Biodiversity Analysis of Selected Riparian Ecosystems within a Fragmented Landscape

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For:
Michigan Great Lakes Protection Fund
and
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ABSTRACT

Riparian ecosystems of the Great Lakes Basin influence the quality of the Great Lakes and provide habitat for many characteristic elements of biodiversity within the region. Extensive human landscape modifications have dramatically changed the character of terrestrial and aquatic ecosystems in Michigan, especially in Lower Michigan, where riparian ecosystems are among the only remaining contiguously forested areas within highly fragmented landscapes. The significance of these isolated riparian ecosystems for maintaining regional biodiversity in a highly fragmented landscape is not fully understood. Historically, these areas have been poorly inventoried, and only a few elements of biodiversity are locally well known. This study was initiated to gain a better understanding of the biodiversity refuge potential of riparian corridors within fragmented landscapes. Our approach was unique in that we surveyed multiple elements of both terrestrial and aquatic communities, including plants, natural communities, migratory birds, amphibians and reptiles, small mammals, and multiple aquatic taxa. We used multivariate statistics to determine whether these community parameters were patterned among riparian corridors with varied levels of riparian forest width and connectivity. While there was little statistical evidence to suggest patterns at this stage of the work (Phase I), we anticipate, based on a thorough literature review, that we will observe predictable patterns following analysis of a more extensive and robust combined data set augmented by Phase II field surveys. Such patterning can contribute to the development of a riparian biodiversity model for southern Lower Michigan that may have wider regional applicability. Correlation analyses of the riparian community data indicated some expected and surprising associations among community parameters. In addition, spatial analysis of land cover properties of local and upstream riparian buffer areas provided an additional level of correlation analysis for riparian community components and multi-scale environmental properties of landscapes. These multi-spatial analyses identified some strong associations between community measures and upstream properties, suggesting that riparian biodiversity modeling and management may need to be conducted at larger spatial scales in order to be effective.

Contents

INTRODUCTION

Riparian areas serve as functional interfaces within landscapes, mediating matter and energy exchange between terrestrial and aquatic ecosystems (Hynes 1970, Meehan et al. 1977, Peterjohn and Correll 1984, Gregory et al. 1987, Gregory et al. 1991, Gould and Walker 1997). Functionally, riparian forests act as transitional zones, or ecotones, between terrestrial and aquatic ecosystems. Ecotones are considered areas of particularly high diversity because they encompass sharp gradients of environmental properties and ecological processes (Ricklefs 1989). Like other ecotones (e.g., wetland/upland interface), riparian zones are rich in biodiversity. The limited spatial extent of riparian ecosystems within landscapes belies their biodiversity value in terms of both the variety and abundance of local taxa and diversity of available microhabitats (Kaufman and Krueger 1984, Nilsson et al. 1988, Medin and Clary 1990, Gregory et al. 1991, Naiman et al. 1993).

Riparian corridors may harbor twice the number of species occurring in adjacent upland areas (Gregory et al. 1991). Fluvial processes such as erosion, flooding, channel migration and sediment deposition are widely regarded to influence the distribution and occurrence of individual plant species and plant communities within riparian ecosystems (Gregory et al. 1991, Mitsch and Gosselink 1993, Baker and Walford 1995). Intact riparian corridors often support higher diversity bird, reptile, amphibian and small mammal communities by providing necessary hibernacula, breeding sites and foraging areas (Carothers et al. 1974, Carothers and Johnson 1975, Kauffman and Krueger 1984, Doyle 1990, Olson and Knopf 1988, Burbrink et al. 1998). In adjacent streams, riparian forest canopy provides shade that limits instream primary productivity and water temperature fluctuation (Sweeney 1993). Leaf-fall materials from riparian forest canopies provide the primary energy base for invertebrate food webs, particularly in headwater streams (Hynes 1975, Gregory et al. 1987, Gregory et al. 1991, Sweeney 1993). Woody riparian zones also physically limit the movement of soils and nutrients from land surfaces to stream channels (Peterjohn and Correll 1984, Lowrance et al. 1984, Behmer and Hawkins 1986, Gregory et al. 1987, Osborne and Kovacic 1993). Clearly, riparian forests play important roles in structuring associated terrestrial and aquatic communities, although studies of community level responses to multiscale changes in riparian and landscape land cover properties are just beginning to emerge (e.g., Allan et al. 1997, Goforth 1999).

Human-induced landscape changes may be the greatest contributing factor for the decline of ecological resources. Habitat destruction is one of the five largest threats to aquatic ecosystem health and biodiversity (Karr and Chu 1999). The primary human disturbance to forested watersheds of eastern North America has been deforestation. This is demonstrated by the small percentage of old-growth native forests remaining. Secondary growth forests are the norm for eastern North America, and native forests within Michigan's southern lower pennisula are no exception (Albert 1994). A secondary response to forest removal has been the use of newly cleared landscapes for cattle grazing and row-cropping. In the last 200 years, cultivation, livestock grazing and other anthropogenic activities have destroyed 80% of the riparian corridors along North American and European streams and other water bodies (Dechamps and Naiman 1989, Dix et al. 1997). Southern Lower Michigan's landscape has been modified for agricultural land uses, fragmenting the forests that remain. Habitat fragmentation and resulting edge effects can significantly reduce native biodiversity (Wilcox and Murphy 1985). However, habitat corridors, such as riparian ecosystems, may potentially sustain viable populations of native plants and animals. Riparian ecosystems therefore represent potential habitat for sustaining a significant portion of regional biodiversity within southern Michigan's fragmented landscapes.

The extent to which remnant riparian forests in fragmented landscapes provide refuge for native biodiversity was evaluated by surveying plant, terrestrial vertebrate, fish and aquatic invertebrate communities within riparian corridors of varied width and connectivity. The central hypothesis of this study is that native plant, terrestrial vertebrate and aquatic community attributes of riparian ecosystems within fragmented landscapes are dependent upon the width and connectivity of the riparian corridors in which they exist. We predicted that species richness, the relative abundance of intolerant and native taxa, and measures of terrestrial and aquatic community integrity would be higher in wider, more contiguous riparian forest corridors within an agricultural landscape. Stream community integrity measures based on fish, benthic macroinvertebrate and mussel communities were expected to be positively correlated with higher quality habitat properties (except the relative abundance of tolerant unionids, which was expcected to be negatively associated with higher quality habitat properties). These habitat properties were expected to be associated with increasing forest buffer widths. We expected that ecological descriptors of plant communities would vary according to multiple factors, including riparian width and connectivity, study site, riparian basin (i.e., Raisin, Grand, Saint Joseph and Kalamazoo watersheds) and within-site ecological zones. We also expected that our community and ecological response variables would be variably associated with land cover properties of varying buffer widths adjacent to and upstream from our sample sites.

METHODS

Study Sites

Riparian study sections (Figure 1) were chosen based on forested buffers estimated from USGS topographic maps (1:24,000 scale) and aerial photos (Michigan Department of Natural Resources 1988). Twelve stream sections consisting of three different forested riparian buffer categories (<125m, 125-250m and 250-500m) within four adjacent river basins were sampled. The four river basins included the Grand River (GR), Kalamazoo River (KZ), River Raisin (RR) and St. Joseph River, Lake Michigan drainage (SJ). These basins were chosen due to the close proximity of their headwaters; the boundaries of all four headwater catchments can be encompassed within a 30km radius. Sites were identified by river basin and riparian buffer class (e.g., GR<125m is the <125m site in the Grand River basin). The survey sites were reaches within the study sections located 20-60km downstream from their respective sources. Selected study sites ranged from small 3rd order to large 4th order stream reaches (Table 1). Access to selected riparian areas was based on landowner permission; this immediately narrowed the potential number of sites considerably. Secondary criteria involved accessibility of the river for transporting sampling equipment. Selected areas were evaluated to determine whether aquatic and terrestrial habitats representative of the entire study section were present. A 150m stream reach served as a sampling unit for the aquatic surveys and variably sized adjacent riparian areas (up to one linear km) were designated as sampling sites for terrestrial vertebrate, vegetation and floristic sampling.

Aquatic Sampling

Habitat quality evaluation is critical for assessing ecological integrity given that biological diversity and stream habitat integrity have been shown to be closely linked (Raven 1998). Instream habitat and surrounding topographic features are major determinants of aquatic community potential (Plafkin et al. 1989, Barbour and Stribling 1991). Physical habitat characterization was evaluated using the US Environmental Protection Agency's (EPA) Habitat Assessment Field Data Sheet for Low Gradient Streams (Barbour et al. 1999), hereafter referred to as the HQI. This visual-based assessment method guides users to examine 10 site physical parameters using a rating scale from 1-20 for a best possible reach score of 200. The HQI reflects professional-based judgements of stream condition (i.e., meander, riffle/run/pool ratios, habitat availability, riparian disturbance, etc.) in relation to best possible conditions that could be expected. The HQI was performed in conjunction with stream morphology measurements of stream width, channel depth, substrate characterization and % woody substrate taken at 10m increments within the reach. Instream woody substrate is reported as the percentage of wood surface area per length of stream bottom in a transect (e.g., 4m of wood in a 16m wide transect=25% woody cover). Since the HQI integrates habitat metrics that range from instream substrate to the immediate riparian area, it is a good measure of the overall reach habitat condition that can be measured consistently among sites. In addition to the HQI evaluations, physiochemical parameters (i.e., temperature, pH and conductivity) were also taken on-site with an Oakton hand-held combo meter.

Fish communities were sampled at each of the 12 study reaches from 19-June to 9-Sept 2000 using a Coffelt™ gas-powered backpack electroshocker and a 20-ft, ¼" mesh, straight-haul seine (Photo 1). Depletion survey methods were not used for abundance data. Instead, a qualitative species depletion method (Saylor and Alhstedt 1992) was used to obtain a representative species occurrence list and species' relative abundance. Beginning at the bottom of the reach and working in an upstream direction, a single electroshocking pass was made that included all habitats within 3-5m from the streambank. In wide riffle areas, the seine was stretched and held in place by two workers while an area 10m upstream from the net was fished using the shocker, effectively driving fish into the seine. This method significantly reduces fish injuries and mortality commonly experienced with kickseining. Netted and electro-seined fish were placed in a bucket and held in fresh stream water until they were identified and released.

Deep runs and pools were sampled by Mad-dog™ seining. Mad-dog™ seining consisted of walking the seine in a downstream direction rapidly enough to maintain an upstream bow in the seine and lead–line contact with the bottom. At the end of the seine run (≈20m) fish were encircled in a slow-current area or beached. Fish seined using these methods were recorded separately from the eletroshocking efforts. Fish were identified to species (Page and Burr 1991),

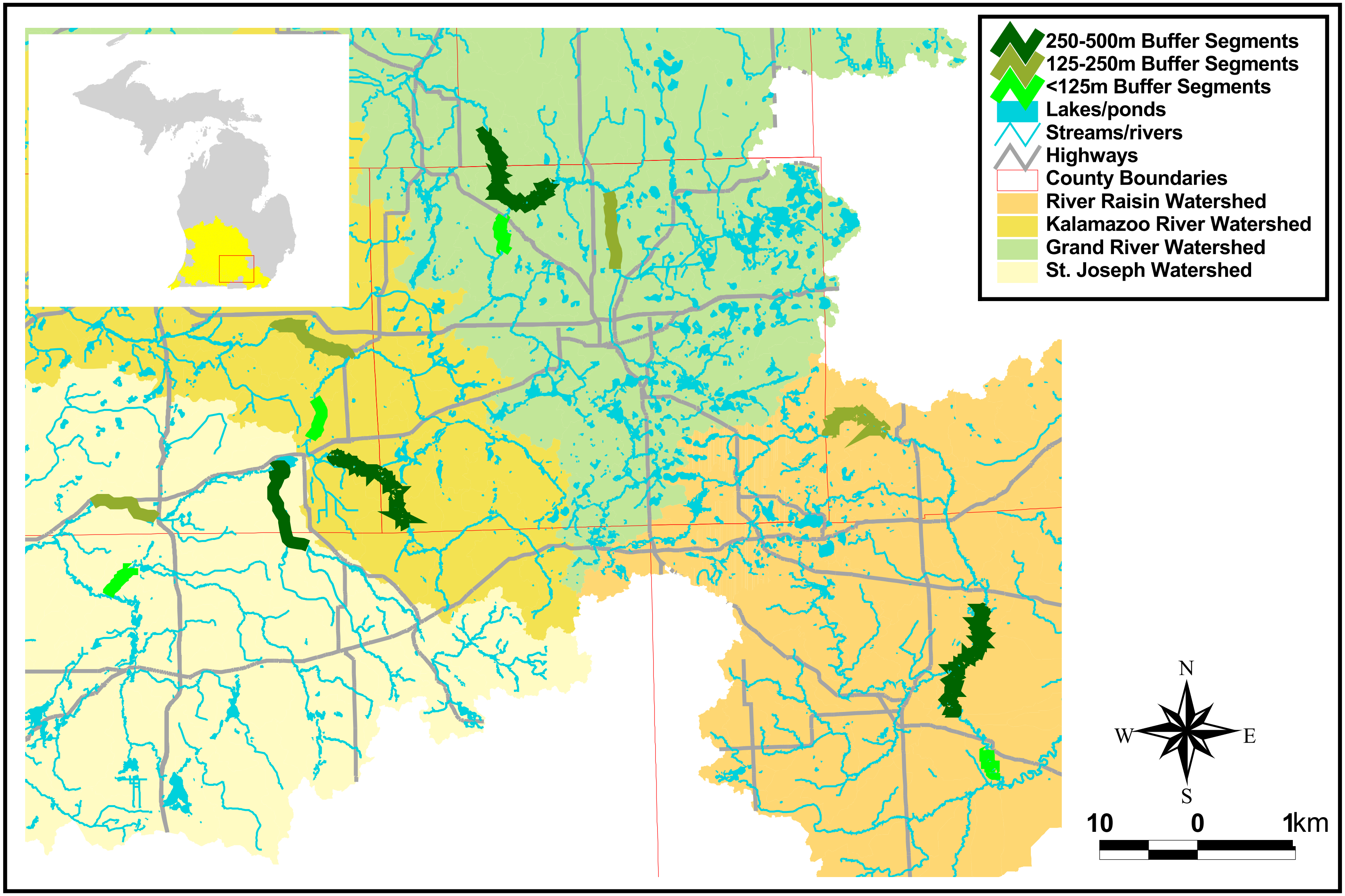


Figure 1. Riparian study sections used for the riparian ecosystem study. Survey data collected from reaches within these sections were used to test whether riparian community and habitat properties were different among three riparian forest buffer classes.

Photo 1. Electroshocking crew preparing to sample fish communities at the RR125-250 survey reach.

Photo 2. Field sampling crew using aquascopes (i.e., glass-bottomed buckets) to survey unionid clams along a stream transect. Survey flags mark the locations of mussels along the transect.

counted, examined for overall condition and age, and then released. Mortality rates were very low using these methods, although the few specimens lost to mortality were retained as vouchers.

Modified Indices of Biotic Integrity (Karr 1981, using Midwest modifications after Barbour et al. 1999) were used to estimate the fish community integrity (FIBI) of each site (poor to high scores ranging from 12-60). The site electroshock effort was reported in seconds, but was converted to minutes when reporting catch per unit effort (FCPUE) for the reach (#fish/minute) or individual species (#of darters/minute, Appendix I). Tolerance and trophic values required for the IBI were determined from Barbour et al. (1999). In addition to the FIBI, the relative abundance of intolerant individuals in the total catch (RAIF) was used as an additional measure of stream quality, given the assumption that intolerant species will become scarce with increasing levels of disturbance.

Mussels were sampled using a catch-per-unit-effort approach because the emphasis of our study was to determine species composition and relative abundance and not to quantify densities. Catch-per-unit-effort techniques provide a more complete look at the mussel assemblage than substrate excavation quadrat methods, and are more likely to locate rare mussels (Strayer et. al 1996, Vaughn et al. 1996). Visual surveys were conducted along a series of defined transects (nine per site) across the width of the stream. Aquascopes (glass bottomed buckets) were used for underwater viewing while wading (Photo 2), or in depths >1m, SCUBA was utilized along transects. Mussels (and dead valves) observed during the timed-transect period were placed in mesh bags for later processing. Live individuals collected were identified to species, enumerated and released in the field. Dead valves were taken back as a collection record to be deposited at the University of Michigan museum, but were not included in the survey data.

This survey technique enabled surveyors to search an entire cross-section of the stream without bias towards the best habitat. However, when high densities of mussels were encountered, efforts were increased in that general area. Surveyors on each side of the stream channel worked toward the middle, searching approximately 1m above and below the transect line. This procedure began at the most downstream transect in the reach. Pools and runs were sampled within each site, including a range of substrate types (e.g., silt, sand, gravel and rock). Visual surveys tend to be biased toward larger individuals, but by remaining consistent across all stream reaches, the data collected was expected to be comparable across sites. Time searched by the surveyors was converted to catch per unit effort (MCPUE) expressed as #mussels/person-hour. Intolerant mussel species (Appendix II) were reported as the relative abundance of intolerant individuals in the total catch (RAIF). Species tolerant of silty, mucky or degraded aquatic habitats (e.g., *Lampsilis siliquoidea,* fatmucket, and *Strophitus undulatus*, squawfoot) and habitat generalists (*Amblema plicata*, three-ridge, and *Anadonta grandis*, giant floater) were combined and analyzed as relative abundance of tolerant mussels (RATU).

Benthic invertebrate samples were collected from riffle habitats using a 500µm mesh Surber™ sampler. Nine Surber samples were taken within each reach between 20-Jul and 7-Sept 2000. At each site, sampling was initiated at the most downstream riffle, and subsequent samples were collected by systematically moving upstream with each sampling effort. For example, if the study reach contained three riffle/pool sequences, three replicate samples would be taken from each riffle. If shallow riffle areas were not present, but suitable substrate was present, an alternative quantitative method was used. A long-handled dip net (12"x 24" net opening, 500µm mesh) was held firmly against the bottom and the substrate 0.5m upstream from the net was thoroughly disturbed to dislodge associated benthic taxa. The EPA's multi-habitat dipnet sampling protocol (Barbour et al. 1999) was used to collect aquatic invertebrate samples from all substrates and microhabitats within each reach (i.e., deep riffles, undercut backs, logjams and macrophytes). A multi-habitat dip net sample was taken at the lower and upper reach of the site (n=2, ~75m represented for each discrete sample). To collect the samples, twenty 0.5m jabs were taken in proportion to the habitat types identified in the reach with a 500µm mesh, long-handled dip net. Contents of the net were washed thoroughly and preserved using 70% ethanol (EtOH). Samples were later processed and identified (genus/species level) in the laboratory using protocols and taxonomic resources outlined in Barbour et al. (1999).

Total aquatic invertebrate species richness (ISR) and the total number of Ephemeroptera, Plecoptera and Trichoptera taxa (i.e., EPT Index) reported for each site were estimated by combining species collected using both sampling methods. The invertebrate biotic index (InBI) and the relative abundance of intolerant benthic invertebrates (RAIB) were calculated by averaging data from six Surber samples (multi-habitat sample data were not used in these calculations). These calculations involve the use of tolerance values of the organisms (ranked 0-10, Barbour et al. 1999), or their ability to withstand degraded environmental conditions. Invertebrates intolerant of disturbance are represented by low ranks (0-3), while those very tolerant of disturbance are ranked higher (7-10). The InBI was calculated by multiplying the number of individuals of taxon^i found in a sample (n^I) by that taxon's tolerance value (TV^i) and summing all ($n^i TV^i$) in the sample. Finally, this sum is divided by the total number of individuals in the sample (TN) to derive the InBI for the sample. Six InBI values were averaged to provide a mean InBI value for each site. The RAIB was simply the sum of all individuals with tolerance rankings 0-3 divided by the total number of individuals in a sample.

Terrestrial Vertebrate Sampling

Amphibian and reptile communities were sampled using straight-line drift fences with pitfall and funnel traps between 15-May and 27-May 2000. Three trap arrays were installed at each site. Trap arrays were oriented parallel to the river to intercept animals moving between upland and riparian areas and perpendicular to the river within the riparian zone. Trap arrays were placed in areas that were relatively flat and open, and judged to have lower likelihood of flooding. Arrays were located from 5-100m from the river, and were spaced ≈30-100m apart, depending on the width and length of the study site. At three study sites (i.e., GR250-500m, RR<125m and RR125-250m) trap arrays were placed among two or three disjunct parcels to accommodate landowner permission and availability of suitable areas for trap installation.

Each trap array consisted of two 15m long drift fence sections separated by a pitfall trap in the middle. Two funnel traps were placed at each end, one on each side of the fence (four traps total/array, Photos 3 and 4, Mierzwa pers. comm.). Drift fences were constructed using 15m long x 50cm high aluminum valley flashing. The bottom edges of the drift fences were buried ≈10-15cm deep for the length of the fence, and were supported by 60cm wooden stakes placed on either side of the fence every 1.2-1.5m. Pitfall traps consisted of 19-liter plastic buckets that were buried in the ground with the opening flush with the surface (Corn 1994). In areas where the water table was high, rocks were placed in the traps to help hold them in place. Pitfall traps contained 5-8cm of water and were emptied when filled with excess water. When pitfall traps were not in use, plastic lids were used to cover the traps. Funnel traps were constructed from 60cm wide x 76cm long pieces of rigid hardware cloth rolled into a circular tube or cylinder and attached with plastic cable ties (Karns 1986, Vogt and Hine 1982). The body of the trap was approximately 20cm in diameter and 76cm long. A 20cm diameter plastic funnel with 4cm diameter opening was attached to one end of the trap with plastic cable ties, and a piece of circular particleboard was attached to the opposite end to close the trap. Funnel traps were placed parallel and immediately adjacent to the drift fence, and small logs and/or large branches were placed next to the traps to hold them in place. Traps were shaded with leaf litter, loose bark and other woody debris. Soil was placed at the funnel end of the trap to create a level surface from the ground to the funnel opening.

Trap arrays were open for 10 nights at each site, resulting in 150 trap-nights per site ideally. However, many sites experienced flooding or problems associated with a high water table during the trapping period, which reduced the number of trap-nights at these sites. Only two sites (KZ<125m and KZ125-250) had 150 trap-nights, while the other sites had from 126 to 149 trap-nights. Trap arrays along the GR and KZ Rivers were checked after every one to four trap-nights, while those along the River Raisin and St. Joseph River were checked after every one to six trap-nights. This schedule resulted in traps being checked three to four times per site. Trap arrays were removed from study sites after trapping was completed.

Amphibians and reptiles captured in the pitfall and funnel traps were identified, marked and released in the field. Frogs and salamanders were marked by toe clipping, and snakes and turtles were marked by painting a spot on their tail or shell, respectively. Other incidental animals caught in the traps and observed at or near trap arrays were noted and released on site. Dead specimens also were noted. Dead incidental small mammals captured in the traps were collected and later identified in the lab. Several crayfish captured in the traps also were collected for identification. Data on the species and number of individuals caught, specific array and trap type, weather conditions and time of trap checks were recorded in the field.

A single time-constrained (two person-hours) visual encounter survey (Crump and Scott 1994) was conducted at each site from 29-May to 7-Jun 2000. Visual encounter surveys were conducted by walking 100m transects parallel to the river. Transects were initiated at randomly selected points immediately adjacent to the study reach, and subsequent transects were placed 20m apart and further inland. Surveys were conducted during daylight hours and under appropriate weather conditions. These surveys involved overturning cover (i.e., logs, boulders, etc.), inspecting retreats, and looking for basking and active individuals in the river and on land. All animals encountered within one meter of the transect path were recorded. The species, number of individuals, age class, location (i.e., approximate distance from the river), activity, substrate and time of observation were noted. Weather conditions and start and end times of

Photo 3. Installation of drift fence for trapping amphibians and reptiles.

Photo 4. Example of amphibian and reptile drift fence, pitfall and funnel trap array. Two funnel traps were placed at both ends of drift fence.

surveys also were recorded.

Breeding frogs were surveyed at the study sites by conducting frog call surveys on the nights of 20-May, 22-May, 26-May and 6-Jun. Surveys were conducted by listening for frog calls after dark (from 9 PM to 1 AM) for ten minutes from the road or adjacent habitat at all properties with herp trap arrays. Each site was surveyed only once during the breeding season, in part due to sub-optimal weather conditions (e.g., heavy rain, high winds and/or cool evening temperatures) during the breeding season. Species, call index values indicating relative abundance, location, time and weather conditions were recorded. Call indices were defined in the following manner: 1 = individuals can be counted, space between calls (i.e., 1-5 individuals); 2 = individual calls can be distinguished but some overlapping calls (6-12 individuals); and 3 = full chorus, calls are constant, continuous and overlapping, unable to count individuals (Michigan Frog and Toad Survey Protocol 2000).

Overall species composition and richness for each site was derived by combining the species recorded from all three-survey methodologies. Incidental species documented during herp surveys or aquatic community surveys was also included in a separate estimate of species richness to see if study results differed with these additional species. Relative herp abundance per site was calculated separately for herp trapping and visual encounter surveys. Relative abundance based on herp trapping was expressed as number of individuals per trap-night and was derived by dividing the total number of individuals captured by the total number of trap-nights. Relative abundance based on visual surveys was expressed as the number of individuals per person-hour of survey time and was derived by dividing the number of individuals observed by two person-hours of survey time. Relative abundance estimates did not include incidental observations.

Bird surveys using the point count method were conducted using standard methodology (Ralph et al. 1993, 1995). Three point count stations were established at each study site for a total of nine point count stations per watershed and an overall total of 36 stations for the study. Each station was located at least 100m from the edge of the river and no closer than 100m to the boundary of the riparian forested habitat. Point counts stations were established at least 250m apart to ensure that each bird was counted only once. Standard field forms for point counts were used to record the birds that were seen and heard at each point count station. All birds seen or heard within a 50m radius were tallied for five minutes during spring migration and for 10 minutes during the breeding season. Birds seen or heard outside the 50m radius were noted as well. Spring bird counts were conducted between sunrise and 1200 hr on 13-May to 15-May 2000. Breeding bird counts were conducted between sunrise and 1200 hr on 23-Jun to 29-Jun 2000. All counts were conducted when there was no precipitation and little or no wind.

The relative abundance of dominant species and overall bird abundance per site was calculated by counting the number of birds within 50m of each survey point and dividing by the total number of points per site. Species richness measures represented the total number of bird species observed at each study site. Correlation analysis was utilized to investigate the influence that habitat structure and floristics had on overall bird abundance and species richness during the breeding season.

Small mammal trapping was conducted during August 2000. Sherman live-traps were placed along a 200m transect with a single trap placed at 10m intervals along the transect (total of 20 traps per site). Traps were baited with a peanut butter and oatmeal mixture and left open for four consecutive trap-nights (Cooper 1997). All captured individuals were marked by clipping the tips from a small patch of hair on the animal's rump, exposing the darker, basal portion of the hair and creating a distinctive mark (Myers, pers. comm.). Recaptures of marked animals were noted on data sheets. All species captured were recorded per site and the relative abundance of the overall small mammal capture per site and the abundance of dominant small mammal species per site were calculated and expressed as the number of captures per 100 trap-nights. Traps that were sprung were not included in the total number of trap-nights per site. In addition, small mammal species captured in pit-fall traps during reptile and amphibian surveys were recorded at each study site.

The presence of furbearers was documented by looking for animal tracks and sign throughout each of the study sites. In addition, scent stations were used to document the occurrence of mammal species. Two stations were established per site and spaced ≈250-300m apart. Each station consisted of a circular area of sifted dirt 2m in diameter. In the center of each station a fatty acid tablet was placed as a mammal attractant. Stations were operated for four consecutive days and checked daily (Roughton and Sweeny 1982).

Terrestrial Vegetation and Floristic Surveys

Vegetation and ecological sampling was conducted from 22-May to 15-Jun 2000 and 17-Aug to 29-Aug 2000. These sampling periods were selected to optimize identification of both early and late season floras, given that it was not possible to conduct more than two site visits during the study. The locus of vegetation sampling within survey sites was established following a thorough site reconnaissance and timed meander search. This approach facilitated the identification of a representative sampling transect within the study area (see below). During the preliminary site assessment, the number of distinct ecological zones (e.g., levee, first bottom, second bottom, sparsely forested bottom, upland forest, etc.) was determined. Transects were established approximately perpendicular to stream reaches in areas that captured the variability of microhabitats observed and that facilitated sampling across a site's ecologically distinct zones.

Plastic piping was staked at the origin of the base transects, marking the immediate river edge. Measuring tapes (m) were drawn out to the edge of the riparian buffer, and a transect compass bearing was taken and recorded. The width of each distinct ecological zone was measured and a random number table was used to determine the location of sampling transects within each zone. These transects were oriented perpendicular to the initial base transect. Five flags were placed along each of the sampling transects within the different zones. The location of these flags was also determined using a random number table**.** These numbers defined the number of paces to be used along the sampling transect. For each zone, flags were placed on each side of the base transect with either three on the right side and two on the left side or two on the right side and three on the left. The flags were used as the center of three sampling plots: a $1m^2$ groundcover plot, a 5m radius circular understory plot and a 10-factor prism plot for the overstory.

Within each ecological zone a nested sampling scheme was used to establish 15 sampling plots. A $1m^2$ sampling frame was used for the groundcover plots. Within each groundcover plot, species were identified and assigned a percent cover. A mean percent cover per plot was determined for each species, and a mean number of species per plot (GCSE and GCSL for early and late season surveys, respectively) and mean percent groundcover per plot (%GCE and %GCL for early and late season surveys, respectively) were calculated for each site. In areas that were seasonally inundated, the water depth within $1m^2$ plots was measured. Within the 5m radius plots, all woody stems and vines less than 4 inches in diameter and greater than one meter high were identified and tallied. The mean number of stems per plot was determined for each species, and the mean number of species (USSp) and mean number of stems per plot (USSt) were calculated for each site. Within the 10-factor prism plots, trees greater than 4 inches in diameter were identified and tallied. Trees within adjacent prism plots were alternately included only in the first or last plot sampled to avoid repeated tallying of the same trees. Diameter at breast height (DBH) was noted for each tree within the prism plot. The mean basal area (m^2) per hectare per plot was determined for each tree species, and the mean number of tree species per plot (TSP), mean total basal area per plot, and mean DBH per plot were calculated for each site. Data from the 10-factor prism plots were used to generate the mean basal area by site and zone and the mean basal area of species by site and zone.

The base transect was also used to establish a topographic profile for each site. Starting from the riverbank, a clinometer was used to determine the elevation above or below the starting point five and ten meters away. This was accomplished by positioning a leveled piece of plastic pipe (marked at three inch increments along its length) at the five and ten meter intervals along a transect. A clinometer was sighted from the transect zero point to determine the elevation at each point surveyed relative to the zero point. This procedure was repeated at intervals of ten meters over the entire transect. A topographic profile was graphed for each site and a coefficient of topographic variation (CTV) was calculated to provide a measure of elevational variability within and between sites. The CTV was calculated by dividing the standard error of the height above or below the riverbank by the mean height above or below the riverbank.

In addition to the quantitative surveys, each site was qualitatively evaluated. Notes were taken describing anthropogenic disturbance; flood status; the extent, structural diversity, microhabitat variability, abundance and status of dead and down material; and the extent and pervasiveness of exotic, adventive or dominant species. Representative sites and zones were photographed when possible or as appropriate. Field forms were completed for rare plant species as well as for floodplain communities recognized as high quality examples of southern floodplain forest. Following field sampling, rare plant and natural community occurrences were transcribed and processed into MNFI's statewide BioTICS database.

All communities surveyed during this study were defined in relation to the Michigan Natural Features Inventory (MNFI) Natural Community Classification (MNFI 1990). Two community types were identified during this study, southern floodplain forest (occurring at every site) and prairie fen (occurring in only one floodplain buffer). Assessment of natural community quality was guided by established MNFI methodology detailed in MNFI (1988). In addition, the quality of surveyed communities was gauged by consulting the MNFI statewide BioTICs database, which contains benchmark examples of southern floodplain forests and prairie fen. Those surveyed communities determined to meet the qualifying criteria were included as high quality occurrences in the statewide database and were appropriately ranked.

A complete floristic list was compiled for the 12 riparian sampling sites by identifying all vascular plants within each study area. An initial list was compiled by first conducting a timed meander search of a site encompassing all observed habitats and microhabitats. This included surveying the vegetation of the river and river edge, levee areas, successive flood bottoms (e.g., first bottom, second bottom, etc.), mounds and other notable rises, seasonally inundated areas and backwaters, depressions, and upland areas up to the extent of the *a priori* delimited forested buffer zone. Following the meander search, which also served as general site reconnaissance for selecting a subsequent representative sampling transect, new species were added as they were observed within and adjacent to vegetation sampling plots.

An existing field checklist for southern floodplain forest based on the MNFI natural community classification (MNFI 1990) was used to compile an initial species list, and additional species were added as they were encountered and identified. All floristic surveys took place in conjunction with vegetation and ecological sampling during the periods noted previously. Specimens of species that could not be reliably identified in the field were collected for verification and keying. Collections included large numbers of sedges (especially *Carex* spp.), rushes and grasses. Sterile specimens were also collected for further study to attempt to identify them beyond genus level. A relatively small number of specimens were pressed and dried so that they could be verified by botanical experts and/or submitted as appropriate to the University of Michigan Herbarium (MICH); these included voucher specimens for the documentation of new occurrences of rare species and a few significant county records. Taxonomy and nomenclature for flowering plants largely follows the Michigan Flora (Voss 1996, 1985, 1972), with the exception of Case (1987) for orchids, Case and Case (1997) for trilliums, and Gleason and Cronquist (1991) for a more contemporary treatment of the genus *Carex* and other sedges. Lastly, pteridophytes (ferns and fern allies) follow the North America Flora treatment provided in Morin et al. (1993), as this group is not included in the Michigan Flora.

Following all field sampling and specimen verification, species lists for each site were compiled. A careful review was conducted by examining field checklists with the vegetation sampling data for each site as well as specimen identification lists; these were further reconciled with a master species list compiled for all sampling sites. Following a full reconciliation of these data, plant lists for each site were entered via a Floristic Quality Assessment (FQA) program (Wilhelm and Masters 2000) containing an embedded Michigan flora list. Herman et al. (1996) and Swink and Wilhelm (1994) provide a detailed description of this system and its applications. Floristic Quality Assessment (FQA) was designed as a tool to assess the floristic integrity of sites (i.e., ecological integrity or natural area quality) based upon the objective application of a subjectively determined value for each native plant species known as its "coefficient of conservatism" (Herman et al. 1996, Swink and Wilhelm 1994). The Coefficient of conservatism (*C*), which follows a 0-10 scale, can be defined as the estimated probability that a plant occurs within a plant community relatively unaltered from what is believed to be a presettlement condition. Low values are given to plants with little fidelity to remnant natural communities (e.g., *Acer negundo*, box elder), whereas high values are assigned to species that are consistently restricted to higher quality natural areas emulating presettlement conditions (e.g., *Potentilla fruticosa*, shrubby cinquefoil). A floristic quality index (FQI) is calculated by multiplying the mean coefficient of conservatism ($\overline{C}$) of a plant inventory by the square root of the total number of plants ($\sqrt{n}$): $\text{FQI} = \overline{C} \times \sqrt{n}$. The square root of *n* is used as a multiplier to enable a better comparison of FQI values between large sites with a high number of species and small sites with fewer species (Herman et al. 1996). In addition to the Chicago region (Swink and Wilhelm 1994) and Michigan, floristic quality assessment systems have also been prepared and used in Illinois (Taft et al. 1997), Ontario (Oldham et al. 1995), northern Ohio (Andreas and Lichvar 1995), and Missouri (Ladd, in prep.).

Our sampling sites were systematically assessed and compared with respect to several attributes as summarized by the FQA, including total floristic diversity, proportions of native and non-native species, FQI score, native mean coefficient of conservatism ($\overline{C}$) and average wetness coefficient. The FQA also provided a means by which to assess and summarize sites with regard to their respective proportions of physiognomic groups or life form categories (i.e., tree, shrub, vine, forb, grass, sedge or pteridophyte).

Spatial Analysis

A land cover database was developed by integrating aerial photograph interpretations of areas adjacent to and upstream from the study stream sections into a Geographic Information Systems (GIS, ESRI 2000) database. Aerial photographs from flyovers conducted for the Michigan Department of Natural Resources in 1988 were used to create updated land cover databases within a GIS. The 1988 photos were the most current data sources available when interpretation work began. The black-and-white photos used depicted landscape properties at 1:24,000 scale. Land covers were distinguished using interpretation techniques provided in Avery and Berlin (1985) and represented land cover classifications commonly identified for landscape data sets. Polygons representing homogeneous land cover units interpreted from the photos were hand-drawn on mylar overlays. The mylar line work was digitized using a large format Eagle scanner. The resulting scanned images were converted to ArcInfo grids that were vectorized using the ArcScan command within ArcINFO (ESRI 2000). The resulting coverages were carefully edited for quality control, and the land cover polygons were attributed.

Nearstream buffers served as the primary spatial units in the landscape analysis. Stream buffers were created in ArcView that represented 30m, 60m, 120m, 240m, 480m and 960m buffer areas around selected stream segments (e.g., the 30m buffer class included 15m lateral bands on both sides of the selected stream segments). The buffers were used as templates to extract the land cover types that fell within the stream buffers using clipping procedures. Buffer delineations were chosen based on the common recommendation of preserving 30m riparian buffers around streams in environmental planning (Petersen and Petersen 1992, Rabeni and Smale 1995) and the widths of the riparian existing conditions treatments used in the study (i.e., <125m, 125-250m and 250-500m). Buffer areas and associated land cover properties were quantified over four spatial scales, hereafter referred to as landscape contexts. The local landscape context was comprised of buffer areas immediately adjacent to each survey stream segment (Figure 2a). Buffer areas adjacent to the reach or reaches immediately upstream (U/S-1, ≈8 stream-km), two reaches upstream (U/S-2, ≈16 stream-km) and three reaches upstream (U/S-3, ≈24 stream-km) from each study site defined landscape contexts of progressively increasing scale (e.g., Figure 2b-d). The U/S-2 landscape context included the buffer areas and land cover properties of both the first and second reaches upstream from a survey site. The U/S-3 landscape context included the first, second and third buffer areas combined. Environmental properties of landscape contexts beyond the U/S-3 and downstream from the study segments may have also influenced local biological and ecological properties of survey sites, although analyses of these potential associations were beyond the scope of this study.

In cases where upstream reaches included tributary confluences, only buffers for tributaries of equal order and those not more than one order lower than the survey reach were included in the analysis. Streams more than one order smaller than main stem survey reaches were not expected to have a significant influence on the dynamics of these reaches.

The proportion of the each buffer area encompassed by distinct land cover types was quantified for all landscape contexts using the GIS. Land cover types were combined into land cover groups according to expected similarity of influence on stream ecosystems, including forest (forest, brush and plantations combined), wetlands (all wetland types combined) forest-wetlands (forest, brush, plantations and wetlands combined), agricultural (row crop and pastures combined), and all modified (row crop, pasture, construction, extraction, residential, municipal and clear-cuts combined). Other land cover types that represented minor contributions to the landscape were not included in these classifications (e.g., water bodies and inactive agricultural tracts).

Data Handling and Statistical Analysis

Following all field sampling and specimen verification, sampling data for each site were compiled in electronic databases. A careful review of entered data was conducted by comparing field checklists and specimen identification lists for each site with the vegetation sampling data. Similar quality control and consistent methodology were employed across all data evaluation of the terrestrial and aquatic components. Data were analyzed using SPSS 10.0.5 for windows (SPSS 1999). One-way (single-factor) analysis of variance (ANOVA) and multiple analysis of variance (MANOVA) techniques were used to determine whether the measured riparian community and habitat attribute variables were different among the four buffer width classes (<125m, 125-250m and 250-500m). MANOVA was used to test for community responses while ANOVA was used to test for individual taxonomic group or habitat variable responses. For terrestrial vegetation survey data ANOVA was also used to test for differences in plant community variables across ecological zones (e.g., forested bottom, levee, upland, etc.), individual sites (e.g., KZ<125m, SJ125-250m, RR250-500m, etc.) and river basins (i.e., GR, KZ, RR and SJ). All statistical results reported from ANOVA and MANOVA tests were considered significant at alpha=0.05.

Spearman Rank correlations were used to determine whether measures of community integrity for study sites were correlated with other site community and habitat integrity measures and land cover properties of nearstream buffers over several

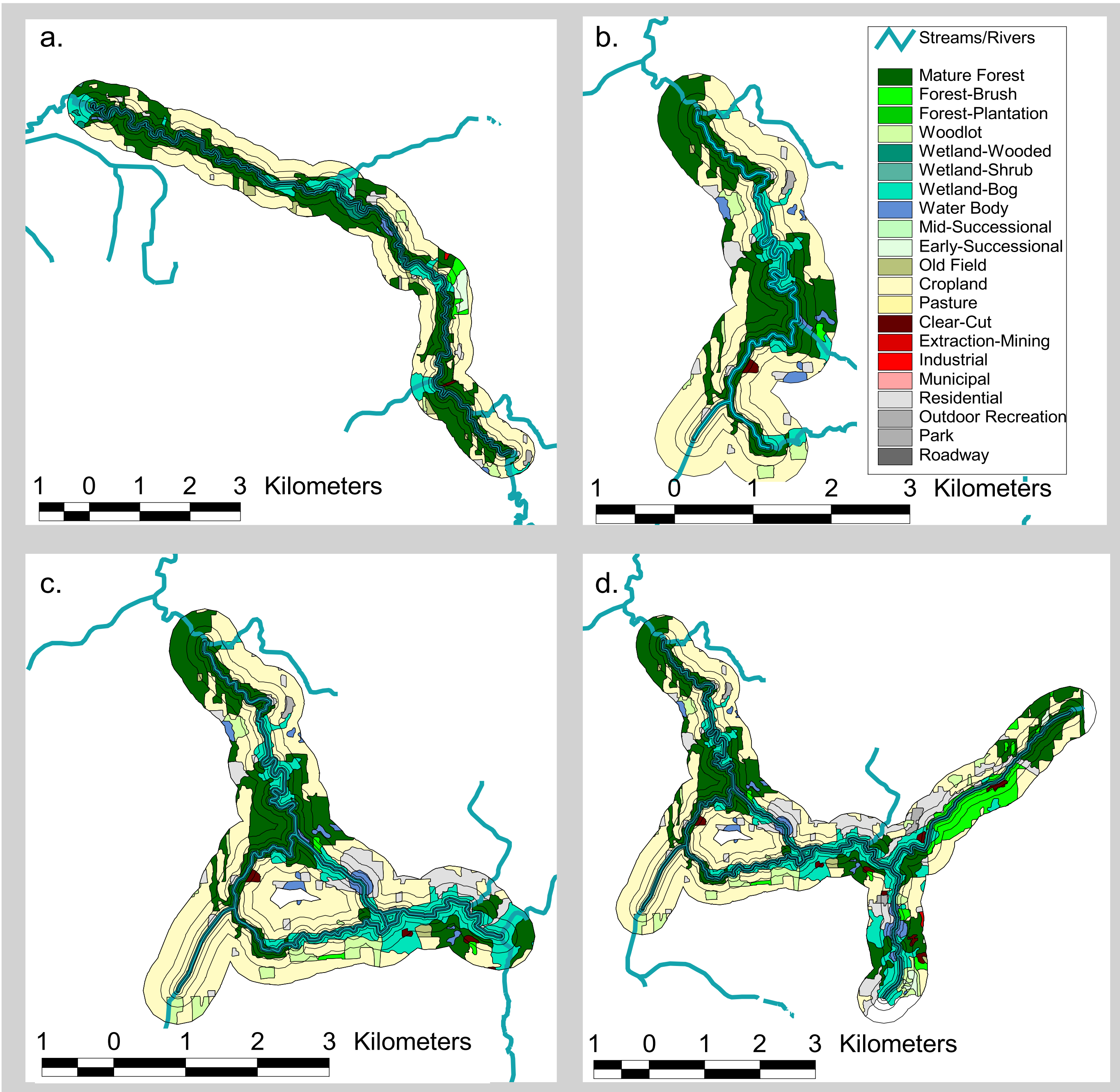


Figure 2. KZ250-500m site local (a), US-1 (b), U/S-2 (c) and U/S-3 (d) buffers areas within landscape contexts defined for spatial analysis. Land cover properties displayed are defined by the largest buffer width used for analysis (960m). Linework defining the 30, 60, 120, 240 and 480m buffers are also included.

landscape contexts. Of greatest interest in the statistical analyses was whether the measures of community integrity calculated based on site-specific surveys were associated with the land cover properties of the various landscape contexts. An alpha level of 0.01 was used for all correlations to provide a conservative threshold for interpreting the results.

RESULTS

Overall Riparian Communities

MANOVA tests for overall aquatic, terrestrial vertebrate and plant species richness (Λ=0.41, p>0.32) and individual taxonomic (e.g., fish, mussel, mammal, native plant, etc.) species richness measures (Λ=0.13, p>0.40) indicated no community level responses to changes in riparian forest buffer width among the sites sampled. MANOVA tests for intolerant/tolerant taxa measures (Λ=0.39, p<0.54) and community biotic integrity measures (Λ=0.34, p>0.43) also indicated no community level differences in these variables among riparian forest buffer classes. Biodiversity patterns at the reach-level within riparian width categories were unpredictable among river basins, and varied spatially according to individual site microhabitat types and heterogeneity (Figure 3). As such, biodiversity or biological integrity across communities could not be predicted through classifications of local forested buffer width alone. In terms of special concern plants, animals and communities, 40 element occurrences (EOs) were recorded from the 12 study sites, 78% (31) of these were found in the sites with average riparian widths >125m (Table 1).

Aquatic Communties

Overall, the relative abundance of intolerant aquatic organisms (AQ&IN, all groups) positively correlated with the total # of aquatic species per site (TASR, R=0.72, p<0.009, Table 2). However, these measures were not significantly different among riparian forest buffer width classes (Table 3). AQ&IN was associated with site HQI scores (R=0.73, p<0.009) and TASR was marginally associated with site HQI scores (R=0.59, p=0.05). The HQI varied from a low score of 103 in a heavily impacted (i.e., previously dredged) stream reach (GR125-250m) to a nearly perfect 193 at the Nature Conservancy Ides Road Fen Preserve site (RR250-500m). The average HQI score for the 12 sites was 153 (±25.9 SE), and there were no significant differences in HQI values among the riparian forest buffer classes (F=0.19, p>0.82). Over half of the aquatic community parameters measured were correlated with site HQI scores (p<0.01, Table 2). Among river basins, the River Raisin had significantly higher HQI values compared to the other rivers (ANOVA, p<0.05, Table 4). HQI values ranked the Grand River sites the poorest quality regardless of riparian forest buffer width. Woody debris in the stream channel (% woody cover per meter of channel width, %Wood) was not different among the riparian forest buffer classes (F=0.25, p>0.79) and was not associated with watershed drainage area (R=0.30, p>0.34). Sites with large %Wood consistently ranked lower with the HQI (GR125-250m, GR250-500m and RR<125m). However, several aquatic community parameters were correlated with the %Wood at a site, including RAIU (R=-0.81, p<0.002), RATU (R=0.64, p=0.01), ISR (R=-0.69, p=0.01) and TASR (R=-0.76, p<0.005).

Fish community species richness was highly variable among river basins and among riparian forest buffer classes. A total of 43 fish species were collected among the four river basins during the study (Table 5), and 13 of the 17 reported fish species clusters (SPA) for lower Michigan were represented (Zorn et al. 1998). The River Raisin (33 species) and St. Joseph River (32 species) systems were characterized by higher fish species richness. Samples from the Kalamazoo (26) and Grand (24) Rivers had comparably fewer fish species. Fourteen fish species were common to all basins, while seven species were observed in only one of the four rivers. For example, the state-listed as endangered species, *Notropis photogenis* (silver shiner), and the silverjaw minnow were restricted to the River Raisin basin (RR125-250m and RR250-500m), while the yellow perch, pirate perch and the American brook lamprey were only observed in the St. Joseph river basin. The latter example was probably attributed to random sampling error rather than species distribution, since these species are known to occur in other basins of southern Michigan (Zorn et al. 1998).

Fish species group associations (SPA, *sensu* fish clusters, Zorn et al. 1998) were examined, and the number of SPA was not different among riparian forest buffer width classes (F=0.68, p>0.85). The number of SPAs per site was also not correlated with any other site-specific aquatic community parameters (Table 2). Across all basins, fish SPA-1 (i.e., creek chub group) dominated the communities ($\bar{x}$=4.3 species/site). SPA-15 and SPA-14 were the second and third most dominate groups ($\bar{x}$=3.7 and $\bar{x}$=2.3 species per site, respectively, Appendix I). Changes in fish species group associations across river basins were most dramatic when viewed in a cluster analysis dendrogram (Figure 4). Once the basin linkages were established

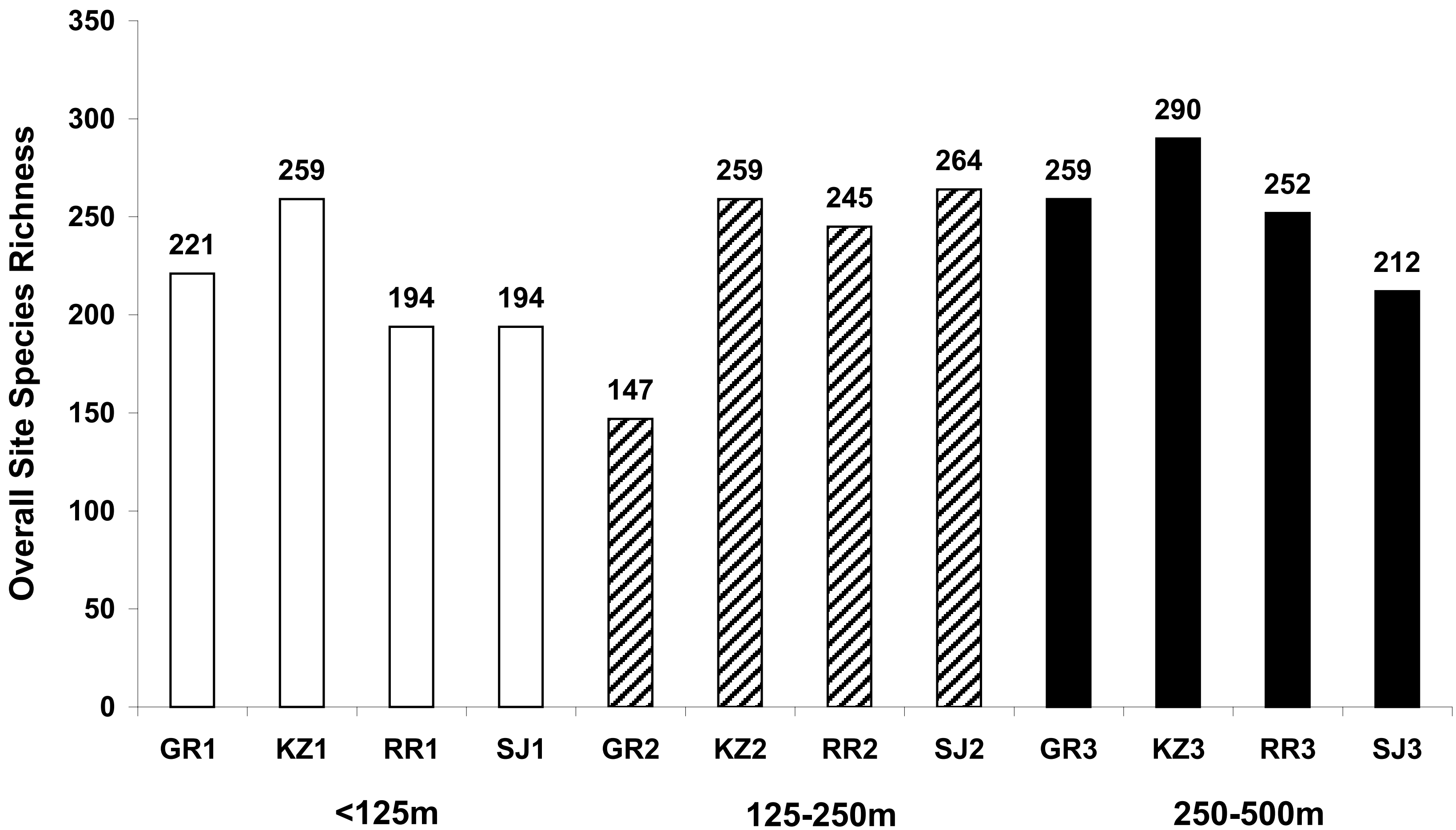


Figure 3. Overall native species richness (terrestrial and aquatic combined) for the riparian project study sites.

Table 1. Natural community (C), animal (A), invertebrate (I) and rare plant (P) occurences documented during 2000 riparian ecosystem surveys.

Site	Element	Type	State Status	Global/State rank
Grand River <125m	Prairie fen	C	-	G3/S3
Grand River <125m	*Carex trichocarpa*	P	SC	G4/S2
Grand River <125m	*Pleurobema coccineum*	I	SC	G4/S2S3
Grand River <125m	*Villosa iris*	I	SC	G5/S2S3
Grand River <125m	Blanding's Turtle	A	SC	G4/S3
Grand River 125-250m	Southern floodplain forest	C	-	G3?/S3
Grand River 250-500m	Southern floodplain forest	C	-	G3?/S3
Grand River 250-500m	*Carex squarrosa*	P	SC	G4G5/S1
Grand River 250-500m	*Morus rubra*	P	T	G5/S2
Grand River 250-500m	*Stylurus amnicola*	I	SC	G4/S1S2
Kalamazoo River <125m	*Alasmidonta viridis*	I	SC	G4G5/S2S3
Kalamazoo River <125m	*Pleurobema coccineum*	I	SC	G4/S2S3
Kalamazoo River <125m	*Villosa iris*	I	SC	G5/S2S3
Kalamazoo River 125-250m	*Pleurobema coccineum*	I	SC	G4/S2S3
Kalamazoo River 125-250m	*Villosa iris*	I	SC	G5/S2S3
Kalamazoo River 250-500m	Southern floodplain forest	C	-	G3?/S3
Kalamazoo River 250-500m	*Lampsilis fasciola*	I	T	G4/S1
Kalamazoo River 250-500m	*Pleurobema coccineum*	I	SC	G4/S2S3
Kalamazoo River 250-500m	*Venustaconcha ellipsiformis*	I	SC	G3G4/S2S3
Kalamazoo River 250-500m	*Villosa iris*	I	SC	G5/S2S3
River Raisin <125m	*Alasmidonta marginata*	I	SC	G4/S2S3
River Raisin 125-250m	*Cyclonaias tuberculata*	I	SC	G5/S2S3
River Raisin 125-250m	*Lampsilis fasciola*	I	T	G4/S1
River Raisin 125-250m	*Notropis photogenis*	A	E	G5/S1
River Raisin 125-250m	*Pleurobema coccineum*	I	SC	G4/S2S3
River Raisin 125-250m	*Venustaconcha ellipsiformis*	I	SC	G3G4/S2S3
River Raisin 125-250m	*Villosa iris*	I	SC	G5/S2S3
River Raisin 250-500m	Southern floodplain forest	C	-	G3?/S3
River Raisin 250-500m	*Alasmidonta marginata*	I	SC	G4/S2S3
River Raisin 250-500m	*Lampsilis fasciola*	I	T	G4/S1
River Raisin 250-500m	*Pleurobema coccineum*	I	SC	G4/S2S3
St. Joseph River <125m	*Pleurobema coccineum*	I	SC	G4/S2S3
St. Joseph River <125m	*Villosa iris*	I	SC	G5/S2S3
St. Joseph River 125-250m	Southern floodplain forest	C	-	G3?/S3
St. Joseph River 125-250m	*Fraxinus profunda*	P	T	G4/S2
St. Joseph River 125-250m	*Villosa iris*	I	SC	G5/S2S3
St. Joseph River 250-500m	*Alasmidonta marginata*	I	SC	G4/S2S3
St. Joseph River 250-500m	*Venustaconcha ellipsiformis*	I	SC	G3G4/S2S3
St. Joseph River 250-500m	*Villosa iris*	I	SC	G5/S2S3
St. Joseph River 250-500m	*Euonymus atropurpurea*	P	SC	G5/S3

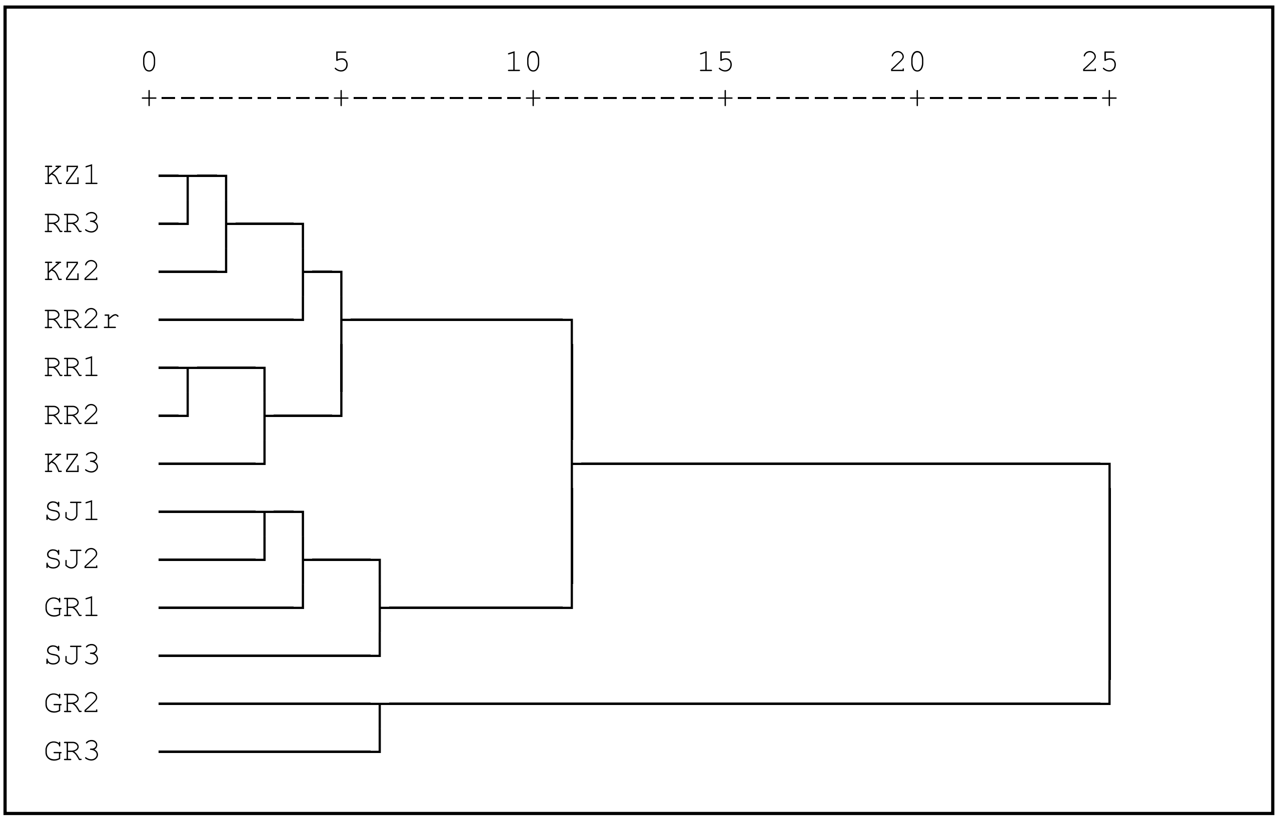


Figure 4. Fish species group association (SPA) dendrogram by study site based on hierarchical cluster analysis using average linkage between groups (#fish species/SPA). Measure bar provides re-scaled cluster distance. Watersheds include the Kalamamazoo (KZ), Raisin (RR), Grand (GR) and St. Joseph (SJ) Rivers and riparian forest buffer classes are <125m (1), 125-250m (2) and 500m (3).

Table 2. Spearman's-Rank correlation coefficients (R) and two-tailed statistical significance values (p) for correlations between 16 aquatic community descriptors of the 12 riparian survey sites. Correlations with p<0.01 are highlighted in gray. Astericks (*) indicate p<0.05). Community descriptors include Habitat Quality Index (HQI, Barbour et al. 1999), fish species richness (FSR), fish Index of Biotic Integrity (FIBI, Karr 1981) relative abundance of intolerant fish (RAIF), fish catch per unit effort (FCPUE), fish species association (FSA), mussel species richness (MSR), relative abundance of intolerant unionids (RAIU), relative abundance of tolerant unionids (RATU), insect species richness (ISR), invertebrate biotic index (InBI), relative abundance of intolerant benthos (RAIB), Ephemerotpera, Plecoptera and Trichoptera Index (EPT), total aquatic species richness (TASR) and percent woody substratum (%Wood).

	HQI		FISHSR		FIBI		RAIF		FCPU		FISHSPA		MUSR		RAIU	
	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
HQI	.	.	0.54	0.07	0.64	0.02*	0.82	<0.001	0.63	0.02*	0.19	0.54	0.42	0.16	0.59	0.04*
FSR			.	.	0.82	<0.001	0.46	0.13	0.25	0.43	0.46	0.15	0.76	0.004	0.31	0.33
FIBI					.	.	0.55	0.07	0.35	0.27	0.28	0.36	0.55	0.06	0.33	0.28
RAIF							.	.	0.75	0.005	0.13	0.69	0.49	0.10	0.62	0.03*
FCPUE									.	.	-0.03	0.92	0.35	0.26	0.62	0.03*
FSA											.	.	0.59	0.05*	-0.39	0.20
MSR													.	.	0.09	0.79
RAIU															.	.

Table 2. (cont.)

	RATU		MCPU		INSR		InBI		RAIB		EPT		Total Aq. SR		% Instream Wood	
	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
HQI	-0.71	<0.01	0.48	0.11	0.74	0.06	-0.74	0.006	0.22	0.48	0.47	0.12	0.58	0.05*	-0.43	0.15
FSR	-0.33	0.29	0.68	0.01	0.43	0.16	-0.35	0.26	0.53	0.07	0.48	0.11	0.61	0.04*	-0.57	0.06
FIBI	-0.41	0.018*	0.56	0.07	0.37	0.24	-0.5	0.09	0.15	0.65	0.43	0.16	0.52	0.09	-0.26	0.41
RAIF	-0.66	0.02	0.36	0.26	0.33	0.29	-0.53	0.07	0.17	0.63	0.24	0.46	0.45	0.14	-0.51	0.09
FCPUE	-0.81	<0.001	0.56	0.06	0.48	0.11	-0.69	0.01	0.02	0.94	0.49	0.11	0.43	0.17	-0.56	0.06
FSA	-0.23	0.48	0.37	0.24	0.20	0.41	0.26	0.38	0.38	0.21	-0.12	0.71	-0.09	0.76	0.19	0.57
MSR	-0.29	0.35	0.76	<0.005	0.36	0.26	-0.40	0.19	0.31	0.32	0.43	0.16	0.36	0.25	-0.29	0.35
RAIU	-0.82	0.001	0.22	0.5	0.79	0.002	-0.46	0.13	0.28	0.38	0.43	0.16	0.77	0.003	-0.81	0.001
RATU	.	.	-0.46	0.13	-0.6	0.04*	0.74	0.006	-0.17	0.6	-0.59	0.04*	-0.61	0.04*	0.64	0.01
MCPUE			.	.	0.54	0.06	-0.41	0.18	0.24	0.46	0.53	0.08	0.72	0.009	-0.47	0.13
ISR					.	.	-0.56	0.06	0.47	0.11	0.76	0.005	0.93	<0.001	-0.69	0.01
InBI							.	.	-0.41	0.19	-0.74	0.006	-0.53	0.07	0.43	0.16
RAIB									.	.	0.76	<0.005	0.49	0.1	-0.36	0.25
EPT											.	.	0.76	<0.005	-0.52	0.08
TASR													.	.	-0.76	0.004
%Wood															.	.

Table 3. Statistical significance values (p) for overall ANOVA and post-hoc analysis of attributes of the aquatic communities with the riparian buffer widths. Riparian widths are labeled: <125m (A), 125-250 (B) & 250-500m (C). Significant values with $p<0.05$ are highlighted in gray. Community descriptors include Habitat Quality Index (HQI, Barbour et al. 1999), percent intolerant aquatics (AQ%IN), fish species richness (FSR), fish Index of Biotic Integrity (FIBI, Karr 1981) relative abundance of intolerant fish (RAIF fish catch per unit effort (FCPUE), fish species association (FSA), mussel species richness (MSR), relative abundance of intolerant unionids (RAIU), relative abundance of tolerant unionids (RATU), insect species richness (ISR), invertebrate biotic index (InBI), relative abundance of intolerant benthos (RAIB), Ephemerotpera, Plecoptera and Trichoptera Index (EPT) and total aquatic species richness (TASR).

	HQI	TASR	AQ%IN	FSR	FIBI	RAIF	FCPUE	FSA
Riparian Width	p	p	p	p	p	p	p	p
A x B x C	0.83	0.75	0.98	0.98	0.81	0.57	0.63	0.68
A x B	0.41	0.14	0.84	0.001	0.30	0.76	0.78	0.11
A x C	0.59	0.90	0.65	0.02	0.17	0.54	0.82	0.48
B x C	0.76	0.11	0.51	0.36	0.71	0.35	0.64	0.54

Table 3 (cont.)

	MSR	RAIU	RATU	MCPUE	ISR	InBI	RAIB	EPT
Riparian Width	p	p	p	p	p	p	p	p
A x B x C	0.85	0.92	0.87	0.82	0.66	0.74	0.22	0.57
A x B	0.07	0.92	0.23	0.21	0.38	0.13	0.23	0.05
A x C	0.18	0.95	0.22	0.26	0.79	0.82	0.08	0.91
B x C	0.56	0.96	0.97	0.03	0.26	0.18	0.01	0.06

Table 4. Summary of habitat, fish and benthic macroinvertebrate community indices for 12 riparian sites in the four Michigan river basins. Ratings include excellent (EXC.), very good (VG), good, fair, fairly-poor (FP) and poor. These ratings are based on literature recommendations and professional judgement.

Site	HQI	HQI Rating	RAIF	FishIBI	FIBI Rating	EPT	EPT Rating	Mean INBI	InBI Rating	RAIB
GR<125	175	VG	0.38	46	VG	22	Good	5.51	Fair	0.05
KZ<125	154	Good	0.33	44	Good	22	Good	5.42	Fair	0.04
RR<125	126	Fair	0.10	38	Fair	20	Fair	5.81	Fair	0.10
SJ125	157	Good	0.13	48	Good	27	Good	6.15	FP	0.02
GR125-250	103	Poor	0.00	28	Poor	12	FP	7.25	Poor	0.00
KZ125-250	164	Good	0.27	42	Good	26	Good	5.08	Good	0.09
RR125-250	182	VG	0.20	47	VG	40	Exc	4.69	Good	0.19
SJ125-250	140	Fair	0.12	44	Good	25	Good	6.41	FP	0.06
GR500	124	FP	0.09	26	Poor	18	Fair	6.09	FP	0.02
KZ500	163	Good	0.19	44	Good	25	Good	4.94	Good	0.01
RR500	193	Exc	0.57	46	VG	19	Fair	5.09	Good	0.01
SJ500	158	Good	0.22	50	Exc	19	Fair	5.76	Fair	0.03

Table 5. Fish presence (X) /absence data and species group associations (SPA) for each river basin. NA indicates species not listed by Zorn et al. (1998), but placed in similar group. State endangered species are designated with an "E."

		River Basin			
Fish Species	SPA	GR	KZ	RR	SJ
Central stoneroller	1		X	X	X
Common Shiner	1	X	X	X	X
Redfin Shiner	1	X	X	X	
Bluntnose Minnow	1	X	X	X	X
Creek Chub	1	X	X	X	X
Johnny Darter	1	X	X	X	X
Green Sunfish hybrid	2	X	X		X
Bluegill	2	X	X	X	X
Mottled Sculpin	3		X	X	
Fathead Minnow	4		X		
White Sucker	4	X	X	X	X
Green Sunfish	8	X	X	X	X
Blackside Darter	9	X	X	X	X
Pirate Perch	9				X
Bowfin	9	X			X
Central Mudminnow	9	X	X	X	X
Walleye	10	X			
Common carp	10	X	X	X	X
Spotfin Shiner	12	X		X	
Logperch	12			X	X
Shorthead Redhorse	12		X		
Hornyhead Chub	13	X	X	X	X
Grass Pickerel	13	X		X	X
American Brook Lamprey	na				X
Rock Bass >5 inches	14	X	X	X	X
Rock Bass <5 inches	14		X	X	X
Rainbow Darter	14	X	X	X	X
Largemouth Bass	14	X		X	X
Silver Shiner (E)	na			X	
Striped Shiner	15	X	X	X	X
Northern Hogsucker	15		X	X	X
River Chub	15	X		X	X
Greenside Darter	15		X	X	X
Smallmouth Bass	15			X	X
Black Redhorse	15		X	X	X
Stonecat	15	X	X	X	X
Rosyface Shiner	16		X	X	X
Silverjaw Minnow	na			X	
Yellow Perch	16				X
Spottail Shiner	17	X		X	
Golden Redhorse	17			X	X
Total Species		24	26	33	32

(SJ & GR, RR and KZ), it was not uncommon for the smallest and largest riparian width sites to be most closely linked. Two Grand River sites (GR125-250m and GR250-500m) separated completely from the other sites at a significant linkage distance of 25. This indicated large differences in the SPA due to fewer groups in the case of the GR125-250m site, and the inclusion of more tolerant and unique groups, such as in the walleye group (SPA-10) at the GR250-500m. The next cluster to distinctly separate out was the St. Joseph River basin and the GR<125m site from the Kalamazoo and River Raisin sites at a linkage distance of 11. This split in the dendrogram indicates that the St. Joe and Grand Rivers are more closely linked by their fish SPA than with the Kalamazoo River and the River Raisin, which separated out together (Figure 4). Fish species from SPA-8, SPA-9 and SPA-10 were collected more often in the Grand and St. Joe River basins; these groups are comprised of more tolerant species. Fish species characteristic of high quality warmwater streams (SPA-15) dominated the River Raisin sites ($\bar{x}$=4.8 species/site). An interesting result of the SPA evaluation involved the Michigan endangered silver shiner, *Notropis photogenis*. This species was collected at one study site (RR125-250m) site, and was associated with the full compliment of SPA-1 (six species), five species from SPA-15, and no members from groups SPA-8, SPA-9 or SPA-10 (Appendix II).

