Vegetation Survey of the Carbon Limestone Sanitary Landfill in Poland Township, Mahoning County, Ohio

By

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ABSTRACT

An eight month long survey conducted during the growing season (March through October of 1998) provides an overview of the vegetation of a depleted limestone quarry that now serves as a sanitary landfill facility. The landfill facility is located within the Glaciated Allegheny Plateau Province of the Appalachian Highlands of Eastern Ohio.

Soils of the landfill facility consist predominantly of an unconsolidated heterogeneous mixture of mine spoil, glacial till, and other geologic materials resulting from activity of quarrying and landfill operations. The climate of the area is classified as continental, characterized by wide seasonal temperature fluctuations and moderate precipitation.

The vegetation survey compiles baseline data on the flora of the tract. Three hundred eighty seven species of vascular plant species representing 231 genera and 82 families were identified. Comparison of species richness and abundance were made to a similar site at Egypt Swamp, Green Township, Mahoning County, Ohio. Additional observations on successional status and pathways of plant communities were made in order to make comparisons to successional concepts and models.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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INTRODUCTION

In order to set aside a portion of the landfill facility for scientific study, teaching, and recreation, Browning Ferris Industries created the Charles Cronin Wildlife Habitat area. As a part of the permitting process for this Wildlife Habitat area, submission of a species list of vascular plants found to occur within the proposed habitat area, was required.

The primary purpose of this study is to provide the plant species list required by the permitting process. To make the study more useful, additional data on relative abundance of species and successional status of plant communities encountered at the facility was gathered. Data is compared to that gathered during a previously conducted floristic study done at Egypt Swamp in Green Township, Mahoning County, in Ohio.

Previous relevant floristic literature for Mahoning County includes, *Catalog of Ohio Vascular Plants* (Schaffner 1914), *Revised Catalog of Ohio Vascular Plants* (Schaffner 1932), *Deciduous Forests of Eastern North America* (Braun 1950), *The Woody Plants of Ohio* (Braun 1961),*The Monocotyledoneae of Ohio* (Braun 1967), *Pteridophyte Checklist of Ashtabula, Trumbull, and Mahoning Counties* (Chuey and Sturm 1969), *The Herbaceous Angiosperm Flora of Mahoning County Ohio* (Chuey 1972), *Noteworthy Collection* (Chuey 1995), *The Asteraceae of Ohio-Missed Records* (Chuey and Isaac 1996), *The Dicotyledoneae of Ohio Part 3: Asteraceae* (Fisher 1988), *The Vascular Flora of the Glaciated Allegheny Plateau Region of Ohio* (Andreas 1989), *The Dicotyledoneae of Ohio Part 2: Linaceae through Campanulaceae* (Cooperrider 1995), and *A Phytogeographical and Ecological Study of Prenanthes crepidinea Michx. (Asteraceae)* (Isaac 2000).

The objectives of this study are to:

1. Collect and identify all vascular plant species within the landfill unit.

2. Create the list of vascular plants required by the permitting process.

3. Prepare duplicate sets of herbarium specimens. One for baseline data and future reference work at Youngstown State University and the other for use as a teaching collection at the landfill facility.

4. Compare the species richness and abundance of the landfill flora to that of Egypt Swamp, in Green Township, Mahoning County Ohio deemed to be "floristically representative" of the county.

5. Describe plant communities encountered at the landfill facility and their successional status.

6. Develop an annotated plant list summarizing the landfill vegetation useful for:

   a. Studies of animal communities within the landfill area (Anderson 1999; and Jones personal communication).

   b. Developing a comprehensive checklist of the flora of Mahoning County, Ohio; based on collections at YUO (Herbarium of Youngstown State University) and CM (Carnegie Museum of Natural History), as well as, previous publications.

   c. Management of flora within the facility including; cultivated crops, reclamation plantings, landscaping, and weed control.

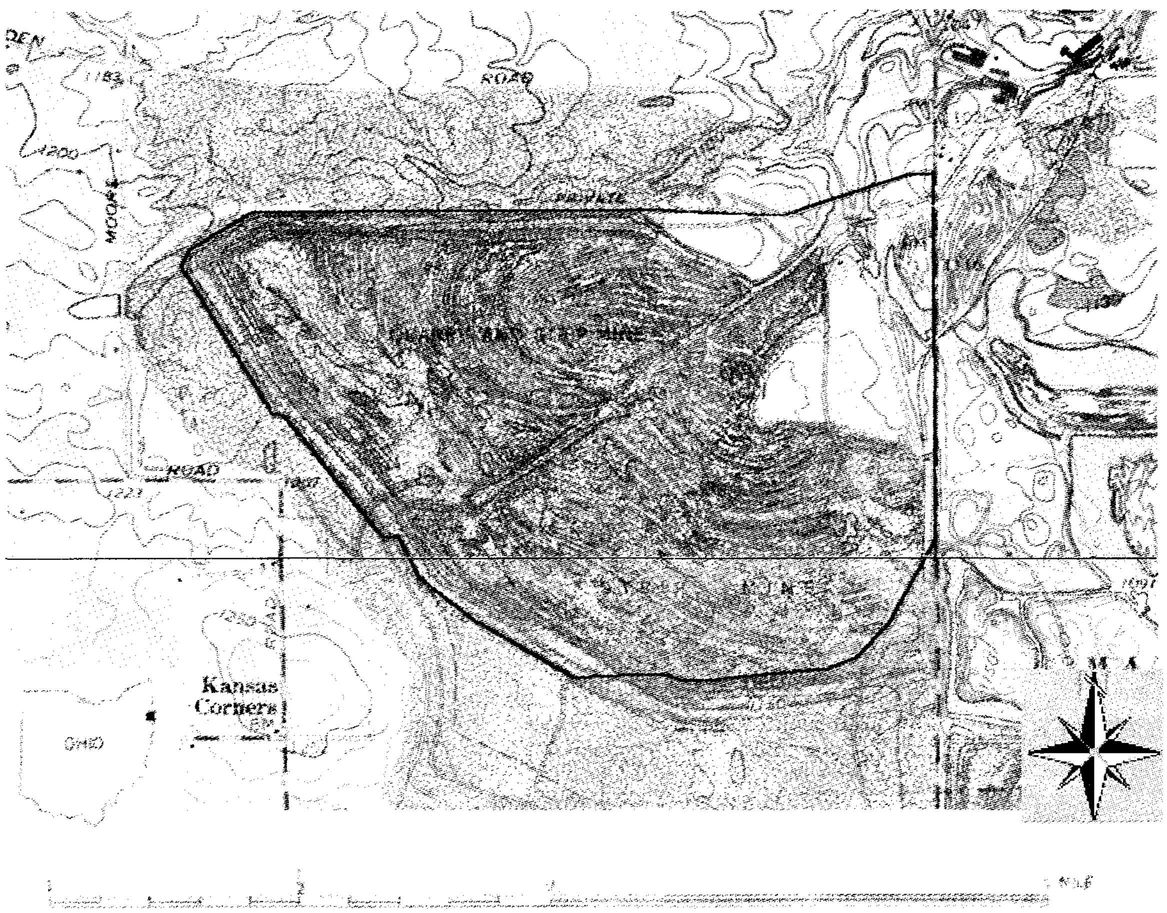
During the course of the study, ownership and operation of the facility changed from Browning Ferris Industries to Waste Management. Several of the personnel remained at the facility in managerial and operational capacities. Changes did not affect the study.

MATERIALS AND METHODS

Total species inventories require techniques that include small habitat areas, which otherwise may go unsurveyed, and provide the most accurate measure of species richness. Since plot based sampling provides only an estimate of a sites true species richness, the inventory was made utilizing botanical reconnaissance meander surveys, which eliminates plot boundary and other constraints allowing active searches for plants (Carbonneau and Allen 1995). Active searches, conducted early in the growing season, for unusual communities or habitats that may harbor unusual plant species, as well as ongoing meander surveys throughout the season, allowed good coverage of all landfill areas.

Collections of vascular plants from the Carbon Limestone Sanitary Facility (Fig.1) were made on 24 days. These were spaced at weekly intervals throughout the growing season. Plants to be used as voucher specimens were collected in duplicate sets using standard herbarium techniques (Foreman & Bridson 1989). Specimen samples were collected during flowering and fruiting stages whenever possible. Generally entire plants of herbs were taken, and two years growth from woody plants. For many species (i.e., woody plants, etc.) two sets of vouchers were collected to show various stages of phenology, making the collections more useful to non-botanists.

Specimens were identified using the currently completed volumes of the *Flora of North America* (Flora of North America Editorial Committee 1993), the *Manual of Vascular Plants of Northeastern United States and Adjacent Canada* (Gleason and Cronquist 1991), *The Plants of Pennsylvania* (Rhoads and Block 2000), and the *Manual of Cultivated Plants* (Bailey 1951). Verifications were based on collections at YUO (Herbarium of Youngstown State University) and CM (Carnegie Museum of Natural


ROAD
MOORE
PRIVATE
ROAD
ROAD
Kansas
Corners
1200
1223

History-Section of Botany). Herbarium acronyms follow standard international abbreviations (Holmgren 1981). Order of arrangement follows the new Flora of North America (1993) for all relevant species; otherwise the Gleason and Cronquist manual (1991) was used. The genera and species were listed in alphabetical order within their families.

Label data for each specimen included the following information: The scientific name for each plant, a vernacular name whenever possible, collector name and number, date of collection, locality- state, county, township, area within the landfill site, relative abundance, habitat and status as a native, cultivated, or alien species.

Relative abundance of plant species within the study area were ranked as Rare-few plants occurring in a single or few scattered locations, Sparse- infrequently found, Common-frequently encountered, Abundant-occurring in large populations often encountered. Abundance was estimated based on visual impression of the numbers of plants encountered in the field, density, and the amount of area they covered. Relative abundance rankings follow Chuey (1972)

Comparison of the degree of similarity between the landfill facility site and the Egypt Swamp site were made using Sørenson's Index of Similarity. The index measures number of coinciding species occurrences against the number of theoretically possible co-occurrences (Mueller-Dombois and Ellenberg 1974). The Sørenson Index of Similarity was determined using the formula SSI=2C/A+B x 100, where A = total number of species at site A, B = total number of species at site B, and C = total number of species at both sites A and B. Barbour et al (1987) consider any two sites with a SSI value greater than 0.5 to be similar or closely related.

Relative abundance, total numbers of plant families and species, and total numbers of alien and introduced monocots and dicots were also compared. Botanical reconnaissance meander surveys were utilized during the Egypt Swamp survey, which was conducted from March through September of 1967.

Delineation of communities observed at the landfill facility follows Fike (1999) and is based upon The Nature Conservancy's International Vegetation Classification that is currently under development and refinement. Community types listed in this system are based on physiognomy, hydrology, species composition, ecological processes, and distribution.

Additional observations on successional status and pathways of plant communities were made in order to make comparisons to successional concepts and models. These include the Monoclimax community theory advanced by Clements (1916); the Holistic concept proposed by Odum (1983); the Reductionist concept proposed by Noble and Slatyer 1980; Peet and Christianson 1980); Facilitation, Inhibition, and Tolerance models proposed by Connell and Slatyer (1997); and the Resource Ratio model proposed by Tillman (1985, 1988).

In order to make the annotated checklist more user friendly, all label data has been entered into a searchable computer database file. The file is in a Paradox 4.0 format.

CARBON LIMESTONE SANITARY FACILITY SITE DESCRIPTION

The Carbon Limestone Sanitary Facility is located in southeastern Poland Township, Mahoning County, Ohio. The study site includes an area of approximately 1.1 square miles. It is a partially reclaimed, depleted limestone quarry that served as a sanitary landfill (Rizzo Associates) for Browning Ferris Industries, but is now operated by Waste Management.

Geologically the landfill area lies within the Glaciated Allegheny Plateau Province of the Appalachain Highlands (Braun 1950). The area is underlain by sandstone bedrock formed during the Mississippian and Pennsylvanian Periods. During the Pleistocene Epoch, the Illinoin and Wisconsin glaciers invaded the area (White 1953). Area soils have formed almost entirely of parent material deposited during the late Wisconsin glaciation (Lessig et al. 1971).

