3R2N
2000 Biotic Assessment
General Summary
July 2001

One goal of the 3R2N project is to promote understanding of preservation and restoration of green infrastructure in the Three Rivers area. By accurately ***identifying*** and understanding the ***distribution*** and ***abundance*** of plant species along our rivers, planners and citizens will be better informed to discuss opportunities for restoration and implement ecologically informed riverbank management. This assessment summary compliments the *2000 Riverbank Conditions Report* and addresses woody plant ***biodiversity*** along riverbanks in the Pittsburgh Pool. This assessment establishes baseline data for defining the quality and types of habitats present using ***streambank woody vegetation*** and mapping their distribution in the region.

Biodiversity

Biodiversity describes the wealth and variety of plants, animals, and microorganisms found in an area. The first step in understanding the biodiversity of an area is to identify the species found there. Since groups of woody species are used by ecologists to define terrestrial habitat types, we have focused our data collection on the identification and association of woody species along the rivers. Individual woody species can be used as indicators of habitat quality (soil types, disturbance level, soil moisture, etc.). Groups of plant species found in association with one another indicate specific habitat types. In addition to the identification of all woody vegetation, we make special note of all non-native plant species, woody or herbaceous. The presence of non-native plants can be an indication of changes in the ecological conditions of an area -- including repeated habitat disturbance, changes in habitat conditions, or local loss of native species**.** Some of the non-native plants present along our riverbanks have become invasive and are considered undesirable for these reasons. (Examples of these invasive plants include Japanese knotweed and purple loosestrife.) Some of the most important issues in urban biodiversity -- habitat restoration and development -- relate to the control of introduced species, particularly those that are becoming invasive species. Understanding the relative distribution and abundance of native and introduced species will be of vital importance for preserving local biodiversity as riverbank development continues.

Distribution and Abundance

Species identity, distribution and abundance will allow us to determine the frequency of habitats along the rivers. A long-term goal of our project is the production of a database, allowing us to map the distribution of habitat types along the rivers. To date we have identified 76 species of woody plants along the riverbanks. Of these 76 species 13 were very common and found in all of the 2000 survey areas The native tree, **Sycamor**e (Platanus occidentalis) is the most frequent woody plant growing along the

rivers in the Pittsburgh Pool. The introduced **Tree of Heaven** (Alianthus altissima) is the second most abundant woody plant.

Although the data in our assessment are not yet correlated with other contemporary or historical data, this study is significant in that it establishes an accurate baseline to compare with future data and historical information. Some of the significant findings that came out of our study establish the relative frequency and abundance of native and introduced plants in the Pittsburgh Pool:

- Brunot Island has the highest average vegetation cover composed of woody plants, followed by the left bank of the Ohio River. For all other river areas measured in 2000, the percentage of woody plants is approximately equivalent.
- The percentage of introduced species averages 36% across all riverbanks in the Pittsburgh Pool. Herr's Island has the highest average abundance of introduced species (55%). The Ohio River has the highest average incidence of introduced plants relative to the Allegheny or Monogahela Rivers.
- Islands in the Allegheny River display both the highest and lowest averages of introduced plants (Herrs Island at 55% and Six Mile Island at 20%).

Continuity and Canopy

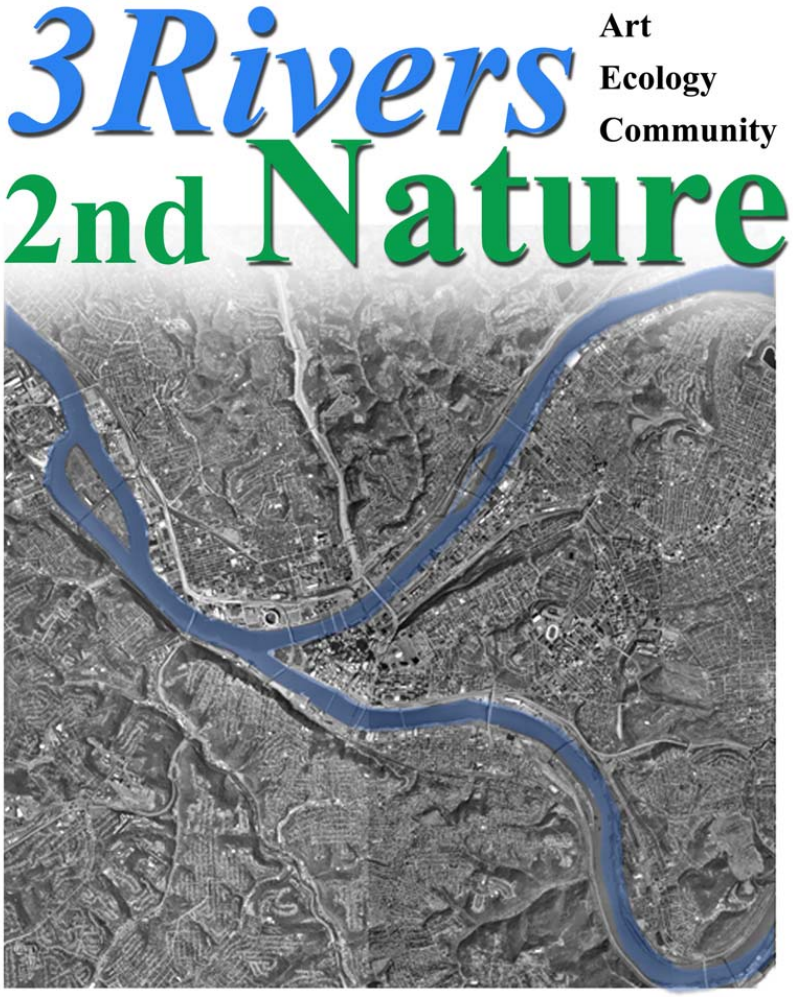
We collected data on ***continuity of vegetation*** and the ***height of woody plant canopy*** to help us estimate the age, extent and quality of different habitat types. Our vegetation continuity types range from areas with no woody vegetation to areas of woody vegetation both continuous and dense like a forest. Canopy height measured in 2000 ranged from 0-34 meters above the ground.

- 2.6% of the area surveyed along both banks of the Allegheny River, the Monongahela and Ohio had no vegetation.
- Conversely, 40.9% of the areas surveyed had a 75% or better coverage of continuous and dense vegetation.
- Six Mile Island has the tallest average canopy height of any area we sampled in 2000.
- The most mature forests in the Pittsburgh Pool are along the Allegheny River where woody vegetation is the tallest.
- The shortest canopy heights are found on Brunot Island and on the banks of the Ohio. This is also where Japanese knotweed is the most abundant species.

Over 88% of the riverbanks in the Pittsburgh Pool are currently not managed. Incorporating a broader representation of citizenry into planning discussions will be of paramount importance in the near future. A complete copy of the 2000 Biotic Assessment is available by request from 3R2N.

April 30, 2001

Biotic Assessment 2000



The STUDIO for Creative Inquiry
Carnegie Mellon

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Partners in this project include

3 Rivers Wet Weather Incorporated (3RWW)
Allegheny County Health Department (ACHD)
Allegheny County Sanitary Authority (ALCOSAN)

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For more information on the 3 Rivers – 2nd Nature Project, see http://3r2n.cfa.cmu.edu

If you believe that **ecologically healthy rivers are 2nd Nature** and would like to participate in a river dialogue about water quality, recreational use and biodiversity in the 3 Rivers Region.

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Table of Contents
3R-2N Biotic Assessment, Year 1

TABLES

APPENDICES

SUMMARY

This aspect of 3 Rivers 2nd Nature focused on an assessment of a key indicator group -- streambank woody vegetation -- as part of baseline data on the green infrastructure of the Three Rivers. These plants include trees, shrubs, and woody vines that are adapted to periodic flooding and tolerant of seasonally wet soils. Although the general vegetation of this region is well-studied, no spatially-referenced information on vegetation of the Three Rivers exists. In addition, there is an assumption by the public and most land managers in the area that the riverbank vegetation consists primarily of introduced and invasive species. The objective of assessing biodiversity within the overall context of 3 Rivers 2nd Nature is to provide scientifically-based biological information that will be critical to informed conservation and land management decisions affecting the Three Rivers.

Almost 50 miles of riverbanks and islands in the Pittsburgh Pool were assessed during June to August 2000 from a boat that traversed pre-determined 0.10 mi study units. Data were collected on species composition and abundance, percent exotic plants, selected herbaceous plant groups, vegetation density, vegetation continuity types, height of the woody plant canopy, plant viability, and human impact. For most plants, identification was done to the species level, but given the boat-based survey method, species-level identifications were not always possible. Identifications ranged from species to genus to family, and all of these levels of taxonomic identification are treated equally as an Operational Taxonomic Unit (OTU) in calculations.

A total of 76 woody plant OTUs occur along the riverbanks of the Pittsburgh Pool. Thirteen OTUs (eight native, four introduced, and one undetermined status) are found in all of the river areas surveyed during 2000. Overall, sycamore (*Platanus occidentalis*) is the most frequent woody plant growing along the rivers, followed by tree of heaven (*Ailanthus altissima*) and Japanese knotweed (*Polygonum cuspidatum/Polygonum sachalinense*), both introduced species. Two native OTUs (sycamore and willows (*Salix* spp.)), two introduced plants (tree of heaven and Japanese knotweed), and one OTU of uncertain native status (wild grapes (*Vitis* spp.)) rank among the top ten in all river areas. Introduced OTUs are more abundant in the Ohio drainage with Japanese knotweed being the most abundant on both banks as well as on Brunot Island, followed by tree of heaven. In terms of abundance, more native woody plants are found along the Allegheny River and its islands than along the other two rivers in the Pittsburgh Pool.

Based on number, native OTUs comprise more than 50% of the woody flora in all river areas, ranging from 51.1% (Allegheny Right) to 66.7% (Six-Mile Island and Brunot Island). Of the 76 OTUs occurring in the Pittsburgh Pool, 36 are native, 33 introduced, and seven with an undetermined native status (52.2% native). Native OTUs also are more dominant in abundance with an average abundance per OTU per unit of 0.44 compared to 0.25 for introduced OTUs, and 0.33 for OTUs with an undetermined status.

Frequency is the number of study units in which an OTU occurs regardless of abundance level. Six native OTUs, three introduced OTUs, and one OTU of uncertain status (wild grapes) occur in a majority of the units. Diversity is the number of woody OTUs in an individual study unit, and ranges from no woody plants in a unit to a high of 24 OTUs in Unit 64 on the left bank of the Allegheny River near the Highland Park Bridge. The average number of OTUs per study unit ranges from 8.0 (Six-Mile Island) to 14.7 (Herrs Island). The river area with the richest overall diversity in terms of total OTU representation is Herrs Island with an average of 19.3% of the total OTUs found in each unit.

Vegetation cover ranges from units with no vegetation (0% cover) to 100% vegetated. Average cover for all units is 64.9% with Brunot Island (79.0%) and Six-Mile Island (78.0%) having the highest average cover per study unit. The right bank of the Monongahela River has a significantly lower average than other river areas at 57.7%. The percent of the vegetation composed of woody plants ranges from none to 100% with an average of 75.9% for all river areas. Brunot Island again has the highest average with 90.8% of vegetation in each unit composed of woody plants, followed by the left bank of the Ohio River with 82.3%. The average woody plant percent for all other river areas is approximately equivalent.

