ABSTRACT

Title of Thesis: APPLYING VEGETATION DYNAMICS THEORY TO THE LONG-TERM ECOLOGICAL DESIGN AND MANAGEMENT OF URBAN PUBLIC PARKS: UPPER LONG BRANCH STREAM VALLEY, MARYLAND

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Calls for ecological applications in landscape architecture have increased as the world faces compounding crises of climate change, biodiversity loss, and human disconnection with natural systems. Landscape architects are uniquely situated to address these crises as practitioners who engage at multiple scales with ecological systems, placemaking, and land use planning. A sustainability ethic exists within the discipline, but ecological principles and theory are inconsistently applied in built work. Vegetation dynamics theory generalizes the mechanisms of plant community change over time, and presents a useful framework for the planting design, long-term adaptive management, and stewardship of urban parks. The principles of the theory can be interwoven with ecological and aesthetic goals of designed landscapes. This thesis demonstrates how centering vegetation dynamics theory in urban park design can enhance ecological function of urban landscapes, create heightened place attachment through aesthetic and interpretive experience, and guide the long-term management and stewardship of urban ecosystems in the Mid-Atlantic United States.

APPLYING VEGETATION DYNAMICS THEORY TO THE LONG-TERM ECOLOGICAL DESIGN AND MANAGEMENT OF URBAN PUBLIC PARKS: UPPER LONG BRANCH STREAM VALLEY, MARYLAND

by

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Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Landscape Architecture
2021

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Dedication

This project is dedicated to Aaron, who is always with me.

Acknowledgements

First, I would like to thank my committee members David Myers, Lea Johnson, and Jana Vandergoot. This project would not have been possible without your guidance and mentorship. Thank you!

I would also like to thank Lea Johnson, Eric Podietz, Piers Duffell, and Chris Samoray for assisting me with my fieldwork. Special thanks to Lea Johnson for providing me with the equipment and training that made the plant inventory for this project possible.

Next, thank you to Bill Hamilton, Chuck Kines, Corinne Stephens and Christina Sassaki of the Maryland-National Capital Park and Planning Commission (M-NCPPC) for your input and guidance on this project, and to community member and Weed Warrior Melanie Figg for the informative interview.

Finally, I want to thank my partner Piers, my parents, my friends, and my colleagues and instructors at UMD for supporting me consistently through this process.

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Definition of Terms

Vegetation Dynamics: A theory describing the underlying mechanisms of vegetation change over time: *site availability, species availability,* and *species performance*. (Pickett et al., 1987). This encompasses the process of ecological succession.

Ecological Succession: The process of vegetation change following an initial disturbance (Meiners et al, 2015).

Managed Succession: A process by which the succession of a plant community is modified and/or guided over time by management interventions (Luken, 1990).

Ecological design: A process of landscape design that "aims… to apply our knowledge of nature to create high-performing landscapes in which our design goals and natural processes go hand in hand" (Beck, 2013)

Scenic aesthetic: A mode of landscape appreciation that regards landscapes both wild and designed for their "visual, scenic, and picturesque qualities" (Gobster, 1999, p. 56).

Ecological restoration: "An attempt to recover a natural range of ecosystem composition, structure, and dynamics." (Palmer et al., 2016)

Assisted regeneration: "A restoration approach that focuses on actively harnessing any natural regeneration capacity of biota remaining on-site or nearby." (Gann et al., 2019)

Forest or landscape restoration: "A planned process that aims to regain ecological functionality and enhance human well-being in deforested or degraded landscapes." (Gann et al., 2019)

Reforestation: "Planting trees on lands that were previously forested." (Gann et al., 2019)

Extinction of experience: A term describing the cycle of disaffection and indifference towards nature resulting from people having less and less contact with it. (Soga & Gaston, 2016)

Box 1: Definition of Terms

Chapter 1: Introduction

Project Intention

In the face of compounding global issues of climate change, biodiversity loss, and ecological collapse, it is easy for those who care about ecosystems to become pessimistic. We could choose to assume that the forces of capitalism and consumerism, combined with a growing human population, extinguish any hope for a sustainable future. The emotional impact of these existential threats manifest differently for each one of us. But these struggles must be met with hope, creativity, experimental thought, and the discomfort that accompanies uncertainty. This project chooses to believe in a future in which humans assume a more ecologically responsible role. It embodies my choice to embrace hope.

Project Scope & Structure of Thesis Document

This project demonstrates the application of vegetation dynamics theory to the design and management of urban public parks. Because of the heavy focus on plant communities, a systematic vegetation inventory was completed on the study site; original data was collected as part of the project. This data, along with traditional site inventory elements such as hydrology, topography, zoning, and land use, was used to inform design decisions. Other products of this thesis include a master plan for the Upper Long Branch Stream Valley parks; this master plan includes siting of various programmatic elements, conceptual grading, and planting design recommendations. A conceptual timeline was created showing the development of various planting design typologies over a 50-year period, along with general management recommendations for each typology. The design of detailed site features and interpretive elements was not within the project scope, though recommendations are made in these areas. This thesis project was completed over one year between the spring of 2020 and the spring of 2021; during this time, the COVID-19 pandemic presented some limitations to the work that would otherwise not have existed. Community engagement was not the focus of the project and was not within its scope, but it is

acknowledged here that community engagement is integral to the success of any design project and should be a first step if these ideas were to move forward.

This thesis is divided into seven chapters. In the current chapter, I explain the project intention, give a brief background on the impacts of forest loss in the Mid-Atlantic United States, contextualize the importance of the integration of ecological science in landscape architecture, and clarify some assumptions that were made in this project. Chapter 2 is an interdisciplinary review of literature and case studies that are relevant to the project. Chapter 2 also reviews the project's conceptual framework, which delineates the integration of vegetation dynamics theory with long-term urban park design. Chapter 3 introduces the Long Branch site and its general characteristics, reviews the site inventory, and describes the vegetation inventory process. Analysis of the site and reference vegetation communities are also detailed here. Chapter 4 characterizes the vegetation communities on the site, describes existing and proposed vegetation typologies, and explains the design goals. Chapter 5 describes the site plan for the study area and breaks down the design interventions into 5 sections of the site. Chapter 6 discusses further recommendations in terms of programming, site interpretation, management, and monitoring. Chapter 7 summarizes the project and explains the applicability of this case study to comparable urban parks.

Background: Forest Loss in the Mid-Atlantic United States

In the Mid-Atlantic United States, most forests have been cut for timber or cleared for agriculture at least once since European contact. Thus, most of the forests we interact with today are relatively young. Even where forests are conserved, they are often faced with additional pressures of habitat fragmentation, air, water, and noise pollution, and invasive species, especially in urban areas (L. Johnson et al., 2020; Shifley & Moser, 2016). Forest loss and degradation lead to a loss of habitat for species that previously inhabited that area, and often lead to a decline in biodiversity of native species. When forests are fragmented, damaged, or replaced with other vegetation communities such as lawns, new types of habitat may be created, but species must be tolerant of modified environmental conditions (McKinney &

Lockwood, 1999). Urban environments act as filters, excluding species who are intolerant of harsher urban conditions and favoring those who can persist (Aronson et al., 2016). Climate change presents an overarching threat that will likely exacerbate biodiversity loss in yet unknown ways. However, understanding and monitoring the challenges facing our forested ecosystems is the first step to conserving and restoring them.

Ecosystem services provided by forests include water filtration, stormwater mitigation, carbon sequestration, air filtration, amelioration of heat island effects, wildlife habitat, noise pollution reduction, and stress reduction (Gómez-Baggethun & Barton, 2013). The productive capacity of a forest is directly linked to its ability to provide ecosystem services; therefore, it is vital that land stewardship aim to not only conserve forest area, but maximize forest health and productivity through active management (Franks & Jensen, 2003).

Increased urbanization and landscape degradation, among other factors, have led to a phenomenon known as the "extinction of experience" (Soga & Gaston, 2016). This is a cycle in which people spend less and less time interacting with and observing the natural world. The consequences of this include "deteriorating public health and well-being, reduced emotional affinity toward nature, and a decline in pro-environmental attitudes and behavior, implying a cycle of disaffection toward nature" (Soga & Gaston, 2016). The argument arising from this phenomenon is that in a rapidly urbanizing world, we must ensure that biodiversity is present "where people live and work", to drive increased interaction and affinity toward nature (Miller & Hobbs, 2002). It follows that urban parks must strive to support wildlife not only for wildlife's sake, but for the sake of humans' connection to it. In this realm, landscape architects can play a role by forging connections between people and ecosystems through the design and interpretation of landscapes (Gobster et al., 2007; Nassauer, 1995).

The loss of and damage to forest ecosystems due to human activity necessitates decisive restoration action in areas where forests grow naturally. In the rapidly urbanizing state of Maryland, whose population has doubled since 1950 and continues to grow, the challenge of sustaining healthy, ecologically functional forests looms large due to development pressure (Franks & Jensen, 2003). In

2016, there were an estimated 2,462 acres of forest in Maryland; the quality, ownership, and contiguity of those forests remains variable, and many of them remain under constant pressure of being cleared (US Department of Agriculture, 2016). However, there are many ways to protect, conserve, and steward existing forests, and to restore those that have been lost. Placing existing forest land into a legal category such as a conservation easement protects that land from development in perpetuity (Maryland DNR Forest Service, 2004). Regulatory mechanisms, such as Maryland's Forest Conservation Act, establish thresholds of development which correspond to afforestation requirements (Chesapeake Bay Foundation, 2004). Laws governing forest conservation and amelioration of development activity have gotten stronger in recent years in Maryland, due to watershed protection efforts and a recognized need for urban green space (Maryland DNR Forest Service, 2004). Forests may also spontaneously regenerate on abandoned or unmanaged land; in the past, these types of forests have provided key opportunities for studying ecological succession (Meiners et al., 2015). Finally, landscape practitioners can actively advocate and participate in the conservation and restoration of forests. This thesis will demonstrate how vegetation dynamics theory can be integrated with efforts to conserve and steward urban forest patches in the context of urban park design.

Strengthening the role of science in design

Landscape architects are uniquely positioned to facilitate both the restoration of urban ecosystems and the connection of people with those ecosystems. The link between landscape architecture and ecology has been forged through the realm of ecological design, which aims to unite ecological quality with design goals (Beck, 2013). Despite the growing prevalence of ecological design, ecological theory and concepts have been only selectively incorporated into landscape architecture practice. Further interdisciplinary visioning and research are needed to strengthen the relationship between design and science (Ahern et al., 2014; Lenzholzer et al., 2013; Swaffield, 2013). Incorporating adaptive management, post-implementation monitoring, and clear metrics into project conceptualization and

design can lead to improvements in landscape performance of current and future projects (Felson & Pickett, 2005).

An analytic framework created by Nassauer and Opdam (2008), proposes a route by which science can be integrated with design practice through knowledge innovation. Knowledge innovation is defined as "translat[ing] generalised scientific knowledge (e.g. on biodiversity) into spatially explicit landscape pattern rules (e.g. about habitat creation), and thence into locally expressed actions (e.g. a particular plan for landscape conservation and enhancement)" (Swaffield, 2013, 1194; Nassauer and Opdam, 2008, 635). In their model, design is a shared activity which functions as a bridge between science and society, allowing societal goal setting and scientific theory to participate in the same conversation. Following the idea of knowledge innovation, this thesis demonstrates one way of translating ecological theory into design directives which are then applied to a site.

Chapter 2: Literature Review

Vegetation Dynamics & Ecological Succession Theory

Main points:

- Modern succession theory focuses on individual species responses to site conditions, recognizes the importance of site context and history, recognizes that succession has multiple possible trajectories, and does not imply a prescribed endpoint (Meiners et al, 2015).
- Vegetation dynamics theory encompasses the idea of ecological succession.
- The three drivers of plant community change over time, according to the theory of vegetation dynamics, are differential site availability, differential species availability, and differential species performance (Pickett, 1987).
- Vegetation dynamics theory is applicable to landscape management and design (Luken, 1990).

Vegetation dynamics theory is a generalized framework for describing the mechanisms of plant community change over time (Meiners et al., 2015). Vegetation dynamics encompasses the process of ecological succession, which is the change in a vegetation community following an initial disturbance (Meiners et al., 2015). Whether or not a plant community is characterized as "successional", the primary drivers of vegetation dynamics as described in the theory remain the same (Meiners et al., 2015). Studying successional systems presents an opportunity to learn how to guide the trajectory of regenerating plant communities in the context of ecological restoration, landscape design, or land management. Due to anthropogenic landscape change and large-scale disturbances, more and more successional communities exist today in an ever-increasing variety of conditions, so understanding the mechanisms of successional processes means "understanding the forces regulating a significant portion of our modern landscape" (Meiners et al., 2015).

Ecological succession is one of the foundational themes around which the field of ecology has developed (Meiners et al., 2015). Despite major shifts, some of the ideas put forth by early developers of successional theory remain foundational today (Steward T. A. Pickett et al., 2009). In 1916, Frederic E.

Clements published one of the first descriptions of ecological succession as a sequence of processes (Clements, 1916). Clements conceptualized vegetation communities as discrete units or organisms, separated by differences in environmental conditions in which they naturally grew (Meiners et al., 2015). Clements' theories were countered by Henry Allen Gleason, who challenged the "organismal" view by stressing the importance of individual species performance (Gleason, 1917). Rather than following a predictable trajectory within discrete boundaries, Gleason posited that succession was driven by the responses of individual species to environmental conditions, and asserted that the boundaries between plant communities were not as strictly defined as Clements had argued (Gleason, 1917). This created a foundational theoretical divide: one viewed succession as a series of consistently associated species working together to form an "organism", the other a series of individuals responding to their environment. It was Gleason's individualistic approach that would eventually be affirmed by future studies (Steward T. A. Pickett et al., 2009).

Following the Clementsian paradigm, the idea of *relay floristics* took hold in the early to mid-20th century. Relay floristics posited that defined waves or "relays" of plant communities establish and take hold in a predictable sequence throughout successional stages until a stable state is reached (Luken, 1990). This now obsolete idea was challenged in 1954 by Frank Egler, who emphasized that the initial composition of propagules and seeds on a site is an important driver of successional trajectories (Egler, 1954). Egler's *initial floristic composition* idea again emphasized the importance of individual species responses and site-specificity. Later studies in successional theory shifted from studying patterns of vegetation change (phenomenological approach) to delineating the mechanisms behind the patterns (mechanistic approach) (Meiners et al., 2015). The shift in focus toward individual plant responses in successional research also continued through the late 20th century. Drury and Nisbet (1973) conceptualized succession as a series of individual species responses to changing resource gradients over time (Drury & Nisbet, 1973). In 1977, Joseph H. Connell and Ralph O. Slatyer put forth three potential models of successional change: *facilitation, tolerance,* and *inhibition* (Connell & Slatyer, 1977). Further research revealed that all three of these models may occur in plant communities, sometimes

simultaneously; in other words, plants may facilitate the success of others, tolerate the success of others, or inhibit the success of others, depending on site conditions (Meiners et al., 2015). In 1987, Pickett et. al. developed a conceptual model delineating the general causes of vegetation dynamics, their contributing processes, and the factors modifying them (Luken, 1990; Pickett et al., 1987). This generalizable model encompassed many aspects of successional theory, and it is the theory on which this thesis is based.

Through these theoretical shifts, ecologists have struggled to conceptualize an endpoint to succession. Early theories posited that succession always ends in a "climax community", in which a state of equilibrium is reached and "stabilization" occurs (Clements, 1916; Meiners et al., 2015). The concept of a climax community has now been rejected and the equilibrium idea replaced by the idea of *dynamic equilibrium* which recognizes the dynamism and change ever-present in plant communities (Meiners et al., 2015; Walker et al., 2007). Meiners et. al. (2015) describes the end of succession as a point in time when vegetation dynamics are no longer driven by the disturbance that initiated the successional process. Importantly, however, in an era of compounding global ecological crises, fewer ecological communities can be described as having reached a state of dynamic equilibrium. In other words, more large-scale disturbances in the form of severe weather events, human development, and land use change may lead to more communities being classified as successional, making the question of the existence of a successional endpoint almost moot (Meiners et al., 2015). In this context of ecological uncertainty, it may be more useful for landscape practitioners to accept change as constant and ask how humans can impact ecosystem dynamics in a way that encourages positive change (M. Hunter, 2011; Palmer et al., 2016).

The theory of vegetation dynamics put forth by Pickett et. al. (1987) has three main components. The first is *differential site availability*, which relates to the conditions of the site in which vegetation may grow. Sites are made available by disturbances that modify the resource availability in an existing plant community or by events that create new surfaces that were not previously occupied by plants (Meiners et al., 2015). For example, Figure 1 shows a small sunny area of open soil in the forest where a plant could potentially grow. The environmental conditions of a given site are determined by moisture levels, nutrient availability, sunlight, and any other factor that may affect the ability of a plant to germinate and grow.

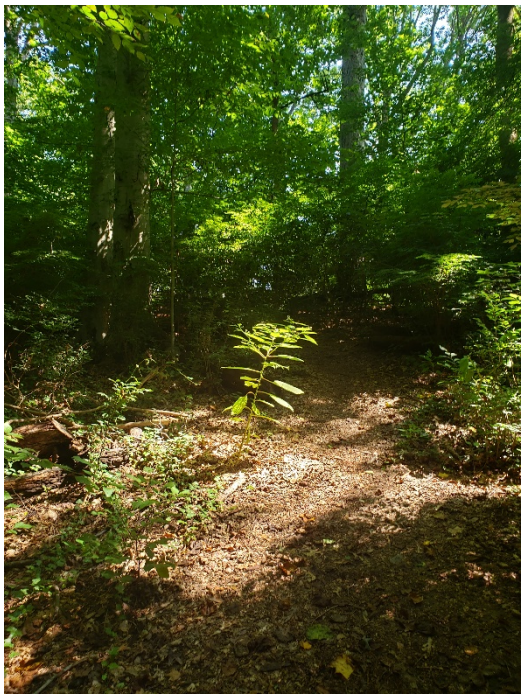


Figure 1: Sunny canopy gap at Long Branch forest. Photo by author.

The second driver of vegetation dynamics is *differential species availability*, which relates to any plant species that may colonize a given site when the site becomes available. In Figure 1, this would refer to all the plants surrounding the sunny canopy opening, any in the seed bank, and any plants that could be dispersed to that site by other means. When a species disperses propagules in a site, this is referred to as *dispersal rain*. Dispersal rain is influenced by the degree of *landscape connectivity* and by the presence of dispersal vectors such as animals, wind, or water. Species may already be present on the site in the *propagule pool* or seed bank, which includes plants that remain after a disturbance. The availability of species in the propagule pool is influenced by the site's current and previous land use and the mortality rate of propagules (Meiners et al., 2015; Pickett et al., 2009). The third driver of vegetation dynamics is *differential species performance*, which refers to the physiological, life history and ecological interactions of plants on a site (Meiners et al., 2015). Species performance can be conceptualized as an emergent property of species availability and site availability acting together and is driven by several mechanisms relating to ecological interactions and environmental constraints on a given site. A species' life history, physiology, and stress tolerance level will determine how it responds to environmental

conditions. Site-specific interactions, such as competition, chemical interference from other plants or microbes, and consumers, further determine species performance (Meiners et al., 2015). For example, our canopy gap plant could eventually find the site too hot and dry to survive, or it could be trampled by a person or eaten by a deer (Figure 1).

The theory of vegetation dynamics can be used to describe the successional development of any plant community. It can also be applied to planting design and management. Luken (1990) applies the model's three components to specific management actions that constitute *managed succession*. He links site availability to the idea of "designed disturbance", species availability to "controlled colonization", and species performance to "controlled species performance". For example, the act of vegetation cutting affects all three drivers of vegetation dynamics: it partially clears a site which another plant may colonize, reduces the availability of a particular species, and modifies the ability of that species to compete.



Figure 2: A successional community in Philadelphia, 2019. Photo by author.

Successional communities are often characterized in terms of how their structure and composition changes following an initial disturbance. When soil is absent on a disturbed site, succession often takes five to ten times longer than it would if soil were present (Barbour et al., 1980). At any point in the trajectory of a vegetation community, small or large scale disturbances can bring different parts of the community to different successional stages, creating a mosaic of differently aged patches (Barbour et al., 1980; Forman, 1995). This applies to all vegetation communities, including intact and conserved forests; disturbance regimes can be natural or anthropogenic, and the effect on vegetation dynamics depends on a

disturbance's size, severity, and frequency (Holl, 2020). In the Mid-Atlantic United States, successional communities may occur in surprising places such as on the surfaces of long-abandoned infrastructure (Zipperer, 2011). For example, Figure 2 shows an early successional community on an abandoned elevated railway in Philadelphia. The railway bed was covered in gravel and was not previously occupied by vegetation; the plants that thrive there now are dry meadow grasses and shrubs that tolerate poor soil conditions. Additional examples of successional communities may be found in abandoned agricultural fields, forests recently cleared for timber, and unmanaged land such as vacant lots. In the Mid-Atlantic United States, forests grow naturally in most places; successional communities will eventually become dominated by trees if left unmanaged.

Any design or management intervention in a plant community engages with vegetation dynamics, even if it is not discussed in those terms. Viewing design and management interventions as actions that affect site availability, species availability, and species performance does not necessarily change what those actions are, but it can contextualize them on a temporal scale and help facilitate engagement with ecological concepts. Using this framework to invite successional dynamics and vegetation change into the design process can be an exciting step forward for ecological applications in landscape architecture.

Urban Plant Communities

Main points:

- Social-ecological approaches are important in the study of urban ecosystems.
- Many native species in the Mid-Atlantic U.S. do not thrive in urban environments, but cities can and sometimes do support high levels of biological diversity.
- Invasive species threaten biodiversity within and outside of urban systems.

Urban plant communities exist on a wide spectrum of composition, structure, and management regimes, from lawns to forests and from abandoned to manicured. In working with the ecological dynamics of human-dominated environments, it is helpful to conceptualize them as *social-ecological* systems (Irwin, 2019; Ostrom, 2009). In addition to the biological and physical components of ecosystems, a social-ecological framework includes social and constructed components introduced by

human culture and action. It makes explicit that humans are active participants in any ecosystem in which we live, and the study of human-dominated ecosystems should reflect that. The idea of humans as active participants in urban ecosystems may seem obvious to some, but it has not always been incorporated in ecological studies (Cadenasso et al., 2007).

The importance of incorporating these realities reveals itself in the results of urban ecology research. The overall decrease of biological diversity at local, regional, and global scales due to human activity is well-documented, but ecosystem patterns at smaller scales present a complex picture (M-NCPPC et al., 2020)(McKinney & Lockwood, 1999). Long-term ecological research such as the Baltimore Ecosystem Study has revealed that while urban ecosystems can provide substantial ecosystem services and exhibit high levels of biodiversity, anthropogenic factors remain the "ultimate drivers of ecosystem change" (L. Johnson et al., 2020, page 2; Kowarik et al., 2020). Species richness is often high in urban areas due to factors such as the introduction of plant species by people and a high degree of heterogeneity in habitat conditions in the urban landscape (Cadenasso et al., 2007; Irwin, 2019). Species richness may be high while taxonomic, phylogenetic, and ecosystem type diversity can be low, and all of these metrics have implications for ecological function (McKinney & Lockwood, 1999). The concentration of native plant and animal species is generally much lower within urban areas than outside of them; again, high species richness counts include nonnative species such as those used in ornamental plantings (Aronson et al., 2014). Native species biodiversity is threatened by the introduction of non-native invasive species, and urban environments are hotspots for the introduction of these species (Gaertner et al., 2017; Green & Grosholz, 2021; Kowarik et al., 2020). The findings of urban ecology research highlight the importance of conserving existing intact vegetation within urban areas, preventing and controlling non-native invasive species invasions, and consistently managing urban ecosystems for long-term health (Aronson et al., 2014; Green & Grosholz, 2021; Johnson & Handel, 2019).

An awareness of broad patterns of urban biodiversity can inform the local decision making of landscape practitioners and provide important context for urban ecosystem stewardship. Aronson et al. (2016) provide a framework for understanding how urban species pools develop in response to modified

urban conditions. Species first must be adapted to regional climate, biogeography, and land use patterns. In urban environments, species are then filtered out by human facilitation of certain species over others, and further modified by urban form and landscape history. Human facilitation and species interactions again modify species compositions at local scales. Returning to vegetation dynamics theory, species pools determine species availability on a site, which is one of the major drivers of vegetation change over time (Pickett et al., 1987). Conceptualizing the diverse cultural, physical, biological, and built conditions of cities as filters for ecological communities can help us grasp the complexity of urban ecosystems and the importance of attention to context.

Urban Forests and Streams in the Mid-Atlantic United States

Main points:

- Human actions are major drivers of urban forest trajectories and stream conditions.
- Urban forests and streams face elevated levels of stress.
- Protections for urban forests and streams have grown stronger in recent years.

Forests grow naturally in the Mid-Atlantic United States, and for a variety of reasons, many conserved urban forest patches are located along riparian corridors. A forest is defined here as "an ecosystem type with a closed, interlocking canopy, containing multiple vegetation layers such as an understory, shrub layer, and ground cover layer" (Barbour et al., 1980). It is important not to conflate this with the idea of tree canopy, because an area with tree canopy cover may not contain any other structural layers; for example, a street with large trees planted in tree pits, or a residential lawn with large canopy trees providing shade. Forest definitions vary, but in this study a forest necessitates the presence of multiple structural layers apart from the canopy. Urban streams are small flowing bodies of water that may or may not pass through urban forests but are located within the urban matrix (Walsh et al., 2005). Urban forests and streams face exacerbated levels of stress compared to those in non-urban areas. Increased levels of negative anthropogenic disturbance such as land clearing, trampling, trash dumping, and arson are more prevalent in cities (NYC Department of Parks & Recreation, 2015; Zipperer, 2011).

As mentioned above, cities are hotspots for invasive species introductions, putting competitive pressure on native species (Gaertner et al., 2017). Urban temperatures are often higher in cities due to impervious surface cover and the heat island effect, which some species cannot tolerate (Hobbie & Grimm, 2020). Impervious surface cover also leads to elevated levels of stormwater runoff being channeled into urban water bodies, carrying with it elevated nutrient and pollutant loads (Ehrenfeld, 2008; Walsh et al., 2005). These conditions constitute some examples of "filters" determining which species will persist in urban species pools (Aronson et al., 2016). These compounding factors, among others, create the conditions for highly altered vegetation succession trajectories in urban ecosystems (Johnson & Handel, 2019; Zipperer, 2011).

Urban forest and stream conditions are also driven by patterns in urban development and the structure of the built environment. Urban forests are often highly fragmented or divided into smaller areas by roads, areas of cleared land, or other infrastructure. Fragmentation increases the area of forest edge and reduces the area of interior forest, leading to reduced habitat for forest interior species, which are often of conservation importance (Forman et al., 1996). Increased edge area leads to increased prevalence of sometimes detrimental edge effects, which are changes in environmental conditions at the point of transition between two patches (Beck, 2013; Forman, 1995). Urban forests in the Mid-Atlantic are often surrounded by unvegetated patches, leaving their edges vulnerable to wind throw, increased drying from sun exposure, and colonization by invasive species that thrive in edge habitats (Forman, 1995; Matthews et al., 2016). The spatial extent of edge effects can vary depending on the orientation of the edge; the specific edge effects mentioned here are most prevalent on south and west-facing forest edges where sun exposure is greatest (Forman, 1995).

Urban development patterns affecting streams are predominantly related to the presence of stormwater infrastructure that directs surface runoff into urban water bodies. Urban streams are often buried or channelized during development; smaller water bodies such as headwaters streams are more consistently buried than larger water bodies (Elmore & Kaushal, 2008). During storm events, urban streams experience higher surges of stormwater in shorter periods of time due to water being efficiently

channeled into stream bodies instead of infiltrated into the ground. Among other effects, this leads to an increase in stream bank scouring, stream channel incision, less retention of stream bank vegetation, and disruption of aquatic species habitats (Hughes et al., 2014; Walsh et al., 2005). Figure 3 shows an example of stream bank scouring on the site studied in this thesis. Urban streams also often experience elevated inputs of nitrogen and phosphorous, suspended solids, contaminants such as petrochemicals, and sometimes sewage due to issues of combined overflow (Walsh et al., 2005). Deforestation around stream corridors can cause elevated water temperatures and sediment loading, which alters aquatic habitat (Walsh et al., 2005). Finally, nonnative invasive plants which thrive in riparian conditions are often disruptive to urban stream ecosystems (Aronson et al., 2017; Ehrenfeld, 2008). *Urban stream syndrome* is a term used to describe the confluence of these degraded stream conditions (Hughes et al., 2014; Walsh et al., 2005). Though the urban stream syndrome is complex and multifaceted, studies emphasize that ameliorating the negative effects of development on urban streams should focus on watershed-scale approaches to mitigating stormwater runoff volume (Elmore & Kaushal, 2008; Hughes et al., 2014; Walsh et al., 2005).



Figure 3: Stream bank scouring, Long Branch, MD. Photo by author.

Inventories of urban forests in the Mid-Atlantic have revealed some common patterns, many of which were found to be present on the study site. In a survey of 100 coastal urban forest sites across the Chesapeake and Delaware Bay watersheds, Johnson et al. (2020) found that non-native plants were present in 94% of forest plots, over half of all shrubs were invasive, most trees were native, but there was

a dearth of tree saplings, and deer herbivory was common. Similar trends were reflected in documentation of existing conditions on restoration sites in New York City Parks; other important anthropogenic impacts there included trampling, arson, and trash dumping (NYC Department of Parks & Recreation, 2015).

Overall, urban forests and streams are under disproportionate pressure to provide habitat as well as important ecosystem services (Johnson & Handel, 2016). There is also growing recognition of the importance of access to high-quality ecological systems as a remedy to the "extinction of experience" phenomenon (Soga & Gaston, 2016). The negative impacts of urban development on forests and streams in the Mid-Atlantic, combined with the acknowledged importance of access to these systems for an increasing urban population, have contributed to increased protection for these areas in recent years and highlight the importance of urban forest stewardship. For example, the Maryland Forest Conservation Act mitigates forest loss during the development process (Maryland DNR Forest Service, 2004). Also in Maryland, stormwater best management practices (BMPs) are mandated during new construction projects to increase stormwater infiltration. At a broader scale, the Chesapeake Bay Agreements mandate multi-state implementation of watershed protection measures, leading to increased resources for watershed restoration efforts which include ecological restoration. Statewide projects such as the Maryland Green Infrastructure Assessment characterize and map the state's vegetated areas in an effort to guide landscape connectivity and identify areas of conservation priority (Maryland DNR, 2021). The effectiveness of the practices influenced by these policy solutions is beginning to be assessed, but the long-term effectiveness is yet to be determined. For the future trajectory of urban forests and streams, however, the increased strength of environmental protections in urban areas in the Mid-Atlantic is promising.

Urban Forest and Stream Restoration Strategies

Main points:

- Ecological restoration principles and strategies can be used in design projects.
- Relevant urban forest restoration strategies include community engagement, consistent management, intensive invasive species removal, and species packing in all forest layers.
- Relevant urban stream restoration strategies include watershed-scale stormwater management, bank revegetation, and erosion control structures.

Ecological restoration is "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (Gann et al., 2019). Restoration reignites ecosystem processes that had been interrupted, recovers biodiversity, restores ecosystem services from which people benefit, facilitates human-nature connection, and provides a common pursuit around which people can unite (Aronson & Clewell, 2013). Though the practice of ecological restoration is relatively young, some key findings and best practices have been revealed through monitoring and research. This section will review general restoration principles that apply to this project as well as some important considerations in the restoration of urban forests and streams in the Mid-Atlantic United States.

Though community engagement was outside the scope of this project, it should be noted here that community engagement has been found to improve both the public perception and ecological outcomes of restoration projects (Holl, 2020; Sorensen et al., 2018). Community engagement describes a range of possible ways in which people can engage with a project, from simply knowing about its existence to participating directly in restoration activities. The dedication of resources that marks the beginning of a restoration project should include setting guidelines for the long-term management and stewardship of the project (Aronson & Clewell, 2013; Holl, 2020). In urban restoration projects, public support is particularly important to the success and longevity of restoration programs (Gobster et al., 2016; NYC Department of Parks & Recreation, 2015). Though these are all context-dependent, public support for restoration projects has been found to be linked to people's knowledge about the project, the nature of management techniques used, and various sociocultural factors, depending on the community (Gobster et al., 2016; Holl, 2020). Public engagement through direct participation in restoration activities can also be

a major driver of long-term stewardship and support (Sorensen et al., 2018). The literature reviewed suggests that a multi-faceted approach which allows early and continuous engagement with the restoration process through community partnerships and clear distribution of information about the project can garner support from the public (Aronson & Clewell, 2013; Gobster et al., 2016; NYC Department of Parks & Recreation, 2015; Sorensen et al., 2018).

Ecological restoration and ecological succession are intrinsically linked. Ecological succession is the change in plant communities following a disturbance, and restoration implies an intervention to assist in that process in order to achieve specific goals (Walker et al., 2007). Ecological design can borrow techniques from restoration science, and practitioners can consciously set restoration goals as part of design conceptualization (Beck, 2013). The types of ecological restoration relevant to this case study are *assisted regeneration, forest or landscape restoration,* and *reforestation* (Gann et al., 2019; Holl, 2020). They are defined as follows:

Assisted regeneration: "A restoration approach that focuses on actively harnessing any natural regeneration capacity of biota remaining on-site or nearby."

Forest or landscape restoration: "A planned process that aims to regain ecological functionality and enhance human well-being in deforested or degraded landscapes."

Reforestation: "Planting trees on lands that were previously forested."
All referenced from Gann et al. 2019.

Restoration actions are determined by the goals that are set at the beginning of the restoration process. Often, these goals are guided by an *ecological reference,* which may be a nearby intact site that exhibits ecological conditions to strive for in a restoration project (Aronson & Clewell, 2013; Palmer et al., 2016). Because of the complex landscape legacies and disturbance regimes present on urban sites, there may be no reference landscape that matches site conditions (Holl, 2020; Palmer et al., 2016). In these cases, reference sites can provide an idea of conditions to strive for or plant species to use, and site constraints then determine what can be reasonably achieved (Palmer et al., 2016). In other words, on

highly modified sites, restoration goals can still be set which aim for adaptive capacity within a range of desired conditions. In urban settings, assessing what is within the realm of possibility given site-specific conditions may be a more useful strategy for some sites than sticking strictly to the conditions present in a reference site (Palmer et al., 2016).

Beginning a restoration project with a thorough assessment of abiotic and biotic site conditions also helps shape restoration goals and strategies (Holl, 2020). If habitat restoration for native plants and animals is part of restoration goals, suitable abiotic site conditions for target species must be restored first; native biota are unlikely to survive if the abiotic conditions in which they thrive are not present (Holl, 2020). It is also important to identify the major issues or negative disturbances that are inhibiting ecological quality on the site, whether those are biotic or abiotic (Holl, 2020; Palmer et al., 2016). In Mid-Atlantic urban forests, some common elements that may be observed are trampling by humans, deer herbivory, excessive stormwater runoff, and invasive plant species (Aronson & Handel, 2011; NYC Department of Parks & Recreation, 2015). Ameliorating major negative impacts as a first stage in a restoration project may pave the way for positive outcomes in future stages (Aronson & Handel, 2011; Holl, 2020; Johnson & Handel, 2016).

Invasive species are a major threat to ecosystems in both urban and non-urban areas. Because of the stressors already present in urban forests, these forests may be more vulnerable to colonization by invasive plant species (Beauchamp et al., 2013; L. Johnson et al., 2020). Invasive plant management is likely to be a crucial step in most urban forest restoration projects, so some general strategies for it are reviewed here. Invasive species removal can be done by mechanical, manual, and chemical means, depending on the species present, the laws determining chemical use on the site, and the scale of the problem (Holl, 2020; Johnson & Handel, 2016; Luken, 1990; M-NCPPC et al., 2020). The timing of invasive species treatments is essential and should consider the life history characteristics of the problem species (M-NCPPC et al., 2020). Even after removal, propagules of invasive plants are likely to persist in the seed bank (Beauchamp et al., 2013; M-NCPPC et al., 2020; NYC Department of Parks & Recreation, 2015). In response to this, it may reduce future management to allow several life cycles of invasive plants

to germinate from the seed bank and be exterminated (NYC Department of Parks & Recreation, 2015). Changing abiotic conditions that favor problematic invasive species may also be an important strategy for their suppression; this can be a long-term planting design strategy (Holl, 2020). For example, creating more shade in sunny riparian areas or forest edges could help suppress shade-intolerant invasive species. Even with these interventions, however, it is important to note that total eradication of invasive species may be near impossible given limited management resources (Green & Grosholz, 2021). Instead of setting the goal at total eradication, Green and Grosholz (2021) propose *functional eradication* as a management framework for invasive species; this is defined as "suppressing invader populations below levels that cause unacceptable ecological effects". Overall, invasive plants can be managed by a combination of initial mass removal, follow-up treatments, and long-term management.

Post-implementation studies of urban forest restoration projects have shown that planting native species following invasive species removal effectively encourages native plant regeneration in urban forests, and may in many cases be more beneficial than invasive species removal alone (Aronson & Handel, 2011; Johnson & Handel, 2019). A compendium of urban forest restoration strategies developed by New York City Parks and Recreation's Natural Resources Group (NRG) recommends *species packing* as a strategy to suppress invasive species and build native structural and species diversity (Bazzaz, 1996; NYC Department of Parks & Recreation, 2015). This recommended strategy is characterized by dense planting following invasive species removal in all structural layers of the forest. Aside from its success in the context of NYC parks, there are many reasons to support the species packing strategy. For example, species packing may decrease colonization by shade-tolerant invasive plants while increasing native species availability (Beck, 2013; Pickett et al., 1987). Additionally, some studies suggest that planting native shrubs alongside trees bolsters tree growth and survival rates (Oldfield et al., 2015). Finally, a rapid restoration of vegetation structural diversity would quickly benefit wildlife, especially birds (Cerra & Crain, 2016). Generally, the idea of excluding invasives by filling structural and temporal niches with native plants is a strategy in urban planting design as well as urban forest restoration (Beauchamp et al., 2013; Holl, 2020; West & Rainier, 2015).

One limitation of this strategy is that there may not be native species in the Mid-Atlantic that fill all niches occupied by invasive plants. This is especially apparent on the ground layer of the forest, where total plant cover is not typical in the ground layer (USNVC, 2021). For example, *Hedera helix* (English ivy) is an invasive evergreen ground cover that is commonly found on forest floors, and there is no native equivalent that grows quite so vigorously. These are areas where invasive species management must be especially focused. Additionally, if natural regeneration falls short in any structural layer, *enrichment planting* may be necessary to build desired population levels (Holl, 2020). In terms of vegetation dynamics theory, these strategies would mean increasing the species availability of native plants in all structural layers of a forest while reducing species availability of invasive species (Pickett et al., 1987).

Another important consideration in restoration work is plant species selection. Species used in restoration projects can be selected based on the ecological reference chosen for the project, and can be supplemented with others based on site constraints and needs (Falk et al., 2016). Plant selection should consider species' life history, growth rate, light and moisture requirements, tolerance to urban conditions, vulnerability to pests and herbivores, and wildlife resource provision; it can then be judged whether species with given attributes are appropriate for a site (Conway & Vander Vecht, 2015; Darke & Tallamy, 2014; NYC Department of Parks & Recreation, 2015). Where people are present, it is also important to consider the aesthetics of selected plant species: their visual interest, edibility or toxicity, scent, and texture (West & Rainier, 2015). Finally, climate change is an important consideration in species selection; tools such as those provided by the US Forest Service's Climate Change Atlas are informative in projecting potential suitability of habitat for specific plant and animal species (USDA Forest Service Northern Research Station, 2021). Categorizing species by these criteria can help form planting design schemes that suit site conditions, provide aesthetic interest, and can reasonably be expected to survive.

To bolster biodiversity and native species availability in restoration plantings, it is also beneficial to plant a diverse selection of species in each forest structural layer (Beck, 2013). There are many different types of diversity; this section will focus on functional, species, and structural diversity. *Species diversity* is ecologically important because the evolutionary relationships that native plant species have

with native animal species allow native plant communities to support native animal communities (Burghardt et al., 2009; Tallamy, 2009). Some generalist animal species can be supported by a wide variety of plants, but more specialized ones depend on specific plants as part of their life cycle (Tallamy, 2009). The concept of *species function* refers to the niche that a species fills in an ecosystem – functional diversity indicates an array of different niches being simultaneously filled (Beck, 2013; M. R. Hunter & Hunter, 2008). It may also be helpful to choose a series of species with similar functional niches as problematic invasives so that those niches are not available for colonization (Holl, 2020). Some studies suggest that functional diversity may be a better indicator of ecological function than is species richness, which is simply a count of the number of species (Beck, 2013). It is also important to consider the role of *functional redundancy*: multiple plants fulfilling the same niche can lead to greater resilience in the case that one of those species does not survive (M. Hunter, 2011). *Structural diversity* refers to the spatial distribution of vegetation growth forms, both above and below ground (West & Rainier, 2015). Planting all structural forest layers simultaneously would create vertical structural diversity quickly, but in selecting a resilient species mix within each structural layer, it is important to consider structural niches below ground as well. Planting species with diverse root morphologies can decrease competition among native species and lead to increased planting success (Beck, 2013; West & Rainier, 2015). For example, The NYC Parks report recommends interspersing species that reproduce clonally with species that do not (NYC Department of Parks & Recreation, 2015). Aiming for species, structural and functional diversity in restoration plantings may help bolster plant success, competitively exclude invasive species, provide seasonal interest for humans, and provide more shelter and food source diversity for wildlife (Beck, 2013; M. Hunter, 2011; NYC Department of Parks & Recreation, 2015).

Finally, a restoration planting scheme should consider that initial restoration plantings will set the stage for the successional trajectory of the landscape. One way to account for this is to plant a mixture of early and late successional species so that as shorter lived early successional species die off, the number of native plant propagules in the seed bank increase (Beck, 2013; NYC Department of Parks & Recreation, 2015). This strategy accounts for successional dynamics by anticipating cycles of growth and

senescence and creating conditions under which native species are more likely to fill available sites. If forest cover is desired in a yet unforested area, succession can be encouraged by planting clusters of trees in those areas to attract perching birds who disperse species from other areas (Holl, 2020; Robinson & Handel, 2000). Importantly, however, many invasive plants in the Mid-Atlantic are also bird-dispersed; this highlights the need for consistent management of invasive species during the restoration process.