Fish species richness was not different among the riparian forest buffer width classes (F=0.16, p>0.85, Figure 5a). Other fish community parameters were also not different among the riparian forest buffer width classes (Table 4). Fish species richness and mussel species richness were highly correlated (R=0.76, p<0.005, Fig 6b). Fish IBI values averaged a fair-good quality rating ($\bar{x}$=42± 5.8 SE) across all sites (Figure 5c, Table 4) and were not significantly different among riparian forest buffer width classes (F=0.22, p>0.80). Fish IBI scores were positively correlated with fish species richness (R=0.82, p<0.001), but RAIF values were not correlated with fish species richness (R=0.55, p=0.06, Table 2). RAIF values did not differ between riparian width classes (F=0.60, p>0.56, Fig 5b), but were correlated with fish abundance at sites measured as FCPUE (# fish/minute, R=0.75, p<0.005) and with the HQI (R=0.82, p<0.001, Table 2). For example, the RR250-500m site had the highest HQI score, a catch rate of >4 fish/min and 0.56 RAIF.

Eighteen native mussel species were identified from all 12 sites; 16 species were observed in the River Raisin, 12 in the St. Joseph River, 11 in the Kalamazoo River, and eight in the Grand River (Table 6). No mussel species was ubiquitous across sites, although *Actinonais ligamentina* (mucket) and *Lampsilis ventricosa* (pocketbook) were both collected at nine sites (Appendix III and IV). Two Michigan state-listed as special concern species, *Villosa iris* (rainbow) and *Pleurobema sintoxia* (round pig-toe), were collected at eight sites each. At the Sandstone Creek site (GR<125m), *V. iris* and *P. sintoxia* contributed a combined 0.51 mussel community relative abundance (0.13 and 0.38, respectively). A new element occurrence record for the state-listed as threatened, *Lampsilis fasciola* (wavy-rayed lampmussel), was recorded at the KZ250-500m site. This species has not previously been reported from the Kalamazoo River drainage. Updates on the state-listed as special concern *Cyclonias tuberculata* (purple wartyback) were also recorded at the RR125-250m site. The mussel surveys reported numerous records for the more recently listed Michigan special concern species, including *Alasmidonta marginata* (elktoe) and *A. viridis* (slippershell**,** Table 1). *Ptychobranchus fasciolaris* (kidneyshell) was reported as one individual at only one site, and may be considered to be in decline, although it is not currently listed in Michigan. *Elliptio dilatata* (spike) is a common species throughout its range that is often very abundant in headwater streams. This species was present at eight of the sites and was the dominant species at four sites (Appendix IV). *E. dilatata* did not appear to be influenced by the different riparian forest buffer width classes given that it was the dominant species at two sites representing the largest and smallest buffer size-classes (Appendix IV). Other sites, usually within the same basin, exhibited trends towards increasing species richness within increasing riparian forest buffer width. For example, the RR and the SJ added three and five mussel species, respectively, as the riparian width classes progressed from <125m to 250-500m (Appendix IV). These additional species were usually considered to be more intolerant of degraded environmental conditions (e.g., *P. sintoxia*, *L. fasciola*, *A. marginata* and *V. iris*).

Mussel species richness was positively associated with site HQI scores (R=0.46, p=0.15, Figure 6a), although mussel species richness and MCPUE were not different among riparian forest buffer width classes (F=0.17, p>0.84, and F=0.21, p>0.81, respectively, Figures 7a and 7c). The RAIU was not different between riparian forest buffer width classes (F=0.09, p>0.92, Figure 7b) and was not significantly correlated with site HQI scores (R=0.47, p=0.1). The RAIU and MCPUE were correlated with TASR (R=0.61, p<0.05, Figure 8), and RAIU was marginally correlated with ISR, although RAIU was not associated with any other aquatic community parameters (Table 2). Overall,

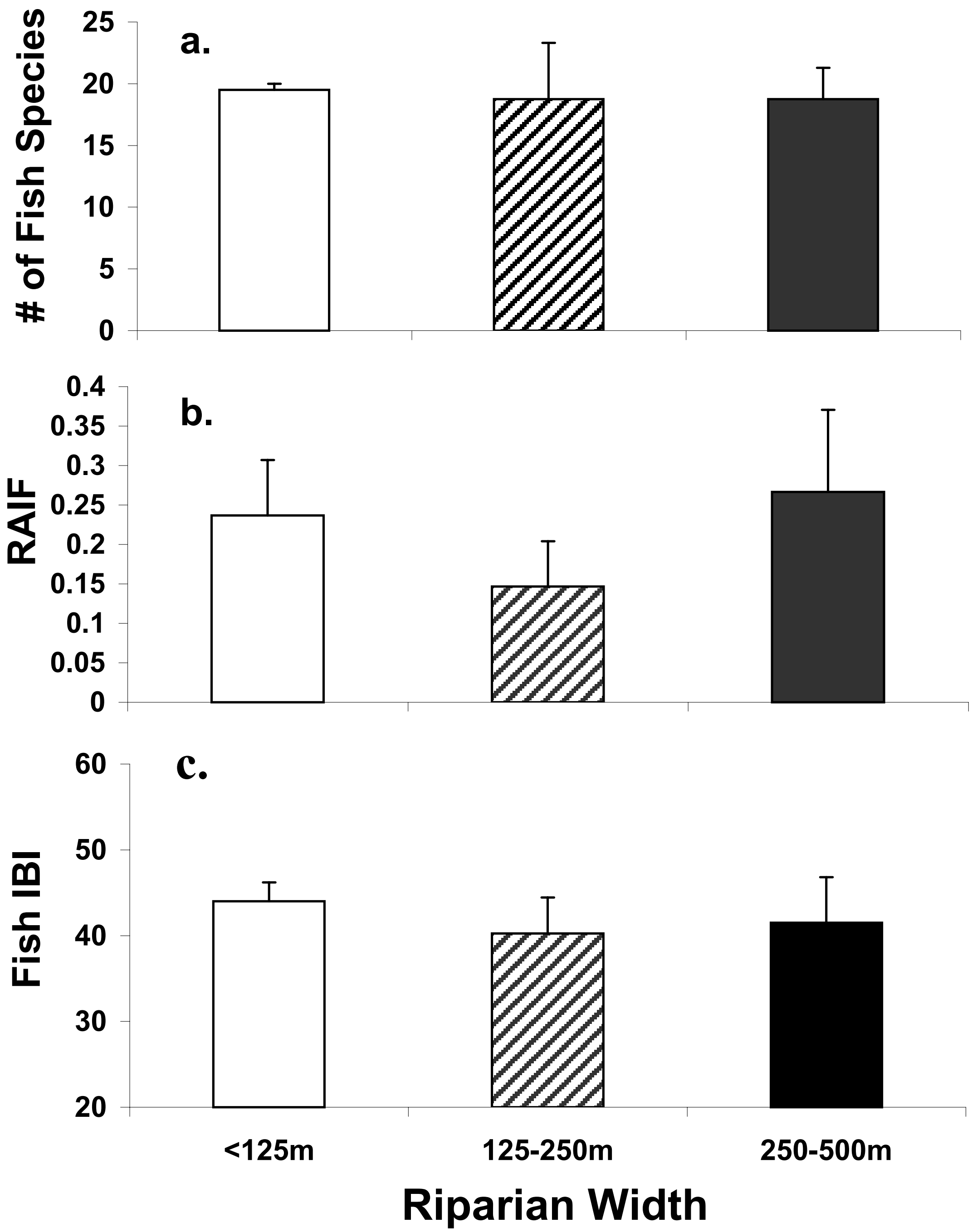


Figure 5. Comparisons of the mean # of fish species (a), relative abundance of intolerant fish (RAIF) (b), and the Fish Index of Biotic Integrity (c) with the riparian width replicates. * indicates a significant difference with a one-way ANOVA at $p<0.05$.

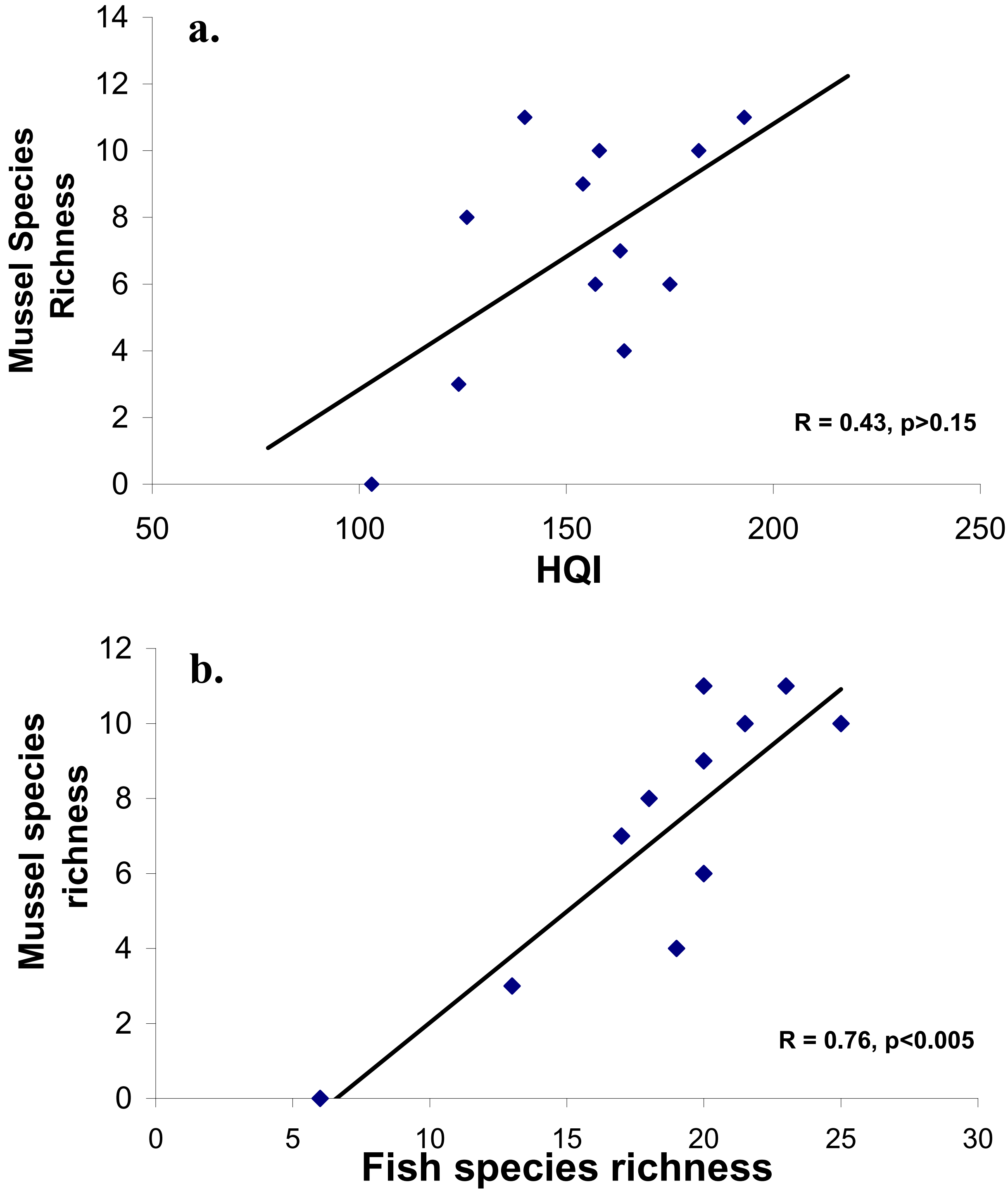


Figure 6. Associations between mussel species richness and a) Habitat Quality Index (HQI) and b) fish species richness. Spearman rank correlation coefficients (R) and two-tailed statistical significance values (p) are shown.

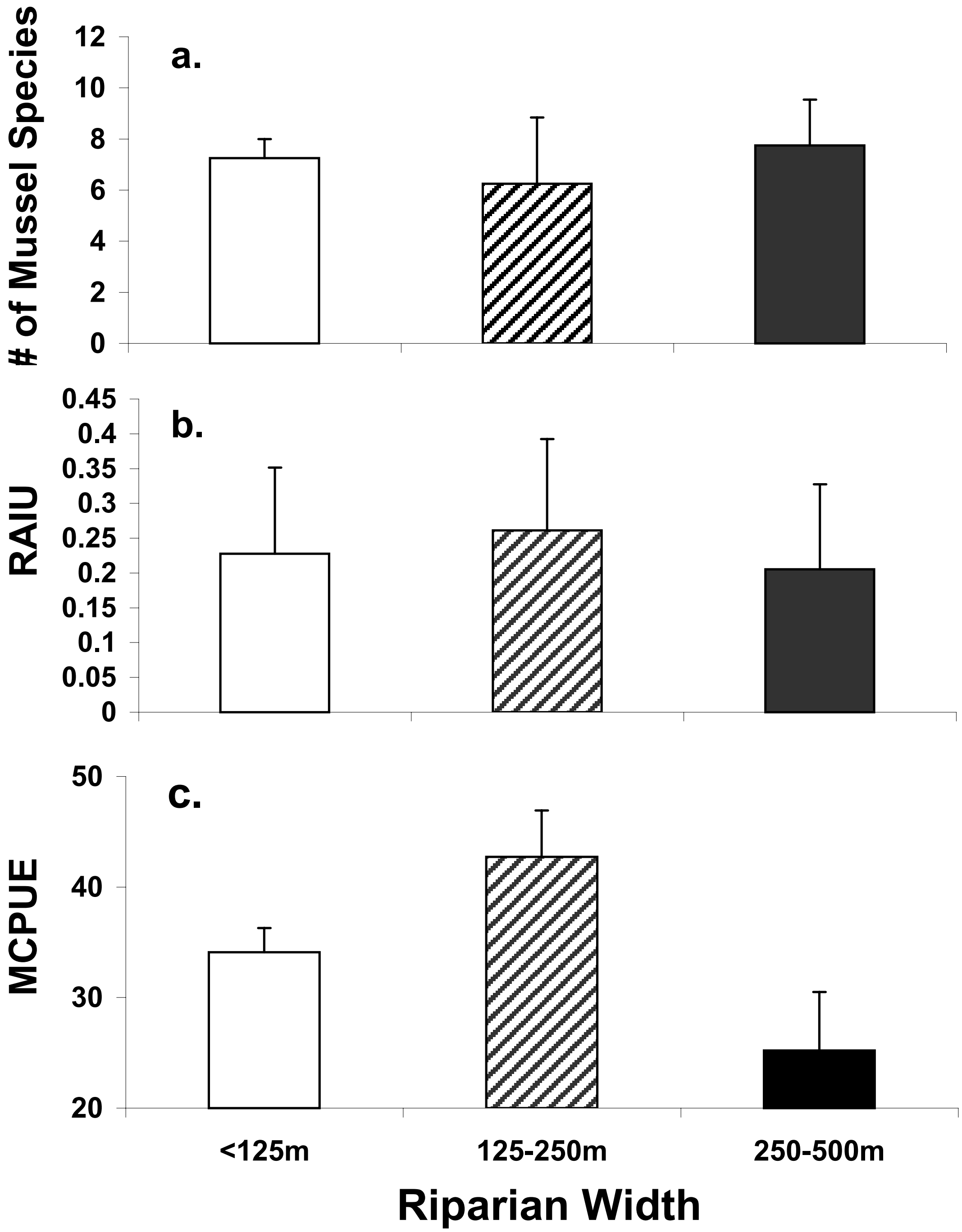


Figure 7. Comparisons of the mean a) # of mussel species, b) relative abundance of intolerant mussels (RAIU), and c) mussel catch rate (MCPUE) with the riparian width classes. * indicates a significant difference with a one-way ANOVA at p<0.05.

Table 6. Mussel species presence/absence data for the river basins. (X) indicates presence, (*) indicates valves, but no live specimens and blanks absence. (T)=state threatened and (SC)=state special concern.

	River Basin			
Mussel Species	GR	KZ	RR	SJ
Actinonaias ligamentina (Mucket)	X	X	X	X
Amblema plicata (Three-ridge)	X		*	
Alasmidonta marginata (Elktoe)[SC]			X	X
Alasmidonta viridis (Slippershell)[SC]		X		*
Anadonta grandis (Giant Floater)			X	
Cyclonaias tuberculata (Purple Warty-back)[SC]			X	
Elliptio dilatata (Spike)	X	X	X	X
Fusconaia flava (Wabash Pig-toe)	*	X	X	X
Lampsilis fasciola (Wavy-rayed Lampmussel)[T]		X	X	
Lampsilis ventricosa (Plain Pocketbook)	X	X	X	X
Lampsilis siliquoidea (Fatmucket)	X	X	X	X
Lasmogona compressa (Creek Heelsplitter)		X	X	X
Lasmigona costata (Fluted-shell)		*	X	X
Pleurobema coccinium (Round Pig-toe)[SC]	X	X	X	X
Ptychobranchus fasciolaris (Kidneyshell)			X	
Strophitus undulatus (Squawfoot)	X		X	X
Venustaconcha ellipsiformis (Ellipse)[SC]		X	X	X
Vilosa iris (Rainbow)[SC]	X	X	X	X
Total # of Native Mussel Species	8	11	16	12
Exotic Mussel Species				
Corbicula flumenia (Asiatic Clam)	X	X	X	X
Dressenia polymorpha (Zebra Mussel)			X	

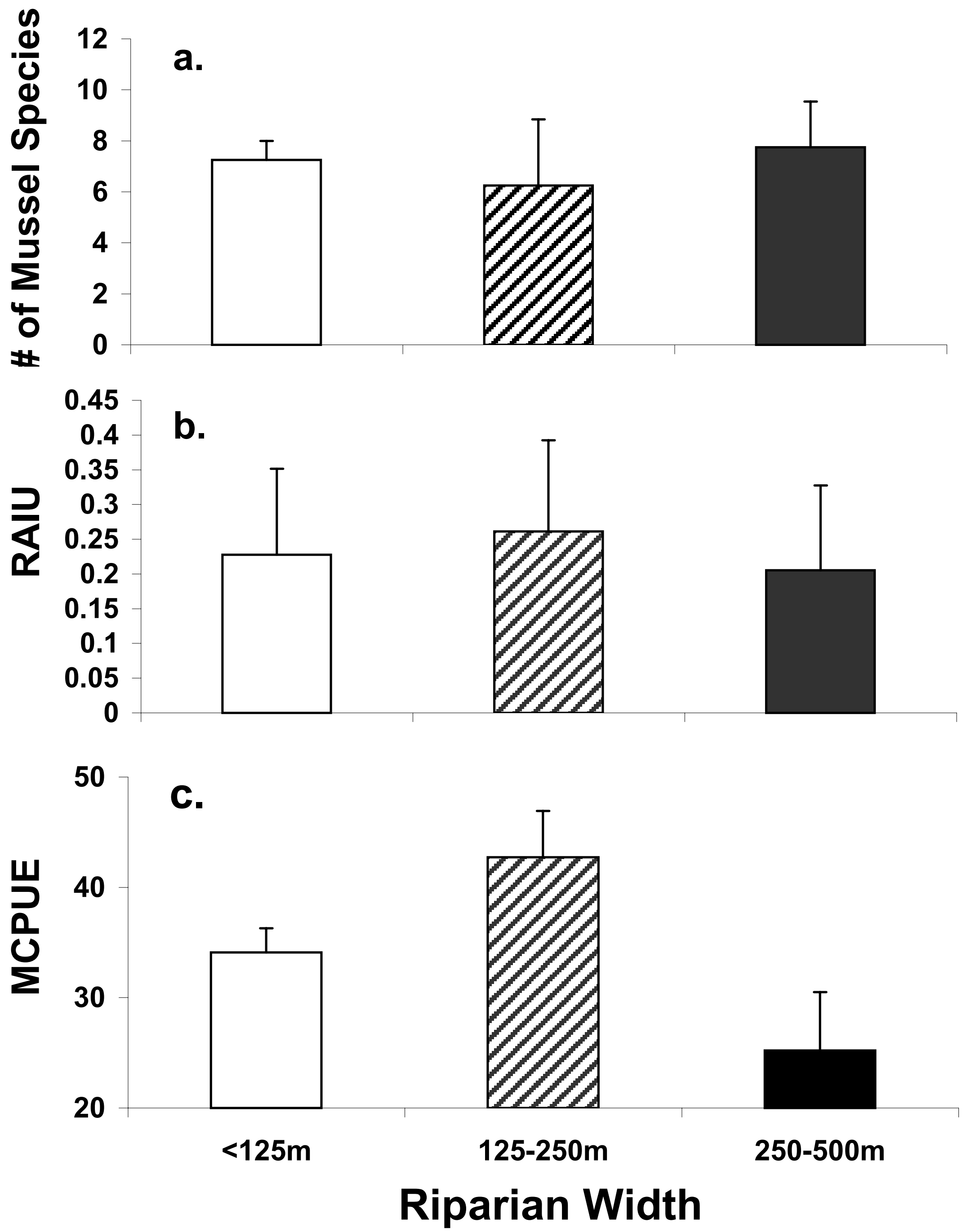


Figure 7. Comparisons of the mean a) # of mussel species, b) relative abundance of intolerant mussels (RAIU), and c) mussel catch rate (MCPUE) with the riparian width classes. * indicates a significant difference with a one-way ANOVA at $p<0.05$.

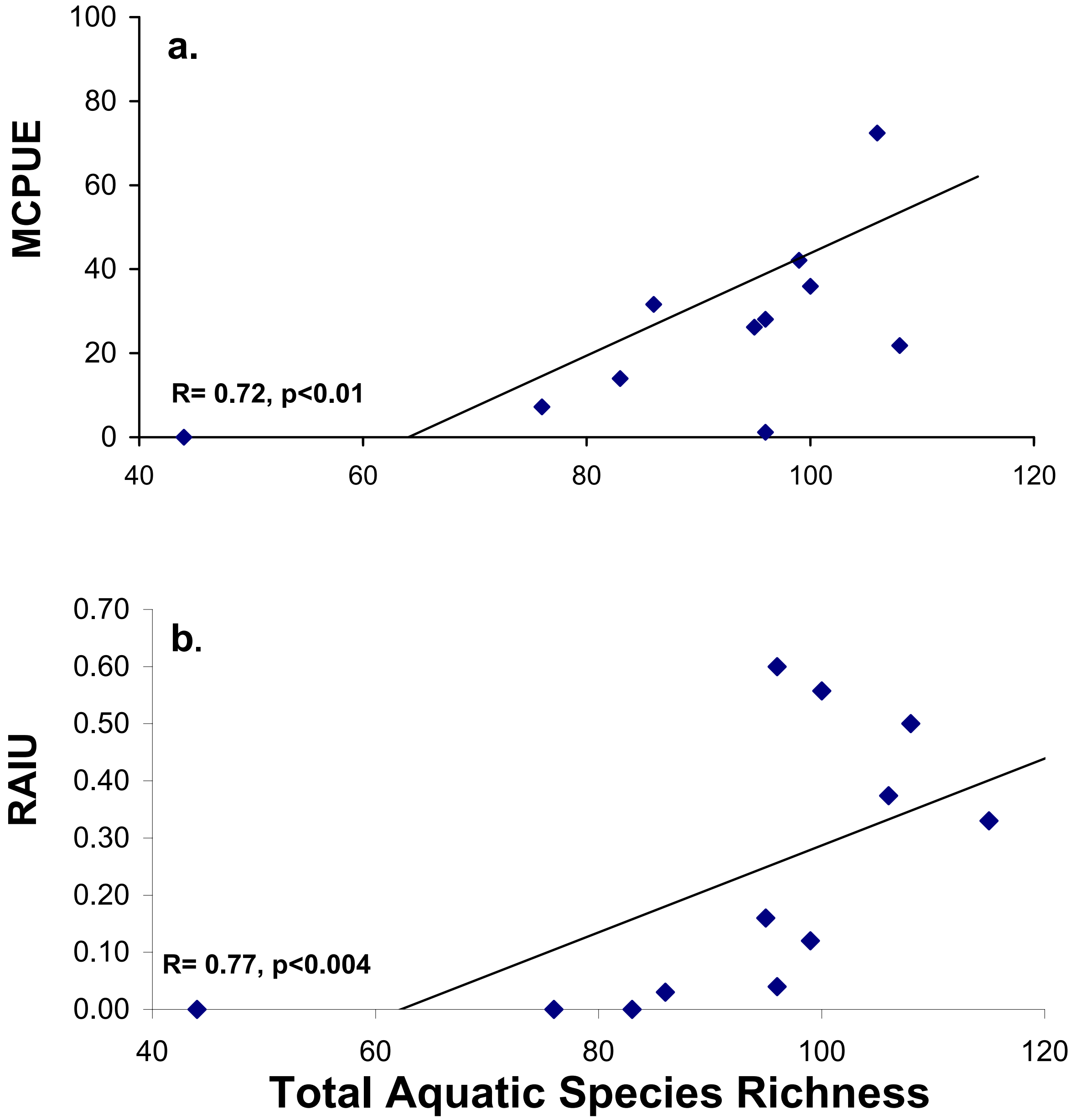


Figure 8. Correlations of a) mussel abundance (MCPUE) and b) the relative abundance of intolerant mussels (RAIU) with total aquatic species richness at a site with. Spearman rank correlation coefficients (R) and two-tailed, statistical significance values (p) are shown.

MSR was highest in the River Raisin basin, and it also had the highest number of state-listed mussel species (Table 1).

RATU values were not significantly different among the riparian forest buffer width classes (F=0.14, p>0.86). However, RATU measures were negatively associated with site HQI scores (R=-0.71, p<0.001), suggesting that the taxa comprising this tolerant group are proportionately more abundant at sites with areas of slow current and dominated by fine, silty substrates. The RATU was the only aquatic parameter that was positively correlated with %Wood in the channel (R=0.64, p<0.05, Table 2). MSR and FSR were highly correlated (R=0.76, p<0.005, Figure 6b). However, densities of fish and mussels (inferred from CPUE for both taxonomic groups) were marginally associated (R=0.56, p=0.06). Mussel densities were significantly correlated with increasing MSR, FSR and TASR (R=0.76, 0.68 and 0.72, respectively, Table 2 and Figure 8a).

The relative abundance of exotic aquatic organisms was not different among the riparian forest buffer width classes (F=0.76, p>0.49). However, there was a significant positive correlation between the relative abundance of aquatic exotic taxa and relative abundance of terrestrial exotic species (R=0.80, p<0.003), suggesting that sites may be prone to invasion by exotics across all community levels. MSR and MCPUE were negatively associated with the relative abundance of the exotic Asiatic clam, *Corbicula fluminea*, in the Kalamazoo River (R=0.78, p<0.001), but this association was not consistent across all river basins where this exotic occurred (R=0.33, p>0.05). The zebra mussel, *Dreissenia polymorpha*, was observed at one site (RR125-250m) during the 2000 field season, but was restricted to a single individual attached to a native mussel.

Appendix V provides a complete inventory of the macroinvertebrate species identified during the study, including tolerance values used in calculating InBI scores (Barbour et al. 1999). Macroinvertebrates contributed the greatest number of species to the overall aquatic community measures (38-83 species), often in numbers 3-5 times greater than the number of fish and unionid species at a site. Because of this dominance in species richness, statistical test results of TASR at a site often followed those of the invertebrate analyses. Macroinvertebrate metrics were not significantly different among the riparian forest buffer width classes (Table 3, Figure 9). Within-treatment (i.e., riparian forest buffer width class) variation was greater than between-riparian treatment variation for macroinvertebrate data (e.g., InBI, Fig. 9b). The EPT, InBI and ISR were all correlated with site HQI scores (Table 2). EPT, InBI, ISR and TASR tended to auto-correlate with each other, since EPT taxa are included within the total species richness and contributed a certain percentage to the InBI. Another auto-correlated metric with the EPT Index was the RAIB (R=0.76, p<0.005) for similar reasons. Additionally, the InBI and RATU showed significant positive relationships (R=0.74, p<0.007, Table 2). Densities of the invertebrates were not statistically analyzed for this study, but outwardly showed no significant differences by basin or among riparian width classes, except for one site with a significantly dense benthic invertebrate community (Appendix VI). This outlier site (GR<125m) averaged ~14,000 individuals/m^2, while the mean densities for all other sites was ~1,500 individuals/m^2. Sites ranked low based on HQI scores had invertebrate densities that were comparable to high quality habitat sites (Appendix VI).

Table 4 provides a summary of community ratings based on habitat, fish and aquatic invertebrate metrics. Only three riparian study sites achieved "Good" or better ratings across all measures; these were the Kalamazoo mid and largest riparian classes (KZ125-250m, KZ250-500m) and the River Raisin mid range riparian site (RR125-250m). The River Raisin site clearly ranked highest in overall aquatic integrity with good and very good ratings for all measures (Table 4). In a few cases, metrics did not all agree in the ranking of the site, and varied from excellent to fair ratings (i.e., SJ250-500m & RR250-500m).

Terrestrial Vertebrate Communities

Fourteen amphibian and reptile species were detected as a result of pitfall and funnel trapping, visual encounter surveys and frog call surveys (Table 7). These include seven frog species, two salamander species, two snake species and three turtle species. Three additional species were observed only incidentally during trapping or aquatic community surveys, including the northern water snake (*Nerodia sipedon*), mudpuppy (*Necturus maculosus maculosus*) and the state-listed as special concern Blanding's turtle (*Emydoidea blandingii*). In terms of overall abundance (i.e., total number of individuals observed) measures based on trapping and visual survey data, the most common herp species were the wood frog (*Rana sylvatica*, n=70) and the American toad (*Bufo americana*, n=42), followed by the painted turtle (*Chrysemys picta*, n=15) and green frog (*Rana clamitans*, n=13). Frequency of occurrence (i.e., number of sites at which a species was documented) measures based on the data from all three survey methodologies indicated that the most common species was *B. americana* (11 sites), followed by the eastern

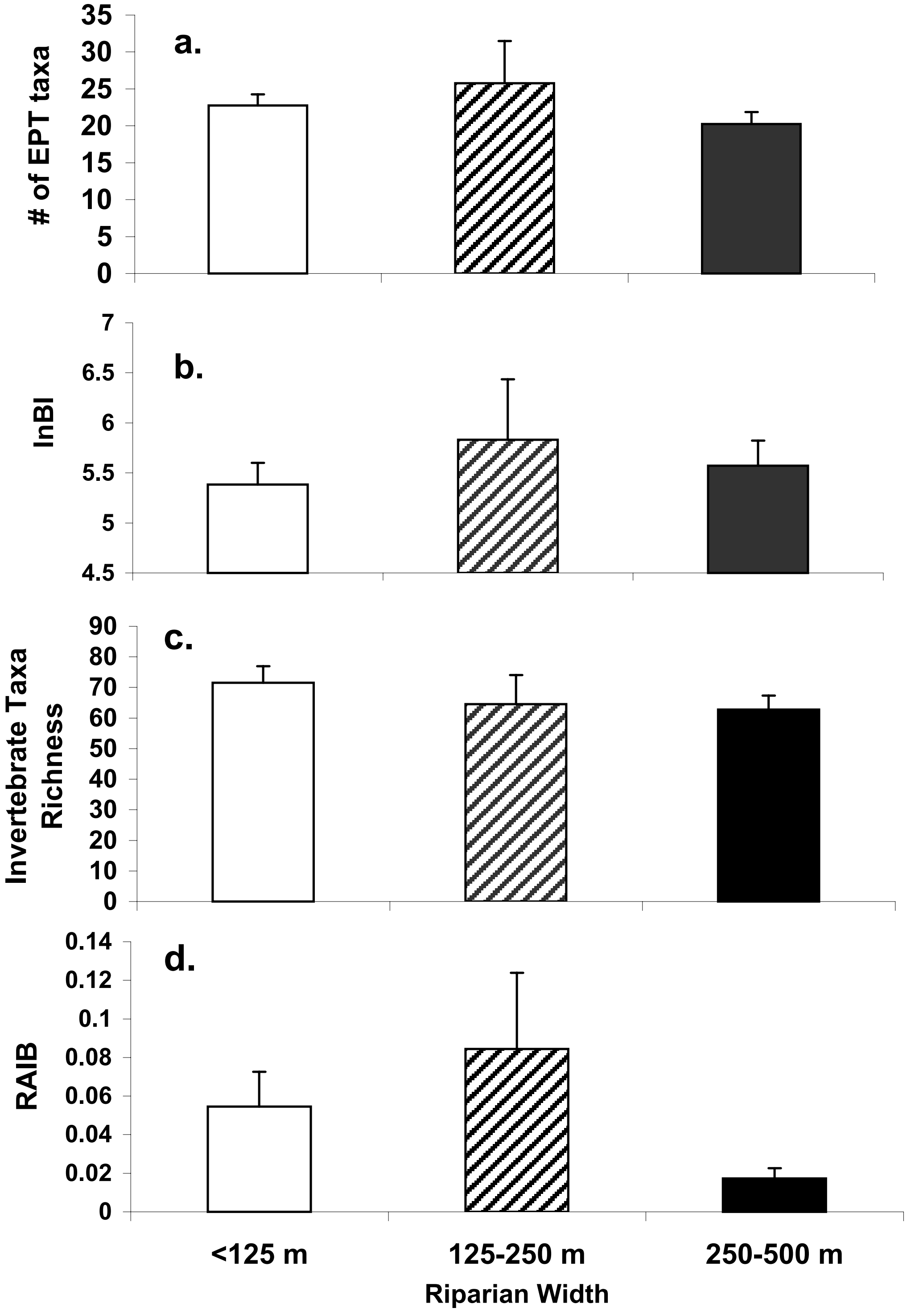


Figure 9. Comparisons of the mean a) EPT Index, b) Invertebrate Biotic Index (InBI), c) invertebrate taxa richness and d) the relative abundance of intolerant benthos (RAIB) within the riparian width size classes. * indicates a significant difference with a one-way ANOVA with p<0.05.

Table 7. Amphibian and reptile species documented during pitfall and funnel trapping, frog call surveys and visual encounter surveys conducted in riparian areas of three different width classes along the Grand River (GR), Kalamazoo River (KR), River Raisin (RR) and St. Joseph River (SJR) in southern Michigan.

	<125 m				125-250 m				250-500 m			
Species or species groups	GR	KR	RR	SJR	GR	KR	RR	SJR	GR	KR	RR	SJR
<u>Frogs and toads</u>												
Bufo americana (American toad)	x	x	x	x	x	x	x	x	x	x		x
Rana sylvatica (Wood frog)	x		x	x	x	x	x	x		I		x
Pseudacris crucifer (Spring peeper)	x	x		x		x		x		x		x
Rana pipiens (Northern leopard frog)	x									I		
Rana clamitans (Green frog)	x		x	x		x	x		x	x		I
Hyla versicolor (Eastern gray treefrog)		x		x	x	x	x	x	x	x		x
Pseudacris triseriata triseriata (Western chorus frog)				x				x				x
<u>Salamanders</u>												
Ambystoma laterale (Blue-spotted salamander)	x								x			x
Plethodon cinereus (Red-backed salamander)		x								x		
Necturus maculosus maculosus (Mudpuppy)[1]	I[3]											
<u>Snakes</u>												
Thamnophis sirtalis (Common garter snake)	I						x	x	x	I		
Storeria dekayi (Brown snake)										x		
Nerodia sipedon (Northern water snake)[1]		I					I	I			I	
<u>Turtles</u>												
Chrysemys picta (Painted turtle)						x				x		
Graptemys geographica (Common map turtle)						x		x	x		I	
Chelydra serpentina serpentina (Common snapping turtle)	I	I									x	
Emydoidea blandingii (Blanding's turtle) (SC)[2]	I											

[1]Species observed only incidentally during aquatic community surveys.

[2]Species observed only incidentally during pitfall and funnel trapping. Species listed as state special concern.

[3]I=Indicates species was observed at site only incidentally.

gray treefrog (*Hyla versicolor*, nine sites), *R. sylvatica* (eight sites) and spring peepers (*Pseudacris crucifer*, seven sites). *R. clamatins* was moderately common, occurring at six sites excluding incidental observations and eight sites including incidental observations. The western chorus frog (*Pseudacris triseriata triseriata*) was documented only at the St. Joseph River sites. The *P. triseriata triseriata* and *H. versicolor* were documented only through frog call surveys.

Overall species richness per site ranged from one to seven species without incidental species, and from three to nine species when incidental observations were included. Mean species richness without incidental species ($\bar{x}$=4.9 species/sites) was slightly lower than mean site species richness measures that included incidental observations ($\bar{x}$=6.0 species/site). The GR<125m, KZ125-250m, SJ125-250m, KZ250-500m and SJ250-500m sites had the highest herp species richness documented during this study (Figure 10).

Relative abundance of herps captured in pitfall and funnel traps ranged from 0 to 0.22 individuals per trap-night per site (Table 8). The SJ250-500m site had the highest capture rate, followed by the RR<125m and SJ<125m sites. Relative abundance at the SJ250-500m site was twice that of the next highest relative abundance estimates, and over 80% of the herps captured at this site were wood frogs. Relative abundance of herps encountered during visual surveys ranged from 0.0 to 15.5 individuals per person-hour per site (Table 8). The KZ125-250m site had the highest relative abundance of herps observed during visual surveys, primarily due to a large number of painted turtles present, followed by the SJ250-500m site.

Mean species richness of amphibians and reptiles did not differ significantly among the three riparian width classes (F=0.28, p>0.75, Figure 11). The addition of incidental herp species did not change this result (F=0.05, p>0.95, Figure 11). The mean relative abundance of herps based on trapping and visual surveys was also not significantly different among the three riparian width classes (F=0.04, p>0.95, Figure 12, and F=0.34, p>0.70, Figure 13, respectively).

As indicated by Spearman-Rank correlation analysis, herp species richness without and with incidental species were negatively correlated with site CTV (R=-0.62, p=0.03 and R=-0.73, p=0.007, respectively, Table 9). The absolute value of the CTV, indicating the overall degree of topographic variability, was also used in the herp habitat correlation analysis since the CTV is a directional variable (i.e., positive value indicating elevational variability above the riverbank and negative value indicating variability below the riverbank). This analysis provided some evidence, although not conclusive, that herp species richness was negatively correlated with the absolute value of the CTV (R=-0.54, p=0.07 without incidentals, R=-0.54, p=0.07 with incidentals). Relative abundance of herps based on pitfall and funnel trapping was marginally correlated with the following three variables: tree diameter at breast height (DBH) across sample plots (R=0.56, p<0.07), mean tree DBH within sample plots (R=0.55, p<0.08) and total number of native plant species (R=-0.65, p<0.03). Relative abundance of herps derived from visual encounter surveys was significantly correlated with the number of ecological zones per site (R=-0.74, p<0.007).

A total of 58 bird species were observed during migration counts, and 54 bird species were observed during breeding bird surveys (Appendix VII). Bird abundance and species richness measures based on migration counts and breeding bird surveys were moderately varied among sites (Table 10). Spearman-Rank correlation analysis suggested that overall bird abundance at sites was associated with mean tree DBH (R= 0.77, p<0.004), although bird community attributes were not significantly different among the riparian forest buffer width classes and were not significantly associated with any other site community or ecological properties (p>0.05).

A total of 17 mammal species was documented among all sites with the greatest species richness documented at the GR250-500m and KZ<125m sites (10 species/site, Table 11, Appendix VIII). Total small mammal captures among sites varied widely (0-37 captures) and relative abundance measures were also highly variable among sites (0 captures/100 trap-nights to 40.2 captures/100trap-nights). Small mammals captured during trapping sessions in August consisted almost entirely of *Peromyscus* spp. (98% of all mammals captured). Scent stations were most frequently visited at all sites by raccoons; raccoon tracks and sign were extremely abundant throughout all study sites. The small mammal capture in pitfall traps consisted primarily of shrew species. Mammal species richness was not significantly different among riparian buffer width classes and was not significantly correlated with any other site community or ecological measures (p>0.05).

Terrestrial Vegetation and Floristic Communities

<u>Overall Vegetation and Floristic Results</u>

A complete catalog of the vascular plant species identified during the study, with separate listings for native and non-native (adventive) species, is provided in Appendix IX and X, respectively. Total floristic diversity for each study site, including the proportion of non-native species, is shown in Figure 14. Site FQI

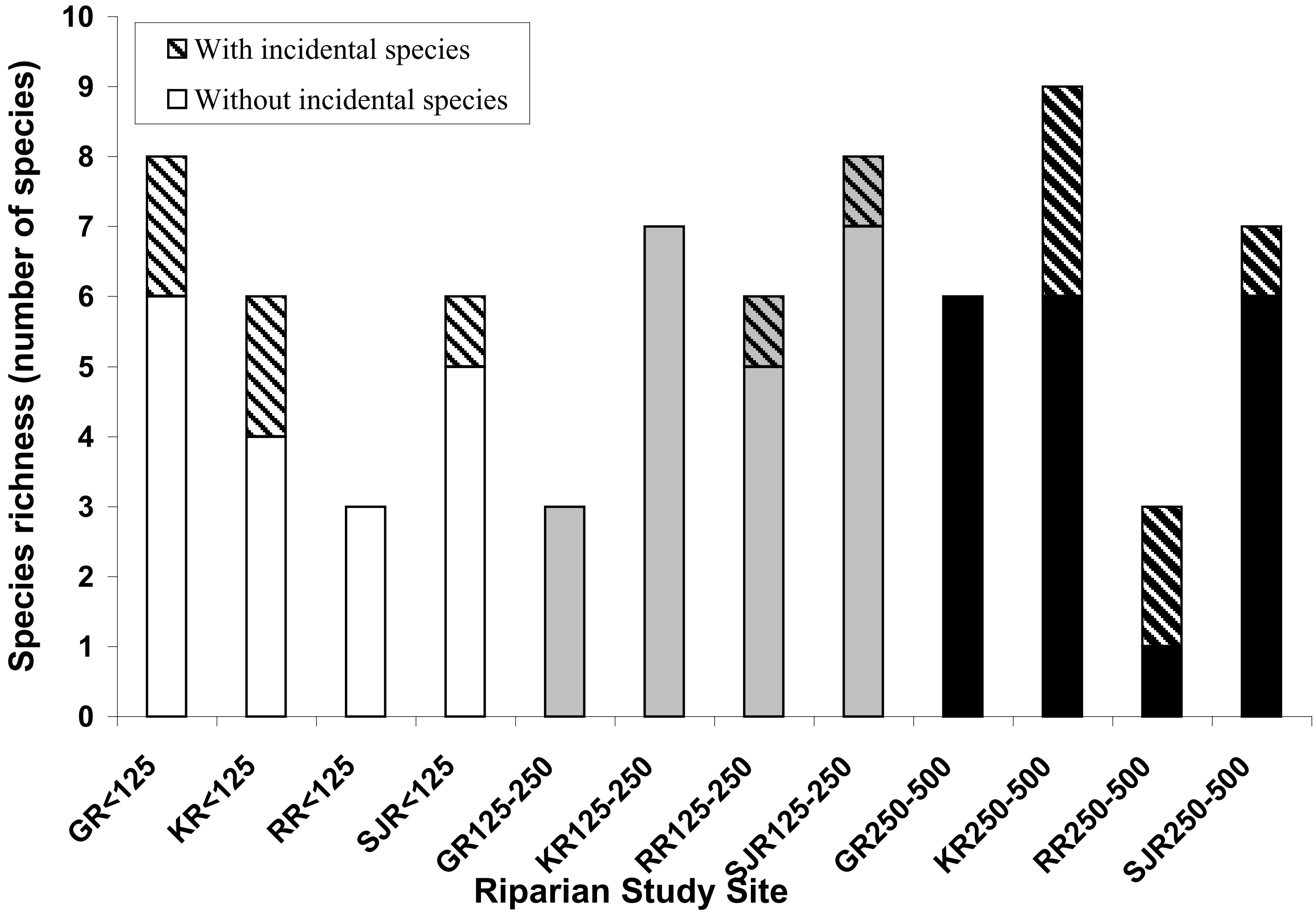


Figure 10. Species richness of amphibians and reptiles in riparian areas of three different widths (<125m, 125-250m, 250-500m) along the Grand River (GR), Kalamazoo River (KR), River Raisin (RR) and St. Joseph River (SJR) in southern Michigan.

Table 8. Relative abundance[1] of amphibians and reptiles based on pitfall and funnel trapping and visual encounter surveys in riparian areas of three different width classes along the Grand River (GR), Kalamazoo River (KR), River Raisin (RR) and St. Joseph River (SJR) in southern Michigan.

	<125 m				125-250 m				250-500 m			
Survey methodology	GR	KR	RR	SJR	GR	KR	RR	SJR	GR	KR	RR	SJR
Pitfall and funnel trapping[2]	0.05	0.01	0.10	0.10	0.06	0.07	0.07	0.03	0.03	0.03	0.00	0.22
Visual encounter surveys[3]	4.5	1.5	3.5	3.5	0.0	15.5	4.0	2.5	1.5	3.0	0.5	8.0

[1]Relative abundance estimates do not include any incidental species or observations.

[2]Number of individuals per trap-night.

[3]Number of individuals observed per person-hour of survey effort.

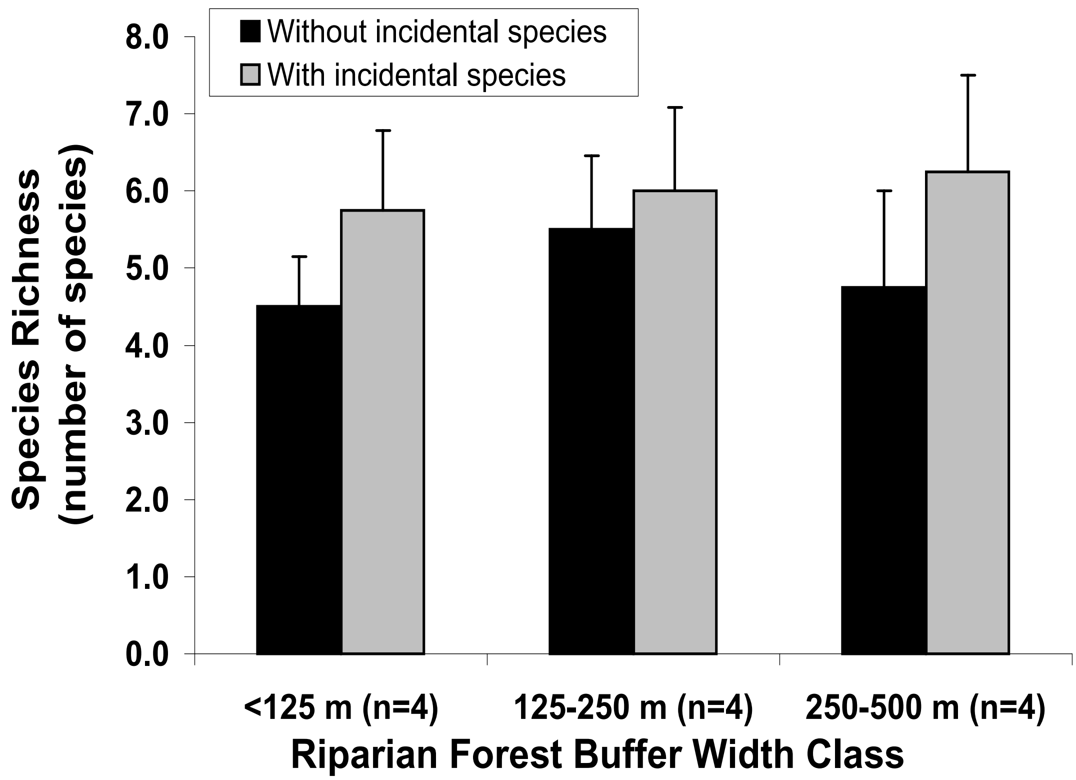


Figure 11. Mean (+ SE) species richness of amphibians and reptiles in riparian areas of three different widths along the Grand River, Kalamazoo River, River Raisin and St. Joseph River in southern Michigan.

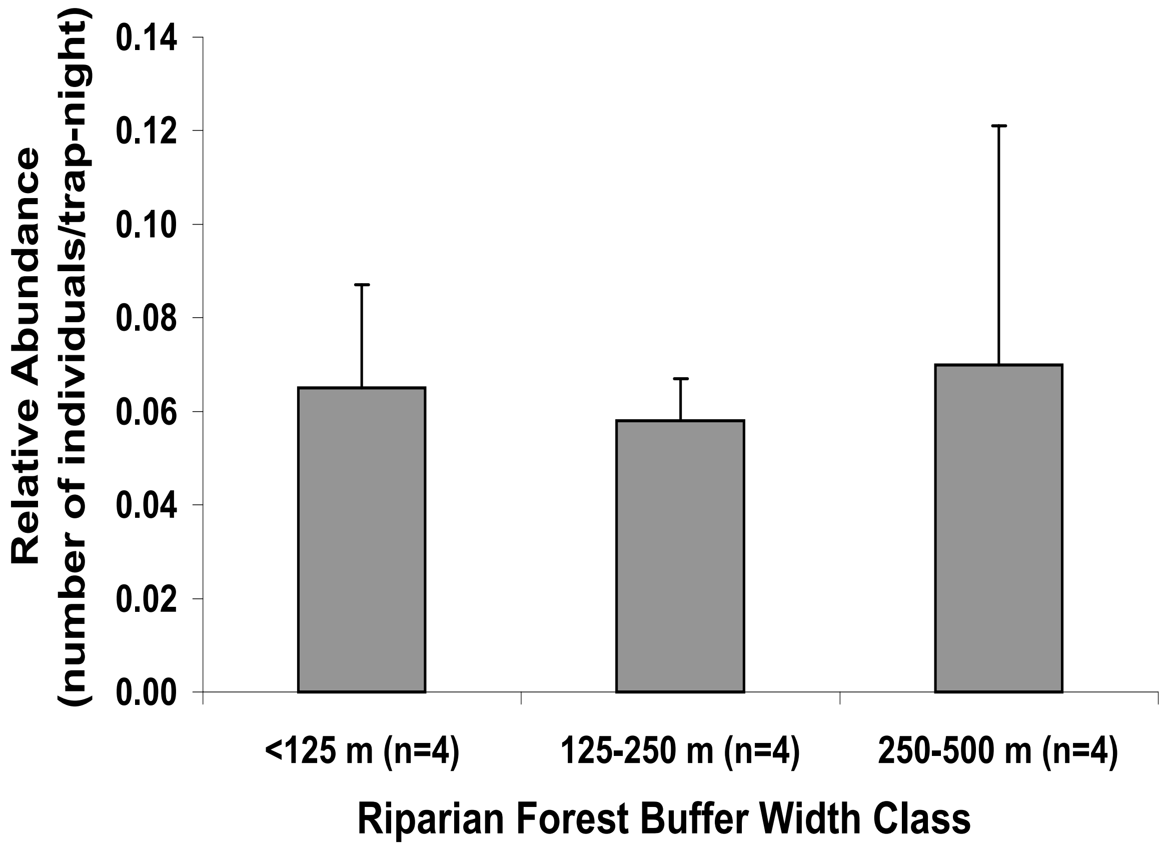


Figure 12. Mean (+SE) relative abundance of amphibians and reptiles based on pitfall and funnel trapping in riparian areas of three different widths along the Grand, Kalamazoo, Raisin and St. Joseph rivers in southern Michigan.

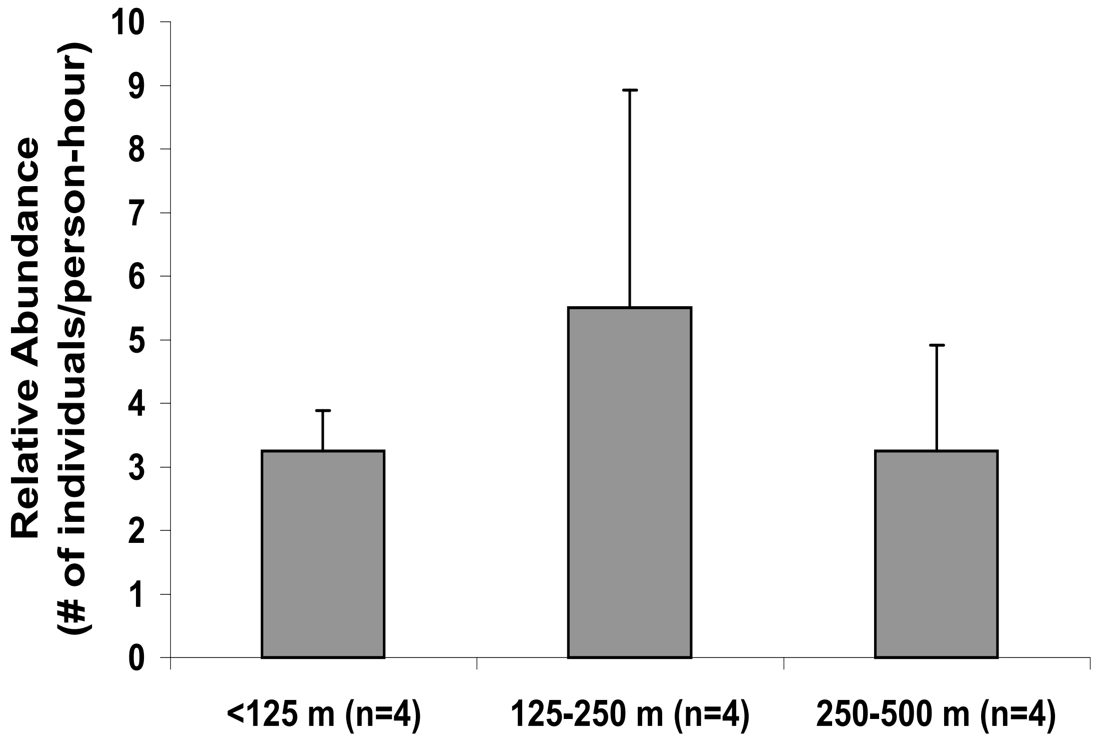


Figure 13. Mean (+SE) relative abundance of amphibians and reptiles based on visual encounter surveys in riparian areas of three different widths along the Grand Kalamazoo, Raisin and St. Joseph rivers in southern Michigan.

Table 9. Results of habitat correlation analyses between amphibian and reptile species richness and relative abundance (PFT=pitfall and funnel trapping, VES=visual encounter surveys) and habitat variables associated with riparian areas of different widths (<125m, 125-250m, 250-500m) (N=12) along the Grand, Kalamazoo, Raisin and St. Joseph rivers in southern Michigan. R=Spearman correlation coefficient, p=significance level. Highlighted cells indicate significant correlations (p<0.01). See vegetation sampling methods for detailed explanation of habitat variables.

Habitat Variable	Species Richness (w/o incidentals)	Species Richness (w/ incidentals)	Relative Abundance-PFT	Relative Abundance-VES
NO. OF ZONES	R=-0.31 p>0.30	R=-0.42 p=0.17	R=-0.46 p=0.13	R=-0.74 p=0.006
CTV[1]	R=-0.62 p=0.03	R=-0.73 p=0.007	R=-0.14 p=0.67	R=-0.42 p=0.17
CTV ABSOLUTE VALUE	R=-0.54 p=0.07	R=-0.54 p=0.07	R=-0.05 p=0.89	R=-0.16 p=0.62
BASAL AREA	R=-0.23 p=0.48	R=-0.20 p=0.53	R=0.29 p=0.36	R=-0.06 p=0.86
# OVERSTORY TREE SPECIES	R=-0.03 p=0.92	R=0.06 p=0.86	R=-0.27 p=0.40	R=-0.13 p=0.69
TREE DBH	R=-0.12 p=0.72	R=-0.13 p=0.70	R=0.56 p=0.06	R=0.38 p=0.22
MEAN DBH	R=-0.06 p=0.84	R=-0.05 p=0.88	R=0.55 p=0.07	R=0.35 p=0.26
# UNDERSTORY WOODY STEMS	R=-0.17 p=0.59	R=-0.25 p=0.44	R=-0.33 p=0.30	R=-0.34 p=0.28
# UNDERSTORY SPECIES	R=-0.01 p=0.99	R=-0.17 p=0.59	R=-0.29 p=0.36	R=-0.13 p=0.68
# GR. COVER SPECIES (EARLY)	R=0.49 p=0.11	R=0.58 p=0.05	R=-0.46 p=0.14	R=0.17 p=0.60
% GROUND COVER (EARLY)	R=-0.04 p=0.90	R=0.12 p=0.72	R=-0.17 p=0.61	R=0.26 p=0.42
# NATIVE SPECIES	R=0.31 p=0.33	R=0.31 p=0.33	R=-0.65 p=0.02	R=-0.23 p=0.48
# EXOTIC SPECIES	R=-0.28 p=0.38	R=-0.48 p=0.11	R=-0.32 p=0.31	R=-0.30 p=0.34
TOTAL PLANT SPECIES	R=0.24 p=0.45	R=0.22 p=0.50	R=-0.62 p=0.03	R=-0.25 p=0.44
FLORISTIC QUAL. INDEX	R=0.33 p=0.29	R=0.43 p=0.17	R=-0.68 p=0.02	R=-0.27 p=0.40

[1]CTV=Coefficient of topographic variation

Table 10. Species richness and relative abundance measures for bird communities of riparian study sites surveyed during migration and breeding seasons. Relative abundance measures represent the mean number of birds/point derived from individual 50m plot surveys.

Riparian Buffer Class	River	Season	Species Richness	Relative Abundance
<125m	KZ	Migration	21	7
125-250m	KZ	Migration	20	9
500m	KZ	Migration	20	3.3
<125m	GR	Migration	22	8.3
125-250m	GR	Migration	20	6.7
500m	GR	Migration	14	1.7
<125m	RR	Migration	13	6
125-250m	RR	Migration	19	8
500m	RR	Migration	17	5.3
<125m	SJ	Migration	15	6.3
125-250m	SJ	Migration	15	5.6
500m	SJ	Migration	15	6
<125m	KZ	Breeding	14	5.3
125-250m	KZ	Breeding	17	6.3
500m	KZ	Breeding	13	2.7
<125m	GR	Breeding	18	4.3
125-250m	GR	Breeding	11	3
500m	GR	Breeding	16	4.7
<125m	RR	Breeding	18	9
125-250m	RR	Breeding	20	15
500m	RR	Breeding	13	7.3
<125m	SJ	Breeding	17	11.3
125-250m	SJ	Breeding	19	9.3
500m	SJ	Breeding	15	9.3

Table 11. Mammal data collected from riparian study sites in the Kalamazoo (KZ), Grand (GR), Raisin (RR) and St. Joseph (SJ) River basins. Total rap-nights is the number of traps per site that had a captured small mammal or were empty over a four day period (20 traps per site for four trap-nights). Sprung traps were not included in calculating total trap-nights and the number of sprung traps varied per site. Total Captures is the total number of small mammals captured per site over four trap-nights. Small Mammal Relative Abundance is the number of captures per 100 trap nights (e.g., total captures per site/total number of trap-nights per site. *Peromyscus* Abundance is the number of captures per 100 trap nights for *Peromyscus spp*. (e.g., total *Peromyscus* captures per site/total number of trap-nights per site).

Riparian Buffer Width Class	River	Total trapnights	Total Captures	Small mammal relative abundance	*Peromyscus* abundance	Small mammal species richness	Mammal species richness
<125m	SJ	46	6	13	11	2	7
125-250m	SJ	65	8	12.3	12.3	1	5
500m	SJ	67	27	40.2	40.2	1	4
<125m	RR	50	37	74	74	1	4
125-250m	RR	52	10	19	19	1	4
500m	RR	62	27	44	44	1	4
<125m	KZ	65	0	0	0	0	6
125-250m	KZ	72	17	23.6	23.6	1	3
500m	KZ	72	9	12.5	12.5	1	7
<125m	GR	66	22	33.3	30.3	3	5
125-250m	GR	50	5	10	10	1	3
500m	GR	73	0	0	0	0	6

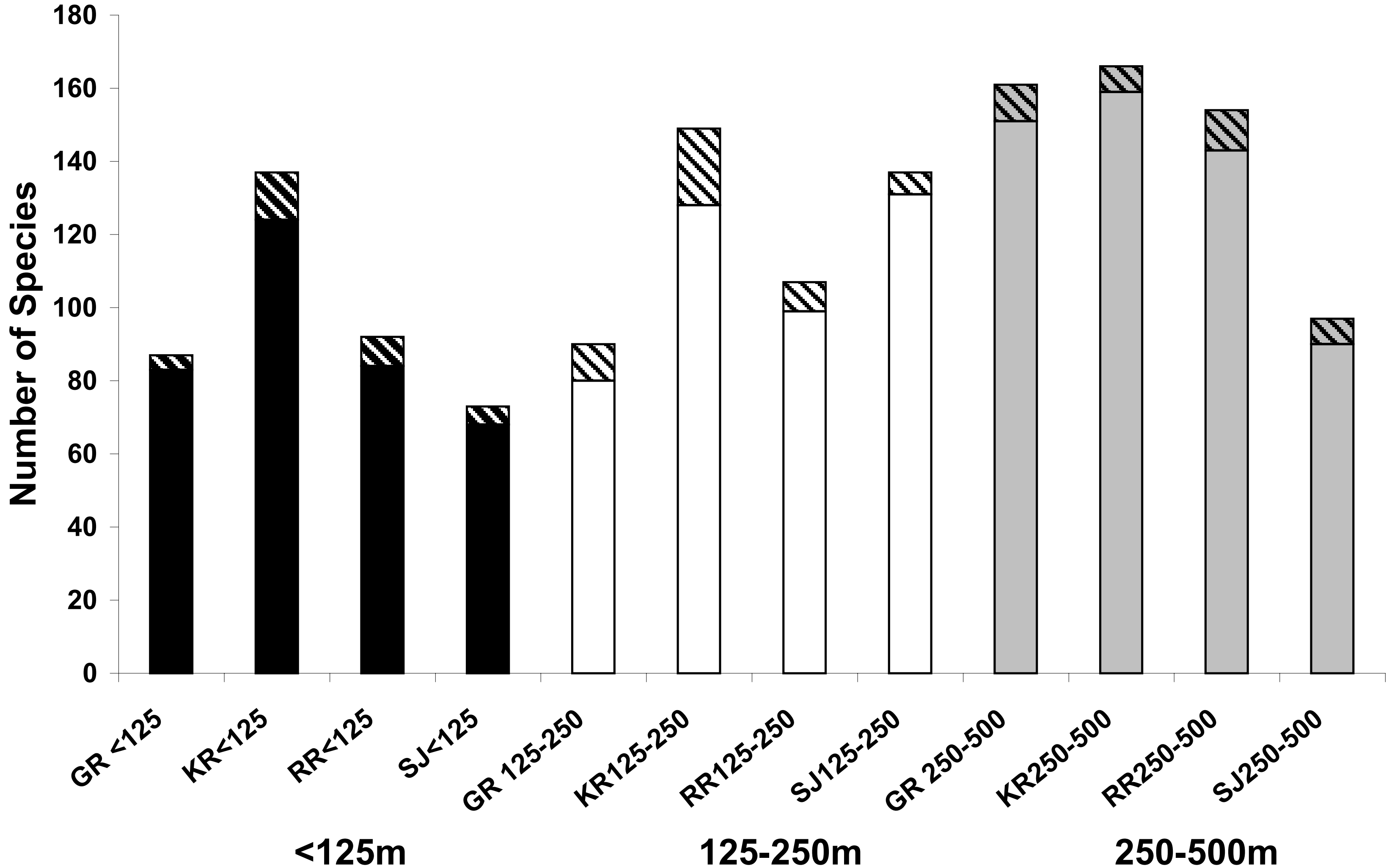


Figure 14. Total number of native species (solid) and adventive species (striped) by site, grouped by riparian forest buffer width class (<125m black, 125-250m white, 250-500m gray).

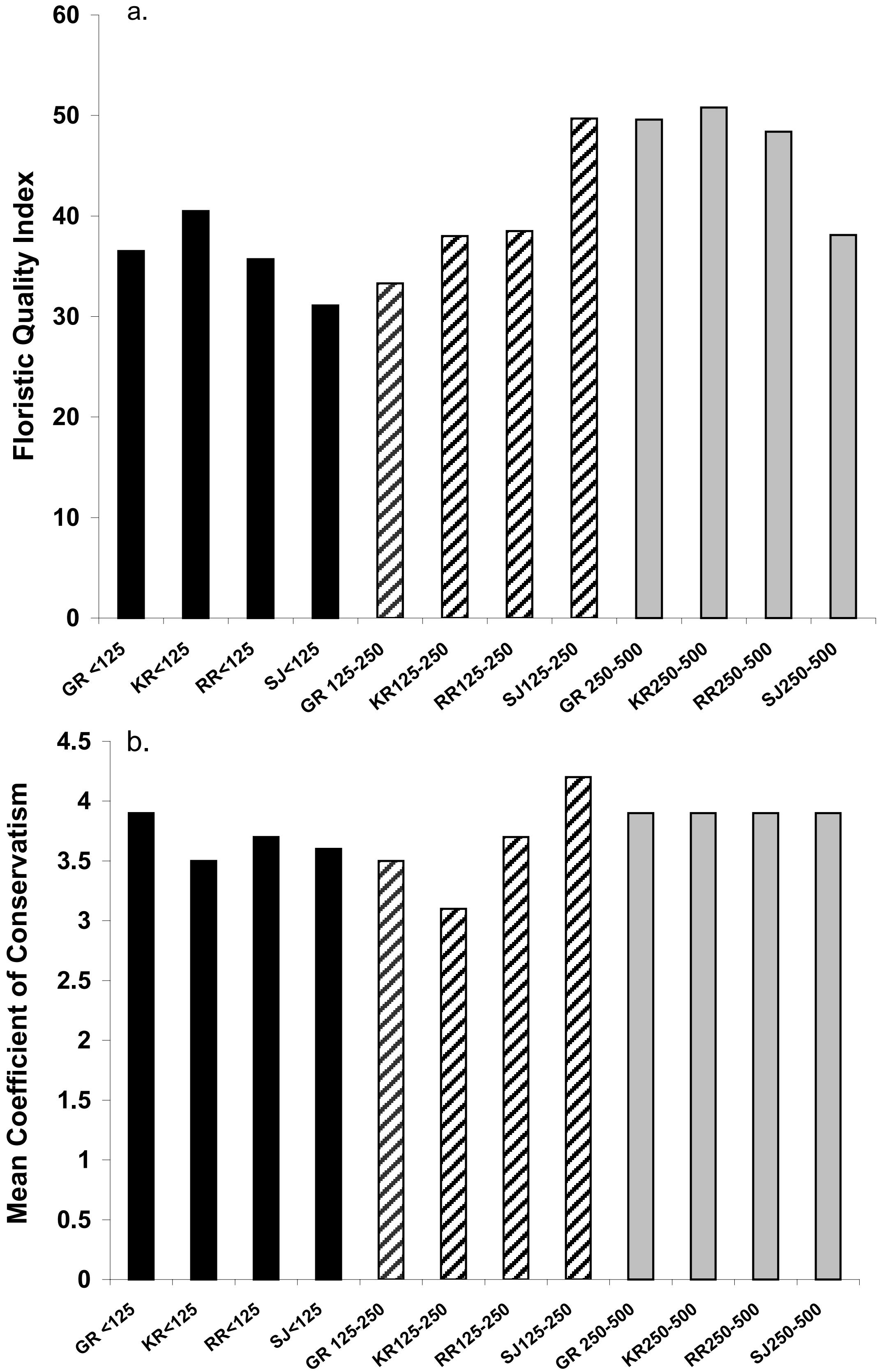


Figure 15. Summary of floristic results by site, grouped by buffer width (<125m black, 125-250m striped, 250-500m gray). Data include a) FQI scores and b) mean Coefficient of Conservatism.

scores and $\overline{C}$ values are provided in Figure 15. Site FQI values ranged widely from 31 to 51, whereas site $\overline{C}$ values had a narrow dispersion, ranging from 3.1 to 4.2. The frequency of $\overline{C}$ values for all sites is provided in Figure 16. Fifty percent of the sampling sites had $\overline{C}$ values of 3.9 or 4.2, while the remaining site scores ranged from 3.1 to 3.7 (median=3.7).

