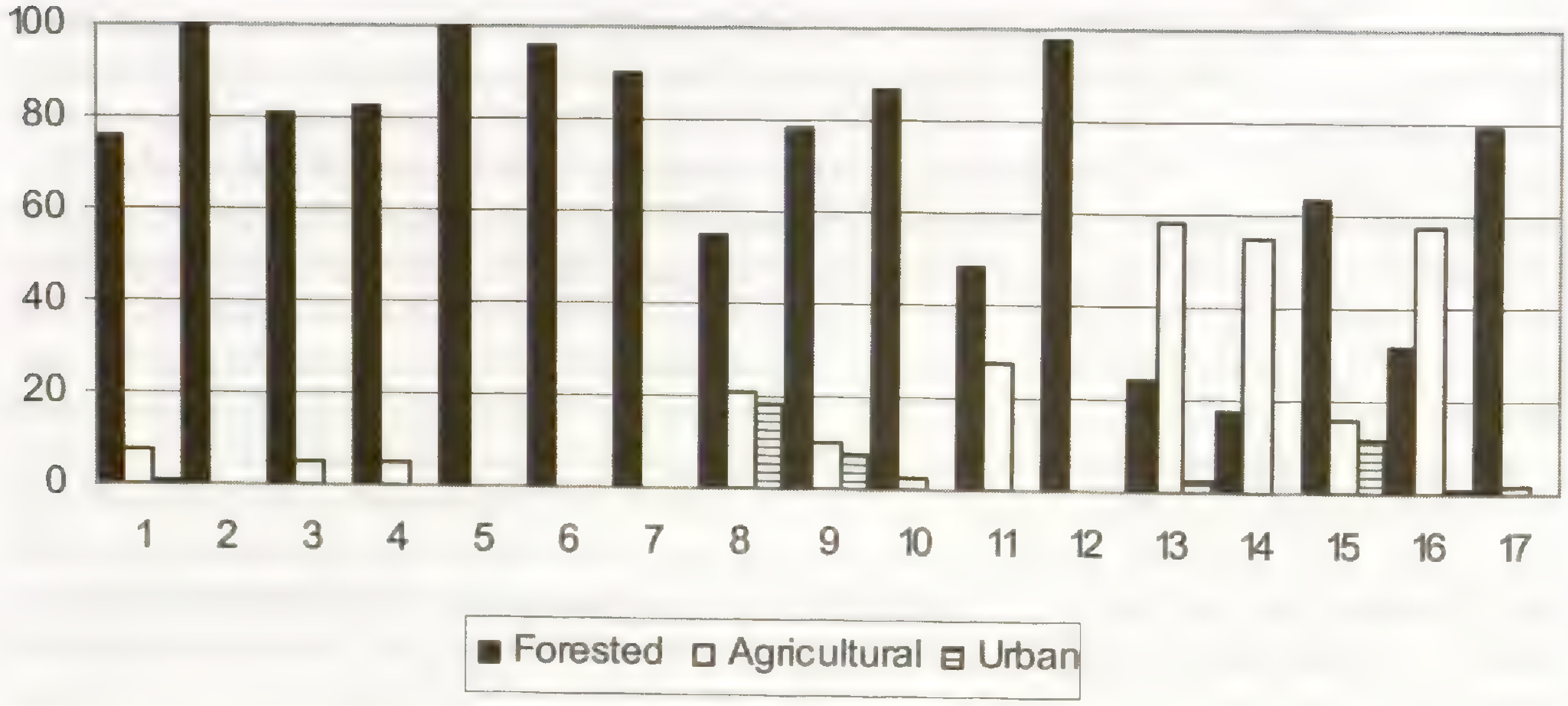


Figure 2. Percentage of forested, agricultural and urban land use within a 1 km circle centered on each site. Forest was the dominate land use at most sites within the Upper Penns Creek watershed, although at some sites within Penns Valley, agricultural was the prevailing land use. Urban land uses make up only a small fraction of the watershed.

(*Tsuga canadensis*) and American elm (*Ulmus americana*). Understory trees and shrubs observed include native (hop hornbeam [*Ostrya virginica*], alternate-leaved dogwood [*Cornus alternifolia*], silky dogwood [*Cornus amomum*], hawthorn [*Crataegus punctata*], blackberry [*Rubus occidentalis*]) and non-native (Japanese barberry [*Berberis thunbergii*], autumn olive [*Elaeagnus umbellata*], Morrow's honeysuckle [*Lonicera morrowii*], multiflora rose [*Rosa multiflora*]) species. In addition to woody plants, over one hundred species of cryptogams, graminoids, and forbs were recorded in the herbaceous layer. Invasive species, in particular, were restricted to valley sites and included the non-native noxious weeds, Canada thistle (*Cirsium arvense*) and purple loosestrife (*Lythrum salicaria*), as well as the native invasive reed canary grass (*Phalaris arundinacea*). Sites in Penns Valley also supported sediment-tolerant species (Wardrop and Brooks 1998) including rice cutgrass (*Leersia oryzoides*) and jewelweed (*Impatiens capensis*).

Riparian areas within the Bald Eagle State Forest are dominated by a mixture of hardwood species and evergreens. Many of the woody species found in Penns Valley also occur at these sites along with serviceberry (*Amelanchier arborea*), rosebay rhododendron (*Rhododendron maximum*), yellow and black birch (*Betula alleghaniensis*, *B. lenta*), mountain holly (*Ilex montana*), mountain laurel (*Kalmia latifolia*), tulip poplar (*Liriodendron tulipifera*), and white pine (*Pinus strobus*). Like valley sites, the herbaceous layer is a mixture of cryptogams, graminoids and forbs.

Non-native species were found at both valley sites and those within the Bald Eagle State Forest. However, a higher proportion of non-native species (26%) comprised the flora of sites in Penns Valley compared to less than 15% at state forest sites.

Condition Assessment

In the upper Penns Creek watershed, riparian condition followed a fairly predictable pattern with high quality sites occurring in forested watersheds and low quality sites within agricultural and urban settings, where streamside forests have been subjected to human-mediated disturbances. FQAI scores ranged from 16 to 58 (Table 2) and were positively correlated with forested land cover ($r = 0.71$, $P = 0.001$). Sites with high floristic quality included both mainstem and tributary locations in Bald Eagle State Forest where forest cover ranges from 80 to 100%. Sites with low floristic quality occurred within Penns Valley, with a forest cover of 70% or less.

Habitat scores ranged from 123 to 183 (Table 2) and increased as the amount of forest in the watershed increased. Like the FQAI, scores at both mainstem and tributary sites were lowest in Penns Valley and highest within the Bald Eagle State Forest. Sites with high habitat scores coincided with forested cover values of 80-100% and were characterized by wide, vegetated riparian corridors, stable stream banks with meandering channels, diverse instream substrates such as fallen logs, snags, cobble and rooted banks, and diverse velocity depth regimes (Genito and Shervinskie 2002). Sites with low scores were associated with percent forested cover of less than 70% and exhibited increased sediment deposition, loss of herbaceous streamside vegetation, and a narrow riparian zone. Habitat scores for all sites were also significantly correlated with forest cover ($r = 0.65$, $P = 0.005$) although the relationship was slightly weaker than with the FQAI.

The pattern observed for the FQAI was mirrored by the aquatic insect metrics for headwater streams, with both total and EPT taxa positively correlated with increasing forested cover ($r = 0.78$, $P = 0.003$). We did not observe a similar trend for the mainstem portion of Penns Creek ($r = 0.05$, $P = 0.935$ and $r = 0.15$, $P = 0.805$). As expected, mainstem sites in Penns Valley showed poor condition. This trend persisted, however, as the stream flowed through

Table 2. FQAI scores, Habitat Assessment scores and instream metrics for the 17 sites assessed as part of an ecological assessment of the upper PennsCreek Watershed (Genito and Shervinskie, 2002).

Site Number	Stream segment	FQAI score	Habitat Score*	Taxa richness	EPT taxa
	Mainstem stream segments				
1	Penns Creek w/Weikert Run	55.75	166.5	46	28
3	Penns Creek w/Cherry Run	46.51	182.5	44	25
6	Penns Creek w/Poe Creek	35.98	164.5	42	26
8	Penns Creek w/Elk Creek	30.99	123	46	28
16	Penns Creek at Spring Mills	41.24	156.5	34	17
	Headwater stream segments				
2	Weikert Run	57.08	179	57	40
4	Cherry Run	57.87	180.5	61	42
5	Poe Creek	50	164	61	40
7	Swift Run	38.91	161.5	53	40
9	Elk Creek	32.84	158	31	17
10	Pine Creek at bridge	33.18	158	49	37
11	Pine Creek at mouth	21.17	141.5	39	24
12	Elk Creek at Stover Gap	56.85	168.5	73	53
13	Elk Creek at Coburn	21.16	160	27	8
14	Muddy Creek	15.93	133	44	26
15	Sinking Creek near Spring Mills	21.86	143.5	42	21
17	Sinking Creek	29.36	169.5	54	37

*Scores represent the average of April and November measurements. Stream condition is ranked as Poor: 0-59; Marginal: 60-109; Suboptimal: 110-159; Optimal: 160-200 based on EPA's Rapid Bioassement Protocol (Plafkin, et al. 1989; Barbour et al., 1999)

Bald Eagle State Forest, despite the predominance of forested cover in this part of the watershed. Aquatic insect data also appeared to be closely related to instream water quality (Genito and Shervinskie 2002). Headwater sites with higher numbers of total and EPT taxa also had lower sediment and nitrate concentrations than downstream sites with lower numbers of macroinvertebrates.

Total taxa and EPT taxa metrics were also positively correlated with floristic quality for all sites (Figs. 3a and 3b). However, when we examined mainstem and headwater sites separately, we found that while FQAI scores at headwater sites were significantly correlated with total and EPT taxa ($r = 0.80$, $P = 0.002$ and $r = 0.83$, $P = 0.001$, respectively), there was no relationship between the FQAI and aquatic metrics at mainstem sites ($r = 0.10$, $P = 0.870$). This is because along the mainstem of Penns Creek, floristic quality increased as the stream flowed from the agriculturally-dominated Penns Valley into Bald Eagle State Forest. However, total taxa and EPT taxa metrics remained relatively static over this same distance.

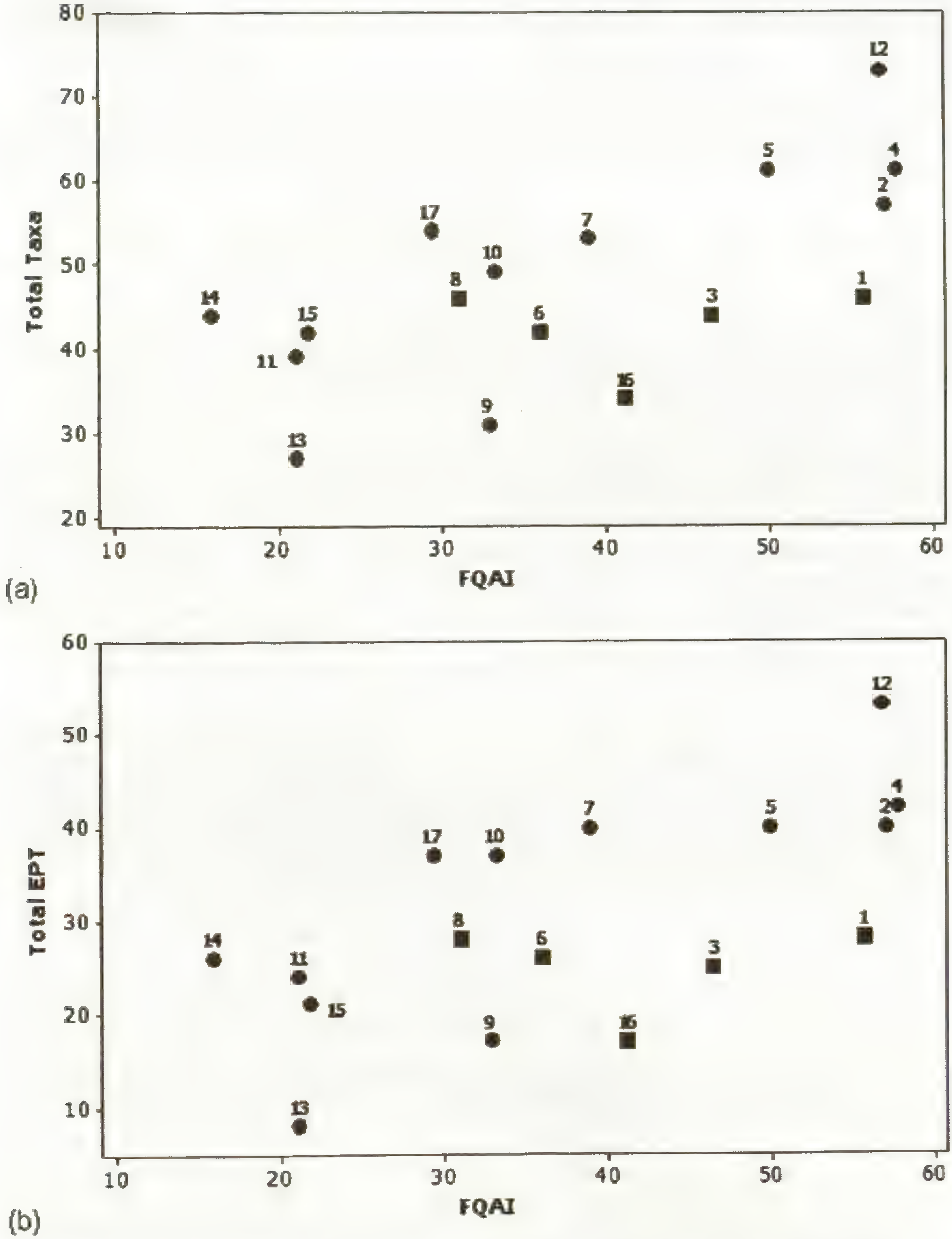
In the evaluation of FQAI and % forest as predictors of instream quality, CART generated four condition categories for both total taxa and EPT, with identical thresholds and predictor variables. The first separation of sites occurred at 79% forest (Table 3). Sites with greater than 79% forest were further partitioned into high and superior quality by the FQAI. The distinct separation of the sites into four condition groups shows the predictive power of the landscape and FQAI assessments in assigning sites to broad condition categories. It also indicates that the FQAI is valuable in discriminating sites of the highest condition.

When Habitat Assessment scores were added to % forest and FQAI metrics as predictor variables, the resulting condition categories were virtually identical. CART, again, generated four categories for both total taxa and EPT, with identical thresholds and predictor variables. The first separation of sites occurred at 79% forest. For sites with less than 79% forest, the Habitat Assessment metric split the sites again into two groups, low and moderate quality, while sites with greater then 79% forest, were further defined into two groups, high and superior quality by the FQAI. Thus, Habitat Assessment scores proved useful in distinguishing between the two lowest condition categories, while the FQAI best discriminates the two highest condition categories. Overall, Habitat Assessment scores predicted more low quality sites than when % forest and FQAI metrics were used alone.

Discussion

In the upper Penns Creek watershed, the FQAI was a reliable predictor of instream condition along headwater streams, but not along the mainstem of Penns Creek. Penns Creek originates at a spring near Penns Cave and flows through the agriculturally-dominated Penns Valley (where it is subjected to both increased sedimentation and nutrient enrichment) before entering Bald Eagle State Forest. At both headwater and mainstem sites in Penns Valley, riparian and instream metrics are similar and both signal poor condition. As Penns Creek flows into Bald Eagle State Forest, the metrics diverge as mainstem instream metrics continue to reflect the poor condition of upstream sites in Penns Valley, while the FQAI reflects the good condition of the local forested riparian zone.

Both riparian and instream metrics were responsive to changes in condition, but our results indicate that this response was related to scale. The FQAI was more sensitive to localized changes in riparian condition, while instream metrics were responsive to changes in the watershed as a whole. In headwater systems, the catchment area is small and stream integrity



Figures 3a and 3b. Scatterplots of FQAI vs. total and EPT taxa. At headwater sites (●), both instream metrics are positively correlated with the FQAI, whereas at mainstem sites (■), there is no definitive relationship between these metrics and the FQAI.

Table 3. CART output for landscape and local metrics. Partition 1 used % forest and FQAI as predictor variables while Partition 2 used Habitat Assessment (HA) score as an additional predictor variable.

	Response Variable			
Category	Total Taxa	EPT	Category Range	Sites Within Each Category
Partition 1				
Superior	63	44	≥79% forest, FQAI > 50	2,4,5,12
High	48	33	≥79% forest, FQAI < 50	3,6,7,10,17
Moderate	41	24	48-78% forest	1,8,9,11,15
Low	35	17	0-47% forest	13,14,16
Partition 2				
Superior	63	44	≥79% forest, FQAI > 50	2,4,5,12
High	48	33	≥79% forest, FQAI < 50	3,6,7,10,17
Moderate	43	26	<79% forest, HA ≥ 144	8,11,14
Low	35	18	<79% forest, HA< 144	1,9,13,15,16

is influenced primarily by the adjacent riparian zone. At these sites, riparian condition was found to be closely correlated with instream condition. In mainstem systems, the physical, chemical and biological attributes of the stream are an expression of the cumulative effects of the many tributaries and their subwatersheds that contribute to the system. Riparian and instream metrics diverge at mainstem sites because where the FQAI continues to express the condition of the local riparian zone, aquatic metrics express the influence of the overall watershed. The presence of high quality riparian vegetation downstream of Penns Valley, although important to the local stream community, does little to ameliorate the effects of these upstream stressors once they enter the water column.

The divergence of the FQAI and aquatic metrics indicates instream condition is clearly influenced more by landscape-level than by local factors. Roth et al. (1996) reached a similar conclusion in a study of 23 streams in Michigan. They found that instream IBI scores related strongly with regional land use, but exhibited either weak or non-significant relationships with local site vegetation. Benthic community condition was positively correlated with the amount of forested land area and negatively correlated with indicators of urbanization in the Chesapeake Bay watershed (Dauer et al. 2006). Basin-wide land use practices, namely agriculture and urbanization, and their resulting stressors have also been implicated as the fundamental cause of decreases in benthic community diversity in five watersheds in northern Virginia (Mangun 1989), as well as, a decrease in the abundance and biomass of benthic macroinvertebrates, and shifts in benthic species composition in a Georgia river (Grubaugh and Wallace 1995).