Urban streams within urban forests are likely to benefit from forest restoration efforts. For example, planting riparian shrubs and trees on or near stream banks may reduce stream sedimentation and bank erosion. Furthermore, new plantings would absorb stormwater runoff, which would decrease the amount of runoff that reaches the stream and may increase water quality (Booth et al., 2004; Holl, 2020). However, the origins of many problems faced by urban streams originate offsite, so it is important to address those issues before or simultaneously with in-stream restoration efforts (Bernhardt & Palmer, 2007; Booth et al., 2004; Hughes et al., 2014). In urban settings, the strategic placement of stormwater infiltration structures such as bioswales and rain gardens can help mitigate runoff and provide visual interest (Everett et al., 2018). After or alongside these implementations, in-stream restoration techniques may be used (Bernhardt & Palmer, 2007; Hughes et al., 2014). Figure 4 illustrates the in-stream restoration technique of *live staking*, which aims to revegetate and stabilize stream banks (NRCS, 2020). *Salix* (willow) species of trees and shrubs are commonly used for this purpose, but other riparian species that grow from cuttings can be used as well (NRCS, 2020). Depending on site-specific needs, this technique can be combined with bank protection using structures such as geotextiles, rocks or boulders, and gabion baskets. If live stakes or cuttings are used on a large scale, care should be taken to ensure genetic diversity in the source cuttings (Holl, 2020). Where it is needed, riparian revegetation presents an opportunity for unique and diverse restoration plantings that can provide ecological and aesthetic benefits.

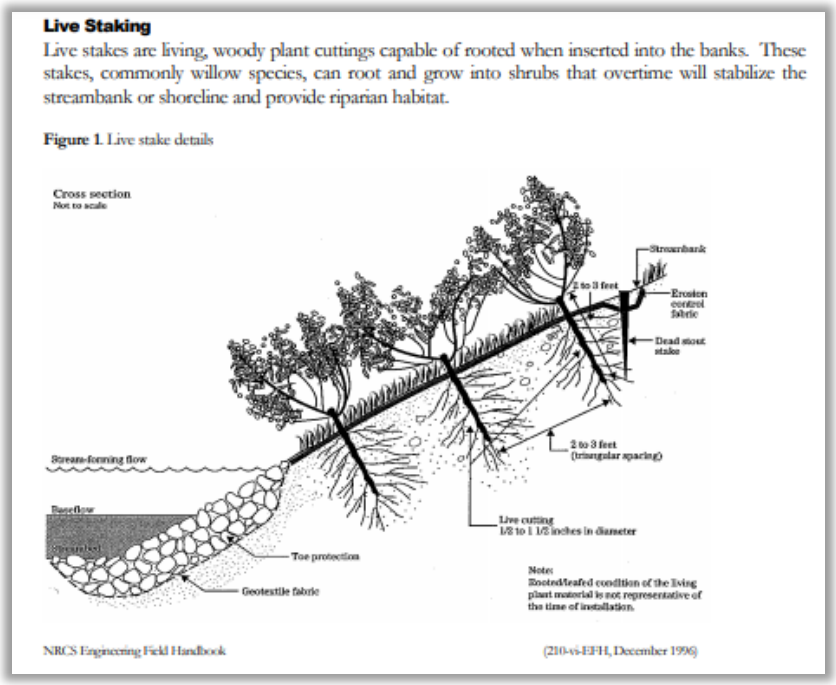


Figure 4: Live staking – bank stabilization diagram (NRCS 1996)

A final important consideration is that of plant material sourcing. Generally, plant sourcing is important because the origin and growing conditions of seedlings can affect plant establishment and growth, potentially spread unwanted plant species or pathogens via nursery soil, and affect the long-term genetic integrity of plant populations (NYC Department of Parks & Recreation, 2015). Havens et al. (2015) point out that restoration practitioners often stress sourcing seeds as locally as possible, but that the assumption that local is best may not always make sense in the context of climate change and ecological uncertainty. Whether locally sourced or not, ensuring genetic diversity in the supply of restoration plants is important for the longevity and adaptability of plant populations (Beck, 2013; Havens et al., 2015; NYC Department of Parks & Recreation, 2015). Holl (2020) points out that it has become increasingly popular to collect seeds from a variety of sources, environmental gradients, and disturbance conditions to ensure genetic diversity; those seeds can then be grown in a nursery and used on a restoration site. Options for plant sourcing will depend on project goals and resources, plant availability, and local seed collection and propagation initiatives.

Anticipating the unique pressures faced by urban ecosystems and drawing on past urban forest restoration practices will guide the success of future projects (Johnson & Handel, 2019). Numerous studies reveal the effectiveness of consistent, long-term management interventions on ecological outcomes in urban restoration projects and even suggest that urban forests may not be capable of sustaining goal conditions without human intervention (Johnson & Handel, 2019; Sorensen et al., 2018).

This highlights the importance of refining and studying the outcomes of urban restoration initiatives over the long term.

Ecological Planting & Landscape Design

Main Points:

- Ecological planting design originates from the connection between plants and place.
- Ecological design attempts to unite ecological function with design goals.
- Ecological landscape design should integrate both object and process-based approaches.

Ecological planting design originates from the connection between plant and place. Woudstra (2004) traces the origin of "ecological planting" to scientist and adventurer Alexander von Humboldt (1769-1859). Through his travels to disparate regions of the Earth, Humboldt drew a connection between plant communities and their environmental conditions. In Humboldt's time, neither the discipline of ecology nor the discipline of landscape architecture existed in name, yet Humboldt laid the conceptual foundation for the idea of connecting plants to place. His publications and iconic diagrams inspired new styles of planting design in Europe, termed *phytogeographical planting,* and this eventually became *ecological planting* (Woudstra, 2004). Later, the discipline of ecology (from Ernst Haeckel's term '*Oekologie'*) would be established largely by plant geographers (Woudstra, 2004).

Some landscape architects in the 19th and early 20th century developed a conservation ethic in response to rapid landscape loss due to urbanization and industrial development. Frederick Law Olmsted, for example, advocated tirelessly for land conservation for large urban parks in the late 19th century. In the early 20th century, Jens Jensen used locally native plants to forge an awareness and emotional connection to native landscapes that were rapidly being destroyed for development (Grese, 1992; Woudstra, 2004). Later in the 20th century, practitioners such as Darrell Morrison continued in the tradition of Jens Jensen, creating ecologically-inspired designs on landscape and site scales, outlining a methodology for ecological landscape design that aims to "reconnect our designed landscapes with the natural heritage of the region...and restore regional landscape character" (Morrison, 2004). On a planning

scale, landscape architect Ian McHarg pioneered an ecological approach to landscape architecture based on early geographic information systems (GIS) technology, aiming to locate the least ecologically harmful outcome in terms of development (McHarg, 1969). More and more practitioners today are integrating ecological goals into built work, exemplified by the practice of interdisciplinary firms such as Biohabitats and Andropogon.

Table 1: The Spectrum of Ecological Planting Design

FOCUS ON NATIVE SPECIES IN DESIGN	PLANTING DESIGN TYPOLOGY				
	Formal planting	Informal planting	Stylized nature	Biotope planting	Habitat restoration
Native Species Only	Formal garden aesthetics with natives	Informal garden style with natives	Naturalistic style, using only natives, no succession	Designed for visual impact, only natives planted, some succession	Ecologically restored landscape, managed for public access
Native & Non-native mix	Formal garden aesthetics with mix	Informal style with mix	Naturalistic style, using mix, no succession	Designed for visual impact, selected nonnatives, some succession	Restored or successional, managed for public access
No emphasis on natives	Formal style, mostly exotics, static	Informal style, mostly exotics, static	Naturalistic style, many exotics, no succession		
STATIC (formal)	< ----------			---------->	DYNAMIC (successional)

Relationships between native species-focused design and planting design typology. Adapted from Kingsbury, 2004, in "The Dynamic Landscape", page 60. Orange squares indicate types of projects that are the focus of this study.

In spite of the inspiration landscape architects have drawn from ecological systems, ecological concepts have been incorporated in design projects to varying degrees. A useful distinction is drawn by Dagenais (2008), who posits that ecological applications in landscape architecture can be described as either "object-oriented" or "process-oriented". An object-oriented approach engages with the immediately tangible elements in a landscape, such as plants, soils, and building materials, more than it

engages with long-term landscape processes such as energy flows, biogeochemical cycles, and successional changes (Dagenais, 2008). The immediate applicability of an object-based approach is more in line with the time frame of most design projects, and a process-based approach would involve more long-term thinking as well as deeper engagement with ecological science (Dagenais, 2008). For this reason, it is easier for landscape practitioners to engage with object-based approaches; for example, using native plants instead of exotic plant species in a designed planting. Engaging with both object and process-based approaches could be an important step forward in further engagement with ecological theory for landscape architects.

The degree of engagement with long-term landscape dynamism and change, or "process-based" approaches, can be an important concept in the characterization of ecological design applications (Dagenais, 2008; Kingsbury, 2004; Woudstra, 2004). Adapted from Kingsbury's diagram (2004), Table 1 shows ecological design as spectrum in terms of planting design typologies, the degree of focus on native species, and the degree of dynamism embraced in the design. According to this framework, "formal planting" design maintains plantings in a static condition, as opposed to habitat restoration, which embraces dynamic successional processes to a larger degree. Native plants can be used in all typologies here, but the degree of landscape dynamism may differ according to the design intent. The squares on the chart highlighted in red represents the categories of planting design that are used in this thesis project, here described as "stylized nature", "biotope planting" and "habitat restoration". Kingsbury (2004) defines *biotope planting* as "a plant community with all the dynamism of wild habitat...but whose species mix is chosen for aesthetic effect as well as their ecological suitability for the conditions at the site". *Stylized nature* is a planting that uses native plants but discourages successional development. *Habitat restoration* has the same definition as *ecological restoration,* defined in the previous sections. Thinking of ecological design as a multifaceted spectrum allows us to conceptualize the degree to which landscape practitioners engage with ecological concepts and processes of change over time.

Ecological Aesthetics

Main Points:

- The "scenic" or "pastoral" aesthetic is deeply engrained in the design, management, and experience of landscape in the U.S.
- Aesthetics are important to ecological design because landscape perception can drive human action towards landscapes.
- "Ecological aesthetics" can take many forms but require moving beyond the picturesque aesthetic and embracing dynamic processes.
- Design strategies towards this include cues to care, sightline maintenance, visibility, and heterogeneity (variety).

The relationship between ecology, a scientific field that studies the phenomena of the natural world, and aesthetics, the realm of how the world is experienced, has complex implications for landscape architecture. The design, management, and experience of landscapes in the United States has been deeply influenced by picturesque landscape conventions. The picturesque landscape tradition in the United States and elsewhere grew out of landscape painting and aesthetic theory that began in seventeenth and eighteenth-century Europe (Ellison, 2013; Gobster, 1999). As the American frontier was transformed from forest to farmland, the fear of wilderness began to recede and a romanticization of nature took hold in American culture. While this cultural shift in conceptualizations of nature perhaps cultivated an appreciation for natural landscapes and increased their legibility, it also reinforced the idea of nature as a separate entity from human society (Cronon, 1995). Gobster (1999) uses the term "scenic aesthetic" to refer to a mode of landscape appreciation that regards landscapes both wild and designed for their "visual, scenic, and picturesque qualities". The scenic aesthetic is deeply culturally engrained in landscape architecture design, the practice of landscape appreciation and perception, and the practice of landscape management (Ellison, 2013; Gobster, 1999). For example, the practice of removing dead wood from forests, despite the ecological importance of dead wood, was a widespread forestry management practice that was influenced by picturesque aesthetic preferences rather than ones "where the dynamics of change are apparent" (Gobster, 1999). In landscape architecture, the scenic aesthetic has embedded design conventions and management practices that aim to preserve a static landscape composition (Ellison, 2013; Gobster, 1999). The scenic aesthetic tends to anchor us culturally in an idealized and somewhat static

conceptualization of nature. The romanticization of natural systems as static entities contrasts with contemporary ecological science, which emphasizes constant dynamism and change as the norm (Meiners et al., 2015). This contrast exemplifies how design conventions driven by picturesque aesthetic traditions overlook dynamic landscape processes (Gobster et al., 2007; Hill, 2005). This tension in landscape architecture emphasizes how challenging it is to integrate modern ecological theory with deeply ingrained aesthetic preferences, and to cultivate a fascination with landscape dynamism.

This challenge is deepened by a historic tension in the field of landscape architecture. Throughout its establishment as a professional field, landscape architecture has experienced a culture war of sorts, with some claiming landscape architecture's cultural currency as art, and others claiming its currency as science (Mozingo, 1997). Many argue that the future of ecological design lies in bridging the false divide between aesthetic concerns and ecological concerns (Gobster et al., 2007; Meyer, 2008; Nassauer, 1995). Though all landscape architects must necessarily draw from both artistic and scientific realms, examples of landscape architects who may be categorized in the "art" camp include modernist landscape architects such as Dan Kiley and Peter Walker; examples of those who draw more from ecological sciences may include Ian McHarg, Anne Spirn, and James Urban. At its worst, the art/science divide can perpetuate false narratives on both sides: one claiming that aesthetic concerns are superficial and unnecessary, and the other claiming that science-driven design is reductive and removed from cultural expression (Mozingo, 1997). Looking beyond this divide, it is important to acknowledge the aesthetic and cultural possibilities of ecologically-driven design, as well as the extent to which aesthetic experiences can drive human action and therefore ecological quality (Gobster et al., 2007; Meyer, 2008).

Meyer (2008) emphasizes usefully that the aesthetic realm is not superficial; rather, it is the filter through which we experience the world. Positive aesthetic experiences within landscapes can cultivate recognition, attachment, and respect for the environment (Meyer, 2008; Nassauer, 1997). Following this logic, Meyer (2008) suggests that the appearance of a landscape can be conceptualized as category of landscape performance; she refers to this as the "performance of appearance". Similarly, Gobster et al. (2007) and Nassauer (1995) emphasize that people act on what they perceive, and that ecologically

valuable landscapes may not be protected or maintained if certain aesthetic preferences or drivers are not met. It follows that aesthetics are directly connected to ecological quality, because they can be a driver of anthropogenic landscape change (Gobster et al., 2007).

In accepting the importance of aesthetics as drivers of connection between people and ecosystems, and rejecting the false dichotomy between landscape architecture as "art" or as "science", it becomes necessary to develop an "ecological aesthetic" (Gobster, 1999). Some key aesthetic strategies emerge from landscape architecture theory related to ecological aesthetics. Nassauer (1995) argues that placing linear features, crisp edging, vivid patterns, colorful flowers, and fences around landscapes that some might consider to be "messy" can promote stewardship and connection to those landscapes (Nassauer, 1995). She calls these small interventions "cues to care" (1995). The emphasis here is on creating a positive aesthetic experience of landscapes that may be ecologically valuable but may have a "messy" appearance; the average person may not be able to perceive the ecological value of that messiness (Nassauer, 1995). Others emphasize the importance of "landscape legibility"; for example, using maintenance to emphasize the visual separation of vegetation layers in a designed planting (West & Rainier, 2015). In many studies, people have demonstrated preferences for landscapes where there is visible permeability and an abundance of vantage points (Appleton, 1996; Hoyle et al., 2017; Kaplan & Kaplan, 1989). The idea of visibility and vantage points is particularly important in cultivating a sense of safety in locations where crime rates are higher. Some studies have shown that perceptions of remnant or unmanaged urban landscapes, which may be ecologically valuable, change dramatically according to vegetation structure (Brun et al., 2018). Visual permeability, clarity of vegetation structure, and visual cues to care emerge as key factors in the positive perception of landscapes and key strategies in cultivating an ecological aesthetic (Brun et al., 2018; Nassauer, 1995; West & Rainier, 2015). It is also important to emphasize that aesthetic expectations vary with landscape type, and preferences relating to different landscape types may change at different rates over time (Nielsen & Jensen, 2007). Carefully designing the aesthetic experience of an ecologically functional landscape may prove central to the care, stewardship, and long-term place attachment people have to that landscape.

While some ecological aesthetic strategies may use picturesque conventions to create positive aesthetic experiences of landscapes, others try to push the boundaries of these conventions beyond the picturesque (Gobster et al., 2007; Meyer, 2008). Gobster et al. (1999, 2007) emphasize that an ecological aesthetic should include knowledge sharing to help people interpret the landscape, making education part of the aesthetic experience (Gobster et al., 2007). The combination of positive aesthetic experiences with interpretive features in a designed landscape may effectively increase the legibility of ecological plantings for people without ecological knowledge (Gobster et al., 2007; Meyer, 2008; Nassauer, 1995). Gobster (1999) also suggests making aspects of landscape management visible even if they do not fit picturesque conventions; again, the example of dead wood is a useful one here. Meyer (2008) and others emphasize that the future of ecological aesthetics should embrace dynamism of ecological communities, stating that "the intrinsic beauty of landscape resides in its change over time" (Gustavsson, 2004; Hill, 2005). The future of ecological aesthetics, thus, aims to move cultural aesthetic preferences away from static conceptualizations of landscape and to cultivate a fascination with ecological dynamism.

Case Studies & Precedents

Freshkills Park, Staten Island, NY – James Corner Field Operations & Freshkills Park Alliance



Figure 5: Freshkills Park, Staten Island, NY [Photo: Freshkillspark.org]

Freshkills Park in Staten Island, New York is an example of a large urban restoration project that integrates scientific research and successional dynamics in its planning and design while creating functional spaces for people (Freshkills Park Alliance, 2021). The 2,200-acre site is a massive landfill which has gradually been capped and transformed into a dynamic space for people to enjoy, and where ecological restoration of marshland and coastal forests has developed piece by piece over time. In the restoration process, local plant ecotypes from the Greenbelt Native Plant Center were used to restore the coastal marshlands at Freshkills (Beck, 2013). The design and construction of Freshkills is managed by an alliance which includes landscape architect James Corner Field Operations, environmental researchers, ecological restoration practitioners, and a broad range of public education initiatives (Freshkills Park Alliance, 2021).

The restoration of one of the park's closed landfill mounds became the site of an important study in urban ecology into which successional dynamics were invited (Robinson and Handel, 1993). Clusters

of bird-attracting trees were planted together to encourage seed dispersal around the site and accelerate reforestation (Beck, 2013; Robinson & Handel, 1993). To enhance site availability, patches of bare earth were opened to receive these seedlings. This study aimed to assess the effectiveness of this technique, termed applied nucleation, in reforestation efforts (Robinson & Handel, 2000). Freshkills provides an example of applying animal seed dispersal as a design tool; in other words, "using animals to plant plants" (Beck, 2013). It also provides an example of making designed landscapes part of scientific studies which can inform ecological applications in future projects (Beck, 2013; Felson & Pickett, 2005).

Brooklyn Bridge Park, Brooklyn NY – Michael van Valkenburgh Associates



Figure 6:Brooklyn Bridge Park, Brooklyn, NY Sumac Grove [Photo: mvvainc.com]

Brooklyn Bridge Park is also a large urban park that was built through a long-term collaboration between designers, scientists, municipal bodies, and community members. Designed by Michael Van Valkenburgh and Associates, the 13.6-acre site on the Brooklyn waterfront provides an example of

wildlife habitat creation in an urban context and the use of managed succession plantings on a much smaller scale than was used at Freshkills. The plantings at Brooklyn Bridge Park are inspired by native ecological communities in the New York area, and their diversity is derived from the topographical variation of the site. For example, areas that touch the water became salt marsh plantings, and dry upland areas became groves of sumac and native shrubs (Handel, 2010). The plantings were specifically designed to embrace long-term change as "managed succession" plantings in which plant competition is managed to maintain the diversity of plantings in each layer (Pevzner & McKay, 2016). The design of the space allows clear sightlines amidst islands of dense and multi-layered planting, with plants periodically pruned to maintain visibility and clarity of vegetation structure. The effectiveness of these plantings as wildlife habitat was measured in a Landscape Performance Series report. The report found that "74 [bird] species use [the site] as a migratory stopover point, including one New York Species of Special Concern" (Pevzner & McKay, 2016). In a site embedded within the urban matrix, wildlife habitat creation predominantly benefits mobile species; this project exemplifies a planting design approach that worked within urban constraints. The monitoring and research that was done on this site to measure the design's effectiveness is also exemplary and will likely inform future projects.

Natur-Park Südgelände, Berlin, Germany – ÖkoCon & Planland; ODIOUS

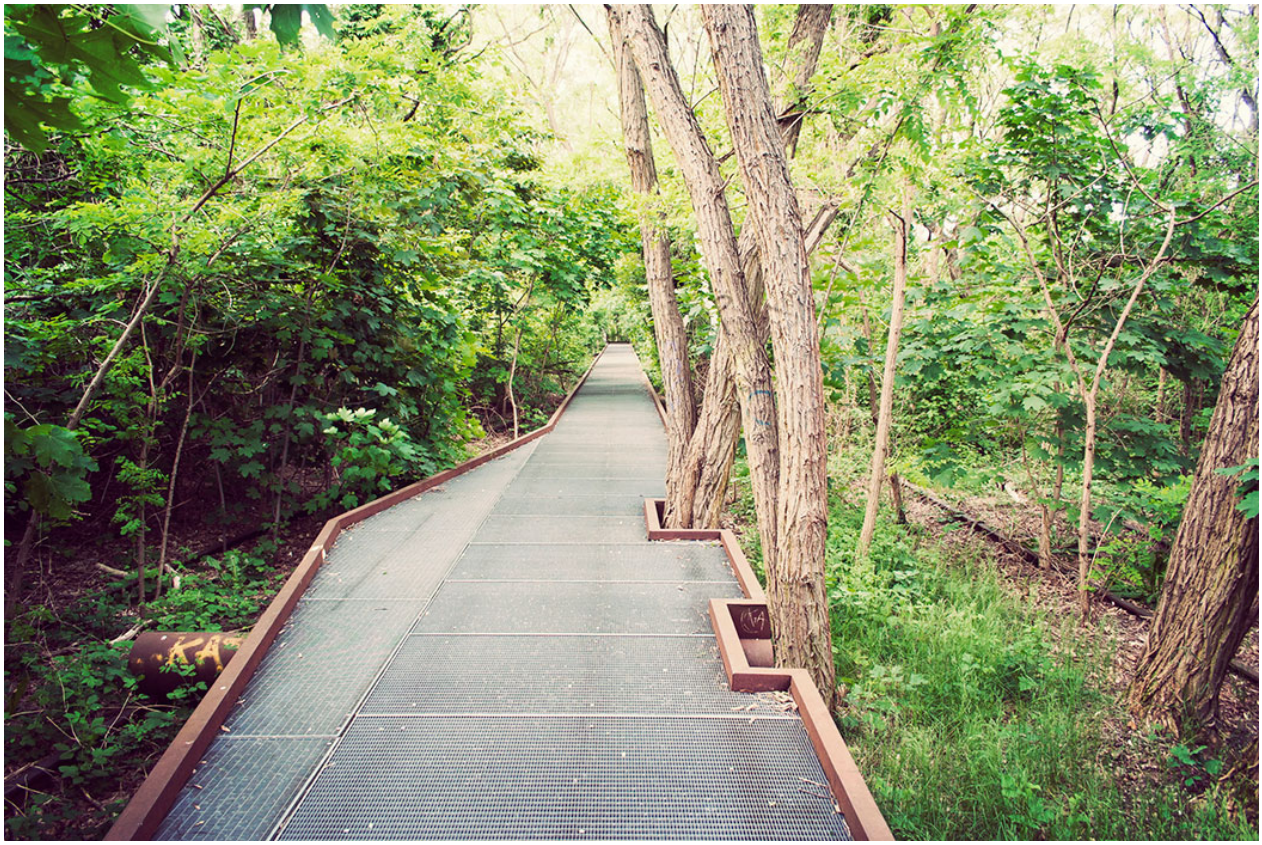


Figure 7:Natur-park Schoeneberg- Südgelände, Berlin, Germany [Photo: S.B & J.G.M. - Landezine.com]

Natur-park Schoeneberg-Südgelände in Berlin, Germany provides an example of thoughtful design and management interventions within an existing successional landscape. This unique 44-acre park was formerly the Templehof industrial rail yard, which was abandoned for almost half a century due to the political situation in Berlin after World War II (Kowarik & Langer, 2005). This period of disuse allowed for the successional development of species-rich woodlands, grasslands and shrublands. The site's development as a park was a response to the recognition of the value of the spontaneous ecosystems that had developed there. Minimal design interventions aimed to provide access to the forested areas and meadows, highlight the site's industrial history, and maximize its cultural potential; much of the park is designated as a conservation area by the city of Berlin. Public art is an essential part of the site design; many of the access points into the site were designed by the artist collective ODIOUS, who specialize in

steel sculpture. The park is now a vibrant place for experimental art and theater productions, and art pieces are integrated into the park grounds. The railway infrastructure was kept intact and integrated into the experience of the park, highlighting the history of the site.

Importantly, Natur-park Schoeneberg-Südgelände also exemplifies a multifaceted approach to vegetation management which responds closely to the ecological communities found on the site (Kowarik & Langer, 2005). Some areas of the site, for example, are left to grow into woodland without intervention on the vegetation composition; other areas are maintained as open grasslands to preserve the species diversity of the successional plant communities (Kowarik & Langer, 2005). Interestingly, non-native species such as *Robinia pseudoacacia* (Black locust) are recognized as playing an important ecological role in the spontaneous forest here and are not removed. The gradient of engagement with the site's ecological communities is also reflected in the channeling of visitor movement throughout the site; in some places, raised pathways signal that users should stay on the path and intervene minimally in the surrounding landscape; in other places, visitors are free to explore the grounds of the site at their will.

Conceptual Framework

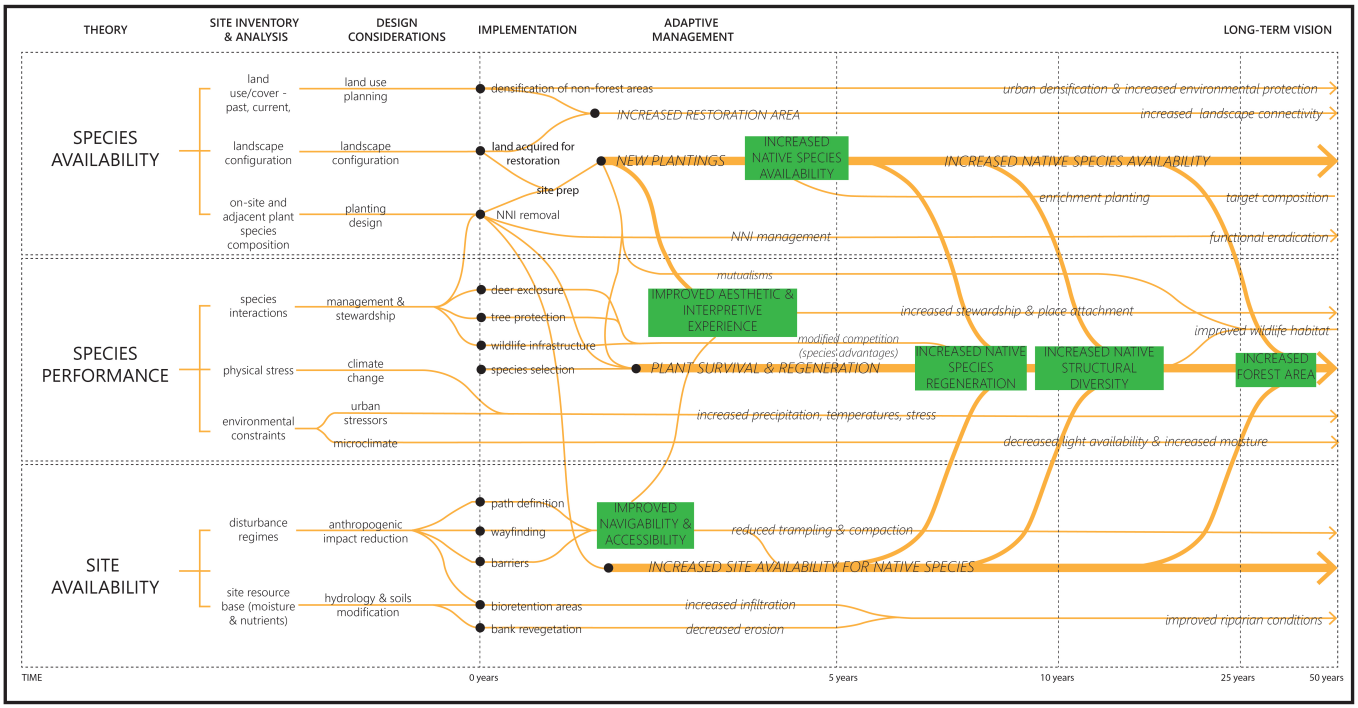


Figure 8: Conceptual Framework: Integrating vegetation dynamics theory with urban park design.

The conceptual framework developed for this project illustrates how the components of vegetation dynamics theory relate to the site inventory, design considerations, and long-term management of a project (Figure 8; see Appendix 4 for full-page image). The framework shown here contains design goals (highlighted in green) that specifically relate to the site studied in this project; those goals will be discussed in more detail in Chapter 3 when the site is introduced and described in more detail. Time is represented along the x-axis, and stages of the design, implementation, and management process are distributed along it. The vertical axis is organized by the three components of vegetation dynamics theory, which interact with one another throughout time as plant communities mature (Pickett et al., 1987). The diagram highlights the types of vegetation dynamics that need to occur on the site throughout time in order for the design goals of the project to be achieved; for example, increased site availability for native species, increased native species availability, and plant survival and regeneration (Figure 8).

The specific considerations during site inventory, analysis, and design that relate to those vegetation dynamics are highlighted in the second and third column of the diagram. The "site inventory and analysis" column shows concepts that are related to the respective components of vegetation dynamics theory according to the original model (Pickett et al., 1987). Gathering information about land use, species composition, urban stressors, and anthropogenic impact during the site inventory process, for example, will provide the information necessary to make informed decisions about vegetation dynamics on the site at hand. Next, this information is integrated into the design phase, where it is translated from objective site information into design directives. At the next stage, implementation, certain components of the design begin immediately, such as invasive species removal, tree protection, and path definition. Following these concepts through the model, it is important to note that many of them continue indefinitely. This is meant to show that consistent management is essential to the achievement of design goals. The phrase "adaptive management" is included in the model to describe an iterative management approach that responds to the needs of the project over time (Ahern et al., 2014). The timeline ends at 50 years with a long-term vision, suggesting that this vision be part of the design process from the beginning of project conceptualization.

In the "species availability" row, the design interventions highlighted here relate to land use and modification species on the site. Increased urban densification and legal requirements for reforestation can potentially lead to increased land acquisition for restoration areas. This, in turn, could lead to greater forest patch size as well as increased landscape connectivity, if other forest patches are adjacent to the site. Land use directly influences species availability because it determines what is permitted to survive and regenerate on the site. Related to this, invasive species removal is the first step toward achieving planting design goals, and it must continue throughout time. New plantings on the site, supplemented by enrichment plantings, aim to gradually increase native species availability (Figure 9). The confluence of functional eradication of invasive species, urban densification and increased area designated for reforestation, and enrichment planting, would allow native species availability to increase over time.

In the “site availability” row, the design interventions highlighted include path definition, wayfinding measures, barriers to movement, and altered site hydrological regimes. These interventions modify the disturbance conditions of the site by controlling human movement and reducing stormwater runoff. These structural interventions on the site immediately improve navigability and accessibility to the site, which reduces trampling and compaction over time. This would lead to increased site availability for native species, given that invasive species management was taking place simultaneously (Figure 9).

The “species performance” section includes design interventions that directly modify the way species interact with one another, such as deer exclosures, tree protection measures, and wildlife infrastructure. The specific interventions mentioned here reflect common urban forest conditions found on the Long Branch site and other sites in the Mid-Atlantic. Climate change, urban stressors, and microclimate are also listed here but are not associated with direct design intervention; they are listed because they are anticipated to influence species performance continually throughout time. In the diagram, native species availability and site availability are shown to be connected throughout time to plant survival and regeneration, which is a function of species performance. Plant survival and regeneration is, in turn, directly connected to most of the design goals in this project, such as increased native species regeneration, increased structural diversity, and increased forest area.

Chapter 3: Long Branch Case Study Methods

This chapter will introduce the Upper Long Branch Stream Valley site and will describe the inventory and methods of the case study in detail. First, basic site inventory components such as context, urban planning, hydrology, and land cover will be discussed. Following this is a description of the vegetation inventory method used in the project. Finally, the site analysis is described in detail. A mixed-methods approach was used for this project, due to its interdisciplinary nature. Because the study focused heavily on vegetation dynamics, the site inventory process included a vegetation survey. The semiquantitative, observation-based Braun-Blanquet relevé method was used to document and characterize the vegetation on the site; this method was chosen because it was most feasible given time, personnel, and resource constraints (CA Native Plant Society, 2007). The site inventory also included a photographic inventory and detailed Geographic Information Systems (GIS) mapping of important abiotic, biotic and cultural attributes (LaGro Jr., 2008). Historical aerial photographs of the site were obtained from Bill Hamilton at M-NCPPC and from Google Earth imagery. For all inventory maps created in ArcGIS, publicly available spatial datasets were used for the map layers; those were obtained from Montgomery County, Maryland's Open GIS online resources, the Chesapeake Bay Trust 2014 Land Cover dataset, and U.S. Census Bureau data.

Site Context

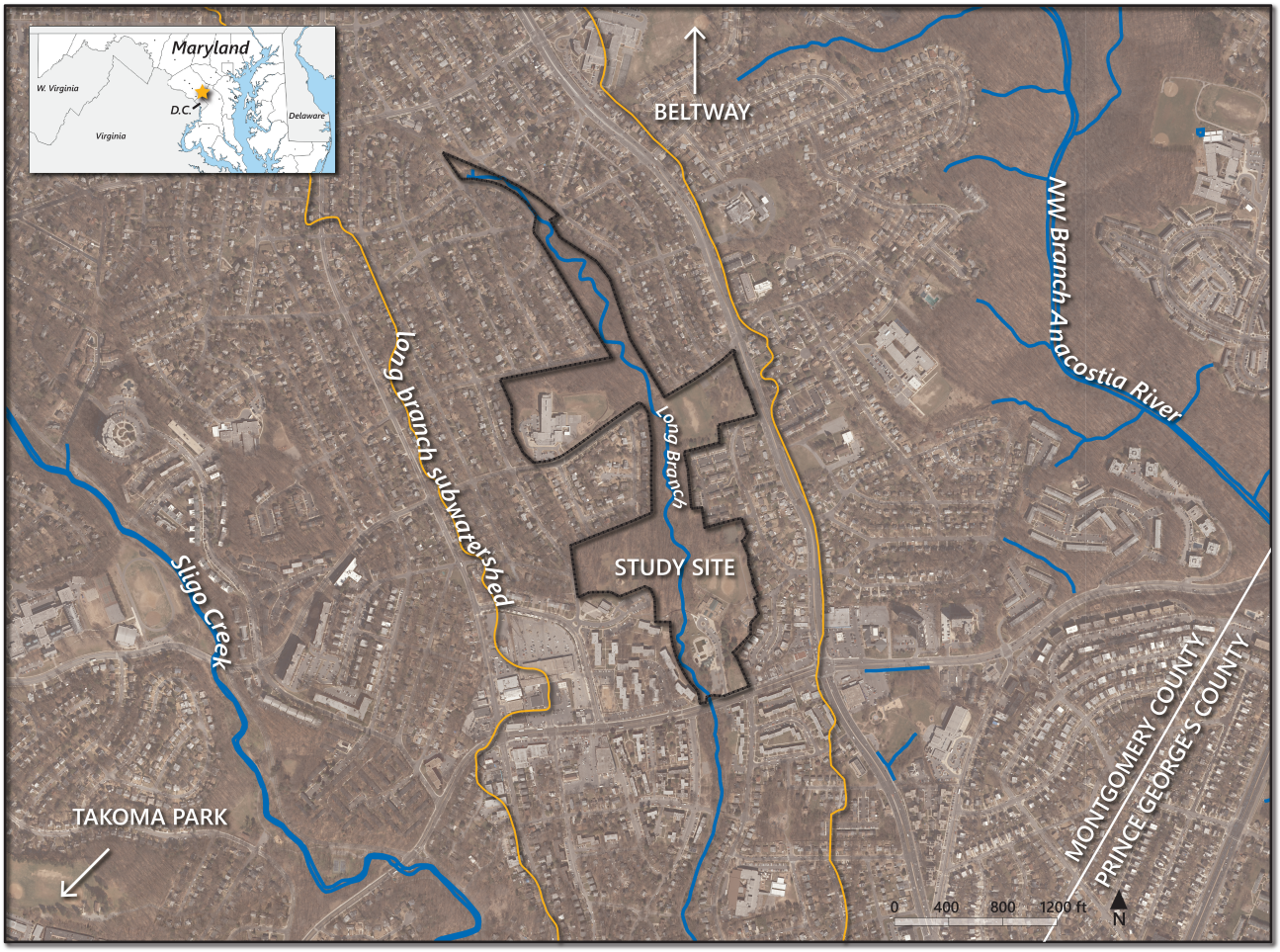


Figure 9: Context Map

The Long Branch Stream Valley is located in southern Montgomery County, Maryland, near the border of Prince George's County and just outside of Washington, D.C. (Figure 9). The 49-acre site chosen for this project contains the upper portion of Long Branch Stream Valley and the parks that surround it. The site is located just north of the fall line between the Coastal Plain and the Piedmont physiographic regions of Maryland. The stream valley is surrounded by urban development, including four small parks that are directly adjacent to the stream valley: Upper Long Branch Neighborhood Park, Long Branch-Wayne Local Park, Long Branch-Arliss Neighborhood Park, and Long Branch Local Park (See Figure 12). White Oak Elementary School is also adjacent to the stream valley and is included in the

site boundary, though it is not owned by M-NCPPC. The Upper Long Branch Stream Valley was recommended for this thesis by Bill Hamilton of M-NCPPC, on the basis that the forest patch vegetation was designated as ecologically degraded, and M-NCPPC intended to partition more resources to upgrading the parks in this area for reasons of environmental justice (Bill Hamilton, personal communication, 2020). The site is surrounded by single and multi-family residential developments (Figure 10). Denser residential and commercial developments exist at various locations along Piney Branch Rd, Flower Ave, and University Blvd (Anderson-Watters et al., 2019). The residential areas surrounding the site were part of a wave of post-World War II development in the Washington region. Many of the single family homes in the neighborhoods surrounding the study site were built in the 1940s and 1950s with FHA and VA home loan programs, and multifamily apartment complexes were constructed around this time as well (MNCPPC, 2013). The parks on the study site were built along with the suburban development in the area. Throughout the 1960s and 1970s, the Long Branch area served as an attractive "gateway" to the Washington region, presenting a more affordable alternative to many DC neighborhoods with good community services and public transportation (MNCPPC, 2013). In the 1980s,

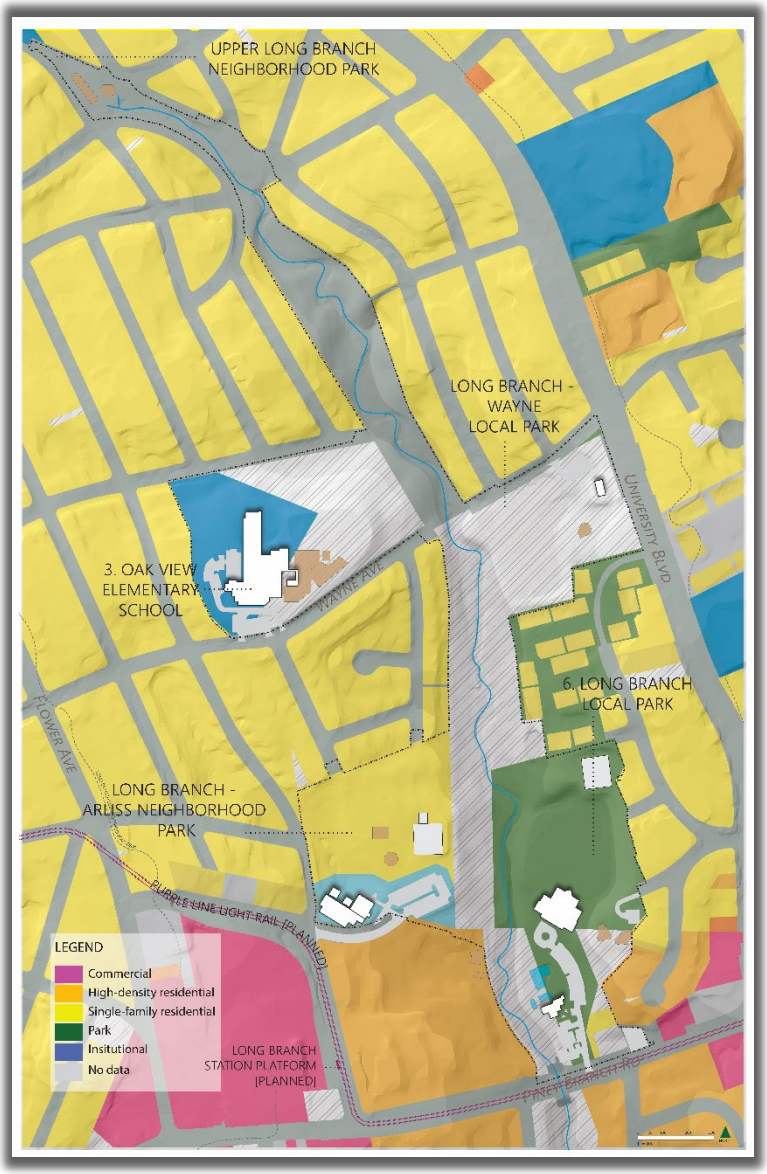


Figure 10: Zoning

a large influx of immigrants from Central America began to move to Long Branch. Additional waves of immigrant communities from West Africa and more from Central America followed this initial wave. Today, Long Branch is a very diverse, bustling small community with a high percentage of immigrant-owned businesses (Anderson-Watters et al., 2019; MNCPPC, 2013).