The percent of introduced species per unit ranges from none to units composed entirely of non-native woody plants, however the average is 36.8% across all riverbanks in the Pittsburgh Pool. Allegheny River islands display both the highest average percent of introduced plants (Herrs Island at 54.7%) as well as the

lowest (Six-Mile Island at 20%). Other than Herrs Island, the Ohio River, including both banks and Brunot Island, exhibits the highest percent of introduced plants (43.8% to 49.7%).

Vegetation continuity types range from no significant woody vegetation present to woody vegetation both continuous and dense within a study unit. Both extremes of the continuity types are rare. Areas with no woody vegetation occur along both banks of the Allegheny River and both banks of the Monongahela River, but not along the Ohio River. Likewise, continuous and dense woody vegetation is found in the same river areas plus along the left bank of the Ohio River, but not along the right bank of the Ohio River or on any of the islands in the Pittsburgh Pool. The most common continuity type is woody vegetation clumped unevenly, which occurs in almost half of the total units (43.7%).

Minimum canopy height ranges from 0 m (e.g., no woody vegetation) to 5 m; maximum height from 0-34 m; and average height from 0-24 m. The average maximum canopy height is greatest on the three islands probably due to the fact that they are more inaccessible to visitation and development. Six-Mile Island has on average the tallest canopy of any river area, although the tallest individual trees occur along the right bank of the Monongahela River. In general, the woody vegetation along the Allegheny River and its islands is the tallest and thus perhaps the most mature forests in the Pittsburgh Pool. The shortest average heights are found along both banks of the Ohio River and on Brunot Island, probably due to the fact that Japanese knotweed is the most abundant species in these river areas.

Of the herbaceous vegetation types studied, grasses and sedges occur most frequently, being found in 77% of the study units. Grasses and sedges occur least often on Brunot Island (23.1%) and most frequently on the right bank of the Monongahela River (91%). Emergent aquatic plants are not common, except along the shore of Six-Mile Island (60% of study units) and elsewhere along the right bank of the Allegheny River (42.6%). Ferns are not common in any of the Pittsburgh Pool river areas, being found most often on the right bank of the Monongahela River to lacking on Six-Mile Island.

Although purple loosestrife (*Lythrum salicaria*) is a rampant invasive plant in wetlands in other areas of Pennsylvania and elsewhere in North America, it does not appear to be a major problem in the Pittsburgh Pool, except along the left bank of the Monongahela River where it occurs in over half of the study units (59.8%). However even in that region, the average abundance is 0.83 indicating that although plants are widespread, the populations are mostly small. Overall, purple loosestrife occurs in 30.3% of the study units at an average abundance of 0.37. Wave action likely contributes to the low density of this and other emergent aquatic vegetation as most plants were found in areas of quiet water, such as behind docks and piers.

Over 88% of the riverbank in the Pittsburgh Pool are not managed and this preponderance of unmanaged areas is consistent across all river areas. A majority of study units in all river systems contain dead woody plants, ranging from 58.8% of units on Herrs Island to 76.5% of units on the right bank of the Allegheny River. For all river areas combined, 64.3% of study units contain dead wood with an abundance rank of 13 and average abundance score of 0.81.

This report focuses on the biodiversity data and does not include correlations of these data with other data collected as part of the 3 Rivers 2nd Nature project. Preliminary analysis suggests a correlation between introduced taxa with areas of less soil, but this trend needs to be tested statistically. Other potential correlations to explore include species composition and access; specific plants and historical use; water quality and vegetation density; water quality and species composition; and species composition and bank slope.

INTRODUCTION

Resource managers and municipalities along the Three Rivers have an increasing demand for information on natural systems (= green infrastructure) to facilitate regional planning and decision-making. Informed restoration of urban landscapes must be based on scientific assessments of present ecological conditions, including the integrity of the biological community and the substrates supporting those communities. A biodiversity assessment of the riverbanks is necessary to know what presently grows in these areas, both in terms of species composition as well as density and cover.

Biodiversity is defined as the variety of species, their genetic make-up, and the natural communities in which they occur (Anonymous, 2001). A comprehensive biodiversity assessment should include all organisms, but given the lack of taxonomic expertise in many groups of plants and animals, most biodiversity studies focus on key indicator species. Plants, especially woody plants, are the most visible members of biological communities and serve to define habitats, and therefore are often the focus of biodiversity assessments, especially those employing rapid assessment techniques (Keel, et al., 2000).

The study of biodiversity in an urban context requires a paradigm shift from biodiversity assessments in natural areas, and the methods used in this study reflect these differences. Instead of assessing continuous natural communities through the use of random sampling techniques, urban settings present patchy vegetation, and thus require a different sampling strategy. In studies of natural vegetation, areas of disturbance are avoided, however intensive disturbance is rampant in urban areas and must be included in study areas to achieve representative sampling.

In addition, the motivating reasons for biodiversity assessments in natural areas is different from that in urban settings. In most studies of natural areas, the development of management plans for rare species is the focus of concern, while in urban areas, the control of introduced species, particularly invasive species, is a major focus. Urban assessments typically collect data relevant to restoration objectives rather than conservation of natural habitats. Studies in urban settings are often prompted by impending development and the need to inform such development in an ecological context as opposed to studies in natural settings which focus on ways to preserve wilderness areas.

Although the general vegetation of this region is well-studied, no spatially-referenced information on vegetation of the Three Rivers exists. In addition, there is a prevailing assumption by the public and most land managers in the area that the riverbank vegetation consists primarily of introduced and invasive species. This lack of information combined with the patchiness of the vegetation prevented the use of random sampling techniques for vegetation assessment. Unique challenges to this project included the study of a riverine system and the inaccessibility of many areas from the land side. Given all of these factors, a decision was made to survey all of the riverbanks in the study area in order to achieve an accurate representation of plant diversity and to better inform land management decisions on a site-specific basis.

OBJECTIVES

The overall objective of 3 Rivers 2nd Nature is to assess relative health of the green infrastructure of the rivers and stream valleys in Allegheny County in an historical context. By showing the transition from an industrial past to an emerging knowledge-based economy with a strong emphasis on environmental quality and recreation, the potential for a dynamic and vibrant river-oriented landscape becomes apparent.

This aspect of the overall project focused on an assessment of a key indicator group -- streambank woody vegetation -- as part of baseline data on the green infrastructure of the Three Rivers. These plants include trees, shrubs, and woody vines that are adapted to periodic flooding and tolerant of seasonally wet soils. Since the general flora and fauna of this region are relatively well-known, this study involved an intensive inventory of woody plants along the riverbanks within the Pittsburgh Pool, an area delineated by the Emsworth Lock and Dam on the Ohio River, Lock and Dam No. 2 on the Allegheny River near the Highland Park Bridge, and Lock and Dam No. 2 on the Monongahela River near West Mifflin. Woody plants were chosen as the primary measure of biodiversity for this study for the following reasons:

- Woody plants define plant communities.
- Woody plants are stable elements of communities.

- Woody plants are key elements of biological communities.
- Woody plants can be identified from a distance.
- Woody plants are frequently used as indicators in other studies.

The objective of assessing biodiversity within the overall context of 3 Rivers 2nd Nature is to provide scientifically-based biological information that will be critical to informed conservation and land management decisions affecting the Three Rivers. Specific objectives include:

- Provide estimates of biodiversity.
- Characterize the extent of specific introduced plants, both woody and herbaceous, especially potentially invasive species.
- Map the occurrence of woody vegetation along the rivers.
- Assess overall biotic conditions of riverbanks.
- Provide general resource data on the Three Rivers, including data on both woody plants and selected groups of herbaceous plants (grasses/sedges, ferns, and aquatic plants).
- Inform the public process for restoration and development.

METHODS AND MATERIALS

General: Almost 50 miles of riverbanks and islands were assessed during June to August 2000 from an open 16-foot boat that slowly traversed pre-determined 0.10 mi study units using a handheld Global Positioning System (GPS) unit (Garmin GPSIII Plus) for navigation. In addition, GIS maps incorporating aerial photos, road layers, and study unit points were available in the boat as a visual check for GPS readings. A total of 499 units were surveyed with approximately 10-20 minutes allotted to each unit. Typically each unit was traversed three times, twice at a distance of 1-5 m from the riverbank to identify individual plants and once from a distance of 5-10 m to determine overall canopy height and woody plant density. Taxonomic identification to genus or species was primarily by visual methods from the boat, but landings and near-shore approaches were made to check difficult-to-see plants as well as to collect voucher specimens. Riverine plant communities and specific plants were documented with photographs.

GPS Points: Consistent river GPS navigation points for each 0.10 mi unit were created by first tracing the river edge from aerial images into a consistent polyline and then distributing perpendicular objects at the desired interval (0.10 mi) along the river edge. It was necessary to offset these points from the river edge into the river by a consistent distance in order to avoid problems with structures blocking GPS readings. The distributed objects were extended to intersect the offset objects and points were built from the intersections of the interval distributed objects and offset objects.

Each intersection point was assigned a unique identification code, indicating river (A(llegheny), M(onongahela), O(hio), I added for islands); side of river (L(eft) or R(ight) facing downstream); and a unique number ascending upstream. These point locations were converted from aerial UTM17 coordinates to latitude and longitude, and the latitude/longitude points with their identification codes were loaded into a GPS unit. While in the field, navigation to points was via GPS, which indicated the beginning and end of each study unit. This navigation point system was implemented using double precision techniques with TotalFit by Landbase Systems and FME by Safe Software.

Specific: The following data were collected using a standard field form (see Appendix 1) by the same individual (SAT) for all 499 study units:

Composition
- List of woody plants (trees, shrubs, and woody vines)
- Abundance of each woody plant (0-4)
  - 0 = not observed
  - 4 = abundant/dominant plant
  - 3 = common
  - 2 = frequent
  - 1 = rare (<5 individuals)
- Exotic plants (woody) (%)

- Herbaceous component
  - Grass/sedge (0-4 as above)
  - Ferns (0-4 as above)
  - Aquatic (0-4 as above)
  - Specific plants of interest (georeferenced)

- Vegetation Density
  - Total cover (%)
  - Woody vs. herbaceous (%)
  - Continuity type (1-7 types defined)
    - 1 = No significant woody vegetation
    - 2 = Woody vegetation clumped unevenly
      - 2N = Not vegetated between clumps
      - 2V = Low woody/herbaceous vegetation between clumps
    - 3 = Woody vegetation clumped evenly
      - 3N = Not vegetated between clumps
      - 3V = Low woody/herbaceous vegetation between clumps
    - 4 = Woody vegetation sporadic unevenly
      - 4N = Not vegetated between patches
      - 4V = Low woody/herbaceous vegetation between patches
    - 5 = Woody vegetation sporadic evenly
      - 5N = Not vegetated between patches
      - 5V = Low woody/herbaceous vegetation between patches
    - 6 = Woody vegetation ±continuous with only small breaks
    - 7 = Woody vegetation continuous and dense

- Size of Woody Plan Community
  - Average canopy height (m)
  - Maximum canopy height (m)
  - Minimum canopy height (m)

- Human Impact/Viability
  - Management type
    - AM = Active Management of Vegetation
    - I = Industrial
    - NM = Vegetation Not Managed
    - SM = Vegetation Semi-Managed
  - Abundance of dead woody plants (0-4 as above)

Identification of plants was done primarily by sight from the water using standard floras and manuals for this region as needed (Fernald, 1970; Flora of North America Editorial Committee, 1997; Gleason and Cronquist, 1991; Holmgren, 1998; Rhoads and Block, 2000; Rhoads and Klein, 1993). Abundance of woody plants as well as percent cover (both herbaceous and woody) and percent exotic species was estimated specific to each study unit. Codes for management type and vegetation continuity type were determined for each unit in the field.