Soils of the Carbon Limestone Sanitary Facility can be divided into three types. 1: Naturally occurring soils. Soils such as Canfield silt-loam and other silty, gravely, or clay loams are common throughout the county. These soils can be found in undisturbed areas on the periphery of the landfill site. 2: Strip mine spoils, shale, and sandstone materials. These soils consist of ungraded materials removed as overburden during the limestone quarrying process. They are often mixed with the overburden (glacial till materials), and are quite steep and rocky in some areas. Large areas at both the northern and southern limits of the facility have this type of soil composition. 3: Reclaimed soils. These soils are typical in areas that have been graded and reclaimed during the landfill process. Slopes are lessened to prevent erosion and a layer of mixed soil material is applied to encourage plant growth.

Woody species planted in reclaimed areas included *Pinus strobus* L., *P. rigida* Miller, *Picea abies* (L.) Karsten, and *Elaeagnus umbellata* Thunb. Herbaceous species included *Festuca elatior* L. *Tridens flava* (L.) Hitchc., *Trifolium* sps., *Viccia* sps., *Melilotus alba* Medikus, *Lespideza virginica* (L.) Britton, and *Lotus corniculatus* L.

Large interior sections of the landfill area have been reclaimed as part of the landfill process. A few outcrops of exposed limestone left by quarry operations are still evident at the facility. They can be found in areas where the high wall remains, as well as in a few small pockets along the northern periphery of the site.

Maximum elevation at the site is approximately 1,271 ft.; the minimum is approximately 1,051 ft., giving a maximum relief of just over 220 ft. Within Mahoning County, a maximum elevation of 1,314 feet lies to the southwest in Green Township, and a minimum elevation of 795 feet is found just north of the landfill site in Poland Township, giving a maximum relief of 519 feet.

The Carbon Limestone Sanitary Facility is drained by two small streams. Falling Springs Run which flows northeastward into the Mahoning River, and Hickory Creek which flows southeastward into the Beaver River. Both systems eventually flows southeastward into the Ohio River. Occasional pumping of surface water is conducted to assist in maintaining ground water levels at the landfill facility.

The continental climate of Mahoning County is characterized by wide seasonal temperature differences. Average yearly precipitation is 34.25 inches, which falls mostly during the warmer parts of the year. Measurable amounts of this precipitation fall on an average of about 150 days of the year (Lessig et al. 1971).

The study area lies within the Maple-Beech Forest Region of Ohio (Braun 1950), but the original forest cover has been removed from the study site by past land use practices.

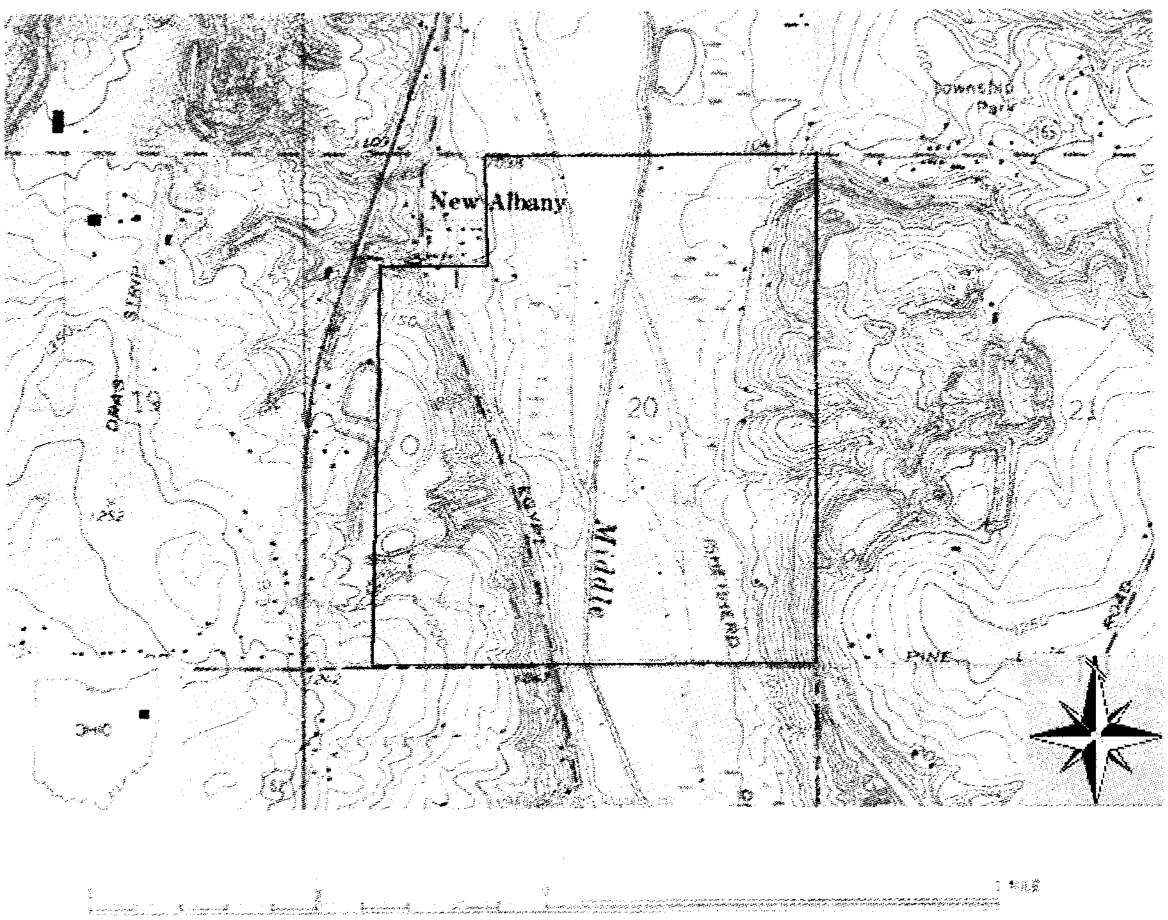
Ecologically, the Carbon Limestone Sanitary Landfill Facility contains many different plant communities, though many are relatively small in area. These include cultivated and mowed fields, landscaped areas, old fields in various successional stages, mowed and unmowed roadsides, regenerated hardwood forest, open quarried areas, sedimentation ponds, vernal ponds and pools, other wetland communities, and others such as reclaimed areas seeded in grasses or other herbs.

EGYPT SWAMP SITE DESCRIPTION

The Egypt Swamp study site was described by Chuey (1972) as "A 512-acre section of the county, the northern third of what is locally known as 'Egypt Swamp', was chosen by the author for intensive study. The area is located in Green Township (Fig.2) and consists of a broad valley with slopes averaging 20 degrees (maximum of 45 degrees) facing east and west. The area is bounded on the north by State Route 165 and on the south by Pine Lake Road.

Ecologically 'Egypt Swamp' contains many different communities: oldfield, beech-maple woods, and roadside communities on all topographical features; powerline right-of-way and swamp communities on the bottomland and terraces; and strip-mine vegetation only on the upland. Because of the large number of habitats present, it is believed that this portion of 'Egypt Swamp' is floristically representative of the various habitats of the entire county."

The Egypt Swamp site lies approximately 15 miles west south west of the landfill facility. Geology, climate, past land use practice, strip mining, and inclusion in the Maple-Beech Forest Region are common to both sites.


New Albany
19
20
21
Middle

RESULTS

Over the course of the growing season 614 collections were made at the landfill facility. Specimens were stored at Youngstown State University. One set was processed for deposition into the herbarium (YUO), and the duplicate set was processed for a collection to be kept at the landfill facility for educational purposes. These collections included plants representing 82 families, 231 genera, and 387 species (Appendix A). This represents over 39% of the known county flora when cultivated species are excluded. Collecting some species in both flowering and fruiting stages, as well as making multiple collections of difficult taxa, account for the differences in collection and species numbers.

Twenty-six cultivated species were collected. Of these three were gymnosperms, three were woody dicots, and 20 were herbaceous dicots. These cultivated species are used to reduce erosion and dust problems, or to add to the aesthetics of roadsides and managed areas surrounding buildings at the facility. Several species used for this purpose are native species or aliens of widespread distribution, which already had occurred in the wild state at the landfill or elsewhere in Mahoning County. Good examples of these species are *Rudbeckia triloba* L. (Coneflower), *Festuca elatior* L. (Fescue), and *Pyrus baccata* L. (Siberian crabapple).

Collections included five pteridophytes; five gymnosperms; and 377 angiosperms, of which 77 species were monocots and 300 were dicots. Of the 83 woody species collected; six were cultivated (three gymnosperms and three dicots), and 77 were wild (two gymnosperms and 75 dicots). No woody monocots were encountered. Of the 361 non-cultivated species collected, 37 represent new county records (Table 1).

Table 1. County records collected at the Carbon Limestone Facility, Poland Township, Mahoning County, Ohio. (Nativity: n=native, a=alien, c=cultivated)

Cupressaceae	
Juniperus virginiana	n
Ranunculaceae	
Anemone virginiana	n
Ulmaceae	
Ulmus pumila	a
Chenopodiaceae	
Chenopodium leptophyllum	a
Polygonaceae	
Polygonum hydropiper	a
Rumex orbiculatus	n
Salicaceae	
Salix myricoides	n
Capparaceae	
Cleome ornithopodioides	a
Polanisia dodecandra	a
Brassicaceae	
Erucastrum gallicum	a
Thlaspi arvense	a
Resedaceae	
Reseda lutea	a
Rosaceae	
Potentilla simplex	n
Prunus persica	a
Pyrus baccata	a
Rosa canina	a
Rosa setigera	a
Fabaceae	
Coronilla varia	a
Lespedeza virginica	n
Trifolium campestre	a
Onagraceae	
Epilobium parviflorum	n
Rubiaceae	
Galium trifidum	n
Asteraceae	
Centaurea jacea	a
Eupatorium altissimum	n
Helianthus annuus	a
Lactuca saligna	a
Potamogetonaceae	
Potamogeton pusillus	n
Juncaceae	
Juncus nodosus	n
Cyperaceae	
Carex bushii	n
Carex comosa	n
Carex granularis	n
Carex hystericina	n
Eleocharis palustris	n
Poaceae	
Eragrostis minor	a
Glyceria melicaria	n
Glyceria septentrionalis	n
Liliaceae	
Allium schoenoprasum	a

The largest families were Asteraceae (61 species representing 35 genera), Poaceae (38 species representing 23 genera), and Cyperaceae (17 species representing four genera). The largest genus encountered was *Carex* (represented by 12 species) of the family Cyperaceae.

Before the field season was complete a partial species list was given to Browning Ferris Industries for submission to the ODNR (Ohio Department of Natural Resources). This fulfilled part of a requirement for status as wildlife habitat for an unused section of the landfill area. A final checklist was provided to Waste Management upon it's completion.

As anticipated, no federally or state endangered, threatened or rare species of plants were encountered during this survey. Highly disturbed habitats rarely provide adequate habitat for federally or state protected species.

The flora of the landfill contains many alien species. These are defined as species both purposefully or accidentally introduced over time, which would not otherwise naturally occur at the site. Many of these species are of European origin, others have become adventive, moving unaided into our area due, to human activity or other factors. The total number of alien species encountered was 152, approximately 39%. Excluding cultivated species these figures drop to 135 and 36% respectively. Of the 387 vascular plant species collected at Carbon Limestone Sanitary Facility 48 species ranked as abundant, 162 species ranked as common, 166 species ranked as sparse, and 11 species ranked as rare.