The Purple Line light rail project is planned to be built directly adjacent to the study site, near the intersection of Piney Branch Rd and Arliss St (Figure 11). This has important implications for future urban development and population trends in the area. Development pressure in the area surrounding the future Long Branch Purple Line station is high. The adapted 2013 Long Branch Sector Plan envisions the intersection of Flower Ave and Piney Branch Rd as Long Branch's future "town center", meaning a future proliferation of mixed-use redevelopment in that area (outlined in red in Figure 11) (MNCPPC, 2013). The retention of small businesses in the area and the affordability of housing in this community is at risk because of this development pressure (Anderson-Watters et. al, 2019). However, appropriate urban planning measures can be taken to

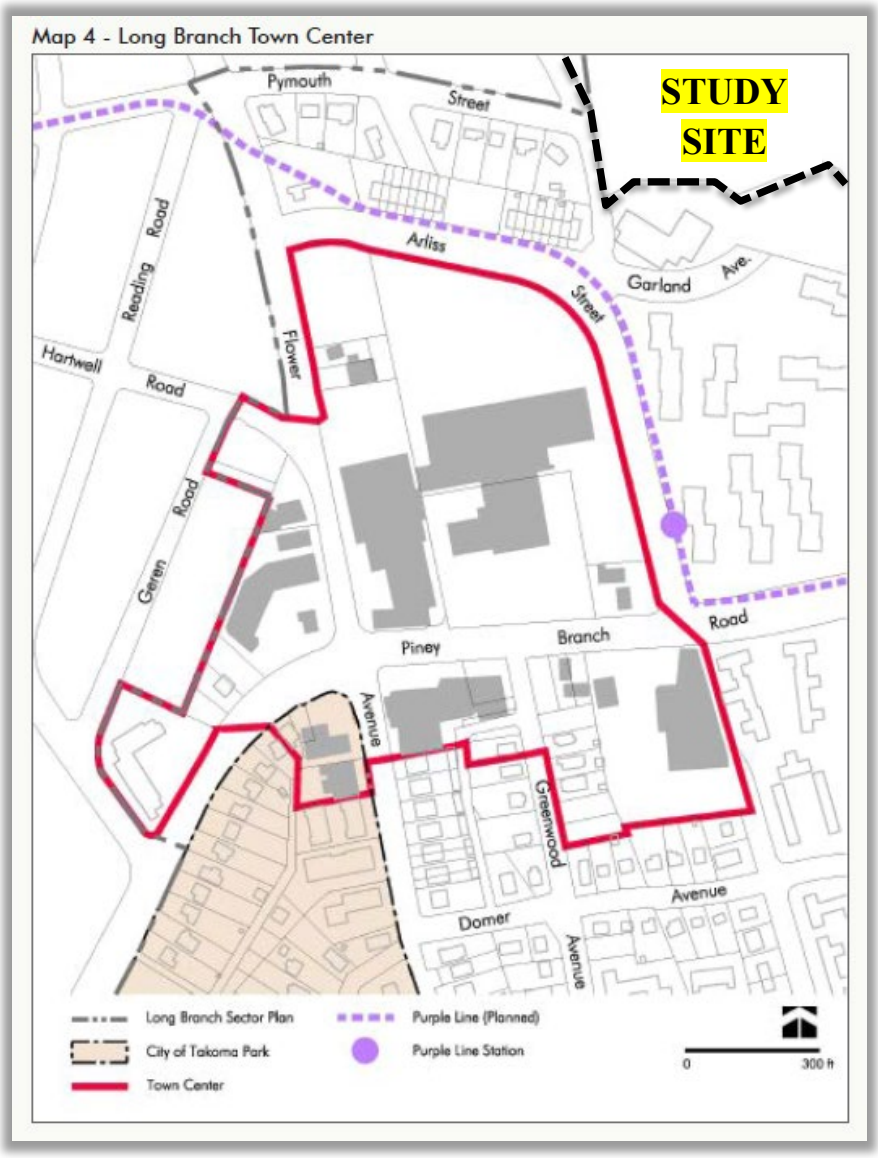


Figure 11: Long Branch Town Center planned area (M-NCPPC, 2013)

ensure the retention of small businesses in the area and to ameliorate rising costs of living (Anderson-Watters et al, 2019). The anticipated development trends around the Long Branch Purple Line station highlight the need to upgrade local parks and protect and steward urban forest patches as high-value amenities to current and future community members.

Site Inventory

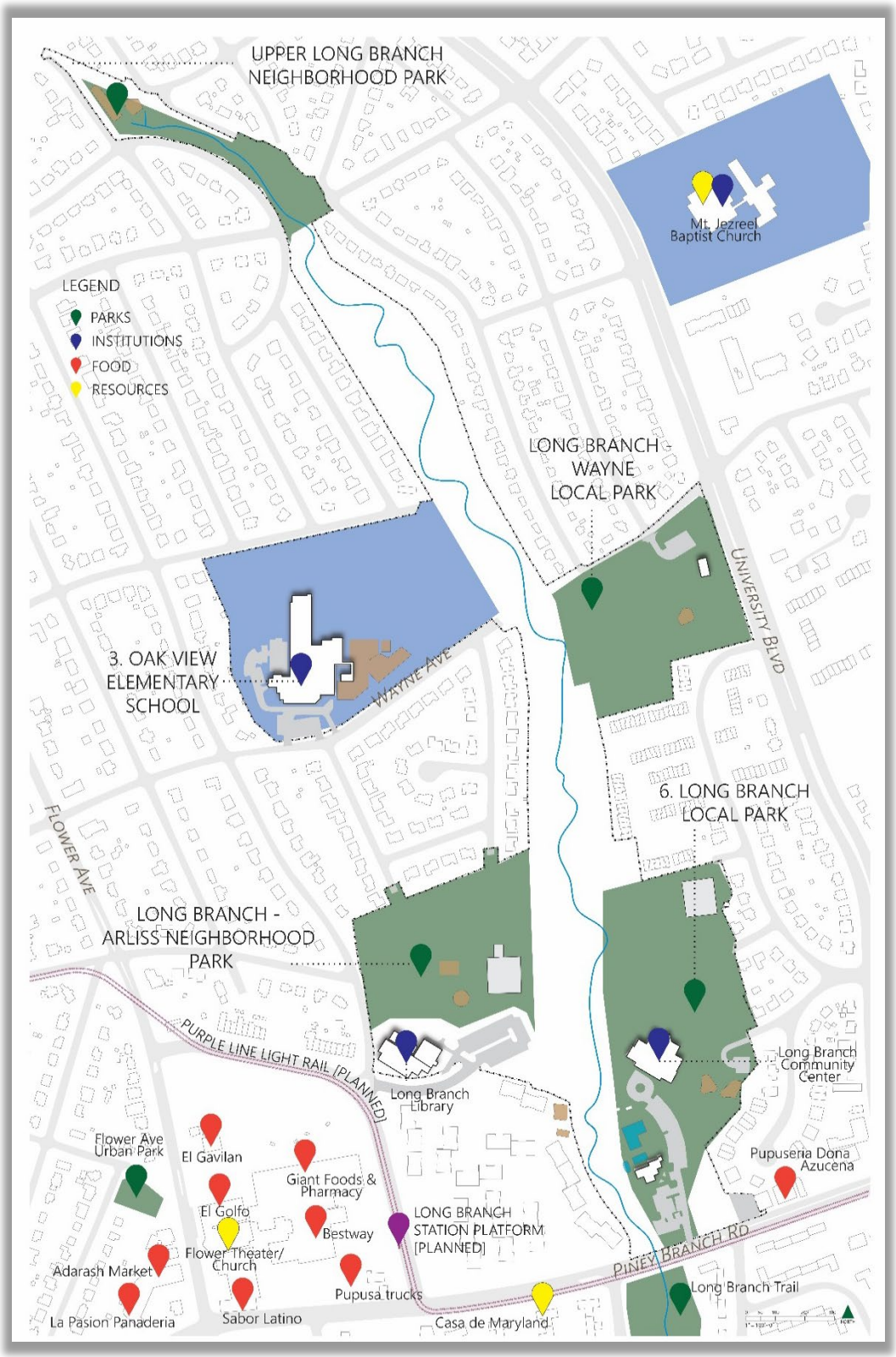
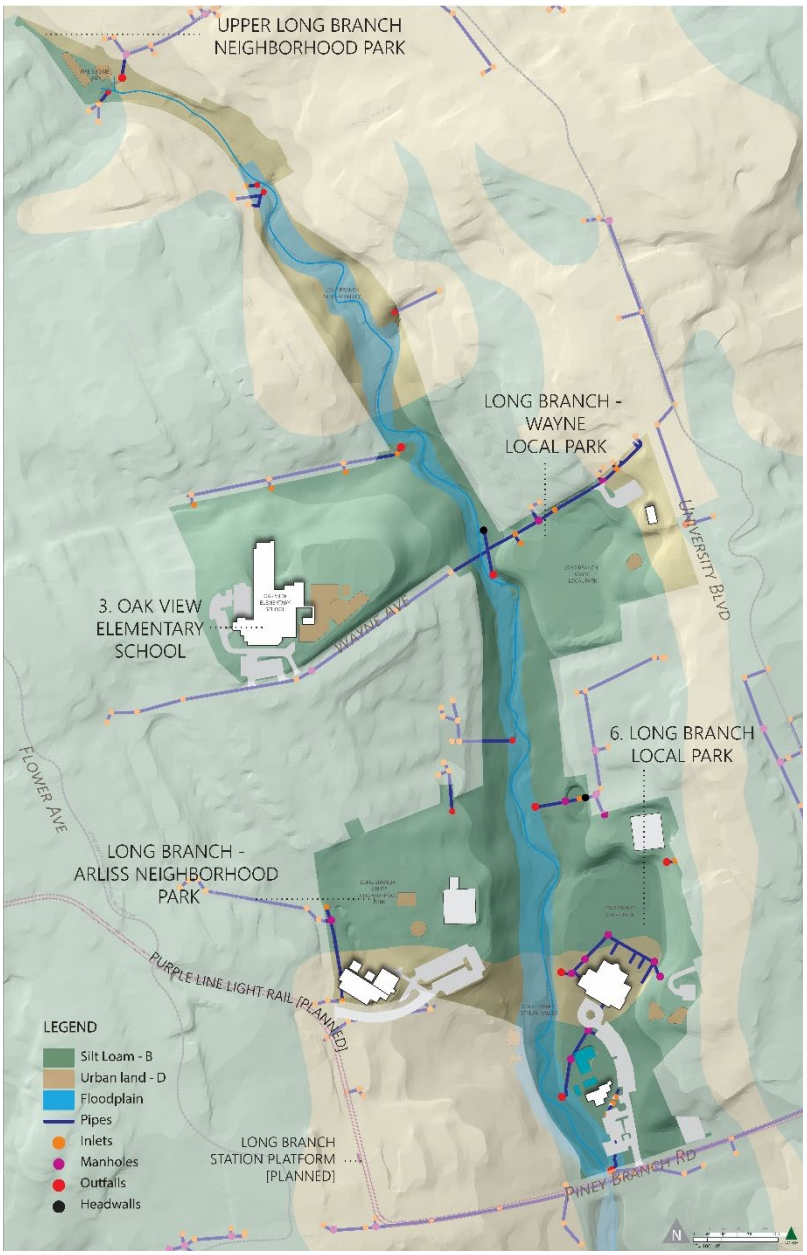


Figure 12: Main spaces and community resources

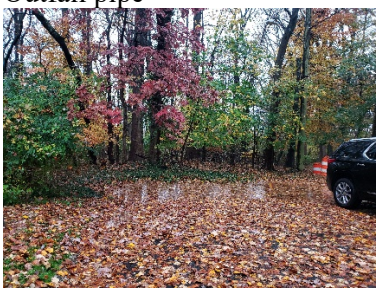
Figure 12 shows the parks, institutions, and community resources in the immediate area of the study site. The site contains 4 parks that are owned and maintained by the Maryland National Capital Park and Planning Commission (M-NCPPC); the stream valley is owned by M-NCPPC but is not officially within the boundaries of any of these parks. In the northern portion of the site is Upper Long Branch Neighborhood Park, at approximately 3 acres, with a basketball court, small playground, and parkland. Long Branch-Wayne Local Park, at approximately 7 acres, contains a multipurpose sports field, a pastoral hillside with shade trees, a basketball court, a picnic pavilion, and a small playground. Long Branch-Arliss Neighborhood Park is adjacent to the Long Branch Library. At 6.16 acres, it contains a playground, 2 tennis courts, and a large area of lawn with shade trees. Long Branch Local Park (12.4 acres) is adjacent to the Long Branch Community Center, and contains a diamond baseball field with a soccer field overlay, a basketball court, 2 tennis courts, a playground, a paved trail, and a community pool. Oak View Elementary School and its surrounding playing field and woodlands are also included in the study site.

The Long Branch Community Center and the Long Branch Library are valuable resources that are heavily used by the surrounding community. Other institutions in the area include Mt. Jezreel Baptist Church across University Blvd. from the study site. The intersection of Flower Ave and Piney Branch Rd southwest of the site is where most businesses and community resources are concentrated. On Flower Ave, the historic art deco Flower Theater has been converted to an evangelical church. Across Piney Branch, the nonprofit Casa de Maryland is a Latinx-focused immigration advocacy and assistance organization (Casa de Maryland, 2021). This intersection also contains a variety of small community restaurants and pupuserias, as well as a Giant grocery store and pharmacy and a Bestway grocery store. Overall, foot traffic and community resources are concentrated near the southwest portion of the study site, which is also the area of future transit-oriented Purple Line development (MNCPPC, 2013).

Hydrology & Soils




Outfall pipe


Flooding at a dead end


Headwaters area

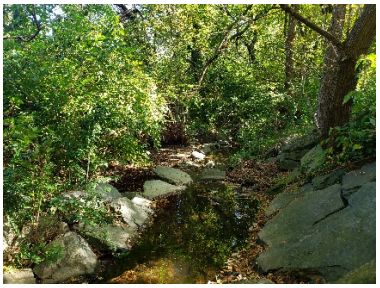

Bank stabilization

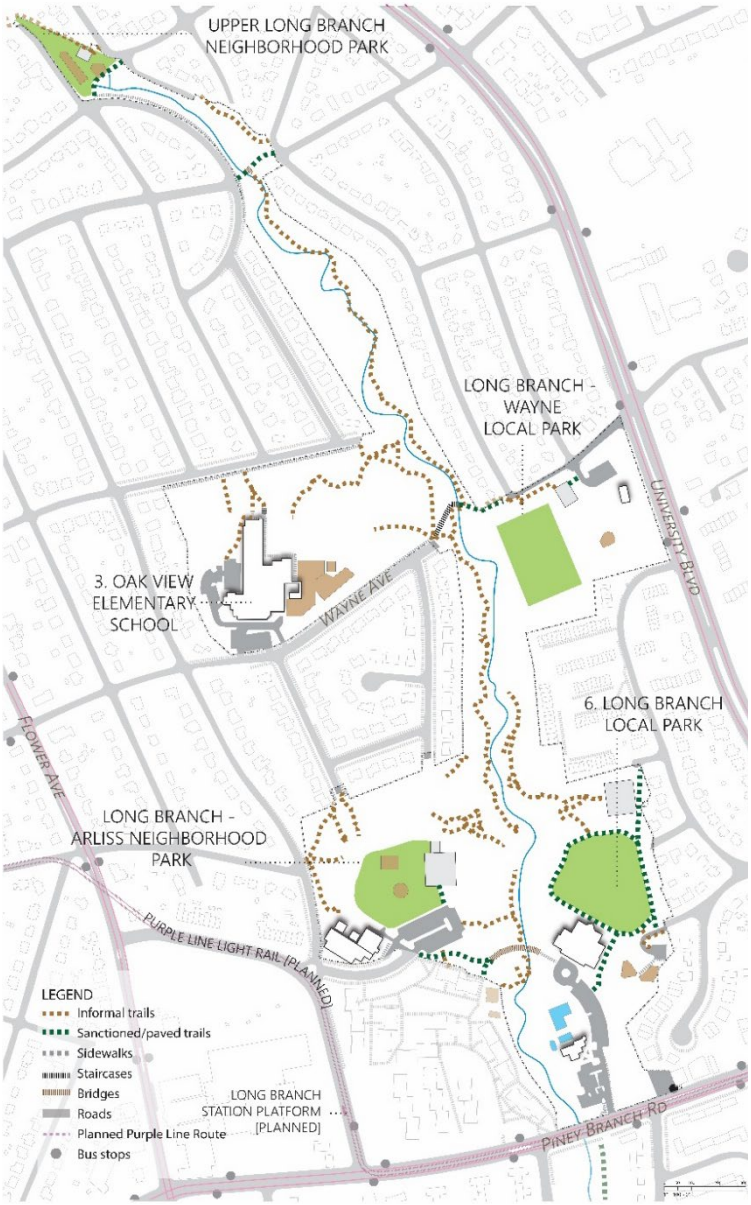
Figure 13: Hydrology & Soils

Long Branch is located within the Anacostia River watershed and it is one of the upper reaches of Sligo Creek. Long Branch can be characterized as an urban headwaters stream (Elmore & Kaushal, 2008; Irwin, 2019). Its natural headwaters were largely buried during urban development around the site, so the headwaters of the stream now come from gutters, sidewalks, and other urban infrastructure before coming together where the stream becomes visible within Upper Long Branch Neighborhood Park (Figure 13).

The stream flows south through the study site and underneath Piney Branch Road and continues south until it meets Sligo Creek. Given common land use history trends in Maryland, it is likely that before the development of the surrounding neighborhoods and parks, many of the flatter areas around the stream valley were used for agriculture. This likely led to heavy siltation and stream degradation in the past, which may have legacy effects on the current site. A full documentation of these legacy effects was not within the scope of this project but should be considered in future studies on this site. Additionally, it is likely that siltation and other sources of stream degradation continue into the present due to surrounding urban development. In recent years, riprap has been installed by Montgomery County in some locations along the stream to stabilize the banks, but stream conditions are still suboptimal likely due to elevated stormwater runoff levels.

There are at least 10 stormwater outfall pipes within the study site; these were built to channel runoff from surrounding residential neighborhoods into Long Branch (Figure 13). Some of the existing impervious structures, specifically the Long Branch Community Center parking lot, are located partly within the floodplain. According to a NRCS WebSoilSurvey analysis, soils on the site are silt loams with slopes ranging from 0% to 25%, making them particularly vulnerable to soil erosion because of their steep grade; fortunately, most steep areas of the stream valley are vegetated, with the exception of some areas of the stream bank (NRCS, 2021). Soils on some portions of the site, shown in yellow, are categorized as “urban land”, which indicates a heavy history of development and likely compaction (NRCS, 2021) (Figure 13). In terms of hydrologic soil group, most soils on the site are in drainage class B, indicating well-drained soils suitable for planting, while riparian soils and urban soils are in drainage class D, indicating poor drainage and poorer suitability for planting (NRCS, 2021).

Transit & Circulation





Informal Paths



Parking lots & paved paths



Unsafe / nonexistent crossings



Unclear entrances

Figure 14: Transit & Circulation

Cars are the dominant mode of transportation in this community. However, many local bus routes run along Piney Branch Rd, University Blvd, and Flower Ave (Figure 14). There are both formal and informal entrances to the site: there are four parking lots near the Community Center, Long Branch Library, Long Branch-Wayne Local Park, and Long Branch Neighborhood Park, the largest one being the community center parking lot off Piney Branch Rd. There are many dead-end streets in the surrounding residential areas which lead informally into the wooded areas, and people use these to enter the park on

foot. Within the site, there are both formal and informal walking trails; in Figure 14, formal trails are shown by dashed green lines and informal trails are shown in brown dashes. Formal walking trails exist at some of the dead-end entrances as well as around the soccer field at Long Branch Local Park. Across Piney Branch Rd to the south of the study site, the paved Long Branch Trail travels south along the middle portion of Long Branch stream. There is a network of informal natural surface trails throughout the forest patch on the site, and many desire paths scattered throughout the local parks. These informal trails were mapped by the author with a free GPS application; the author walked the trails and recorded their location, later transferring them from Google Earth .kmz files to .shp files in ArcMap. People were observed using these informal routes for streamside walking, dog walking, and mountain biking.

Slope & Aspect

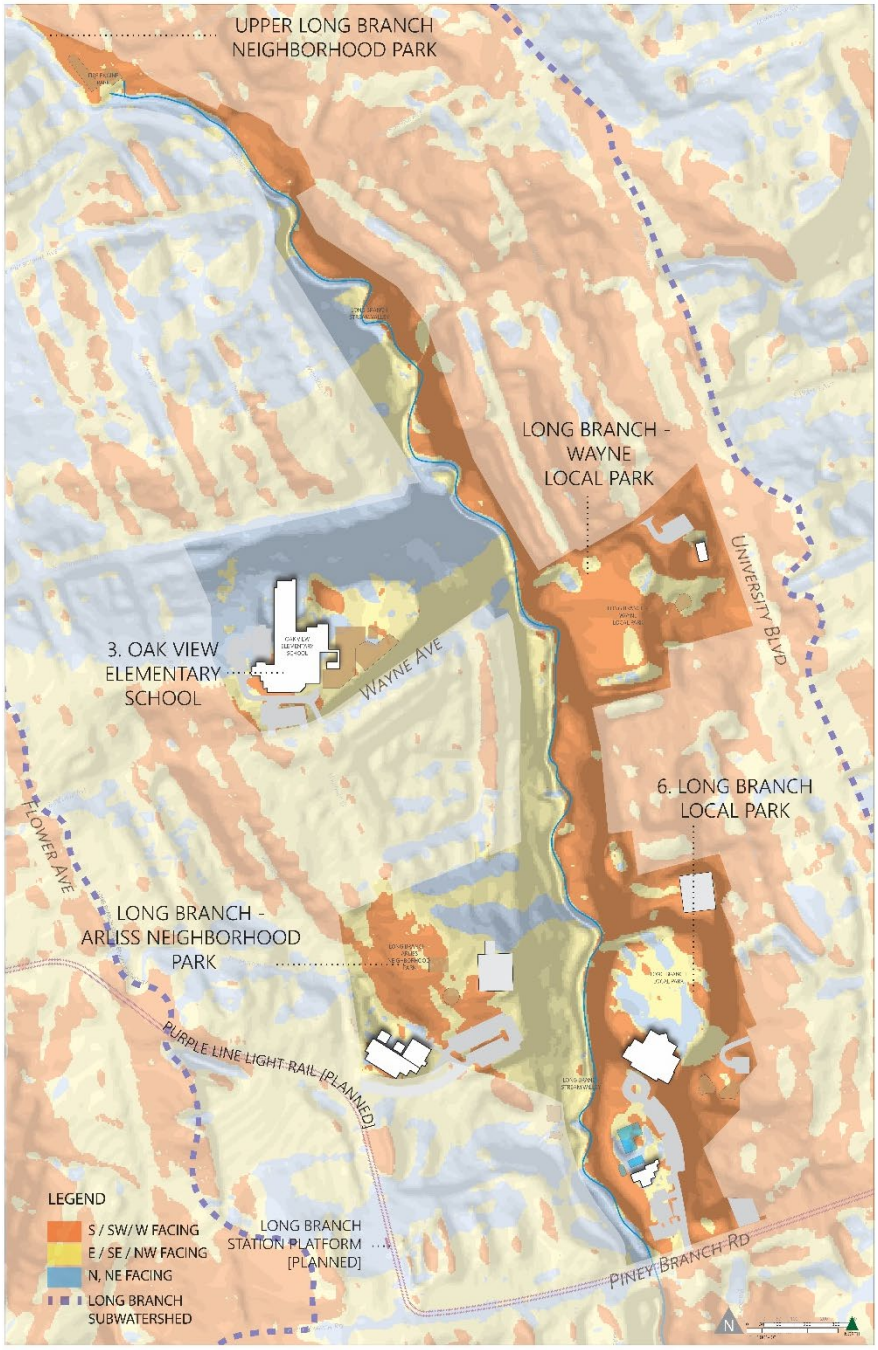


Figure 15: Slope & Aspect

The Long Branch stream valley has substantially steep slopes, especially in the northern portion of the site (Figure 15). The flattest areas of the site are the most developed and are all part of the sanctioned park system: the multipurpose playing fields, Oak View Elementary School, and Long Branch Local Park. The stream runs North to South, making its eastern bank (West-facing) most exposed to sunlight.

Forest Cover




Canopy, no mowing

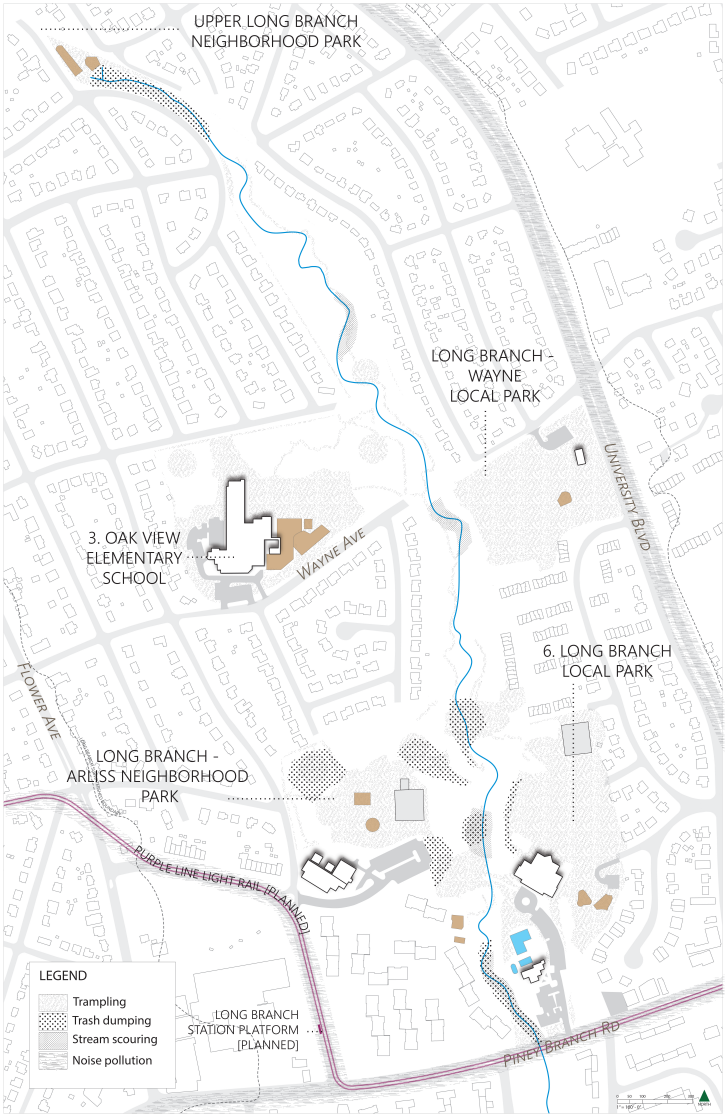

No canopy, with mowing


Canopy with mowing

Figure 16: Forest Cover

In terms of forest cover, the study site is comprised of a forest patch (59%), canopy trees with mowed grass underneath (18%), and areas of mowed lawn (22%). Figure 16 shows a delineation of these areas that is based on site observations during the vegetation inventory and aerial imagery analysis. Forest cover here is distinguished from canopy cover; "forest" is defined as having multiple structural layers of vegetation while canopy cover only requires the canopy layer.

Anthropogenic Impacts





Bank scouring



Trash caught in trees



Trampled forest floor

Figure 17: Anthropogenic Impacts

Anthropogenic impacts on the Long Branch site were assessed in terms of trampling, stream scouring, and litter. Trampled areas shown on the map include informal trails in the forest patch, areas of the forest floor where trampling was documented during the vegetation inventory process, and heavily used spaces such as sports fields and grassy parkland. In Figure 17, stream scouring sites are shown where they were directly observed by the author during site inventory; it is likely that stream bank scouring is present in other areas as well. Likewise, areas where trash was documented are only shown

where they were directly observed by the author during the inventory process. Noise pollution is shown in Figure 17 to be coming predominantly from Piney Branch Rd and University Blvd. These impacts do not make up all anthropogenic impacts affecting the site, but what was in the confines of the study.

Land Cover

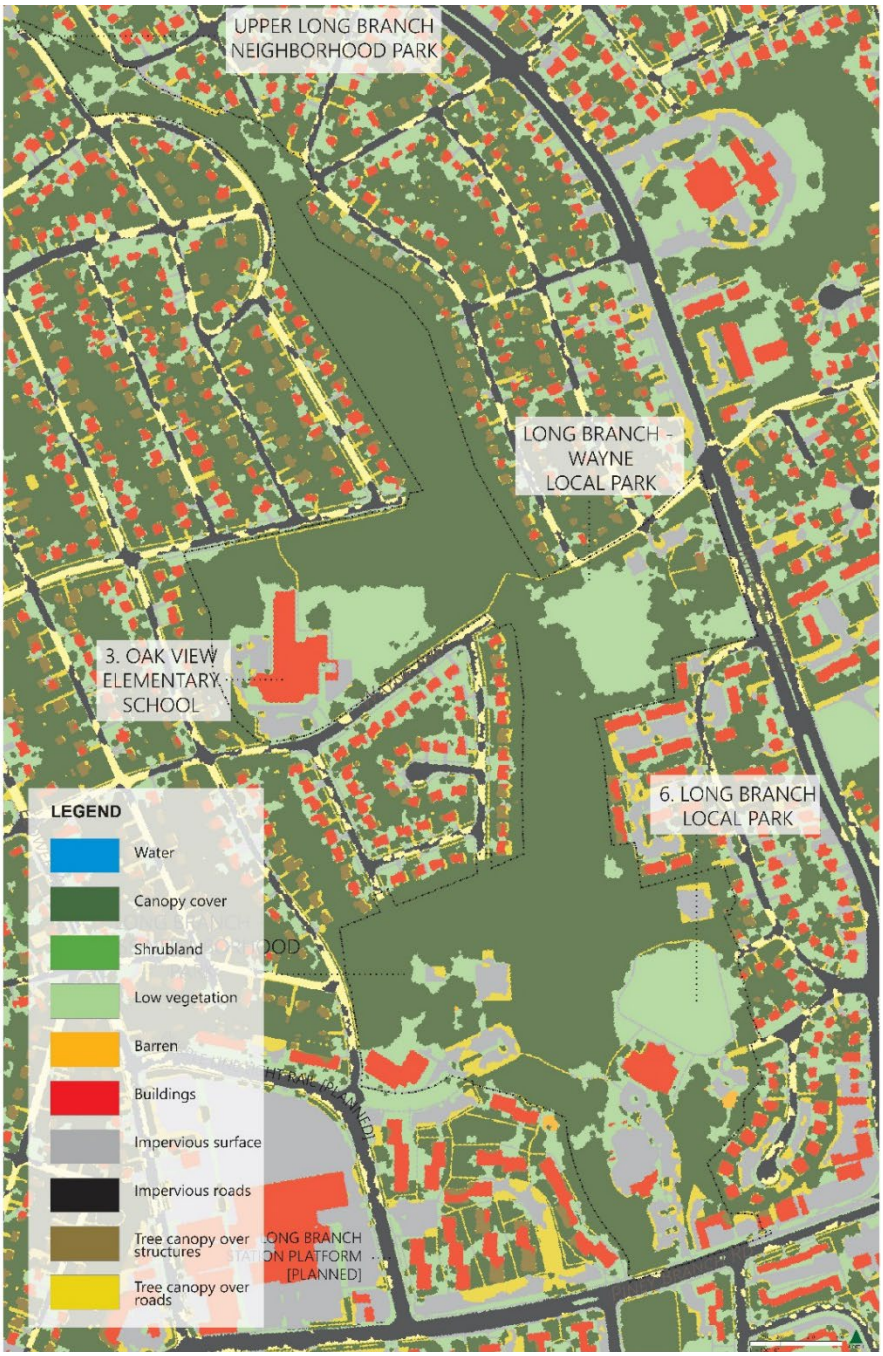


Figure 18: Land Cover

Land Cover data was obtained from the 2014 Chesapeake Bay Land Cover dataset. The predominant land cover layer on the site is tree canopy (Figure 18). Impervious surfaces cover a small percentage of the site, as there are few buildings and roads. Low vegetation covers mowed grassy areas of the site. Adjacent land has a relatively high proportion of canopy cover due to canopy trees in residential yards, but impervious surfaces are much higher in these areas. The largest area of impervious surface is the Giant Foods parking lot to the southwest.

Community Character & Demographics

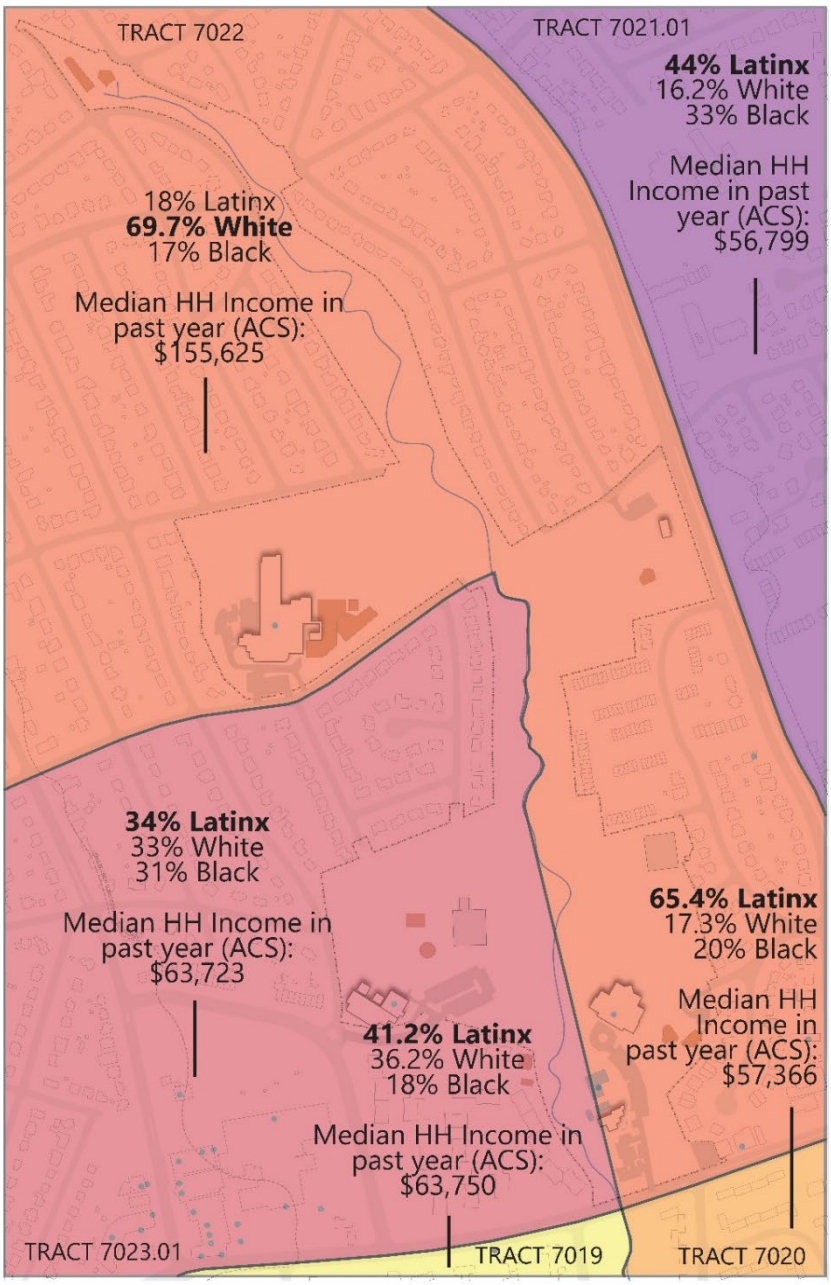


Figure 19: Community character & Demographics

Long Branch is valued by residents for its cultural diversity, active community, and thriving small businesses (Anderson-Watters et al., 2019). The study site overlaps two census tracts and is adjacent to three more (U.S. Census Bureau, 2019). Most of the site is covered by census tract 7022, which is predominantly white in racial makeup, with a median household income over the past 12 months of $155, 625 (MNCPPC, 2013, 2020) . In the four adjacent census tracts, minority populations are much higher and median household income is much lower. For example, tract 7020 is 65.4% Latinx and has a median income of $57,366. These numbers suggest that the neighborhoods surrounding the study site are relatively segregated in terms of race and income disparity. This highlights the importance of the local parks as gathering spaces for all residents of surrounding communities. It is worth noting here that M-NCPPC considers the restoration of the Long Branch parks as a matter of environmental justice for underserved communities (Bill Hamilton, pers. Comm).

Vegetation Inventory

A vegetation inventory was completed on the Long Branch site using the Braun-Blanquet or relevé method. This is a semiquantitative method that uses visual observations to estimate coverage classes of species throughout a large area (CA Native Plant Society, 2007). Following the protocol as described by the California Native Plant Society (2007), vegetation areas were delineated based on their compositional and structural integrity. Areas with similar composition and structure are called *stands,* and boundaries between stands may be abrupt or indistinct (CA Native Plant Society, 2007). Once stands were delineated, a representative relevé survey was done in each stand. Plot sizes were 1000 m^2 for all plots except for riparian plots, which were 400 m^2. Plot shapes varied based on the constraints of the stand; some plots were circular, others were rectangular, but the square footage added up to the appropriate amount for the given area (see Figure 21 for plot locations and shapes).

Vegetation delineation efforts began in July of 2020. Visual observations of vegetation structure and composition were made and spatially documented by the author using the Google MyMaps application over several walks of the entire site. These data points were then imported into ArcMap, where the observations were used to estimate the spatial delineation of stands. The delineation was then verified to the maximum extent possible on the ground by the author.

Table 2: Coverage Classes Used in Relevé Protocol (CA Native Plant Society, 2007)

Cover Class	Estimated Percentage
0	No Coverage
1	<1% coverage
2	1-5% coverage
3a	>5-15% coverage
3b	>15-25% coverage
4	>25-50% coverage
5	>50-75% coverage
6	>75% coverage

Box 2: Data Gathered in Each relevé plot

LOCATION & ENVIRONMENTAL DESCRIPTION

- Relevé number, date, geographic coordinates of center plot point
- Site disturbances (Disturbance codes from CNPS Relevé Protocol were used)
- Site History & Use observations (evidence of human activity, grazing, etc)
- Site management observations (mowing, cutting, spraying, weeding, planting)
- Estimated % surface cover of large rocks, small rocks, open ground (soil, sand, mud), leaf litter, basal area of plant stems, water, coarse woody debris, fine woody debris

PLANT SPECIES & ESTIMATED COVER

- All species (as opposed to all individual plants) listed
- The structural layer in which each species was present (ground, shrub layer, understory, subcanopy, canopy)
- For each species, percent coverage was estimated

A total of 15 relevé surveys were completed on the study site between August and October of 2020. Plots were measured by the author and field assistants using a laser hypsometer and delineated using flags. Photographs were taken on each site in all four cardinal directions (Figure 20). For each relevé plot, observations were made of the location, environmental description, plant species, and estimated cover (Box 2). Percent cover was estimated using cover classes, as opposed to specific percentages (CA Native Plant Society, 2007) (Table 2). Cover classes were estimated for each plant species found on each relevé plot; since vegetation layers overlap, percent coverage for each plot added up to more than 100%. Additionally, a project was created for the Long Branch site using the citizen science application INaturalist (INaturalist, 2021). INaturalist aims to provide an interactive way to record observations in nature, identify observed species, and grow awareness of local biodiversity. The Long Branch INaturalist project is a collector project, which groups together INaturalist observations made within the geographic boundaries of the study site. As of 4/9/2021, 124 observations had been made of 75 species by 30 people. Throughout the inventory process, the INaturalist community helped identify plant species on the site that could not be identified at the time of observation.

On the Long Branch site, vegetation types range from dense forest to open field. Vegetation types were generalized into six broad categories: upland forest, forest edge, riparian forest, riparian edge, lawn, and parkland (Table 3, Figure 21). Within these categories, 15 different vegetation subtypes were identified based on the observed structural and compositional integrity of vegetation stands (Box 3, Figure 22). Plant species were identified by the author as well as field assistants with plant knowledge. Some species could not be identified beyond their genus based on the life stage at the time of observation; these species were recorded with the specific epithet listed as "sp". Some species could not be identified at all

Table 3: Broad Vegetation Types at Long Branch. Photos by author.

Upland Forest (12.8 acres): Forest plots outside of riparian zone 	Forest Edge (10.9 acres): Semi-open areas on edges of forest patches, not adjacent to stream 	Riparian forest (3.8 acres): Forest directly adjacent to or intersecting riparian zone 
Riparian edge (2.3 acres): Non-canopied area adjacent to stream 	Lawn (8.45 acres): Leveled area covered in grasses 	Parkland (17.4 acres): Area with scattered canopy trees over mowed grass 

at the time of observation; these species were recorded on the INaturalist application and the image time stamp was recorded on the data sheet. The author verified any identifications made by INaturalist users by using a plant key. Plant keys used to identify species included the Flora of Virginia app, gobotany.net, and Muenscher's key to woody plants (Cope & Muenscher, 2001; Flora of Virginia Project, 2021; Native Plant Trust, 2021).

After the 15 relevés were completed, further informal observations were taken using Google MyMaps to refine the delineation of each vegetation subtype. Using these observations, combined with high-resolution aerial imagery obtained from Montgomery County Open Data, the spatial delineation of each of the 15 subtypes was estimated (Figure 22). Some of the subtype areas were discontinuous; for example, Figure 22 shows that the Tulip poplar / Norway maple / Amur honeysuckle / Spicebush / English ivy subtype was present on both sides of Long Branch, broken spatially by other subtype areas. Time and resources did not permit a relevé to be taken in all of these areas; this map reflects a compilation of vegetation observations that were made throughout the inventory process. A full summary of the data collected in the inventory process can be found in Appendices 1 & 2.

Box 3: List & description of vegetation subtypes by dominant species

See Appendices 1 & 2 for full dataset.

