Hydrology, sedimentology, and geomorphology as drivers of succession vs. flood disturbance within riparian forests of middle order streams of Western New York State, USA

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ABSTRACT

Development of riparian forests typically reflects varying influences of flood disturbance and/or primary succession. The main objective of this study within the Lake Erie Gorges of New York and Pennsylvania was to understand the contributions of geomorphology, hydrology, and sedimentology to a disturbance vs. succession continuum within middle order riparian zones of the Northeast. Forest composition has been quantitatively surveyed within eight selected river corridors in the region, chosen to be as free of human disturbance as possible, with stand ages estimated by increment coring. (Data from the extensively surveyed Zoar Valley Canyon of Cattaraugus Creek are also discussed throughout this thesis in terms of their contribution to the regional patterns assessed here.) Some river corridors were characterized by coarse cobble/boulder sediments, whereas others represented fine cohesive muds and silts. Total basal area and basal area (BA) for each species were catalogued on various sized quadrats on aggradational landforms. Also calculated were mean diameter at breast height (DBH) and its coefficient of variation (CV), species diversity (Shannon Weiner H'), and percentage of BA in shade tolerant species. Patterns in species composition and stand structure and their association with stand age were assessed by logarithmic regression and nonmetric multi-dimensional scaling ordination. Thirty-seven tree species were encountered, and stand ages ranged from 9 to 147 years (some Zoar Valley stands exceeded 250 years). Coarse sediment landforms exhibited high diversity and shade tolerance, both of which increased at greater stand age. In contrast, fine sediment landforms exhibited lower diversity, dominated by shade intolerant, flood responding pioneer species, with no increase in diversity at greater stand age. Riparian forests on coarse-sediment landforms,

including Zoar Valley Canyon, reflected primary succession driven by establishment of gravel-cobble landforms deposited as punctuated events. Conversely, stable or incrementally growing meanders of silt/mud-bank streams often support bands of increasing vegetation age moving inland, possibly reflecting either patterns in flood disturbance, or meander progression, or both.

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I. INTRODUCTION

Riparian systems are mosaic interfaces between aquatic and terrestrial ecosystems. In these areas direct interactions between water and land exist, providing many functions including streambank stabilization, streamflow regulation, and supplies of woody debris to the river system, to name a few (Swanson et al. 1982; Zimmermann et al. 1967). The main objective of this study within the Lake Erie Gorges of New York and Pennsylvania was to understand the contributions of geomorphology, hydrology, and sedimentology to a disturbance vs. succession continuum within middle order riparian zones of Western New York State. The heterogeneity of these vegetative habitats reveals clues that link past fluvial disturbances and depositional processes to present-day plant communities (Gregory et al. 1991; Naiman et al. 2005). Although these areas are high in ecological diversity they are also, unfortunately, some of the most heavily human impacted ecosystems. Landscape changes as a result of grazing, farming, deforestation and channelization have directly influenced watershed (i.e. drainage basin) characteristics and processes (Allan 1995; Naiman et al. 2005). Due in part to these anthropogenic impacts late successional riparian forest communities are not common, particularly in the eastern region of the United States (Hedman and Van Lear 1995; Frelich 1995). From an environmental standpoint it is important to maintain the remaining natural, undisturbed riparian sites because they provide a suite of ecosystem services including erosion resistance (which leads to reduced sediment and pollutant load in waterways via runoff), and habitat preservation for fishes and terrestrial organisms (Richter and Richter 2000).

Secondary successional riparian areas are most frequently observed in the eastern United States (e.g. Hedman and Van Lear 1995; Hupp and Osterkamp 1985), where flood frequency disrupts the continued development and maturation of the vegetative community. Secondary succession occurs where a vegetative community was previously present in an area that experienced either a natural or anthropogenic disturbance (e.g. severe flood or fire disturbing a present vegetative community or a forest to field conversion) (van der Maarel 1988). Usually secondary successional cases involve fertile soils, allowing for the quick recovery of vegetation. On the other hand, primary successional communities develop in areas where either no community was formerly present or where there are no remnants of an earlier vegetative community (van der Maarel 1988). Such locations include newly established landforms in river channels and areas left devoid of any plant life as a result of volcanic activity.

Due to heavy logging of valuable hardwood species in the Midwestern and Eastern areas of the United States (concurrent with European settlement), over 99% of pre-settlement forests no longer exist (Hunt et al. 2002). This has eliminated much of the later stages of succession in riparian zones of the Eastern United States. As a result, the majority of the knowledge of later successional stages is obtained from the Pacific Northwest (Balian and Naiman 2005, Fonda 1974, Van Pelt et al. 2006). The unmodified and unlogged reaches of the lower Queets River, located in the Olympic Peninsula of Washington State, arguably represent the most prominent and well-defined chronosequence (i.e. collections of existing sites that are said to represent time passage; Van Pelt et al. 2006) that has been recorded to date. The lower reaches of the Queets River exhibit forest development of nearly 400 years, from stand initiation on depositional bars progressing all the way to late-seral stages on the upper river terraces (Balian and Naiman 2005; Van Pelt et al. 2005).

As a result of prominent anthropogenic impacts from logging, farming, and river regulation, the Eastern United States is nearly devoid of a long-temporal scale riparian succession reconstruction. However, Zoar Valley Canyon, located in western New York State, offers pristine examples of late successional tree stands in a negligibly disturbed riparian forest system along the unregulated 6th order Cattaraugus Creek (Diggins 2013). For a variety of reasons, including its rugged topography, the expanse of this old-growth forest has been left to develop with very little human disturbance (Pfeil et al. 2007). Zoar Valley can thus provide comparative insight for additional riparian corridors in the eastern United States in terms of the geomorphology, hydrology, and sedimentology that aid in determining riparian forest structure and composition.

The hardwood-dominated riparian forest in Zoar Valley was found to follow a 300-year successional sequence, qualifying it as the longest middle-order riparian sequence studied in the eastern United States thus far (Diggins 2013). The present study is an extension of a single-system chronosequence (i.e. "space-for-time" substitution; Walker et al. 2010) investigation conducted in Zoar Valley Canyon, New York by Diggins (2013). The present study will include additional riparian corridors within the Lake Erie Gorges allowing for: 1) the identification of relationships between geomorphology, hydrology and sedimentology in the hydrological system, and 2) the recognition of relationships between riparian succession and disturbance in the establishment and community composition of the Hemlock-Northern Hardwood riparian forests of the northeastern United States.

The framework of the present study is built on the evaluation of a geomorphic dichotomy (or perhaps a geomorphic continuum). At one end, stable landforms comprised of fine, cohesive sediments near the observed channels were expected to yield vegetation age and structure that was primarily regulated by flood regime, with higher landforms farther from the channel perhaps also being simultaneously regulated by successional processes (Diggins 2013; Gregory et al. 1991; Naiman and Decamps 1997). Site specific vegetation exhibiting flood-driven banding usually becomes established on stable channel banks that are formed from fine, cohesive sediments such as silts and clays (Malanson 1993). At the other end of the suggested continuum very coarse sediments (large gravel up to boulders) reveal punctuated depositional occurrences as a result of markedly high discharge events (Allan 1995; Diggins 2013). Streams dominated by highly erodible sediments, such as sand and fine gravel, may not have landforms stable enough to support the establishment of perennial vegetation (Diggins 2013; Malanson 1993).

The present study is intended to evaluate the disturbance vs. succession dynamics in the northeastern riparian river systems of the Lake Erie Gorges ecoregion in western New York State. It will be assessed whether riparian forest structure and composition in this study region experience secondary succession (or perhaps even suspended succession) in response to variable hydrologic disturbance (Hupp and Osterkamp 1985), or experience primary succession following landform establishment, which has been the predominant case in Zoar Valley Canyon, New York (Diggins 2013). The constructs of this study are built around "discovery-driven" questions meant to evaluate the prominence of a few closely related hypotheses, as opposed to adhering to the strict investigation of one hypothesis. The broad research question and its coinciding hypotheses can be expressed as follows:

> How do processes of flood disturbance and ecological succession influence forest structure and composition within riparian ecosystems of the eastern deciduous biome? Where succession predominates, it is anticipated that stand age will be consistent with landform establishment and stabilization. Where disturbance predominates, stand age of vegetation should instead reflect the time since the last disruptive flood event. Additionally, distinct differences will often be observed between forest stand age and landform age (Diggins 2013); e.g. young forest on a much older landform, as might be seen if flood disturbance habitually resets the successional trajectory.

Background

Riparian Zones

The Latin word *riparius* means "of or belonging to the bank of a river" (Webster's New Universal Unabridged Dictionary 1976), and the term *riparian* refers to the ecosystems along the shores of lakes and streams. The riparian landscape is a unique environment because, while it is a terrestrial habitat, it strongly affects and is affected by aquatic environments. Riparian areas within landscapes are environmental resource patches that are distinguished from their surroundings by the influence of the hydrologic regime (Malanson 1993). Riparian zones are dynamic and complex environments characterized by strong energy regimes, habitat heterogeneity, and a variety of ecological processes and gradients (Naiman and Decamps 1997).

There is a difference in opinion regarding whether these zones typically extend from the edges of streams or rivers to the edges of upland communities (e.g. upland forest), or are limited to areas that experience flooding. Due to the landform and community mosaics that comprise these areas, riparian zones can be difficult to delineate (Gregory et al. 1991). The majority of riparian classification methods rely solely on just a few characteristics of the riparian zones themselves, such as hydric soils and the associated vegetation (Cowardin et al. 1979). Such methods may sufficiently address terrestrial plant community characteristics, but they leave out an evaluation of the community associations and ecological processes that occur within the terrestrial-aquatic interface (Gregory et al. 1991). The present study focused on riparian zones in the context of the temporal and spatial patterns of terrestrial plant communities, as well as the hydrologic and geomorphic processes affecting those riparian communities.

Riparian zones are often small in forest-embedded headwater streams, but are larger in midsized streams where they are represented by a band of vegetation whose width is determined by annual discharge and long-term (>50 years) channel dynamics (Naiman et al. 2005). The riparian zones of the largest streams (generally >6th order) exhibit physically complex and well-developed floodplains subjected to long periods of seasonal flooding, oxbow lakes in old river channels, moist soils, diverse vegetation, and lateral channel migration (Naiman et al. 2005). Even vegetation occurring outside the area that is not directly influenced by hydrologic conditions is oftentimes considered to be part of the riparian zone based on a broader definition by, e.g. Malanson (1993). In order for such vegetation to be included in the riparian definition it must influence the floodplain and/or channel by shading, or it must contribute organic matter (e.g. wood, leaves) to the floodplain or channel (Naiman and Decamps 1997).

Eastern Deciduous Forest

Before extensive logging by humans the expanse of the eastern deciduous forest of North America once spanned from the northern New England states south to central Florida and west to the start of the North American Prairie. The eastern deciduous forest comprises a portion of the temperate deciduous forests, which is one of Earth's major biomes found in eastern North America, and in Europe, Japan and China (Wildscreen Arkive 2011). Nearly all of the eastern United States is covered by the eastern deciduous forest, with exceptions being the southernmost portion of Florida consisting of subtropical vegetation and an area known as the prairie peninsula, an intrusion of grassland extending from the Mississippi River eastward to Illinois and central Indiana, with outlier prairie areas occurring as far east as central Ohio and as far north as southern Wisconsin and southern Michigan (Stuckey and Reese 1981). Coniferous forests in southeast Canada bound the deciduous forest in the USA to the north, while large swaths of farmland, prairie and grassland to the west separate the eastern deciduous forest from the predominant conifer forests of the western United States (Wildscreen Arkive 2011). Near the Canadian border the northern hardwood forest is comprised predominantly of yellow birch (*Betula alleghaniensis*), American beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*). Eastern hemlock (*Tsuga canadensis*) and white pine (*Pinus strobus*) are two prevailing conifer species in the northern hardwood forest (Wildscreen Arkive 2011). Often, pine species are the pioneer woody species in these areas on abandoned farmland or after a forest fire event. They grow more quickly on poor soil than their deciduous counterparts, comprising much of the upper tree layer in northeastern areas with variable rocky terrain. Pines will develop as second-growth vegetation in areas that have been heavily logged (USDA 1980). Tree species in the low-to-mid elevation of the Eastern USA are primarily deciduous, which are understood to have developed as an adaptation to cold winters and a growing season that is particularly long, warm, and humid (Walter 1973).

The Society of American Foresters and the U.S. Department of Agriculture has further divided the eastern forest into three generally broad regions: Lake States and Northeast, Central Mountains and Plateaus, and Southern States (Patton 1992). The study area of the Lake Erie Gorges ecoregion falls into the broad forest region of the Lake States and Northeast with more mesophytic (i.e. adapted to moist environments) ecotypes extending in from the Lake Plain, and is further classified as the hemlock-northern hardwood region, as defined by the ecosystem and the forest composition. This region is principally dominated by sugar maple and beech, or sugar maple and basswood associations (Braun 1950). Beech and maple species often occur in all stages of forest development in this region. Both species are highly shade tolerant and typically occupy more mesic locations in the Temperate Zone of the Northern Hemisphere. Additionally, the variety of mixed hardwood species that occupy much of the eastern United States include many bottomland species such as elms, ashes, walnuts, hornbeams, sycamores, chestnuts, willows, and alders (Spurr and Barnes 1980).

Successional Processes

Plant succession is simply defined as "the successive occurrence of plant communities at a given state" (van der Maarel and Werger 1978). This definition refers to a plant community as a portion of vegetation comprised of populations growing and interacting in a similar environment, while displaying similar structure and composition in flora that is unique in comparison to any surrounding vegetation (van der Maarel 1988). The two most prevalent forms of successional dynamics pertinent to this study are primary and secondary successions. Primary succession is the development of an ecosystem over a longer time period, on substrate that has never supported plant life or has been altered (via lava flow, glacial retreat, or even landform generation as a result of a severe flood event) to the point where no remnants of earlier vegetation remain. These environments consisting of virginal substrates are generally low in nitrogen, requiring nitrogen-fixing organisms in the early stages of ecosystem development (van der Maarel 1988).

In contrast to primary succession, secondary succession takes place on substrate that previously sustained a vegetative community (van der Maarel 1988). Secondary succession occurs after an ecological disturbance (e.g. flood, fire, farming, etc.) has destroyed the vegetative community while leaving remnants of previously established plant species. Soil is present, unlike in primary succession, and the pioneer community develops as a result of the remaining plant remnants along with new colonizing species. Much of the present-day knowledge of secondary succession circumstances derives from what are known as 'old-field successions' (Egler 1954), in which fertile soils of old farm fields or grazing land allow for the prompt return to a well-structured forest.

Forest Succession

Forest succession progresses in four stages (without the influence of a major disturbance event): establishment, stem exclusion, understory initiation, and mature (Oliver and Larson 1996). In the establishment stage, plants colonize a site after a disturbance or the formation of a new depositional landform. This period of development occurs before the available growing space in an area is fully occupied. Once all the available growing space is occupied by vegetation, species with an advantage in terms of growth rate or size expand and occupy the space that is being used by other less competitive plants. This process, referred to as the stem exclusion stage, prohibits new plants from colonizing (Naiman et al. 2005). Even-aged stands emerge at this stage with some individuals in the vegetative community growing faster than others (Cox and Moore 2005). During the understory initiation phase, development of individuals in the understory is triggered in response to mortality in the overstory (Naiman et al. 2005). This stage is characterized by the invasion of shade tolerant herbaceous plants and trees. These species may be present in the stem exclusion stage; however, the individuals are slower growing, resulting in a stand with multi-aged canopy layers (Naiman et al. 2005). The final successional stage is the mature stage, where individual trees die as a forest stand ages, opening new canopy space to be occupied by regeneration in the understory (Cox and Moore 2005; Naiman et al. 2005). The forest stand reaches a state of old-growth when the trees that invaded immediately after the initial disturbance begin to die (Naiman et al. 2005; Oliver and Larson 1996). This progression, whereby trees regenerate and grow without external disturbance influence, is known as an autogenic process in which the biota initiates changes in the community (Naiman et al. 2005).

Riparian and Floodplain Succession

Allogenic processes, those that originate from the environment, are also important in shaping the forest composition and structure (e.g. hydrologic regime, landform inundation period, and stream channel shifts) (Naiman et al. 2005). Allogenic processes are often considered to be the main driving factors of riparian vegetation composition and structure (Francis 2006). Hydrology and geomorphology influence channel form, which in turn influence the establishment of vegetation in riparian areas. Riparian plants are often pioneer species that require bare patches of sediment to become established. Therefore, hydrogeomorphic processes that lead to channel bar and floodplain formations are responsible for creating bare patches upon which vegetation may become established, and those formations may differ greatly in their sedimentary compositions (e.g. sand, gravel, and/or cobble) (Francis 2006).

Distribution and composition of riparian vegetation communities are incredibly diverse. The geomorphic surfaces of the valley floor (e.g. active channels, channel bars, floodplains) provide the physical template upon which riparian plant communities develop (Gregory et al. 1991). Floodplains, hillslopes, and terraces adjacent to active channels are usually occupied by shrubs and trees of various age classes that may or may not reflect the history of flood regime. Riparian communities on surfaces nearer the active channel are often characterized by younger stands comprised of deciduous trees and shrubs. Moving away from the active channel, floodplains usually contain plant communities that are older. The older plant communities are either comprised of typical riparian species (e.g. alder, willow, and cottonwood) or upland plant species that have extended down onto the floodplain (Gregory et al. 1991). The lateral meandering of stream channels has a tendency to alter this pattern, because older riparian plant communities can be cut into along the outer edge of a meandering channel, with the simultaneous deposition along the inner edge (Hugget 2007, Malanson 1993). The newly formed depositional surfaces (e.g. point bars) provide areas for the establishment of younger riparian stands. The composition and abundance of terrestrial vegetation vary among different riparian successional stages (Gregory et al. 1991).

The successional processes of riparian communities are understood to have multiple seemingly-stable states, where influences from autogenic and allogenic processes may make it difficult to predict successional patterns (Naiman and Decamps 1997, Naiman et al. 2005). For example, flood events introduce sudden allogenic alterations in soil development or substrate particle size, and can even reset patch age when flooding disrupts vegetation progression (Naiman et al. 2005). However, between flood events the autogenic alterations that occur in surface sediment size are much more gradual as soil develops. The autogenic and allogenic influences combine to create multiple successional states in riparian forests that may persist for decades or even centuries. As a result, such successional stages are viewed as quasi-stable (or seemingly-stable) states (Naiman et al. 2005).

Fluvial Geomorphology

Fluvial geomorphology is the study of stream shape and how streams interact with the surrounding land (Hugget 2011). Hydrological and geomorphological processes (i.e. flooding, channel avulsions, and point-bar deposition) are responsible for both the establishment and removal of riparian vegetation (Egger et al. 2015). Flood effects also include sediment deposition and erosion. Deposition of new landforms creates a blank canvas for the development of riparian pioneer species (e.g. willows and cottonwoods). Sediment-type plays a role in determining the composition of riparian areas (Asaeda and Rashid 2012).

Coarse sediments (e.g. cobbles, slabs, boulders) resist erosion due to their large mass in relation to their surface area. In order for a stream to move such sediments it must create shear force equal to or exceeding that necessary for the movement of the sediment particles (Hugget 2011). This translates to a gravel/cobble river requiring high streamflow velocity for sediments to be transported (Nanson and Croke 1992). Coarser sediments are dropped out of the bed load (i.e. sediments rolled along channel bed via traction (Hugget 2011)) as soon as the shear-force of the stream drops below the threshold required to keep them suspended. As a result, punctuated sediment deposits are generated as point bars, channel bars, and channel islands (Naiman et al. 2005). These abrupt deposits can become colonized by herbaceous plants and early riparian pioneer trees (e.g. sandbar willow and eastern cottonwood), especially if the landforms have some sort of geomorphic protection and/or accumulate protective woody debris (Naiman and Decamps 1997). As these landforms age and become stabilized by vegetation, new landforms may be generated by other flood events, creating mosaics of differently-aged surfaces and forest stands in the riparian landscape (Gregory et al. 1991).

I. STUDY SITES

Study Area

The Lake Erie Gorges ecoregion includes a total of approximately 410,668 hectares (Hunt et al. 2002), encompassing much of western New York State (**Figure 2.1**). This ecoregion covers portions of three broader ecoregions established by The Nature Conservancy (1999, 2001): Great Lakes, Western Allegheny Plateau, and High Allegheny Plateau ecoregions (Hunt et al. 2002). The areal expanse of the Lake Erie

Gorges ecoregion is shown in **Figure 2.2**. Due to the sudden elevational break between the Appalachian Plateau to the southeast and the Great Lakes Plain nearer to Lake Erie the physiography of the boundary separating these ecoregions is very well defined. The largest rivers of the Lake Erie watershed generally travel through this escarpment as confined mid-reach streams bounded by sharp-sided gorges (Hunt et al. 2002). This ecoregion shapes the easternmost segment of the Lake Erie-Lake Saint Claire drainage basin that extends from New York through Michigan (Myers et al. 2000).

The Lake Erie Gorges ecoregion was delineated by the New York Natural Heritage Program as a means to document rare species and important natural communities of several of the forested gorges through which Lake Erie tributaries flow (Hunt et al. 2002). This involved a two-year project funded by the Central/Western New York Chapter of The Nature Conservancy, with the goals of conserving the biodiversity characteristic to those gorge communities, as well as determining the quality of the streams flowing through the gorges in Chautauqua, Cattaraugus, and Erie counties of New York.

Four of the five streams under evaluation by the present study fall within the Lake Erie Gorges ecoregion, extending just south of Buffalo, New York west to approximately Erie, Pennsylvania. These include Chautauqua, Twenty-mile, Eighteen-mile, and Cattaraugus creeks. The fifth stream, Tonawanda Creek, falls outside of the Lake Erie Gorges ecoregion approximately 20 kilometers to the northeast of Buffalo. The Tonawanda Plain is nestled between two east-west ridges, the Onondaga Escarpment to the south and the Niagara Escarpment to the north (Stratton and Seleen 2003).

The humid temperate region of New York State in the northeastern United States receives an annual, distribution of precipitation of approximately 107 cm. Flow rates are highest in the spring (March through May) and generally lowest late summer and in the fall (August through October) (NYSDEC 2005). The surficial geology of the Lake Erie Gorges ecoregion is primarily till in the Appalachian uplands, with fine sediments (e.g. silts and clays) in the Lake Plain (Hunt et al. 2002). Bedrock is comprised of calcareous shales and siltstones of the Canadaway, Conneaut, and West Falls Groups. Gravels and sands are particularly abundant along the Cattaraugus Creek river system (Hunt et al. 2002).

New York State was comprised mostly of forested land prior to European settlement, but by the 1890s, nearly 85% of the land was used for agriculture. Currently, approximately 62% of the state consists of second growth forests (NYSDEC 2005). According to the U.S. Census Bureau (2010), New York State has a resident population over 19 million. Over 12 million of those residents inhabit the metropolitan region of New York City. Many of the remaining residents are located in the larger cities of upstate New York, such as Albany, Binghamton, Buffalo, Rochester, Syracuse, and Watertown (NYSDEC 2005). For the Lake Erie Gorges ecoregion in particular, the major populated areas include Buffalo (population 261,310), Gowanda (population 2,709), Springville (population 4,367), Fredonia (population 10,909), East Aurora (population 6,234), and Hamburg (population 56,936) (Hunt et al. 2002; U.S. Census Bureau 2010).

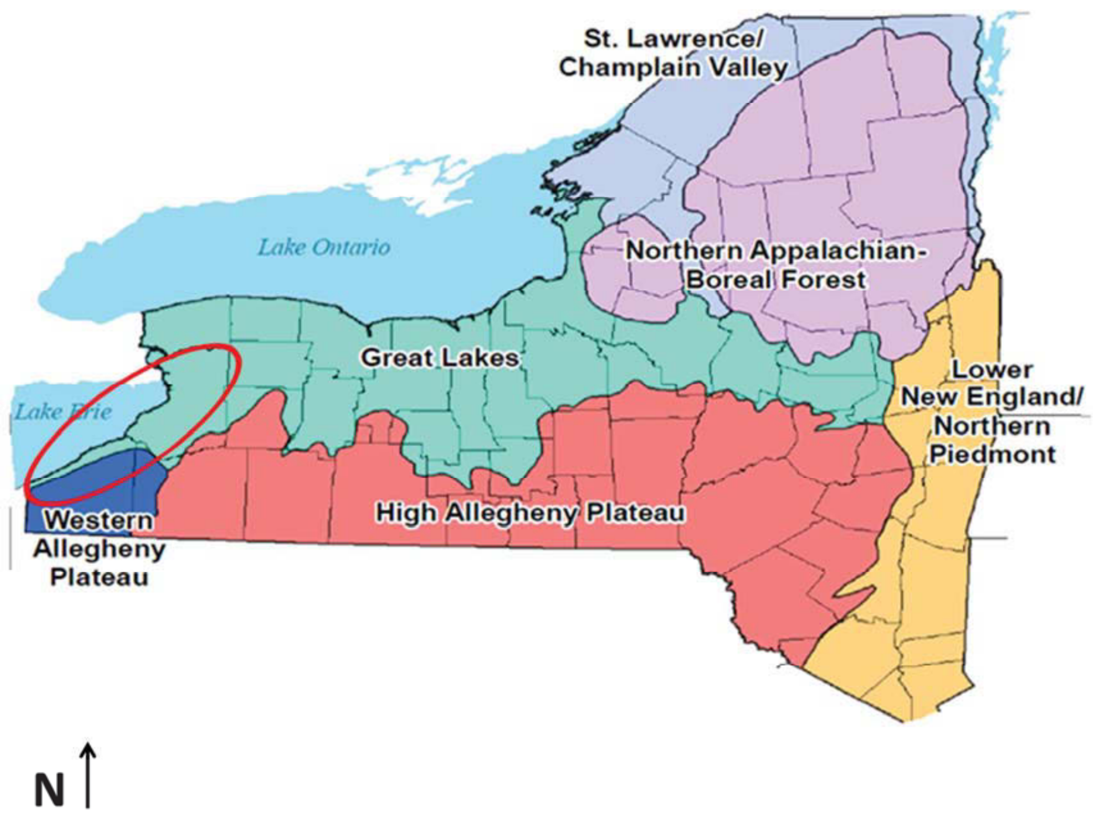


Figure 2.1 - New York state ecoregions as defined by The Nature Conservancy (image adapted from NYSDEC 2005), with areal expanse of the present study bounded in red.

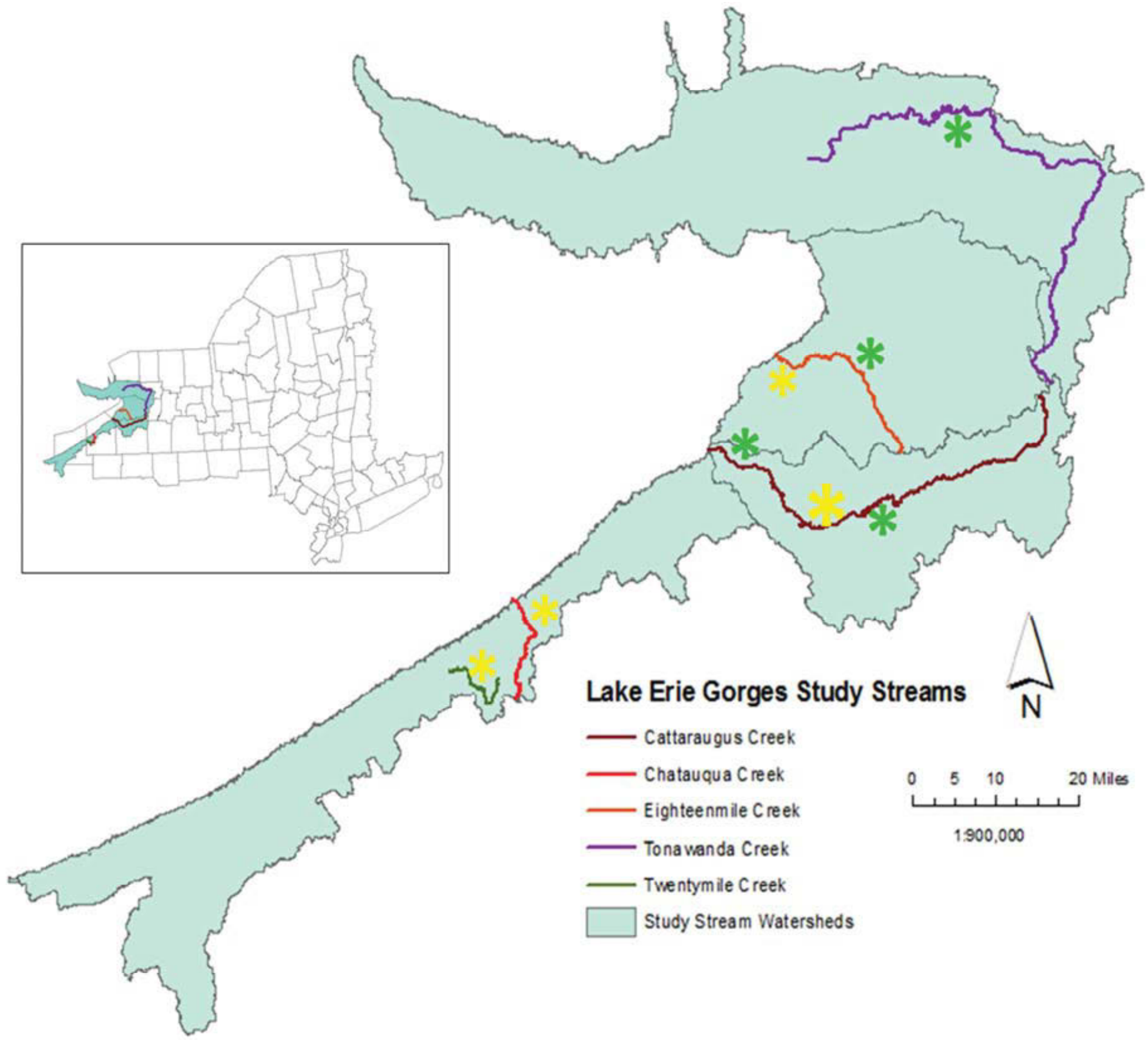


Figure 2.2- Map of the Lake Erie Gorges ecoregion with locations of study streams. Yellow asterisks represent study sites comprised of coarse-sediments (with Zoar Valley being the largest, central asterisk), while green asterisks represent those comprised of fine-cohesive sediments.

Glacial History

Glaciation was a significant and expansive event in the natural history of eastern North America. At the peak of glacial advance during the Pleistocene, approximately 32 percent of the world's land area was covered with ice (Spurr and Barnes 1980. During this glaciation, the Cattaraugus Creek within Zoar Valley was covered by the Laurentide Ice Sheet, a massive sheet of ice that also covered the majority of Canada and much of the northern United States (Cox and Moore 2005). The riverbed in Zoar Valley Canyon, along with the other coarse-sediment rivers in the Lake Erie Gorges ecoregion are primarily comprised of cobble and gravel, along with boulders that are both local sedimentary rocks and erratic igneous and metamorphic rocks that are outwash deposits from the glacial advance (Hunt et al. 2002).

