3R2N Terrestrial Report: Allegheny River Phase 3 - 2002 Vegetation Assessment

Susan Kalisz, Ph.D.
Jessica Dunn
University of Pittsburgh, Department of Biological Sciences

3 Rivers 2nd Nature, STUDIO for Creative Inquiry
Carnegie Mellon University

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Authors
Susan Kalisz, Ph.D.
Jessica Dunn, B.S.

3Rivers 2nd Nature
STUDIO for Creative Inquiry
Carnegie Mellon University

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I. Abstract

The conservation and restoration of river systems is an area of global concern and action (Dynesius and Nilsson 1994). Riparian zones, the areas of contact between land and water along streams, rivers, ponds, lakes, and wetlands and the plants that live in them are key components in river ecosystem stability (Wetzel, 2001 chapter 10). Riparian plants' root systems help to stabilize riverbanks and stream banks, reduce erosion and decrease runoff and therefore significantly decrease the concentration of diverse nutrients, including nitrogen and phosphorus as well as other pollutants entering the river. Riparian plants provide habitat structure, food for terrestrial organisms and maintain water temperature through shading. Research in this area indicates the importance of riparian zones in the health and function of watershed ecosystems (reviewed in Ward and Tockner, 2001).

However, long-standing disturbance of the river and riverbank creates conditions that both diminish the local native biodiversity in the plant community and can foster the invasion of non-native plant species (e.g. Gilvear et al., 2000). Both of these factors can diminish ecosystem health. Maintenance of biodiversity is important because high levels of biodiversity have been shown to enhance the reliability of ecosystems in terms of primary productivity (Naeem and Li, 1997). Biodiversity within the plant community also distributes functional diversity across multiple physical scales of the ecosystems, which allows for subsequent renewal and recovery after disturbance (Peterson et al, 1998), especially when habitats are fragmented. In addition, disturbances that cause declines in biodiversity have been shown to increase the invasibility of the community to non-native species (Tilman, 1999). Therefore, understanding the structure and composition of plant communities along rivers in the context of the management (disturbance) milieu is a key first step in maintaining and/or improving river function and health.

The Botany Team's goal in the 3R2N project is to create a large-scale spatially referenced database of woody vegetation and selected herbaceous plants. This database will be used to determine the occurrence of native plant communities and invasive species in the context of human management of the Three Rivers.

II. 2002 Statement of Goals

In the 2002 field season, we had four main goals. First, as in previous years, our primary goal was to expand the vegetation database and characterize another section of the Three Rivers. This year we sampled the farthest reaches of the Allegheny River to be included in the 3R2N project. Second, we revisited and scored the sites along the Monongahela and Allegheny portions of the Pittsburgh pool measured in 2000 in an effort to standardize the overall plant database. Because of inconsistencies in sampling techniques used in 2000, that data could not be readily compared to our 2001 and 2002 data. Our new data for the Pittsburgh Pool allows us to make full comparisons of the Allegheny and Monongahela Rivers regarding the vegetative conditions and the plant communities of the Allegheny River to the Monongahela River (2001 study).

Third, to quantify the status of the islands in the study area, we surveyed the vegetation on all but one of the islands in the Allegheny River in Allegheny County. Since islands are a distinctive part of the natural beauty of the Allegheny River and have high recreational potential, these data will enable us to assess the condition of and vegetation on these islands, and identify places with promise for natural area preservation or recreational use.

The final goal of the 2002 vegetation survey was to evaluate the extent of exotic species invasion on our riverbanks. We have especially focused our efforts on Polygonum cuspidatum (Japanese knotweed) due to its high abundance along all riverbank sampled thus far, particularly along the Allegheny River and the level of public concern expressed about this invasive species at the River Dialogue public forums held by 3R2N in 2001 and 2002.

A. The Three Rivers Watershed belongs to the River Bed—Bank—Floodplain Plant Community Complex

Fike (1999) details the plant species and abiotic conditions that define typical native plant community complexes found in the state of Pennsylvania. (Note: These plant communities are cross listed by The Nature Conservancy's International Vegetation Classification and the Society of American Foresters' Forest Cover Types). The River Bed–Bank–Floodplain Complex (RBBFC) (Fike 1999) is a mosaic of forest, shrub woodland, grassland, partially vegetated gravel or sand bar community found in association with major rivers. Because of the heterogeneous nature of river habitat due to factors such as flooding and variation in the substrate, this complex is composed of several distinct plant communities that can intergrade with no clear boundaries.