Operational Taxonomic Units (OTUs): For most plants, identification was done to the species level, but given the boat-based survey method, species-level identifications were not possible in many similar species groups. Identifications ranged from species (e.g., *Ailanthus altissima*, tree of heaven) to species pairs (e.g., *Polygonum cuspidatum/Polygonum sachalinense*, Japanese knotweed/giant knotweed), to genus only (e.g., *Salix*, willows) to family only (e.g. Rosaceae cultivar). In the Results and Discussion section below, all of these levels of taxonomic identification are treated equally as an Operational Taxonomic Unit (OTU) in terms of the calculations of percentages and numbers.

Voucher Specimens: The collection of vouchers, also called specimen-based documentation, is an essential component of any responsible biotic inventory, and vouchers were collected as part of this project. For

groups of organisms that are not currently revised or easily identified, the preservation of vouchers as part of current studies provides the basis for future biodiversity assessments. Professional and scientifically-useful preservation of vouchers is required (1) to render ongoing investigations credible, (2) to provide context for current studies as systematic or biological discoveries are made in the future, and (3) to provide an indication of past diversity as expertise develops to identify groups of organisms not presently revised. These voucher specimens will be curated and preserved in a regional collection for future study by conservationists, naturalists, and the international scientific community.

RESULTS AND DISCUSSION

Composition (Tables 1-4): A total of 76 woody plant OTUs (see definition above) occur along the riverbanks of the Pittsburgh Pool. Thirteen OTUs (eight native, four introduced, and one undetermined status) are found in all of the river areas surveyed during 2000 (Table 1). Table 2 lists all woody OTUs in order of abundance within each river area and Table 3 summarizes these data for the top ten OTUs in each area. Overall, sycamore (*Platanus occidentalis*) is the most frequent woody plant growing along the rivers, followed by tree of heaven (*Ailanthus altissima*) and Japanese knotweed (*Polygonum cuspidatum/sachalinense*), both introduced species. Sycamore is the first or second most abundant woody plant in five out of nine of the river areas, including both banks of the Allegheny and Monongahela rivers. Two native OTUs (sycamore and willows (*Salix* spp.)), two introduced plants (tree of heaven and Japanese knotweed), and one OTU of uncertain native status (wild grapes (*Vitis* spp.)) rank among the top ten in all river areas. Introduced OTUs are more abundant in the Ohio drainage with Japanese knotweed being the most abundant on both banks of the Ohio River as well as on Brunot Island, followed by tree of heaven in all three of these river areas. Tree of heaven is also the second most abundant woody plant along the right bank of the Monongahela River. In terms of abundance, more native woody plants are found along the Allegheny River and its islands than along the other two rivers in the Pittsburgh Pool (see Graphs 1 and 2, Appendix 2).

Four OTUs rank in the top ten in only a single river area: alder (*Alnus* sp.) on Brunot Island, false indigo (*Amorpha fruticosa*) on the left bank of the Monongahela River, poison ivy (*Toxicodendron radicans*) on the left bank of the Ohio River, and Oriental bittersweet (*Celastrus orbiculatus*) on Herrs Island.

Based on number of OTUs, native ones comprise more than 50% of the woody flora in all river areas, ranging from 51.1% (Allegheny Right) to 66.7% (Six-Mile Island and Brunot Island) (Table 4). Of the 76 OTUs occurring in the Pittsburgh Pool, 36 are native, 33 introduced, and seven with an undetermined native status (52.2% native). Native OTUs also are more dominant in abundance with an average abundance per OTU per unit of 0.44 compared to 0.25 for introduced OTUs, and 0.33 for OTUs with an undetermined status.

Frequency (Table 5): Frequency is the number of study units in which an OTU occurs regardless of abundance level. Six native OTUs, three introduced OTUs (in bold), and one OTU of uncertain status (wild grapes) occur in a majority of the units: **tree of heaven, 86.6%**; **Japanese knotweed, 80.2%**; sycamore, 79.6%; wild grapes, 79.4%; willows, 71.9%; **white mulberry (*Morus alba*), 69.5%**; silver maple (*Acer saccharinum*), 64.9%; elm (*Ulmus americana/rubra*), 62.3%; box elder (*Acer negundo*), 61.1%; dogwood (*Cornus* spp.), 50.3%.

Eleven OTUs are found in only a single study unit, including red maple (*Acer rubrum*), buckeye (*Aesculus* sp.), devil's-walking-stick (*Aralia spinosa*), barberry (*Berberis thunbergii/vulgaris*), hop-tree (*Ptelea trifoliolata*), sassafras (*Sassafras albidum*), snowberry (*Symphoricarpos* cf. *albus*), lilac (*Syringa vulgaris*), and cultivars of holly (*Ilex*), juniper (*Juniperus*), spruce (*Picea*).

Diversity (Table 6): Diversity is the number of woody OTUs in an individual study unit, and ranges from no woody plants in a unit to a high of 24 OTUs in Unit 64 on the left bank of the Allegheny River near the Highland Park Bridge. The average number of OTUs per study unit ranges from 8.0 (Six-Mile Island) to 14.7 (Herrs Island). The river area with the richest overall diversity in terms of total OTU representation is Herrs Island with an average of 19.3% of the total OTUs found in each unit.

Vegetation Density (Tables 7-8): Vegetation density was assessed through quantitative estimates of percent of land in each unit covered by plants, including both herbaceous and woody plants (e.g., total cover); quantitative estimates of the percent of that vegetation that was woody (e.g., an estimate of woody vs. herbaceous plants); and a qualitative assessment of how continuous the woody vegetation is within the study unit (see Graph 3, Appendix 2).

Cover ranges from units with no vegetation (0% cover) to 100% vegetated (Table 7). Average cover for all units is 64.9% with Brunot Island (79.0%) and Six-Mile Island (78.0%) having the highest average cover per study unit. The right bank of the Monongahela River has a significantly lower average than other river areas at 57.7%. The percent of the vegetation composed of woody plants also ranges from none to 100% with an average of 75.9% for all river areas. Brunot Island again has the highest average with 90.8% of vegetation in each unit composed of woody plants, followed by the left bank of the Ohio River with 82.3%. The average woody plant percent for all other river areas is approximately equivalent, ranging from 70.6% (Herrs Island) to 77.9% (Ohio Right).

Visual quantitative estimates were also made of the percent of the woody vegetation composed of introduced plants, although the abundance codes associated with individual introduced OTUs allow a more precise measurement of impact of exotic plants in each unit (see discussion above). Combining all data, the percent of introduced species per unit ranges from none to units composed entirely of non-native woody plants, however the average is 36.8% across all riverbanks in the Pittsburgh Pool (Table 7). Allegheny River islands display both the highest average percent of introduced plants (Herrs Island at 54.7%) as well as the lowest (Six-Mile Island with an average of 20% introduced plants per unit). Other than Herrs Island, the Ohio River, including both banks and Brunot Island, exhibits the highest percent of introduced plants (43.8% to 49.7%).

Seven general continuity types were established based on a preliminary survey of the study area with subclassifications within some of these types (see Material and Methods above). The continuity types range from no significant woody vegetation present to woody vegetation both continuous and dense within a study unit. Both extremes of the continuity types are rare with no significant woody vegetation occurring in only 4.8% of the total study units and continuous and dense woody vegetation found in just 3.2% of units (Table 8). Areas with no woody vegetation occur along both banks of the Allegheny River and both banks of the Monongahela River, but not along the Ohio River. Likewise, continuous and dense woody vegetation is found in the same river areas plus along the left bank of the Ohio River, but not along the right bank of the Ohio River or on any of the islands in the Pittsburgh Pool. The most common continuity type is woody vegetation clumped unevenly, which occurs in almost half of the total units (43.7%). Six-Mile Island has perhaps the most continuous woody vegetation with 60% of units classified as Type 6, continuous with only small breaks.

Height of Woody Plant Community (Table 9): Estimates were made of minimum canopy height, maximum canopy height, and average canopy height for each study unit both as an approximation of woody plant maturity and also overall aspect of the woody vegetation. Study units with no woody vegetation occur in three river areas (Allegheny Left, Allegheny Right, and Monongahela Right). Minimum height ranges from 0 m (e.g., no woody vegetation) to 5 m; maximum height from 0-34 m; and average height from 0-24 m. The average maximum canopy height is greatest on the three islands: Six-Mile Island (average maximum = 25.8 m), Herrs Island (20.8 m), and Brunot Island (19.8 m), probably due to the fact that they are more inaccessible to visitation and development. Six-Mile Island has on average the tallest canopy of any river area, although the tallest individual trees occur along the right bank of the Monongahela River. In general, the woody vegetation along the Allegheny River and its islands is the tallest and thus perhaps the most mature forests in the Pittsburgh Pool. The shortest average heights are found along both banks of the Ohio River and on Brunot Island, probably due to the fact that Japanese knotweed is the most abundant species in all three of these river areas.

Herbaceous Component (Table 10): Although this study focused on woody vegetation, limited data were collected on specific herbaceous plant groups, including grasses (Poaceae) and sedges (Cyperaceae), ferns (Pteridophyta), emergent aquatic vegetation, and selected plant species of ecological interest, particularly species known to be invasive in other areas (e.g., purple loosestrife (*Lythrum salicaria*) and Amur

honeysuckle (*Lonicera maackii*)), and specific aquatic species (e.g., water willow (*Justicia americana*) and yellow iris (*Iris pseudacorus*)). Data on abundance in each study unit on the same 0-4 scale used for woody plants were recorded for the first three plant types above plus purple loosestrife. Occurrences of the other species as well as purple loosestrife were marked on maps and these georeferenced points have been added to the 3 Rivers 2nd Nature GIS.

Of the herbaceous vegetation types studied, grasses and sedges occur most frequently, being found in 77% of the study units (384 units out of 499 units total) at an average abundance of 1.32. Grasses and sedges occur least often on Brunot Island (23.1% of study units, average abundance = 0.23) and most frequently on the right bank of the Monongahela River (91% of study units, average abundance = 1.65). Emergent aquatic plants are not common, except along the shore of Six-Mile Island (60% of study units, average abundance = 1.40) and elsewhere along the right bank of the Allegheny River (42.6% of study units, average abundance = 0.74). Ferns are not common in any of the Pittsburgh Pool river areas, being found most often on the right bank of the Monongahela River (33.9% of study units, average abundance = 0.44) to completely lacking on Six-Mile Island.

Although purple loosestrife is a rampant invasive plant in wetlands in other areas of Pennsylvania and elsewhere in North America (Westbrooks, 1998), it does not appear to be a major problem in the Pittsburgh Pool, except along the left bank of the Monongahela River where it occurs in over half of the study units (59.8%). However even in that region, the average abundance is 0.83 indicating that although plants are widespread, the populations are mostly small. Overall, purple loosestrife occurs in 30.3% of the study units at an average abundance of 0.37. Wave action likely contributes to the low density of this and other emergent aquatic vegetation as most plants were found in areas of quiet water, such as behind docks and piers.