A total of 376 plant species was identified across the twelve study sites. Of this total, 333 (89%) were native and 43 (11%) were non-native (adventive) species. The native species observed included 49 trees, 31 shrubs, eight woody vines, 146 perennial forbs, six biennial forbs, 16 annual forbs, 19 perennial grasses, 41 perennial sedges and 19 ferns. The adventive species observed included six trees, 10 shrubs, 13 perennial forbs, four biennial forbs, four annual forbs and six perennial grasses. Presence/absence data for all 376 species across the 12 sites are provided in Appendix XI. Six native tree and shrub species were usually common to prevalent at all 12 study sites, including *Acer saccharinum* (silver maple), *Fraxinus pennsylvanica* (green ash), *Prunus serotina* (black cherry), *Quercus bicolor* (swamp white oak), *Rubus occidentalis* (black raspberry) and *Ulmus americana* (American elm). Woody vines ubiquitous across all sites included *Parthenocissus quinquefolia* (Virginia creeper) and *Toxicodendron radicans* (poison ivy). Forbs found at all study sites included *Aster lateriflorus* (side flowering aster), *Boehmeria cylindrica* (false nettle), *Galium aparine* (annual bedstraw), *Laportea canadensis* (wood nettle) and *Viola sororia* (common blue violet). Twelve species were found at 11 sites, including the floodplain forest woody plants *Carya cordiformis* (bitternut hickory), *Populus deltoides* (Eastern cottonwood), *Tilia americana* (American basswood) and *Vitis riparia* (riverbank grape), and the common forbs *Cinna arundinacea* (wood reedgrass), *Circaea lutetiana* (enchanter's nightshade), *Elymus virginicus* (Virginia wild rye), *Impatiens capensis* (touch-me-not), *Iris virginica* (southern blue-flag), *Onoclea sensibilis* (sensitive fern), *Podophyllum peltatum* (Mayapple) and *Ranunculus hispidus* (swamp buttercup).

Species typical of floodplain forests that were found at eight to ten of the study sites included *Arisaema dracontium* (green dragon), *Asarum canadense* (wild ginger), *Carex amphibola* (sedge), *Carex grayi* (Gray's sedge), *Carpinus caroliniana* (blue-beech), *Dioscorea villosa* (hairy wild yam), *Fraxinus nigra* (black ash), *Geum canadense* (white avens), *Leersia virginica* (white grass), *Lindera benzoin* (spicebush), *Lysimachia ciliata* (fringed loosestrife), *Platanus occidentalis* (sycamore), *Polygonum virginianum* (jumpseed), *Quercus macrocarpa* (bur oak), *Symplocarpus foetidus* (skunk cabbage), *Urtica dioica* (stinging nettle) and *Zanthoxylum americanum* (prickly ash). Site occurrence frequencies for all species are provided in Figure 17. Species occurring in samples from a majority of the sampling sites, defined here as eight or more of the 12 sites, comprised 20% of the 376 taxa identified during our surveys. In contrast, most of the remaining species were found at relatively few sites. Approximately one-third (34%) of these remaining species were found at only one site, 50% were found at two or fewer sites, and just over two-thirds (69%) of the taxa identified occurred at four or fewer sites. We consider the above species found at eight to12 sites to comprise a group of taxa particularly characteristic of southern floodplain forest communities, although in many cases these taxa occur in other natural communities, especially in ecologically similar habitats such as mesic southern forest and southern swamp.

Exotic Species

Of the 43 non-native species identified across the 12 sites, most were observed at fewer than four of the sites visited (Figure 18). The most frequently observed exotic species was *Rosa multiflora* (multiflora rose), a highly invasive shrub that was found at 11 of the 12 sites (not observed at SJ<125m). Several other invasive shrubs were also found (generally at four or fewer sites), including *Berberis thunbergii* (Japanese barberry), *Elaeagnus umbellata* (autumn olive), *Euonymus europaea* (spindle tree), *Ligustrum vulgare* (common privet), *Lonicera maackii* (amur honeysuckle), *Lonicera morrowii* (Morrow honeysuckle), *Lonicera tatarica* (tatarian honeysuckle), *Rhamnus cathartica* (common buckthorn) and *Rhamnus frangula* (glossy-leaved buckthorn). Additional frequently observed (i.e., observed at eight sites) non-native taxa included *Alliaria petiolata* (garlic mustard), *Lysimachia nummularia* (moneywort), and *Morus alba* (white mulberry). Of particular concern is *A. petiolata*, which is a well-known invasive species with a rapidly expanding range in southern Lower Michigan that represents the greatest exotic species threat to southern floodplain communities. *Lythrum salicaria* (purple loosestrife) is a well known, widely distributed wetland invasive that was observed at three sites. *Solanum dulcamara* (bittersweet nightshade) was found at five sites, although it was not dominant or particularly abundant at these sites. The remaining species were primarily less invasive exotic taxa usually found within disturbed areas of study sites, often along or near forest borders or similar abrupt boundaries. These species included *Arctium minus* (burdock), *Cirsium arvense* (Canada thistle), *Cirsium vulgare* (bull thistle), *Barbarea vulgaris* (rocket cress), *Glechoma hederacea* (gill-over-the-ground), *Poa compress* (Canada bluegrass) and other common weedy forbs. Occasionally, invasive species were found in association with local disturbances within floodplain forests. For example, a large *Ailanthus altissima*, tree-of-heaven, and a small grove of *Catalpa speciosa*, northern catalpa, were each found in disturbance openings where they have the potential to compete and become more widespread.

Natural Community and Rare Species Occurrences

Six natural community occurrences and five state listed plant species were documented during the study site surveys (Table 1). One occurrence of prairie fen and five occurrences of southern floodplain forest were identified from six sites. Prairie fen is a globally and state rare community (G3/ S3) known from 112 sites in Michigan. Southern floodplain forest is currently classified as G3?/S3, indicating that it is tentatively considered globally rare and rare within the state; high quality floodplain forests are tracked in approximately 40 sites in Michigan. Two state-listed as threatened species (*Morus rubra*, red mulberry, and *Fraxinus profunda*, pumpkin ash) and three state-listed as special concern species (*Carex trichocarpa*, sedge, *Carex squarrosa*, sedge, and *Euonymus atropurpurea*, wahoo) were identified at four sites. All of these plant species are restricted to southern Lower Michigan, where they reach the northern edge of their range within the state.

Vegetation and Floristic Results:Riparian Forest Buffer Width Classes

Means for sample plot data were calculated for sites and by riparian forest buffer width class for TSP, DBH, USSt, USSp, GCSE, GCSL, %GCE and %GCL. In addition, means were calculated for the total number of plant species per site (TPSpS), total number of native plant species per site (TNPS), total number of adventive plant species per site (TAPS), site floristic quality index (FQI) and site mean coefficient of conservatism ($\bar{C}$) for each riparian forest buffer width class (Table 12). Analysis of variance for these parameters indicated no significant differences in these variables among riparian forest buffer width class, possibly due to the small sample size of four sites per buffer class.

Plot data means where lumped across sites by riparian forest buffer width class and analyzed for differences using one-way ANOVA (Table 13). Mean basal area per plot was greater in areas with wider riparian forest buffers (F=3.34, p<0.04). Post-hoc tests (LSD) indicated that mean basal area for the 250-500m sites ($\bar{x}$=83.8 m^2/hectare), was significantly greater than the <125m sites ($\bar{x}$=66.9 m^2/hectare, p<0.03). Mean TSP values were also significantly greater for the 250-500m sites ($\bar{x}$=4.2 species/plot) compared to the <125m sites (3.4 species/plot, p<0.04). Mean DBH decreased with increasing buffer size (F=4.12, p<0.02) and post hoc tests indicated that DBH was significantly higher for the <125m plots ($\bar{x}$=39.86 cm) compared to the 250-500m plots ($\bar{x}$=32.5 cm, p<0.015). Within the understory layer, USSt was higher at the <125m sites (F=4.3, p<0.016). Post hoc tests indicated that the mean USSt for <125m sites ($\bar{x}$=38.0 stems/plot) was significantly higher than USSt at 125-250m sites ($\bar{x}$=22.2 stems/plot, p<0.01). Plots within smaller riparian buffers also had higher mean percent ground cover for both early (F=14.4, p<0.001) and late (F=4.6, p<0.011) season samples. The mean %GCE for <125m sites ($\bar{x}$=56.5%) was significantly higher than the mean %GCE for the 125-250m ($\bar{x}$=35.3%, p<0.001) and 250-500m sites ($\bar{x}$=29.8%, p<0.001). This difference can be partially attributed to the absence of severely inundated and sparsely vegetated-forested bottom zones within the <125m sites. Mean USSp (F=1.7, p>0.18), GCSE (F=0.49, p>0.62) and GCSL (F=0.20, p>0.82) were not significantly different among the riparian forest buffer width classes.

Floristic species richness uniformly increased with increasing riparian forest buffer width class (Figure 19 and Table 12). Mean floristic species richness was 97.2 species/site in the 125m buffer width class, 120.8 species/site in the 125-250m buffer width class, and 144.5 species/site in the 250-500m buffer width (Table 12). The FQI also increased similarly among buffer width classes, scoring from 36 (<125m) to 40 (125-250m) and nearly 47 in the 250-500m riparian forest buffer width class (Table 12). The $\bar{C}$, however, shows little difference between buffer widths, owing to the small sample size and narrow dispersion of values, which only ranged from 3.1 to 4.2.

Vegetation and Floristic Results: River Basins

Plot data means where lumped across sites by riparian system and analyzed for differences using one-way analysis of variance (Table 14). The mean basal area per plot was marginally lower for the KZ basin compared to the other basins (F=2.58, p<0.05, $\bar{x}$=67.4 m^2/hectare, $\bar{x}$=77.5 m^2/hectare, $\bar{x}$=81.5 m^2/hectare and $\bar{x}$=88.1 m^2/hectare for the KZ, GR, RR and SJ, respectively). Post hoc analysis indicated that mean basal area was higher at the SJ basin compared to the KZ basin (p<0.04). Mean DBH for the GR basin ($\bar{x}$=30.3 cm) and KZ basin ($\bar{x}$=28.1 cm) was significantly lower than the DBH means for the RR ($\bar{x}$=38.7 cm) and the St. Joe ($\bar{x}$=44.4 cm, F=16.54,

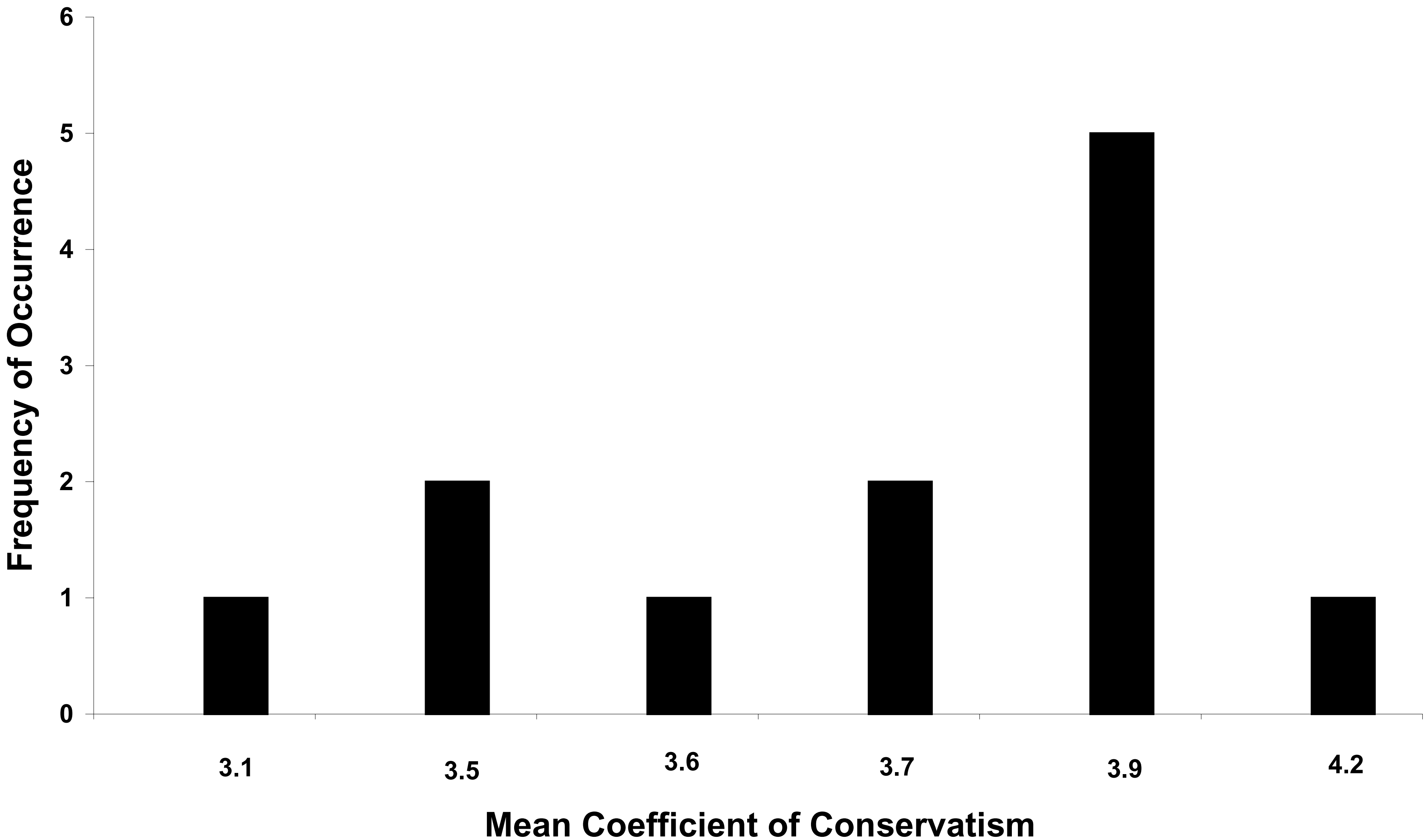


Figure 16. Frequency of mean Coefficient of Conservatism values among the 12 riparian ecosystem survey sites visited.

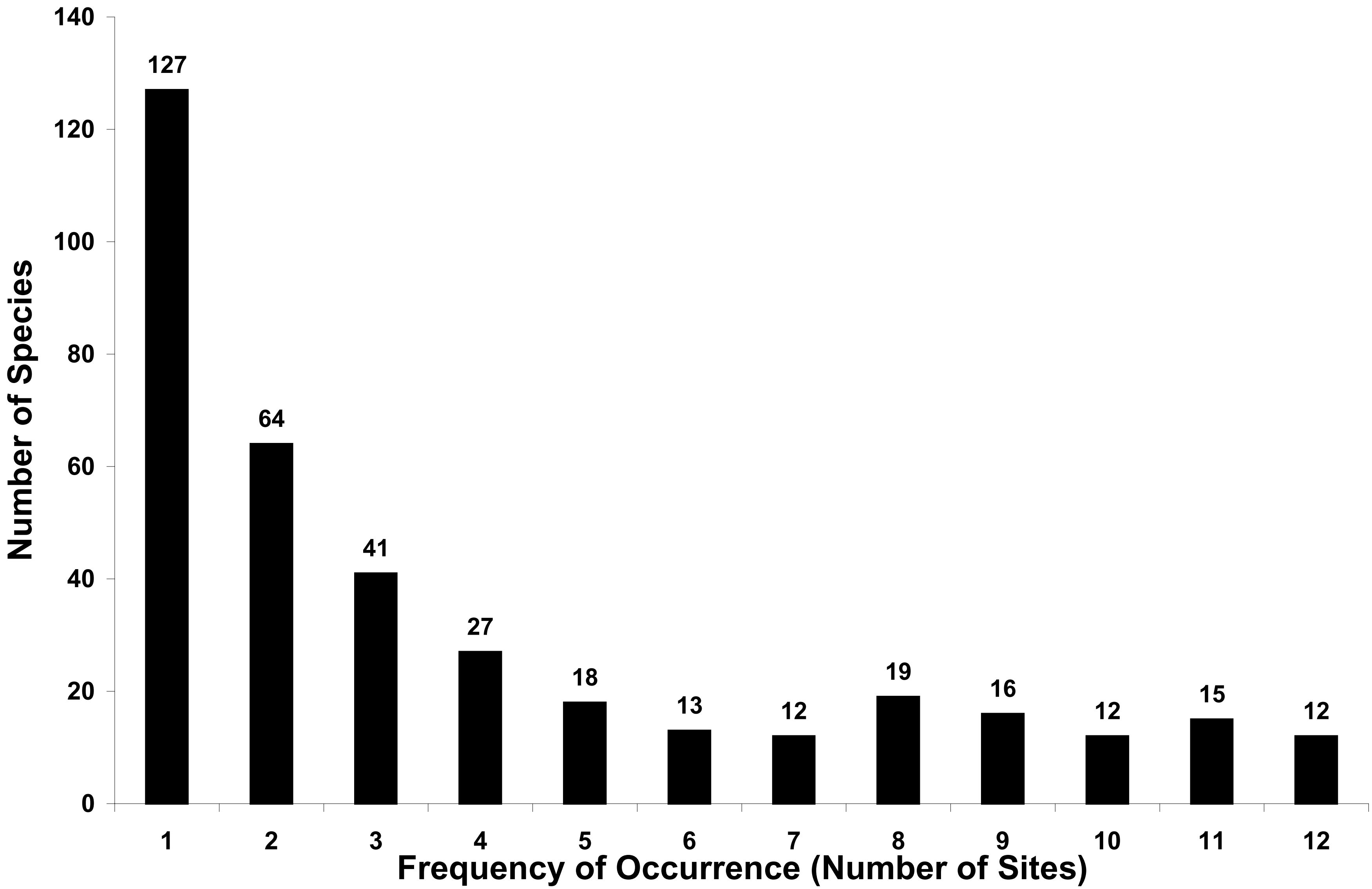


Figure 17. Species site frequency (i.e., 127 species occurred at only one site, 64 species occurred at two sites, 41 species occurred at three sites, etc.)

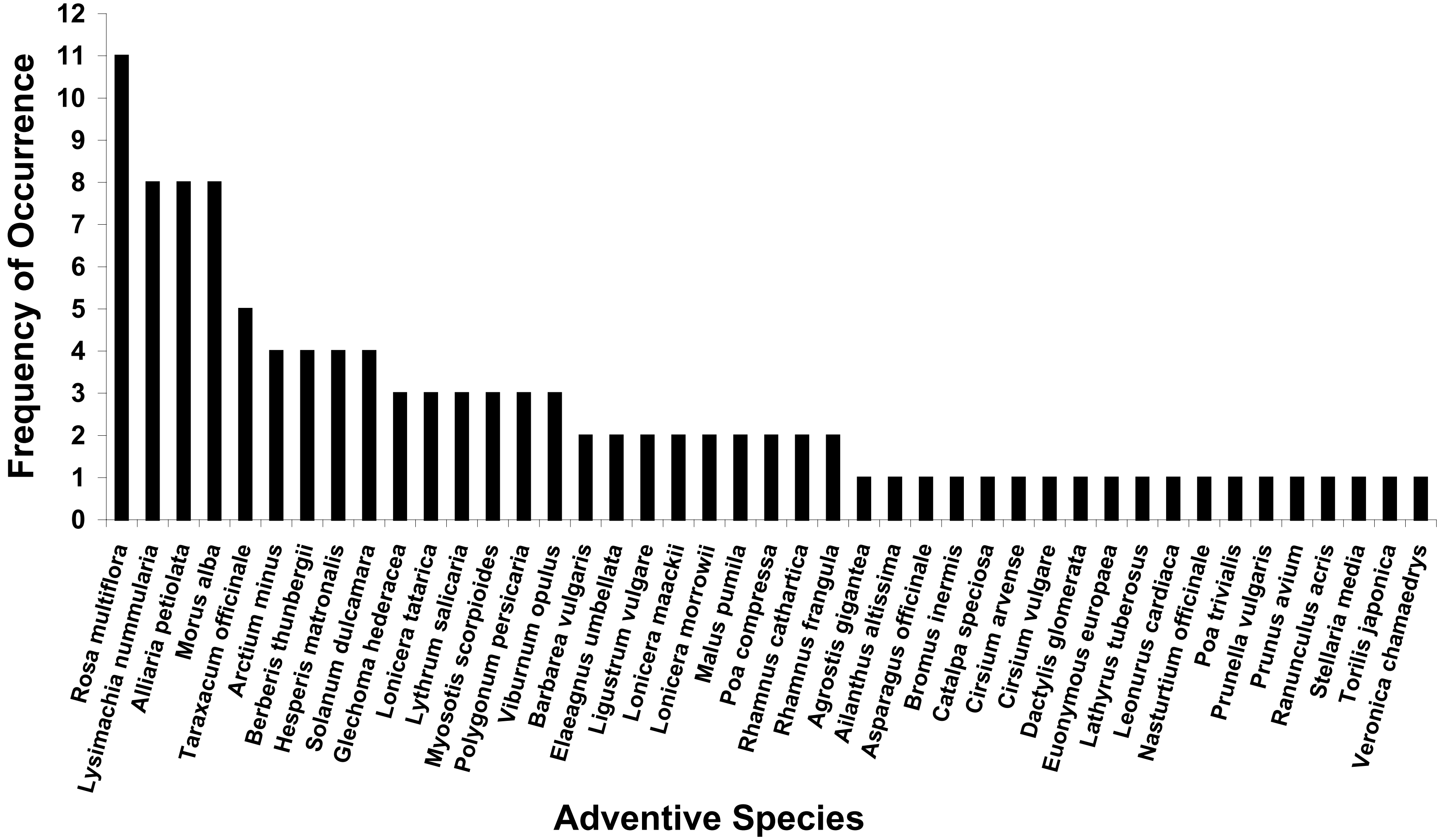


Figure 18. Frequency of occurrence of the 43 adventive species observed at riparian sites (e.g.,*R. multiflora* occurred at 11 sites, *L. nummularia* occurred at eight sites, etc.)

p<0.001). TSP measures were significantly different among basins (F=5.24, p<0.003) and were highest in the RR basin. Both USSp (F=6.64, p<0.001) and USSt (F=3.27, p<0.025) were significantly lower in the GR basin compared to the KZ and RR basins. Mean number of understory species and stems per plot for the basins are as follows: GR ($\bar{x}$=4.1 species/plot and $\bar{x}$=19.2 stems/plot), KZ ($\bar{x}$=7.0 species/plot and $\bar{x}$=34.8 stems/plot), RR ($\bar{x}$=6.8 species/plot and $\bar{x}$=32.1stems/plot), and SJ ($\bar{x}$=5.8 species/plot and $\bar{x}$=31.0 stems/plot). For both the early and late season sampling, the GR basin had the lowest mean GCSE and GCSL ($\bar{x}$=5.8 species/plot and $\bar{x}$=5.6 species/plot, respectively, F=5.8, p<0.002), and the KZ basin had the highest GCSE ($\bar{x}$=10.0 species/plot) and GCSL ($\bar{x}$=8.7 species/plot, F=4.2, p<0.008). The mean %GCE for the GR basin ($\bar{x}$=25.3%) and the SJ basin ($\bar{x}$=28.0%) were significantly different (F=12.7, p<0.001) from the means for the KZ basin ($\bar{x}$=54.3%) and the RR basin ($\bar{x}$=43.9%). %GCL measures were not different among the basins included in this study (F=1.70, p>0.17)

The highest mean floristic species richness observed was in the KZ basin, followed by the RR, GR, and SJ basins (Figure 20, Table 15). Floristic species richness generally increased with increasing riparian forest buffer widths within river basins (Figure 21). The mean number of exotic species was also highest in the KZ basin, followed again by the RR, GR and SJ basins (Table 15). Mean FQI values also followed this pattern, but within a much narrower range (Figure 20). The FQI values for each basin generally increased from the small buffer to the large buffer width sites, whereas the $\overline{C}$ values showed no clear pattern (Figure 22). Despite the KZ basin's uniformly high plant diversity, only one site within the KZ basin (250-500m) scored within the top half of the $\overline{C}$ values, with the medium buffer site (125-250m) reflecting the lowest $\overline{C}$ value recorded (3.1, Figure 22). High floristic species richness in the latter case was offset to some extent by the highest recorded proportion of adventive species, which indicate the more disturbed nature of the site and lower natural area quality.

<u>Vegetation and Floristic Results: Ecological Zones</u>

Four different ecological zones were identified during this study: levee, forested bottom, sparsely forested bottom and upland forest. Means for plot data were calculated by zone for the following variables: basal area, TSP, DBH, USSt, USSp, GCSE, GCSL, %GCE and %GCL (Table 16). Groundcover typical of levees and forested bottoms included *Saururus cernuus* (lizard tail), *Laportea canadensis* (wood nettle), *Urtica dioica* (stinging nettle), *Arisaema dracontium* (green dragon), *Arisaema triphyllum* (Jack-in-the-pulpit), *Asarum canadense* (wild ginger), *Aster lateriflorus* (aster), *Carex grayi* (Gray's sedge), *Cinna arundinacea* (wood reedgrass), *Dioscorea villosa* (hairy wild yam), *Iris virginica* (southern blue-flag), *Pilea fontana* and *P. pumila* (clearweed), *Ranunculus hispidus* (swamp buttercup), *Smilax ecirrhata* (carrion flower) and *Verbesina alternifolia* (bellwort). Characteristic shrubs of these two ecological zones included *Lindera benzoin* (spice bush), *Cephalanthus occidentalis* (buttonbush), *Zanthoxylum americanum* (prickly ash), *Ilex verticilata* (Michigan holly), and *Carpinus caroliniana* (musclewood).

Levees were identified at the GR125-250m, GR250-500m and RR<125m study sites. The GR sites were distinct sediment rises adjacent to the river, while the RR levee was clearly artificial, created by the dredging of the river and formation of a spoil bank. The levees were narrow zones characterized by large diameter trees, typically *Acer saccharinum* (silver maple). The mean DBH was greatest for levees ($\bar{x}$=37.6cm, F=3.33, P<0.03), and the mean TSP was lowest in levees (F=2.78, p<0.05). Other ecological measures for levees were similar to other zones identified in the study areas.

Sixteen of the 31 zones sampled were classified as forested bottoms, including GR<125m (zone one), GR125-250m (zones two and three), GR250-500m (zones two and three), KZ125-250m (zone one), KZ250-500m (zones two and three), RR<125m (zone two), RR125-500m (zone one), RR250-500m (zones one and two), SJ<125m (zone one), SJ125-250m (zones one and two), and SJ250-500m (zone one). The forested bottoms were the broadest of the zones (20m to 250m wide), and were characterized by varying degrees of seasonal inundation. Forested bottoms were most frequently dominated by large diameter *Acer saccharinum* (silver maple) and *Fraxinus pennsylvanica* (green ash) in high densities and were characterized by sparse understory and ground layer vegetation. The forested bottoms had the greatest mean basal area of all zones ($\bar{x}$=83.4m^2/hectare), which was significantly higher (p<0.003) than the mean basal area of sparsely forested bottoms ($\bar{x}$=45.9m^2/hectare). The mean USSp ($\bar{x}$=4.6 species/plot) and the mean USSt ($\bar{x}$=21.6 stems/plot) were the lowest among zones and were significantly lower than measures for the sparsely forested bottom zone ($\bar{x}$=8.4 species/plot and $\bar{x}$=59.6 stems/plot, p<0.004 and p<0.001, respectively) and the upland zone ($\bar{x}$=7.2 species/plot and $\bar{x}$=33.1 stems/plot, p<0.001 and p<0.04, respectively). The mean GCSE ($\bar{x}$=6.7 species/plot) and GCSL ($\bar{x}$=5.8 species/plot) were the lowest across zones and were significantly lower than

Table 12. Summary of floristic results by buffer width class.

Buffer Width	Total # Plant Species		Total # Native Plant		Total # Adventive		FQI		Mean COC	
	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE
<125m	97.3	13.8	89.8	12.0	7.5	2.0	36.0	1.9	3.7	0.1
125-250m	120.8	13.5	109.5	12.2	11.3	3.4	39.9	3.5	3.6	0.2
250-500m	144.5	16.0	135.8	15.6	8.8	1.0	46.7	2.9	3.9	0.0

Table 13. Means of vegetation survey variable data by riparian forest buffer width class. Superscript letters indicate significant post hoc differences between buffer class means.

Buffer Width	Basal Area (m^2/hectare)		# tree species/plot		DBH cm by prism plot		# of woody stems/plot		# understory species/plot		# Ground Cover species/plot (early)		# Ground Cover species/plot (late)		% Ground Cover/plot (early)		% Ground Cover/plot (late)	
	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE
<125m	66.9^{a}	5.3	3.4^{b}	0.2	39.9^{c}	2.2	38.0^{d}	6.2	6.3	0.7	7.2	0.6	7.1	0.6	56.5^{ef}	5.2	24.5	3.5
125-250m	79.4	4.1	3.7	0.2	34.8	1.8	22.2^{d}	2.8	5.2	0.5	8.0	0.7	6.7	0.6	35.3^{e}	3.3	28.1^{g}	3.2
250-500m	83.8^{a}	3.9	4.2^{b}	0.2	32.5^{c}	1.3	29.2	2.5	6.2	0.4	8.1	0.6	6.6	0.5	29.8^{f}	2.4	17.6^{g}	1.6

Table 14. Means of vegetation survey variable data among study river basins. Superscript letters indicate significant post hoc differences between buffer class means.

River Basin	Basal Area (m^2/hectare)		# tree species/plot		DBH cm by prism plot		# of woody stems/plot		# understory species/plot		# Ground Cover species/plot (early)		# Ground Cover species/plot (late)		% Ground Cover/plot (early)		% Ground Cover/plot (late)	
	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE
Grand	77.5	5.5	3.2^{b}	0.2	30.3^{de}	1.1	19.2^{hi}	3.2	4.1^{jk}	0.5	5.8^{l}	0.7	5.6^{mn}	0.7	25.3^{op}	3.5	18.5	2.9
Kalamazoo	67.4^{a}	5.5	3.5^{c}	0.3	28.1^{fg}	2.0	34.8^{h}	5.6	7.0^{j}	0.5	10.0^{l}	0.6	8.7^{m}	0.6	54.3^{qo}	4.4	27.7	3.7
Raisin	81.5	4.2	4.5^{bc}	0.3	38.7^{df}	1.8	32.1^{i}	2.9	6.8^{k}	0.5	7.8	0.5	6.2^{n}	0.5	43.9^{rp}	3.4	24.8	3.0
St. Joe	88.1^{a}	4.5	4.0	0.3	44.4^{eg}	2.2	31.0	4.7	5.8	0.6	8.4	1.1	7.1	0.8	28.0^{qr}	3.8	21.2	2.8

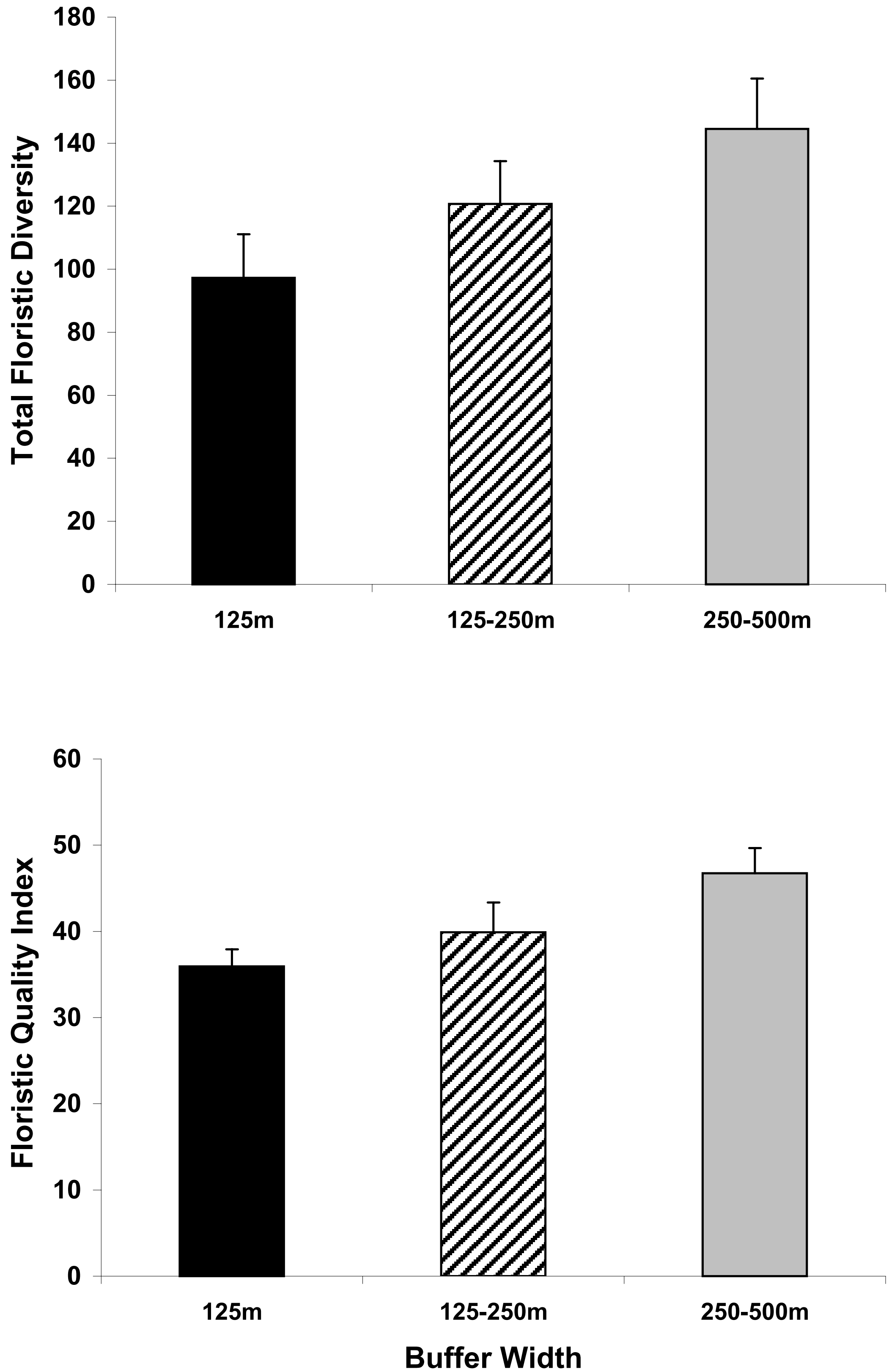


Figure 19. Comparison of a) total mean floristic diversity and b) mean FQI scores among riparian buffer width classes (<125m black, 125-250m striped, 250-500m gray).

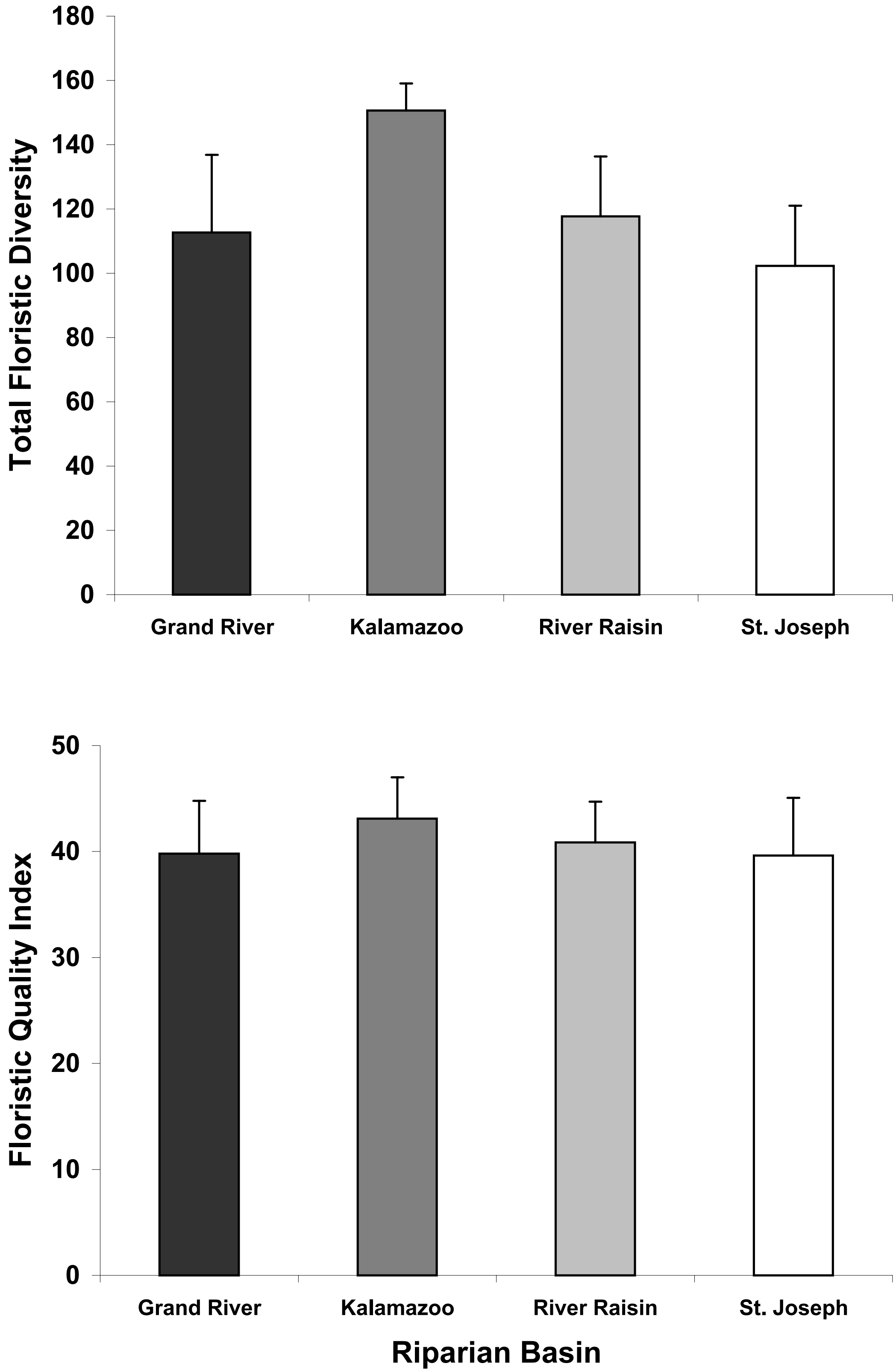


Figure 20. Comparison of total mean floristic diversity and mean FQI scores among riparian study river basins (Grand River- black, Kalamazoo- dark gray, River Raisin- light gray, St. Joseph- white)

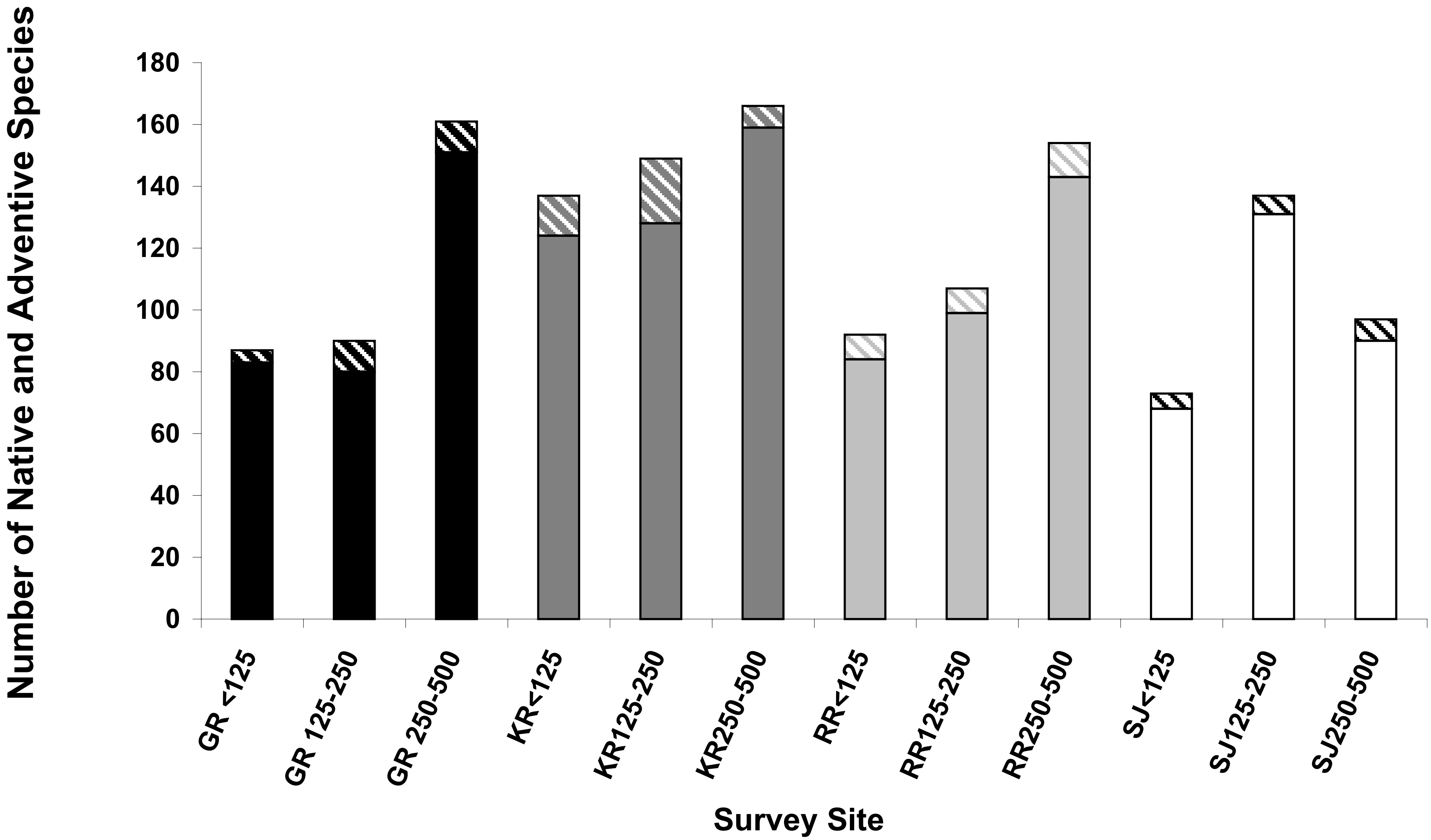


Figure 21. Total number of native species (solid) and adventive species (striped) among sites grouped by riparian basin (Grand River- black, Kalamazoo- dark gray, River Raisin- light gray, St. Joseph- white).

the upland zone GCSE ($\bar{x}$=9.5 species/plot, $p<0.005$) and GCSL ($\bar{x}$=8.24 species/plot, $p<0.006$) means. Mean %GCE in forested bottoms ($\bar{x}$=33.7%) was the lowest observed for all zones and significantly lower than the sparsely forested bottom %GCE ($\bar{x}$=69.6%, $p<0.001$).

Sparsely forested bottoms were narrow zones characterized by a scattered canopy of small diameter trees with open areas dominated by diverse herbaceous species or dense, diverse shrub thickets. There were only two zones across all study sites that were classified as sparsely forested bottom: zone one of KZ<125m and zone three of RR250-500m. The sparsely forested bottoms were characterized by the lowest mean basal area ($\bar{x}$=45.9 m^2/hectare) observed and post hoc tests indicated that they had significantly lower basal area than the forested bottom ($p<0.003$) and upland ($p<0.02$) areas, and marginally lower basal area than levees ($p<0.055$). Sparsely forested bottoms also had the lowest mean tree diameter ($\bar{x}$= 23.6cm) observed, significantly lower than the levee ($\bar{x}$=37.7, $p<0.03$), forested bottom ($\bar{x}$=35.9, $p<0.015$) and upland ($\bar{x}$=35.0, $p<0.04$) zone means. The mean USSp and USSt in sparsely forested bottoms were the highest across zones. The mean USSp ($\bar{x}$=8.4 species/plot) was significantly higher than the forested bottom zone USSp ($\bar{x}$=4.6 species/plot, $p<0.004$), and the mean USSt for sparsely forested bottoms ($\bar{x}$=59.6 stems/plot) was significantly higher than the levee ($\bar{x}$=31.5 stems/plot, $p<0.02$), forested bottom ($\bar{x}$=21.7 stems/plot, $p<0.001$), and upland USSt means ($\bar{x}$=33.1 stems/plot, $p<0.008$). In comparison to the other zones, mean GCS and %GC measures were high. Mean %GCE in the sparsely forested bottoms ($\bar{x}$=69.6%) was statistically higher than the mean %GCE values for the levee ($\bar{x}$=41.2%, $p<0.03$), the forested bottom ($\bar{x}$=33.7%, $p<0.001$) and the upland zones ($\bar{x}$=36.8%, $p<0.002$).

Upland forest was the second most frequently observed ecological zone in the study (10 of 31 total zones). Upland forests were sampled in the final zones of all sites but GR<125m and SJ<125m. Upland forest zones were characteristically dominated in the overstory by a mix of mesic, mid-tolerant species such as *Tilia americana, Quercus rubra, Fraxinus americana* and *Prunus serotina*, which are typical of second growth (previously logged) forests. The upland forest zones were predominantly narrow with diverse ground cover and understory vegetation and a prevalent adventive species component due to upland forests acting as the edge zones of the forested buffer. The upland forest had a high mean basal area ($\bar{x}$=77.1m^2/hectare), which was significantly higher than the basal areas of sparsely forested bottoms ($\bar{x}$=45.9 m^2/hectare, $p<0.003$). The mean upland USSp ($\bar{x}$=7.2 species/plot) and mean USSt ($\bar{x}$=33.1 stems/plot) were relatively high and were significantly higher than the mean USSp and USSt measures of the forested bottom zone ($\bar{x}$=4.6 species/plot, $p<0.004$, and $\bar{x}$=21.6 stems/plot, $p<0.04$, respectively). The mean GCSE ($\bar{x}$=9.5 species/plot) and GCSL ($\bar{x}$=8.2species/plot) were high and were significantly higher than the GCSE and GCSL means for the forested bottom ($\bar{x}$=6.7 species/plot, $p<0.005$ and $\bar{x}$=5.8 species/plot, $p<0.006$, respectively). Mean %GCE in upland forest ($\bar{x}$=36.8%) was lower than the mean %GC of sparsely forested bottom areas ($\bar{x}$=69.6%, $p<0.002$).

Vegetation and Floristic Results: All Study Sites

Site-specific means for plot data (Table 17) were calculated for the following variables: basal area (Figure 23), TSP (Figure 23), DBH (Figure 23), USSt (Figure 24), USSp (Figure 24), GCSE and GCSL (Figure 25), and %GCE and %GCL (Figure 25). Statistical differences between individual site means are discussed below within the site summaries. The number of zones per site, site coefficient of topographic variation, total number of plant species per site, total number of native plant species per site, total number of adventive plant species per site, site floristic quality index and site mean coefficient of conservatism are given in Table 18. Native and adventive plant species richness, the floristic quality index and mean coefficient of conservatism ($\bar{C}$) are provided in Figures 14 and 15. Coefficients of topographic variation across sites are provided in Figure 26, and topographic change along the sampling transects is depicted in Figures 27 (125m sites), 28 (125-250m sites), 29 (250-500m sites), 30 (125m sites), 31 (125-250m sites), and 32 (250-500m sites).

Vegetation and Floristic Results: GR<125m

Vegetation and ecological sampling. This site was unique in that the ecological buffer did not correspond with the forested buffer. The following three very distinct ecological zones were identified at this site: floodplain bottom, prairie fen and a remnant oak savanna slope. Each zone was sampled; however, for purposes of comparative analysis, only the data collected from the floodplain forest were utilized. The total length of the base transect was 160m. Figures 27 and 30 show height above or below the riverbank graphed on distance along the base transect. The CTV for the floodplain bottom was -0.65. The absolute value of this CTV was the second highest across all sites indicating that there was a high degree of topographic variability from sample point to sample point along the transect (Figure 26). The forested floodplain bottom, which spanned from the riverbank

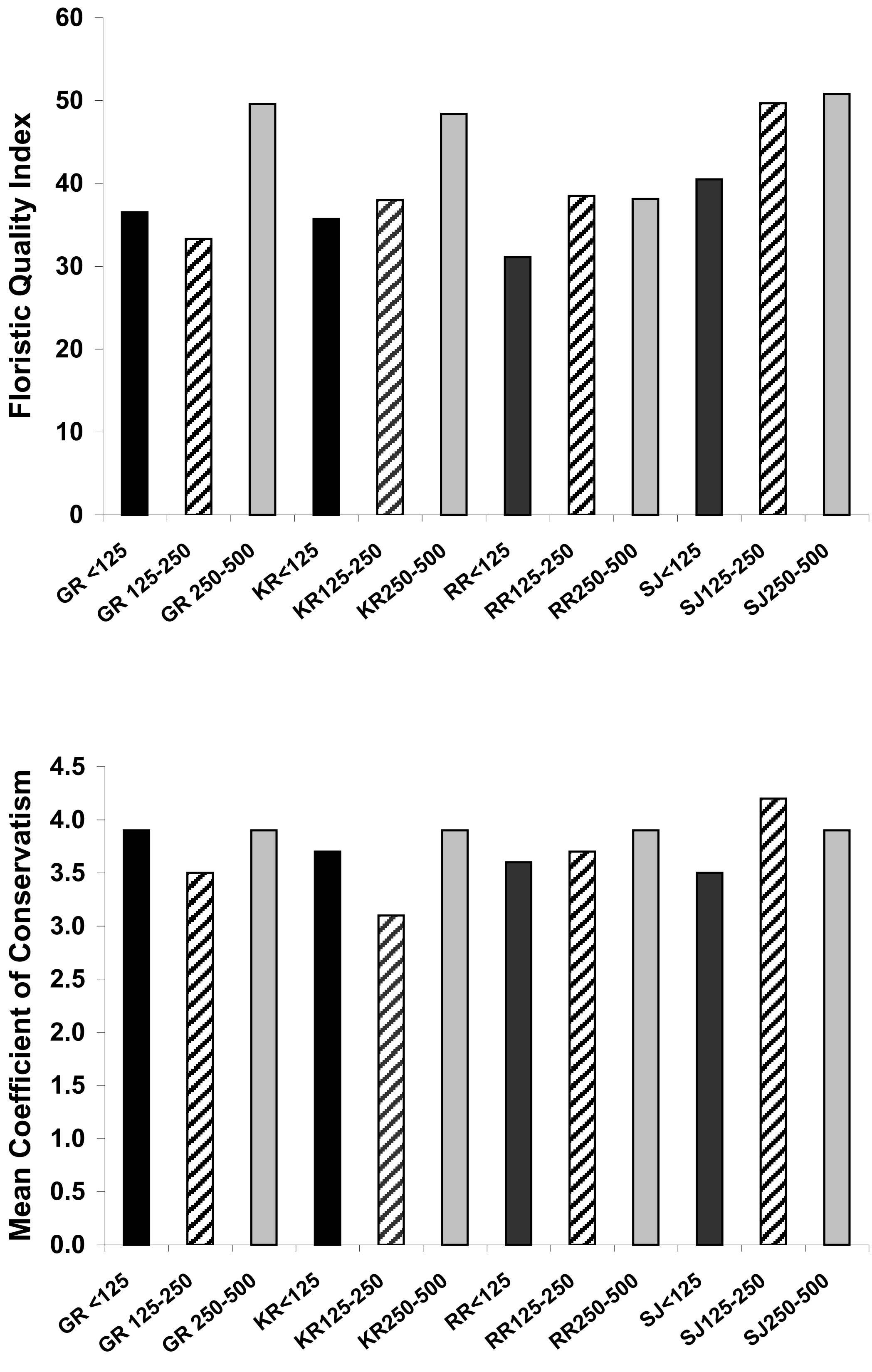


Figure 22. Summary of floristic results by riparian sites grouped within river basins (<125m black, 125-250m striped, 250-500m gray)

Table 17. Means and standard errors (SE) for ecological variables measured at 12 riparian forests sites. River basins sampled include the Grand, (GR), Kalamazoo (KZ), Raisin (RR) and St. Joseph (SJ) Rivers. Riparian forest buffer width classes include <125m, 125-250m and 250-500m.

	Basal Area (m^2/hectare)		# tree species/plot		DBH (cm) / site		DBH cm by prism plot		# of woody stems/plot		# understory species/plot		# Ground Cover species/plot (early)		# Ground Cover species/plot		% Ground Cover/plot (early)		% Ground Cover/plot (late)	
SITE	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**	**MEAN**	**SE**
GR <125	58.9	5.5	3.2	0.4	37.2	30.6	38.2	3.7	4.2	1.1	1.6	0.2	8.6	1.1	10.6	1.4	56.8	13.4	17.4	4.4
GR 125-250	82.1	7.7	2.8	0.3	29.2	0.8	28.4	1.2	6.0	1.6	2.2	0.8	4.1	1.1	4.0	1.1	24.0	5.1	20.6	5.5
GR 250-500	77.2	9.5	3.8	0.3	29.9	0.8	30.3	1.6	36.1	4.9	6.7	0.8	6.9	1.3	6.1	1.2	18.7	3.7	16.7	3.5
KR<125	49.0	10.7	2.5	0.4	35.9	3.3	31.9	5.4	63.0	14.2	9.1	1.2	8.6	0.8	8.4	1.1	72.0	8.7	15.9	2.7
KR125-250	64.8	11.2	3.4	0.6	28.4	1.5	26.5	4.0	21.2	3.3	7.3	0.9	10.7	0.9	9.9	1.0	57.2	8.1	49.9	8.5
KR250-500	80.8	6.0	4.4	0.3	26.6	0.9	26.6	1.4	25.2	5.5	5.3	0.6	10.5	1.1	8.0	0.9	40.6	4.7	20.9	3.1
RR<125	75.8	9.6	3.9	0.3	43.3	1.7	44.0	2.3	43.3	6.6	7.7	0.9	7.6	0.7	6.5	0.8	60.6	6.2	35.9	6.3
RR125-250	88.1	8.1	4.2	0.5	48.9	2.8	49.1	4.6	25.4	5.7	5.8	0.8	7.4	1.2	5.8	1.2	39.1	4.8	25.9	6.3
RR250-500	82.8	6.4	5.0	0.5	30.3	1.0	29.6	1.2	27.0	2.3	6.7	0.7	8.2	0.8	6.1	0.7	33.7	4.1	15.8	2.6
SJ<125	81.3	14.0	3.6	0.6	42.3	3.4	45.1	6.0	5.6	1.2	1.4	0.2	1.6	0.9	3.0	0.9	12.6	8.2	14.8	10.2
SJ125-250	80.3	5.9	4.7	0.5	39.4	1.8	39.3	3.1	42.4	5.9	7.3	0.6	11.7	1.5	8.6	1.3	33.2	5.6	25.2	4.0
SJ250-500	103.9	4.9	3.2	0.1	51.8	2.3	51.6	2.9	26.5	8.5	5.8	1.2	6.9	1.7	6.8	1.3	28.0	5.9	18.3	3.3

Table 18. Floristic and ecological variables measured at riparian study sites, including total number of plant species (TSP), total number of native plant species (TNPS), total number of adventive plant species (TAPS), percent of all species as native species (%Native), percent of all species as adventive species (%Adventive), Floristic Quality Index (FQI), Coefficient of Conservatism (COC), number of ecological zones (#Zones) and coefficient of topographic variation (CTV). River basins include the Grand (GR), Kalamazoo (KZ), Raisin (RR) and St. Joseph (SJ) Rivers. Riparian forest buffer width classed include <125m, 125-250m and 250-500m.

SITE	TPS	TNPS	TAPS	%Native	%Adventive	FQI	Mean COC	#Zones	CTV
GR <125	87	83	4	0.95	0.05	36.5	3.9	1.00	-0.65
GR 125-250	90	80	10	0.89	0.11	33.3	3.5	4.00	0.72
GR 250-500	161	151	10	0.94	0.06	49.6	3.9	4.00	0.23
KR<125	137	124	13	0.91	0.09	40.5	3.5	2.00	0.27
KR125-250	149	128	21	0.86	0.14	38.0	3.1	2.00	0.31
KR250-500	166	159	7	0.96	0.04	50.8	3.9	3.00	-0.08
RR<125	92	84	8	0.91	0.09	35.7	3.7	3.00	0.32
RR125-250	107	99	8	0.93	0.07	38.5	3.7	2.00	0.38
RR250-500	154	143	11	0.93	0.07	48.4	3.9	4.00	0.51
SJ<125	73	68	5	0.93	0.07	31.1	3.6	1.00	-0.27
SJ125-250	137	131	6	0.96	0.04	49.7	4.2	3.00	-0.25
SJ250-500	97	90	7	0.93	0.07	38.1	3.9	2.00	-0.11

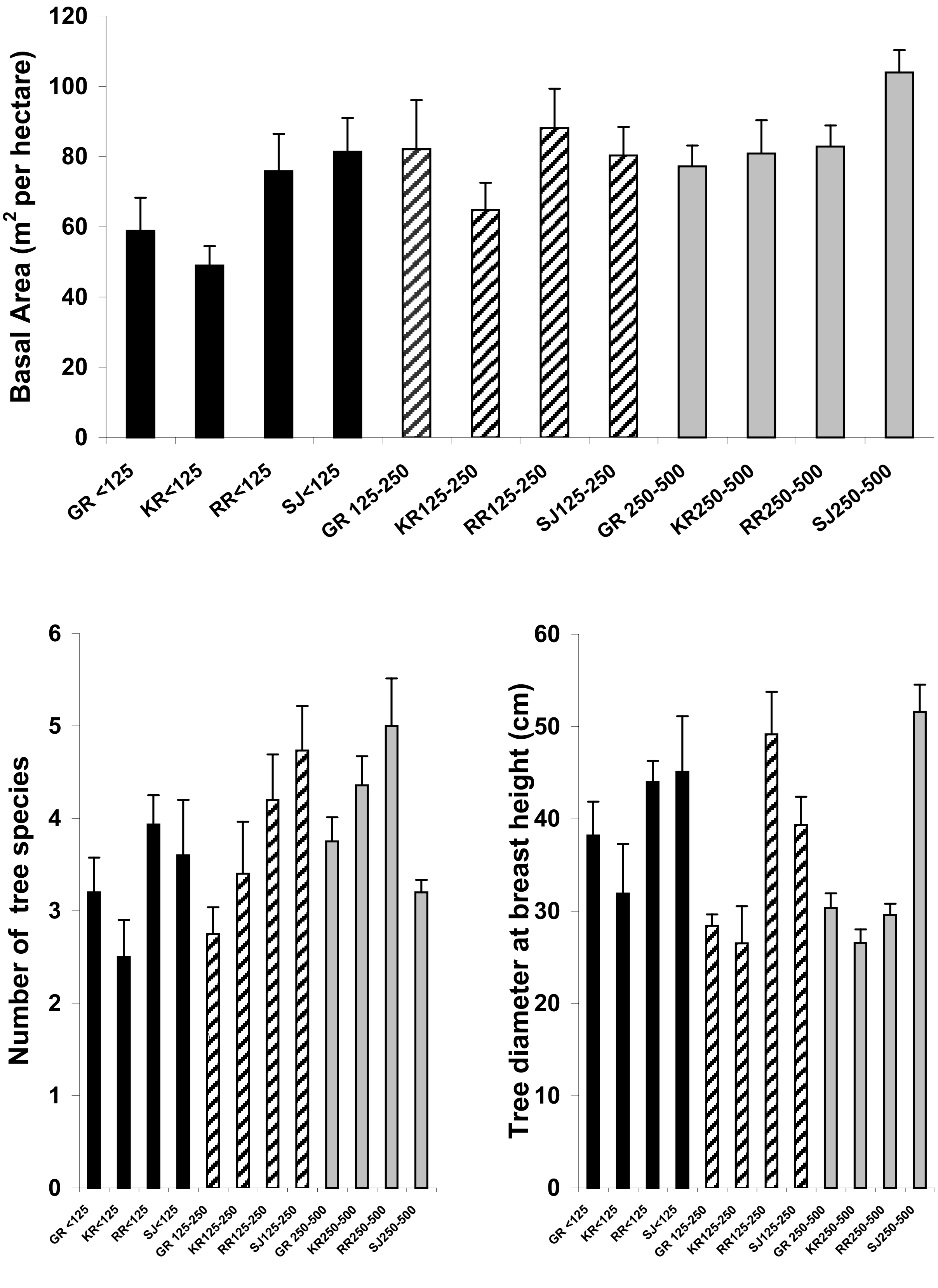
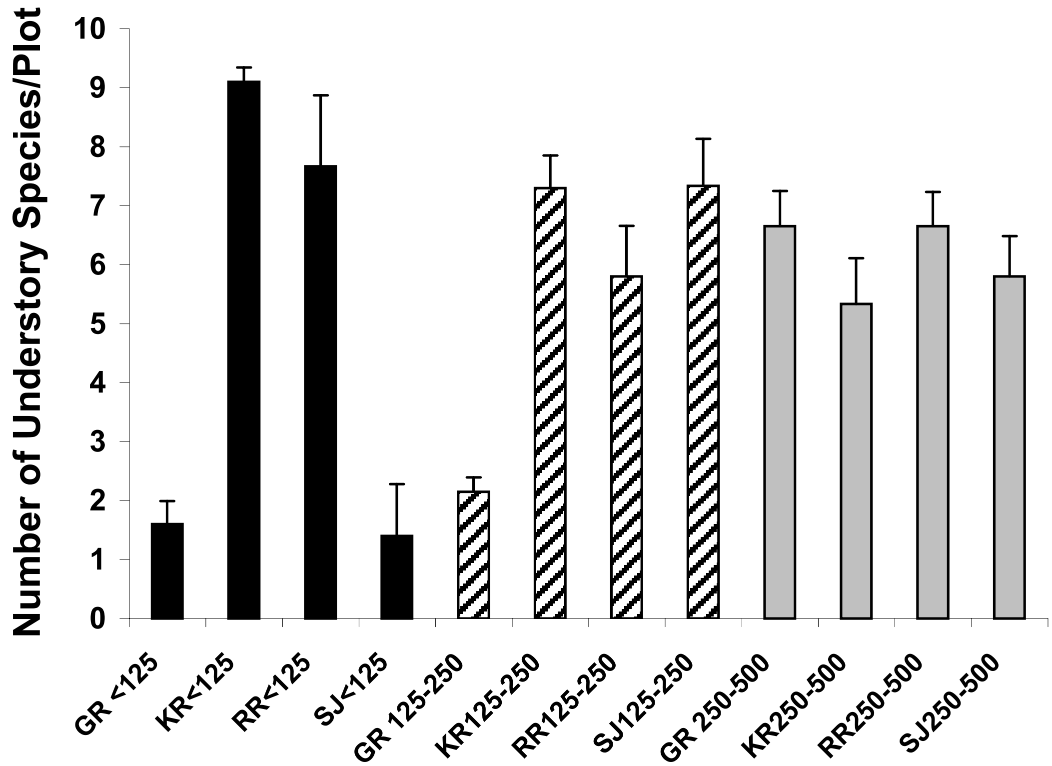


Figure 23. Summary of results from 10-factor prism plots by sites grouped into buffer width classes (<125m black, 125-250m striped, 250-500m gray).



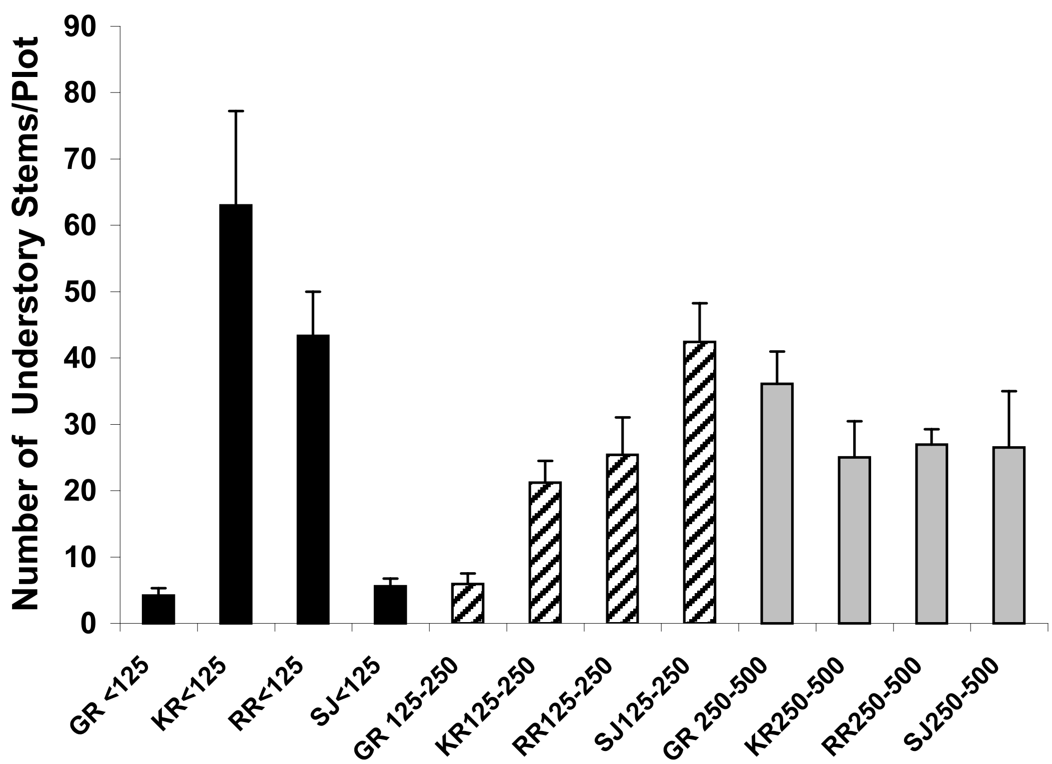


Figure 24. Summary of results for 5m radius understory plots at survey sites grouped by buffer width classes (<125m black, 125-250m pin stripes, 250-500m gray).

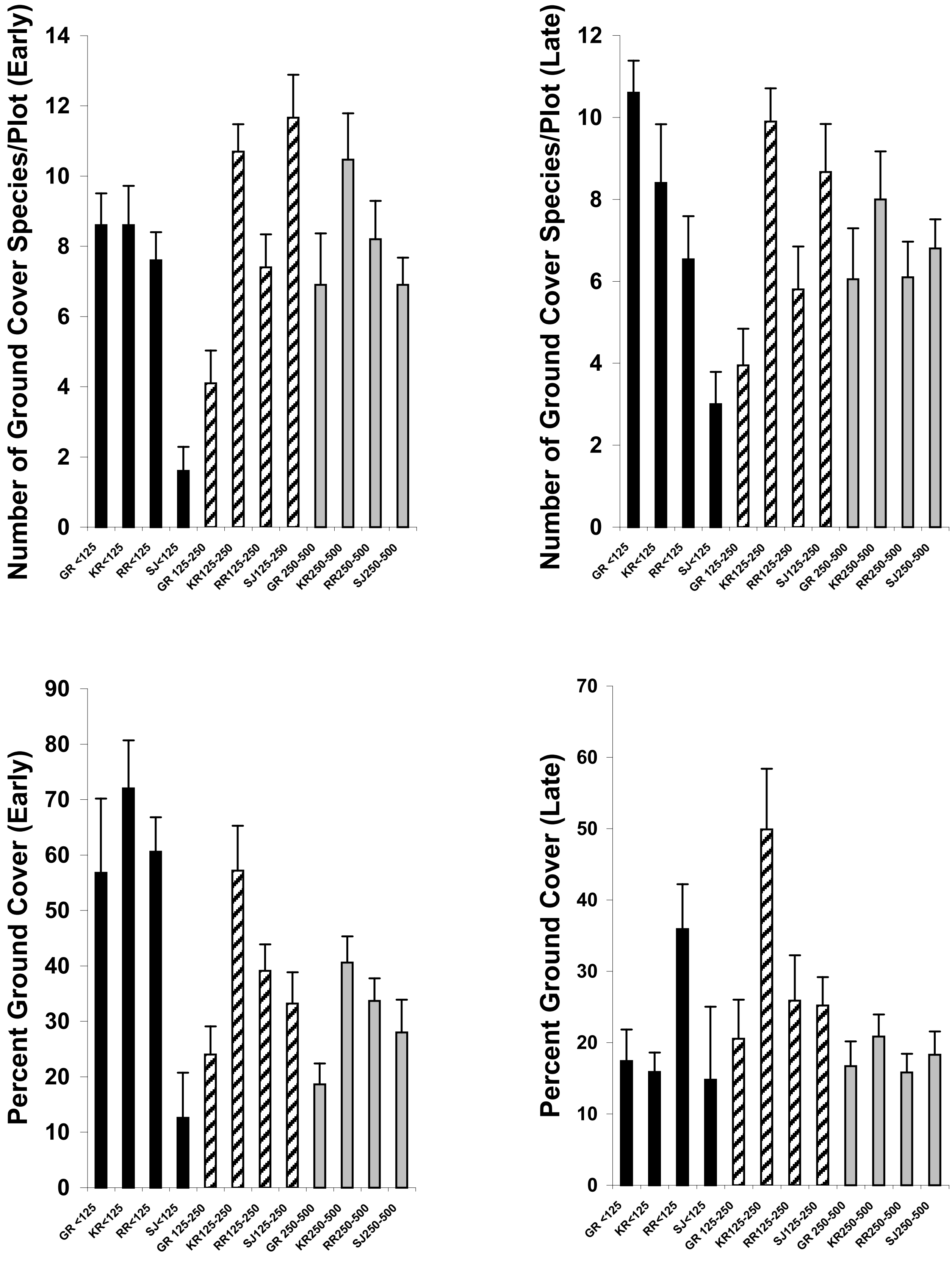


Figure 25. Summary of results from $1m^2$ ground cover plots at survey sites grouped by buffer width class (<125m black, 125-250m striped, 250-500m gray).