The Laurentide Ice Sheet extended south from Canada to the northeastern portion of the United States during the peak of the last continental glaciation about 18,000 to 20,000 ago (Delcourt and Delcourt 2008), influencing the full-glacial climate. Northeastern areas currently inhabited by temperate deciduous forests, such as the Lake Erie Gorges ecoregion, were either glaciated or occupied by tundra vegetation including mosses, grasses, and dwarf shrubs (Cox and Moore 2005). Successive climatic changes led to the extirpation of various tree species that preferred warmer conditions. The hemlock (*Tsuga*) and the tulip tree (*Liriodendron*) were lost in Europe, but survived in North America. This was due to the north-south orientation of the Rocky Mountains in the western United States and the Appalachian Mountains in the eastern United States, which allowed sensitive vegetative species to migrate southward during the glacial expansion in the northern United States (Cox and Moore 2005).

The Flora of North America Editorial Committee (Delcourt and Delcourt 2008) summarizes that in the northeastern portion of the United States, across the Great Lakes and New England regions, is a latitudinal band consisting of mixed conifer-northern hardwoods forest related directly with the broad Polar Frontal Zone. Consequently, this zone represented the climatic boundary between boreal and temperate climatic regions. Deciduous forests subsequently migrated northward with the expansion of the Maritime Tropical air mass during glacial recession (Delcourt and Delcourt 2008). Approximately 6,000 years ago as residual continental ice sheets continued to retreat into northern Canada (north of latitude 60 ^{O}N) and the Maritime Tropical air mass migrated to the north, deciduous forests became more prominent across the eastern portion of the United States (Matthews et al. 1989).

Forest Ecotypes

Presently, the Lake Erie Gorges ecoregion is made predominantly of fragmented forest and agricultural land, comprising 54% and 42% of the land cover, respectively (Myers et al. 2000). In the Lake Plain of the Great Lakes ecoregion (refer to **Figure 2.1**) mesic forests were dominated by maple-basswood species prior to European settlement in the 1600s. Coinciding forests included the hemlock-northern hardwood and beech-maple mesic forest regions of the High Allegheny Plateau ecoregion, with the hemlock-northern hardwoods also dominating the Western Allegheny Plateau ecoregion in combination with a rich mesophytic forest-type (Hunt et al. 2002). Historical land survey records suggest that there may have been up to 14 distinct forest community types within the Lake Erie Gorges study area. Up to 30,000 acres of contiguous forested land (of which Zoar Valley Canyon is the largest expanse) still exist today, holding remnant communities of the original matrix forests. The majority of these remnant communities can be found along the larger streams that flow into Lake Erie (i.e. Cattaraugus Creek), in localized gorge areas protected by steep slopes (Hunt et al. 2002).

Study Streams

Temporal sequences of aerial photographs reveal changes (or lack of change) in the channel morphology of each study stream reach over time. Streams are presented in order from westernmost creek eastward. In order from west to east these streams are Twentymile, Chautauqua, Cattaraugus, Eighteenmile, and Tonawanda Creeks. The morphology of each of the seven study reaches, along with landform designations of each study site, are shown in **Figures 2.3-2.18**. In these figures, upper terraces are designated by numerals while lower terraces/floodplains are designated by capital letters. Belt transects that are narrow in width (e.g. 10 meters) are designated by dashed lines and labeled as numbered bands.

The origin of Twentymile Creek is located approximately 3.2 kilometers NE of Sheldon Corners and discharges into Lake Erie two miles NW of State Line, New York in Pennsylvania (Hunt et al. 2002). Fourth-order Twentymile Creek (**Figures 2.3** and **2.4**) is lined with calcareous shoreline outcrop shelves, as well as accumulated glacial till comprised mostly of cobbles with some riverside sand/gravel bars. The surrounding landscape includes a post-glacial shale gorge carved, in part, by the riffle-run-pool dominated Twentymile Creek through the Cattaraugus Highlands. Predominant to the watershed are agricultural land and multi-aged successional forests, with interspersed residential areas. The entirety of Twentymile Creek is undammed, allowing it to flow unregulated and directly into Lake Erie (Hunt et al. 2002).

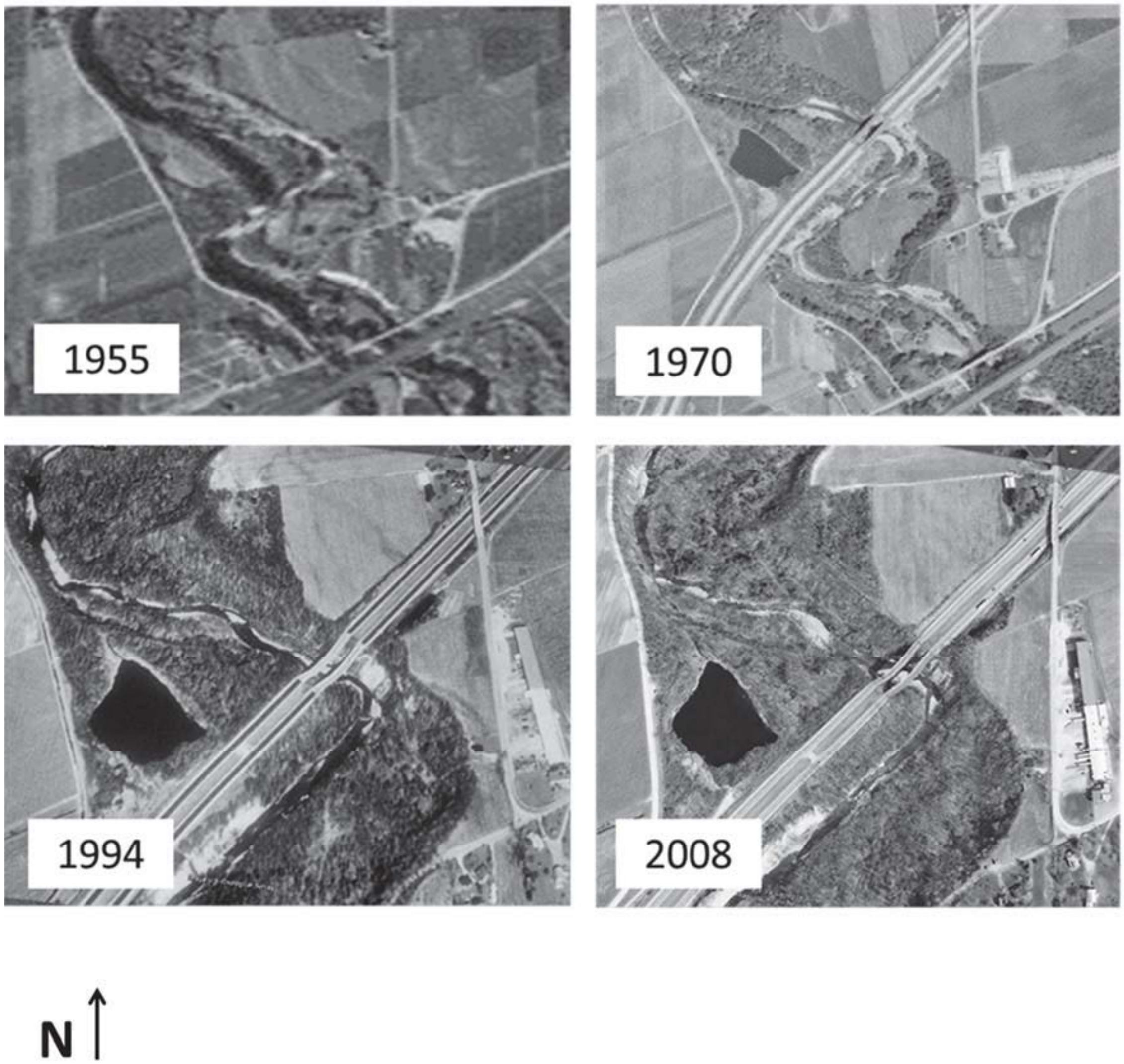


Figure 2.3 – Aerial image time series of the Twentymile Creek study reach

Figure 2.4 – Landform study site designations for Twentymile Creek. Letters A and B delineate exact lower terrace study site locations.

Chautauqua Creek (**Figures 2.5 – 2.7**) begins near the Village of Sherman and empties into Lake Erie near Westfield, New York after flowing approximately 24 kilometers north (Hunt et al. 2002). Chautauqua is a fourth-order, riffle-run-pool dominated low-gradient river confined by fractured shale substrate and containing a cobble-bottomed area in its middle reaches. It flows through a post-glacial gorge, which is several miles long. The gorge's towering slopes are approximately 60 to 91 meters tall and is centered on the escarpment of the Cattaraugus Highlands (Hunt et al. 2002). The watershed is comprised mostly of a mix of selectively-logged climax forest types, agricultural fields, plantations, and successional northern hardwoods (Hunt et al. 2002).

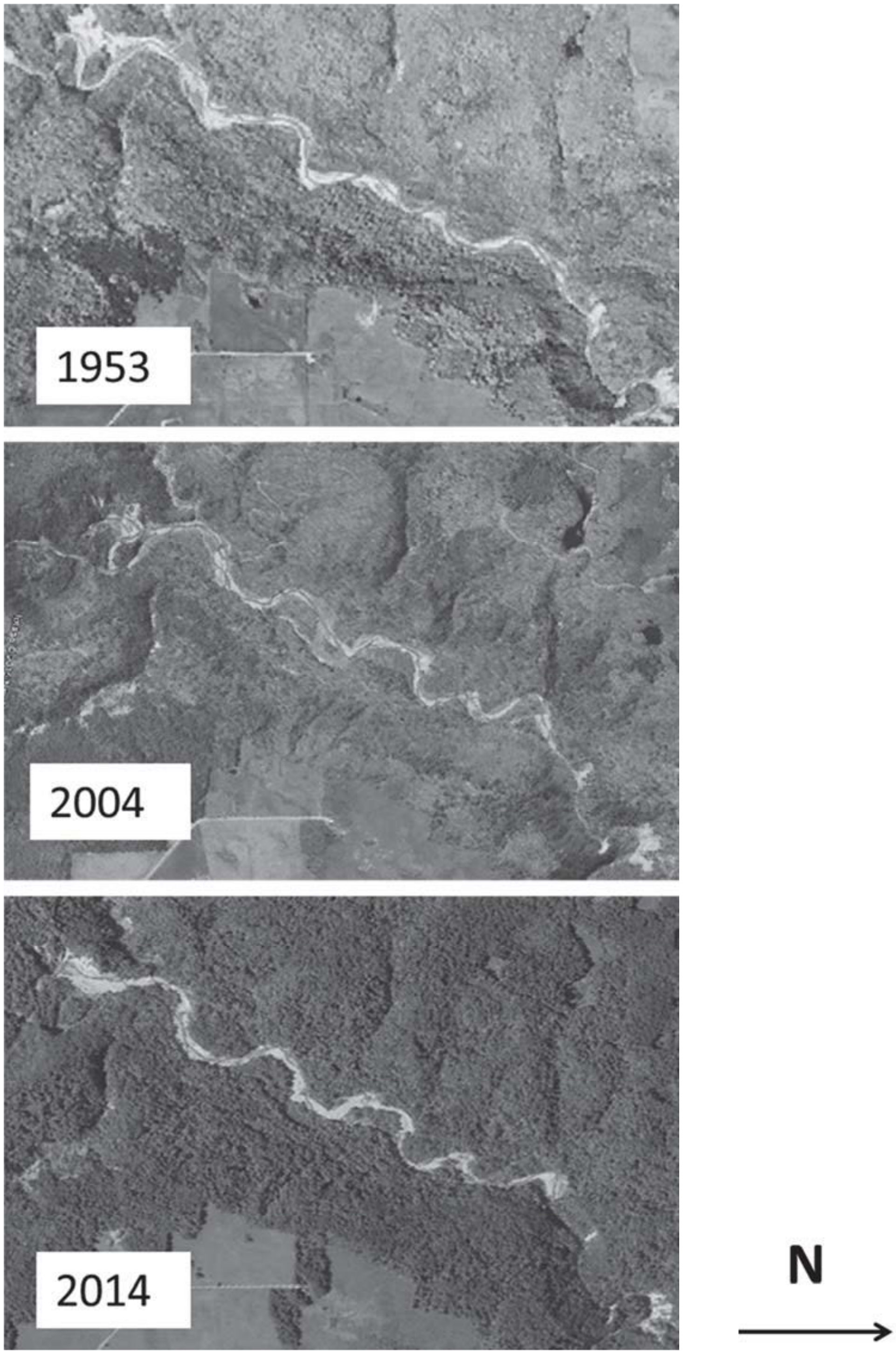


Figure 2.5 – Aerial image time series of the Chautauqua Creek study reach.

Figure 2.6 - Landform study site designations for Chautauqua Creek. Numerals delineate exact upper terrace study site locations.

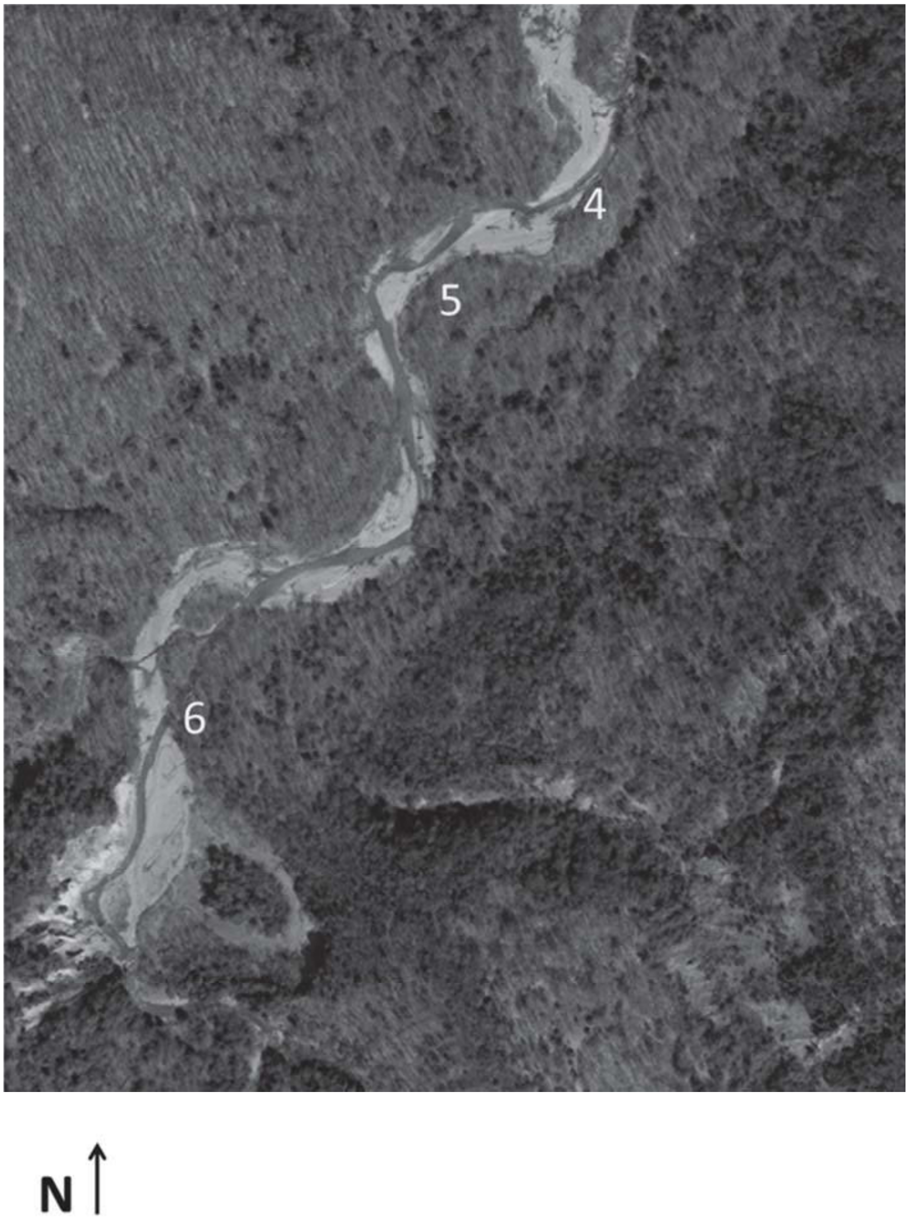


Figure 2.7 – Landform study site designations for Chautauqua Creek. Numerals delineate exact locations of upper terrace study sites.

Fifth to sixth-order Cattaraugus Creek (**Figures 2.8 – 2.12**) has the largest watershed of all of the study streams, encompassing more than 1,420 square kilometers of western New York State (Hunt et al. 2002). It begins in western Wyoming County at Java Lake and empties into Lake Erie approximately 80 kilometers west at Sunset Bay (Hunt et al. 2002). Cattaraugus Creek was the most utilized stream in this study, due to its diverse sedimentary environments, resulting in unique channel morphology (as shown in **Figure 2.11**) and contributing to the development of distinctly different vegetative community structures. Two reaches of the Cattaraugus Creek were evaluated in reference to Zoar Valley Canyon: one downstream of Zoar Valley which consisted primarily of fine, cohesive silt and clay sediments (**Figure 2.12**), and another upstream of Zoar Valley containing a mix of sand/gravel substrate with some cobbles (**Figure 2.9**). The lower (downstream) reach of the Cattaraugus is known for its accumulation of fertilizers, pesticides, and sediment runoff from agricultural fields (Myers et al. 2000). Characteristic of the lower Cattaraugus reach are stable clay banks, slow flow at low-water, high turbidity, and broad meanders (Hunt et al. 2002). The upstream study reach of the Cattaraugus has characteristic high flow velocity, and the deposition of sediments eroding from agricultural lands contributes to the well-developed floodplain forests, cobble shore, and riverside sand/gravel bars typical of this study area (Hunt et al. 2002). Reported old-growth is extensive in Zoar Valley (Diggins 2013), and the remainder of the watershed is comprised of natural communities such as forests, wetlands, and open water, along with scattered rural residential areas and agricultural land (Hunt et al. 2002).

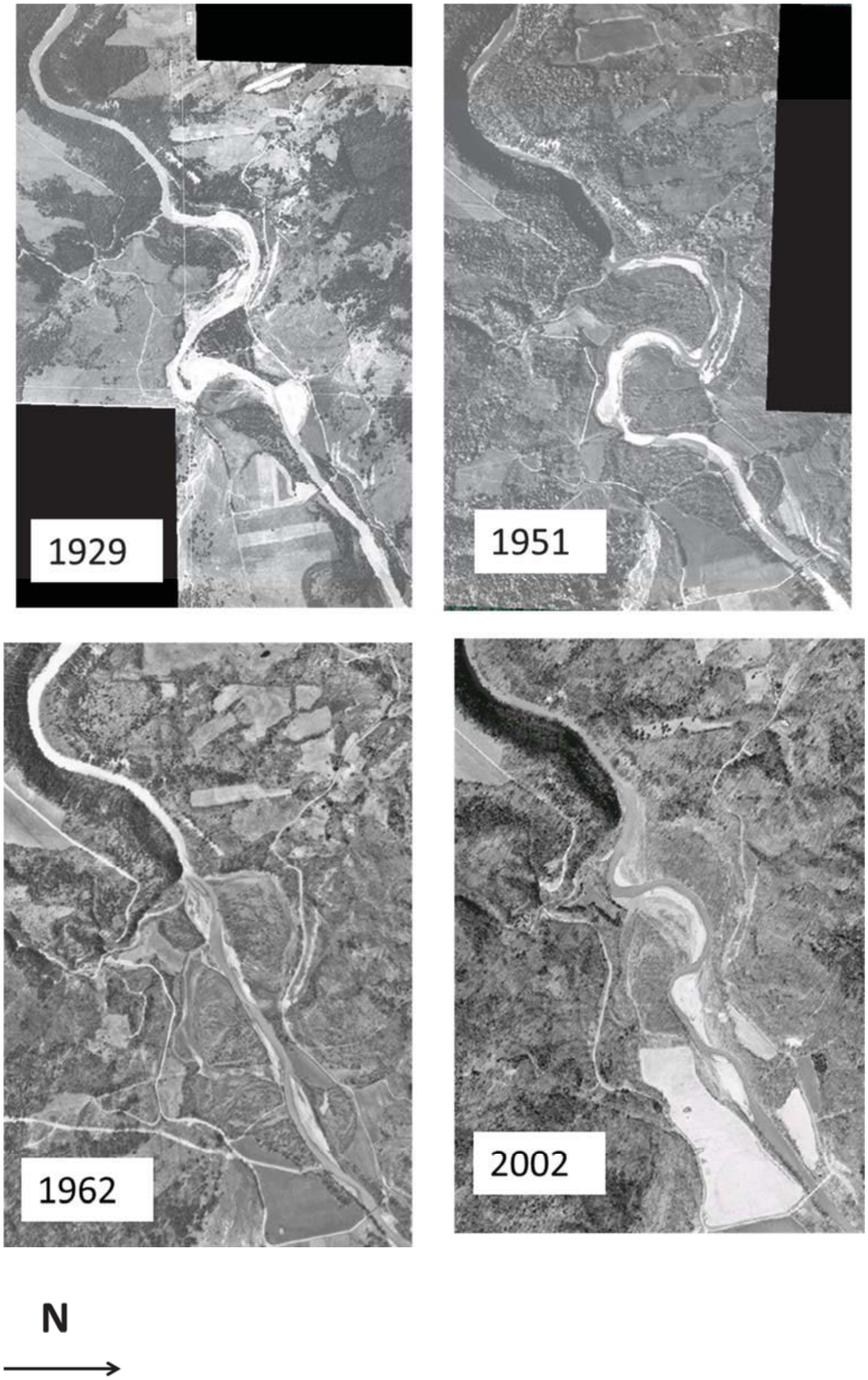


Figure 2.8 – Aerial image time series of the upper Cattaraugus Creek study reach

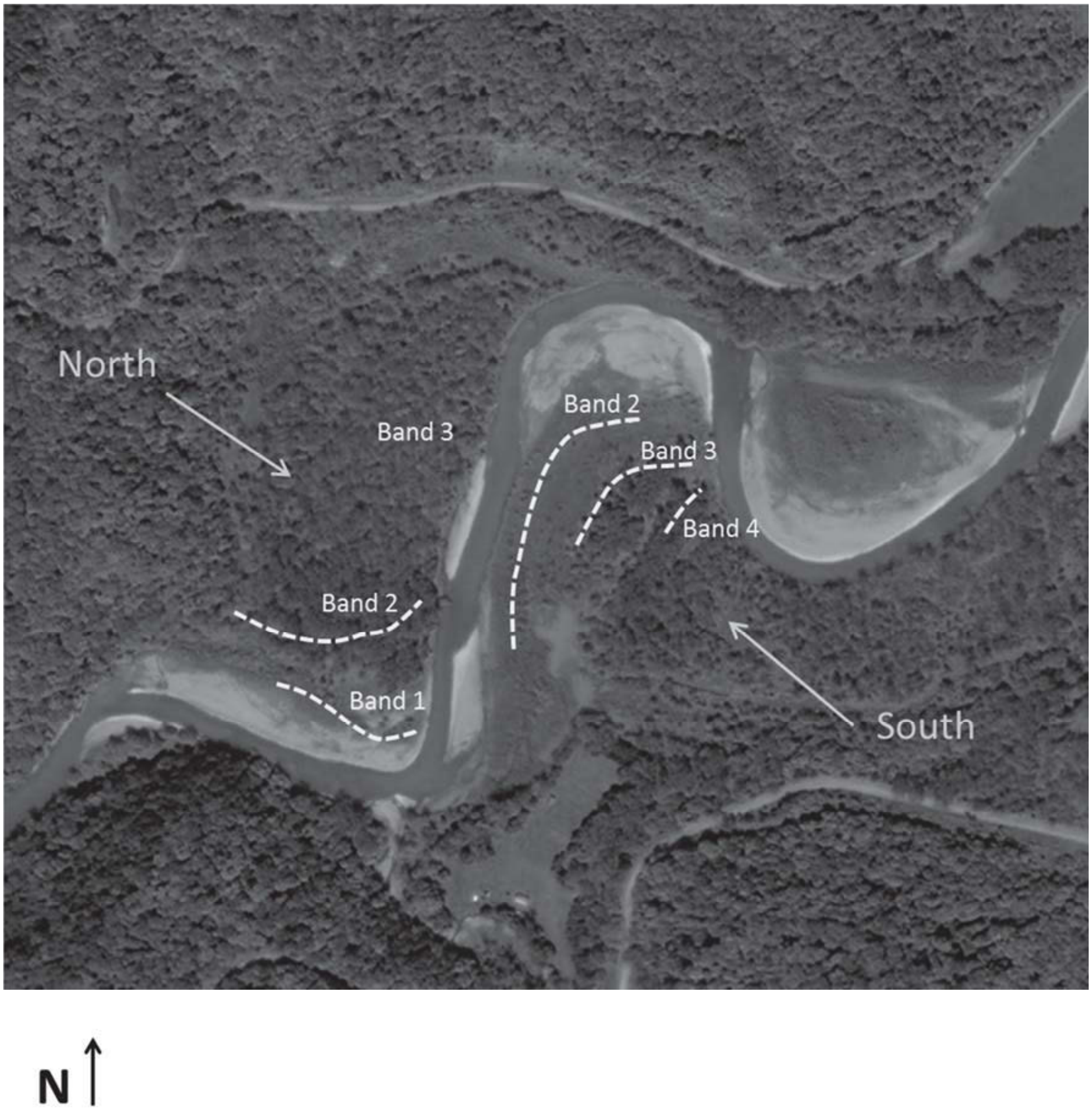


Figure 2.9 – Landform study site designations for upper Cattaraugus Creek. Numbered bands represent exact locations of belt transects on corresponding north and south creek banks.

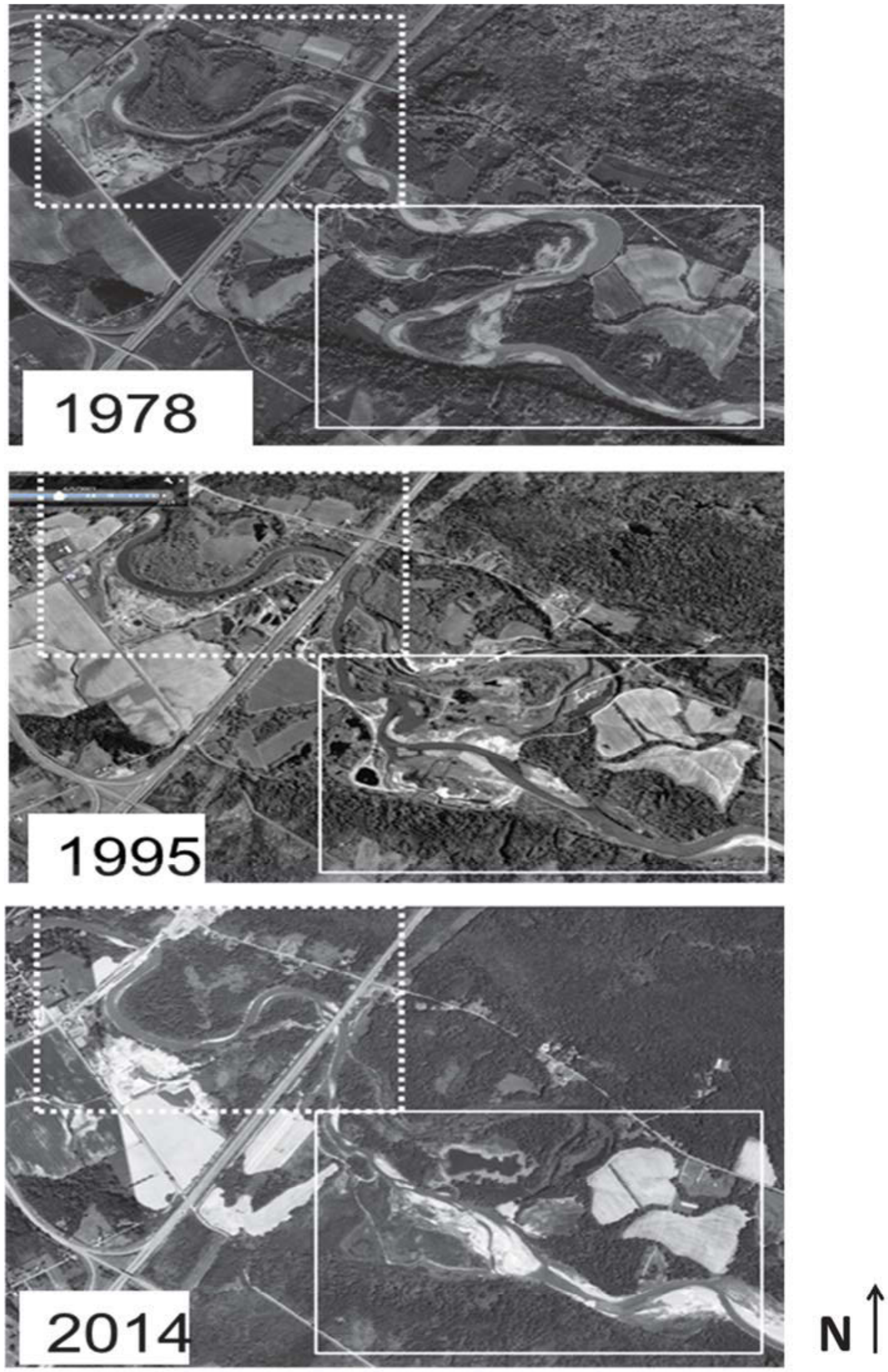


Figure 2.10 – Aerial image time series of lower Cattaraugus Creek study reach. Dashed box delineates stable stream segment that has undergone little geomorphological change since 1951, and solid box delineates dynamic stream segment that has undergone much geomorphological change since 1951.

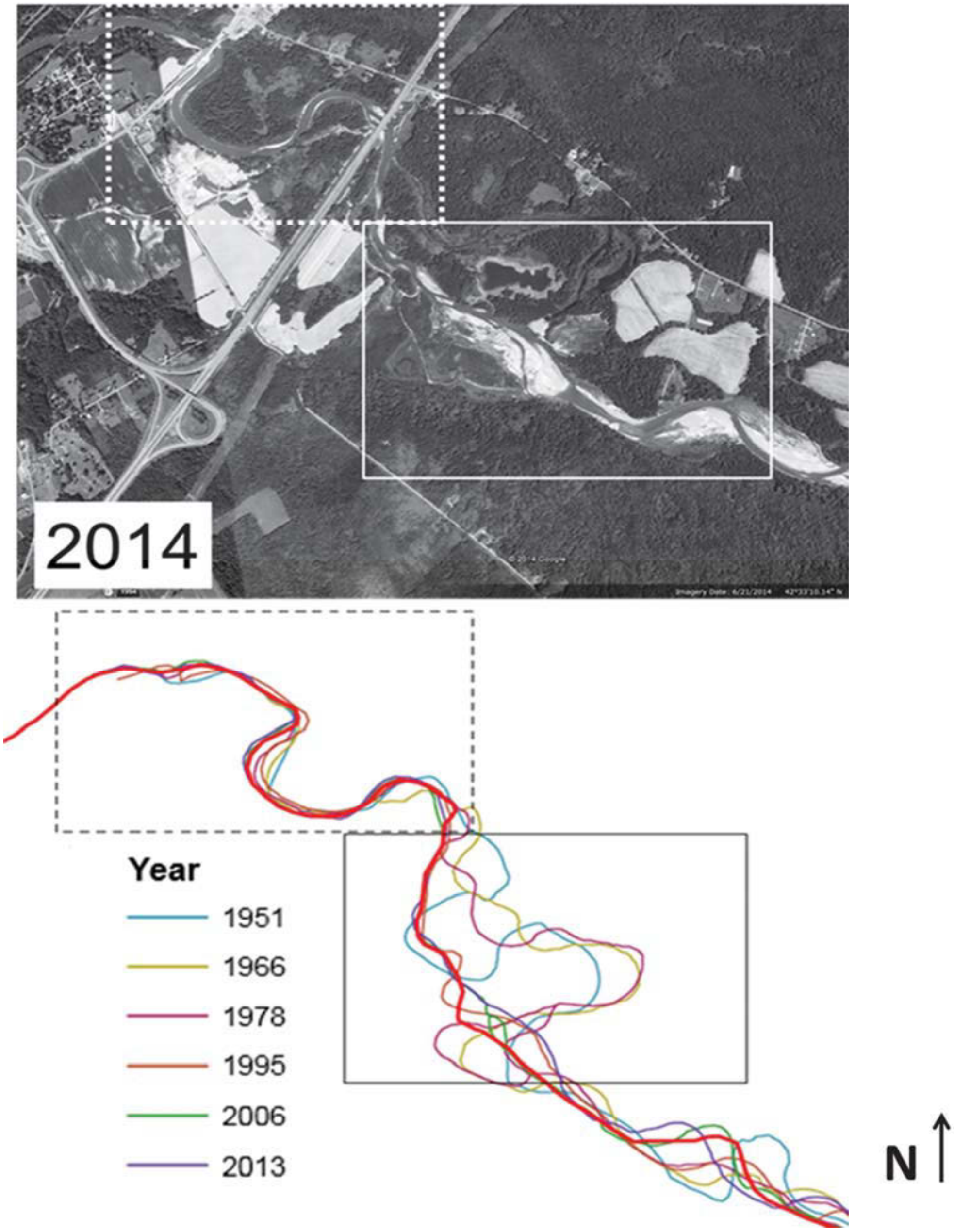


Figure 2.11 – Digitized stream flow paths of Cattaraugus Creek. Dashed box delineates stable stream segment that has undergone little geomorphological change since 1951, and solid box delineates dynamic stream segment that has undergone much geomorphological change since 1951. The dark red line denotes the present-day channel.