Human Impact (Table 11): Whether the vegetation of each study unit was being actively managed, semi-managed, or not managed was noted. Over 88% of the riverbank in the Pittsburgh Pool (442 out of 499 units) are not managed and this preponderance of unmanaged areas is consistent across all river areas. The greatest percentage of study units without any management is on Brunot Island with 100% in the not managed category. Areas rated as not managed included both active industrial and abandoned industrial sites.

Viability (Table 12): The occurrence of dead woody plants was noted for each unit on the same 0-4 abundance scale used for live plants as an indicator of overall health of the woody vegetation. A majority of study units in all river systems contain dead plants, ranging from 58.8% of units on Herrs Island to 76.5% of units on the right bank of the Allegheny River. In terms of abundance rankings, dead wood ranges from being the 7th most abundant plant group on Six-Mile Island to 17th most abundant on Herrs Island. Average abundance scores range from 0.67 (Ohio Left) to 1.60 (Six-Mile Island). For all river areas combined, 64.3% of study units contain dead wood (321 units out of 499 total units) with an abundance rank of 13 and average abundance score of 0.81.

RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE DIRECTIONS

Presentations: The following information which was collected as georeferenced data could readily be incorporated into the 3 Rivers 2nd Nature GIS presentation for each study unit:

List of woody OTUs (pop-up for each unit).
Number of native OTUs vs. introduced OTUs
Abundance of native OTUs vs. introduced OTUs
Abundance of dead wood.
Amount of vegetated area (%cover).
Area covered by woody vegetation (%woody).

The following data are amenable to presentation at the level of each river unit, either as pie charts or bar graphs:

Total native OTUs vs. introduced OTUs
Total native abundance vs. introduced abundance.

Top ten OTUs in abundance.
Top ten OTUs in frequency.
Management unit types.
Vegetation continuity types.
Top ten units for taxonomic richness.

Information that is more appropriate for Web-based presentation includes:
Photographs of individual plant species.
Photographs of examples of vegetation continuity types.
Short accounts (200-300 words) for ecologically-important woody plants, including both native and introduced plants.

Historical Biodiversity Data: Information on current ecological conditions can be especially useful for ecological restoration when viewed in an historical context. To facilitate analysis of trends in stability of riparian biodiversity, data from museum specimens, literature sources, or other historical records should be compiled as year-referenced and georeferenced GIS layers. In addition, historic air photos within the study area should be analyzed to determine changes over time, specifically gains and losses in riparian vegetation.

Additional Data Analysis: The most obvious additional statistical analysis is a correlation matrix of OTU occurrences to determine if specific OTUs group with other OTUs at a statistically significant level. A cluster analysis of study units based on vegetation occurrence and a cluster analysis of vegetation based on occurrence in study units are two other useful possibilities to determine which river areas are most similar to one another. Factor analysis or principal component analysis would not be very meaningful, although extracted axes of variation might correlate with some of the other factors and suggest possibilities.

Correlations With Other Data. This report focuses on the biodiversity data and does not include correlations of these data with the other data collected as part of the 3 Rivers 2nd Nature project. Preliminary analysis suggests a correlation between introduced taxa with areas of less soil, but this trend needs to be tested statistically. Other potential correlations to explore include species composition and access; specific plants and historical use; water quality and vegetation density; water quality and species composition; and species composition and bank slope.

LITERATURE CITED

Anonymous. 2001. Statewide educational definition for biodiversity. EE Connections Winter 2001:7. Pennsylvania Center for Environmental Education.

Fernald, M.L. 1970. Gray's Manual of Botany, 8th edition. Van Nostrand Co., New York.

Flora of North America Editorial Committee. 1997. Flora of North America, North of Mexico, Vol. 3. Oxford University Press, New York.

Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and adjacent Canada, 2nd edition. New York Botanical Garden, Bronx.

Holmgren, N.H. 1998. Illustrated Companion to Gleason and Cronquist's Manual: Illustrations of the Vascular Plants of Northeastern United States and Adjacent Canada. New York Botanical Garden, Bronx.

Keel, S., R. Sayre, and G. Sedaghatkish. 2000. Vegetation and plant species surveys. *In* Nature in Focus: Rapid Ecological Assessment (R. Sayre, E. Roca, G. Sedaghatkish, B. Young, S. Keel, R. Roca, S. Sheppard, eds.). Island Press, Washington, D.C.

Rhoads, A.F. and W.M. Klein, Jr. 1993. The Vascular Flora of Pennsylvania: Annotated Checklist and Atlas. American Philosophical Society, Philadelphia.

Rhoads, A.F. and T.A. Block. 2000. The Plants of Pennsylvania: An Illustrated Manual. University of Pennsylvania Press, Philadelphia.

Westbrooks, R.G. 1998. Invasive Plants, Changing the Landscape of America: Fact Book. Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW), Washington, DC.

TABLES

Table 1: Similarity. Woody OTUs occurring in all river areas surveyed during Year 1 (2000).

Native OTU	Introduced OTU
Acer saccharinum (silver maple)	*Ailanthus altissima* (tree of heaven)
Cornus spp. (dogwood)	*Morus* cf. *alba* (white mulberry)
Parthenocissus quinquefolia (Virginia creeper)	*Polygonum cuspidatum/sachalinense* (Japanese knotweed)
Platanus occidentalis (sycamore)	*Rosa multiflora* (multiflora rose)
Populus deltoides (cottonwood)	
Robinia pseudoacacia (black locust)	
Salix spp. (willow)	Native status uncertain:
Ulmus americana/rubra (elm)	*Vitis* spp. (grape)

Table 2: Abundance. Woody OTUs occurring in each river area with order of abundance within each area indicated (1=ranked first in order of abundance) and average abundance per unit in parentheses on a scale of 1-4 (4=most abundant) (N/I=Native or Introduced; n=number of OTUs).

		RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=76	n=54	n=51	n=36	n=13	n=49	n=49	n=50	n=52	n=35
Acer cv. (maple cultivar)	I	47-49 (0.018)	28-30 (0.10)	42-51 (0.01)			46-49 (0.01)				
Acer negundo (box-elder)	N	8 (1.401)	16 (0.52)	8 (1.43)	7 (2.06)		5 (1.80)	5 (1.79)	8 (1.20)	8 (1.36)	14-15 (0.46)
Acer platanoides (Norway maple)	I	28 (0.142)	25 (0.19)	34-35 (0.06)			25-26 (0.16)	33-34 (0.05)	24 (0.26)	20 (0.38)	28-35 (0.04)
Acer rubrum (red maple)	N	67-76 (0.002)							40-50 (0.02)		
Acer saccharinum (silver maple)	N	6 (1.725)	1 (2.87)	2 (2.68)	5 (2.41)	1 (3.40)	8 (1.37)	10 (1.11)	6 (1.37)	5 (1.72)	17-18 (0.35)
Acer saccharum (sugar maple)	N	65-66 (0.004)		42-51 (0.01)					40-50 (0.02)		
Aesculus sp. (buckeye)	N	67-76 (0.002)								47-52 (0.02)	
Ailanthus altissima (tree of heaven)	I	2 (2.152)	5 (2.06)	5 (2.03)	3 (2.59)	8-9 (0.40)	4 (2.04)	2 (2.09)	2 (2.20)	2 (2.47)	2 (2.85)
Alnus sp. (alder)	N	23 (0.255)	21-22 (0.28)	18-19 (0.35)	22-23 (0.29)		22 (0.26)	26-27 (0.13)	21 (0.33)	40-46 (0.04)	10 (0.73)
Amorpha fruticosa (false indigo)	N	15 (0.661)	26-27 (0.12)	23 (0.24)	29-32 (0.12)		9 (1.36)	11 (1.05)	18 (0.54)	27-28 (0.17)	26-27 (0.08)
Ampelopsis brevipedunculata (porcelain-berry)	I	31 (0.094)	20 (0.39)	39-41 (0.03)	24-27 (0.24)		41-45 (0.02)	29-30 (0.10)		40-46 (0.04)	
Aralia spinosa (devil's-walking-stick)	N	65-66 (0.004)		39-41 (0.03)							
Berberis cv. (barberry cultivar)	I	47-49 (0.018)		36-38 (0.04)						31-33 (0.13)	

		RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=76	n=54	n=51	n=36	n=13	n=49	n=49	n=50	n=52	n=35
Berberis thunbergii/ vulgaris (barberry)	I	67-76 (0.002)								47-52 (0.02)	
Betula cv. (birch cultivar)	I	45-46 (0.020)	26-27 (0.12)								
Betula spp. (birch)	N	40 (0.036)	44-46 (0.03)	42-51 (0.01)			32-34 (0.06)	40-43 (0.02)	35-38 (0.07)	38-39 (0.06)	26-27 (0.08)
Catalpa spp. (catalpa)	I	19 (0.415)	12 (0.76)	21 (0.29)	19-20 (0.41)		20-21 (0.35)	16 (0.44)	25 (0.22)	19 (0.45)	16 (0.38)
Celastrus orbiculatus (Oriental bittersweet)	I	18 (0.431)	18-19 (0.43)	20 (0.31)	10-11 (1.29)		24 (0.22)	21 (0.27)	12-13 (0.78)	14 (0.81)	13 (0.54)
Celtis occidentalis (hackberry)	N	32 (0.088)	44-46 (0.03)		16 (0.94)		39-40 (0.03)	35-36 (0.04)	26 (0.20)	29-30 (0.15)	22-25 (0.12)
Cephalanthus occidentalis (buttonbush)	N	27 (0.152)	32-38 (0.07)	22 (0.26)	33-36 (0.06)		23 (0.24)	25 (0.15)	39 (0.04)	34-35 (0.11)	28-35 (0.04)
Cercis canadensis (redbud)	N	59-60 (0.008)	39-41 (0.06)								
Cornus spp. (dogwood)	N	12 (0.834)	13 (0.72)	9 (1.31)	13-15 (1.06)	10-13 (0.20)	12 (0.91)	13 (0.56)	16-17 (0.63)	9-10 (1.17)	14-15 (0.46)
Crataegus spp. (hawthorn)	?	51-53 (0.014)					36-38 (0.04)	44-49 (0.01)	40-50 (0.02)	47-52 (0.02)	
Forsythia cv. (forsythia)	I	54 (0.012)					46-49 (0.01)	33-34 (0.05)			
Fraxinus spp. (ash)	N	20 (0.345)	18-19 (0.43)	17 (0.40)	24-27 (0.24)		16 (0.52)	19 (0.32)	31-33 (0.11)	22 (0.28)	
Gleditsia triacanthos (honey locust)	N	45-46 (0.020)	39-41 (0.06)	42-51 (0.01)	28 (0.18)			44-49 (0.01)		47-52 (0.02)	
Hibiscus syriacus (rose-of-Sharon)	I	61-64 (0.006)						44-49 (0.01)		40-46 (0.04)	
Hydrangea arborescens (wild hydrangea)	N	44 (0.024)	47-54 (0.01)		29-32 (0.12)		32-34 (0.06)	44-49 (0.01)	40-50 (0.02)		

		RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=76	n=54	n=51	n=36	n=13	n=49	n=49	n=50	n=52	n=35
Ilex cv. (holly cultivar)	I	67-76 (0.002)	47-54 (0.01)								
Juglans sp. (walnut)	N	51-53 (0.014)						40-43 (0.02)	40-50 (0.02)	36-37 (0.09)	
Juniperus cv. (juniper cultivar)	I	67-76 (0.002)		42-51 (0.01)							
Ligustrum vulgare (privet)	I	55-58 (0.010)	42-43 (0.04)	39-41 (0.03)							
Liquidambar styraciflua cv. (sweet-gum)	I	39 (0.040)		26-27 (0.16)						25-26 (0.19)	
Liriodendron tulipifera (tuliptree)	N	35 (0.076)	28-30 (0.10)	30 (0.10)			30-31 (0.07)	35-36 (0.04)	30 (0.15)	47-52 (0.02)	19-21 (0.15)
Lonicera maackii (Amur honeysuckle)	I	30 (0.122)	32-38 (0.07)	36-38 (0.04)	22-23 (0.29)		25-26 (0.16)	23 (0.19)	31-33 (0.11)	38-39 (0.06)	28-35 (0.04)
Lonicera spp. (shrub honeysuckles)	I	43 (0.024)		42-51 (0.01)			41-45 (0.02)	44-49 (0.01)	40-50 (0.02)	29-30 (0.15)	
Lonicera spp. (vine honeysuckles)	I	36 (0.072)	32-38 (0.07)		24-27 (0.24)		41-45 (0.02)	31-32 (0.07)	27-29 (0.17)	25-26 (0.19)	
Maclura pomifera (Osage orange)	I	38 (0.042)					35 (0.04)	28 (0.12)	40-50 (0.02)	40-46 (0.04)	
Malus cf. *coronaria* (crabapple)	N	55-58 (0.010)	32-38 (0.07)								
Malus cf. *pumila* (apple)	I	34 (0.082)	42-43 (0.04)	34-35 (0.06)			32-34 (0.06)	26-27 (0.13)	27-29 (0.17)	36-37 (0.09)	28-35 (0.04)
Morus cf. *alba* (white mulberry)	I	7 (1.499)	15 (0.58)	10 (1.28)	10-11 (1.29)	6 (1.60)	7 (1.67)	3 (1.95)	4-5 (1.46)	6 (1.68)	6 (1.62)
Ostrya virginiana (hop-hornbeam)	N	42 (0.030)					30-31 (0.07)	37-39 (0.03)	40-50 (0.02)	40-46 (0.04)	28-35 (0.04)
Parthenocissus quinquefolia (Virginia-	N	13 (0.729)	8 (1.19)	12 (1.01)	9 (1.82)	7 (0.80)	18 (0.47)	20 (0.29)	16-17 (0.63)	13 (0.83)	9 (1.04)

		RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=76	n=54	n=51	n=36	n=13	n=49	n=49	n=50	n=52	n=35
creeper)											
Physocarpus opulifolius (ninebark)	N	16 (0.599)	11 (0.79)	18-19 (0.35)	29-32 (0.12)		14 (0.81)	14 (0.55)	14 (0.76)	17 (0.51)	17-18 (0.35)
Picea cv. (spruce cultivar)	I	67-76 (0.002)							40-50 (0.02)		
Pinus cv. (pine cultivar)	I	41 (0.034)	47-54 (0.01)	31-32 (0.09)						23-24 (0.21)	
Platanus occidentalis (sycamore)	N	1 (2.459)	2 (2.61)	1 (2.94)	1 (2.82)	5 (2.20)	1 (2.96)	1 (2.37)	4-5 (1.46)	4 (2.00)	7 (1.42)
Polygonum cuspidatum/ sachalinense (Japanese knotweed)	I	3 (2.080)	3 (2.36)	6 (1.94)	4 (2.47)	4 (2.60)	2 (2.15)	8 (1.15)	1 (2.46)	1 (2.68)	1 (3.27)
Populus deltoides (cottonwood)	N	17 (0.477)	10 (1.00)	13 (0.76)	24-27 (0.24)	3 (2.80)	20-21 (0.35)	17 (0.41)	27-29 (0.17)	34-35 (0.11)	19-21 (0.15)
Populus tremuloides (quaking aspen)	N	55-58 (0.010)	47-54 (0.01)	36-38 (0.04)			46-49 (0.01)				
Prunus spp. (wild cherry)	N	33 (0.086)	31 (0.09)	42-51 (0.01)	33-36 (0.06)		29 (0.08)	37-39 (0.03)	22-23 (0.30)	31-33 (0.13)	22-25 (0.12)
Prunus cv. (cherry cultivar)	I	37 (0.068)	32-38 (0.07)	33 (0.07)			36-38 (0.04)	40-43 (0.02)	40-50 (0.02)	21 (0.36)	
Ptelea trifoliolata (hop-tree)	N	67-76 (0.002)						44-49 (0.01)			
Quercus spp. (oak)	N	61-64 (0.006)	44-46 (0.03)							47-52 (0.02)	
Rhamnus frangula (alder buckthorn)	I	24 (0.192)	24 (0.22)	16 (0.44)	13-15 (1.06)		27-28 (0.14)	37-39 (0.03)	31-33 (0.11)	31-33 (0.13)	22-25 (0.12)
Rhus typhina (staghorn sumac)	N	11 (0.868)	17 (0.46)	14 (0.54)	2 (2.65)		13 (0.82)	12 (0.96)	12-13 (0.78)	9-10 (1.17)	8 (1.15)
Ribes sp. (currant)	?	61-64 (0.006)	47-54 (0.01)	42-51 (0.01)			46-49 (0.01)				

		RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=76	n=54	n=51	n=36	n=13	n=49	n=49	n=50	n=52	n=35
Robinia pseudoacacia (black locust)	N	10 (1.052)	9 (1.10)	11 (1.07)	18 (0.59)	10-13 (0.20)	15 (0.73)	9 (1.14)	7 (1.28)	11 (1.13)	5 (1.81)
Rosa multiflora (multiflora rose)	I	25 (0.168)	28-30 (0.10)	28-29 (0.12)	29-32 (0.12)	10-13 (0.20)	27-28 (0.14)	22 (0.23)	19 (0.48)	40-46 (0.04)	28-35 (0.04)
Rosaceae cv. (rose family cultivar)	I	61-64 (0.006)		42-51 (0.01)				40-43 (0.02)			
Rubus spp. (blackberry)	?	21 (0.337)	21-22 (0.28)	31-32 (0.09)	21 (0.35)		17 (0.49)	29-30 (0.10)	15 (0.65)	16 (0.53)	11-12 (0.62)
Salix cv. (weeping willow)	I	50 (0.016)		28-29 (0.12)							
Salix spp. (willow)	N	5 (1.840)	7 (1.58)	4 (2.13)	8 (1.88)	2 (3.00)	3 (2.11)	6 (1.55)	9 (1.07)	3 (2.15)	3 (2.38)
Sambucus spp. (elderberry)	N	29 (0.136)	32-38 (0.07)	25 (0.19)	17 (0.76)		39-40 (0.03)	31-32 (0.07)	22-23 (0.30)	27-28 (0.17)	19-21 (0.15)
Sassafras albidum (sassafras)	N	67-76 (0.002)	47-54 (0.01)								
Sorbus cf. *aucuparia* (European mountain-ash)	I	51-53 (0.014)	47-54 (0.01)		33-36 (0.06)		41-45 (0.02)		35-38 (0.07)		
Spiraea sp. (meadow-sweet)	?	55-58 (0.010)	39-41 (0.06)	42-51 (0.01)							
Symphoricarpos cf. *albus* (snowberry)	?	67-76 (0.002)			33-36 (0.06)						
Syringa vulgaris (lilac)	I	67-76 (0.002)							40-50 (0.02)		
Tilia americana (basswood)	N	47-49 (0.018)	47-54 (0.01)				41-45 (0.02)		35-38 (0.07)	40-46 (0.04)	28-35 (0.04)
Toxicodendron radicans (poison ivy)	N	14 (0.683)	14 (0.60)	15 (0.49)	12 (1.12)		11 (0.96)	15 (0.48)	10 (0.96)	15 (0.62)	11-12 (0.62)
Ulmus americana/rubra (elm)	N	9	6	7	13-15	10-13 (0.20)	10	7	11	12	22-25

		RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=76	n=54	n=51	n=36	n=13	n=49	n=49	n=50	n=52	n=35
(elm)		(1.228)	(1.82)	(1.51)	(1.06)	(0.20)	(1.28)	(1.25)	(0.80)	(1.00)	(0.12)
Ulmus pumila (Siberian elm)	I	26 (0.162)	23 (0.24)	26-27 (0.16)	19-20 (0.41)		36-38 (0.04)	24 (0.16)	35-38 (0.07)	18 (0.47)	
Viburnum sp. (arrow-wood)	?	59-60 (0.008)							34 (0.09)		
Vitis spp. (wild grape)	?	4 (1.914)	4 (2.13)	3 (2.28)	6 (2.18)	8-9 (0.40)	6 (1.78)	4 (1.86)	3 (1.76)	7 (1.66)	4 (2.08)
Wisteria floribunda (Japanese wisteria)	I	22 (0.265)	32-38 (0.07)	24 (0.22)			19 (0.36)	18 (0.39)	20 (0.39)	23-24 (0.21)	28-35 (0.04)

Table 3: Top Ten OTUs. Top ten OTUs in abundance in each river system grouped by native status (top three are in bold).

OTU	RIVER AREA									
	Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
Native OTUs										
Acer negundo (box elder)	8		8	7		5	5	8	8	
Acer saccharinum (silver maple)	6	**1**	**2**	5	**1**	8	10	6	5	
Alnus sp. (alder)										10
Amorpha fruticosa (false indigo)						9				
Cornus spp. (dogwood)			9						9-10	
Parthenocissus quinquefolia (Virginia creeper)		8		9	7					9
Platanus occidentalis (sycamore)	**1**	**2**	**1**	**1**	5	**1**	**1**	4-5	4	7
Populus deltoides (cottonwood)		10			**3**					
Rhus typhina (staghorn sumac)				**2**					9-10	8
Robinia pseudoacacia (black locust)	10	9					9	7		5
Salix spp. (willows)	5	7	4	8	**2**	**3**	6	9	**3**	**3**
Toxicodendron radicans (poison ivy)								10		
Ulmus americana/rubra (elm)	9	6	7			10	7			
Native Status Uncertain										
Vitis spp. (wild grape)	4	4	**3**	6	8-9	6	4	**3**	7	4
Introduced OTUs										
Ailanthus altissima (tree of heaven)	**2**	5	5	**3**	8-9	4	**2**	**2**	**2**	**2**
Celastrus orbiculatus (Oriental bittersweet)				10						
Morus cf. *alba* (white mulberry)	7		10	10	6	7	**3**	4-5	6	6
Polygonum cuspidatum/sachalinense (Japanese knotweed)	**3**	**3**	6	4	4	**2**	8	**1**	**1**	**1**

Table 4: Composition Summary. Summary of the total number of woody OTUs, native OTUs, and introduced OTUs in each river unit.