UPLAND FOREST (UF)
Total area: 12.8 acres
Vegetation Subtypes Described by Dominant Species

- Tulip poplar / Norway maple / Honeysuckle / Spicebush / English ivy
- White Oak / Mixed hickory / Blackgum / Mapleleaf viburnum / English ivy
- Tulip poplar / Beech / Linden viburnum
- Tulip poplar / Amur honeysuckle / English ivy

RIPARIAN FOREST (RF)
Total area: 3.8 acres
Vegetation Subtypes Described by Dominant Species

- Tulip poplar / Beech / Spicebush stream
- Tulip poplar / Red Maple / Beech / Kudzu
- Tulip poplar / Beech / Witch-hazel

RIPARIAN EDGE (RE)
Total area: 2.3 acres
Vegetation Subtypes Described by Dominant Species

- Box elder / White mulberry / Rose of Sharon / English ivy
- Knotweed / Spicebush / Amur Honeysuckle
- Tulip poplar / Red Maple

FOREST EDGE (FE)
Total area: 10.9 acres
Vegetation Subtypes Described by Dominant Species

- Mile-a-minute / Porcelain berry / Ground ivy
- Tulip poplar / Pokeweed / Poison Ivy / Wineberry
- Tulip poplar / Porcelain berry / Purple passionflower

LAWN/FIELD (L)
Total area: 8.45 acres
Vegetation Subtypes Described by Dominant Species

- Bermuda grass / Goose grass / White clover

PARKLAND (P)
Total area: 17.4 acres

- Persimmon / Bermuda grass / Plantain / White clover


NORTH
SOUTH
EAST
WEST
Releve 1: Bermuda grass / goose grass / white clover field
Releve 2: Mile-a-minute / Porcelain berry / ground ivy edge
Releve 3: Tulip Poplar / Norway maple / Honeysuckle / Spicebush / English ivy forest
Releve 4: Box elder / White mulberry / Rose of Sharon / English ivy stream edge
Releve 5: Tulip Poplar / Beech / Spicebush stream
Releve 6: Knotweed / Spicebush / Honeysuckle stream
Releve 7: White Oak / Hickory / Blackgum / Mapleleaf viburnum / English ivy forest
Releve 8: Tulip Poplar / Pokeweed / Poison Ivy / Wineberry edge



Figure 20: Photographs of all relevé plots

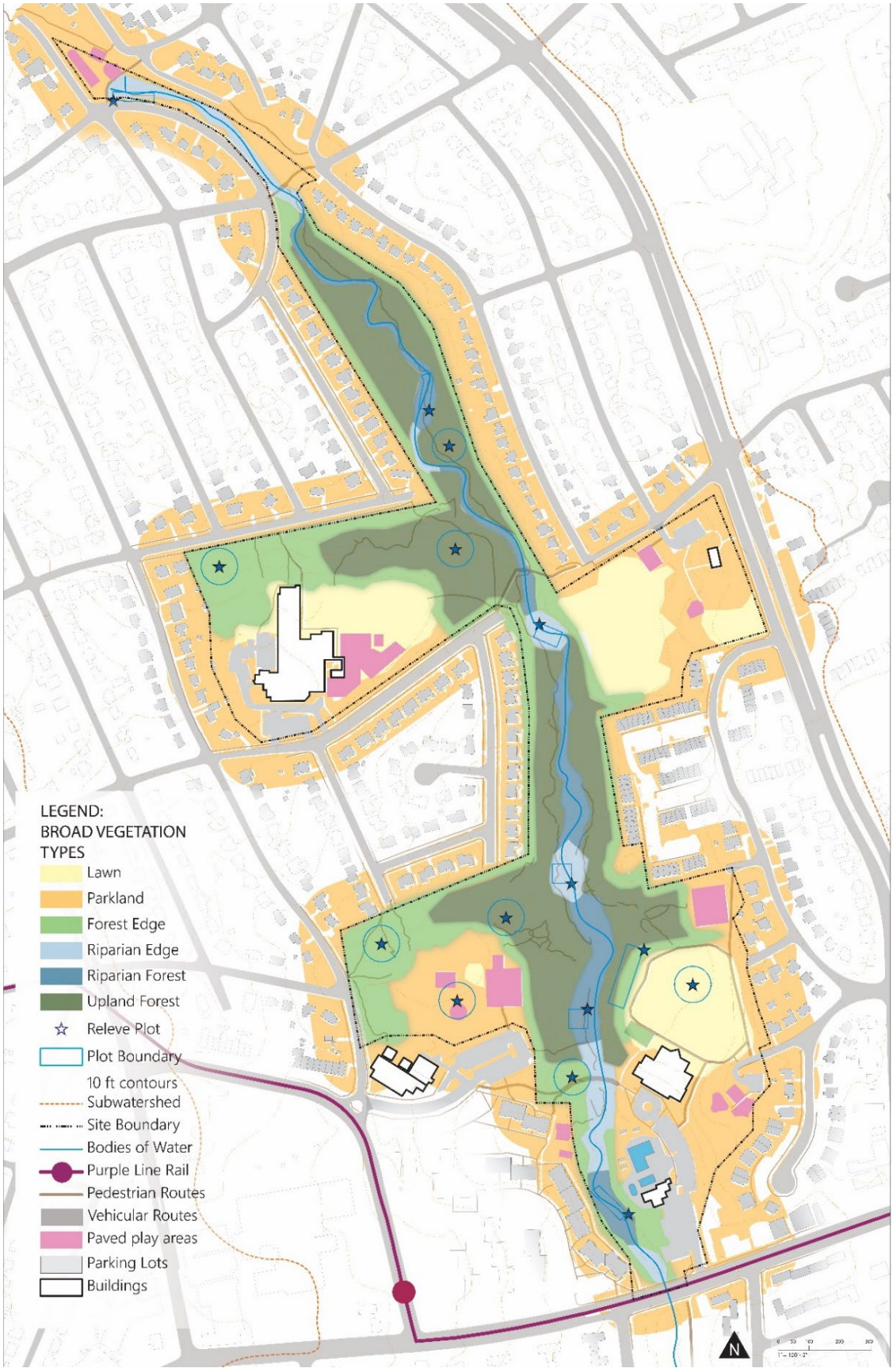


Figure 21: Vegetation delineation by broad type

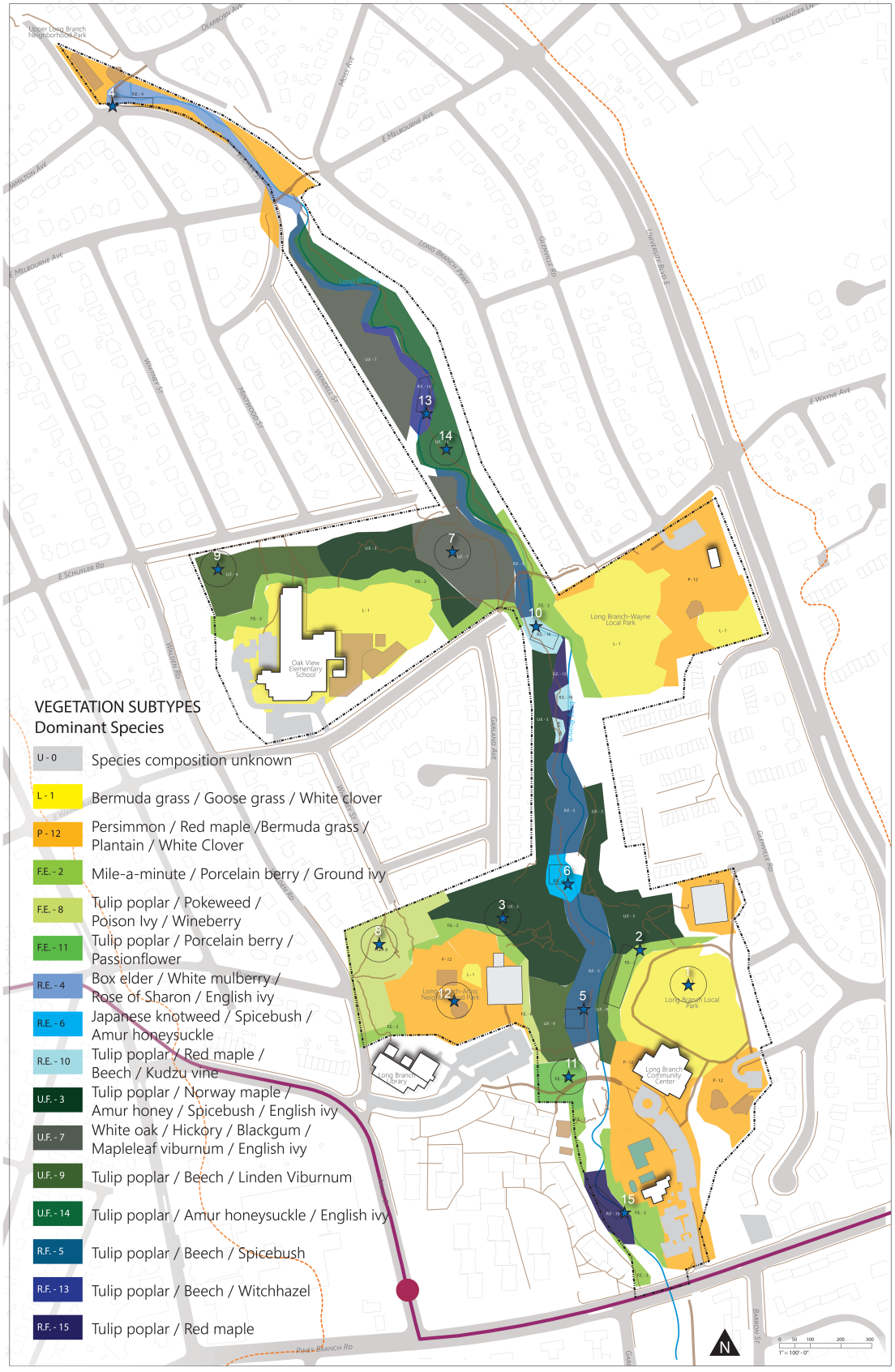


Figure 22: Vegetation delineation by subtype (dominant species)



Figure 23: Illustrative map of existing vegetation conditions

Figure 23 is an illustrative map of existing vegetation conditions. The map begins to show some of the trends that will be discussed in detail in Chapter 4 of this paper. Invasive species, shown in red, were problematic across the entire site. Some areas of the forest were very open, allowing visual permeability, and others were very dense and nearly impassable even by informal trails. Vegetation transitioned very abruptly from non-forest to forest structure; mature forests butted up against open mowed fields, mowed parkland, or sidewalks.

There are areas on the site and directly adjacent to the site where no relevé data was gathered and no observations were made due to time and resource constraints. Some of these may have important implications for the site's vegetation trajectory. Perhaps most importantly, the residential parcels immediately surrounding the site directly influence species availability on the site, but due to time and resource constraints, no relevé data could be gathered on any of these residential plots. Using a combination of visual observations, studies of residential landscape patterns (Livingston & Myers, 2004; Wheeler et al., 2017), and aerial imagery, some assumptions were made about the vegetation in surrounding residential plots (Box 4).

Box 4: Assumptions made about residential plots surrounding the Long Branch site

- Most of the ground layer in both front and back yards is seeded with grass and mowed regularly.
- Ornamental shrubs and annuals planted in residential front and back yards may be native or nonnative species and may or may not disperse onto the study site.
- Canopy trees in backyards, front yards, and lining streets may be native or nonnative species and may or may not disperse onto the study site.
- At least some of the species that exist within site boundaries spread by seed dispersal from adjacent residential areas.

Modifications to protocol & limitations of the dataset

Each observed species was sorted into the structural vegetation layer in which it was found. It must be noted here that the author modified the way in which vegetation structure is traditionally recorded following the CANPS Relevé Protocol. While the CANPS protocol strata are categorized by growth habit (tree, shrub, herb, etc.), the author renamed these categories to reflect the structural layer based on vegetation height (canopy, understory, ground, etc.). The changes made were intended to allow species of one growth form to be recorded in multiple structural layers, so that for example, a tree species could be recorded in the ground layer as a seedling and the canopy layer as a mature tree. These categorizations both aim to record vegetation structure, and in many cases, growth habit and structural layer coincide. For example, the data would not reflect a difference if an herbaceous species were recorded in the "Herb" layer versus the "Ground" layer. However, it would make a difference if a tree species were recorded in the "Shrub" layer. Though the CANPS Protocol has some built in instructions to account for such variations in growth form, it was judged at the time of data collection that the modifications would clarify things for the author.

A "vine" structural layer was added in an effort to document vines separately as species that can occur in any structural layer from the ground to the canopy. Retrospectively, this created a limitation in the dataset because even though vines were observed in multiple structural layers, the only layer they were recorded in was the "vine" layer. At the time of data collection, the structural layer in which the vines were observed was not recorded, so this important piece of information is not reflected in the dataset. The dataset was not modified to attempt to fix this omission. All changes made to the CANPS vegetation strata categories are noted in Table 4 below.

It was retrospectively noted during data analysis that the height classifications used by the author may have yielded some unclear results in the Subcanopy and Understory layers. For example, some specimens of *Ilex opaca* were categorized in the dataset as subcanopy trees (25-50'), when they likely should have been recorded as understory trees. This was due to errors in height estimation at the time of

data collection. Since this happened with other species as well as *Ilex opaca*, only three species were recoded in the understory layer across the entire site. It must be recognized that this does not reflect the reality of the vegetation structure on the plot; many species categorized as "subcanopy" likely should be "understory". The dataset was not modified to attempt to fix these errors, because it is unknown how many times the error was made.

Name of Growth Strata	Code used by CANPS	Related Layer Used by Author	Code used by author	Height Classification
Tree	T	Canopy	C	Over 50'
		Sub-canopy	SC	25-50'
Understory	U	Understory	U	10'-25'
Shrub	S	Shrub	S	3'-10'
Ground	H	Ground	G	0-3'
		Vine (Added by author)	V	Any height

Table 4: Changes made to CANPS vegetation protocol

Site Analysis

Key design & planning recommendations

- Strategically site stormwater BMPs and daylight streams where possible.
- Path siting and definition should aim to reduce trampling in forest, keep paths out of floodplain and steep slopes, and reinforce connections made by informal routes.
- Existing program should be kept for the most part, but facilities can be spatially densified.
- Accessibility of entrances, circulation routes, and gathering spaces should be improved.
- Adjacent parcels should be acquired where possible in order to increase forest & stream buffer area.

The Upper Long Branch stream valley and surrounding parks already are strong amenities to the surrounding communities and neighborhoods. Figure 24 illustrates some of the opportunities and constraints of the site that will be described in this section. A variety of formal and informal uses exist within the study site (Figure 24). Formal uses are centered in the existing parks, recreational facilities, and trails that are sanctioned and maintained by M-NCPPC. Informal uses of the site occur predominantly within the stream valley forest in the form of trail networks, desire paths, and gathering spaces that are neither sanctioned nor maintained by the county. These informal uses physically mark a desire for increased connectivity through the stream valley, access to the stream, access to the woods, and gathering spaces within those places. Considering the anticipated transit-oriented development of Long Branch, focus should be placed on the potential for this site to support current formal and informal uses, fulfill community needs, anticipate an increased number of visitors, and improve the park's ecological quality. This focus dovetails with the goals of the 2050 Master Plan for Montgomery County as well as the 2013 adopted Long Branch Sector Plan (MNCPPC, 2020; MNCPPC, 2013). An analysis of the constraints and opportunities documented through the site inventory reveal a series of solutions that are aligned with this focus (Figure 24). The Long Branch stream both divides and unifies the site; it physically runs between the parks alongside it and provides a valuable amenity for patrons of all neighborhood parks. Observed hydrological conditions reveal that many characteristics of the urban stream syndrome are present on the site, particularly bank scouring (Walsh et al., 2005). Following the literature, improving urban riparian conditions should focus on reducing peak flow through stormwater runoff infiltration measures outside of



Figure 24: Site Analysis map with figures

the water body in question, and ideally at a watershed scale (Bernhardt & Palmer, 2007; Walsh et al.,

2005). It follows that strategically siting stormwater BMPs should be a priority in improving riparian water quality and reducing the anthropogenic impact of impervious surface runoff in Long Branch. This can also happen by tracing the location of buried water bodies, daylighting streams where possible, and increasing riparian buffer area where possible. This is especially prevalent on the Northern portion of the Long Branch site, where the riparian buffer is in some places no more than 10 feet wide. In-stream restoration strategies such as bank stabilization and bank revegetation can then be used to supplement stormwater runoff infiltration measures. The Long Branch subwatershed is relatively narrow, so there is also potential for stormwater BMPs in the neighborhood to quickly impact water quality positively in the stream itself. Another area of concern is that many of the informal paths and some existing impervious surfaces on the site are located within the floodplain. Moving informal paths and especially areas of impervious surface, such as the community center parking lot, out of the floodplain can bolster water quality, reduce erosion, and minimize flooding. The desire to walk along the side of the stream can be accommodated through the construction of boardwalk paths to replace natural surface paths.

In addition to high stormwater runoff volume, other anthropogenic impacts on the site included trash dumping and trampling. Both were observed in conjunction with informal park use along edges of woods and within forest patches; people tended to use the wooded areas as gathering spaces for drinking, eating, smoking, and other socialization. Since existing routes through the woods are either informal or unclear, trampling and soil compaction was widespread. The movement of people through the forest patch as well as the tendency to litter should be addressed to avoid the negative ecological impacts of these actions (Lehvävirta et al., 2014). Possible solutions to trampling and compaction include defining pathways through the woods, using structures to deter people from walking through sensitive areas, and spatially redefining gathering areas. Solutions to littering include placing more trash collection receptacles at strategic points on the site, cultivating awareness of the detrimental effects of littering, and creating a greater sense of place attachment and stewardship mentality. It should be noted that the location of informal paths, gathering spaces, and even litter piles indicate where people want to move and gather; the proposed design should reflect and reinforce this natural movement of people as much as

possible to the extent that detrimental ecological effects can be avoided. Another way to say this is that informal and formal programs should be cohesively unified.

Future development trends anticipate a dramatic increase in population of the area and increased densification around the southern portion of the site where the Purple Line stop will be. Increased development in the area will in turn create a legal impetus for afforestation, reforestation, or protection of existing forested areas (Maryland DNR Forest Service, 2004). It follows that the proposed design for the site should maintain the existing recreational program, accommodate additional recreational needs of the current community, anticipate a future increase in both local and destination users, and plan strategically for increased reforestation efforts. Currently, recreational facilities on the site are more spread out than they need to be. Since housing redevelopment and densification is likely to happen around the Purple Line stop, it makes most sense to densify most recreational facilities within walking distance of where that stop will be on Arliss Street, while densifying some existing facilities elsewhere. Maximizing the spatial efficiency of recreational facilities will then free up space for reforestation (via managed succession) to occur in designated areas. Freeing up space for reforestation on the existing site, particularly sites adjacent to existing forest patches and within the riparian buffer, fulfills a regulatory need and also presents the opportunity to increase forest patch size and invite a gradient of successional communities into the site.

Another current constraint on the site is the inconsistent accessibility and navigability of existing entrances, trails, facilities, and gathering spaces (Figure 24). As stated above, the inventory reveals a gradient of uses ranging from formal to informal, and the built components of the site reflect that. The parks surrounding Long Branch were designed as separate entities and they were not planned to be connected, so people have made their own connections. Currently, many of the neighborhood entrances to the various parks are wheelchair-inaccessible and are unmarked except by desire paths. Some formal entrances, such as that at Piney Branch Road, warrant aesthetic and safety improvements. The proposed design should consider that compliance with the Americans with Disabilities Act (ADA) is imperative, and that future development trajectories anticipate less people traveling by car and more people traveling

by public transit, bicycle, or foot (MNCPPC, 2020). It follows that existing vehicular circulation and surface parking can be maintained if needed but should not be expanded. To increase stormwater infiltration, permeable paving materials should be considered for any redevelopment of paved areas. Bicycle parking in destination areas should also be implemented. The widespread need for improved aesthetics, navigability, and accessibility, combined with the desire for connectivity suggested by the informal trail network, opens an opportunity to reconceptualize the Long Branch parks as a more cohesive network with a diverse array of recreational uses. Care should be taken to preserve the character of the site's well-used spaces while improving their accessibility, navigability, and aesthetic quality.

The aesthetic quality of the site ranges from high to low and was observed to be a principal driver of the dynamics of site use. Many of the forested areas next to the stream are very beautiful, particularly in the northern portions of the stream, and the presence of informal trails indicated a desire to walk along the stream and through the forest(NRCS, 2020). People sit with one another on large, flat rocks next to the stream and dip their feet in the water or watch the stream go by. Groups of young men regularly bathe in the stream on hot summer days. The drive to have these types of immersive aesthetic experiences in nature within Long Branch stream valley is present and should be reinforced in the proposed design.

In some areas of the site, vegetation aesthetic quality could be vastly improved. For example, mowed areas often butted up directly against forest edges, creating a stark visual transition and inviting an overgrowth of invasive shrubs and vines climbing into the canopy. This lack of visual permeability due to overgrowth of vines and shrubs was cited as a safety concern by managers and in the Long Branch Sector Plan (MNCPPC, 2013). These concerns drive the current management regime of mowing at least 10 feet on either side of all sanctioned paths as well as under bridges and in other interstitial spaces where people may hide (Bill Hamilton, personal communication, 2020). Additionally, some recreational amenities, such as the playground next to the Long Branch Community Center, are seldom used by families because they are visually inaccessible, and this raises safety concerns (Chuck Kines, personal communication, February 2021). These very real safety concerns reflect the findings in literature related to ecological aesthetics; that the legibility, visual permeability, and clarity of structural layers in vegetation is a key

driver of aesthetic preference and landscape experience (Gobster et al., 2007; Nassauer, 1995; West & Rainier, 2015). The proposed design, therefore, should consider how vegetation structural changes could ameliorate safety concerns and improve aesthetic experiences.

The current informal uses of the site reflect a desire for connectivity between the local parks, immersive aesthetic experiences in nature, and contemplative as well as active recreation. At the same time, the consolidation of recreational facilities in future areas of urban densification can open space on the site for reforestation. An argument can be made here for including vegetation of various successional stages in the proposed design for Long Branch and for other parks under similar conditions. The reforestation of newly opened areas by way of natural succession creates the possibility of having a matrix of plant communities at different successional stages on the site, which would increase aesthetic and experiential variety, habitat heterogeneity, and interpretive opportunities. Considering how instrumental vegetation structure is in the aesthetic experience and safety of urban communities, the structural variety introduced by successional communities can be used strategically to provide wildlife habitat, improve aesthetic experience, and increase visibility and safety. If new parcels are acquired to grow the size of the urban forest patch in the future, inviting managed successional processes on the acquired sites renews the interpretive process throughout time. The Long Branch study site presents a useful case study for the demonstration of how vegetation dynamics, including succession, can help build the ecological and experiential quality of urban parks.

Reference Communities

An ecological reference was used to make recommendations for the restoration of forested areas on the site. Planting design goals were aimed to reflect the structure and composition of nearby intact forests to the maximum extent that was judged to be possible given site conditions. After the plant inventory was completed, it became evident that the forest patch on the site contained many species that corresponded closely to some of the forest types delineated by the United States National Vegetation Classification (USNVC, 2021). The reference community that the site already most closely represents is called American Beech – Tuliptree – Bitternut hickory – Northern Spicebush – Mayapple forest, or Northern Coastal Plain-Piedmont Basic Mesic Hardwood Forest (Fleming et al., 2007). According to the USNVC, this forest association is naturally found throughout Maryland with the highest degree of certainty (Fleming et al., 2007). This forest community was chosen as the guide to target composition for the site because the existing forest at Long Branch is already dominated by *Liriodendron tulipifera* (Tulip poplar) and *Fagus grandifolia* (American beech), with *Carya cordiformis* (bitternut hickory) as a close associate in some plots. The dominant native species in the shrub layer was found to be *Lindera benzoin* (northern spicebush). The association detail names a suite of other species typically found in this type of forest, and those were also used as references for what is proposed on the Long Branch site. The interior forest areas were the only vegetation category on the site for which a reference community was used, because other areas did not match any of the categories in the U.S. National Vegetation Classification for Maryland. Plant selection for other vegetation areas is discussed in the next section.

Chapter 4: Vegetation Characterization & Planting Design Goals

Vegetation Characterization

Key Points

- The forest patch was characterized by a lack of regeneration of native plants.
- Invasive species were widespread in both sunny and shaded areas.
- Invasive species were most widespread in the ground and shrub layers of the forest patch.
- Tree species found on the site were mostly native (71%).
- Species richness of native plants was higher than species richness of invasive plants.

A total of 118 plant species were observed within the 15 relevé plots taken in the vegetation survey. 61 of those 118 species were native to Maryland or the Eastern United States, 49 were non-native, and 8 could not be determined (Figure 25). 45 out of the 49 nonnative plants were listed as invasive in Maryland (UMD Extension, 2021). Non-native invasive plants were found in all 15 relevé plots. Invasive woody vines were found in 87% of relevé plots, and were particularly prevalent on the forest floor. There was a consistent absence of tree seedlings in forest plots, signaling a lack of regeneration. Figure 26 breaks down the origin of all species found on the site by growth form, showing important differences. 71% of trees on the site were native, while 35% of shrubs and 43% of vine species were native, respectively. 20% of grass species were native, and 43% of herbaceous species were native. The origin of 3% of trees, 20% of graminoids, and 13% of herbaceous species could not be determined because they were only able to be identified to the genus level.

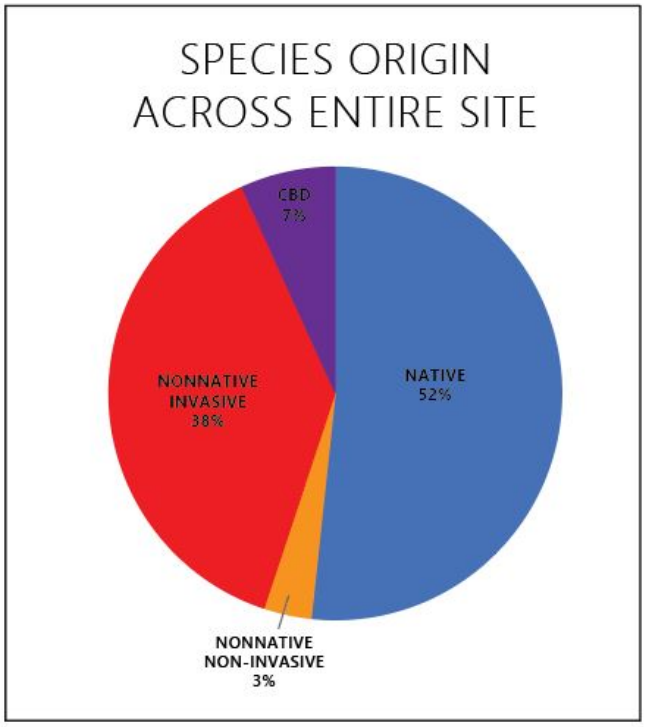


Figure 25: Species Origin Across Site

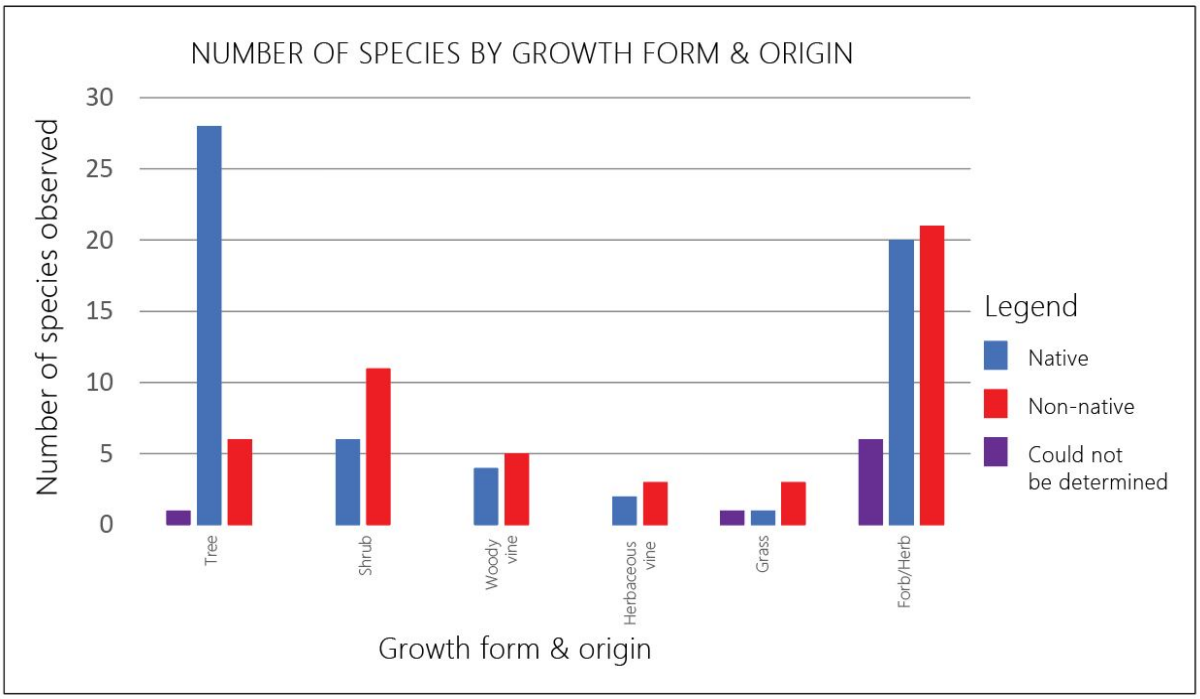


Figure 26:Number of species by growth form & origin across site

Figure 27 shows the most abundant species across all plots. The most abundant species on the entire site was *Liriodendron tulipifera* (Tulip poplar), the dominant canopy tree. Native species *Fagus grandifolia* (American beech) and *Acer rubrum* (Red maple) were also an important part of the forest canopy and understory layers. Invasive *Acer platanoides* (Norway maple) competed with the latter species for dominance in the subcanopy, and invasive *Morus alba* (white mulberry) was often found in the canopy in riparian areas. Nonnative *Prunus* (cherry) species were also observed frequently in forested plots. In the shrub layer, *Lonicera maackii* (Amur honeysuckle) and *Lindera benzoin* (Spicebush) were consistently found in all forested plots, riparian plots, and forest edges. On sunny edges, *Glechoma hederachea* (ground ivy), *Phytolacca americana* (pokeweed), and *Rosa multiflora* (Multiflora rose) were often found in abundance, and woody vine *Ampelopsis glandulosa* was often found climbing from the ground to the canopy. Woody vines *Toxicodendron radicans* (Poison ivy) and *Parthenocissus quinquefolia* (Virginia creeper) were the most dominant native vines found on the site, and were most often observed on the forest floor and forest edges. Shade tolerant invasive woody vines were also highly abundant in the forest patch; the second most abundant species on the site was *Hedera helix* (English ivy)

which blanketed the forest floor in many plots. *Euonymus fortunei* (Wintercreeper) was often found alongside English ivy on the forest floor and on stream banks. Lawn and parkland plots were seeded with a grass mix, so *Cynodon dactylon* (Bermuda grass) was found in high numbers.

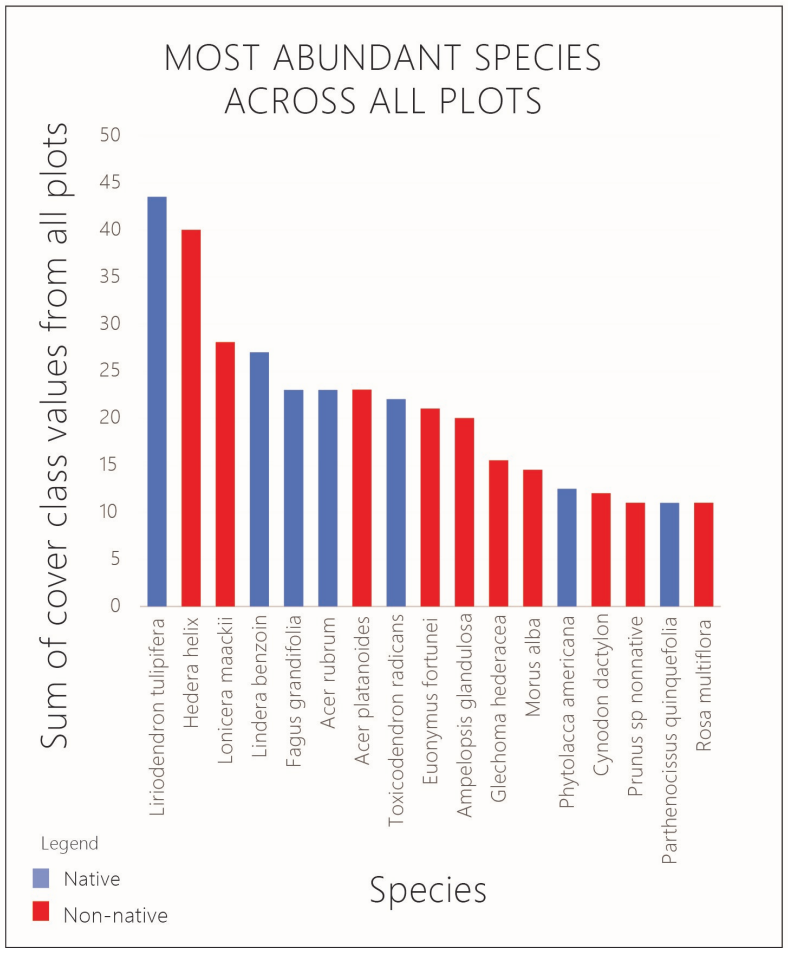


Figure 27: Most abundant species across all plots

Rank abundance data was calculated for each vegetation broad type (this section) and for each subtype (see Appendix, section 2). Rank abundance data was calculated using the cover class values for each species across all broad type plots (For cover class values, see Vegetation Inventory section, Table 2). For the vegetation broad types, for example, there were 4 upland forest plots; for each species found in all upland forest plots, the cover class values were averaged together to calculate the rank abundance data. Rank abundance data for each individual relevé plot (see Appendix) shows the cover class value for each species observed.

In all charts and graphs in this section, "instances" refers to the number of species for which a given attribute was present. For example, for lawn plots (Figure 29), there were 5 forb species (5 instances) and 2 graminoid species (2 instances) found in the ground layer. In Figure 30, there was one species (1 instance) of undetermined origin and 6 species (6 instances) of nonnative origin. This applies to all figures created for each broad vegetation type.

Lawn Plots

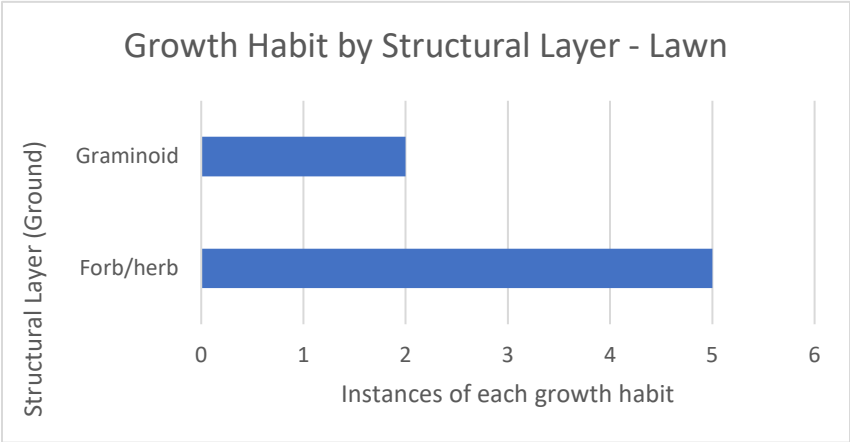


Figure 29: Growth Habit by structural layer - lawn

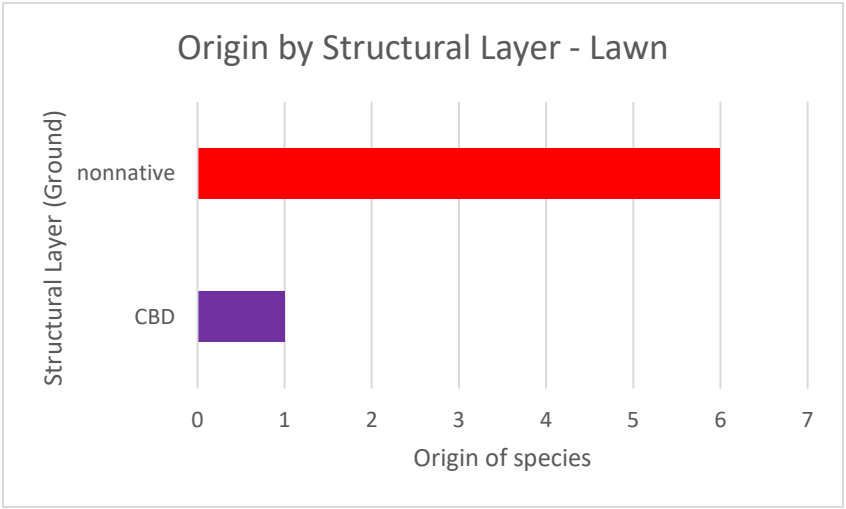


Figure 30: Origin by structural layer - lawn

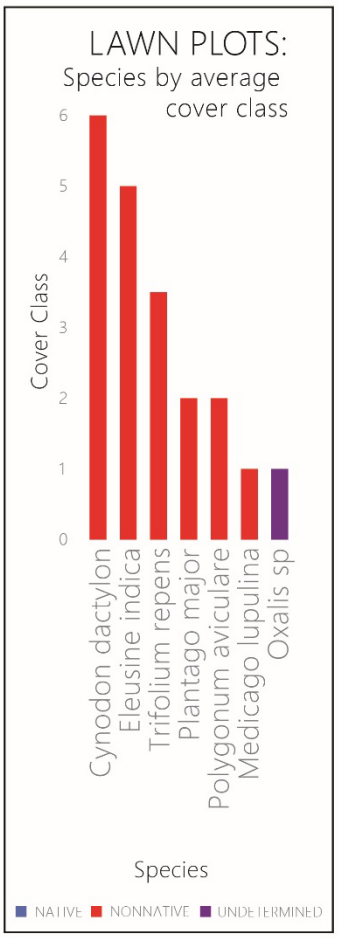


Figure 28: Rank abundance of species in lawn plots

One relevé was done on a lawn plot (Relevé 1). Structural layers in lawn areas were limited to ground cover only, due to constant mowing (Figure 29). Areas of lawn were dominated by *Cynodon dactylon* (Bermuda grass), *Eleusine indica* (Goose grass), *Trifolium repens* (white clover), and *Plantago major* (broadleaf plantain) (Figure 28). All of these species are considered invasive, but are suppressed by constant mowing.

Parkland Plots

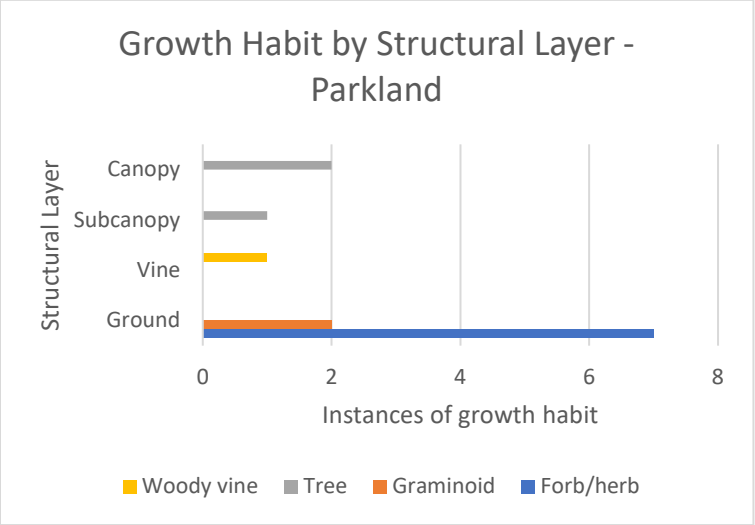


Figure 32: Growth habit by structural layer - parkland

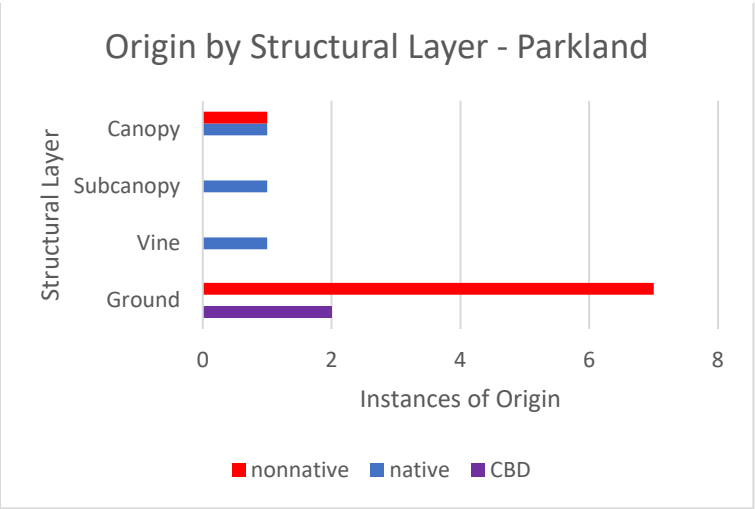


Figure 33: Origin by structural layer - parkland

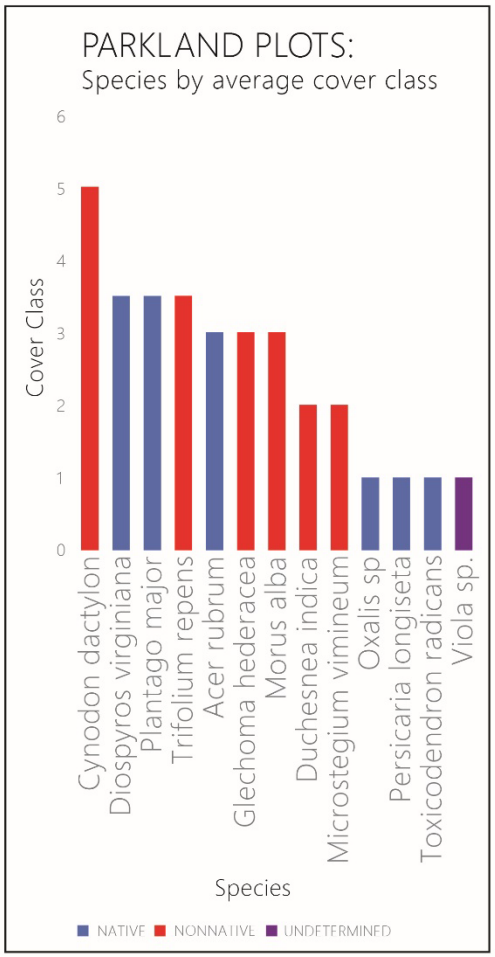


Figure 31: Rank abundance of species found in parkland plots

Mowed areas with canopy trees (parkland) had a similar composition of grasses as the lawn plot (Figure 31). Canopy tree species in these areas included *Diospyros virginiana* (American persimmon), *Acer rubrum* (Red maple), and *Morus alba* (white mulberry) (Figure 31). Lawn and parkland areas were drastically different in structure and composition from the other vegetation areas, and the differentiation between these areas was driven by the mowing regime. Due to time constraints, only one relevé was done in parkland areas (Relevé 12). However, subsequent site observations by the author revealed that canopy

tree species found in other parkland areas included *Platanus x acerifolia* (London planetree), *Quercus spp.* (Oaks), *Pinus strobus* (Eastern white pine), and *Tsuga canadensis* (Eastern hemlock).