Although landscape-level factors appear to be the driving influence on instream condition, there is ample evidence supporting the importance of streamside riparian forests to the integrity of adjacent streams. Riparian vegetation can lessen both sediment and nutrient inputs to streams by intercepting and reducing overland flows (Lowrance et al. 1984; Osborne and Kovacic 1993). Jones et al. (1999) point to a number of negative changes to stream ecosystems with the removal of streamside vegetation including stream bank destabilization, increased sedimentation, decreased water quality, alteration of light and thermal regimes, and modifications in hydrologic flows. In a study of fish communities in North Carolina and Georgia, they reported that deforested, vegetated riparian zones of more than 1 km in length contributed to a decrease in fish species abundance and shift in species composition, even though these deforested zones occurred in largely forested landscapes. The proportion of stream channel length with riparian vegetation was an important predictor of biotic integrity in Ontario streams (Steedman 1988). Roth et al. (1996) propose the existence of a threshold level of riparian vegetation necessary to maintain high-quality instream habitat, that once exceeded, will result in extreme degradation. Indeed, as watersheds become more developed, streamside buffers will become increasingly critical to maintaining instream integrity because of the impracticality of augmenting forested cover on a watershed scale (Dauer et al. 2006).

Although the FQAI was not a consistent predictor of instream condition over the length of Penns Creek and its tributaries, CART analysis indicated that the FQAI, when combined with other landscape and local metrics, is useful in partitioning sites into broad condition categories. CART initially partitioned sites based on landscape position: those occurring in the predominately agricultural Penns Valley versus those located in forested areas, primarily Bald Eagle State Forest. The basis for the second partition into four condition categories is somewhat imprecise, but is likely due to the presence of localized stressors for low to moderate quality sites or the lack of human-mediated disturbances in the surrounding catchment for high to superior quality sites. When Habitat Assessment scores were added as a predictor variable, there was no effect on high quality sites, but these scores were better predictors than % forest for partitioning lower quality sites. The increased sensitivity of the Habitat Assessment scores is likely reflective of the ten parameters that comprise this variable and which relate to the quality of both instream and riparian habitat. It is interesting to note that the FQAI was a better indicator than Habitat Assessment scores in distinguishing high quality sites, even though these scores are routinely used for planning and management purposes.

Of the two approaches evaluated, the use of multiple metrics to assess condition appears to be the most useful. This approach allowed us to assign broad categories of condition to sites within the watershed, rather than relying on a single data point to evaluate habitat integrity. Because it incorporated both landscape and local metrics, the multi-metric approach is more applicable to hierarchical systems like streams that operate over a multitude of spatial scales. It also proved effective for both mainstem and headwater sites, unlike the FQAI, which was more suited to evaluating headwater systems alone. Furthermore, it appears to be a suitable surrogate to sampling macroinvertebrates, which can be costly, labor intensive, and may require the use of experts to process and identify. In stream systems like upper Penns Creek, the use of such a multi-metric approach - which includes both landscape and local, as well as terrestrial and aquatic metrics - would not only ensure a comprehensive assessment of aquatic and riparian condition, but also would support EPA's vision of a watershed-based strategy for the protection and management of surface and groundwater resources (Barbour et al. 1999).

CONCLUSIONS

The FQAI Calculator

In the summer of 2006, the Pennsylvania Department of Environmental Protection launched a pilot study to determine the condition of wetlands within the lower Susquehanna River basin. Subsequent efforts beginning in 2007 will seek to evaluate the condition of wetlands in the Commonwealth on a rotating basin schedule and, thus, will require tools that can rapidly and effectively assess condition. This and previous studies underscore the efficacy of the FQAI as such an assessment technique.

An important outcome of the Penns Creek study and one that will advance the FQAI as a broad-based assessment tool was the development of a web-based, interactive calculator for determining FQAI scores. The calculator was developed by Fell Design for the PNPS and is available at their Web site (www.pawildflower.org/g3/index.htm). To determine the FQAI score, the user first compiles a plant list using prefabricated drop-down boxes. Two scores are then generated automatically: the FQAI (Swink and Wilhelm 1979, 1994) and the adjusted FQAI (Miller and Wardrop 2006) based on coefficients of conservatism developed for the plants of Centre County, Pennsylvania (Beatty et al. 2002), the number of native plants, and for the adjusted FQAI, the number of non-native plants. The list can be amended as necessary by manually adding plants and assigning coefficient values.

Preliminary testing of the coefficients assigned by Beatty et al. (2002) indicates that they may be applicable statewide (Miller et al. 2006); however, there is a strong desire to develop coefficients that would be valid throughout the Commonwealth following the lead of Ohio (Andreas et al. 2004), Indiana (Rothrock 2004), Michigan (Herman et al. 1997), Missouri (Ladd 1993) and Wisconsin (Bernthal 2003). Once statewide coefficients are available, the FQAI calculator will be a powerful addition to the ever-growing inventory of bioassessment tools available for monitoring terrestrial habitats in Pennsylvania.

Acknowledgments

The authors would like to thank Dennis Genito and Tom Shervinskie for enthusiastically granting permission to use their data in this study. Members of the Pennsylvania Native Plant Society and Penn State Cooperative Wetland Center provided many hours of field work and plant identification that made this study possible and we gratefully acknowledge their efforts. We would especially like to thank Joe Isaac for his unmatched expertise in plant identification, as well as Robert Gruver and Jennifer Rubbo both of whom contributed significantly to the field study and data entry and analysis. This project was funded by a Growing Greener Grant from the Pennsylvania Department of Environmental Protection.

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Bartonia No. 64: 37-44, 2009

Some Ecological Observations on a Shortleaf Pine (*Pinus echinata*) Stand in the Piedmont of North Carolina

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ABSTRACT. The oldest stand of shortleaf pine, *Pinus echinata*, on the Piedmont of North Carolina—a stand established in ca. 1810 to 1837 and occupying a 1.9 ha site at the Duke Forest, Durham—was sampled for trees with a diameter at breast height greater than 7.6 cm. in sixteen 10 m. × 10 m. quadrats. *P. echinata*, an important successional species in the region, is the dominant species with an importance value of 79, and accounts for 46.5% of the basal area of all trees sampled at the site. From comparisons with data collected at the same site 63 years earlier and with other mixed shortleaf pine hardwoood stands of ages 21, 31, 56 and 83 years, the overall successional trend of conifers as a group being replaced by hardwoods is clear even though *P. echinata* remains the dominant species at this site.

INTRODUCTION

The objectives of the study were 1) to examine the survival of shortleaf pine, *Pinus echinata* on a 1.9 ha. site, located within the Duke University Forest, the site of the mature shortleaf pine stand selected by Billings for study over 70 years ago (Billings 1936, 1938), which originated on a field abandoned ca. 1810; and 2) to compare in forests aged nine to about 170 years, the density of *P. echinata* in sites occupying former agricultural fields in the Piedmont near Duke University in Durham, North Carolina.

Pinus echinata, scattered across more than one million km.^{2} across 24 states from eastern Texas to New York, has the widest range of any pine species in the southeastern United States (Lawson 1990). It is called by various common names—shortleaf, yellow, spruce, two leaf, heart, rosemary, and old-field pine—in different portions of its range (Mattoon 1915). The average height of mature *P. echinata* is 24 to 30 m, though it may reach 37 m. on favorable soil. The diameter at breast height (dbh) of mature trees usually ranges from 0.6 to 0.9 m. On favorable sites it may grow to 1.2 m. in diameter. *P. echinata* reaches its best development in Arkansas (Mattoon 1915) where trees commonly reach ages of 200 to 300 years, with a few reaching 400 years (Lawson 1990).

Pines play an important role in community development on abandoned land in the southeastern United States (Oosting 1942, 1956; Oosting and Livingston 1964; Quarterman and Keever 1962; Odum 1971). Stalter (1971) described a mature *Pinus taeda* (loblolly pine) stand in the Congaree Swamp, South Carolina, where most of the loblolly pines were established ca. 1795 to 1870. This was one of the first reports of a major stand of pine containing

Manuscript received 14 April 2004; revised 27 January 2007.

many trees 150 years old or older in the southeast. *P. taeda* was the dominant tree in the portion of the Congaree Swamp decribed by Stalter (1971) with a relative dominance (percent basal area of all trees sampled) value of 48%. *Liquidambar styraciflua* (sweet gum), with a relative dominance value of 22%, ranked second at this site. No other tree had values higher than 17%. Stalter (1971) reported on a 6.1 ha. stand of *P. taeda* in northeastern North Carolina, where the oldest trees dated ca. 1800. This stand was still dominated by *P. taeda* in 1971 (Stalter 1971).

The oldest stand of *Pinus echinata* in North Carolina described in the literature is the stand reported by Billings (1938) with trees that were established ca. 1810-1837. By comparison, several 100+ year-old loblolly pine stands are described by Stalter (1971), Jones et al. (1981), Pederson (1994) and Pederson et al. (1997). Mattoon (1915) compared the dbh of different aged stands of shortleaf pine in North Carolina with those in Arkansas. Mattoon (1915) was able to measure the dbh of living *P. echinata* in stands up to 200 years old in Arkansas, but his measurements of dbh of shortleaf pine in North Carolina were confined to 332 stumps with annual ring counts ranging 26-89 years.

The oldest trees of *Pinus echinata* in the Billings stand, the site of the present study, were cored by Oosting (1968 personal communication) and date from ca. 1833. Trees in the Billings stand were cored again in 1995 and in March 2003 by Judson Edeburn (personal communication) at Duke University. In Edeburn's sample of trees, the number of annual rings of *P. echinata* in this stand ranged from 165 to 185 placing their establishment between ca. 1810 to1837 which is our best estimation of the age of this stand of *P. echinata*.

The Duke Forest lies within the Durham Triassic Basin (Billings 1938). The soils are derived from sedimentary Triassic sandstone, mudstone, and shales. Billings (1936, 1938) restricted his shortleaf pine study sites to a single soil type, Granville sandy loam, "to eliminate the variability of soils as a factor." Granville sandy loam is derived from sandstone, mudstone and shales of Triassic age. The association has a grayish or yellowish surface soil and a yellowish or reddish sandy clay to clay subsoil.

The modern classification of soils at the Duke Forest are Ultic Alfisols of the Enon Series (Allen et al. 2000). We measured soil pH at the Duke Forest and found it was acidic with a pH range of 4.6 to 5.2. Billings (1936) minimized the topographical factor in his study by selecting pine stands on level ground or nearly so. The then 110 year-old shortleaf pine stand, at an elevation of approximately 107 m. (Edeburn personal communication) occupied ground with a slight slope toward the south.

Based on climatological data taken from the weather station at Raleigh Durham Airport (ca. 24 km. from the study site and the nearest site with continuous yearly weather records), the Durham area is mild with short winters, long summers, and a growing season averaging 201 days (Anonymous 1983). The warmest month is July, with a mean temperature of 26.1° C. January is the coldest month with an average temperature of 4.4° C. Average annual precipitation is 1,095 mm. Rainfall is heaviest in July and September, both with an average of 109 mm. April is the driest month, averaging 71.1 mm. Summer precipitation is mainly by thunderstorms. Snowfall in Durham is rare. There was a slight increase in temperature from the 30-year period 1961-1990 to 1971-2000. The mean January temperature increased from 3.8 to 4.4° C, while the July temperature increased from 25.8 to 26.2° C.

METHODS

Trees over 7.6 cm. dbh were sampled in 2001 in sixteen 10 m. × 10 m. quadrats located within the stand (35° 59′ 35.89324″ N, 78° 56′ 19.57275″ W) of *Pinus echinata* sampled by

Billings (1936). The plots were located at least 20 m. from the adjacent road and parking lot. All trees over 7.6 cm. dbh within the quadrats were measured with a diameter tape and identified by species. Tree species were classified by Radford et al. (1968).

Billings (1936, 1938) sampled the arborescent vegetation at this site in 1935 with ten 25-milacre quadrats. There are 98.84 milacre quadrats in one hectare. Thus Billings' 25-milacre plots are slightly larger than the 10 m. × 10 m. (0.01 ha.) quadrats used in this study. For comparative purposes the tree density values of Billings (1936, 1938) were converted to trees per hectare by dividing his density values by 0.9884. The personnel at the Duke University School of Forestry determined the ages of *Pinus echinata* in this stand in 1995 and in 2003.

Data analyses were performed using JMP version 5.1.2 (SAS) and by computer programs written by us for calculating species area curves by approximate randomization and programs written for obtaining bootstrap confidence intervals of importance values and Jaccard coefficients. The number of bootstrap samples per run was 50,000. Importance value, the sum of percent relative density, percent relative frequency and percent relative dominance, is on a scale of 0 to 300% (Mueller-Dombois and Ellenberg 1974). Working from pair-wise comparisons of taxa in 2 × 2 contingency tables where species presence/absence data

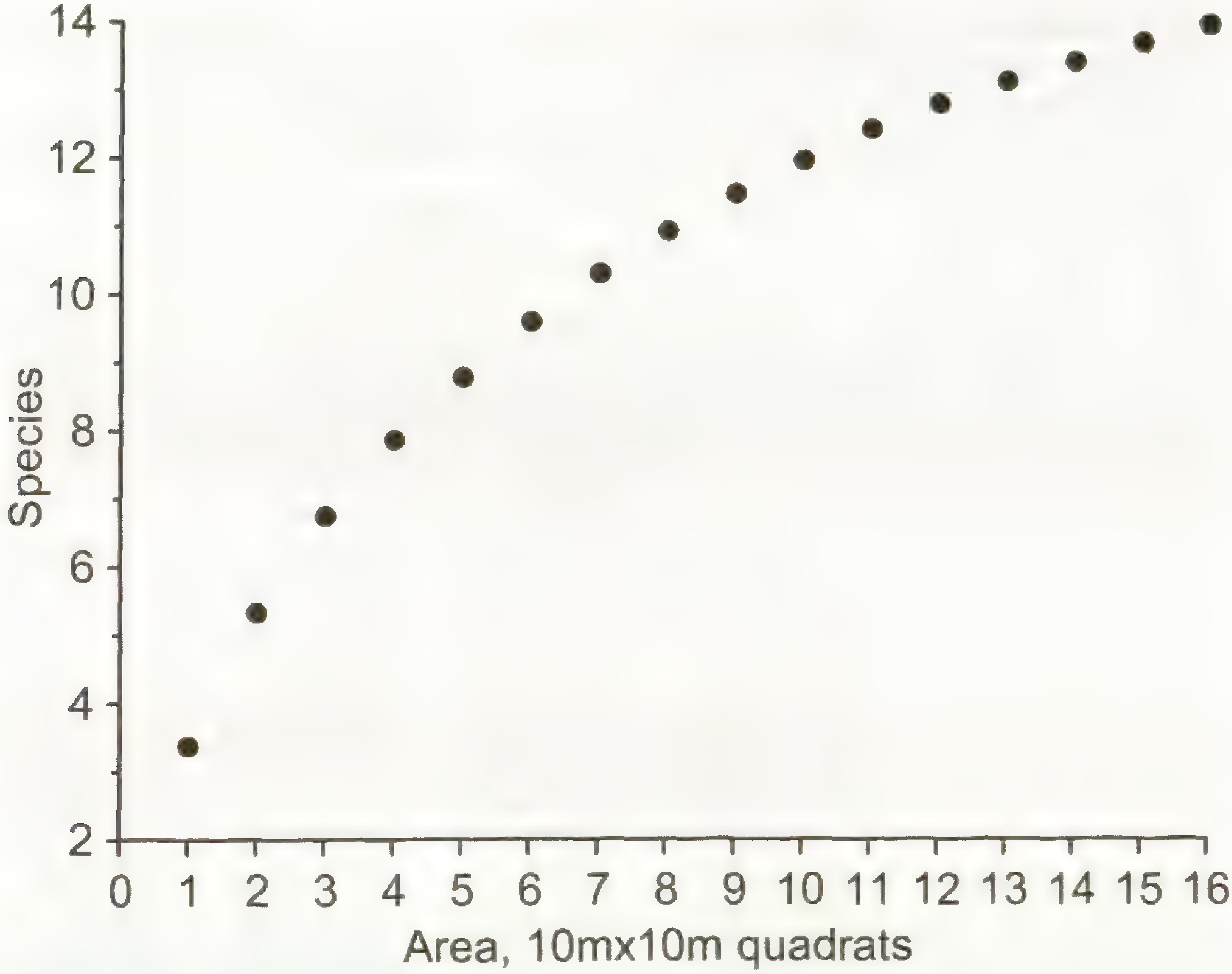

Figure 1. Species area curve for the 2001 study. Mean number of species accumulated as the number of 10 m × 10 m quadrats is increased. Each point is the mean of the number of species from 50,000 random combinations of observed quadrats.

are cross-tabulated for quadrats, the Jaccard coefficient of similarity (Jaccard 1912) is S = a/(a + b + c) where a is the number of quadrats common to both taxa, b is the number of quadrats containing species 1 but not 2, and c is the number of quadrats containing species 2 but not species 1 (Kent and Coker 1992). Also working from the contingency table, the phi coefficient measures on a scale from −1 to +1, the negative and positive aspects of species association across the quadrats (Sokal and Rohlf 1995, p. 743).

RESULTS AND DISCUSSION

Our 2001 survey of sixteen 10 m. × 10 m. quadrats yielded 78 trees of dbh > 7.6 cm. comprising 14 species. The species-area curve, achieved by approximate randomization (Fig. 1) is reasonably leveled off at the 14 taxa of the 2001 survey. *Pinus echinata* was the dominant tree at the 170 year-old stand surveyed in 2001, with an importance value of 77.9 (Table 1). *Acer rubrum* ranked second with an importance value of 77.7 while *Quercus alba* and *Pinus taeda* were third and fourth in dominance with values of 42.4 and 17.9, respectively. When the importance values of all oaks were summed, they were nearly half the importance value of *P. echinata*.

Pinus echinata had the highest relative dominance value at the 170-year-old stand, accounting for nearly half (45.9%) of the basal area of all trees. *Acer rubrum*, the most numerous tree at this site (34.6% relative density), was second in relative dominance at 19.1%. *Quercus alba* and *Pinus taeda* followed, both with relative dominance of 11.6%. No other species had a relative dominance value higher than 4.5.

Descriptive statistics for abundance, quadrat occurrence, dbh, and bootstrap 95% confidence intervals for importance values for the ten most dominant species in the 2001 survey

Table 1. Ecological dominance measured by importance values for the 2001 survey. Sixteen quadrats of 10 m. × 10 m. each in the Duke Forest. Cumulative values for relative density (proportion of total trees), relative frequency (proportion of total points of occurrence), relative dominance (proportion of total basal area) and importance value (sum of the previous three measures × 100) are given in parentheses.