Figure 2.12 – Landform study site designations for the lower Cattaraugus Creek. Bands represent exact locations of belt transects on creek banks.

Eighteenmile Creek (**Figures 2.13** and **2.14**) is a fourth-order stream. In this study, middle sections of Eighteenmile were surveyed due to their minimal recent anthropogenic impact as well as their mixed composition of shale bedrock and cobble substrate. It originates in the Town of Concord, flowing north and then west before entering Lake Erie in the Town of Evans, New York (Hunt et al. 2002). The Eighteenmile Creek Gorge averages 30 to 45 meters deep (Hunt et al. 2002), with predominant shale cliff. There are no old-growth forest areas reported in this watershed, which has been heavily logged and cleared for agricultural purposes, with urbanized and residential areas interspersed throughout the watershed (Hunt et al. 2002).

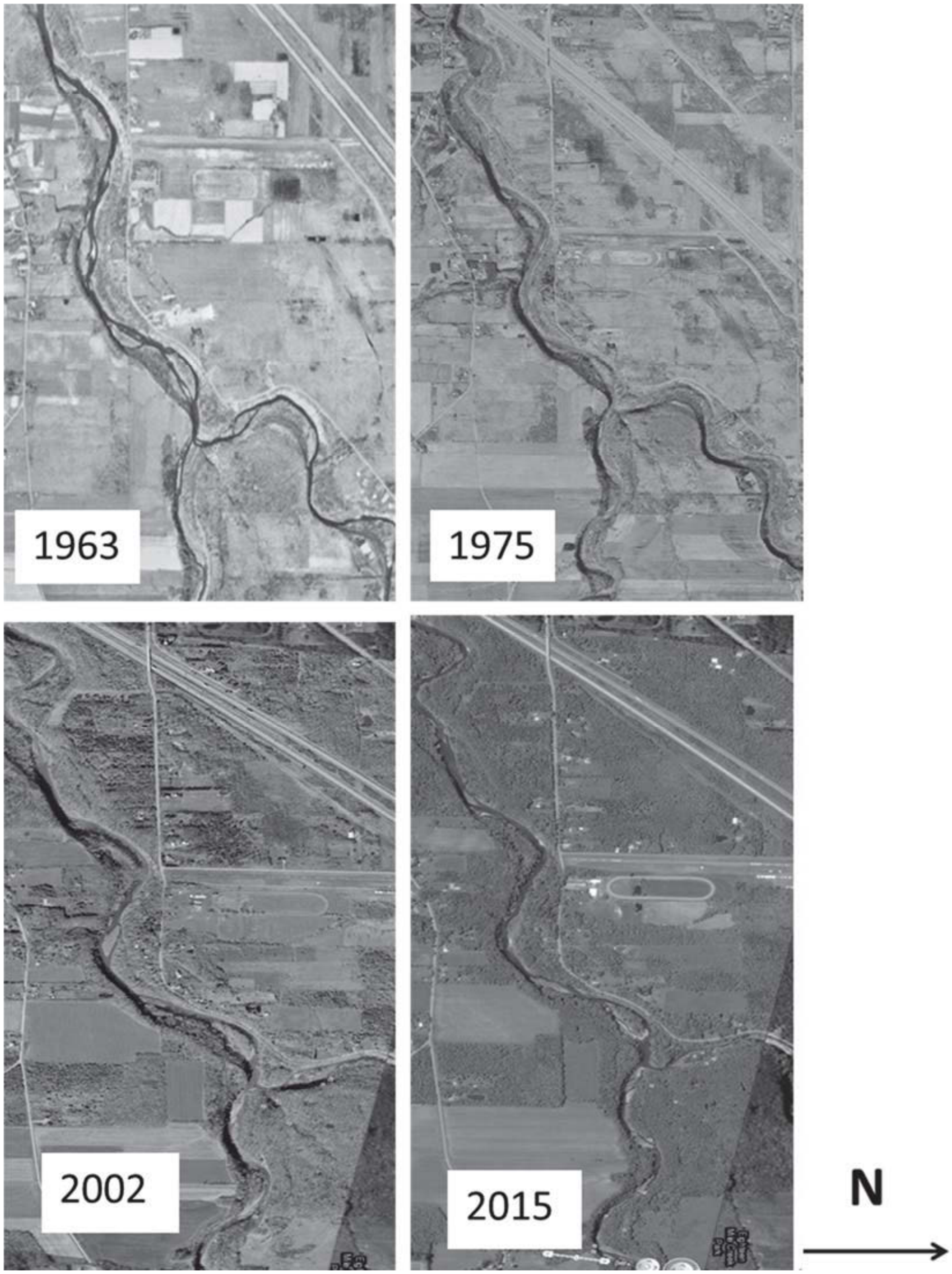


Figure 2.13 – Aerial image time series of Eighteenmile Creek study reach

Figure 2.14 – Landform study site designations for Eighteenmile Creek. Letters A and B delineate exact lower terrace study site locations, while numbers 1 and 2 represent exact upper terrace study site location (number 1 upper terrace extends on the other side of lower terrace A, which is why it is shown in two locations).

Tonawanda Creek (**Figures 2.15 – 2.18**) approximately 20 kilometers outside of the Lake Erie Gorges ecoregion (refer to **Figure 2.1**), lies within the Niagara River watershed and contains surficial geology of the Lake Ontario Plain comprised of lake clays. It flows into the Niagara River to the east of Grand Island, through the former Glacial Lake Tonawanda, a flat and poorly drained lowland (Stratton and Seleen 2003). This area contains many classified wetlands, with fine, cohesive clay and silt sediments dominating the study area. This stream is the most heavily human-influenced creek in the present study area, dominated by residential and agricultural fields throughout (Stratton and Seleen 2003). Only a single belt transect was utilized at each of the Tonawanda sites (i.e. Akron and Reservation). This was due to site accessibility (much of the land along the creek is privately owned) and availability of minimally disturbed land (i.e. there had to be no evidence of logging and forest conversion from previously agricultural land).

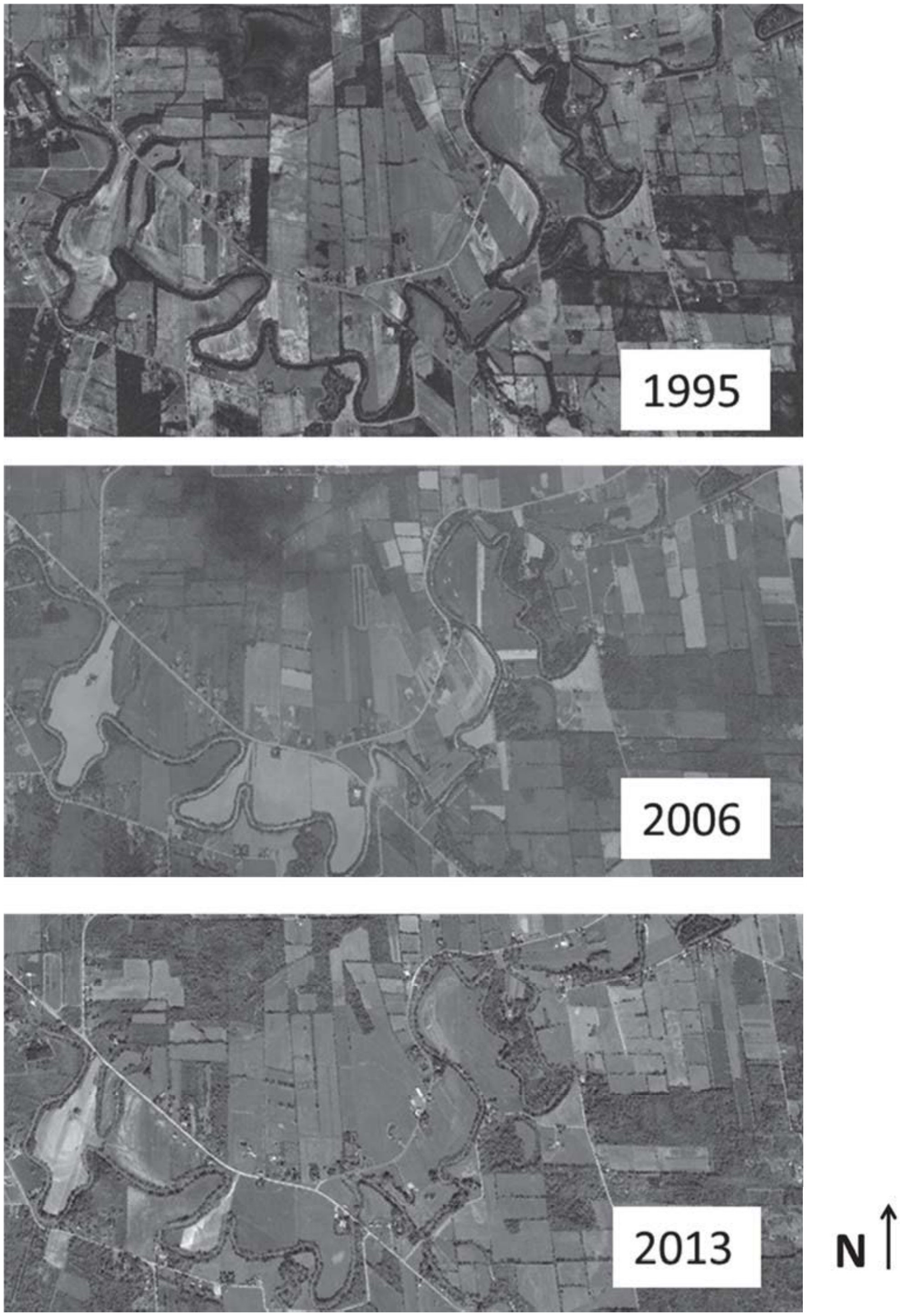


Figure 2.15 – Aerial image time series of Tonawanda Creek Akron study reach

Figure 2.16 – Landform study site designation for Tonawanda Creek – Akron. Dashed line delineates exact location of single belt transect used to survey this site.

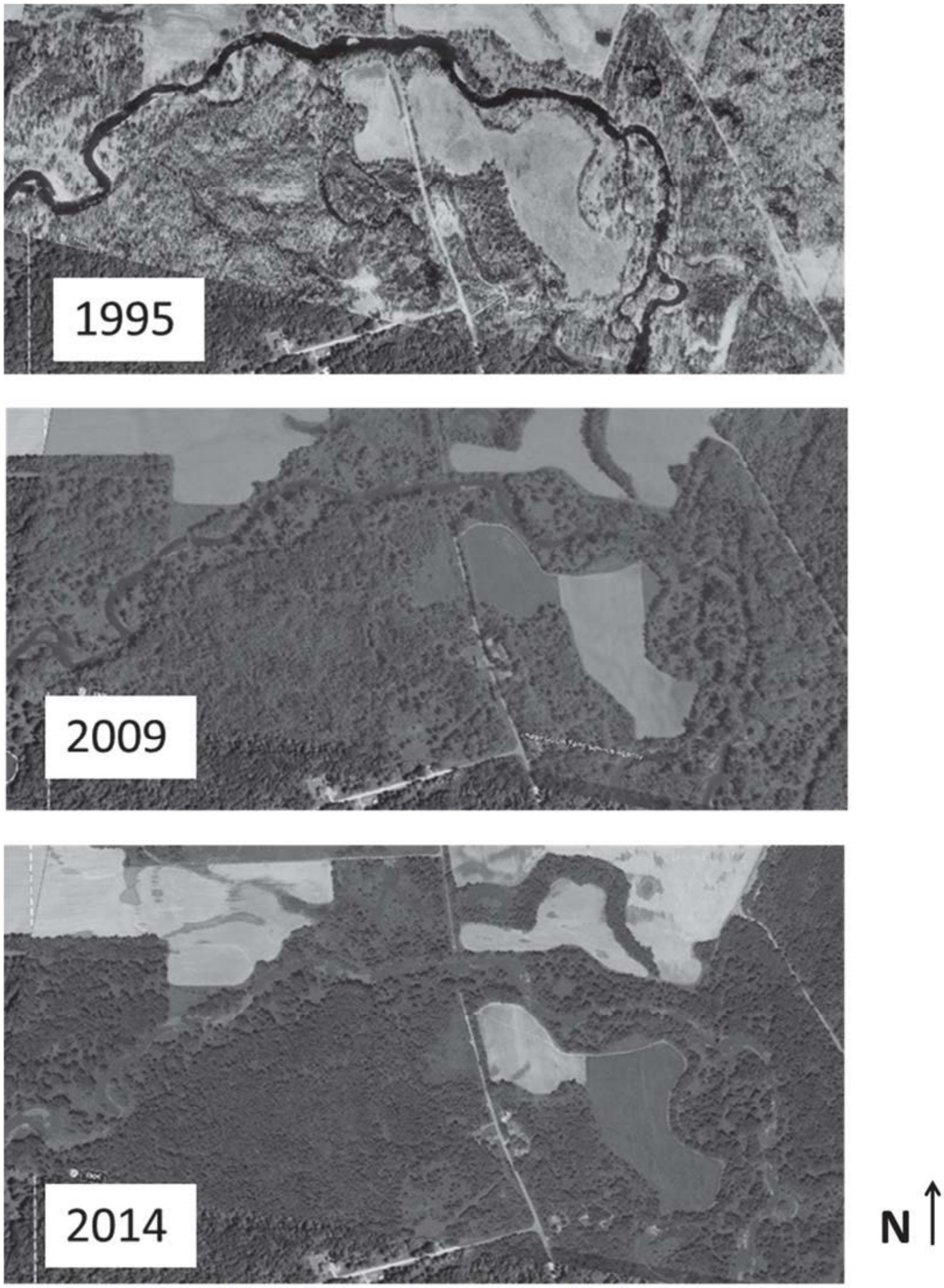


Figure 2.17 – Aerial image time series of Tonawanda Creek Reservation study reach

Figure 2.18 – Landform study site designation for Tonawanda Creek – Reservation. Dashed band delineates exact location of single belt transect used to survey this site.

II. METHODS

Study Site/Landform Criteria

Five 4^{th}-6^{th} order study streams were selected based on the presence of riparian habitat which lacked recent (i.e. 100 years) anthropogenic influence, and which had a variety of geomorphic, hydrologic, and sedimentary riverine environments. A total of seven study sites were chosen at the river reach scale (i.e. hundreds of meters to a few kilometers) on aggradational landforms. The ages of these landforms are a function of the sedimentary and hydrologic environment, as opposed to incised landforms that could be of far less certain age. One of the five streams, Tonawanda Creek, was initially chosen to represent a flood-driven riparian forest composition, as an antithesis to the minor influence flooding that was projected to be seen on the other four streams.

In correspondence with the Diggins (2013) Zoar Valley study, a broad definition of the riparian zone was used in determining study site locations to include all landforms that at one point or another comprised the riverbed (Malanson 1993). Stream bank composition was classified based on visual assessments of the sedimentary environment at each study site using the Wentworth Scale (1922). Sediment classification fell into two general categories: coarse-sediments consisting of some combination of pebbles (2 – 64 mm), cobbles (64 – 256 mm), and/or boulders (≥ 256 mm); and fine-sediments consisting of silts (0.002 – 0.0625 mm), clays (≤ 0.002 mm), and in some instances sand (0.0625 – 2 mm).

Two primary sources of coarse sediments include extensive glacial outwash deposits and more locally-derived clasts of the friable shale canyon walls that occur through much of the study area. Fine clays and silts are predominantly derived from glacial lake sediments.

Vegetation Survey

Tree surveying was conducted from June 2015 through October 2015. The quantification process of riparian forest structure/composition implemented semi-random (i.e. no overlap or edge contact), discrete survey quadrats of 10-30 meters on a side, in order to evaluate distinct points in locations on each of the landforms in the study (Diggins 2013). Quadrats were arranged in a stratified manner (i.e. attempting to sample comparable proportions of different landforms), such that quadrats did not overlap one another or extend off of the landforms (Van Pelt et al. 2006). Some transect sampling was also conducted where local ecological gradients were clearly evident, such as across vegetative banding that extends from the edge of a river and moving inland. All trees within quadrats were identified to species, while also making note of the species composition on landforms that fell outside of quadrats. A catalogue of all tree species recorded for the present study is provided in **Table 3.1**, with the associated shade tolerance, flood tolerance, scientific name, and four-letter code for each species. The diameter or circumference at breast height (DBH or CBH, measured at approximately 1.37 m) was obtained for each individual tree in a sampled quadrat, with CBHs converted to diameters.

Table 3.1 – Tree species consolidated from all study sites, including Zoar Valley, with shade tolerances and flood tolerances obtained from Burns and Honkala (1990) and Diggins (2013).

Species, with naming authority	Common Name	Abbreviated Name	Shade Tolerance	Flood Tolerance
Acer negundo L.	Ashleaf maple	ACNE	Tolerant	Tolerant
Acer rubrum L.	Red maple	ACRU	Tolerant	Tolerant
Acer saccharum Marsh.	Sugar maple	ACSA	Tolerant	Intolerant
Alnus incana subsp. *Rugosa* (Du Roi) R.T. Clausen	Speckled alder	ALRU	Intolerant	Intermediate
Betula alleghaniensis Britton	Yellow birch	BEAL	Intermediate	Intermediate
Betula lenta L.	Black/Sweet birch	BELE	Intermediate	Intermediate
Carpinus caroliniana Walt.	American hornbeam	CACA	Very Tolerant	Intermediate
Carya cordiformis (Wangenh.) K. Koch	Bitternut hickory	CACO	Intolerant	Intolerant
Carya ovata (Mill.)	Shagbark hickory	CAOV	Intermediate	Intermediate
Cornus florida L.	Flowering dogwood	COFL	Very Tolerant	Intolerant
Crataegus sp.	Hawthorn sp.	CRAT	Intolerant	Intolerant
Fagus grandifolia L.	American beech	FAGR	very Tolerant	Tolerant
Fraxinus americana L.	White ash	FRAM	Intolerant	Tolerant
Hamamelis virginiana L.	Witch hazel	HAVI	Intolerant	Tolerant
Juglans nigra L.	Black walnut	JUNI	Intolerant	Intermediate
Liriodendron tulipifera L.	Tulip tree	LITU	Intolerant	Intolerant
Magnolia acuminata L.	Cucumbertree	MAAC	Intermediate	Intolerant
Ostrya virginiana (Mill.) K. Koch	Hop hornbeam	OSVI	Tolerant	Intermediate
Pinus strobus L.	White pine	PIST	Intermediate	Intolerant
Platanus occidentalis L.	American sycamore	PLOC	Intermediate	Tolerant
Populus deltoides Bartr. Ex. Marsh.	Eastern cottonwood	PODE	very Intolerant	Tolerant
Prunus serotina Ehrh.	Black cherry	PRSE	Intolerant	Intolerant
Quercus rubra L.	Northern red oak	QURU	Intermediate	Intolerant
Robinia pseudoacacia L.	Black locust	ROPS	very Intolerant	Intermediate
Salix alba L.	White willow	SAAL	Intolerant	Tolerant
Salix interior L.	Sandbar willow	SAIN	Intolerant	Tolerant
Salix nigra Marsh.	Black willow	SANI	very Intolerant	Tolerant
Tilia americana L.	American basswood	TIAM	Tolerant	Intolerant
Tsuga canadensis (L.) Carr.	Eastern hemlock	TSCA	Very Tolerant	Intolerant
Ulmus americana L.	American elm	ULAM	Intermediate	Intermediate
Ulmus rubra Muhl.	Slippery/red elm	ULRU	Tolerant	Intermediate

Derived measurements included: density of trees per hectare, mean DBH and its associated coefficient of variation (CV) for all trees ≥ 5 cm in quadrats, basal area (i.e. average amount of an area occupied by tree stems at breast height) for each tree species, as well as for each quadrat as a whole, tree species richness and tree species diversity (i.e. Shannon-Weiner) were determined in terms of basal area. Percentage of shade tolerance in terms of basal area was derived based on the presence of the very shade tolerant species sugar maple, eastern hemlock, and American beech. Percentage of flood tolerance in terms of basal area was derived based on the presence of the generally flood tolerant species black willow, sandbar willow, eastern cottonwood, black locust, ashleaf maple, and American sycamore.

Stand age was estimated in survey quadrats by increment coring at breast height a select number of trees that were suspected to be the oldest. Suunto 25 cm and 40 cm borers were used. The general lack of alluvium build-up around the tree bases allowed the location of breast height coring to be consistent. Large DBH trees in these riparian areas were often the oldest specimens, and typically 2-3 tree cores were obtained from each quadrat in order to provide an accurate stand age estimate. Cores were examined in the lab at 3-40x magnification to effectively date the tree samples.

<u>Riparian/Channel Morphodynamics</u>

For each study reach of every creek aerial images were georeferenced using ArcGIS. Fixed landform features were used as points of control, allowing for the visual assessment of surficial changes in landforms over time. Time series panels for each study reach were then made by sizing and aligning those georeferenced aerial images from years with the best image clarity and resolution. These time series panels were useful in determining the timing of landform deposition and vegetation establishment. By comparing aerial image dates both before and after the appearance of a depositional landform, in concurrence with core-based forest-stand ages, a maximum time-frame from the deposition to the development of woody vegetation was able to be established for the coarse-sediment type stream study reaches.

Historical reconstruction of stream meanders was dependent on image availability/accessibility and clarity for georeferencing purposes. Date ranges for aerial images pertaining to each stream study reach include: Twentymile Creek from 1955 – 2008, Chautauqua Creek from 1953 – 2014, the upper reach of Cattaraugus Creek from 1929 – 2002, the lower reach of Cattaraugus Creek from 1978 – 2014, Eighteenmile Creek from 1963-2015, the Akron reach of Tonawanda Creek ranging from 1995 – 2013, and the reservation reach of Tonawanda Creek from 1995 – 2014. These images were used to help determine recent geomorphic changes and potential patterns in the composition and structure of the riparian forest study sites. Due to the erosion-resistant nature of the fine-cohesive sediment banks of Tonawanda Creek there has been no major morphological change to the study stream reaches at this particular site, allowing for a more recent channel reconstruction to compensate for the lack of available imagery prior to 1995. Aerial images were obtained via Fairchild Aerial Surveys (1929) and USGS Aerial photos (2016).

<u>Statistical Analyses</u>

Although data were collected within discrete separate quadrats, data were pooled by landform (e.g. terrace, arcuate band) for comparisons among river corridors. Analyses conducted for the present study strongly mirrored those conducted by Diggins (2013).

Stand descriptor variables were regressed on core-based estimates of forest-stand age (see Results **Figures 4.1-4.4**, in which data from Zoar Valley and additional coarse-sediment vs. fine-sediment locations are distinguished). Logarithmic models were employed because they demonstrated the strongest fit.

SPSS 13.0 was used to implement non-metric multidimensional scaling (NMDS) in the construction of ordination axes representing stand characteristics and species composition. Non-metric multidimensional scaling is a non-parametric (i.e. no assumptions about underlying data distributions) Euclidean-distance-based ordination technique that performs especially well with data on distribution and abundance of species. Ordination in general is a multi-variate approach that distills multiple potential co-varying variables into one or more pairs of axes that are much more easily interpreted. Spearman rank correlation coefficients (rho) were also calculated for stand descriptor variables and selected tree species vs. the two NMDS dimensions. Use of correlation coefficients is not intended to imply that any such associations are necessarily linear.

IV. RESULTS

Forest Stand Composition and Structure

Overall, there were a combined 37 different tree species for the entire study region (refer to **Table 3.1** in Methods section), 7 of which were only present at Zoar Valley sites. Stand ages outside of Zoar Valley ranged from 9 years (Upper-Catt North Band 1 and Upper-Catt South Band 2) up to 147 years (Eighteenmile 1). Riparian stand descriptor variables for landforms used in this study are represented in **Table 4.1**. Basal areas (units of m^2/ha) of selected individual tree species pertaining to each study landform are represented in **Table 4.2**. Collectively, all riparian stand characteristics for both Zoar Valley comparison sites and current study sites are portrayed in **Tables 4.2** and **4.3**. The landform with the greatest basal area in the present study is Eighteenmile 1 at 68.78 m^2/ha, and also reflected the oldest stand age.

The basal areas of upper terrace sites (i.e. approximate height above low water > 2.0 m) present in Zoar Valley and portions of Eighteenmile Creek were dominated by late-successional sugar maple and American beech with some eastern hemlock, as well as mid-successional northern red oak and American basswood. Lower terraces (i.e. approximate height above low water < 2.0 m) present at a number of study sites in Zoar Valley, Eighteenmile Creek, Twentymile Creek, and Chautauqua had an abundance of sugar maple, as well as early-successional American sycamore and eastern cottonwood. The Tonawanda Creek sites had a mix of young to middle-aged ashleaf maple and eastern cottonwood, with a few advanced-stage black willows present at the Reservation site, despite the fine-sediment banks of the floodplain. The youngest stands present on the fine-sediment sites of the Lower Cattaraugus and portions of the Upper Cattaraugus had basal areas dominated by thickets of young (< 12 yrs) sandbar willow intermixed with eastern cottonwood and American sycamore.

Across nearly all landforms species diversity (H´) was highest among coarse-sediment comprised landforms, while being generally lower among fine-sediment comprised landforms (**Table 4.1**). The coarse-sediment Eighteenmile 2 site exhibited the highest species diversity at 1.802, with a respectable basal area of 60.13 m^2/ha. The lowest species diversity of 0.431 was found at the fine-sediment comprised Tonawanda-Akron site, containing a basal area of 49.71 m^2/ha dominated by Eastern cottonwood. Among all the site locations in the present study, Twentymile A and Chautauqua 2, both lower terrace forests, exhibited the highest landform richness of 15 different tree species (**Table 4.1**). The lowest richness (4 different species total) was exhibited at three portions of the Cattaraugus Creek: Lower Catt-upstream (inland), and Upper Catt-south Band 2 and Band 3.

The Tonawanda Reservation site had the largest recorded DBH (cm) of all the study locations, belonging to a 133 cm Black willow (**Table 4.2**). Trees of this size were not common at this particular site, because there were only three black willows (although multi-stemmed) near this size on the entire landform, with the mean DBH (determined for trees > 5cm) being 40.3 cm. The variability in tree size on this landform is represented by the high coefficient of variation (DBH CV% for trees > 5cm) of 87.5%, suggesting that the large, old Black willows (oldest was 117 years) are the aging remnants of previously forested riparian stand. Eighteenmile Creek 2, while not containing the largest tree (88 cm) did have the highest CV of 137.9% relative to its mean DBH of 17.2 cm. Band 2 of Upper Catt-south had the smallest mean DBH of 6.9 cm (the largest tree being 10 cm), as well as the smallest CV of 32.1%. This area was predominantly comprised of young (stand age of 9 years), dense willow thickets, so there was lower variability among the distribution of tree sizes.

Table 4.1 – Collective table of riparian stand descriptor variables pertaining to each landform used in this study.

Sediments	Site location	Designation	BA	H'	Richness	% Shade	% Flood	Largest DBH	Stand Age
Coarse	Twenty Mile	A	33.7	1.477	13	28.2	23.1	45	53
Coarse	Twenty Mile	B	52.1	1.734	15	23.9	22.3	57	75
Coarse	Eighteen Mile	A	44.8	0.988	7	14	0	58	47
Coarse	Eighteen Mile	B	39.29	1.63	12	37	28	53	80
Coarse	Eighteen Mile	1	68.78	1.31	10	65	0	90	147
Coarse	Eighteen Mile	2	60.13	1.802	10	33	0	88	135
Fine	Tonawanda	Akron	49.71	0.431	7	0	100	91	70
Fine	Tonawanda	Reservation	46.1	0.5006	5	0	100	133	117
Fine	Lower Catt-upstream	inland	57.28	0.701	4	0	100	102	80
Fine	Lower Catt-downstream	Band 3	29.62	1.059	5	0	100	66	80
Fine	Lower Catt-downstream	Band 2	2.07	1.511	5	0	100	20	18
Fine	Upper Catt-north	Band 1	2.82	0.6804	2	0	100	18	9
Fine	Upper Catt-north	Band 2	32.19	0.6988	6	0	100	54	31
Fine	Upper Catt-north	Band 3	15.98	1.4137	11	7		52	68
Fine	Upper Catt-south	Band 2	2.16	0.963	4	0	100	10	9
Fine	Upper Catt-south	Band 3	16.29	0.644	4	0	100	38	26
Fine	Upper Catt-south	Band 4	39.62	1.47	11	0	77.8	61	58
Coarse	Chautauqua	1	15.8	0.8892	5	0	99.9	25	20
Coarse	Chautauqua	2	32.18	1.3209	15	52.6	23.7	56	72
Coarse	Chautauqua	4	18.81	1.0533	13	6	94.7	40	37
Coarse	Chautauqua	5	26.1205	2.022	12	34	36.3	69	90
Coarse	Chautauqua	6	22.06	1.4066	14	52.3	0	44	60

Table 4.2 – Landform values of tree species basal areas (refer to Table 3.1 for common and scientific names), in addition to Zoar Valley sites reported by Diggins (2013), included here for comparison.