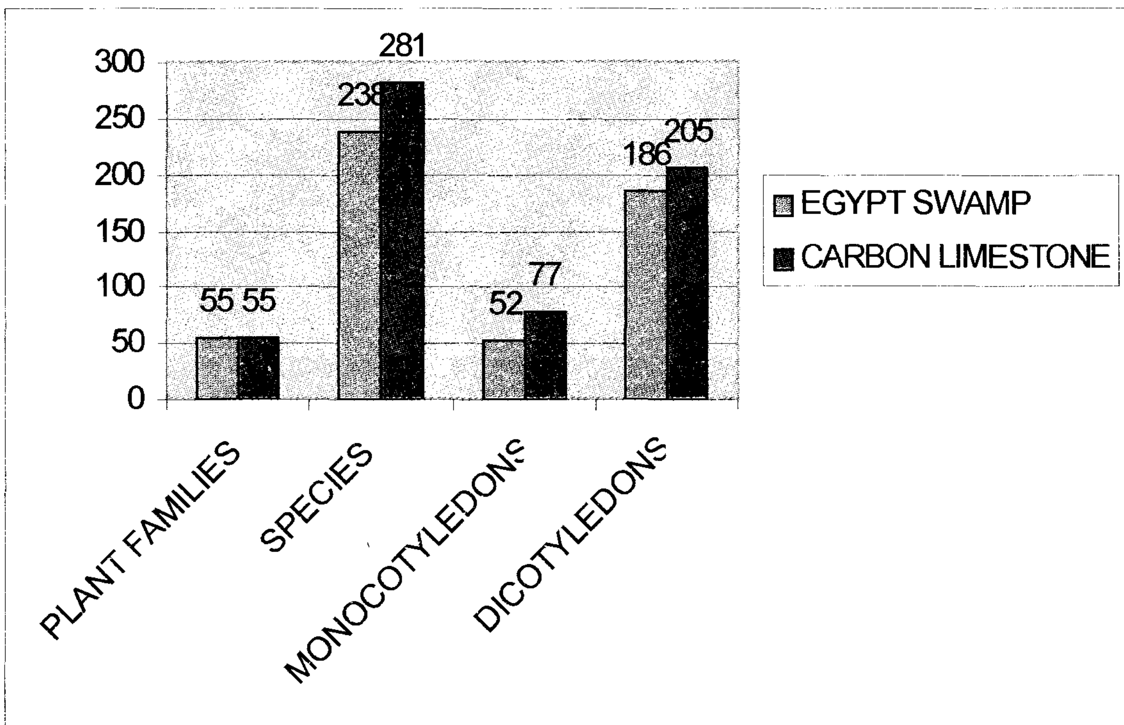
The Carbon Limestone Sanitary Facility survey resulted in a species list that includes 281 herbaceous angiosperms, of which 77 are monocots from ten families and

204 are dicots from 45 families (this excludes the 106 species of woody, cultivated, and non-angiosperm species) which occur at the landfill site (an area of approximately 684 acres) (Fig. 3). Forty nine of the Monocots (65%) are native to the area, 27 (35%) are alien species. One hundred two of the dicots (50%) are native species. One hundred two (50%) are alien species (Figs.4; Table 2).

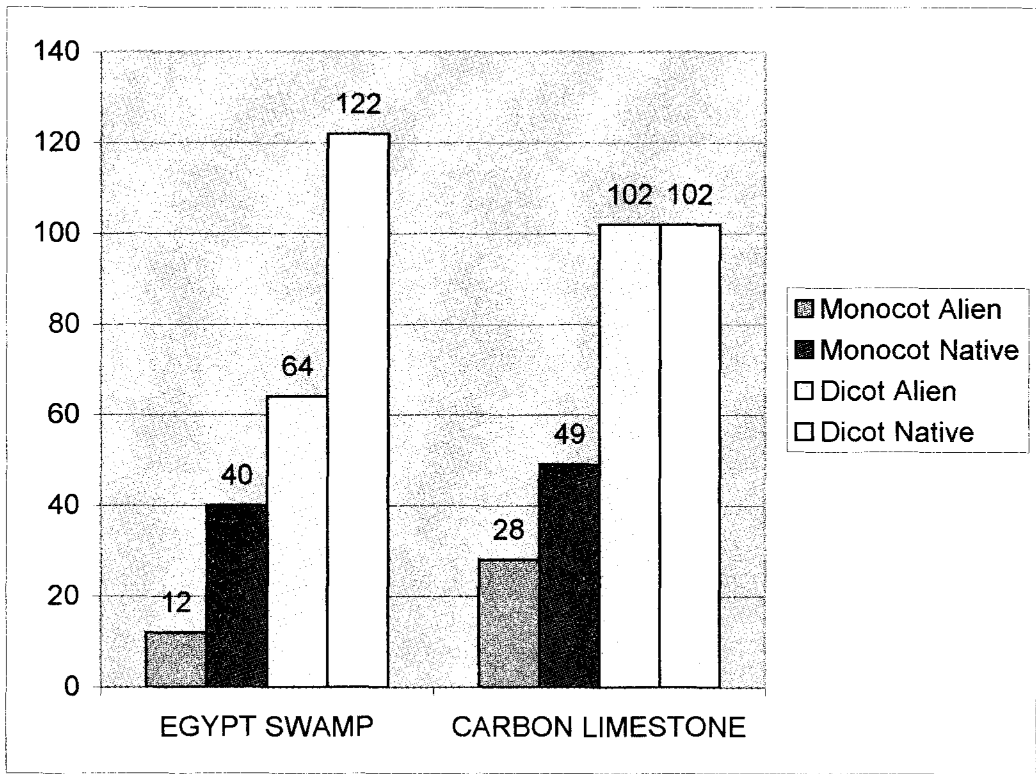
Relative abundance rankings for herbaceous angiosperms at the landfill facility were: abundant 35 (12%), common 126 (45%), sparse 115 (41%), and rare five (2%) (Fig. 5). Since no woody species were collected during the Egypt Swamp survey the comparison to the 82 species (six cultivated) from 27 families is impossible (Table 3).

The Egypt Swamp survey (Chuey 1972) included 238 herbaceous angiosperms including 52 monocots from ten families, and 186 dicots from 46 families. Forty of the Monocots (73%) are native to the area. Twelve (27%) are alien species. One hundred twenty three of the dicots (66%) are native species. Twenty-eight (34%) are alien species. Overall 75 of the 238 species, or 31.5% of the total species herbaceous angiosperm flora at Egypt Swamp, were aliens. Of the species collected at Egypt Swamp, 54 (26%) were ranked as abundant, 118 (57%) as common, 34 (16%) as sparse, and 2 (1%) as rare. Relative abundance of thirty species was unranked.

Species richness of the landfill area, which is comprised of approximately 684 acres, is comparable to that of at least some areas of the county outside the landfill. A survey of a 512 acre area within Mahoning County, Ohio known as Egypt Swamp (Fig. 2); an area believed to be "floristically representative of the county" (Chuey 1972); demonstrates this fact well. The large number of habitats within that study area contained



300
250
200
150
100
50
0
281
238
205
186
77
55 55
52
EGYPT SWAMP
CARBON LIMESTONE
PLANT FAMILIES
SPECIES
MONOCOTYLEDONS
DICOTYLEDONS



140
120
100
80
60
40
20
0
122
102 102
64
49
40
28
12
EGYPT SWAMP
CARBON LIMESTONE
Monocot Alien
Monocot Native
Dicot Alien
Dicot Native

Table 2. Comparison of herbaceous angiosperm flora of Egypt Swamp, Green Township, Mahoning County, Ohio and the Carbon Limestone Sanitary Facility, Poland Township, Mahoning County, Ohio.

	EGYPT SWAMP		CARBON LIMESTONE	
PLANT FAMILIES	55		55	
SPECIES	238		281	b
MONOCOTYLEDONS	52		77	
	Aliens	*Native*	*Aliens*	*Native*
	12	40	28	49
DICOTYLEDONS	186		204	
	Aliens	*Native*	*Aliens*	*Native*
	64	122	102	102
TOTALS				
	Aliens	*Native*	*Aliens*	*Native*
	76	162	130	151

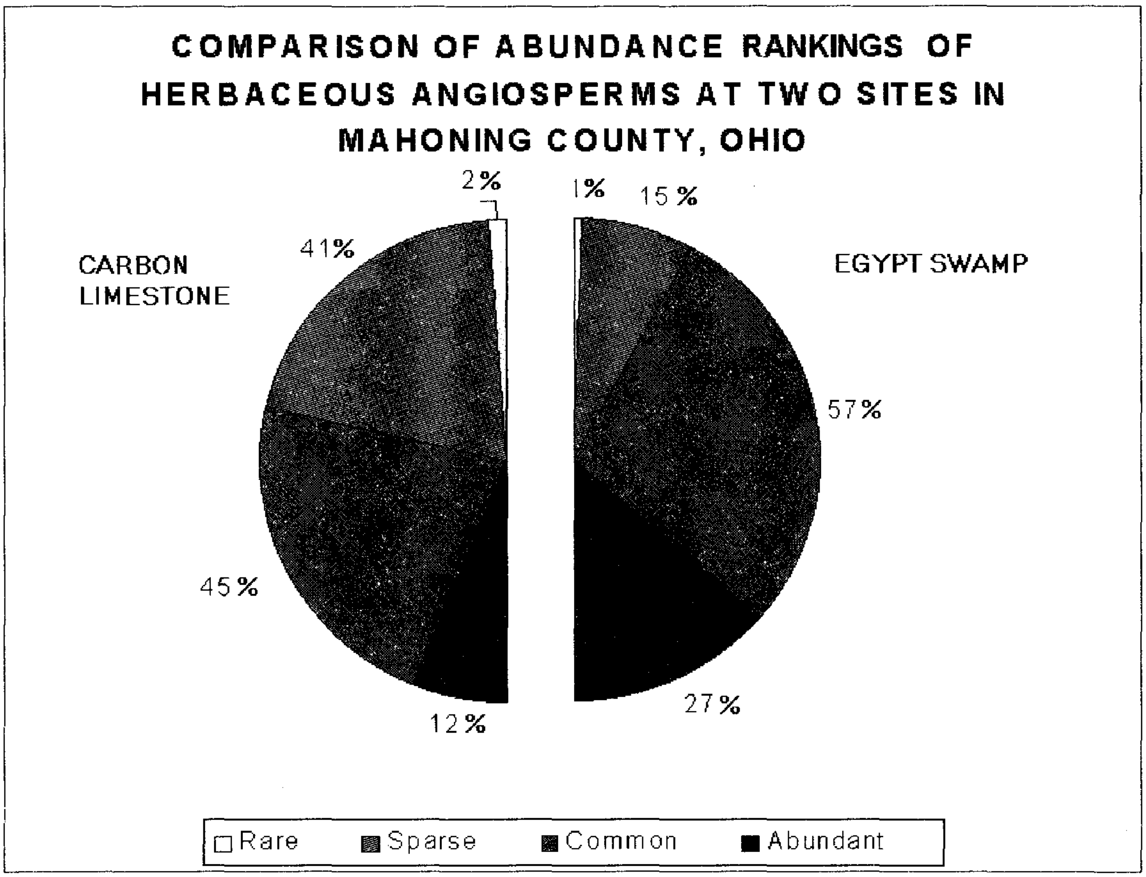

COMPARISON OF ABUNDANCE RANKINGS OF HERBACEOUS ANGIOSPERMS AT TWO SITES IN MAHONING COUNTY, OHIO
CARBON LIMESTONE
EGYPT SWAMP
2%
41%
45%
12%
1%
15%
57%
27%
Rare
Sparse
Common
Abundant

Table 3. Abundance rankings of herbaceous angiosperm flora of Egypt Swamp, Green Township, Mahoning County, Ohio and the Carbon Limestone Sanitary Facility, Poland Township, Mahoning County, Ohio.

ABUNDANCE RANKINGS	EGYPT SWAMP	CARBON LIMESTONE
Rare	2	5
Sparse	34	115
Common	118	126
Abundant	54	35

a variety of different communities found within the landfill unit as well. These include oldfield, 'forested' areas, and roadside communities on a variety of topographical features such as terraces and bottom lands. Swamp communities on the bottoms and terraces at Egypt Swamp can be compared to the settling ponds (Fig. 6), small watercourses, and vernal pools at the landfill facility. Several facultative wetland species (Rhoads and Klein 1993) were encountered during both surveys. These include *Typha angustifolia* L., *T. latifolia* L., *Alisma subcordatum* Raf., *Glyceria canadensis* (Michx.) Trin., *Symplocarpus foetidus* (L.) Nutt., *Ludwigia palustris* (L.) Elliott., *Lysimachia nummularia* L., *Asclepias incarnata* L., *Mimulus ringens* L., several species of *Carex*, *Scirpus*, *Juncus*, and others.

Both sites contained, or had contained pastures and oldfield habitats. Many oldfield species are common at landfill sites (Stalter 1984). A partially abandoned farm at the landfill site provided habitat for several early successional plant communities commonly found in abandoned pastures and agricultural fields, as well as, a variety of agricultural weeds typical of active farms. Some common agricultural weeds encountered at both Egypt swamp and the landfill facility include; *Cirsium vulgare* (Savi) Tenore., *Elytrigia repens* (L.) Nevski., *Echinocloa crusgalli* (L.) P. Beauv., *Asclepias syricia* L., *Chenopodium album* L., and *Glechoma hederacea* L. Although the forest cover had been removed from the landfill site, several woodland species were able to persist in the marginal habitat found in brushy swales along roadsides at the edges of the facility. Species numbers for these upland plants were generally lower for the landfill site than at Egypt Swamp. Some species common to forested areas of both studies are *Dactylis glomerata* L., *Arabis laevigata* (Muhl.) Poiret., *Lysimachia quadrifolia* L., *Impatiens capensis* Meerb., *Solidago caesia* L., and *Viola striata* Aiton.