Species	Relative Density	Relative Frequency	Relative Dominance	Importance Value
1. *Pinus echinata*	0.1538 (0.154)	0.1667 (0.167)	0.4585 (0.459)	77.90 (77.90)
2. *Acer rubrum*	0.3462 (0.500)	0.2407 (0.407)	0.1905 (0.649)	77.74 (155.64)
3. *Quercus alba*	0.1410 (0.641)	0.1667 (0.574)	0.1161 (0.765)	42.38 (198.02)
4. *Pinus taeda*	0.0256 (0.667)	0.0370 (0.611)	0.1158 (0.881)	17.85 (215.87)
5. *Fagus grandifolia*	0.0641 (0.731)	0.0741 (0.685)	0.0086 (0.890)	14.68 (230.55)
6. *Quercus rubra*	0.0513 (0.782)	0.0370 (0.722)	0.0448 (0.934)	13.31 (243.86)
7. *Liriodendron tulipifera*	0.0385 (0.821)	0.0556 (0.778)	0.0372 (0.971)	13.12 (256.97)
8. *Oxydendron arboreum*	0.0513 (0.872)	0.0556 (0.833)	0.0101 (0.982)	11.69 (268.67)
9. *Carya glabra*	0.0513 (0.923)	0.0556 (0.889)	0.0060 (0.987)	11.28 (279.95)
10. *Liquidambar styraciflua*	0.0256 (0.949)	0.0370 (0.926)	0.0024 (0.990)	6.51 (286.45)
11. *Quercus falcata*	0.0128 (0.962)	0.0185 (0.944)	0.0048 (0.995)	3.62 (290.07)
12. *Quercus velutina*	0.0128 (0.974)	0.0185 (0.963)	0.0027 (0.997)	3.41 (293.48)
13. *Cornus florida*	0.0128 (0.987)	0.0185 (0.981)	0.0019 (0.999)	3.32 (296.80)
14. *Cercis canadensis*	0.0128 (1.000)	0.0185 (1.000)	0.0007 (1.000)	3.20 (300.00)

Table 2. Descriptive statistics for abundance, quadrat occurrence, dbh and bootstrap 95% confidence intervals for importance values for the top ten species from the 2001 survey. Bootstrap 95% confidence intervals for importance value were realized from 50,000 bootstrap samples of 78 trees taken from the parent sample. Importance value expressed as a sum of percentages, 0 to 300.

Trees		Quadrats (%)	DBH mean (SD)	Importance Value Bootstrap 95% CI
1. *Pinus echinata*	2	9 (56.3)	56.7 (7.6)	46.3 to 106.2
2. *Acer rubrum*	27	13 (81.3)	22.4 (10.3)	59.4 to 106.2
3. *Quercus alba*	11	9 (56.3)	22.6 (20.7)	20.3 to 65.7
4. *Pinus taeda*	2	2 (12.5)	69.9 (12.6)	0 to 38.9
5. *Fagus grandifolia*	5	4 (25.0)	11.2 (5.3)	4.2 to 24.1
6. *Quercus rubra*	4	2 (12.5)	27.9 (15.4)	3.9 to 26.2
7. *Liriodendron tulipifera*	3	3 (18.8)	26.2 (23.6)	0 to 26.2
8. *Oxydendron arboreum*	4	3 (18.8)	14.0 (5.3)	3.9 to 20.4
9. *Carya glabra*	4	3 (18.8)	10.8 (3.8)	3.8 to 19.4
10. *Liquidambar styraciflua*	2	2 (12.5)	10.2 (0)	0 to 12.4

are listed in Table 2. The overlap in importance value confidence intervals leads to the prediction that *Pinus echinata* has a dominance ranking of at least third among species across the larger Duke Forest (Table 2). Mean dbh for *P. echinata* (56.7 cm.) was significantly different ($P < 0.05$, Dunnett's test) from all taxa except when compared with *Acer rubrum* (22.4 cm) and *Pinus taeda* (69.9 cm.).

The association between *Pinus echinata* and *Acer rubrum* was positive with both species occurring together in 57.1% of quadrats in which either occurred, with a 95% confidence interval of 30.8 to 83.3 (Table 3). There was a positive spatial relationship between *P. echinata* and *Quercus alba*, a mature forest associate. There was a negative spatial relationship between *Q. alba* and the more moisture-tolerant *A. rubrum*.

Table 4 presents tree density per hectare in six stands of *Pinus echinata* aged 21 through 170 years and documents successional change in tree density from seral dominance in early post agricultural abandonment by *Pinus echinata* to hardwoods (Figure 2). Data in the 170-year-old stands are from the present study while density data from the other five stands, ranging in age from 21 to 110 years, are from Billings (1936). *P. echinata* comprised 99% of trees in the 21-year-old stand, 90% in the 31-year-old stand, 27% in the 56-year-old-stand, 13.7% in the 83-year-old stand, 6.3% in the 110-year-old stand, and 15.4% in the 170-year-

Table 3. Jaccard similarity coefficients among the top three ecologically dominant species across the 16 quadrats of the 2001 study. Confidence intervals for Jaccard similarity achieved by obtaining 50,000 bootstrap samples of the quadrats. Phi coefficients measure whether quadrat association between species is positive or negative.

	Jaccard Coefficient	Bootstrap 95% confidence interval	Phi Coefficient
Pinus echinata vs. *Acer rubrum*	0.571	0.308 to 0.833	+0.222
Pinus echinata vs. *Quercus alba*	0.500	0.214 to 0.778	+0.238
Acer rubrum vs. *Quercus alba*	0.375	0.125 to 0.625	–0.424

Table 4. Density, expressed as trees per hectare, found in six stands of *Pinus echinata* ranging in age from 21 to 170 years. Data in stands ranging from 21 to 110 years, transposed from Billings (1936); the 170-year-old stand from the present study.

	Stand Age (years)					
	21	**31**	**56**	**83**	**110**	**173**
Pinus echinata	3054	1265	623	346	148	80
Pinus taeda	158	79	10			13
Juniperus virginiana		10	395	465	148	
Liriodendron tulipifera	49	40	99	89	198	19
Oxydendron arboreum		10	188	148	89	25
Cornus florida			702	810	771	6
Quercus spp.			59	376	405	113
Liquidambar styraciflua			128	158	99	13
Acer rubrum			79	49	336	156
Carya spp.			30	20	90	25
Ulmus spp.			10	40	20	
Nyssa sylvatica			20	10	20	
Cercis canadensis				10		6
Fagus grandifolia						31
Total Trees per ha.	3261	1414	2738	2986	2482	500

old stand (Table 4). The difference in frequency of *P. echinata* between the 110-year-old and 170-year-old stand is probably explained by the decline of *Cornus florida* due to Dogwood anthracnose (*Discula distructiva*) (Little 1995; Daughtry 1998) and significant declines in numbers of oak and other tree species due to natural thinning as the forest matured into a community with fewer but larger (dbh) trees. With the exception of *Fagus*, which appeared for the first time in the 170-year-old stand, all other species are lower in density in the 110-year-old stand, relative to the 170-year-old stand.

Cornus florida shows a significant decline in numbers from 1936 through the present, in the 170-year-old stand, ranging from 7.8 trees per quadrat in 1936 (Billings 1936) to 0.06 trees in 2001. *Juniperus virginiana*, an early successional species, attained a density of 1.5 trees per quadrat and a frequency of 90% in the 110-year-old stand of *Pinus echinata* sampled by Billings (1936) but was absent in 2001.

Although *Pinus echinata* grows best on deep, well-drained soils on floodplains, it is more abundant than *Pinus taeda* on drier, less fertile soils in the Piedmont (Lawson 1990; Maple and Mesavage 1958). *P. echinata's* larger root system (Billings 1936) and lower demand for nutrients enables it to out compete *P. taeda* where the two species occur on less fertile soils. *P. echinata* has maintained its dominance at the Duke Forest for a longer period than in stands elsewhere in the Piedmont of North Carolina. The long dominance of *P. echinata* at this site may be explained by 1) its presence in a forest protected from selective cutting; 2) the decline of hardwoods by natural thinning (Table 4); 3) the decline of dogwood by disease, and 4) the longevity of *P. echinata*, as documented by tree-ring analysis (Mattoon 1915; Lawson 1990). The overall successional trend of conifers as a group being displaced over time by hardwoods is clear (Fig. 2). However, in the 170-year-old forest, *Pinus echinata*, with the highest importance value, remained the most ecologically dominant species.

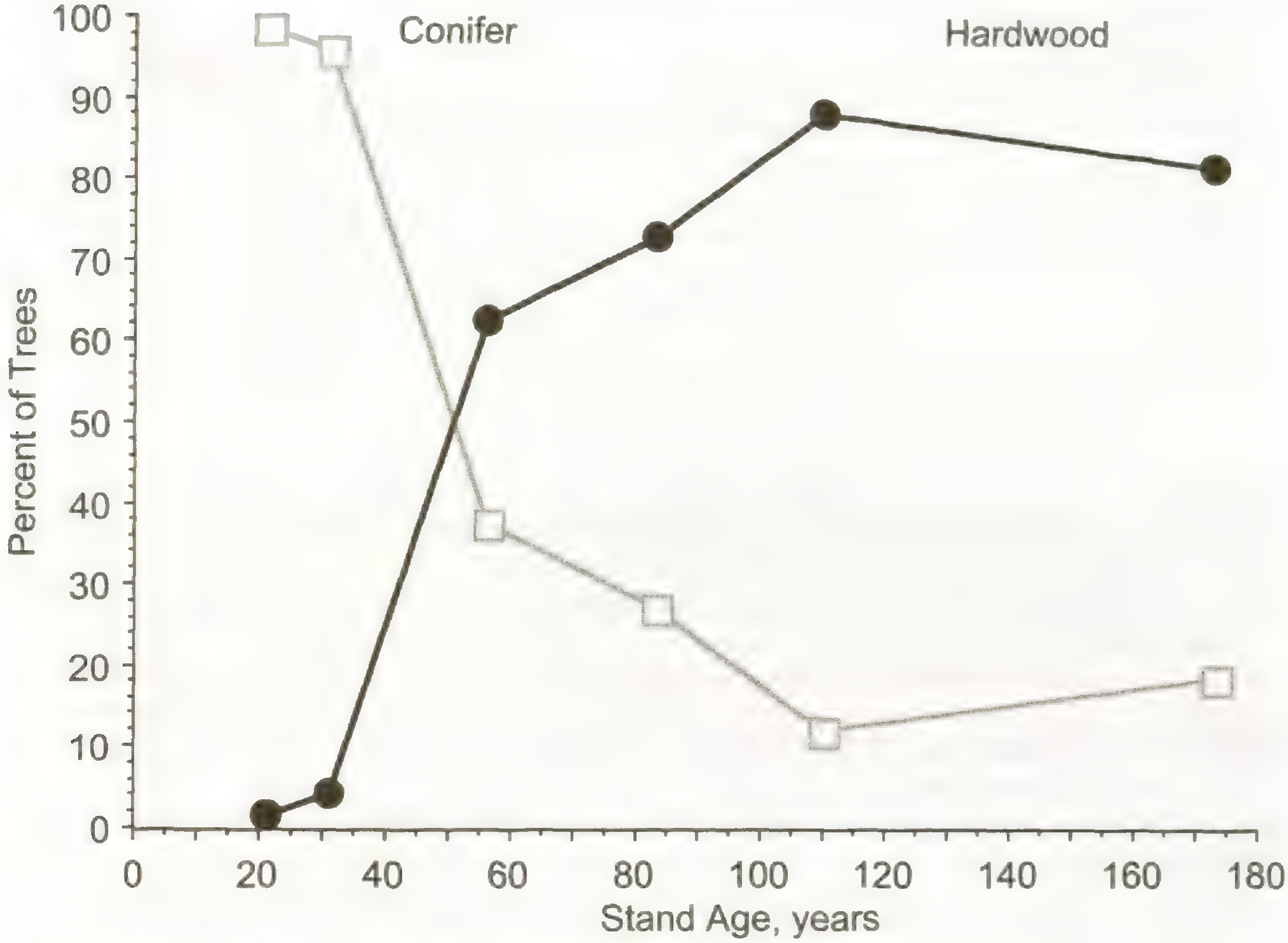

Figure 2. Percent of conifers and hardwoods in six stands aged 21 to 170 years on the Piedmont of North Carolina.

Acknowledgments

We greatly appreciate the assistance of Judson Edeburn, Dan Ritcher and Wendy Weihr, Duke University, Forest Resource Center, Nicholas School of the Environment for access to the site, sharing the location of Billings' 110-year-old stand of *Pinus echinata*, providing location maps for stands of pines and hardwoods of various ages, information on soil associations, and providing data on the ages of *P. echinata*. We thank Cheryl-Ann Beharry and Olga Konykhov for their assistance with this project. Henry Oosting is appreciated for providing Stalter in 1968 with the age of the *P. taeda* stand in northeastern North Carolina. We acknowledge the anonymous reviewers and Editor Roger Latham, whose comments greatly improved this manuscript.

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Bartonia No. 64: 45-54, 2009

The Historic Bartram's (Carr's) Garden Collection in West Chester University's William Darlington Herbarium (DWC)

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ABSTRACT. An overview is provided on the specimens collected by John Bartram in the wild and those collected at Bartram's (Carr's) Garden. In this study, material collected from Bartram's Garden (mostly from the 1820s and 1830s) and housed at the William Darlington Herbarium (DWC) at West Chester University was examined. Only 55 specimens cite a collector, 48 of these indicate John Bartam Carr as collector. Of the 176 specimens (on 123 herbarium sheets) examined, 118-128 were determined to have been collected from Bartram's Garden, the exact number being uncertain due to vague or inconsistent labeling. All but one of the 176 specimens was able to be identified to species, with 96-102 species (in 52 families and 83 or 84 genera) definitively being collected from Bartram's Gardens. A table is provided of all species that were identified with selected synonymy. Further discussions on the nomenclature and taxonomy of some of the more problematic specimens are also provided. The material from DWC examined in this study represents the largest known herbarium collection from Bartram's Garden, documenting a number of species that occurred on the grounds during the Carr era. These specimens may also provide further insights into the interests and activities of John Bartram and the Carrs.

INTRODUCTION

John Bartram (1699-1777) was one of the most important botanists of eighteenth century America (Harshberger 1899; Faris 1932; Cruickshank 1957; Pennsylvania Horticultural Society 1976; Berkeley and Berkeley 1982, 1992; McLean 1992). He collected plant specimens from a wide range of habitats throughout eastern colonial America (Schuyler and Newbold 1987) and, in 1731, established, in Philadelphia, one of America's first botanical gardens (Harshberger 1899; Earnest 1940; Leighton 1976; Overlease 1992).

John Bartram lived in an era of active botanical exploration. Through his contacts with Europeans, including Peter Collinson and Lord Petrie (Berkeley and Berkeley 1982), John Bartram may have been responsible for as many as 200 of the 320 new American species introduced into eighteenth century English gardens (Barnhardt 1931). The exact number of specimens to be credited to John Bartram is unclear because his correspondents did not always give credit to the collectors (McLean 1992).

Most of the specimens that John Bartram collected were from the wild (A. E. Schuyler pers. comm.) and are deposited primarily in five herbaria: Sloane's (BM-SL) in the British Natural History Museum (BM), Dillenius' and Sherard's at the University of Oxford

Manuscript submitted 3 July 2007; revised 21 November 2008.

(OXF), Petrie's in the Sutro Library in San Francisco, and the Muséum National d'Histoire Naturelle (P) in Paris (Berkeley and Berkeley 1982). Recent studies of specimens collected by John Bartram include, Buck and McLean's examination of mosses (1985, Petrie Herbarium), Schuyler and Newbold's examination of vascular plants (1987, Petrie Herbarium), and Manville's examination of mosses (1987, Sloane Herbarium).

The largest known collection of herbarium specimens from Bartram's Garden is housed in the William Darlington Herbarium (DWC) at West Chester University in West Chester, Pennsylvania. This collection was reported to contain 118 specimens collected from 1818-1861 (Overlease 1992). The herbarium at the Academy of Natural Sciences of Philadelphia (PH) also contains specimens from Bartram's Garden, including those in the herbarium of Benjamin Smith Barton.

The Bartram's Garden specimens now at DWC were originally sent to the Chester County Cabinet of Natural Sciences, a scientific collection managed until 1850 by Dr. William Darlington and other Chesterians (Gordon 1943; Lansing 1986; Overlease 1992; Fry 1994). DWC, the second oldest institutional herbarium in the U.S. (PH is the oldest; Holmgren et al. 1990), has housed this collection since 1850.

The majority of the specimens from Bartram's Garden at DWC were collected during the 1820s and 1830s when the garden was owned and managed as a commercial nursery by Robert Carr and his wife, Ann Bartram Carr, the granddaughter of John Bartram. Ann Carr was trained in botany by John Bartram's brother, her uncle, William Bartram, and she was regarded as a highly competent botanist (Gordon 1837; Fry 1994). John Bartram Carr, a young botanist and the son of Robert Carr by his first marriage (Fry 1994) prepared many of the Bartram's Garden specimens at DWC (Overlease 1992).

While little is known about the operation of the garden under the Carrs (McLean 1984; Fry 1994), it is clear that during the Carr Period, the Garden existed as a major horticultural establishment (Harshberger 1899; McLean 1984; Fry 1994). Beginning in 1783 the Carrs published several catalogs. In the 1832 catalog, the Carrs' foreman, Wynne, described the garden as having over 2000 native plants in addition to a fruit orchard and vineyard. Other reports of the period list ten greenhouses on the grounds and over 10,000 potted plants (Fry 1996).

In 1891, through the efforts of Thomas Meehan and others, Bartram's Garden was preserved as part of the Philadelphia Park System (Harshberger 1899; Berkeley and Berkeley 1982; McLean 1992). Since then, various restoration projects have taken place, mostly since 1923, when the Fairmount Park Commission took responsibility for the site (Baxter 1931; Cheston 1938). The recent restoration effort has been led by Martha Leigh Wolf, executive director of Bartram's Garden until 2001, and Joel Fry, its historical curator. Fry (1996) has updated the nomenclature of plants listed in the 1783 catalog of Bartram's Garden plants for sale, when the Garden was run by John Bartram's son, John Bartram Jr.

Methods

We examined the Bartram's Garden (Carr's Garden) collection at DWC to describe the collection and to report a list of specimens. Specimen identifications were verified and made where appropriate and the nomenclature was updated. In cases where multiple specimens were mounted on a single herbarium sheet, all specimens were examined, regardless of whether their source was Bartram's Garden. Such a list of Bartram's Garden specimens at

DWC will inform current and future efforts to accurately restore and reintroduce species grown during the historic Bartram and Carr period (about 1730-1850).