Site location	Designation	Stand age	ALRU	ACNE	ACRU	ACSA	BEAL	BELE	CACA	CACO
Zoar	P	35	0	1.5	0	0.1	0	0	0.5	0.3
Zoar	N	9	0	0	0	0	0	0	0	0
Zoar	M	8	0	0	0	0	0	0	0	0
Zoar	L	33	0	0	0	0	0	0	0	0
Zoar	K	55	0	0	0	5.3	0.2	0	0.7	0.1
Zoar	J	9	0	0	0	0	0	0	0	0
Zoar	H	54	0	0	0	8.9	0	0	0	0
Zoar	G	95	0	0	0	9.0	0	0	0	7.7
Zoar	F	55	0	0	0	1.3	0	0	1.2	0
Zoar	E	32	0	0.1	0	0	0	0	0.2	0
Zoar	D	60	0	0	0	7.6	0	0	0.6	0
Zoar	C	61	0	0	0	1.9	0	0	1.3	0.3
Zoar	B	34	0	0.5	0	0.0	0	0	0.3	0
Zoar	A	49	0	0	0	4.5	0	0	2.3	0.1
Zoar	10	287	0	0	0	18.7	0.1	0	0.4	3.1
Zoar	9	226	0	0	0	21.7	1.9	0	0.3	0
Zoar	8	232	0	0	0	10.3	0.5	0	0.3	2.6
Zoar	7	155	0	0	0	12.1	0.7	0	0.9	2.4
Zoar	6	247	0	0	0	13.5	0.9	0	0	1.9
Zoar	6'	126	0	0	0	4.9	0.0	0	0	0
Zoar	5	301	0	0	2.3	13.0	1.5	0	0	0
Zoar	4	254	0	0	0	11.7	1.1	0	0.5	1.9
Zoar	4'	127	0	0	0	6.3	0.0	0	0	1.8
Zoar	11	114	0	0	0	10.1	0.0	0	0.7	11.0
Twenty Mile	A	53	0	0	0	9.52	0.67	0	0	0
Twenty Mile	B	75	0	0	0	12.14	3.77	0	0	0
Eighteen Mile	A	47	0	0	0	6.03	0.03	5.84	0	0
Eighteen Mile	B	80	0	0	0	14.69	0.91	0	0.63	0
Eighteen Mile	1	147	0	0	0	32.72	0	2.54	0	0
Eighteen Mile	2	135	0	0	0	16.52	5.69	10.37	0.57	0
Tonawanda	Akron	70	0	7.35	0	0	0	0	0	0
Tonawanda	Reservation	117	0	6.79	0	0	0	0	0	0
Lower Catt-upstream	Inland	80	0	8.67	0	0	0	0	0	0
Lower Catt-downstream	Band 3	80	0	1.12	0	0	0	0	0	0
Lower Catt-downstream	Band 2	18	0	0.64	0	0	0	0	0	0
Upper Catt-north	Band 1	9	0	0	0	0	0	0	0	0
Upper Catt-north	Band 2	31	0	0	0	0	0	0	0	0
Upper Catt-north	Band 3	68	0	0	0	1.13	0	0	1.69	0
Upper Catt-south	Band 2	9	0	0	0	0	0	0	0	0
Upper Catt-south	Band 3	26	0	0	0	0	0	0	0	0
Upper Catt-south	Band 4	58	0	0	0	0	0	0	2.76	0
Chautauqua	1	20	0	0	0	0	0	0	0	0
Chautauqua	2	72	0	0	0	16.89	2.02	0	0.43	0
Chautauqua	4	37	0	0	0	1.12	0	0	0.05	0
Chautauqua	5	90	0	0	0	8.89	1.5	0	0	0
Chautauqua	6	60	0	0	0	10.5	3.67	0	0.1	0

Site location	Designation	COFL	cornus	CAOV	CRAT	FAGR	FRAM	HAVI	JUNI	LITU
Zoar	P	0	0	0	0	0	0	0	0.5	1.2
Zoar	N	0	0	0	0	0	0	0	0	0
Zoar	M	0	0	0	0	0	0	0	0	0
Zoar	L	0	0.1	0	0	0	0	0	0	0
Zoar	K	0	0	0	0	0.2	0.3	0	0	2.5
Zoar	J	0	0	0	0	0	0	0	0	0
Zoar	H	0	0	0	0	0	2.2	0	0	0.1
Zoar	G	0	0	0	0	0	0	0	0	0
Zoar	F	0	0.6	0	0	0.1	0.5	0	0.2	0
Zoar	E	0	0.5	0	0	0	0	0	0.7	0
Zoar	D	0	0	0	0	0	0.6	0	9.6	0
Zoar	C	0	0	0	0	0.1	0	0.2	3.0	0
Zoar	B	0	0	0	0	0.3	0.5	0	0	0
Zoar	A	0	0	0	0	0	1.2	0	3.2	1.1
Zoar	10	0	0	0	0	2.6	2.8	0	0	0
Zoar	9	0	0	0	0	2.3	4.0	0.3	0	0
Zoar	8	0	0	0	0	11.7	2.6	0	0	3.6
Zoar	7	0	0	0.6	0	2.0	1.7	0.1	3.6	5.6
Zoar	6	0	0	0	0	5.4	4.1	0	0	6.3
Zoar	6'	0	0	0	0	0.2	2.4	0	2.2	0
Zoar	5	0	0	0	0	8.7	3.4	0	0	2.1
Zoar	4	0	0	0	0	0.6	3.4	0	0	18.3
Zoar	4'	0	0	0	0	5.9	4.7	0	1.6	7.7
Zoar	11	0	0	0.5	0	1.4	0	0.2	0	0
Twenty Mile	A	0	0	0	0	0	2.77	0	0	2.21
Twenty Mile	B	0	0	0	0	0	0	0	0	16.68
Eighteen Mile	A	0	0	0	0	0	0.03	0	0	0
Eighteen Mile	B	0	0	0	0	0	5.09	0	1.6	0
Eighteen Mile	1	0	0	0	0	9.68	0	0.51	0	0
Eighteen Mile	2	0	0	0	0	0	7.73	0.04	0	0
Tonawanda	Akron	0	0	0	0	0	0	0	0	0
Tonawanda	Reservation	0	0.008	0	0	0	0	0	0.75	0
Lower Catt-upstream	inland	0	0	0	0	0	0	0	0	0
Lower Catt-downstream	Band 3	0	0	0	0	0	0	0	0	0
Lower Catt-downstream	Band 2	0	0	0	0	0	0	0	0	0
Upper Catt-north	Band 1	0	0	0	0	0	0	0	0	0
Upper Catt-north	Band 2	0	0	0	0	0	0	0	0	0
Upper Catt-north	Band 3	0.05	0	0	0.01	0	2.37	0	7.42	0
Upper Catt-south	Band 2	0	0	0	0	0	0	0	0	0
Upper Catt-south	Band 3	0	0	0	0	0	0	0	0	0
Upper Catt-south	Band 4	0	0.13	0	0	0	0.59	0	5.76	0
Chautauqua	1	0	0	0	0	0	0	0	0	0
Chautauqua	2	0	0	0	0	0.04	0	0	0	0
Chautauqua	4	0	0	0	0	0	0	0	0	0
Chautauqua	5	0	0	0	0	0	1.95	0	0	0
Chautauqua	6	0	0	0	0	0.1	0	0.04	0	0

Site location	Designation	MAAC	OSVI	PLOC	PODE	PRSE	PIST	POTR	QURU	ROPS
Zoar	P	0	0	0	19.2	0	0	0	0.1	1.4
Zoar	N	0	0	0.2	0.1	0	0	0	0	2.4
Zoar	M	0	0	0.5	0.2	0.1	0	0	0	0
Zoar	L	0	0	5.9	5.9	0	0	0	0	5.0
Zoar	K	0	0.9	1.5	6.0	0	1.4	0	1.4	7.4
Zoar	J	0	0	0.4	0.3	0	0	0	0	0.2
Zoar	H	0	0	3.6	2.2	0	0.7	3.1	6.8	1.0
Zoar	G	0	0.2	7.2	1.8	0	1.3	0	8.3	1.7
Zoar	F	0	0.2	3.8	13.6	0	0	0	6.6	5.3
Zoar	E	0	0.2	3.3	5.4	0	0.2	0	0.1	4.4
Zoar	D	0	0.3	2.0	0	0	0	0	1.3	2.7
Zoar	C	0	1.2	0.9	6.9	0	0	0	4.2	5.1
Zoar	B	0	0	8.4	7.4	0	0.2	0	0.3	6.6
Zoar	A	0	0	0.2	17.9	0	0.1	0	0.8	3.6
Zoar	10	0	0	0.4	0	1.6	0	0	1.3	0
Zoar	9	0	0.2	0	0	0	0	0	0	0
Zoar	8	0	0.5	0	0	1.2	0	0	0	0
Zoar	7	0	0.5	1.2	0	0	0	0	0.3	0
Zoar	6	0	0	1.0	1.7	0	0	0	0.7	0
Zoar	6'	0	0	13.0	2.7	0	0	0	0.5	0
Zoar	5	0	0	0	0	0	0	0	0	0
Zoar	4	0	0.3	3.3	0	0.9	0	0	1.0	0
Zoar	4'	0	0	0.5	0	0	0	0	5.5	0
Zoar	11	0	1.8	0	0	0	0	0	0	0
Twenty Mile	A	0	0	0	0	3.48	0	0	5.36	7.8
Twenty Mile	B	0	0	2.16	0	2.37	0	0	4.83	9.8
Eighteen Mile	A	0	0	0	0	0	0	0	30.02	0
Eighteen Mile	B	0	0	11.18	0	0	0	0	0	0
Eighteen Mile	1	0	0	0	0	0.17	0	0	20.38	0
Eighteen Mile	2	10.17	0	0	0	0	0	0	8.73	0
Tonawanda	Akron	0	0	0	42.3	0	0	0	0	0
Tonawanda	Reservation	0	0	0	0	0	0	0	0	0
Lower Catt-upstream	Inland	0	0	0	43.8	0	0	0	0	0
Lower Catt-downstream	Band 3	0	0	2.6	13.8	0	0	0	0	0
Lower Catt-downstream	Band 2	0	0	0.57	0	0	0	0	0	0
Upper Catt-north	Band 1	0	0	1.19	1.63	0	0	0	0	0
Upper Catt-north	Band 2	0	0	2.56	24.5	0	0	0	0	2.34
Upper Catt-north	Band 3	0	0	0	0	0	0	0	3.31	0
Upper Catt-south	Band 2	0	0	1.22	0.7	0	0	0	0	0.22
Upper Catt-south	Band 3	0	0	0.63	13.1	0	0	0	0	0.23
Upper Catt-south	Band 4	0	0	1.42	20.8	0	0	0	0	4.05
Chautauqua	1	0	0	0	0	0	0	0	0	0
Chautauqua	2	0	1.42	7.64	0	0	0	0	0	0
Chautauqua	4	0	0	11.54	0.13	0	0	0	0	4.58
Chautauqua	5	0	1.84	4.99	1.88	0	0	0	0	0.82
Chautauqua	6	0	0	0	0	0	0	1.66	4.89	0

Site location	Designation	SAAL	SAIN	SANI	RHTY	TIAM	TSCA	ULAM	ULRU
Zoar	P	0	0	0	0	0	0	1.2	0
Zoar	N	0	0	0.2	0	0	0	0	0
Zoar	M	0	0	0	1.2	0	0	0	0
Zoar	L	0	0	1.8	0.4	0	0	0.3	0
Zoar	K	0	0	0	0	0.3	2.2	0.1	0
Zoar	J	0	0	0.2	0	0	0	0	0
Zoar	H	0	0	0	0	0	0	0.9	0
Zoar	G	0	0	0	0	0	0.3	0	0
Zoar	F	0	0	0	0	0	0	0	0
Zoar	E	0	0	0.6	0	0	0	0.2	0
Zoar	D	0	0	0	0	0	0.1	0.2	0
Zoar	C	0	0	0	0	0	0.5	0.1	0
Zoar	B	0	0	0.5	0	0	0	0	0
Zoar	A	0	0	1.1	0	0.6	0	0.1	0
Zoar	10	0	0	0	0	2.2	0.8	0.9	0
Zoar	9	0	0	0	0	1.9	1.8	0.2	0
Zoar	8	0	0	0	0	1.2	2.1	0	0
Zoar	7	0	0	0	0	3.5	0.2	0	0
Zoar	6	0	0	0	0	1.5	0.7	0	2.3
Zoar	6'	0	0	0	0	7.0	0	0.9	0
Zoar	5	0	0	0	0	2.8	8.5	0	0
Zoar	4	0	0	0	0	3.6	2.4	0.5	0
Zoar	4'	0	0	0	0	3.5	0	0	2.7
Zoar	11	0	0	0	0	0	4.1	0	0
Twenty Mile	A	0	0	0	0	0	0	1.93	0
Twenty Mile	B	0	0	0	0	0	0.32	0	0
Eighteen Mile	A	0	0	0	0	0	0	2.86	0
Eighteen Mile	B	0	0	0	0	3.43	0	1.76	0
Eighteen Mile	1	0	0	0	0	0.44	2.33	0	0
Eighteen Mile	2	0	0	0	0	0	0.3	0	0
Tonawanda	Akron	0	0	0.08	0	0	0	0	0
Tonawanda	Reservation	0	0	38.54	0	0	0	0	0
Lower Catt-upstream	inland	0	0	4.86	0	0	0	0	0
Lower Catt-downstream	Band 3	0	0	12.11	0	0	0	0	0
Lower Catt-downstream	Band 2	0.19	0.24	0.44	0	0	0	0	0
Upper Catt-north	Band 1	0	0	0	0	0	0	0	0
Upper Catt-north	Band 2	0	0	5.4	0	0	0	0	0
Upper Catt-north	Band 3	0	0	0	0	0	0	0	0
Upper Catt-south	Band 2	0	0.02	0	0	0	0	0	0
Upper Catt-south	Band 3	0	0	2.38	0	0	0	0	0
Upper Catt-south	Band 4	0	0	4.1	0	0	0	0	0
Chautauqua	1	0	0	0	0	0	0	0	0
Chautauqua	2	0	0	0	0	3.65	0.09	0	0
Chautauqua	4	0	0	1.39	0	0	0	0	0
Chautauqua	5	0	0	1.85	0	0.49	0	0.52	1.39
Chautauqua	6	0	0	0	0	0	0.99	0	0

Table 4.3 – Landform values of riparian stand characteristics.

Site location	Designation	BA	H'	Richness	% Shade	% Flood
Zoar	P	25.8	1.057	9	0.3	85.5
Zoar	N	3.0	0.706	5	0	100.0
Zoar	M	2.1	1.095	6	0	34.2
Zoar	L	19.4	1.48	12	0	95.5
Zoar	K	30.5	2.179	16	25.3	48.8
Zoar	J	1.0	1.323	5	0	100.0
Zoar	H	29.6	1.938	16	30.0	23.0
Zoar	G	37.7	1.796	10	24.9	28.6
Zoar	F	33.2	1.673	16	4.0	68.4
Zoar	E	15.9	1.694	17	0	87.2
Zoar	D	25.1	1.621	11	30.8	19.0
Zoar	C	25.7	2.031	17	9.6	50.2
Zoar	B	25.0	1.517	11	1.3	93.4
Zoar	A	36.8	1.773	14	12.3	61.9
Zoar	10	34.9	1.68	13	63.3	1.1
Zoar	9	34.6	1.342	10	74.4	0
Zoar	8	36.5	1.87	11	65.7	0
Zoar	7	35.0	2.092	15	40.6	3.3
Zoar	6	40.0	2.05	13	48.9	6.8
Zoar	6'	33.7	1.729	9	15.1	46.4
Zoar	5	42.4	1.817	9	71.4	0.0
Zoar	4	49.4	1.946	14	29.9	6.6
Zoar	4'	40.0	2.127	10	30.4	1.3
Zoar	11	29.8	1.508	8	52.3	0
Twenty Mile	A	33.7	1.477	13	28.2	23.1
Twenty Mile	B	52.1	1.734	15	23.9	22.3
Eighteen Mile	A	44.8	0.988	7	14	0
Eighteen Mile	B	39.3	1.63	12	37	28
Eighteen Mile	1	68.8	1.31	10	65	0
Eighteen Mile	2	60.1	1.802	10	33	0
Tonawanda	Akron	49.7	0.431	7	0	100
Tonawanda	Reservation	46.1	0.501	5	0	100
Lower Catt-upstream	Inland	57.3	0.701	4	0	100
Lower Catt-downstream	Band 3	29.6	1.059	5	0	100
Lower Catt-downstream	Band 2	2.07	1.511	5	0	100
Upper Catt-north	Band 1	2.82	0.68	2	0	100
Upper Catt-north	Band 2	32.2	0.699	6	0	100
Upper Catt-north	Band 3	16	1.414	11	7	0
Upper Catt-south	Band 2	2.16	0.963	4	0	100
Upper Catt-south	Band 3	16.3	0.644	4	0	100
Upper Catt-south	Band 4	39.6	1.47	11	0	77.8
Chautauqua	1	15.8	0.889	5	0	99.9
Chautauqua	2	32.2	1.321	15	52.6	23.7
Chautauqua	4	18.8	1.053	13	6	94.7
Chautauqua	5	26.1	2.022	12	34	36.3
Chautauqua	6	22.1	1.407	14	52.3	0

Site location	Designation	Largest DBH	Mean DBH > 5 cm	DBH CV% > 5 cm	Stand age
Zoar	P	49	14.9	84.1	35
Zoar	N	15	10.3	32.5	9
Zoar	M	8	6.2	18.3	8
Zoar	L	44	16.0	47.0	33
Zoar	K	31	12.1	64.9	55
Zoar	J	8	6.2	24.7	9
Zoar	H	33	14.1	54.7	54
Zoar	G	73	17.6	80	95
Zoar	F	57	14.7	79.2	55
Zoar	E	31	12.4	59.2	32
Zoar	D	52	13.7	67.8	60
Zoar	C	46	15.9	72.8	61
Zoar	B	38	14.1	46.6	34
Zoar	A	57	12.6	71.2	49
Zoar	10	78	20.3	97.9	287
Zoar	9	103	17.1	91.3	226
Zoar	8	89	16.7	98.4	232
Zoar	7	75	24.4	69.7	155
Zoar	6	114	22.2	90.8	247
Zoar	6'	76	24.0	81.0	126
Zoar	5	100	20.3	84.3	301
Zoar	4	85	24.6	113.1	254
Zoar	4'	81	36.2	63.0	127
Zoar	11	66	13.5	104.6	114
Twenty Mile	A	45	12.2	72.2	53
Twenty Mile	B	57	16.5	86.9	75
Eighteen Mile	A	58	11.9	100.4	47
Eighteen Mile	B	53	15.1	69.6	80
Eighteen Mile	1	90	27.7	100.1	147
Eighteen Mile	2	88	17.2	137.9	135
Tonawanda-Akron		91	31.8	79.5	70
Tonawanda-Res		133	40.3	87.5	117
Lower Catt-upstream	inland	102	30.9	88.8	80
Lower Catt-downstream	Band 3	66	30.1	47.4	80
Lower Catt-downstream	Band 2	20	11.4	35.1	18
Upper Catt-north	Band 1	18	10.7	37.2	9
Upper Catt-north	Band 2	54	23.9	57.4	31
Upper Catt-north	Band 3	52	21.8	58.3	68
Upper Catt-south	Band 2	10	6.9	32.1	9
Upper Catt-south	Band 3	38	14.4	54.5	26
Upper Catt-south	Band 4	61	19.4	63.6	58
Chautauqua	1	25	11.3	47.1	20
Chautauqua	2	56	13.9	84.9	72
Chautauqua	4	40	13.8	61.4	37
Chautauqua	5	69	15.3	75.2	90
Chautauqua	6	44	14.6	65	60

Stand Age and Characteristics

Across all riparian study sites, regardless of sediment composition, there was a positive logarithmic association between basal area (m^2/ha) and stand age (**Figure 4.1**). For all locations, basal area of woody vegetation increased with increasing forest stand age. Eighteenmile Creek generated the highest basal area (68.8 m^2/ha), coinciding with it being the oldest stand (147 years) of all the study sites. Band 2 of Upper Catt-south (see **Figure 2.9** for visual location) had one of the lowest basal areas (2.16 m^2/ha) in addition to being the youngest stand (9 years).

Forest diversity for Zoar Valley had a strong positive logarithmic association with stand age (**Figure 4.2**). Riparian zones sharing similar coarse-sediments to the Zoar Valley environment (e.g. Twentymile, Eighteenmile, and Chautauqua Creeks) displayed a comparable trajectory of increasing diversity with aging stands to an eventual plateau. Fine-sediment based riparian study sites (e.g. Tonawanda (both Akron and Reservation), Upper Cattaraugus, and Lower Cattaraugus Creeks) revealed no such trend, with diversity experiencing no increase in correspondence with increasing stand age.

Percent shade tolerance (**Figure 4.3**) exhibited a positive logarithmic association among Zoar Valley and the coarse-sediment comprised riparian study sites. In these areas more shade tolerant species became prevalent with increasing stand age, indicating that as these stands age they acquire more late-seral tree species (e.g. eastern hemlock, sugar maple, and American beech). Fine-sediment study sites exhibited no increase of shade-tolerant species. The fine-sediment comprised areas consisted mainly of early-seral species (e.g. eastern cottonwood, American sycamore, black and sandbar willows).

Percent flood tolerance (**Figure 4.4**) exhibited a negative logarithmic association among Zoar Valley and the coarse-sediment comprised study sites. This indicates that flood-tolerant species, such as eastern cottonwood and black and sandbar willows, became scarcer as forest stands in coarse-sediment areas aged and developed. The negative association that the coarse-sediment areas have with flood tolerance complements their positive association with shade tolerance. The trends in the data for the coarse-sediment study sites are indicative of the occurrence of successional displacement of early seral tree species for more shade tolerant species as the stand progresses. Quite the opposite trend occurs in the fine-sediment comprised study sites, where there is nearly 100% flood-tolerance among all landforms, regardless of age. The fine-sediment areas are dominated by early-seral species that are less sensitive to the impacts of flooding. Few species are able tolerate inundation for days at a time, and the data trends reveal that, despite forest stands growing older, the fine-sediment study sites are not acquiring any new tree species that are less flood-tolerant, suggesting that a successional regime may be suspended due to flood effects.

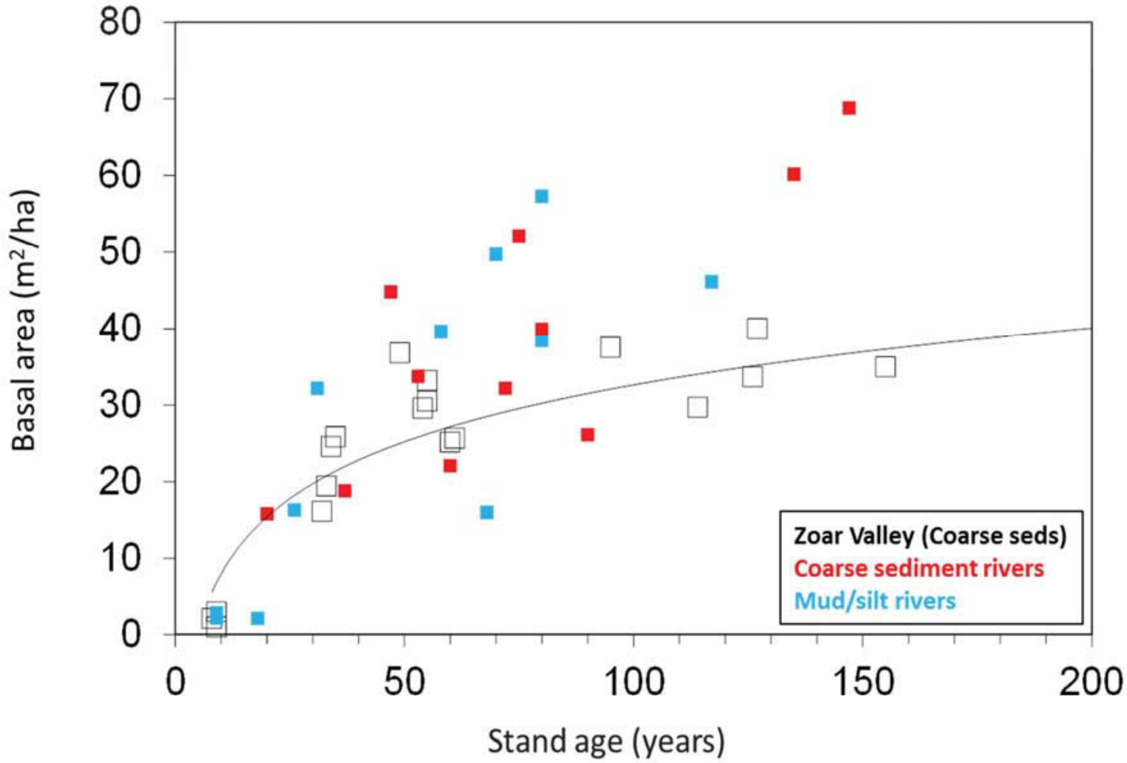


Figure 4.1 – Whole-landform total basal area (all species) plotted against core-based stand age estimates for 46 landforms, including 22 from present study and 24 reported from Zoar Valley by Diggins (2013) for comparison. Coarse-sediment rivers for Figures 4.1 - 4.4 comprised: Twentymile Creek, Eighteenmile Creek, and Chautauqua Creek. Fine-sediment rivers for Figures 4.1 - 4.4 comprised: Tonawanda Creek (both sites), Lower Cattaraugus Creek, and Upper Cattaraugus Creek.

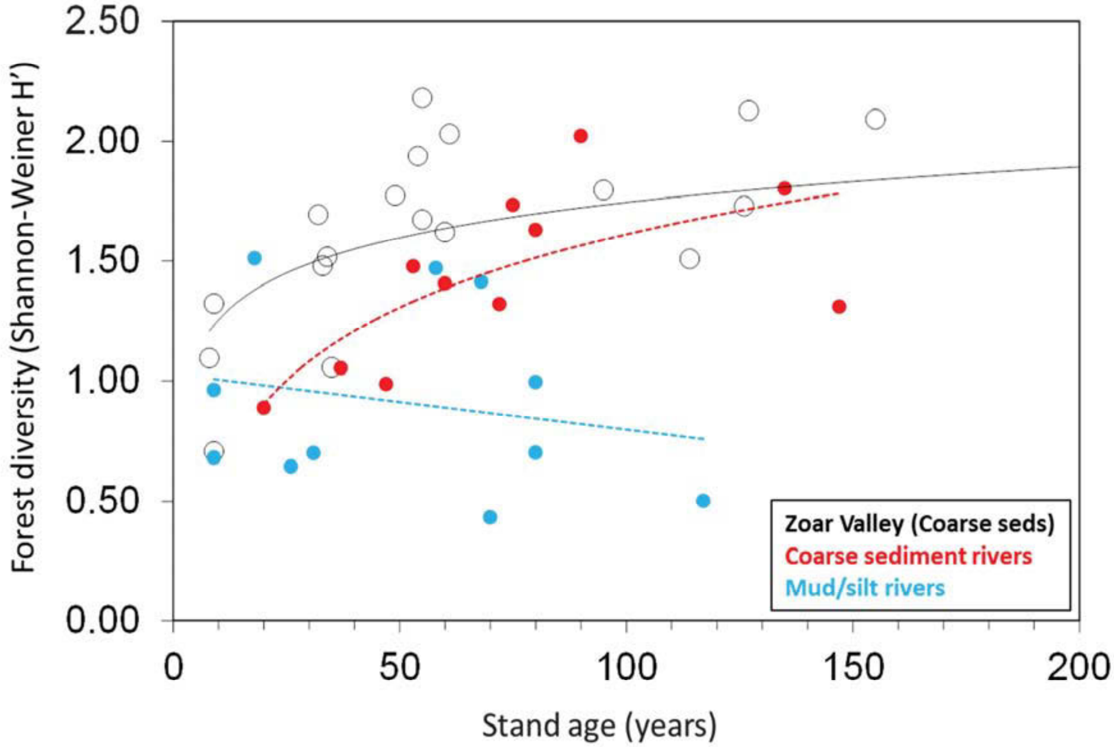


Figure 4.2 – Whole-landform total forest diversity (Shannon H') plotted against core-based stand age estimates for 46 landforms.

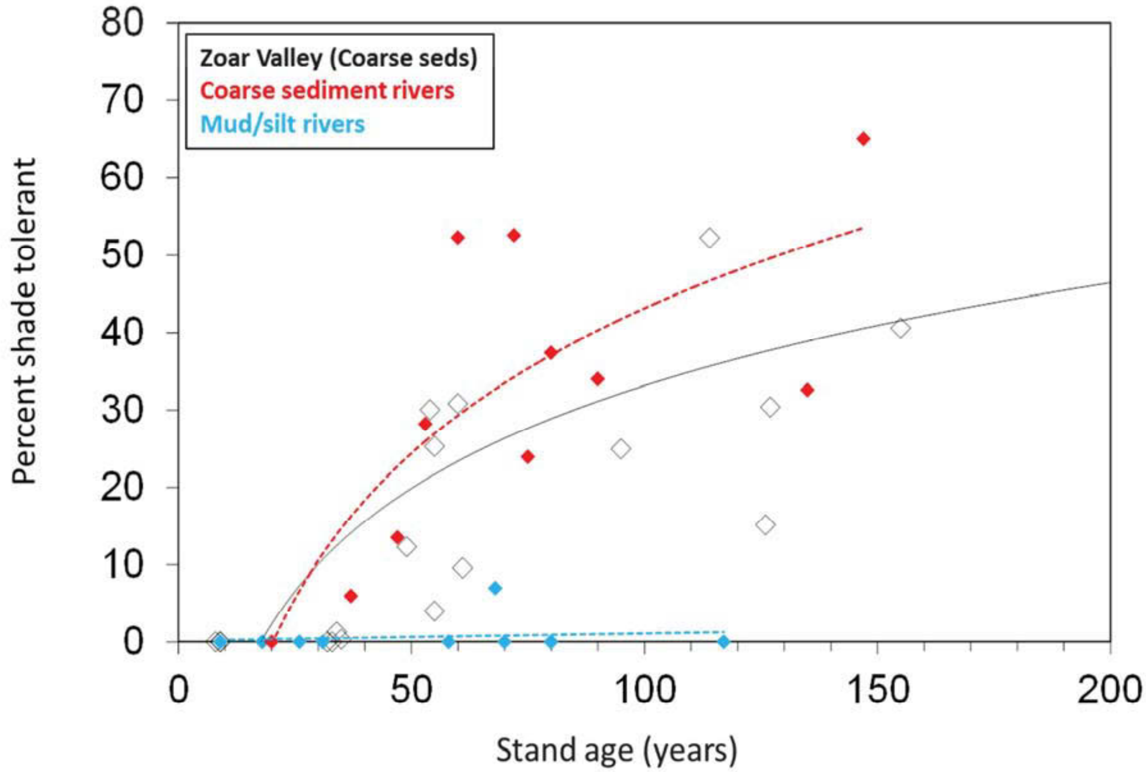


Figure 4.3 Whole-landform % shade tolerance plotted against core-based stand age estimates for 46 landforms. Shade tolerant species comprise Sugar maple, Eastern hemlock, and American beech.