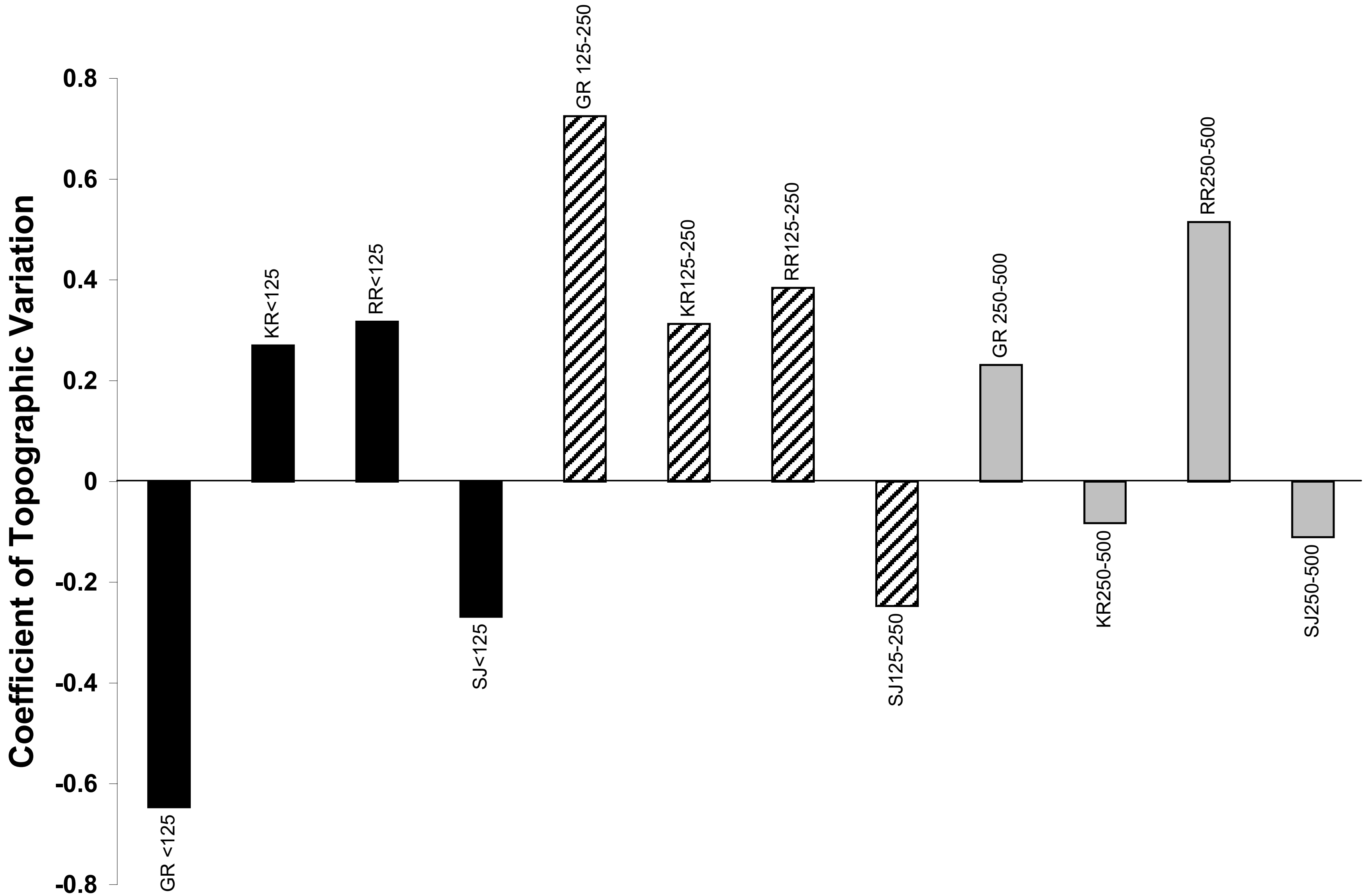


Figure 26. Coefficient of topographic variation for survey sites grouped by buffer width class (<125m black, 125-250m striped, 250-500m gray)

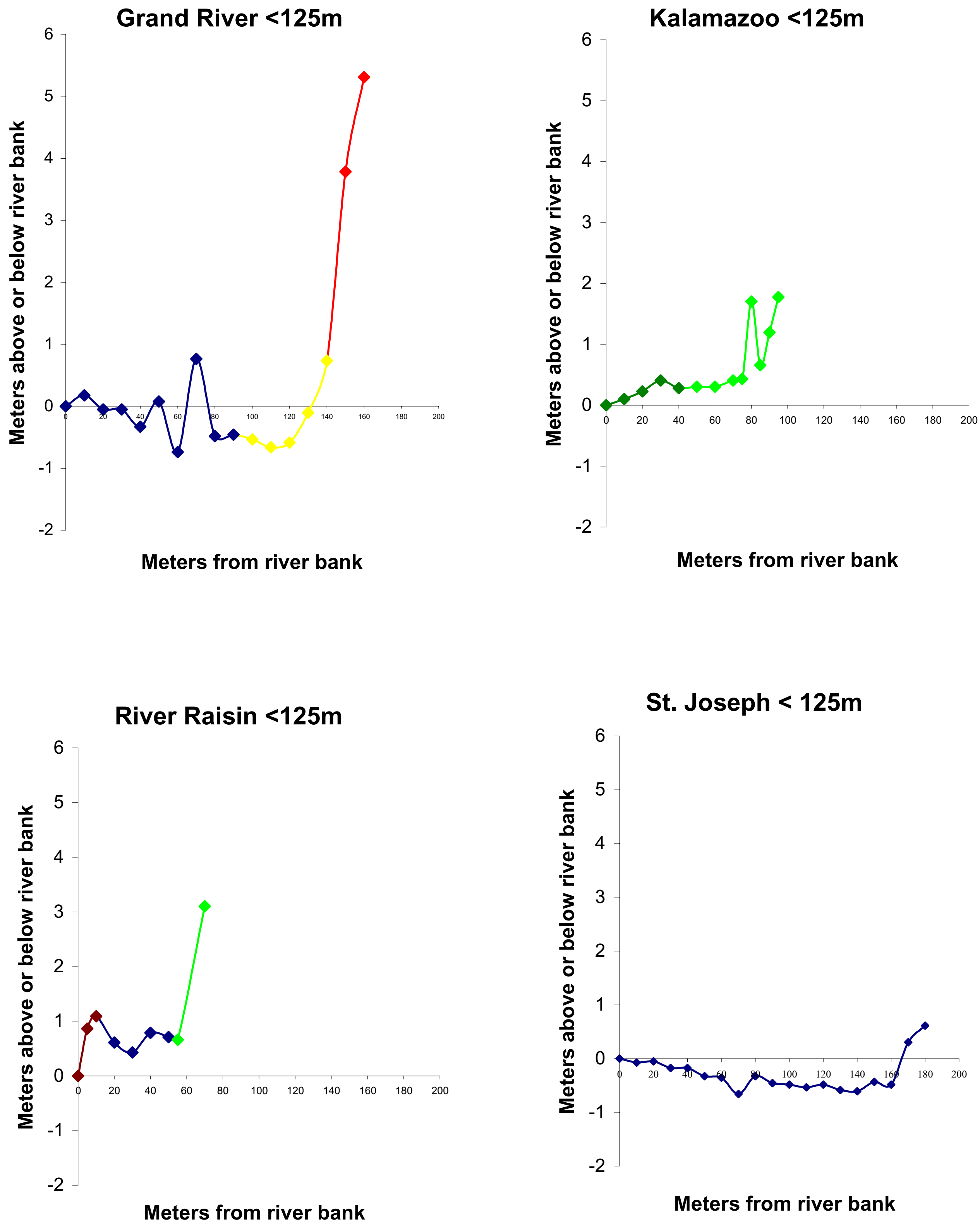


Figure 27. Topographic variation along <125m site transects with ecological zones color coded: levee (brown), 1st bottom (dark blue), shrub thicket/sedge meadow (dark green), prairie fen (yellow), upland forest (green), and oak slope (red).

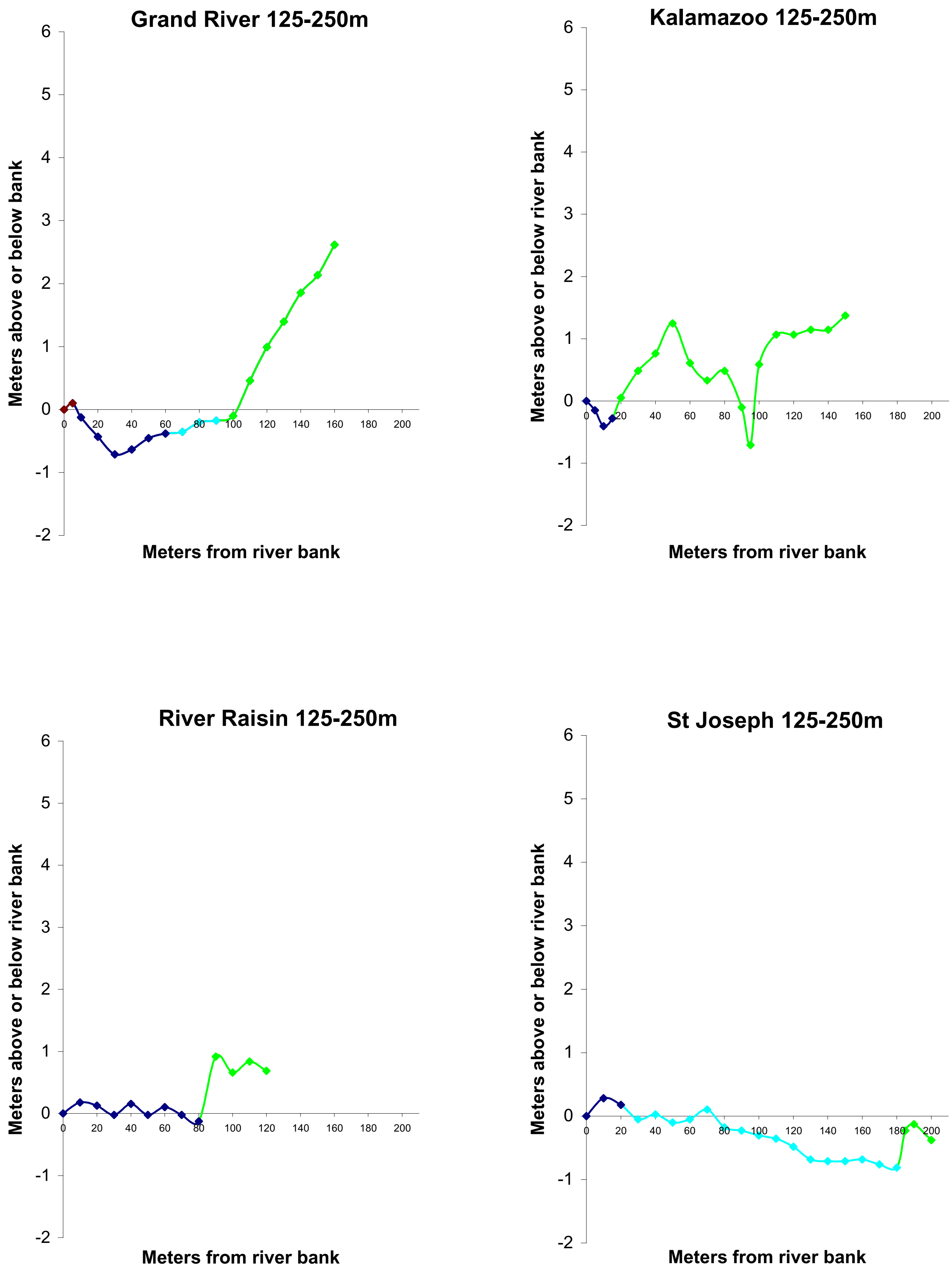


Figure 28. Topographic variation along sampling transect for 125-250m sites with ecological zones color coded: levee (brown), first bottom (dark blue), second bottom (light blue), and upland forest (green).

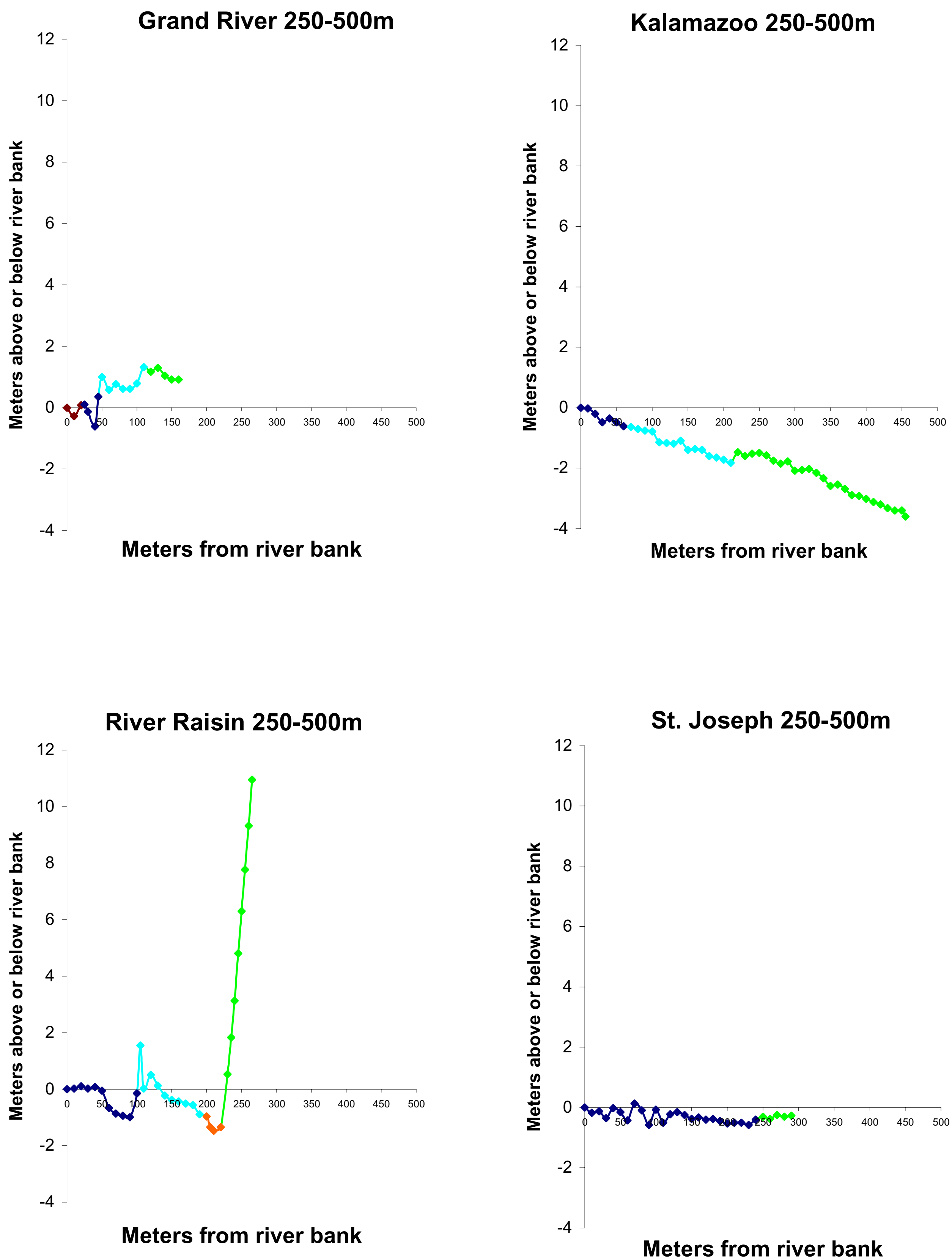


Figure 29. Topographic variation along sampling transect for 250-500m sites with ecological zones color coded: levee (brown), first bottom (dark blue), second bottom (light blue), moat (orange), and upland forest (green).

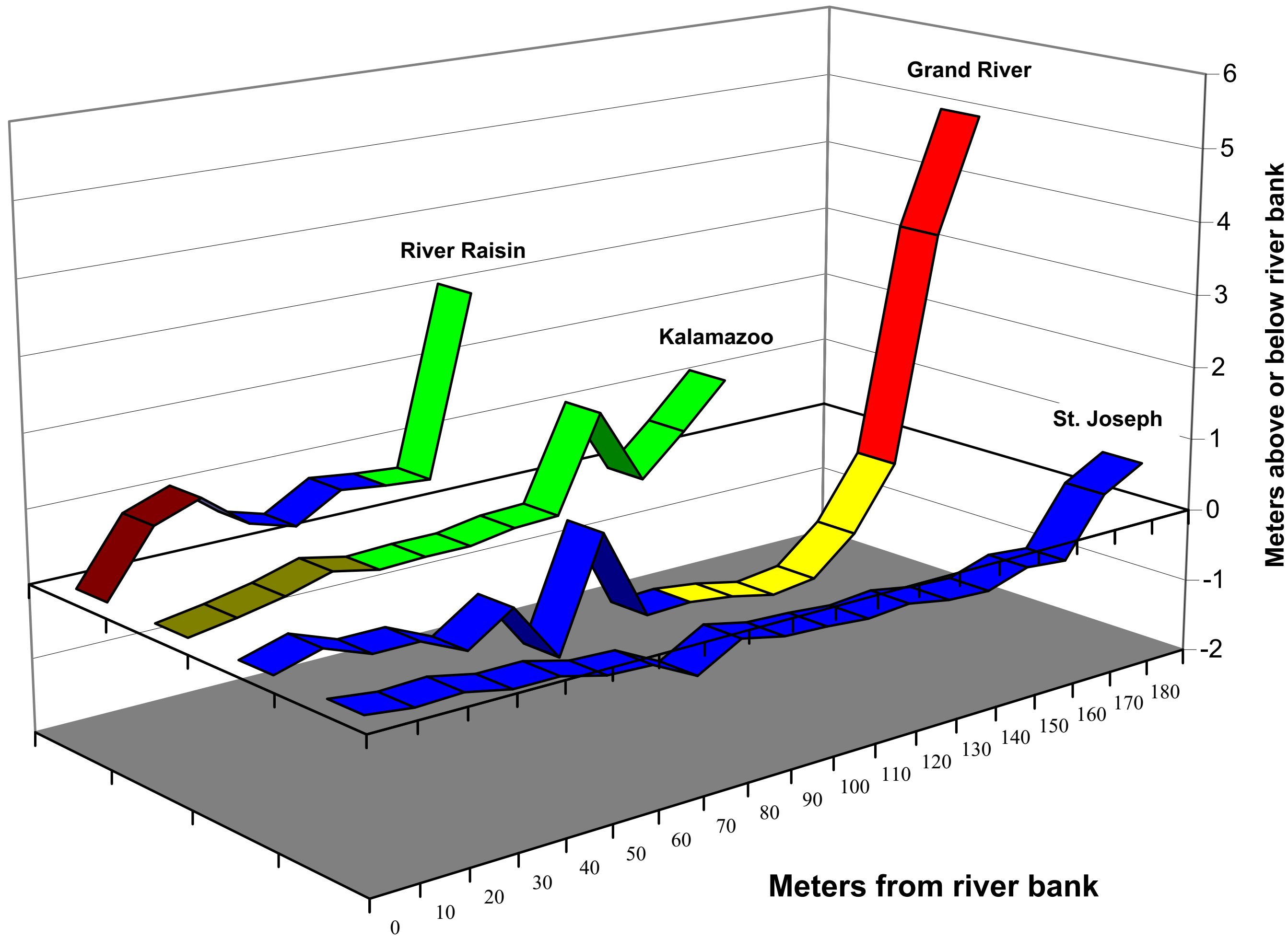


Figure 30. Topographic variation along sampling transects for <125m sites with ecological zones color coded: levee (brown), 1st bottom (blue), shrub thicket/sedge meadow (olive), prairie fen (yellow), upland forest (green) and oak slope (red).

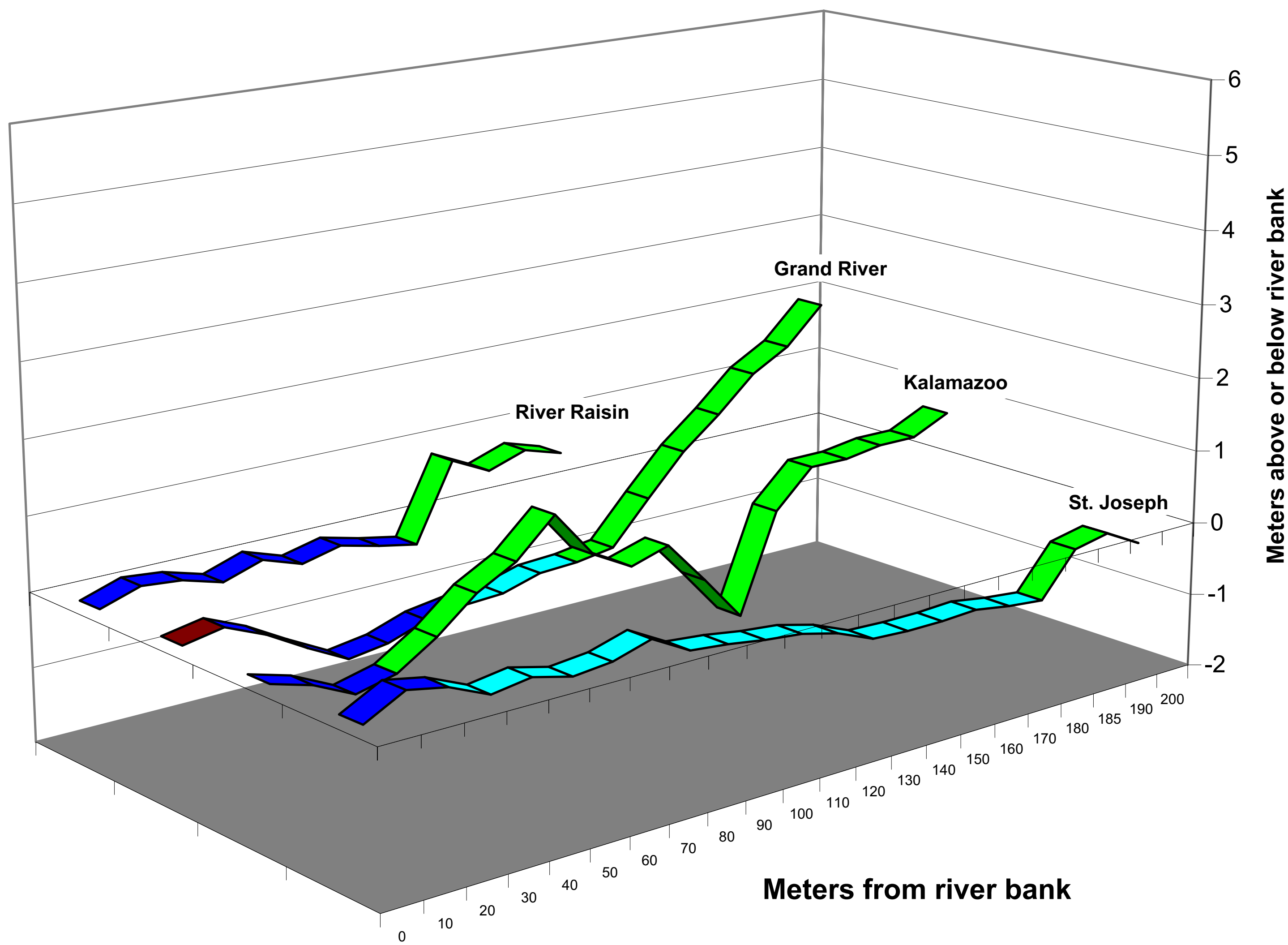


Figure 31. Topographic variation along sampling transect for 125-250m sites with ecological zones color coded as follows: levee (brown), first bottom (blue), second bottom (light blue), and upland forest (green).

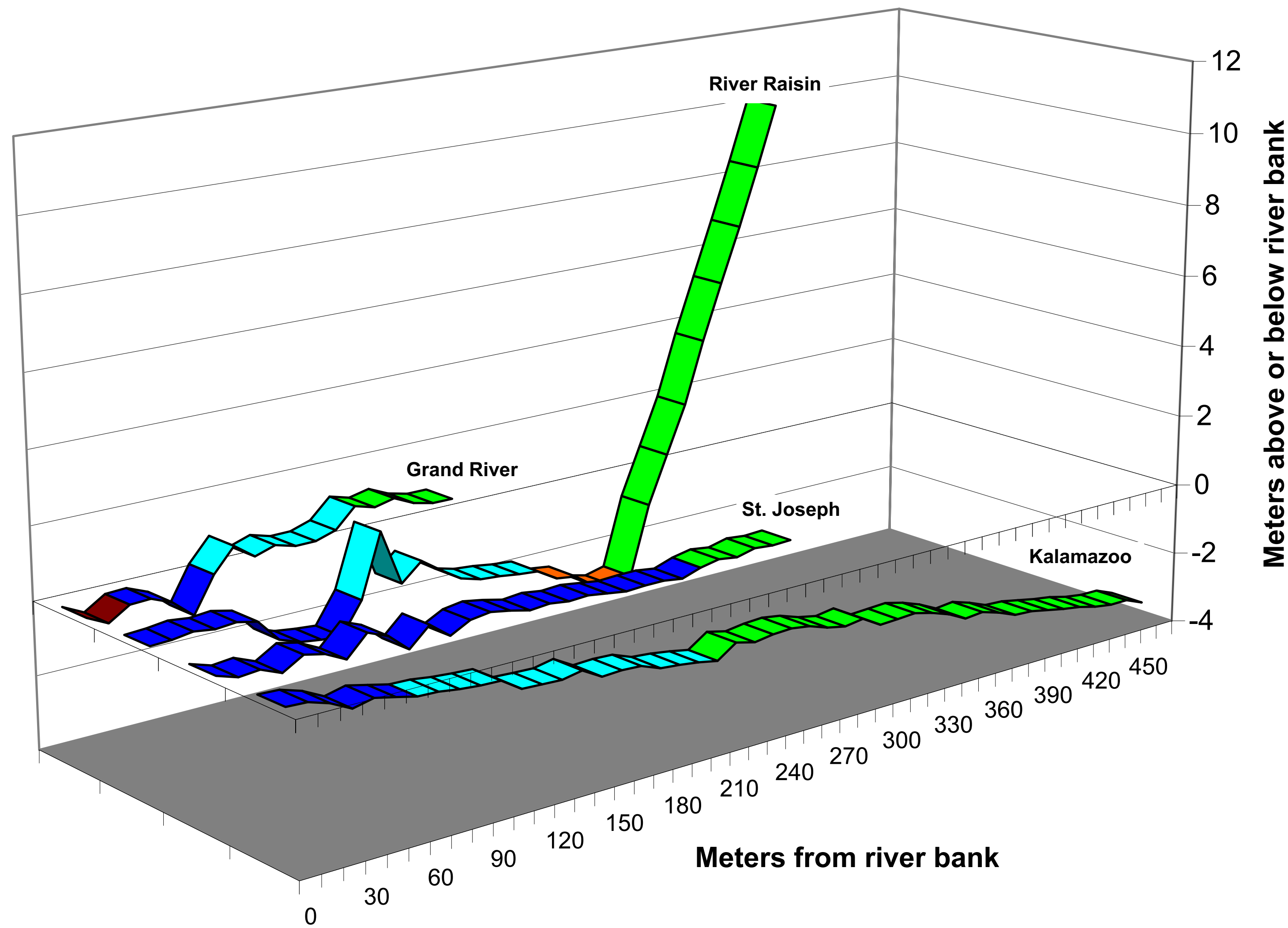


Figure 32. Topographic variation along sampling transect for 250-500m sites with ecological zones color coded as: levee (brown), first bottom (blue), second bottom (light blue), moat (orange), and upland forest (green).

to 90m, was patchily inundated in depressions during both sampling visits. The canopy of this forest was dominated by *Acer saccharinum*, *Fraxinus pennsylvanica* and *Quercus macrocarpa*. *Carpinus caroliniana* and *Fraxinus pennsylvanica* were prevalent in the understory.

The mean basal area ($\bar{x}$=58.9m^2/hectare) was low in comparison to the mean basal area for the other sites. On average, there were 3.2 tree species/10-factor prism plot and the mean DBH per plot was 38.2cm. The mean USSt ($\bar{x}$=4.2 stems/plot) was the lowest stem density across all sites and was significantly lower than the USSt measures at the KZ<125m ($\bar{x}$=63.0 stems/plot), RR<125m ($\bar{x}$=43.3 stems/plot) and SJ125-250m ($\bar{x}$=42.4 stems/plot). This site was the second most depauperate in terms of understory species richness ($\bar{x}$=1.6 species/plot) and was lower than the USSp measures at the GR250-500m ($\bar{x}$=6.7 species/plot), KZ<125m ($\bar{x}$=9.1 species/plot), KZ125-250m ($\bar{x}$=7.3 species/plot), RR<125m ($\bar{x}$=7.7 species/plot), RR250-500m ($\bar{x}$=6.7 species/plot) and SJ125-250m sites ($\bar{x}$=7.3 species/plot). The mean GCSE ($\bar{x}$=8.6 species/m^2) and GCSL ($\bar{x}$=10.6 species/m^2) were the highest observed across all sites and were significantly higher than those observed at the GR250-500m site (4.0 species/m^2).

The prairie fen zone and the oak savanna slope extended along the transect from 90 to 140m and from 140 to 160m, respectively (Photos 5 and 6). The prairie fen was characterized by many herbaceous and shrub species, notably sedges and willows. Based on its high floristic diversity and low level of disturbance, this prairie fen was classified as a new element occurrence in MNFI's BioTICs statewide database. The canopy of the oak savanna slope was dominated by scattered *Quercus alba*, *Quercus velutina* and *Carya cordiformis*. The herbaceous layer included prairie species, invasive weeds and exotic species. Including all ecological zones, the total number of species identified at this site was 193, the highest of all 12 sites. The high species richness of this site can be attributed to the diversity of shrub and herbaceous species in the prairie fen and the diversity of adventive species on the oak savanna slope.

Floristic sampling. The total number of species identified was 87, exclusive of the adjoining prairie fen and upland oak savanna slope. Of the 87 vascular plant species identified, only four (4.6%) were non-native taxa (Figure 14 and Table 18). With the inclusion of the adjacent prairie fen and oak savanna slope, the total number of species was 193, including 30 non-native species. As noted previously, only those species recorded up to the edge of the forest buffer were used for comparative analyses. The 87 species noted is the second lowest for this buffer category. The FQI score for this site (36.5) ranked it ninth among all sites surveyed and second within its buffer class (Figure 15). The $\bar{C}$, however, was 3.9, the second highest for all sites surveyed, indicating an inherent high quality (Figure 15 and Table 18). Interestingly, when the FQI score is calculated with the inclusion of the prairie fen and oak savanna zones (50.7 total score) it nearly ties as the highest ranked site in our study. The mean wetland coefficient of –2.0, classifying the vegetation as "facultative wetland (-)," categorized this site as the wettest. This is consistent with its unique landscape setting, in that the forest edge occurred well within the river terrace and not at an abrupt upland boundary as was characteristic of nearly all other sampling sites.

One rare species, *Carex trichocarpa* (hairy-fruited sedge), was documented during floristic and vegetation sampling. This state-listed as special concern species is currently known from only 16 localities in southern Lower Michigan; of these sites, only six records have been documented within the last 20 years. Typical habitats include low deciduous woods, riverbanks, floodplain marshes and wet ditches (Voss 1972). Within the study site, it formed a localized colony at the forest periphery along the sampling transect and likely occurred more broadly along the forest-prairie fen transition zone.

Only four non-native species were identified within the study site, the lowest documented overall (Figure 15 and Table 18). However, three of the four are known to be highly invasive species with the potential to seriously degrade this site. These consisted of *Alliaria petiolata* (garlic mustard), *Rosa multiflora* (multiflora rose), and *Lysimachia nummularia* (moneywort). Garlic mustard, which we observed to be established in the groundcover, is well known as a rapidly invading species in forest habitats of southern Lower Michigan, and can be highly competitive in floodplain communities. The range of this species has been expanding rapidly in southern Lower Michigan, and it is likely that this highly invasive, pernicious species is the most recent arrival of the three invasives noted here. We found multiflora rose and moneywort to be well established in the shrub layer and groundcover, respectively, although neither of these species has the inherent potential to invade like garlic mustard, which can form a monoculture in the ground layer.

Vegetation and Floristic Results: GR125-250m

Vegetation and ecological sampling. Four distinct ecological zones were identified within the forested buffer, including levee (0-9m), first "inundated" bottom (10-63m), second "sloping" bottom (63-89m) and upland forest (89-156m). Figures 28 and 31 depict height above or below the riverbank graphed on distance along the base transect (156m total length). The CTV was 0.73, the highest value across all sites, indicating that there was a high degree of microtopography along the sampling transect (Figure 26). The levee, a distinct sediment deposit rise adjacent to the river, was dominated by *Laportea canadensis* in the ground layer and *Acer saccharinum* in the overstory and understory. *Ulmus americana* and *Fraxinus pennsylvanica* were also prevalent in the understory and overstory. At the time of early season sampling, the levee was sharply distinguished from the adjacent first bottom, which was inundated by water ranging up to 0.5 meters in depth (Photo 7). Due to seasonal flooding, the groundcover throughout this zone was sparsely vegetated (Photo 8). Only *Boehmeria cylindrica* was recorded in the 1m^2 plots, although *Saururus cernuus* and *Solanum dulcamara* were scattered throughout. *Acer saccharinum* saplings and *Cephalanthus occidentalis* dominated the understory while *Acer saccharinum* and *Fraxinus pennsylvanica* were canopy dominants. In contrast to the first bottom, the second bottom, which sloped gently, was not inundated. Characteristic herbaceous species recorded were *Laportea canadensis, Boehmeria cylindrica* and *Lysimachia nummularia*, the latter an invasive exotic. Species occurring frequently in the understory layer included *Ulmus americana*, *Crataegus* sp., *Fraxinus pennsylvanica* and *Acer saccharinum*. Dominant overstory species were *Fraxinus pennsylvanica*, *Quercus bicolor* and *Ulmus americana*. Several tree species were prominent in the fourth (upland) zone, a heavily degraded rich mesic forest. Canopy dominants included *Fraxinus americana*, *Quercus rubra*, *Carya cordiformis* and *Prunus serotina*. Prevalent understory species were *Carya cordiformis, Prunus serotina* and *Crataegus* spp. Numerous groundcover species were common (e.g., *Parthenocissus quinquefolia*, *Galium aparine*, *Viola sororia* and the invasive exotic *Alliaria petiolaria*).

Mean basal area was 82.1m^2/hectare, and there were 2.8 tree species ($\bar{x}$) per 10-factor prism plot, significantly fewer than the RR250-500m (5.0 tree species/plot) and SJ125-250m (4.7 tree species/plot) sites. The mean DBH ($\bar{x}$=28.4cm) was low in comparison to other sites and was significantly lower than DBH at the RR<125m ($\bar{x}$=44.0cm), RR125-250m ($\bar{x}$=49.1cm), SJ<125m ($\bar{x}$=45.1cm), SJ125-250m ($\bar{x}$=39.3cm) and SJ250-500m sites ($\bar{x}$=51.6cm). The mean USSt ($\bar{x}$=6.0 stems/p/plot) was the third lowest stem density across all sites and was significantly lower than USSt measures at GR250-500m ($\bar{x}$=36.1 stems/plot), KZ<125m ($\bar{x}$=63.0 stems/plot) and SJ125-250m ($\bar{x}$=42.4 stems/plot). This site was the third most depauperate in terms of USSp ($\bar{x}$=2.2 species/plot) and was significantly lower than the GR250-500m ($\bar{x}$=6.7 species/plot), KZ<125m ($\bar{x}$=9.1 species/plot, K125-250m ($\bar{x}$=7.3 species/plot), RR<125m ($\bar{x}$=7.7 species/plot), RR250-500m ($\bar{x}$=6.7 species/plot) and SJ125-250m sites ($\bar{x}$=7.3 species/plot). The mean GCSE ($\bar{x}$=4.1 species/m^2) and GCSL ($\bar{x}$=4.0 species/m^2) were both the second lowest among all sites. The mean GCSE for this site was lower than GCSE at the KZ125-250m ($\bar{x}$=10.7 species/m^2), KZ250-500m ($\bar{x}$=10.5 species/m^2) and SJ125-250m sites ($\bar{x}$=11.7 species/m^2). The mean GCSL was lower than GCSL at the GR<125m ($\bar{x}$=10.6 species/m^2), KZ125-250m ($\bar{x}$=9.9 species/m^2), and SJ125-250m ($\bar{x}$=8.6 species/m^2) sites.

Despite the moderate floristic richness of this site (see below) and the high degree of degradation of the upland forest, the heterogeneous plant community zonation and large size of the floodplain forest justified its classification as a new southern floodplain forest element occurrence in the MNFI BioTICs database.

Floristic sampling. The total number of species identified was 90, including 10 (11.1%) non-native taxa. This was the lowest species richness measured for this riparian forest buffer width class (Figure 14 and Table 18). The FQI score for this site (33.3) ranked it eleventh among all sites surveyed and lowest within its buffer class (Figure 15 and Table 18). The $\bar{C}$ was 3.5 (Figure 15 and Table 18), and the mean wetland coefficient was –0.5, ranking the vegetation of the site as "facultative (+)." No rare plant species were identified during vegetation and floristic surveys of this study site.

Of the 10 exotic taxa identified in this site, the most notable invasives were *Alliaria petiolata* (garlic mustard), *Lysimachia nummularia* (moneywort), *Rosa multiflora* (multiflora *rose*), *Rhamnus cathartica* (common buckthorn) and *Solanum dulcamara* (bittersweet nightshade). Garlic mustard was well established and represents the strongest potential threat to this site; moneywort was also well established and common throughout. Multiflora rose occurred primarily in the upper zones or bottoms of the site in shrubby thickets, as did common buckthorn, whereas we found bittersweet nightshade to be scattered throughout. The greatest threat to this site is the presence of garlic mustard, which has the ability to proliferate rapidly in the ground layer and outcompete much of the native vegetation.

Photo 5. Prairie fen zone with floodplain forest in the background (GR<125m site).

Photo 6. Prairie fen zone with oak savanna slope in the background (GR<125m site).

Photo 7. Sharp distinction between vegetated levee (foreground) and the inundated bottom (background) at the GR125-250m site.

Photo 8. Inundated bottom with channel and levee in the background (GR125-250m site).

Vegetation and Floristic Results: GR 250-500m

Vegetation and ecological sampling. Four distinct ecological zones were identified within the GR250-500m site. Levee (0-23m), first "inundated" bottom (23-45m), second "sloping" bottom (45-110m) and upland forest/shrub thicket (110-160m) were identified as distinct ecological zones within this site's moderately logged forest buffer. CTV (0.23) was the third lowest CTV value observed, indicating that there was a comparatively low degree of topographic variability from sample point to sample point along the transect (Figure 26). Figures 29 and 32 depict height above or below the riverbank graphed on distance along the base transect, which was 160m in total length. The levee, a subtle sediment deposit rise adjacent to the river, had been heavily logged in the past. The groundcover was characterized by *Fraxinus pennsylvanica, Parthenocissus quinquefolia, Sanicula gregaria, Thalictrum dasycarpum* and *Viola sororia*. *Zanthoxylum americanum* occurred in thick brambles in the understory. Other prevalent elements of the understory were *Staphylea triloba, Carpinus caroliniana, Lindera benzoin, Crataegus* spp., saplings of *Carya cordiformis* and *Fraxinus pennsylvanica,* and the vine *Vitis riparia*. The canopy dominant in the levee was *Quercus macrocarpa*, with *Prunus serotina, Fraxinus pennsylvanica* and *Acer saccharinum* of secondary importance. At the time of early season sampling, the levee was distinguished from the adjacent first bottom, which was inundated by water up to 30cm deep. The groundcover throughout this zone was sparsely vegetated in response to seasonal flooding. No plants were observed in the early season groundcover plots, and only *Fraxinus pennsylvanica* seedlings were recorded in the late season sampling. In the second bottom, *Acer saccharinum* saplings were dense and widespread. *Fraxinus pennsylvanica* and *Ulmus americana* saplings and vines of *Vitis riparia* and *Toxicodendron radicans* were also prevalent in the understory. Canopy dominants included *Acer saccharinum*, *Fraxinus pennsylvanic* and *Quercus bicolor*.

In contrast to the first bottom, the second bottom, which was gently sloping, was patchily inundated at the time of sampling. Numerous herbaceous species were characteristic (e.g., *Viola sororia, Thalictrum dioicum, Symplocarpus foetidus, Galium aparine, Cicuta maculata, Solidago gigantea, Impatiens biflora, Geum canadensis, Laportea canadensis* and *Cicuta maculata*). Species occurring frequently in the understory layer included *Corylus americana, Ulmus americana, Fraxinus pennsylvanica*, *Acer saccharinum, Cornus amom* and *Quercus bicolor.* Dominant overstory species were *Acer saccharinum, Fraxinus pennsylvanica*, *Populus deltoides* and *Ulmus americana*. Several tree species were prominent in the fourth zone (upland), a heavily degraded forest/shrub thicket which contained a disturbed opening adjacent to Tompkins Road. Canopy dominants included *Acer rubrum, Quercus rubra, Fraxinus americana*, *Quercus velutina*, *Populus tremuloides* and *Ulmus americana*. *Prunus serotina, Acer rubrum*, *Corylus americana, Crataegus* spp. and *Malus coronaria* were prevalent in the understory. Numerous groundcover species were locally common (e.g., *Rubus hispidus, Rubus flagellaris, Rubus allegheniensis, Symplocarpus foetidus, Potentilla simplex* and *Acer rubrum* and *Fraxinus americana* seedlings).

This site's mean basal area was 77.2 m^2/hectare and the mean TSP was 3.8 species/plot. The mean DBH ($\bar{x}$=30.3cm) was low in comparison to other sites and was significantly lower than DBH at the KZ250-500m ($\bar{x}$=26.6cm), RR<125m ($\bar{x}$=44.0cm) and SJ250-500m sites ($\bar{x}$=51.8cm). The mean USSt ($\bar{x}$=36.1 stems/plot) was the highest stem density across all GR sites and was significantly higher than the USSt at the GR125-250m site ($\bar{x}$=6.0 stems/plot) and lower than the USSt at the KZ<125m site ($\bar{x}$=63.0 stems/plot). The mean USSp ($\bar{x}$=6.7 species/plot) was also the highest across the GR sites and was significantly higher than the USSp at the GR<125m ($\bar{x}$=1.6 species/plot), GR125-250m ($\bar{x}$=2.2 species/plot) and SJ<125m ($\bar{x}$=1.4 species/plot) sites. The mean GCSE ($\bar{x}$=6.9 species/m^2) and mean GCSL ($\bar{x}$=6.1 species/m^2) were different from only one other site (SJ125-250m GCSE, $\bar{x}$=11.7 species/m^2). Mean %GCE ($\bar{x}$=18.7%) was the second lowest mean observed across sites.

Based on the high floristic diversity (see below), microhabitat diversity, heterogeneous plant community zonation, large size and presence of two rare species (see below), the floodplain forest was classified as a new southern floodplain forest element occurrence in MNFI's BioTICs database.

Floristic results. The total number of species identified was 161, including 10 (6.2%) non-native taxa (Figure 14 and Table 18). This was the most diverse site we sampled within the GR watershed, and the 161 species observed placed it third among all sampling sites in the study. The FQI score was 49.6, the second highest recorded for all sampling sites and second highest in its riparian forest buffer width class. The $\bar{C}$ was 3.9, the second highest calculated among all sites (Figure15 and Table 18). The mean wetland coefficient was -0.4, classifying the vegetation of the site as "facultative." The high quality of this site is corroborated in part by documentation of the presence of two rare plant taxa, the most found within any of our sampling areas. The two rare species documented at this site were the state-listed as threatened *Morus rubra* (red mulberry) and the state-listed as special concern *Carex squarrosa* (sedge). A single individual of red mulberry was discovered adjacent to the opening by a nearby pipeline project, representing one of the few recently documented occurrences recorded in the MNFI statewide database. There are only 17 known occurrences of red mulberry in Michigan, all occurring in the southern Lower Peninsula. Nine of these records were recorded prior to 1950. This new locality represents one of only four records documented within the last 20 years. Red mulberry reaches its northern range limit in southern Lower Michigan, where it appears to be highly restricted to river floodplains. The rarity of this species in Michigan may also be due to the fact that it is a dioecious tree (i.e., comprised of individuals that produce either male or female flowers but not both), possibly explaining the extreme patchiness of populations. For most recently documented records, usually only a single individual was noted. *Carex squarrosa* is rare sedge of lowland forests, swamps, and thickets (Voss 1972). Nearly all of the 14 known occurrences are clustered in southeastern Lower Michigan, with the exception of two southwestern Michigan sites (including the locality documented during this inventory) and an anomalous location on the Keweenaw Peninsula in western Upper Michigan. Only six occurrences have been documented within the last 20 years, while half of all the known state occurrences were collected prior to 1924, including three pre-1900 records. This record is thus particularly notable.

The 10 non-native species represented a relatively small percentage of the total number of species at this site. Among the more serious invasives were *Alliaria petiolata* (garlic mustard), *Lysimachia nummularia* (moneywort), *Rosa multiflora* (multiflora rose), *Lonicera tatarica* (tatarian honeysuckle) and *Elaeagnus umbellata* (autumn olive). Garlic mustard occurred throughout the floodplain, with the remaining species, especially the shrubs, occurring principally in the thicket areas along the upland transition zones. *Myosotis scirpoides* (forget-me-not), a garden escapee that may be common in floodplain forests, was observed, but only in very localized patches near the riverbank.

Vegetation and Floristic Results: KZ<125m

Vegetation and ecological sampling. Two very distinct ecological zones were identified at this site: a shrubby thicket interspersed with mucky sedge meadow openings and a heavily disturbed upland of dry mesic to mesic forest. The total length of the base transect was 93m. Figures 27 and 30 show height above or below the riverbank graphed on distance along the base transect. The CTV (0.27) indicated a comparatively low degree of topographic variability from sample point to sample point along the transect (Figure 26). The shrub thicket/sedge meadow zone, which spanned from the riverbank to 37m, was predominantly a tangle of shrubs and vines with sparse tree cover and pockets of open, floristically diverse sedge meadow and mucky, skunk cabbage springs (Photo 9). Herbaceous species prevalent in the forb-dominated open areas included *Carex stricta, Symplocarpus foetidus, Asarum canadense, Stellaria longifolia, Impatiens capensis, Eupatorium maculatu* and *Angelica atropurpurea*. The diverse and dense shrub thicket was comprised of *Alnus rugosa* (which was locally dominant), *Cornus stolonifera, Viburnum opulus, Physocarpus opulifolius, Cornus amomum, Rubus allegheniensis, Vitis riparia* and *Corylus americana*. Dominant species comprising the scattered canopy included *Tilia americana, Fraxinus pennsylvanica, Acer rubru* and *Acer saccharinum*. The second zone, a degraded dry mesic to mesic upland forest, spanned the transect from 37 to 93m (Photo 10). This site has an old railroad grade passing through the highly disturbed forest and was bordered by an agricultural field planted with soybean. A significant portion of the groundcover was occupied by the invasive exotics *Alliaria petiolata* and *Rosa multiflora,* the latter a shrub that was also dominant in the understory layer (54 stems of *Rosa multiflora* were documented in one understory plot). In one ground cover plot, *Alliaria petiolata* covered more than 80% of the $1m^2$ area sampled. Additional species common in the groundcover plots included *Galium aparine*, *Rubus occidentalis*, *Prunus virginiana, Fraxinus american* and *Prunus serotina* seedlings. In addition to *Rosa multiflora*, characteristic species of the understory layer were *Prunus serotina, Fraxinus americana, Prunus virginian* and *Viburnum lentago*. The overstory was predominantly composed of *Quercus macrocarpa, Tilia americana, Prunus serotina, Fraxinus americana* and *Sassafras albidum.*

The site's mean basal area ($\bar{x}$=48.9 m^2/hectare) was the lowest recorded among sites and was significantly lower than the basal area of the SJ250-500m site ($\bar{x}$=103.9 m^2/hectare). The mean TSP ($\bar{x}$=2.5 species/plot) was the lowest for all sites and the mean DBH ($\bar{x}$=31.9 cm) was significantly lower than DBH measures at the RR125-250m ($\bar{x}$=49.1cm) and SJ250-500m ($\bar{x}$=51.6cm) sites. The mean USSt ($\bar{x}$=63.0 stems/plot) was the highest stem density across all sites and was significantly higher than USSt at the GR<125m ($\bar{x}$=4.20 stems/plot), GR125-250m ($\bar{x}$=6.0 stems/plot), GR250-500m ($\bar{x}$=36.1 stems/plot), KZ125-250m ($\bar{x}$=21.2),

Photo 9. The shrub thicket/sedge meadow zone of KZ<125m was predominantly a tangle of shrubs and vines with sparse tree cover and pockets of open, floristically diverse sedge meadow and mucky, skunk cabbage springs.

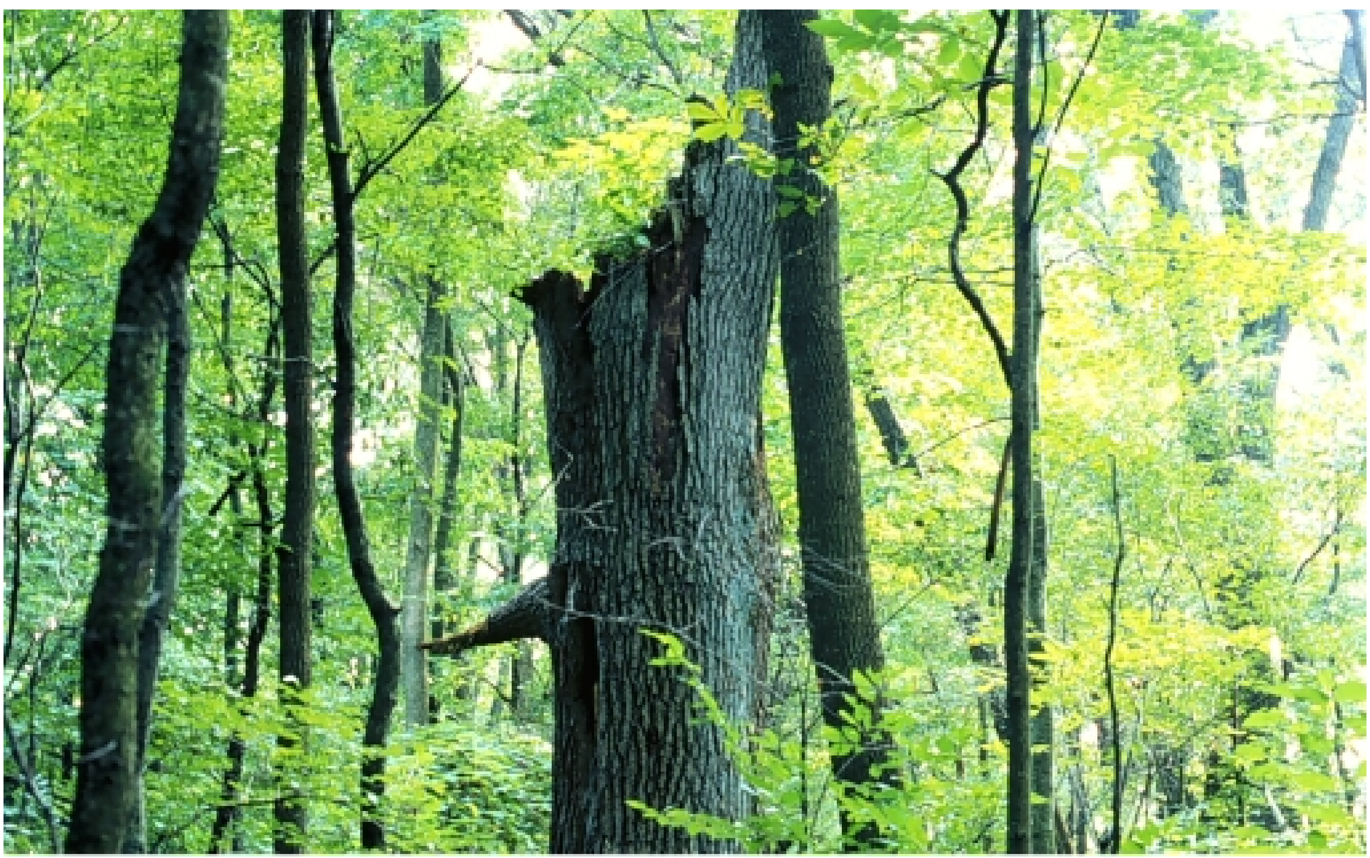


Photo 10. The second zone of the KZ<125m site, a degraded dry mesic to mesic upland forest.

KZ250-500m ($\bar{x}$=25.2 stems/plot), RR125-250m ($\bar{x}$=25.4 stems/plot), RR250-500m ($\bar{x}$=27 stems/plot), SJ<125m ($\bar{x}$=5.6 stems/plot) and SJ125-250m sites ($\bar{x}$=26.5 stems/plot). The mean USSp ($\bar{x}$=49.1species/plot) was also the highest in comparison to the other sites and was significantly higher than USSp at the GR<125m ($\bar{x}$=1.6 species/plot), GR125-250m ($\bar{x}$=2.2 species/plot) and SJ<125m sites ($\bar{x}$=1.4 species/plot). The mean number of species in the $1m^2$ groundcover plots in the early and late survey sampling were 8.6 and 8.4 species/m^2, respectively. Mean %GCE was 72.0%, the highest observed %GCE observed across all sites.

Floristic results. A total of 137 species were identified at this site, including 13 (9.5 %) non-native species (Figure 14 and Table 18). This total was by far the highest for this buffer category type, as well as one of the highest recorded during the study. The high diversity was, in part, reflected in the FQI score (40.5), ranking this site fifth among all sites sampled (Figure 15 and Table 18). However, the $\bar{C}$ (3.5) was the second lowest observed for all sites (Figure 15 and Table 18). With regard to wetland status, the mean coefficient was –1.1, classifying the vegetation of the site as "facultative (+)."

The vegetation zone structure and properties helped to explain the apparent disparity between the relatively high FQI score and low $\bar{C}$. As previously described, there were two distinct ecological zones, the first consisting of diverse alder thickets and pocketed sedge meadow underlain by well-developed muck soils with numerous alkaline springs and seeps. The first zone provided much of the floristic diversity of the site, whereas the second zone consisted of a highly disturbed, weedy, early successional forest community. Thus, an overall, relatively high floristic diversity with a component of conservative native species (e.g., *Symplocarpus foetidus, Saxifraga pensylvanica, Carex praire* and *Glyceria canadensis*) resulted in a relatively high FQI score. Although the FQI was comparatively high, the average $\bar{C}$ was quite low, providing a good reflection of the overall diminished site quality due to the very disturbed upland forest with a high complement of exotics forming the outer zone.

No rare plant species were identified during vegetation and floristic surveys of this study site. However, one relatively uncommon species, *Quercus imbricaria* (shingle oak), was identified, comprising one of the two sites this tree was documented during surveys. Shingle oak is a southern tree species that reaches the northern edge of its range in southern Lower Michigan where it is known only from eight counties.

Several exotic species were recorded at this site, primarily due to the highly disturbed second ecological zone. The 13 species noted comprised the second highest total in the study. The most notable invasives were *Alliaria petiolata* (garlic mustard), *Rosa multiflora* (multiflora rose), *Rhamnus frangula* (glossy-leaved buckthorn), *Lonicera morrowii* (Morrow's honeysuckle) and *Lythrum salicaria* (purple loosestrife).

Vegetation and Floristic Results: KZ125-250m

Vegetation and ecological sampling. Two very distinct ecological zones were identified at this site: a first bottom and a second (upland) bottom. The total length of the base transect was 150m. Figures 28 and 31 depict height above or below the riverbank graphed on distance along the base transect. The CTV (0.31) indicated a moderate degree of topographic variability among sampling points (Figure 26). The first bottom was a very narrow zone ranging from the riverbank to 16m along the transect. The overstory was sparse throughout this zone and there were small, pocketed areas of open sedge meadow. The following species of small to medium sized diameter trees (mean DBH=4cm) were thinly distributed in the overstory: *Tilia americana, Quercus bicolor, Fraxinus pennsylvanica* and *Populus deltoides*. Prevalent herbaceous species included: *Lysimachia nummularia* (a locally dominant invasive exotic), *Symplocarpus foetidus, Elymus virginicus, Laportea canadensis, Boehmeria cylindrica, Aster lateriflorus* and *Thalictrum dasycarpum*. The understory was characterized by the following shrubs, vines and saplings: *Physocarpus opulifolius, Rosa multiflora* (invasive exotic), *Fraxinus nigra, Acer negundo, Fraxinus pennsylvanica, Viburnum lentago, Toxicodendron radicans*, *Vitis riparia* and *Corylus americana*. The second zone, which spanned along the transect from 16 to 150m, was a gently sloping, second bottom/upland bottom that was intersected by a man-made drainage ditch (occurring from 90-100m along the base transect). Species common in the groundcover plots included *Geum canadense, Fraxinus pennsylvanica, Fraxinus americana, Viola sororia, Parthenocissus quinquefolia, Rubus allegheniensis, Vitis riparia, Toxicodendron radicans* and *Rosa multiflora* (invasive exotic). Numerous species were common in the understory (e.g., *Ulmus americana, Prunus virginiana, Fraxinus pennsylvanica, Carya cordiformis, Zanthoxylum americanum* and *Prunus serotina*). The overstory was composed predominantly of *Prunus serotina, Fraxinus pennsylvanica, Tilia americana, Populus deltoides, Ulmus americana* and *Catalpa speciosa,* the latter occurring in a small mono-species grove.

The site's mean basal area ($\bar{x}$=64.8m²/hectare) was the third lowest observed, and the average DBH ($\bar{x}$=26.5 cm) was the lowest across all sites, significantly lower than DBH at the RR<125m ($\bar{x}$=44.0cm), RR125-250m ($\bar{x}$=49.1cm), SJ<125m ($\bar{x}$=45.1cm) and SJ250-500m ($\bar{x}$=51.8cm) sites. There were $\bar{x}$=3.4 tree species/10-factor prism plot. The mean USSt ($\bar{x}$=21.2 stems/plot) was significantly lower than the KZ<125m USSt ($\bar{x}$=63.0 stems/plot), and the mean USSp ($\bar{x}$=7.3 species/plot) was significantly higher than USSp at the GR<125m ($\bar{x}$=1.6 species/plot), GR125-250m ($\bar{x}$=2.2 species/ plot) and SJ<125m sites ($\bar{x}$=1.4 species/plot). The site's mean GCSE ($\bar{x}$=10.7 species/m^2) and GCSL ($\bar{x}$=9.9 species/m^2) were significantly higher than the GCSE and GCSL at the GR125-250m ($\bar{x}$=4.1 species/ m^2 and $\bar{x}$=4.0 species/m^2, respectively) and SJ<125m sites ($\bar{x}$=1.6 species/m^2 and $\bar{x}$=3.0 species/m^2, respectively). During late season sampling, The mean %GCL ($\bar{x}$=49.9%) was the highest observed across all sites.

Floristic sampling. There were 149 plant species identified at this site, including 21 (14.1%) non-native taxa (Figure 14 and Table 18). This total number of species ranked the site as the highest within its riparian forest buffer width class and fourth in over all sites. The number of non-native species was the highest recorded for all study sites. The FQI score (38.0) for this site ranked it eighth overall and third within its buffer class (Figure 15 and Table 18). However, the $\bar{C}$ was only 3.1, the lowest recorded among all sites (Figure 15 and Table 18). The relatively low FQI and $\bar{C}$ values both reflect the generally disturbed nature of this site, which was exemplified in part by the high number of non-native species recorded. The mean wetland coefficient for the site was –0.9, ranking the vegetation as "facultative (+)." No rare plant species were identified during vegetation and floristic surveys of this study site.

This site had the greatest number of exotic plant species observed among all study sites (21). The most significant invasives noted were *Alliaria petiolata* (garlic mustard), *Berberis thunbergii* (Japanese barberry), *Bromus inermus*, *Catalpa speciosa* (Northern catalpa), *Euonymus europaea*, *Hesperis matronalis* (dame's rocket), *Ligustrum vulgare* (common privet), *Lythrum salicaria* (purple loosestrife), *Lysimachia nummularia* (moneywort), *Morus alba* (white mulberry), *Prunus avium* (sweet cherry), *Rhamnus frangula* (glossy-leaved buckthorn), *Rosa multiflora* (multiflora rose) and *Viburnum opulus* var. *opulus* (European highbush cranberry). These species indicate a high level of disturbance within all vegetation strata, as evidenced by a particularly high number of exotic shrubs and trees in addition to such common and expected groundcover species as the ubiquitous garlic mustard, dame's rocket and moneywort.

Vegetation and Floristic Results: KZ250-500m

Vegetation and ecological sampling. Three broad ecological zones were identified at this site, including a first bottom, a second, swamp bottom, and a third, heterogeneous bottom characterized by upland vegetation on distinct rises with swamp vegetation in depressions. The total length of the base transect was 455m, the longest transect conducted in the study. This site was unique because the transect progressed along a gradual downward slope away from the river. Figures 29 and 32 depict height above or below the riverbank graphed on distance along the base transect. As indicated by the CTV (0.08), the lowest CTV value observed for the study, topographic variability among sampling points was very low (Figure 26). However, microhabitats were abundant throughout the site (e.g., rises, mounds and pond depressions) and dead and down material of diverse size and decay classes was present. In addition, the first and second bottoms were characterized by patches of sedge-dominated vegetation. The first bottom spanned along the transect from the riverbank to 61m. Prevalent herbaceous species included *Symplocarpus foetidus, Carex stricta, Glyceria striata, Onoclea sensibilis, Carex stipata* and *Phalaris arundinacea* (invasive exotic). The understory was characterized by *Lindera benzoin* and saplings of *Fraxinus nigra, Acer saccharinum and Ulmus americana*. Overstory dominants included *Acer saccharinum, Fraxinus pennsylvanica, Fraxinus nigra* and *Quercus bicolor*. The second zone, the swamp bottom, occurred along the transect from 61 to 216m and was distinguished from the first bottom by a greater density of smaller diameter trees. The canopy was dominated by *Fraxinus nigra, Quercus bicolor* and *Fraxinus pennsylvanica* with *Acer saccharinum* and *Quercus macrocarpa* of secondary importance. Numerous species were common in the understory (i.e., *Fraxinus nigra, Corylus americana, Lindera benzoin, Carpinus caroliniana, Viburnum lentago, Acer rubrum* and *Ilex verticilata).* A total of 44 species were found in the groundcover plots. Common herbaceous species were *Symplocarpus foetidus, Onoclea sensibilis, Carex bromoides, Carex gracillima* and *Senecio aureus*. The groundcover species richness in this zone was very high in comparison to the first bottom and the upland bottom. The mean GCSE ($\bar{x}$=14.8 species/m^2) and GCSL ($\bar{x}$=11.4 species/m^2) were significantly higher than mean values for the first bottom ($\bar{x}$=7.4 species/m^2 and $\bar{x}$=6.4 species/m^2, respectively) and upland bottom ($\bar{x}$=9.2 species/m^{2}and $\bar{x}$=6.2 species/m^2, respectively). The upland bottom spanned from 216 to 455m and was upland in species composition but sloped downward gradually. Species common in the groundcover plots included *Rubus occidentalis, Rubus allegheniensis, Parthenocissus quinquefolia, Podophyllum peltatum, Lindera benzoin, Carex pennsylvanic* and *Arisaema triloba. Zanthoxylum americanum* was locally dominant in the understory. Other prevalent understory species were *Lindera benzoin, Ulmus americana* and *Fraxinus americana*. The overstory of this zone was distinguished from the swamp bottom in composition and in that it contained fewer trees of larger diameter. Components of the diverse but heavily logged canopy included *Acer saccharinum, Fraxinus americana, Acer rubrum, Quercus rubra*, *Prunus serotina* and *Quercus velutina.*

The site's mean basal area was 80.8 m^2/hectare, and the mean DBH ($\bar{x}$=26.6cm) was the second lowest across all sites. DBH was significantly lower than the DBH for the RR<125m ($\bar{x}$=44.0cm), RR125-250m ($\bar{x}$=49.1cm), SJ<125m ($\bar{x}$=45.1cm), SJ125-250m ($\bar{x}$=39.3cm) and SJ250-500m sites ($\bar{x}$=51.8cm). There were $\bar{x}$=4.3 tree species/10-factor prism plot and there were $\bar{x}$=5.4 USSp/5m radius plot. The mean USSt ($\bar{x}$=25.2 stems/plot) was significantly lower than USSt at the KZ<125m site ($\bar{x}$=63.0 stems/plot). The GCSE ($\bar{x}$=10.5 species/m^2) was the third highest across all study sites and was significantly higher than GCSE at the GR125-250m ($\bar{x}$=4.1 species/m^2) and SJ<125m sites ($\bar{x}$=1.6 species/m^2). The mean GCSL for this site was $\bar{x}$=7.8 species/m^2.

Based on the site's high floristic richness (see below), microhabitat diversity, heterogeneous plant community zonation, and large size, the floodplain forest was classified as a new southern floodplain forest element occurrence in MNFI's BioTICS database.

Floristic sampling. There were 166 total plant species identified at this site, including seven (4.2%) non-native species (Figure 14 and Table 18). This floristic richness was the highest recorded during the study, and this site had the lowest percentage of exotics comprising the flora. This high plant species richness and low occurrence of invasives is reflected in the FQI score (50.8), the highest recorded in the study (Figure 15 and Table 18). The $\bar{C}$ (3.9) was the second highest among sites (Figure 15 and Table 18). Both the floristic richness and quality correlated with the high quality of the natural community, which was considered a new southern floodplain forest element occurrence. The mean wetland coefficient was –0.4, ranking the vegetation of the sites as "facultative."

No rare plant species were identified during vegetation and floristic surveys of this study site. One uncommon species was noted, *Quercus imbricaria* (shingle oak). Very few non-native species were found in this site, which was considered to be a high quality natural community. The most notable species documented were *Hesperis matronalis* (dame's rocket) and *Rosa multiflora* (multiflora rose), both of which are known to be invasive. Dame's rocket has a well-known ability to proliferate in floodplain forests. Notably absent were such species as *Alliaria petiolata* (garlic mustard) and *Lysimachia nummularia* (moneywort), as these taxa occurred at most study sites. The remaining exotic species included *Taraxacum officinale* (dandelion), *Polygonum persicaria* (smartweed) and *Barbarea vulgaris* (rocket cress), which were tallied largely due to their occurrence along a disturbed two-track road within a portion of the sampling site.

Vegetation and Floristic Results: RR<125m

Vegetation and Ecological Sampling. Three narrow, distinct ecological zones were identified at this highly disturbed site, including an artificial levee, a first bottom and an upland slope. The total length of the base transect was 70m. Figures 27 and 30 show height above or below the riverbank graphed on distance along the base transect. The CTV (0.32) indicates a moderate degree of topographic variability from sampling point to sampling point along the transect (Figure 26). The artificial levee, created by the spoils of river dredging, occurred along the transect from 0-10m and was dominated by *Acer negundo* in the overstory. Additional canopy elements were *Acer saccharinum, Fraxinus pennsylvanica, Celtis occidentalis* and *Gleditsia triacanthos.* This southernmost site of the study had the only observed occurrence of *Gleditsia triacanthos* and was one of two sites where *Cercis canadensis* was found. Dense thickets of the invasive exotics *Rosa multiflora* and *Ligustrum vulgare* occurred throughout this zone. Also prevalent in the understory were *Acer negundo* and *Fraxinus pennsylvanica* saplings and vines of *Toxicodendron radicans* and *Vitis riparia*. Common herbaceous species included *Carex grayii, Lysimachia nummularia,* (invasive exotic), *Geum canadense, Laportea canadensis, Asarum canadense*, *Solidago gigantea* and *Alliaria petiolata* (invasive exotic). The first bottom spanned from 10-52m. Compared to the levee and upland, this zone lacked shrub species in the understory layer. Large and numerous vines of *Toxicodendron radicans* and *Acer negundo, Fraxinus* *pennsylvanica* and *Celtis occidentalis* saplings dominated the understory layer. Primary components of the scattered canopy were *Gleditsia triacanthos* and *Fraxinus pennsylvanica* with *Acer negundo, Tilia americana* and *Ulmus americana* of secondary importance. In addition to historic harvesting along the mesic upland slope, this site has been degraded by the creation of an artificial drainage that extends from the adjacent cornfield through the upland edge to the first bottom. The narrow upland zone spanned from 52-70m and occurred on a very steep slope. Components of the canopy included *Gleditsia triacanthos*, *Ulmus americana*, *Tilia americana* and *Fraxinus americana. Rosa multiflora*, *Rubus occidentalis* and *Rubus allegheniensis* were locally dominant in the understory. Numerous groundcover species were common (i.e., *Parthenocissus quinquefolia*, *Podophyllum peltatum*, the invasive exotic *Alliaria petiolata*, *Circaea lutetiana* and *Asarum canadense*).

The site's mean basal area was 75.8 m^2/hectare and the mean DBH ($\bar{x}$=44.0cm) was comparatively high. Site DBH was significantly higher than the DBH at the GR125-250m ($\bar{x}$=29.2cm), GR250-500m ($\bar{x}$=29.9cm), KZ125-250m ($\bar{x}$=26.5cm), KZ250-500m ($\bar{x}$=26.6cm) and RR250-500m sites ($\bar{x}$=29.6cm). There were $\bar{x}$= 3.9 tree species/10-factor prism plot. The mean USSt ($\bar{x}$=43.3 stems/plot) was the second highest stem density across all sites and was significantly higher than the USSt at the GR<125m ($\bar{x}$=4.20 stems/plot), GR125-250m ($\bar{x}$=6.0 stems/plot) and SJ<125m sites ($\bar{x}$=5.6 stems/plot). The mean USSp ($\bar{x}$=7.7 species/plot) was also the second highest observed among sites and was significantly higher than the USSp at the GR<125m ($\bar{x}$=1.6 species/plot), GR125-250m ($\bar{x}$=2.2 species/plot) and SJ<125m sites ($\bar{x}$=1.4 species/plot). The mean GCSE and GCSL were $\bar{x}$=7.6 species/m^2 and $\bar{x}$=6.5 species/m^2, respectively. During early season sampling, mean percent ground cover was $\bar{x}$=60.6%, the second highest mean across all sites.