A strip mine adjacent to the upland sites at Egypt Swamp provided openings on a variety of soils similar to those typically found in both reclaimed and unreclaimed areas of the landfill. Encountered in both studies were plants such as *Potentilla simplex* Michx., *Polygonum pensylvanicum* L., *Setaria glauca* (L.) P. Beauv., *Juncus effusus* L., and *Aster pilosus* Willd.

Species composition of roadside ditches, where water is generally available year round, proved to be remarkably similar. Species typical of such sites encountered during both studies included *Typha latifolia* L., *Carex vulpinoidea* Michx., *Alisma subcordatum* Raf., *Lysimachia nummularia* L., and *Cyperus strigosus* L.

The high percentage of alien herbaceous dicots at the landfill facility suggests that many of these species are well adapted to colonizing disturbed ecosystems and did so more readily than our native species. Plausible reasons for this include; growth of invading species in nearby ruderal habitats, easily disseminated seeds, and attractiveness of propagules to mammals and avifauna in the vicinity.

Calculating Sørenson's Index of Similarity shows the sites to be similar. The SSI for the sites = 2(134)/(281+238) x 100 =51.6.

Comparisons on a larger scale also proved interesting as well. The total known flora of Mahoning County, Ohio can be readily compared with that of adjacent Lawrence County, Pennsylvania. Currently the known flora of adjacent Lawrence County Pennsylvania consists of 999 species. This figure is easily derived from the completed databases at CM and YUO. Databases for Lawrence County are regularly maintained by both herbaria, and accuracy of data is high due to careful examination of all specimens and data by herbaria personnel. Both the YUO and CM databases are incomplete for

Mahoning County, Ohio, however. Three hundred forty seven species are currently included in the YUO database. The CM database contains only 76 additional species. Previous literature citations Chuey 1972, Braun 1967, Fisher 1988 and Cooperrider 1995, as well as undatabased specimens at YUO will add another 527 species to the known flora of Mahoning County for a total flora of 950 species. Thirty-seven additional county records from Carbon Limestone Sanitary facility will increase the total to 987 vascular plant species. Once the data for the rest of the herbarium records are checked for accuracy, and the database project is completed, a checklist for the vascular flora of Mahoning County will be easily assembled.

In spite of the high number of alien herbaceous dicots, the flora of the landfill facility is composed of 65% native and 35% alien species. This closely approximates the percentages of aliens found on both a county and statewide basis. The Mahoning County flora consists of approximately 987 species of which 32% are alien. Of the 999 plant species found in Lawrence County flora 20.3% are alien. On a statewide basis the alien component of the flora of Ohio is 25.8% of the known 3,152 species representing 176 families. While 27.3% of the 3,694 species, representing 180 families included for the flora of Pennsylvania, are considered aliens (Kartesz 1999). Despite a variety of factors, species richness of alien and natural components at the landfill facility vary little from known species richness of county and state levels in our area. Species diversity, however, does vary. By percentage, fewer species encountered at landfill facility were listed as abundant and common, and more species were listed as sparse or rare when compared to those at Egypt Swamp. Frequency and amplitude of disturbance due in part to landfill operations, as well as time required, not only for establishment, but also for species stabilization, may be the primary causal factor for this disparity.

Communities at the landfill facility were delineated using Fike's descriptions and are divided into terrestrial and palustrine (Table 4). Although Fike's system fits well for many communities, it is not designed for some very early successional communities or for aquatic communities.

Several very different community types occur in areas of unreclaimed quarry. A small area adjacent to the eastern boundary, which suffers from regular minimal human disturbance, but is part of the designated wildlife area, is one of the earliest mined sites at the facility. It has a closed canopy Black Locust forest community dominated by *Robinia pseudoacacia* L., a relatively long lived tree species. The somewhat mesic soil of the area is composed of shaley overburden on steep slopes and flat bottoms. In this area of low diversity *Toxicodendron radicans* (L.) Kuntze., *Rosa multiflora* Thunb., *Rubus allegheniensis* T. C. Porter, and *Lonicera morrowii* A. Gray grow as understory woody plants. Few species of herbs are relatively abundant these include *Cardamine hirsuta* L., *Alliaria petiolata* (Beib.) Cavara & Grande, and *Eupatorium rugosum* Houttyun. Little change has occurred since canopy closure was achieved, probably several decades ago. A hiking trail has been installed in this area and will doubtless assist a few weedy species in establishing a presence in the future. After several decades a flora much different from the original Beech Maple climax forest has developed in this portion of the landfill facility. Final composition of trees and herbs in this area is unlikely to reflect the native mixed deciduous forests common to the area in the past. Obviously the pioneering concepts set

Table 4. Plant communities encountered at the Carbon Limestone Facility, Poland Township, Mahoning County, Ohio.

Terrestrial Plant communities

1. Dry White Pine (hemlock) - oak forest

2. Dry oak -mixed hardwood forest

3. Black Cherry -northern hardwood forest

4. Tuliptree -beech-maple forest

5. Red maple -terrestrial forest

6. Aspen/gray (paper) birch forest

7. Black locust forest

Palustrine (Wetland) Plant communities

1. Cat-tail marsh

2. Mixed forb marsh

3. Herbaceous vernal pond

4. Wet meadow

5. Skunk cabbage -golden saxifrage forest seep

forth by Clements (1916) are incomplete and cannot fully explain successional pathways encountered at the landfill facility.

The Resource Ratio model proposed by Tillman (1985) which incorporates competition for resources and limiting resources best explains evolution of this community. The black locust trees, a pioneer species capable of establishing themselves in nitrogen poor soils, invaded the nitrogen poor shale soils, which were exposed to high light levels. As the trees grew and matured they produced densely shaded areas inhospitable to potential competitors such as black cherry or red maple even though levels of available nitrogen have increased due to the presence of the black locust.

A second area of unreclaimed quarry along the northern periphery of the landfill is somewhat larger, and now covered by a young Dry Oak-Mixed hardwood forest. The herbaceous pioneer species that originally colonized this area have mostly been replaced by a forest co-dominated by *Robinia pseudoacacia* L. and *Ulmus americana* L., with *Populus tremuloides* Michx., *Fraxinus americana* L., and *Prunus serotina* Ehrh., growing together as minor components. Understory woody plants display high diversity and include *Quercus rubra* L., *Ostrya virginiana* (Miller) K. Koch., *Cornus florida* L., *Elaeagnus umbellata* Thunb., *Parthenocissus quinquefolia* (L.) Planchon., *Vitis riparia* Michx., *Rubus pensylvanica* T. C. Porter., and *Juniperus virginiana* L. The herbaceous layer is very sparse due to canopy closure. Herbs include *Osmorhiza longistylis* Torr. DC., *Lysimachia quadrifolia* L., *Dryopteris carthusiana* (Villars) H. P. Fuchs., *Oxalis stricta* L., and *Galium circaezans* Michx.

Communities on these dryer sites where resources like water and organic materials are somewhat limited best demonstrate the Inhibition model proposed by Connell and

Slatyer (1997). On these sites no species is completely superior to others. The early colonists establish themselves, modify the environment to their advantage, and hold out against invaders until they are eventually supplanted by better adapted, longer lived species.

Wet lands on unreclaimed sites including vernal pools, Herbaceous Vernal Pond communities, contain minor woody components such as *Acer rubrum* L. and *Salix* sps. Herbs were more varied at these sites and included a variety of grasses, sedges, and rushes, as well as aquatic and semi-aquatic herbs.

Change in vegetation covering the dry portions of the unreclaimed areas will continue at a slow pace because soils are nutrient poor, accumulation of biomass is relatively slow, and distance to seed sources for other, well adapted species is relatively great. Wetter sites in this area are somewhat subject to nutrient input caused by upslope erosion. Increasing nutrient levels will continue to allow stochastic invasion of new species, which will ultimately displace some of the previously established species. As erosion of upslope areas diminishes communities will stabilize, then slowly proceed to their final composition.

Studies of diversity trends in long term succession show increasing diversity on mesic sites until forests reached middle age followed by a subsequent diversity decrease in older forests. In contrast, on dry sites, diversity increases with increasing age of the forest (Auclair and Goff 1971). In mesic forests increases in potential niches due to increasing levels of biomass, and biological organization are more than offset by competitive exclusion by well established dominant species. On xeric sites the dominance of well established species is in some ways compromised, lessening the effects of competitive exclusion by species that would be dominants on more mesic sites, often leading to species packing.

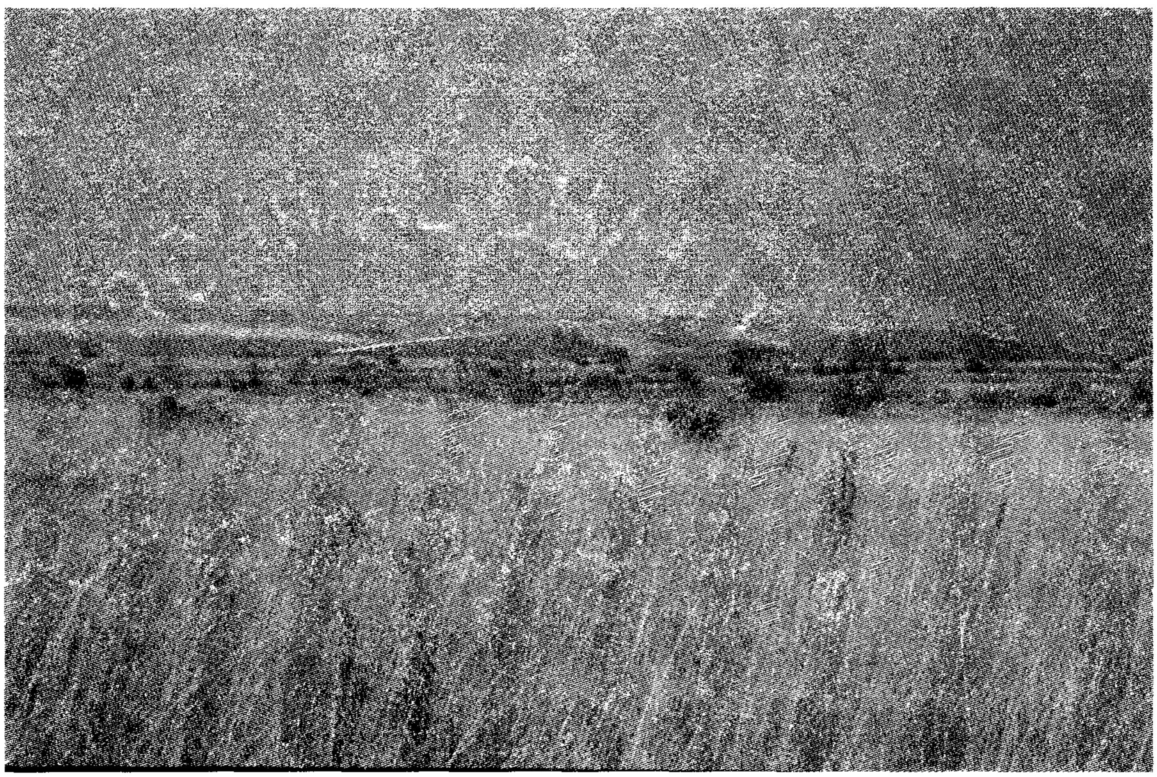
Areas planted in spruce and pines have reached canopy closure. Communities here are artificial but would fall into a Dry White Pine (hemlock) - Oak Forest community. Few woody plants grow in the understory of these trees. *Rosa multiflora* Thunb., *Rubus pensylvanica* T. C. Porter., *Rhamnus frangula* L., and *Lonicera morrowii* A. Gray are persisting at this site. Few herbs are found in these low light areas, they include various grasses, *Viola striata* Aiton, *Potentilla recta* L., *Trifolium dubium* Sibth., and *Polygonum virginianum* L. Some of the area planted in *Pinus strobus* L. is currently being incorporated into the landfill.