The specimens were identified using primarily horticultural manuals and encyclopedias (e.g., Sargent 1890-1902, 1905; Bailey 1937, 1949; Bailey et al. 1976; Rehder 1940; Graf 1963; Taylor 1965; Dirr 1975, 1977, 1990, 1998; Krüssmann 1984-1986; Huxley 1992; Griffiths 1994; Brickell and Zuk 1997); geographical floras and manuals (e.g., Small 1933; Fernald 1950; Tutin et al.1964-1980, 1993; Ohwi 1963; Davis et al. 1965-1988; Radford et al. 1968; Zohary and Feinbrun-Dothan 1968-1980; Correll et al. 1970; Strausbaugh and Core 1978; Wiggins 1980; Great Plains Flora Association 1986; Gleason and Cronquist 1991); wildflower guides (e.g., Rickett et al. 1966-1973; Peterson and McKenney 1968; Newcomb 1976); and, when available, living material from the Henry Foundation for Botanical Research (Gladwyne, Pennsylvania), Historical Bartram's Garden (Philadelphia,), Longwood Gardens (Kennett Square, Pennsylvania), Morris Arboretum (Philadelphia), Scott Arboretum at Swarthmore University (Swarthmore, Pennsylvania), Tyler Arboretum (Media, Pennsylvania), University of Delaware Botanical Gardens (Newark, Delaware) and Winterthur Museum (Winterthur, Delaware). Comparisons were also made with herbarium specimens from DWC and PH. (Herbarium specimens from the historic John Bartram collection at BM are not available for loan.) Historical resources were also used including some of the Bartram's Garden catalogs (the Bartram 1783 catalog as updated by Fry in1996 and the Carr 1828 catalog) as well as other botanical literature of and about the period (e.g., Curtis' *Botanical Magazine* from 1787-1801; Edwards' *Botanical Register* from 1815-1833; Bartram 1791; Meehan 1853; Ewan 1957; McLean 1984).

The primary source for nomenclatural changes was Rhoads and Klein (1993). For plants not included in Rhoads and Klein (1993, ~40% of the total), the current name was determined based on other nomenclatural and taxonomic resources (e.g., Kartesz 1994, Missouri Botanical Garden's web searchable database, Tropicos <www.tropicos.org>).

Results

From the 123 herbarium sheets, 176 specimens were identified, with 118-128 collected from Bartram's Garden. The exact number of specimens from Bartram's Garden could not be determined due to collector and labeling inconsistencies (Schneider 2000). John Bartram Carr was cited (either as "J. B. Carr" or "B. Carr") on 48 of the 55 specimens that listed a collector. While Overlease (1992) identified John Bartram Carr as the collector of 63 specimens at DWC, his total also included non-Bartram's Garden specimens.

In this collection, 106 species (in 52 families and 84 genera) were identified with the Bartram's Garden specimens representing between 96 and 102 species (52 families, 83 or 84 genera) (Table 1). Of these, 102 Bartram's Garden specimens were representative of a contemporary eastern flora (57% native, 27% introduced), with a good percentage found in contemporary Pennsylvania (31% native; 27% introduced) (Table 1). Forty-three percent of the total species and 72% of the tree and shrub species are listed in the 48 page Carr 1828 catalog, with 30% of the tree and shrub species and 13% of the total species listed in the Bartram 1783 catalog (one-page, mostly woody, Fry 1996), published six years after John Bartram's death (Table 1). An additional ten species not listed in the Carr 1828 catalog were listed in the Carr 1836 catalog (Schneider 2000).

Of the 176 specimens studied, 133 were correctly identified, 24 were misidentified, and 19, representing species mostly non-native to North America, were originally unidentified.

Table 1. Herbarium specimens constituting the Bartram's Garden Collection in the William Darlington Herbarium (DWC) (A more detailed listing is available in Schneider 2000.)

Aceraceae
Acer spicatum Lam.
Adiantaceae
Cheilanthes concolor (Langsd. & Fisch.) R.M.Tryon & A.Tryon[1]
[*Dryopteris concolor* (Langsd. & Fisch.) Kuhn][2]
Cheilanthes viridis (Forssk.) Sw.
[*Pellaea viridis* (Forssk.) Prantl][2]
Apocynaceae
Amsonia tabernaemontana Walter
[*A. salicifolia* Pursh]
[*A. latifolia* Michx.]
Vinca minor L.
Aristocholaceae
Asarum canadense L.
Asclepiadaceae
Matelea obliqua (Jacq.) Woodson
[*Gonolobus obliquus* Jacq.]
Vincetoxicum hirundinaria Medik.
[*V. officinale* Moench.]
[*Cynanchum vincetoxium* (L.) Pers.][2]
Asteraceae
Achillea filipendulina All.
Coreopsis tripteris L.
Dahlia pinnata Cav.
[*Dahlia varabilis* (Willd.) Desf.]
[*Dahlia rosea* Cav.]
Euthamia graminifolia (L.) Nutt.
[*Solidago graminifolia* L.][2]
Gaillardia pulchella Foug.
[*G. drummondi* (Hook.) DC.]
[*G. picta* D.Don]
[*G. pulchella* var. *picta* (Sweet) A.Gray]
Galinsoga parviflora Cav.
Galinsoga quadriadiata Ruiz & Pavon
[*Galinsoga ciliata* (Raf.) Blake]
Parthenium integrifolium L.
Petasites hybridus (L.) Gaertn. Mey. & Scherb.
[*Tussiago petasites* L.]
Solidago stricta Nutt.
Sonchus congestus Will
[*S. jacquinii* DC.]
Tanacetum parthenifolium (Willd.) Sch. Bip.
[*Chrysanthemum parthenifolium* Pers.][2]
Brassicaceae (Cruciferae)
Arabidopsis thalliana (L.) Heynh.
[*Arabis thalliana* L.]
Caesalpinaceae
Cercis canadensis L.
Chaemaecrista fasciculata (Michx.) Greene
[*Cassia chamaecrista* L.]
[*Cassia fasciculata* Michx.][2]
Caprifoliaceae
Viburnum obovatum Walter[3]
Viburnum trilobum Marsh.
[*V. opulus* Ait. var. *americanum*][2]
Caryophyllaceae
Vaccaria hispanica (Mill.) Rausch.[3]
[*V. pyramidata* Medik.][2]
[*V. segetalis* (Neck.) Garcke ex Asch.]
[*Saponaria vaccaria* L.]
Silene antirhinna L.[3]
Silene vulgaris (Moench.) Garcke
Celastraceae
Eunoymus atropurpureus Jacq.
Clethraceae
Clethra acuminata Michx.
Clusiaceae (Guttiferae)
Hypericum crux-andreae (L.) Crantz
[*H. stans* P.Adams & N.Robson] [2]
[*Ascyrum stans* Michx.]
Hypericum hypericoides ssp. *multicaule* (Michx. ex Willd.) N.Robson[3]
[*H. stragulum* P.Adams & N.Robson] [2]
[*Ascyrum multicaule* Michx. ex Willd.]
Convolvulaceae
Ipomoea hederacea Jacq.
[*Convolvulus hederacea* L.]
I. macrorhiza Michx.
[*Convolvulus macrorhizos* L.]
Cornaceae
Cornus mas L.
Cyrillaceae
Cliftonia monophylla (Lam.) Britt. ex Sarg.
[*C. ligustrina* Sims ex Spreng.]
[*Mylocarium ligustrinum* Willd.]
Ericaceae
Oxydendrum arboreum (L.) DC.
Rhododendron carolinianum Rehd. or
R. minus Michx.
[*R. punctatum* Andr.]
Euphorbiaceae
Chaemaecyse maculata (L.) Small
[*Euphorbia maculata* L.][2]
Euphorbia helioscopia L.[3]
Euphorbia marginata Pursh
Fabaceae
Amorpha fruticosa L.
Chamaecytisus supinus (L.) Link
[*Cytisus supinus* L.][2]
Colutea arborescens L.
Coronilla valentina ssp. *glauca* (L.) Batt.
[*C. glauca* L.][2]
Lathyrus niger (L.) Bernh.
[*Orobus niger* L.]

Table 1. (*cont'd*)

Fagaceae
Quercus laurifolia Michx.
Quercus lyrata Walter
Quercus macrocarpa Michx.
Quercus robur L.
[*Quercus pedunculata* Ehrh.]
Fumariaceae
Dicentra eximia Walp.
Geraniaceae
Erodium cicutarium (L.) L'Herit. ex Sol.
Geranium sanguineum L.
Hamamaelidaceae
Fothergilla gardenii L.
[*Fothergilla alnifolia* L.f., nomen illeg., superfluous when published]
Hydrophillaceae
Nemophila phacelioides Nutt. ex Bart.
Iridaceae
Iris cristata Soland.[3]
Iris verna L.
Lamiaceae
Lamium maculatum L.
Monarda didyma L.
[*M. coccinea* Michx.]
[*M. kalmiana* Pursh]
Monarda fistulosa L.
[*M. allophyla* Willd.]
[*M. oblongata* Ait.]
Monarda russeliana Nutt. ex Sims
[*M. bradburiana* Beck][2]
Monarda virgata Raf.[3]
[*M. russeliana* Nutt.][2]
Salvia splendens Sell. ex Roemer & J. A. Schultes
Liliaceae
Helonias bullata L.
[*H. latifolius* Michx.]
Trillium grandiflorum (Michx.) Salisb.
Loganiaceae
Spigelia marilandica L.
Magnoliaceae
Magnolia fraseri Walter
[*M. auriculata* Desr.]
Magnolia macrophylla Michx.
Magnolia tripetala L.
[*M. umbrella* Desr.]
Malvaceae
Sida hermaphrodita L.[3]
[*S. napaea* Cav.]
Meliaceae
Melia azedarach L.
Menispermaceae
Cocculus carolinus (L.) DC.
Mimoceaceae
Albizzia julibrisson (Willd.) Durazz.
[*Acacia julibrisson* Willd.]
Oleaceae
Osmanthus americanus (L.) A.Gray
[*Olea americana* L.]
Papaveraceae
Chelidonium majus L.
Plumbaginaceae
Armeria maritima (Mill.) Willd.
(*Statice maritima* Mill.)
Polemoniaceae
Phlox carolina var. *triflora* (Michx.) Wherry
[*P. glaberrima* ssp. *triflora* (Michx.) Wherry][2]
Phlox divaricata L.
Phlox stolonifera Sims.
[*Phlox reptans* Michx.]
Primulaceae
Dodecatheon meadia L.[3]
Ranunculaceae
Xanthoriza simplicissima Marsh.
[*Xanthoriza apiifolia* L'Herit.]
Rhamnaceae
Rhamnus alaternus L.
Rosaceae
Filipendula ulmaria (L.) Maxim.
[*Spiraea ulmaria* L.]
Rosa setigera Michx.
[*R. rubifolia* R. Br.]
Rubiaceae
Bouvardia ternifolia (Cav.) Schlect.
[*B. tryphylla* Salisb.]
[*Houstonia coccinea* Andr.]
Hedyotis canadensis (Willd.) Fosberg
[*Houstonia canadensis* Willd.][2]
[*Houstonia ciliolata* Torr.]
[*Hedyotis purpurea* var. *ciliolata* (Torr. ex Spreng.) Fosberg][2]
Saxifragaceae
Tiarella cordifolia L.
Scrophulariaceae
Alonsoa incisifolia Ruiz & Pavon
Veronica persica Poir.
[*V. buxbaumii* Tenore]
[*V. tournefortii* C.C. Gmel.][2]
Veronica polita Fries[3]
[*V. didyma* Tenore]
Solanaceae
Nicotiana longiflora Cav.
Petunia ×hybrida Vilm.
[*P. axillaris* BSP][2]
[*P. integrifolia* (Hook.) Schinz. & Thell.]
[*P. nyctaginiflora* Juss.]
[*P. violacea* Lindl.]

Table 1. (*cont'd*)

Styracaceae	**Thymelaeaceae**
Halesia carolina L.	*Dirca palustris* L.
[*H. tetraptera* Ell.][2]	**Verbenaceae**
Halesia diptera Ell.	*Lantana camara* L.
Styrax americanus Lam.	*Vitex agnus-castus* L.
Styrax grandifolius Ait.	*Vitex negundo* var. *heterophylla* (Franch.) Rehd.
Tamaricaceae	[*V. incisa* Lam.][2]
Tamarix gallica L.	**Violaceae**
Theaceae	*Viola sagittata* Ait.
Franklinia alatamaha Bartr. ex Marsh.	[*V. fimbriatula* Sm.]
[*Gordonia pubescens* L'Herit.]	[*V. emarginata* (Nutt.) LeConte]
Stewartia malachodendon L.	**Xyridaceae**
[*S. virginica* Cav.]	*Xyris torta* Sm.

[1]The *Cheilanthes concolor* specimen may have been originally misidentified and the *Ipomoea macrorhiza* and *Dicentra eximia* were determined to be misidentified. The original names indicated on the labels of these specimens were listed in the 1828 (or 1830 additions) catalog.

[2]Synonym is used as the current name by at least one technical (1976 or later) source (Bailey 1976; Krüssmann 1984-1986; Gleason and Cronquist 1991; Rhoads and Klein 1993; Griffiths 1994; Kartesz 1994).

[3]For *Dodecatheon meadia, Iris cristata, Sida hermaphrodita, Veronica polita* and *Viburnum obovatum*, it could not be determined whether they were from Bartram's Garden or from another location. *Silene antirhinna* and *Vaccarica hispanica* were mounted on the same herbarium sheet and one but not both is from Bartram's Garden. *Euphorbia helioscopia, Hypericum hypericoides* subsp. *multicaule*, and *Monarda virgata* specimens were probably not collected from Bartram's Garden, but were mounted on the same sheet as a Bartram's Garden specimens.

These 19 were identified in this study. Of those specimens correctly identified, 72 currently have different accepted names due to changes in classifications and nomenclatural rules (Schneider 2000).

The original identifications were remarkably accurate, reflecting the extensive botanical knowledge of the collectors including John Bartram Carr and William Darlington. Despite the original accuracy of most of the identifications, specimens lacking key characteristics, being faded, or otherwise in general poor condition contributed to the difficulty of verifying some original identifications (Schneider 2000). Fifteen specimens lacked the parts needed to properly identify to species or were so similar to a closely related species that proper identification may require verification by a specialist of the group (Schneider 2000).

Twenty-one species from the Bartram's Garden collection at DWC go by different names when technical sources published in 1976 or later (Bailey et al. 1976; Krüssmann 1984-1986; Gleason and Cronquist 1991; Rhoads and Klein 1993; Griffiths 1994; Kartesz 1994) are compared.

Of the 176 specimens, 175 were identified to species. One *Rhododendron* specimen could not be identified to species, it being either *Rhododendron carolinianum* Rehd. or *R. minus* Michx., although some taxonomists (e.g., Duncan and Pullen 1962; Davidian 1982) do not recognize *R. carolinianum,* treating it as a synonym of *R. minus.*

Two specimens of *Galinsoga quadriradiata* Ruiz. & Pav. (*Adventina ciliata* Raf.), although poorly pressed, and a specimen of *G. parviflora* Cav. (*Adventina parviflora* Raf.), are potential original material, from which lectotypes could be designated, for the heterotypic synonyms of Rafinesque's. Rafinesque described and named these two *Adventina* species based on Bartram's Garden specimens he saw during the Carr era (Rafinesque 1836).

Rafinesque (1836) on his new genus, *Adventina*, and its species: "Named after its adventitious production in Philadelphia . . . Messrs. Carr . . . of Bartram's garden cannot account for the spontaneous production of these plants and several others in their garden." Based on Rafinesque's (1836) writings on *Adventina* and *A. parviflora*, it is quite clear that he was unaware of the genus name *Galinsoga* Ruiz. & Pav. and species name *G. parviflora* Cav.; therefore the use of the epithet *"parviflora"* in his *A. parviflora* was coincidental (see Blake 1922) and not based on the earlier *G. parvilfora* Cav.

Discussion

The Bartram's Garden collection at DWC documents a significant number of specimens existing in the Carr era and represents the largest known collection of historically important Bartram's Garden specimens. Other existing studies of the historic Bartram's Garden record are based on the 1783 Bartram broadside plant sale catalog including Leighton's (1976) listing of the original names and Fry's nomenclatural update of the names (Fry 1996). The sale catalogs are presently the best source of records on the specimens growing in the historical Bartram's Garden (Fry 1996) because there is no known complete inventory of species and/or their location within the garden. These catalogs reflect species of commercial horticultural interest during that era and likely did not include species naturalized to the site. For example, in the 20 pages of the 48-page 1828 catalog devoted to greenhouse plants, only seven specimens are represented in the collection reported here. The Bartram's Garden collection at DWC most likely represents the native or naturalized species growing on the five acre area that was the main focus of John Bartram's Garden. Indeed, one species in the collection, *Galinsoga quadriradiata* (*Adventina ciliata* Raf.), was cited by Rafinesque (1836) as growing in the orchard.

Published observations of the composition of gardens from the Carr era overlap little with the species reported in this study (Carr 1831; Gordon 1837; McLean 1984). At most, only 20% of the Bartram's Garden collection at DWC is reflected in the following sources: the 1783 1-page catalog of mostly woody specimens (Fry 1996), the Bartram vascular herbarium specimens, collected in 1742 or earlier, in the Petrie herbarium (Schuyler and Newbold 1987), and an index of species listed in the John Bartram letters published in Darlington's 1849 *Memorials* (Ewan 1969). A comprehensive consideration of all of the known herbarium specimens from the garden as well as the written records from catalogs, letters, diaries, etc. might result in a more complete list of plants from Bartram's Garden during the historical Carr and Bartram eras. Even the historical documentation may not list all of the species that J. Bartram grew and some species may be listed only by an ambiguous common name or a dubious Latin name. Many important botanical books that dealt with the eastern American flora were published in the 25 year period after J. Bartram's death (e.g., Aiton 1789, Marshall 1785, Bartram 1791, Michaux 1803). Some of the species that were first described by these authors were collected by J. Bartram many years before and the specimens are now located in the Petrie Herbarium (McLean 1992).

In addition to further documenting the historical horticultural importance of Bartram's Garden during the Carr era (Harshberger 1899; McLean 1984; Fry 1994), the Bartram's Garden specimens at DWC may also provide insight into the interests and activities of John Bartram.

Acknowledgments

This research was supported by West Chester University and a grant to MAP from the National Science Foundation (BSR-8803181). At the time of this study, MAP was a faculty member and curator of DWC and WMS was a Master's student in biology at West Chester University. Special thanks are extended to Dr. A. E. Schuyler, Martha Leigh Wolf, Joel Fry, Dr. G. W. Fairchild, Dr. S. Began, and Dr. J. La Duke. Their help on this project was certainly appreciated.

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Bartonia No. 64: 55-76, 2009

2005-2006 FIELD TRIPS

Reports reviewed, formatted, and edited by TED GORDON.

2005 Field Trips

22-24 April: Beginner Bryophyte Weekend, Delaware Water Gap National Recreation Area, Pike and Monroe Counties, Pennsylvania.