Floristic sampling. There were 92 plant species identified at this site, including eight (8.7%) non-native species (Figure 14 and Table 18). This species richness ranked the site eighth among all sites and second within its buffer class. Despite a low FQI score (35.7) that ranked this site tenth among all sites, the $\bar{C}$ (3.7) was the third highest $\bar{C}$ reported (Figure 15 and Table 18). However, a mean coefficient of conservatism (3.7) was also the median $\bar{C}$ value, and thus cannot be considered particularly high for this study (Figure 16). Thus, both the FQI and the $\bar{C}$ reflect the somewhat degraded quality of the site, as indicated in the vegetation description. The mean wetland coefficient was 0.3, ranking the vegetation of the site as "facultative." No rare plant species were identified during vegetation and floristic surveys of this study site.

Of the eight exotic species identified at this site, the most noteworthy were *Alliaria petiolata* (garlic mustard), *Hesperis matronalis* (dame's rocket), *Ligustrum vulgare* (common privet), *Lonicera maackii* (Amur honeysuckle), *Lysimachia nummularia* (moneywort), *Morus alba* (white mulberry) and *Rosa multiflora* (multiflora rose). This suite of species indicates the highly disturbed nature of the site within the overstory, understory and groundcover layers.

Vegetation and Floristic Results: RR125-250m

Vegetation and ecological sampling. Two very distinct ecological zones were identified at this site, a first bottom and an upland forest slope. The total length of the base transect was 120m. Figures 28 and 31 depict height above or below the riverbank graphed on distance along the base transect. The CTV (0.38) was the fourth highest of the study sites, indicating that the degree of topographic variability for this site was relatively high (Figure 26). The first bottom was a wide zone, ranging from the riverbank to 81m along the transect, with *Laportea canadensis* prominent in the herbaceous layer and large diameter *Acer saccharinum* and *Fraxinus pennsylvanica* dominating the overstory. The same tree species were prevalent as saplings in the understory layer. The second zone, a narrow band of rich upland forest spanning along the transect from 81 to 120m, was dominated by large diameter mesic hardwoods (*Tilia americana, Fraxinus americana, Quercus rubra* and *Acer saccharum*). *Podophyllum peltatum, Parthenocissus quinquefolia, Anemonella thalictroides, Geranium maculatum* and *Arctium minus* (invasive exotic) were plentiful in the groundcover plots. A diverse array of shrub and sapling species comprised the understory (i.e., *Acer saccharum, Ostrya virginiana, Ribes cynosbati, Carpinus caroliniana, Tilia americana* and the invasive exotic *Rosa multiflora*).

The site's mean basal area ($\bar{x}$=88.1m^2/hectare) was the second highest observed among the study sites. The average DBH ($\bar{x}$=49.1cm) was also the second highest among study sites and was significantly greater than the DBH at the GR125-250m ($\bar{x}$=29.2cm), GR250-500m ($\bar{x}$=29.9cm), KZ<125m ($\bar{x}$=31.9cm), KZ125-250m ($\bar{x}$=26.53cm), KZ250-500m ($\bar{x}$=26.6cm) and RR250-500m sites ($\bar{x}$=29.6cm). There were $\bar{x}$=4.2 tree species/10-factor prism plot and there were $\bar{x}$=5.8 USSp/5m radius plot. The mean USSt ($\bar{x}$=25.2 stems/plot) was significantly lower than the USSt at the KZ<125m site ($\bar{x}$=63.0 stems/plot). The mean GCSE and GCSL in the 1m^2 groundcover plots were $\bar{x}$=7.4

species/ m^2 and $\bar{x}$=5.8 species/ m^2, respectively.

Floristic Results. There were 107 species identified at the site, including eight (7.5%) non-native species (Figure 14 and Table 18). This species richness ranked the site sixth overall and third within its buffer category. The FQI value was 38.5, which ranked it sixth overall, with a $\bar{C}$ of 3.7 (Figure 15 and Table 18). Both of these values reflect the moderate quality of the site. No rare plant species were identified during vegetation and floristic surveys of this study site.

Of the relatively modest number of non-native taxa identified, the most notable were *Elaeagnus umbellata* (Autumn olive), *Lonicera tatarica* (tatarian honeysuckle), *Lysimachia nummularia* (moneywort), *Morus alba* (white mulberry), *Rosa multiflora* (multiflora rose) and *Viburnum opulus* var. *opulus* (European highbush cranberry). The majority of these species were found in the second zone, where they occurred along a disturbed edge at the boundary of a planted grassland field. Notably absent was *Alliaria petiolata* (garlic mustard). *Arctium minus* (burdock), which was noted as being somewhat common in groundcover plots, occurred largely within the disturbed second zone where it had invaded from the disturbed field edge.

Vegetation and Floristic Results: RR250-500m

Vegetation and ecological sampling. This site was the most diverse topographically and had a wide array of microhabitat. Old logging roads and large stumps throughout the site indicated that the site had been previously logged. Four distinct ecological zones were identified at this site, including a first bottom, a second sloping bottom, a moat and an upland forest slope. The total length of the base transect was 268m. Figures 29 and 32 depict height above or below the riverbank graphed on distance along the base transect. The CTV for this site (0.38) was the fourth largest observed, indicating high topographic variability among sampling points (Figure 26). The first bottom, a wide zone with a meander channel and diverse microtopography, ranged from the riverbank to 100m along the transect. The channel, which varied in depth from 15 to 30cm, crossed the transect at two locations, between 62 and 71m and between 80 and 90m. The highly varied microtopography of this zone was reflected in the diversity of canopy dominants, with mesic to dry mesic species thriving on the rises (i.e., *Tilia americana, Acer nigra, Quercus velutina* and *Prunus serotina*) and mesic to wet mesic species in the depressional pockets and level bottomland (*Fraxinus pennsylvanica, Fraxinus nigra, Populus deltoides, Acer saccharinum* and *Quercus bicolor*). Prevalent shrub species included *Lindera benzoin, Carpinus caroliniana, Ostrya virginiana* and *Rosa multiflora* (invasive exotic). *Aralia petiolata* (invasive exotic), *Equisetum hyemale* (locally dominant), *Parthenocissus quinquefolia, Geranium maculatum, Laportea canadensis, Asarum canadense* and *Polygonum virginianu* were common in groundcover plots.

The second bottom, distinguished from the first by forming an abrupt, distinct terrace, occurred along the transect from 100-205m and had an overstory dominated by the following mesic hardwoods: *Tilia americana, Prunus serotina, Carya cordiformis, Quercus velutina, Acer nigra* and *Acer saccharum*. Species occurring frequently in the understory layer were *Carpinus caroliniana, Ostrya virginiana,* and *Acer saccharum* and *Acer nigra* saplings. A diverse array of species was found evenly distributed in the groundcover plots, including *Podophyllum peltatum, Parthenocissus quinquefolia, Cystopteris fragilis* and *Geranium maculatum*. Separating the second bottom and the steep upland slope was a narrow, 20m wide moat with saturated black muck soils, pools of standing water and a sparse canopy of *Acer saccharinum, Fraxinus nigra, Ulmus americana, Fraxinus pennsylvanica* and *Tilia americana*. *Ilex verticillata* and *Symplocarpus foetidus* were locally dominant in the understory and herbaceous layers, respectively. Additional elements of the understory were *Rosa multiflora* (an invasive exotic), *Ribes americanum* and saplings of *Acer nigra, Acer saccharinum, Ulmus american,* and *Fraxinus pennsylvanica*. *Glyceria striata, Laportea canadensis, Iris virginica* and *Caltha palustris* were also common in the herbaceous layer. The fourth zone, ranging from 225-268m along the transect, consisted of a steep upland forest slope dominated by mesic hardwoods (e.g., *Quercus rubra, Juglans nigra, Quercus velutina* and *Celtis occidentalis*). Saplings of *Acer nigra, Ulmus americana, Celtis occidentalis* and *Fraxinus americana* were common in the understory. Species that were common in the groundcover plots included *Sanicula gregaria, Parthenocissus quinquefolia* and *Smilacina racemosa.*

The site's mean basal area was $\bar{x}$=82.9m^2/hectare, and the mean DBH ($\bar{x}$=29.6cm) was significantly smaller than the DBH for RR<125m ($\bar{x}$=44.0cm), RR125-250m ($\bar{x}$=49.1cm) and SJ250-500m ($\bar{x}$=51.8cm). The TSP ($\bar{x}$=5.0 tree species/10-factor prism plot) was the highest observed across the study sites and was statistically higher than the TSP at GR125-250m ($\bar{x}$=2.8 tree species/plot) and KZ<125m ($\bar{x}$=2.5 tree species/plot). The mean USSp ($\bar{x}$=6.7 species/plot) was statistically higher than the USSp at the GR<125m ($\bar{x}$=1.6 species/plot), GR125-250m

($\bar{x}$=2.2 species/plot) and SJ<125m sites ($\bar{x}$=1.4 species/plot). The mean USSt ($\bar{x}$=25.2 stems/plot) was significantly lower the USSt at the KZ<125m site ($\bar{x}$=63.0 stems/plot). The mean GCSE and GCSL in the 1m^2 groundcover plots were $\bar{x}$=8.2 species/ m^2 and $\bar{x}$=6.1 species/ m^2, respectively.

Despite the degradation from previous logging and the high degree of invasive exotics (see below), this site's high floristic richness (see below), heterogeneous plant community zonation and large size were sufficient for classifying this southern floodplain forest as a new element occurrence in MNFI's BioTICs database.

Floristic sampling. There were 154 plant species identified at this site, the third highest species richness recorded for all sites and second within its buffer class (Figure 14 and Table 18). Of this total, 11 (7.1%) were non-native species. The FQI score for this site (48.4) ranked it second among all survey sites (Figure 15 and Table 18). The $\bar{C}$ was correspondingly high at 3.9, which was the second highest value recorded during the study (Figure 15 and Table 18). The high FQI and $\bar{C}$ values corroborate the natural area character of this site, which was cataloged as a natural community occurrence. Particularly noteworthy was the relatively large number of pteridophytes (ferns and fern allies) that were recorded; 12 of the 18 fern species found during the entire study were tallied within this sampling site. A mean wetland coefficient of 0.5 ranked the vegetation of this site as "facultative." No rare plant species were identified during vegetation and floristic surveys of this study site.

Of the 11 non-native species identified, the majority comprised many invasive species, which collectively were found in all structural vegetation layers. These included *Ailanthus altissima* (tree-of-heaven), *Alliaria petiolata* (garlic mustard), *Berberis thunbergii* (Japanese barberry), *Hesperis matronalis* (dame's rocket), *Lonicera maackii* (amur honeysuckle), *Lonicera tatarica* (tatarian honeysuckle), *Lysimachia nummularia* (moneywort), *Morus alba* (white mulberry), *Rhamnus cathartica* (buckthorn) and *Rosa multiflora* (multiflora rose). Despite the somewhat lengthy list of invasives, most were fairly localized within the site, such as tree-of-heaven, which was identified within one small area. Garlic mustard, however, was widely distributed but especially common within the first bottom.

<u>Vegetation and Floristic Results: SJ<125m</u>

Vegetation and ecological sampling. This site was floristically and structurally the simplest of all the study sites, with a wide, level floodplain bottom abutting a corn field (Photo 11). The base transect was 180m long. A flooded ditch of half a meter in depth crossed the transect between 140-145m. Figures 27 and 30 show height above or below the riverbank graphed on distance along the base transect and reveal how level the site was. The CTV for this site was 0.27 (Figure 26). A previously logged forest, the canopy was dominated by *Acer saccharinum,* with *Fraxinus pennsylvanica* and *Ulmus americana* of secondary importance. Saplings of these tree species were also prevalent in the understory. Mild rises in the floodplain bottom were dominated by large colonies of *Laportea canadensis*, while seasonally wet depressions were characterized by *Saururus cernuus* or thickets of *Cephalanthus occidentalis.* Other than in the *Cephalanthus occidentalis* depressions, shrubs were absent from the understory layer. Though previously logged, many of the residual canopy dominants were marked for harvesting. Any further overstory removal would result in significant degradation.

The site's mean basal area was 81.3m^2/hectare and mean TSP was 3.6 tree species/10-factor prism plot. The average DBH ($\bar{x}$=45.1cm) was the third highest among sites and was significantly larger than DBH at the GR125-250m ($\bar{x}$=29.2cm), KZ<125m ($\bar{x}$=31.9cm) and KZ125-250m sites ($\bar{x}$=26.5cm). The mean USSp ($\bar{x}$=1.40 species/plot) was the lowest observed among all sites and was statistically lower than USSp at the GR250-500m ($\bar{x}$=6.7species/plot), KZ<125m ($\bar{x}$=9.1 species/plot), KZ125-250m ($\bar{x}$=7.3 species/plot), RR250-500m ($\bar{x}$=6.7 species/plot) and SJ125-250m sites ($\bar{x}$=7.3 species/plot). The mean USSt ($\bar{x}$=5.6 stems/plot) was the second lowest stem density across all sites and was significantly lower than USSt at the KZ<125m ($\bar{x}$=63.0 stems/plot), RR<125m ($\bar{x}$=43.3 stems/plot) and SJ125-250m sites ($\bar{x}$=42.4 stems/plot). The mean GCSE ($\bar{x}$=1.6 species/ m^2) was significantly lower than the GCSE at the KZ125-250m ($\bar{x}$=10.7 species/ m^2), KZ250-500m ($\bar{x}$=10.5 species/ m^2) and SJ125-250m sites ($\bar{x}$=11.7 species/ m^2). The mean GCSL ($\bar{x}$=3.0 species/ m^2) was statistically lower than the GCSL at the KZ125-250m site ($\bar{x}$=9.9 species/ m^2). The mean %GCE and %GCL were lowest at this site ($\bar{x}$=12.60% and $\bar{x}$=14.8%, respectively).

Floristic sampling. There were 73 plant species identified at this site, including five (6.8%) non-native species (Figure 14 and Table 18). This species richness was the lowest measured for this buffer category, and was the second lowest (eleventh ranked) for the entire study. The FQI score for this site (31.1) was the lowest recorded for the study, and the $\bar{C}$ was 3.6 ranking in the lower tier of values (Figure 15 and Table 18).

Despite the low FQI and $\bar{C}$ values, the site was not quite as degraded as the numbers suggest. Previous logging activities had clearly degraded the site, but the flora appeared to be inherently modest in diversity, being composed of a single, uniform, simple floodplain bottom. The mean wetland coefficient was –1.5, ranking the vegetation of the site as "facultative wetland," which is consistent with the physiography of the site. No rare plant species were identified during vegetation and floristic surveys of this study site.

Relatively few non-native species were identified, including *Arctium minus* (burdock), *Cirsium arvense* (Canada thistle), *Cirsium vulgare* (bull thistle), *Glechoma hederacea* (gill-over-the-ground) and *Poa compressa* (Canada bluegrass). Few of these could be considered invasive within the site, with only gill-over-the-ground occurring within the floodplain proper. Notably absent were serious invasives such as *Alliaria petiolata* (garlic mustard) and *Rosa multiflora* (multiflora rose).

Vegetation and Floristic Results: SJ125-250m

Vegetation and ecological sampling. Three distinct ecological zones of highly diverse overstory were identified at this site, including a rich mesic forest terrace, a rolling second bottom and a narrow upland forest strip. Previous anthropogenic disturbance appeared to be limited to light selective logging. The total length of the base transect was 200m. This site was unique in that as one moved along the transect from the rich mesic forest terrace, there was a gradual slope downward through the rolling bottom until the base of upland forest slope. Figures 28 and 31 depict height above or below the riverbank graphed on distance along the base transect. The CTV for this site (0.25) indicated moderate topographic change among transect sampling points (Figure 26). Microhabitat and dead and down material of diverse size and decay classes was abundant throughout the site. The rich mesic forest terrace ranged along the transect from the riverbank to 25m. This zone was characterized by a diverse overstory with numerous rich mesic forest species (e.g., *Liriodendron tulipifera, Tilia americana, Quercus rubra, Carya ovata, Acer saccharinum* and *Fraxinus pennsylvanica*). Dominant understory species included *Asimina triloba, Staphylea trifolia, Carpinus caroliniana, Lindera benzoin* and *Zanthoxylum americanum*. A diverse array of species (24) was found evenly distributed in the groundcover plots (e.g., *Sanicula gregaria, Parthenocissus quinquefolia, Cryptotaenia canadensis, Viola sororia* and *Polygonum virginianum*).

The rolling bottom, spanning from 25-182m, was dominated by *Quercus bicolor* and *Fraxinus pennsylvanica* (Photos 12 and 13). Included within one of the prism plots was a single *Fraxinus profunda* (pumpkin ash, state threatened) (Photo 14). Characteristic of the understory were *Lindera benzoin*, *Carpinus caroliniana* and *Acer saccharum, Fraxinus nigra, Acer saccharinum* and *Fraxinus pennsylvanica* saplings. This zone was sparsely vegetated in the herbaceous layer with several seasonally inundated, non-vegetated depressions. The mean number of species per early season groundcover plot in the rolling bottom was $\bar{x}$=5.4 species/plot compared to $\bar{x}$=15.0 species/plot for the mesic terrace and $\bar{x}$=14.6 species/plot for the upland forest. Common groundcover species in this second zone included *Fraxinus pennsylvanica* seedlings, *Sanicula gregaria, Symplocarpus foetidus* and *Cryptotaenia canadensis.* The final zone was a very narrow band of upland forest on the transect from 182-200m. Overstory dominants were *Populus deltoides, Quercus rubra, Fraxinus americana* and *Acer saccharinum*. Prevalent understory species included *Staphylea trifolia, Prunus serotina, Carpinus caroliniana, Ulmus americana, Carya ovata, Zanthoxylum americanum* and *Ribes cynosbati*. A diverse array of species (28) was found evenly distributed in the groundcover plots (e.g., *Sanicula gregaria, Parthenocissus quinquefolia, Geum canadense, Galium aparine* and *Polygonum virginianum*).

The site's mean basal area was 80.34 m^2/hectare and the mean TSP ($\bar{x}$=4.7 tree species/10-factor prism plot) was the second highest for the study and was statistically higher than TSP at the GR125-250m ($\bar{x}$=2.8 tree species/plot) and KZ<125m sites ($\bar{x}$=2.5 tree species/plot). The mean DBH ($\bar{x}$=39.3cm) was significantly greater than DBH at GR125-250m ($\bar{x}$=28.4cm) and KZ250-500m ($\bar{x}$=26.8cm). The mean USSt ($\bar{x}$=42.4 stems/plot) was the third highest stem density across all sites and was significantly higher than USSt at GR<125m ($\bar{x}$=4.2 stems/plot), GR125-250m ($\bar{x}$=6.0 stems/plot) and SJ<125m ($\bar{x}$=5.6 stems/plot). The mean USSp ($\bar{x}$=7.3 species/plot) was also the third highest in comparison to the other sites and was significantly higher than USSp at the GR<125m ($\bar{x}$=1.6 species/plot), GR125-250m ($\bar{x}$=2.2 species/plot) and SJ<125m sites ($\bar{x}$=1.4 species/plot). The mean GCSE ($\bar{x}$=11.7 species/ m^2) was the highest observed and was significantly higher than the GCSE for GR125-250m ($\bar{x}$=4.1 species/ m^2), GR250-500m ($\bar{x}$=6.9 species/ m^2) and SJ<125m ($\bar{x}$=1.6 species/ m^2). The mean GCSL ($\bar{x}$=8.6 species/ m^2) statistically greater than the GCSL for GR125-250m ($\bar{x}$=4.0 species/ m^2).

Based on the high floristic diversity and quality (see below), microhabitat diversity, heterogeneous plant community zonation, presence of a rare tree

Photo 11. Wide, level floodplain bottom of the SJ<125m site with ground cover carpet of *Laportea canadensis* (wood nettle).

Photo 12. The rolling bottom ecological zone of the SJ125-250m site was dominated by *Quercus bicolor* and *Fraxinus pennsylvanica.*

species, and large size, the floodplain forest was classified as a new element occurrence with respect to the statewide database for southern floodplain forests.

Floristic sampling. There were 137 plant species identified at this site, including six (4.4%) non-native species (Figure 14 and Table 18). This floristic richness was the fifth highest in the study and the highest for this buffer class. The FQI score (49.7) ranked this site second overall, with a $\overline{C}$ of 3.9, which was also the second highest recorded (Figure 15 and Table 18). The mean wetland coefficient was –0.1, ranking the vegetation of the site as "facultative." These values, including the especially low number of exotics identified, clearly indicate the high diversity and natural area quality of this riparian site. Of particular note was the lack of artificial disturbance, including excessive tree harvesting. Also notable was the number of southern species encountered, including *Aesculus glabra* (Ohio buckeye), *Liriodendron tulipifera* (tuliptree) and *Fraxinus profunda* (pumpkin ash). The state-listed as threatened *F. profunda* (pumpkin ash) constituted a significant discovery (Photo 14). This species was not known in Michigan until 1992, when it was discovered near the Ohio border in Hillsdale County (Voss 1996). The species is now known only from approximately four sites within four counties, apparently reaching the northern edge of its range in southern Lower Michigan. All known sites are bottomland and other types of southern swamp communities.

Very few non-native species were tallied within this survey site, the only notable taxa consisting of *Berberis thunbergii* (Japanese barberry), *Lysimachia nummularia* (moneywort), *Morus alba* (white mulberry) and *Rosa multiflora* (multiflora rose). Notably absent was *Alliaria petiolata* (garlic mustard) a serious invasive.

Vegetation and Floristic Results: SJ250-500m

Vegetation and Ecological Sampling. This site was floristically and structurally simple with a wide, level floodplain bottom, and a narrow band of upland forest abutting an agricultural field. The base transect was a 290m long, the second largest transect in the study. The first zone had been heavily logged in the past and contained several ATV trails. This vast, level floodplain bottom with a meander channel, spanned along the transect from 0-250m (Photos 15 and 16). The channel, which ranged in depth from 15 to 75cm, crossed the transect at three locations, between 20 and 30m, between 45 and 55m and between 60 and 80m. Figures 29 and 32 show height above or below the riverbank graphed on distance along the base transect. The CTV (0.11), the second lowest value observed among survey sites, indicated very low topographic variability among sampling points (Figure 26). During the time of early season sampling, the floodplain bottom was inundated. Water depth measurements along the transect varied from 2-30cm. Flooding was observed out to 230m from the stream bank. Due to seasonal flooding, the groundcover throughout this zone was sparsely to moderately vegetated. All groundcover plots were covered in water ranging in depth from 5-30cm. Characteristic plants of the saturated to inundated herbaceous layer included *Boehmeria cylindrica, Saururus cernuus*, *Onoclea sensibilis* and *Peltandra virginica*. In localities where *Cephalanthus occidentalis* did not occur in thickets, *Lindera benzoin* and saplings of *Acer saccharinum* and *Ulmus americana* were dominant. The densely stocked canopy was predominantly composed of large-diameter, multiple-stemmed *Acer saccharinum* with *Fraxinus pennsylvanica, Ulmus americana* and *Fraxinus nigra* of secondary importance. The narrow band of heavily degraded upland forest, which occurred along the transect from 250-285m, was dominated in the overstory by *Quercus bicolor*. *Acer saccharinum, Fraxinus pennsylvanica* and *Populus deltoides* were also important canopy components. Prevalent understory species were *Lindera benzoin, Zanthoxylum americanum, Toxicodendron radicans, Acer saccharinum* and *Prunus serotina.* Numerous groundcover species were common (e.g., *Parthenocissus quinquefolia*, *Laportea petiolata, Cryptotaenia canadensis, Podophyllum peltatum, Sanicula gregaria* and *Thalictrum dasycarpum*).

The site's mean basal area ($\bar{x}$=103.9 m^2/hectare) was the highest of all the sites and was significantly greater than the basal area at the KZ<125m site ($\bar{x}$=49.0 m^2/hectare). Mean TSP was $\bar{x}$= 3.2 tree species/10-factor prism plot. Mean DBH ($\bar{x}$=51.6cm) was the highest across sites and was significantly greater than DBH at the GR125-250m ($\bar{x}$=29.2cm), GR250-500m ($\bar{x}$=29.9cm), KZ<125m ($\bar{x}$=31.9cm), KZ125-250m ($\bar{x}$=26.5cm), KZ250-500m ($\bar{x}$=26.6cm) and RR250-500m sites ($\bar{x}$=29.6cm). There were $\bar{x}$=5.80 USSp/plot and the mean USSt ($\bar{x}$=26.5 stems/plot) was significantly lower than the mean USSt for KZ<125m ($\bar{x}$=63.0 species/plot). The mean GCSE and CGCSL were $\bar{x}$=6.9 species/ m^2 and $\bar{x}$=6.8 species/ m^2, respectively.

Floristic sampling. There were 97 plant species identified at this site, including seven (7.2%) non-native species (Figure 15 and Table 18). This floristic richness is markedly lower than that recorded for all other sites within its buffer category, demonstrating in

Photo 13. Rolling bottom zone of SJ125-250m site with Fraxinus pennsylvanica (green ash) seedling carpet.

Photo 14. The state-listed as threatened *Fraxinus profunda* (pumpkin ash) was a significant discovery at the SJ125-250m site.

part the structural uniformity of the site. Excessive timber harvesting and a relatively high degree of degradation are reflected in the FQI score (38.1), the lowest value by far within this buffer class (the other sites in this class had scores ranging from 48 to 51, Figure 15 and Table 18). However, the $\overline{C}$ (3.9) was notably high, suggesting that this sampling site was intrinsically low in species diversity, likely owing to its ecological homogeneity (Figure 15 and Table 18). The mean wetland coefficient was -0.4, ranking the vegetation of the site as "facultative."

One rare plant species, the state-listed as special concern *Euonymus atropurpurea* (wahoo), was documented during vegetation and floristic sampling. This state special concern species is known from 12 counties in southern Lower Michigan, where it is confined to riverbanks and floodplain forests (Voss 1985).

Seven non-native species were recorded, most of which are considered invasive, including *Alliaria petiolata* (garlic mustard), *Berberis thunbergii* (Japanese barberry), *Lysimachia nummularia* (moneywort), *Lythrum salicaria* (purple loosestrife), *Morus alba* (white mulberry) and *Rosa multiflora* (multiflora rose). Several of these taxa, however, occurred in the somewhat limited upland forest zone with a disturbed edge along an agricultural field.

Spatial Analysis Results

Land Cover Properties

Agricultural land uses dominated the landscapes of all four study watershed areas digitized as part of this project (Figure 33). Forested land covers generally occurred within close proximity of stream channels, while agricultural land covers dominated upland areas beyond stream channels. Other land cover types generally comprised smaller areas of the watershed (i.e., <0.10 of the digitized areas, Figure 33).

Aqautic Community Analyses

Reach specific measures of aquatic community attributes were variably associated with landscape properties over multiple upstream landscape contexts. HBI scores, mussel species richness, MCPUE, RAEAS, fish species richness, FIBI scores, ITBI scores and EPT scores were not significantly correlated with any land cover properties measured within buffers of any width or upstream spatial extent (Appendix XII-XVI). Total aquatic species richness was most highly correlated with the spatial extent of wetlands within all buffer areas of the U/S-1 upstream context (R>0.83, p<0.002). Overall aquatic species richness was also positively correlated with wetlands comprising the larger buffer areas (i.e., 240m and 480m) of the U/S-2 upstream context (R=0.73, p<0.004) and was negatively correlated with the spatial extent of forests comprising local buffer areas (Appendix XIV). RAIF values were only associated with the proportion of local 30m buffer areas comprised of wetlands (R=0.83, p<0.002). Similarly, FCPUE values were positively correlated with the extent of wetlands comprising local 30m (R=0.73, p<0.009), 60m (R=0.83, p<0.002), 120m (R=0.83, P<0.002) and 240m (R=0.72, p<0.009) buffer areas. RAIU measures were associated with the spatial extent of wetlands within buffer areas quantified at the U/S-1 (R=0.77-0.86, p<0.005), U/S-2 (R=0.79-0.88, p<0.003) and U/S-3 (R=0.77-0.86, p<0.005) landscape contexts (Appendix XV). RAIU measures were also negatively correlated with forests comprising buffers of the U/S-2 context (R=-0.71-0.82, p<0.01). Benthic macroinvertebrate species richness was negatively correlated with the local spatial extent of forests within buffers (R=-0.74-0.81, p<0.007). However, ISR was positively correlated with the spatial extent of wetlands within all buffers of the U/S-1 (R=0.80-0.93, p<0.002), 480m and 960m buffers of the U/S-2 (R=0.81, p<0.002 and R=0.85, p<0.001, respectively) and 960m buffers of the U/S-3 (R=0.80, p<0.003) landscape contexts (Appendix XV). RAIB values were negatively correlated with the spatial extent of forest (R=-0.74-0.76, p<0.006) and forest-wetland (R=-0.73, p<0.008) land covers of U/S-1 buffer areas (Appendix XIV and XVI). RAIB values were positively correlated with the spatial extent of all modified land covers within the 60m (R=0.86, p<0.001), 120m (R=0.83, p<0.002) and 240m (R=0.79, p<0.003) U/S-1 buffer areas. The %woody material in the channel was positively correlated with the spatial extent of forests within most buffers of the U/S-1 (R=0.74-0.89, p<0.007) and U/S-2 (R=0.71-0.79, p<0.01) contexts (Appendix XIV) and was negatively associated with the spatial extent of wetlands within most U/S-1 (R=-0.74-0.82, p<0.007), all U/S-2 (R=-0.82-0.88, p<0.002) and all U/S-3 (R=-0.71-0.83, R<0.01) buffer areas (Appendix XV).

Terrestrial Community Analyses

Terrestrial community parameters were variably associated with the spatial extent of land covers comprising stream buffers of varying width quantified over multiple upstream spatial contexts. Most site vegetation sampling measures were not associated with buffer land cover properties of local or upstream spatial contexts (Appendix XII-XVI). Basal area was negatively associated with the spatial extent of agricultural (R=-0.74, p<0.006) and all modified

Photo 15. Vast, level floodplain bottom of the SJ250-500m site.

Photo 16. Inundated floodplain bottom of the SJ250-500m site.

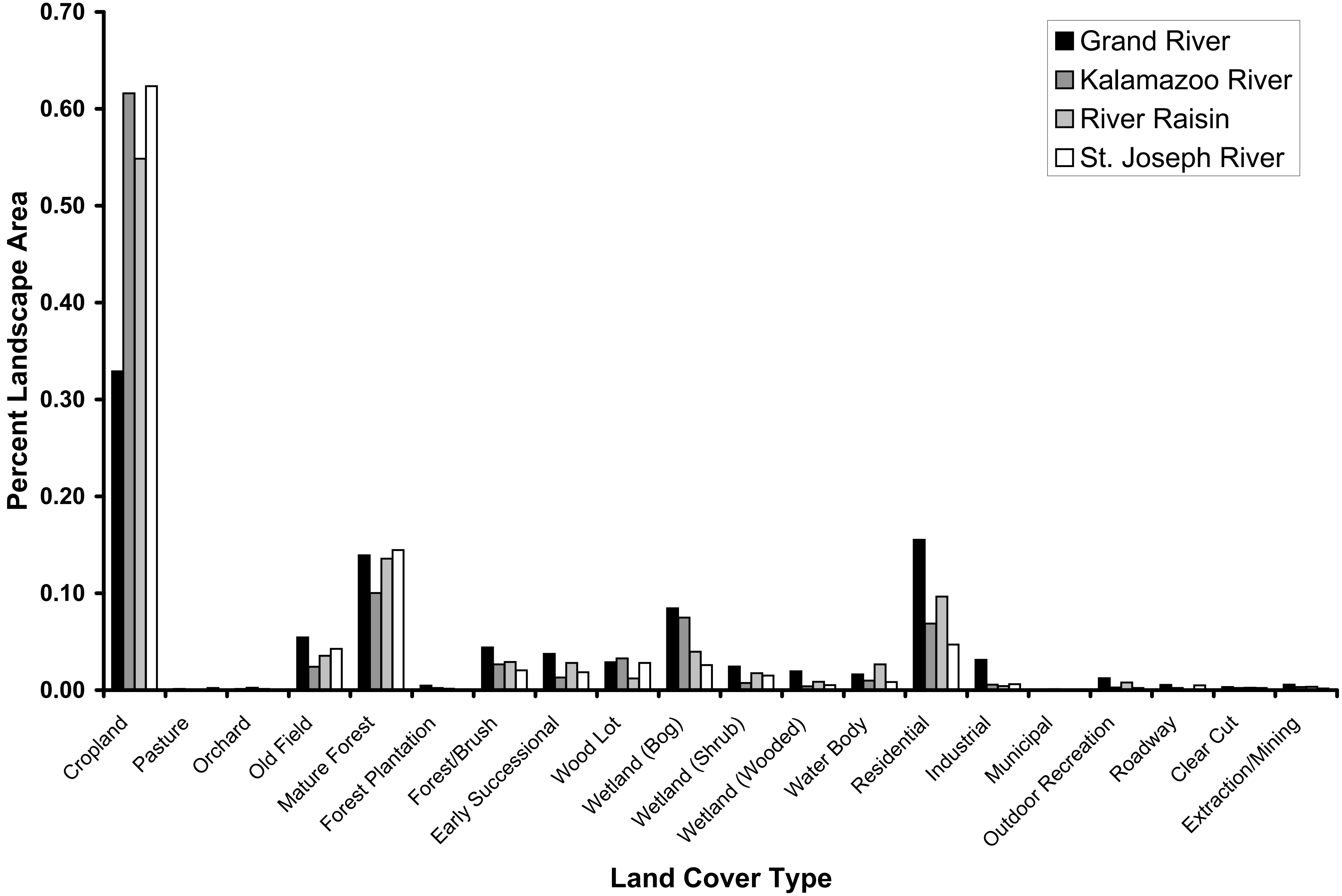


Figure 33. Land cover compositions of landscape areas (by river basin) digitized adjacent to and upstream from riparian study sites.

(R=-0.79, p<0.003) land covers within local 960m buffer areas. TSP was positively correlated with the spatial extent of forest land covers within the local 960m (R=0.74, p<0.007), U/S-1 30m (R=0.73, p<0.008), U/S-1 60m (R=0.75,p<0.006) and U/S-1 120m (R=0.73, p<0.008) buffer areas. Site mean GCSE was negatively associated with the forest component of local 30m (-0.78, p<0.004) and 120m (R=-0.74, p<0.007) buffer areas. The number of ecological zones at a sites was positively associated with the forest-wetland component of local 120m (R=0.73, p<0.008) and 240m (R=0.74, p<0.006) buffer areas, while site CTV was negatively correlated with the spatial extent of agriculture within U/S-2 30m (R=-0.71, p<0.011), 60m (R=-0.75, p<0.006) and 120m (R=-0.70, p<0.012) buffer areas.

Floristic measures were generally associated with land cover properties of buffer areas used in the spatial analysis (Appendix XII-XVI). NPSR was positively correlated with wetland components of local 240m (R=0.78, p<0.004) and 480m (R=0.73, p<0.008) buffer areas. APSR was negatively associated with the agricultural component of U/S-2 120m (R=-0.78, p<0.004), 240m (R=-0.76, p<0.005), 480m (R=-0.74, p<0.007) and 960m (R=-0.72, p<0.01) buffer areas and U/S-3 240m buffer areas (R=-0.74, p<0.007). Site FQI scores were positively correlated with the wetland component of local 240m (R=0.76, p<0.005) and 480m (R=0.74, p<0.007) buffer areas.

Terrestrial vertebrate community measures were largely uncorrelated with land cover properties of buffer areas over all landscape contexts (Appendix XII-XVI). However, bird species richness was negatively correlated with the forest-wetland component of local 120 and 240m buffer areas (R=-0.76, p<0.005).

DISCUSSION

Terrestrial and aquatic communities rely on riparian forest properties that contribute to the functionality of both ecosystem types. Despite the widely documented roles of riparian zones in providing specialized terrestrial habitat and mediating terrestrial-aquatic processes, there was little evidence to suggest that predictable patterns of biodiversity occurred among the riparian forest buffer width classes established in this study. The absence of predictable community responses among riparian classes precluded the development of an effective riparian biodiversity model at this stage. There are several possible explanations for this lack of predictability. The sampling design for the study was initially thought to provide adequate replication and a suitable sample size for the analyses used. However, there was a high degree of variability within and among riparian forest buffer width classes, and a larger sample size and additional stratification of sites was likely needed to provide more rigorous statistical tests of the data. Additional replicates and stratification that will be provided by surveys conducted during the summer 2001 field season will provide us with a larger, more appropriate data set for evaluating responses and building a riparian biodiversity model. The model developed based on two years of field data collection can then be tested during the third year of the study.

Another possible reason for the absence of significant results is that upstream conditions of sites were not comparable within and among the riparian forest buffer width classes. Local riparian criteria were relatively easy to define within the basins used for this study, although upstream land cover properties varied widely and could not be standardized for each riparian buffer width class. This was likely most important for aquatic communities (see Aquatic Community Discussion), although there were some indications that terrestrial factors were also influenced by upstream properties (see Spatial Analysis Discussion). Thus, the riparian reaches used as replicates in the study were essentially “dirty test tubes” that were not truly comparable within and among treatments due to upstream influences. This is not uncommon for comparative study designs (Kuel 1994). One way to compensate for this variability in upstream conditions is to increase the number of replicates in the data set as described previously.

We assumed that the riparian forest units we defined in this study were spatially appropriate for predicting patterns of resident biodiversity. It is possible that riparian community patterns do not occur within this spatial context, although there is repeated documentation of the influence of riparian zones on resident communities in the literature (e.g., Kaufman and Krueger 1984, Nillson et al. 1988, Medin and Clary 1990, Gregory et al. 1991, Naiman et al. 1993, and others). The spatial analyses performed as part of this project suggest that larger scale properties may also be very important, especially (but not solely) for aquatic communities. Other studies have reported that such large-scale properties have significant influences on local communities (e.g., Corkum 1989, Corkum 1991, Richards and Minshall 1992, Richards and Host 1994, Lammert 1995, Allan and Johnson 1997, Allan et al. 1997, Richards et al. 1997), suggesting that focusing on riparian forest buffers may not be adequate for identifying significant biodiversity within fragmented landscapes. Additional data collected during 2001 should enable us to better test the riparian forest buffer width hypothesis and evaluate whether these spatial units are appropriate for biodiversity modeling.

The terrestrial vertebrate data reflected especially small sample sizes due to our efforts to collect data for multiple taxonomic groups. Based on the first year of study, we have determined that our analysis would benefit more from enhanced surveys of particular groups rather than attempting to include data from multiple taxa. Among the herptiles, riparian forests are likely to be most important for anurans (frogs and toads) which will serve as the herpetofaunal focus for the remainder of the study. Bird migrations can be unpredictable and require large time investments in order to obtain adequate data. Breeding bird surveys are more likely to provide suitable data for our analyses and will serve as a second focus in terrestrial vertebrate surveys. No additional mammal surveys will be conducted as part of this study.

Additional sections follow that discuss the results for aquatic and terrestrial vertebrate community analyses as well as the spatial analyses. Discussion points for terrestrial plant community and floristic surveys are included within the Results section above.

Aquatic Community Discussion

In this component of the study, we documented aquatic community integrity, species richness and other attributes of fish, mussel and aquatic invertebrate communities in four watersheds within fragmented landscapes. At the stream reach scale, these aquatic communities were not significantly different among the riparian corridor classes in which they were surveyed. Allan et al. (1997) also reported that local riparian areas are poor predictors of aquatic habitat quality and ecological integrity. Additional studies have suggested that local stream habitats and communities are shaped by environmental process interacting over multiple spatial scales (Leopold et al. 1964, Dunne and Leopold 1978, Vannote et al. 1980, Frissel et al. 1986, Steedman 1988, Schlosser 1991, Richards et al. 1996, Allan and Johnson 1997). Aquatic communities within survey reaches appeared to be more highly associated with more localized instream conditions and showed no clear response to changes in local riparian forest buffer width classes defined in this study (see spatial analysis for contrasting results for some taxonomic groups). However, the relatively small sample sizes for most groups and high variability within buffer width classes may have also contributed to the lack of significant responses to changes in riparian forest buffer width. Additional data and further site stratification is needed to better evaluate potential relationships between aquatic community parameters and riparian buffer width classes.

Some of the sites chosen based on topographic maps and aerial photos had local habitat properties that departed from the hypothesized pattern of higher quality instream habitat in streams with wider adjacent riparian forest buffer zones. GR125-250m had been previously dredged, greatly altering the local benthic habitats. No stable benthic substrate was identified at this site and mussel surveys could not be performed, eliminating a whole component of the aquatic community. Additionally, woody debris and snags were the only stable substrates for macroinvertebrate colonization. Such instream conditions could not be reliably predicted by the site selection criteria used in this study. GR250-500m did not appear to have been dredged, but the habitat availability at this site was not considered optimal for aquatic communities. This stream segment has a deeply incised, U-shaped channel morphology that is often associated with fine textured glacial till surficial geology. Only 20m of the 150m reach was characterized by scattered gravel substrates required for stable benthic colonization (i.e., mussels and invertebrates). The remainder of the reach was dominated by clay/loamy substrates covered with fine silts and organic materials. This stream type does not necessarily indicate low stream integrity. However, criteria for identifying high quality examples of such sites have not been developed, and the criteria used for assessing streams in this study are better suited to shallow, fast-flowing, clear, rocky-bottomed streams and likely undervalue the integrity of sites with channel morphology similar to the GR250-500m site.

Land cover properties of upstream areas varied greatly among the riparian segments included in this study. Fundamental changes in instream parameters (e.g., water quality) that are the product of upstream processes may supercede local habitat availability related to local riparian function as an influencing factor for aquatic communities (Goforth 1999). Comparability of sites comprising the existing conditions treatments used in this study (i.e., riparian forest buffer width classes) was limited by the high degree of variability in upstream conditions among sites. These upstream sources of variability may contribute to the lack of significant relationships between the aquatic community attributes and the riparian buffer classes used in this study. Additionally, the riparian buffer area classes used in this analysis may not be appropriately scaled for detecting responses of stream communities to nearstream changes in riparian forest cover.

Watershed position of riparian study segments showed no interaction with the riparian width classes or aquatic parameters that were measured. This suggested that our randomized selection of sites was appropriate. If positive or negative relationships were reported with riparian width and watershed area, the premise of the study would have been violated because aquatic communities naturally change in a predictive manner from the headwaters to mid-reach systems (Hynes 1970, Vannote et al. 1980, Minshall et al. 1985). In this scenario, any changes in aquatic communities or species richness realized from the different riparian width classes would have been suspect, and may have been auto-correlated with the natural changes of the communities along a longitudinal stream gradient.

Woody debris is generally considered to be a highly desirable component of stream and river habitats (Benke et al. 1984, Bisson et al 1987, Barbour and Stribling 1991). Woody materials provide instream physical habitat and serve to moderate current velocity, providing refugia for numerous aquatic taxa and limiting streambank erosion. In a study on low gradient Wisconsin streams, Wang et al. (1998) found that % instream wood cover positively affected habitat quality and fish IBI scores. However, in our study, most aquatic community parameters exhibited either no relationship (Fish IBI), or were negatively correlated with the %Wood in the stream channel (i.e., RAIU, ISR and TASR). Slower water currents, deeper channels and suboptimal benthic substrate characterized most sites with high %Wood. Slower moving water currents and depositional areas enable woody materials being carried by streamflow to settle and become established increasing wood in these areas. Hence, increased wood in the channel does not necessarily positively influence overall quality of stream habitat. The aforementioned stream reaches do not provide suitable habitat for intolerant mussel species and are generally characterized by lowered benthic taxa richness. Because invertebrate taxa comprised a large portion of the TASR, these measures also tended to be lower at sites with higher %Wood. However, these sites do provide habitat suitable for more tolerant unionid species as reflected in the positive association between RATU and %Wood.

Correlations between total intolerant aquatic species richness and TASR suggested that higher diversity in aquatic communities leads to less dominance of particular taxa and enhances the ability of sensitive or less tolerant species to persist. Degraded conditions often provide stressors that eliminate the intolerant species of communities, enabling the more tolerant species to become dominant. Within the GR250-500m reach the mussel community was comprised of only four mussel species and the tolerant fatmucket dominated this community assemblage at 60%. At other study sites with 10 or more mussel species, the fatmucket never contributed more than 5% of the individuals to the total assemblage. The invertebrate parameter, % dominant family, is expected to increase under increasingly degraded conditions (Plafkin et al. 1989), and is often used in biomonitoring studies. We did not specifically address this parameter, but expected the invertebrate biotic index, based on tolerance and abundance, to encompass the connotation of dominance in the community. For example, the invertebrate biotic index for the GR125-250m site (i.e., the dredged site) averaged 7.25, where tolerance values of 7-10 characterize tolerant organisms. This value was the highest in the study, ranking the site poor because of the dominance of invertebrates able to withstand human-induced alterations to stream habitats.

Fish community attributes were not different among riparian forest buffer width classes, although this was not altogether surprising. Fish are highly mobile organisms, and they have the ability to move between stream reaches regardless of riparian properties. This fact coupled with patchy stream fish distribution both spatially and temporally (Angermeier and Smogor 1995) complicates the assumption that our samples reflected representative fish communities at sites based on a single sampling event. For example, when we were able to perform two fish sampling visits within the RR125-250m reach (reaches ~3 km apart), samples averaged 21 fish species/sites (RR125-250m had 19 and RR125-250mr had 23), but the total # of fish species collected between the two sites was 27. Since four fish species were not common to both sites, our data supports patchy fish species distribution within these variably buffered streams. A reevaluation of the single site visit methodology may be necessary if it becomes important to document all fish species inhabiting riparian width class reaches.

Fish communities are widely regarded to shift from low diversity cool water assemblages in headwaters to higher diversity warmwater assemblages in larger rivers with open canopies (Huet 1954, Vannote et al. 1980). Stream temperatures are largely mediated by groundwater inputs and warming from penetrating sunlight rays. Riparian canopy can provide shading that moderates stream temperatures, although canopy shading of stream reaches was largely consistent among the riparian buffer classes. Given that shade and temperature regime were comparable among sites, it is not surprising that local fish community measures were not significantly different among sites in response to these factors. This is also true for invertebrate communities that were responding not to forest canopy influences, but to instream habitat properties determined over a wide range of physical properties interacting over multiple spatial scales. Sedimentation regimes were also likely to be highly variable within and among buffer classes due to varied upstream land cover properties. Sedimentation regime can have a significant influence on fish communities (Karr and Schlosser 1977, Murphy et al. 1981, Hawkins et al. 1983, Rabeni and Smale 1995, Goforth 1999). This locally realized environmental property that is mediated by upstream processes might have also influenced fish communities to the extent that no significant differences could be detected among riparian buffer classes due to this extraneous source of variation.

Mussel community descriptors were also not different among the riparian forest buffer width classes. Strayer (1983) suggested that quaternary geology and watershed position were significant (although not necessarily the only) determinants of mussel species richness and abundance at sites. Instream habitat is also a significant driver for local unionid abundance and diversity, although this often occurs at the microhabitat scale, which can be highly unpredictable. Water quality is also of great importance to unionids, particularly those intolerant of degraded environmental conditions. Again, larger scale, upstream properties that drive water quality attributes may supercede local habitat availability, negating the positive influence of local riparian forest corridors.

RATU measures were negatively associated with site HQI scores, suggesting that these taxa were appropriately assigned to the tolerant group as a measure of mussel community tolerance. Higher quality habitats would be expected to support intolerant taxa that would decrease the RATU. Intolerant mussels, containing many special concern species, are considered to be bioindicators of degraded conditions, and their presence should represent good stream quality. However, this was not the case at the KZ125-250m site where we found two individual rainbow mussels and a round pig-toe (both special concern) in a community that had lost the majority of its native mussel species (as evidenced by dead valves and high densities of the exotic Asiatic clam). The relative abundance of intolerant mussels (RAIU) at this site was 0.6 (3 of 5 total individuals were intolerant), but that value is more reflective of the small number of individuals collected rather than high stream integrity. This example underscores the use of multiple components of the aquatic community, instead of wholly relying on any one metric as a descriptor of the stream conditions.

It is not surprising that MSR and FSR were highly correlated given the intricate relationship between freshwater unionids and their fish hosts. This correlation between mussel and fish community diversity has been documented on the scale of entire drainage basins (Watters 1992), and may possibly be explained by the life cycle of most unionids (e.g., use of fish hosts by mussel glochidia, the parasitic larval stage). Since different mussel species require very specific host fish species for propagation, it is logical to assume that an increase in the numbers of fish species present will increase the possibility of greater mussel species recruitment. There is often little overlap in fish host species among unionids occupying the same reach. High MSR therefore relies on high FSR to enable mussels within a highly diverse community to successfully reproduce and persist at a site. Densities of host fish communities have positively correlated with increased densities of certain mussels in streams of Alabama (Haag and Warren, unpublished data). However, this pattern was marginal within our study streams. Mussel density measurements are usually performed with quantitative methods (Strayer et al. 1996), while our methods took a qualitative approach. It is possible that relating the MCPUE estimates we calculated to the FCPUE is a gross under-representation of the actual mussel densities at the survey sites.

Exotic species are an increasing threat in southern Lower Michigan, particularly as Asiatic clams (*C. fluminea*) and zebra mussels (*D. polymorpha*) which continue to move upstream in Great Lakes tributary rivers. Mechanisms for introduction of these species are varied, but are generally associated with anthropogenic activities. It was expected, therefore, that more intact, wider forest buffer areas would be less susceptible to invasion by exotic aquatic species. This was not the case. The mechanisms for spread of *C. fluminea* and *D. polymorpha* in these rivers are likely to be more closely associated with the locations of reservoirs along rivers that serve as significant recreational purpose rather than any site specific criteria. However, the significant positive correlation between the relative abundance of aquatic exotic taxa and relative abundance of terrestrial exotic species suggested that sites might be prone to invasion by exotics across all community levels. This may relate back to upstream land cover properties that drive local habitat and community attributes of riparian ecosystems. More disturbed upstream areas may increase the incidence of disturbance in instream and nearstream areas at downstream locations, providing the initial foothold for colonization by opportunistic exotic species.

Macroinvertebrate communities generally

represented the greatest taxonomic contribution to overall site aquatic community species richness. They were also highly variable within sites and within-treatments (i.e., riparian forest buffer width class). Within treatment variation was often greater than the variation among riparian classes for macroinvertebrate data. There was also a relatively high degree of autocorrelation among invertebrate measures given that several measures served as components in the calculation of other macroinvertebrate community metrics. Despite the lack of significant differences in macroinvertebrate community measures among buffer classes, EPT, InBI and ISR were correlated with site HQI scores, suggesting strong ties between insect communities and local instream habitat attributes. The InBI and the RATU were also positively correlated, although this was not surprising because increasing values within these groups were closely linked to the degrading conditions of the river bottom (i.e., increased silt and organics). A lack of correlation between the RAIB and the RAIU was surprising, because both groups depend on high quality substrate conditions and water quality to maintain healthy populations. One explanation alluded to previously involves the variability of the RAIU and its ineffectiveness at conveying the ecological condition of the site (e.g., KZ125-250m). Metrics that are unreliable or inconsistent across sites in comparison to the majority of metrics should be reconsidered for inclusion in biomonitoring protocols (Karr and Chu 1999).

Ecological integrity ratings of stream communities are the basis for determining the extent of human-induced impacts to the system and for determining subsequent management plans. Stream impairment ratings provide the guidelines for biomonitoring decisions and specific actions to protect aquatic life and stream uses (Ohio EPA 1987). Biological indices and stream assessment protocols based on fish and invertebrates have evolved tremendously since their inception (Barbour et al. 1999, Karr and Chu 1999, Simon 1999). However, the development of comprehensive unionid community indices has lagged behind the other aquatic assemblages. Therefore, within our rating system mussel communities could not effectively be included, although we are evaluating the use of a mussel biotic index that would represent the integrity of the community and be specific to southern Michigan rivers. The RR125-250m site clearly ranked highest in overall aquatic integrity with good and very good ratings for all measures, and although not included, its mussel community contained diverse, abundant and intolerant species. It was surprising that the KZ125-250m site would rank high in ecological integrity category, because the mussel community was decimated at this site by the exotic Asiatic clam. If a mussel community metric were included, the KZ135-250m site would likely rank lower in ecological integrity. Several sites ranked very good to excellent in certain areas (HQI and fish), but only fair in the InBI ranking. These included three sites within the <125m riparian class (GR, KZ and SJ). For these cases, invertebrate biotic ratings seem to agree with our riparian width hypothesis, while other community measures did not. Another noteworthy site is the RR250-500m site which lies within a Nature Conservancy Preserve; this site ranked highest with the HQI and had an excellent RAIF and fish IBI rating, good InBI, but only fair EPT and RAIB. Decreasing trends of the EPT index are traditionally reported during the summer months (Lenat and Barbour 1994) because emergence of most EPT taxa has already occurred, and early instars are more difficult to reliably collect. However, EPT rankings were higher elsewhere in the basin. An alternative strategy to achieve more consistent EPT scores would be to conduct sampling earlier in the year. The EPT Index, as an invertebrate community descriptor, is easier to sample for and calculate compared to other invertebrate metrics (e.g., InBI) with which it is significantly correlated. So, its use as the representative invertebrate metric may be considered. In terms of invertebrate measures, the EPT agrees with the site ratings of the other community indices far more than the other measures (e.g., InBI and RAIB). The ability of the EPT index to effectively track environmental conditions has been found in other studies as well (Wallace et al. 1996; Lenat 1984).

Terrestrial Vertebrate Community Discussion

Data collected during 2000 bird migration counts were not adequate for drawing any meaningful ecological conclusions related to avian use of riparian corridors during spring migration. This is likely attributed to two primary factors. Sites could only be visited once during migration, which probably resulted in missing many species that used sites throughout the spring migration. Secondly, migration during 2000 was quite sporadic and eruptive for certain species. An early spring followed by cold, rainy and windy weather may have contributed to the apparent lack of a peak or wave of migratory birds passing through that is usually detected each year. Many birders during the spring of 2000 observed that migrating birds trickled in over the spring rather than gathering in large concentrations at any particular time. The breeding bird survey data were also limited by a small sample size (only 12 sites) and single visit surveys. Multiple visits to each site would have given a better measure of the avian community composition and abundance. Such data would have greater usefulness in gaining insight into factors that influence bird use in riparian ecosystems. Therefore, breeding bird survey efforts will be intensified and sample sizes will be increased during the 2001 field season.

Based on general habitat requirements and species' known ranges within the state (Harding 1997), the forested floodplain, or riparian, habitat surveyed as part of this study has the potential to support four salamander species, six frog and toad species, six snake species and six turtle species, totaling 22 species. This total comprises 42% of the 53 amphibian and reptile species found in Michigan. Thus, forested riparian areas could provide habitat for a relatively high percentage of herp species in the state. This study documented only 15 (68%) of the 22 potential species that could occur in forested riparian areas. The two most common species were the wood frog and American toad. Wood frogs prefer moist wooded habitats and are typically inhabit water only during a short (six to 14 days) breeding season (Harding 1997). Vernal ponds, floodings, wooded swamps and quiet stream backwaters are all used by wood frogs for breeding. American toads utilize a wide variety of habitats, ranging from open woodlands, prairies and marshes to residential yards, parks and agricultural areas (Harding 1997). They prefer to breed in shallow, temporary waters with sparse to moderate amounts of emergent and submergent vegetation, including flooded fields, ditches, stock ponds, open marshes and backwaters of slow-moving streams. Species that have potential to occur in forested riparian habitat but were not documented during this study may have been absent due to the lack of specific habitat requirements at the community and/or microhabitat scales at the study sites. Alternatively, these species may have eluded detection due to insufficient sampling or the secretive ad/or cryptic nature of the species.

A few species typically associated within non-forested riparian habitat were found during this study, likely due to adjacent habitat. One such species was the northern leopard frog, which is typically associated with marshes, meadows and grassy edges of ponds, lakes and streams. This species was found at the GR<125m site and incidentally at the KZ250-500m site, likely due to the presence of prairie fen habitat and open grassy areas adjacent to the forested riparian zones at these sites, respectively. Similarly, the Blanding's turtle, the only rare herp species documented during the study, can occur in river backwaters and embayments, but is commonly associated with shallow, vegetated waters such as ponds, marshes and wet prairies. This species was found at the GR<125m site, probably due to the presence of the prairie fen adjacent to the forested riparian area.

Herp communities in the forested riparian areas examined in this study were comprised primarily of frogs and toads. Frogs and toads represented over 75% of the individuals captured or observed during this study. Given their need for moist environments and standing water during portions of their life history, frogs and toads as a group are probably more suited to occupy forested floodplain or riparian areas that experience frequent flooding and, in some cases, high water levels for extended periods of time than other herp groups (e.g., snakes, terrestrial salamanders). The predominance of frogs and toads also may have been an artifact of the sampling methodologies used for this study. The pitfall and funnel trapping may have been more effective at capturing frogs and toads, and certain species of frogs and toads in particular, than other species or species groups. Frogs and toads also are generally easier to observe than other species groups such as snakes or salamanders. Timing also may have been a factor, since trapping and visual surveys were conducted when many of the sites were still inundated. Continued trapping and visual surveys later in the season and during drier conditions might have resulted in more captures and/or observations of other groups such as snakes and turtles. The herp community in the study areas may shift somewhat during dry conditions or different times of the year, although frequent flooding and associated habitat conditions in some of these riparian areas would likely still make them sub-optimal or unsuitable for certain herp species or species groups.

Results from the one-way ANOVA and the habitat correlation analyses suggest that species richness and relative abundance of amphibians and reptiles are not affected by width of the riparian habitat. Instead, herp communities may be responding to local or site-level habitat conditions, such as presence and amount of standing water, vegetative community type, amount of woody debris or cover and/or adjacent upland or wetland habitat. The habitat correlation analyses also provide evidence that amphibian and reptile communities may be related to other local or site-level habitat factors such as topographic variability, basal area and tree DBH. These site-level habitat conditions are not necessarily associated with width of the riparian habitat. Burbrink et al. (1998) documented similar results in a study that looked at species richness of amphibians and reptiles utilizing a riparian corridor of different widths in southern Illinois. They found that species richness was not significantly affected by width of the riparian corridor, and that the habitat heterogeneity needed to provide all the life cycle requirements of amphibians and reptiles was not associated with riparian width. However, statistical results from this first year of the study need to be viewed with caution since sample size was fairly low (n=4 in each riparian width class).

For the most part, species richness was higher at sites with low to moderate topographic variability and relatively wide, level floodplains with significant amounts of backwater or standing water (e.g., Kalamazoo River and St. Joseph River 125-250m and 250-500m sites). The negative correlation between species richness and topographic variability is puzzling and counterintuitive since one would think as topographic variability increases, habitat heterogeneity and microhabitat diversity would increase, thus potentially providing habitat for more species. CTV also is positively correlated with the number of zones within the riparian area, which also would seem to indicate increased habitat heterogeneity with more zones. Amphibian and reptile species may be responding to habitat heterogeneity and microhabitat diversity or variability at a different scale or in ways other than topographic variability and zonation as defined by this study. The two sites with the highest CTV's and most zones (n=4), the GR125-250m and RR250-500m sites, had the lowest species richness (and relative abundance estimates) of almost all the sites. It is unclear why herp observations were so low given apparently suitable habitat for herps at these two sites. The GR<125m site had the second highest CTV of all the sites but had only one ecological zone and had high species richness. The adjacent prairie fen habitat and pockets of grassy areas within the riparian zone may have contributed to increased habitat heterogeneity and higher species richness at the site.

Herp relative abundance was positively correlated with tree DBH. This variable indicates larger trees and hence more mature forests. Mature forests may be generally characterized by greater structural diversity, greater plant species diversity, wetter soil conditions, cooler microclimates, deeper forest floor leaf litter and more large dead and down woody debris than younger forest stands, and may provide greater habitat diversity for amphibian and reptile communities. The negative correlation between herp relative abundance and number of native plant species in the riparian area is puzzling, and may be an artifact of the negative correlation between native species and tree DBH. Additional data and analyses are needed to more closely examine possible relationships between amphibian and reptile communities and riparian habitat characteristics.

In addition to site-level habitat conditions, amphibian and reptile use of riparian areas, and wildlife use in general, may also be influenced by climatic conditions and landscape-level factors other than width. McComb et al. (1991), in a study in western Oregon, found that the contribution of amphibian and reptile species from riparian areas was greater than upslope habitat in coniferous forests, particularly during a dry season as opposed to a wet season, and in drier regions than in moist regions. They also found that the contribution of species from riparian habitat seems to be influenced by plant community and seral stage of the riparian and surrounding habitats. For example, in the Oregon Coast Range, the contribution of riparian areas to sub-basin herp species richness was not different than from adjacent upslope areas in mature forests. These results suggest that it may be worthwhile to examine amphibian and reptile use of riparian areas within a landscape context (e.g, adjacent or surrounding land cover or land use).

Finally, although the use of multiple survey methodologies was fairly successful in documenting the suite of amphibian and reptile species that inhabited the study areas, the addition of incidental species indicates that surveys failed to document the full range of species that utilized these areas. Also, although survey methodologies were fairly good at detecting species, relative abundance estimates were fairly low compared to other studies (e.g., Karns 1986). This may be due to different herp densities associated with different habitats, and low herp densities may characterize forested floodplain or riparian habitat. Low relative abundance estimates also may be an artifact of limited sampling. Since some herps can be secretive and difficult to find, and since survey results can vary significantly with weather and survey conditions, strong likelihood exists that extended or multiple trapping periods and multiple visits to each site for frog call and visual surveys would have yielded more herp species and higher numbers. Other studies also have found that multiple methodologies and long-term sampling efforts are needed to capture or document the full range of herp species and adequately estimate the abundance of herps that occur in an area (Campbell and Christman 1982, Karns 1986, Corn 1994, Greenberg et al. 1994). Therefore, results from this year's study should be viewed as baseline data, and additional work is needed to continue to elucidate amphibian and reptile use of riparian ecosystems.

Spatial Analysis Discussion

Land cover properties quantified over local and catchment scales influence stream communities and habitats (Corkum 1989, Corkum 1991, Richards and Minshall 1992, Richards and Host 1994, Lammert 1995, Allan and Johnson 1997, Allan et al. 1997, Richards et al. 1997). Correlation analyses of reach specific habitat and community measures with buffer land cover properties quantified over multiple scales presented herein provide additional support for the argument that local stream ecology is driven by multispatial environmental properties. In addition, associations between local measures of stream integrity and land cover types can also change within the context of relatively subtle changes in landscape scale (e.g., among the upstream contexts used for this study). These analyses suggest that characterization of riparian communities and identification of significant biodiversity refugia in fragmented landscapes cannot rely solely on local riparian zone condition, but must also include upstream, and possibly downstream, contexts for effective conservation.

Aquatic Community Correlations

TASR was most highly correlated with the spatial extent of wetlands within all buffer areas of the U/S-1 upstream context and the larger buffers (i.e., 240m and 480m) within the U/S-2 upstream context. These correlations were likely driven by the ISR component of TASR, given that benthic macroinvertebrate taxa comprised the bulk of all aquatic taxa observed at most sites and that TASR correlations with land cover properties were similar to ISR analyses. ISR was highly correlated with wetland components of all U/S-buffers and larger buffer areas of the U/S-2 and U/S-3 upstream contexts. Local-scale responses of benthic communities to changes in riparian structure have been richly documented (Hawkins et al. 1982, Gregory et al. 1987, Gregory et al. 1991, Sweeney 1993, Goforth 1999, and others), although ISR and RAIB measures in this study were consistently associated with larger scale properties. Such results are consistent with other studies reporting relationships between benthic communities and landscape properties (Richards et al. 1993, Richards and Host 1994, Richards et al. 1997, Goforth 1999). RAIB values were negatively correlated with forest and forest wetland components of U/S-1 buffer areas and were positively correlated with the proportion of U/S-1 buffer areas encompassed by all modified land covers. This was unexpected given that RAIB values are usually high in streams with forest canopies and generally decrease under environmental stress. Modified land covers in upstream areas would presumably contribute to lower water quality and lower RAIB values in downstream areas, although this was not the case. Aquatic insects typically exhibit "drifting" behavior, in which they periodically release from stream substrates and are swept downstream by water flow, later settling in a new location. The correlations observed may reflect different levels of drifting activity by benthic invertebrates in response to changes in nearstream land cover. Intolerant benthos inhabiting streams flowing through fragmented landscapes may preferentially drift from reaches surrounded by agriculture and settle (and perhaps aggregate) in reaches with forest cover that essentially provide islands of preferred habitat. Greater prevalence of agriculture upstream may lead to increased RAIB downstream while greater prevalence of forest land covers upstream may enable intolerant benthos to be more sparsely distributed among upstream areas.

The only fish community descriptor that was associated with buffer land cover properties was FCPUE, a surrogate for fish density in this study, which was correlated with wetland components of local buffer areas. This may reflect increased fish densities or increased sampling effectiveness in reaches with low current velocity often associated with low lying, broad floodplains with extensive wetlands. FIBI scores were not correlated with any buffer land cover properties. However, other studies have reported contrasting results indicating that fish IBI scores could be predicted by upstream (Steedman 1988 and Allan et al. 1997) or local land cover properties (Goforth 1999). Goforth (1999) reported that RAIF scores were correlated with upstream land cover properties, presumably because of the role that upstream physical processes play in determining downstream water quality parameters important for intolerant taxa. While RAIB and RAIU were both associated with upstream properties, RAIF values were not correlated with buffer land cover properties in this study.

Mussel species richness and distribution are associated with increasing stream size (Strayer 1983, van der Schalie 1938) and surficial geology, presumably in response to instream ecological factors related to these properties (e.g., current velocity, substrates, etc., Strayer 1983). Changes in land cover can influence such factors, although perhaps not significantly within the spatial contexts used in this study. It is therefore not surprising that there was no correlation between buffer land cover features and mussel species richness. Mussel densities within stream reaches can vary highly depending on the availability of microhabitats (e.g., substratum and current velocity). MCPUE was used as a surrogate for density in this study and was not correlated with land cover properties of buffer widths over any spatial extent. Mussel samples were not conducted to maximize effort in areas with dense mussel beds. Rather, the transects used provided an overall estimate of mussel abundance and richness for the site without regard to microhabitat type. Given that sampling transects spanned a wide range of microhabitats, it is not surprising that MCPUE was highly varied and was not correlated with land cover properties of buffer areas. Additionally, substrate composition heavily influences mussel distribution and is often patchily distributed throughout local stream reaches. This patchy distribution of microhabitats is difficult and perhaps impossible to predict based on adjacent and upstream land cover properties. The RAIU is a essentially a surrogate for mussel community tolerance to degraded environmental conditions such as increased turbidity, high nutrient loads, disturbed hydrologic regime and increased sedimentation. These are watershed processes mediated primarily by larger scale environmental properties (Dunne and Leopold 1978, Omernik et al 1981, Hildrew and Giller 1994, Roth et al. 1996, Allan et al. 1997). The positive correlation observed between site RAIU values and wetland components of the U/S-1, U/S-2 (strongest correlations were with this spatial extent) and U/S-3 buffer areas likely reflects the capacity of wetlands to moderate hydrologic variability and serve as sediment and nutrient sinks, thus improving water quality parameters in downstream areas.

HQI scores were not correlated with buffer land cover properties, although the suite of variables evaluated using the HQI methodology includes physical properties that are influenced by combinations of local and large scale processes. The resulting value from this combination of variables may be so spatially homogenized that it is not associated with land cover properties at any scale. Alternatively, the land cover types used for analysis may not have been appropriately defined or segregated in relation to the HQI and other measures that were not associated with buffer land cover properties. These land cover properties may also influence riparian attributes over spatial contexts not evaluated in this study (e.g., downstream, sub-basin, basin and larger upstream spatial contexts). The %woody material in the channel was positively correlated with forest components of U/S-1 buffers and was negatively associated with the spatial extent of wetlands within most U/S-1 buffer areas. This was not surprising given that forests in upstream areas provide downed woody material that can be swept into downstream areas, while wetlands are not significant sources for these types of materials but serve as sinks for woody materials from upstream areas.

Terrestrial Community Correlations

Terrestrial community parameters were variably associated with buffer land cover properties quantified over multiple upstream spatial contexts. Most site vegetation sampling measures were not associated with buffer land cover properties of local or upstream spatial contexts. This was not surprising given that these properties are often dependent upon highly localized microhabitat properties. Most significant correlations for vegetation sampling measures were most highly correlated with local buffer areas. This was expected, given that measures like basal area, which was negatively associated with the agricultural component of local 960m buffers, are probably more dependent upon site history (e.g., logging, land clearing) than any upstream properties, at least with respect to the landscape in which the study was conducted. It was also not surprising that TSP was positively correlated with forest land covers of the local 960m and several U/S-1 buffer areas. Larger forest areas locally and contiguity of riparian corridors (U/S-1) contribute to the establishment and sustainability of higher tree species richness. Higher mean GCSE values in areas with less forest comprising local buffer areas were also not surprising given that ground cover species are more successful in areas with lower canopy density and greater penetration of sunlight to lower vegetation layers. Site ecological zonation was positively associated with the forest-wetland component of mid-sized local buffer areas, due, in part, to the high degree of microtopographic and vegetative variability inherent in wetlands. Interestingly, site CTV was negatively correlated with the spatial extent of agriculture within the small to mid-sized U/S-2 buffer areas. Agricultural land uses can greatly alter hydrodynamic regimes of landscapes, increasing instream hydrologic variability and sediment loading. Channel morphology and meander within the floodplain is driven to a great extent by the hydrology and sediment load of streams. Increased hydrologic variability and sediment deposition in upstream areas can homogenize stream channels and floodplains, decreasing local topographic variation in downstream areas.