Upland Forest Plots

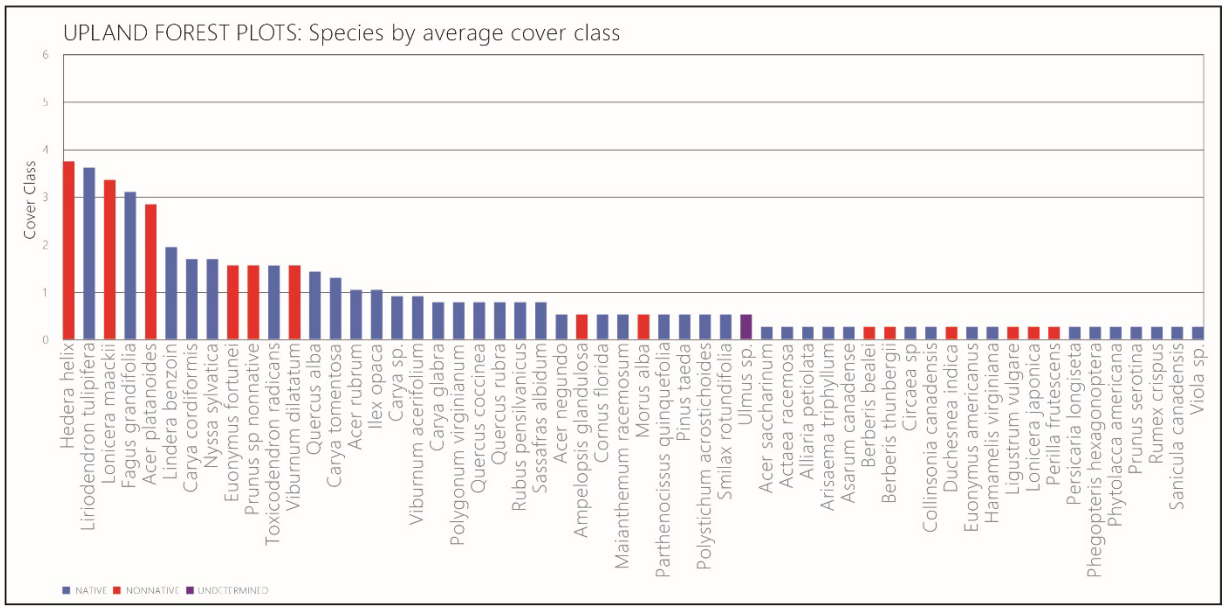


Figure 34: Rank abundance of species found in upland forest plots

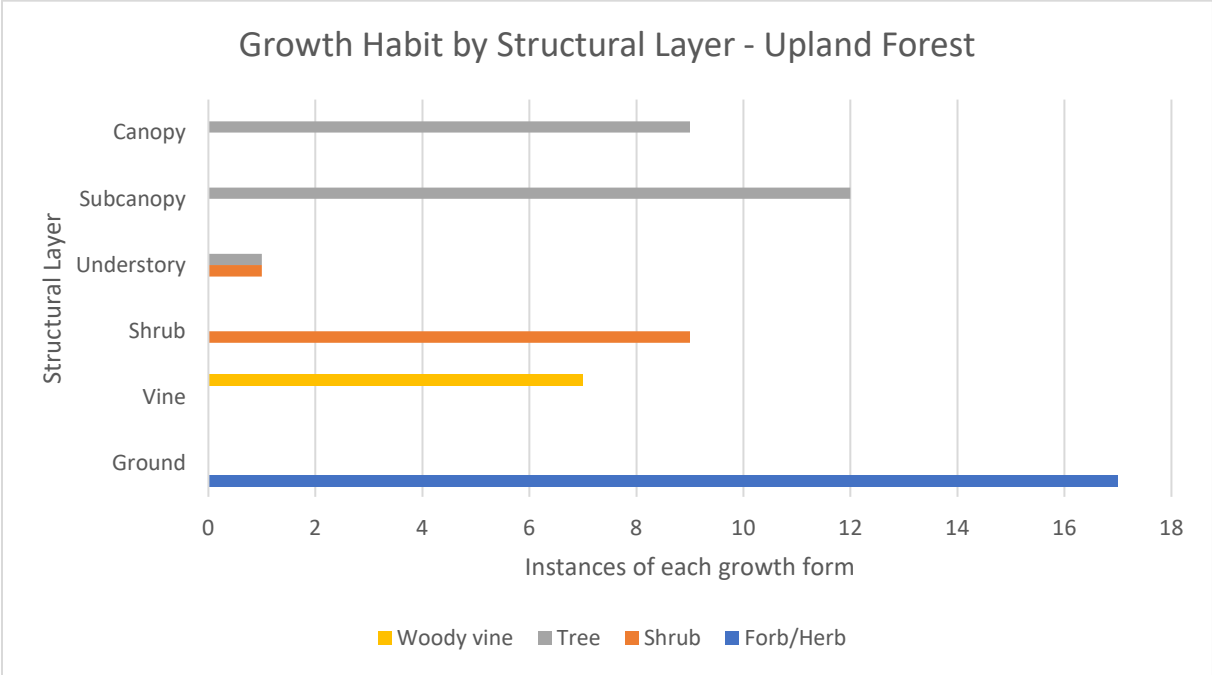


Figure 35: Growth Habit by structural layer – upland forest

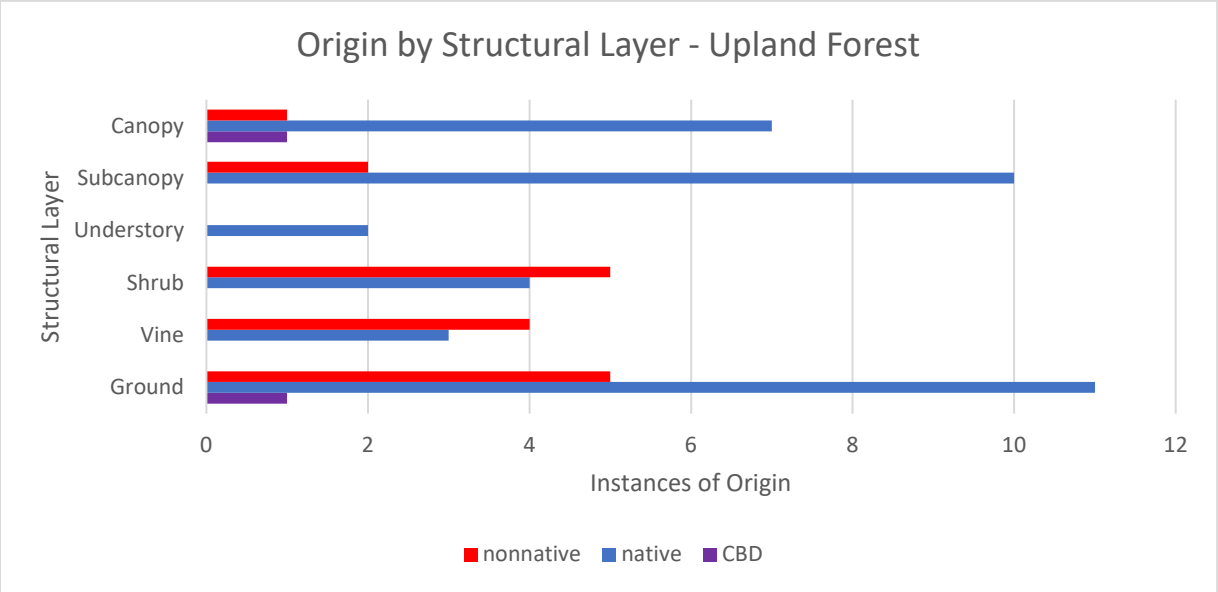


Figure 36: Origin by structural layer – upland forest

Upland forest plots are defined as areas of full canopy cover that were not directly adjacent to the stream. Four relevés were taken in upland forest plots where changes in vegetation structure and composition were observed, as per the relevé protocol (Relevés 3, 7, 9, and 14). The dominant canopy trees were *Liriodendron tulipifera* (Tulip poplar) and *Fagus grandifolia* (American beech) (Figure 34). The subcanopy was dominated by *Acer rubrum* (Red maple) and *Acer platanoides* (Norway maple) (figure); the latter species appeared in dense stands. Less abundant native canopy and subcanopy trees included *Quercus alba* (white oak), *Quercus rubra* (Red oak), *Quercus coccinea* (scarlet oak), *Nyssa sylvatica* (blackgum), *Carya cordiformis* (bitternut hickory), and *Prunus serotina* (black cherry). A commonly observed understory species was *Ilex opaca* (American holly). Less common understory species included *Cornus florida* (flowering dogwood) and *Hamamelis virginiana* (witchhazel). Shrub layers were dominated by deer-resistant native *Lindera benzoin* (spicebush) and invasive *Lonicera maackii* (Amur honeysuckle). Both native and invasive species of *Viburnum* were abundant in the shrub layer in some forest plots (*Viburnum acerifolium* – mapleleaf viburnum, and *Viburnum dilatatum* – linden viburnum). Vines appeared in all structural layers of the forest, but especially on the ground layer. The

invasive woody vines *Euonymus fortunei* (Wintercreeper), and *Hedera helix* (English ivy) were widespread, and the native but poisonous *Toxicodendron radicans* (poison ivy) was also commonly observed. Native woodland herbs such as *Polygonum virginianum* (American jumpseed), *Arisaema triphyllum* (Jack-in-the-pulpit), *Collisonia canadensis* (citronella horse balm), *Polystichum acristichoides* (Christmas fern), and *Asarum canadense* (Canadian wild ginger) were found in small numbers in upland forest plots (Figure 34).

The data shows that growth habit corresponded nearly all of the time to structural layer, signaling a lack of regeneration in the forest (Figure 35). Native tree seedlings and saplings were not recorded in any forest plots. Site observations suggest that this may be due to trampling, compaction, herbivory, and competition by invasive species. Assisted regeneration emerges as a key strategy in restoring the ecological quality of this forest. Native species richness in multiple forest layers suggest that with the removal of invasive species and reduction of trampling and deer herbivory, the site could support increased regeneration of a native forest community.

Forest Edge Plots

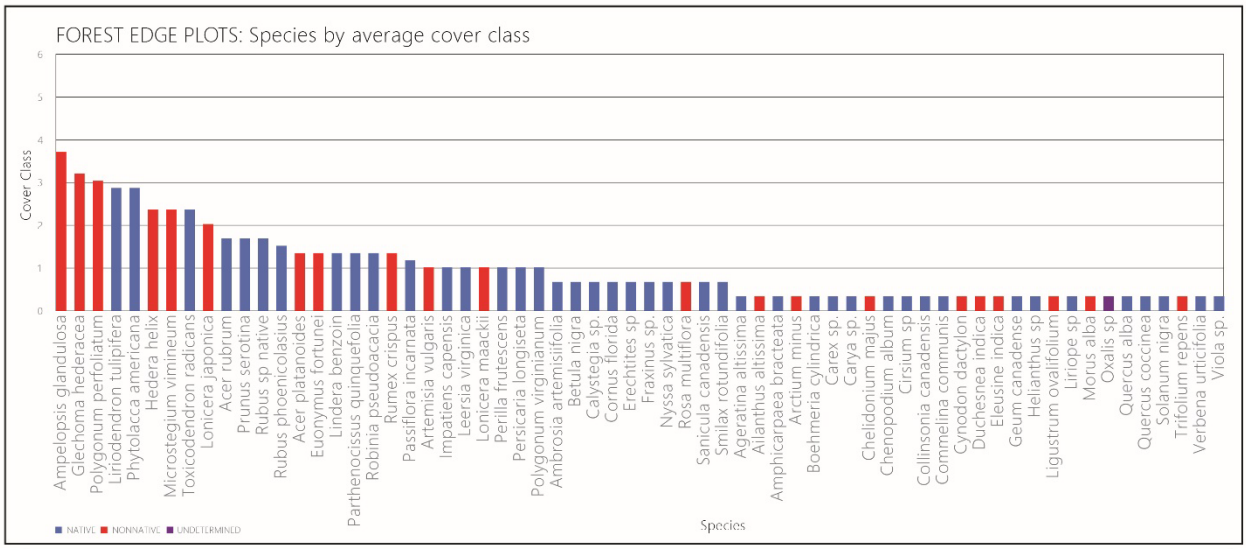


Figure 37: Rank abundance of species found in forest edge plots

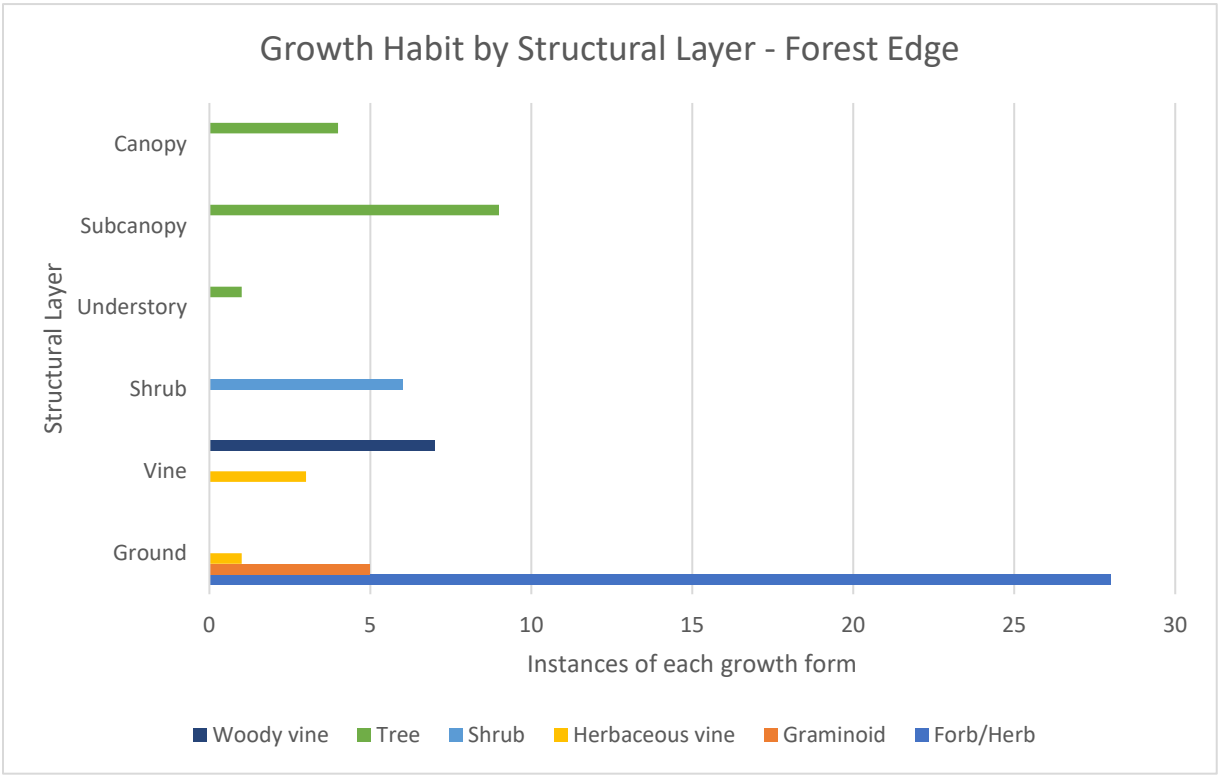


Figure 38: Growth habit by structural layer: forest edge

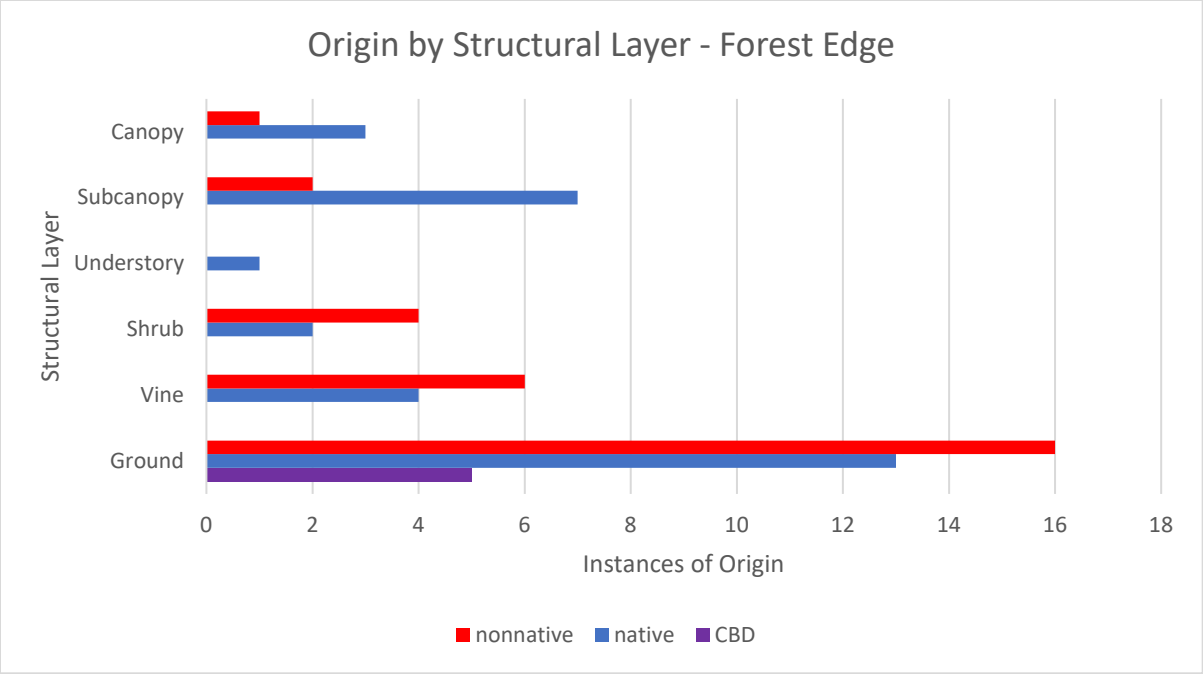


Figure 39: Origin by structural layer – forest edge

Forest edges were defined as transition zones between upland forest areas and open, sunny areas. A total of 3 relevés were taken on forest edge plots (Relevés 2, 8, and 11). These areas had partial canopy cover and were characterized by a species-rich ground layer including invasive vines, grasses, and herbs (Figure 38). Edge habitats are abundant on the Long Branch site because of the shape of the forest patch, and site observations revealed a marked difference in structure and composition between south-facing forest edges and north-facing forest edges. While north-facing forest edges appeared to exhibit similar compositions to the forest interior, south-facing edges had a very different composition from the interior forest patches they were adjacent to. The three forest edge plots in which relevés were taken faced south or southeast. Because north-facing forest edges were so similar to their adjacent interior forest patches, they were not chosen for relevé plots; if they had been included, forest edge data would have likely included more interior forest species.

The most species-rich layer in forest edge plots was the ground layer (under 3') (Figure 38). A total of 28 forb species, 5 graminoids, and 1 herbaceous vine were found in the ground layers of forest edge plots (Figure 38). Of these species, 16 were invasive, 13 were native, and 5 had an origin that could

not be determined (Figure 39). Vines were documented as a separate structural layer, but it is noted here that they were also abundant in the ground layer and were often observed climbing up into canopy trees. In some plots, vines such as *Ampelopsis glandulosa* (Porcelain berry) completely blanketed the trees and shrubs on the site and needed to be moved aside in order to identify the species underneath (Relevé 11). Other woody and herbaceous vines that thrive on sunny edges, such as *Polygonum perfoliatum* (Mile-a-minute), were observed with similar trends. In Relevé 11, near the pedestrian bridge connecting the library to the community center, a particularly striking patch of the native vine *Passiflora incarnata* (Purple passionflower) was observed alongside invasive vines. Structurally, forest edges were characterized by an abrupt transition from canopied forest to non-canopied open areas. Observed management activities included some trimming of woody vines along pathways. Later site observations revealed that occasional mowing and clearing of the ground layer along forest edges was also done to prevent overgrowth of vegetation near pathways.

Riparian Forest Plots

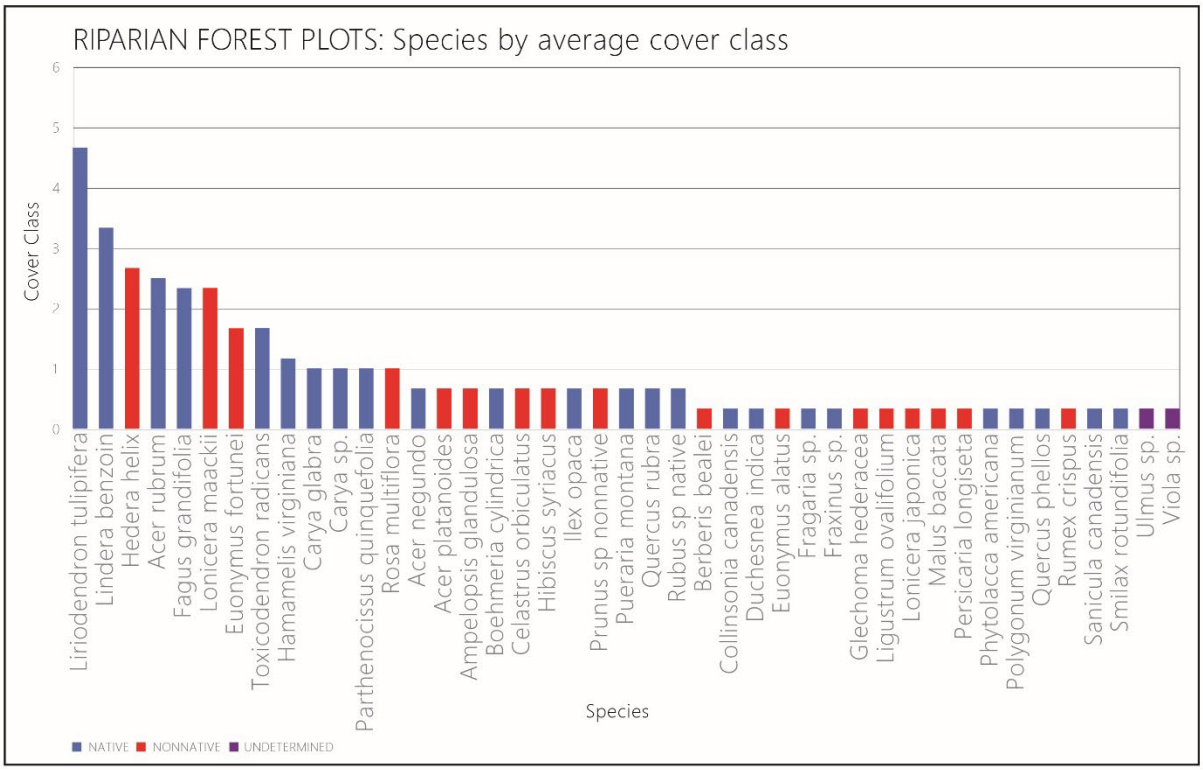


Figure 40: Rank abundance of species found in riparian forest plots

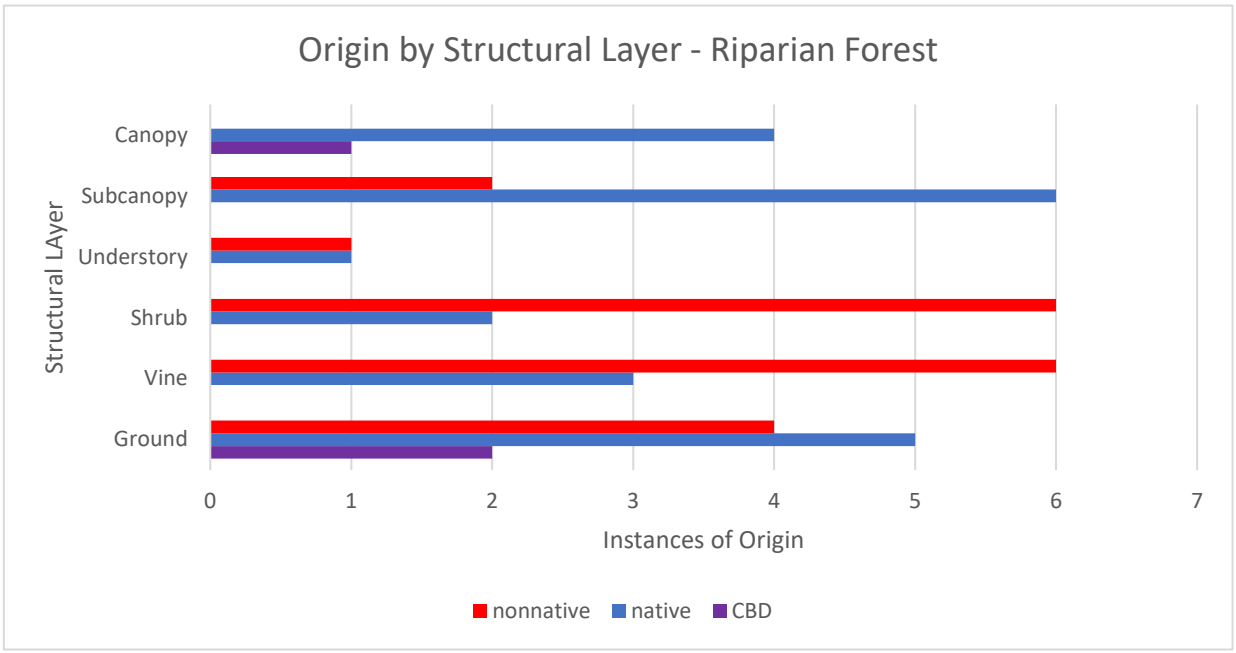


Figure 41: Origin by structural layer – Riparian forest

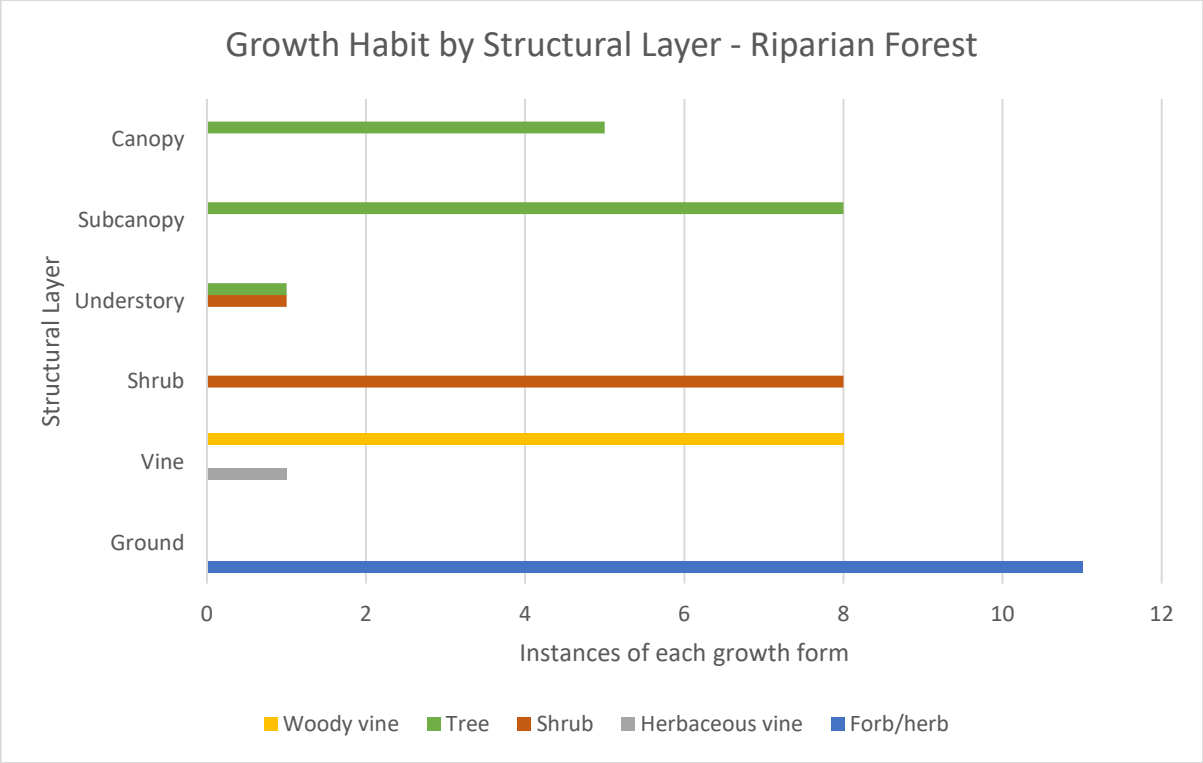


Figure 42: Growth habit by structural layer – riparian forest

Riparian forests were defined as forest areas directly adjacent to or overlapping with Long Branch stream. A total of 3 relevés were taken in these areas (Relevés 5, 13, and 15). Like the upland forest plots, the dominant canopy trees here were *Liriodendron tulipifera* (Tulip poplar), *Fagus grandifolia* (American beech), and *Acer rubrum* (Red maple) (Figure 40). The subcanopy and understory tree species were also like those that characterized upland forest plots. *Acer negundo* (box elder) also characterized riparian forest plots, commonly found growing on stream banks. Reflecting trends found in upland forest plots, invasive species were most problematic in the ground, shrub, and vine layers. 9 vine species were observed, 3 of which were native and 6 of which were nonnative invasive (Figure 41). Vines were often observed climbing from the ground into the tree canopy and hanging down above the stream. Stream banks were often colonized by evergreen invasive woody vines such as *Hedera helix* (English ivy), *Euonymus fortunei* (wintercreeper), and *Lonicera japonica* (Japanese honeysuckle). There were also many instances where stream banks were completely unvegetated.

Riparian Edge Plots

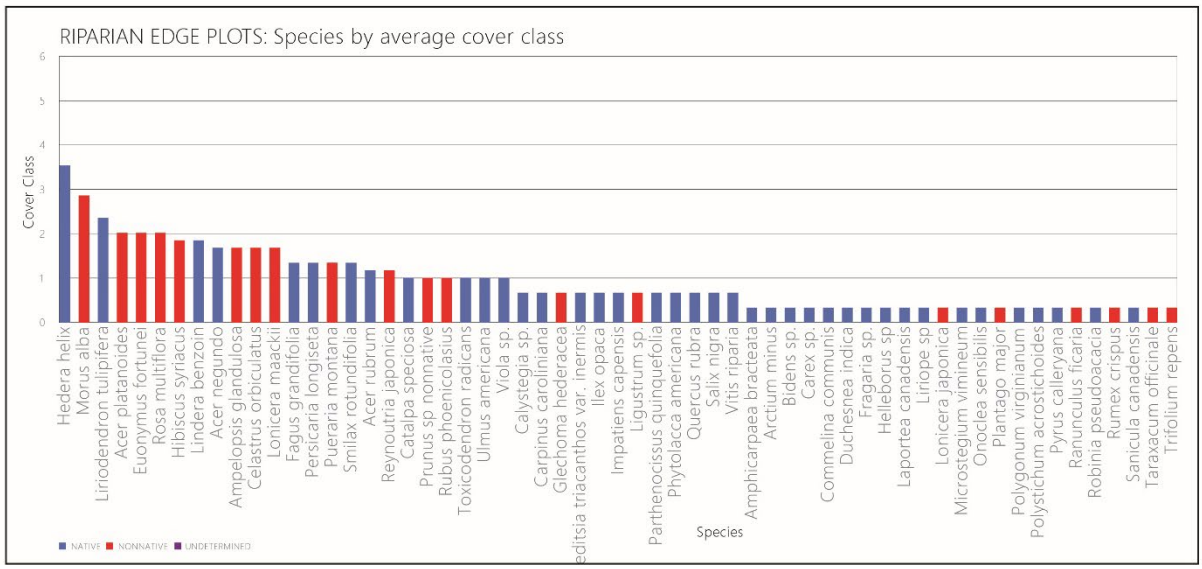


Figure 43: Rank abundance of species in riparian edge plots

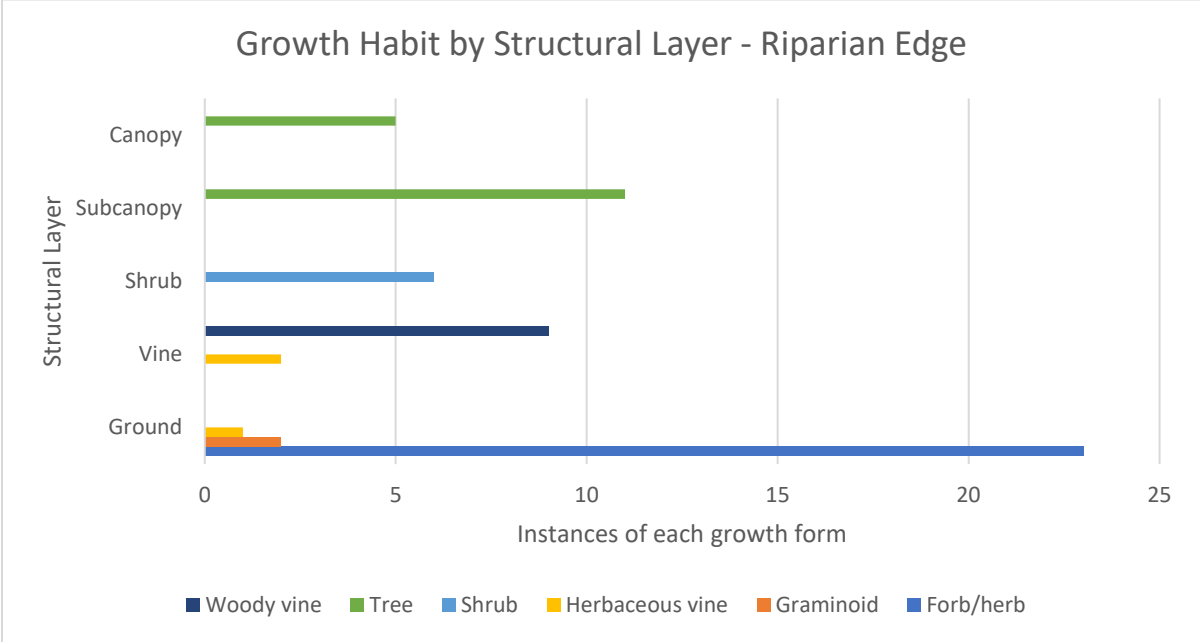


Figure 44: Growth habit by structural layer – riparian edge

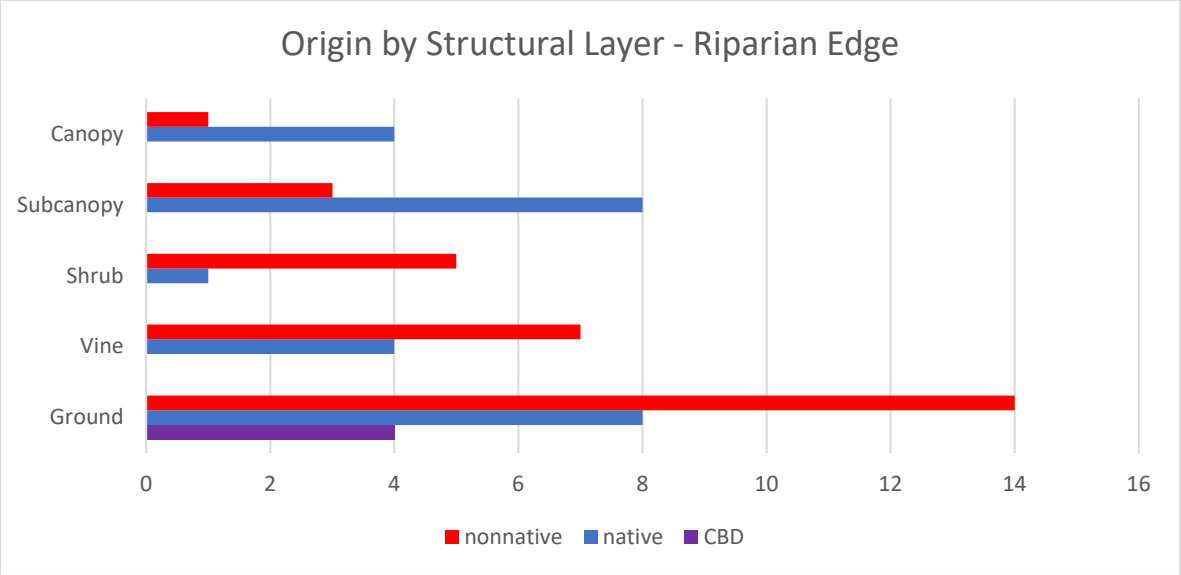


Figure 45: Origin by structural layer – riparian edge

Riparian edges are defined as places directly adjacent to or overlapping with Long Branch stream that had partial or no canopy cover. A total of 3 relevés were taken in riparian edge areas (Relevés 4, 6, and 10). These plots were characterized by various types of invasive species that commonly invade sunny riparian areas, such as *Pueraria montana* (kudzu), *Reynoutria japonica* (Japanese knotweed) and *Rosa multiflora* (Multiflora rose) (Figure 43). The three species mentioned here were more abundant in riparian edge plots than in any other plot type. Like forest edge plots, the ground layer in riparian edge plots had a higher species richness than any other structural layer. 26 species were observed in the ground layer of these plots; 14 invasives, 8 natives, and 4 that could not be determined (Figure 45). 11 vine species were observed in riparian edge plots, more than any other plot type. English ivy and wintercreeper were again among the most abundant woody vines, along with porcelain berry and *Celastrus orbiculatus* (Oriental bittersweet). Native vine species, such as *Vitis riparia* (riverbank grape) and *Smilax rotundifolia*

(Catbrier), were also observed, though in smaller numbers. When canopy and understory trees were present, their composition was similar to other forested plots, with the exception of an elevated abundance of invasive *Morus alba* (white mulberry) and scattered individual native trees such as *Catalpa speciosa* (northern catalpa) and *Carpinus caroliniana* (American hornbeam) (Figure 43).

Existing Vegetation Typologies

The Long Branch vegetation inventory and characterization led to the generalization of eight primary typologies that represent areas where various planting design and management schemes are recommended. Two typologies were created for each of the following habitat types: forest interior, forest edge, riparian areas, and open areas (including parkland and lawn). The forest edge typologies included the transition zone between open mowed areas, named "Field-Forest Edge", and in-between spaces such as parking lot islands, named "Interstitial Edges" (Figures 46 & 47). Field-forest edges occurred on the site where sports fields or parkland butted up directly against the Long Branch forest patch. Especially on south and West-facing edges, an impermeable layer of shrubs and vines were found in the edge zone. An example of this pattern was found in Relevé 2. Interstitial edges varied in structure and composition throughout the site. The area illustrated in Figure 47 is a planted buffer between Wayne Avenue and the LB-Wayne Local Park parking lot. Other examples include parking lot islands in the community center parking lot, vegetated areas around park entrances, and other slivers of vegetation that may or may not be managed.



Figure 46: Field-Forest Edge

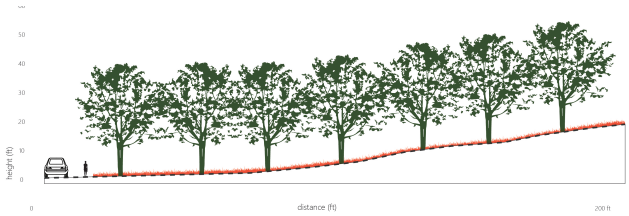


Figure 47: Interstitial edge

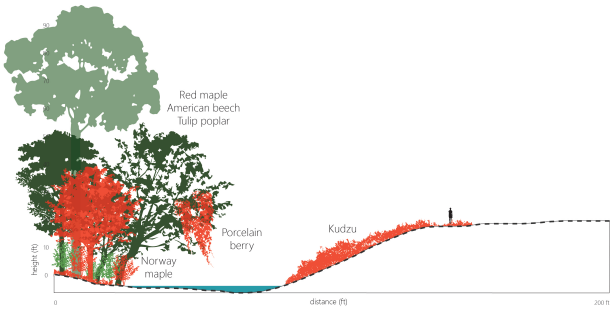


Figure 48: Sunny vineland

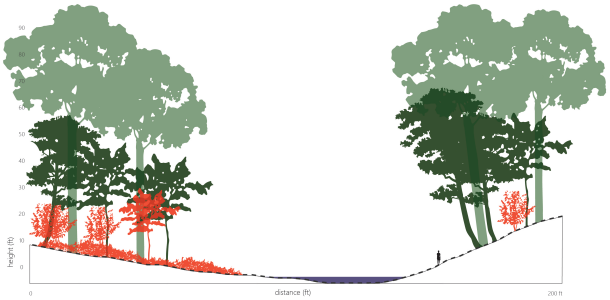


Figure 49: Scoured bank

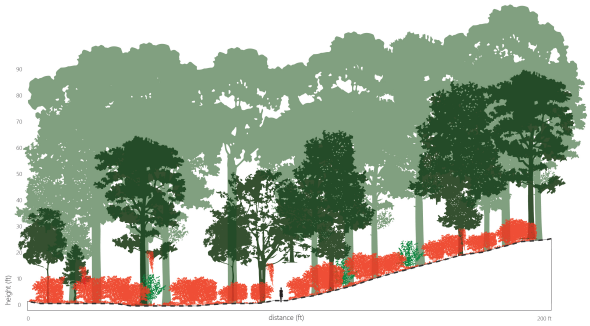


Figure 50: Less invaded forest

Riparian area typologies were named "Sunny Vinelands" and "Scoured banks" (Figures 48 & 49). Scoured bank areas were riparian areas where bank scouring was observed (ex. Relevé 14). Sunny vinelands were found on riparian edges with large gaps in canopy cover (ex. relevé 6 & 10). These sunny gaps were found to be largely colonized with invasive species such as *Reynoutria japonica* (Japanese knotweed) and *Puerira montana* (Kudzu), indicating the importance of canopy cover to discourage shade-intolerant invasives that may be present in the area.

Forested areas included "Fully invaded forest" and "Less invaded forest" typologies (Figures 50 & 51). Fully invaded forests were areas in which invasive species were prevalent in the ground, shrub, and understory/subcanopy layers. For example, Relevé 3 had an estimated 50-75% coverage of *Acer platanoides* (Norway maple) in the subcanopy layer. Less invaded forest types were those in which invasive species were prevalent in the ground and shrub layers, but not in the understory or canopy layers. For example, in Relevé 7, 4 native tree species had an estimated cover of between 15 and 25% each, while only one invasive tree species was recorded at 1-5% coverage (see Appendices 1 & 2 for full details on each relevé plot).



Figure 51: Fully invaded forest

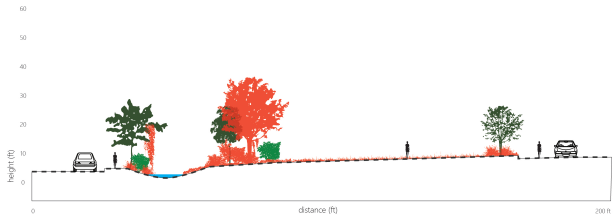


Figure 52: Pastoral parkland



Figure 53: Visibility Corridor

Open areas such as lawn and parkland included "Pastoral parkland" areas and "Visibility corridors" (Figures 52 & 53). Pastoral parkland areas were characterized by mowed grass and scattered canopy trees. These areas were sometimes located where a riparian buffer should ideally be, as illustrated in Figure 52. Pastoral parkland settings allow free movement through the ground layer and also provide shade. "Visibility corridors" are places where vegetation needs to be low or absent at eye level, due to safety concerns and/or to maintain vantage points. These areas are at least partially mowed. Some areas that were designated as visibility corridors, such as the area shown in Figure 53, have existing vegetation that impedes visual permeability and may or may not be maintained. Where this was determined to be problematic from a safety standpoint, a recommendation was made to replace existing vegetation with plantings that fulfill visibility needs.

These vegetation typologies translate the vegetation trends found in the data into a set of problems to solve through design and management interventions. The illustration of these trends helps visualize how these areas can be transformed to fulfill their aesthetic and ecological potential.

Design Goals and Strategies

The design goals for this project are a response to the site conditions recorded in the inventory and vegetation characterization, the review of planning documents, and conversations with M-NCPPC staff and community members who were able to provide insight into community needs. Box 5 lists the design goals for this project as well as specific strategies that are recommended to achieve them.