We again applied Fike's (1999) plant community types to this year's data to determine the extent to which native riparian communities are present along the Allegheny River and Monongahela River. In total, the database for 2002 surveys includes eighty-five plus species (table 1). Additional data on non-woody species was collected for four herbaceous species or plant functional groups (see section V. Methods for details). The herbaceous species censused were Iris pseudacorus, Polygonum cuspidatum, Lythrum salicaria and Justicia americana. All species in the dataset were categorized as native, introduced and/or invasive.

Despite Pittsburgh's long industrial history and intensive industrial use of the rivers, our data indicates that native plant community complexes are present and sections of the riverbank where native plant communities remain intact. Of the eight communities listed in the RBBFC, we found five present along the Allegheny and Monongahela Rivers: four distinct native woody and one native herbaceous plant community (see fig. 5). We have indicated the occurrence of these five native communities detailed below on our maps.

III. Results

A. Distribution of species and community types on River Banks and Islands

Overall, we have identified eighty-five plant species occurring along the Three Rivers to date. Species include native, introduced and introduced and invasive plants. All species found in our surveys are listed in table 1. The distribution of all woody species (including Japanese knotweed) in the Pittsburgh Pool (fig. 1), the Allegheny (fig. 2) and Monongahela (fig. 3) Rivers indicate that the species are not uniformly distributed across the three sampling areas. For example, in a comparison of mean abundance of individual species between the two Rivers, silver maple and Japanese knotweed were more abundant along the Allegheny while box-elder and false indigo were more abundant along the Monongahela River (all comparisons significant by t-test, $p<0.05$). In addition, purple loosestrife (Lythrum salicaria) was found frequently along the Monongahela River, although never very densely. Surprisingly, this species was very uncommon in our 2002 study of the Allegheny, finding only one dense stand on a small island.

Of the eight riverine communities listed by Fike (1999), we found five present along the Allegheny and Monongahela Rivers. Four distinct native woody and one native herbaceous plant community (see fig. 5) were found commonly. We have indicated the occurrence and distribution of these five native communities on our maps (fig. 5-10). Although we found the same community types along both the Allegheny and Monongahela, the rivers clearly differ in dominant community types. As shown by figure 11, the Allegheny River is dominated by Silver Maple Floodplain Forest while the Monongahela is dominated by Sycamore–Box-elder Floodplain Forest.

Along the Allegheny Islands banks, four of the five native community types were found: Silver Maple Floodplain Forest, Sycamore–Box-elder Floodplain Forest, Black Willow Scrub/Shrub Wetland, and Water Willow–Smartweed River Bed Community.

Similarly, we found that the Allegheny Islands differed in the predominant community represented. Silver Maple Floodplain Forest was found on Herr's Island, Six-mile Island, Sycamore Island, Nine-mile Island, Twelve Mile Island, and Jack's Island. Sycamore–Box-elder Forest was found on Herr's Island only. Black Willow Scrub/Shrub Wetland was found on Six-mile Island, Fourteen Mile Island, and Jack's Island. Finally, the Water Willow–Smartweed Riverbed Community was found on Twelve Mile Island and Fourteen Mile Island (see fig. 12-18 for relative species abundances on islands). As expected the number of species was significantly higher on mainland when compared to the islands (t-test, $p< 0.05$). These results were expected based on the disturbed nature of islands and the species-area curve. Interestingly, the abundance of the invasive species, Japanese knotweed, on an island was significantly related to the area of the island using regression analysis ($R^2=0.47$) (see fig. 19).

Management of Islands We were surprised to find intact native plant communities along the islands given the fact that the combined effects of exposure to flooding, ice scouring and the high edge to area ratio of islands lead us to expect that they would be highly disturbed. On the contrary, these sites could be great candidates for the creation of natural areas and parks for recreation. Specifically, Sycamore Island is mostly composed of Silver Maple Floodplain Forest and Nine Mile Island has beautiful intact stretches of Black Willow Scrub/Shrub Wetlands.

Hardwood floodplain forests are among the most rare plant community types globally. The Pennsylvania Natural Diversity Index (PNDI) considers all floodplain forest to be imperiled in the state of Pennsylvania (http://www.dcnr.state.pa.us/forestry/pndi/pndiweb.htm). Large intact stretches should be conserved for this reason. Additionally, the presence of relatively intact floodplain RBBF complexes and elements of the native forest throughout the surveyed region means that restoration of our riverbanks could be expected to have a high probability of success.