Floristic measures were variably associated with buffer land cover properties in the spatial analysis NPSR and site FQI scores were positively correlated with wetlands of the mid-large local buffer areas. The inherent high degree of floristic richness characteristic of wetlands contributed greatly to this significant association. APSR was negatively associated with agriculture in U/S-2 mid-large buffers. APSR was also positively correlated with CTV, which was negatively correlated with U/S-2 buffer agricultural extent. This chain of associations suggests that the driver for the negative association between APSR and U/S-2 buffer agricultural extent is CTV. Lower site CTV resulting from hydrologic instability related to upstream agricultural land covers results in lowered local microhabitat diversity for colonization by potential exotic species. This indirect relationship between upstream agricultural land use and site APSR demonstrates the highly complex nature of multispatial processes in shaping local communities.

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APPENDICES

Appendix I. Number of fish species from a species group association (SPA), a representative of that group and the average # of species collected within a river study site. Rivers include the Kalamazoo (KZ), Grand (GR), Raisin (RR) and St. Joseph (SJ) Rivers. Riparian forest buffer width classes include <125m (1), 125-250m (2) and 250-500m (3). Dominate SPA's are shaded.

SPA	Representative	GR1	GR2	GR3	Avg #	KZ1	KZ2	KZ3	Avg #
1	**Creek Chub**	**5**	**1**	**2**	**2.67**	**5**	**5**	**5**	**5.00**
2	**Bluegill**	**1**	**0**	**2**	**1.00**	**2**	**2**	**0**	**1.33**
3	**Mottled Sculpin**	**0**	**0**	**0**	**0.00**	**0**	**0**	**1**	**0.33**
4	**White Sucker**	**1**	**0**	**1**	**0.67**	**2**	**1**	**1**	**1.33**
8	**Green Sunfish**	**1**	**1**	**1**	**1.00**	**0**	**1**	**0**	**0.33**
9	**Blackside Darter**	**4**	**2**	**1**	**2.33**	**1**	**0**	**1**	**0.67**
10	**Common Carp**	**1**	**0**	**1**	**0.67**	**1**	**1**	**0**	**0.67**
12	**Logperch**	**0**	**0**	**1**	**0.33**	**0**	**0**	**1**	**0.33**
13	**Hornyhead Chub**	**2**	**1**	**1**	**1.33**	**1**	**1**	**1**	**1.00**
14	**Rockbass**	**3**	**1**	**1**	**1.67**	**2**	**3**	**3**	**2.67**
15	**Smallmouth Bass**	**3**	**0**	**1**	**1.33**	**5**	**5**	**3**	**4.33**
16	**Rosyface Shiner**	**0**	**0**	**0**	**0.00**	**1**	**0**	**1**	**0.67**
17	**Golden Redhorse**	**0**	**0**	**1**	**0.33**	**0**	**0**	**0**	**0.00**

Appendix I. (Cont.)

SPA	Representative	RR1	RR2r	RR2	RR3	Avg #	SJ1	SJ2	SJ3	Avg #
1	**Creek Chub**	**5**	**6**	**5**	**5**	**5.25**	**4**	**4**	**4**	**4.00**
2	**Bluegill**	**0**	**1**	**1**	**1**	**0.75**	**2**	**1**	**1**	**1.33**
3	**Mottled Sculpin**	**1**	**1**	**1**	**0**	**0.75**	**0**	**0**	**0**	**0.00**
4	**White Sucker**	**1**	**1**	**1**	**1**	**1.00**	**1**	**1**	**1**	**1.00**
8	**Green Sunfish**	**1**	**0**	**0**	**0**	**0.25**	**1**	**1**	**1**	**1.00**
9	**Blackside Darter**	**1**	**0**	**1**	**1**	**0.75**	**3**	**2**	**4**	**3.00**
10	**Common Carp**	**1**	**0**	**1**	**1**	**0.75**	**0**	**1**	**1**	**0.67**
12	**Logperch**	**1**	**1**	**2**	**1**	**1.25**	**0**	**1**	**0**	**0.33**
13	**Hornyhead Chub**	**1**	**1**	**1**	**1**	**1.00**	**1**	**2**	**3**	**2.00**
14	**Rockbass**	**1**	**3**	**2**	**2**	**2.00**	**3**	**4**	**2**	**3.00**
15	**Smallmouth Bass**	**4**	**6**	**4**	**5**	**4.75**	**4**	**4**	**5**	**4.33**
16	**Rosyface Shiner**	**0**	**1**	**0**	**2**	**0.75**	**0**	**1**	**2**	**1.00**
17	**Golden Redhorse**	**1**	**1**	**0**	**0**	**0.50**	**1**	**1**	**1**	**1.00**

Appendix II. Fish species sample data (individuals / site), tolerance values, trophic status and species group associations (SPA) for the riparian river reaches. Rivers include the Grand (GR), Kalamazoo (KZ), Raisin (RR) and St. Joseph (SJ) Rivers, and riparian buffer width classes include <125m (1), 125-250m (2) and 250-500m (3). NA indicates species not listed by Zorn et al. (1998), but placed in similar group. (E) =state endangered.

				Sample Site		
Fish Species	**SPA**	**TV[1]**	**TR[2]**	**GR1**	**GR2**	**GR3**
Central stoneroller	1	m	h	0	0	0
Common Shiner	1	m	i	13	0	0
Redfin Shiner	1	m	i	1	0	0
Bluntnose Minnow	1	t	o	1	0	1
Creek Chub	1	t	i	6	0	0
Johnny Darter	1	m	i	3	7	3
Green Sunfish hybrid	2	t	i	0	0	1
Bluegill	2	t	i	2	0	2
Mottled Sculpin	3	m	i	0	0	0
Fathead Minnow	4	t	o	0	0	0
White Sucker	4	t	o	6	0	3
Green Sunfish	8	t	i	8	6	2
Blackside Darter	9	m	i	2	0	0
Pirate Perch	9	m	i	0	0	0
Bowfin	9	m	p	1	1	0
Central Mudminnow	9	t	o	6	2	1
Walleye	10	m	p	0	0	1
Common carp	10	t	o	1	0	0
Spotfin Shiner	12	m	i	0	0	3
Logperch	12	m	i	0	0	0
Shorthead Redhorse	12	m	i	0	0	0
Hornyhead Chub	13	i	i	6	0	0
Grass Pickerel	13	m	p	1	2	1
Amer. Brook Lamprey	na	i	f	0	0	0
Rock Bass >5 inches	14	i	i	1	0	0
Rock Bass <5 inches	14	m	i	0	0	0
Rainbow Darter	14	i	i	26	0	0
Largemouth Bass	14	t	p	2	2	14
Silver Shiner (E)	na	i	i	0	0	0
Striped Shiner	15	m	i	1	0	0
Northern Hogsucker	15	i	i	2	0	2
River Chub	15	i	i	0	0	0
Greenside Darter	15	m	i	2	0	0
Smallmouth Bass	15	m	i	0	0	0
Black Redhorse	15	i	i	0	0	0
Stonecat	15	i	i	0	0	0
Rosyface Shiner	16	i	i	0	0	0
Silverjaw Minnow	na	m	i	0	0	0
Yellow Perch	16	m	p	0	0	0
Spottail Shiner	17	i	i	0	0	1
Golden Redhorse	17	m	i	0	0	0
Total Species per site				20	6	13
Total Ind. Per site				91	20	35
CPUE (# fish/minute)				1.61	0.49	0.82

[1] i =Intolerant, m=intermediate, t =tolerant

[2] i = insectivore, o =omnivore, p = piscivore, f =filterer, h =herbivore

Appendix II. (Cont.)

Fish Species	SPA	TV[1]	TR[2]	Sample Site KZ1	KZ2	KZ3
Central stoneroller	1	m	h	0	2	0
Common Shiner	1	m	i	2	17	6
Redfin Shiner	1	m	i	1	0	2
Bluntnose Minnow	1	t	o	9	7	12
Creek Chub	1	t	i	37	1	5
Johnny Darter	1	m	i	21	1	9
Green Sunfish hybrid	2	t	i	1	1	0
Bluegill	2	t	i	1	1	0
Mottled Sculpin	3	m	i	0	0	2
Fathead Minnow	4	t	o	8	0	0
White Sucker	4	t	o	6	1	5
Green Sunfish	8	t	i	0	1	0
Blackside Darter	9	m	i	6	0	0
Pirate Perch	9	m	i	0	0	0
Bowfin	9	m	p	0	0	0
Central Mudminnow	9	t	o	0	0	1
Walleye	10	m	p	0	0	0
Common carp	10	t	o	1	1	0
Spotfin Shiner	12	m	i	0	0	0
Logperch	12	m	i	0	0	0
Shorthead Redhorse	12	m	i	0	0	1
Hornyhead Chub	13	i	i	2	7	4
Grass Pickerel	13	m	p	0	0	0
Amer. Brook Lamprey	na	i	f	0	0	0
Rock Bass >5 inches	14	i	i	0	3	5
Rock Bass <5 inches	14	m	i	3	3	14
Rainbow Darter	14	i	i	58	7	16
Largemouth Bass	14	t	p	0	0	0
Silver Shiner (E)	na	i	i	0	0	0
Striped Shiner	15	m	i	20	26	18
Northern Hogsucker	15	i	i	1	6	1
River Chub	15	i	i	3	3	0
Greenside Darter	15	m	i	0	0	0
Smallmouth Bass	15	m	i	2	12	1
Black Redhorse	15	i	i	0	0	0
Stonecat	15	i	i	3	1	0
Rosyface Shiner	16	i	i	19	0	35
Silverjaw Minnow	na	m	i	0	0	0
Yellow Perch	16	m	p	0	0	0
Spottail Shiner	17	i	i	0	0	0
Golden Redhorse	17	m	i	0	0	0
Total Species				20	19	17
Total Ind. Per site				204	101	137
CPUE (# fish/minute)				4.23	2.53	2.99

[1] i =Intolerant, m=intermediate, t =tolerant

[2] i = insectivore, o =omnivore, p = piscivore, f =filterer, h =herbivore

Appendix II. (Cont.)

Fish Species	SPA	TV[1]	TR[2]	Sample Site RR1	RR2r	RR2	RR3
Central stoneroller	1	m	h	1	1	0	0
Common Shiner	1	m	i	0	18	4	15
Redfin Shiner	1	m	i	5	7	8	7
Bluntnose Minnow	1	t	o	3	8	5	5
Creek Chub	1	t	i	8	8	2	1
Johnny Darter	1	m	i	10	13	2	2
Green Sunfish hybrid	2	t	i	0	0	0	0
Bluegill	2	t	i	0	7	14	4
Mottled Sculpin	3	m	i	3	1	4	0
Fathead Minnow	4	t	o	0	0	0	0
White Sucker	4	t	o	1	4	5	6
Green Sunfish	8	t	i	3	0	0	0
Blackside Darter	9	m	i	3	0	0	2
Pirate Perch	9	m	i	0	0	0	0
Bowfin	9	m	p	0	0	0	0
Central Mudminnow	9	t	o	0	0	1	0
Walleye	10	m	p	0	0	0	0
Common carp	10	t	o	1	0	1	1
Spotfin Shiner	12	m	i	9	6	7	15
Logperch	12	m	i	0	0	1	0
Shorthead Redhorse	12	m	i	0	0	0	0
Hornyhead Chub	13	i	i	1		0	23
Grass Pickerel	13	m	p	0	2	1	0
Amer. Brook Lamprey	na	i	f	0	0	0	0
Rock Bass >5 inches	14	i	i	0	2	4	0
Rock Bass <5 inches	14	m	i	1	1	0	0
Rainbow Darter	14	i	i	0	1	4	4
Largemouth Bass	14	t	p	0	0	0	1
Silver Shiner (E)	na	i	i	0	10	0	0
Striped Shiner	15	m	i	0	4	17	13
Northern Hogsucker	15	i	i	5	6	4	49
River Chub	15	i	i	0	3	0	52
Greenside Darter	15	m	i	9	6	2	7
Smallmouth Bass	15	m	i	1	2	0	3
Black Redhorse	15	i	i	3	0	0	0
Stonecat	15	i	i	0	0	2	0
Rosyface Shiner	16	i	i	0	4	0	13
Silverjaw Minnow	na	m	i	0	0	0	3
Yellow Perch	16	m	p	0	0	0	0
Spottail Shiner	17	i	i	1	0	0	0
Golden Redhorse	17	m	i	0	1	0	0
Total Species				18	22	19	20
Total Ind. Per site				68	115	88	226
CPUE (# fish/minute)				1.25	1.35	1.75	4.12

[1] **i =Intolerant, m=intermediate, t =tolerant**

[2] **i = insectivore, o =omnivore, p = piscivore, f =filterer, h =herbivore**

Appendix II. (Cont.)

Fish Species	SPA	TV[1]	TR[2]	Sample Site SJ1	SJ2	SJ3
Central stoneroller	1	m	h	0	2	0
Common Shiner	1	m	i	2	17	6
Redfin Shiner	1	m	i	1	0	2
Bluntnose Minnow	1	t	o	9	7	12
Creek Chub	1	t	i	37	1	5
Johnny Darter	1	m	i	21	1	9
Green Sunfish hybrid	2	t	i	1	1	0
Bluegill	2	t	i	1	1	0
Mottled Sculpin	3	m	i	0	0	2
Fathead Minnow	4	t	o	8	0	0
White Sucker	4	t	o	6	1	5
Green Sunfish	8	t	i	0	1	0
Blackside Darter	9	m	i	6	0	0
Pirate Perch	9	m	i	0	0	0
Bowfin	9	m	p	0	0	0
Central Mudminnow	9	t	o	0	0	1
Walleye	10	m	p	0	0	0
Common carp	10	t	o	1	1	0
Spotfin Shiner	12	m	i	0	0	0
Logperch	12	m	i	0	0	0
Shorthead Redhorse	12	m	i	0	0	1
Hornyhead Chub	13	i	i	2	7	4
Grass Pickerel	13	m	p	0	0	0
Amer. Brook Lamprey	na	i	f	0	0	0
Rock Bass >5 inches	14	i	i	0	3	5
Rock Bass <5 inches	14	m	i	3	3	14
Rainbow Darter	14	i	i	58	7	16
Largemouth Bass	14	t	p	0	0	0
Silver Shiner (E)	na	i	i	0	0	0
Striped Shiner	15	m	i	20	26	18
Northern Hogsucker	15	i	i	1	6	1
River Chub	15	i	i	3	3	0
Greenside Darter	15	m	i	0	0	0
Smallmouth Bass	15	m	i	2	12	1
Black Redhorse	15	i	i	0	0	0
Stonecat	15	i	i	3	1	0
Rosyface Shiner	16	i	i	19	0	35
Silverjaw Minnow	na	m	i	0	0	0
Yellow Perch	16	m	p	0	0	0
Spottail Shiner	17	i	i	0	0	0
Golden Redhorse	17	m	i	0	0	0
Total Species				20	23	25
Total Ind. Per site				130	101	77
CPUE (# fish/minute)				2.12	1.49	1.25

[1] i =Intolerant, m=intermediate, t =tolerant

[2] i = insectivore, o =omnivore, p = piscivore, f =filterer, h =herbivore

Appendix III. Mussel species data from three riparian forest buffer width classes in replicated in four river basins, including the Grand (GR), Kalamazoo (KZ), Raisin (RR) and Joseph (SJ) rivers. Tolerance values- I=intolerant, m=intermediate, t=tolerant. Species with letters are listed as (T) =state threatened or (SC) =state special concern within the State Michi

		<125m				125-250m				250-500m			
Mussel Species	**TV**	**GR1**	**KZ1**	**RR1**	**SJ1**	**GR2**	**KZ2**	**RR2**	**SJ2**	**GR3**	**KZ3**	**RR3**	**SJ3**
Actinonaias ligamentina	**m**	**4**	**1**	**2**	**7**	**0**	*	**2**	**55**	*	**1**	**12**	**4**
Amblema plicata	**t**	**1**								**1**			
Alasmidonta marginata SC	**i**			**5**								**4**	**2**
Alasmidonta viridis SC	**i**		**1**		*						**4**		
Anadonta grandis	**t**	**0**		**1**								**0**	
Cyclonaias tuberculata SC	**i**							**93**					
Elliptio dilatata	**m**	**6**	**248**	**0**	**35**	**0**	*	**61**	**13**	*	**44**	**2**	**28**
Fusconaia flava	**m**	*	*	*			**1**	**190**	**1**	*	**1**	**7**	**1**
Lampsilis fasciola T	**i**							**11**			**2**	**1**	
Lampsilis ventricosa	**m**	**1**	**9**	**2**	**6**		**1**	**30**	**5**			**15**	**6**
Lampsilis siliquoidea	**t**	**0**	**1**	**11**			**0**		**4**	**4**		**1**	**1**
Lasmogona compressa	**m**		**4**	**5**					**2**			**14**	
Lasmigona costata	**m**		*	**1**	**3**		*	*	**2**			**1**	**4**
Pleurobema coccinium SC	**i**	**9**	**74**		*		**1**	**31**	**1**		**6**	**1**	**2**
Ptychobranchus fasciolaris	**m**											**2**	
Strophitus undulatus	**t**			**1**	**1**			**1**	**7**	**1**			
Venustaconcha ellipsiformis SC	**i**		**2**					**1**	**1**		*		**1**
Vilosa iris SC	**i**	**3**	**80**	*	**2**		**2**	**1**	**10**	*	**46**		**6**
Total # of Individuals		**24**	**420**	**28**	**54**	**0**	**5**	**421**	**101**	**6**	**104**	**60**	**55**
Total Native Species per site		**6**	**9**	**8**	**6**	**0**	**4**	**10**	**11**	**3**	**7**	**11**	**10**
Mussels / man-hour		**21.8**	**72.4**	**14.0**	**28.1**	**0.0**	**1.2**	**127.6**	**42.1**	**7.2**	**35.9**	**31.6**	**26.2**
Relative abundance of Intolerant		**0.5**	**0.4**	**0.2**	**0.0**	**0.0**	**0.6**	**0.3**	**0.1**	**0.0**	**0.6**	**0.1**	**0.2**
Relative abundance of Tolerant		**0.0**	**0.0**	**0.5**	**0.0**	**1.0**	**0.0**	**0.0**	**0.1**	**1.0**	**0.0**	**0.0**	**0.0**

Appendix IV. Mussel species presence/absence data for the river basins by riparian width. (X) indicates presence, (XX) indicates dominant species, (*) indicates valves, but no live specimens and blanks absence. Species with letters are listed as T-Threatened or SC-Special Concern within the State of Michigan.

	Study Sites (<125m)			
Mussel Species	**GR**	**KZ**	**RR**	**SJ**
Actinonaias ligamentina **(Mucket)**	X	X	X	X
Amblema plicata **(Three-ridge)**	X		*	
Alasmidonta marginata **(Elktoe)**[SC]			X	
Alasmidonta viridis **(Slippershell)**[SC]		X		
Anadonta grandi **(Giant Floater)**			X	
Cyclonaias tuberculata **(Purple Warty-back)**[SC]				
Elliptio dilatata **(Spike)**	X	XX		XX
Fusconaia flava **(Wabash Pig-toe)**	*	X	*	*
Lampsilis fasciol **a (Wavy-rayed Lampmussel)**[T]				
Lampsilis ventricosa **(Plain Pocketbook)**	X	X	X	X
Lampsilis siliquoidea **(Fatmucket)**		X	XX	
Lasmogona compressa **(Creek Heelsplitter)**		X	X	
Lasmigona costata **(Fluted-shell)**		*	X	X
Pleurobema coccinium **(Round Pig-toe)**[SC]	XX	X		*
Ptychobranchus fasciolaris **(Kidneyshell)**				
Strophitus undulatus **(Squawfoot)**			X	X
Venustaconcha ellipsiformis **(Ellipse)**[SC]		X		
Vilosa iris **(Rainbow)**[SC]	X	X	*	X
Total # of Native Mussel Species	**6**	**10**	**8**	**6**
Exotic Mussel Species				
Corbicula flumenia **(Asiatic Clam)**		X		X
Dressenia polymorpha **(Zebra Mussel)**				

Appendix V. Qualitative invertebrate species data from the combined Surber and multi-habitat dipnet sampling for sites with varied riparian forest buffer widths in the Grand (GR), Kalamazoo (KZ), Raisin (RR) and St. Joseph (SJ) rivers. Presence or absence is indicated by a (1) or a (0), respectively. (L) indicates larvae in cases of the Coleoptera where adults were also collected and identified to species.

		<125m				125-250m				250-500m			
Family	**Genus**	**GR**	**KZ**	**RR**	**SJ**	**GR**	**KZ**	**RR**	**SJ**	**GR**	**KZ**	**RR**	**SJ**
Dytiscidae	*Hydroporus*	0	0	0	0	1	0	0	0	0	0	0	0
Elmidae	*Ancyronyx variegata*	0	0	0	0	1	0	1	0	0	0	1	1
Elmidae	*Dubiraphia (L)*	1	0	1	1	0	0	0	1	1	1	1	1
Elmidae	*Dubiraphia bivittata*	1	1	1	0	1	0	0	0	0	0	1	0
Elmidae	*Macronychus glabratus*	1	1	1	1	1	1	1	1	1	1	1	1
Elmidae	*Optioservus fastiditus*	0	0	0	0	0	0	0	1	0	0	0	0
Elmidae	*Optioservus (L)*	1	1	1	1	1	1	1	1	1	1	1	1
Elmidae	*Optioservus ovalis*	0	0	0	0	0	1	0	0	0	0	0	0
Elmidae	*Optioservus trivittatus*	1	1	0	0	0	0	0	0	0	1	0	0
Elmidae	*Stenelmis (L)*	1	1	1	1	0	1	1	1	1	1	1	1
Elmidae	*Stenelmis crenata*	1	1	1	1	0	0	1	1	0	0	1	1
Elmidae	*Stenelmis decorata*	0	0	1	0	0	0	0	0	0	0	0	0
Elmidae	*Stenelmis grossa*	0	0	1	0	0	0	0	0	0	0	0	0
Elmidae	*Stenelmis musgravii*	0	1	0	0	0	1	0	0	0	0	0	0
Gyrinidae	*Dineutus (L)*	0	0	0	0	0	0	1	0	0	1	0	0
Gyrinidae	*Gyrinus*	0	0	0	0	1	0	0	0	1	0	0	0
Hydrophilidae	*Sperchopsis sp.*	1	1	0	0	0	1	1	0	0	1	0	0
Psephenidae	*Ectopria nervosa*	1	1	0	0	0	0	1	0	0	1	0	1
Psephenidae	*Psephenus herricki*	0	1	0	0	0	1	1	1	0	1	0	0
Scirtidae	*Scirtes*	1	0	1	0	0	0	0	0	0	1	0	0
Athericidae	*Atherix variegata*	1	1	0	0	0	0	0	0	0	1	1	0
Ceratopogonidae	*Bezzia/Palpomyia sp.*	1	0	0	0	0	0	1	0	1	0	1	1
Ceratopogonidae	*Probezzia*	0	0	0	0	1	0	0	0	0	0	0	0
Chironomidae	*Chironominae*	1	1	1	1	0	1	1	1	1	1	1	1
Chironomidae	*Corynoneura*	1	0	0	0	0	0	0	0	0	0	0	0
Chironomidae	*Cricotopus*	0	1	1	1	0	0	1	0	0	1	0	1
Chironomidae	*Microtendipes*	0	1	0	0	0	1	0	1	0	0	0	0
Chironomidae	*Orthocladiinae*	0	0	1	1	1	1	1	1	0	1	1	1
Chironomidae	*Orthocladiinae sp. 1*	1	1	1	1	1	1	1	1	1	1	1	1
Chironomidae	*Orthocladiinae sp. 2*	1	1	1	0	0	0	0	0	1	1	1	1
Chironomidae	*Orthocladiinae sp. 3*	0	0	0	0	0	0	0	0	0	0	0	0
Chironomidae	*Paratendipes*	1	1	0	0	0	0	1	1	1	1	0	0
Chironomidae	*Polypedilum sp. A*	1	1	0	0	0	0	1	1	1	0	1	0
Chironomidae	*Stenochironomus*	0	0	0	1	0	1	1	1	0	0	0	0
Chironomidae	*Tanypodinae*	1	1	1	1	1	1	1	1	1	1	1	1
Chironomidae	*Tanypodinae sp2*	1	1	1	1	1	1	1	1	1	1	1	0
Chironomidae	*Tanypodinae sp3*	0	1	0	1	0	0	0	0	0	0	0	0
Chironomidae	*Tanytarsini sp1*	1	1	1	0	1	0	1	0	1	0	1	1

Appendix V. (cont.)

		<125m				125-250m				250-500m			
Family	**Genus**	**GR1**	**KZ1**	**RR1**	**SJ1**	**GR2**	**KZ2**	**RR2**	**SJ2**	**GR3**	**KZ3**	**RR3**	**SJ3**
Chironomidae	*Xylotopus*	0	1	0	0	1	0	0	0	1	1	1	0
Empididae	*Chelifera*	0	0	0	1	0	0	0	1	0	0	0	0
Empididae	*Clinocera*	0	1	0	1	0	0	0	0	0	0	0	0
Empididae	*Hemerodromia*	1	1	1	1	0	0	1	1	1	1	1	1
Pychodidae	*Psychoda*	1	0	0	0	0	0	0	0	0	0	0	0
Simuliidae	*Simulium*	1	0	0	1	1	1	1	1	1	1	1	0
Tabanidae	*Chrysops*	1	1	0	1	0	1	1	1	0	1	0	0
Tabanidae	*Tabanus sp.*	0	0	0	1	0	0	0	0	0	0	0	0
Tipulidae	*Antocha*	1	1	0	0	0	1	1	1	0	1	0	1
Tipulidae	*Hexatoma*	0	1	1	1	0	0	1	0	0	0	1	0
Tipulidae	*Pedicia*	0	0	0	1	0	0	1	0	0	0	0	0
Tipulidae	*Tipula abdominalis*	0	0	0	0	0	0	0	0	0	1	0	0
Ameletidae	*Ameletus lineatus*	0	0	0	1	0	0	1	0	0	1	0	0
Baetiscidae	*Baetisca laurentia*	0	0	0	1	0	0	0	0	1	0	0	1
Beatidae	*Acentrella*	1	0	0	0	0	0	0	0	0	0	0	0
Beatidae	*Acerpenna pygmaeus*	1	1	0	0	1	1	1	0	1	1	0	0
Beatidae	*Baetis sp.*	1	1	1	0	1	1	1	1	1	1	1	1
Beatidae	*Baetis tricaudatus*	0	1	0	0	0	1	0	0	0	0	0	0
Caenidae	*Brachycercus sp1*	0	0	0	0	0	0	1	0	0	0	0	0
Caenidae	*Caenis anceps*	0	1	0	1	0	0	1	1	0	1	0	1
Caenidae	*Caenis hilaris*	0	1	0	1	0	1	1	0	0	1	0	0
Ephemerallidae	*Attenella attenuata*	0	0	0	0	0	0	0	1	0	0	0	0
Ephemerallidae	*Seratella deficiens*	0	0	0	0	0	0	0	0	0	0	1	0
Ephemerallidae	*Timpanoga simplex*	0	0	0	0	0	0	0	0	0	1	0	0
Ephemeridae	*Ephemera simulans*	0	1	0	1	0	0	0	0	0	0	0	1
Ephemeridae	*Hexagenia limbata*	0	0	0	0	0	0	0	0	1	1	0	0
Heptageniidae	*Heptagenia flavescens*	0	0	0	1	0	0	0	0	1	0	0	0
Heptageniidae	*Leucrocuta hebe*	0	0	0	0	0	0	1	0	0	0	1	0
Heptageniidae	*Stenacron interpunctatum*	1	0	1	1	1	0	0	1	1	0	0	1
Heptageniidae	*Stenonema exiguum*	1	1	1	1	0	1	1	1	1	1	1	1
Heptageniidae	*S. luteum*	0	0	0	0	0	0	0	1	0	1	0	0
Heptageniidae	*S. mediopunctatum*	0	1	0	1	0	0	1	1	0	1	0	0
Heptageniidae	*S. pulchellum*	1	0	1	1	0	1	1	1	1	0	0	1
Heptageniidae	*S. terminatum*	1	1	1	1	1	1	1	1	1	1	1	1
Isonychiidae	*Isonychia bicolor*	1	1	0	0	0	1	1	1	0	1	1	0
Leptohyphidae	*Tricorythodes*	0	1	1	0	0	1	1	1	0	1	1	0
Leptohyphidae	*Tricorythodes sp2*	0	0	1	0	0	1	0	0	0	0	0	0
Leptophlebiidae	*Paraleptophlebia*	0	0	0	1	0	0	1	0	0	0	0	0
Polymitarcyidae	*Epheron leukon*	0	1	1	1	0	1	1	1	0	1	1	1
Potamanthidae	*Anthopotamus distinctus*	0	1	0	0	0	0	0	0	0	0	0	0
Belastomatidae	*Belastoma flumineum*	0	0	0	0	1	0	0	0	0	0	0	0
Corixidae		0	1	0	1	0	0	0	1	0	0	0	1
Gerridae	*Gerris sp.*	0	0	0	0	0	1	0	0	1	0	0	0
Veliidae	*Metrobates*	0	0	1	0	1	1	1	0	0	0	1	0
Veliidae	*Rhagovelia obesa*	0	0	1	1	0	0	1	0	0	1	1	1
Veliidae	*Rheumatobates*	0	0	1	0	0	0	1	0	1	0	1	1

Appendix V. (cont.)

		<125m				125-250m				250-500m			
Family	**Genus**	**GR1**	**KZ1**	**RR1**	**SJ1**	**GR2**	**KZ2**	**RR2**	**SJ2**	**GR3**	**KZ3**	**RR3**	**SJ3**
Hydropsychidae	*Hydropsyche orris*	0	0	1	0	0	0	1	0	0	0	0	0
Hydropsychidae	*Hydropsyche phalearata*	0	0	0	0	0	1	1	0	0	0	0	0
Hydropsychidae	*Hydropsyche simulans*	1	1	1	0	1	1	1	1	1	0	1	0
Hydropsychidae	*Macrostemum zebratum*	0	0	0	0	0	0	1	0	0	0	1	0
Hydroptilidae	*Hydroptila*	1	1	0	1	0	0	0	0	0	0	0	0
Lepidostomatidae	*Lepidostoma*	0	0	0	0	1	1	0	0	1	0	0	0
Leptoceridae	*Nectopsyche diarina*	0	1	1	0	0	1	1	1	0	1	1	1
Leptoceridae	*Nectopsyche exquisita*	0	0	1	1	0	0	0	1	0	0	0	0
Leptoceridae	*Mystacides*	0	0	0	1	0	1	0	0	0	0	0	0
Leptoceridae	*Oecetis avara*	0	1	0	1	0	0	0	0	0	1	0	0
Leptoceridae	*Oecetis persimilis*	1	0	0	0	0	0	0	0	0	0	0	0
Leptoceridae	*Oecetis sp.*	0	0	1	0	0	0	0	0	0	0	0	0
Leptoceridae	*Trianoides ignitus*	1	0	1	0	0	0	1	0	0	0	0	0
Leptoceridae	*Trianoides marginatus*	1	0	0	0	1	0	0	0	0	0	0	1
Limnephilidae	*Hydatophylax*	0	0	0	0	0	0	1	0	0	0	0	0
Limnephilidae	*Pycnopsyche*	1	0	0	0	0	0	1	1	0	1	0	0
Molannidae	*Molanna flavicornis*	0	0	0	1	0	0	0	0	0	0	0	0
Philopotamidae	*Chimarra*	1	0	0	0	0	0	1	1	0	1	1	0
Polycentropodidae	*Neureclipsis*	1	1	1	1	1	1	1	0	1	1	0	0
Polycentropodidae	*Cyrnellus fraternus*	1	0	0	0	0	0	0	0	1	0	0	0
Polycentropodidae	*Polycentropus*	1	0	1	1	1	0	1	0	1	0	1	1
Psychomidae	*Lype diversa*	1	0	0	0	0	0	0	0	1	0	0	0
Psychomidae	*Psychomyia flavida*	0	0	0	1	0	0	0	0	0	0	0	0
Rhyacophilidae	*Rhyacophila*	1	0	0	0	0	0	0	0	0	0	0	0
Uenoidae	*Neophylax*	1	1	0	1	0	1	1	1	0	0	0	1
Acariformes		0	1	1	1	1	0	1	1	0	0	1	1
Hirundinia	*Glossisphonidae*	0	0	0	0	0	0	0	0	1	0	0	0
Oligochaeta	*Naididae*	1	0	0	0	1	0	0	0	1	0	0	0
Oligochaeta	*Tubificidae*	1	1	1	1	1	1	1	1	1	1	1	1
Cambaridae	*Orconectes propinquus*	1	0	0	0	0	0	0	0	0	0	0	1
Cambaridae	*Orconectes rusticus*	1	1	1	1	1	0	0	1	1	1	1	0
Gammaridae	*Gammarus sp*	1	1	1	1	1	1	1	1	1	1	1	1
Gammaridae	*Hyallela azteca*	1	0	0	0	0	0	1	1	1	0	0	0
Isopoda	*Caecidotea*	1	0	1	1	1	1	0	0	1	0	0	0
Ancylidae	*Ferrissia*	1	0	1	1	0	1	1	0	1	1	1	1
Hydrobiidae		1	1	0	1	0	1	1	1	1	1	0	1
Lymnaeidae	*Fossaria*	1	1	0	0	1	0	0	0	1	1	0	1
Physidae	*Physa/Physella*	0	1	0	1	1	1	0	0	1	1	0	1
Planorbiidae		1	1	0	0	0	1	0	1	1	0	0	1
Pleuroceridae		1	0	0	0	0	0	0	0	1	0	0	1
Pleuroceridae	*Elimia sp.*	0	0	1	0	0	0	0	1	1	0	0	0
Pleuroceridae	*Leptoxis sp.*	1	1	0	0	0	1	0	0	1	1	0	1
Viviparidae	*Viviparus*	1	0	0	0	0	0	0	0	1	0	0	0
Corbiculidae	*Corbicula fluminea*	0	1	0	0	0	1	0	0	0	0	1	1
Sphaeridae	*Musculium*	1	0	1	1	0	0	1	1	1	0	1	1
Sphaeridae	*Pisidium*	1	1	1	1	1	0	1	1	1	1	1	1
Sphaeridae	*Sphaerium*	1	1	1	1	0	1	1	1	1	1	1	1
Total species per site		**82**	**77**	**57**	**75**	**38**	**59**	**83**	**69**	**60**	**76**	**55**	**60**

Appendix VI. Quantitative Invertebrate species data (mean individuals / m2) from Surber samples (n=6) for the river basins by riparian width. Tolerance values- 0-3=intolerant, 3.5-6.5=intermediate, 7-10=tolerant. (L) indicates larvae in cases of the Coleoptera where adults were also collected and identified to species.

			<125m				125-250m				250-500m			
Family	**Genus**	**TV**	**GR1**	**KZ1**	**RR1**	**SJ1**	**GR2**	**KZ2**	**RR2**	**SJ2**	**GR3**	**KZ3**	**RR3**	**SJ3**
Dytiscidae	*Hydroporus*	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elmidae	*Ancyronyx variegata*	4.5	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	1.6
Elmidae	*Dubiraphia (L)*	4.5	148.2	0.0	12.8	0.0	0.0	1.8	0.0	0.0	3.7	0.9	0.0	1.6
Elmidae	*Dubiraphia bivittata*	4.5	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elmidae	*Macronychus glabratus*	4.5	0.0	0.0	0.0	0.0	0.0	0.9	0.0	1.8	0.0	0.0	0.0	0.0
Elmidae	*Optioservus fastiditus*	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0
Elmidae	*Optioservus (L)*	4.5	740.8	106.3	21.1	20.2	0.0	121.0	165.0	249.3	1.8	124.7	49.5	111.6
Elmidae	*Optioservus trivittatus*	4.5	63.5	3.7	0.0	0.0	0.0	0.9	0.0	0.0	0.0	1.8	0.0	0.0
Elmidae	*Stenelmis (L)*	4.5	2391.8	786.5	209.0	81.6	0.0	109.1	682.0	221.8	31.2	83.4	165.0	279.7
Elmidae	*Stenelmis crenata*	4.5	317.5	5.5	0.0	7.3	0.0	14.7	38.5	23.8	0.0	0.0	0.0	4.7
Elmidae	*Stenelmis decorata*	4.5	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elmidae	*Stenelmis grossa*	4.5	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elmidae	*Stenelmis musgravii*	4.5	0.0	33.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0
Gyrinidae	*Dineutus (L)*	4.5	0.0	0.0	0.0	0.0	0.0	0.9	1.8	0.0	0.0	1.8	0.0	0.0
Psephenidae	*Ectopria nervosa*	4.5	148.2	3.7	0.0	0.0	0.0	5.5	3.7	0.0	0.0	0.9	0.0	1.6
Psephenidae	*Psephenus herricki*	4.5	0.0	0.0	0.0	0.0	0.0	10.1	14.7	0.0	0.0	3.7	0.0	0.0
Scirtidae	*Scirtes*	4.5	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	1.8	0.0	0.0
Athericidae	*Atherix variegata*	4.0	42.3	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceratopogonidae	*Bezzia/Palpomyia sp.*	6.0	42.3	0.0	0.0	0.0	0.0	0.0	14.7	0.0	5.5	0.0	7.3	3.1
Ceratopogonidae	*Probezzia*	6.0	0.0	0.0	0.0	0.0	84.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chironomidae	*Chironominae*	6.0	465.7	183.3	40.3	69.7	0.0	10.1	36.7	66.0	33.0	13.8	40.3	133.6
Chironomidae	*Corynoneura*	6.0	127.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chironomidae	*Cricotopus*	6.0	0.0	53.2	9.2	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	133.6
Chironomidae	*Orthocladiinae*	6.0	0.0	0.0	52.3	117.3	0.0	10.1	90.0	160.0	16.5	13.8	62.3	9.4
Chironomidae	*Orthocladiinae sp. 1*	6.0	550.3	183.3	51.3	99.0	0.0	10.1	88.0	155.8	16.5	13.8	58.7	121.0
Chironomidae	*Orthocladiinae sp. 2*	6.0	444.5	88.0	10.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	114.7
Chironomidae	*Stenochironomus*	6.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	7.3	0.0	0.0	0.0	0.0
Chironomidae	*Tanypodinae*	6.0	550.3	128.3	51.3	85.3	0.0	10.1	88.0	91.7	33.0	13.8	60.5	25.1
Chironomidae	*Tanypodinae sp2*	6.0	0.0	104.5	44.0	76.1	148.2	10.1	88.0	18.3	0.0	13.8	60.5	0.0
Chironomidae	*Tanytarsini sp1*	6.0	63.5	0.0	2.8	0.0	0.0	0.0	60.5	0.0	14.7	0.0	49.5	1.6
Empididae	*Chelifera*	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0
Empididae	*Clinocera*	6.0	0.0	1.8	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Empididae	*Hemerodromia*	6.0	148.2	5.5	0.0	1.8	0.0	7.3	14.7	44.0	9.2	1.8	14.7	36.1
Pychodidae	*Psychoda*	4.0	42.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Simuliidae	*Simulium*	4.0	486.8	0.0	0.0	0.0	0.0	26.6	7.3	1.8	0.0	0.0	7.3	0.0
Tabanidae	*Chrysops*	5.0	42.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tipulidae	*Antocha*	3.0	127.0	34.8	0.0	0.0	0.0	11.9	20.2	5.5	0.0	3.7	0.0	22.0
Tipulidae	*Hexatoma*	4.0	0.0	3.7	0.9	0.0	0.0	0.0	12.8	0.0	0.0	0.0	42.2	0.0

Appendix VI. (cont.)

Family	Genus	TV	GR1	KZ1	RR1	SJ1	GR2	KZ2	RR2	SJ2	GR3	KZ3	RR3	SJ3
Ameletidae	*Ameletus lineatus*	3.0	0.0	0.0	0.0	0.0	0.0	1.8	16.5	0.0	0.0	1.8	0.0	0.0
Baetiscidae	*Baetisca laurentia*	3.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	7.3	0.0	0.0	6.3
Beatidae	*Acerpenna pygmaeus*	4.5	0.0	0.0	0.0	0.0	0.0	0.0	23.8	0.0	0.0	0.0	0.0	0.0
Beatidae	*Baetis sp.*	4.5	105.8	34.8	19.3	0.0	0.0	17.4	1.8	0.0	5.5	5.5	1.8	0.0
Caenidae	*Caenis anceps*	7.0	0.0	273.2	0.0	44.9	0.0	73.3	630.7	67.8	0.0	493.2	0.0	12.6
Caenidae	*Caenis hilaris*	7.0	0.0	18.3	0.0	0.0	0.0	4.6	67.8	0.0	0.0	47.7	0.0	0.0
Ephemeridae	*Ephemera simulans*	4.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heptageniidae	*Leucrocuta hebe*	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	1.8	0.0
Heptageniidae	*Stenacron interpunctatum*	6.0	359.8	0.0	44.0	1.8	0.0	0.0	0.0	0.0	5.5	0.0	0.0	15.7
Heptageniidae	*Stenonema exiguum*	3.0	21.2	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0
Heptageniidae	*S. luteum*	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	0.0	0.0	0.0	0.0
Heptageniidae	*S. mediopunctatum*	4.0	0.0	11.0	0.0	1.8	0.0	2.8	45.8	3.7	0.0	13.8	0.0	0.0
Heptageniidae	*S. pulchellum*	3.0	21.2	0.0	1.8	1.8	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0
Heptageniidae	*S. terminatum*	4.0	359.8	25.7	132.9	12.8	0.0	7.3	25.7	9.2	0.0	35.8	11.0	0.0
Isonychiidae	*Isonychia bicolor*	2.0	21.2	0.0	0.0	0.0	0.0	1.8	1.8	0.0	0.0	2.8	0.0	0.0
Leptohyphidae	*Tricorythodes*	4.0	0.0	16.5	67.8	0.0	0.0	75.2	432.7	11.0	0.0	0.0	0.0	0.0
Leptohyphidae	*Tricorythodes sp2*	4.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leptophlebiidae	*Paraleptophlebia*	2.0	0.0	0.0	0.0	3.7	0.0	0.0	58.7	0.0	0.0	0.0	0.0	0.0
Polymitarcyidae	*Epheron leukon*	2.0	0.0	29.3	4.6	8.3	0.0	5.5	78.8	34.8	0.0	0.9	7.3	12.6
Veliidae	*Metrobates*	5.0	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0
Veliidae	*Rhagovelia obesa*	5.0	0.0	0.0	0.9	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0
Veliidae	*Rheumatobates*	5.0	0.0	0.0	1.8	0.0	0.0	0.0	1.8	0.0	1.8	0.0	1.8	0.0
Pyralidae	*Petrophila*	5.0	0.0	1.8	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0
Corydalidae	*Corydalus cornutus*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0
Corydalidae	*Nigronia serricornis*	2.5	148.2	0.0	0.0	0.0	0.0	0.9	0.0	1.8	0.0	2.8	0.0	1.6
Sialidae	*Sialis*	4.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aeschnidae	*Boyeria vinosa*	4.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0
Calopterygidae	*Calopteryx maculata*	5.0	0.0	0.0	0.0	0.9	0.0	0.9	0.0	0.0	0.0	0.9	0.0	0.0
Gomphidae	*Ophiogomphus carolinus*	4.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	1.8	0.0	0.9	0.0	0.0
Gomphidae	*O. rupinsulensis*	4.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gomphidae	*Stylogomphus albistylus*	4.0	0.0	9.2	0.0	0.0	0.0	1.8	0.0	3.7	0.0	3.7	0.0	0.0
Gomphidae	*Stylurus notatus*	4.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.9	0.0	0.0
Chloroperlidae	*Utaperla gaspersium*	0.0	0.0	0.0	20.2	8.3	0.0	0.0	9.2	0.0	0.0	0.0	0.0	0.0
Nemouridae	*Amphinemura*	2.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	0.0	0.0	0.0	0.0	0.0
Perlidae	*Acroneuria arida*	1.0	21.2	0.0	0.0	0.9	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0
Perlidae	*Paragnetina*	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0
Perlidae	*Perlesta placida complex*	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0
Pteronarcyidae	*Pteronarcys*	1.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brachycentridae	*Brachycentrus numerosus*	3.0	0.0	0.0	0.0	0.0	0.0	1.8	9.2	1.8	5.5	0.0	0.0	3.1
Brachycentridae	*Micrasema sp.*	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0
Glossosomatidae	*Glossosoma*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.3	0.0	0.0	0.0	0.0	1.6
Helicopsychidae	*Helicopsyche borealis*	3.0	21.2	0.0	0.0	0.0	0.0	0.9	9.2	1.8	7.3	0.0	0.0	1.6
Hydropsychidae	*Ceratopsyche bronta*	3.5	0.0	3.7	0.0	0.0	0.0	0.0	0.0	20.2	0.0	1.8	0.0	0.0

Appendix VI. (continued)

Family	Genus	TV	GR1	KZ1	RR1	SJ1	GR2	KZ2	RR2	SJ2	GR3	KZ3	RR3	SJ3
Hydropsychidae	***Ceratopsyche morosa***	**3.5**	**0.0**	**3.7**	**0.0**	**0.0**	**0.0**	**10.1**	**1.8**	**0.0**	**0.0**	**10.1**	**0.0**	**0.0**
Hydropsychidae	***C. slossonae***	**3.5**	**0.0**	**0.0**	**0.0**	**0.9**	**0.0**	**5.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Hydropsychidae	***C. sparna***	**3.5**	**0.0**	**14.7**	**0.0**	**0.0**	**0.0**	**6.4**	**3.7**	**3.7**	**0.0**	**19.3**	**0.0**	**0.0**
Hydropsychidae	***Cheumatopsyche***	**5.0**	**2201.3**	**122.8**	**15.6**	**35.8**	**0.0**	**21.1**	**148.5**	**58.7**	**14.7**	**34.8**	**12.8**	**78.6**
Hydropsychidae	***Hydropsyche betteni***	**5.0**	**0.0**	**3.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.6**
Hydropsychidae	***Hydropsyche demora***	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Hydropsychidae	***Hydropsyche leonardi***	**3.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Hydropsychidae	***Hydropsyche orris***	**3.5**	**0.0**	**0.0**	**2.8**	**0.0**	**0.0**	**0.0**	**3.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Hydropsychidae	***Hydropsyche phalearata***	**3.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**12.8**	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Hydropsychidae	***Hydropsyche simulans***	**5.0**	**21.2**	**5.5**	**2.8**	**0.0**	**0.0**	**19.3**	**51.3**	**11.0**	**0.0**	**0.0**	**0.0**	**0.0**
Hydropsychidae	***Macrostemum zebratum***	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Hydroptilidae	***Hydroptila***	**4.0**	**63.5**	**14.7**	**0.0**	**0.9**	**0.0**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Lepidostomatidae	***Lepidostoma***	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**16.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Leptoceridae	***Nectopsyche diarina***	**4.0**	**0.0**	**0.0**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Leptoceridae	***Nectopsyche exquisita***	**4.0**	**0.0**	**0.0**	**0.0**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Leptoceridae	***Oecetis avara***	**4.0**	**0.0**	**3.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Leptoceridae	***Oecetis sp.***	**4.0**	**0.0**	**0.0**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Leptoceridae	***Trianoides ignitus***	**4.0**	**0.0**	**0.0**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Limnephilidae	***Pycnopsyche***	**4.0**	**21.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5.5**	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**
Philopotamidae	***Chimarra***	**3.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**55.0**	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**
Polycentropodidae	***Neureclipsis***	**4.0**	**0.0**	**0.0**	**0.9**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Polycentropodidae	***Polycentropus***	**4.0**	**0.0**	**0.0**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Psychomidae	***Lype diversa***	**2.0**	**42.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Uenoidae	***Neophylax***	**4.0**	**529.2**	**49.5**	**0.0**	**0.9**	**0.0**	**0.9**	**38.5**	**25.7**	**0.0**	**0.0**	**0.0**	**28.3**
Acariformes		**4.0**	**148.2**	**11.0**	**15.6**	**15.6**	**0.0**	**7.3**	**9.2**	**33.0**	**0.0**	**0.0**	**3.7**	**37.7**
Hirundinia	***Glossisphonidae***	**6.0**	**0.0**	**0.0**	**0.0**	**0.0**	**21.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Oligochaeta	***Tubificidae***	**8.0**	**2561.2**	**33.0**	**83.4**	**357.5**	**867.8**	**2.8**	**75.2**	**38.5**	**104.5**	**3.7**	**49.5**	**484.0**
Cambaridae	***Orconectes propinquus***	**6.0**	**42.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.6**
Cambaridae	***Orconectes rusticus***	**6.0**	**0.0**	**0.0**	**0.0**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Gammaridae	***Gammarus sp***	**4.0**	**444.5**	**40.3**	**46.8**	**43.1**	**42.3**	**50.4**	**62.3**	**188.8**	**137.5**	**53.2**	**23.8**	**106.9**
Gammaridae	***Hyallela azteca***	**8.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**148.5**	**3.7**	**0.0**	**0.0**	**0.0**	**0.0**
Isopoda	***Caecidotea***	**8.0**	**105.8**	**0.0**	**6.4**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**3.7**	**0.0**	**0.0**	**0.0**
Ancylidae	***Ferrissia***	**6.0**	**148.2**	**0.0**	**32.1**	**38.5**	**0.0**	**4.6**	**7.3**	**0.0**	**0.0**	**3.7**	**1.8**	**17.3**
Hydrobiidae		**6.0**	**0.0**	**9.2**	**0.0**	**0.0**	**0.0**	**2.8**	**0.0**	**18.3**	**12.8**	**3.7**	**0.0**	**4.7**
Lymnaeidae	***Fossaria***	**6.0**	**21.2**	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.8**	**0.0**	**0.0**	**1.6**
Physidae	***Physa/Physella***	**6.0**	**0.0**	**0.0**	**0.0**	**0.0**	**42.3**	**0.0**	**0.0**	**0.0**	**5.5**	**0.0**	**0.0**	**1.6**
Planorbiidae		**6.0**	**0.0**	**5.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.8**	**0.0**	**0.0**	**0.0**
Pleuroceridae	***Elimia sp.***	**6.0**	**0.0**	**0.0**	**0.9**	**0.0**	**0.0**	**0.9**	**0.0**	**7.3**	**0.0**	**0.0**	**0.0**	**0.0**
Pleuroceridae	***Leptoxis sp.***	**6.0**	**0.0**	**11.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.7**	**0.0**	**0.0**	**4.7**
Corbiculidae	***Corbicula fluminea***	**4.0**	**0.0**	**1.8**	**0.0**	**0.0**	**0.0**	**10.1**	**0.0**	**0.0**	**0.0**	**0.0**	**276.8**	**3.1**
Sphaeridae	***Musculium***	**6.0**	**0.0**	**0.0**	**0.0**	**0.9**	**0.0**	**0.0**	**1.8**	**5.5**	**3.7**	**0.0**	**0.0**	**0.0**
Sphaeridae	***Pisidium***	**6.0**	**84.7**	**33.0**	**2.8**	**7.3**	**0.0**	**12.8**	**11.0**	**16.5**	**242.0**	**23.8**	**7.3**	**78.6**
Sphaeridae	***Sphaerium***	**6.0**	**63.5**	**14.7**	**0.0**	**12.8**	**0.0**	**22.0**	**7.3**	**51.3**	**133.8**	**33.9**	**1.8**	**75.4**
Average Total Densities			**14850**	**2539**	**1044**	**1174**	**1207**	**876**	**3518**	**1689**	**865**	**1092**	**1023**	**1982**

Appendix VII. Bird species observed during migration surveys (M, May 2001) and breeding surveys (B, June 2001). Incidental sightings by other research team members are indicated by "X." State-listed as special concern (SC) and threatened (ST) species are indicated.

	Grand River			Kalamazoo River			River Raisin			St. Joesph		
Species Common Name	<125	125-250	250-500	<125	125-250	250-500	<125	125-250	250-500	<125	125-250	250-500
Great Blue Heron	X			X	X		B	X	M		X	X
Mallard	M		B		B							
Wood Duck	M	MB	M			M						
Canada Goose	MB			M		M		M	M		M	M
Mute Swan								M				
Northern Harrier (SC)							B					
Cooper's Hawk (SC)					X							
Red Tailed Hawk					B		B				M	
Wild Turkey		B				B			B			
Killdeer			B			B						
Mourning Dove	M									B		
Yellow-billed Cuckoo												M
Ruby-throated Hummingbird				M								
Belted Kingfisher	M	M			B		X				X	X
Red-headed Woodpecker												M
Red-bellied Woodpecker		MB		MB	M	MB					B	B
Downy Woodpecker	MB	B		MB	M	MB	B	M	B		B	B
Hairy Woodpecker										M B		M
Northern Flicker		M		M		M	M	M	B		B	
Pileated Woodpecker							B					
Eastern Wood Peewee	B	B	B	MB	B	B	B	B	M B	M B	M B	M B
Acadian Flycatcher	B		B	B	M	B		B	B	B	B	B
Least Flycatcher											M	
Great Crested Flycatcher	MB	M	M	MB	B		B	M B	M B	M B	B	B
Tree Swallow								M B				
Yellow-throated Vireo		B	M	M		M		B				
Warbling Vireo	B								B			
Red-eyed Vireo	B	B		MB	MB		B	B	M B	M B	M B	M B
Blue Jay		M	B		MB	B	M B	M B		B		M B
American Crow	MB		MB	MB	M	M		B	M B	M B	M B	M B
Black-capped Chickadee	MB	M	MB	B	B	MB	M	M B	B	B	M B	M
Tufted Titmouse	B	M	MB	M	MB	M	B	M		B	B	M B
White-breasted Nuthatch	M	B	B		MB	M	M B	M		M		B
House Wren	M			B			M	M		M	M	
Blue-gray Gnatcatcher	M	M	M					M	M B		B	
Eastern Bluebird							B					
Veery	B		M	M					M			
Swainson's Thrush									M			M
Hermit Thrush											M	M
Wood Thrush				M	B	B	M B	B				M
American Robin	M	M	B			M				B		
Gray Catbird		B	B	B	M	B	M B	M			B	
Tennessee Warbler	M	M		M	M							M
Nashville Warbler		M										
Northern Parula												B
Yellow Warbler	MB			M				M			M B	
Black-throated Blue Warbler										M		
Blackburnian Warbler		M		M	M					M		
Yellow-throated Warbler (ST)								M				
BlacK-and-white Warbler			B									
American Redstart										M	M	
Ovenbird			MB	M	M					M		
Northern Waterthrush						B						
Common Yellowthroat	MB	M	MB			MB		M B				
Scarlet Tanager	MB	B				M					B	M
Eastern Towhee				M				B				
Field Sparrow	B			B	M	M		B	B			
Song Sparrow	MB	M	MB	B	MB	MB	B	M B		M B	M B	B
Swamp Sparrow	M				M							
White-throated Sparrow								M				M
Northern Cardinal	MB	M	MB	MB	B	B	M B	B	M	M B	M B	
Rose-breasted Grosbeak	M	M			B	M	M B	M B		M	M	M
Indigo Bunting	B			M	MB				M B	M	M B	B
Bobolink								B				
Red-winged Blackbird								B				
Common Grackle		M					B		M	B		
Brown-headed Cowbird	B		M	B	M			M B				
Baltimore Oriole	MB		M		M	M	M		M	B	B	
American Goldfinch		B	M	M	B	MB	M	M B	M B	B	B	

Appendix VIII. Mammal species observed from trap arrays set within riparian study sites representing three levels of riparian forest buffer width (<125m, 125-250m and 250-500m).

Mammal Species	**Grand River**			**Kalamazoo River**			**River Raisin**			**St. Joesph River**		
	<125	125-250	250-500	<125	125-250	250-500	<125	125-250	250-500	<125	125-250	250-500
Peromyscus spp.	X	X	X	X	X	X	X	X	X	X	X	X
Raccoon (*Procyon lotor*)	X	X	X	X	X	X	X	X	X	X	X	X
Eastern Chipmunk (*Tamias striatus*)			X									
Fox Squirrel (*Sciurus niger*)	X	X	X	X	X	X	X	X	X	X	X	X
Oppossum (*Didelphis virginiana*)			X	X		X	X	X	X	X		X
Grey Squirrel (*Sciurus carolinensis*)				X							X	
Striped Skunk (*Mephitis mephitis*)				X								
Red- Fox (*Vulpes vulpes*)				X						X	X	
White-tailed Deer (*Odocoileus virginianus)*	X	X	X	X	X	X	X	X	X	X	X	X
Coyote (*Canis latrans*)			X			X						
Muskrat (*Ondatra zibethicus*)						X				X		
Long-tailed Weasle (*Mustela frenata*)	X				X							
Masked Shrew (*Sorex cinereus*)	X	X	X	X	X	X					X	
Meadow Vole (*Microtus pennsylvanicus*)	X									X		
Northern short-tailed shrew (*Blarina brevicauda*)	X		X	X	X	X			X			
Meadow jumping mouse (*Zapus hudsonius*)	X	X	X				X	X	X			X
Star-nosed mole (*Condylura cristata*)		X						X				
Total # of Mammal Species	9	7	10	10	7	9	6	7	7	8	7	6

Appendix IX. Native plant species observed during the riparian ecosystem study. Coefficients of conservatism (C), wetness classes and physiognomy descriptions are provided for each species.

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Agrimonia gryposepala	TALL AGRIMONY	2	FACU+	Nt P-Forb
Agrimonia pubescens	SOFT AGRIMONY	5	UPL	Nt P-Forb
Alisma plantago-aquatica	WATER PLANTAIN	1	OBL	Nt P-Forb
Allium cernuum	NODDING WILD ONION	5	UPL	Nt P-Forb
Allium tricoccum	WILD LEEK	5	FACU+	Nt P-Forb
Alnus rugosa	TAG ALDER	5	OBL	Nt Shrub
Ambrosia trifida	GIANT RAGWEED	0	FAC+	Nt A-Forb
Amphicarpaea bracteata	HOG PEANUT	5	FAC	Nt A-Forb
Anemone canadensis	CANADA ANEMONE	4	FACW	Nt P-Forb
Anemone quinquefolia	WOOD ANEMONE	5	FAC	Nt P-Forb
Anemonella thalictroides	RUE ANEMONE	8	UPL	Nt P-Forb
Angelica atropurpurea	ANGELICA	6	OBL	Nt P-Forb
Apios americana	GROUNDNUT	3	FACW	Nt P-Forb
Apocynum cannabinum	INDIAN HEMP	3	FAC	Nt P-Forb
Arabis laevigata	SMOOTH BANK CRESS	5	UPL	Nt B-Forb
Arenaria lateriflora	WOOD SANDWORT	5	FACU	Nt P-Forb
Arisaema dracontium	GREEN DRAGON	8	FACW	Nt P-Forb
Arisaema triphyllum	JACK IN THE PULPIT	5	FACW-	Nt P-Forb
Asarum canadense	WILD GINGER	5	UPL	Nt P-Forb
Asclepias syriaca	COMMON MILKWEED	1	UPL	Nt P-Forb
Asimina triloba	PAWPAW	9	FAC	Nt Tree
Asplenium platyneuron	EBONY SPLEENWORT	2	FACU	Nt Fern
Aster cordifolius	HEART LEAVED ASTER	4	UPL	Nt P-Forb
Aster lateriflorus	SIDE FLOWERING ASTER	2	FACW-	Nt P-Forb
Aster oolentangiensis	PRAIRIE HEART LEAVED ASTER	4	UPL	Nt P-Forb
Aster pilosus	HAIRY ASTER	1	FACU+	Nt P-Forb
Aster puniceus	SWAMP ASTER	5	OBL	Nt P-Forb
Aster umbellatus	TALL FLAT TOP WHITE ASTER	5	FACW	Nt P-Forb
Athyrium filix-femina	LADY FERN	4	FAC	Nt Fern
Athyrium thelypterioides	SILVERY SPLEENWORT	6	FAC	Nt Fern
Betula alleghaniensis	YELLOW BIRCH	7	FAC	Nt Tree
Boehmeria cylindrica	FALSE NETTLE	5	OBL	Nt P-Forb
Botrychium dissectum	CUT LEAVED GRAPE FERN	5	FAC	Nt Fern
Botrychium virginianum	RATTLESNAKE FERN	5	FACU	Nt Fern
Bromus latiglumis	EAR LEAVED BROME	6	FACW-	Nt P-Grass
Calamagrostis canadensis	BLUE JOINT GRASS	3	OBL	Nt P-Grass
Caltha palustris	MARSH MARIGOLD	6	OBL	Nt P-Forb
Calystegia sepium	HEDGE BINDWEED	2	FAC	Nt P-Forb
Campanula americana	TALL BELLFLOWER	8	FAC	Nt A-Forb
Campanula aparinoides	MARSH BELLFLOWER	7	OBL	Nt P-Forb
Cardamine bulbosa	SPRING CRESS	4	OBL	Nt P-Forb
Carex amphibola	SEDGE	8	FACW-	Nt P-Sedge
Carex bebbii	SEDGE	4	OBL	Nt P-Sedge
Carex bicknellii	SEDGE	10	FAC-	Nt P-Sedge
Carex blanda	SEDGE	1	FAC	Nt P-Sedge
Carex bromoides	SEDGE	6	FACW+	Nt P-Sedge
Carex cephaloidea	SEDGE	5	FACU+	Nt P-Sedge
Carex cephalophora	SEDGE	3	FACU	Nt P-Sedge
Carex crinita	SEDGE	4	FACW+	Nt P-Sedge
Carex deweyana	SEDGE	3	FACU-	Nt P-Sedge
Carex gracilescens	SEDGE	5	UPL	Nt P-Sedge
Carex gracillima	SEDGE	4	FACU	Nt P-Sedge
Carex granularis	SEDGE	2	FACW+	Nt P-Sedge
Carex grayi	SEDGE	6	FACW+	Nt P-Sedge

Appendix IX. (Cont.)

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Carex hirtifolia	SEDGE	5	UPL	Nt P-Sedge
Carex hystericina	SEDGE	2	OBL	Nt P-Sedge
Carex intumescens	SEDGE	3	FACW+	Nt P-Sedge
Carex jamesii	JAMES' SEDGE	8	UPL	Nt P-Sedge
Carex lacustris	SEDGE	6	OBL	Nt P-Sedge
Carex laxiculmis	SEDGE	8	UPL	Nt P-Sedge
Carex leptalea	SEDGE	5	OBL	Nt P-Sedge
Carex leptonervia	SEDGE	3	FAC	Nt P-Sedge
Carex lupulina	SEDGE	4	OBL	Nt P-Sedge
Carex molesta	SEDGE	2	FACU+	Nt P-Sedge
Carex muskingumensis	SEDGE	6	OBL	Nt P-Sedge
Carex normalis	SEDGE	5	FACW	Nt P-Sedge
Carex pensylvanica	SEDGE	4	UPL	Nt P-Sedge
Carex prairea	SEDGE	10	FACW+	Nt P-Sedge
Carex projecta	SEDGE	3	FACW+	Nt P-Sedge
Carex rosea	CURLY STYLED WOOD SEDGE	2	UPL	Nt P-Sedge
Carex rostrata	SEDGE	10	OBL	Nt P-Sedge
Carex sparganioides	SEDGE	5	FAC	Nt P-Sedge
Carex sprengelii	SEDGE	5	FAC	Nt P-Sedge
***Carex squarrosa* (SC)**	**SEDGE**	**9**	**OBL**	**Nt P-Sedge**
Carex stipata	SEDGE	1	OBL	Nt P-Sedge
Carex stricta	SEDGE	4	OBL	Nt P-Sedge
Carex swanii	SEDGE	4	FACU	Nt P-Sedge
***Carex trichocarpa* (SC)**	**HAIRY FRUITED SEDGE**	**8**	**OBL**	**Nt P-Sedge**
Carex vesicaria	SEDGE	7	OBL	Nt P-Sedge
Carex vulpinoidea	SEDGE	1	OBL	Nt P-Sedge
Carpinus caroliniana	BLUE BEECH	6	FAC	Nt Tree
Carya cordiformis	BITTERNUT HICKORY	5	FAC	Nt Tree
Carya glabra	PIGNUT HICKORY	5	FACU	Nt Tree
Carya laciniosa	SHELLBARK HICKORY	9	FACW	Nt Tree
Carya ovata	SHAGBARK HICKORY	5	FACU	Nt Tree
Celastrus scandens	AMERICAN BITTERSWEET	3	FACU	Nt W-Vine
Celtis occidentalis	HACKBERRY	5	FAC-	Nt Tree
Cephalanthus occidentalis	BUTTONBUSH	7	OBL	Nt Shrub
Cercis canadensis	REDBUD	8	FACU	Nt Tree
Chelone glabra	TURTLEHEAD	7	OBL	Nt P-Forb
Cicuta maculata	WATER HEMLOCK	4	OBL	Nt B-Forb
Cinna arundinacea	WOOD REEDGRASS	7	FACW	Nt P-Grass
Circaea lutetiana	ENCHANTER'S NIGHTSHADE	2	FACU	Nt P-Forb
Cirsium discolor	PASTURE THISTLE	4	UPL	Nt B-Forb
Cirsium muticum	SWAMP THISTLE	6	OBL	Nt B-Forb
Claytonia virginica	SPRING BEAUTY	4	FACU	Nt P-Forb
Clematis virginiana	VIRGIN'S BOWER	4	FAC	Nt W-Vine
Collinsonia canadensis	RICHWEED	8	FAC	Nt P-Forb
Conopholis americana	SQUAWROOT	10	UPL	Nt P-Forb
Conyza canadensis	HORSEWEED	0	FAC-	Nt A-Forb
Cornus alternifolia	ALTERNATE LEAVED DOGWOOD	5	UPL	Nt Tree
Cornus amomum	SILKY DOGWOOD	2	FACW+	Nt Shrub
Cornus florida	FLOWERING DOGWOOD	8	FACU-	Nt Tree
Cornus foemina	GRAY DOGWOOD	1	FACW-	Nt Shrub
Cornus stolonifera	RED OSIER DOGWOOD	2	FACW	Nt Shrub
Corylus americana	HAZELNUT	5	FACU-	Nt Shrub
Cryptotaenia canadensis	HONEWORT	2	FAC	Nt P-Forb
Cuscuta gronovii	COMMON DODDER	3	FACW	Nt A-Forb
Cyperus esculentus	FIELD NUT SEDGE	1	FACW	Nt P-Sedge
Cystopteris fragilis	FRAGILE FERN	4	FACU	Nt Fern

Appendix IX. (Cont.)

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Decodon verticillatus	WHORLED or SWAMP LOOSESTRIFE	7	OBL	Nt Shrub
Dentaria laciniata	CUT LEAVED TOOTHWORT	5	FACU	Nt P-Forb
Desmodium glutinosum	CLUSTERED LEAVED TICK TREFOIL	5	UPL	Nt P-Forb
Dioscorea villosa	WILD YAM	4	FAC-	Nt P-Forb
Dryopteris carthusiana	SPINULOSE WOODFERN	5	FACW-	Nt Fern
Dryopteris cristata	CRESTED SHIELD FERN	6	OBL	Nt Fern
Dryopteris intermedia	EVERGREEN WOODFERN	5	FAC	Nt Fern
Echinocystis lobata	WILD CUCUMBER	2	FACW-	Nt A-Forb
Elymus canadensis	CANADA WILD RYE	7	FAC-	Nt P-Grass
Elymus virginicus	VIRGINIA WILD RYE	4	FACW-	Nt P-Grass
Epilobium coloratum	CINNAMON WILLOW HERB	3	OBL	Nt P-Forb
Equisetum arvense	COMMON HORSETAIL	0	FAC	Nt Fern Ally
Equisetum hyemale	SCOURING RUSH	2	FACW-	Nt Fern Ally
Equisetum laevigatum	SMOOTH SCOURING RUSH	2	FACW	Nt Fern Ally
Erigeron annuus	ANNUAL FLEABANE	0	FAC-	Nt B-Forb
Erigeron philadelphicus	MARSH FLEABANE	2	FACW	Nt P-Forb
***Euonymus atropurpurea* (SC)**	**WAHOO; BURNING BUSH**	**8**	**FAC-**	**Nt Shrub**
Euonymus obovata	RUNNING STRAWBERRY BUSH	5	UPL	Nt Shrub
Eupatorium maculatum	JOE PYE WEED	4	OBL	Nt P-Forb
Eupatorium perfoliatum	COMMON BONESET	4	FACW+	Nt P-Forb
Eupatorium purpureum	PURPLE JOE PYE WEED	5	FAC	Nt P-Forb
Eupatorium rugosum	WHITE SNAKEROOT	4	FACU	Nt P-Forb
Euphorbia corollata	FLOWERING SPURGE	4	UPL	Nt P-Forb
Euthamia graminifolia	GRASS LEAVED GOLDENROD	3	FACW-	Nt P-Forb
Fagus grandifolia	AMERICAN BEECH	6	FACU	Nt Tree
Festuca subverticillata	NODDING FESCUE	5	FACU+	Nt P-Grass
Fragaria virginiana	WILD STRAWBERRY	2	FAC-	Nt P-Forb
Fraxinus americana	WHITE ASH	5	FACU	Nt Tree
Fraxinus nigra	BLACK ASH	6	FACW+	Nt Tree
Fraxinus pennsylvanica	RED ASH	2	FACW	Nt Tree
***Fraxinus profunda* (T)**	**PUMPKIN ASH**	**9**	**OBL**	**Nt Tree**
Galium aparine	ANNUAL BEDSTRAW	0	FACU	Nt A-Forb
Galium boreale	NORTHERN BEDSTRAW	3	FAC	Nt P-Forb
Galium circaezans	WHITE WILD LICORICE	4	FACU-	Nt P-Forb
Galium labradoricum	BOG BEDSTRAW	8	OBL	Nt P-Forb
Galium obtusum	WILD MADDER	5	OBL	Nt P-Forb
Galium tinctorium	STIFF BEDSTRAW	5	OBL	Nt P-Forb
Galium triflorum	FRAGRANT BEDSTRAW	4	FACU+	Nt P-Forb
Geranium maculatum	WILD GERANIUM	4	FACU	Nt P-Forb
Geum canadense	WHITE AVENS	1	FAC	Nt P-Forb
Gleditsia triacanthos	HONEY LOCUST	8	FAC	Nt Tree
Glyceria canadensis	RATTLESNAKE GRASS	8	OBL	Nt P-Grass
Glyceria striata	FOWL MANNA GRASS	4	OBL	Nt P-Grass
Hackelia virginiana	BEGGAR'S LICE	1	FAC-	Nt P-Forb
Hamamelis virginiana	WITCH HAZEL	5	FACU	Nt Shrub
Helenium autumnale	SNEEZEWEED	5	FACW+	Nt P-Forb
Helianthus giganteus	TALL SUNFLOWER	5	FACW	Nt P-Forb
Hepatica americana	ROUND LOBED HEPATICA	6	UPL	Nt P-Forb
Hypericum prolificum	SHRUBBY ST.JOHN'S WORT	5	FACU	Nt Shrub
Hystrix patula	BOTTLEBRUSH GRASS	5	UPL	Nt P-Grass
Ilex verticillata	MICHIGAN HOLLY	5	FACW+	Nt Shrub
Impatiens capensis	SPOTTED TOUCH ME NOT	2	FACW	Nt A-Forb
Iris virginica	SOUTHERN BLUE FLAG	5	OBL	Nt P-Forb
Juglans cinerea	BUTTERNUT	5	FACU+	Nt Tree
Juglans nigra	BLACK WALNUT	5	FACU	Nt Tree
Juncus biflorus	TWO FLOWERED RUSH	8	FACW	Nt P-Forb

Appendix IX. (Cont.)