1. Reduce anthropogenic impact on Long Branch forest
    - Reduce trampling by clarifying pathways, entrances, and gathering spaces and installing fences where appropriate.
    - Reduce stream bank scouring and improve water quality by implementing bioretention facilities and using in-stream restoration measures.
2. Increase forest area
    - Designate areas adjacent to existing forest patches where succession will occur.
    - Where possible, acquire additional properties adjacent to the forest patch throughout time and designate those for reforestation/managed succession.
3. Increase structural and species diversity of native plants
    - Reduce availability of nonnative-invasive species.
    - Focus new plantings on all vegetation structural layers.
    - Include a variety of plant community types in proposed planting design.
4. Increase regeneration of native plants
    - Reduce availability of nonnative-invasive species.
    - Use brightly colored tree sleeves to aid survival of saplings.
    - Use enrichment planting if regeneration levels are insufficient.
    - Reduce trampling and other disturbances to the forest floor.
5. Improve aesthetic & interpretive experience
    - Maintain sightlines, clarity of vegetation layers, and visual permeability in plantings.
    - Use “cues to care” along borders and pathways to bring attention to landscape management and stewardship.
    - Use multilingual interpretive features to provide information about ecological dynamics and suggest easy avenues of stewardship for visitors.
    - Designate opportunities for the integration of public art.
6. Improve navigability & accessibility
    - Clarify pathways, entrances, and gathering spaces.
    - Install multilingual signage and place markers.
    - Improve connectivity between local parks and key destinations for the community.

Box 5: Design Goals and Strategies

Proposed Vegetation Typologies

Figure 54 shows on a 50-year timeline how the existing vegetation typologies are transitioned to proposed vegetation typologies through design and management interventions (see Appendix 4 for enlarged image). Each typology has different aesthetic and planting design goals and therefore a different management scheme. This section will describe these goals and will provide very general management guidelines as well as suggested plant species for each typology (see Appendix 3 for full lists of recommended plants). It should be noted that some of the existing vegetation types have the same end goal composition, as illustrated in the timeline; for example, both "invaded" forest types, riparian forests, and successional forests all end as part of the Beech-Tulip forest.



Figure 54: Proposed typology timeline

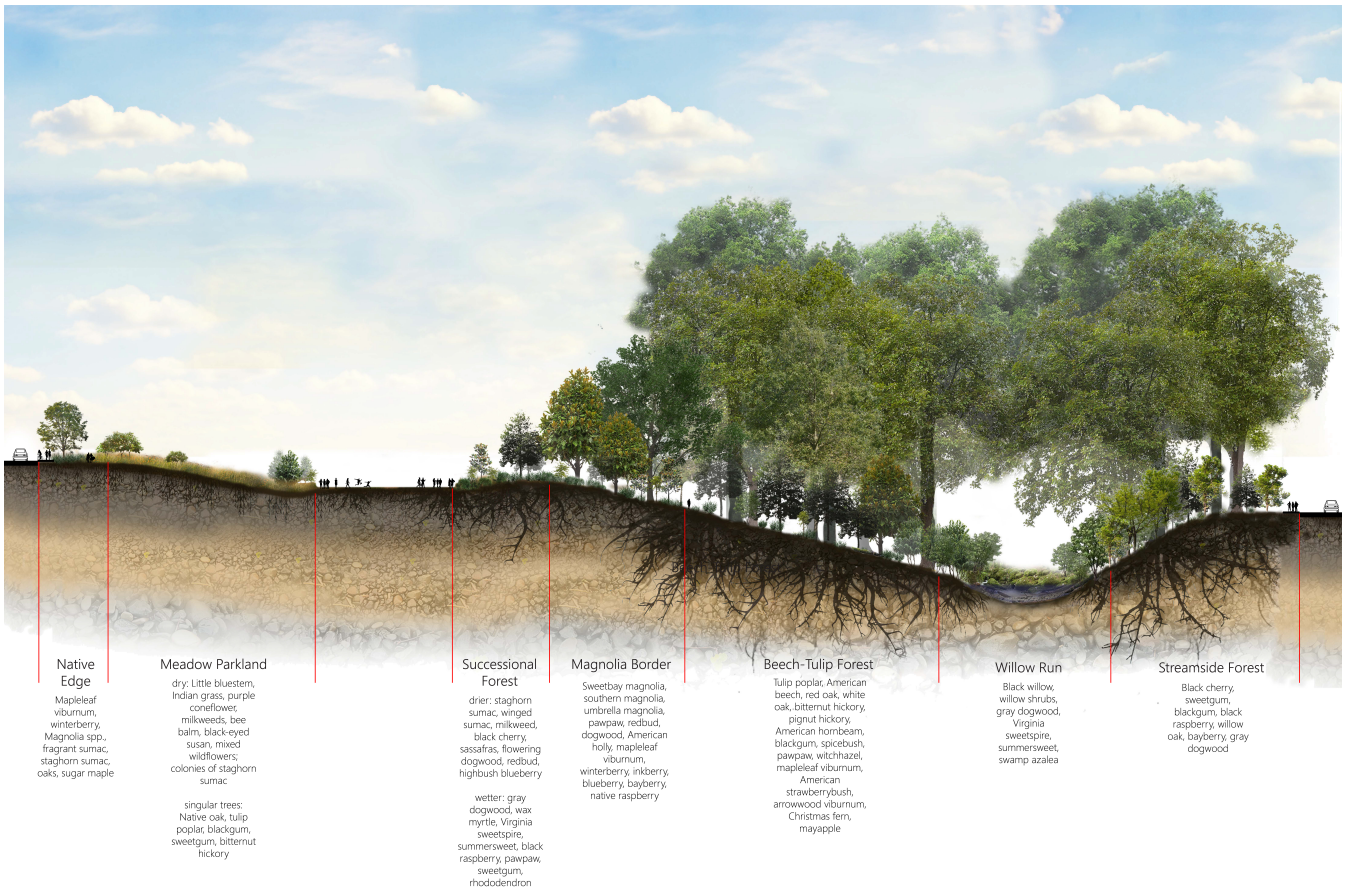


Figure 55: Habitat types and plant species suggestions

Magnolia Border



Figure 56: Magnolia Border



Figure 57: Magnolia Border locations

The Magnolia Border planting design typology is a response to conditions found on many sunny forest edge habitats throughout the Long Branch site. The idea for this typology was developed during conversations with Lea Johnson (personal communication, 2020). The proposed plantings would be situated along paths around sports fields, where an abrupt transition from field to forest is present and will be maintained. Figure 56 shows the goal conditions of this typology and a conceptual representation of its development over time, and Figure 57 shows the proposed location of magnolia borders on the site.

The magnolia border is designed with both ecological and aesthetic improvements in mind. Magnolias are the dominant species here, but a mixed evergreen composition is proposed to break up the planting visually and provide functional diversity. The evergreen border is intended to cast dense shade on the forest interior, shielding it from detrimental edge effects of drying and wind throw. This dense shade could also help to deter sun-loving invasive species from colonizing the forest edge, and would provide a welcome respite from the summer heat for park visitors.

Layering the evergreen edge plantings strategically would allow faster-growing species such as *Pinus strobus* (eastern white pine) to provide shade to the forest interior while slower-growing species such as *Magnolia virginiana* (sweetbay magnolia), *Ilex opaca* (American holly), and *M. grandiflora* (Southern magnolia) fill in over time. These suggested species would flower and fruit at different times of the year, providing consistent visual interest as well as seasonally variable wildlife resources. The section in Figure 56 shows that the lawn extends approximately 20 feet into the forest from the pathway (where the person is shown standing); it is recommended that mowing continue underneath the evergreen canopy to deter invasive vines from colonizing ground layers on these sunny edges and climbing into the canopy. This would also maintain visual permeability underneath the canopy, enhancing the sense of safety for people walking on the path bordering the field. Where mowing stops, a border of native fruit-bearing shrubs could be planted to further shade the interior, deter people from entering the forest via non-sanctioned paths, provide multiple layers of visual interest, and provide foraging opportunities for both wildlife and humans. Suggested species for this part-shade shrub border, depending on moisture conditions, include *Rubus pennsylvanicus* (Pennsylvania blackberry), *Ilex verticillata* (winterberry), *Ilex glabra* (inkberry), *Gaylusaccia baccata* (huckleberry), and native *Viburnum* species.

Native Edge



Figure 58: Native Edge



Figure 59: Native Edge locations

Native edges are focused on the insterstital spaces on the site (Figure 58). These spaces mark entrances, serve as landmarks, and buffer the park spaces from the street. As areas of high visibility, they are opportunities for vibrant and dense plantings that mark the site visually and provide wildlife habitat. The proposed typology would include dense layered native plantings of ground cover, shrubs, and understory trees. Eye-catching understory trees of different colors and textures such as *Cornus florida* (Flowering dogwood), *Cercis canadensis* (Eastern redbud), *Nyssa sylvatica* (blackgum), *Magnolia virginiana* (sweetbay magnolia), *Magnolia tripetala (*umbrella magnolia), *Asimina triloba* (pawpaw), and *Rhus typhina*

(staghorn sumac) can be mixed and clustered based on site moisture and light conditions to maximize visual interest through seasonal changes. Using clusters of the same understory trees in these interstitial spaces that are found less densely throughout the site would create visual continuity for these species within the park.

The shrub and ground cover layers should be managed in these areas to be kept quite dense to minimize site availability for invasive species, but they should also be trimmed keep vegetation cleared at eye level to maximize a sense of safety and legibility of vegetation layers. Depending on moisture conditions, recommended shrub species could include *Viburnum acerifolium* (mapleleaf viburnum), *Viburnum dentatum* (arrowwood viburnum), *Kalmia latifolia* (Mountain laurel), *Hamamelis virginiana* (Witchhazel), and *Clethra alnifolia* (Summersweet). Ground cover species could include *Rhus aromatica* (fragrant sumac), *Asarum canadense* (Wild ginger), *Polystichum acristichoides* (Christmas fern), and *Cornus canadensis* (bunchberry). The Native Edge sites are in a range of light and moisture conditions, which would have to be considered in plant selection.

Willow Run



Figure 60: Willow Run



Figure 61: Willow Run Locations

The "willow run" typology is located in areas where stream banks are scoured and/or unvegetated. Revegetating banks with willow species is a common in-stream restoration strategy (NRCS, 2020). The main proposed species used in this typology is *Salix nigra* (black willow), a fast-growing canopy species that is commonly used to stabilize stream banks because of its shallow roots and affinity for wet environments (NRCS, 2020). Plantings of *Salix nigra* will eventually create a willow canopy over nearby natural surface trails. Shorter riparian shrubs are proposed to be densely planted between the black willows, to anchor soils while

maintaining visibility to the stream corridor and providing wildlife habitat. These species could include a wide variety of eye-catching riparian shrubs, such as *Rhododendrum viscosum* (swamp azalea), *Cornus racemosa* (gray dogwood), *Myrica pennsylvanica* (bayberry), *Clethra alnifolia* (pepperbush), *Sambuca canadensis* (Elderberry), and others.

Streamside Forest

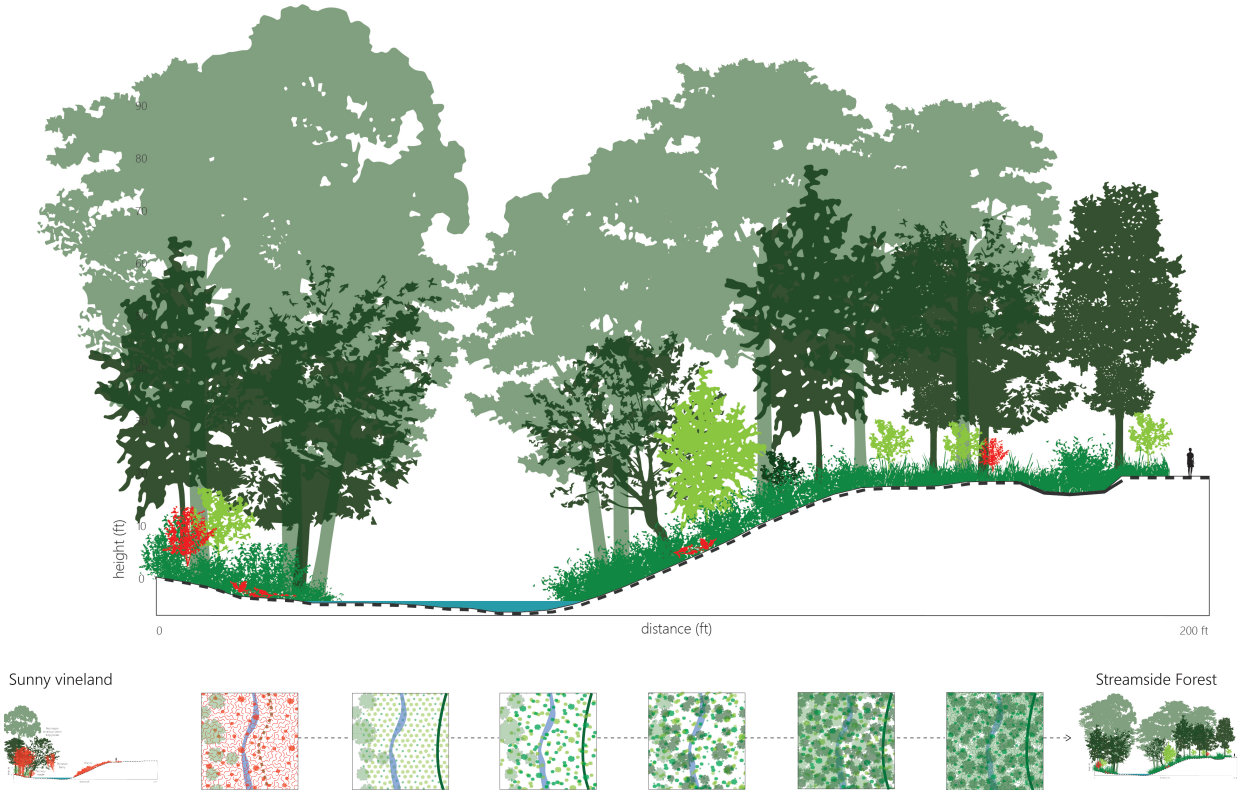


Figure 62: Streamside Forest



Figure 63: Streamside Forest locations

The streamside edge typology is a response to the sunny vinelands found in many riparian edge habitats on the site (Figure 62). The goal composition for these plantings should eventually be the same as for all forested areas (see Beech Tulip Forest typology), but a more immediate goal of this typology is to achieve canopy cover to shade out sun-loving invasive species. Initial invasive species removal and site preparation should be followed by dense planting of fast-growing native tree species that do well in riparian conditions. Recommendations for fast-growing tree species include *Liriodendron tulipifera* (Tulip poplar), *Salix nigra* (black willow), *Ulmus rubra*

(slippery elm), and *Liquidambar styraciflua* (sweetgum). Species that form clonal colonies, such as sweetgums, are highly recommended to help stabilize disturbed sites such as these (Luken, 1990). Slower growing riparian trees that may fill in as shorter-lived species die out include *Nyssa sylvatica* (blackgum), *Platanus occidentalis* (American sycamore), *Quercus palustris* (Pin oak), and *Quercus phellos* (willow oak). Planting slow and fast-growing pecies simultaneously can allow for this shift in forest development to occur. Riparian shrubs such as *Rubus pennsylvanicus* (Pennsylvania blackberry) can help quickly form a dense shrub layer, keep people out of these disturbed area (with thorns), and provide foraging opportunities. As canopy gaps fill in, enrichment plantings can include later successional forest species that tolerate riparian conditions. For example, this type of environment could support an understory of *Asimina triloba* (pawpaw). Pawpaws are recommended due to their aesthetic qualities, ethnobotanical interest, and foraging opportunities for people and wildlife.

The spacing of these streamside areas throughout the Long Branch site creates an unanticipated planting design opportunity. Figure 58 shows how the areas designated for this typology are arranged rhythmically along the stream valley. Creating these small stands of fast-growing trees provide interpretive opportunities at regular intervals along the trail and would break up the visual composition of the forest. Furthermore, dense colonies of species such as sweetgums, with brilliant fall colors, would create points of interest along the trail, enhancing the aesthetic experience of the forest.

Beech Tulip Forest

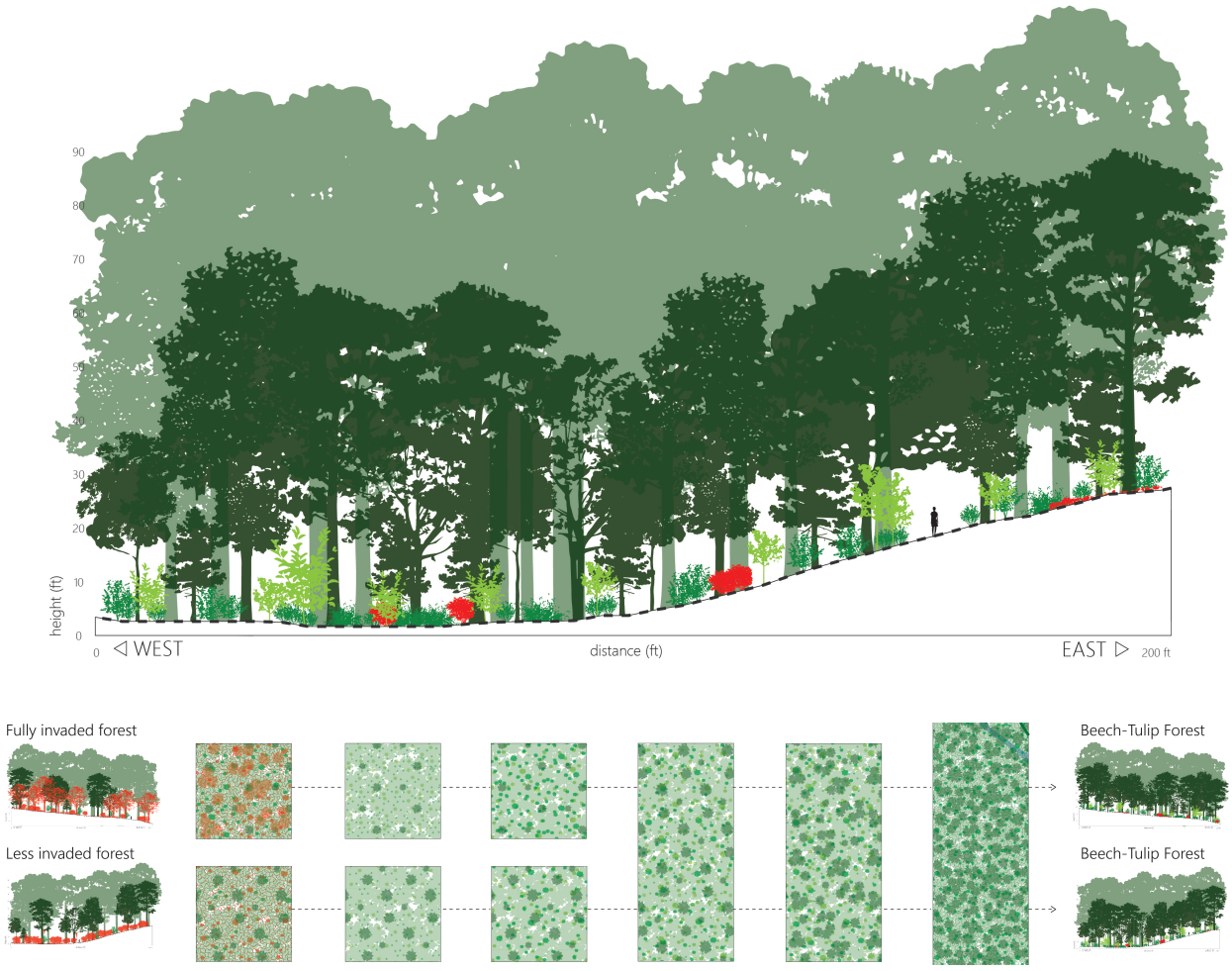


Figure 64: Beech Tulip Forest

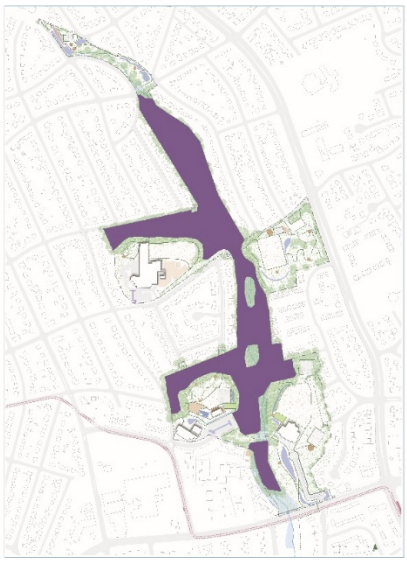


Figure 65: Beech tulip forest locations

Perhaps the most important typology, the Beech Tulip forest represents the target forest composition that is drawn from the NVCS forest type named American Beech – Tuliptree – Bitternut hickory – Northern Spicebush – Mayapple forest (Fleming et al., 2007). This forest type was amended with other species that create visual interest, are already found on the site, and/or have specific wildlife or aesthetic benefits.

The existing forest already contains many characteristic species of the goal forest type, but regeneration is low and invasive

species are rampant. Initial interventions should include mass invasive species removal, focusing on woody vines in the ground cover layer and invasive shrubs in the shrub layer. Stands of *Acer platanoides* (Norway maple) are recommended to be removed to the maximum extent possible in heavily invaded forest areas, following initial invasive species removal in the ground and shrub layers. After these interventions, the recommendation is that the site be planted heavily with young canopy trees. Many species characteristic of this forest type can live in the shade for long periods of time, and when a canopy gap opens up, they quickly grow to fill it in (American beech is a good example). The target canopy species on the site should be *Liriodendron tulipifera* (Tulip poplar), *Fagus grandifolia* (American beech), *Carya cordifomis* (bitternut hickory), *Prunus serotina* (Black cherry), *Quercus alba* (white oak) and *Quercus rubra* (Red oak). Recommended understory trees include *Carpinus caroliniana* (American hornbeam), *Nyssa sylvatica* (blackgum), and *Ilex opaca* (American holly). *Sassafras albidum* (sassafras) may also be used in drier areas, and in wetter areas, *Asimina triloba* (pawpaw) is recommended as an understory tree. In the shrub layer, the existing population of *Lindera benzoin* (spicebush) should be permitted to regenerate, as this is a key component of this forest type. New plantings should include *Viburnum acerifolium* (mapleleaf viburnum), *Viburnum dentatum* (arrowwood viburnum), *Hamamelis virginiana* (witchhazel), and *Euonymus americanus* (American strawberrybush). In the ground layer, an effort should be made to cover as much soil as possible with native forbs and herbaceous species. According to the NVCS classification, the ground layer in this forest type is characterized by "patch dominance of clonal forbs and herbs", predominantly *Podophyllum peltatum* (mayapple) (Fleming et al., 2007). Other clonal forbs and herbs that are recommended are *Polystichum acrostichoides* (Christmas fern), *Maianthemum racemosum* (False Solomon's seal), and *Actaea racemosa* (black cohosh). These ground plantings should be implemented in clusters simultaneously with shrub and tree plantings (NYC Department of Parks & Recreation, 2015).

The forest should be regularly monitored to assess the success of regeneration of native plants and control invasive species. There is a huge potential for the Long Branch community to become involved in forest stewardship and restoration; the forest patch is adjacent to a community center with a

large afterschool program, a short walk from several elementary and middle schools, and is already a focus site for the Weed Warriors program.

Successional Forest

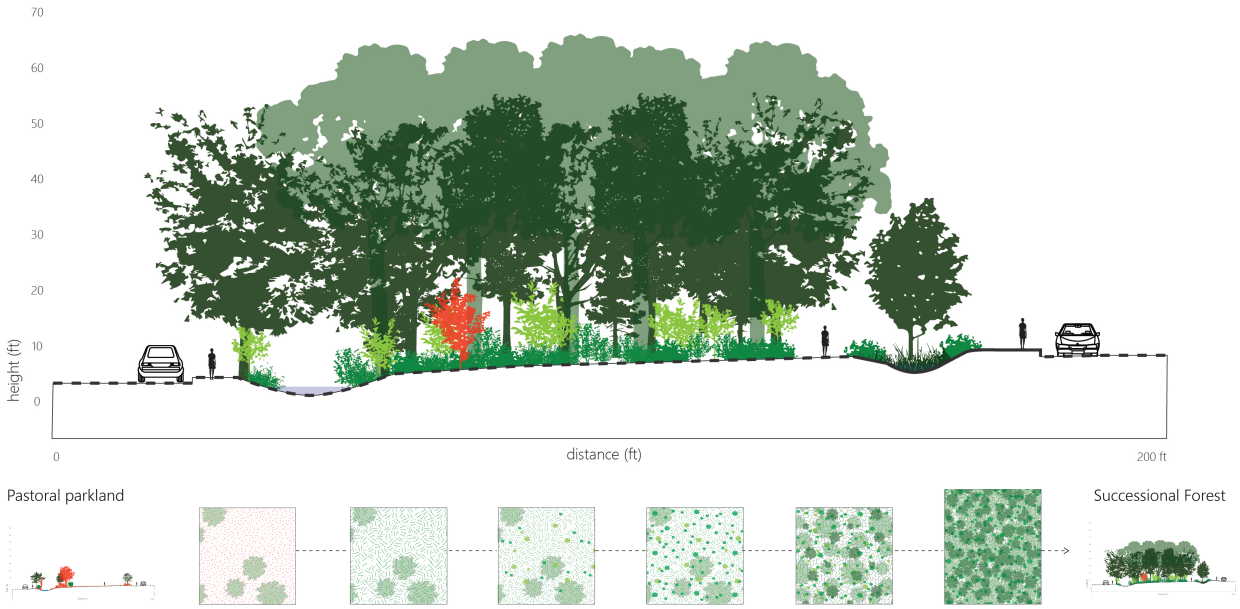


Figure 66: Successional forest



Figure 67: Successional forest locations

Successional forests are sites that begin as meadows and are transitioned to forest through managed succession (Figure 66). The management of these areas would likely include several waves of plantings over a long time period in order to encourage successional development of the forest. The eventual goal composition of this typology is to become part of the Beech Tulip forest type with the same or similar composition. Intermediate planting design goals, however, relate to the successional development of that forest type. The initial intervention in these spaces would be seeding a meadow, after either clearing areas of lawn completely of vegetation or seeding directly into the lawn. A typical meadow mixture for a mesic to dry site might include *Schizachyrium scoparium* (little bluestem), Sorghastrum nutans (Indian grass), *Echinacea purpurea* (purple coneflower), *Asclepias spp.*

(milkweeds), *Rudbeckia hirta* (black-eyed susan), and other mixed wildflowers. The meadow can be established within 2-5 years of initial planting. After 5-10 years, some woody species may be selectively maintained in the meadow, and others can be planted to encourage further colonization by desired species. These may include early successional, fast-growing trees such as *Prunus serotina* (Black cherry), *Pinus strobus* (Eastern white pine), *Juniperus virginiana* (eastern redcedar), and shrubs such as *Rhus typhina* (staghorn sumac) and *Vaccinium spp* (blueberries). In areas where successional meadows overlap with bioretention areas, these wetter zones can be blended in to the surrounding mesic/dry plantings by using a wet meadow species mix and planting shrubs and trees that thrive in sunny, wet conditions. As the meadow is eventually shaded out by woody species, succession can be guided by invasive species control and supplemental planting of interior forest species.

Witnessing the successional dynamics of a growing forest is a huge interpretive opportunity, which is why many of the site's gathering places are sited in these successional areas (described in next chapter). The gradual transition from field to woodland to forest is a rare sight in urban woodlands, but incorporating successional communities within this site makes it possible. This type of planting would also increase the habitat diversity found on the Long Branch site, and would increase overall native species and structural diversity. As successional areas are transitioned to forest, adjacent areas that may be acquired for reforestation can then be designated as successional forests, resetting the process.

Meadow Parkland

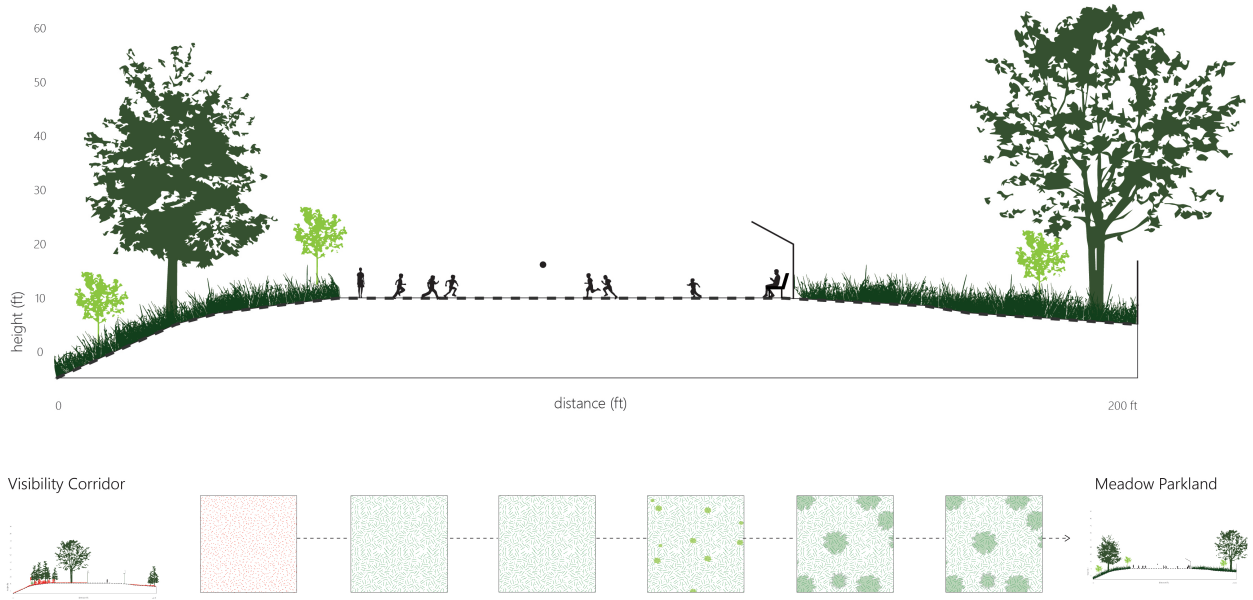


Figure 68: Meadow Parkland



Figure 69: Meadow Parkland locations

The Meadow Parkland typology is placed in areas where visibility needs to be maintained. These areas would be seeded with the same or similar meadow species mix as the successional forest. After the meadow establishes, singular canopy trees or clusters of native shrubs should be protected and permitted to grow within the meadow to shade gathering spaces and provide visual variety. A recommended shrub species for this purpose, especially on dry hillsides, is *Rhus typhina* (staghorn sumac). This species has unique visual appeal, striking fall color, and provides many benefits to wildlife, including a winter food source. Other tree species that are recommended for planting within the maintained meadow are *Quercus alba* (white oak), *Nyssa sylvatica* (blackgum), and *Tilia americana* (Linden), all of which have an attractive canopy form.

Chapter 5: Master Plan: Upper Long Branch Stream Valley Parks

Master Plan: Upper Long Branch Stream Valley Parks

The study site encompasses four parks and one elementary school, all bordering on the stream valley. All of these spaces together are referred to as the Long Branch Stream Valley Parks. The master plan includes programmatic changes in each of these spaces, mapping of vegetation typologies and trajectories, natural surface and paved trail alignments, re-siting of existing recreational facilities, and designation of areas for bioretention. Figure 70 shows the master plan divided into five sections, which will be described in detail in this chapter. Enlarged versions of all images in this section can be found in Appendix 4.

There were several key strategies used in the design process. First, the informal and formal trail networks were defined and connected to one another in order to decrease the anthropogenic impacts of trampling and stream bank erosion, to allow ease of movement between the four parks on the site, and to improve navigability. Desire paths show where people are inclined to go; many of these routes were reinforced by the proposed network of sanctioned trails. Informal trails along the stream corridor were moved out of the floodplain wherever possible, but some original routes were maintained where this was not possible.

The second strategy was to densify existing recreational facilities in the southern portion of the site to accommodate anticipated development trends due to the Purple Line. Following recommendations provided by M-NCPPC and by the Long Branch Sector Plan, the existing park programs were maintained and some recreational facilities were added in light of community needs (pers. Comm)(M-NCPPC, 2013a). Arranging existing and proposed recreational facilities more efficiently then opened up more land for ecological restoration.

The third strategy was to increase stormwater retention by adding 15 new bioretention facilities on the site. The proposed location of these facilities was decided upon by looking at the topography of the

site and designating places where streams were likely to have been buried. There were also places where pooling was observed by the author during storm events; those areas were included in the bioretention proposals. This stormwater management strategy would be supplemented with in-stream restoration strategies (see the "Willow Run" planting typology in the previous chapter), and these interventions would hopefully improve water quality and stream conditions in Long Branch.

Finally, after the above changes were made, the author designated areas where the forest patch area could be expanded through ecological succession. These areas are sited adjacent to the existing forest patch as much as possible. Each of the five divisions of the site (the four parks and the elementary school) contains an area designated for forest succession, as well as trails and gathering spaces within this area. The argument here is that inviting ecological succession into the planting design of this park would provide expanded interpretive opportunities as well as improving ecological quality.

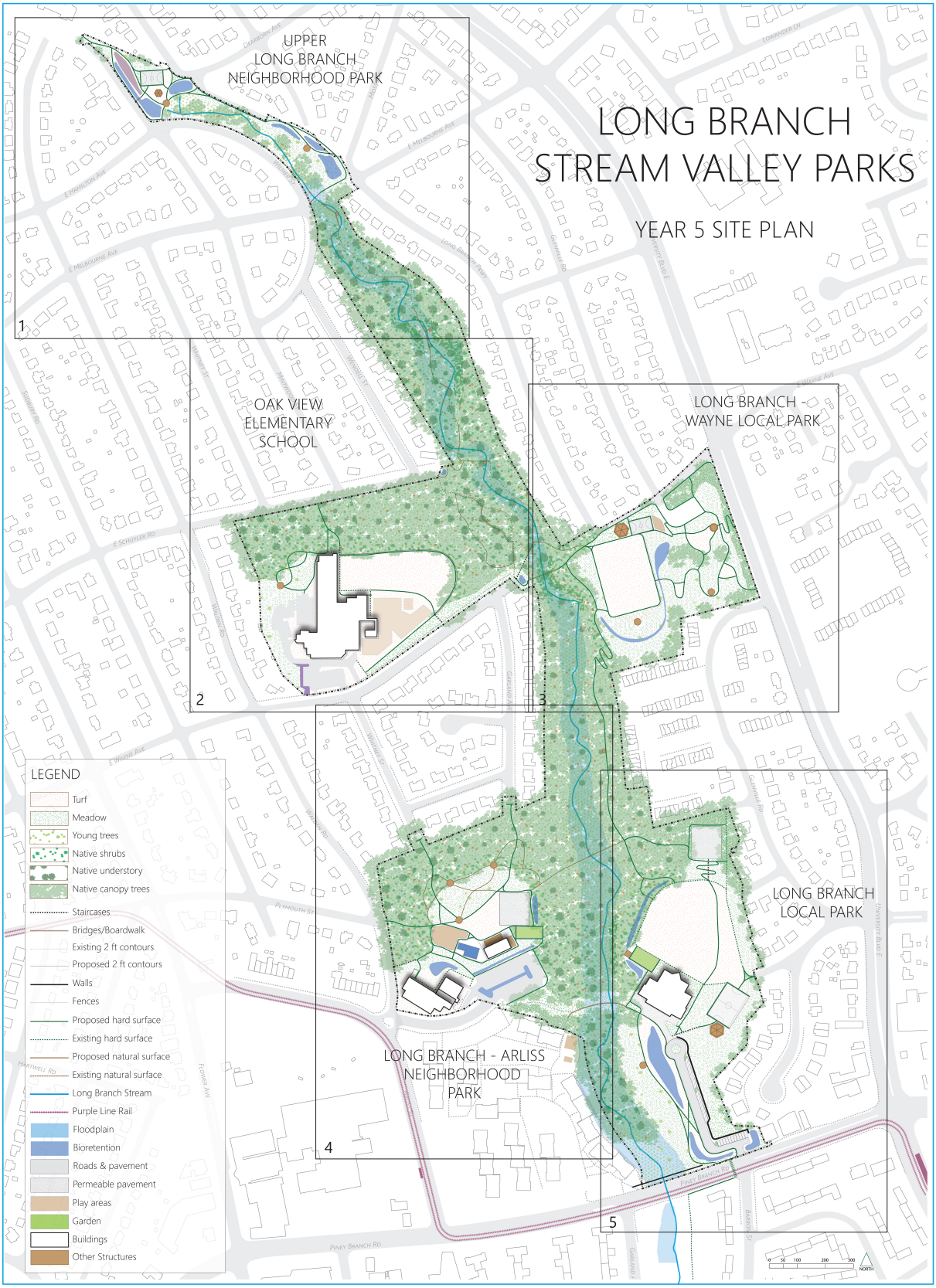


Figure 70: Year 5 Master Plan

1. Upper Long Branch Neighborhood Park



Figure 71: Upper Long Branch Neighborhood Park

Upper Long Branch Neighborhood Park is where the Long Branch stream becomes visible. Here, the existing basketball court and playground are moved to allow additional space for a picnic pavilion, expanded bioretention facilities, a successional meadow, and a gathering circle at the headwaters of the stream. All new paved surfaces are recommended to be built with permeable pavement. Though the stream headwaters technically begin outside of this area in pipes and gutters of people's homes, it is argued that naming the gathering circle after the headwaters and including an interpretive feature here would heighten awareness of local hydrological systems and increase awareness of this urban headwaters condition.

To expand the almost nonexistent stream buffer in this area, successional areas are proposed in sections that are currently mowed. Paths are sited through these areas to maintain ease of movement for residents of the surrounding neighborhoods who use this area. The riparian forest here is sited for

restoration, as per the “streamside forest” typology. South of this, one enters the stream valley natural surface trail via an existing bridge, and immediately encounters a boardwalk proposed to ameliorate the erosion caused by the existing informal paths along the stream bank. Swings along the boardwalk allow places for people to sit and observe the stream. The existing informal trail continues after the boardwalk and moves south through the stream valley.



Figure 72: Upper Long Branch stream valley boardwalk

2. Oak View Elementary School

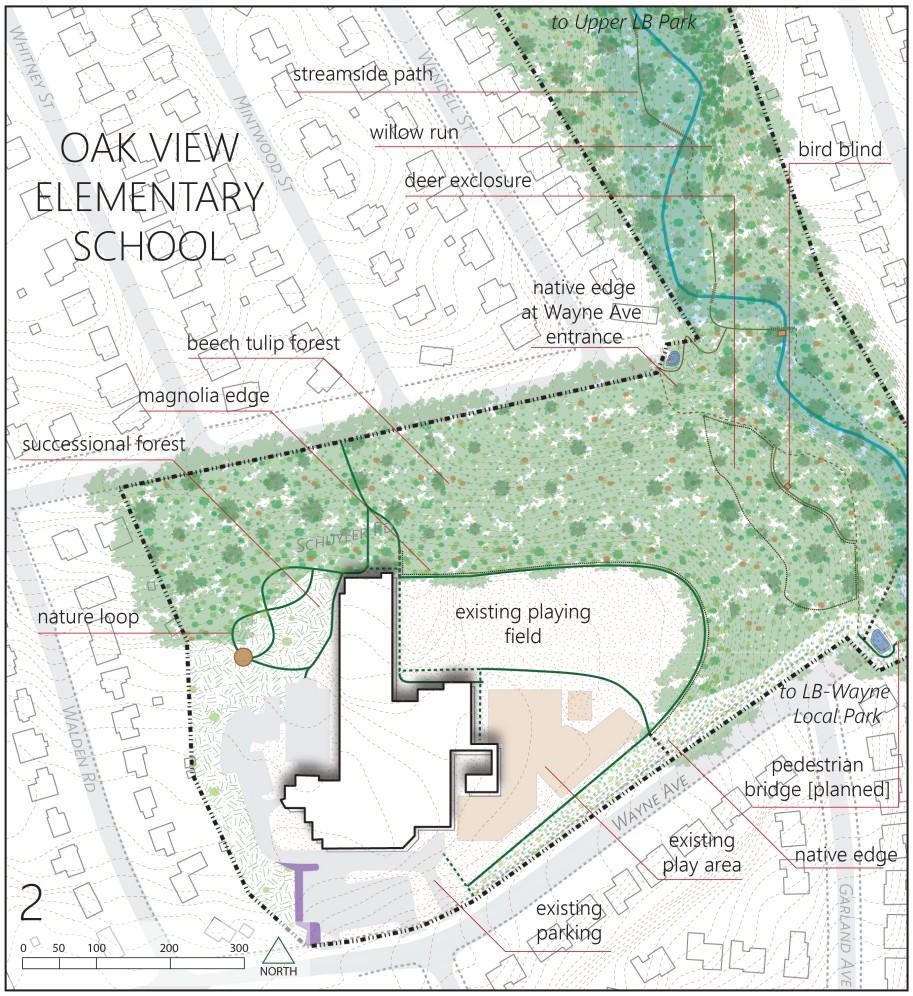


Figure 73: Oak View Elementary School

The proposed interventions adjacent to Oak View Elementary school are intended to clarify and sanction routes to and from the school and provide students with interpretive opportunities in natural areas. Hard surface paths are proposed around the existing playing field, through the woods connecting the school grounds to Schuyler Rd to the North and through the proposed successional forest area. The existing playing field is maintained and surrounded by a magnolia border and new paved trail. In the successional area nature loop, elementary school students can participate in and watch a meadow become a forest over time. Additionally, a deer exclosure is proposed nearby to protect an area of high-quality forest on the site (ex. Relevé 7). A natural surface trail brings people past the deer exclosure and bird blind, providing an excellent opportunity for comparative observation and study.



Figure 74: Forest path near deer exclosure

3. Long Branch-Wayne Local Park



Figure 75: Long Branch-Wayne Local Park

Long Branch-Wayne Local Park is situated on a slope between University Blvd and the stream valley, providing an excellent opportunity for numerous vantage points on the hillside. The existing parking lot is maintained, and the existing basketball court, picnic pavilion, and playground are re-sited next to the playing field. The existing playing field is moved slightly further from the floodplain to create space for a successional forest area and riparian (streamside) forest restoration. Much of the hillside is proposed to be converted from mowed grass to the "Meadow parkland" typology in order to maintain views down the hillside. Paved paths wind down the hill and past several gathering spaces built into the meadow. The existing bioretention area at the bottom of the hill expands into the successional meadow to the south of the playing field. An accessible paved path, moved out of the floodplain, connects this park to Long Branch Local Park to the south. A planned pedestrian bridge connects the park across Wayne Avenue to Oak View Elementary School.