River Area	Total OTUs (#)	Native OTUs (#)	Introduced OTUs (#)	Status Uncertain (#)	%Native
Allegheny L	54	29	21	4	58.0%
Allegheny R	51	24	23	4	51.1%
Herrs I	36	21	12	3	63.6%
Six-Mile I	13	8	4	1	66.7%
Monongahela L	49	25	20	4	55.6%
Monongahela R	49	26	20	3	56.5%
Ohio L	50	27	19	4	58.7%
Ohio R	52	27	22	3	55.1%
Brunot I	35	22	11	2	66.7%
TOTAL OTUs	76	36	33	7	52.2%
Total Abundance		7928	4100	1143	
Average Abundance/OTU/Unit		0.441	0.249	0.327	

Table 5: Frequency. The number of study units and percentage of total study units within each river area in which a species occurs (n=total number of study units in each river area; N/I=Native or Introduced).

OTU	N I	RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
Acer cv. (maple cultivar)	I	4 0.8%	2 3.0%	1 1.5%			1 0.9%				
Acer negundo (box elder)	N	305 61.1%	20 29.9%	39 57.4%	11 64.7%		88 78.6%	80 72.1%	27 58.7%	33 70.2%	7 26.9%
Acer platanoides (Norway maple)	I	58 11.6%	8 11.9%	4 5.9%			15 13.4%	5 4.5%	11 23.9%	14 29.8%	1 3.9%
Acer rubrum (red maple)	N	1 0.2%							1 2.2%		
Acer saccharinum (silver maple)	N	324 64.9%	58 86.6%	55 80.9%	13 76.5%	5 100%	73 65.2%	52 46.9%	26 56.5%	36 76.6%	6 23.1%
Acer saccharum (sugar maple)	N	2 0.4%		1 1.5%					1 2.2%		
Aesculus sp. (buckeye)	N	1 0.2%								1 2.1%	
Ailanthus altissima (tree of heaven)	I	432 86.6%	57 85.1%	59 86.8%	16 94.1%	2 40.0%	94 83.9%	91 82.0%	42 91.3%	45 95.7%	26 100%
Alnus sp. (alder)	N	79 15.8%	9 13.4%	14 20.6%	3 17.7%		19 17.0%	12 10.8%	10 21.7%	2 4.3%	10 38.5%

OTU	NI	RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
Amorpha fruticosa (false indigo)	N	181 36.3%	8 11.9%	13 19.1%	1 5.9%		72 64.3%	64 57.7%	14 30.4%	7 14.9%	2 7.7%
Ampelopsis brevipedunculata (porcelain-berry)	I	32 6.4%	14 20.9%	2 2.9%	13 17.7%		2 1.8%	9 8.1%		2 4.3%	
Aralia spinosa (devil's-walking-stick)	N	1 0.2%		1 1.5%							
Berberis cv. (barberry cultivar)	I	7 1.4%		3 4.4%			1 0.9%			3 6.4%	
Berberis thunbergii/ vulgaris (barberry)	I	1 0.2%								1 2.1%	
Betula cv. (birch cultivar)	I	4 0.8%	2 3.0%					2 1.8%			
Betula spp. (birch)	N	13 2.6%	2 3.0%	1 1.5%			3 2.7%		3 6.5%	3 6.4%	1 3.9%
Catalpa spp. (catalpa)	I	144 28.9%	28 41.8%	15 22.1%	5 29.4%		30 26.8%	37 33.3%	7 15.2%	15 31.9%	7 26.9%
Celastrus orbiculatus (Oriental bittersweet)	I	101 20.2%	17 25.4%	9 13.2%	8 47.1%		11 9.8%	12 10.8%	17 37.0%	19 40.4%	8 30.8%
Celtis occidentalis (hackberry)	N	29 5.8%	1 1.5%		7 41.2%		3 2.7%	4 3.6%	7 15.2%	5 10.6%	2 7.7%
Cephalanthus occidentalis	N	67	5	16	1		21	16	2	5	1

OTU	NI	RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
(buttonbush)		13.4%	7.5%	23.5%	5.9%		18.8%	14.4%	4.4%	10.6%	3.9%
Cercis canadensis (redbud)	N	4 0.8%	4 6.0%								
Cornus spp. (dogwood)	N	251 50.3%	28 41.8%	41 60.3%	11 64.7%	1 20.0%	61 54.5%	44 39.6%	22 47.8%	34 72.3%	9 43.6%
Crataegus spp. (hawthorn)	?	6 1.2%					3 2.7%	1 0.9%	1 2.2%	1 2.1%	
Forsythia cv. (forsythia)	I	4 0.8%					1 0.9%	3 2.7%			
Fraxinus spp. (ash)	N	110 22.0%	21 31.3%	18 26.5%	2 11.8%		36 32.1%	18 16.2%	5 10.9%	10 21.3%	
Gleditsia triacanthos (honey locust)	N	8 1.6%	3 4.5%	1 1.5%	2 11.8%			1 0.9%		1 2.1%	
Hibiscus syriacus (rose-of-Sharon)	I	3 0.6%						1 0.9%		2 4.3%	
Hydrangea arborescens (wild hydrangea)	N	8 1.6%	1 1.5%		1 5.9%		4 3.6%	1 0.9%	1 2.2%		
Ilex cv. (holly cultivar)	I	1 0.2%	1 1.5%								
Juglans sp. (walnut)	N	5 1.0%						2 1.8%	1 2.2%	2 4.3%	

OTU	NI	RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
Juniperus cv. (juniper cultivar)	I	1 0.2%		1 1.5%							
Ligustrum vulgare (privet)	I	6 1.2%	3 4.5%	2 2.9%			1 0.9%				
Liquidambar styraciflua (sweet-gum)	I	7 1.4%		4 5.9%						3 6.4%	
Liriodendron tulipifera (tuliptree)	N	33 6.6%	7 10.5%	5 7.4%			9 8.0%	4 3.6%	4 8.7%	1 2.1%	3 11.5%
Lonicera maackii (Amur honeysuckle)	I	41 8.2%	4 6.0%	2 2.9%	5 29.4%		11 9.8%	12 10.8%	3 6.5%	3 6.4%	1 3.9%
Lonicera spp. (shrub honeysuckles)	I	12 2.4%		1 1.5%			2 1.8%	1 0.9%	1 2.2%	7 14.9%	
Lonicera spp. (vine honeysuckles)	I	20 4.0%	3 4.5%		2 11.8%		1 0.9%	5 4.5%	5 10.9%	4 8.5%	
Maclura pomifera (Osage orange)	I	17 3.4%					5 4.5%	9 8.1%	1 2.2%	2 4.3%	
Malus cf. *coronaria* (crabapple)	N	2 0.4%	2 3.0%								
Malus cf. *pumila* (apple)	I	37 7.4%	3 4.5%	4 5.9%			5 4.5%	13 11.7%	8 17.4%	3 6.4%	1 3.9%
Morus cf. *alba* (white	I	347	24	44	9	5	88	90	32	35	20

OTU	NI	RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
mulberry)		69.5%	35.8%	64.7%	52.9%	100%	78.6%	81.1%	69.6%	74.5%	76.9%
Ostrya virginiana (hop-hornbeam)	N	12 2.4%					5 4.5%	3 2.7%	1 2.2%	2 4.3%	1 3.9%
Parthenocissus quinque-folia (Virginia-creeper)	N	202 40.5%	36 53.7%	31 45.6%	11 64.7%	3 60.0%	38 33.9%	22 19.8%	17 37.0%	24 51.1%	20 76.9%
Physocarpus opulifolius (ninebark)	N	172 34.5%	30 44.8%	16 23.5%	2 11.8%		46 41.1%	33 29.7%	22 47.8%	14 29.8%	9 34.6%
Picea cv. (spruce cultivar)	I	1 0.2%							1 2.2%		
Pinus cv. (pine cultivar)	I	6 1.2%	1 1.5%	2 2.9%						3 6.4%	
Platanus occidentalis (sycamore)	N	397 79.6%	55 82.1%	57 83.8%	16 94.1%	4 80.0%	100 89.3%	90 81.1%	28 60.9%	34 72.3%	13 50.0%
Polygonum cuspidatum/ sachalinense (Japanese knotweed)	I	400 80.2%	59 88.1%	55 80.9%	15 88.2%	5 100%	93 83.0%	63 56.8%	39 84.8%	45 95.7%	26 100%
Populus deltoides (cottonwood)	N	107 21.4%	21 31.3%	19 27.9%	3 17.7%	5 100%	24 21.4%	25 22.5%	5 10.9%	3 6.4%	2 7.7%
Populus tremuloides (quaking aspen)	N	4 0.8%	1 1.5%	2 2.9%			1 0.9%				
Prunus cv. (cherry cultivar)	I	22	2	3			4	2	1	10	

OTU	NI	RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
		4.4%	3.0%	4.4%			3.6%	1.8%	2.2%	21.3%	
Prunus spp. (wild cherry)	N	39 7.8%	6 9.0%	1 1.5%	1 5.9%		7 6.3%	3 2.7%	13 28.3%	5 10.6%	3 11.5%
Ptelea trifoliolata (hop-tree)	N	1 0.2%						1 0.9%			
Quercus spp. (oak)	N	3 0.6%	2 3.0%							1 2.1%	
Rhamnus frangula (alder buckthorn)	I	75 15.0%	11 16.4%	23 33.8%	11 64.7%		16 14.3%	3 2.7%	5 10.9%	3 6.4%	3 11.5%
Rhus typhina (staghorn sumac)	N	223 44.7%	17 25.4%	23 33.8%	16 94.1%		49 43.8%	54 48.7%	19 41.3%	27 57.5%	18 69.2%
Ribes sp. (currant)	?	3 0.6%	1 1.5%	1 1.5%			1 0.9%				
Robinia pseudoacacia (black locust)	N	238 47.7%	29 43.3%	32 47.1%	6 35.3%	1 20.0%	46 41.1%	58 52.3%	24 52.2%	26 55.3%	16 61.5%
Rosa multiflora (multiflora rose)	I	53 10.6%	7 10.5%	5 7.4%	2 11.8%	1 20.0%	11 9.8%	12 10.8%	12 26.1%	2 4.3%	1 3.9%
Rosaceae cv. (rose family cultivar)	I	2 0.4%		1 1.5%				1 0.9%			
Rubus spp. (blackberry)	?	113 22.6%	13 19.4%	4 5.9%	6 35.3%		28 25.0%	11 9.9%	21 45.7%	16 34.0%	14 53.9%

OTU	NI	RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
Salix cv. (weeping willow)	I	2 0.4%		2 2.9%							
Salix spp. (willow)	N	359 71.9%	44 65.7%	56 82.4%	13 76.5%	5 100%	90 80.4%	71 64.0%	19 41.3%	40 85.1%	21 80.8%
Sambucus spp. (elderberry)	N	58 11.6%	5 7.5%	9 13.2%	9 52.9%		4 3.6%	8 7.2%	11 23.9%	8 17.0%	4 25.4%
Sassafras albidum (sassafras)	N	1 0.2%	1 1.5%								
Sorbus cf. *aucuparia* (European mountain-ash)	I	6 1.2%	1 1.5%		1 5.9%		2 1.8%		2 4.4%		
Spiraea sp. (meadow-sweet)	?	4 0.8%	3 4.5%	1 1.5%							
Symphoricarpos cf. *albus* (snowberry)	?	1 0.2%			1 5.9%						
Syringa vulgaris (lilac)	I	1 0.2%							1 2.2%		
Tilia americana (basswood)	N	6 1.2%	1 1.5%				1 0.9%		2 4.4%	1 2.1%	1 3.9%
Toxicodendron radicans (poison ivy)	N	180 36.1%	25 37.3%	19 27.9%	9 52.9%		51 45.5%	30 27.0%	20 43.5%	17 36.2%	9 34.6%
Ulmus americana/rubra	N	311	53	47	9	1	76	69	24	29	3

OTU	NI	RIVER AREA									
		Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
		n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
(elm)		62.3%	79.1%	69.1%	52.9%	20.0%	67.9%	62.2%	52.2%	61.7%	11.5%
Ulmus pumila (Siberian elm)	I	54 10.8%	10 14.9%	5 7.4%	5 29.4%		4 3.6%	15 13.5%	3 6.5%	12 25.5%	
Viburnum sp. (arrow-wood)	?	3 0.6%							3 6.5%		
Vitis spp. (wild grape)	?	396 79.4%	55 82.1%	59 86.8%	14 82.4%	2 40.0%	92 82.1%	79 71.2%	34 73.9%	36 76.6%	25 96.2%
Wisteria floribunda (Japanese wisteria	I	79 15.8%	3 4.5%	8 11.8%			25 22.3%	26 23.4%	10 21.7%	6 12.8%	1 3.9%

Table 6: Diversity. Summary of the number of woody OTUs occurring in each study unit (n=total number of woody OTUs in each river area).