B. Introduced vs. Invasive Plant Species

Not all species that are introduced to a new ecosystem become invasive. Many introduced

species become naturalized in the new ecosystem and do not increase in abundance. Of the eighty-five woody species in our database (table 1), twenty-nine are introduced (two from southern USA, seven from Europe and twenty from Asia). Of those twenty-nine species, nine are considered invasive. The US federal government definition of an invasive species:

> *An 'invasive species' is defined as a species that is 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112). Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions (http://www.invasivespecies.gov).*

Invasive plant species are of special concern in the Three Rivers because they appear to be establishing among the native plants on the riverbanks and can be expected to supplant the native species, resulting in a loss of biodiversity in the area. Our database will allow us to determine the occurrence and extent of woody and key herbaceous invasive exotic plants. The invasive woody plants in the 2002 survey area are listed in red in table 1.

Given the disturbed nature of the river, it is not surprising that we find introduced and invasive plants along all of the banks surveyed. As was shown by our 2001 study of the Monongahela, the proportion of introduced plants again decreases significantly with distance from Point State Park on the Allegheny River. While 19.2% of woody species are introduced on the Lower Allegheny River, 15.3% of woody species are introduced on the Upper Allegheny. The Upper Monongahela River had 14% introduced species and 86% native while the Lower Monongahela River had 24% introduced and 76% native. This trend is likely due to the high degree of human disturbance of the riverbank closest to Point State Park, which facilitates invasion of exotic species. This idea is supported by the fact that most examples of relatively intact RBBF complex are found in the upstream reaches of the watershed. Overall, the Allegheny and Monongahela Rivers do not differ significantly in the number of introduced woody species. However, the Allegheny and Monongahela Rivers differ significantly in the abundance of Polygonum cuspidatum ($p<0.05$, two-tailed paired t-test).

Year	2001	2002
River	Monongahela	Allegheny
Native	82.1%	83.0%
Introduced	17.9%	17.0%
Japanese Knotweed	5.9%	9.5%

In addition to Japanese knotweed, many other introduced and introduced-invasive species are found along the Allegheny River. We found that the same woody invasive species occur in both the Allegheny and Monongahela Rivers (see fig. 4). The most abundant of these species is the Tree of Heaven (Ailanthus altissima), which comprises 5.4% of all woody species abundance.

C. Japanese knotweed

Another goal of the 2002 survey is to evaluate the extent to which exotic species have invaded our riverbanks. Riparian zones are especially vulnerable to invasive species due to the disturbed nature of water edges. Human development along the banks of our rivers in urban areas further disturbs riparian zones and facilitates the spread of invasive species. In recent years, world-wide interest, as well as local interest, has been generated over the issue of invasive species. Three Rivers Second Nature has held several public dialogues and found that there is considerable public concern about controlling invasive species and promoting native species reintroduction in the Pittsburgh area. One species in particular, Japanese knotweed (Polygonum cuspidatum), which spans all of our riverbanks in the Pittsburgh area, has generated much concern. We focused especially on Japanese knotweed this year, due to local interest and the high abundance of this species.

Polygonum cuspidatum, also known as Reynoutria japonica and Fallopia japonica, is an herbaceous plant native to Japan. It was introduced to the United States in the late 19th century (Connoly 1977) and since has become invasive, out-competing native species, especially in riparian zones. The plant is widespread in most European countries (Beerling 1994) and has become so invasive in Great Britain that it has been illegal to introduce it into the wild since 1981 (Hollingsworth 2000). Outside of its native range, P. cuspidatum is male-infertile and propagates through its long lateral rhizomes (Beerling 1994; Seiger 1997). Very small segments of rhizomes are capable of producing a new stand (Beerling 1994), therefore the plant is easily dispersed by human movement of soil. This is especially a concern on our riverbanks where disturbing the soil can send rhizome fragments downstream to univaded areas.

Complete extirpation of P. cuspidatum has proven extremely difficult, but the species can be controlled with continuous effort (The Nature Conservancy 1992). Digging up the rhizomes is not recommended because dispersal of rhizome fragments usually occurs. The most recommended methods of control are cutting back of the above ground stems and herbicide application. Cutting must be done four times in a season to reduce rhizome biomass (Seiger 1997). Because even stem tissue can regenerate plants (DeWaal 2001), the cut material must be disposed of carefully. Herbicide application has also been recommended. Glyphosate [N-(phophonomethyl)glycine] is recommended by The Nature Conservancy (1992) and is approved for use near water. Both of these methods require several years of application and may be more effective if used in conjunction (The Nature Conservancy 1992). Because this species is not very shade-tolerant (Beerling 1994), planting native trees after removal by cutting or spraying may prevent future regrowth.