A few young red maple trees have invaded the conifer plantings, and are starting to grow rapidly. They may eventually out-compete the planted pines and spruce, allowing deciduous forest to eventually cover the area since Norway Spruce seldom produces seedlings in our area and pines generally lack the ability to regenerate in the dense shade beneath their own branches.

The Facilitation model proposed by Connell and Slatyer (1977) fits this community type well. It is autogenic, stating that changes to the community, wrought by the organisms themselves, prepare the site for successive successional stages and species, thus insuring their own displacement. In many landfill areas biomass accumulation is proceeding slowly as herbaceous plants gradually cover the landscape. This accumulating debris gradually sets the stage for invasion by longer lived woody species.

Autumn olive, *E. umbellata,* plantings have reached old age and many are in senescent stages. In some cases it is reproducing both vegetatively and by seed. Although the shrubby canopy has been nearly closed for some time by the autumn olive, intraspecific competition has led to some mortality and has allowed invasion and replacement by the other woody species like *Acer rubrum* L., *Rubus occidentalis* L., *Rubus pensylvanica* T. C. Porter, *Crataegus crus-galli* L., *Rosa multiflora* Thunb., *Lonicera morrowii* A. Gray., *Populus tremuloides* Michx., *Rhamnus frangula* L., and *Rhus typhina* L. which grow in the gaps between the *E. umbellata*. A developing Red Maple (terrestrial) Forest community is slowly replacing the *E. umbellata* plantings. A variety of herbs grow in limited numbers in these thickets. They include *Lactuca canadensis* L., *Oenothera biennis* L., *Solidago caesia* L., *Aster lateriflorus* (L.) Britton., *Verbascum thapsus* L. , and a few species of grasses. As invading woody species grow taller, they will shade out the *E. umbellata* and many of the herbs eventually favoring establishment deciduous forest cover.

Areas planted in herbaceous cover, predominantly a mix of warm and cool season grasses, have changed very little over the years. They are for the most part still in herbaceous cover (Fig. 7). These unmanaged, artificial Grassland communities cannot be classified within Fike's current classification system, which was developed for natural communities. Invasion of these grasslands by woody species, once begun, proceeds rapidly. As shrubby vegetation gradually encroaches, speed of invasion by woody species increases. Visits by dispersal agents of woody seeds become more and more common as woody plant density increases, intensifying the process (Robinson and Handel 1993). In many of these grasslands a mixture of wind and bird dispersed woody species are beginning to appear. A gradual transformation to a Red Maple (terrestrial) forest is taking place in these grasslands. The invading woody plants include *Acer rubrum* L., *Juniperus*



virginiana L., *Rosa multiflora* Thunb., *Ulmus americana* L., *Ulmus rubra* Muhl., *Cornus florida* L., *Rhus typhina* L., *Populus tremuloides* Michx., and *P. grandidentata* Michx. For the most part these are very thinly scattered, but in some cases are starting to form small pure stands. Wherever *P. grandidentata* and *P. tremuloides* become the dominant species, Aspen/Gray (paper) Birch Forest communities will persist. Areas with better soils and more organic materials tend to have most woody invaders. Areas with poor barren soils have the lowest diversity of woody plants and in many cases lack woody plants altogether. Eventual accumulation of biomass will allow more and more invasion of woody species, leading eventually to woody deciduous forest cover.

Few areas of extremely poor soils often have very low diversity as well as sparse herbaceous cover (Fig. 8). Both interspecific and intraspecific competition for available moisture and nutrients evidently limit both diversity and abundance. Examples of this phenomenon include widely scattered but near pure stands of *Reseda lutea* L., an alien herb, growing on dry reclaimed soil near the southern edge of the facility, and mixed populations of *Centauraea* and *Chenopodium* on nutrient poor shales just north of there. These areas typically include a few other herbaceous plants, generally grasses, and although no good community classification exists for these unstable, early succession communities, they can perhaps best be labeled as Grassland communities even though they are sometimes predominately composed of forbs, broad-leaved herbs.

Vegetation of the low wet areas that have developed since reclamation includes few woody plants. Most notable are *Salix exigua* Nutt., *S discolor* Muhl., and *Spiraea alba* Duroi. The great variety of herbaceous plants in these high diversity, species rich, wetland areas includes grasses, sedges and rushes common to the area, as well as *Typha*

latifolia L., *Rumex verticillatus* L., and *Alisma subcordatum* Raf. Since few woody species inhabit these areas, and few species adapted to them are near at hand. They will persist for a long time as predominantly herbaceous wetlands. These communities can be variously labeled as Cattail Marsh, Mixed Forb Marsh, or Wet Meadow communities depending upon dominant species within each of them.

Margins of settling ponds in reclaimed areas often have developed extensive floral components (Fig. 9). Woody plants take advantage of the more consistent moisture regime and higher nutrient levels due to erosion and nutrient leaching of upslope soils. *Salix exigia* Nutt., *Rosa multiflora* Thunb., *Rubus pensylvanica* T. C. Porter, *Rubus occidentalis* L., *Cornus florida* L., *Spiraea alba* Duroi., and *Rhus typhina* L. all border the pond margins.

Many aquatic and semi-aquatic plants have colonized these generally shallow ponds. These include various species of *Potamogeton*, *Typha*, *Carex*, *Juncus*, and *Polygonum*, as well as, *Ceratophyllum demersum* L. and *Lemna minor* L.

A small area near the outflow of one settling pond has developed a sphagnous mat which hosts a wide variety of herbs including *Lysimachia nummularia* L., *Epilobium ciliatum* Raf., *Eupatorium perfoliatum* L., *Polygonum sagittatum* L., and *Liparis loeselii* (L.) Rich. This is an excellent example of a Wet Meadow community. Since some activity centered on maintenance of these ponds is ongoing little change will occur. The wetland areas, however, are relatively small and eventually deciduous cover surrounding them will diminish species diversity and richness surrounding and within them.

These diverse wetland communities generally originate as low diversity sites colonized by low growing r-selected species. These reproduce rapidly, but soon loose

their temporary dominance to K-selected species larger, longer-lived species, more capable of utilizing the newly modified environment. Eventually this leads to stable communities capable of self-regeneration. This Reductionist concept (Noble and Slatyer 1980; Peet and Christensen 1980) emphasizes the importance of competition and life histories of the species involved in succession throughout its course from an open site to a closed stable community.

Several small areas of naturally occurring soils can still be found at the landfill facility. A partially abandoned farm can be found near the northeastern corner. During the survey a crop of soybeans was grown in two small fields near the northeast corner of the facility. An old pasture and three small woodlots adjacent to the former site of the house and barn have been abandoned and are reverting to wild condition. The old pasture is in a very early successional state. It is grown up in *Solidago rugosa* Miller, *Eupatorium fistulosum* Barratt, *Eupatorium altissimum* L., *Euthamnia graminifolia* (L.) Nutt., and a variety of other perennial herbs. Mowing in past years, as well as, partial mowing during the survey period is maintaining it as oldfield habitat.

One woodlot in the northeastern corner of the survey area is the result of succession of a long neglected field, which has grown up into a Black Cherry - northern hardwood forest. The canopy is thick, and a few herbaceous woodland plants including *Smilacina racemosa* (L.) Desf., *Viola striata* Aiton and *Osmorhiza claytonia* (Michx) C.B. Clarke are present. This type of community results from what ecologists have come to recognize as the 'normal' pattern of succession. It demonstrates the 'Holistic' concept of succession, which is driven by changes in attributes of evolving systems (Odum 1983). This view stresses orderly transition of a series of successional stages leading ultimately to a final climax community.

A second woodlot is adjacent to currently cultivated fields and has grown up from old pasture into a Red Maple (terrestrial) forest community. Understory herbs include many alien species, some originally planted at the old homestead. These alien herbs include *Teucrium canadense* L., *Hemerocaulis fulva* (L.) L., *Dipsacus sylvestris* Hudson, and *Polygonum cuspidatum* Sieb. & Zucc.

The most successful of these herbaceous aliens is the *P. cuspidatum* (Mexican bamboo). Early colonizers neither aid nor inhibit its growth. It is tolerant of low resource levels brought about by earlier colonizers. It has spread to form large pure stands because it can limit resources to other species by interference competition. It's ability to invade herbaceous cover, compete well, and eventually crowd out earlier colonizers provides an example of the Tolerance model proposed by Connell and Slatyer (1977) which emphasizes the importance of competition.

A third woodlot has been nearly destroyed by expansion of haul roads used by both the landfill operators and Esroc Corporation, a limestone mining company working on adjacent lands in the area. This woodlot now is confined to a very small area, perhaps 0.3 acres and is surrounded by haul roads and graveled areas. Fill as deep as 15 feet surrounds the small patch. An artificial drainage system keeps it from flooding. Due to its low topographic position (even before the fill was added) the ground is very mesic. Plants characteristic of this Skunk cabbage -golden saxifrage seep community include *Symplocarpus foetidus* (L.) Nutt., *Impatiens capensis* Meerb., *Lindera benzoin* (L.) Blume, and *Pilia pumila* (L.) A. Gray.

A small, forested area of perhaps 1.5 acres can be found adjacent to the scales near the eastern edge of the facility. It has reverted into a Tuliptree - beech - maple forest community. It is dominated by large tulip poplars, and has a mixed shrubby understory of *Acer rubrum* L. and *Lonicera morrowii* A. Gray.

Roadside areas also contain narrow strips of relatively undisturbed soils. A large variety of both native and alien herbs grow in these habitats. Roadside habitats contain wet and dry ditches, sunny and shady banks, and highly disturbed and natural soils. Vegetation of some roadsides consists entirely of plantings of native and non-native herbaceous species. Many roadside plantings are maintained to help reduce dust and noise and erosion levels. These plantings are generally of a temporary nature since many are cultivated species which do not persist in our area and will have very little or no impact upon the final realized communities.

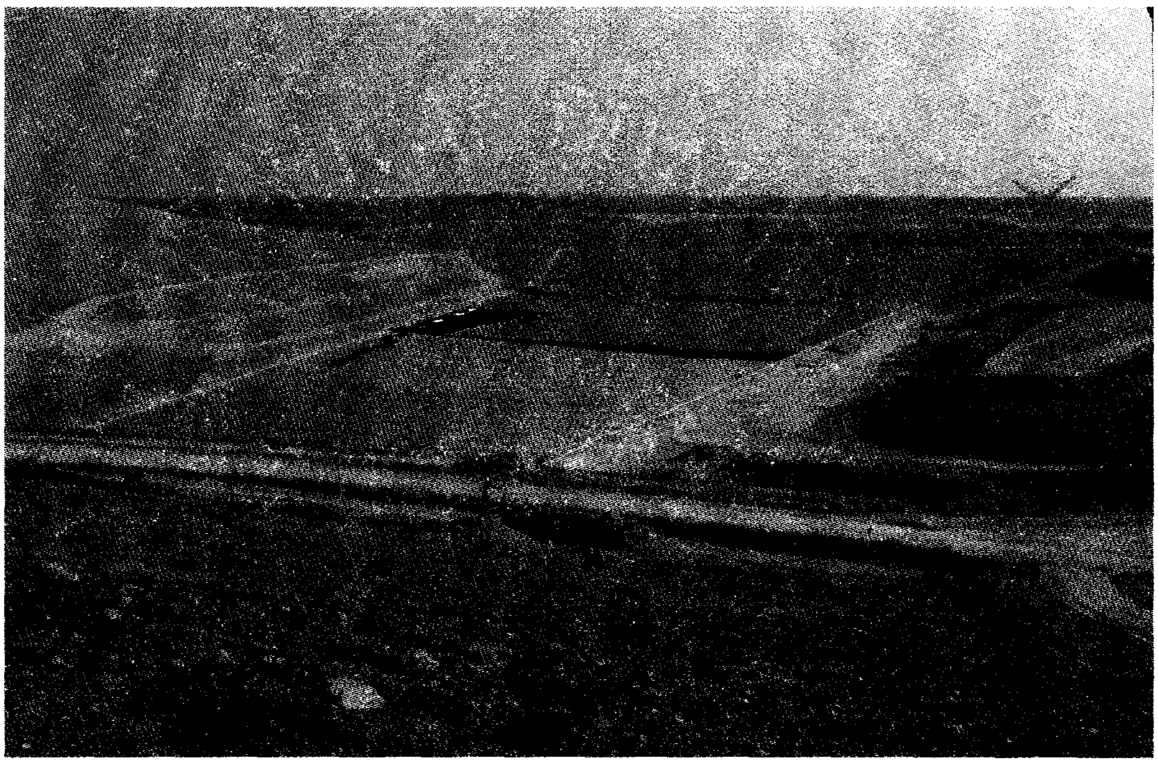
A few well maintained power right of ways help keep open habitats for light loving herbaceous plants such as *Oenothera biennis* L., *Danthonia spicata* (L.) F. Beauv., *Phytolacca americana* L., *Polygala sanguinea* L., and *Lactuca canadensis* L.