	RIVER AREA									
	Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
	n=76	**n=54**	**n=51**	**n=36**	**n=13**	**n=49**	**n=49**	**n=50**	**n=52**	**n=35**
# of OTUs/unit (range)	0-24	0-24	0-21	10-22	6-10	2-23	0-21	1-22	4-20	7-16
# of OTUs/unit (average)	12.5	12.3	12.3	14.7	8.0	13.2	11.4	12.8	14.1	11.3
% OTUs/unit/total OTUs in each river area (range)	0-76.9%	0-44.4%	0-41.2%	27.8-61.1%	46.2-76.9%	4.1-46.9%	0-42.9%	2.0-44.0%	7.7-38.5%	20.0-45.7%
% OTUs/unit/total OTUs in each river area (average)	26.2%	22.9%	24.1%	40.8%	61.5%	26.9%	23.3%	25.6%	27.1%	32.4%
% OTUs/unit/total OTUs for all river areas (range)	0-31.6%	0-31.6%	0-27.6%	13.2-28.9%	7.9-13.2%	2.6-30.3%	0-27.6%	1.3%-28.9%	5.3-26.3%	9.2-21.1%
% OTUs/unit/total OTUs for all river areas (average)	16.5%	16.2%	16.2%	19.3%	10.5%	17.3%	15.0%	16.8%	18.6%	14.9%

Table 7: Vegetation Density and Cover. Area covered with vegetation, area covered with woody vegetation, and area covered with introduced plants in each study unit (n=total number of study units in each river area; all measurements in percentages).

	RIVER AREA									
	Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
	n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
Total cover (range)	0-100%	0-100%	0-95%	40-95%	50-90%	2-95%	0-100%	15-100%	10-90%	40-95%
Total cover (ave.)	64.9%	65.7%	65.7%	69.4%	78.0%	65.4%	57.7%	71.3%	61.3%	79.0%
Total cover (mode)	70%	70%	70%	70%	90%	70%	80%	60%,90%	70%	90%
Woody plants (range)	0-100%	0-95%	0-95%	40-90%	50-80%	20-100%	0-95%	30-100%	30-95%	80-95%
Woody plants (ave.)	75.9%	74.6%	72.4%	70.6%	74.0%	74.0%	74.5%	82.3%	77.9%	90.8%
Woody plants (mode)	80%	90%	80%	80%	80%	80%	90%	80%,90%	80%	90,95%
Introduced (range)	0-100%	0-90%	0-100%	30-70%	10-40%	5-80%	0-100%	10-100%	10-90%	10-80%
Introduced (ave.)	36.8%	38.6%	35.4%	54.7%	20.0%	31.2%	29.7%	49.7%	43.8%	45.8%
Introduced (mode)	20%	20%	20%	50%	10%,20%	20%	10%	60%,90%	20%, 30%,50%	30%

Table 8: Continuity Types. Number of units classified in each continuity types (n=total number of study units in each river area; see text for more detailed definition of continuity types; units containing more than one continuity type are included under the dominant category).

Continuity Type	RIVER AREA									
	Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
	n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
No woody veg (1)	24 4.8%	5 7.5%	3 4.4%			1 0.9%	15 13.6%			
Clumped unevenly (2)	218 43.7%	22 32.8%	27 39.7%	10 58.8%	1 20.0%	55 49.1%	31 27.9%	25 54.4%	32 68.1%	15 57.7%
Clumped evenly (3)	22 4.4%	2 3.0%	1 1.5%	1 5.9%		1 0.9%	11 9.9%	1 2.2%	5 10.6%	
Sporadic unevenly (4)	70 14.0%	10 14.9%	9 13.2%	5 29.4%	1 20.0%	15 13.4%	13 11.7%	7 15.2%	6 12.8%	4 15.4%
Sporadic evenly (5)	42 8.4%	7 10.4%	9 13.2%			18 16.1%	5 4.5%	1 2.2%	2 4.3%	
Continuous w/ breaks (6)	107 21.4%	20 29.9%	15 22.1%	1 5.9%	3 60%	20 17.9%	29 26.1%	10 21.7%	2 4.3%	7 26.9%
Continuous & dense (7)	16 3.2%	1 1.5%	4 5.9%			2 1.8%	7 6.3%	2 4.4%		

Table 9: Canopy Height. Minimum, maximum, and average canopy height within each river area based on estimates for each study unit (n=total number of study units in each river area; 0 indicates study units in which no woody vegetation occurred; all measurements in meters).

	RIVER AREA									
	Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
	n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
Minimum height (range)	0-5	0-2	0-5	1-2	0.5-1	0.5-2	0-2	0.5-1	0.5-1	0.5-1
Minimum height (average)	0.8	1.0	1.2	1.5	0.9	0.8	0.7	0.7	0.8	0.8
Maximum height (range)	0-34	0-30	0-32	16-26	22-30	2-32	0-34	2-28	3-26	14-30
Maximum height (average)	18.1	17.0	19.1	20.8	25.8	17.9	17.5	16.9	18.2	19.8
Average height (range)	0-24	0-18	0-24	8-18	10-16	1-18	0-16	1-15	1-14	3-16
Average height (average)	9.4	10.8	13.0	12.5	13.2	8.7	8.4	6.8	7.6	8.2

Table 10: Herbaceous Plant Frequency and Abundance. The number of study units and percentage of total study units within each river area in which herbaceous plant types occur; average abundance (on a scale of 0-4 with 4=most abundant) for each river system is listed in parentheses (n=total number of study units in each river area).

HERBACEOUS PLANT GROUP	RIVER AREA									
	Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
	n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
Emergent aquatic plants	92 18.4% (0.25)	9 13.4% (0.13)	29 42.6% (0.74)	3 17.6% (0.35)	3 60.0% (1.40)	25 22.3% (0.24)	16 14.4% (0.16)	1 2.2% (0.02)	5 10.6% (0.11)	1 3.8% (0.04)
Ferns	98 19.6% (0.25)	17 25.4% (0.37)	12 17.6% (0.22)	6 35.3% (0.47)		38 33.9% (0.44)	17 15.3% (0.17)	1 2.2% (0.04)	2 4.3% (0.04)	5 19.2% (0.19)
Grasses and sedges	384 77.0% (1.32)	50 74.6% (1.48)	48 70.6% (1.00)	10 58.8% (0.82)	4 80.0% (1.40)	98 87.5% (1.65)	101 91.0% (1.41)	31 67.4% (1.13)	36 76.6% (1.57)	6 23.1% (0.23)
Purple loosestrife (*Lythrum salicaria*)	151 30.3% (0.37)	11 16.4% (0.18)	13 19.1% (0.24)	5 29.4% (0.29)		67 59.8% (0.83)	34 30.6% (0.34)	8 17.4% (0.17)	9 19.1% (0.19)	4 15.4% (0.15)

Table 11: Management Types. Management types summarized for each river area. (n=total number of study units in each river area).

	RIVER AREA									
	Total	**Alleg L**	**Alleg R**	**Herrs**	**6-Mi**	**Mon L**	**Mon R**	**Ohio L**	**Ohio R**	**Brun I**
	n=499	**n=67**	**n=68**	**n=17**	**n=5**	**n=112**	**n=111**	**n=46**	**n=47**	**n=26**
Actively Managed	12	3	4		1	1	2		1	
Semi-Managed	8	4	1			3				
Not Managed	442	54	59	16	2	99	106	45	35	26
Combination - Active/Semi	5	1	1			3				
Combination - Active/Not	18	2	3	1		5	1		6	
Combination - Semi/Not	14	3			2	1	2	1	5	

Table 12. Dead Wood. Occurrence of dead wood in each river area, ranked in relation to abundance of live woody OTUs.

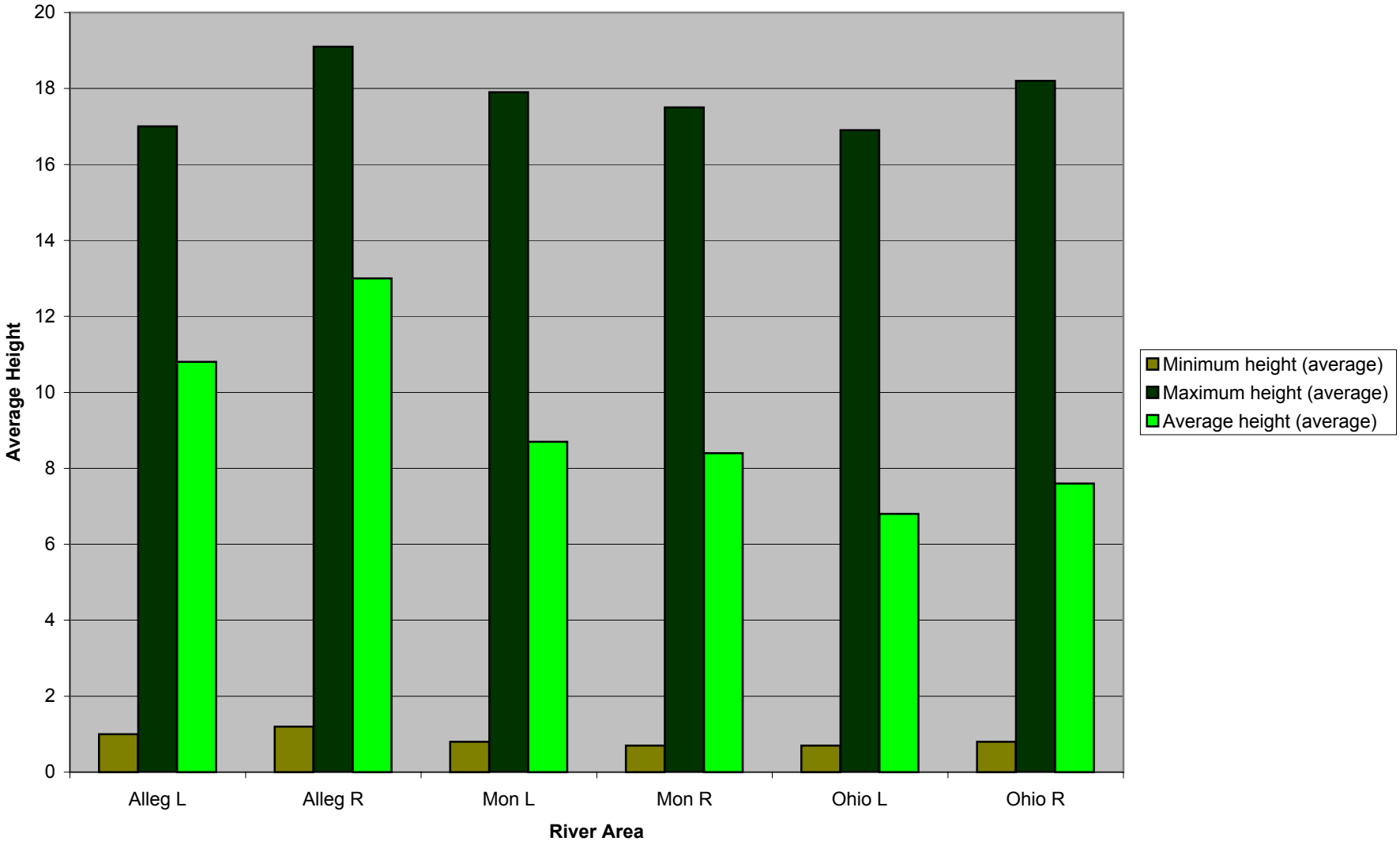
River Area	Abundance (Ranking)	Abundance (Average)	Frequency (# Units)	Frequency (% Units)
Allegheny Left	12	0.76	42	62.7%
Allegheny Right	11	1.13	52	76.5%
Herrs Island	17	0.82	10	58.8%
Six-Mile Island	7	1.60	3	60.0%
Monongahela Left	15	0.81	74	66.1%
Monongahela Right	13	0.73	66	59.5%
Ohio Left	15	0.67	28	60.9%
Ohio Right	15	0.77	29	61.7%
Brunot Island	10	0.73	17	65.4%
All Rivers	13	0.81	321	64.3%