Figure 76: Meadow parkland at Wayne local park

4. Long Branch-Arliss Neighborhood Park & Library

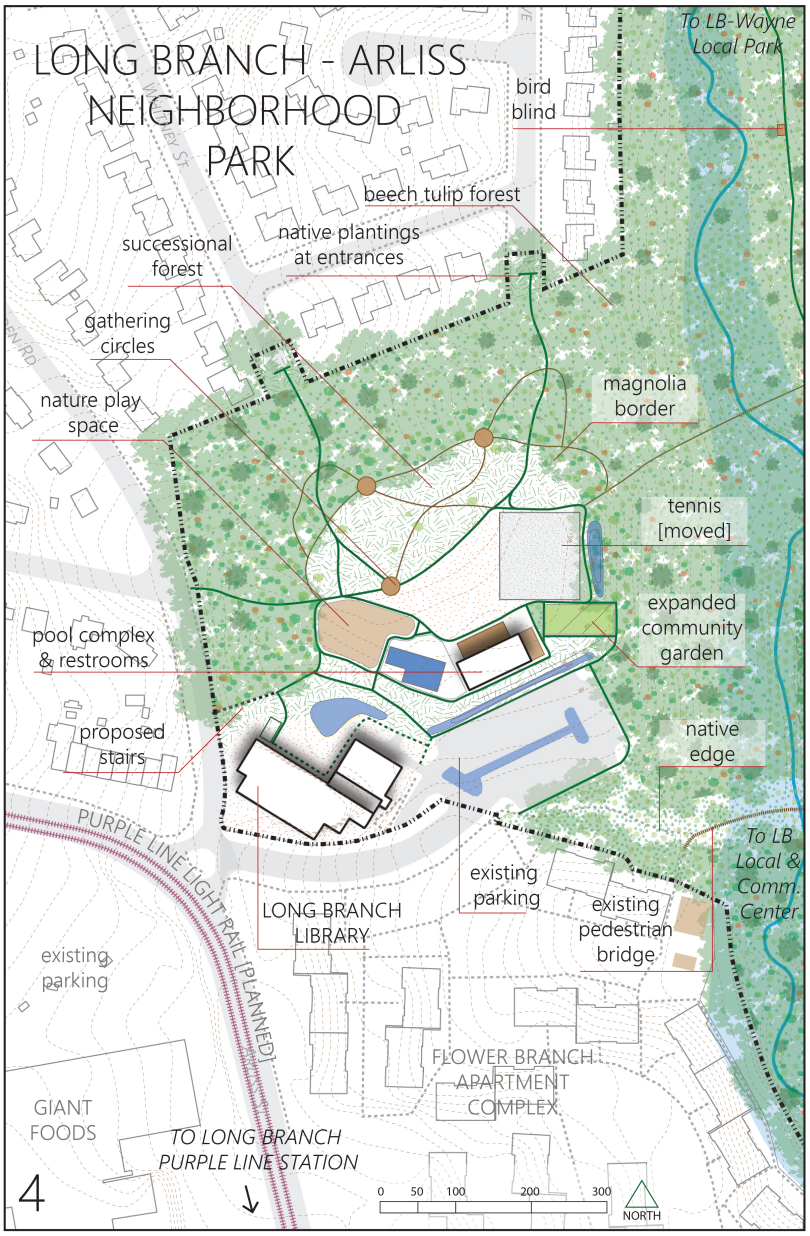


Figure 77: Long Branch-Arliss Neighborhood Park

Long Branch-Arliss Neighborhood Park is the closest section of this park complex to the proposed Long Branch Purple Line station. To accommodate the increased development and traffic that will accompany this station, a new condensed recreation complex is proposed here. The new community pool complex is re-sited from where it currently is next to the community center. An expanded community garden is proposed to supplement the extremely popular existing garden near the community center. A large nature play space is proposed to condense several small existing play areas into one large one with improved visibility. The existing tennis court is re-sited and proposed to be built with permeable pavement. The hillside between the existing library parking lot and the new recreation complex is proposed to be meadow parkland, as visible permeability is required here for safety reasons. New bioretention areas are proposed adjacent to the parking lot. Finally, a large area of successional

forest is proposed, punctuated by gathering spaces and natural surface trail loops. Paved pathways are defined to connect this park to local neighborhoods, improving the unclear informal trails that currently exist. An existing pedestrian bridge and a new stream crossing are proposed to connect this complex to nearby parks and to clarify routes through the stream valley and restored forest.



Figure 78: Long Branch-Arliss Neighborhood Park recreational complex

5. Long Branch Local Park & Community Center

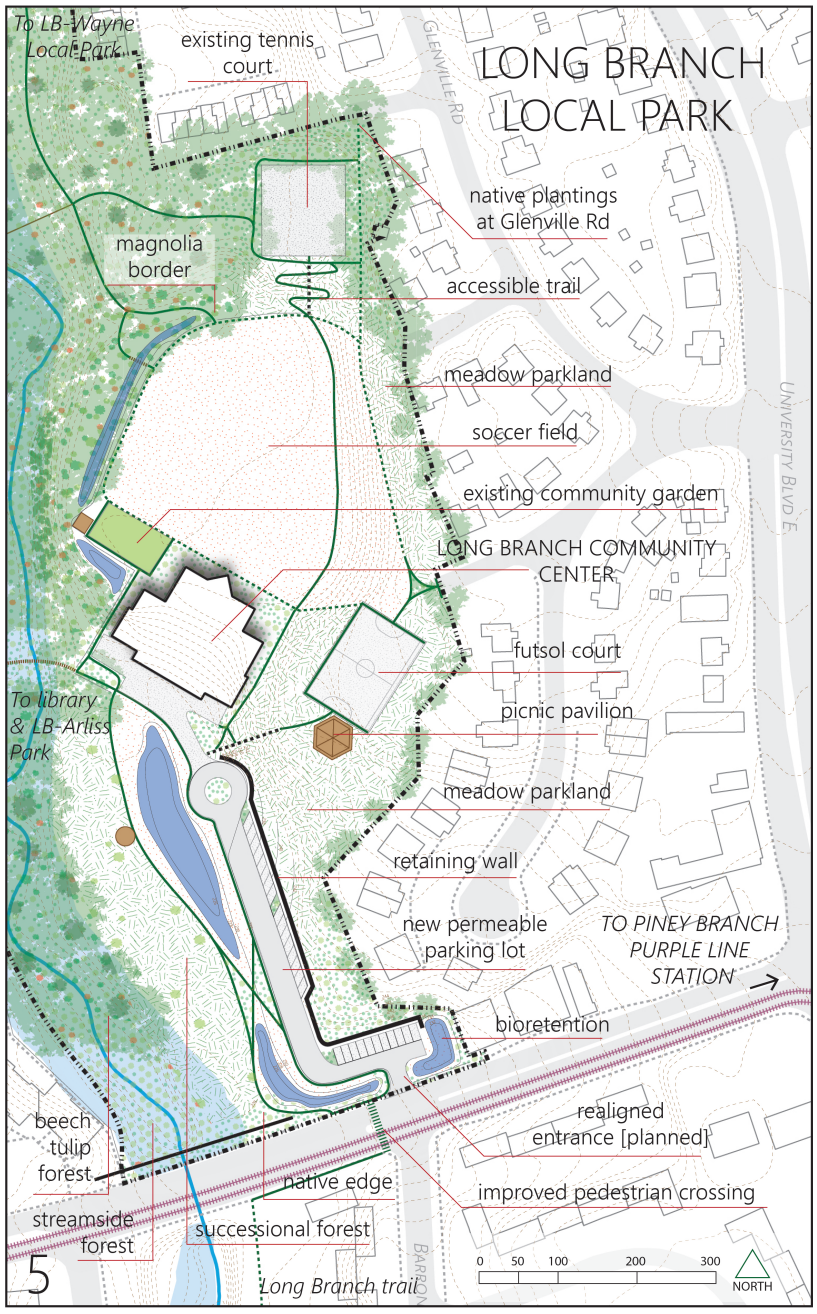


Figure 79: Long Branch Local Park and Community Center

This park serves as the main entrance from Piney Branch Road. The existing parking lot is proposed to be re-sited from its existing location within the floodplain, opening up areas for riparian buffer restoration through successional plantings. Paved paths wind through these new successional plantings, leading north to the soccer field and west to Long Branch-Arliss Neighborhood Park. Redefined paved paths wind up the hillside to the existing tennis court, around the soccer field, and past the community garden. Bioretention areas are proposed at low points throughout the site.

Responding to the popularity of soccer in this community, the existing basketball court and small playground are replaced with a futsal court and picnic pavilion at the top of the hill near the parking lot.

The hillsides between the court and parking lot are proposed to be planted with the meadow parkland typology to maintain visibility for safety reasons, as per county staff recommendations (Chuck Kines, personal communication, February 2021). Following recommendations made in the Long Branch Sector Plan, the entrance at Piney Branch Road is realigned and a pedestrian crossing is added across Piney Branch Road to connect the proposed trails to the existing Long Branch trail which continues south (M-NCPPC, 2013).



Figure 80: Magnolia border at Long Branch Local Park

Chapter 6: Further Recommendations

Limitations

The scope of this project needed to be narrowed from the way it was originally proposed. By nature, the project had no budget and was limited in terms of time and resources. An additional constraint was that the project was completed at the height of the coronavirus pandemic in 2020-2021. The societal stress and trauma associated with the pandemic was a limiting factor in its development, and community interviews were also extremely limited. Additionally, different activities would have been observed on the site had there not been a pandemic. The purpose of the following discussion section is to make further recommendations and put forth additional ideas that the author did not have time or resources to devote to fleshing out in the site plan.

Site Interpretation & Public Art

Interpretive features are a key part of the legibility of any landscape design. In a project that makes use of landscape typologies that are unconventional or unfamiliar to the average person, interpretive features are especially important. Given that Long Branch is and hopefully will remain a highly diverse and multiethnic community, interpretive features should be multilingual and incorporate languages widely spoken in surrounding communities such as Spanish and Amharic. The content of the interpretive features should relate to the ecological dynamics of the site and help people interpret the changing landscape. They could also help people complete small participatory interventions in the forest: for example, planting an acorn in the ground and marking it with a colorful pole, placing a tree sleeve on a volunteer sapling, or picking up litter. Marking the landscape in these ways may help enhance a sense of place attachment to the forest and encourage continuity of stewardship.

The use of public art is also highly recommended on this site. Long Branch is already marked by colorful murals along the commercial corridors of Piney Branch Rd and Flower Ave and continuing this

practice in designated spaces within the park by engaging local artists would allow local people to participate in placemaking. Places designated for this could include the floors of gathering spaces, the external walls of the pool complex building, and any existing or proposed retaining wall. Sculptures could also be placed within the meadows or successional areas.

Programming & Community Engagement

Though this was within the scope of this thesis, it should be acknowledged that the success of any landscape architecture or ecological restoration project is enhanced by early and consistent community engagement (Holl, 2020; Sorensen et al., 2018). The conceptual design proposed here should be first and foremost discussed with community members before any interventions are decided upon. If this project were implemented, management and stewardship would need to be coordinated through a variety of sources as county resources are limited and successful urban forest restoration requires consistent management. Programmatic recommendations would include creating partnerships with existing groups and organizations for activities such as tree planting, invasive species control, trash pickup, or citizen science efforts. Management activities should be coordinated through M-NCPPC so that participants act according to the same set of guidelines. Existing avenues for community participation in restoration and stewardship in Long Branch include:

- Montgomery County Recreation's Youth Development Team
- Weed Warriors volunteers (who already work on the site)
- Local schools: Oak View Elementary, Highland View Elementary School, Montgomery Knolls Elementary School, Eastern Middle School, Takoma Academy, Silver Spring International Middle School
- Community gardeners and/or local gardening organizations
- Local naturalists, citizen science organizations or interested folks.

A final programming recommendation is that local homeowners be provided with information about invasive plant species commonly used in backyards. As invasive plants from residential yards would likely continue to make their way into the forest patch, it would be beneficial to make the connection between ecological health and backyard plantings. Encouraging the use of native plants instead of encouraging people to get rid existing exotic species may be a more positive angle. Montgomery County already has some programming in place for the purposes of promoting native plant species.

Plant Sourcing

Planting recommendations for this site were based partially on the local availability of the recommended species from Montgomery County's reforestation initiatives (Bill Hamilton, personal communication, 2021). Montgomery County has an existing list and order form for species to be used in reforestation projects; the available species that the author was made aware of include trees, shrubs, and herbaceous plants. Montgomery County grows these species from seed collected in the wild, and when this is not possible, they source plants from other local vendors. These local ecotypes are the recommended primary source for planting materials on the Long Branch site. If plants are unavailable from these sources, ecotypes should be sourced from a source that matches site conditions. A smaller number of plants could also be cultivated in the community greenhouse proposed at Long Branch-Arliss Neighborhood Park as part of programming efforts.

Adaptive Management & Monitoring

Adaptive management is an integral concept in the functioning of urban ecosystems. As expressed in the literature review and conceptual framework for this project, adaptive management should continue throughout the project's lifetime. Very loose management guidelines were proposed in this thesis; these should be further fleshed out by land management professionals based on restoration and planting design goals that are judged to be feasible within resource constraints. Management approaches should be adjusted throughout time based on the outcomes of project monitoring and evaluation of project

success. Based on the site inventory completed in this project, monitoring could address the following aspects of ecological health:

- Degree of native plant regeneration
- Population of invasive plant species, with attention to forest floor and shrub layers
- Water quality of Long Branch stream (already periodically monitored)
- Stormwater runoff volume and rate
- Occurrences of anthropogenic impacts (trampling, trash, scouring)

Clear metrics for these and other ecological criteria should be established before project implementation. Community surveys regarding the experience of the Long Branch local parks can also be included in monitoring efforts. This data would allow management to be maximally effective, and it would also measure the effectiveness of the approach to urban park design taken in this project. The utility of landscape performance metrics for the field of landscape architecture is reflected in the Landscape Architecture Foundation's Landscape Performance Series.

Chapter 7: Conclusion

The case study presented in this thesis demonstrates how the application of ecological theory to urban park design can enhance ecological function of urban landscapes, create heightened place attachment through aesthetic and interpretive experience, and guide the long-term management and stewardship of urban ecosystems in the Mid-Atlantic United States. The Upper Long Branch Stream Valley master plan and site designs show how centering ecological quality in urban park design can simultaneously achieve the aesthetic and community needs of urban populations. The conceptual framework illustrates how vegetation dynamics theory generalizes the mechanisms of plant community change over time and presents a useful conceptual road map for the planting design, long-term adaptive management, and stewardship of urban parks. The conceptual framework can be extrapolated from this case study and design goals from a different site can be used in place of the ones from this project. The specific plant community dynamics addressed in this thesis apply most directly to forested ecosystems in the Mid-Atlantic United States, but vegetation dynamics theory can be applied universally.

Landscape architects have the capacity to act as translators of scientific research into landscape modification at multiple spatial and temporal scales, through the design of attractive, biodiverse urban spaces that allow visitors to interpret their surroundings and find meaning in place. Though humans have altered urban ecosystems irreversibly, urban ecology research tells us that urban ecological restoration is possible. Committing to both the ecological and aesthetic potential of urban ecosystems is compelling from a landscape architectural standpoint because it allows us to tell the story of a specific place on the Earth. Engaging with successional processes and using dynamic vegetation change as an asset instead of an inconvenience opens up transformational possibilities for park program and use, as well as ecological function. Learning to embrace and plan for long-term dynamic changes in plant communities can be an exciting step forward for the application of ecological concepts and theory in the practice of landscape architecture.

Appendices

Appendix 1: Vegetation Data Summary Tables

Table 5: General Relevé Categorization				
Relevé	Broad Type	Sub-type (Dominant Species)	Area m2	Plot Shape
1	Lawn	Bermuda grass / goose grass / white clover	1000 m2	Circle
2	Forest Edge	Mile-a-minute / Porcelain berry / ground ivy	1000 m2	Rectangle
3	Upland Forest	Tulip poplar / Norway maple / Honeysuckle / Spicebush / English ivy	1000 m2	Circle
4	Riparian Edge	Box elder / White mulberry / Rose of Sharon / English ivy stream	400 m2	Rectangle
5	Riparian Forest	Tulip poplar / Beech / Spicebush	400 m2	Rectangle
6	Riparian Edge	Knotweed / Spicebush / Honeysuckle	400 m2	Rectangle
7	Upland Forest	White Oak / Hickory / Blackgum / Mapleleaf viburnum / English ivy	1000 m2	Circle
8	Forest Edge	Tulip poplar / Pokeweed / Poison Ivy / Wineberry	1000 m2	Circle
9	Upland Forest	Tulip poplar / Beech / Linden Viburnum	1000 m2	Circle
10	Riparian Edge	Tulip poplar / Red Maple / Beech / Kudzu	400 m2	Rectangle
11	Forest Edge	Tulip poplar / Porcelain berry / passionflower	1000 m2	Circle
12	Parkland	Persimmon / Bermuda grass / Plantain / white clover	1000 m2	Circle
13	Riparian Forest	Tulip poplar / Beech / Witchhazel	400 m2	Polygon
14	Upland Forest	Tulip poplar / Amur honeysuckle / English ivy	1000 m2	Circle
15	Riparian Forest	Tulip poplar / Red Maple	400 m2	Polygon

Table 5:General Relevé Categorization

Table 6: Disturbance & Management Data by Relevé Plot

	DISTURBANCE								MANAGEMENT				
Relevé #	Competition from exotic species	Surface Water Diversion	Road/trail construction or maintenance	Vandalism/Trash	Trampling/Foot Traffic	Erosion	Recreational Use	Rip-Rap or stream channelization	Mowing	Cutting	Spraying	Weeding	Planting
1	N	N	N	Y	Y	N	Y	N	Y	N	Y	N	N
2	Y	N	Y	Y	Y	N	N	N	Y	Y	Y	N	N
3	Y	N	Y	Y	Y	N	Y	N	N	Y	N	Y	N
4	Y	N	N	Y	Y	N	N	Y	Y	N	N	N	Y
5	Y	N	Y	Y	Y	Y	N	N	N	N	N	N	N
6	Y	Y	Y	Y	Y	N	Y	Y	N	N	N	N	N
7	Y	N	N	N	Y	N	N	N	N	N	N	N	N
8	Y	N	Y	Y	Y	N	N	N	N	N	N	N	N
9	Y	N	N	N	Y	N	N	N	N	N	N	N	N
10	Y	N	Y	N	Y	Y	N	N	N	N	N	N	N
11	Y	N	N	N	Y	N	Y	N	Y	Y	N	N	Y
12	Y	N	N	N	Y	N	N	N	Y	N	Y	N	N
13	Y	N	N	N	Y	Y	N	N	N	N	N	N	N
14	Y	N	Y	N	Y	N	N	N	N	N	N	N	N
15	Y	N	N	Y	N	Y	N	Y	N	N	N	N	N

Table 6: Disturbance & Management Data by Relevé Plot

Table 7: Ground Surface Data by Relevé Plot								
GROUND SURFACE COVER CLASS								
Relevé #	Large Rock	Small Rock	Bare/Fine (open soil)	Leaf Litter	Basal area of stems	Water	Coarse woody debris	Fine Woody debris
1	0	0	3a	0	0	0	0	0
2	0	2	3a	3a	3a	0	2	2
3	0	1	3b	5	3a	0	2	3a
4	3b	3a	2	2	3a	4	3a	3a
5	1	3a	3a	4	3a	2	2	3b
6	3b	3a	1	1	3a	4	2	2
7	0	0	2	3	2	0	1	2
8	0	0	2	3a	2	0	2	2
9	0	1	4	4	2	0	2	3b
10	2	2	2	2	3a	3b	1	2
11	0	0	3a	2	5	0	1	2
12	0	0	0	0	2	0	0	0
13	3a	3a	3b	2	3a	5	2	1
14	0	0	3a	3b	3b	1	2	3b
14	2	2	6	5	2	3b	2	1

Table 7: Ground Surface Cover Data by Relevé Plot

Table 8: Attributes of all Species found in Relevé Plots							
Species name	Common Name	Structural Layer	Growth Habit	Frequency (number of plots in which it was found)	Origin	MD Invasive	Family
Acer negundo	Box elder	SC	Tree	3	native	N	Sapindaceae
Acer platanoides	Norway maple	SC	Tree	10	nonnative	Y	Sapindaceae
Acer rubrum	Red maple	SC	Tree	9	native	N	Sapindaceae
Acer saccharinum	Silver maple	C	Tree	1	native	N	Sapindaceae
Actaea racemosa	Black cohosh	G	Forb/Herb	1	native	N	Ranunculaceae
Ageratina altissima	White snakeroot	G	Forb/Herb	1	native	N	Asteraceae
Ailanthus altissima	Tree of heaven	SC	Tree	1	nonnative	Y	Simaroubaceae
Alliaria petiolata	Garlic mustard	G	Forb/Herb	1	nonnative	Y	Brassicaceae
Ambrosia artemisiifolia	Common ragweed	G	Forb/herb	1	native	N	Asteraceae
Ampelopsis glandulosa	Porcelain Berry	V	Woody vine	9	nonnative	Y	Vitaceae
Amphicarpaea bracteata	Hog peanut	G	Herbaceous vine	2	native	N	Fabaceae
Arctium minus	Lesser burdock	G	Forb/herb	2	nonnative	Y	Asteraceae
Arisaema triphyllum	Jack in the pulpit	G	Forb/herb	1	native	N	Araceae
Artemisia vulgaris	Mugwort	G	Forb/herb	2	nonnative	Y	Asteraceae
Asarum canadense	Canadian wild ginger	G	Forb/herb	1	native	N	Aristolochiaceae
Berberis bealei	Leatherleaf mahonia	S	Shrub	2	nonnative	Y	Caprifoliaceae
Berberis thunbergii	Japanese barberry	S	Shrub	1	nonnative	Y	Berberidaceae
Betula nigra	River birch	SC	Tree	1	native	N	Betulaceae
Bidens sp.	Bur marigolds	G	Forb/herb	1	CBD	CBD	Asteraceae
Boehmeria cylindrica	False Nettle	G	Forb/herb	2	native	N	Urticaceae
Calystegia sp.	Bindweed	V	Herbaceous vine	2	nonnative	N	Convolvulaceae
Carex sp.	Sedge	G	Graminoid	2	CBD	CBD	Cyperaceae
Carpinus caroliniana	American hornbeam	SC	Tree	1	native	N	Betulaceae

Carya cordiformis	Bitternut hickory	SC	Tree	2	native	N	Juglandaceae
Carya glabra	Pignut hickory	SC	Tree	2	native	N	Juglandaceae
Carya sp.	Hickory	SC	Tree	3	native	N	Juglandaceae
Carya tomentosa	Mockernut hickory	SC	Tree	2	native	N	Juglandaceae
Catalpa speciosa	Northern Catalpa	SC	Tree	1	native	N	Bignoniaceae
Celastrus orbiculatus	Oriental bittersweet	V	Woody vine	4	nonnative	Y	Celastraceae
Chelidonium majus	Greater celandine	G	Forb/herb	1	nonnative	Y	Papaveraceae
Chenopodium album	Lamb's quarters	G	Forb/herb	1	nonnative	Y	Chenopodiaceae
Circaea sp	Enchanter's nightshades	G	Forb/herb	1	native	N	Onagraceae
Cirsium sp	Thistle	G	Forb/herb	1	CBD	CBD	Asteraceae
Collinsonia canadensis	Citronella horse balm	G	Forb/herb	3	native	N	Lamiaceae
Commelina communis	Asiatic dayflower	G	Forb/herb	2	nonnative	Y	Commelinaceae
Cornus florida	Flowering dogwood	U	Tree	2	native	N	Cornaceae
Cynodon dactylon	Bermuda grass	G	Graminoid	3	nonnative	Y	Poaceae
Diospyros virginiana	American persimmon	C	Tree	1	native	N	Ebenaceae
Duchesnea indica (Potentilla indica)	Mock strawberry	G	Forb/herb	5	nonnative	Y	Rosaceae
Eleusine indica	Goose grass	G	Graminoid	2	nonnative	Y	Poaceae
Erechtites sp	Groundsels	G	Forb/herb	2	CBD	CBD	Asteraceae
Euonymus alatus	Winged euonymus	S	Shrub	1	nonnative	Y	Celastraceae
Euonymus americanus	American Strawberrybush	S	Shrub	1	native	N	Celastraceae
Euonymus fortunei	Wintercreeper	V	Woody vine	9	nonnative	Y	Celastraceae
Fagus grandifolia	American beech	C	Tree	7	native	N	Fagaceae
Fragaria sp.	Strawberry	G	Forb/Herb	2	CBD	CBD	Rosaceae
Fraxinus sp.	Ash	SC	Tree	3	native	N	Oleaceae
Geum canadense	White avens	G	Forb/herb	1	native	N	Rosaceae
Glechoma hederacea	Ground ivy	G	Forb/herb	6	nonnative	Y	Lamiaceae
Gleditsia triacanthos var. inermis	Thornless honey locust	SC	Tree	1	native	N	Fabaceae
Hamamelis virginiana	Witchhazel	U	Shrub	2	native	N	Hamamelidaceae

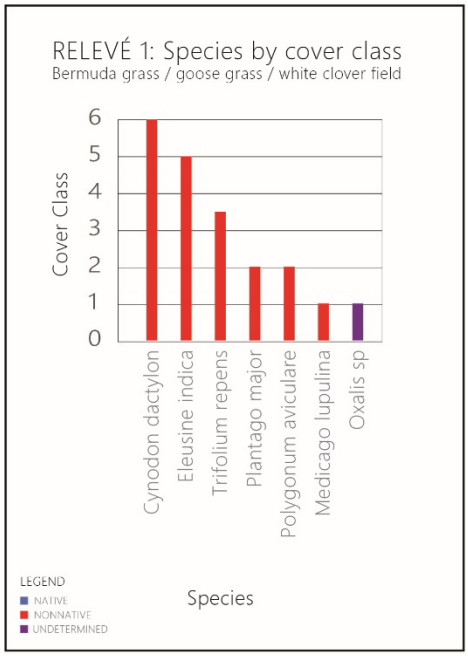
Hedera helix	English ivy	V	Woody vine	13	nonnative	Y	Araliaceae
Helianthus sp	Sunflowers	G	Forb/Herb	1	native	N	Asteraceae
Helleborus sp	Hellebore	G	Forb/Herb	1	nonnative	N	Ranunculaceae
Hibiscus syriacus	Rose of sharon	S	Shrub	5	nonnative	Y	Malvaceae
Ilex opaca	American holly	SC	Tree	7	native	N	Aquifoliaceae
Impatiens capensis	Jewel weed	G	Forb/herb	2	native	N	Balsaminaceae
Laportea canadensis	Wood nettle	G	Forb/herb	1	native	N	Urticaceae
Leersia virginica	White grass	G	Graminoid	1	native	N	Poaceae
Ligustrum ovalifolium	Garden privet	S	Shrub	2	nonnative	Y	Oleaceae
Ligustrum sp.	Privets	S	Shrub	1	nonnative	Y	Oleaceae
Ligustrum vulgare	European privet	S	Shrub	1	nonnative	Y	Oleaceae
Lindera benzoin	Spicebush	S	Shrub	10	native	N	Lauraceae
Liriodendron tulipifera	Tulip poplar	C	Tree	10	native	N	Magnoliaceae
Liriope sp	Liriope	G	Forb/herb	2	nonnative	N	Liliaceae
Lonicera japonica	Japanese honeysuckle	V	Woody vine	6	nonnative	Y	Caprifoliaceae
Lonicera maackii	Amur honeysuckle	S	Shrub	11	nonnative	Y	Caprifoliaceae
Maianthemum racemosum	False Solomon's Seal	G	Forb/herb	2	native	N	Liliaceae
Malus baccata	Siberian crabapple	U	Tree	1	nonnative	Y	Rosaceae
Medicago lupulina	Black medick	G	Forb/herb	1	nonnative	Y	Fabaceae
Microstegium vimineum	Stiltgrass	G	Graminoid	5	nonnative	Y	Poaceae
Morus alba	White mulberry	C	Tree	7	nonnative	Y	Moraceae
Nyssa sylvatica	Blackgum	SC	Tree	4	native	N	Cornaceae
Onoclea sensibilis	Sensitive fern	G	Forb/herb	1	native	N	Dryopteridaceae
Oxalis sp	Woodsorrel	G	Forb/herb	3	CBD	CBD	Oxalidaceae
Parthenocissus quinquefolia	Virginia creeper	V	Woody vine	9	native	N	Vitaceae
Passiflora incarnata	Purple passionflower	V	Herbaceous vine	1	native	N	Passifloraceae
Perilla frutescens	Perrilla mint	G	Forb/herb	2	nonnative	Y	Lamiaceae
Persicaria longiseta	Common waterpepper	G	Forb/herb	9	nonnative	Y	Polygonaceae
Phegopteris hexagonoptera	Broad beech fern	G	Forb/herb	1	native	N	Thelypteridaceae

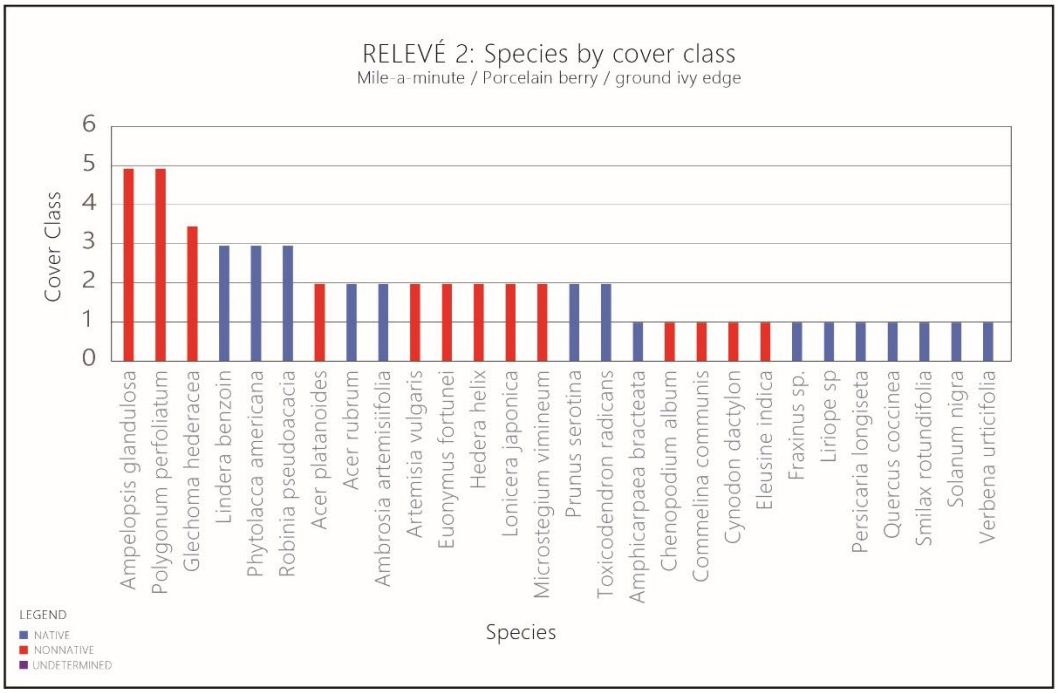
Phytolacca americana	American pokeweed	G	Forb/herb	7	native	N	Phytolaccaceae
Pinus taeda	Loblolly pine	C	Tree	1	native	N	Pinaceae
Plantago major	Broadleaf plantain	G	Forb/herb	3	nonnative	Y	Plantaginaceae
Polygonum aviculare	Prostrate knotweed	G	Forb/herb	1	nonnative	Y	Polygonaceae
Polygonum perfoliatum	Mile a Minute	V	Herbaceous vine	3	nonnative	Y	Polygonaceae
Polygonum virginianum	Jumpseed	G	Forb/herb	7	native	N	Polygonaceae
Polystichum acrostichoides	Christmas fern	G	Forb/herb	3	native	N	Dryopteridaceae
Prunus serotina	Black cherry	SC	Tree	4	native	N	Rosaceae
Prunus sp nonnative	Cherry	SC	Tree	4	nonnative	Y	Rosaceae
Pueraria montana	Kudzu	V	Herbaceous vine	2	nonnative	Y	Fabaceae
Pyrus calleryana	Callery pear	SC	Tree	1	nonnative	Y	Rosaceae
Quercus alba	White oak	C	Tree	3	native	N	Fagaceae
Quercus coccinea	Scarlet oak	C	Tree	2	native	N	Fagaceae
Quercus phellos	Willow oak	C	Tree	1	native	N	Fagaceae
Quercus rubra	Red oak	C	Tree	3	native	N	Fagaceae
Ranunculus ficaria	Lesser celandine	G	Forb/herb	1	nonnative	Y	Ranunculaceae
Reynoutria japonica	Japanese knotweed	G	Forb/herb	1	nonnative	Y	Polygonaceae
Robinia pseudoacacia	Black locust	SC	Tree	3	native	N	Fabaceae
Rosa multiflora	Multiflora rose	S	Shrub	7	nonnative	Y	Rosaceae
Rubus pensilvanicus	Pennsylvania blackberry	S	Shrub	1	native	N	Rosaceae
Rubus phoenicolasius	Wineberry	S	Shrub	4	nonnative	Y	Rosaceae
Rubus sp native	Brambles	S	Shrub	3	native	N	Rosaceae
Rumex crispus	Curly dock	G	Forb/herb	5	nonnative	Y	Polygonaceae
Salix nigra	Black willow	SC	Tree	1	native	N	Saliaceae
Sanicula canadensis	Canadian black snakeroot	G	Forb/herb	5	native	N	Apiaceae
Sassafras albidum	Sassafras	SC	Tree	1	native	N	Lauraceae
Smilax rotundifolia	Catbrier	V	Woody vine	8	native	N	Smilacaceae
Solanum nigra	Ground cherry	G	Forb/herb	1	nonnative	N	Solanaceae
Taraxacum officinale	Dandelion	G	Forb/herb	1	nonnative	Y	Asteraceae
Toxicodendron radicans	Poison ivy	V	Woody vine	13	native	N	Anacardiaceae

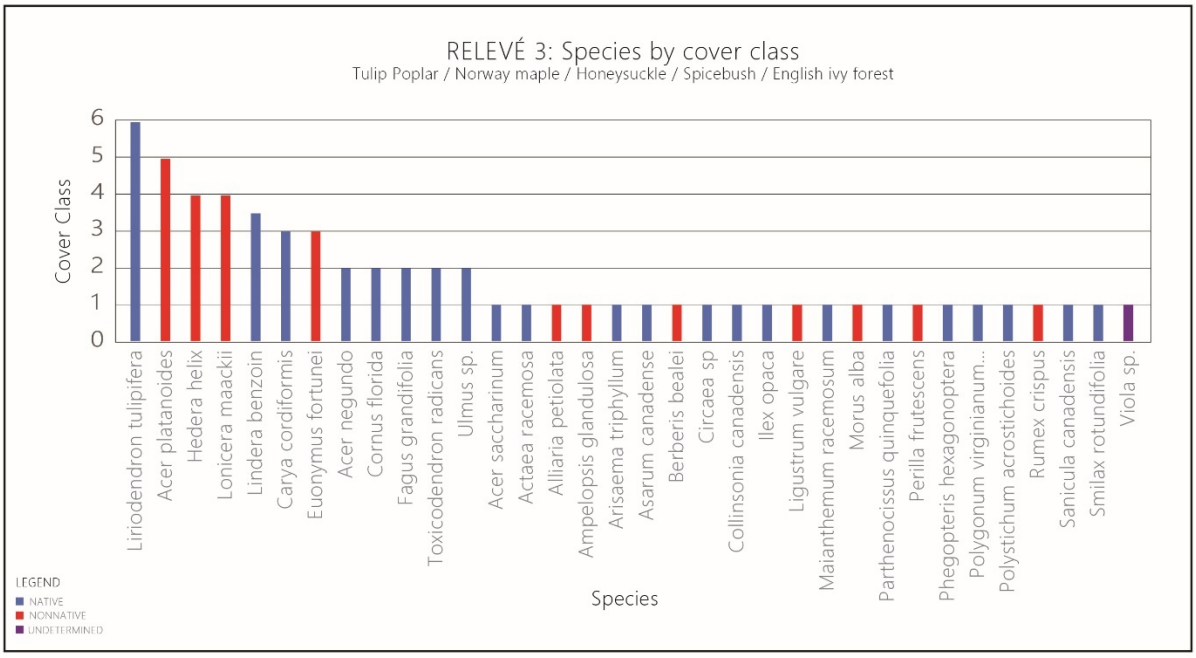
Trifolium repens	White clover	G	Forb/herb	4	nonnative	Y	Fabaceae
Ulmus americana	American elm	C	Tree	2	native	N	Ulmaceae
Ulmus sp.	Elm	C	Tree	2	CBD	CBD	Ulmaceae
Verbena urticifolia	White vervain	G	Forb/herb	1	native	N	Verbenaceae
Viburnum acerifolium	Mapleleaf viburnum	S	Shrub	1	native	N	Caprifoliaceae
Viburnum dilatatum	Linden viburnum	S	Shrub	2	nonnative	Y	Caprifoliaceae
Viola sp.	Violets	G	Forb/herb	5	CBD	CBD	Violaceae
Vitis riparia	Riverbank grape	V	Woody vine	1	native	N	Vitaceae

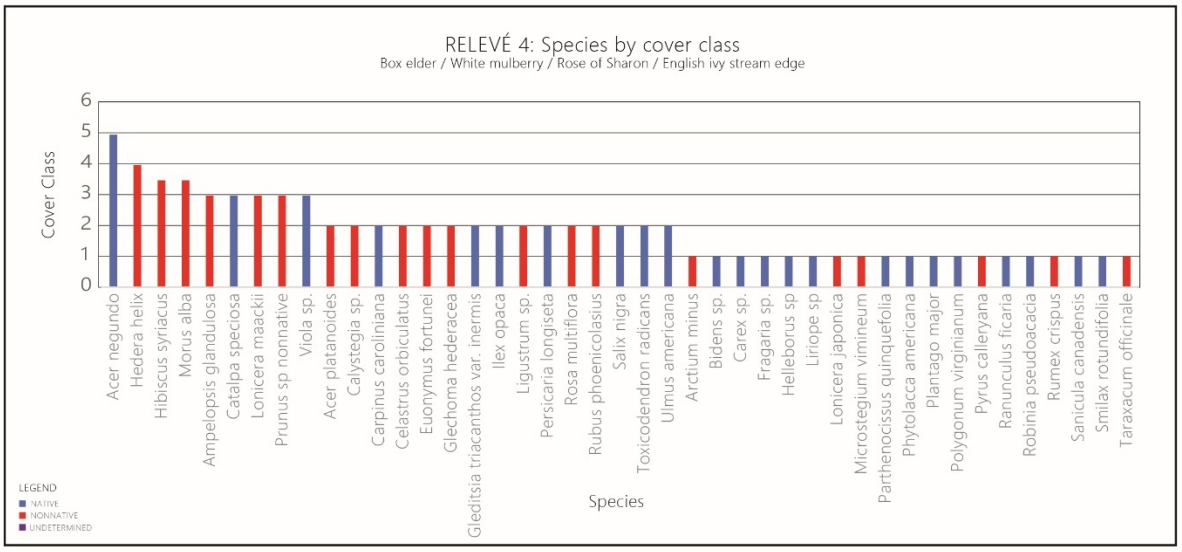
Table 8: Attributes of all Species found in Relevé Plots