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Juncus effusus	SOFT STEMMED RUSH	3	OBL	Nt P-Forb
Juncus tenuis	PATH RUSH	1	FAC	Nt P-Forb
Juniperus virginiana	RED CEDAR	3	FACU	Nt Tree
Lactuca biennis	TALL BLUE LETTUCE	2	FAC	Nt B-Forb
Laportea canadensis	WOOD NETTLE	4	FACW	Nt P-Forb
Lathyrus palustris	MARSH PEA	7	FACW	Nt P-Forb
Leersia oryzoides	CUT GRASS	3	OBL	Nt P-Grass
Leersia virginica	WHITE GRASS	5	FACW	Nt P-Grass
Lemna minor	SMALL DUCKWEED	5	OBL	Nt A-Forb
Lilium michiganense	MICHIGAN LILY	5	FAC+	Nt P-Forb
Lindera benzoin	SPICEBUSH	7	FACW-	Nt Shrub
Liriodendron tulipifera	TULIP TREE	9	FACU+	Nt Tree
Lobelia cardinalis	CARDINAL FLOWER	7	OBL	Nt P-Forb
Lobelia siphilitica	GREAT BLUE LOBELIA	4	FACW+	Nt P-Forb
Lonicera dioica	RED HONEYSUCKLE	5	FACU	Nt W-Vine
Luzula acuminata	HAIRY WOOD RUSH	5	FAC-	Nt P-Forb
Luzula multiflora	COMMON WOOD RUSH	5	FACU	Nt P-Forb
Lycopus americanus	COMMON WATER HOREHOUND	2	OBL	Nt P-Forb
Lycopus uniflorus	NORTHERN BUGLE WEED	2	OBL	Nt P-Forb
Lysimachia ciliata	FRINGED LOOSESTRIFE	4	FACW	Nt P-Forb
Lysimachia quadriflora	WHORLED LOOSESTRIFE	10	OBL	Nt P-Forb
Lysimachia thyrsiflora	TUFTED LOOSESTRIFE	6	OBL	Nt P-Forb
Maianthemum canadense	CANADA MAYFLOWER	4	FAC	Nt P-Forb
Malus coronaria	AMERICAN CRAB	4	UPL	Nt Tree
Menispermum canadense	MOONSEED	5	FAC	Nt W-Vine
Mentha arvensis	WILD MINT	3	FACW	Nt P-Forb
Mitella diphylla	BISHOP'S CAP	8	FACU+	Nt P-Forb
Monarda fistulosa	WILD BERGAMOT	2	FACU	Nt P-Forb
***Morus rubra* (T)**	**RED MULBERRY**	**9**	**FAC-**	**Nt Tree**
Muhlenbergia mexicana	LEAFY SATIN GRASS	3	FACW	Nt P-Grass
Muhlenbergia sylvatica	WOODLAND SATIN GRASS	8	FACW	Nt P-Grass
Nuphar advena	YELLOW POND LILY	8	OBL	Nt P-Forb
Nuphar variegata	YELLOW POND LILY	7	OBL	Nt P-Forb
Onoclea sensibilis	SENSITIVE FERN	2	FACW	Nt Fern
Osmorhiza claytonii	HAIRY SWEET CICELY	4	FACU-	Nt P-Forb
Osmorhiza longistylis	SMOOTH SWEET CICELY	3	FACU-	Nt P-Forb
Osmunda regalis	ROYAL FERN	5	OBL	Nt Fern
Ostrya virginiana	IRONWOOD; HOP HORNBEAM	5	FACU-	Nt Tree
Oxalis stricta	COMMON YELLOW WOOD SORREL	0	FACU	Nt P-Forb
Panicum clandestinum	PANIC GRASS	3	FACW	Nt P-Grass
Parthenocissus quinquefolia	VIRGINIA CREEPER	5	FAC-	Nt W-Vine
Pedicularis lanceolata	SWAMP BETONY	8	FACW+	Nt P-Forb
Peltandra virginica	ARROW ARUM	6	OBL	Nt P-Forb
Penstemon digitalis	FOXGLOVE BEARD TONGUE	2	FAC-	Nt P-Forb
Phalaris arundinacea	REED CANARY GRASS	0	FACW+	Nt P-Grass
Phlox divaricata	WOODLAND PHLOX	5	FACU	Nt P-Forb
Physocarpus opulifolius	NINEBARK	4	FACW-	Nt Shrub
Phytolacca americana	POKEWEED	2	FAC-	Nt P-Forb
Pilea fontana	BOG CLEARWEED	5	FACW	Nt A-Forb
Pilea pumila	CLEARWEED	5	FACW	Nt A-Forb
Platanus occidentalis	SYCAMORE	7	FACW	Nt Tree
Poa alsodes	BLUEGRASS	9	FACW-	Nt P-Grass
Poa nemoralis	BLUEGRASS	5	FAC	Nt P-Grass
Poa sylvestris	WOODLAND BLUEGRASS	8	FAC	Nt P-Grass
Podophyllum peltatum	MAY APPLE	3	FACU	Nt P-Forb
Polygonatum biflorum	SOLOMON SEAL	4	FACU	Nt P-Forb

Appendix IX. (Cont.)

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Polygonatum pubescens	DOWNY SOLOMON SEAL	5	UPL	Nt P-Forb
Polygonum punctatum	SMARTWEED	5	OBL	Nt A-Forb
Polygonum sagittatum	ARROW LEAVED TEAR THUMB	5	OBL	Nt A-Forb
Polygonum virginianum	JUMPSEED	4	FAC	Nt P-Forb
Polymnia canadensis	LEAFCUP	6	UPL	Nt P-Forb
Polystichum acrostichoides	CHRISTMAS FERN	6	UPL	Nt Fern
Populus deltoides	COTTONWOOD	1	FAC+	Nt Tree
Populus grandidentata	BIG TOOTHED ASPEN	4	FACU	Nt Tree
Populus tremuloides	QUAKING ASPEN	1	FAC	Nt Tree
Potamogeton pectinatus	SAGO PONDWEED	3	OBL	Nt P-Forb
Potentilla simplex	OLD FIELD CINQUEFOIL	2	FACU-	Nt P-Forb
Prenanthes alba	WHITE LETTUCE	5	FACU	Nt P-Forb
Prunus serotina	WILD BLACK CHERRY	2	FACU	Nt Tree
Prunus virginiana	CHOKE CHERRY	2	FAC-	Nt Shrub
Pycnanthemum virginianum	COMMON MOUNTAIN MINT	5	FACW+	Nt P-Forb
Quercus alba	WHITE OAK	5	FACU	Nt Tree
Quercus bicolor	SWAMP WHITE OAK	8	FACW+	Nt Tree
Quercus imbricaria	SHINGLE OAK	5	FAC-	Nt Tree
Quercus macrocarpa	BUR OAK	5	FAC-	Nt Tree
Quercus muehlenbergii	CHINQUAPIN OAK	5	UPL	Nt Tree
Quercus palustris	PIN OAK	8	FACW	Nt Tree
Quercus rubra	RED OAK	5	FACU	Nt Tree
Quercus velutina	BLACK OAK	6	UPL	Nt Tree
Ranunculus abortivus	SMALL FLOWERED BUTTERCUP	0	FACW-	Nt A-Forb
Ranunculus flabellaris	YELLOW WATER CROWFOOT	10	OBL	Nt P-Forb
Ranunculus hispidus	SWAMP BUTTERCUP	5	FAC	Nt P-Forb
Ranunculus recurvatus	HOOKED CROWFOOT	5	FACW	Nt A-Forb
Ribes americanum	WILD BLACK CURRANT	6	FACW	Nt Shrub
Ribes cynosbati	PRICKLY or WILD GOOSEBERRY	4	UPL	Nt Shrub
Rosa palustris	SWAMP ROSE	5	OBL	Nt Shrub
Rubus allegheniensis	COMMON BLACKBERRY	1	FACU+	Nt Shrub
Rubus flagellaris	NORTHERN DEWBERRY	1	FACU-	Nt Shrub
Rubus hispidus	SWAMP DEWBERRY	4	FACW	Nt Shrub
Rubus occidentalis	BLACK RASPBERRY	1	UPL	Nt Shrub
Rubus pubescens	DWARF RASPBERRY	4	FACW+	Nt P-Forb
Rubus strigosus	WILD RED RASPBERRY	2	FACW-	Nt Shrub
Rudbeckia hirta	BLACK EYED SUSAN	1	FACU	Nt P-Forb
Rudbeckia laciniata	CUT LEAVED CONEFLOWER	6	FACW+	Nt P-Forb
Rumex orbiculatus	GREAT WATER DOCK	9	OBL	Nt P-Forb
Salix amygdaloides	PEACH LEAVED WILLOW	3	FACW	Nt Tree
Salix discolor	PUSSY WILLOW	1	FACW	Nt Shrub
Salix nigra	BLACK WILLOW	5	OBL	Nt Tree
Sambucus canadensis	ELDERBERRY	3	FACW-	Nt Shrub
Sambucus racemosa	RED BERRIED ELDER	3	FACU+	Nt Shrub
Sanguinaria canadensis	BLOODROOT	5	FACU-	Nt P-Forb
Sanicula gregaria	BLACK SNAKEROOT	2	FAC+	Nt P-Forb
Sanicula marilandica	BLACK SNAKEROOT	4	FACU	Nt P-Forb
Sassafras albidum	SASSAFRAS	5	FACU	Nt Tree
Saururus cernuus	LIZARD'S TAIL	9	OBL	Nt P-Forb
Saxifraga pensylvanica	SWAMP SAXIFRAGE	10	OBL	Nt P-Forb
Scirpus atrovirens	BULRUSH	3	OBL	Nt P-Sedge
Scutellaria galericulata	COMMON SKULLCAP	5	OBL	Nt P-Forb
Scutellaria lateriflora	MAD DOG SKULLCAP	5	OBL	Nt P-Forb
Senecio aureus	GOLDEN RAGWORT	5	FACW	Nt P-Forb
Sisyrinchium albidum	COMMON BLUE EYED GRASS	7	FACU	Nt P-Forb
Sium suave	WATER PARSNIP	5	OBL	Nt P-Forb

Appendix IX. (Cont.)

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
Smilacina racemosa	FALSE SPIKENARD	5	FACU	Nt P-Forb
Smilacina stellata	STARRY FALSE SOLOMON SEAL	5	FAC-	Nt P-Forb
Smilax ecirrhata	UPRIGHT CARRION FLOWER	6	UPL	Nt P-Forb
Smilax tamnoides	BRISTLY GREEN BRIER	5	FAC	Nt W-Vine
Solidago altissima	TALL GOLDENROD	1	FACU	Nt P-Forb
Solidago caesia	BLUE STEMMED GOLDENROD	7	FACU	Nt P-Forb
Solidago canadensis	CANADA GOLDENROD	1	FACU	Nt P-Forb
Solidago flexicaulis	BROAD LEAVED GOLDENROD	6	FACU	Nt P-Forb
Solidago gigantea	LATE GOLDENROD	3	FACW	Nt P-Forb
Solidago patula	SWAMP GOLDENROD	6	OBL	Nt P-Forb
Solidago rugosa	ROUGH GOLDENROD	3	FAC+	Nt P-Forb
Sphenopholis intermedia	SLENDER WEDGEGRASS	4	FAC	Nt P-Grass
Spiraea alba	MEADOWSWEET	4	FACW+	Nt Shrub
Stachys tenuifolia	SMOOTH HEDGE NETTLE	5	OBL	Nt P-Forb
Staphylea trifolia	BLADDERNUT	9	FAC	Nt Shrub
Stellaria longifolia	LONG LEAVED CHICKWEED	5	FACW+	Nt P-Forb
Symplocarpus foetidus	SKUNK CABBAGE	6	OBL	Nt P-Forb
Thalictrum dasycarpum	PURPLE MEADOW RUE	3	FACW-	Nt P-Forb
Thalictrum dioicum	EARLY MEADOW RUE	6	FACU+	Nt P-Forb
Thelypteris noveboracensis	NEW YORK FERN	5	FAC+	Nt Fern
Thelypteris palustris	MARSH FERN	2	FACW+	Nt Fern
Tilia americana	BASSWOOD	5	FACU	Nt Tree
Toxicodendron radicans	POISON IVY	2	FAC+	Nt W-Vine
Tradescantia ohiensis	COMMON SPIDERWORT	5	FACU+	Nt P-Forb
Trillium grandiflorum	COMMON TRILLIUM	5	UPL	Nt P-Forb
Triosteum aurantiacum	HORSE GENTIAN	5	UPL	Nt P-Forb
Triosteum perfoliatum	HORSE GENTIAN	5	UPL	Nt P-Forb
Ulmus americana	AMERICAN ELM	1	FACW-	Nt Tree
Ulmus rubra	SLIPPERY ELM	2	FAC	Nt Tree
Urtica dioica	NETTLE	1	FAC+	Nt P-Forb
Uvularia grandiflora	BELLWORT	5	UPL	Nt P-Forb
Verbena urticifolia	WHITE VERVAIN	4	FAC+	Nt P-Forb
Verbesina alternifolia	WINGSTEM	4	FACW	Nt P-Forb
Vernonia missurica	MISSOURI IRONWEED	4	FAC+	Nt P-Forb
Veronicastrum virginicum	CULVER'S ROOT	8	FAC	Nt P-Forb
Viburnum dentatum	SMOOTH ARROW WOOD	6	FACW-	Nt Shrub
Viburnum lentago	NANNYBERRY	4	FAC+	Nt Shrub
Viola blanda	SWEET WHITE VIOLET	5	FACW-	Nt P-Forb
Viola nephrophylla	NORTHERN BOG VIOLET	8	FACW+	Nt P-Forb
Viola pubescens	YELLOW VIOLET	4	FACU-	Nt P-Forb
Viola sororia	COMMON BLUE VIOLET	1	FAC-	Nt P-Forb
Vitis riparia	RIVERBANK GRAPE	3	FACW-	Nt W-Vine
Zanthoxylum americanum	PRICKLY ASH	3	UPL	Nt Shrub
Zizia aurea	GOLDEN ALEXANDERS	6	FAC+	Nt P-Forb

Appendix X. Adventive plant species observed during the riparian ecosystem study. Coefficients of conservatism (C), wetness classes and physiognomy descriptions are provided for each species.

SCIENTIFIC NAME	COMMON NAME	C	WETNESS	PHYSIOGNOMY
AGROSTIS GIGANTEA	REDTOP	0	FAC	Ad P-Grass
AILANTHUS ALTISSIMA	TREE OF HEAVEN	0	UPL	Ad Tree
ALLIARIA PETIOLATA	GARLIC MUSTARD	0	FAC	Ad B-Forb
ARCTIUM MINUS	COMMON BURDOCK	0	UPL	Ad B-Forb
ASPARAGUS OFFICINALIS	ASPARAGUS	0	FACU	Ad P-Forb
BARBAREA VULGARIS	YELLOW ROCKET	0	FAC	Ad B-Forb
BERBERIS THUNBERGII	JAPANESE BARBERRY	0	FACU-	Ad Shrub
BROMUS INERMIS	SMOOTH BROME	0	UPL	Ad P-Grass
CATALPA SPECIOSA	NORTHERN CATALPA	0	FACU	Ad Tree
CIRSIUM ARVENSE	CANADIAN THISTLE	0	FACU	Ad P-Forb
CIRSIUM VULGARE	BULL THISTLE	0	FACU-	Ad B-Forb
DACTYLIS GLOMERATA	ORCHARD GRASS	0	FACU	Ad P-Grass
ELAEAGNUS UMBELLATA	AUTUMN OLIVE	0	FACU	Ad Shrub
EUONYMUS EUROPAEA	SPINDLE TREE	0	UPL	Ad Shrub
GLECHOMA HEDERACEA	GROUND IVY	0	FACU	Ad P-Forb
HESPERIS MATRONALIS	DAME'S ROCKET	0	UPL	Ad P-Forb
LATHYRUS TUBEROSUS	TUBEROUS VETCHLING	0	UPL	Ad P-Forb
LEONURUS CARDIACA	MOTHERWORT	0	UPL	Ad P-Forb
LIGUSTRUM VULGARE	COMMON PRIVET	0	FAC-	Ad Shrub
LONICERA MAACKII	AMUR HONEYSUCKLE	0	UPL	Ad Shrub
LONICERA MORROWII	MORROW HONEYSUCKLE	0	UPL	Ad Shrub
LONICERA TATARICA	SMOOTH TARTARIAN HONEYSUCKLE	0	FACU	Ad Shrub
LYSIMACHIA NUMMULARIA	MONEYWORT	0	FACW+	Ad P-Forb
LYTHRUM SALICARIA	PURPLE LOOSESTRIFE	0	OBL	Ad P-Forb
MALUS PUMILA	APPLE	0	UPL	Ad Tree
MORUS ALBA	WHITE MULBERRY	0	FAC	Ad Tree
MYOSOTIS SCORPIOIDES	FORGET ME NOT	0	OBL	Ad P-Forb
NASTURTIUM OFFICINALE	WATERCRESS	0	OBL	Ad P-Grass
POA COMPRESSA	CANADA BLUEGRASS	0	FACU+	Ad P-Grass
POA TRIVIALIS	BLUEGRASS	0	FACW	Ad P-Grass
POLYGONUM PERSICARIA	LADY'S THUMB	0	FACW	Ad A-Forb
PRUNELLA VULGARIS	LAWN PRUNELLA	0	FAC	Ad P-Forb
PRUNUS AVIUM	SWEET CHERRY	0	UPL	Ad Tree
RANUNCULUS ACRIS	TALL or COMMON BUTTERCUP	0	FACW-	Ad P-Forb
RHAMNUS CATHARTICA	COMMON BUCKTHORN	0	FACU	Ad Tree
RHAMNUS FRANGULA	GLOSSY BUCKTHORN	0	FAC+	Ad Shrub
ROSA MULTIFLORA	MULTIFLORA ROSE	0	FACU	Ad Shrub
SOLANUM DULCAMARA	BITTERSWEET NIGHTSHADE	0	FAC	Ad P-Forb
STELLARIA MEDIA	COMMON CHICKWEED	0	FACU	Ad A-Forb
TARAXACUM OFFICINALE	COMMON DANDELION	0	FACU	Ad P-Forb
TORILIS JAPONICA	HEDGE PARSLEY	0	UPL	Ad A-Forb
VERONICA CHAMAEDRYS	GERMANDER SPEEDWELL	0	UPL	Ad A-Forb
VIBURNUM OPULUS	EUROPEAN HIGHBUSH CRANBERRY	0	FAC	Ad Shrub

Appendix XI. Presence/absence data for plant species observed at 12 survey sites with varied riparian forest buffer widths (i.e., <125m, 125-250m and 250-500m). Non-native species are indicated in red.

	Study Site											
	Grand River			Kalamazoo River			River Raisin			St. Joseph River		
Species	<125	125-250	250-500	<125	125-250	250-500	<125	125-250	250-500	<125	125-250	250-500
Acer negundo				X	X		X	X	X		X	
Acer nigrum		X					X	X	X			
Acer rubrum			X	X	X	X				X		
Acer saccharinum	X	X	X	X	X	X	X	X	X	X	X	X
Acer saccharum				X			X	X	X		X	X
Acorus calamus					X							
Actaea pachypoda						X						
Actaea rubra									X			
Adiantum pedatum											X	
Aesculus glabra											X	
Agalinus purpurea						X						
Agrimonia gryposepala					X			X				
Agrimonia pubescens		X	X	X		X			X		X	X
Agrostis gigantea					X							
Ailanthus altissima									X			
Alisma plantago-aquatica										X		
Alliaria petiolata	X	X	X	X	X		X		X			X
Allium cernuum	X		X			X	X	X	X		X	
Allium tricoccum									X			
Alnus rugosa				X	X	X						
Ambrosia trifida						X	X		X			X
Amphicarpaea bracteata	X		X	X	X	X					X	
Anemone canadensis			X									
Anemone quinquefolia			X		X	X						
Anemonella thalictroides				X				X				
Angelica atropurpurea				X					X			
Apios americana				X	X							
Apocynum cannabinum			X									
Arabis laevigata							X					
Arctium minus				X				X		X	X	
Arenaria lateriflora			X									
Arisaema dracontium	X	X	X			X	X	X	X	X	X	X
Arisaema triphyllum	X		X	X	X	X	X	X	X		X	X
Asarum canadense	X		X	X	X		X	X	X		X	X
Asclepias syriaca						X		X				
Asimina triloba											X	
Asparagus officinale									X			
Asplenium platyneuron									X			
Aster cordifolius									X			
Aster lateriflorus	X	X	X	X	X	X	X	X	X	X	X	X
Aster novae-angliae	X											
Aster oolentangiensis			X									
Aster pilosus	X				X							
Aster puniceus	X			X	X							
Aster umbellatus				X								
Athyrium filix-femina			X			X			X		X	
Athyrium thelypterioides									X		X	
Barbarea vulgaris			X			X						
Berberis thunbergii					X				X		X	X
Betula alleghaniensis	X											
Boehmeria cylindrica	X	X	X	X	X	X	X	X	X	X	X	X
Botrychium dissectum						X				X		X
Botrychium virginianum						X			X		X	
Bromus inermis					X							
Bromus latiglumis						X						
Calamagrostis canadensis	X			X	X	X			X			
Caltha palustris				X	X	X			X		X	
Calystegia sepium	X			X								
Campanula americana									X			
Campanula aparanoides	X			X					X			
Cardamine bulbosa	X				X	X						

Appendix XI. (Cont.)

	Study Site											
	Grand River			Kalamazoo River			River Raisin			St. Joseph River		
Species	<125	125-250	250-500	<125	125-250	250-500	<125	125-250	250-500	<125	125-250	250-500
Carex amphibola	X	X	X		X	X	X	X	X		X	
Carex bebbii					X							
Carex bicknellii	X											
Carex blanda	X	X	X	X		X	X		X			X
Carex bromoides						X			X		X	
Carex cephaloidea		X										
Carex cephalophora	X		X			X						
Carex crinita		X	X					X			X	X
Carex deweyana									X			
Carex gracilescens						X						
Carex gracillima	X	X	X		X	X		X			X	
Carex granularis			X	X	X	X						
Carex grayi	X	X	X				X	X	X	X	X	X
Carex hirtifolia		X				X			X		X	
Carex hystericina	X				X							
Carex intumescens	X					X					X	
Carex jamesii									X			
Carex lacustris	X		X			X			X	X		
Carex laxiculmis									X			
Carex leptalea				X		X						
Carex leptonervia		X	X		X				X		X	X
Carex lupulina	X		X		X		X			X	X	X
Carex molesta									X			
Carex muskingumensis			X									
Carex normalis		X										
Carex pensylvanica			X			X		X	X		X	
Carex prairea				X								
Carex projecta			X		X				X			
Carex rosea	X	X	X		X	X			X	X	X	
Carex rostrata					X							
Carex sparganioides	X								X			
Carex sprengelii									X			
Carex squarrosa			X									
Carex stipata	X	X	X	X	X	X				X	X	
Carex stricta			X	X	X	X				X	X	X
Carex swanii			X	X		X				X		
Carex trichocarpa	X											
Carex vesicaria					X							
Carex vulpinoidea				X		X				X		
Carpinus caroliniana	X		X		X	X		X	X	X	X	
Carya cordiformis	X	X	X	X	X	X	X	X	X		X	X
Carya glabra							X		X			
Carya laciniosa											X	X
Carya ovata			X			X		X	X		X	X
Catalpa speciosa					X							
Celastrus scandens									X		X	X
Celtis occidentalis			X				X		X	X		
Cephalanthus occidentalis	X	X	X					X		X	X	X
Cercis canadensis							X		X			
Chelone glabra	X				X					X		
Cicuta maculata			X	X	X	X		X	X	X	X	X
Cinna arundinacea	X		X	X	X	X	X	X	X	X	X	X
Circaea lutetiana	X	X	X	X	X	X	X	X	X		X	X
Cirsium arvense										X		
Cirsium discolor					X							
Cirsium muticum				X	X	X						
Cirsium vulgare										X		
Claytonia virginica						X						
Clematis virginiana			X	X	X	X			X			
Collinsonia canadensis			X	X		X	X		X		X	
Conopholis americana						X						
Conyza canadensis						X						
Cornus alternifolia					X	X	X		X		X	
Cornus amomum			X	X								
Cornus florida											X	

Appendix XI. (Cont.)

	Study Site											
	Grand River			Kalamazoo River			River Raisin			St. Joseph River		
Species	<125	125-250	250-500	<125	125-250	250-500	<125	125-250	250-500	<125	125-250	250-500
Cornus foemina				X	X	X		X			X	X
Cornus stolonifera	X	X		X	X	X			X			
Corylus americana		X	X	X	X	X		X	X		X	X
Crataegus sp.	X	X	X	X	X	X	X	X	X		X	
Cryptotaenia canadensis		X	X			X		X	X	X	X	X
Cuscuta gronovii		X		X								
Cyperus esculentus						X						
Cystopteris fragilis									X			
Dactylis glomerata					X							
Decodon verticillatus						X						
Dentaria laciniata		X				X						
Desmodium glutinosum									X			
Dioscorea villosa			X	X	X	X	X	X			X	X
Dryopteris carthusiana			X		X	X			X			X
Dryopteris cristata				X		X						
Dryopteris intermedia		X			X							
Echinocystis lobata		X	X	X	X		X	X				X
Elaeagnus umbellata			X					X				
Elymus canadensis						X						
Elymus virginicus	X	X	X		X	X	X	X	X	X	X	X
Epilobium coloratum				X								
Equisetum arvense	X		X	X	X	X	X		X		X	X
Equisetum hyemale							X	X	X		X	
Equisetum laevigatum					X							
Erigeron annuus									X			
Erigeron philadelphicus		X	X	X	X	X		X	X			
Euonymous europaea					X							
Euonymus atropupurea												X
Euonymus obovata			X		X	X					X	
Eupatorium maculatum				X	X		X					
Eupatorium perfoliatum				X								
Eupatorium purpureum							X		X			
Eupatorium rugosum							X					
Euphorbia corollata			X									
Euthamia graminifolia						X						
Fagus grandifolia						X	X	X	X		X	X
Festuca subverticellata						X			X			
Fragaria virginiana			X	X	X						X	
Fraxinus americana		X	X	X	X	X	X	X	X	X	X	X
Fraxinus nigra	X			X	X	X		X	X	X	X	X
Fraxinus pennsylvanica	X	X	X	X	X	X	X	X	X	X	X	X
Fraxinus profunda											X	
Galium aparine	X	X	X	X	X	X	X	X	X	X	X	X
Galium boreale											X	
Galium circaezens			X			X			X		X	
Galium labradoricum	X											
Galium obtusum			X			X					X	
Galium tinctorium			X									
Galium triflorum	X											
Geranium maculatum	X		X	X	X	X	X	X	X		X	
Geum canadense	X	X	X	X	X	X	X		X		X	X
Glechoma hederacea			X		X					X		
Gleditisia triacanthos							X					
Glyceria canadensis				X								
Glyceria striata		X	X		X	X		X	X	X	X	X
Hackelia virginiana				X	X							
Hamamelis virginica											X	
Helenium autumnale			X	X								
Helianthus giganteus					X							
Helianthus sp.						X						
Hepatica americana								X	X			
Hesperis matronalis					X	X	X		X			
Hypericum prolificum			X									
Hystrix patula						X		X	X			
Ilex verticillata			X		X	X		X	X		X	X

Appendix XI. (Cont.)

Species	Grand River <125	Grand River 125-250	Grand River 250-500	Kalamazoo River <125	Kalamazoo River 125-250	Kalamazoo River 250-500	River Raisin <125	River Raisin 125-250	River Raisin 250-500	St. Joseph River <125	St. Joseph River 125-250	St. Joseph River 250-500
Pilea pumila						X		X			X	X
Platanus occidentalis		X	X				X	X	X	X	X	X
Poa alsodes		X			X							
Poa compressa						X				X		
Poa nemoralis				X								
Poa sylvestris									X			
Poa trivialis			X									
Podophyllum peltatum		X	X	X	X	X	X	X	X	X	X	X
Polygonatum biflorum			X						X			X
Polygonatum pubescens			X			X						
Polygonum persicaria		X		X		X						
Polygonum punctatum					X							
Polygonum sagittatum					X							
Polygonum virginianum	X		X	X	X	X	X	X	X		X	X
Polymnia canadensis			X								X	
Polystichum acrostichoides									X			
Populus deltoides	X	X	X	X	X	X	X	X	X		X	X
Populus grandidentata						X					X	
Populus tremuloides	X	X	X	X	X	X		X			X	
Potamogeton pectinatus					X							
Potentilla simplex		X	X	X		X					X	X
Prenanthus alba						X		X	X			
Prunella vulgaris					X							
Prunus avium					X							
Prunus serotina		X	X	X	X	X	X	X	X	X	X	X
Prunus virginiana		X	X	X	X	X	X	X	X		X	X
Pycnanthemum virginianum				X								
Quercus alba				X					X		X	
Quercus bicolor	X	X	X	X	X	X	X	X	X	X	X	X
Quercus imbricaria				X		X						
Quercus macrocarpa	X	X	X	X		X		X	X	X	X	
Quercus muehlenbergii								X			X	
Quercus palustris			X									
Quercus rubra		X	X			X	X	X	X	X	X	X
Quercus velutina		X	X		X	X	X	X	X		X	
Ranunculus abortivus	X	X	X	X	X				X	X	X	
Ranunculus acris					X							
Ranunculus flabellaris												X
Ranunculus hispidus	X		X	X	X	X	X	X	X	X	X	X
Ranunculus recurvata			X	X		X			X			
Rhamnus cathartica		X							X			
Rhamnus frangula				X	X							
Ribes americanum	X	X	X	X	X	X	X		X			X
Ribes cynosbati		X	X			X	X	X	X		X	X
Rosa multiflora	X	X	X	X	X	X	X	X	X		X	X
Rosa palustris	X			X		X				X		X
Rubus allegheniensis		X	X	X	X	X	X		X		X	X
Rubus flagellaris			X									X
Rubus hispidus			X									
Rubus occidentalis	X	X	X	X	X	X	X	X	X	X	X	X
Rubus pubescens			X			X						
Rubus strigosis	X	X	X									
Rudbeckia hirta				X	X							
Rudbeckia laciniata	X		X				X					
Rumex orbiculatus	X		X	X		X						
Salix amygdaloides	X				X		X		X		X	
Salix discolor				X	X			X				
Salix nigra		X										
Sambucus canadensis		X	X	X	X	X	X	X	X		X	
Sambucus racemosa				X								
Sanguinaria canadensis							X	X	X			
Sanicula gregaria			X	X	X	X		X	X	X	X	X
Sanicula marilandica					X							
Sassafras albidum				X						X	X	
Saururus cernuus		X	X							X	X	X

Appendix XI. (Cont.)

Species	Study Site											
	Grand River			Kalamazoo River			River Raisin			St. Joseph River		
	<125	125-250	250-500	<125	125-250	250-500	<125	125-250	250-500	<125	125-250	250-500
Saxifraga pensylvanica				X								
Scirpus atrovirens					X	X						
Scutellaria galericulata				X								
Scutellaria lateriflora					X							X
Senecio aureus	X	X	X	X	X	X					X	
Sisyrinchium albidum			X			X					X	
Sium suave	X			X		X			X	X		X
Smilacina racemosa			X	X	X	X	X	X	X			
Smilacina stellata			X	X	X	X						
Smilax ecirrhata	X		X			X	X	X	X		X	
Smilax tamnoides		X	X		X	X	X	X	X		X	
Solanum dulcamara		X		X			X					X
Solidago altissima				X		X			X			
Solidago caesia				X				X	X		X	
Solidago canadensis			X						X			
Solidago flexicaulis											X	
Solidago gigantea	X		X	X	X	X	X		X			X
Solidago patula	X			X	X							
Solidago rugosa	X		X	X	X	X						
Sphenopholis intermedia			X			X			X			X
Spiraea alba	X		X			X						
Stachys tenuifolia							X			X		
Staphylea trifoliata			X				X	X			X	
Stellaria longifolia	X			X								
Stellaria media				X								
Symplocarpus foetidus	X		X	X	X	X		X	X	X	X	X
Taraxacum officinale			X		X	X		X			X	
Thalictrum dasycarpum	X	X	X	X	X	X		X	X	X		X
Thalictrum dioicum			X		X	X					X	
Thelypteris noveboracensis						X			X			
Thelypteris palustris	X			X	X	X			X			
Tilia americana	X	X	X	X	X	X	X	X	X	X	X	
Torilis japonica						X						
Toxicodendron radicans	X	X	X	X	X	X	X	X	X	X	X	X
Tradescantia ohioensis									X			
Trillium grandiflorum								X	X			
Triosteum aurantiacum							X					
Triosteum perfoliatum				X	X							
Ulmus americana	X	X	X	X	X	X	X	X	X	X	X	X
Ulmus rubra								X			X	
Urtica dioica		X	X	X	X		X	X		X		X
Uvularia grandiflora									X			
Verbena urticifolia						X						
Verbesina alternifolia							X		X			
Vernonia missurica		X	X									
Veronica chamaedrys		X										
Veronicastrum virginicum			X									
Viburnum dentatum			X		X							
Viburnum lentago	X	X	X	X	X	X			X	X	X	X
Viburnum opulus				X	X			X				
Viola blanda						X						
Viola nephrophylla				X								
Viola pubescens								X	X			
Viola sororia	X	X	X	X	X	X	X	X	X	X	X	X
Vitis riparia	X	X	X	X	X		X	X	X	X	X	X
Zanthoxylum americanum		X	X	X	X	X	X	X	X		X	X
Zizia aurea				X	X							
TOTALS	87	90	161	137	149	166	92	107	154	0	0	0

Appendix XII. Correlation coefficients (R) and levels of significance (p) for correlation analyses of riparian site community parameters with the spatial extent of agricultural land covers within 30, 60, 120, 240, 480 and 960m buffers adjacent to (i.e., Local) and upstream (i.e., U/S-1, U/S-2 and U/S-3) from survey sites. Significant correlations are highlighted in gray ($p<0.01$). Community parameter descriptions are provided within the report text.

Landscape Context	Buffer Width (m)	TASR		%Wood		HQI		MSR		RAIU		RAEX		MCPUE		FSR		FIBI		RAIF	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.00	0.991	0.48	0.118	-0.04	0.910	-0.03	0.919	-0.19	0.558	-0.44	0.157	-0.03	0.928	0.09	0.782	0.38	0.228	-0.27	0.401
Local	60	0.25	0.429	0.21	0.518	-0.09	0.772	-0.21	0.516	-0.04	0.913	-0.38	0.224	-0.05	0.866	0.03	0.932	0.14	0.673	-0.22	0.494
Local	120	0.40	0.194	-0.08	0.811	-0.04	0.905	0.08	0.805	0.13	0.692	-0.16	0.611	0.17	0.607	0.35	0.259	0.34	0.280	0.09	0.777
Local	240	0.41	0.180	-0.17	0.601	-0.05	0.879	0.11	0.739	0.18	0.575	-0.09	0.782	0.16	0.624	0.38	0.227	0.31	0.327	0.11	0.745
Local	480	0.44	0.149	-0.19	0.546	-0.10	0.760	-0.10	0.755	0.18	0.565	-0.10	0.746	0.13	0.678	0.09	0.781	0.04	0.895	-0.02	0.948
Local	960	0.26	0.415	-0.16	0.622	-0.22	0.488	-0.27	0.394	0.15	0.644	-0.14	0.661	-0.01	0.965	-0.13	0.689	-0.12	0.708	-0.05	0.887
U/S-1	30	0.31	0.334	-0.52	0.085	0.22	0.494	0.03	0.938	0.46	0.133	0.01	0.972	-0.04	0.894	0.40	0.193	0.37	0.235	0.36	0.257
U/S-1	60	-0.02	0.954	-0.35	0.269	-0.20	0.530	0.10	0.754	0.17	0.599	0.23	0.473	-0.01	0.982	0.36	0.244	0.17	0.599	0.02	0.954
U/S-1	120	-0.06	0.852	0.00	0.991	-0.30	0.345	0.07	0.838	-0.06	0.859	0.03	0.932	-0.06	0.860	0.38	0.222	0.15	0.652	-0.38	0.227
U/S-1	240	0.09	0.786	0.08	0.812	-0.21	0.512	0.22	0.492	-0.09	0.785	-0.09	0.778	0.15	0.648	0.48	0.118	0.28	0.376	-0.37	0.240
U/S-1	480	0.09	0.769	0.28	0.383	-0.21	0.519	0.18	0.572	-0.17	0.606	-0.30	0.337	0.20	0.526	0.38	0.220	0.37	0.234	-0.36	0.243
U/S-1	960	0.22	0.497	0.24	0.456	-0.06	0.863	0.27	0.391	-0.04	0.905	-0.29	0.363	0.36	0.249	0.28	0.378	0.44	0.151	-0.09	0.770
U/S-2	30	0.42	0.174	-0.38	0.220	0.26	0.406	0.32	0.311	0.49	0.106	0.01	0.968	0.34	0.286	0.52	0.084	0.55	0.064	0.19	0.563
U/S-2	60	0.31	0.325	-0.31	0.326	0.19	0.546	0.26	0.413	0.43	0.167	-0.02	0.950	0.25	0.432	0.43	0.158	0.48	0.114	0.19	0.561
U/S-2	120	0.30	0.347	0.03	0.931	0.05	0.870	0.25	0.431	0.18	0.581	-0.31	0.329	0.31	0.327	0.39	0.216	0.45	0.137	-0.17	0.607
U/S-2	240	0.31	0.335	0.04	0.905	0.01	0.983	0.25	0.430	0.15	0.638	-0.32	0.311	0.35	0.269	0.38	0.221	0.44	0.154	-0.21	0.512
U/S-2	480	0.30	0.344	0.11	0.744	-0.01	0.965	0.24	0.458	0.12	0.709	-0.37	0.240	0.37	0.242	0.32	0.306	0.43	0.159	-0.20	0.524
U/S-2	960	0.22	0.484	0.12	0.713	-0.04	0.897	0.31	0.328	0.05	0.879	-0.31	0.327	0.32	0.308	0.42	0.174	0.52	0.082	-0.06	0.863
U/S-3	30	0.31	0.334	-0.35	0.271	0.32	0.315	0.43	0.164	0.39	0.205	0.13	0.694	0.38	0.217	0.55	0.065	0.61	0.036	0.30	0.344
U/S-3	60	0.35	0.258	-0.32	0.316	0.40	0.200	0.45	0.141	0.38	0.224	0.05	0.883	0.43	0.163	0.59	0.043	0.68	0.016	0.32	0.304
U/S-3	120	0.32	0.311	-0.15	0.637	0.30	0.348	0.47	0.123	0.27	0.396	-0.02	0.963	0.39	0.208	0.61	0.036	0.67	0.018	0.13	0.686
U/S-3	240	0.35	0.260	-0.07	0.819	0.13	0.678	0.38	0.221	0.21	0.506	-0.15	0.648	0.39	0.213	0.56	0.058	0.58	0.046	-0.07	0.828
U/S-3	480	0.34	0.285	-0.08	0.795	-0.04	0.897	0.41	0.184	0.13	0.678	-0.08	0.796	0.45	0.145	0.56	0.059	0.51	0.089	-0.12	0.713
U/S-3	960	0.32	0.318	-0.15	0.649	-0.02	0.948	0.43	0.160	0.16	0.615	-0.01	0.964	0.41	0.183	0.60	0.039	0.57	0.054	0.06	0.863

Appendix XII. (Cont.)

Landscape Context	Buffer Width (m)	TSP		DBH		USSt		USSp		GCSE		GCSL		%GCE		%GCL		NPSR		APSR	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	**30**	**-0.07**	**0.825**	**0.52**	**0.085**	**-0.27**	**0.388**	**-0.43**	**0.163**	**-0.54**	**0.069**	**-0.42**	**0.169**	**-0.11**	**0.743**	**-0.13**	**-0.683**	**-0.66**	**0.021**	**-0.52**	**0.081**
Local	**60**	**-0.16**	**0.614**	**0.33**	**0.300**	**-0.25**	**0.441**	**-0.25**	**0.439**	**-0.24**	**0.450**	**-0.09**	**0.781**	**0.15**	**0.645**	**-0.20**	**-0.543**	**-0.65**	**0.023**	**-0.54**	**0.069**
Local	**120**	**-0.32**	**0.317**	**0.48**	**0.118**	**0.02**	**0.948**	**-0.01**	**0.974**	**-0.07**	**0.831**	**0.20**	**0.524**	**0.31**	**0.326**	**0.01**	**-0.965**	**-0.56**	**0.058**	**-0.53**	**0.074**
Local	**240**	**-0.29**	**0.364**	**0.42**	**0.178**	**0.02**	**0.940**	**0.05**	**0.883**	**0.06**	**0.845**	**0.31**	**0.323**	**0.35**	**0.258**	**-0.05**	**-0.888**	**-0.54**	**0.068**	**-0.54**	**0.072**
Local	**480**	**-0.17**	**0.606**	**0.12**	**0.702**	**-0.06**	**0.862**	**0.05**	**0.883**	**0.17**	**0.598**	**0.25**	**0.439**	**0.38**	**0.226**	**-0.09**	**-0.777**	**-0.44**	**0.148**	**-0.41**	**0.182**
Local	**960**	**-0.23**	**0.473**	**-0.12**	**0.710**	**-0.07**	**0.828**	**0.06**	**0.861**	**0.18**	**0.574**	**0.24**	**0.446**	**0.31**	**0.320**	**0.08**	**-0.802**	**-0.35**	**0.266**	**-0.27**	**0.397**
U/S-1	**30**	**-0.19**	**0.560**	**-0.20**	**0.526**	**-0.47**	**0.119**	**-0.29**	**0.360**	**0.36**	**0.257**	**0.54**	**0.071**	**-0.06**	**0.859**	**-0.12**	**0.714**	**-0.24**	**0.444**	**-0.45**	**0.137**
U/S-1	**60**	**-0.14**	**0.655**	**0.10**	**0.755**	**0.05**	**0.881**	**0.17**	**0.601**	**0.22**	**0.498**	**0.29**	**0.365**	**-0.16**	**0.618**	**-0.10**	**0.755**	**-0.09**	**0.782**	**-0.14**	**0.667**
U/S-1	**120**	**0.06**	**0.865**	**0.47**	**0.126**	**0.07**	**0.835**	**0.10**	**0.749**	**-0.05**	**0.877**	**0.00**	**0.991**	**-0.31**	**0.322**	**0.27**	**0.389**	**-0.19**	**0.550**	**-0.34**	**0.274**
U/S-1	**240**	**0.20**	**0.529**	**0.61**	**0.034**	**0.11**	**0.729**	**0.04**	**0.914**	**-0.09**	**0.782**	**-0.06**	**0.863**	**-0.30**	**0.347**	**0.24**	**0.449**	**-0.19**	**0.564**	**-0.54**	**0.067**
U/S-1	**480**	**0.12**	**0.707**	**0.70**	**0.012**	**0.10**	**0.761**	**-0.11**	**0.744**	**-0.32**	**0.307**	**-0.24**	**0.455**	**-0.27**	**0.396**	**0.07**	**0.828**	**-0.30**	**0.340**	**-0.62**	**0.031**
U/S-1	**960**	**0.03**	**0.931**	**0.59**	**0.044**	**0.16**	**0.617**	**-0.09**	**0.790**	**-0.26**	**0.418**	**-0.17**	**0.601**	**0.08**	**0.803**	**-0.08**	**0.803**	**-0.30**	**0.336**	**-0.54**	**0.072**
U/S-2	**30**	**0.24**	**0.460**	**0.09**	**0.778**	**-0.23**	**0.468**	**-0.20**	**0.543**	**0.35**	**0.263**	**0.34**	**0.286**	**-0.07**	**0.834**	**0.05**	**0.886**	**-0.01**	**0.982**	**-0.59**	**0.042**
U/S-2	**60**	**0.20**	**0.523**	**0.04**	**0.896**	**-0.18**	**0.576**	**-0.15**	**0.637**	**0.33**	**0.293**	**0.35**	**0.266**	**-0.07**	**0.819**	**-0.06**	**0.845**	**0.02**	**0.939**	**-0.55**	**0.062**
U/S-2	**120**	**0.36**	**0.253**	**0.32**	**0.312**	**-0.12**	**0.703**	**-0.25**	**0.428**	**0.07**	**0.840**	**0.05**	**0.879**	**-0.20**	**0.532**	**0.10**	**0.752**	**-0.06**	**0.845**	**-0.78**	**0.003**
U/S-2	**240**	**0.34**	**0.274**	**0.36**	**0.253**	**-0.07**	**0.820**	**-0.23**	**0.475**	**0.03**	**0.922**	**0.01**	**0.983**	**-0.21**	**0.505**	**0.09**	**0.770**	**-0.05**	**0.871**	**-0.76**	**0.004**
U/S-2	**480**	**0.29**	**0.356**	**0.38**	**0.217**	**-0.03**	**0.931**	**-0.22**	**0.487**	**-0.04**	**0.913**	**-0.04**	**0.896**	**-0.15**	**0.646**	**0.04**	**0.896**	**-0.08**	**0.794**	**-0.74**	**0.006**
U/S-2	**960**	**0.09**	**0.778**	**0.51**	**0.089**	**0.06**	**0.846**	**-0.15**	**0.640**	**-0.11**	**0.728**	**0.01**	**0.966**	**-0.07**	**0.829**	**-0.13**	**0.681**	**-0.24**	**0.443**	**-0.72**	**0.009**
U/S-3	**30**	**0.28**	**0.380**	**0.12**	**0.718**	**-0.14**	**0.662**	**-0.15**	**0.653**	**0.29**	**0.366**	**0.24**	**0.460**	**-0.14**	**0.662**	**-0.17**	**0.599**	**0.07**	**0.828**	**-0.44**	**0.149**
U/S-3	**60**	**0.35**	**0.261**	**0.13**	**0.690**	**-0.20**	**0.532**	**-0.25**	**0.435**	**0.24**	**0.445**	**0.20**	**0.539**	**-0.24**	**0.460**	**-0.24**	**0.460**	**0.11**	**0.744**	**-0.53**	**0.075**
U/S-3	**120**	**0.40**	**0.198**	**0.35**	**0.272**	**-0.15**	**0.637**	**-0.22**	**0.495**	**0.16**	**0.627**	**0.12**	**0.720**	**-0.20**	**0.542**	**0.00**	**1.000**	**-0.05**	**0.876**	**-0.66**	**0.021**
U/S-3	**240**	**0.33**	**0.297**	**0.45**	**0.140**	**-0.10**	**0.752**	**-0.21**	**0.518**	**0.07**	**0.835**	**0.05**	**0.870**	**-0.18**	**0.568**	**0.12**	**0.702**	**-0.13**	**0.678**	**-0.74**	**0.006**
U/S-3	**480**	**0.19**	**0.564**	**0.57**	**0.051**	**0.12**	**0.713**	**-0.01**	**0.965**	**0.04**	**0.914**	**0.04**	**0.897**	**-0.07**	**0.829**	**0.08**	**0.812**	**-0.20**	**0.542**	**-0.65**	**0.023**
U/S-3	**960**	**0.01**	**0.974**	**0.57**	**0.053**	**0.15**	**0.649**	**0.03**	**0.922**	**0.04**	**0.905**	**0.14**	**0.665**	**0.03**	**0.931**	**-0.08**	**0.812**	**-0.28**	**0.379**	**-0.59**	**0.045**

Appendix XII. (Cont.)

Landscape Context	Buffer Width (m)	TSP		DBH		USSt		USSp		GCSE		GCSL		%GCE		%GCL		NPSR		APSR	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	**30**	**-0.07**	**0.825**	**0.52**	**0.085**	**-0.27**	**0.388**	**-0.43**	**0.163**	**-0.54**	**0.069**	**-0.42**	**0.169**	**-0.11**	**0.743**	**-0.13**	**-0.683**	**-0.66**	**0.021**	**-0.52**	**0.081**
Local	**60**	**-0.16**	**0.614**	**0.33**	**0.300**	**-0.25**	**0.441**	**-0.25**	**0.439**	**-0.24**	**0.450**	**-0.09**	**0.781**	**0.15**	**0.645**	**-0.20**	**-0.543**	**-0.65**	**0.023**	**-0.54**	**0.069**
Local	**120**	**-0.32**	**0.317**	**0.48**	**0.118**	**0.02**	**0.948**	**-0.01**	**0.974**	**-0.07**	**0.831**	**0.20**	**0.524**	**0.31**	**0.326**	**0.01**	**-0.965**	**-0.56**	**0.058**	**-0.53**	**0.074**
Local	**240**	**-0.29**	**0.364**	**0.42**	**0.178**	**0.02**	**0.940**	**0.05**	**0.883**	**0.06**	**0.845**	**0.31**	**0.323**	**0.35**	**0.258**	**-0.05**	**-0.888**	**-0.54**	**0.068**	**-0.54**	**0.072**
Local	**480**	**-0.17**	**0.606**	**0.12**	**0.702**	**-0.06**	**0.862**	**0.05**	**0.883**	**0.17**	**0.598**	**0.25**	**0.439**	**0.38**	**0.226**	**-0.09**	**-0.777**	**-0.44**	**0.148**	**-0.41**	**0.182**
Local	**960**	**-0.23**	**0.473**	**-0.12**	**0.710**	**-0.07**	**0.828**	**0.06**	**0.861**	**0.18**	**0.574**	**0.24**	**0.446**	**0.31**	**0.320**	**0.08**	**-0.802**	**-0.35**	**0.266**	**-0.27**	**0.397**
U/S-1	**30**	**-0.19**	**0.560**	**-0.20**	**0.526**	**-0.47**	**0.119**	**-0.29**	**0.360**	**0.36**	**0.257**	**0.54**	**0.071**	**-0.06**	**0.859**	**-0.12**	**0.714**	**-0.24**	**0.444**	**-0.45**	**0.137**
U/S-1	**60**	**-0.14**	**0.655**	**0.10**	**0.755**	**0.05**	**0.881**	**0.17**	**0.601**	**0.22**	**0.498**	**0.29**	**0.365**	**-0.16**	**0.618**	**-0.10**	**0.755**	**-0.09**	**0.782**	**-0.14**	**0.667**
U/S-1	**120**	**0.06**	**0.865**	**0.47**	**0.126**	**0.07**	**0.835**	**0.10**	**0.749**	**-0.05**	**0.877**	**0.00**	**0.991**	**-0.31**	**0.322**	**0.27**	**0.389**	**-0.19**	**0.550**	**-0.34**	**0.274**
U/S-1	**240**	**0.20**	**0.529**	**0.61**	**0.034**	**0.11**	**0.729**	**0.04**	**0.914**	**-0.09**	**0.782**	**-0.06**	**0.863**	**-0.30**	**0.347**	**0.24**	**0.449**	**-0.19**	**0.564**	**-0.54**	**0.067**
U/S-1	**480**	**0.12**	**0.707**	**0.70**	**0.012**	**0.10**	**0.761**	**-0.11**	**0.744**	**-0.32**	**0.307**	**-0.24**	**0.455**	**-0.27**	**0.396**	**0.07**	**0.828**	**-0.30**	**0.340**	**-0.62**	**0.031**
U/S-1	**960**	**0.03**	**0.931**	**0.59**	**0.044**	**0.16**	**0.617**	**-0.09**	**0.790**	**-0.26**	**0.418**	**-0.17**	**0.601**	**0.08**	**0.803**	**-0.08**	**0.803**	**-0.30**	**0.336**	**-0.54**	**0.072**
U/S-2	**30**	**0.24**	**0.460**	**0.09**	**0.778**	**-0.23**	**0.468**	**-0.20**	**0.543**	**0.35**	**0.263**	**0.34**	**0.286**	**-0.07**	**0.834**	**0.05**	**0.886**	**-0.01**	**0.982**	**-0.59**	**0.042**
U/S-2	**60**	**0.20**	**0.523**	**0.04**	**0.896**	**-0.18**	**0.576**	**-0.15**	**0.637**	**0.33**	**0.293**	**0.35**	**0.266**	**-0.07**	**0.819**	**-0.06**	**0.845**	**0.02**	**0.939**	**-0.55**	**0.062**
U/S-2	**120**	**0.36**	**0.253**	**0.32**	**0.312**	**-0.12**	**0.703**	**-0.25**	**0.428**	**0.07**	**0.840**	**0.05**	**0.879**	**-0.20**	**0.532**	**0.10**	**0.752**	**-0.06**	**0.845**	**-0.78**	**0.003**
U/S-2	**240**	**0.34**	**0.274**	**0.36**	**0.253**	**-0.07**	**0.820**	**-0.23**	**0.475**	**0.03**	**0.922**	**0.01**	**0.983**	**-0.21**	**0.505**	**0.09**	**0.770**	**-0.05**	**0.871**	**-0.76**	**0.004**
U/S-2	**480**	**0.29**	**0.356**	**0.38**	**0.217**	**-0.03**	**0.931**	**-0.22**	**0.487**	**-0.04**	**0.913**	**-0.04**	**0.896**	**-0.15**	**0.646**	**0.04**	**0.896**	**-0.08**	**0.794**	**-0.74**	**0.006**
U/S-2	**960**	**0.09**	**0.778**	**0.51**	**0.089**	**0.06**	**0.846**	**-0.15**	**0.640**	**-0.11**	**0.728**	**0.01**	**0.966**	**-0.07**	**0.829**	**-0.13**	**0.681**	**-0.24**	**0.443**	**-0.72**	**0.009**
U/S-3	**30**	**0.28**	**0.380**	**0.12**	**0.718**	**-0.14**	**0.662**	**-0.15**	**0.653**	**0.29**	**0.366**	**0.24**	**0.460**	**-0.14**	**0.662**	**-0.17**	**0.599**	**0.07**	**0.828**	**-0.44**	**0.149**
U/S-3	**60**	**0.35**	**0.261**	**0.13**	**0.690**	**-0.20**	**0.532**	**-0.25**	**0.435**	**0.24**	**0.445**	**0.20**	**0.539**	**-0.24**	**0.460**	**-0.24**	**0.460**	**0.11**	**0.744**	**-0.53**	**0.075**
U/S-3	**120**	**0.40**	**0.198**	**0.35**	**0.272**	**-0.15**	**0.637**	**-0.22**	**0.495**	**0.16**	**0.627**	**0.12**	**0.720**	**-0.20**	**0.542**	**0.00**	**1.000**	**-0.05**	**0.876**	**-0.66**	**0.021**
U/S-3	**240**	**0.33**	**0.297**	**0.45**	**0.140**	**-0.10**	**0.752**	**-0.21**	**0.518**	**0.07**	**0.835**	**0.05**	**0.870**	**-0.18**	**0.568**	**0.12**	**0.702**	**-0.13**	**0.678**	**-0.74**	**0.006**
U/S-3	**480**	**0.19**	**0.564**	**0.57**	**0.051**	**0.12**	**0.713**	**-0.01**	**0.965**	**0.04**	**0.914**	**0.04**	**0.897**	**-0.07**	**0.829**	**0.08**	**0.812**	**-0.20**	**0.542**	**-0.65**	**0.023**
U/S-3	**960**	**0.01**	**0.974**	**0.57**	**0.053**	**0.15**	**0.649**	**0.03**	**0.922**	**0.04**	**0.905**	**0.14**	**0.665**	**0.03**	**0.931**	**-0.08**	**0.812**	**-0.28**	**0.379**	**-0.59**	**0.045**

Appendix XII. (Cont.)

Landscape Context	Buffer Width (m)	TPSR		%Native		%Adventive		FQI	
		R	p	R	p	R	p	R	p
Local	30	-0.66	0.020	-0.08	0.799	0.08	0.799	-0.60	0.041
Local	60	-0.69	0.012	-0.01	0.966	0.01	0.966	-0.60	0.040
Local	120	-0.63	0.027	0.06	0.863	-0.06	0.863	-0.43	0.166
Local	240	-0.62	0.030	0.05	0.873	-0.05	0.873	-0.41	0.181
Local	480	-0.51	0.091	0.03	0.925	-0.03	0.925	-0.38	0.222
Local	960	-0.38	0.219	-0.03	0.925	0.03	0.925	-0.35	0.261
U/S-1	30	-0.32	0.307	0.22	0.492	-0.22	0.492	-0.16	0.616
U/S-1	60	-0.12	0.711	-0.02	0.939	0.02	0.939	-0.07	0.836
U/S-1	120	-0.24	0.444	0.05	0.866	-0.05	0.866	-0.16	0.611
U/S-1	240	-0.28	0.383	0.27	0.396	-0.27	0.396	-0.08	0.795
U/S-1	480	-0.38	0.226	0.28	0.385	-0.28	0.385	-0.18	0.578
U/S-1	960	-0.35	0.261	0.20	0.532	-0.20	0.532	-0.17	0.594
U/S-2	30	-0.10	0.765	0.42	0.170	-0.42	0.170	0.09	0.783
U/S-2	60	-0.06	0.853	0.41	0.182	-0.41	0.182	0.09	0.785
U/S-2	120	-0.17	0.591	0.56	0.057	-0.56	0.057	0.06	0.862
U/S-2	240	-0.16	0.620	0.57	0.055	-0.57	0.055	0.08	0.803
U/S-2	480	-0.18	0.576	0.53	0.077	-0.53	0.077	0.05	0.879
U/S-2	960	-0.34	0.285	0.40	0.198	-0.40	0.198	-0.09	0.779
U/S-3	30	0.00	0.996	0.36	0.245	-0.36	0.245	0.15	0.646
U/S-3	60	0.01	0.970	0.51	0.094	-0.51	0.094	0.21	0.517
U/S-3	120	-0.15	0.636	0.46	0.137	-0.46	0.137	0.06	0.858
U/S-3	240	-0.24	0.452	0.47	0.124	-0.47	0.124	0.01	0.983
U/S-3	480	-0.29	0.359	0.35	0.270	-0.35	0.270	-0.03	0.931
U/S-3	960	-0.36	0.244	0.24	0.454	-0.24	0.454	-0.11	0.729

Appendix XIII. Correlation coefficients (R) and levels of significance (p) for correlation analyses of riparian site community parameters with the spatial extent of all modified land covers within 30, 60, 120, 240, 480 and 960m buffers adjacent to (i.e., Local) and upstream (i.e., U/S-1, U/S-2 and U/S-3) from survey sites. Significant correlations are highlighted in gray (p<0.01). Community parameter descriptions are provided within the report text.

Lands cape Conte	Buffer Width (m)	TASR		%Wood		HQI		MSR		RAIU		RAEX		MCPUE		FSR		FIBI		RAIF	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.33	0.289	-0.09	0.793	-0.16	0.612	0.225	0.483	0.07	0.825	-0.10	0.749	0.35	0.268	0.34	0.281	0.36	0.243	0.06	0.861
Local	60	0.33	0.289	-0.17	0.607	-0.14	0.662	0.273	0.391	0.15	0.652	-0.06	0.865	0.29	0.362	0.51	0.093	0.43	0.164	0.09	0.777
Local	120	0.46	0.130	-0.28	0.387	-0.14	0.670	0.165	0.609	0.18	0.581	-0.01	0.977	0.30	0.344	0.38	0.225	0.24	0.459	0.12	0.710
Local	240	0.37	0.239	-0.20	0.525	-0.09	0.786	0.032	0.922	0.19	0.552	-0.04	0.910	0.07	0.837	0.31	0.328	0.20	0.532	0.09	0.769
Local	480	0.42	0.170	-0.20	0.524	-0.11	0.744	-0.124	0.701	0.20	0.536	-0.09	0.777	0.10	0.760	0.07	0.825	0.02	0.948	-0.01	0.965
Local	960	0.35	0.268	-0.28	0.383	-0.22	0.490	-0.169	0.599	0.20	0.538	-0.04	0.910	0.13	0.696	-0.06	0.847	-0.12	0.714	0.01	0.965
U/S-1	30	0.28	0.377	-0.64	0.026	0.12	0.704	-0.016	0.961	0.48	0.115	0.28	0.379	-0.12	0.721	0.34	0.287	0.19	0.552	0.48	0.114
U/S-1	60	-0.09	0.790	-0.44	0.153	-0.20	0.540	0.051	0.874	0.18	0.574	0.50	0.098	-0.12	0.720	0.24	0.446	0.01	0.978	0.15	0.631
U/S-1	120	-0.19	0.563	-0.35	0.269	-0.36	0.249	-0.033	0.918	0.07	0.836	0.46	0.130	-0.19	0.549	0.19	0.556	-0.12	0.718	-0.01	0.974
U/S-1	240	0.00	1.000	-0.39	0.208	-0.27	0.404	0.032	0.922	0.16	0.615	0.50	0.095	-0.07	0.829	0.33	0.288	0.03	0.922	0.00	1.000
U/S-1	480	-0.01	0.974	-0.30	0.342	-0.29	0.366	-0.088	0.786	0.18	0.584	0.39	0.205	-0.13	0.697	0.23	0.476	0.03	0.931	-0.04	0.897
U/S-1	960	-0.21	0.516	-0.15	0.638	-0.07	0.828	0.053	0.870	0.11	0.733	0.49	0.103	-0.23	0.473	0.18	0.580	0.11	0.725	0.18	0.576
U/S-2	30	-0.13	0.682	-0.33	0.289	-0.08	0.803	-0.067	0.836	0.16	0.621	0.40	0.198	-0.06	0.854	-0.14	0.674	-0.11	0.734	0.21	0.518
U/S-2	60	-0.09	0.786	-0.35	0.258	-0.05	0.871	-0.056	0.862	0.17	0.590	0.37	0.232	-0.03	0.931	-0.11	0.736	-0.07	0.840	0.22	0.483
U/S-2	120	-0.18	0.570	-0.26	0.409	-0.14	0.672	-0.113	0.727	0.11	0.735	0.32	0.307	-0.12	0.712	-0.08	0.808	-0.01	0.965	0.17	0.593
U/S-2	240	-0.07	0.820	-0.31	0.323	-0.24	0.455	-0.157	0.626	0.22	0.494	0.23	0.475	-0.07	0.820	-0.06	0.860	-0.01	0.983	0.02	0.940
U/S-2	480	-0.07	0.824	-0.21	0.519	-0.29	0.358	-0.224	0.484	0.17	0.590	0.09	0.790	-0.11	0.736	-0.09	0.787	0.03	0.930	-0.02	0.957
U/S-2	960	-0.19	0.544	-0.07	0.820	-0.21	0.505	-0.040	0.901	0.07	0.819	0.14	0.675	-0.13	0.696	0.09	0.787	0.20	0.530	0.07	0.829
U/S-3	30	-0.16	0.611	-0.31	0.334	0.15	0.647	0.004	0.991	0.12	0.709	0.40	0.203	-0.07	0.820	-0.02	0.947	0.04	0.904	0.33	0.300
U/S-3	60	-0.21	0.516	-0.26	0.420	0.04	0.913	-0.120	0.709	0.09	0.793	0.29	0.367	-0.16	0.615	-0.09	0.778	-0.01	0.969	0.19	0.546
U/S-3	120	-0.21	0.521	-0.16	0.624	-0.02	0.957	-0.106	0.743	0.01	0.965	0.19	0.558	-0.15	0.648	-0.02	0.952	0.12	0.722	0.12	0.720
U/S-3	240	-0.22	0.484	-0.09	0.779	0.00	1.000	-0.014	0.965	-0.02	0.948	0.22	0.487	-0.10	0.762	0.09	0.783	0.20	0.531	0.01	0.983
U/S-3	480	-0.25	0.425	-0.08	0.795	-0.10	0.762	-0.053	0.871	0.01	0.965	0.18	0.570	-0.18	0.579	0.12	0.699	0.21	0.516	-0.05	0.880
U/S-3	960	-0.45	0.140	0.12	0.702	-0.12	0.702	-0.020	0.952	-0.16	0.612	0.16	0.623	-0.26	0.413	0.10	0.747	0.23	0.462	0.05	0.887

Appendix XIII. (Cont.)

Land scape Conte	Buffe r Widt	FCPUE		ISR		InBI		EPT		RAIB		MAMSR		BSR		HSR		NoZone		CTV		BaAr	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.11	0.725	0.28	0.377	-0.04	0.896	0.20	0.526	0.03	0.925	-0.12	0.701	0.22	0.497	-0.27	0.396	-0.57	0.054	-0.38	0.219	-0.22	0.492
Local	60	-0.03	0.935	0.29	0.355	0.07	0.819	0.15	0.632	-0.20	0.533	-0.23	0.471	0.31	0.323	-0.08	0.808	-0.62	0.033	-0.50	0.094	-0.16	0.614
Local	120	0.10	0.751	0.46	0.136	-0.02	0.957	0.30	0.338	0.08	0.798	-0.08	0.805	0.51	0.092	-0.09	0.778	-0.66	0.020	-0.54	0.068	-0.52	0.082
Local	240	0.03	0.918	0.38	0.218	-0.06	0.845	0.37	0.242	0.09	0.781	-0.26	0.407	0.61	0.036	0.00	0.996	-0.71	0.010	-0.59	0.045	-0.55	0.063
Local	480	0.14	0.661	0.47	0.121	-0.20	0.539	0.52	0.085	0.21	0.520	-0.03	0.920	0.60	0.038	-0.01	0.982	-0.63	0.029	-0.48	0.115	-0.65	0.021
Local	960	0.32	0.318	0.40	0.192	-0.13	0.680	0.40	0.202	0.39	0.211	0.27	0.388	0.32	0.315	0.05	0.873	-0.49	0.109	-0.44	0.150	-0.79	0.002
U/S-1	30	0.26	0.418	0.22	0.486	0.07	0.820	0.12	0.703	0.53	0.075	-0.23	0.478	0.08	0.794	0.38	0.227	-0.55	0.064	-0.43	0.158	-0.48	0.111
U/S-1	60	0.21	0.509	-0.13	0.678	0.11	0.744	0.08	0.814	0.86	0.000	0.05	0.880	-0.09	0.785	0.26	0.413	-0.24	0.452	-0.12	0.703	-0.29	0.364
U/S-1	120	0.03	0.918	-0.17	0.593	0.21	0.512	0.00	0.996	0.83	0.001	0.11	0.725	-0.03	0.935	0.28	0.382	-0.17	0.593	-0.10	0.753	-0.30	0.341
U/S-1	240	0.00	0.991	0.04	0.914	0.05	0.880	0.20	0.540	0.79	0.002	-0.02	0.956	0.20	0.532	0.20	0.543	-0.37	0.233	-0.08	0.795	-0.22	0.484
U/S-1	480	0.00	1.000	0.07	0.829	-0.03	0.931	0.22	0.482	0.68	0.016	-0.03	0.920	0.17	0.608	0.17	0.604	-0.44	0.151	-0.09	0.779	-0.24	0.443
U/S-1	960	0.14	0.665	-0.23	0.473	-0.08	0.811	0.02	0.961	0.37	0.237	-0.32	0.303	-0.13	0.680	-0.04	0.908	-0.27	0.399	0.14	0.662	-0.07	0.836
U/S-2	30	0.47	0.126	-0.20	0.528	-0.05	0.879	-0.04	0.905	0.43	0.158	0.24	0.444	-0.57	0.052	0.06	0.860	0.05	0.875	0.26	0.414	-0.17	0.592
U/S-2	60	0.46	0.128	-0.17	0.592	-0.05	0.871	-0.03	0.926	0.42	0.174	0.22	0.488	-0.57	0.051	0.04	0.908	0.03	0.933	0.26	0.415	-0.14	0.672
U/S-2	120	0.36	0.249	-0.23	0.465	-0.02	0.957	-0.09	0.785	0.37	0.239	0.16	0.618	-0.58	0.046	0.02	0.947	-0.05	0.889	0.21	0.511	-0.09	0.786
U/S-2	240	0.27	0.404	-0.09	0.769	0.01	0.965	0.04	0.896	0.35	0.264	0.17	0.590	-0.48	0.113	0.16	0.611	-0.16	0.620	0.11	0.736	-0.09	0.786
U/S-2	480	0.23	0.471	-0.07	0.828	0.00	0.991	0.06	0.862	0.24	0.455	0.12	0.708	-0.43	0.165	0.09	0.770	-0.27	0.392	0.00	1.000	-0.15	0.640
U/S-2	960	0.13	0.687	-0.23	0.476	0.05	0.880	-0.12	0.719	0.04	0.903	-0.11	0.730	-0.46	0.130	-0.02	0.947	-0.24	0.450	0.03	0.931	0.07	0.820
U/S-3	30	0.44	0.155	-0.27	0.400	-0.10	0.761	-0.08	0.802	0.17	0.595	0.17	0.589	-0.57	0.052	0.07	0.825	0.13	0.689	0.26	0.408	0.07	0.820
U/S-3	60	0.32	0.314	-0.29	0.362	-0.03	0.931	-0.09	0.776	0.10	0.747	0.16	0.613	-0.58	0.050	0.11	0.736	0.12	0.714	0.26	0.420	0.09	0.786
U/S-3	120	0.27	0.400	-0.30	0.340	-0.07	0.828	0.00	0.996	0.06	0.849	0.06	0.845	-0.48	0.113	0.00	0.991	-0.03	0.929	0.16	0.616	0.14	0.664
U/S-3	240	0.19	0.555	-0.32	0.307	-0.15	0.649	0.14	0.671	0.06	0.862	0.03	0.920	-0.33	0.289	0.02	0.948	-0.04	0.902	0.15	0.633	0.32	0.308
U/S-3	480	0.09	0.778	-0.33	0.301	-0.06	0.854	0.12	0.711	0.01	0.965	-0.04	0.894	-0.29	0.354	0.13	0.691	-0.13	0.682	0.04	0.914	0.28	0.378
U/S-3	960	0.09	0.780	-0.51	0.094	-0.01	0.974	-0.15	0.640	-0.14	0.673	-0.09	0.783	-0.45	0.144	-0.05	0.873	-0.07	0.839	0.04	0.913	0.28	0.387

Appendix XIII. (Cont.)