This trip and workshop was based at the Pocono Environmental Education Center (PEEC). A small group of beginner bryologists visited various habitats around PEEC to learn some of the common mosses and liverworts of the area. Some of the species observed were *Polytrichum commune, P. ohioense, P. virginianum, P. piliferum, Atrichum angustatum, Leucobryum glaucum, Dicranum scoparium, D. flagellare, Hedwigia ciliata, Aulacomnium palustre, Bartramia pomiformis, Dicranella heteromalla, Ceratodon purpureus, Plagiomnium cuspidatum, P. affine, Bryum argenteum, Thelia hirtella, T. lescurii, Anomodon attentuatus, A. rostratus, Thuidium recognitum, Climacium americanum, Bryoandersonia illecebra, Platygerium repens, Hypnum imponens,* and *Pleurozium schreberi.*

Attendance: 7. Report by leader: **Bill Olson.**

23 April: Mexico, Juanita County, Pennsylvania. Joint trip with the Central Pennsylvania Conservancy to one of their properties. Leader: Todd Sampsell. No report received.

30 April: Knights Island Preserve, Cecil County, Maryland. Joint trip with the Delaware Native Plant Society.

A North American Land Trust easement property, Knights Island Preserve is actually a long, narrow peninsula that juts out into Chesapeake Bay north of the Sassafras River. Walking swiftly in the rain, we traveled down the access road along the spine of the peninsula to our first stop, the narrow wooded "neck" of the property. There we descended a boat dock access road, examining on the way the lush spring ephemeral flora growing on the steep road bank, including a huge population of violet wood-sorrel (*Oxalis violacea*) in bloom.

After examining a small pocket of swamp by the dock, we retraced our steps and continued down the main road, stopping from time to time to point out notable species. Due to the hot spring most of the spring wildflowers were past their prime, but spring-beauty (*Claytonia virginica*), cut-leaved toothworth (*Cardamine concatenata*), Dutchman's-breeches (*Dicentra cucullaria*), and yellow and blue violets (*Viola* spp.) still formed large carpets of green. Many of the trees lining the road were black locust (*Robinia pseudoacacia*) and honey locust (*Gleditsia triacanthos*), originally planted when the property was a hunting preserve and now well-established, along with numerous pears (*Pyrus communis*). The steeper and drier slopes were home to many mighty oaks, including white, black, red, southern red, and especially chestnut oak. Amongst them were several large chinquapin oaks (*Quercus muhlenbergii*), an extremely uncommon tree on the Eastern Shore, and a few redbuds (*Cercis canadensis*).

After walking to and along the sandy tip of the peninsula and discussing the effects of last year's Hurricane Floyd on both the property and its flora (many trees on the numerous steep slopes were lost), we visited the south side shoreline to see how a population of a Maryland rarity, sandbar willow (*Salix exigua*), had fared. Much to our dismay, the willow was almost completely buried. This plant, however, is adapted to this sort of occurrence, and we discussed the possibility of revisiting the population a few years in the future to see if it has survived.

Persistent drizzle had chased away many participants by noon. The last holdouts made a trip to the northeast quarter of the preserve, where we visited a population of great white trillium (*Trillium grandiflorum*), noting how poorly it had flowered compared to two years prior. We relocated an occurrence of ginseng (*Panax quinquefolius*) and the rare gladefern (*Diplazium pycnocarpon*) at its only known Delmarva population, and found some silvery spleenwort (*Deparia acrostichoides*), another uncommon Delmarva species. Lastly we examined a steep north-facing slope, once home to many large hemlocks, but now open and almost evergreen-free due to woolly adelgids and the recent hurricane. To our surprise, two of the uncommon species known from this slope, woodrush (*Luzula acuminata*) and the sedge *Carex platyphylla*, were now flourishing in the increased light, with many new and large individual plants.

Attendance: 14. Report by leaders: **Jack Holt and Janet Ebert.**

15 May: Xeric Limestone Prairie Remnants at Westfall Ridge and McAlisterville Ridge, Juniata County, Pennsylvania. Joint trip with the Pennsylvania Native Plant Society.

Partially protected by the Nature Conservancy but nonetheless declining and critically imperiled, these are two of less than a dozen small remnants in Pennsylvania of a plant community that was apparently much more widespread in prehistoric times across the Ridge and Valley and Great Valley ecological regions. Among the highlights of the visit were masses of the chrome-yellow flowers of hoary puccoon (*Lithospermum canescens*), set off dramatically by the scarlet and lavender flowers of wild columbine (*Aquilegia canadensis*) and arrow-leaved violet (*Viola sagittata*). Also abundant and flowering in the prairies and adjacent woodlands were wild-coffee (*Triosteum aurantiacum*), round-leaved ragwort (*Senecio obovatus*), and redbud (*Cercis canadensis*). Fragrant sumac (*Rhus aromatica*) was already in fruit. The new leaves of side-oats gramma (*Bouteloua curtipendula*), the dominant species in all of Pennsylvania's xeric limestone prairie remnants and listed as threatened in the state, were just starting to grow, but a few of the previous year's inflorescences were still intact enough to show their unique structure. Other rare species spotted by the group included marbleseed (*Onosmodium molle* var. *hispidissimum*) and southern wild senna (*Senna marilandica*), both listed as endangered in Pennsylvania. Among the trees surrounding the prairie remnants were yellow oak (*Quercus muhlenbergii*) and Table Mountain pine (*Pinus pungens*). A small contingent of die-hards ended the sunny, warm day with exploratory visits to two other sites in Juniata County previously identified as potential limestone prairie remnants.

Attendance: 10. Report by leader: **Roger Latham.**

27-31 May: Catskill Park, Ulster County, New York. Joint Field Meeting of the Northeast Section of the Botanical Society of America, the Torrey Botanical Society, and the Philadelphia Botanical Club.

Participants were housed at SUNY New Paltz Ashokan Field Campus in Shokan. Field trips sites in the heart of the Catskills included a floating bog (visited by canoe); the Escarpment Trail at North-South Lake Public Campground; Maple Crest Bog; Big Valley; Stony Clove Notch; Dry Brook Ridge old growth forest; Slide Mountain; and an old growth cherry grove at the Frost Valley YMCA. Maple Crest Bog in particular yielded several significant species: *Chamadaphne calyculata, Gaultheria hispidula, Kalmia angustifolia, K. polifolia, Vaccinium angustifolium, V. myrtilloides, V. oxycoccos, Carex pauciflora, Corallorhiza trifida, Eriophorum vaginatum* var. *spissum, Sarracenia purpurea, Sphagnum fuscum,* and *S. magellanicum.* At Stony Clove Notch *Clematis occidentalis* and a New York endangered disjunct, *Adoxa moschatellina,* were noted.

Evening programs with the theme "Catskill Botany: Then and Now" included "A Catskill Welcome" by Bill Rudge; "Resources of the Catskills" by Aaron Bennett; "A Visit with John Burroughs" by Jack Maquire; the Catskill Flora Project by Dr. Morton Adams and Steve Parisio; and "Catskill Botany—an Ecological Gardener's Perspective" by Francis Groeters.

Attendance: 55. Leaders: **Morton Adams, Aaron Bennett, Greg Edinger, Frank Knight, Mike Kudish, Rich Parisio, and Steve Parisio.** Report by **Ted Gordon**, as gleaned, modified, and condensed from a trip report titled "Catskill Park" in the *Journal of the Torrey Botanical Society*, Vol. 132, No. 4, Oct.-Dec., 2005, pp. 645-646.

18 June: Savannahs (Savannas) in the Batsto Natural Area, Wharton State Forest, Burlington County, New Jersey.

We met at the Atsion Ranger Station along Route 206 in Shamong Township, consolidated into 4-wheel drive vehicles, and drove 1.8 miles southeast on the old Tuckerton Stage Road (Quaker Bridge Road) to our first stop just beyond a concrete bridge. Here, along the shrubby lower third of a bluff overlooking the Mullica River, a brief, unsuccessful search was conducted for a small patch of the state-endangered dwarf azalea, *Rhododendron atlanticum,* last seen by the leader in the late 1980s. In the adjacent wetland on sphagnous hummocks beneath scattered specimens of *Chamaecyparis thyoides,* we noted in flower *Gaylussacia dumosa, Ilex glabra, Vaccinium macrocarpon, Eriocaulon compressum, Iris prismatica, Panicum lucidum,* and, in fruit, *Carex exilis.*

We next veered south onto the Mullica Campsite trail, pausing to look at a large, active beaver lodge in the middle of an expansive stream meander. Over the past forty years, flooding caused by beaver has expunged several *Narthecium* savannah segments along the Mullica. Equally destructive of these communities has been advanced succession by Atlantic white cedar and shrubs.

A half mile south of The Locks, the remains of an historic dam associated with the bog iron industry, we entered "Below the Locks" savannah, a former bog ore excavation. Over a period of >30 years, the leader has compiled the following list of 15 rare species for this site: *Muhlenbergia torreyana, Panicum scabriusculum, Rhynchospora cephalantha, Scirpus longii, Juncus caesariensis, Solidago stricta, Potamogeton confervoides, Schizaea pusilla, Rhynchospora pallida, Lobelia canbii, Carex barrattii* (a few), *Rhynchospora oligantha* (one patch in flower), *Calamofilva brevipilis* (several clumps), *Asclepias rubra* (one young plant), and *Narthecium americanum* (a few in flower). Only the last five species listed, to which the 2005 parenthetical data apply, were seen on the present site visit. Associate flowering species observed were *Mitchella repens, Viburnum nudum* var. *nudum, Gaylussacia frondosa, Sarracenia purpurea, Pogonia ophioglossoides, Hypericum canadense, H. mutilum, Carex striata* var. *brevis, Danthonia epilis (D. sericea* var. *epilis), Utricularia striata, U. subulata,* with *Lophiola aurea* in bud and *Carex atlantica* ssp. *capillacea* in fruit.

In November 1997, the state Office of Natural Lands Management cut down a number of tall Atlantic white cedar (evidence of which we saw), believing that their shading was responsible for the reduction in flowering of bog asphodel. After seeing several vegetative patches, but only a few flowering stems, of bog asphodel, we concluded that in addition to shading there are other factors (e.g., prolonged periods of inundation or untimely flooding or extended drought periods) responsible for preventing bloom.

Our next stop was the northwest lobe of extensive Long Savannah (another ore excavation) along the west bank of the Batsto River about 2.5 miles north of the village street in Batsto. Common flowering plants observed were several patches of *Calapogon tuberosus, Pogonia ophioglossoides, Utricularia subulata,* and *Eleocharis tuberculosa.* Also noted were *Sabatia difformis, Triadenum virginicum, Lophiola aurea, Drosera intermedia,* and *Cladium mariscoides.* Of special interest were several plants of *Lycopodiella ×copelandii,* a hybrid between *L. alopecuroides* and *L. appressa,* growing among their parents. While this small lobe produced no *Narthecium,* it yielded three rare species: a single plant of *Asclepias rubra,* a few patches of *Sclerolepis uniflora,* and some pockets of *Sphagnum portoricense.* The latter two species were additions to an extensive list of 16 rare plants (similar to the list for Below the Locks) the leader has observed over many seasons at this extensive site. We also saw a specimen of pine tentatively identified as *Pinus serotina.*

About half a mile to the south, we paused at a river meander that abuts the road to see in the water small occurrences of *Potamogeton confervoides, Sclerolepis uniflora,* and *Utricularia purpurea.* These rare plants have persisted here for several decades along with the common *Juncus militaris* and *Dulichium arundinaceum.*

After breaking for lunch at Constable Bridge, we stopped briefly east of Batsto at an historic, still-thriving occurrence of the state-endangered *Stylisma pickeringii* var. *pickeringii.* Batsto Bog, just south of Long Savannah but on the east side of the Batsto two miles north of the "Washington Turnpike," was our final stop. Here we explored only the infrequently visited eastern lobe bisected by an unnamed tributary that flows west to a *Narthecium* savannah near the Batsto. It was necessary to bushwhack through shrub thicket to reach the foot of a steep, spring-fed ravine with lush carpets of sphagnum and a somewhat open canopy of cedar/hardwood. This habitat type was more quaking bog (providing treacherous footing) and cedar swamp than savannah. It had *Carex collinsii, C. trisperma* var. *billingsii, C. atlantica* ssp. *capillacea, Eriophorum virginicum, Orontium aquaticum, Sarracenea purpurea* var. *purpurea, Osmunda cinnamomea* var. *cinnamomea, Trientalis borealis* ssp. *borealis,* the foliage of *Platanthera clavellata, Leucothoe racemosa, Lyonia mariana,* and most of the other common shrubs and herbs already observed at the other sites visited. Rare species noted were *Arethusa bulbosa,* new to this site with more than a dozen specimens in bloom, a few small patches of *Schizaea pusilla,* and a few culms of *Juncus caesariensis.* However, the highlight of the trip was the discovery of a new population of the state-endangered *Uvularia puberula* var. *pudica,* to be added with *Arethusa* to the leader's list of 15 rare species previously recorded at the greater Batsto Bog site. Janet Novak discovered the first cluster of 9 plants, well concealed in a thicket on the lower third of the slope leading to the stream; the leader found 5 additional plants nearby, not too far from a few flowering stalks of *Xerophyllum asphodeloides.*

Thanks go to Bill Standaert for maintaining a species list. Attendance: 20. Report by leader: **Ted Gordon.**

24-26 June: Grasses, Sedges, and Rushes of the Delaware Water Gap National Recreation Area, Pennsylvania. This workshop at PEEC was cancelled because of low registration. Leader: Bill Olson.

22-24 July: Woody Plants Weekend, Delaware Water Gap National Recreation Area, Pike and Monroe Counties, Pennsylvania. This trip and workshop was based at the Pocono Environmental Education Center (PEEC). The group visited areas around the PEEC campus and some nearby road edges to observe and learn the woody plant flora of the Park. A list of 116 species of woody vines, shrubs, and trees was recorded. Some of the more interesting species included mountain maple (*Acer spicatum*), hackberry (*Celtis occidentalis*), bush-honeysuckle (*Diervilla lonicera*), mountain holly (*Ilex montana*), fetterbush (*Leucothoe racemosa*), flowering raspberry (*Rubus odoratus*), red elderberry (*Sambucus racemosa*), and poison sumach (*Toxicodendron vernix*). Attendance: 10. Report by leader: **Bill Olson.**

13 August: Spungs, Cripples, Blue Holes, and Savannahs (Savannas) of the Pine Barrens of Atlantic and Gloucester Counties, New Jersey.

The trip participants assembled at the municipal building in Buena Vista Township to hear co-leader Mark Demitroff's PowerPoint presentation on sites intended to be visited, four distinct topographic features colloquially known as spungs, cripples, blue holes, and savannahs. It is within these wetlands that many of the region's rare, threatened, and endangered plant species are found. Today, development and an apparent lowering of the regional water table imperil many of these hydrogeologic features. Spungs (spongs) are enclosed wetland basins, created by deflation under cold, nonglacial (i.e., periglacial) conditions. Both leaders concur with the assessment of archeologists Bonfiglio and Cresson (1982) that these basins, also known as intermittent ponds or vernal ponds, served as watering places for ambulant peoples over a period of 12,000 years. Cripples are short, broad, damp to wet, often wooded paleovalleys that lack a modern stream channel. Surface wash flowing over frozen ground helped shape these waterways. Found within or alongside watercourses, blue holes are deep, strong, ancient, perennial springs that welled-up under cold climate conditions during the Pleistocene. Exhibiting both microtopography and fluctuating hydrology, savannahs (savannas) are flat stretches of sedge- and grass-dominated, sparsely wooded meadow which once occupied thousands of acres of paleochannel along Pinelands streams. They are relicts of extreme snowmelt events over frozen ground, further modified by strong winds. (For more information on these hydrologic features, see Demitroff 2003, *A Geography of Spungs and Some Attendant Hydrological Phenomena on the New Jersey Outer Coastal Plain.*)

Special thanks go to Pat and Alexis Demitroff for providing and serving a fine selection of complimentary, Pinelands-themed refreshments during and after the talk.

About 3.5 miles northeast of the municipal building and southwest of Newtonville, just to the east of Route 54 and south of Leghorn Road, our first field stop was once the location of a riverine pond, one of three "Great Ponds" along Three Pond Branch. Four spungs or intermittent ponds concealed in a partially wooded tract were all that remained of an upper pond associated with the east prong of the stream. Extensive open patches revealed a surface layer of moist to wet loamy sand. Among the flowering species observed here were *Gratiola aurea, Drosera intermedia, Hypericum canadense, Lobelia nuttallii, Eriocaulon aquaticum, Xyris difformis* var. *difformis, Rhexia virginica, Juncus pelocarpus, Juncus debilis, Calamogrostis coarctata (C. cinnoides), Panicum spretum, P. rigidulum, Eleocharis tricostata, Bulbostylis capillaris, Fimbristylis autumnalis,* and *Clethra alnifolia.* Associated species not flowering were *Aletris farinosa, Proserpinaca pectinata, Viola lanceolata* ssp. *lanceolata, Hypericum mutilum, Cladium mariscoides, Eleocharis microcarpa, E. robbinsii, Rhynchospora capitellata, R. chalarocephala, Schizachyrium scoparium* var. *scoparium, Kalmia angustifolia, Chamaedaphne calyculata,* and *Vaccinium corymbosum* var. *caesariensis.* Three Pinelands listed rare species were noted: *Carex barrattii, Scleria reticularis,* and *Lobelia canbyi.*

Still largely undeveloped, this tract was once slated to become North Buena Farms. Old "paper" roads and non forested pockets reveal the scars of off-road vehicles. Fortunately, Buena Vista Township is acquiring lots to develop a potential 500-acre reserve to protect the stream's headwaters.

Our second stop was Inskeeps (Inskips) Blue Hole along the Great Egg Harbor River in the southwest corner of Winslow Wildlife Management Area near Berryland, Monroe Township, Gloucester County. From the parking lot and shooting range off E. Piney Hollow Road, we walked a one mile trail through low sand dunes that gently sloped to moist forested wetlands. En route we recorded the following shrubs: *Hudsonia ericoides, Quercus ilicifolia, Ilex glabra, Clethra alnifolia, Rubus hispidus, Decodon verticillatus, Smilax rotundifolia, Gaultheria procumbens, Gaylussacia frondosa, Kalmia angustifolia* var. *angustifolia, Lyonia mariana, Rhododendron viscosum, Vaccinium corymbosum,* and of interest from a distribution perspective, *V. angustifolium and Leiophyllum buxifolium.* Among the herbs in flower were *Eupatorium pilosum, Polygala lutea, P. nuttallii, Diodia teres, Solidago odora* var. *odora, Melampyrum lineare* var. *pectinatum,* and *Xyris difformis* var. *difformis.* Not yet in flower was *Euthamia tenuifolia* var. *tenuifolia (E. caroliniana),* and in fruit was *Lachnanthes caroliniana.* Among the graminoids were *Amphicarpum purshii, Deschampsia flexuosa* var.

flexuosa, Andropogon glomeratus var. *glomeratus, Juncus pylaei (J. effusus* var. *pylaei), Scyrpus cyperinus, Rhynchospora capitellata,* and *Cyperus dentatus.*

A brief, though unsuccessful search of suitable moist pockets was conducted for the foliage of *Gentiana autumnalis.*

As on past visits, the most famous of southern New Jersey's blue holes (situated < 45 m. from the river) produced nothing of botanical significance. Floating on the surface of the pond, an algal scum obscured much of its turquoise-blue water. We were unable to detect the blue-green alga said to be the origin of this hue. Trees bordering the pond were typical of those in the surrounding wetland, *Acer rubrum* var. *trilobum, Nyssa, Chamaecyparis thyoides, and Pinus rigida;* the dense shrubs were among those already noted.