APPENDIX 1
3R2N VEGETATION STUDY
DATA COLLECTION FORM

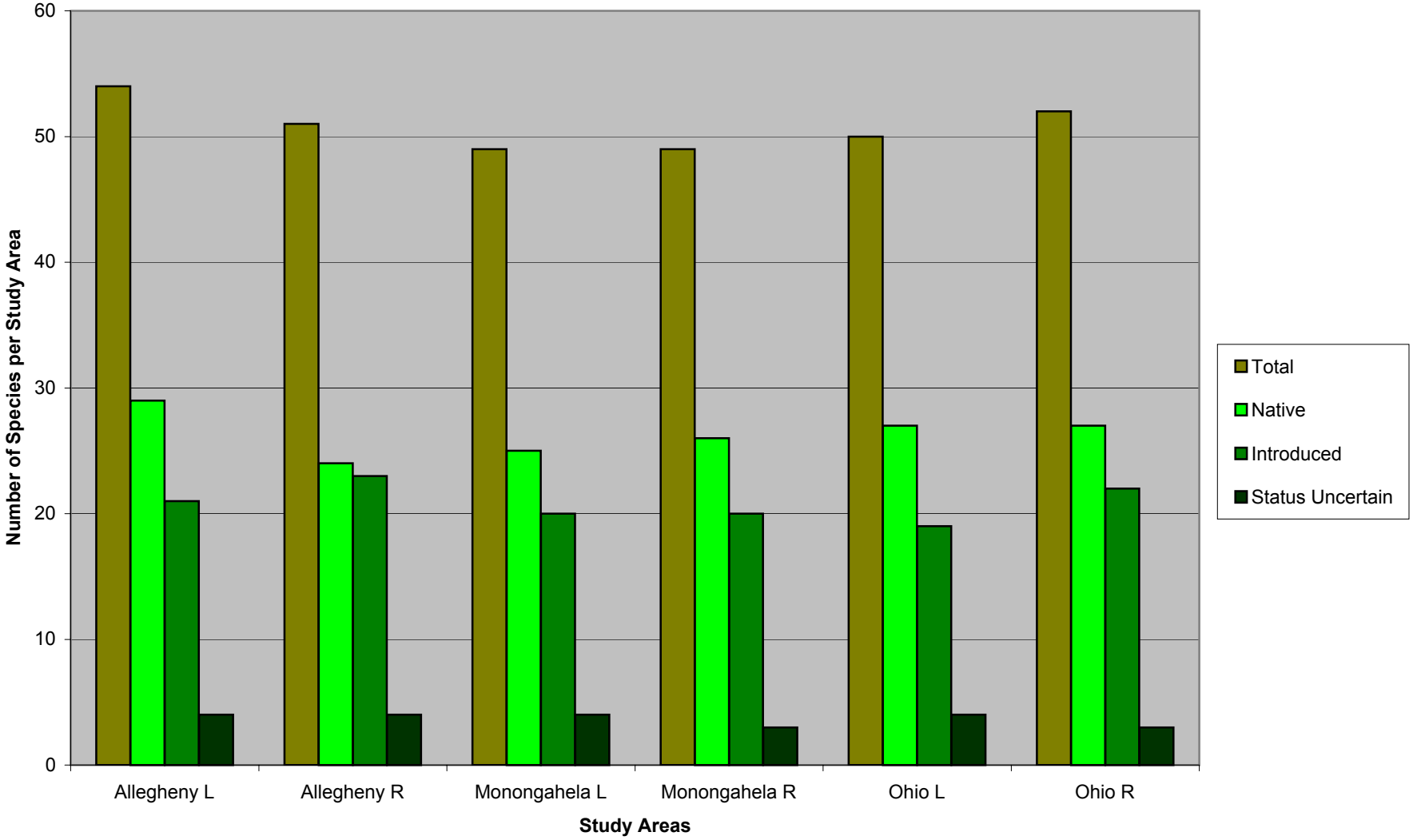
DATE: **PEOPLE:**	**UNIT NUMBER**				
Acer negundo					
Acer platanoides					
Acer saccharinum					
Acer saccharum					
Ailanthus altissima					
Alnus					
Amorpha fruticosa					
Ampelopsis brevipedunculata					
Carpinus caroliniana					
Catalpa					
Celastrus					
Celtis occidentalis					
Cephalanthus occidentalis					
Crataegus spp.					
Fraxinus					
Lonicera maackii					
Lonicera - vining					
Morus					
Parthenocissus					
Platanus occidentalis					
Polygonum cusp/sach					
Populus					
Prunus					
Quercus					
Rhus typhina					
Robinia pseudoacacia					
Rosa multiflora					
Rubus					

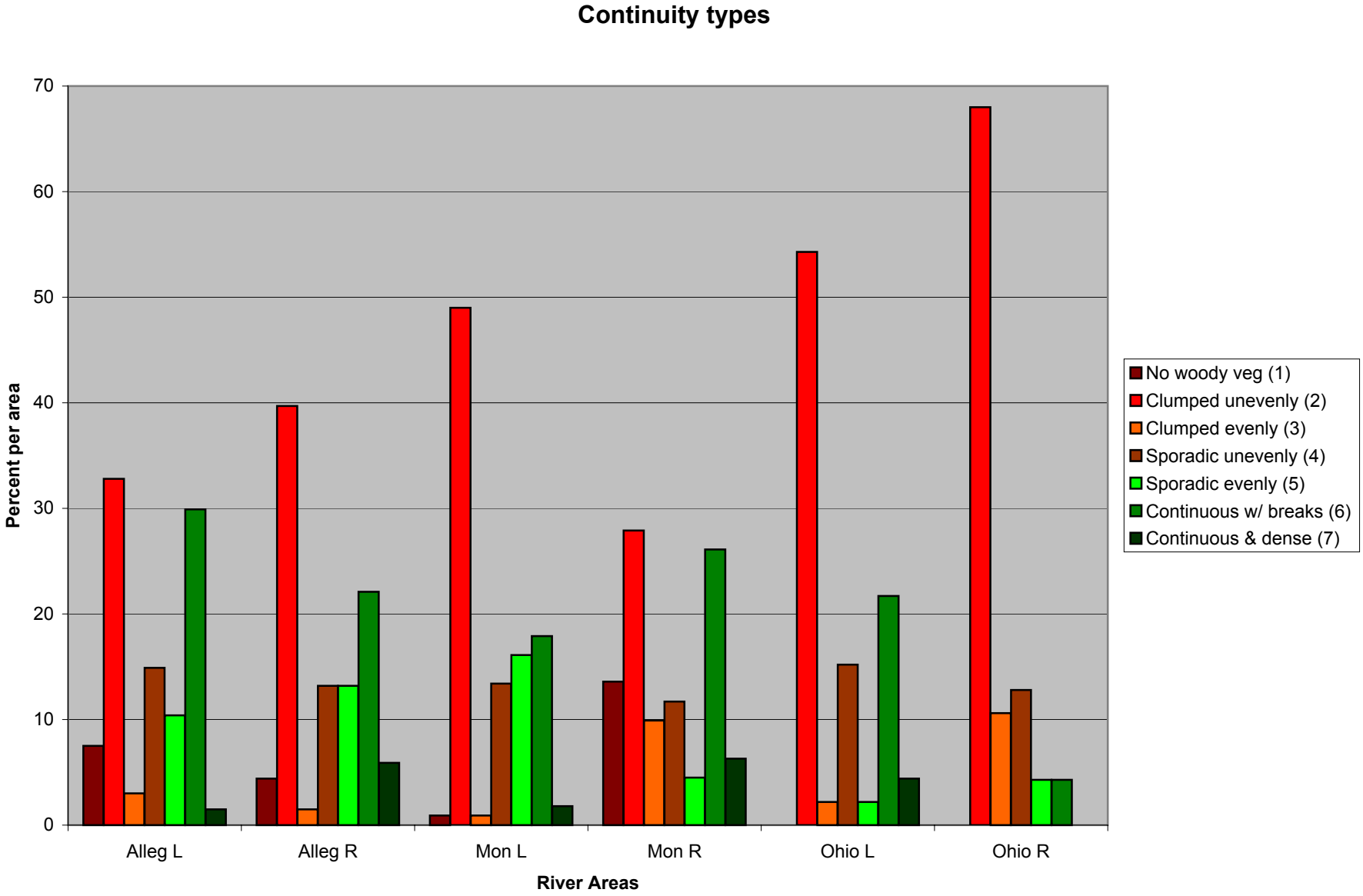
DATE: **PEOPLE:**	**UNIT NUMBER**				
Salix					
Toxicodendron radicans					
Ulmus americana/rubra					
Ulmus pumila					
Vitis					
Dead trees/shrubs					
Management Type					
% Exotic (woody by mass)					
% Woody (vs. herbaceous)					
% Cover					
Continuity Type					
Grass/sedge					
Ferns					
Aquatic plants					
Purple loosestrife					
Average canopy height (m)					
Maximum canopy height (m)					
Minimum canopy height (m)					

Canopy Height



Total Native Species vs Total Introduced




Continuity types
70
60
50
40
30
20
10
0
Percent per area
Alleg L
Alleg R
Mon L
Mon R
Ohio L
Ohio R
River Areas
No woody veg (1)
Clumped unevenly (2)
Clumped evenly (3)
Sporadic unevenly (4)
Sporadic evenly (5)
Continuous w/ breaks (6)
Continuous & dense (7)

Top Three Species in abundance, in each river area
natives in green - invasives in reds