Completed landfill areas have been planted in herbaceous cover and are subject to periodic maintenance in the form of mowing and fertilization. "If the crowns of … landfills are seeded and maintained by mowing, grasses will dominate these areas" (Stalter 1984). Prevention of the growth deep-rooted woody plants, which could damage the landfill cap, requires these maintenance activities. These activities create disclimax communities, communities that cannot undergo natural successional pathways due to the periodic disruptions caused by man. Creation of these perturbation-dependent communities, which can be more prone to rapid succession, makes long term management strategies more difficult and complex. The reduction in biomass associated with mowing, as well as the elimination of woody species, keeps these areas in early successional condition. Some woody plants typically thought of as pioneer species will continuously attempt to invade this area, especially on the steep berms where mowing is most difficult. They include various species of *Populus*, *Prunus*, *Salix*, *Rosa*, and *Lonicera.* Many herbs found locally, also typically thought of as pioneers, have already invaded these areas, they include *Aster pilosus* Willd., *Cirsium discolor* (Muhl.) Sprengel., *Rumex crispus* L., *Potentilla recta* L., and many species of grasses. Continuing efforts to maintain these areas in herbaceous cover will be necessary. Erosion prone slopes and presence of lines which remove landfill generated gasses limit use of methods such as use of fire and grazing to stem succession of woody species on areas of completed landfill.

Areas actively being incorporated into landfill are experiencing some invasion of herbaceous species (Fig. 10), but at rates so slow that they do not experience significant successional development prior to further disruption, grading and coverage by landfill materials.

Identification of plants within both planted and natural experimental plots designed for a separate study at the facility helped identify forage plants utilized by meadow voles inhabiting experimental plots (Anderson 1999). Several small plots were seeded with mixes of herbaceous plants as part of that study.

The checklist was sent to naturalist Randy Jones of Poland, Ohio to aid in his study of the avifauna of the landfill facility. Many bird species are at least partially dependent upon plants found within the landfill for food sources, nesting cover, and habitat



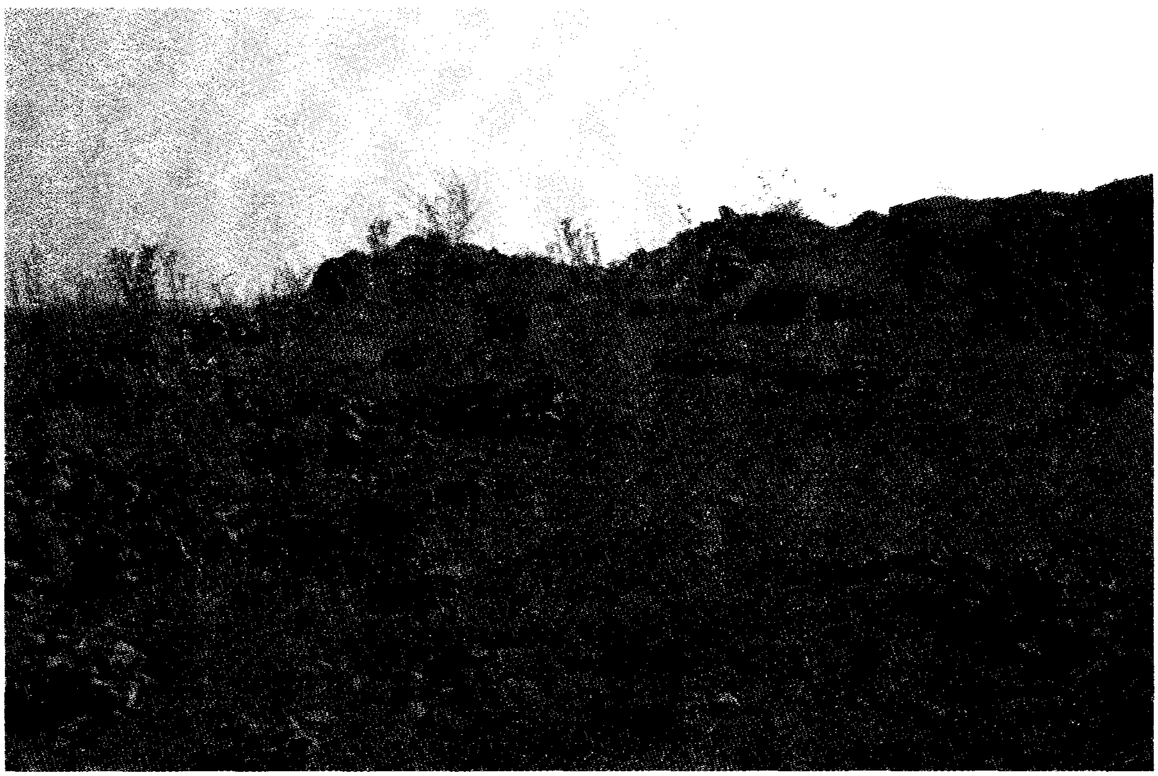
throughout the year. Also, avian activity helps to spread seed and vegetative propagules within the landfill facility, as well as, bring them in from outside areas.

The species checklist (Appendix A) also provides information useful for the construction of a larger, inclusive checklist of the vascular flora of Mahoning County, Ohio, which is now in progress at YUO (Herbarium of Youngstown State University).

DISCUSSION

Collection of plant species at the Carbon Limestone Sanitary Facility provides information useful for analysis of ongoing natural processes. It has been stated that "When degraded lands are abandoned, they rarely change but instead persist as scars on urban and rural landscapes" (Robinson and Handel 1993). The degraded lands of the Carbon Limestone Facility certainly are persisting as scarred land, but slow steady change is very evident. Lack of reclamation efforts in the first half of the century allowed stochastic invasion of disrupted areas to take place. Many r-selected plant species adapted to colonizing disturbed areas slowly invaded the barren landscapes from adjacent and nearby areas (Fig. 11). The grasses and composites, particularly, produce prodigious amounts of wind carried seeds capable of colonizing landfill areas (Stalter 1984). And although, "what ecologists have come to recognize as patterns of normal succession come from those produced through succession of old fields into woodlands, these patterns do not occur at landfills, or at best, occur only at a snails pace" (Robinson and Handel 1993), succession is indeed taking place. "In predicting and managing recovery after a disturbance, such as strip mining, one must know in detail the succession pattern and recovery potential of the particular ecosystem in question so that reclamation efforts will help and not hinder the natural recovery process" (McIntosh 1980).

With the landfill comes reclamation and stabilization of the previously disturbed landscape surface. In many areas of the landfill facility planned changes are now taking place. True reclamation will not have to wait for stochastic successional changes, but will provide useful and predictable plant communities.



CONCLUSION

Species richness and diversity at the Carbon Limestone Sanitary Facility is comparable to that of some other areas of Mahoning County. The native and alien components of the flora there reflect those on a county and statewide basis. Both urbanization of the county and continuing disturbance may provide mechanisms for increases in species richness. Since no slowdown of introduction of exotic species to the landfill site (or the county) can be expected to occur in the near future, the number of alien species will continue to increase slowly. Native species will also continue to invade the landfill as habitat change occurs. Succession will continue at the facility until species reach an equilibrium point at which supply rates are lowered to the point at which other species can no longer invade. This equilibrium however has been shifted by the regular disturbance regimes required by landfill activities. Eventually a balance between colonization and elimination of species will be reached. Too little work has been done on community structure and composition locally to provide even modest baseline data on which accurate predictions of successional pathways of communities encountered at the landfill facility could be made. Due to spatial heterogeneity and temporal differences in disturbance regimes, successional status of communities, as well as species composition varies widely within the several communities found at this active landfill facility.

Current efforts toward reclamation are very limited if one considers species richness and diversity since they are aimed only at stabilization of disrupted communities. Future reclamation efforts would be more effective if efforts were made to address these shortcomings. Current efforts at wetland remediation are aimed at addressing these. Creation of entire, self-sustaining communities is now considered, not just temporary stabilization of degraded ones. Perhaps reclamation efforts aimed at terrestrial systems should be conducted with that in mind.

FUTURE STUDIES

A comprehensive list of the Mahoning county flora is still a long way from complete. Prior to recent rapid changes such as urbanization and strip mining (Chuey 1972) the flora of Mahoning County was understudied. Although it remains so, field studies conducted to date have documented approximately 670 native and 315 alien vascular plant species, excluding cultivars, for Mahoning County.

Previous to published works by Braun 1967 and Chuey 1972, the known herbaceous angiosperm flora of Mahoning County as represented by specimens in three herbaria within the region (BHO, KE, and OS) tallied to 426 species. Chuey's addition of 101 species as county records boosted it to 527 species, listed in a more formal catalogue form. Subsequent works by Cooperrider (1995) and Fisher (1988) coupled with current efforts to computerize the herbarium records at YUO will result in an easily obtainable checklist of over 987 species of vascular plants. Not only will herbaceous angiosperms be accounted for, but all vascular plants.

Creation of the Herbarium of Youngstown State University (YUO) and subsequent efforts to raise it to a quality regional facility provide abundant opportunities for ambitious students interested in floristics, life histories, phytogeography, and other botanical studies.

Although work by past botanists has compiled some very useful baseline data, many small but unique areas within the county remain largely untouched by botanical inventories. Some of these include lakes and smaller streams, private ponds and other aquatic habitats; as well as, areas of steep terrain along tributaries to the Mahoning River such as Gray's Run in Lowellville. Many ruderal areas within the county remain unstudied as well. Periodic checks of representative areas within the county must be an ongoing process to keep knowledge of the flora up to date and accurate since plant communities are dynamic and ever changing. Regular surveys of a given area circumvent problems of aperiodic survey events (Hoagstrom, personal communication). Many species persist over long periods of time. Others, perhaps fewer, are ephemeral, disappearing rapidly as habitat is enhanced or degraded. Other species are adventive to the area, coming in as habitats change, escape from cultivation is achieved, or as accidental introduction occurs.

Many non-native species of the landfill facility have been introduced by various means. The methods of invasion are the same as for our native species. The fact that surrounding areas show the same approximate proportion of alien species to native species could provide insight into floral trends on larger scales. Agriculture, landscaping, erosion control, wildlife management, forestry practices, and mining all heavily impact floras, occasionally eliminating species, but also introducing new ones. Many are now a part of our flora and play poorly understood, but often dynamic, roles in its ecology. More knowledge of the ecological roles these plants play can be critical in making cost efficient management decisions.

Future studies and botanical efforts within the landfill area, as well as, other portions of the county, will undoubtedly contribute much to the knowledge of our local flora. These in turn help with synthesis of the state flora. Only with a good understanding of our flora, both locally and statewide, can we manage it wisely.

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APPENDIX A

Appendix A. Table 1. Catalogue of the vascular flora of the Carbon Limestone Facility, Poland Township, Mahoning County, Ohio.