A lunch break (and a reprieve from the heat) was taken at Weymouth Furnace County Park, Hamilton Township, Atlantic County, off Elwood Road (CR 623) just east of Route 322. Species randomly observed here were *Juglans nigra, Microstegium vimineum, Anemone virginiana, Dianthus ameria, Geum canadense, Botrychium dissectum,* and *Asplenium platyneuron.* Maps were examined to interpret the impacts of the iron industry on the extensive wetlands along the Great Egg Harbor River and to point out that the narrow river channel of today was 7000 feet wide during the Ice Age. The relict channel is apparent if one travels Elwood Road north towards the Makepeace Lake cranberry tract, site of a *Carex striata* dominated remnant of a once more extensive iron ore savannah mapped by Harshberger (1916). These sites were not visited.

Our fourth stop was "Cleveland Pond" in Laureldale, Hamilton Township, a nearly circular pond with a level bottom. Demitroff hypothesized that the spung's flat bottom, a feature shared with numerous intermittent ponds in the region, was a result of wind erosion down to the local water table, which was probably frozen at the time of katabatic wind action off the Laurentide Ice Sheet.

From a perspective of species diversity, species distribution, and species stability this small spung constitutes a classic botanical site. The attractive floral display we observed featured four rare species in relatively large numbers: *Muhlenbergia torreyana, Scleria reticularis* (mostly in immature fruit), *Coreopsis rosea,* and *Lobelia canbyi;* a fifth, *Panicum wrightianum (Dichanthelium w.),* occurred in scattered patches. Three distinct zones were recognizable with *Muhlenbergia* occupying the outer edge of the pond beyond the shrub border, *Scleria,* the next concentric circle, and *Coreopsis,* the center which generally holds flood waters the longest. Other flowering plants were more widely distributed: *Bartonia viginica, Gratiola aurea, Polygala cruciata, P. lutea Xyris difformis* var. *difformis, Juncus debilis, J. pelocarpus, Hypericum denticulatum* var. *denticulatum* and *Sabatia difformis.* Not in flower were the following: *Eleocharis olivacea (E. flavescens* var. *o.), E. tricostata, Panicum rigidulum, Viola lanceolata* ssp. *lanceolata,* and quite immature plants of *Panicum verrucosum.*

Except for the possible absence of two rare species, *Scleria minor and Agalinis fasciculata (A. purpurea* var. *racemulosa),* observed at this site by Gordon in August 1985, this habitat and its species composition have remained virtually stable.

Our final stop was Big Goose Pond in Hamilton Township, southwest of Egg Harbor City. One of South Jersey's largest spungs, this pond encompasses thirty acres. On our visit, water depth varied only slightly, between four to six inches, over the entire, remarkably flat bottom. Although we recorded no new species for this well documented botanical site (See field trip reports by Gordon, *Bartonia* No. 53:70; No. 61:65; No. 63:64,65), we relocated a patch of the endangered *Eleocharis equisetoides* and admired the large, 4-merous, lavender petals atop the long stems of the endangered *Rhexia aristosa.* Other rare species noted were *Rhynchospora inundata, Nymphoides cordata,* and an abundance of *Panicum hemitomon*. Here and there patches of yellow represented flowering populations of *Xyris smalliana, Utricularia striata,* and *U. cornuta.* Thanks go to Bill Standaert for maintaining a species list.

Attendance: 22. Report by leaders: **Ted Gordon and Mark Demitroff.**

20 August: Milmay Area, Atlantic, Cumberland, and Cape May Counties, New Jersey. Joint trip with the Torrey Botanical Society.

The first stop of this trip was a cedar swamp dominated by *Chamaecyparis thyoides, Acer rubrum*, and *Nyssa sylvatica* along a tributary of Stephen Creek in Weymouth Township, Atlantic County. Among the shrubs were *Clethra alnifolia, Ilex laevigata, I. verticillata, Kalmia latifolia, Leucothoe racemosa,* and *Viburnum nudum. Helonias bullata* was noted, along with *Orontium aquaticum, Osmunda cinnamomea, O. regalis,* and *Sparganium americanum.* In a strip of upland adjacent to Maple Avenue, a stand of *Cypripedium acaule* was noted along with *Gaultheria procumbens, Quercus prinus, Q. velutina,* and *Sassafras albidum.*

The group then traveled to Mosquito Landing in the Tuckahoe Wildlife Management Area in Upper Township, Cape May County. Surrounded by stands of *Phragmites australis* was a tidal marsh with diverse vegetation. Species noted included *Amaranthus cannabinus, Baccharis halimifolia, Bidens coronata, Distichlis spicata, Iva frutescens, Kosteletzkya virginica, Panicum virgatum, Pluchea odorata, Polygonum ramosissimum, Ptilimnium capilaceum, Sabatia stellaris, Samolus floribundus, Spartina alterniflora, S. cynosuroides, S. patens,* and *Symphiotrichum subulatum.* Two rare species were also noted here: *Ammannia latifolia* and *Lythrum lineare.*

Staying in Upper Township, a wetland in a power line cut was visited along Route 49, SSE of Head-of-River. It was dominated by *Chamaecyparis thyoides* (recently cut). Species noted here included *Decodon vertcillatus, Dulichium arnundinaceum, Epilobium coloratum, Eriophorum virginicum, Juncus canadensis, Lachnanthes caroliniana, Platanthera blephariglottis, Rhynchospora alba, R. capitellata, Sagittaria engelmanniana, Vernonia noveboracensis,* and *Woodwardia virginica.* A small stand of the rare species *Eupatorium resinosum* was also noted here. Another rare species, *Solidago tarda*, grew in the uplands along the roadside.

Hunters Mill (Estell Manor, Atlantic County) was then visited. Here along Hunters Mill Road (First Avenue) in oak-pine uplands two rare species were noted: *Croton willdenowii (Crotonopsis elliptica)* and *Malus angustifolia* (in fruit). Also seen here were *Eurybia compacta (Aster gracilis), Euthamia tenuifolia, Rubus cuneifolius,* and *Viola sagittata* (with cleistogamous fruit).

The group then visited a power line cut and a large intermittent pond in the South River watershed east of the Pennsylvania-Reading Seashore Railroad in Buena Vista Township, Atlantic County. The wetlands along the power line were in an early stage of regeneration of Atlantic white cedar. Species noted here included *Panicum mattamuskeetense, Polygala cruciata, Vaccinium macrocarpon, Xyris difformis,* and *X. torta.* Species noted in the pond included *Eleocharis microcarpa, E. obtusa, E. olivacea, E. robbinsii* (abundant), *Fimbristylis autumnalis, Lindernia dubia* var. *anagallidea, Ludwigia palustris, L. sphaerocarpa, Polygonum hydropiperoides* var. *hydropiperoides, Rhexia virginica, Scirpus cyperinus,* and *Xyris smalliana.* Two rare species were noted in the pond, *Rhynchospora inundata* and *R. scirpoides (Psilocarya scirpoides).*

Another intermittent pond in Buena Vista Township was also visited. This one was a much smaller, circular pond located at the terminus of Greco Road (formerly Park Avenue) south of Route 40 in the headwater of the South River watershed. Rare species noted here were *Coreopsis rosea, Panicum wrightianum,* and *Scleria reticularis.* Other species noted included *Bartonia virginica, B. paniculata, Gratiola aurea, Panicum longifolium, P. spretum,* and *Rhynchospora capitellata.* A few days earlier a small stand of *Rhynchospora nitens (Psilocaria nitens)* was also noted here by the leaders; impending darkness and the need to visit another site prevented the group from noting this species.

The group then traveled to its last stop of the day, another intermittent pond. This pond near the headwater of the Cedar Branch of the Manantico Creek is located along Vine Road adjacent to the New Jersey Central Railroad in Vineland, Cumberland County. This site is commonly known as the Main Avenue or Main Road Station. The following sixteen rare species have historically been reported from this area: *Asclepias rubra, Coreopsis rosea, Cuscuta coryli, Eleocharis melanocarpa, Eleocharis minima* (only known station from New Jersey), *Eupatorium resinosum, Lobelia canbyi, Ludwigia hirtella, Lysimachia hybrida, Muhlenbergia torreyana, Nymphoides cordata, Oldenlandia uniflora, Paspalum dissectum, Scleria minor, Solidago elliottii,* and *Stachys hyssopifolia.* The area has been heavily impacted by agriculture, and the intermittent area is now limited to a linear ditch-like basin adjacent to areas under active agriculture. Only two of the historically rare 16 species were noted, *Coreopsis rosea* and *Cuscuta coryli,* while two other rare species, *Rotala ramosior* and *Schoenoplectus smithii* (the latter found by Ted Gordon) are new additions. Also observed were *Eleocharis acicularis, E. microcarpa, E. obtusa, Gratiola aurea, Helianthus angustifolius, Juncus debilis, Paspalum leave,* and *Sagittaria graminea.* Further east along Vine Road a stand of *Vitex agnus-castus* (chaste-tree) was noted. This species, native to Eurasia, was until recently thought to have escaped only as far north as Maryland.

Attendance: 14. Report by leaders: **Renée Scagnelli and Gerry Moore.**

20 August: Deer- and Elk-maintained Meadows in the Quehanna State Forest Wild Area, Clearfield County, Pennsylvania. Joint trip with the Pennsylvania Native Plant Society.

What happens when very high deer densities in northern Pennsylvania's Big Woods prevent tree regeneration for a half-century or more? Open meadows and low shrub heaths dominated by browsing- and grazing-tolerant native herbaceous plants are making a comeback two centuries after native elk and bison were extirpated and the eviction of the Indians halted routine, large-scale burning. We explored examples of the new/old native plant community called by the trip leader "wild-ungulate pasture." Dotted by just a few surviving trees, including red maple (*Acer rubrum*), pitch pine (*Pinus rigida*), northern red oak (*Quercus rubra*), and smooth serviceberry (*Amelanchier laevis*), the meadows were dominated by hay-scented fern (*Dennstaedtia punctilobula*), bracken (*Pteridium aquilinum*), black huckleberry (*Gaylussacia baccata*), sweet-fern (*Comptonia peregrina*), and hardhack (*Spiraea tomentosa*). Areas of damp soil were marked by a cover of tawny cotton-grass (*Eriophorum virginicum*), wool-grass (*Scirpus cyperinus*), other sedges (*Carex debilis* var. *rudgei*, *C. folliculata*, *C. intumescens*), and rushes (*Juncus canadensis*, *J. effusus*, *J. subcaudatus*). Drier patches were dominated by grasses, including fly-away grass (*Agrostis scabra*), bearded shorthusk (*Brachyelytrum aristosum*), northern oatgrass (*Danthonia compressa*), deer-tongue (*Dichanthelium clandestinum*), and other panic grasses (*D. acuminatum*, *D. boscii*, *D. commutatum*, *D. sphaerocarpon*), interspersed with clubmosses (*Diphasiastrum digitatum*, *D. tristachyum*, *Lycopodium obscurum*), interrupted fern (*Osmunda claytoniana*), teaberry (*Gaultheria procumbens*), mountain-laurel (*Kalmia latifolia*), lowbush blueberry (*Vaccinium pallidum*), and low sweet blueberry (V. angustifolium). The few dicots in flower in late summer included pearly everlasting (*Anaphalis margaritacea*), grass-leaved goldenrod (*Euthamia graminifolia*), Canadian St. John's-wort (*Hypericum canadense*), Indian-tobacco (*Lobelia inflata*), and field milkwort (*Polygala sanguinea*). The day was bright and sunny but not too hot. A bountiful crop of ripe swamp dewberry (*Rubus hispidus*) provided a welcome treat.

Attendance 9. Report by leader: **Roger Latham.**

10 September: FDR Park, Philadelphia, Pennsylvania.

A large group of club members, members of the American Swedish Historical Museum, and students from the University of Pennsylvania walked through much of FDR Park in South Philadelphia where we identified wild and cultivated plants in aquatic, wetland, and terrestrial habitats. In order to pay homage to Linnaeus and remind us of the forthcoming Linnaean exhibit at the Swedish Museum, Bob Savage serenaded us with a trumpet when we found something of particular interest. (Note that many of the species on our list were named by Linnaeus.) Three state-listed rare species, *Cyperus odoratus, Heteranthera multiflora,* and *Echinochloa walteri* were growing around the margins of ponds. One of the former ponds, once used for swimming, is now a wetland managed by Fairmount Park, and has a diverse aquatic/wetland flora. In another portion of the park, we went into an unusual forest dominated by *Ulmus pumila* and *Morus alba* with a herbaceous layer of introduced species. A list of the plants we encountered follows:

Woody—*Acer negundo* L., *Acer rubrum* L., *Ailanthus altissima* (Mill.) Swingle, *Alnus glutinosa* (L.) Gaertn., *Amorpha fruticosa* L., *Aronia melanocarpa* (Michx.) Ell., *Baccharis halimifolia* L., *Betula nigra* L., *Betula pendula* Roth, *Cephalanthus occidentalis* L., *Cercidophyllum japonicum* Sieb. & Zucc., *Chamaecyparis pisifera* (Sieb. & Zucc.) Endl., *Fagus sylvatica* L., *Fraxinus pennsylvanica* Marsh., *Ginkgo biloba* L., *Gleditsia triacanthos* L., *Juniperus virginiana* L., *Liquidambar styraciflua* L., *Metasequoia glyptostroboides* Hu & Cheng, *Morus alba* L., *Ostrya virginiana* (Mill.) K. Koch, *Pinus strobus* L., *Pinus thunbergiana*

(Parl.) Franco, *Platanus ×acerifolia* (Ait.) Willd., *Platanus occidentalis* L., *Populus alba* L., *Populus deltoides* Marsh., *Prunus serotina* Ehrh., *Rosa* L., *Quercus alba* L., *Quercus bicolor* Willd., *Quercus macrocarpa* Michx., *Quercus michauxii* Nutt., *Quercus palustris* Muenchh., *Quercus rubra* L., *Salix babylonica* L., *Salix nigra* Marsh., *Sophora japonica* L., *Taxodium distichum* (L.) Richard, *Tilia europaea* L., *Ulmus americana* L., *Ulmus pumila* L., and *Viburnum dentatum* L.

Herbaceous—*Artemisia vulgaris* L., *Asclepias incarnata* L., *Asclepias tuberosa* L., *Bidens connata* Muhl., *Bidens frondosa* L., *Bidens polylepis* Blake, *Ceratophyllum demersum* L., *Cyperus brevifolioides* Thieret & Delahoussaye, *Cyperus bipartitus* Torr., *Cyperus odoratus* L., *Echinochloa muricata* (P. Beauv.) Fern., *Echinochoa walteri* (Pursh) A. Heller, *Eclipta alba* (L.) Hassk., *Elymus canadensis* L., *Eupatorium rugosum* Houtt., *Eupatorium serotinum* Michx., *Euthamia graminifolia* (Pursh) Greene, *Heteranthera multiflora* (Griseb.) Horn, *Hibiscus moscheutos* L., *Leersia oryzoides* (L.) Sw., *Ludwigia peploides* (Kunth) P.H. Raven, *Lycopus uniflorus* Michx., *Lythrum salicaria* L., *Oenothera biennis* L., *Panicum dichotomiflorum* Michx., *Panicum virgatum* L., *Peltandra virginica* Raf., *Polygonum lapathifolium* L., *Polygonum pensylvanicum* L., *Polygonum perfoliatum* L., *Polygonum punctatum* Ell., *Polygonum sagittatum* L., *Polygonum* sp., *Pontederia cordata* L., *Sagittaria latifolia* Willd., *Scirpus cyperinus* (L.),Kunth, *Solidago altissima* L., *Solidago gigantea* Ait., *Sorghastrum nutans* (L.) Nash, *Strophostyles helvola* (L.) Ell., *Tridens flavus* (L.) Hitchc., and *Typha ×glauca* Godr.

Report by leader: **Alfred E. Schuyler.**

2006 Field Trips

29 April: Pink Hill Serpentine Barrens, Tyler Arboretum, Media, Pennsylvania.

We botanized two areas within Tyler Arboretum: Pink Hill and Dismal Creek. Pink Hill is a serpentine barrens: an area with thin soil over serpentine rock, with vegetation dominated by grasses and herbs. The grasses, although they were mostly not identifiable in April, included *Sorghastrum nutans, Schizachyrium scoparium, Andropogon gerardii,* and *Aristida* spp. Pink Hill gets its name from *Phlox subulata,* which in earlier times is said to have colored the whole hill pink. The phlox is not nearly so predominant now, though still common and quite conspicuously in bloom on the day of our trip. Two other plants characteristic of serpentine barrens were also in bloom: *Arabis lyrata* and *Cerastium arvense ssp. velutinum* var. *villosum*. Other plants included *Ceanothus americanus, Houstonia caerulea, Viola sagittata,* and, at the edges of the barrens, *Saxifraga virginiana*. We also noted remains of last year's *Lilium philadelphicum,* which the arboretum staff enclosed in chicken wire to protect it from deer.

This serpentine barrens, like many others in the region, is threatened by succession. On our trip, we noted a number of woody plants that, if unchecked, could transform barrens into woodland. These plants included *Acer rubrum, Ailanthus altissima, Robinia pseudoacacia,* and *Elaeagnus umbellata*. Tyler Arboretum and the Nature Conservancy have been working to preserve the open barrens and its plant community. In 2003, in a program one volunteer described as "bulldozers for botany," the Nature Conservancy used a front-end loader to scrape parts of the barrens clear of vegetation and most of the topsoil. A year later, half of the barrens was burned, and *Robinia pseudoacacia* was killed with herbicide. The benefit of the scraping was obvious to us; the scraped areas had particularly high concentrations of the characteristic serpentine barrens plants. The following were additional species observed in both the barrens and wood margins: *Achillea millefolium, Allium vineale, Celastrus* sp., *Claytonia virginica, Dennstaedtia punctilobula, Juniperus virginiana, Lindera benzoin, Lonicera japonica, Polystichum acrostichoides, Potentilla canadensis, Prunus serotina, Rubus* sp., *Rumex acetosella, Sassafras albidum, Saxifraga virginiana, and Smilax* sp.