Also essential to controlling P. cuspidatum is preventing the spread of this species. Soil from an invaded area should not be transported and any soil disturbance in an invaded area near a watercourse should be minimized. New colonies should be cut as soon as identified, before they become established.

Polygonum cuspidatum was found in all pools of the study area in the years 2000, 2001, and 2002. Over all area surveyed, it comprises 11.5% of abundance of all woody species. It was found in 70% of survey units on the Monongahela River and 78% of survey units on the Allegheny River (see fig. 20). P. cuspidatum is significantly higher in abundance along the upper Allegheny River as compared to the upper Monongahela River (see fig. 3).

The high abundance of this species along our rivers leads us to believe that it is overtaking native riparian species. It has a higher abundance than more than 90% of native species, and is the third most abundant species along the upper Allegheny River. Research has shown that other herbaceous species cannot survive under the dense canopy of Japanese knotweed (Beerling 1994) and the recruitment of woody species is likely impaired. Upon re-sampling of Pool 1, we found P. cuspidatum in areas in which it did not occur only two years ago, confirming the species' ability for rapid spread in our area.

We recommend that measures be taken to prevent the spread of P. cuspidatum as well as eradicate it where possible. To prevent the spread, disturbance of soil in infested areas should be minimized. We recommend cutting a few times per season and spraying Glyphosate [N-(phophonomethyl)glycine] on very large, dense stands. Because this herbicide is non-selective, it should only be used in areas of complete P. cuspidatum cover and care should be taken not to spray surrounding plants. For smaller, less-established stands, we recommend cutting along with planting of native woody species such as Sycamore (Platanus occidentalis), Box-elder (Acer negundo), or Silver Maple (Acer saccharinum). We do not recommend Black Willow (Salix nigra) because P. cuspidatum was often found growing along with Black Willow in our survey, probably due to the Willow's sparse canopy.

IV. Conclusions

- The data thus far shows that the Monongahela and Allegheny Riverbanks accommodate diverse plant communities, which are comprised of native, introduced and invasive species.

- Four native woody plant communities and one native herbaceous plant community typical of large rivers in North America are found along both Monongahela and Allegheny Rivers.

- Although the same communities can be found along the Monongahela and Allegheny Rivers, the two rivers differ in which native communities are most common. Since floodplain forests are globally endangered, these forests contribute to regional and national biodiversity. This information can be used to direct conservation and restoration efforts along our rivers.

- Including Japanese knotweed, introduced species comprise 17-18% of woody plants along both the Allegheny and Monongahela Rivers. However, a lower proportion of those are both introduced and invasive.

- The frequency of invasive species decreases with distance from Point State Park on both the Allegheny and Monongahela Rivers, suggesting that human disturbance may be facilitating invasion or maintenance of invasive species once introduced.

- Tree of heaven and Japanese knotweed are the most common invasive species found to date in our database.

- Japanese knotweed, a species of great public concern, is found throughout the surveyed area at high abundances and poses a threat to our native species. It has increased in abundance in our sampling area even over the short span of this project. Serious eradication efforts are required to prevent further spreading and domination of this species.

- The islands of the Allegheny River support four of the five community types found on the riverbanks. Public use planning for these islands can provide opportunities to enhance the natural beauty of Pittsburgh, adding to the scenic quality of the rivers and potentially providing a recreational resource.

- There are several regions of the riverbank that are worth protecting as natural areas, especially the remnant floodplain forests.

- Several of the floodplain areas are associated with novel geological and anthropologically important features of the region. These could be simultaneously developed and protected to increase recreation, tourism and for the protection of wild land.

V. Field Methods for 2002

In 2002, Pools 1, 2, 3 and part of Pool 4 of the Allegheny River were the focus of the data collection effort. The length of the river studies was divided into one-tenth of a mile segments. Locations of sampling designated by Global Positioning System (GPS) coordinates were located through a hand-held GPS unit. As in the 2001 Monongahela River survey, the vegetation types along the river rarely change significantly between 0.1 mile segments in Pools 2 to 4 of the Allegheny, and we again sampled every other 0.1 mile segment. Because of the spatial correlation in vegetation in adjacent segments, it is clear that sampling every other 0.1 mile segment provides sufficient detail to characterize the riverbank vegetation. Thus, we are able to accurately characterize the entire length of stream bank of Pools 2, 3, and 4 using this sampling scheme.