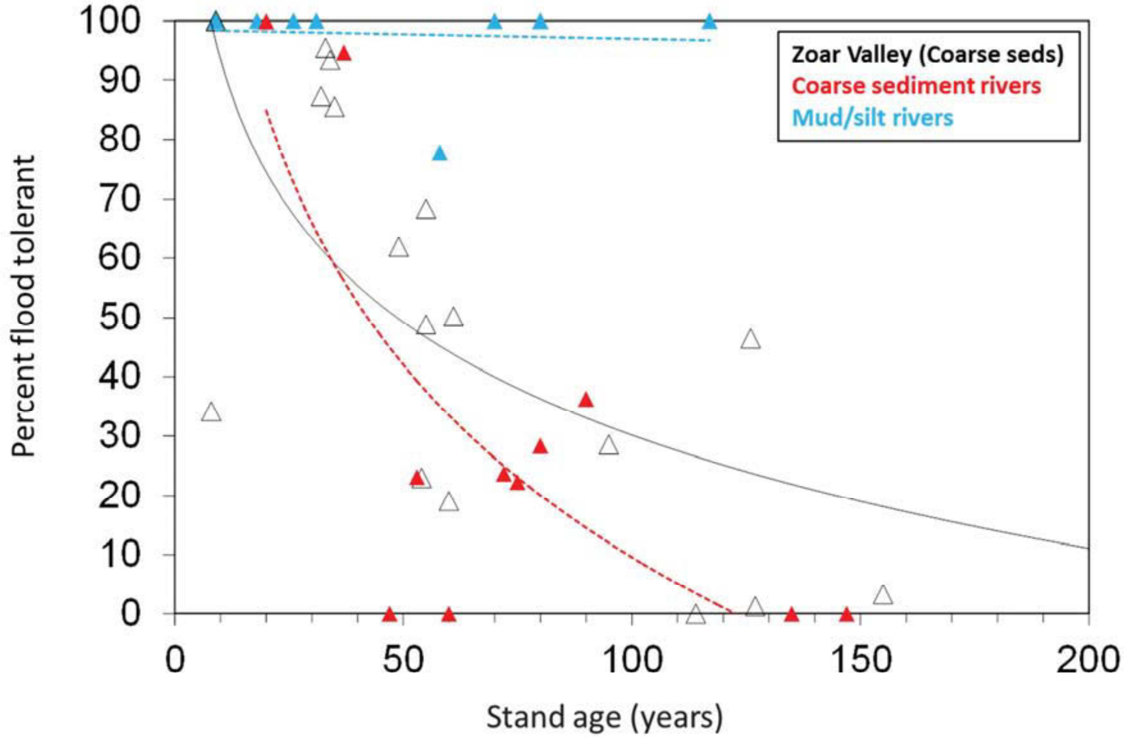


Figure 4.4 – Whole-landform % flood tolerance plotted against core-based stand age estimates for 46 landforms. Flood tolerant species comprise Black willow, Sandbar willow, Eastern cottonwood, Black locust, Ashleaf maple, and American sycamore.

Riparian Forest Structure/Composition Ordination

Non-metric multidimensional scaling ordination of species distributions and stand structure variables converged on a solution in four iterations with residual stress (i.e. the proportional lack of fit between the NMDS solution and the underlying distance matrix) of 0.0523.

Along the NMDS dimension 1 axis (*x*) there was a strong positive association with stand age (logarithmic $R^2 = 0.789$ NMDS 1 scores regressed on stand age), with forest stand maturation occurring left-to-right (**Figure 4.5** – A). Interestingly, young stands (< 20 years) among all riparian sediment-type sites exhibited similar stand characteristics before diverging as stand age progressed. Non-metric multidimensional scaling ordination of species basal areas and stand characteristics distinguished a clear divergence between the coarse-sediment comprised study sites (including Zoar Valley) and the fine-sediment comprised study sites along the NMDS dimension 2 axis (*y*).

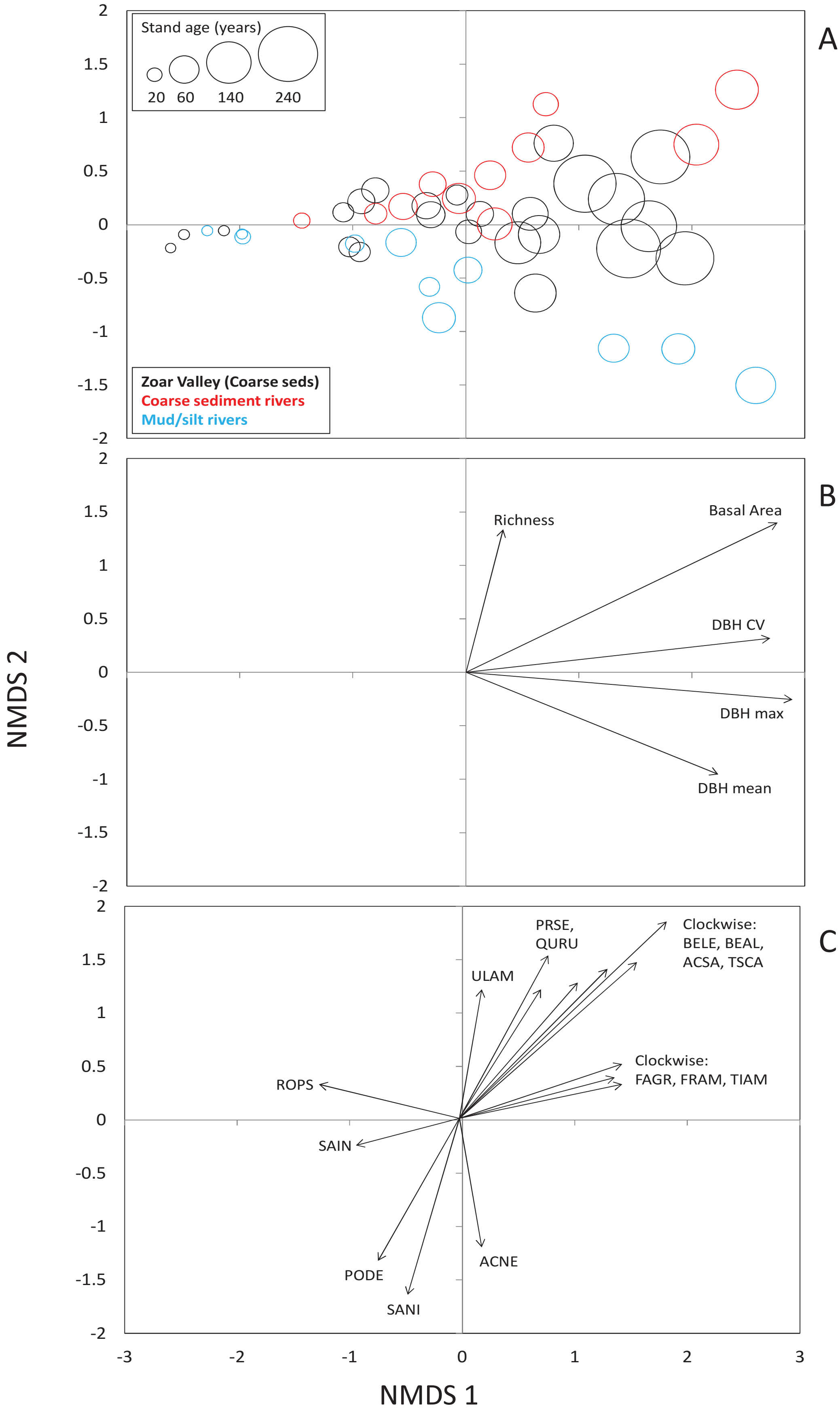
Stand structure variables (**Figure 4.5** – B) exhibited positive associations with the NMDS dimension 1 axis to varying degrees, except for diversity which was non-significant to either axis, and richness, which was associated only with NMDS 2. Basal area, maximum DBH and DBH coefficient of variation all had the strongest positive associations with NMDS 1, with Spearman correlation coefficients ranging from 0.903 to 0.969. No variables trended to the left of the NMDS dimension 2 axis. This is not unexpected in studies of forest development over time, as these widely reported basic stand structure variables are essentially intended to reflect forest maturation. Species richness and DBH coefficient of variation both had the strongest positive associations with NMDS 2, with corresponding Spearman correlation coefficients (rho) of 0.438 and

0.455, respectively. Basal area, maximum DBH and mean DBH were not significantly associated with NMDS 2.

In panel C of **Figure 4.5** American beech, white ash, and American basswood all had strong positive associations with NMDS 1 (but minimal association with NMDS 2), with Spearman correlation coefficients ranging from 0.443 – 0.481. These species were most associated with older landforms comprised of coarse-sediments and are considered to be later successional tree species or gap pioneers (i.e. the first species to inhabit a forest canopy gap). In contrast, the strongest negative associations with NMDS 1 are exhibited by black locust (-0.416) and sandbar willow (-0.305), which proliferate on younger landforms comprised of fine-sediments.

The species with nearly equally high positive associations with both the NMDS 1 and NMDS 2 axes included sugar maple, black birch, yellow birch, and eastern hemlock. Sugar maple had the highest Spearman correlation coefficients out of all species pertaining to both axes (0.614 for NMDS 1 and 0.602 for NMDS 2). Sugar maple and eastern hemlock are considered late-seral species, while black birch and yellow birch are common to mid-seral mesic forests. These species were found in a variety of study sites ranging in age, species richness, and diversity, suggesting that they may be in abundance in a number of forest environments at different successional stages.

Black cherry and northern red oak were neither positively nor negatively associated with NMDS 1, which reflected the fact that they tended to be well distributed across a broad range of stand ages rather than being restricted to younger or older stand ages. Likewise, several of the most important riverside species (e.g. eastern cottonwood, black willow, ashleaf maple) did not trend in either direction on the age-related x-axis, again reflecting their tendency to be important in both young and old stands, although in this case widely restricted to fine-sediment riparian sites. Eastern cottonwoods and black willows were found as young trees (< 9 years) on fine-sediment comprised landforms, but were also found as older specimens (e.g. 117 year-old black willow at Tonawanda Reservation).



A
Stand age (years)
20 60 140 240
Zoar Valley (Coarse seds)
Coarse sediment rivers
Mud/silt rivers
B
Richness
Basal Area
DBH CV
DBH max
DBH mean
C
PRSE,
QURU
ULAM
Clockwise:
BELE, BEAL,
ACSA, TSCA
Clockwise:
FAGR, FRAM, TIAM
ROPS
SAIN
PODE
SANI
ACNE
NMDS 2
NMDS 1
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-3
-2
-1
0
1
2
3

Figure 4.5 – Ordination of 46 survey landforms by non-metric multidimensional scaling (NMDS) of stand structure variables and basal areas of individual canopy tree species. In panel A, the bubble areas represent core-based stand ages. In panel B, Spearman rank correlations of stand structure variables with NMDS axes are indicated by vector arrows. Panel C presents Spearman correlations of individual species basal areas with NMDS axes for the 15 selected species, which were abundant and significantly correlated with at least one axis. Identification of four letter species codes can be found in Table 3.1. Straight line vectors are utilized in panels B and C in order to portray trends, with no implication that relationships are linear. Spearman correlation values were multiplied by a factor of 3 for plotting in order to better visually display the data at the scale of the NMDS axes.

V. DISCUSSION

Influences of the Sedimentary Environment on Riparian Forest Development

Sediment type and cohesiveness can play integral roles in the shaping of riparian forests (Asaeda and Rashid 2012, Naiman et al. 2005, Nanson and Croke 1992). Coarse-sediment streams in the present study (e.g. Twentymile, Eighteenmile, and Chautauqua Creeks) exhibited distinct and highly diverse patches of woody vegetation (see **Figure 5.1**), where forest stand ages reflected time since landform deposition, as was also well demonstrated in coarse-sediment Zoar Valley (Diggins 2013). Species richness and diversity in the present study increased with stand age at coarse-sediment study sites, with a greater prevalence of more shade tolerant species as stand development progressed. This suggests that riparian forests here are following a successional trajectory, in which newly deposited landforms are colonized by early-seral species (see Ward et al. 2002) and then later followed by more shade tolerant (and flood intolerant) species. Even though these landforms may still be subjected to occasional flooding, there appears to have been minimal flood-driven alteration of the riparian community (Steiger et al. 2005). This may be due to the unconsolidated nature of the coarse sediments, allowing flood water to quickly drain rather than inundating the landforms for extended periods (i.e. days to weeks).

Conversely, fine-sediment comprised study streams (e.g. Tonawanda, Upper Cattaraugus, and Lower Cattaraugus Creeks) often exhibited distinct bands of vegetation of increasing age moving inland from the stream banks (see **Figure 5.2**). These areas generally lacked mid-to-late seral species, with forest composition dominated by early-seral eastern cottonwood, sandbar and black willows, and black locust. Even in such forest stands of relatively advanced age (> 80 years) there was no increase in diversity, which is a stark contrast to the landform/vegetation mosaics occurring in Zoar Valley and the other coarse-sediment comprised study sites, such as Eighteenmile and Chautauqua Creeks. Fine-cohesive sediments do not allow for the quick drainage of flood waters from a landform (Nanson and Croke 1992; Osterkamp and Hupp 2010), as is the case for coarse sediments, but instead may lead to longer term inundation. Relatively few tree species are specialized to tolerate such inundation (Naiman and Decamps 1997, Naiman et al. 2005), and as a result fine-sediment stands of low diversity are generated, with these species dominating. In these areas it is suspected that flood-regime does not necessarily destroy vegetation (there are older trees at these sites, and stands are accumulating basal area), but rather may regulate the communities by effectively suspending the successional trajectory described at coarse-sediment sites. Bands of vegetation closest to the edge of the streams represent young stands that experience habitual flooding (multiple events per year), while those farthest from the river are decades older, although they are still comprised of early-seral species. It is possible that these older stands may still experience enough flooding that late successional species are not present (Nilsson et al. 1989).

It is worth noting that sediment-type was not included as an input variable for the NMDS ordination presented here (i.e. the ordination axes were generated solely from riparian forest composition and structure), so the emerging trend of divergence between the fine-sediment and coarse-sediment comprised areas associated with greater stand age is a strong indicator that sediment composition is a major driving force in how riparian forests develop. Consistent trends of high diversity and shade tolerance were present at the coarse-sediment sites, suggesting landform mosaics representing different successional stages. Conversely, lower diversity and lack of shade tolerant species were observed at fine-sediment sites, even at relatively advanced stand age, suggesting a suspension of successional processes.

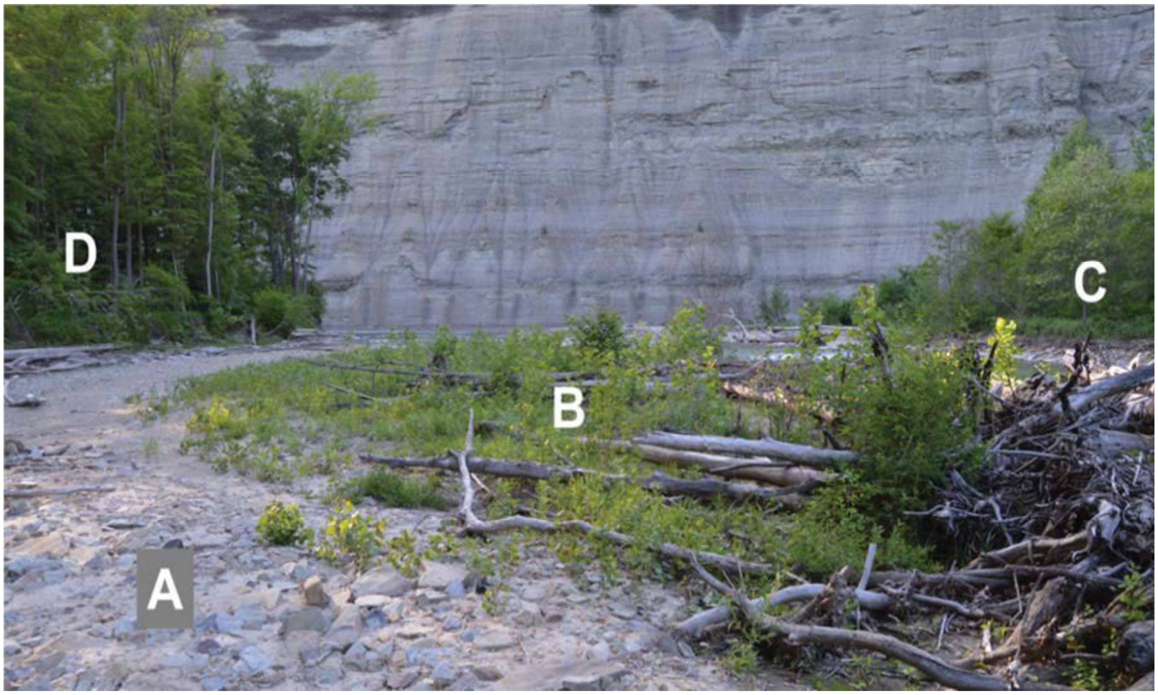


Figure 5.1 – Representative vegetational mosaic from coarse-sediment riparian corridor (Zoar Valley). Letters indicate as follows: A) active channel = bare sediments, B) 6-year-old channel bar = willow/cottonwood pioneers, C) 40-year island = diverse species mix, D) >150-year river terrace = species-rich mature and old-growth.

Figure 5.2 – Representative banded vegetation from fine-sediment riparian corridor (Cattaraugus Creek). Letters indicate as follows: A) near-continual flooding = bare sediments, B) habitual flooding = 1-m sandbar willow, C) occasional flooding = 2 – 3-m young willow/cottonwood, D) rare flooding = mature cottonwood.

Relative Influences of Disturbance and Succession

Studies of flood effects as a mechanism of disturbance in riparian zones are abundant (e.g. Bendix and Hupp 2000, Gurnell et al. 2012, Hupp 1983, Hupp and Osterkamp 1985). Although studies have been conducted pertaining to the relationships between geomorphic processes and riparian vegetation development (e.g. Hupp and Osterkamp 1996, Swanson et al. 1988, Ward et al. 2002), it has not been thoroughly addressed how and where flood-regime directly affects riparian development, vs. acting *indirectly* in correspondence with the geomorphic and sedimentary environments to shape the ecological community (Egger 2015; Ward et al. 2002). Over the course of the present study it has been discovered that hydrology, geomorphology (including sedimentology), and ecology cannot and should not be treated as entities independent of one another in regard to riparian zones (see the conceptual model in **Figure 5.3**). Rather, they should be viewed as a series of intertwined feedback loops, with each aspect ultimately contributing to where riparian forests develop, how they become established, and what species make up their composition.

Riparian zones, being land-water interfaces (Gregory et al. 1991), have a close relationship with the hydrologic regime. Hydrology is the driving force behind landform deposition (Osterkamp and Hupp 2010; Naiman et al. 2005), eroding sediments for transport either as bed load or suspended load (Hugget 2011). It was observed (both directly and through examination of imagery) at coarse-sediment study sites that landforms were deposited as punctuated events following major floods. These landforms were then often stabilized by colonizing vegetation, displaying primary successional processes and following a successional trajectory as forest stands matured. In contrast, fine-sediment study sites were observed to have slow sediment accretion on meander banks over time. The hydrologic regime seemed to more directly regulate the vegetation at the fine-sediment study sites, resulting in low species diversity and the prevalence of a few highly flood tolerant species. Such a display is indicative of the Intermediate Disturbance Hypothesis (Connell 1978), where environments exposed to high disturbance (in this case frequent flooding) are predicted to exhibit low community diversity, with only those species tolerant of fluvial disturbance are able to proliferate.

While hydrology may act as a disturbance factor in riparian zones, and geomorphology may set the stage for primary succession to occur, the ecological community plays an important role in regulating both of these processes (Osterkamp and Hupp 2010). Vegetation not only stabilizes landforms, but it also aids in regulating hydrology by moderating runoff and flood regime (Naiman et al. 2005, Ward et al. 2002). The degree to which each aspect influences the other is case-specific depending on the sediments present at the study sites, as well as their erodibility. A study conducted by Hering et al. (2004) revealed little destruction to willow thickets and floodplain forest after the occurrence of a 100-year flood event in an alpine floodplain of Isar, Germany. New gravel bars were also formed as a result of the flood, leading Hering et al. (2004) to conclude that even extreme floods may not be capable of removing large amounts of woody vegetation in alluvial floodplains.

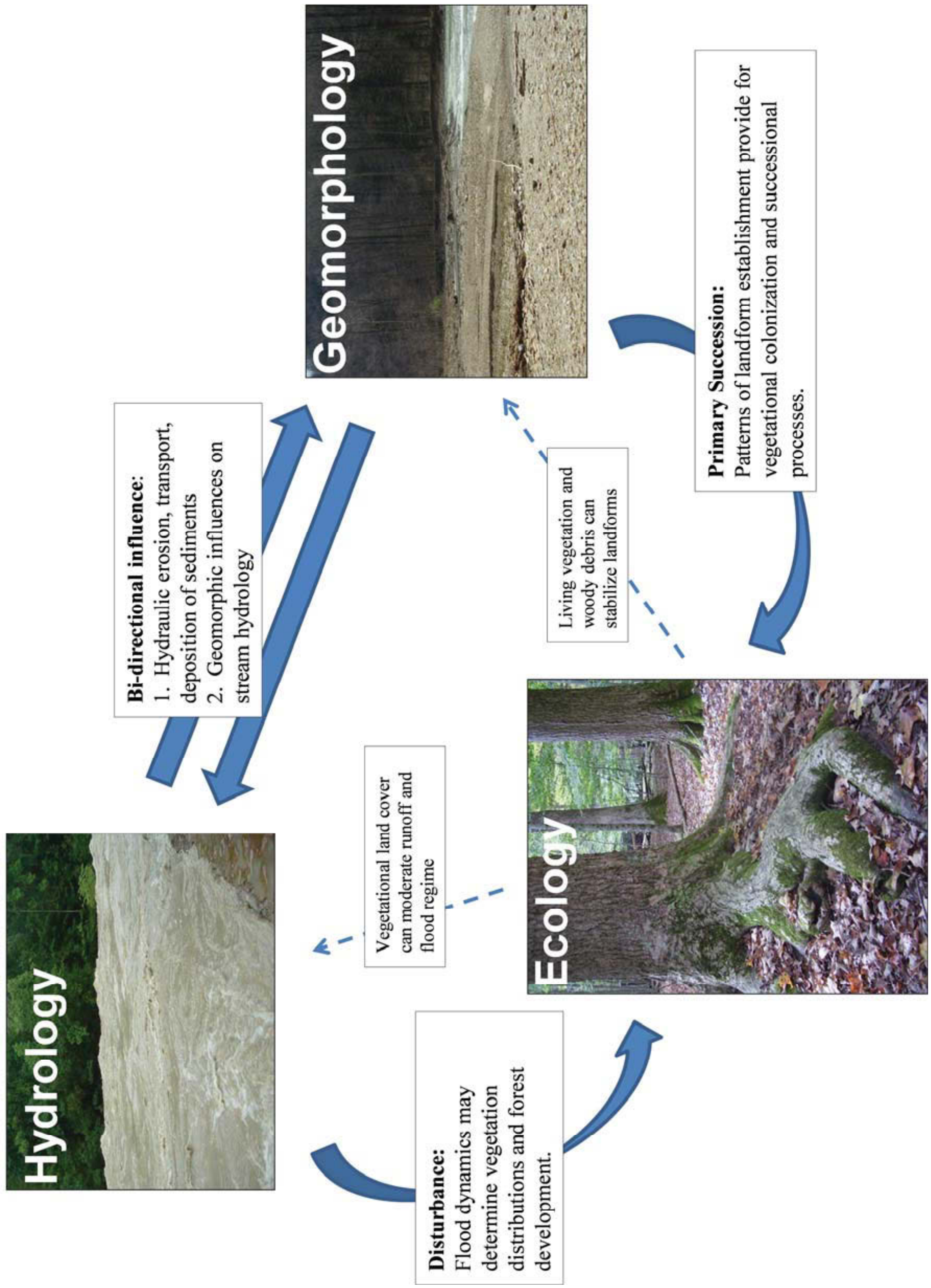

Geomorphology
Hydrology
Ecology
Bi-directional influence:
1. Hydraulic erosion, transport, deposition of sediments
2. Geomorphic influences on stream hydrology
Living vegetation and woody debris can stabilize landforms
Primary Succession:
Patterns of landform establishment provide for vegetational colonization and successional processes.
Vegetational land cover can moderate runoff and flood regime
Disturbance:
Flood dynamics may determine vegetation distributions and forest development.

Figure 5.3 – Proposed conceptual model of hydrologic, geomorphic, and ecological interactions in riparian zones.

A Continuum versus a Dichotomy

In the initial stages of the present study there was thought to exist a geomorphic continuum in riparian zones based on the types of sediments present in correspondence with the hydrologic regime (see **Figure 5.4**). However, based on the convincing divergence between coarse-sediment and fine-sediment comprised study sites revealed in this study, there is suggestive evidence that a geomorphic *dichotomy* actually exists. In order for vegetation to colonize a landform, the composition of that landform must be sufficiently erosion-resistant such that it is not destroyed every time a flood occurs (Nanson and Croke 1992; Osterkamp and Hupp 2010). Fine cohesive sediments and coarse clastic sediments are both erosion-resistant, but for very different reasons. Fine-sediments such as clay and silt are difficult to erode due to their cohesive nature (Hugget 2011), making these sediments easily compactible with very few pore spaces. Erosion acts on these sediments by slowly degrading them (Ward et al. 2002), generating very little change in stream morphology over time (as revealed by Tonawanda and lower Cattaraugus Creeks). Coarse-sediments require large flood events with high velocity to be transported and deposited abruptly (Steiger et al. 2005), often only being moved modest distances (tens to hundreds of meters) downstream by each event (as revealed by Chautauqua, Eighteenmile, Twentymile, and the Zoar Valley portion of the Cattaraugus Creeks). Thus, a geomorphic dichotomy is suggested, because vegetation was shown to only colonize those areas with erosion-resistant sediments that occur at opposite ends of the sedimentary spectrum.

In contrast, the middle of this spectrum consists of fine erodable sediments (e.g. sand and coarse silt) that are not cohesive. Minimal woody vegetation occurs at such locations due to the lack of landform stabilization. Landforms comprised of erodable sediments are often so transient that herbaceous layers are the only vegetation present (Fahnstock 1963, Leopold and Wolman 1957, Naiman et al. 2005). In a historical morphological study conducted by Fahnstock (1963) on the White River in Mount Ranier, Washington, no vegetation was fould in the valley train of the study area due to the "incessant reworking of the surface." Erodable sediments comprising the channel bars of the White River experienced frequent shifting with the hydrologic regime (Fahnstock 1963). Studies assessing riparian communitites in association with geomorphological and hydrological processes have become more prevalent over the past two decades (e.g. Asaeda and Rashid 2012, Bendix and Hupp 2000, Dixon and Turner 2006, Egger 2015, Richards et al. 2002). Given the widely accepted premise that riparian zones foster high vegetational diversity (Naiman et al. 1992), it is understandable that highly varied hydrologic and geomorphic regimes should play a major role (Francis et al. 2009). The intriguing possibility that the patterns in such factors may often represent a dichotomy in terms of their ability support riparian forest communities suggests even further how high biological diversity can develop, both among and within riparian sites.

Fine cohesive clay/silt (erosion resistant) – Tonawanda Creek Akron site

Highly erodible sand/silt (minimal forest development) – North Fork Toutle River, southwestern Washington State

Coarse gravel/cobble/boulder (erosion resistant) – Zoar Valley Canyon

Figure 5.4 – Fluvial geomorphic continuum; intermediate-sized sand/silt sediments often yield highly dynamic and even transient landforms sometimes not colonized by woody vegetation. Riparian forest dichotomy? Fine-cohesive and coarse-clastic sediments are sufficiently erosion resistant to allow forest development on stabilized landforms.