We saw a rather different habitat—rich woods—along Dismal Creek. This area had an abundance of spring wildflowers. Species in bloom included *Polemonium reptans, Geranium maculatum, Caulophyllum thalictroides, Claytonia virginica, Erythronium americanum, Uvularia perfoliata,* and *Viola pensylvanica*. Among ferns, silvery glade fern (*Deparia acrostichoides*), was particularly abundant. The following additional species occurred in wooded areas along the orange and blue trails: *Actaea* sp. *(racemosa?), Alliaria petiolata, Allium tricocum, Aplectrum hyemale, Arisaema triphylla, Asarum canadense, Athyrium filix-femina, Berberis thunbergii, Botrychium virginianum, Cardamine concatena, Circaea lutetiana, Dioscorea* sp., *Duchesnea indica, Galium* sp., *Hamamelis virginiana, Ligustrum* sp., *Maianthemum racemosum, Menispermum canadense, Onoclea sensibilis, Osmorhiza sp., Panax quinquefolius, Podophyllum peltatum, Polygonatum pubescens, Rosa multiflora, Rubus phoenicolasius, Sanguinaria canadensis, Symplocarpus foetidus, Toxicodendron radicans, Veronica hederifolia,* and *Viola sororia.*

Report by leader: **Janet Novak.**

6-7 May: Violets of Southern New Jersey, Cape May, Atlantic, Cumberland, and Salem Counties.

Joint trip with the Torrey Botanical Society.

On the first day, trip participants met in Woodbine at the intersections of Cape May County Routes 550 and 557. Along the roadsides here *Sherardia arvensis* (field-madder), native to Eurasia and northern Africa, was noted in bloom. The focus of this trip was violets. Besides the treatments in the regional manuals by Fernald and Gleason and Cronquist, the leader also brought *Viola* treatments by Brainerd (1921), Baird-Brainerd (1942), Russell (1965), McKinney (1992), and Gil-ad (1997).

Southeast of Woodbine off County Route 550 along an abandoned right-of-way of the former Pennsylvania Reading Seashore Lines, the group saw in open, sandy areas excellent stands of *Viola pedata* and *V. sagittata* s.l. in bloom. The material of *V. sagittata* was remarkably variable with respect to the flowers (petal shape, pubescence of sepals and auricles), leaves (outline, lobing, pubescence, degree of development), and overall size of the plants. In splittier treatments, this material would key to three species: *V. emarginata, V. fimbriatula,* and *V. sagittata.* There was also significant variation in flower color, with specimens ranging from white, bluish, magenta, to violet. The group also puzzled over the *Potentilla* here and determined that two species were present: *P. canadensis* and *P. simplex.* Other species noted in bloom were *Antennaria neodioica* and *Fragaria virginiana.*

The group then botanized along another right-of-way of the former Pennsylvania Reading Seashore Lines from Woodbine Junction to Tuckahoe. (Having presumed that the railroad was not active, the group was startled when a railcar approached and the engineer informed us that the track was being tested for a possible extension of the Richland-Tuckahoe tourist line.) Here the group saw in bloom a population of the rare *Lupinus perennis* along with three other flowering species: *Krigia virginica, Linaria canadensis (Nuttallanthus canadensis),* and *Vicia hirsuta.* Further north along the railroad several populations of the rare and distinctive *V. brittoniana* were noted. The plants were usually found growing in moist sand. Several populations of two white violets, *V. lanceolata* and *V. primulifolia,* were also noted. Several populations of *V. sagittata* (some material would key to *V. fimbriatula* in splittier treatments) were also noted. In an open swamp along the railroad, Ted Gordon observed a large population of *Carex barrattii.*

After lunch at the Tuckahoe railroad station, the group headed to Aetna Furnace in Atlantic County. Along County Route 666 near the entrance to the furnace site, the group puzzled over material in the *Viola sagittata* complex. The specimens were in full anthesis, but the leaves were scarcely developed at all. In the swampy areas near the Tuckahoe River, robust specimens of *V. primulifolia,* as well as *Acorus calamus* and *Orontium aquaticum* were seen.

On 7 May, the second day of the trip, the group met at Gum Tree Corner Wildlife Management Area in western Cumberland County. In farm fields, the non-native pansy violet, *Viola arvensis,* was noted with its yellow to purple petals. The leader brought material of *Viola rafinesquii (V. bicolor)* he had collected in Millville for comparison. *V. rafinesquii's* flowers were paler and bluish, and its roots, as noted by Fernald, smelled like wintergreen. Further south at Gum Tree Corner proper, the group saw *Hedyotis caerulea* in bloom, an unusual species for Cumberland County.

The group then traveled south to Tindall Island and botanized in rich, deciduous woodlands. Here large stands of *Cardamine concatenata (Dentaria laciniata)* in bloom were noted, as well as other spring wildflowers such as *Podophyllum peltatum* and *Arisaema triphyllum.* Renée Scagnelli discovered a small population of the rare fern *Ophioglossum pusillum.* Large specimens of *Carya cordiformis* were also noted.

At our next stop in moist woodlands along County Route 602 near its intersection with Buckhorn Road, the focus returned to *Viola.* At this site two closely related species were noted, *V. sororia* and *V. affinis.* With us, *V. sororia* is represented by the common, weedy dooryard violet (also known as *V. papilionacea* and *V. domestica),* and it was more prevalent along the roadsides. *V. affinis* was more commonly found in the woodlands. *V. affinis* can be distinguished from *V. sororia* on the basis of its pubescent capsules (glabrous in *V. sororia)* and much more delicate habit.

The group continued to look at *V. sororia* and *V. affinis* at Muttontown Woods near Quinton in Salem County. Other species noted in these rich woods included *Cardamine concatenata, Dicentra cucullaria, Erythronium americanum, Luzula echinata, Ranunculus recur-*

vatus, Sanguinaria canadensis, and *Smilax pulverulenta.* The last stop of the day was Sharptown in Salem County. In rich woodland adjacent to the Salem River, the group saw many of the spring ephemerals noted at Muttontown Woods, as well as *Allium tricoccum, Viola pubescens,* and the state-endangered *Polemonium reptans* (in bloom).

Attendance: 15. Report by leader: **Gerry Moore.**

13 May—14 October: Plant Families of the Pine Barrens, Pinelands Preservation Alliance, Bishop Farmstead, Southampton Township, Burlington County, New Jersey.

Six Saturday classes and 3 field trips. Instructors/Leaders: **Bill Olson, Wayne Ferren,** and **Russell Juelg.** No report submitted, but see *Journal of the Torrey Botanical Society,* Vol. 134, No. 1, Jan.-Feb, 2007, pp. 149-150 for G. Russell Juelg's trip reports titled "Pinelands Preservation Alliance."

20 May: Crosswicks Creek County Park, Upper Township, Monmouth County, New Jersey.

We explored an undeveloped segment of Crosswicks Creek County Park in southern Monmouth County, about 1.3 miles northwest of New Egypt. The parcel is situated on the east bank of Crosswicks Creek just north of the creek's intersection with Mount Holly-Freehold Road (Route 537). Beginning at the parking area along Route 537 between Holmes Mill Road (CR 271) and Lawrence Drive, we followed a fisherman's path a short way north to an east-west depression or floodplain that opened up into a view of the creek. After exploring the creek bank, we proceeded up an embankment and followed the northern ridge overlooking the floodplain to an old field to the north. It was along this ridge that we found about a dozen plants of the rare *Silene caroliniana* var. *pensylvanica* (wild pink) in bloom. We explored the boundaries of the old field and then retraced our route to the parking area. After lunch, we followed the creek along its eastern bank to the north for just under a half mile until we reached a deep ravine on the north. It was on the ridge here that we found >25 plants of *Galearis spectabilis (showy orchid)* in bloom. Following the ravine for a short distance east, we found the northern boundary of the old field we had explored in the morning. We returned south through the woods and then retraced our route from the morning to return to the parking area.

In addition to *Silene* and *Galearis,* other plants of interest observed were *Floerkea proserpinacoides* (false mermaidweed), *Hydrophyllum virginianum* (Virginia waterleaf), *Panax trifolius* (dwarf ginseng), *Orobanche uniflora, Botrychium matricariifolium,* and a big pocket of *Matteuccia struthiopteris* (ostrich fern) growing at its southernmost site in the state in an island of the creek. According to Montgomery and Fairbrothers (1992), in Monmouth County this fern is known only from a couple of sites.

The following list includes additional species observed: **Trees and Shrubs**—*Ilex opaca, Carya alba, Sassafras albidum. Juniperus virginiana, Fagus grandifolia, Quercus alba, Q. falcata, Q. velutina, Rhus copallinum, Prunus serotina, Taxus* sp., *Acer saccharinum, A. negundo, Platanus occidentalis, Liriodendron tulipifera, Corylus* sp., *Tilia americana, Cornus* sp., *Carpinus carolinianus, Ulmus* sp., *Liquidambar styraciflua, Betula nigra, Hamamelis virginiana, Elaeagnus umbellata, Viburnum acerifolium, V. dentatum, V. prunifolium, Rosa multiflora Lonicera japonica, L. morrowii, Alnus* sp., *Toxicodendron radicans, Smilax rotundifolia, Euonymus alatus, E. americanus, Chimaphila maculata, Morella pensylvanica, Sambucus canadensis, Lindera benzoin, Ilex verticillata, Rubus* sp., *Dioscorea villosa, Clethra alnifolia. Berberis thunbergii, Campsis radicans, Celastrus orbiculatus, and Vitis* sp.

Herbs and Ferns—*Botrychrium virginianum, Thelypteris noveboracensis, Onoclea sensibilis, Asplenium platyneuron, Osmunda cinnamomea, O. claytoniana, Woodwardia areolata, Dryopteris carthusiana, Athyrium filix-femina, Maianthemum racemosum, Circaea lutetiana, Eurybia divaricata, Desmodium canadense, D. paniculatum, Geum* sp., *Galium aparine Polygonum arifolium, P. biflorum, P. cuspidatum, P. sagittatum, P. virginianum, Uvularia perfoliata, U. sessilifolia, Luzula* sp., *Podophyllum peltatum, Thalictrum* sp., *Solidago caesia, S. rugosa, S.* sp., *Impatiens capensis, Saxifraga virginiensis, Symplocarpus foetidus, Lysimachia ciliata, L. nummularia, Chelone glabra, Arisaema triphyllum, Peltandra virginica, Microstegium vimineum, Cardamine bulbosa, C. concatenata, Geranium maculatum, Sanquinaria canadense, Maianthemum canadense, Claytonia virginiana, Collinsonia canadensis, G. carolinianum, Mitchella repens, Fragaria virginiana, Medeola virginiana, Ranunculus recurvatus, Pilea pumila, Arabis laevigata, Potentilla simplex, Arabidopsis thaliana, Artemisia vulgaris, Achillea millefolium, Veronica arvensis, Cerastium arvense, Nuttallanthus canadensis, Opuntia humifusa, Asclepias tuberosa, Apocynum cannabinum, Rumex acetosella, Schizachyrium scoparium, Ipomea* sp., *Triodanis perfoliata, Tragopogon dubius, Scleranthus annuus, Andropogon virginicus, Bromus* sp., *Monarda punctata, Hypochaeris radicata, Iris pseudacorus, Phytolacca americana, Allium arvense, A. canadense, Lobelia* sp., *Ornithogalum umbellatum, Viola pubescens* (?), *V.* sp., *Menispermum canadense, Aralia nudicaulis, Monotropa uniflora, Osmorhiza longistylis, Commelina communis, Alliaria petiolata, Sanicula* sp., *Juncus effusus,* and *Eleocharis* sp.

Attendance: 4. Report by leader: **Linda Rohleder.**

27 May: Bryophytes of Birdsboro Reservoir, Berks County, Pennsylvania. Leader: Susan Munch. No report received.

10 June: Red Clay Creek, Chester County, Pennsylvania.

We met on a cool windy day to explore a private nature preserve near the Delaware state line. Before and during the actual walk William Ryan, the land manager, gave a talk regarding the history of the property and current efforts to both replant and encourage native vegetation and plant communities, control aliens, and protect plantings and native plant populations from deer. The property includes a wide variety of both native and recovering habitats, including old farm fields, now being returned to meadows, a native tree arboretum, rich woods, hardwood floodplain woods, wetlands, and the feature habitat on the property: a broad floodplain meadow for which a comprehensive plant list was kept. Notable woodland species observed included *Trillium cernuum, Lilium canadense* (both fenced off from deer), *Juglans cinerea,* and in the floodplain, a large specimen of *Arisaema dracontium.* Notable meadow species observed (some of which we spent considerable time searching for) included *Aristolochia serpentaria* (a large population), *Carex conoidea, C. emoryi, C. tricho-*

carpa, Cirsium horridulum, Gentiana andrewsii (deer-protected), *Panicum rigidulum,* and *Phlox maculata* (just past flowering).

Meadow Species List: *Acalypha rhomboidea, Acer negundo, Acer rubrum, Achillea millefolium, Acorus calamus, Agrimonia parviflora, Alliaria petiolata, Allium canadense, A. vineale, Ambrosia trifida, Andropogon virginicus, Anthoxanthum odoratum, Apocynum cannabinum, Arctium minus, Arisaema triphyllum, Aristolochia serpentaria, Asclepias incarnata v. pulchra, A. syriaca, Aster puniceus* (*Symphyotrichum puniceum* var. *puniceum*), *Bromus commutatus, Calystegia sepium, Cardamine bulbosa, Carex aggregata, C. amphibola, C. annectens, C. blanda, C. caroliniana, C. conoidea, C. debilis, C. emoryi, C. festucacea, C. granularis, C. laevivaginata, C. lurida, C. normalis, C. radiata, C. scoparia, C. squarrosa, C. stipata, C. stricta, C. styloflexa, C. tribuloides, C. trichocarpa, C. vulpinoidea, Celastrus orbiculatus, Cephalanthus occidentalis, Cerastium fontanum, Cicuta americana, Cirsium horridulum, Clematis virginiana, Conium maculatum, Crataegus crus-gallii, Dactylis glomerata, Dicanthelium acuminatum, Elaeagnus umbellata, Eleocharis tenuis, Equisetum arvense, Eupatorium fistulosum, Euthamia graminifolia, Festuca obtusa, Fragaria virginiana, Galium mollugo, G. tinctorium, Gentiana andrewsii, Glechoma hederacea, Glyceria striata, Hackelia virginiana, Holcus lanatus, Impatiens capensis, Juncus acuminatus, J. effusus, J. tenuis, Lactuca canadensis, Lilium canadense, Lonicera japonica, Ludwigia alternifolia, Luzula echinata, Lycopus americanus, L. uniflorus, L. virginiana, Lysimachia ciliata, L. nummularia, Malus* spp., *Onoclea sensibilis, Oxalis dillenii, Panicum anceps, P. rigidulum, Phalaris arundinacea, Phleum pratense, Phlox maculata, Physalis heterophylla, Pilea pumila, Pimpinella saxifraga, Plantago lanceolata, Poa trivialis, Polygonum arifolium, P. caespitosum, P. perfoliatum, P. sagittatum, P. scandens, P. virginiana, Potentilla canadensis, P. simplex, Prunella vulgaris, Prunus avium, Pycnanthemum virginianum, Pyrus calleryana, Quercus bicolor, Q. palustris, Ranunculus bulbosus, Rosa carolina, R. multiflora, R. palustris, Rubus allegheniensis, R. flagellaris, Rudbeckia laciniata, Rumex acetosella, R. crispus, R. obtusifolius, Salvia lyrata, Schizachyrium scoparius, Scirpus cyperinus, S. georgianus, Scutellaria integrifolia, Senecio aureus* (*Packera aurea*), *Sisyrinchium angustifolium, Smilax rotundifolia, Solanum carolinense, Solidago canandensis, S. gigantea, S. patula, S. rugosa, Stellaria longifolia, Symplocarpus foetidus, Taraxacum officinale, Teucrium canadense, Thalictrum pubescens, Thelypteris palustris, Toxicodendron radicans, Tragopogon dubius, Trifolium aureum, T. pratense, T. repens, Veratrum viride, Vernonia noveboracensis, Vicia angustifolia, V. tetrasperma, Viola sororia, Vitis labrusca, V. vulpina.*

Attendance: 7. Report by leaders: **Janet Ebert and Jack Holt.**

17 June: Hairgrass Savanna on Blue Mountain (Kittatinny Ridge) near Palmerton, Carbon and Lehigh Counties, Pennsylvania. Joint trip with the Pennsylvania Native Plant Society.

The hairgrass-lowbush blueberry sananna on the ridgetop just southwest of Lehigh Gap is one of the largest areas of wholly native, unplanted grassland remaining in Pennsylvania. It is very likely a remnant of a landscape managed for centuries by American Indians using fire. In the 20^{th} century, fallout of heavy metals from the smoke of a nearby zinc smelter killed most of the trees, allowing the plants of the native grassland community, which are more tolerant of the contaminated soil, to spread out over nearly 100 acres dotted along three miles of the ridgetop. We carpooled on a rocky track that put our high-clearance, four-wheel drive vehicles to the test, parking next to a microwave transmission tower at the summit. The walking route was more then two miles round-trip along the ridge line, mostly through savanna dominated by billowing masses of hairgrass (*Deschampsia flexuosa*) and early low blueberry (*Vaccinium angustifolium*), both in full flower. The open vegetation and clear, sunny weather allowed spectacular views of the valleys of the Lehigh River and Aquashicola Creek, and, in the distance, the escarpment of the Pocono Plateau. Other prominent members of the flora included sheep-laurel (*Kalmia angustifolia*, also in prolific bloom, bush-honeysuckle (*Diervilla lonicera*), whorled loosestrife (*Lysimachia quadrifolia*), scrub oak (*Quercus ilicifolia*), sweet birch (*Betula lenta*), blackgum (*Nyssa sylvatica*), chestnut oak (*Quercus montana, Q. prinus*), and pitch pine (*Pinus rigida*). We saw small native stands of the state-endangered wild bleeding-heart (*Dicentra eximia*) in flower and looked out over the base of the mountain at a hollow where bleeding-heart was the dominant understory species. Also clearly visible at the base of the mountain were fields dominated by Pitcher's stitchwort (*Minuartia patula*), a disjuct population of a mainly Midwestern and Southern rock outcrop and prairie species. We failed to find two other unusual plants that occur on the site—climbing fern (*Lygodium palmatum*) and a heavy-metal-tolerant ecotype of thrift (*Armeria maritima, Plumbaginaceae*), which is thoroughly naturalized and abundant on Blue Mountain just a half-mile northeast of the field trip route, originally planted from seed collected at a European zinc mine. The trip crossed through State Game Land 217, the national Park Service's Appalachian Trail corridor, and the Lehigh Gap Wildlife Refuge, a privately owned conservation, education and research facility headquartered at the Lehigh Gap Nature Center on the Lehigh River in the heart of the Gap.