As in 2001, we focused on determining the presence and relative abundance of the woody vegetation because they are diagnostic of plant community types (described below). When present, emergent woody and herbaceous aquatic vegetation was also recorded. Our primary survey method of the riverbank woody vegetation involved scanning the riverbank from the 3R2N vessel. We surveyed all woody vegetation from the shoreline to approximately twenty feet back from the river edge. This area encompasses the riparian zone. Because of the accessibility of the riverbank, we were usually able to collect data from within thirty feet of the shoreline in the boat and most identifications were easily made using binoculars. If closer examination was required to make an unambiguous identification, we went on shore and did a survey from on land, and either identified the plant(s) on-site or took a sample of the plant for later identification in our lab.

All raw data was recorded on data sheets (currently housed in binders in Kalisz's lab). The data was later entered into both an excel spreadsheet for data analysis and into access to create a geo-referenced database using GIS.

Data Collection and Definition of Variables: At each segment, each woody species was identified and each species identified was given an abundance rating from 1 to 4, denoting the percent of the total sample area covered by that species where the total sample area = [(0.1 mile X 20 ft.); not a percent of the vegetated area alone]. The scale for percent cover used is:

1 = ‹5% of the area
2 = 5-15%
3 = 16-40%
4 = ›40%

Estimates of total percent cover and percent composition of woody plants was taken at <u>every</u> 0.1 mile segment, including the segments not surveyed in detail. Taking this data at every segment would have revealed any large break in continuity that taking surveying every other segment might have missed. Percent composition of exotic woody plants was estimated at every other segment.

A rating of continuity was also given to <u>every</u> 0.1 mile segment, again in order to reveal any large break in continuity that might have been missed by surveying every other segment. Each segment was given a rating from 1 to 7, with 1 being not continuous and 7 being completely continuous (see fig. 21).

Management type was recorded at the same locations in which we collected detailed vegetation data. The management type of every area was noted as one of four types of classification: industrial, managed, semi-managed, not managed. Definitions of the four management types are:

1. Industrial areas are the areas where plant growth was inhibited by industry. These are the areas most impacted by humans.
2. Managed areas are areas where plant growth is directly controlled by humans (as in recreation areas or private homes).
3. Semi-managed areas are areas showing some human impact or controlled. Examples of these areas are areas around railroad beds and power-lines through relatively natural areas.
4. Unmanaged areas are those that showed no

current, readily perceptible impact or control by humans, although those effects may have occurred in the past .

For the segments surveyed in detail, we also recorded average canopy height, maximum canopy height, and minimum canopy height, as these variables are typically correlated with the presence and size/age of the trees and can indicate areas of significant shading of the river.

The abundance of standing dead trees was also noted at every other segment. Dead trees can be ecologically important to a forest community as habitats for cavity nesting birds and mammals. Each segment was given a rating from zero to four based on the number of standing dead trees. This is the scale used:

0 = 0
1 = 1-5
2 = 6-10
3 = 11-15
4 = 16+

As in 2000 and 2001 studies, additional data on non-woody species was collected for a small number of species or plant functional groups. Three of these plants, Justicia Americana, Iris psuedacorus, and Lythrum salicaria, were mapped and geo-referenced. These herbaceous plants are useful indicator species, plants of special concern, or invasive. Their place in the database is warranted, as these baseline data can be used to monitor spread or decline of these species in the future.

Justicia americana (water willow) is a native aquatic species found along edges of lakes, ponds, and streams. It usually indicates a healthy and intact riparian zone and is the dominant member of the Waterwillow-Smartweed Community. Iris pseudacorus (yellow iris) is an introduced species also found along edges of lakes, ponds, and streams. I. pseudacorus was often found growing near acid mine drainage in the Monogahela pools studied in 2001, but was rarely found on the Allegheny River, where there is little acid mine drainage. Lythrum salicaria (purple loose-strife) is a highly invasive species that was introduced to the United States from Europe. Here it is co-occuring with the native floodplain species Lobelia cardinalis (cardinal flower). It is found in scattered areas along our Pittsburgh Rivers and can be closely monitored for spread using this geo-referenced system.

The other non-woody plants noted, were emergent aquatic grasses, sedges and rushes, which form a plant functional group. Due to the distance constraints, grasses and sedges were not distinguishable and recorded in one category (grasses/sedges). Rushes were placed in a separate category. The presence of emergent grasses and sedges typically indicates the presence of sand and/or shallow water.

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