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APPENDIX

1.1 Twentymile Creek, downstream lower terrace (10 x 10 m quadrats)

Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)				
1	ACSA	1	22	7.002823	0.1779	0.0248				
1			19	6.047893	0.1536	0.0185				
1				3	0.0762	0.0046				
1				2	0.0508	0.0020	Total # of Trees	Total # of Trees per Ha		
1				1	0.0254	0.0005	28			
1				1	0.0254	0.0005				
1				0.5	0.0127	0.0001	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
1				2	0.0508	0.0020	1	0.0678	0.1561	-0.2899
1				2	0.0508	0.0020	2	0.1846	0.4400	-0.3612
1				3	0.0762	0.0046	3	0.0665	0.1585	-0.2920
1				2	0.0508	0.0020	4	0.0428	0.1020	-0.2328
1				1	0.0254	0.0005	5	0.0578	0.1379	-0.2732
1				1	0.0254	0.0005	6	0.0147	0.0350	-0.1174
1				1	0.0254	0.0005				
1				2	0.0508	0.0020				
1				1	0.0254	0.0005				
1				2	0.0508	0.0020				
1	ROPS	2	29	9.230994	0.2345	0.0432				
1			49	15.5972	0.3961	0.1232				
1				6	0.1524	0.0182				
1	LITU	3	36	11.45917	0.2910	0.0665				
1	PRSE	4	26	8.276064	0.2102	0.0347				
1				4	0.1016	0.0081				
1	ULAM	5	29	9.230994	0.2345	0.0432				
1				2	0.0508	0.0020				
1				5	0.1270	0.0127				
1	FRAM	6		2	0.0508	0.0020				
1				5	0.1270	0.0127				

Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)				
2	ACSA	1		5	0.1270	0.0127				
2				2	0.0508	0.0020				
2				2	0.0508	0.0020				
2				3	0.0762	0.0046				
2				3	0.0762	0.0046				
2				3	0.0762	0.0046	Total # of Trees	Total # of Trees per Ha		
2				1	0.0254	0.0005	24			
2				2	0.0508	0.0020				
2				2	0.0508	0.0020	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
2				2	0.0508	0.0020	1	0.1066	0.5753	-0.3181
2				6	0.1524	0.0182	2	0.0493	0.2661	-0.3523
2				2	0.0508	0.0020	4	0.0046	0.0246	-0.0911
2				0.5	0.0127	0.0001	6	0.0248	0.1339	-0.2692
2				5	0.1270	0.0127				
2				1	0.0254	0.0005				
2				5	0.1270	0.0127				
2				4	0.1016	0.0081				
2				2	0.0508	0.0020				
				0.5	0.0127	0.0001				
				1	0.0254	0.0005				
				5	0.1270	0.0127				
	ROPS	2	31	9.867615	0.2506	0.0493				
	PRSE	4		3	0.0762	0.0046				
	FRAM	6		7	0.1778	0.0248				

Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)				
3	ACSA	1		6	0.1524	0.0182				
3				1	0.0254	0.0005				
3				3	0.0762	0.0046				
3				1	0.0254	0.0005	Total # of Trees	Total # of Trees per Ha		
3				0.5	0.0127	0.0001	15	**1500**		
3				1	0.0254	0.0005				
3				2	0.0508	0.0020	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
3				1	0.0254	0.0005	1	0.1112	0.2831	-0.3572
3				1	0.0254	0.0005	4	0.0569	0.1450	-0.2800
3				1	0.0254	0.0005	6	0.0437	0.1112	-0.2442
3				4	0.1016	0.0081	7	0.0200	0.0509	-0.1516
3				0.5	0.0127	0.0001	8	0.1609	0.4097	-0.3656
3				2	0.0508	0.0020				
3				2	0.0508	0.0020				
3				0.5	0.0127	0.0001				
3			27	8.5944	0.2183	0.0374				
3			25.5	8.1169	0.2062	0.0334				
3	PRSE	4	16	5.093	0.1294	0.0131				
3			26	8.2761	0.2102	0.0347				
3				3	0.0762	0.0046				
3				3	0.0762	0.0046				
3	FRAM	6	29	9.231	0.2345	0.0432				
3				1	0.0254	0.0005				
3	BEAL	7		5	0.1270	0.0127				
3				1	0.0254	0.0005				
3				1	0.0254	0.0005				
3				1	0.0254	0.0005				
3				1	0.0254	0.0005				
3				0.5	0.0127	0.0001				
3				0.5	0.0127	0.0001				
3				1	0.0254	0.0005				
3				1	0.0254	0.0005				
3				2	0.0508	0.0020				
3				2	0.0508	0.0020				
3	QURU	8	56	17.825	0.4527	0.1609				

1.2 Twentymile Creek, channel form downstream from I-90 (10 x 10 m quadrats)

Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)				
1	ACSA	1	66	21.00847	**0.5336**	0.2235				
1				3	0.0762	0.0046				
1				5	0.1270	0.0127				
1				2	0.0508	0.0020	Total # of Trees	Total # of Trees per Ha		
1				0.5	0.0127	0.0001	11	**1100**		
1				1	0.0254	0.0005				
1				4	0.1016	0.0081	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
1	BEAL	2	35	11.14086	0.2830	0.0629	1	0.2515	0.4205	-0.3643
1	PLOC	3	41	13.05072	0.3315	0.0863	2	0.0629	0.1051	-0.2368
1	LITU	4	60	19.09861	0.4851	0.1847	3	0.0863	0.1442	-0.2793
1	TSCA	5		5	0.1270	0.0127	4	0.1847	0.3089	-0.3629
							5	0.0127	0.0212	-0.0816
				AVG DBH	**19.6**					
				STDEV	**18.4**					
				CV	**94.2**			Total Basal Area per Ha		Diversity (Basal Area)
								59.80		**1.3248**
							understory			
							Shade = 44.17%			

Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)				
2	ACSA	1	34	10.82255	0.2749	0.0593				
2				2	0.0508	0.0020				
2				3	0.0762	0.0046				
2				3	0.0762	0.0046				
2				2	0.0508	0.0020				
2				3	0.0762	0.0046	Total # of Trees	Total # of Trees per Ha		
2				6	0.1524	0.0182	18	**1800**		
2				2	0.0508	0.0020				
2				2	0.0508	0.0020	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
2				2	0.0508	0.0020	1	0.1262	0.4087	-0.3657
2				3	0.0762	0.0046	2	0.0491	0.1591	-0.2925
2				2	0.0508	0.0020	6	0.1335	0.4323	-0.3625
2				6	0.1524	0.0182				
2	BEAL	2		4	0.1016	0.0081				
2				4	0.1016	0.0081				
2				7	0.1778	0.0248				
2				4	0.1016	0.0081				
2	ROPS	6	51	16.23382	**0.4123**	0.1335				
				AVG DBH	**11.6**					
				STDEV	**9.5**			Total Basal Area per Ha		Diversity (Basal Area
								30.87		**1.0207**
				CV	**81.7**		understory			
							Shade = 40.87%			

Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)					
3	ACSA	1		4	0.1016	0.0081					
3				2	0.0508	0.0020					
3				2	0.0508	0.0020					
3				4	0.1016	0.0081	Total # of Trees	Total # of Trees per Ha			
3				2	0.0508	0.0020	15	**1500**			
3				1	0.0254	0.0005					
3				2	0.0508	0.0020	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)	
3				6	0.1524	0.0182	1	0.0430	0.0618	-0.1720	
3	BEAL	2		6	0.1524	0.0182	2	0.0309	0.0443	-0.1381	
3				5	0.1270	0.0127	4	0.3642	0.5227	-0.3391	
3	LITU	4	55	17.50706	0.4447	0.1552	6	0.2586	0.3712	-0.3679	
3			37	11.77748	0.2991	0.0702	7	0.0000	0.0000	-0.0002	
3			52	16.55213	0.4204	0.1387					
3	ROPS	6	71	22.60002	**0.5740**	0.2586					
3	PRSE	7	0.5	0.159155	0.0040	0.0000					
								Total Basal Area per Ha		Diversity (Basal Area)	
				AVG DBH	**17.4**			**69.68**		**1.0173**	
				STDEV	**17.6**		understory	1.32			
							Shade = 6.18%				
				CV	**101.5**						

Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)				
4	ACSA	1	25	7.957754	0.2021	0.0321				
4				3	0.0762	0.0046				
4				3	0.0762	0.0046	Total # of Trees	Total # of Trees per Ha		
4				2	0.0508	0.0020	18	**1800**		
4				4	0.1016	0.0081				
4				2	0.0508	0.0020	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
4				1	0.0254	0.0005	1	0.0650	0.1356	-0.2709
4				1	0.0254	0.0005	2	0.0081	0.0169	-0.0690
4				2	0.0508	0.0020	4	0.1182	0.2466	-0.3453
4				2	0.0508	0.0020	7	0.0949	0.1979	-0.3206
4				2	0.0508	0.0020	8	0.1932	0.4030	-0.3663
4				3	0.0762	0.0046				
4	BEAL	2		4	0.1016	0.0081				
4	LITU	4	48	15.27889	**0.3881**	0.1182				
4	PRSE	7	43	13.68734	0.3476	0.0949				
4	QURU	8	41	13.05072	0.3315	0.0863				
4			40	12.73241	0.3234	0.0821		Total Basal Area per Ha		Diversity (Basal Area
4				7	0.1778	0.0248		**47.93**		**1.3720**
							understory	1.88		
				AVG DBH	**13.9**		**Shade = 13.56%**			
				STDEV	**12.4**					
				CV	**89.0**					

2.1 Chautauqua Creek, Landform 1 (15 x 20 m quadrat)

20X15											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)	per hectare				
1	ROPS	1	29	9.230994	0.2345	0.0432	1.4384				
1			20	6.366203	0.1617	0.0205	0.6841				
1				5	0.1270	0.0127	0.4220	Total # of Trees	Total # of Trees per Ha		
1				3	0.0762	0.0046	0.1519				
1				3	0.0762	0.0046	0.1519				
1				6	0.1524	0.0182	0.6077	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
1				6	0.1524	0.0182	0.6077	1	6.3087	0.3993	-0.3666
1				5	0.1270	0.0127	0.4220	2	8.3998	0.5316	-0.3359
1				2	0.0508	0.0020	0.0675	3	1.0904	0.0690	-0.1845
1				3	0.0762	0.0046	0.1519	4	0.0042	0.0003	-0.0022
1				5	0.1270	0.0127	0.4220				
1				4	0.1016	0.0081	0.2701				
1				3	0.0762	0.0046	0.1519				
1				4	0.1016	0.0081	0.2701				
1				4	0.1016	0.0081	0.2701				

1				3	0.0762	0.0046	0.1519				Total Basal Area per Ha	Diversity (Basal Area)
1				2	0.0508	0.0020	0.0675	AVG DBH	**9.9**		**15.80**	**0.8892**
1	PLOC	2	31	9.867615	0.2506	0.0493	1.6436	STDEV	**5.9**	Shade = 0%		
1				6	0.1524	0.0182	0.6077					
1				3	0.0762	0.0046	0.1519	CV	**59.6**			
1				3	0.0762	0.0046	0.1519					
1				2	0.0508	0.0020	0.0675					
1				1	0.0254	0.0005	0.0169					
1				4	0.1016	0.0081	0.2701					
1				2	0.0508	0.0020	0.0675					
1				3	0.0762	0.0046	0.1519					
1				5	0.1270	0.0127	0.4220					
1				6	0.1524	0.0182	0.6077					
1				5	0.1270	0.0127	0.4220					
1				7	0.1778	0.0248	0.8271					
1				7	0.1778	0.0248	0.8271					
1				5	0.1270	0.0127	0.4220					
1				2	0.0508	0.0020	0.0675					
1				7	0.1778	0.0248	0.8271					
1				6	0.1524	0.0182	0.6077					
1				3	0.0762	0.0046	0.1519					
1				0.5	0.0127	0.0001	0.0042					
1				2	0.0508	0.0020	0.0675					
1				1	0.0254	0.0005	0.0169					
1	SANI		23	7.321134	0.1859	0.0271	0.9048					
1				1	0.0254	0.0005	0.0169					
1				1	0.0254	0.0005	0.0169					
1				2	0.0508	0.0020	0.0675					
1				2	0.0508	0.0020	0.0675					
1				1	0.0254	0.0005	0.0169					
1	CAOV			0.5	0.0127	0.0001	0.0042					

2.2 Chautauqua Creek, Landform 2 (quadrats: 10 x 10 m, 15 x 20 m, 10 x 10 m)

10X10												
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m	per hectare					
1	ACSA	1	32	10.18592	0.2587	0.0525	5.2541					
1			18	5.729583	0.1455	0.0166	1.6624					
1			25	7.957754	0.2021	0.0321	3.2068	Total # of Trees	otal # of Trees per Ha			
1				2	0.0508	0.0020	0.2026					
1				0.5	0.0127	0.0001	0.0127					
1				1	0.0254	0.0005	0.0506	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)	
1				4	0.1016	0.0081	0.8102	1	12.9212	0.5263	-0.3378	
1				3	0.0762	0.0046	0.4558	2	1.2660	0.0516	-0.1529	
1				1	0.0254	0.0005	0.0506	5	0.4558	0.0186	-0.0740	
1				1	0.0254	0.0005	0.0506	8	9.9065	0.4035	-0.3662	
1				1	0.0254	0.0005	0.0506					
1				4	0.1016	0.0081	0.8102					
1				1	0.0254	0.0005	0.0506					
1				2	0.0508	0.0020	0.2026					
1				1	0.0254	0.0005	0.0506					
1	OSVI	2		5	0.1270	0.0127	1.2660					
1	CACA	5		3	0.0762	0.0046	0.4558					
1	BEAL	8	28	8.912684	0.2264	0.0402	4.0226					
1			30	9.549305	0.2425	0.0462	4.6178					
1				5	0.1270	0.0127	1.2660					
									Total Basal Area per Ha		Diversity (Basal Area)	
				AVG DBH	**9.8**				**24.55**		**0.9309**	
				STDEV	**8.0**			Shade = 52.63%				
				CV	**82.2**							

20x15											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m	per hectare				
2	ACSA	1	25	7.957754	0.2021	0.0321	1.0689				
2			69	21.9634	0.5578	0.2443	8.1428				
2			32	10.18592	0.2587	0.0525	1.7514	Total # of Trees	otal # of Trees per Ha		
2			41	13.05072	0.3315	0.0863	2.8750				
2				1	0.0254	0.0005	0.0169				
2				4	0.1016	0.0081	0.2701	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
2				4	0.1016	0.0081	0.2701	1	17.5517	0.6621	-0.2730
2				1	0.0254	0.0005	0.0169	2	1.9486	0.0735	-0.1919
2				2	0.0508	0.0020	0.0675	3	3.6190	0.1365	-0.2718
2				2	0.0508	0.0020	0.0675	4	2.5848	0.0975	-0.2270
2				3	0.0762	0.0046	0.1519	5	0.5233	0.0197	-0.0775
2				4	0.1016	0.0081	0.2701	6	0.0675	0.0025	-0.0152
2				6	0.1524	0.0182	0.6077	7	0.1519	0.0057	-0.0296
2				2	0.0508	0.0020	0.0675	8	0.0675	0.0025	-0.0152
2				3	0.0762	0.0046	0.1519				
2				3	0.0762	0.0046	0.1519				
2				7	0.1778	0.0248	0.8271				
2				1	0.0254	0.0005	0.0169				
2				6	0.1524	0.0182	0.6077				
2				3	0.0762	0.0046	0.1519				

2	OSVI	2	28	8.912684	0.2264	0.0402	1.3409				
2				6	0.1524	0.0182	0.6077				
2	PLOC	3	46	14.64227	0.3719	0.1086	3.6190				
2	TIAM	4	34	10.82255	0.2749	0.0593	1.9771				
2				6	0.1524	0.0182	0.6077				
2	CACA	5		1	0.0254	0.0005	0.0169				
2				2	0.0508	0.0020	0.0675				
2				3	0.0762	0.0046	0.1519				
2				1	0.0254	0.0005	0.0169				
2				2	0.0508	0.0020	0.0675				
2				2	0.0508	0.0020	0.0675				
2				2	0.0508	0.0020	0.0675				
2				2	0.0508	0.0020	0.0675				
2	FAGR	6		2	0.0508	0.0020	0.0675				
2	TSCA	7		3	0.0762	0.0046	0.1519				
2	BEAL	8		2	0.0508	0.0020	0.0675				
									Total Basal Area per Ha		Diversity (Basal Area
				AVG DBH	**12.2**				**26.51**		**1.1012**
				STDEV	**11.6**			Shade = 67.0%			
				CV	**95.0**						

10X10											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (n	per hectare				
3	ACSA	1	36	11.45917	0.2910	0.0665	6.6497				
3			30	9.549305	0.2425	0.0462	4.6178				
3				3	0.0762	0.0046	0.4558	Total # of Trees	Total # of Trees per Ha		
3				2	0.0508	0.0020	0.2026				
3				3	0.0762	0.0046	0.4558				
3				4	0.1016	0.0081	0.8102	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
3				6	0.1524	0.0182	1.8230	1	18.8635	0.3320	-0.3661
3				2	0.0508	0.0020	0.2026	3	27.3427	0.4812	-0.3520
3				5	0.1270	0.0127	1.2660	4	10.4999	0.1848	-0.3120
3				3	0.0762	0.0046	0.4558	5	0.1139	0.0020	-0.0125
3				6	0.1524	0.0182	1.8230				
3				1	0.0254	0.0005	0.0506				
3				1	0.0254	0.0005	0.0506				
3	PLOC	3	73	23.23664	0.5902	0.2734	27.3427				
3	TIAM	4	43	13.68734	0.3476	0.0949	9.4871				
3				2	0.0508	0.0020	0.2026				
3				4	0.1016	0.0081	0.8102				
3	CACA	5		0.5	0.0127	0.0001	0.0127				
3				1	0.0254	0.0005	0.0506				
3				1	0.0254	0.0005	0.0506				
									Total Basal Area per Ha		Diversity (Basal Area)
				AVG DBH	**13.0**				**56.82**		**1.0425**
				STDEV	**14.2**			Shade = 33.2%			
				CV	**109.5**						

2.3 Chautauqua Creek, Landform 4 (quadrats: 15 x 15 m, 10 x 20 m)

15x15											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m	per hectare				
1	SANI	1		1	0.0254	0.0005	0.0225				
1				1	0.0254	0.0005	0.0225				
1				0.5	0.0127	0.0001	0.0056	Total # of Trees	otal # of Trees per Ha		
1				0.5	0.0127	0.0001	0.0056				
1				0.5	0.0127	0.0001	0.0056				
1				1	0.0254	0.0005	0.0225	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
1				0.5	0.0127	0.0001	0.0056	1	2.6220	0.1361	-0.2714
1				1	0.0254	0.0005	0.0225	2	14.0385	0.7285	-0.2308
1				1	0.0254	0.0005	0.0225	3	0.2363	0.0123	-0.0540
1				1	0.0254	0.0005	0.0225	4	2.3688	0.1229	-0.2577
1				1	0.0254	0.0005	0.0225	5	0.0056	0.0003	-0.0024
1				0.5	0.0127	0.0001	0.0056				
1				0.5	0.0127	0.0001	0.0056				
1				6	0.1524	0.0182	0.8102				
1				6	0.1524	0.0182	0.8102				
1				6	0.1524	0.0182	0.8102				
1	PLOC	2	29	9.23099	0.2345	0.0432	1.9178	AVG DBH	**8.2**		
1			34	10.8225	0.2749	0.0593	2.6362	STDEV	**7.6**		
1			20	6.3662	0.1617	0.0205	0.9122				
1			30	9.5493	0.2425	0.0462	2.0524	CV	**93.0**		
1			25	7.95775	0.2021	0.0321	1.4253				
1			27	8.59437	0.2183	0.0374	1.6624				
1				4	0.1016	0.0081	0.3601				
1				0.5	0.0127	0.0001	0.0056		Total Basal Area per Ha		Diversity (Basal Are
1				0.5	0.0127	0.0001	0.0056		**19.27**		**0.8162**
1				3	0.0762	0.0046	0.2026	Shade = 0%			
1				3	0.0762	0.0046	0.2026				
1				4	0.1016	0.0081	0.3601				
1				1	0.0254	0.0005	0.0225				
1				6	0.1524	0.0182	0.8102				
1				6	0.1524	0.0182	0.8102				
1				2	0.0508	0.0020	0.0900				
1				5	0.1270	0.0127	0.5627				
1	PODE	3		0.5	0.0127	0.0001	0.0056				
1				0.5	0.0127	0.0001	0.0056				
1				1	0.0254	0.0005	0.0225				
1				3	0.0762	0.0046	0.2026				
1	ROPS	4		2	0.0508	0.0020	0.0900				
1				0.5	0.0127	0.0001	0.0056				
1				6	0.1524	0.0182	0.8102				
1				4	0.1016	0.0081	0.3601				
1				2	0.0508	0.0020	0.0900				
1				3	0.0762	0.0046	0.2026				
1				6	0.1524	0.0182	0.8102				
1	CACA	5		0.5	0.0127	0.0001	0.0056				

10X20											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)	per hectare				
2	PLOC	2	43	13.68734	0.3476	0.0949	4.7435				
2			34	10.82255	0.2749	0.0593	2.9657				
2			20	6.366203	0.1617	0.0205	1.0262	Total # of Trees	'otal # of Trees per Ha		
2	ROPS	4	50	15.91551	0.4042	0.1283	6.4137				
2				2	0.0508	0.0020	0.1013				
2				3	0.0762	0.0046	0.2279	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
2				3	0.0762	0.0046	0.2279	2	8.7354	0.4776	-0.3529
2				2	0.0508	0.0020	0.1013	4	7.0720	0.3867	-0.3674
2	CACA	5		2	0.0508	0.0020	0.1013	5	0.1013	0.0055	-0.0288
2	ACSA	6		5	0.1270	0.0127	0.6330	6	2.3801	0.1301	-0.2654
2				4	0.1016	0.0081	0.4051				
2				1	0.0254	0.0005	0.0253				
2				3	0.0762	0.0046	0.2279				
2				5	0.1270	0.0127	0.6330				
2				3	0.0762	0.0046	0.2279				
2				3	0.0762	0.0046	0.2279				
2									Total Basal Area per Ha		Diversity (Basal Area)
2				AVG DBH	**13.1**				**18.29**		**1.0145**
2				STDEV	**11.2**			Shade = 13.0%			
2											
2				CV	**85.5**						

2.4 Chautauqua Creek, Landform 5 (quadrats: 30 x 30 m, 30 x 20 m)

30x30	**Overstory**													
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m2)	Total BA	BA (m2/ha)	BA understory	TOTAL QUAD BA	pi	ln pi	
1	ACSA	1	27	8.5987	0.2184	0.0374	0.0670	0.7447	11.9511	**12.6958**	0.5215	-0.6511	0.3395
1			24	7.6433	0.1941	0.0296							0.0000
1	ROPS	2	35	11.1465	0.2831	0.0629	0.1223	1.3588		**1.3588**	0.0558	-2.8858	0.1611
1			34	10.8280	0.2750	0.0594							0.0000
1	ULRU	3	45	14.3312	0.3640	0.1040	0.1040	1.1556		**1.1556**	0.0475	-3.0478	0.1447
1	FRAM	4	60	19.1083	0.4853	0.1849	0.2311	2.5681		**2.5681**	0.1055	-2.2493	0.2372
1			30	9.5541	0.2427	0.0462							0.0000
1	SANI	5	51	16.2420	**0.4125**	0.1336	0.2779	3.0874		**3.0874**	0.1268	-2.0651	0.2619
1			53	16.8790	0.4287	0.1443							0.0000
1	PODE	6	74	23.5669	0.5986	0.2813	0.2813	3.1250		**3.1250**	0.1284	-2.0530	0.2635
1	BEAL	7	25	7.9618	0.2022	0.0321	0.0321	0.3567		**0.3567**	0.0146	-4.2233	0.0619
	# Trees												
	Trees/ha						BA/ha overstc	12.3963	11.9511	**24.3474**	BA	H'	**1.4697**
											Trees/ha		

20X10	**Understory**							
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m2)	Total BA	BA (m2/ha)
1	ACSA	1		7.0000	0.1778	0.0248	0.2390	11.9511
1				3.0000	0.0762	0.0046		
1				7.0000	0.1778	0.0248		
1				1.0000	0.0254	0.0005		
1				2.0000	0.0508	0.0020		
1				7.0000	0.1778	0.0248		
1				5.0000	0.1270	0.0127		
1				2.0000	0.0508	0.0020		
1				2.0000	0.0508	0.0020		
1				6.0000	0.1524	0.0182		
1				4.0000	0.1016	0.0081		
1				3.0000	0.0762	0.0046		
1				2.0000	0.0508	0.0020		
1				4.0000	0.1016	0.0081		
1				2.0000	0.0508	0.0020		
1				6.0000	0.1524	0.0182		
1				7.0000	0.1778	0.0248		
1				5.0000	0.1270	0.0127		
1				4.0000	0.1016	0.0081		
1				1.0000	0.0254	0.0005		
1				4.0000	0.1016	0.0081		
1				7.0000	0.1778	0.0248		
1				1.0000	0.0254	0.0005		
	# Trees						BA/ha unders	11.9511
	Trees/ha							

30x20	Overstory												
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m2)	Total BA	BA (m2/ha)	BA understory	TOTAL QUAD BA	pi	ln pi	
2	ACSA	1	53	16.8790	0.4287	0.1443	0.3148	3.4983	0.7343	**4.2326**	0.2120	-1.5513	0.3288
2			36	11.4650	0.2912	0.0666							
2			45	14.3312	0.3640	0.1040							
2	ULRU	3	38	12.1019	0.3074	0.0742	0.1037	1.1528		**1.1528**	0.0577	-2.8519	0.1647
2			24	7.6433	0.1941	0.0296							
2	BEAL	7	29	9.2357	0.2346	0.0432	0.1934	2.1492		**2.1492**	0.1076	-2.2290	0.2399
2			32	10.1911	0.2588	0.0526							
2			35	11.1465	**0.2831**	0.0629							
2			26	8.2803	0.2103	0.0347							
2	PLOC	8	85	27.0701	0.6875	0.3711	0.7492	8.3245		**8.3245**	0.4169	-0.8749	0.3647
2			69	21.9745	0.5581	0.2445							
2			51	16.2420	0.4125	0.1336							
2	TIAM	9	38	12.1019	0.3074	0.0742	0.0742	0.8241		**0.8241**	0.0413	-3.1876	0.1316
2	ULAM	10	39	12.4204	0.3155	0.0781	0.0781	0.8680		**0.8680**	0.0435	-3.1356	0.1363
2	OSVI	11	27	8.5987	0.2184	0.0374	0.0374	0.4160	1.5952	**2.0112**	0.1007	-2.2954	0.2312
2	FRAM	4							0.4051	**0.4051**	0.0203	-3.8977	0.0791
	# Trees												
	Trees/ha						BA/ha overs	17.2328	2.7346	**19.9674**	BA	H'	**1.6763**

20X10	Understory							
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m2)	Total BA	BA (m2/ha)
2	ACSA	1		3.0000	0.0762	0.0046	0.0147	0.7343
2				1.0000	0.0254	0.0005		
2				4.0000	0.1016	0.0081		
2				1.0000	0.0254	0.0005		
2				1.0000	0.0254	0.0005		
2				1.0000	0.0254	0.0005		
2	FRAM	4		4.0000	0.1016	0.0081	0.0081	0.4051
2	OSVI	11		2.0000	0.0508	0.0020	0.0319	1.5952
2				5.0000	0.1270	0.0127		
2				3.0000	0.0762	0.0046		
2				5.0000	0.1270	0.0127		
	# Trees						BA/ha under	2.7346

2.5 Chautauqua Creek, Landform 6 (quadrats 20 x 15 m, 10 x 10 m)

20x15											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)	per hectare				
1	ACSA	1	36	11.45917	0.2910	0.0665	2.2166				
1			26	8.276064	0.2102	0.0347	1.1562				
1			32	10.18592	0.2587	0.0525	1.7514	Total # of Trees	Total # of Trees per Ha		
1				1	0.0254	0.0005	0.0169				
1				2	0.0508	0.0020	0.0675				
1				2	0.0508	0.0020	0.0675	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
1				7	0.1778	0.0248	0.8271	1	10.1037	0.4970	-0.3475
1				7	0.1778	0.0248	0.8271	2	4.2018	0.2067	-0.3258
1				2	0.0508	0.0020	0.0675	3	5.1737	0.2545	-0.3483
1				3	0.0762	0.0046	0.1519	4	0.0549	0.0027	-0.0160
1				6	0.1524	0.0182	0.6077	5	0.0338	0.0017	-0.0106
1				2	0.0508	0.0020	0.0675	6	0.6077	0.0299	-0.1049
1				5	0.1270	0.0127	0.4220	7	0.1519	0.0075	-0.0366
1				7	0.1778	0.0248	0.8271				
1				5	0.1270	0.0127	0.4220				
1				6	0.1524	0.0182	0.6077				
1	BEAL	2	37	11.77748	0.2991	0.0702	2.3414				
1			29	9.230994	0.2345	0.0432	1.4384				
1				5	0.1270	0.0127	0.4220				
1	QURU	3	55	17.50706	0.4447	0.1552	5.1737				
1	HAVI	4		1.5	0.0381	0.0011	0.0380				
1				1	0.0254	0.0005	0.0169				
1	FAGR	5		1	0.0254	0.0005	0.0169				
1				1	0.0254	0.0005	0.0169				
1	TSCA	6		6	0.1524	0.0182	0.6077				
1	OSVI	7		3	0.0762	0.0046	0.1519				
									Total Basal Area per Ha		Diversity (Basal Are
				AVG DBH	**13.9**				**20.33**		**1.1897**
				STDEV	**10.5**			Shade = 52.8%			
				CV	**75.9**						

10X10											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)	per hectare				
2	ACSA	1	15	4.774652	0.1213	0.0115	1.1545				
2			16	5.092962	0.1294	0.0131	1.3135				
2			39	12.4141	0.3153	0.0780	7.8041	Total # of Trees	ɔtal # of Trees per Ha		
2				3	0.0762	0.0046	0.4558				
2				2	0.0508	0.0020	0.2026				
2				1	0.0254	0.0005	0.0506	Species	3asal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
2				3	0.0762	0.0046	0.4558	1	11.6900	0.4290	-0.3631
2				2	0.0508	0.0020	0.2026	2	2.0762	0.0762	-0.1962
2				1	0.0254	0.0005	0.0506	3	4.0226	0.1476	-0.2824
2	BEAL	2		5	0.1270	0.0127	1.2660	5	0.2785	0.0102	-0.0468
2				4	0.1016	0.0081	0.8102	6	2.1269	0.0781	-0.1991
2	QURU	3	28	8.912684	0.2264	0.0402	4.0226	8	6.6497	0.2440	-0.3442
2	FAGR	5		0.5	0.0127	0.0001	0.0127	9	0.4051	0.0149	-0.0626
2				1	0.0254	0.0005	0.0506				
2				0.5	0.0127	0.0001	0.0127				
2				2	0.0508	0.0020	0.2026				
2	TSCA	6		5	0.1270	0.0127	1.2660				
2				4	0.1016	0.0081	0.8102				
2				1	0.0254	0.0005	0.0506				
2	PIST	8	36	11.45917	0.2910	0.0665	6.6497				
2	CACA	9		2	0.0508	0.0020	0.2026				
2				2	0.0508	0.0020	0.2026				
									Total Basal Area per Ha		Diversity (Basal Area
				AVG DBH	**9.4**				**27.25**		**1.4943**
				STDEV	**8.5**			Shade = 51.7%			
				CV	**90.1**						

3.1 Upper Cattaraugus Creek-North, Band 1 (quadrats 20 x 20 m)

20X20											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)	per hectare				
1	PLOC	1		4	0.1016	0.0081	0.2026				
1				4	0.1016	0.0081	0.2026				
1				3	0.0762	0.0046	0.1139	Total # of Trees	Total # of Trees per Ha		
1				3	0.0762	0.0046	0.1139				
1				4	0.1016	0.0081	0.2026				
1	PODE	2		5	0.1270	0.0127	0.3165	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
1				6	0.1524	0.0182	0.4558	1	0.8356	0.4591	-0.3574
1				4	0.1016	0.0081	0.2026	2	0.9875	0.5426	-0.3317
1				1	0.0254	0.0005	0.0127				
									Total Basal Area per Ha		Diversity (Basal Area
				AVG DBH	**9.6**				**1.82**		**0.6892**
				STDEV	**3.5**			Shade = 0%			
				CV	**36.9**						

20X20												
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	sal Area/tree	per hectare					
2	PLOC	1		4	0.1016	0.0081	0.2026					
2				4	0.1016	0.0081	0.2026					
2				6	0.1524	0.0182	0.4558		Total # of Tree	l # of Trees per Ha		
2				4	0.1016	0.0081	0.2026					
2				5	0.1270	0.0127	0.3165					
2				2	0.0508	0.0020	0.0506		Species	sal Area/spec	rop (Basal Are	Prop*Ln(Prop)
2				3	0.0762	0.0046	0.1139		1	1.5445	0.4043	-0.3661
2	PODE			7	0.1778	0.0248	0.6203		2	2.2788	0.5965	-0.3082
2				8	0.2032	0.0324	0.8102					
2				2	0.0508	0.0020	0.0506					
2				2	0.0508	0.0020	0.0506					
2				3	0.0762	0.0046	0.1139					
2				5	0.1270	0.0127	0.3165					
2				5	0.1270	0.0127	0.3165					
									Total Basal Area per Ha		Diversity (Basal Area)	
			AVG DBI	**10.9**					**3.82**		**0.6743**	
			STDEV	**4.7**				Shade = 0%				
			CV	**43.3**								

3.2 Upper Cattaraugus Creek-North, Band 2 (quadrats 30 x 30 m, 20 x 20 m)

30X30												
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m	per hectare					
1	ACNE	1	23	7.32113	0.1859	0.0271	0.3016					
1		1		5	0.1270	0.0127	0.1407					
1		1		5	0.1270	0.0127	0.1407		Total # of Tre	otal # of Trees per Ha		
1		1		6	0.1524	0.0182	0.2026					
1	ACSA	2	38	12.0958	0.3072	0.0741	0.8232					
1		2		5	0.1270	0.0127	0.1407		Species	Basal Area/species	Prop (Basal Area	Prop*Ln(Prop)
1		2		6	0.1524	0.0182	0.2026		1	0.7855	0.0246	-0.0912
1		2		3	0.0762	0.0046	0.0506		2	1.4478	0.0454	-0.1404
1		2		5	0.1270	0.0127	0.1407		3	0.2813	0.0088	-0.0417
1		2		4	0.1016	0.0081	0.0900		4	1.7224	0.0540	-0.1576
1	CACA	3		4	0.1016	0.0081	0.0900		5	10.1727	0.3190	-0.3645
1		3		3	0.0762	0.0046	0.0506		6	0.1238	0.0039	-0.0215
1		3		4	0.1016	0.0081	0.0900		7	5.8367	0.1830	-0.3108
1		3		3	0.0762	0.0046	0.0506		8	8.2625	0.2591	-0.3499
1	FRAM	4	40	12.7324	0.3234	0.0821	0.9122		9	3.2587	0.1022	-0.2331
1		4		6	0.1524	0.0182	0.2026					
1		4		5	0.1270	0.0127	0.1407					
1		4		3	0.0762	0.0046	0.0506					
1		4		5	0.1270	0.0127	0.1407					
1		4		7	0.1778	0.0248	0.2757					