Attendance: 13. Report by leader: **Roger Latham.**

20-24 June: Isles of Shoals, New Hampshire. Joint Field Meeting of the Northeast Section of the Botanical Society of America, the Torrey Botanical Society, and the Philadelphia Botanical Club. Chairperson: Jean Stefanik. No report received.

1 July: Burden Hill Forest, Salem County, New Jersey.

Situated on two geologic formations, the Kirkwood and the Cohansey (the latter overlain at its highest elevation by the Bridgeton Gravel), the Burden Hill Forest occupies almost 14,000 acres of the Outer Coastal Plain in the townships of Alloway, Quinton, and Lower Alloways Creek in southwestern Salem County. Extending south nearly 8 miles from Elkinton Millpond southwest of Alloway to its southern border along Stow Creek, this forested escarpment, forming a polygon variable in width from > 2.5 miles in the north to < 1.5 miles southwest of Jericho, stands in sharp contrast to the panoramic "farmscape" on richer land that surrounds the forest. During the 2005 growing season, the leaders conducted a floristic survey here of eight selected parcels owned by the Natural Lands Trust (NLT).

The Thundergut Pond Wildlife Management Area (WMA) in the northern third of the Burden Hill Forest < 2 miles southeast of Alloway was our first stop. There appear to be no records of botanical documentation of this 1,836 acre forested tract. Our exploration was confined to a half mile segment of a northwest-southeast running powerline cut, maintained by periodic cutting. The terrain included both wetland and upland.

We noted three rare species that likely are new records for the Burden Hill Forest: two specimens of heart-leaf boneset, *Eupatorium rotundifolium* var. *cordigerum* (S2), about six racemed milkwort, *Polygala polygama* (S2), and a few pencil-flower, *Stylosanthes biflora* (S3). Also noted was a new occurrence (a few trees) of the state endangered chinquapin, *Castanea pumila* (S1,E). A comprehensive list of species observed follows, with those marked with an asterisk (29) representing additions to a 2005 growing season inventory of 362 species provided by the leaders to the NLT in their March 2006 report, *A Flora of the Burden Hill Forest.*

*Aletris farinosa**, *Andropogon virginicus*, *Apios americanus**, *Baptisia tinctoria*, *Boehmeria cylindrica**, *Carex annectans*, *C. bullata**, *C. crinita* var. *crinita*, *C. intumescens*, *C. longii*, *C. stricta*, *C. swanii*, *C. venusta* var. *minor*, *Castanea pumila*, *Cephalanthus occidentalis*, *Chasmanthium laxum (Uniola laxa)*, *Chrysopsis mariana**, *Comandra umbellata**, *Danthonia compressa**, *D. spicata*, *Decodon verticillatus*, *Dulichium arundinaceum*, *Eleocharis tenuis*, *Epigea repens*, *Erechtites hieracifolia**, *Eupatorium hyssopifolium*, *E. pilosum**, *E. rotundifolium* var. *cordigerum**, *E. rotundifolium* var. *ovatum*, *Gnaphalium purpureum*, *Hypericum gentianoides*, *H. mutilum**, *Iris versicolor*, *Juncus bufonius**, *J. canadensis**, *J. debilis**, *J. dichotomus*, *J. effusus*, *J. marginatus*, *J. scirpoides*, *J. tenuis*, *Kalmia angustifolia*, *Krigia virginica*, *Lactuca canadensis**, *Lechea villosa (L. mucronata)*, *Leersia oryzoides**, *L. virginica*, *Linum* sp.*, *Lonicera morrowii**, *Ludwigia alternifolia*, *Lysimachia quadrifolia*, *L. terrestris*, *Mitchella repens*, *Monotropa uniflora*, *Nuttallanthus canadensis (Linaria c.)*, *Osmunda cinnamomea*, *Panicum boscii**, *P. commutatum*, *P. dichotomum*, *P. latifolium**, *P. meridionale*, *P. scoparium*, *P. sphaerocarpon* var. *isophyllum*, *P. virgatum* var. *virgatum*, *Piptochaetium avenaceum (Stipa avenacea)**, *Polygala nuttallii*, *P. polygama**, *Prenanthese serpentaria**, *Pteridium aquilinum*, *Rhexia virginica*, *Rosa palustris**, *Rubus argutus**, *R. cuneifolius*, *R. hispidus*, *Sisyrinchium angustifolium*, *Smilacina racemosa**, *Smilax glauca*, *S. herbacea**, *S. rotundifolia*, *Solidago nemoralis*, *S. odora*, *Sparganium americanum**, *Spiraea tomentosa**, *Stylosanthes biflora**, *Thelypteris noveboracensis*, *Viola palmata*, *V. sagittata* var. *sagittata*, and *V.* × *primulifolia.*

Just to the west of the WMA, our second stop was a droughty, mature mixed-oak forest, an NLT tract primarily on the Cohansy Formation west of Telegraph Road (Route 540). We came here to see dense thickets of *Castanea pumila*, occupying a sub-canopy position analogous to the role of scrub or bear oak in a Pine Barrens setting. While the state endangered chinquapin historically is only reported to be sparingly distributed in the Middle district from Mercer to Salem counties, core populations as well as widely distributed individuals of this shrub find Burden Hill Forest their primary refuge. Also seen were a few large specimens of *Quercus rubra.*

Located entirely on the Kirkwood Formation in the extreme northwest corner of the Burden Hill Forest, our third stop, a forested site just south of Elkinton Millpond, was accessed by a dirt road from North Burden Hill Road. Underlain by a silty to sandy loam, this NLT tract, once drained and farmed, was later converted to a *Pinus strobus*/*Picea abies* plantation. Among the associated canopy species were *Quercus palustris*, *Q. phellos*, *Q. falcata*, *Pinus virginiana*, *P. echinata*, *P. rigida*, *Fraxinus* sp.*, *Fagus grandifolia*,

Carya tomentosa, *Liquidambar styraciflua*, *Morus rubra*, *Sassafras albidum*, *Nyssa sylvatica*, *Cornus florida*, *Juniperus virginiana*, *Ilex opaca*, *Betula populifolia*, and *Diospyros virgin-*

iana. A relatively sparse understory of shrubs included *Viburnum dentatum, V. prunifolium, Ilex verticillata, Kalmia latifolia, Rhododendron viscosum, Vaccinium corymbosum, Dioscoria villosa, Smilax rotundifolia, Lonicera japonica,* and *Euonymus americanus.* The forest floor was occupied by a diverse layer of herbs, ferns, and clubmosses: *Sanicula marilandica, Ranunculus abortivus, Galium aperine, G. circaezans, G. pilosum, Circaea lutetiana* ssp. *canadensis, Pilea pumila, Maianthemum canadensis, M. racemosum, Carex albolutescens, C. glaucodea, Juncus effusus, Luzula multiflora, Microstegium vimineum, Glyceria obtusa, Anthoxanthum odoratum, Cinna arundinacea, Cypripedium acaule, Goodyera pubescens, Asplenium platyneuron, Botrychium dissectum, B. virginianum, Dennstaedtia punctilobula, Onoclea sensibilis, Thelypteris noveboracensis, Polystichum acrostichoides, Diphasiastrum digitatum (Lycopodium d.), Lycopodium clavatum**, and *L. obscurum,*

Two significant finds were about 25 plants of Virginia snakeroot, *Aristolochia serpentaria**, a rare species quite infrequent in southern New Jersey, and a well distributed population of the state endangered Southern adder's-tongue, *Ophioglossum vulgatum (O. v.* var. *pycnostichum),* identifiable by a characteristic persistent leathery basal leaf sheath.

Our final stop north of Berrys Chapel Road west of Route 49 was the NLT Sickler-Waters parcel. Here in a pond within a narrow headwater stream, we found a small, de novo population of the rare *Utricularia purpurea* (S3)*. Also noted were *Huperzia lucidula,* more specimens of *Castanea pumila,* and several large trees of *Quercus × saulii,* Saul's oak, a putative hybrid of *Quercus alba* and *Q. prinus.*

Since this was primarily an exploratory trip, we did not visit known sites of rare species occurrences of *Listera australis, Helonias bullata, Melanthium virginicum, Amianthium muscitoxicum,* and *Chionanthus virginicus.*

Attendance: 12. Report by leaders: **Ted Gordon and Joe Arsenault.**

29 July: Bunker Hill Bogs and John F. Johnson Memorial Park, Jackson Township, Ocean County, New Jersey. Joint trip with the Torrey Botanical Society and Jackson Pathfinders.

The Bunker Hill Bogs tract lines the stream corridor of the Doves Mill Branch of the Toms River for nearly a mile. Over 450 plant species grow in the tract's Atlantic white cedar swamps, upland pine and oak woods, and abandoned wet and dry cranberry bogs. The Bunker Hill Bogs tract is contiguous with John F. Johnson Memorial Park, which lies to the north. Both parcels are bisected by a wide power line cut which is maintained (by mowing) on a fairly regular basis, so the opening has not become overgrown by woody species.

The power line cut in Johnson Park was our first stop. Several small seeps and a small stream crossed the the right-of-way. In the sphagnous boggy areas we found many flowering species, some of which were *Asclepias incarnata, Decodon verticillatus, Hibiscus moscheutos, Oclemena nemoralis, Desmodium glabellum, Ludwigia alternifolia, Hypericum canadense, Polygala lutea, Xyris difformis,* and *Drosera intermedia.* A small patch of *Carex barrattii* was found near the stream at the edge of the woods. Other sedges seen in the vicinity included *Carex canescens, C. folliculata, Cyperus dentatus, Dulichium arundinaceum, Rhynchospora* *capitellata*, and *Scleria triglomerata*. Buried deep within a shrub thicket was *Smilax pseudo-china*.

Following lunch at the picnic area in Johnson Park, we drove south to a point where we could cross the Doves Mill Branch and explore the forest on the east side of the stream. Little diversity was seen as we bushwhacked through the mature *Chamaecyparis thyoides* swamp to reach the slow-moving water. The shrub understory consisted mostly of *Clethra alnifolia*, *Vaccinium corymbosum*, and *Rhododendron viscosum*. One severely browsed stem of *Smilax laurifolia* was noted. The herbaceous layer was dominated by sedges and ferns, with impressive clumps of *Carex atlantica* ssp. *capillacea*, *Carex collinsii*, and *Thelypteris simulata* covering most of the ground between the tree and shrub hummocks. We were dismayed to find a lush stand of *Microstegium vimineum* beneath an opening in the canopy.

Our final stop was in a dry cranberry bog, probably last cultivated in the 1980s. Thousands of *Vaccinium macrocarpon* plants had persisted and were widespread throughout the bog, which was dominated by graminoids, especially *Carex striata*. *Acer rubrum*, *Spiraea tomentosa*, and *Chamaedaphne calyculata* had begun to colonize the drier areas. Some of the other species present were *Juncus canadensis*, *J. pelocarpus*, *Panicum verrucosum*, *P. longifolium*, *Symphyotrichum novi-belgii*, *Osmunda regalis*, *Woodwardia areolata*, *W. virginica*, *Bartonia paniculata*, *Polygala cruciata*, *and Triadenum virginicum*. Thanks to Bill Standaert for maintaining a species list.

Attendance: 18. Report by leader: **Linda Kelly.**

6 August: Warren Grove Gunnery Range (WGR), East (Lower) Plains, Burlington County, New Jersey.

Within the maintenance complex of WGR, we noted a few plants of *Chenopodium pumilio*, a naturalized annual native of Australia, to be added to a growing list of invasives on severely disturbed upland here.

Over a span of many years, both leaders have conducted extensive surveys of WGR that have resulted in the discovery of 32 rare, threatened, and endangered (RTE) species. Our report on these plants is, in part, the subject of a paper in this issue of *Bartonia*.

The focus of this trip was a thorough search for any species not previously reported from the cedar-hardwood swamp, quaking bogs, and pockets of savannah that primarily occur along the northern border of WGR between Cabin Road (in the vicinity of an abandoned cabin) and the Oswego River. Despite the presence of suitable habitat, we once again were unsuccessful in discovering occurrences of *Platanthera integra*, *P. ciliaris*, *Spiranthes laciniata*, *Asclepias rubra*, and *Xyris fimbriata*. Records of these RTE species are known to occur within a distance of 1.5 miles from the boundary of WGR. We did, however, add another rare species to the WGR list, a small population of alga-like pondweed, *Potamogeton confervoides* (S3, LP), floating in the Oswego River with *Schoenoplectus subterminalis*. Also noted were a new sub-population of six plants of false or viscid asphodel, *Triantha racemosa (Tofieldia r.;* S1,E, LP) and a new sub-population of a few culms of Pickering's reed grass, *Calamogrostis pickeringii* (S1, E, LP).

A comparison was made of the latter grass, containing a twisted, geniculate awn attached near the base of the lemma, with the common Nuttall's reed grass, *Calamogrostis coarctata (C. cinnoides)*, containing a straight awn, inserted well above the middle of the lemma.

Our search further resulted in the relocation of occurrences of the following twelve previously discovered RTE species: *Schizaea pusilla, Narthecium americanum, Triantha racemosa, Sphagnum cyclophyllum, S. perichaetiale, S. portoricense, Calamovilfa brevipilis, Muhlenbergia torreyana, Rhynchospora cephalantha, R. pallida, Juncus caesariensis,* and *Lobelia canbyii.*

Not only does this remarkable wetland complex serve as a refuge to so many RTE species, but it also harbors an extensive number of common species typically associated with nutrient poor fens of the Outer Coastal Plain of New Jersey. From the ranks of the latter, the following were recorded: *Bartonia paniculata* ssp. *paniculata, B. virginica, Utricularia subulata* forma *cleistogoma, U. striata, U. cornuta, U. juncea, Oclomena nemoralis (Aster n.), Symphyotrichum novi-belgii* var. *novi-belgii (Aster n.), Rhexia virginica, Orontium aquaticum, Peltandra virginica, Proserpinaca pectinata, Drosera filiformis, D. intermedia, D. rotundifolia, Sarracenia purpurea* var. *purpurea, Lobelia nuttallii, Sabatia difformis* (several one-flowered specimens of a *Sabatia* first thought to be white forms of *S. angularis* proved to be *S. difformis*), *Polygala brevifolia, P. rotundifolia, Pogonia ophioglossoides, Sagittaria engelmanniana, Triadenum virginicum, Triantalis borealis, Lachnanthes caroliniana, Lophiola aurea, Juncus pelocarpus, Xyris difformis* var. *difformis, X. smalliana, X. torta, Eriocaulon aquaticum, E. compressum, E. decangulare* var. *decangulare, Eleocharis robbinsii, E. tuberculosa, Eriophorum virginicum, Rhynchospora alba, R. fusca, R. gracilenta, Scirpus cyperinus, Scleria muehlenbergia, Carex atlantica* ssp. *atlantica, C. collinsii, C. exilis, C. folliculata, C. livida, C. striata* var. *brevis, Cladium mariscoides, Cyperus dentatus, Dulichium arundinaceum, Andropogon glomeratus, Danthonia sericea* var. *epilis, Saccharum giganteum* (*Erianthus giganteus*), *Glyceria obtusa, Leersia oryzoides, Muhlenbergia uniflora, Panicum longifolium, P. ensifolium, P. virgatum, Lycopodiella alopecuroides, Osmunda cinnamomea, Woodwardia areolata, W. virginica, Hypericum denticulatum, Photinia floribunda,* and *Smilax pseudochina.* Special thanks go to Bill Standaert for maintaining a species list.

Attendance: 20. Leaders: **Ted Gordon and Walter Bien. Report by T. Gordon.**

12 August: Bulls Island Recreation Area, Hunterdon County, New Jersey. Joint trip with the Torrey Botanical Society.

Bulls Island is a low-lying island in the Delaware River. It supports an old growth floodplain forest dominated by large specimens of *Platanus occidentalis, Fraxinus americana, Acer saccharinum,* and *Liriodendron tulipifera*, with a scattering of *Acer negundo, Fraxinus pennsylvanica, Carya ovata*, and other species. The island was severely flooded in June of 2006; flooding is not a rare event, and evidence of this and earlier inundations was apparent everywhere.

After meeting at the park office, our group walked south along the east shore of the island, following a towpath used by 19th century canal boatmen. Deep silt, toppled trees, and washed-up debris covered much of the floodplain beyond the towpath. Visible plant species in bloom were few, and included *Scrophularia marilandica*, *Verbesina alterniflora*, *Laportea canadensis*, *Lythrum salicaria*, and several species of *Polygonum*. Species not in flower included *Perilla frutescens*, *Amaranthus spinosus*, *Asarum canadense*, *Arisaema dracontium*, and *Saururus cernuus*. Invasive species such as *Humulus japonicus* and *Microstegium vimineum* were common, and a few plants of *Polygonum perfoliatum* were noted. Non-flowering plants included *Matteuccia struthiopteris*, *Onoclea sensibilis*, and *Equisetum hyemale*, all of which were common. *Ulmus rubra* was found and compared with *U. americana*. An unusual find was a battered patch of *Ribes missouriense*.

After crossing to the west side of the island, the group found *Justicia americana*, just coming into bloom, growing in profusion on wet riverside gravels. *Pellaea glabella*, brown and much desiccated, was found growing in crevices of the abutments of the footbridge that crossed the Delaware River at that point.

After lunch in a cool, shaded picnic grove, the group drove north a few miles to the site of the old Byram railroad station. A good find there was *Ptelea trifoliata*, in fruit. Also noted were *Verbascum lychnites* (just past bloom) and a small sapling of *Juglans cinerea*. On rocky slopes on the east side of Route 29, *Pycnanthemum incanum*, *Helianthus decapetalus*, and *Silene stellata* were in bloom. Other species found there were *Ceanothus americanus*, *Heuchera americana*, *Woodsia obtusa*, and *Staphylea trifoliata*.

Attendance: 13. Report by leaders: **Karl Anderson and Linda Kelly.**

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Program of Meetings
September 2006-May 2007

Date	*Subject*	*Speaker*
2006		
28 Sep	Members' Reports on Summer Botanizing	
26 Oct	Floristic Diversity in the Western Cape Region of South Africa	Ann F. Rhoads
16 Nov	Botanical Art Before Linnaeus in the Library of the Academy of Natural Sciences	Alfred E. Schuyler
21 Dec	Update on the New Jersey Flora Project	Joseph R. Arsenault
2007		
25 Jan	The *Rubus* Problem: a Review of the Taxonomy of the Raspberries and Blackberries of the Northeastern United States	Gerry Moore
22 Feb	Plants of Belize, Cultural and Botanical Melting Pot	Robert F. C. Naczi
22 Mar	Between a Rock and a Hard Place: Plant Habitats Scrutinized	Richard Mellon
26 Apr	Plants and Geology of Burnt Cape, Newfoundland	Elizabeth Smith and Jackie Bessey
24 May	Recovery of a Lichen Community near the Palmerton Zinc	Natalie M. Howe

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