Family Taxon	Nativity	Common name
(Nativity: n=native, a=alien, c=cultivated)		
Equisetaceae		
Equisetum arvense L.	n	Field horsetail
Aspleniaceae		
Asplenium platyneuron (L.) Oakes	n	Ebony spleenwort
Dryopteris carthusiana (Villars) H. P. Fuchs	n	Spinulose wood fern
Dryopteris marginalis (L.) A. Gray	n	Marginal wood fern
Polystichum acrostichoides (Michx.) Schott	n	Christmas fern
Pinaceae		
Picea abies (L.) Karston	c	Norway spruce
Pinus resinosa Aiton.	c	Red pine
Pinus strobus L.	c	White pine
Pinus sylvestris L.	a	Scotch pine
Cupressaceae		
Juniperus virginiana L.	n	Juniper
Magnoliaceae		
Liriodendron tulipifera L.	n	Tulip poplar
Lauraceae		
Lindera benzoin (L.) Blume	n	Spicebush
Sassafras albidum (Nutt.) Nees	n	Sassafrass
Ranunculaceae		
Anemone virginiana L.	n	Thimbleweed
Delphinium ambiguum L.	c	Garden larkspur
Paeonia lactiflora Pall.	c	Peony
Ranunculus abortivus L.	n	Kidney-leaf buttercup
Ranunculus acris L.	a	Common meadow buttercup
Ranunculus recurvatus Poiret	n	Hooked crowfoot
Berberidaceae		
Berberis thunbergii D.C.	a	Japanese barberry
Podophyllum peltatum L.	n	May-apple
Papaveraceae		
Chelidonium majus L.	a	Swallowwort
Eschscholzia californica Cham.	c	California poppy
Papaver rhoeas L.	c	Red poppy

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Family Taxon	Nativity	Common name
(Nativity: n=native, a=alien, c=cultivated)		
Platanaceae		
Platanus occidentalis L.	n	Sycamore
Ulmaceae		
Ulmus americana L.	n	American elm
Ulmus pumila L.	a	Siberian elm
Ulmus rubra Muhl.	n	Red elm
Moraceae		
Morus alba L.	a	White mulberry
Urticaceae		
Boehmeria cylindrica (L.) Swartz	n	False nettle
Pilea pumila (L.) A. Gray	n	Clearweed
Urtica dioica L.	n	Stinging nettle
Juglandaceae		
Juglans nigra L.	n	Black walnut
Fagaceae		
Quercus coccinea Moenchh.	n	Scarlet oak
Quercus palustris Muenchh.	n	Pin oak
Quercus rubra L.	n	Red oak
Betulaceae		
Carpinus caroliniana Walter	n	Hornbeam
Ostrya virginiana (Miller) K. Koch	n	Hop-hornbeam
Phytolaccaceae		
Phytolacca americana L.	n	Pokeweed
Chenopodiaceae		
Atriplex patula L.	n	Spreading orach
Chenopodium album L.	a	Lamb's quarters
Chenopodium botrys L.	a	Feather geranium
Chenopodium leptophyllum Nutt.	a	Goosefoot
Portulacaceae		
Claytonia virginica L.	n	Spring beauty
Portulaca oleracea L.	a	Purslane

Appendix A. Table 1. Catalogue of the vascular flora of the Carbon Limestone Facility, Poland Township, Mahoning County, Ohio.

Family Taxon	Nativity	Common name
(Nativity: n=native, a=alien, c=cultivated)		
Molluginaceae		
Mollugo verticillata L.	a	Carpet-weed
Caryophyllaceae		
Cerastium viscosum L.	a	Mouse-ear chickweed
Cerastium vulgatum L.	a	Common mouse-ear chickweed
Dianthus armeria L.	a	Deptford pink
Dianthus barbatus L	a	Sweet William
Gypsophila scorzonerifolia Ser.	c	Baby's breath
Saponaria officinalis L.	a	Bouncing-bet
Silene latifolia Poiret	a	White campion
Silene noctiflora L.	a	Night flowering catchfly
Stellaria media (L.) Villars	a	Common chickweed
Stellaria pubera Michx.	n	Great chickweed
Polygonaceae		
Polygonum aviculare L.	a	Knotweed
Polygonum convolvulus L.	a	Black bindweed
Polygonum cuspidatum Sieb. & Zucc.	a	Mexican bamboo
Polygonum hydropiper L.	a	Water pepper
Polygonum pensylvanicum L.	n	Water smartweed
Polygonum punctatum Elliott	n	Dotted smartweed
Polygonum sagittatum L.	n	Arrow-leaved smartweed
Polygonum scandens L.	n	Climbing false buckwheat
Polygonum virginianum L.	n	Jumpseed
Rumex acetosella L.	a	Garden sorrel
Rumex crispus L.	a	Curley dock
Rumex obtusifolius L.	a	Bitter dock
Rumex orbiculatus A. Gray	n	Great water dock
Rumex verticillatus L.	n	Swamp dock
Clusiaceae		
Hypericum perforatum L.	n	St John's wort
Hypericum punctatum Lam.	n	Spotted St. John's wort
Malvaceae		
Malva neglecta Wallr.	a	Common mallow
Violaceae		
Viola cucullata Aiton	n	Blue marsh violet
Viola pubescens Aiton	n	Downey yellow violet

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Family Taxon	Nativity	Common name
(Nativity: n=native, a=alien, c=cultivated)		
Viola sororia Willd.	n	Common blue violet
Viola striata Aiton	n	Striped violet
Salicaceae		
Populus balsamifera L.	c	Balm of Gilead
Populus deltoides Marshall	n	Cottonwood
Populus grandidentata Michx.	n	Big tooth aspen
Populus tremuloides Michx.	n	Quaking aspen
Salix discolor Muhl.	n	Pussy willow
Salix exigua Nutt.	n	Sandbar willow
Salix myricoides (Muhl.) J. Carey	n	Shoreline willow
Salix nigra Marshall	n	Black willow
Capparaceae		
Cleome ornithopodioides L.	a	Birdfoot cleome
Polanisia dodecandra (L.) DC.	a	Clammyweed
Brassicaceae		
Alliaria petiolata (Bieb.) Cavara & Grande	a	Garlic mustard
Alyssum alyssoides (L.) L.	c	Alyssum
Arabis laevigata (Muhl.) Poiret	n	Smooth rock-cress
Barbarea vulgaris R. Br.	a	Yellow rocket
Capsella bursa-pastoris (L.) Medikus	a	Shepard's purse
Cardamine hirsuta L.	a	Hairy bitter-cress
Erucastrum gallicum (Willd.) O.E. Schulz.	a	Dog mustard
Erysimum asperum (Nutt.) DC.	c	Western wall flower
Hesperis matronalis L.	a	Dame's rocket
Lepidium campestre (L.) Br.	a	Field cress
Raphanus raphanistrum L.	a	Wild radish
Thlaspi arvense L.	a	Field penny-cress
Resedaceae		
Reseda lutea L.	a	Dyer's rocket
Primulaceae		
Anagallis arvensis L.	a	Scarlet pimpernil
Lysimachia ciliata L.	n	Fringed loostrife
Lysimachia nummularia L.	a	Moneywort
Lysimachia quadrifolia L.	n	Whorled loosestrife

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Family Taxon	Nativity	Common name
(Nativity: n=native, a=alien, c=cultivated)		
Grossulariaceae		
Ribes americanum Miller	n	Wild black current
Saxifragaceae		
Penthorum sedoides L.	n	Ditch stonecrop
Rosaceae		
Agrimonia gryposepala Wallr.	n	Harvest lice
Crataegus crus-galli L.	n	Cockspur hawthorn
Crataegus pruinosa (H.L. Wendl.) K. Koch	n	Frosted hawthorn
Fragaria vesca L.	a	Woodland strawberry
Fragaria virginiana Duchesne	n	Wild strawberry
Geum aleppicum Jacq.	a	Yellow avens
Geum canadense Jacq.	n	White avens
Geum virginianum L.	n	Cream colored avens
Potentilla recta L.	a	Sulfur cinquefoil
Potentilla simplex Michx.	n	Old field cinquefoil
Prunus avium L.	a	Sweet cherry
Prunus cerasus L.	a	Pie cherry
Prunus pensylvanica Lf.	n	Fire cherry
Prunus persica (L.) Batsch	a	Peach
Prunus serotina Ehrh.	n	Wild black cherry
Prunus virginiana L.	n	Choke cherry
Pyrus baccata L.	a	Siberian crabapple
Pyrus malus L.	a	Apple
Rosa canina L.	a	Dog rose
Rosa multiflora Thunb.	a	Multiflora rose
Rosa setigera Michx.	a	Prairie rose
Rubus allegheniensis T. C. Porter	n	Common blackberry
Rubus flagellaris Willd	n	Prickly dewberry
Rubus occidentalis L.	n	Raspberry
Caesalpiniaceae		
Cercis canadensis L.	n	Red-bud
Fabaceae		
Coronilla varia L.	a	Crown-vetch
Glycine max (L.) Merr.	c	Soy bean
Lathyrus latifolius L.	a	Perrenial sweetpea
Lespedeza virginica (L.) Britton	n	Virginia bush clover
Lotus corniculatus L.	a	Bird's foot trefoil

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Family Taxon	Nativity	Common name
(Nativity: n=native, a=alien, c=cultivated)		
Medicago lupulina L.	a	Black medic
Melilotus alba Medikus	a	White sweet clover
Melilotus officinalis (L.) Pallas	a	Yellow sweet clover
Robinia pseudoacacia L.	n	Black locust
Trifolium campestre Schreber	a	Low hop clover
Trifolium hybridum L.	a	Alsike clover
Trifolium pratense L.	a	Red clover
Trifolium repens L.	a	White clover
Vicia cracca L.	a	Cow vetch
Elaeagnaceae		
Elaeagnus umbellata Thunb.	a	Autumn olive
Haloragaceae		
Myriophyllum sibiricum Komarov	a	Eurasian water-milfoil
Lythraceae		
Lythrum salicaria L.	a	Purple loostrife
Onagraceae		
Circaea lutetiana L.	n	Enchanter's-nightshade
Epilobium ciliatum Raf.	n	Willow-herb
Epilobium hirsutum L.	n	Hairy willow-herb
Gaura biennis L.	n	Guara
Ludwigia palustris (L.) Elliott	a	Marsh-purslane
Oenothera biennis L.	n	Evening-primrose
Oenothera perennis L.	n	Evening-primrose
Cornaceae		
Cornus alternifolia L.f.	n	Alternate leaved dogwood
Cornus florida L.	n	Flowering dogwood
Cornus racemosa Lam.	n	Gray's dogwood
Cornus sericea L.	n	Red-osier dogwood
Celastraceae		
Celastrus scandens L.	n	Bittersweet
Euphorbiaceae		
Acalypha rhomboidea Raf.	n	Three seeded Mercury
Euphorbia cyparissias L.	a	Cypress spurge
Euphorbia dentata Michx.	n	Spurge

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Family Taxon	Nativity	Common name
(Nativity: n=native, a=alien, c=cultivated)		
Euphorbia maculata L.	n	Eye bane
Rhamnaceae		
Rhamnus frangula L.	a	Alder buckthorn
Vitaceae		
Parthenocissus vitacea (Kerr) A. Hitchc.	n	Virginia creeper
Vitis aestivalis Michx.	n	Summer grape
Vitis labrusca L.	n	Fox grape
Vitis riparia Michx.	n	Frost grape
Linaceae		
Linum perrene L.	c	Wild blue flax
Polygalaceae		
Polygala verticillata L.	n	Whorled milkwort
Aceraceae		
Acer negundo L.	a	Box elder
Acer platanoides L.	a	Norway maple
Acer rubrum L.	n	Red maple
Acer saccharinum L.	n	Silver maple
Acer saccharum Marshall	n	Sugar maple
Anacardiaceae		
Rhus glabra L.	n	Smooth sumac
Rhus typhina L.	n	Staghorn sumac
Toxicodendron radicans (L.) Kuntze	n	Poison ivy
Simaroubaceae		
Ailanthus altissima (Miller) Swingle	a	Tree of heaven
Oxalidaceae		
Oxalis stricta L.	n	Common yellow wood-sorrel
Geraniaceae		
Geranium maculatum L.	n	Wild geranium
Balsaminaceae		
Impatiens capensis Meerb.	n	Jewelweed
Impatiens pallida Nutt.	n	Pale Jewelweed

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Family Taxon	Nativity	Common name
(Nativity: n=native, a=alien, c=cultivated)		
Apiaceae		
Daucus carota L.	a	Queen-Anne's-lace
Osmorhiza claytonii (Michx.) C.B. Clarke	n	Sweet-cicely
Pastinaca sativa L.	a	Wild parsnip
Sanicula canadensis L.	n	Snake-root
Gentianaceae		
Centaurium erythraea Raf.	c	Centaury
Apocynaceae		
Apocynum cannabinum L.	n	Indian hemp
Vinca minor L.	a	Common periwinkle
Asclepiadaceae		
Asclepias incarnata L.	n	Swamp milkweed
Asclepias syriaca L.	n	Common milkweed
Solanaceae		
Physalis heterophylla Nees	n	Clammy ground cherry
Physalis longifolia Nutt.	n	Long-leaf ground cherry
Solanum carolinense L.	n	Horse nettle
Solanum dulcamara L.	a	Bittersweet nightshade
Solanum nigrum L.	a	Black nightshade
Convolvulaceae		
Calystegia sepium (L.) R. Br.	n	Wild morning glory
Polemoniaceae		
Phlox paniculata L.	n	Summer phlox
Boraginaceae		
Echium vulgare L.	a	Viper's bugloss
Hackelia virginiana (L.) I.M. Johnston	n	Stickseed
Heliotropium europaeum L.	a	European heliotrope
Verbenaceae		
Caryopteris incana Miq.	c	Bluebeard
Verbena hastata L.	n	Blue vervain
Verbena urticifolia L.	n	White vervain