1	JUNI	5	71	22.6	0.5740	0.2586	2.8739	
1		5	35	11.1409	0.2830	0.0629	0.6984	
1		5	62	19.7352	0.5013	0.1972	2.1915	
1		5	68	21.6451	0.5498	0.2373	2.6362	
1		5	32	10.1859	0.2587	0.0525	0.5838	
1		5	41	13.0507	0.3315	0.0863	0.9583	
1		5		4	0.1016	0.0081	0.0900	
1		5		5	0.1270	0.0127	0.1407	
1	COFL	6		2	0.0508	0.0020	0.0225	
1		6		3	0.0762	0.0046	0.0506	
1		6		3	0.0762	0.0046	0.0506	
1	SANI	7	43	13.6873	0.3476	0.0949	1.0541	
1		7	29	9.23099	0.2345	0.0432	0.4795	
1		7	33	10.5042	0.2668	0.0559	0.6208	
1		7	47	14.9606	0.3800	0.1133	1.2594	
1		7	55	17.5071	0.4447	0.1552	1.7246	
1		7	35	11.1409	0.2830	0.0629	0.6984	
1	PODE	8	40	12.7324	0.3234	0.0821	0.9122	
1		8	41	13.0507	0.3315	0.0863	0.9583	
1		8	53	16.8704	0.4285	0.1441	1.6014	
1		8	61	19.4169	0.4932	0.1909	2.1214	
1		8	61	19.4169	0.4932	0.1909	2.1214	
1		8	31	9.86761	0.2506	0.0493	0.5479	
1	PLOC	9	60	19.0986	0.4851	0.1847	2.0524	
1		9	46	14.6423	0.3719	0.1086	1.2063	
						Total Basal Area per Ha		Diversity (Basal
AVG DB	**24.2**					**31.89**		**1.7108**
STDEV	**15.2**				Shade = 4.5%			
CV	**63.0**							

20x20											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)	per hectare				
2	PODE	1	36	11.45917	0.2910	0.0665	1.6624				
2			38	12.09579	0.3072	0.0741	1.8523				
2			41	13.05072	0.3315	0.0863	2.1563	Total # of Trees	Total # of Trees per Ha		
2			63	20.05354	0.5093	0.2036	5.0912				
2			38	12.09579	0.3072	0.0741	1.8523				
2			26	8.276064	0.2102	0.0347	0.8671	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
2			51	16.23382	0.4123	0.1335	3.3364	1	26.1126	0.7714	-0.2002
2			53	16.87044	0.4285	0.1441	3.6032	2	2.1563	0.0637	-0.1754
2			39	12.4141	0.3153	0.0780	1.9510	3	5.5812	0.1649	-0.2972
2			54	17.18875	0.4366	0.1496	3.7404				
2	PLOC	2	41	13.05072	0.3315	0.0863	2.1563				
2	SANI	3	29	9.230994	0.2345	0.0432	1.0788				
2			16	5.092962	0.1294	0.0131	0.3284				
2			14	4.456342	0.1132	0.0101	0.2514				
2			19	6.047893	0.1536	0.0185	0.4631				
2			32	10.18592	0.2587	0.0525	1.3135				
2			17	5.411273	0.1374	0.0148	0.3707				
2			30	9.549305	0.2425	0.0462	1.1545				
2			22	7.002823	0.1779	0.0248	0.6208				
									Total Basal Area per Ha		Diversity (Basal Are
				AVG DBH	**28.0**				**33.85**		**0.6728**
				STDEV	**11.3**			Shade = 0%			
				CV	**40.4**						

30X30											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m	per hectare				
3	ACSA	2	27	8.594374	0.2183	0.0374	0.4156				
3		2	25	7.957754	0.2021	0.0321	0.3563				
3		2		6	0.1524	0.0182	0.2026	Total # of Trees	Total # of Trees per Ha		
3		2		5	0.1270	0.0127	0.1407				
3		2		4	0.1016	0.0081	0.0900				
3	CACA	3	25	7.957754	0.2021	0.0321	0.3563	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
3		3	25	7.957754	0.2021	0.0321	0.3563	2	1.2052	0.0722	-0.1897
3		3		2	0.0508	0.0020	0.0225	3	1.6073	0.0962	-0.2253
3		3		2	0.0508	0.0020	0.0225	4	3.8395	0.2299	-0.3380
3		3		5	0.1270	0.0127	0.1407	5	6.9642	0.4170	-0.3647
3		3		6	0.1524	0.0182	0.2026	10	3.0546	0.1829	-0.3107
3		3		2	0.0508	0.0020	0.0225	11	0.0281	0.0017	-0.0108
3		3		4	0.1016	0.0081	0.0900				
3		3		3	0.0762	0.0046	0.0506				
3		3		3	0.0762	0.0046	0.0506				
3		3		1	0.0254	0.0005	0.0056				
3		3		4	0.1016	0.0081	0.0900				
3		3		3	0.0762	0.0046	0.0506				
3		3		3	0.0762	0.0046	0.0506				
3		3		2	0.0508	0.0020	0.0225				
3		3		2	0.0508	0.0020	0.0225				
3		3		3	0.0762	0.0046	0.0506				

3	FRAM	4	37	11.77748	0.2991	0.0702	0.7805				
3		4	38	12.09579	0.3072	0.0741	0.8232				
3		4	32	10.18592	0.2587	0.0525	0.5838				
3		4	53	16.87044	0.4285	0.1441	1.6014				
3		4		3	0.0762	0.0046	0.0506				
3	JUNI	5	19	6.047893	0.1536	0.0185	0.2058				
3		5	34	10.82255	0.2749	0.0593	0.6590				
3		5	30	9.549305	0.2425	0.0462	0.5131				
3		5	49	15.5972	0.3961	0.1232	1.3688				
3		5	33	10.50424	0.2668	0.0559	0.6208				
3		5	65	20.69016	0.5255	0.2168	2.4087				
3		5	40	12.73241	0.3234	0.0821	0.9122				
3		5		7	0.1778	0.0248	0.2757				
3	QURU	10	26	8.276064	0.2102	0.0347	0.3854				
3		10	31	9.867615	0.2506	0.0493	0.5479				
3		10	61	19.41692	0.4932	0.1909	2.1214				
3	CRAT	11		1	0.0254	0.0005	0.0056				
3		11		2	0.0508	0.0020	0.0225				
									Total Basal Area per Ha		Diversity (Basal Area
				AVG DBH	**17.8**				**16.70**		**1.4392**
				STDEV	**12.9**			Shade = 7.2%			
				CV	**72.7**						

3.3 Upper Cattaraugus Creek-North, Band 3 (quadrats 10 x 20 m)

10X20											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)	per hectare				
1	SANI	1	38	12.09579	0.3072	0.0741	2.4697				
1			31	9.867615	0.2506	0.0493	1.6436				
1				3	0.0762	0.0046	0.1519	Total # of Trees	Total # of Trees per Ha		
1				6	0.1524	0.0182	0.6077				
1				3	0.0762	0.0046	0.1519				
1				6	0.1524	0.0182	0.6077	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
1				2	0.0508	0.0020	0.0675	1	6.9491	0.2990	-0.3610
1				3	0.0762	0.0046	0.1519	2	13.8170	0.5945	-0.3091
1				2	0.0508	0.0020	0.0675	3	2.4697	0.1063	-0.2382
1				6	0.1524	0.0182	0.6077				
1				4	0.1016	0.0081	0.2701				
1				3	0.0762	0.0046	0.1519				
1	PODE	2	43	13.68734	0.3476	0.0949	3.1624				
1			40	12.73241	0.3234	0.0821	2.7365				
1			65	20.69016	0.5255	0.2168	7.2261				
1				4	0.1016	0.0081	0.2701				
1				5	0.1270	0.0127	0.4220				
1	ROPS	3	38	12.09579	0.3072	0.0741	2.4697				
						Total Basal Area per Ha		Diversity (Basal Area)			
AVG DBH	**18.1**					**23.24**		**0.9084**			
STDEV	**13.3**				Shade = 0%						
CV	**73.4**										

10X20											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)	per hectare				
2	PODE	2	67	21.32678	0.5417	0.2303	7.6776				
2			60	19.09861	0.4851	0.1847	6.1571				
2			40	12.73241	0.3234	0.0821	2.7365	Total # of Trees	Total # of Trees per Ha		
2	ROPS	3	29	9.230994	0.2345	0.0432	1.4384				
2				5	0.1270	0.0127	0.4220				
2				5	0.1270	0.0127	0.4220	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
2				4	0.1016	0.0081	0.2701	2	16.5712	0.6825	-0.2607
2				6	0.1524	0.0182	0.6077	3	3.7678	0.1552	-0.2891
2				6	0.1524	0.0182	0.6077	4	3.9406	0.1623	-0.2951
2	PLOC	4	48	15.27889	0.3881	0.1182	3.9406				
						Total Basal Area per Ha	Diversity (Basal Area)				
AVG DBH	**26.3**					**24.28**	**0.8449**				
STDEV	**16.1**				Shade = 0%						
CV	**61.3**										

3.4 Upper Cattaraugus Creek-South, Band 2 (quadrats 10 x 10, 10 x 40, 10 x 70 m)

10x10											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m	per hectare				
1	PLOC	1		6	0.1524	0.0182	1.8230				
1	ROPS	2		4	0.1016	0.0081	0.8102				
1				1	0.0254	0.0005	0.0506	Total # of Trees	Total # of Trees per Ha		
1				3	0.0762	0.0046	0.4558				
1				4	0.1016	0.0081	0.8102				
1	SAIN	3		2	0.0508	0.0020	0.2026	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
								1	1.8230	0.4393	-0.3614
								2	2.1269	0.5125	-0.3426
								3	0.2026	0.0488	-0.1474
			Total Basal Area per Ha			Diversity (Basal Area)					
AVG DBH	**8.5**			**4.15**		**0.8513**					
STDEV	**4.4**										
CV	**52.5**										

10x40											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)	per hectare				
2	PLOC	1		2	0.0508	0.0020	0.0506				
2				3	0.0762	0.0046	0.1139				
2				2	0.0508	0.0020	0.0506	Total # of Trees	Total # of Trees per Ha		
2				3	0.0762	0.0046	0.1139				
2				3	0.0762	0.0046	0.1139				
2				1	0.0254	0.0005	0.0127	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
2				1	0.0254	0.0005	0.0127	1	1.7123	0.9256	-0.0716
2				1	0.0254	0.0005	0.0127	2	0.1393	0.0753	-0.1947
2				1	0.0254	0.0005	0.0127	4	0.0032	0.0017	-0.0109
2				1	0.0254	0.0005	0.0127				
2				1	0.0254	0.0005	0.0127				
2				1	0.0254	0.0005	0.0127				
2				0.5	0.0127	0.0001	0.0032				
2				0.5	0.0127	0.0001	0.0032				
2				0.5	0.0127	0.0001	0.0032				
2				0.5	0.0127	0.0001	0.0032				
2				0.5	0.0127	0.0001	0.0032				
2				3	0.0762	0.0046	0.1139				
2				2	0.0508	0.0020	0.0506				
2				4	0.1016	0.0081	0.2026				
2				3	0.0762	0.0046	0.1139				
2				1	0.0254	0.0005	0.0127				
2				1	0.0254	0.0005	0.0127				
2				2	0.0508	0.0020	0.0506				

2				4	0.1016	0.0081	0.2026			
2				2	0.0508	0.0020	0.0506			
2				1	0.0254	0.0005	0.0127			
2				1	0.0254	0.0005	0.0127			
2				1	0.0254	0.0005	0.0127			
2				3	0.0762	0.0046	0.1139			
2				4	0.1016	0.0081	0.2026			
2	ROPS	2		3	0.0762	0.0046	0.1139			
2				1	0.0254	0.0005	0.0127			
2				1	0.0254	0.0005	0.0127			
2	PODE	4		0.5	0.0127	0.0001	0.0032			
							Total Basal Area per Ha			Diversity (Basal Area)
		AVG DBH	**4.4**				**1.85**			**0.2772**
		STDEV	**2.9**			Shade = 0%				
		CV	**66.1**							

10x70											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)	per hectare				
3	PLOC	1		2	0.0508	0.0020	0.0289				
3				2	0.0508	0.0020	0.0289				
3				2	0.0508	0.0020	0.0289	Total # of Trees	Total # of Trees per Ha		
3				2	0.0508	0.0020	0.0289				
3				2	0.0508	0.0020	0.0289				
3				4	0.1016	0.0081	0.1158	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
3				3	0.0762	0.0046	0.0651	1	0.8482	0.4138	-0.3651
3				3	0.0762	0.0046	0.0651	4	1.2027	0.5867	-0.3129
3				3	0.0762	0.0046	0.0651	3	0.0018	0.0009	-0.0062
3				1	0.0254	0.0005	0.0072				
3				1	0.0254	0.0005	0.0072				
3				1	0.0254	0.0005	0.0072				
3				1	0.0254	0.0005	0.0072				
3				1	0.0254	0.0005	0.0072				
3				1	0.0254	0.0005	0.0072				
3				0.5	0.0127	0.0001	0.0018				
3				0.5	0.0127	0.0001	0.0018				
3				0.5	0.0127	0.0001	0.0018				
3				0.5	0.0127	0.0001	0.0018				
3				0.5	0.0127	0.0001	0.0018				
3				0.5	0.0127	0.0001	0.0018				
3				3	0.0762	0.0046	0.0651				
3				4	0.1016	0.0081	0.1158				
3				4	0.1016	0.0081	0.1158				
3				1	0.0254	0.0005	0.0072				

3				2	0.0508	0.0020	0.0289
3				0.5	0.0127	0.0001	0.0018
3				0.5	0.0127	0.0001	0.0018
3				0.5	0.0127	0.0001	0.0018
3	PODE	4		0.5	0.0127	0.0001	0.0018
3				0.5	0.0127	0.0001	0.0018
3				2	0.0508	0.0020	0.0289
3				3	0.0762	0.0046	0.0651
3				2	0.0508	0.0020	0.0289
3				2	0.0508	0.0020	0.0289
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				2	0.0508	0.0020	0.0289
3				3	0.0762	0.0046	0.0651
3				3	0.0762	0.0046	0.0651
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				2	0.0508	0.0020	0.0289
3				2	0.0508	0.0020	0.0289
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				2	0.0508	0.0020	0.0289
3				2	0.0508	0.0020	0.0289
3				2	0.0508	0.0020	0.0289
3				2	0.0508	0.0020	0.0289
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				0.5	0.0127	0.0001	0.0018
3				0.5	0.0127	0.0001	0.0018

3				0.5	0.0127	0.0001	0.0018
3				3	0.0762	0.0046	0.0651
3				3	0.0762	0.0046	0.0651
3				2	0.0508	0.0020	0.0289
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				2	0.0508	0.0020	0.0289
3				3	0.0762	0.0046	0.0651
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				2	0.0508	0.0020	0.0289
3				2	0.0508	0.0020	0.0289
3				2	0.0508	0.0020	0.0289
3				4	0.1016	0.0081	0.1158
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				2	0.0508	0.0020	0.0289
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				1	0.0254	0.0005	0.0072
3				2	0.0508	0.0020	0.0289
3	SAIN	3		0.5	0.0127	0.0001	0.0018
				Total Basal Area per Ha			Diversity (Basal Area
AVG DBH	**3.9**				**2.05**		**0.6842**
STDEV	**2.4**			Shade = 0%			
CV	**61.1**						

3.5 Upper Cattaraugus Creek-South, Band 3 (quadrats 30 x 20 m, 30 x 10 m)

30x20													
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)	per hectare						
1	PODE	1	32	10.18592	0.2587	0.0525	0.8757						
1			34	10.82255	0.2749	0.0593	0.9886						
1	ROPS	2	23	7.321134	0.1859	0.0271	0.4524	Total # of Trees	Total # of Trees per Ha				
1	PLOC	3		6	0.1524	0.0182	0.3038						
1				3	0.0762	0.0046	0.0760						
1				5	0.1270	0.0127	0.2110	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)		
1	SANI	4		2	0.0508	0.0020	0.0338	1	1.8642	0.4366	-0.3618		
1				2	0.0508	0.0020	0.0338	2	0.4524	0.1059	-0.2378		
1				1	0.0254	0.0005	0.0084	3	0.5908	0.1384	-0.2737		
1				1	0.0254	0.0005	0.0084	4	1.3673	0.3202	-0.3646		
1				2	0.0508	0.0020	0.0338						
1				4	0.1016	0.0081	0.1350				Total Basal Area per Ha	Diversity (Basal Area)	
1				5	0.1270	0.0127	0.2110	AVG DBH	**8.7**		**4.27**	**1.2380**	
1				2	0.0508	0.0020	0.0338	STDEV	**6.9**	Shade = 0%			
1				2	0.0508	0.0020	0.0338						
1				2	0.0508	0.0020	0.0338	CV	**79.2**				
1				1	0.0254	0.0005	0.0084						
1				1	0.0254	0.0005	0.0084						
1				3	0.0762	0.0046	0.0760						
1				4	0.1016	0.0081	0.1350						
1				1	0.0254	0.0005	0.0084						
1				2	0.0508	0.0020	0.0338						
1				1	0.0254	0.0005	0.0084						
1				1	0.0254	0.0005	0.0084						
1				4	0.1016	0.0081	0.1350						
1				3	0.0762	0.0046	0.0760						
1				6	0.1524	0.0182	0.3038						

30x10												
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	3asal Area/tree (m	per hectare					
2	PODE	1	42	13.36903	0.3396	0.0905	3.0170					
2			29	9.230994	0.2345	0.0432	1.4384					
2				7	0.1778	0.0248	0.8271		Total # of Treotal # of Trees per Ha			
2				6	0.1524	0.0182	0.6077					
2	SANI	4		4	0.1016	0.0081	0.2701					
2				5	0.1270	0.0127	0.4220		Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
2				1	0.0254	0.0005	0.0169		1	5.8902	0.5444	-0.3310
2				1	0.0254	0.0005	0.0169		4	4.9290	0.4555	-0.3582
2				2	0.0508	0.0020	0.0675					
2				4	0.1016	0.0081	0.2701					
2				2	0.0508	0.0020	0.0675					
2				3	0.0762	0.0046	0.1519					
2				7	0.1778	0.0248	0.8271					
2				3	0.0762	0.0046	0.1519					
2				1	0.0254	0.0005	0.0169					
2				5	0.1270	0.0127	0.4220					
2				1	0.0254	0.0005	0.0169					
2				5	0.1270	0.0127	0.4220					
2				3	0.0762	0.0046	0.1519					
2				2	0.0508	0.0020	0.0675					
2				5	0.1270	0.0127	0.4220					
2				3	0.0762	0.0046	0.1519					
2				2	0.0508	0.0020	0.0675					
2				1	0.0254	0.0005	0.0169					
2				2	0.0508	0.0020	0.0675					
2				4	0.1016	0.0081	0.2701					
2				3	0.0762	0.0046	0.1519					
2				5	0.1270	0.0127	0.4220					
										Total Basal Area per Ha		Diversity (Basal Area
				AVG DBH	**9.9**					**10.82**		**0.6892**
				STDEV	**7.1**				Shade = 0%			
				CV	**71.6**							

30x10											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	l Area/tre	per hectare				
3	PODE	1	35	11.14086	0.2830	0.0629	2.0951				
3			15	4.774652	0.1213	0.0115	0.3848				
3			16	5.092962	0.1294	0.0131	0.4378	Total # of Trees	Total # of Trees per Ha		
3			17	5.411273	0.1374	0.0148	0.4943				
3			16	5.092962	0.1294	0.0131	0.4378				
3			17	5.411273	0.1374	0.0148	0.4943	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
3			12	3.819722	0.0970	0.0074	0.2463	1	42.5850	0.9302	-0.0673
3			12	3.819722	0.0970	0.0074	0.2463	3	1.3238	0.0289	-0.1025
3			15	4.774652	0.1213	0.0115	0.3848	4	1.8762	0.0410	-0.1309
3			24	7.639444	0.1940	0.0296	0.9851				
3			24	7.639444	0.1940	0.0296	0.9851				
3			32	10.18592	0.2587	0.0525	1.7514				
3			37	11.77748	0.2991	0.0702	2.3414				
3			44	14.00565	0.3557	0.0993	3.3112				
3			15	4.774652	0.1213	0.0115	0.3848				
3			21	6.684513	0.1698	0.0226	0.7542				
3			30	9.549305	0.2425	0.0462	1.5393				
3			18	5.729583	0.1455	0.0166	0.5541				
3			30	9.549305	0.2425	0.0462	1.5393				
3			21	6.684513	0.1698	0.0226	0.7542				
3			18	5.729583	0.1455	0.0166	0.5541				
3			23	7.321134	0.1859	0.0271	0.9048				
3			35	11.14086	0.2830	0.0629	2.0951				
3			15	4.774652	0.1213	0.0115	0.3848				
3			34	10.82255	0.2749	0.0593	1.9771				
3			6	1.909861	0.0485	0.0018	0.0616				
3			10	3.183102	0.0808	0.0051	0.1710				
3			10	3.183102	0.0808	0.0051	0.1710				
3			15	4.774652	0.1213	0.0115	0.3848				
3			10	3.183102	0.0808	0.0051	0.1710				
3			16	5.092962	0.1294	0.0131	0.4378				
3			14	4.456342	0.1132	0.0101	0.3352				
3			27	8.594374	0.2183	0.0374	1.2468				

3			14	4.456342	0.1132	0.0101	0.3352				
3			33	10.50424	0.2668	0.0559	1.8625				
3			14	4.456342	0.1132	0.0101	0.3352				
3			29	9.230994	0.2345	0.0432	1.4384				
3			18	5.729583	0.1455	0.0166	0.5541				
3			27	8.594374	0.2183	0.0374	1.2468				
3			12	3.819722	0.0970	0.0074	0.2463				
3			21	6.684513	0.1698	0.0226	0.7542				
3			47	14.96058	0.3800	0.1133	3.7781				
3			42	13.36903	0.3396	0.0905	3.0170				
3	PLOC	3	11	3.501412	0.0889	0.0062	0.2069				
3			22	7.002823	0.1779	0.0248	0.8278				
3			13	4.138032	0.1051	0.0087	0.2890				
3	SANI	4	16	5.092962	0.1294	0.0131	0.4378				
3			12	3.819722	0.0970	0.0074	0.2463				
3			21	6.684513	0.1698	0.0226	0.7542				
3			16	5.092962	0.1294	0.0131	0.4378				
									Total Basal Area per Ha		Diversity (Basal Are
				AVG DBH	**17.0**				**45.78**		**0.3007**
				STDEV	**7.9**			Shade = 0%			
				CV	**46.2**						

3.6 Upper Cattaraugus Creek-South, Band 4 (quadrats 20 x 20m, 15 x 20 m)

20x20											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)	per hectare				
1	PODE	1	44	14.00565	0.3557	0.0993	2.4834				
1			42	13.36903	0.3396	0.0905	2.2627				
1			45	14.32396	0.3638	0.1039	2.5975	Total # of Trees	Total # of Trees per Ha		
1			29	9.230994	0.2345	0.0432	1.0788				
1			53	16.87044	0.4285	0.1441	3.6032				
1			53	16.87044	0.4285	0.1441	3.6032				
1			25	7.957754	0.2021	0.0321	0.8017	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
1			35	11.14086	0.2830	0.0629	1.5713	1	27.7805	0.9382	-0.0598
1			26	8.276064	0.2102	0.0347	0.8671	2	1.8272	0.0617	-0.1719
1			37	11.77748	0.2991	0.0702	1.7561	3	10.0818	0.3405	-0.3668
1			27	8.594374	0.2183	0.0374	0.9351	4	1.3135	0.0444	-0.1382
1			47	14.96058	0.3800	0.1133	2.8336	5	2.1142	0.0714	-0.1885
1			29	9.230994	0.2345	0.0432	1.0788	6	0.4051	0.0137	-0.0587
1			38	12.09579	0.3072	0.0741	1.8523	7	0.1139	0.0038	-0.0214
1				6	0.1524	0.0182	0.4558				
1	ROPS	2	25	7.957754	0.2021	0.0321	0.8017				
1				4	0.1016	0.0081	0.2026				
1				7	0.1778	0.0248	0.6203				
1				4	0.1016	0.0081	0.2026				
1	JUNI	3	40	12.73241	0.3234	0.0821	2.0524				
1			76	24.19157	0.6144	0.2964	7.4091				
1				7	0.1778	0.0248	0.6203				

1	SANI	4	32	10.18592	0.2587	0.0525	1.3135		
1	CACA	5		3	0.0762	0.0046	0.1139		
1				5	0.1270	0.0127	0.3165		
1				6	0.1524	0.0182	0.4558		
1				3	0.0762	0.0046	0.1139		
1				3	0.0762	0.0046	0.1139		
1				3	0.0762	0.0046	0.1139		
1				4	0.1016	0.0081	0.2026		
1				4	0.1016	0.0081	0.2026		
1				3	0.0762	0.0046	0.1139		
1				2	0.0508	0.0020	0.0506		
1				4	0.1016	0.0081	0.2026		
1				3	0.0762	0.0046	0.1139		
1	FRAM	6		4	0.1016	0.0081	0.2026		
1				4	0.1016	0.0081	0.2026		
1	CORNU	7		3	0.0762	0.0046	0.1139		
							Total Basal Area per Ha		Diversity (Basal Area)
		AVG DBH	**20.4**				**29.61**		**1.0053**
		STDEV	**13.1**			Shade = 0%			
		CV	**64.2**						

20x15											
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	3asal Area/tree (m	per hectare				
2	PODE	1	29	9.230994	0.2345	0.0432	1.4384				
2			36	11.45917	0.2910	0.0665	2.2166				
2			49	15.5972	0.3961	0.1232	4.1065	Total # of Trees	Total # of Trees per Ha		
2			47	14.96058	0.3800	0.1133	3.7781				
2	ROPS	2		4	0.1016	0.0081	0.2701				
2				5	0.1270	0.0127	0.4220				
2			38	12.09579	0.3072	0.0741	2.4697	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
2			26	8.276064	0.2102	0.0347	1.1562	1	11.5395	0.3368	-0.3665
2			33	10.50424	0.2668	0.0559	1.8625	2	7.0083	0.2046	-0.3246
2			22	7.002823	0.1779	0.0248	0.8278	4	7.8040	0.2278	-0.3370
2	SANI	4		4	0.1016	0.0081	0.2701	5	3.6207	0.1057	-0.2375
2			36	11.45917	0.2910	0.0665	2.2166	6	0.8271	0.0241	-0.0899
2			47	14.96058	0.3800	0.1133	3.7781	7	0.1519	0.0044	-0.0240
2			30	9.549305	0.2425	0.0462	1.5393	8	3.3112	0.0966	-0.2258
2	CACA	5	26	8.276064	0.2102	0.0347	1.1562				
2				2	0.0508	0.0020	0.0675				
2				2	0.0508	0.0020	0.0675				
2				4	0.1016	0.0081	0.2701				
2				2	0.0508	0.0020	0.0675				
2				2	0.0508	0.0020	0.0675				
2				5	0.1270	0.0127	0.4220				
2				4	0.1016	0.0081	0.2701				
2				7	0.1778	0.0248	0.8271				
2				2	0.0508	0.0020	0.0675				
2				4	0.1016	0.0081	0.2701				
2				2	0.0508	0.0020	0.0675				
2	FRAM	6		7	0.1778	0.0248	0.8271				
2	CORNI	7		3	0.0762	0.0046	0.1519				
2	PLOC	8	44	14.00565	0.3557	0.0993	3.3112				
									Total Basal Area per Ha		Diversity (Basal Area
				AVG DBH	**18.1**				**34.26**		**1.6054**
				STDEV	**11.4**			Shade = 0%			
				CV	**62.9**						

4.1 Lower Cattaraugus Creek-Upstream, Inland (quadrats 60 x 10 m)

Lower Catt #1		*40x10 + 20x10												
	60 x 10m*													
	Quadrat	transect		species	cbh (in)	dbh (in)	dbh (m)	BA/tree (m2	Total BA	BA (m2/ha)	TOTAL QUAD BA	pi	ln pi	
	1	5	PODE	1	116	36.943	0.9383	0.6911167	2.6257	43.76	**43.76147902**	0.764	-0.269	0.206
	1				62	19.745	0.5015	0.19743256		0.00				
	1				89	28.344	0.7199	0.4068323		0.00	**0**			
	1				64	20.382	0.5177	0.21037559		0.00	**0**			
	1				77	24.522	0.6228	0.30452073		0.00	**0**			
	1				126	40.127	1.0192	0.81541087		0.00	**0**			
	1		ACNE	2	43	13.694	0.3478	0.09496691	0.5201	8.67	**8.66806339**	0.151	-1.888	0.286
	1				14	4.4586	0.1132	0.0100668		0.00	**0**			
	1				45	14.331	0.364	0.10400649		0.00	**0**			
	1				19	6.051	0.1537	0.0185414		0.00	**0**			
	1				26	8.2803	0.2103	0.03472019		0.00	**0**			
	1				17	5.414	0.1375	0.0148434		0.00	**0**			
	1				32	10.191	0.2588	0.0525939		0.00	**0**			
	1				59	18.79	0.4772	0.17878844		0.00	**0**			
	1				15	4.7771	0.1213	0.01155628		0.00	**0**			

1		SANI	3	58	18.471	0.469	0.17277917	0.2916	4.86		**4.859365985**	0.085	-2.467	0.209
1	4			26	8.2803	0.21	0.03472019		0.00		**0**			
1					2	0.051	0.0020256		0.00		**0**			
1					1	0.025	0.0005064		0.00		**0**			
1					4	0.102	0.00810242		0.00		**0**			
1					6	0.152	0.01823044		0.00		**0**			
1					7	0.1778	0.02481366		0.00		**0**			
1					6	0.152	0.01823044		0.00					
1					2	0.051	0.0020256		0.00					
1					2	0.051	0.0020256		0.00					
1					4	0.102	0.00810242		0.00					
		# Trees											H'	**0.7**
		Trees/ha						BA/ha o	57.29		**57.2889084**	BA		
											1477.8	Trees/ha		

4.2 Lower Cattaraugus Creek-Downstream, Band 2 (quadrat 25 x 40 m)

Lower Catt #2															
	25x40 m	**Band 2**													
	Quadrat	transect		species	cbh (in)	dbh (in)	dbh (m)	Area/tree	Total BA	BA (m2/ha)	BA understory	TOTAL QUAD BA	pi	ln pi	
	1		ACNE	1		1	0.025399	0.000506	0.063806548	0.64		**0.64**	0.308244	-1.17686	0.362761
	1					4	0.101595	0.008102		0.00					
	1					4	0.101595	0.008102		0.00					
	1					6	0.152393	0.01823		0.00					
	1					5	0.126994	0.01266		0.00					
	1					4	0.101595	0.008102		0.00					
	1					4	0.101595	0.008102		0.00					
	1		SAIN	2		4	0.101595	0.008102	0.023800855	0.24		**0.24**	0.11498	-2.163	0.248701
	1					3	0.076196	0.004558		0.00					
	1					2	0.050798	0.002026		0.00					
	1					3	0.076196	0.004558		0.00					
	1					3	0.076196	0.004558		0.00					
	1		SANI	3		3	0.076196	0.004558	0.043550501	0.44		**0.44**	0.210389	-1.5588	0.327954
	1					4	0.101595	0.008102		0.00					
	1					5	0.126994	0.01266		0.00					
	1					6	0.152393	0.01823		0.00					
	1		Salix sp.	4	19	6.050955	0.153687	0.018541	0.018541404	0.19		**0.19**	0.089572	-2.41271	0.216111
	1		PLOC	5	25	7.961783	0.202219	0.032101	0.056914426	0.57		**0.57**	0.274949	-1.29117	0.355006
	1					7	0.177791	0.024814		0.00					
			# Trees											H'	**1.510534**
			Trees/ha						BA/ha overstory	2.07	0	**2.07**	BA		