Landscape Context	Buffer Width (m)	TSP		DBH		USSt		USSp		GCSE		GCSL		%GCE		%GCL		NPSR		APSR	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	-0.37	0.242	0.52	0.084	0.21	0.521	0.07	0.817	-0.12	0.716	0.07	0.827	0.31	0.323	0.14	-0.660	-0.51	0.090	-0.40	0.198
Local	60	-0.41	0.184	0.60	0.040	0.22	0.488	0.11	0.734	-0.07	0.823	0.22	0.502	0.25	0.426	0.05	-0.879	-0.45	0.141	-0.44	0.153
Local	120	-0.35	0.262	0.42	0.180	0.23	0.480	0.21	0.515	0.11	0.730	0.33	0.292	0.41	0.187	0.06	-0.862	-0.42	0.174	-0.40	0.195
Local	240	-0.30	0.351	0.32	0.313	0.02	0.939	0.11	0.727	0.14	0.666	0.38	0.224	0.38	0.224	-0.08	-0.811	-0.51	0.091	-0.46	0.130
Local	480	-0.18	0.576	0.09	0.777	-0.06	0.845	0.06	0.853	0.19	0.552	0.27	0.388	0.39	0.214	-0.10	-0.760	-0.44	0.156	-0.39	0.206
Local	960	-0.25	0.431	-0.08	0.794	0.07	0.820	0.18	0.565	0.26	0.423	0.30	0.346	0.40	0.198	0.10	-0.753	-0.26	0.409	-0.19	0.549
U/S-1	30	-0.51	0.089	-0.17	0.601	-0.22	0.491	0.06	0.862	0.41	0.190	0.68	0.016	0.31	0.324	-0.06	0.863	-0.32	0.313	-0.09	0.777
U/S-1	60	-0.39	0.207	0.04	0.913	0.14	0.663	0.38	0.229	0.25	0.439	0.33	0.289	0.14	0.663	0.00	1.000	-0.19	0.562	0.26	0.418
U/S-1	120	-0.44	0.154	0.11	0.728	0.25	0.436	0.46	0.134	0.15	0.639	0.26	0.409	0.07	0.837	0.05	0.880	-0.15	0.632	0.32	0.316
U/S-1	240	-0.48	0.114	0.33	0.291	0.24	0.457	0.45	0.147	0.08	0.795	0.22	0.499	0.16	0.618	0.22	0.499	-0.28	0.379	0.26	0.421
U/S-1	480	-0.55	0.064	0.32	0.313	0.17	0.602	0.36	0.243	-0.01	0.965	0.15	0.649	0.19	0.557	0.22	0.499	-0.36	0.255	0.24	0.461
U/S-1	960	-0.42	0.173	0.24	0.445	0.12	0.719	0.33	0.302	-0.01	0.987	0.14	0.670	0.28	0.380	0.16	0.614	-0.36	0.256	0.34	0.282
U/S-2	30	-0.32	0.316	-0.33	0.302	0.00	0.991	0.19	0.561	0.18	0.580	0.09	0.778	0.17	0.592	-0.18	0.585	-0.06	0.862	0.49	0.108
U/S-2	60	-0.34	0.286	-0.32	0.308	-0.05	0.888	0.13	0.695	0.16	0.619	0.08	0.812	0.16	0.624	-0.19	0.548	-0.10	0.761	0.45	0.144
U/S-2	120	-0.47	0.125	-0.19	0.547	-0.05	0.879	0.10	0.760	0.00	0.996	0.00	0.991	0.08	0.812	-0.24	0.462	-0.22	0.497	0.43	0.165
U/S-2	240	-0.54	0.070	-0.14	0.675	-0.06	0.845	0.07	0.819	0.01	0.970	0.04	0.914	0.11	0.736	-0.05	0.879	-0.26	0.409	0.31	0.332
U/S-2	480	-0.60	0.038	-0.07	0.820	-0.11	0.745	0.00	0.996	-0.09	0.781	-0.01	0.983	0.12	0.720	-0.11	0.736	-0.41	0.189	0.17	0.587
U/S-2	960	-0.58	0.049	0.17	0.597	0.00	0.991	0.03	0.931	-0.22	0.496	-0.05	0.888	0.06	0.846	-0.14	0.664	-0.42	0.178	0.16	0.619
U/S-3	30	-0.14	0.674	-0.36	0.254	-0.18	0.585	-0.01	0.978	0.12	0.702	0.02	0.957	-0.08	0.794	-0.30	0.346	0.03	0.931	0.44	0.156
U/S-3	60	-0.22	0.484	-0.38	0.226	-0.26	0.407	-0.10	0.768	0.04	0.892	-0.04	0.896	-0.15	0.631	-0.25	0.427	-0.08	0.811	0.39	0.211
U/S-3	120	-0.25	0.427	-0.21	0.518	-0.33	0.301	-0.19	0.546	-0.09	0.777	-0.15	0.640	-0.21	0.511	-0.28	0.383	-0.31	0.329	0.21	0.516
U/S-3	240	-0.09	0.787	-0.04	0.905	-0.31	0.331	-0.19	0.548	-0.14	0.664	-0.26	0.417	-0.33	0.297	-0.15	0.649	-0.29	0.366	0.14	0.655
U/S-3	480	-0.20	0.526	0.03	0.918	-0.28	0.372	-0.16	0.616	-0.15	0.639	-0.18	0.579	-0.30	0.336	-0.07	0.837	-0.35	0.264	0.08	0.807
U/S-3	960	-0.26	0.412	0.15	0.637	-0.12	0.719	-0.08	0.801	-0.32	0.307	-0.24	0.453	-0.32	0.315	-0.32	0.315	-0.33	0.298	0.16	0.624

Appendix XIII. (Cont.)

Landscape Context	Buffer Width (m)	TPSR		%Native		%Adventive		FQI	
		R	p	R	p	R	p	R	p
Local	30	-0.55	0.066	-0.04	0.911	0.04	0.911	-0.33	0.301
Local	60	-0.51	0.094	0.03	0.925	-0.03	0.925	-0.25	0.432
Local	120	-0.49	0.102	0.06	0.854	-0.06	0.854	-0.25	0.432
Local	240	-0.58	0.046	0.00	0.996	0.00	0.996	-0.42	0.172
Local	480	-0.50	0.100	0.01	0.973	-0.01	0.973	-0.39	0.214
Local	960	-0.30	0.346	-0.02	0.947	0.02	0.947	-0.23	0.469
U/S-1	30	-0.34	0.274	-0.17	0.597	0.17	0.597	-0.28	0.384
U/S-1	60	-0.15	0.646	-0.46	0.131	0.46	0.131	-0.22	0.489
U/S-1	120	-0.11	0.736	-0.49	0.109	0.49	0.109	-0.20	0.534
U/S-1	240	-0.23	0.470	-0.55	0.066	0.55	0.066	-0.29	0.354
U/S-1	480	-0.29	0.365	-0.60	0.038	0.60	0.038	-0.40	0.199
U/S-1	960	-0.26	0.408	-0.73	0.007	0.73	0.007	-0.47	0.124
U/S-2	30	0.04	0.892	-0.53	0.077	0.53	0.077	-0.14	0.671
U/S-2	60	0.00	0.996	-0.51	0.090	0.51	0.090	-0.15	0.632
U/S-2	120	-0.11	0.740	-0.60	0.040	0.60	0.040	-0.28	0.377
U/S-2	240	-0.15	0.631	-0.56	0.060	0.56	0.060	-0.28	0.371
U/S-2	480	-0.31	0.334	-0.54	0.067	0.54	0.067	-0.42	0.173
U/S-2	960	-0.32	0.312	-0.56	0.060	0.56	0.060	-0.42	0.170
U/S-3	30	0.11	0.744	-0.38	0.229	0.38	0.229	-0.06	0.862
U/S-3	60	0.01	0.978	-0.41	0.181	0.41	0.181	-0.15	0.631
U/S-3	120	-0.23	0.468	-0.44	0.153	0.44	0.153	-0.36	0.253
U/S-3	240	-0.22	0.498	-0.41	0.189	0.41	0.189	-0.34	0.276
U/S-3	480	-0.28	0.377	-0.43	0.160	0.43	0.160	-0.40	0.194
U/S-3	960	-0.25	0.435	-0.47	0.121	0.47	0.121	-0.42	0.178

Appendix XIV. Correlation coefficients (R) and levels of significance (p) for correlation analyses of riparian site community parameters with the spatial extent of all forest land covers within 30, 60, 120, 240, 480 and 960m buffers adjacent to (i.e., Local) and upstream (i.e., U/S-1, U/S-2 and U/S-3) from survey sites. Significant correlations are highlighted in gray (p<0.01). Community parameter descriptions are provided within the report text.

Landscape Context	Buffer Width (m)	TASR		%Wood		HQI		MSR		RAIU		RAEX		MCPUE		FSR		FIBI		RAIF	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	-0.78	0.003	0.50	0.096	-0.59	0.045	-0.25	0.442	-0.62	0.032	-0.23	0.474	-0.49	0.110	-0.20	0.529	-0.30	0.338	-0.64	0.861
Local	60	-0.60	0.040	0.41	0.183	-0.34	0.276	-0.40	0.192	-0.56	0.056	-0.24	0.451	-0.50	0.095	-0.50	0.099	-0.52	0.087	-0.42	0.777
Local	120	-0.81	0.001	0.54	0.070	-0.37	0.240	-0.24	0.450	-0.64	0.024	-0.25	0.433	-0.59	0.043	-0.22	0.486	-0.24	0.448	-0.39	0.710
Local	240	-0.74	0.006	0.41	0.181	-0.20	0.526	-0.13	0.678	-0.46	0.133	-0.13	0.692	-0.49	0.105	-0.25	0.433	-0.25	0.437	-0.26	0.769
Local	480	-0.58	0.049	0.36	0.248	-0.01	0.965	0.01	0.965	-0.28	0.373	-0.12	0.717	-0.29	0.358	-0.07	0.830	0.01	0.978	-0.14	0.965
Local	960	-0.53	0.075	0.32	0.312	0.03	0.931	0.07	0.836	-0.25	0.438	-0.05	0.874	-0.29	0.358	-0.08	0.812	-0.07	0.823	-0.09	0.965
U/S-1	30	-0.65	0.022	0.89	0.000	-0.19	0.556	-0.03	0.922	-0.71	0.010	-0.31	0.326	-0.23	0.470	-0.40	0.203	-0.19	0.560	-0.43	0.114
U/S-1	60	-0.61	0.035	0.88	0.000	-0.12	0.712	0.01	0.974	-0.71	0.010	-0.35	0.269	-0.18	0.571	-0.35	0.260	-0.12	0.718	-0.35	0.631
U/S-1	120	-0.58	0.046	0.87	0.000	-0.10	0.746	0.01	0.974	-0.70	0.011	-0.34	0.281	-0.16	0.618	-0.36	0.251	-0.12	0.702	-0.36	0.974
U/S-1	240	-0.57	0.052	0.84	0.001	-0.11	0.728	-0.03	0.935	-0.70	0.011	-0.37	0.235	-0.14	0.656	-0.37	0.242	-0.13	0.685	-0.37	1.000
U/S-1	480	-0.42	0.173	0.74	0.006	-0.03	0.923	0.08	0.802	-0.58	0.047	-0.35	0.258	0.04	0.914	-0.34	0.287	-0.10	0.751	-0.30	0.897
U/S-1	960	-0.21	0.511	0.57	0.053	0.12	0.704	0.19	0.558	-0.42	0.170	-0.30	0.347	0.23	0.463	-0.21	0.512	0.02	0.939	-0.22	0.576
U/S-2	30	-0.46	0.130	0.71	0.009	-0.40	0.199	0.06	0.845	-0.74	0.006	-0.35	0.265	-0.14	0.665	0.05	0.869	-0.04	0.913	-0.59	0.518
U/S-2	60	-0.46	0.129	0.73	0.007	-0.40	0.198	0.10	0.748	-0.74	0.006	-0.33	0.303	-0.12	0.712	0.05	0.873	-0.03	0.926	-0.60	0.483
U/S-2	120	-0.48	0.117	0.73	0.007	-0.41	0.183	0.07	0.820	-0.73	0.007	-0.35	0.265	-0.11	0.729	0.02	0.947	-0.05	0.870	-0.62	0.593
U/S-2	240	-0.53	0.078	0.75	0.005	-0.39	0.216	0.12	0.711	-0.79	0.002	-0.31	0.323	-0.09	0.770	-0.02	0.952	-0.08	0.802	-0.56	0.940
U/S-2	480	-0.57	0.052	0.79	0.002	-0.29	0.359	0.18	0.577	-0.82	0.001	-0.26	0.423	-0.08	0.795	-0.03	0.921	-0.05	0.870	-0.43	0.957
U/S-2	960	-0.39	0.215	0.71	0.010	-0.11	0.737	0.26	0.417	-0.71	0.009	-0.18	0.578	0.09	0.778	-0.01	0.969	-0.02	0.952	-0.35	0.829
U/S-3	30	-0.34	0.285	0.55	0.063	-0.36	0.255	0.28	0.370	-0.69	0.013	-0.17	0.594	0.03	0.914	0.22	0.498	0.02	0.948	-0.38	0.300
U/S-3	60	-0.34	0.276	0.55	0.066	-0.35	0.259	0.30	0.339	-0.68	0.014	-0.16	0.622	0.03	0.923	0.23	0.465	0.02	0.939	-0.37	0.546
U/S-3	120	-0.36	0.246	0.51	0.087	-0.36	0.244	0.37	0.237	-0.69	0.013	-0.06	0.844	0.07	0.820	0.25	0.434	0.00	0.996	-0.35	0.720
U/S-3	240	-0.39	0.207	0.54	0.071	-0.32	0.308	0.38	0.224	-0.68	0.014	-0.05	0.875	0.05	0.880	0.26	0.421	0.04	0.913	-0.29	0.983
U/S-3	480	-0.38	0.220	0.52	0.082	-0.24	0.449	0.41	0.183	-0.64	0.025	-0.01	0.982	0.09	0.778	0.21	0.508	0.04	0.900	-0.17	0.880
U/S-3	960	-0.34	0.276	0.49	0.109	-0.23	0.481	0.48	0.113	-0.63	0.028	0.06	0.847	0.19	0.554	0.18	0.585	-0.04	0.904	-0.20	0.887

Appendix XIV. (Cont.)

Landscape Context	Buffer Width (m)	FCPUE		ISR		InBI		EPT		RAIB		MAMSR		BSR		HSR		NoZone		CTV		BaAr	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	-0.64	0.026	-0.74	0.006	0.56	0.059	-0.48	0.112	-0.07	0.823	0.14	0.666	-0.27	0.392	0.14	0.662	0.53	0.073	0.11	0.728	-0.41	0.18
Local	60	-0.33	0.290	-0.57	0.051	0.34	0.276	-0.37	0.233	-0.02	0.939	0.19	0.545	-0.20	0.525	-0.02	0.939	0.58	0.050	0.22	0.499	-0.01	0.97
Local	120	-0.57	0.052	-0.81	0.001	0.55	0.064	-0.66	0.019	-0.31	0.331	-0.08	0.815	-0.37	0.237	0.01	0.969	0.57	0.054	0.15	0.632	-0.40	0.20
Local	240	-0.38	0.218	-0.78	0.003	0.47	0.120	-0.63	0.029	-0.30	0.345	-0.01	0.964	-0.52	0.080	0.14	0.675	0.68	0.014	0.25	0.435	-0.45	0.14
Local	480	-0.29	0.363	-0.60	0.037	0.29	0.358	-0.50	0.097	-0.37	0.240	-0.01	0.982	-0.52	0.085	0.19	0.545	0.55	0.063	0.16	0.609	-0.65	0.02
Local	960	-0.34	0.277	-0.57	0.053	0.36	0.248	-0.57	0.054	-0.48	0.115	-0.12	0.704	-0.46	0.135	0.18	0.583	0.62	0.031	0.26	0.409	-0.60	0.04
U/S-1	30	-0.27	0.401	-0.64	0.025	0.02	0.948	-0.32	0.307	-0.67	0.017	-0.04	0.907	-0.20	0.539	-0.48	0.117	0.56	0.059	0.32	0.307	0.40	0.203
U/S-1	60	-0.23	0.468	-0.63	0.029	0.02	0.948	-0.36	0.254	-0.76	0.004	-0.04	0.907	-0.23	0.467	-0.51	0.094	0.56	0.059	0.29	0.365	0.43	0.162
U/S-1	120	-0.22	0.490	-0.60	0.040	-0.01	0.983	-0.33	0.300	-0.76	0.004	-0.03	0.938	-0.21	0.518	-0.52	0.082	0.56	0.060	0.31	0.331	0.43	0.167
U/S-1	240	-0.21	0.510	-0.57	0.052	-0.01	0.983	-0.31	0.326	-0.76	0.004	0.09	0.780	-0.22	0.495	-0.46	0.134	0.57	0.053	0.26	0.415	0.43	0.165
U/S-1	480	-0.11	0.740	-0.44	0.156	-0.04	0.897	-0.27	0.394	-0.74	0.005	0.18	0.579	-0.24	0.447	-0.42	0.170	0.59	0.042	0.26	0.422	0.43	0.166
U/S-1	960	0.01	0.974	-0.26	0.422	-0.17	0.594	-0.08	0.798	-0.66	0.020	0.25	0.429	-0.18	0.584	-0.36	0.256	0.52	0.082	0.23	0.477	0.51	0.092
U/S-2	30	-0.62	0.030	-0.43	0.158	0.27	0.404	-0.18	0.577	-0.59	0.042	-0.07	0.824	0.37	0.243	-0.29	0.352	0.23	0.469	-0.13	0.681	0.31	0.319
U/S-2	60	-0.60	0.038	-0.45	0.140	0.25	0.442	-0.15	0.639	-0.60	0.040	-0.11	0.730	0.37	0.242	-0.33	0.293	0.23	0.465	-0.10	0.762	0.33	0.301
U/S-2	120	-0.60	0.039	-0.45	0.144	0.25	0.430	-0.17	0.608	-0.60	0.039	-0.01	0.965	0.32	0.316	-0.27	0.390	0.28	0.380	-0.10	0.746	0.35	0.265
U/S-2	240	-0.51	0.093	-0.53	0.076	0.25	0.436	-0.24	0.457	-0.61	0.033	0.03	0.920	0.22	0.492	-0.36	0.256	0.37	0.232	-0.05	0.871	0.32	0.307
U/S-2	480	-0.44	0.155	-0.59	0.043	0.22	0.498	-0.36	0.257	-0.65	0.023	-0.01	0.969	0.09	0.777	-0.47	0.120	0.45	0.141	0.07	0.837	0.38	0.225
U/S-2	960	-0.32	0.308	-0.40	0.193	0.03	0.931	-0.20	0.535	-0.61	0.034	0.04	0.907	0.19	0.561	-0.52	0.081	0.45	0.143	0.17	0.601	0.41	0.182
U/S-3	30	-0.45	0.140	-0.37	0.240	0.29	0.366	-0.20	0.540	-0.48	0.112	-0.07	0.833	0.41	0.180	-0.39	0.214	0.16	0.613	-0.20	0.527	0.13	0.697
U/S-3	60	-0.47	0.124	-0.38	0.227	0.31	0.324	-0.22	0.485	-0.49	0.103	-0.09	0.776	0.41	0.190	-0.38	0.227	0.17	0.589	-0.20	0.541	0.14	0.664
U/S-3	120	-0.44	0.157	-0.41	0.185	0.34	0.285	-0.28	0.384	-0.49	0.107	-0.06	0.859	0.34	0.277	-0.40	0.197	0.24	0.450	-0.12	0.721	0.15	0.632
U/S-3	240	-0.44	0.157	-0.44	0.155	0.33	0.297	-0.34	0.283	-0.49	0.108	-0.12	0.722	0.28	0.376	-0.43	0.167	0.25	0.434	-0.08	0.812	0.20	0.527
U/S-3	480	-0.27	0.404	-0.43	0.159	0.25	0.436	-0.36	0.252	-0.51	0.093	-0.05	0.881	0.17	0.603	-0.45	0.138	0.27	0.389	-0.07	0.837	0.14	0.664
U/S-3	960	-0.22	0.501	-0.41	0.182	0.23	0.481	-0.30	0.336	-0.51	0.090	0.05	0.884	0.18	0.567	-0.46	0.134	0.39	0.206	0.04	0.913	0.15	0.646

Appendix XIV. (Cont.)

Landscape Context	Buffer Width (m)	TSP		DBH		USSt		USSp		GCSE		GCSL		%GCE		%GCL		NPSR		APSR	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.04	0.909	0.07	0.841	0.03	0.922	-0.07	0.823	-0.43	0.163	-0.45	0.146	-0.78	0.003	0.08	-0.811	0.02	0.939	0.08	0.798
Local	60	0.21	0.519	-0.41	0.190	-0.20	0.542	-0.16	0.609	-0.18	0.585	-0.32	0.308	-0.53	0.075	0.19	-0.557	0.04	0.897	0.13	0.695
Local	120	0.04	0.892	-0.07	0.824	-0.13	0.696	-0.21	0.518	-0.42	0.170	-0.37	0.235	-0.74	0.006	0.25	-0.442	-0.02	0.940	0.07	0.824
Local	240	0.20	0.543	-0.24	0.448	-0.09	0.770	-0.15	0.643	-0.21	0.513	-0.25	0.435	-0.62	0.031	0.15	-0.640	0.24	0.448	0.19	0.561
Local	480	0.24	0.444	-0.09	0.782	-0.08	0.812	-0.21	0.517	-0.25	0.430	-0.27	0.396	-0.63	0.029	0.15	-0.640	0.36	0.253	0.13	0.698
Local	960	0.26	0.411	-0.11	0.740	0.01	0.983	-0.10	0.760	-0.14	0.674	-0.14	0.656	-0.46	0.133	-0.01	-0.974	0.43	0.165	0.18	0.572
U/S-1	30	0.52	0.080	0.15	0.648	0.14	0.672	-0.08	0.794	-0.47	0.124	-0.64	0.024	-0.38	0.221	-0.13	0.696	0.09	0.770	0.01	0.983
U/S-1	60	0.54	0.069	0.13	0.688	0.09	0.770	-0.16	0.623	-0.48	0.114	-0.64	0.024	-0.42	0.170	-0.24	0.456	0.10	0.753	-0.05	0.888
U/S-1	120	0.56	0.058	0.13	0.696	0.09	0.779	-0.16	0.624	-0.47	0.120	-0.66	0.020	-0.41	0.183	-0.22	0.484	0.10	0.746	-0.04	0.905
U/S-1	240	0.57	0.051	0.07	0.820	0.06	0.862	-0.20	0.528	-0.48	0.114	-0.68	0.015	-0.51	0.091	-0.30	0.346	0.16	0.624	-0.05	0.887
U/S-1	480	0.64	0.024	0.05	0.888	0.14	0.656	-0.16	0.627	-0.37	0.240	-0.61	0.037	-0.40	0.194	-0.28	0.384	0.32	0.307	-0.05	0.883
U/S-1	960	0.74	0.006	0.03	0.918	0.08	0.803	-0.22	0.496	-0.27	0.395	-0.58	0.047	-0.41	0.190	-0.25	0.442	0.40	0.203	-0.10	0.756
U/S-2	30	0.36	0.244	0.56	0.060	0.22	0.484	-0.02	0.940	-0.50	0.096	-0.51	0.090	-0.58	0.048	-0.08	0.812	-0.12	0.713	-0.35	0.263
U/S-2	60	0.39	0.204	0.58	0.046	0.25	0.429	0.01	0.983	-0.48	0.114	-0.51	0.089	-0.52	0.082	-0.02	0.957	-0.14	0.672	-0.35	0.259
U/S-2	120	0.41	0.186	0.54	0.070	0.25	0.430	-0.01	0.974	-0.49	0.105	-0.54	0.071	-0.59	0.045	-0.06	0.863	-0.06	0.863	-0.33	0.300
U/S-2	240	0.48	0.117	0.48	0.114	0.30	0.341	0.03	0.931	-0.46	0.130	-0.55	0.066	-0.57	0.051	-0.17	0.594	0.00	0.991	-0.27	0.400
U/S-2	480	0.49	0.109	0.48	0.117	0.35	0.269	0.05	0.875	-0.49	0.103	-0.57	0.053	-0.53	0.077	-0.26	0.422	0.06	0.863	-0.16	0.619
U/S-2	960	0.63	0.029	0.46	0.133	0.35	0.259	0.06	0.849	-0.41	0.180	-0.58	0.046	-0.43	0.162	-0.17	0.594	0.18	0.571	-0.11	0.731
U/S-3	30	0.34	0.280	0.65	0.022	0.46	0.131	0.21	0.511	-0.33	0.295	-0.31	0.331	-0.35	0.265	-0.17	0.602	-0.08	0.795	-0.33	0.294
U/S-3	60	0.33	0.292	0.66	0.019	0.48	0.114	0.23	0.479	-0.32	0.308	-0.29	0.365	-0.34	0.280	-0.15	0.640	-0.07	0.829	-0.32	0.307
U/S-3	120	0.33	0.301	0.69	0.013	0.60	0.041	0.34	0.286	-0.29	0.358	-0.27	0.390	-0.29	0.359	-0.14	0.656	0.00	0.991	-0.21	0.503
U/S-3	240	0.29	0.353	0.70	0.011	0.59	0.042	0.33	0.301	-0.33	0.295	-0.28	0.379	-0.28	0.379	-0.16	0.618	0.01	0.983	-0.18	0.585
U/S-3	480	0.33	0.292	0.62	0.030	0.64	0.025	0.37	0.238	-0.27	0.392	-0.24	0.456	-0.20	0.541	-0.27	0.403	0.11	0.737	-0.10	0.748
U/S-3	960	0.48	0.111	0.57	0.051	0.73	0.008	0.46	0.136	-0.16	0.614	-0.24	0.454	-0.15	0.646	-0.18	0.584	0.25	0.427	-0.04	0.904

Appendix XIV. (Cont.)

Landscape Context	Buffer Width (m)	TPSR		%Native		%Adventive		FQI	
		R	p	R	p	R	p	R	p
Local	30	0.05	0.875	-0.06	0.846	0.06	0.846	-0.03	0.922
Local	60	0.05	0.888	0.00	1.000	0.00	1.000	-0.08	0.812
Local	120	-0.01	0.974	-0.04	0.908	0.04	0.908	-0.10	0.753
Local	240	0.27	0.401	0.03	0.938	-0.03	0.938	0.14	0.664
Local	480	0.38	0.217	0.14	0.665	-0.14	0.665	0.28	0.371
Local	960	0.45	0.144	0.14	0.657	-0.14	0.657	0.36	0.248
U/S-1	30	0.11	0.728	0.04	0.912	-0.04	0.912	-0.05	0.888
U/S-1	60	0.11	0.745	0.12	0.706	-0.12	0.706	-0.01	0.974
U/S-1	120	0.11	0.737	0.12	0.707	-0.12	0.707	-0.01	0.983
U/S-1	240	0.16	0.627	0.19	0.554	-0.19	0.554	0.05	0.871
U/S-1	480	0.31	0.326	0.32	0.307	-0.32	0.307	0.26	0.422
U/S-1	960	0.37	0.236	0.43	0.158	-0.43	0.158	0.37	0.230
U/S-2	30	-0.19	0.556	0.25	0.440	-0.25	0.440	-0.10	0.762
U/S-2	60	-0.20	0.526	0.21	0.506	-0.21	0.506	-0.12	0.712
U/S-2	120	-0.12	0.712	0.26	0.420	-0.26	0.420	-0.04	0.897
U/S-2	240	-0.06	0.850	0.27	0.402	-0.27	0.402	0.00	0.991
U/S-2	480	0.01	0.987	0.22	0.488	-0.22	0.488	0.04	0.905
U/S-2	960	0.13	0.688	0.28	0.373	-0.28	0.373	0.17	0.601
U/S-3	30	-0.18	0.571	0.27	0.393	-0.27	0.393	-0.01	0.966
U/S-3	60	-0.17	0.601	0.27	0.392	-0.27	0.392	0.00	0.991
U/S-3	120	-0.08	0.795	0.23	0.481	-0.23	0.481	0.08	0.812
U/S-3	240	-0.07	0.829	0.19	0.556	-0.19	0.556	0.07	0.829
U/S-3	480	0.04	0.905	0.20	0.532	-0.20	0.532	0.14	0.656
U/S-3	960	0.18	0.576	0.25	0.437	-0.25	0.437	0.29	0.363

Appendix XV. Correlation coefficients (R) and levels of significance (p) for correlation analyses of riparian site community parameters with the spatial extent of all wetland land covers within 30, 60, 120, 240, 480 and 960m buffers adjacent to (i.e., Local) and upstream (i.e., U/S-1, U/S-2 and U/S-3) from survey sites. Significant correlations are highlighted in gray (p<0.01). Community parameter descriptions are provided within the report

Landscape Context	Buffer Width (m)	TASR		%Wood		HQI		MSR		RAIU		RAEX		MCPUE		FSR		FIBI		RAIF	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.73	0.007	-0.74	0.006	0.69	0.013	0.316	0.317	0.77	0.003	0.33	0.298	0.48	0.119	0.28	0.381	0.32	0.315	0.83	0.001
Local	60	0.47	0.127	-0.63	0.028	0.44	0.148	0.400	0.198	0.56	0.060	0.62	0.031	0.59	0.044	0.09	0.778	0.04	0.903	0.52	0.087
Local	120	0.47	0.127	-0.63	0.028	0.44	0.148	0.400	0.198	0.56	0.060	0.62	0.031	0.59	0.044	0.09	0.778	0.04	0.903	0.52	0.087
Local	240	0.38	0.218	-0.56	0.058	0.43	0.161	0.410	0.185	0.54	0.071	0.57	0.055	0.56	0.060	0.11	0.728	0.05	0.881	0.46	0.129
Local	480	0.33	0.301	-0.48	0.111	0.37	0.236	0.419	0.176	0.41	0.183	0.50	0.098	0.57	0.051	0.07	0.832	0.02	0.960	0.35	0.261
Local	960	0.20	0.543	-0.26	0.410	0.28	0.372	0.367	0.240	0.19	0.548	0.30	0.350	0.52	0.085	-0.02	0.947	0.00	0.991	0.18	0.566
U/S-1	30	0.83	0.001	-0.82	0.001	0.30	0.340	0.276	0.386	0.72	0.008	0.39	0.214	0.67	0.018	0.25	0.425	0.09	0.784	0.32	0.303
U/S-1	60	0.90	0.000	-0.82	0.001	0.36	0.248	0.186	0.563	0.74	0.006	0.23	0.469	0.57	0.052	0.26	0.410	0.15	0.645	0.46	0.133
U/S-1	120	0.88	0.000	-0.82	0.001	0.40	0.198	0.122	0.706	0.79	0.002	0.26	0.417	0.51	0.089	0.22	0.499	0.13	0.679	0.50	0.101
U/S-1	240	0.90	0.000	-0.82	0.001	0.36	0.248	0.186	0.563	0.74	0.006	0.23	0.469	0.57	0.052	0.26	0.410	0.15	0.645	0.46	0.133
U/S-1	480	0.89	0.000	-0.74	0.006	0.33	0.292	0.038	0.908	0.71	0.010	0.06	0.859	0.51	0.090	0.21	0.511	0.15	0.643	0.37	0.231
U/S-1	960	0.90	0.000	-0.81	0.001	0.48	0.114	0.234	0.464	0.71	0.010	0.22	0.487	0.60	0.038	0.37	0.232	0.26	0.408	0.54	0.068
U/S-2	30	0.69	0.012	-0.85	0.001	0.28	0.375	-0.131	0.685	0.87	0.000	0.26	0.406	0.24	0.454	0.06	0.851	0.04	0.904	0.36	0.252
U/S-2	60	0.69	0.012	-0.85	0.001	0.28	0.375	-0.131	0.685	0.87	0.000	0.26	0.406	0.24	0.454	0.06	0.851	0.04	0.904	0.36	0.252
U/S-2	120	0.69	0.013	-0.85	0.000	0.29	0.368	-0.113	0.725	0.88	0.000	0.28	0.382	0.24	0.460	0.08	0.812	0.04	0.895	0.37	0.236
U/S-2	240	0.69	0.013	-0.85	0.000	0.29	0.368	-0.113	0.725	0.88	0.000	0.28	0.382	0.24	0.460	0.08	0.812	0.04	0.895	0.37	0.236
U/S-2	480	0.77	0.003	-0.88	0.000	0.28	0.386	-0.092	0.775	0.87	0.000	0.21	0.520	0.30	0.343	0.17	0.592	0.12	0.699	0.42	0.173
U/S-2	960	0.77	0.003	-0.82	0.001	0.31	0.327	-0.135	0.677	0.79	0.002	0.15	0.649	0.27	0.400	0.14	0.665	0.05	0.878	0.42	0.179
U/S-3	30	0.56	0.060	-0.71	0.010	0.22	0.495	-0.305	0.335	0.81	0.001	0.11	0.737	0.07	0.819	-0.12	0.710	-0.03	0.930	0.27	0.393
U/S-3	60	0.63	0.027	-0.74	0.006	0.29	0.362	-0.245	0.443	0.86	0.000	0.15	0.644	0.15	0.638	-0.06	0.864	0.03	0.930	0.31	0.320
U/S-3	120	0.64	0.025	-0.76	0.004	0.28	0.375	-0.219	0.493	0.86	0.000	0.17	0.600	0.16	0.615	-0.04	0.894	0.01	0.974	0.31	0.327
U/S-3	240	0.65	0.023	-0.80	0.002	0.26	0.413	-0.205	0.522	0.84	0.001	0.22	0.484	0.18	0.584	-0.01	0.974	0.01	0.974	0.34	0.283
U/S-3	480	0.67	0.018	-0.83	0.001	0.31	0.323	-0.205	0.524	0.83	0.001	0.25	0.442	0.17	0.601	0.05	0.873	0.05	0.866	0.40	0.193
U/S-3	960	0.72	0.008	-0.73	0.007	0.33	0.291	-0.238	0.456	0.77	0.004	0.12	0.719	0.17	0.590	0.06	0.846	0.07	0.821	0.29	0.355

Appendix XV. (Cont.)

Landscape Context	Buffer Width (m)	FCPUE		ISR		InBI		EPT		RAIB		MAMSR		BSR		HSR		NoZone		CTV		BaAr	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.73	0.008	0.64	0.025	-0.36	0.244	0.27	0.397	0.05	0.880	0.01	0.964	-0.05	0.872	0.20	0.530	-0.34	0.285	-0.16	0.610	-0.31	0.331
Local	60	0.83	0.001	0.38	0.226	-0.45	0.144	0.35	0.266	0.17	0.608	0.46	0.137	-0.23	0.463	0.12	0.720	0.07	0.835	0.25	0.426	-0.16	0.627
Local	120	0.83	0.001	0.38	0.226	-0.45	0.144	0.35	0.266	0.17	0.591	0.46	0.137	-0.23	0.463	0.12	0.720	0.07	0.835	0.25	0.426	-0.16	0.627
Local	240	0.72	0.008	0.33	0.303	-0.37	0.235	0.26	0.418	0.13	0.683	0.49	0.106	-0.27	0.388	0.24	0.444	0.16	0.626	0.20	0.534	-0.03	0.930
Local	480	0.62	0.032	0.23	0.476	-0.28	0.382	0.17	0.590	0.03	0.919	0.48	0.111	-0.35	0.264	0.14	0.666	0.30	0.346	0.35	0.272	-0.12	0.708
Local	960	0.42	0.178	0.07	0.826	-0.16	0.628	0.01	0.965	-0.15	0.633	0.41	0.191	-0.45	0.143	-0.03	0.920	0.45	0.141	0.48	0.112	-0.34	0.279
U/S-1	30	0.54	0.068	0.80	0.002	-0.33	0.291	0.61	0.036	0.47	0.124	0.37	0.233	0.25	0.427	0.30	0.344	-0.31	0.322	-0.08	0.800	-0.33	0.297
U/S-1	60	0.51	0.091	0.87	0.000	-0.27	0.392	0.51	0.090	0.43	0.160	0.21	0.518	0.29	0.359	0.27	0.397	-0.46	0.133	-0.25	0.440	-0.47	0.123
U/S-1	120	0.54	0.070	0.88	0.000	-0.33	0.291	0.52	0.082	0.40	0.196	0.18	0.566	0.26	0.406	0.28	0.370	-0.49	0.109	-0.21	0.514	-0.49	0.104
U/S-1	240	0.51	0.091	0.87	0.000	-0.27	0.392	0.51	0.090	0.40	0.198	0.21	0.518	0.29	0.359	0.27	0.397	-0.46	0.133	-0.25	0.440	-0.47	0.123
U/S-1	480	0.45	0.138	0.93	0.000	-0.32	0.315	0.58	0.048	0.42	0.180	0.31	0.324	0.38	0.221	0.35	0.263	-0.53	0.075	-0.42	0.173	-0.51	0.093
U/S-1	960	0.55	0.062	0.88	0.000	-0.35	0.261	0.56	0.058	0.40	0.196	0.28	0.382	0.38	0.226	0.30	0.339	-0.49	0.104	-0.40	0.199	-0.43	0.166
U/S-2	30	0.51	0.094	0.73	0.007	-0.32	0.316	0.56	0.057	0.61	0.034	0.21	0.519	0.07	0.827	0.55	0.063	-0.48	0.110	-0.17	0.599	-0.44	0.156
U/S-2	60	0.51	0.094	0.73	0.007	-0.32	0.316	0.56	0.057	0.63	0.030	0.21	0.519	0.07	0.827	0.55	0.063	-0.48	0.110	-0.17	0.599	-0.44	0.156
U/S-2	120	0.49	0.106	0.73	0.007	-0.29	0.356	0.54	0.072	0.63	0.028	0.18	0.568	0.06	0.848	0.56	0.057	-0.47	0.119	-0.16	0.614	-0.42	0.170
U/S-2	240	0.49	0.106	0.73	0.007	-0.29	0.356	0.54	0.072	0.63	0.029	0.18	0.568	0.06	0.848	0.56	0.057	-0.47	0.119	-0.16	0.614	-0.42	0.170
U/S-2	480	0.48	0.118	0.81	0.001	-0.26	0.412	0.52	0.087	0.62	0.033	0.21	0.510	0.13	0.684	0.54	0.073	-0.58	0.047	-0.31	0.319	-0.48	0.111
U/S-2	960	0.38	0.221	0.85	0.000	-0.23	0.467	0.45	0.139	0.59	0.042	0.24	0.447	0.25	0.431	0.53	0.079	-0.51	0.090	-0.34	0.283	-0.53	0.078
U/S-3	30	0.44	0.157	0.62	0.032	-0.27	0.393	0.46	0.137	0.57	0.055	0.17	0.588	-0.10	0.755	0.56	0.061	-0.41	0.180	-0.11	0.735	-0.38	0.222
U/S-3	60	0.47	0.119	0.70	0.012	-0.35	0.266	0.53	0.074	0.58	0.047	0.17	0.588	-0.02	0.943	0.54	0.069	-0.46	0.131	-0.12	0.702	-0.37	0.241
U/S-3	120	0.46	0.130	0.69	0.013	-0.32	0.316	0.52	0.080	0.60	0.072	0.17	0.589	-0.01	0.974	0.56	0.059	-0.44	0.155	-0.12	0.711	-0.37	0.232
U/S-3	240	0.48	0.117	0.70	0.012	-0.31	0.327	0.51	0.090	0.49	0.108	0.18	0.565	0.00	1.000	0.52	0.086	-0.46	0.130	-0.11	0.744	-0.42	0.179
U/S-3	480	0.46	0.133	0.72	0.008	-0.32	0.317	0.49	0.106	0.55	0.062	0.16	0.626	0.05	0.887	0.49	0.109	-0.50	0.098	-0.12	0.712	-0.41	0.185
U/S-3	960	0.29	0.359	0.80	0.002	-0.34	0.286	0.55	0.062	0.52	0.083	0.07	0.822	0.25	0.436	0.43	0.166	-0.52	0.080	-0.13	0.694	-0.33	0.297

Appendix XV. (Cont.)

Landscape Context	Buffer Width (m)	TSP		DBH		USSt		USSp		GCSE		GCSL		%GCE		%GCL		NPSR		APSR	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	-0.03	0.934	-0.34	0.277	-0.07	0.825	0.05	0.881	0.63	0.028	0.66	0.020	0.62	0.032	0.08	-0.808	0.31	0.331	0.03	0.916
Local	60	0.25	0.425	-0.30	0.351	0.31	0.327	0.42	0.175	0.63	0.029	0.33	0.297	0.53	0.076	-0.05	-0.872	0.62	0.032	0.48	0.114
Local	120	0.25	0.425	-0.30	0.351	0.31	0.327	0.42	0.175	0.63	0.029	0.33	0.297	0.53	0.076	-0.05	-0.872	0.62	0.032	0.48	0.114
Local	240	0.32	0.314	-0.27	0.400	0.35	0.260	0.41	0.188	0.59	0.046	0.31	0.321	0.39	0.207	-0.06	-0.860	0.78	0.003	0.47	0.123
Local	480	0.34	0.276	-0.26	0.407	0.32	0.310	0.33	0.300	0.49	0.102	0.17	0.603	0.29	0.363	-0.06	-0.860	0.73	0.007	0.47	0.128
Local	960	0.35	0.262	-0.23	0.477	0.22	0.492	0.13	0.683	0.27	0.402	-0.08	0.810	0.10	0.759	-0.01	-0.983	0.60	0.038	0.39	0.216
U/S-1	30	0.02	0.959	-0.15	0.639	0.16	0.610	0.28	0.373	0.64	0.024	0.47	0.120	0.57	0.052	0.29	0.352	0.33	0.291	0.09	0.790
U/S-1	60	-0.14	0.664	-0.21	0.510	0.01	0.982	0.13	0.689	0.61	0.034	0.59	0.042	0.62	0.033	0.15	0.635	0.16	0.618	-0.08	0.808
U/S-1	120	-0.19	0.565	-0.26	0.422	-0.04	0.908	0.12	0.706	0.61	0.036	0.60	0.039	0.65	0.021	0.18	0.586	0.15	0.635	-0.01	0.972
U/S-1	240	-0.14	0.664	-0.21	0.510	0.01	0.982	0.13	0.689	0.61	0.034	0.59	0.042	0.62	0.033	0.15	0.635	0.16	0.618	-0.08	0.808
U/S-1	480	-0.11	0.728	-0.25	0.430	-0.12	0.707	-0.02	0.952	0.52	0.084	0.52	0.085	0.44	0.154	0.05	0.886	0.15	0.650	-0.21	0.517
U/S-1	960	0.00	0.991	-0.20	0.541	-0.06	0.862	0.05	0.887	0.59	0.043	0.56	0.056	0.42	0.170	-0.04	0.913	0.23	0.466	-0.17	0.605
U/S-2	30	-0.32	0.309	-0.46	0.137	-0.27	0.400	0.01	0.965	0.59	0.045	0.57	0.053	0.52	0.082	0.30	0.339	0.08	0.811	0.10	0.759
U/S-2	60	-0.32	0.309	-0.46	0.137	-0.27	0.400	0.01	0.965	0.59	0.045	0.57	0.053	0.52	0.082	0.30	0.339	0.08	0.811	0.10	0.759
U/S-2	120	-0.33	0.294	-0.45	0.147	-0.25	0.432	0.03	0.926	0.60	0.041	0.59	0.042	0.53	0.075	0.32	0.309	0.09	0.777	0.11	0.738
U/S-2	240	-0.33	0.294	-0.45	0.147	-0.25	0.432	0.03	0.926	0.60	0.041	0.59	0.042	0.53	0.075	0.32	0.309	0.09	0.777	0.11	0.738
U/S-2	480	-0.41	0.183	-0.36	0.251	-0.23	0.480	0.00	0.996	0.54	0.069	0.61	0.033	0.50	0.096	0.17	0.598	0.04	0.905	0.00	0.996
U/S-2	960	-0.32	0.303	-0.39	0.213	-0.21	0.510	0.00	0.991	0.53	0.079	0.61	0.034	0.44	0.156	0.13	0.695	0.15	0.646	-0.01	0.983
U/S-3	30	-0.39	0.212	-0.58	0.048	-0.42	0.178	-0.14	0.661	0.47	0.126	0.47	0.124	0.44	0.155	0.28	0.387	0.01	0.983	0.10	0.750
U/S-3	60	-0.34	0.281	-0.53	0.079	-0.40	0.204	-0.12	0.701	0.49	0.107	0.48	0.118	0.47	0.127	0.30	0.350	0.04	0.913	0.09	0.784
U/S-3	120	-0.32	0.309	-0.53	0.077	-0.37	0.242	-0.09	0.776	0.53	0.079	0.51	0.092	0.48	0.115	0.32	0.304	0.06	0.845	0.09	0.776
U/S-3	240	-0.38	0.217	-0.49	0.109	-0.32	0.316	-0.04	0.913	0.52	0.086	0.51	0.087	0.51	0.092	0.29	0.363	0.03	0.931	0.14	0.669
U/S-3	480	-0.42	0.172	-0.46	0.129	-0.36	0.253	-0.07	0.832	0.48	0.114	0.51	0.089	0.46	0.133	0.22	0.497	-0.01	0.974	0.14	0.666
U/S-3	960	-0.35	0.272	-0.38	0.225	-0.44	0.151	-0.19	0.562	0.38	0.219	0.41	0.186	0.38	0.226	0.31	0.331	-0.08	0.810	0.00	0.996

Appendix XV. (Cont.)

Landscape Context	Buffer Width (m)	TPSR		%Native		%Adventive		FQI	
		R	p	R	p	R	p	R	p
Local	30	0.27	0.389	0.24	0.454	-0.24	0.454	0.38	0.220
Local	60	0.65	0.021	-0.01	0.986	0.01	0.986	0.60	0.040
Local	120	0.65	0.021	-0.01	0.986	0.01	0.986	0.60	0.040
Local	240	0.81	0.001	0.12	0.714	-0.12	0.714	0.76	0.004
Local	480	0.77	0.004	0.11	0.723	-0.11	0.723	0.74	0.006
Local	960	0.64	0.025	0.13	0.686	-0.13	0.686	0.65	0.021
U/S-1	30	0.31	0.326	0.17	0.602	-0.17	0.602	0.46	0.133
U/S-1	60	0.11	0.729	0.24	0.452	-0.24	0.452	0.32	0.315
U/S-1	120	0.12	0.702	0.16	0.619	-0.16	0.619	0.27	0.392
U/S-1	240	0.11	0.729	0.24	0.452	-0.24	0.452	0.32	0.315
U/S-1	480	0.08	0.800	0.37	0.239	-0.37	0.239	0.29	0.363
U/S-1	960	0.15	0.637	0.41	0.187	-0.41	0.187	0.38	0.217
U/S-2	30	0.11	0.743	-0.08	0.815	0.08	0.815	0.11	0.744
U/S-2	60	0.11	0.743	-0.08	0.815	0.08	0.815	0.11	0.744
U/S-2	120	0.12	0.710	-0.08	0.815	0.08	0.815	0.12	0.702
U/S-2	240	0.12	0.710	-0.08	0.815	0.08	0.815	0.12	0.702
U/S-2	480	0.04	0.896	0.03	0.938	-0.03	0.938	0.12	0.702
U/S-2	960	0.13	0.694	0.17	0.607	-0.17	0.607	0.23	0.481
U/S-3	30	0.06	0.849	-0.14	0.671	0.14	0.671	0.00	1.000
U/S-3	60	0.08	0.798	-0.10	0.747	0.10	0.747	0.04	0.913
U/S-3	120	0.11	0.743	-0.09	0.790	0.09	0.790	0.07	0.828
U/S-3	240	0.07	0.819	-0.14	0.655	0.14	0.655	0.04	0.896
U/S-3	480	0.03	0.931	-0.14	0.661	0.14	0.661	0.01	0.965
U/S-3	960	-0.06	0.853	-0.05	0.889	0.05	0.889	-0.03	0.931

Appendix XVI. Correlation coefficients (R) and levels of significance (p) for correlation analyses of riparian site community parameters with the spatial extent of wetland and forest land covers combined within 30, 60, 120, 240, 480 and 960m buffers adjacent to (i.e., Local) and upstream (i.e., U/S-1, U/S-2 and U/S-3) from survey sites. Significant correlations are highlighted in gray (p<0.01). Community parameter descriptions are provided within the

Landscape Context	Buffer Width (m)	TASR		%Wood		HQI		MSR		RAIU		RAEX		MCPUE		FSR		FIBI		RAIF	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	-0.63	0.027	0.22	0.497	-0.16	0.609	-0.240	0.453	-0.29	0.361	-0.03	0.928	-0.47	0.123	-0.35	0.262	-0.38	0.222	-0.14	0.664
Local	60	-0.46	0.131	0.24	0.448	-0.17	0.592	-0.261	0.412	-0.32	0.313	-0.16	0.621	-0.25	0.434	-0.56	0.060	-0.48	0.114	-0.20	0.525
Local	120	-0.65	0.022	0.32	0.307	-0.20	0.534	-0.118	0.715	-0.35	0.271	-0.13	0.680	-0.32	0.313	-0.35	0.258	-0.28	0.383	-0.18	0.586
Local	240	-0.61	0.037	0.28	0.387	-0.17	0.591	-0.080	0.805	-0.32	0.311	-0.08	0.807	-0.25	0.426	-0.33	0.300	-0.27	0.402	-0.16	0.622
Local	480	-0.49	0.108	0.16	0.617	-0.03	0.923	0.139	0.666	-0.23	0.480	0.09	0.773	-0.10	0.753	-0.06	0.865	-0.08	0.814	-0.01	0.966
Local	960	-0.37	0.239	0.28	0.370	0.14	0.663	0.191	0.552	-0.17	0.590	-0.06	0.847	-0.09	0.786	-0.01	0.978	0.03	0.917	-0.04	0.905
U/S-1	30	-0.23	0.473	0.60	0.040	-0.02	0.948	0.290	0.360	-0.48	0.118	-0.10	0.759	0.25	0.440	-0.19	0.554	-0.09	0.784	-0.35	0.262
U/S-1	60	-0.01	0.965	0.49	0.102	0.27	0.402	0.243	0.446	-0.28	0.380	-0.29	0.365	0.28	0.383	-0.18	0.583	0.07	0.840	-0.08	0.812
U/S-1	120	0.07	0.837	0.43	0.167	0.31	0.331	0.232	0.468	-0.20	0.539	-0.31	0.333	0.29	0.354	-0.17	0.595	0.06	0.845	-0.04	0.897
U/S-1	240	0.16	0.612	0.31	0.324	0.35	0.269	0.160	0.619	-0.12	0.719	-0.34	0.277	0.34	0.280	-0.18	0.575	0.07	0.819	0.03	0.931
U/S-1	480	0.25	0.442	0.17	0.587	0.43	0.167	0.288	0.364	-0.05	0.879	-0.22	0.495	0.38	0.226	-0.07	0.835	0.10	0.760	0.21	0.513
U/S-1	960	0.46	0.129	-0.02	0.957	0.45	0.140	0.305	0.336	0.10	0.752	-0.21	0.512	0.58	0.046	0.06	0.852	0.22	0.501	0.18	0.579
U/S-2	30	0.00	1.000	0.46	0.131	-0.13	0.697	-0.067	0.837	-0.23	0.481	-0.42	0.175	0.03	0.914	-0.13	0.691	-0.11	0.735	-0.48	0.118
U/S-2	60	0.01	0.983	0.47	0.124	-0.12	0.713	-0.032	0.922	-0.23	0.481	-0.39	0.205	0.04	0.897	-0.11	0.724	-0.10	0.768	-0.47	0.124
U/S-2	120	0.04	0.909	0.41	0.185	-0.12	0.712	-0.018	0.957	-0.20	0.538	-0.37	0.232	0.08	0.803	-0.09	0.774	-0.11	0.726	-0.45	0.143
U/S-2	240	0.12	0.720	0.35	0.259	-0.02	0.957	0.116	0.719	-0.19	0.546	-0.31	0.332	0.23	0.470	-0.01	0.969	-0.05	0.883	-0.36	0.254
U/S-2	480	0.28	0.383	0.20	0.527	0.13	0.688	0.132	0.682	-0.06	0.845	-0.30	0.347	0.33	0.291	-0.06	0.847	-0.07	0.840	-0.13	0.680
U/S-2	960	0.46	0.137	-0.04	0.905	0.29	0.352	0.236	0.460	0.09	0.776	-0.15	0.638	0.47	0.123	0.07	0.821	0.02	0.943	0.06	0.862
U/S-3	30	0.08	0.807	0.20	0.527	-0.44	0.147	0.121	0.707	-0.28	0.387	-0.13	0.680	0.26	0.416	0.06	0.860	-0.20	0.538	-0.51	0.092
U/S-3	60	0.10	0.752	0.18	0.577	-0.39	0.210	0.177	0.583	-0.26	0.411	-0.07	0.839	0.30	0.351	0.11	0.736	-0.16	0.624	-0.44	0.157
U/S-3	120	0.11	0.741	0.13	0.680	-0.36	0.249	0.201	0.532	-0.23	0.480	0.02	0.960	0.31	0.324	0.13	0.679	-0.12	0.702	-0.30	0.336
U/S-3	240	0.16	0.624	0.06	0.846	-0.31	0.330	0.224	0.485	-0.14	0.654	0.03	0.928	0.29	0.353	0.13	0.679	-0.16	0.610	-0.23	0.477
U/S-3	480	0.21	0.519	0.07	0.820	-0.17	0.594	0.231	0.471	-0.15	0.646	-0.01	0.987	0.30	0.347	0.08	0.809	-0.17	0.598	-0.08	0.812
U/S-3	960	0.43	0.161	-0.03	0.923	0.06	0.863	0.301	0.342	-0.02	0.939	0.06	0.852	0.51	0.092	0.11	0.732	-0.05	0.887	0.03	0.931

Appendix XVI. (Cont.)

Landscape Context	Buffer Width (m)	FCPUE		ISR		InBI		EPT		RAIB		MAMSR		BSR		HSR		NoZone		CTV		BaAr	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	-0.16	0.611	-0.62	0.033	0.37	0.234	-0.53	0.076	-0.07	0.837	0.24	0.449	-0.54	0.070	0.30	0.347	0.65	0.023	0.18	0.570	0.17	0.601
Local	60	0.05	0.875	-0.47	0.123	0.22	0.496	-0.36	0.245	0.07	0.839	0.48	0.115	-0.55	0.066	0.10	0.757	0.69	0.012	0.25	0.441	0.01	0.965
Local	120	-0.12	0.703	-0.69	0.013	0.40	0.194	-0.62	0.031	-0.25	0.442	0.27	0.402	-0.76	0.004	0.16	0.615	0.73	0.007	0.25	0.429	0.36	0.254
Local	240	-0.10	0.759	-0.65	0.023	0.37	0.231	-0.60	0.040	-0.25	0.431	0.30	0.335	-0.76	0.004	0.15	0.640	0.74	0.005	0.31	0.332	0.39	0.208
Local	480	-0.09	0.769	-0.54	0.068	0.32	0.313	-0.56	0.059	-0.35	0.260	0.21	0.514	-0.65	0.023	0.14	0.655	0.65	0.022	0.29	0.353	0.52	0.084
Local	960	-0.26	0.419	-0.42	0.169	0.25	0.427	-0.48	0.118	-0.49	0.108	-0.10	0.767	-0.42	0.173	0.11	0.736	0.59	0.045	0.27	0.388	0.67	0.017
U/S-1	30	-0.06	0.853	-0.28	0.374	-0.17	0.599	0.01	0.965	-0.54	0.073	0.09	0.779	0.04	0.913	-0.51	0.092	0.49	0.104	0.39	0.214	0.40	0.196
U/S-1	60	0.09	0.777	-0.08	0.803	-0.26	0.415	0.03	0.922	-0.73	0.007	0.04	0.911	0.01	0.970	-0.41	0.186	0.35	0.259	0.16	0.624	0.32	0.306
U/S-1	120	0.09	0.786	0.00	0.991	-0.24	0.443	0.04	0.896	-0.73	0.007	0.02	0.956	0.04	0.914	-0.35	0.267	0.33	0.296	0.13	0.681	0.29	0.354
U/S-1	240	0.17	0.589	0.12	0.704	-0.28	0.378	0.07	0.819	-0.67	0.018	0.18	0.579	0.00	0.991	-0.27	0.405	0.28	0.376	0.05	0.871	0.22	0.484
U/S-1	480	0.25	0.428	0.15	0.632	-0.22	0.484	0.03	0.922	-0.56	0.057	0.07	0.824	0.06	0.862	-0.27	0.390	0.24	0.462	-0.01	0.983	0.08	0.812
U/S-1	960	0.30	0.337	0.39	0.211	-0.33	0.296	0.26	0.423	-0.36	0.253	0.28	0.386	0.13	0.682	-0.15	0.643	0.10	0.749	-0.08	0.803	0.16	0.617
U/S-2	30	-0.36	0.253	0.12	0.704	-0.07	0.829	0.22	0.489	-0.28	0.377	0.06	0.850	0.52	0.081	0.00	1.000	0.05	0.876	-0.22	0.484	0.06	0.846
U/S-2	60	-0.35	0.269	0.11	0.729	-0.08	0.795	0.24	0.448	-0.28	0.386	-0.01	0.982	0.55	0.065	-0.05	0.887	0.03	0.929	-0.20	0.527	0.06	0.863
U/S-2	120	-0.33	0.293	0.15	0.639	-0.06	0.854	0.23	0.467	-0.25	0.439	0.08	0.797	0.55	0.065	0.02	0.956	0.05	0.875	-0.24	0.455	0.03	0.931
U/S-2	240	-0.24	0.451	0.19	0.552	-0.11	0.737	0.25	0.440	-0.26	0.419	0.14	0.659	0.54	0.067	-0.05	0.873	0.10	0.766	-0.20	0.534	0.08	0.795
U/S-2	480	-0.06	0.862	0.33	0.290	-0.13	0.688	0.17	0.588	-0.28	0.373	0.21	0.514	0.42	0.171	-0.07	0.822	0.12	0.715	-0.18	0.586	-0.06	0.863
U/S-2	960	0.08	0.794	0.47	0.124	-0.19	0.555	0.25	0.436	-0.12	0.705	0.24	0.445	0.44	0.157	-0.02	0.947	0.07	0.836	-0.17	0.601	-0.06	0.845
U/S-3	30	-0.29	0.364	0.16	0.624	0.13	0.696	0.21	0.521	0.11	0.728	0.28	0.376	0.58	0.048	-0.10	0.766	-0.01	0.973	-0.23	0.477	-0.21	0.505
U/S-3	60	-0.26	0.419	0.18	0.580	0.09	0.778	0.19	0.545	0.14	0.662	0.25	0.427	0.59	0.045	-0.14	0.654	-0.03	0.937	-0.19	0.547	-0.20	0.532
U/S-3	120	-0.17	0.604	0.19	0.552	0.07	0.837	0.12	0.715	0.16	0.620	0.25	0.425	0.49	0.108	-0.20	0.527	-0.07	0.840	-0.16	0.617	-0.25	0.429
U/S-3	240	-0.19	0.551	0.23	0.469	0.15	0.632	0.04	0.913	0.14	0.667	0.17	0.607	0.48	0.112	-0.14	0.667	-0.03	0.924	-0.15	0.632	-0.30	0.336
U/S-3	480	-0.11	0.724	0.26	0.418	0.13	0.696	-0.05	0.888	0.13	0.679	0.10	0.763	0.45	0.143	-0.25	0.428	0.01	0.987	-0.12	0.721	-0.37	0.230
U/S-3	960	0.09	0.769	0.45	0.140	-0.17	0.601	0.21	0.503	0.26	0.418	0.14	0.659	0.51	0.089	-0.37	0.241	-0.08	0.814	-0.01	0.983	-0.30	0.347

Appendix XVI. (Cont.)

Landscape Context	Buffer Width (m)	TSP		DBH		USSt		USSp		GCSE		GCSL		%GCE		%GCL		NPSR		APSR	
		R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p	R	p
Local	30	0.17	0.596	-0.48	0.116	-0.07	0.837	-0.04	0.909	-0.01	0.965	-0.08	0.795	-0.50	0.099	0.22	-0.497	0.43	0.165	0.34	0.916
Local	60	0.33	0.296	-0.63	0.027	-0.07	0.820	-0.09	0.773	0.05	0.883	-0.20	0.532	-0.38	0.228	0.31	-0.328	0.44	0.157	0.27	0.114
Local	120	0.18	0.574	-0.39	0.209	0.01	0.983	-0.10	0.761	-0.12	0.699	-0.22	0.484	-0.51	0.089	0.31	-0.330	0.42	0.170	0.28	0.114
Local	240	0.19	0.560	-0.37	0.235	0.04	0.896	-0.07	0.835	-0.12	0.722	-0.24	0.453	-0.50	0.100	0.29	-0.362	0.47	0.127	0.34	0.123
Local	480	0.19	0.559	-0.14	0.676	0.18	0.586	0.04	0.896	-0.10	0.757	-0.18	0.586	-0.45	0.144	0.23	-0.470	0.53	0.077	0.36	0.128
Local	960	0.35	0.269	-0.04	0.901	0.05	0.879	-0.12	0.715	-0.12	0.715	-0.17	0.600	-0.39	0.210	-0.02	-0.948	0.49	0.104	0.13	0.216
U/S-1	30	0.73	0.007	0.27	0.400	0.35	0.272	0.11	0.743	-0.20	0.538	-0.54	0.069	-0.11	0.727	0.11	0.744	0.28	0.375	0.00	0.790
U/S-1	60	0.75	0.005	0.02	0.948	0.05	0.879	-0.19	0.546	-0.10	0.752	-0.37	0.234	-0.11	0.745	-0.10	0.753	0.31	0.329	-0.23	0.808
U/S-1	120	0.73	0.007	-0.03	0.923	0.01	0.966	-0.22	0.497	-0.04	0.897	-0.29	0.354	-0.06	0.863	-0.06	0.863	0.34	0.286	-0.25	0.972
U/S-1	240	0.67	0.018	-0.15	0.640	-0.07	0.837	-0.30	0.351	-0.02	0.939	-0.27	0.397	-0.11	0.729	-0.20	0.527	0.38	0.221	-0.25	0.808
U/S-1	480	0.65	0.022	-0.16	0.625	0.01	0.966	-0.17	0.593	0.15	0.632	-0.04	0.897	0.06	0.846	-0.21	0.513	0.39	0.208	-0.26	0.517
U/S-1	960	0.61	0.035	-0.11	0.728	-0.05	0.888	-0.25	0.431	0.14	0.655	-0.10	0.753	-0.04	0.905	-0.21	0.512	0.41	0.182	-0.30	0.605
U/S-2	30	0.49	0.108	0.22	0.498	0.08	0.795	-0.08	0.812	-0.15	0.648	-0.24	0.457	-0.19	0.557	0.25	0.430	0.17	0.602	-0.40	0.759
U/S-2	60	0.49	0.103	0.25	0.429	0.10	0.762	-0.05	0.871	-0.13	0.688	-0.22	0.484	-0.13	0.697	0.30	0.342	0.12	0.713	-0.41	0.759
U/S-2	120	0.50	0.096	0.23	0.479	0.14	0.656	-0.01	0.965	-0.09	0.790	-0.18	0.570	-0.14	0.656	0.27	0.402	0.21	0.504	-0.39	0.738
U/S-2	240	0.60	0.038	0.25	0.435	0.20	0.534	0.01	0.983	-0.05	0.884	-0.20	0.541	-0.15	0.648	0.19	0.556	0.30	0.336	-0.37	0.738
U/S-2	480	0.56	0.060	0.05	0.875	0.19	0.556	0.00	0.991	0.09	0.782	-0.05	0.880	0.02	0.948	0.06	0.863	0.42	0.178	-0.31	0.996
U/S-2	960	0.55	0.063	-0.01	0.970	0.15	0.640	0.00	0.996	0.23	0.467	0.07	0.828	0.07	0.820	0.02	0.940	0.48	0.117	-0.26	0.983
U/S-3	30	0.22	0.483	0.46	0.129	0.55	0.066	0.38	0.219	-0.03	0.918	-0.11	0.729	0.02	0.940	0.20	0.527	0.09	0.778	-0.23	0.750
U/S-3	60	0.21	0.506	0.52	0.086	0.59	0.042	0.43	0.165	-0.04	0.909	-0.10	0.753	0.07	0.837	0.19	0.555	0.11	0.744	-0.18	0.784
U/S-3	120	0.08	0.799	0.55	0.065	0.68	0.016	0.51	0.092	-0.06	0.858	-0.06	0.846	0.16	0.609	0.09	0.770	0.11	0.745	-0.07	0.776
U/S-3	240	0.06	0.850	0.47	0.121	0.69	0.012	0.54	0.067	0.06	0.849	0.10	0.762	0.28	0.372	0.18	0.579	0.18	0.579	-0.06	0.669
U/S-3	480	0.10	0.757	0.36	0.253	0.64	0.026	0.49	0.108	0.10	0.748	0.15	0.640	0.37	0.235	0.08	0.812	0.19	0.549	-0.07	0.666
U/S-3	960	0.23	0.469	0.32	0.306	0.51	0.092	0.38	0.228	0.14	0.663	0.06	0.863	0.43	0.162	0.09	0.770	0.18	0.579	-0.07	0.996

Appendix XVI. (Cont.)

Landscape Context	Buffer Width (m)	TPSR		%Native		%Adventive		FQI	
		R	p	R	p	R	p	R	p
Local	30	0.46	0.132	0.04	0.899	-0.04	0.899	0.28	0.383
Local	60	0.46	0.136	0.15	0.632	-0.15	0.632	0.32	0.316
Local	120	0.47	0.126	0.08	0.795	-0.08	0.795	0.33	0.291
Local	240	0.51	0.087	0.07	0.824	-0.07	0.824	0.38	0.217
Local	480	0.57	0.054	0.09	0.786	-0.09	0.786	0.49	0.108
Local	960	0.50	0.096	0.25	0.431	-0.25	0.431	0.47	0.122
U/S-1	30	0.27	0.393	0.18	0.576	-0.18	0.576	0.24	0.454
U/S-1	60	0.26	0.421	0.47	0.123	-0.47	0.123	0.30	0.346
U/S-1	120	0.28	0.384	0.52	0.082	-0.52	0.082	0.34	0.276
U/S-1	240	0.32	0.312	0.60	0.040	-0.60	0.040	0.41	0.190
U/S-1	480	0.30	0.341	0.63	0.029	-0.63	0.029	0.44	0.152
U/S-1	960	0.32	0.306	0.70	0.011	-0.70	0.011	0.53	0.077
U/S-2	30	0.10	0.762	0.46	0.135	-0.46	0.135	0.15	0.633
U/S-2	60	0.05	0.880	0.42	0.176	-0.42	0.176	0.10	0.746
U/S-2	120	0.14	0.671	0.48	0.112	-0.48	0.112	0.21	0.511
U/S-2	240	0.21	0.504	0.57	0.055	-0.57	0.055	0.33	0.291
U/S-2	480	0.32	0.312	0.66	0.020	-0.66	0.020	0.47	0.121
U/S-2	960	0.37	0.238	0.70	0.012	-0.70	0.012	0.57	0.052
U/S-3	30	0.02	0.953	0.27	0.399	-0.27	0.399	0.18	0.579
U/S-3	60	0.04	0.909	0.24	0.455	-0.24	0.455	0.19	0.547
U/S-3	120	0.06	0.862	0.14	0.665	-0.14	0.665	0.19	0.564
U/S-3	240	0.12	0.712	0.20	0.544	-0.20	0.544	0.27	0.390
U/S-3	480	0.12	0.712	0.26	0.412	-0.26	0.412	0.29	0.365
U/S-3	960	0.11	0.732	0.26	0.406	-0.26	0.406	0.28	0.372