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Family Taxon	Nativity	Common name
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Lamiaceae		
Ajuga reptans L.	a	Carpet bugleweed
Glechoma hederacea L.	a	Gill-over-the-ground
Lamium amplexicaule L.	a	Henbit
Lamium purpureum L.	a	Purple dead-nettle
Leonurus cardiaca L.	a	Common motherwort
Lycopus americanus Muhl.	n	Water-horehound
Nepeta cataria L.	a	Catnip
Prunella vulgaris L.	a	Heal-all
Satureja vulgaris (L.) Fritsch	a	Wild basil
Scutellaria lateriflora L.	n	Mad-dog skullcap
Teucrium canadense L.	a	Wood sage
Plantaginaceae		
Plantago lanceolata L.	a	English plantain
Plantago major L.	a	Broadleaf plantain
Plantago rugelii Decne.	a	Rugel's plantain
Buddlejaceae		
Buddleja davidii Franchet	c	Butterfly bush
Oleaceae		
Fraxinus americana L.	n	White ash
Fraxinus pennsylvanica Marshall	n	Red ash
Ligustrum vulgare L.	a	Common privet
Scrophulariaceae		
Chaenorrhinum minus (L.) Lange	a	Dwarf snapdragon
Mimulus ringens L.	n	Allegheny monkey flower
Penstemon hirsutus (L.) Willd.	n	Beard-tongue
Verbascum blattaria L.	a	Moth mullein
Verbascum thapsus L.	a	Common mullein
Veronica arvensis L.	a	Corn speedwell
Veronica officinalis L.	n	Gypsyweed
Veronica peregrina L.	n	Purslane speedwell
Veronica serpyllifolia L.	a	Thyme-leaved speedwell
Campanulaceae		
Lobelia siphilitica L.	n	Great lobelia

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Family Taxon	Nativity	Common name
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Rubiaceae		
Cephalanthus occidentalis L.	n	Raspberry
Galium aparine L.	n	Cleavers
Galium mollugo L.	a	White bedstraw
Galium trifidum L.	n	Small bedstraw
Galium triflorum Michx.	n	Sweet scented bedstraw
Caprifoliaceae		
Lonicera japonica Thunb.	a	Japanese honeysuckle
Lonicera morrowii A. Gray	a	Morrow's honeysuckle
Lonicera tartarica L.	a	Tartarian honeysuckle
Sambucus canadensis L.	n	American elder
Sambucus racemosa L.	n	Red-berried elder
Viburnum lentago L.	n	Nannyberry
Viburnum opulus L.	a	Guelder-rose
Viburnum prunifolium L.	n	Black-haw
Dipsacaceae		
Dipsacus sylvestris Hudson	a	Teasel
Asteraceae		
Achillea millefolium L.	a	Common yarrow
Ambrosia artemisiifolia L.	n	Common ragweed
Ambrosia trifida L.	n	Giant ragweed
Anthemis cotula L.	a	Dog fennel
Arctium minus (Hill) Bernh.	a	Common burdock
Artemisia vulgaris L.	a	Mugwort
Aster lateriflorus (L.) Britton	n	Calico aster
Aster novae-angliae L.	n	New England aster
Aster pilosus Willd.	n	Heath aster
Aster prenanthoides Muhl.	n	Zig-zag aster
Aster sagittifolius Willd.	n	Arrow leaved aster
Bidens frondosa L.	n	Beggar ticks
Centaurea cyanus L.	c	Bachelor's button
Centaurea jacea L.	a	Brown knapweed
Centaurea maculosa Lam.	a	Bushy knapweed
Chrysanthemum leucanthemum L.	a	Ox-eye daisy
Cichorium intybus L.	a	Blue chicory
Cirsium arvense (L.) Scop.	a	Canada thistle
Cirsium vulgare (Savi) Tenore	a	Bull thistle
Conyza canadensis (L.) Cronq.	n	Horseweed

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Family Taxon	Nativity	Common name
(Nativity: n=native, a=alien, c=cultivated)		
Coreopsis lanceolata L.	c	Longstalk tickseed
Coreopsis tinctoria Nutt.	c	Plains tickseed
Coreopsis tripteris L.	c	Tall tickseed
Cosmos bipinnatus Cav.	c	Cosmos
Echinacea purpurea (L.) Moench	c	Purple coneflower
Erechtites hieracifolia (L.) Raf.	n	Pilewort
Erigeron annuus (L.) Pers.	n	Daisy fleabane
Erigeron philadelphicus L.	n	Daisy fleabane
Erigeron strigosus Muhl.	n	Daisy fleabane
Eupatorium altissimum L.	n	Tall eupatorium
Eupatorium fistulosum Barratt	n	Joe-pye-weed
Eupatorium perfoliatum L.	n	Boneset
Eupatorium rugosum Houttuyn.	n	White-snakeroot
Euthamia graminifolia (L.) Nutt	n	Common flat-topped goldenr
Gaillardia pulchella Foug.	c	Rosering blanket-flower
Galinsoga quadriradiata Ruiz & Pavon	a	Quickweed
Helianthus annuus L.	a	Common sunflower
Hieracium caespitosum Dumort	a	King devil
Lactuca canadensis L.	n	White lettuce
Lactuca saligna L.	a	Willow-leaf lettuce
Lactuca serriola L.	a	Prickly lettuce
Ratibida columnifera (Nutt.) Wooten & Standley	c	Coneflower
Rudbeckia amplexicaulis (Vahl) Cass	c	Clasping coneflower
Rudbeckia hirta L.	n	Black-eyed Susan
Rudbeckia laciniata L.	n	Cutleaf coneflower
Rudbeckia triloba L.	n	Coneflower
Senecio aureus L.	n	Golden ragwort
Senecio vulgaris L.	a	Common groundsel
Solidago caesia L.	n	Blue-stem goldenrod
Solidago canadensis L.	n	Canada goldenrod
Solidago juncea Aiton	n	Early goldenrod
Solidago nemoralis Aiton	n	Gray goldenrod
Solidago rugosa Miller	n	Wrinkle-leaf goldenrod
Sonchus arvensis L.	a	Field sow-thistle
Sonchus asper (L.) Hill	a	Spiny-leaved sow-thistle
Taraxacum officinale Weber	a	Dandelion
Tragopogon dubius Scop.	a	Goat's beard
Tussilago farfara L.	a	Coltsfoot
Verbesina alternifolia (L.) Britt.	n	Wingstem
Vernonia gigantea (Walter) Trel.	n	Tall ironweed
Xanthium strumarium L.	n	Common cocklebur

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Family Taxon	Nativity	Common name
(Nativity: n=native, a=alien, c=cultivated)		
Alismataceae		
Alisma subcordatum Raf.	n	Southern water-plantain
Potamogetonaceae		
Potamogeton crispus L.	a	Curly pondweed
Potamogeton epihydrus Raf.	n	Ribbonleaf pondweed
Potamogeton filiformis Pers.	n	Threadleaf pondweed
Araceae		
Arisaema triphyllum (L.) Schott	n	Jack in the pulpit
Symplocarpus foetidus (L.) Nutt.	n	Skunk cabbage
Lemnaceae		
Lemna minor L.	n	Duckweed
Juncaceae		
Juncus acuminatus Michx.	n	Sharp fruited rush
Juncus articulatus L.	n	Jointed rush
Juncus effusus L.	n	Soft rush
Juncus nodosus L.	n	Knotted rush
Juncus tenuis Willd.	n	Path rush
Juncus torreyi Cov.	n	Torrey's rush
Luzula multiflora (Retz.) Lej.	n	Wood rush
Cyperaceae		
Carex blanda Dewey	n	Sedge
Carex comosa F. Boott.	n	Sedge
Carex complanata Torr & Hook	n	Sedge
Carex granularis Muhl.	n	Sedge
Carex hystericina Muhl.	n	Sedge
Carex laevivaginata (Kuk.) Mackenzie	n	Sedge
Carex normalis Mackenzie	n	Sedge
Carex pensylvanica Lam.	n	Sedge
Carex rosea Schkuhr.	n	Sedge
Carex scoparia Schk.	n	Broom sedge
Carex tribuloides Wahl.	n	Sedge
Carex vulpinoidea Michx.	n	Sedge
Cyperus strigosus L.	n	Nut sedge
Eleocharis ovata (Roth) Roemer & Schultes	n	Spike rush
Eleocharis palustris L.	n	Creeping spike rush
Scirpus atrovirens Willd.	n	Black bulrush

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Family Taxon	Nativity	Common name
(Nativity: n=native, a=alien, c=cultivated)		
Scirpus validus Vahl.	n	Soft-stem bulrush
Poaceae		
Agrostis perennans (Walter) Tuckerman	n	Autumn bent
Anthoxanthum odoratum L.	a	Sweet vernal grass
Avena sativa L.	a	Oats
Bromus commutatus Schrad.	a	Hairy chess
Bromus inermis Leysser	a	Smooth brome
Bromus secalinus L.	a	Cheat
Dactylis glomerata L.	a	Orchard grass
Danthonia spicata (L.) F. Beauv.	n	Poverty grass
Digitaria ischaemum (Schreber) Muhl.	a	Smooth crabgrass
Echinochloa crusgalli (L.) P. Beauv.	a	Barnyard grass
Elytrigia repens (L.) Nevski	a	Quackgrass
Eragrostis minor Host.	a	Lovegrass
Eragrostis pectinacea (Michx.) Nees.	n	Carolina lovegrass
Festuca elatior L.	a	Fescue
Festuca ovina L.	a	Sheep fescue
Festuca rubra L.	a	Red fescue
Glyceria melicaria (Michx.) C. E. Hubbard	n	Slender mannagrass
Glyceria septentrionalis A. S. Hitchc.	n	Floating mannagrass
Glyceria striata (Lam.) A. Hitchc.	n	Fowl mannagrass
Lolium perrene L.	a	Perrenial ryegrass
Muhlenbergia frondosa (Poiret) Fern.	n	Wirestem muhly
Muhlenbergia glomerata (Willd.) Trin.	n	Marsh Muhly
Panicum capillare L.	n	Witchgrass
Panicum dichotomiflorum Michx.	n	Smooth panic grass
Panicum lanuginosum Elliott	n	Panic grass
Panicum miliaceum L.	a	Broomcorn millet
Phalaris arundinacea L.	n	Reed canary-grass
Phleum pratense L.	a	Timothy
Phragmites australis (Cav.) Trin.	n	Common reed
Poa annua L.	a	Annual bluegrass
Poa compressa L.	a	Canada bluegrass
Poa pratensis L.	a	Kentucky bluegrass
Poa trivialis L.	a	Rough bluegrass
Setaria faberi R. Herrm.	a	Giant foxtail
Setaria glauca (L.) P. Beauv.	a	Yellow foxtail
Sphenopholis obtusata (michx.) Scribner	n	Slender wedge-grass
Sporobolus vaginiflorus (Torr.) A. Wood	n	Poverty grass
Triticum aestivum L.	a	Wheat

Appendix A. Table 1. Catalogue of the vascular flora of the Carbon Limestone Facility, Poland Township, Mahoning County, Ohio.

Family Taxon	Nativity	Common name
(Nativity: n=native, a=alien, c=cultivated)		
Typhaceae		
Typha angustifolia L.	n	Narrow-leaf cat-tail
Typha latifolia L.	n	Common cat-tail
Liliaceae		
Allium schoenoprasum L.	a	Chives
Hemerocallis fulva (L.) L.	a	Yellow day-lily
Narcissus pseudonarcissus L.	a	Daffodil
Ornithogalum umbellatum L.	a	Star-of-Bethlehem
Polygonatum pubescens (Willd.) Pursh	n	Soloman's seal
Iridaceae		
Sisyrinchium angustifolium Miller	n	Blue-eyed grass
Orchidaceae		
Liparis loeselii (L.) Rich	n	Loesel's twayblade