4.3 Lower Cattaraugus Creek-Downstream, Band 3 (quadrats 15 x 15 m, 10 x 40 m)

Lower Catt # 2														
15x15 m	Band 3													
Quadrat	transect		species	cbh (in)	dbh (in)	dbh (m)	al Area/tree	Total BA	BA (m2/ha)	BA understory	TOTAL QUAD BA	pi	ln pi	
1		PODE	1	34	10.82803	0.275018	0.059374	1.016336001	45.17		45.17	0.747856	-0.29055	0.217286
1				82	26.11465	0.66328	0.345353		0.00					
1				82	26.11465	0.66328	0.345353		0.00					
1				72	22.92994	0.582392	0.266257		0.00					
1		SANI	2	44	14.01274	0.355906	0.099435	0.34268212	15.23		15.23	0.252158	-1.3777	0.347398
1				40	12.73885	0.323551	0.082178		0.00					
1				56	17.83439	0.452972	0.161069		0.00					
		# Trees											H'	0.564684
		Trees/ha						BA/ha overstory	60.40	0	60.40	BA		

15x15 m	Band 3													
Quadrat	transect		species	cbh (in)	dbh (in)	dbh (m)	al Area/tree	Total BA	BA (m2/ha)	BA understory	TOTAL QUAD BA	pi	ln pi	
2		PODE	1	40	12.73885	0.323551	0.082178	0.082177966	3.65		3.65	0.109025	-2.21617	0.241619
2		SANI	2	43	13.69427	0.347817	0.094967	0.58294995	25.91		25.91	0.7734	-0.25696	0.198732
2				54	17.19745	0.436794	0.149769							
2				48	15.28662	0.388261	0.118336							
2				46	14.64968	0.372084	0.10868							
2				20	6.369427	0.161776	0.020544							
2				26	8.280255	0.210308	0.03472							
2				33	10.50955	0.26693	0.055932							
2		ACNE	3	34	10.82803	0.275018	0.059374	0.088674648	3.94		3.94	0.117645	-2.14009	0.25177
2				18	5.732484	0.145598	0.016641							
2					5	0.126994	0.01266							
		# Trees											H'	0.692121
		Trees/ha						BA/ha overstory	33.50	0	33.50	BA		

15x15 m	Band 3													
Quadrat	transect		species	cbh (in)	dbh (in)	dbh (m)	al Area/tree	Total BA	BA (m2/ha)	BA understory	TOTAL QUAD BA	pi	ln pi	
3		PODE	1	58	18.47134	0.469149	0.172779	0.317052867	14.09		14.09	0.530544	-0.63385	0.336287
3				53	16.87898	0.428705	0.144274							
3		SANI	2	30	9.55414	0.242663	0.046225	0.105110242	4.67		4.67	0.175887	-1.73791	0.305677
3				30	9.55414	0.242663	0.046225							
3					5	0.126994	0.01266							
3		PLOC	4	46	14.64968	0.372084	0.10868	0.17550132	7.80		7.80	0.293677	-1.22528	0.359835
3				26	8.280255	0.210308	0.03472							
3				25	7.961783	0.202219	0.032101							
		# Trees											H'	1.001798
		Trees/ha						BA/ha overstory	26.56	0	26.56	BA		

10X40 m	Band 3													
Quadrat	transect		species	cbh (in)	dbh (in)	dbh (m)	al Area/tree	Total BA	BA (m2/ha)	BA understory	TOTAL QUAD BA	pi	ln pi	
4		PODE	1	36	11.46497	0.291196	0.066564	0.066564153	1.66		1.66	0.163468	-1.81114	0.296063
4		SANI	2	24	7.643312	0.194131	0.029584	0.204725859	5.12		5.12	0.502765	-0.68763	0.345718
4				25	7.961783	0.202219	0.032101							
4				26	8.280255	0.210308	0.03472							
4				28	8.917197	0.226486	0.040267							
4				28	8.917197	0.226486	0.040267							
4				21	6.687898	0.169864	0.02265							
4				10	3.184713	0.080888	0.005136							
4		ACNE	3	25	7.961783	0.202219	0.032101	0.032100768	0.80		0.80	0.078833	-2.54042	0.200269
4		PLOC	4	45	14.33121	0.363995	0.104006	0.104006489	2.60		2.60	0.255419	-1.36485	0.348608
		# Trees											H'	1.190658
		Trees/ha						BA/ha overstory	10.18	0	10.18	BA		

5.1 Eighteenmile Creek, Upper Terrace 1 (quadrats 30 x 15 m, 30 x 20 m)

30x15 m	**Overstory**												
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Area/tree	Total BA	BA (m2/ha)	BA understory	TAL QUAD	pi	ln pi	
1	ACSA	1	111	35.35032	**0.897854**	0.632822	1.852103	41.16		**41.15785**	0.547997	-0.60149	0.329612
1			83	26.43312	0.671369	0.353828		0.00			0		0
1			111	35.35032	**0.897854**	0.632822		0.00			0		0
1			45	14.33121	0.363995	0.104006		0.00			0		0
1				2	0.050798	0.002026		0.00			0		0
1				4	0.101595	0.008102		0.00			0		0
1				2	0.050798	0.002026		0.00			0		0
1				1	0.025399	0.000506		0.00			0		0
1				6	0.152393	0.01823		0.00			0		0
1				6	0.152393	0.01823		0.00			0		
1				7	0.177791	0.024814		0.00			0		0
1				2	0.050798	0.002026		0.00			0		0
1				4	0.101595	0.008102		0.00			0		
1				4	0.101595	0.008102		0.00			0		0
1				6	0.152393	0.01823		0.00			0		
1				1	0.025399	0.000506		0.00			0		
1				1	0.025399	0.000506		0.00			0		
1				5	0.126994	0.01266		0.00			0		
1				2	0.050798	0.002026		0.00			0		
1				1	0.025399	0.000506		0.00			0		
1				2	0.050798	0.002026		0.00			0		

1	FAGR	2	81	25.79618	0.655191	0.336981	1.016883	22.60		**22.5974**	0.300873	-1.20107	0.361369
1			59	18.78981	0.477238	0.178788		0.00			0		0
1			51	16.24204	0.412528	0.133591		0.00			0		0
1			75	23.88535	0.606658	0.288907		0.00			0		0
1			35	11.1465	0.283107	0.062918		0.00			0		0
1				5	0.126994	0.01266		0.00			0		0
1				2	0.050798	0.002026		0.00			0		0
1				1	0.025399	0.000506		0.00			0		0
1				1	0.025399	0.000506		0.00			0		0
1	BELE	3	72	22.92994	0.582392	0.266257	0.266257	5.92		**5.916814**	0.07878	-2.5411	0.200187
1	TSCA	4	69	21.97452	0.558126	0.244531	0.244531	5.43		**5.434018**	0.072351	-2.62622	0.190011
	# Trees											H'	**1.081178**
	Trees/ha						BA/ha ove	75.11	0	**75.10608**	BA		
										1477.8	Trees/ha		

30x20 m	**Overstory**												
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	BA/tree (m2)	Total BA	3A (m2/ha	BA understory	TOTAL QUAD BA	pi	ln pi	
2	ACSA	1	74	23.56688	**0.59857**	0.28125409	1.473143	24.55	1.84	**26.39**	0.351345	-1.04599	0.367502
2			74	23.56688	0.59857	0.28125409		0.00			0		0
2			21	6.687898	**0.169864**	0.022650302		0.00			0		0
2			83	26.43312	0.671369	0.353827507		0.00			0		0
2			68	21.65605	0.550037	0.237494323		0.00			0		0
2			76	24.20382	0.614747	0.296662459		0.00			0		0
2	QURU	5	97	30.89172	0.784611	0.483257804	2.140325	35.67	0.00	**35.67**	0.474957	-0.74453	0.35362
2			96	30.57325	0.776523	0.473345087		0.00			0		0
2			51	16.24204	0.412528	0.133590557		0.00			0		0
2			111	35.35032	0.897854	0.632821703		0.00			0		
2			58	18.47134	0.469149	0.172779175		0.00			0		0
2			69	21.97452	0.558126	0.244530812		0.00			0		0
2	HAVI	6		1	0.025399	0.000506401	0.017851		0.89	**0.89**	0.011884	-4.43259	0.052675
2	TIAM	7		2	0.050798	0.002025605	0.014686		0.73	**0.73**	0.009777	-4.62776	0.045244
2	PRSE	8		3	0.076196	0.004557611	0.004558		0.23	**0.23**	0.003034	-5.79783	0.017591
	# Trees											H'	**0.836633**
	Trees/ha						BA/ha ove	60.22	3.69	**63.91**	BA		

20X10 m	**Understory**							
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	BA/tree (m2)	Total BA	BA (m2/ha)
2	ACSA	1		3	0.076196	0.004557611	0.036714	1.83570426
2				5	0.126994	0.012660029		0
2				2	0.050798	0.002025605		0
2				1	0.025399	0.000506401		0
2				2	0.050798	0.002025605		0
2				2	0.050798	0.002025605		0
2				1	0.025399	0.000506401		0
2				0.5	0.012699	0.0001266		0
2				1	0.025399	0.000506401		0
2				0.5	0.012699	0.0001266		0
2				2	0.050798	0.002025605		0
2				1	0.025399	0.000506401		0
2				2	0.050798	0.002025605		0
2				1	0.025399	0.000506401		0
2				3	0.076196	0.004557611		0
2				2	0.050798	0.002025605		0
2	HAVI	6		1	0.025399	0.000506401	0.017851	0.89253207
2				1	0.025399	0.000506401		0
2				2	0.050798	0.002025605		0
2				3	0.076196	0.004557611		0
2				2	0.050798	0.002025605		0
2				2	0.050798	0.002025605		0
2				1	0.025399	0.000506401		0
2				2	0.050798	0.002025605		0
2				1	0.025399	0.000506401		0
2				2	0.050798	0.002025605		0
2				1	0.025399	0.000506401		0
2				1	0.025399	0.000506401		0
2				0.5	0.012699	0.0001266		0
2	TIAM	7		2	0.050798	0.002025605	0.014686	0.7342817
2				4	0.101595	0.008102419		0
2				3	0.076196	0.004557611		0
2	PRSE	8		3	0.076196	0.004557611	0.004558	0.22788053
	# Trees	13					BA/ha unc	3.69039856

5.2 Eighteenmile Creek, Upstream Terrace 2 (quadrat 30 x 20 m)

30x20 m	Overstory												
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	BA/tree (m2)	Total BA	3A (m2/ha)		TOTAL QUAD	pi	ln pi	
1	ACSA	1	45	14.33121	**0.363995**	0.104006489	0.99118	16.52		**16.51966**	0.274732	-1.29196	0.354943
1			71	22.61146	0.574303	0.258911956		0.00					
1			23	7.324841	**0.186042**	0.02717009		0.00					
1			83	26.43312	0.671369	0.353827507		0.00					
1			57	18.15287	0.46106	0.166872633		0.00					
1				1	0.025399	0.000506401		0.00					
1				2	0.050798	0.002025605		0.00					
1				2	0.050798	0.002025605		0.00					
1				2	0.050798	0.002025605		0.00					
1				1	0.025399	0.000506401		0.00					
1				1	0.025399	0.000506401		0.00					
1				1	0.025399	0.000506401		0.00					
1				2	0.050798	0.002025605		0.00					
1				1	0.025399	0.000506401		0.00					
1				2	0.050798	0.002025605		0.00					
1				3	0.076196	0.004557611		0.00					
1				2	0.050798	0.002025605		0.00					
1				2	0.050798	0.002025605		0.00					
1				0.5	0.012699	0.0001266		0.00					
1				0.5	0.012699	0.0001266		0.00					
1				0.5	0.012699	0.0001266		0.00					
1				1	0.025399	0.000506401		0.00					
1				1	0.025399	0.000506401		0.00					

1				2	0.050798	0.002025605		0.00						
1				4	0.101595	0.008102419		0.00						
1				1	0.025399	0.000506401		0.00						
1				2	0.050798	0.002025605		0.00						
1				6	0.152393	0.018230442		0.00						
1				6	0.152393	0.018230442		0.00						
1				2	0.050798	0.002025605		0.00						
1				3	0.076196	0.004557611		0.00						
1				1	0.025399	0.000506401		0.00						
1				1	0.025399	0.000506401		0.00						
1				1	0.025399	0.000506401		0.00						
1				1	0.025399	0.000506401		0.00						
1	FRAM	2	95	30.25478	0.768434	0.463535092	0.463535	7.73		**7.725585**	0.128481	-2.05197	0.26364	
1	BELE	3	51	16.24204	0.412528	0.133590557	0.622344	10.37		**10.3724**	0.1725	-1.75736	0.303144	
1			46	14.64968	0.372084	0.108680361		0.00						
1			70	22.29299	0.566214	0.251670022		0.00						
1			50	15.92357	0.404439	0.128403073		0.00						

1	QURU	4	101	32.16561	0.816967	0.523935898	0.523936	8.73		**8.732265**	0.145223	-1.92948	0.280206
1	BEAL	5	81	25.79618	0.655191	0.336981024	0.341539	5.69		**5.692311**	0.094667	-2.35739	0.223167
1				3	0.076196	0.004557611		0.00					
1	MAAC	6	109	34.71338	0.881677	0.610222762	0.610223	10.17		**10.17038**	0.16914	-1.77703	0.300566
1	HAVI	7		2	0.050798	0.002025605	0.002532	0.04		**0.0422**	0.000702	-7.26184	0.005096
1				1	0.025399	0.000506401		0.00					
1	TSCA	8		6	0.152393	0.018230442	0.01823	0.30		**0.303841**	0.005053	-5.28776	0.026719
1	CACA	9		3	0.076196	0.004557611	0.034435	0.57		**0.573921**	0.009545	-4.65177	0.0444
1				2	0.050798	0.002025605		0.00					
1				1	0.025399	0.000506401		0.00					
1				1	0.025399	0.000506401		0.00					
1				1	0.025399	0.000506401		0.00					
1				4	0.101595	0.008102419		0.00					
1				6	0.152393	0.018230442		0.00					
	# Trees											H'	**1.801881**
	Trees/ha						BA/ha ove	16.52	0	**60.13**	BA		
										1477.8	Trees/ha		

5.3 Eighteenmile Creek, Lower Terrace A (quadrates 10 x 10 m)

10 x 10										
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)				
2	QURU	1	64	20.37185	0.5174	0.2102				
2		1	72	22.91833	**0.5821**	0.2660				
2		1	22	7.002823	0.1779	0.0248				
2	BELE	2	25	7.957754	0.2021	0.0321	Total # of Trees	Total # of Trees per Ha		
2		2	26	8.276064	0.2102	0.0347	31	**3100**		
2	ACSA	3		1	0.0254	0.0005				
2		3		1	0.0254	0.0005	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
2		3		1	0.0254	0.0005	1	0.5010	0.7887	-0.1872
2		3		2	0.0508	0.0020	2	0.0668	0.1051	-0.2368
2		3		1	0.0254	0.0005	3	0.0219	0.0345	-0.1161
2		3		1.5	0.0381	0.0011	4	0.0446	0.0702	-0.1864
2		3		2	0.0508	0.0020	5	0.0005	0.0008	-0.0057
2		3		1	0.0254	0.0005	6	0.0005	0.0008	-0.0057
2		3		1	0.0254	0.0005				
2		3		2	0.0508	0.0020				
2		3		1	0.0254	0.0005				
2		3		2	0.0508	0.0020				
2		3		3	0.0762	0.0046				
2		3		3	0.0762	0.0046				

2	ULAM	4		3	0.0762	0.0046				
2		4		6	0.1524	0.0182				
2		4		4	0.1016	0.0081				
2		4		2	0.0508	0.0020				
2		4		2	0.0508	0.0020				
2		4		1	0.0254	0.0005				
2		4		2	0.0508	0.0020				
2		4		1	0.0254	0.0005				
2		4		3	0.0762	0.0046				
2		4		2	0.0508	0.0020				
2	BEAL	5		1	0.0254	0.0005				
2	FRAM	6		1	0.0254	0.0005				
				AVG DBH	**9.6**					
				STDEV	**13.2**					
				CV	**137.9**			Total Basal Area per Ha		Diversity (Basal Area)
							understory	**63.52**		**0.7379**
							Shade = 3.45%			

10 x 10										
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	BA/tree (m)				
3	QURU	1	44	14.00565	**0.3557**	0.0993				
3	BELE	2	18	5.729583	0.1455	0.0166				
3				4	0.1016	0.0081				
3				4	0.1016	0.0081				
3				5	0.1270	0.0127				
3				3	0.0762	0.0046	Total # of Trees	Total # of Trees per Ha		
3	ACSA	3	29	9.230994	0.2345	0.0432	35	**3500**		
3				1	0.0254	0.0005				
3				2	0.0508	0.0020	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
3				1	0.0254	0.0005	1	0.0993	0.3812	-0.3676
3				1	0.0254	0.0005	2	0.0500	0.1920	-0.3169
3				1	0.0254	0.0005	3	0.0986	0.3784	-0.3677
3				1	0.0254	0.0005	4	0.0127	0.0486	-0.1469
3				1	0.0254	0.0005				
3				2	0.0508	0.0020				
3				3	0.0762	0.0046				
3				0.5	0.0127	0.0001				
3				1	0.0254	0.0005				
3				1.0000	0.0254	0.0005				
3				2.0000	0.0508	0.0020				

3				2	0.0508	0.0020				
3				4	0.1016	0.0081				
3				2	0.0508	0.0020				
3				6	0.1524	0.0182				
3				4	0.1016	0.0081				
3				0.5	0.0127	0.0001				
3				2	0.0508	0.0020				
3	ULAM	4		1	0.0254	0.0005				
3				2	0.0508	0.0020				
3				1	0.0254	0.0005				
3				1	0.0254	0.0005				
3				2	0.0508	0.0020				
3				3	0.0762	0.0046				
3				2	0.0508	0.0020				
3				1	0.0254	0.0005				
				AVG DBH	**7.0**					
				STDEV	**6.9**			Total Basal Area per Ha		Diversity (Basal Area)
							understory	**26.06**		**1.1992**
				CV	**99.2**		**Shade = 37.84%**			

5.4 Eighteenmile Creek, Lower Terrace B (quadrats 10 x 10 m)

10 x 10										
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)				
1	JUNI	1	25	7.957754	0.2021	0.0321				
1	ACSA	2	41	13.05072	**0.3315**	0.0863				
1			20	6.366203	0.1617	0.0205				
1				1	0.0254	0.0005	Total # of Trees	'otal # of Trees per Ha		
1				4	0.1016	0.0081	23	**2300**		
1				3	0.0762	0.0046				
1				2	0.0508	0.0020	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
1				1	0.0254	0.0005	1	0.0321	0.1045	-0.2360
1				4	0.1016	0.0081	2	0.1529	0.4981	-0.3472
1				2	0.0508	0.0020	3	0.0225	0.0735	-0.1918
1				4	0.1016	0.0081	4	0.0685	0.2233	-0.3348
1				3	0.0762	0.0046	5	0.0127	0.0413	-0.1315
1				1	0.0254	0.0005	6	0.0182	0.0594	-0.1677

1				3	0.0762	0.0046				
1				2	0.0508	0.0020				
1				1	0.0254	0.0005				
1	ULAM	3	20	6.366203	0.1617	0.0205				
1				2	0.0508	0.0020				
1	TIAM	4	33	10.50424	0.2668	0.0559				
1				5	0.1270	0.0127				
1	CACA	5		4	0.1016	0.0081				
1				3	0.0762	0.0046				
1	BEAL	6		6	0.1524	0.0182				
								Total Basal Area per Ha		Diversity (Basal Area)
				AVG DBH	**10.5**			**30.69**		**1.4090**
				STDEV	**7.9**					
							Shade = 49.81%			
				CV	**74.9**					

10 x 10										
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	Basal Area/tree (m)				
2	ACSA	2	33	10.50424	0.2668	0.0559				
2				5	0.1270	0.0127				
2				7	0.1778	0.0248	Total # of Trees	'otal # of Trees per Ha		
2				4	0.1016	0.0081	18	**1800**		
2				5	0.1270	0.0127				
2				2	0.0508	0.0020	Species	Basal Area/species	Prop (Basal Area)	Prop*Ln(Prop)
2				7	0.1778	0.0248	2	0.1536	0.3125	-0.3635
2	ULAM	3		5	0.1270	0.0127	3	0.0127	0.0258	-0.0942
2	PLOC	7	66	21.00847	**0.5336**	0.2235	7	0.2235	0.4546	-0.3584
2	FRAM	8	31	9.867615	0.2506	0.0493	8	0.1018	0.2072	-0.3261
2			32	10.18592	0.2587	0.0525				
								Total Basal Area per Ha		Diversity (Basal Area)
				AVG DBH	**20.0**			**49.16**		**1.1422**
				STDEV	**13.1**		understory	1.88		
							Shade = 17.67%			
				CV	**65.4**					

6.1 Tonawanda Creek, Akron (quadrats 30 x 30 m, 30 x 20 m)

30x20 m														
Quadrat	transect		species	cbh (in)	dbh (in)	dbh (m)	Area/tree	Total BA	3A (m2/ha	BA understory	TAL QUAD	pi	ln pi	
1	0-10	ACNE	1		4	**0.101595**	0.008102	0.325201	5.42		**5.420019**	0.153455	-1.87435	0.287628
1					5	0.126994	0.01266		0.00		**0**			
1					0.5	**0.012699**	0.000127		0.00		**0**			
1					4	0.101595	0.008102		0.00		**0**			
1					1	0.025399	0.000506		0.00		**0**			
1					6	0.152393	0.01823		0.00		**0**			
1					5	0.126994	0.01266		0.00		**0**			
1					7	0.177791	0.024814		0.00		**0**			
1					0.5	0.012699	0.000127		0.00		**0**			
1	20			48	15.28662	0.388261	0.118336		0.00		**0**			
1					7	0.177791	0.024814		0.00		**0**			
1					4	0.101595	0.008102		0.00		**0**			
1					7	0.177791	0.024814		0.00		**0**			
1					7	0.177791	0.024814		0.00		**0**			
1					6	0.152393	0.01823		0.00		**0**			
1	30				5	0.126994	0.01266		0.00		**0**			
1					4	0.101595	0.008102		0.00		**0**			
1	20	PODE	2		19	0.482576	0.182811	1.781519	29.69		**29.69199**	0.840657	-0.17357	0.145915
1					30	0.761963	0.455761		0.00		**0**			
1					31	0.787362	0.486652		0.00		**0**			
1	30				36	0.914355	0.656296		0.00		**0**			
1	20	SANI	3		5	0.126994	0.01266	0.01266	0.21		**0.211**	0.005974	-5.12034	0.030589

30x30 m														
Quadrat	transect		species	cbh (in)	dbh (in)	dbh (m)	BA/tree (m2	Total BA	BA (m2/ha)	BA understory	TAL QUAD	pi	ln pi	
2	10	ACNE	1		8	**0.20319**	0.03240968	0.776945893	8.63		**8.632732**	0.145577	-1.92705	0.280534
2					3	0.076196	0.00455761		0.00		**0**			
2					7	**0.177791**	0.02481366		0.00		**0**			
2					4	0.101595	0.00810242		0.00		**0**			
2					5	0.126994	0.01266003		0.00		**0**			
2				32	10.19108	0.258841	0.0525939		0.00		**0**			
2				26	8.280255	0.210308	0.03472019		0.00		**0**			
2				23	7.324841	0.186042	0.02717009		0.00		**0**			
2				31	9.872611	0.250752	0.04935814		0.00		**0**			
2				25	7.961783	0.202219	0.03210077		0.00		**0**			
2				22	7.006369	0.177953	0.02485883		0.00		**0**			
2					4	0.101595	0.00810242		0.00		**0**			
2					7	0.177791	0.02481366		0.00		**0**			
2					5	0.126994	0.01266003		0.00		**0**			
2				42	13.3758	0.339729	0.09060121		0.00		**0**			
2	20			35	11.1465	0.283107	0.06291751		0.00		**0**			
2				23	7.324841	0.186042	0.02717009		0.00		**0**			
2				30	9.55414	0.242663	0.04622511		0.00		**0**			
2				22	7.006369	0.177953	0.02485883		0.00		**0**			
2				30	9.55414	0.242663	0.04622511		0.00		**0**			
2					3	0.076196	0.00455761		0.00		**0**			
2					4	0.101595	0.00810242		0.00		**0**			

2	30			31	9.872611	0.250752	0.04935814		0.00		**0**			
2				29	9.235669	0.234575	0.04319479		0.00		**0**			
2					7	0.177791	0.02481366		0.00		**0**			
2	20	PODE	2		20	0.507975	0.20256047	4.559847327	50.66		**50.66497**	0.854384	-0.15737	0.134458
2				46	14.64968	0.372084	0.10868036		0.00		**0**			
2				51	16.24204	0.412528	0.13359056		0.00		**0**			
2					26	0.660368	0.34232719		0.00		**0**			
2					20	0.507975	0.20256047		0.00		**0**			
2					30	0.761963	0.45576106		0.00		**0**			
2	30				36	0.914355	0.65629592		0.00		**0**			
2					33	0.838159	0.55147088		0.00		**0**			
2					28	0.711165	0.39701852		0.00		**0**			
2					30	0.761963	0.45576106		0.00		**0**			
2					26	0.660368	0.34232719		0.00		**0**			
2					27	0.685767	0.36916646		0.00		**0**			
2					26	0.660368	0.34232719		0.00		**0**			
		# Trees											H'	**0.414993**
		Trees/ha						BA/ha overst	8.63	0	**59.30**	BA		
											1477.8	Trees/ha		

6.2 Tonawanda Creek, Reservation (quadrats 30 x 60 m, 20 x 30 m)

30x60 m													
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	BA/tree (m2	Total BA	3A (m2/ha	BA understory	TAL QUAD	pi	ln pi	
1	SANI	1	72	22.92994	**0.582392**	0.26625661	9.155802	50.87		**50.86557**	0.916662	-0.08702	0.079765
1			64	20.38217	0.517682	0.21037559							
1			105	33.43949	**0.849322**	0.56625755							
1			104	33.12102	0.841233	0.55552305							
1			49	15.6051	0.39635	0.12331831							
1			106	33.75796	0.85741	0.57709477							
1			165	52.54777	1.334648	1.39830946							
1			110	35.03185	0.889765	0.62147087							
1			137	43.63057	1.108162	0.96399891							
1			100	31.84713	0.808878	0.51361229							
1			53	16.87898	0.428705	0.14427369							
1			94	29.93631	0.760345	0.45382782							
1			100	31.84713	0.808878	0.51361229							
1			99	31.52866	0.800789	0.50339141							
1			72	22.92994	0.582392	0.26625661							
1			130	41.40127	1.051541	0.86800477							
1			108	34.3949	0.873588	0.59907738							
1				3	0.076196	0.00455761							
1				3	0.076196	0.00455761							
1				2	0.050798	0.0020256							

1	ACNE	2	60	19.10828	0.485327	0.18490042	0.736384	4.09		**4.091021**	0.073725	-2.60741	0.192232
1			53	16.87898	0.428705	0.14427369							
1			25	7.961783	0.202219	0.03210077							
1			54	17.19745	0.436794	0.14976934							
1			21	6.687898	0.169864	0.0226503							
1			26	8.280255	0.210308	0.03472019							
1			26	8.280255	0.210308	0.03472019							
1			14	4.458599	0.113243	0.0100668							
1				6	0.152393	0.01823044							
1				4	0.101595	0.00810242							
1				1	0.025399	0.0005064							
1				3	0.076196	0.00455761							
1				6	0.152393	0.01823044							
1				1	0.025399	0.0005064							
1				3	0.076196	0.00455761							
1				0.5	0.012699	0.0001266							
1				5	0.126994	0.01266003							
1				2	0.050798	0.0020256							
1				5	0.126994	0.01266003							
1				2	0.050798	0.0020256							
1				4	0.101595	0.00810242							
1				6	0.152393	0.01823044							
1				5	0.126994	0.01266003							
1	JUNI	3	31	9.872611	0.250752	0.04935814	0.095583	0.53		**0.531018**	0.00957	-4.64916	0.044491
1			30	9.55414	0.242663	0.04622511							
	# Trees											H'	**0.316488**
	Trees/ha						BA/ha ove	55.49	0	**55.49**	BA		

20x30 m	**river edge**													
Quadrat	transect		species	cbh (in)	dbh (in)	dbh (m)	BA/tree (m2)	Total BA	BA (m2/ha)	BA understory	TOTAL QUAD BA	pi	ln pi	
2		SANI	1	150	47.7707	**1.213317**	1.155627654	3.562877099	59.38		**59.38126123**			
2				98	31.21019	0.7927	0.493273244							
2				119	37.89809	**0.962564**	0.727326365							
2				152	48.40764	1.229494	1.186649836							
		# Trees											H'	**0**
		Trees/ha						BA/ha overstc	59.38	0	**59.38**	BA		

20x30 m													
Quadrat		species	cbh (in)	dbh (in)	dbh (m)	BA/tree (m2)	Total BA	BA (m2/ha)	BA understory	TAL QUAD	pi	ln pi	
3	ACNE	2	45	14.33121	**0.363995**	0.10400649	0.663688775	11.06		**11.06148**	0.818157	-0.2007	0.164205
3			102	32.48408	0.825055	0.53436223							
3				5	**0.126994**	0.01266003							
3				5	0.126994	0.01266003							
3	JUNI	3	53	16.87898	0.428705	0.14427369	0.144780094	2.41		**2.413001**	0.178476	-1.7233	0.307568
3				1	0.025399	0.0005064							
3	Cornus sp	4		2	0.050798	0.0020256	0.002532006	0.04		**0.0422**	0.003121	-5.7695	0.018008
3				1	0.025399	0.0005064							
	# Trees											H'	**0.489782**
	Trees/ha						BA/ha overstor	13.52	0	**13.52**	BA		

10x30 m	**inland**													
Quadrat	transect		species	cbh (in)	dbh (in)	dbh (m)	BA/tree (m2)	Total BA	3A (m2/ha	A understor	OTAL QUAD B/	pi	ln pi	
4		ACNE	2	30	9.55414	**0.242663**	0.04622511	0.841968	28.07		**28.06560031**	0.999843	-0.00016	0.000157
4				34	10.82803	0.275018	0.05937358							
4				17	5.414013	**0.137509**	0.0148434							
4				35	11.1465	0.283107	0.06291751							
4				35	11.1465	0.283107	0.06291751							
4				59	18.78981	0.477238	0.17878844							
4				55	17.51592	0.444883	0.15536772							
4				22	7.006369	0.177953	0.02485883							
4				17	5.414013	0.137509	0.0148434							
4				59	18.78981	0.477238	0.17878844							
4					5	0.126994	0.01266003							
4					3	0.076196	0.00455761							
4					3	0.076196	0.00455761							
4					4	0.101595	0.00810242							
4					5	0.126994	0.01266003							
4					1	0.025399	0.0005064							
4		JUNI	3		4	0.101595	0.00810242	0.008102	0.27		**0.270080623**	0.009622	-4.64374	0.044681
		# Trees											H'	**0.044837**
		Trees/ha						BA/ha ove	28.34	0	**28.34**	BA		