Appendix 2: Rank Abundance Data by Relevé Plot

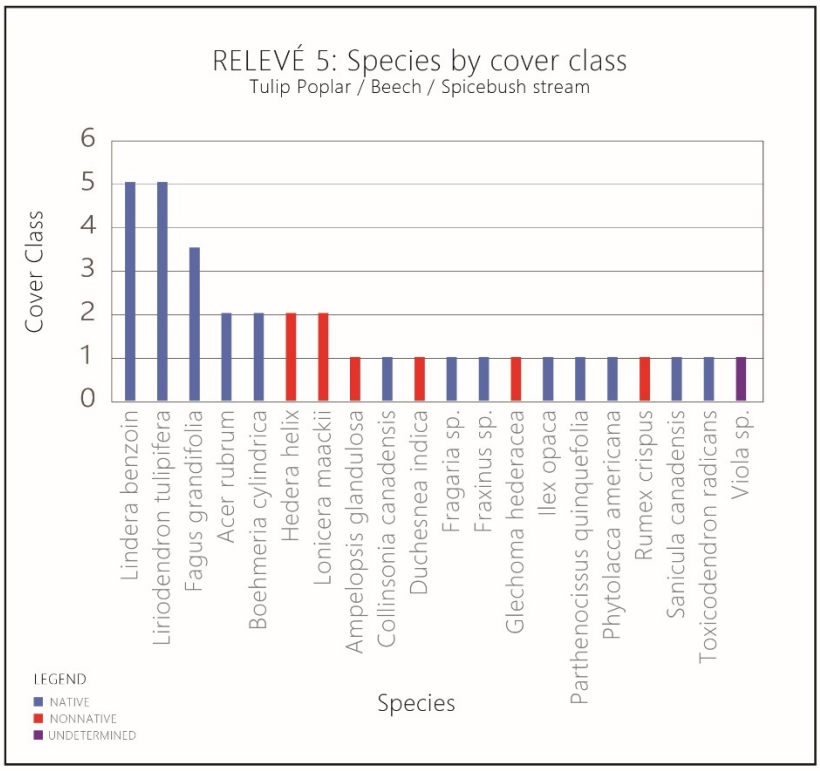


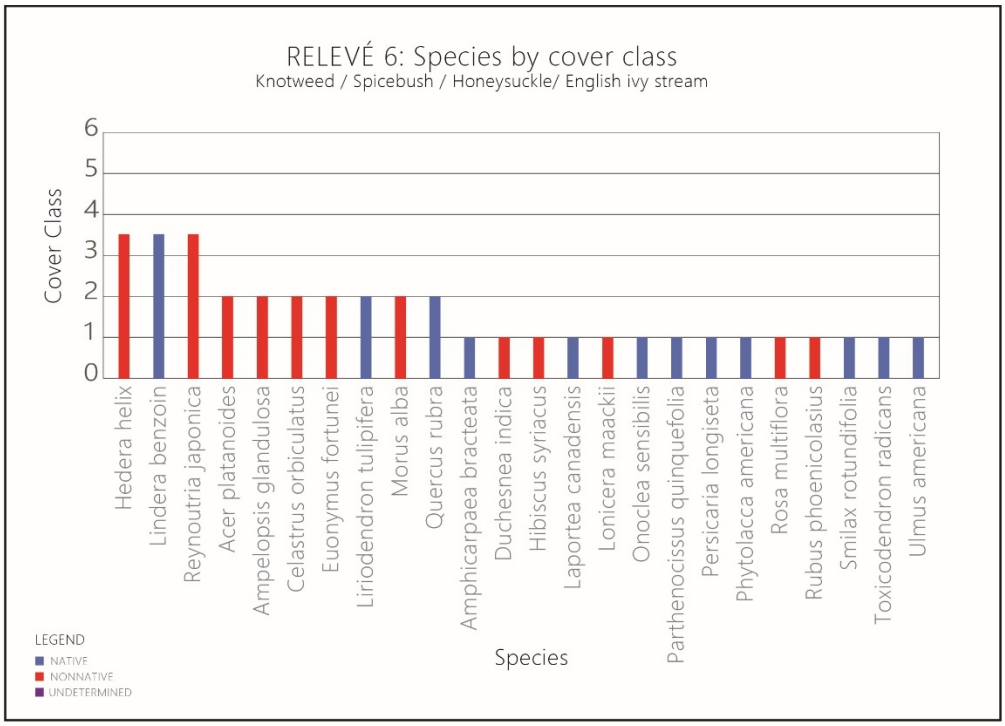


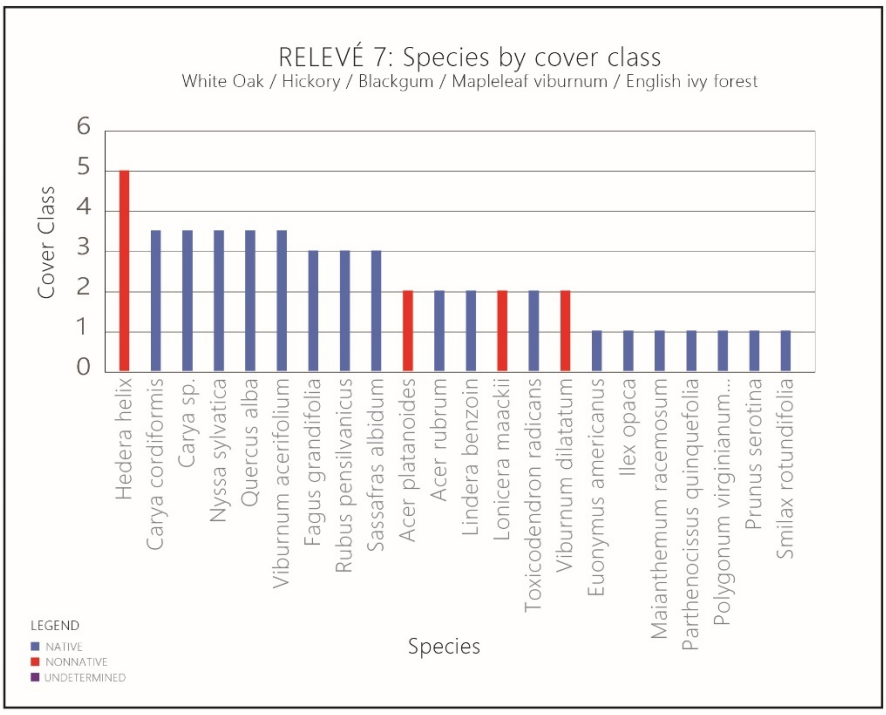

RELEVÉ 3: Species by cover class
Tulip Poplar / Norway maple / Honeysuckle / Spicebush / English ivy forest
Cover Class
0
1
2
3
4
5
6
Liriodendron tulipifera
Acer platanoides
Hedera helix
Lonicera maackii
Lindera benzoin
Carya cordiformis
Euonymus fortunei
Acer negundo
Cornus florida
Fagus grandifolia
Toxicodendron radicans
Ulmus sp.
Acer saccharinum
Actaea racemosa
Alliaria petiolata
Ampelopsis glandulosa
Arisaema triphyllum
Asarum canadense
Berberis bealei
Circaea sp
Collinsonia canadensis
Ilex opaca
Ligustrum vulgare
Maianthemum racemosum
Morus alba
Parthenocissus quinquefolia
Perilla frutescens
Phegopteris hexagonoptera
Polygonum virginianum...
Polystichum acrostichoides
Rumex crispus
Sanicula canadensis
Smilax rotundifolia
Viola sp.
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED

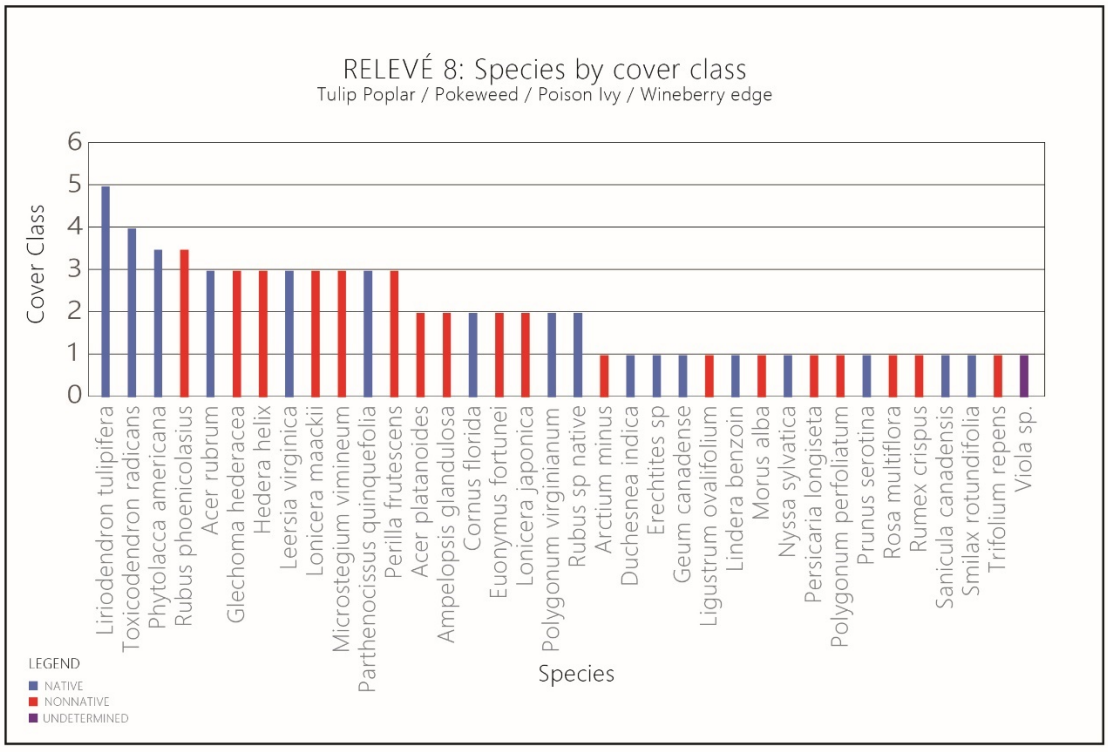

RELEVÉ 4: Species by cover class
Box elder / White mulberry / Rose of Sharon / English ivy stream edge
Cover Class
0
1
2
3
4
5
6
Acer negundo
Hedera helix
Hibiscus syriacus
Morus alba
Ampelopsis glandulosa
Catalpa speciosa
Lonicera maackii
Prunus sp nonnative
Viola sp.
Acer platanoides
Calystegia sp.
Carpinus caroliniana
Celastrus orbiculatus
Euonymus fortunei
Glechoma hederacea
Gleditsia triacanthos var. inermis
Ilex opaca
Ligustrum sp.
Persicaria longiseta
Rosa multiflora
Rubus phoenicolasius
Salix nigra
Toxicodendron radicans
Ulmus americana
Arctium minus
Bidens sp.
Carex sp.
Fragaria sp.
Helleborus sp
Liriope sp
Lonicera japonica
Microstegium vimineum
Parthenocissus quinquefolia
Phytolacca americana
Plantago major
Polygonum virginianum
Pyrus calleryana
Ranunculus ficaria
Robinia pseudoacacia
Rumex crispus
Sanicula canadensis
Smilax rotundifolia
Taraxacum officinale
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED

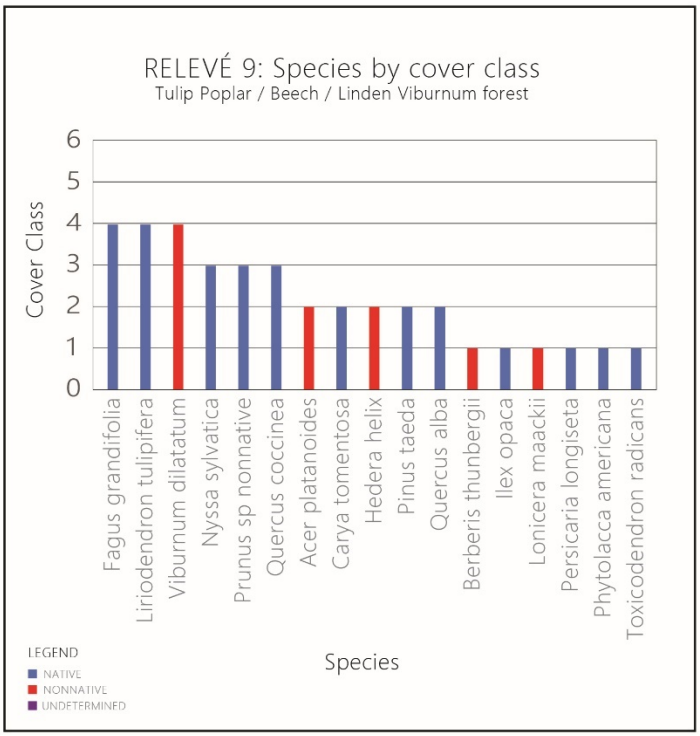
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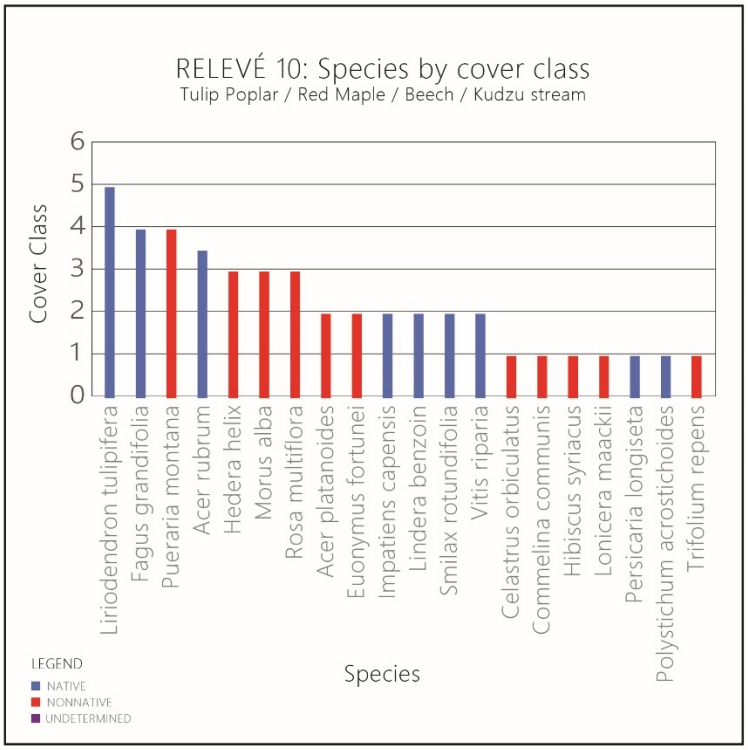

RELEVÉ 5: Species by cover class
Tulip Poplar / Beech / Spicebush stream
Cover Class
6
5
4
3
2
1
0
Lindera benzoin
Liriodendron tulipifera
Fagus grandifolia
Acer rubrum
Boehmeria cylindrica
Hedera helix
Lonicera maackii
Ampelopsis glandulosa
Collinsonia canadensis
Duchesnea indica
Fragaria sp.
Fraxinus sp.
Glechoma hederacea
Ilex opaca
Parthenocissus quinquefolia
Phytolacca americana
Rumex crispus
Sanicula canadensis
Toxicodendron radicans
Viola sp.
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED

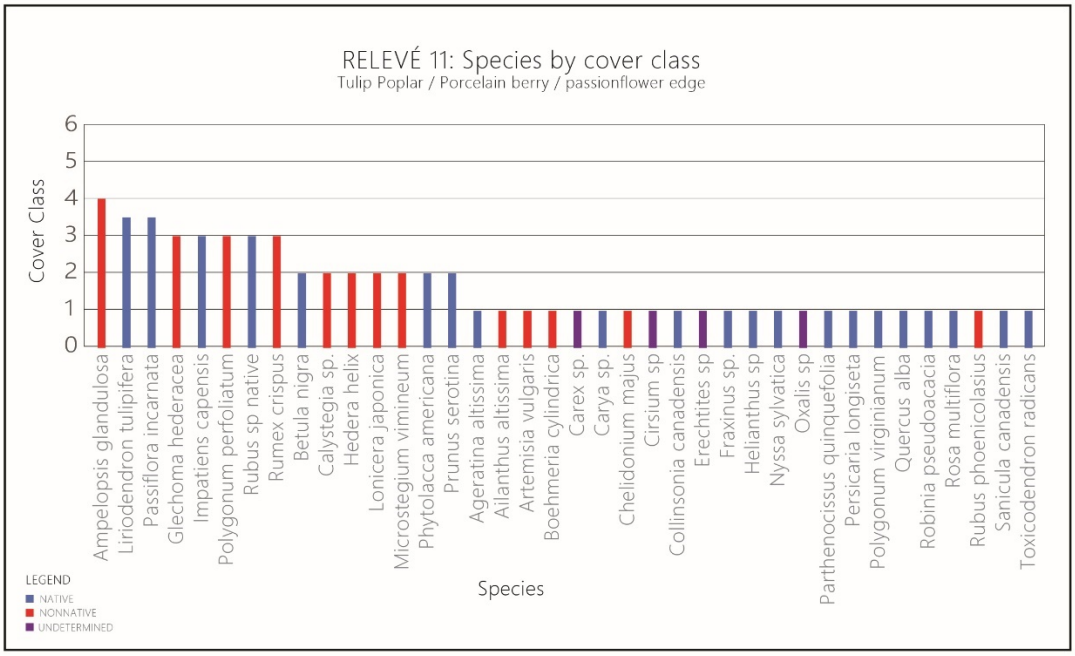

RELEVÉ 6: Species by cover class
Knotweed / Spicebush / Honeysuckle/ English ivy stream
Cover Class
6
5
4
3
2
1
0
Hedera helix
Lindera benzoin
Reynoutria japonica
Acer platanoides
Ampelopsis glandulosa
Celastrus orbiculatus
Euonymus fortunei
Liriodendron tulipifera
Morus alba
Quercus rubra
Amphicarpaea bracteata
Duchesnea indica
Hibiscus syriacus
Laportea canadensis
Lonicera maackii
Onoclea sensibilis
Parthenocissus quinquefolia
Persicaria longiseta
Phytolacca americana
Rosa multiflora
Rubus phoenicolasius
Smilax rotundifolia
Toxicodendron radicans
Ulmus americana
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED

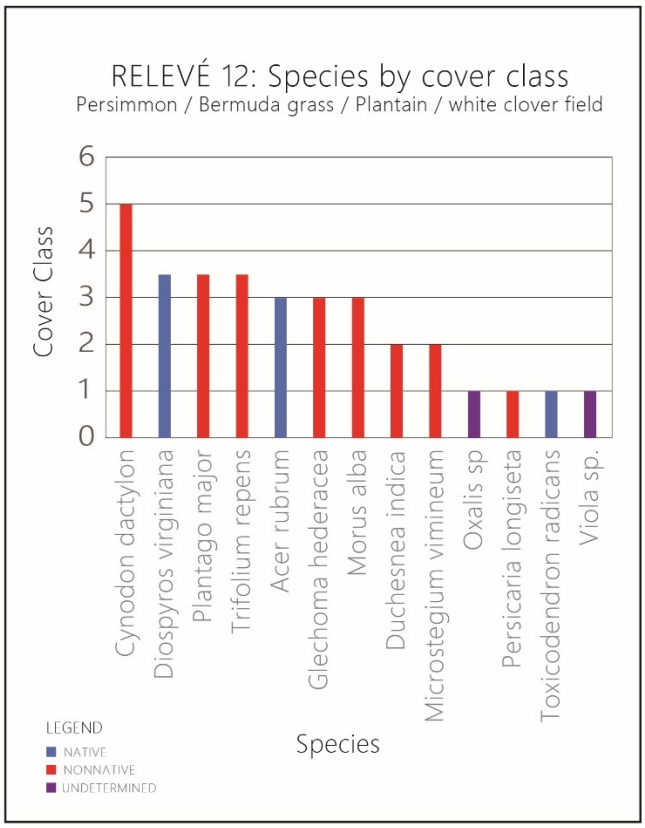

RELEVÉ 7: Species by cover class
White Oak / Hickory / Blackgum / Mapleleaf viburnum / English ivy forest
Cover Class
0
1
2
3
4
5
6
Hedera helix
Carya cordiformis
Carya sp.
Nyssa sylvatica
Quercus alba
Viburnum acerifolium
Fagus grandifolia
Rubus pensilvanicus
Sassafras albidum
Acer platanoides
Acer rubrum
Lindera benzoin
Lonicera maackii
Toxicodendron radicans
Viburnum dilatatum
Euonymus americanus
Ilex opaca
Maianthemum racemosum
Parthenocissus quinquefolia
Polygonum virginianum...
Prunus serotina
Smilax rotundifolia
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED

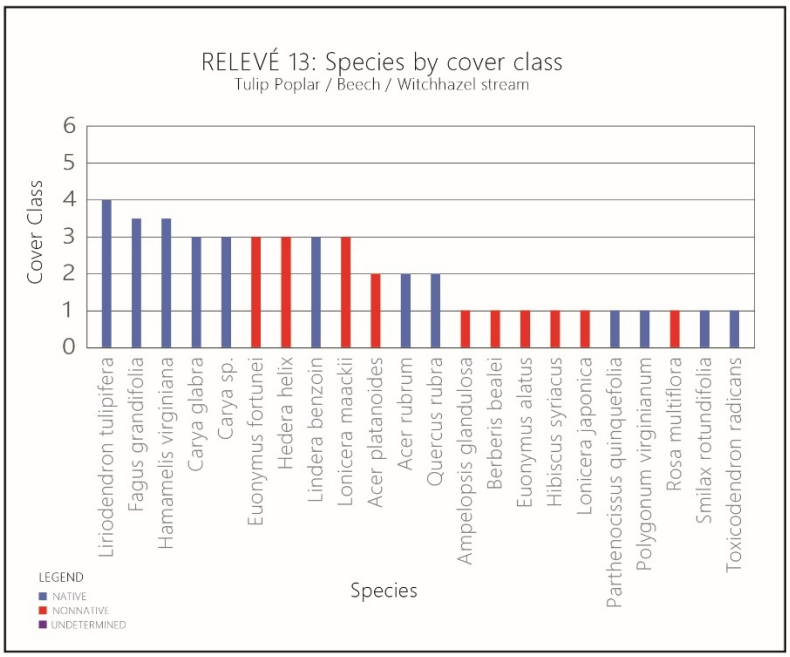

RELEVÉ 8: Species by cover class
Tulip Poplar / Pokeweed / Poison Ivy / Wineberry edge
Cover Class
0
1
2
3
4
5
6
Liriodendron tulipifera
Toxicodendron radicans
Phytolacca americana
Rubus phoenicolasius
Acer rubrum
Glechoma hederacea
Hedera helix
Leersia virginica
Lonicera maackii
Microstegium vimineum
Parthenocissus quinquefolia
Perilla frutescens
Acer platanoides
Ampelopsis glandulosa
Cornus florida
Euonymus fortunei
Lonicera japonica
Polygonum virginianum
Rubus sp native
Arctium minus
Duchesnea indica
Erechtites sp
Geum canadense
Ligustrum ovalifolium
Lindera benzoin
Morus alba
Nyssa sylvatica
Persicaria longiseta
Polygonum perfoliatum
Prunus serotina
Rosa multiflora
Rumex crispus
Sanicula canadensis
Smilax rotundifolia
Trifolium repens
Viola sp.
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED

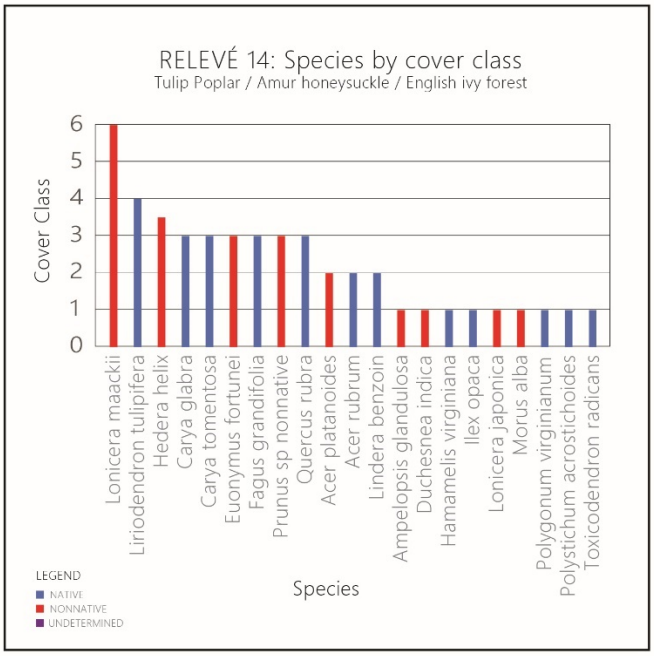

RELEVÉ 9: Species by cover class
Tulip Poplar / Beech / Linden Viburnum forest
Cover Class
0
1
2
3
4
5
6
Fagus grandifolia
Liriodendron tulipifera
Viburnum dilatatum
Nyssa sylvatica
Prunus sp nonnative
Quercus coccinea
Acer platanoides
Carya tomentosa
Hedera helix
Pinus taeda
Quercus alba
Berberis thunbergii
Ilex opaca
Lonicera maackii
Persicaria longiseta
Phytolacca americana
Toxicodendron radicans
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED

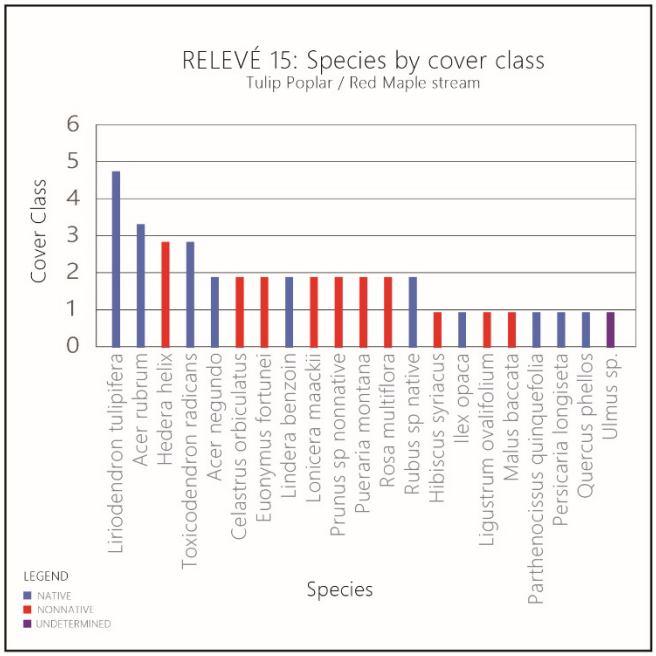

RELEVÉ 10: Species by cover class
Tulip Poplar / Red Maple / Beech / Kudzu stream
Cover Class
0
1
2
3
4
5
6
Liriodendron tulipifera
Fagus grandifolia
Pueraria montana
Acer rubrum
Hedera helix
Morus alba
Rosa multiflora
Acer platanoides
Euonymus fortunei
Impatiens capensis
Lindera benzoin
Smilax rotundifolia
Vitis riparia
Celastrus orbiculatus
Commelina communis
Hibiscus syriacus
Lonicera maackii
Persicaria longiseta
Polystichum acrostichoides
Trifolium repens
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED


RELEVÉ 11: Species by cover class
Tulip Poplar / Porcelain berry / passionflower edge
Cover Class
0
1
2
3
4
5
6
Ampelopsis glandulosa
Liriodendron tulipifera
Passiflora incarnata
Glechoma hederacea
Impatiens capensis
Polygonum perfoliatum
Rubus sp native
Rumex crispus
Betula nigra
Calystegia sp.
Hedera helix
Lonicera japonica
Microstegium vimineum
Phytolacca americana
Prunus serotina
Ageratina altissima
Ailanthus altissima
Artemisia vulgaris
Boehmeria cylindrica
Carex sp.
Carya sp.
Chelidonium majus
Cirsium sp
Collinsonia canadensis
Erechtites sp
Fraxinus sp.
Helianthus sp
Nyssa sylvatica
Oxalis sp
Parthenocissus quinquefolia
Persicaria longiseta
Polygonum virginianum
Quercus alba
Robinia pseudoacacia
Rosa multiflora
Rubus phoenicolasius
Sanicula canadensis
Toxicodendron radicans
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED


RELEVÉ 12: Species by cover class
Persimmon / Bermuda grass / Plantain / white clover field
Cover Class
0
1
2
3
4
5
6
Cynodon dactylon
Diospyros virginiana
Plantago major
Trifolium repens
Acer rubrum
Glechoma hederacea
Morus alba
Duchesnea indica
Microstegium vimineum
Oxalis sp
Persicaria longiseta
Toxicodendron radicans
Viola sp.
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED


RELEVÉ 13: Species by cover class
Tulip Poplar / Beech / Witchhazel stream
Cover Class
0
1
2
3
4
5
6
Liriodendron tulipifera
Fagus grandifolia
Hamamelis virginiana
Carya glabra
Carya sp.
Euonymus fortunei
Hedera helix
Lindera benzoin
Lonicera maackii
Acer platanoides
Acer rubrum
Quercus rubra
Ampelopsis glandulosa
Berberis bealei
Euonymus alatus
Hibiscus syriacus
Lonicera japonica
Parthenocissus quinquefolia
Polygonum virginianum
Rosa multiflora
Smilax rotundifolia
Toxicodendron radicans
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED


RELEVÉ 14: Species by cover class
Tulip Poplar / Amur honeysuckle / English ivy forest
Cover Class
0
1
2
3
4
5
6
Lonicera maackii
Liriodendron tulipifera
Hedera helix
Carya glabra
Carya tomentosa
Euonymus fortunei
Fagus grandifolia
Prunus sp nonnative
Quercus rubra
Acer platanoides
Acer rubrum
Lindera benzoin
Ampelopsis glandulosa
Duchesnea indica
Hamamelis virginiana
Ilex opaca
Lonicera japonica
Morus alba
Polygonum virginianum
Polystichum acrostichoides
Toxicodendron radicans
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED


RELEVÉ 15: Species by cover class
Tulip Poplar / Red Maple stream
Cover Class
6
5
4
3
2
1
0
Liriodendron tulipifera
Acer rubrum
Hedera helix
Toxicodendron radicans
Acer negundo
Celastrus orbiculatus
Euonymus fortunei
Lindera benzoin
Lonicera maackii
Prunus sp nonnative
Pueraria montana
Rosa multiflora
Rubus sp native
Hibiscus syriacus
Ilex opaca
Ligustrum ovalifolium
Malus baccata
Parthenocissus quinquefolia
Persicaria longiseta
Quercus phellos
Ulmus sp.
Species
LEGEND
NATIVE
NONNATIVE
UNDETERMINED

Appendix 3: Planting Recommendation Lists by Vegetation Typology

MAGNOLIA EDGE



Evergreen/magnolia border

Pinus strobus (Eastern white pine)
Magnolia virginiana (Sweetbay magnolia)
Ilex opaca (American holly)
Magnolia grandiflora (Southern magnolia)

Native fruit-bearing shrub interior border

Rubus pennsylvanicus (Pennsylvania blackberry)
Ilex verticillata (winterberry)
Ilex glabra (Inkberry)
Gaylusaccia baccata (Huckleberry)
Viburnum acerifolium (Mapleleaf viburnum)

NATIVE EDGE



Understory massing

Cornus florida (Flowering dogwood)
Cercis canadensis (Eastern redbud)
Nyssa sylvatica (Blackgum)
Magnolia virginiana (Sweetbay magnolia)
*Magnolia tripetala (*Umbrella magnolia)
Asimina triloba (Pawpaw)
Rhus typhina (Staghorn sumac)

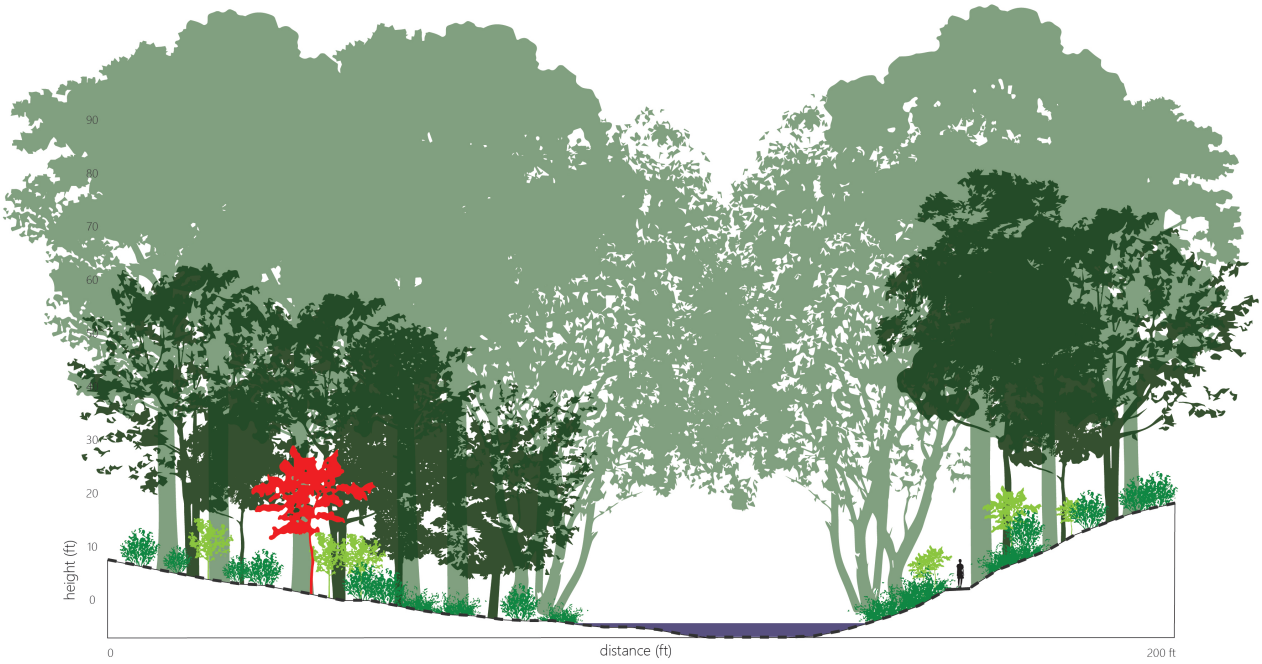
Shrub massing

Viburnum acerifolium (mapleleaf viburnum)
Viburnum dentatum (arrowwood viburnum)
Kalmia latifolia (Mountain laurel)
Hamamelis virginiana (Witchhazel)
Clethra alnifolia (Summersweet).

Ground Cover

Rhus aromatica (fragrant sumac)
Asarum canadense (Wild ginger)
Polystichum acristichoides (Christmas fern)
Cornus canadensis (bunchberry)

WILLOW RUN



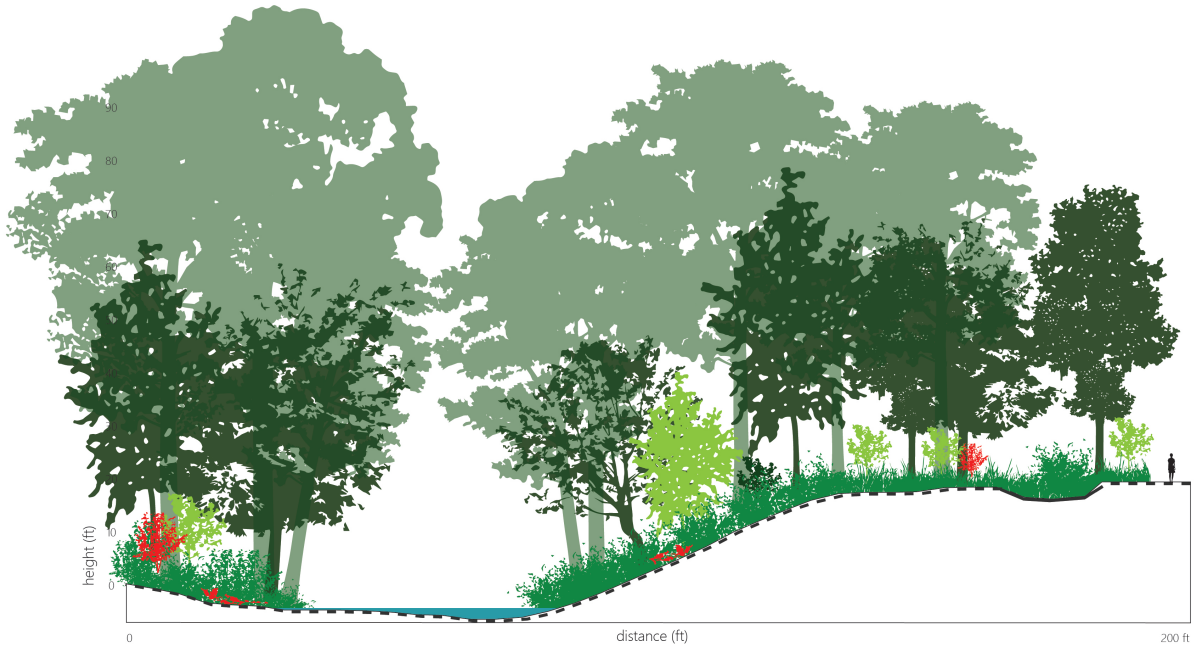
Trees

Salix nigra (black willow)
Platanus occidentalis (Amercan sycamore)
Acer negundo (Boxelder maple)

Shrubs

Rhododendrum viscosum (swamp azalea)
Cornus racemosa (gray dogwood)
Myrica pennsylvanica (bayberry)
Clethra alnifolia (pepperbush)
Sambuca canadensis (Elderberry)

STREAMSIDE FOREST



Fast-growing tree species

Liriodendron tulipifera (Tulip poplar)
Salix nigra (black willow)
Ulmus rubra (slippery elm)
Liquidambar styraciflua (sweetgum)

Slower-growing riparian trees

Nyssa sylvatica (blackgum)
Platanus occidentalis (American sycamore)
Quercus palustris (Pin oak)
Quercus phellos (willow oak)
Asimina triloba (pawpaw)

Riparian shrubs & understory

See "Willow Run" riparian shrub section.

BEECH TULIP FOREST

For details on the ecological reference for this typology, see Fleming et. al., 2007.



Canopy trees

Liriodendron tulipifera (Tulip poplar)
Fagus grandifolia (American beech)
Carya cordifomis (bitternut hickory)
Prunus serotina (Black cherry)
Quercus alba (white oak)
Quercus rubra (Red oak)

Understory trees

Carpinus caroliniana (American hornbeam)
Nyssa sylvatica (blackgum)
Ilex opaca (American holly)
Sassafras albidum (sassafras)
Asimina triloba (pawpaw)

Shrubs

Lindera benzoin (spicebush)
Viburnum acerifolium (mapleleaf viburnum)
Viburnum dentatum (arrowwood viburnum)
Hamamelis virginiana (witchhazel)
Euonymus americanus (American strawberrybush)

Ground Layer

Podophyllum peltatum (mayapple)
Polystichum acrostichoides (Christmas fern)
Maianthemum racemosum (False Solomon's seal)
Actaea racemosa (black cohosh)

SUCCESSIONAL FOREST



Initial meadow planting
See https://www.ernstseed.com/ (Ernst Conservation Seeds, 2021) *for meadow mixes.*

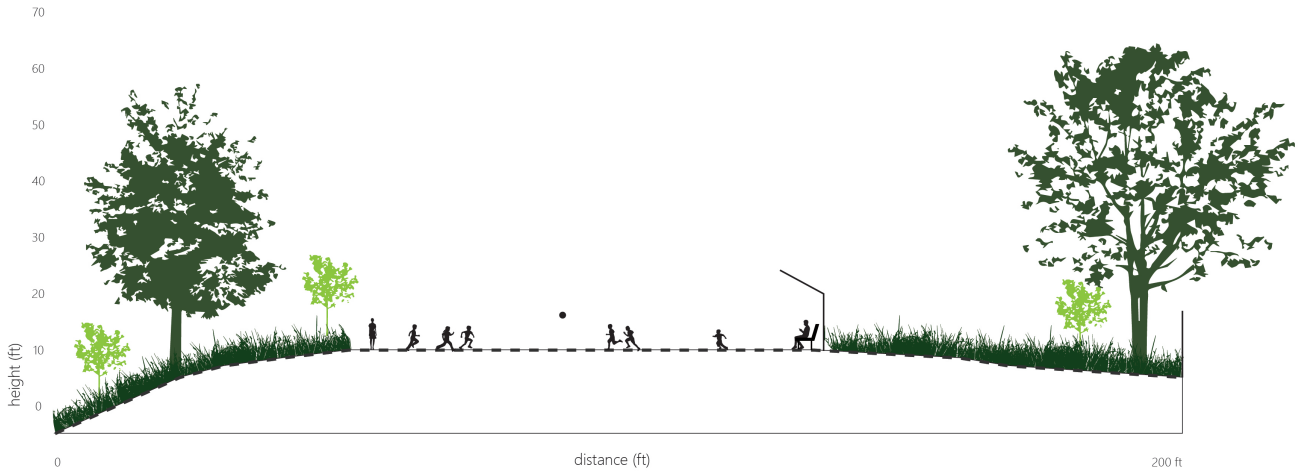
Schizachyrium scoparium (little bluestem)
Sorghastrum nutans (Indian grass)
Echinacea purpurea (purple coneflower)
Asclepias spp. (milkweeds)
Rudbeckia hirta (black-eyed susan)

Early successional trees

Prunus serotina (Black cherry)
Pinus strobus (Eastern white pine)
Juniperus virginiana (eastern redcedar)
Rhus typhina (staghorn sumac)

Later successional enrichment plantings
See recommendations for Beech Tulip Forest typology.

MEADOW PARKLAND



Initial meadow planting
See Successional Forest typology.

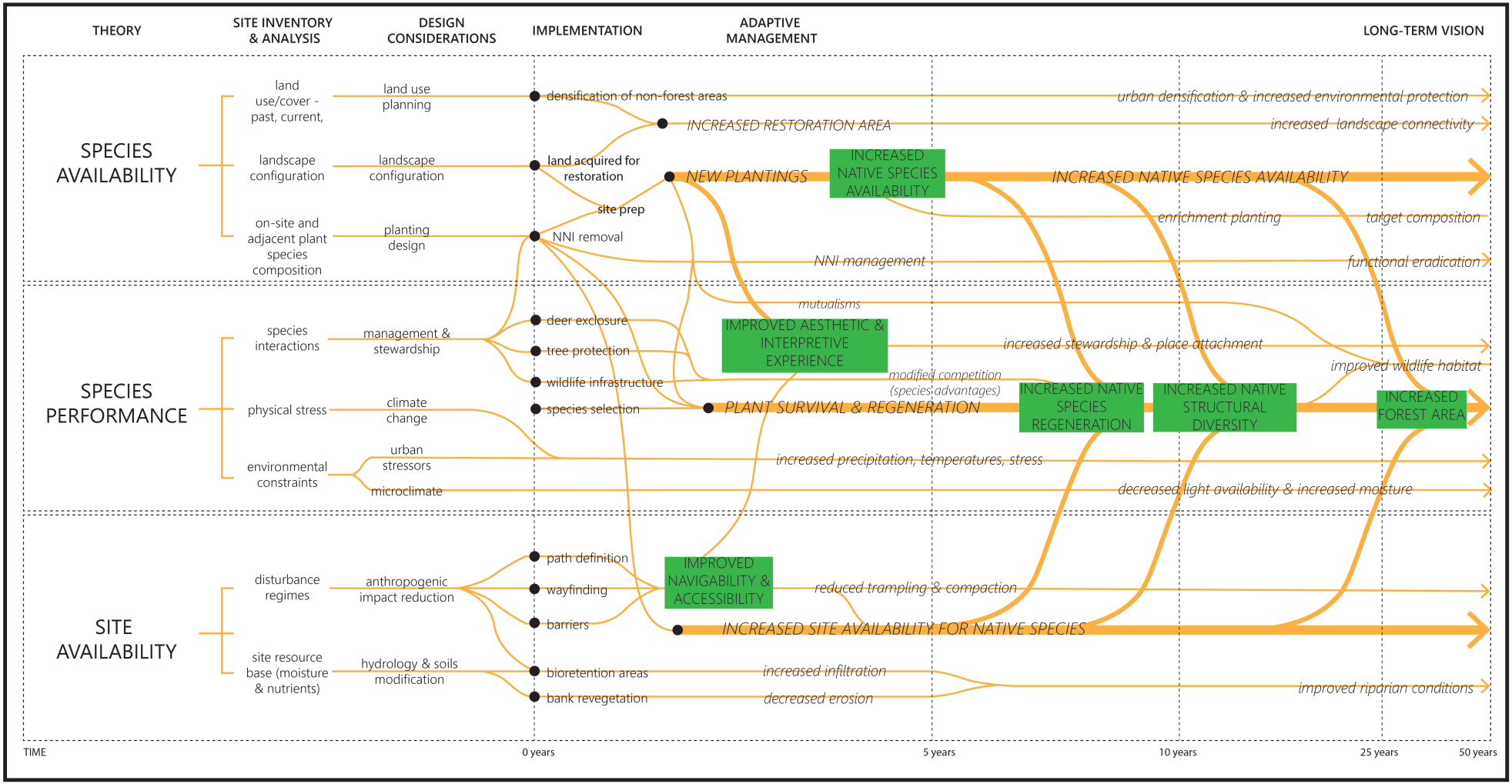
Trees to scatter throughout meadow

Rhus typhina (staghorn sumac)
Quercus alba (white oak)
Nyssa sylvatica (blackgum)
Tilia americana (American linden)

Appendix 4: Full-Page Images

1. Conceptual Framework
2. Timeline of vegetation typology changes
3. Illustrative section of typology placement & planting examples
4. Concept Plan: Upper Long Branch Neighborhood Park
5. Upper Long Branch Stream Valley Boardwalk
6. Concept Plan: Oak View Elementary School
7. Beech Tulip Forest Path with Deer Exclosure
8. Concept Plan: Long Branch-Wayne Local Park
9. Meadow Parkland at Wayne Local Park
10. Concept Plan: Long Branch-Arliss Neighborhood Park
11. Long Branch-Arliss Neighborhood Park Recreation Complex
12. Concept Plan: Long Branch Local Park
13. Magnolia Edge at Long Branch Local Park

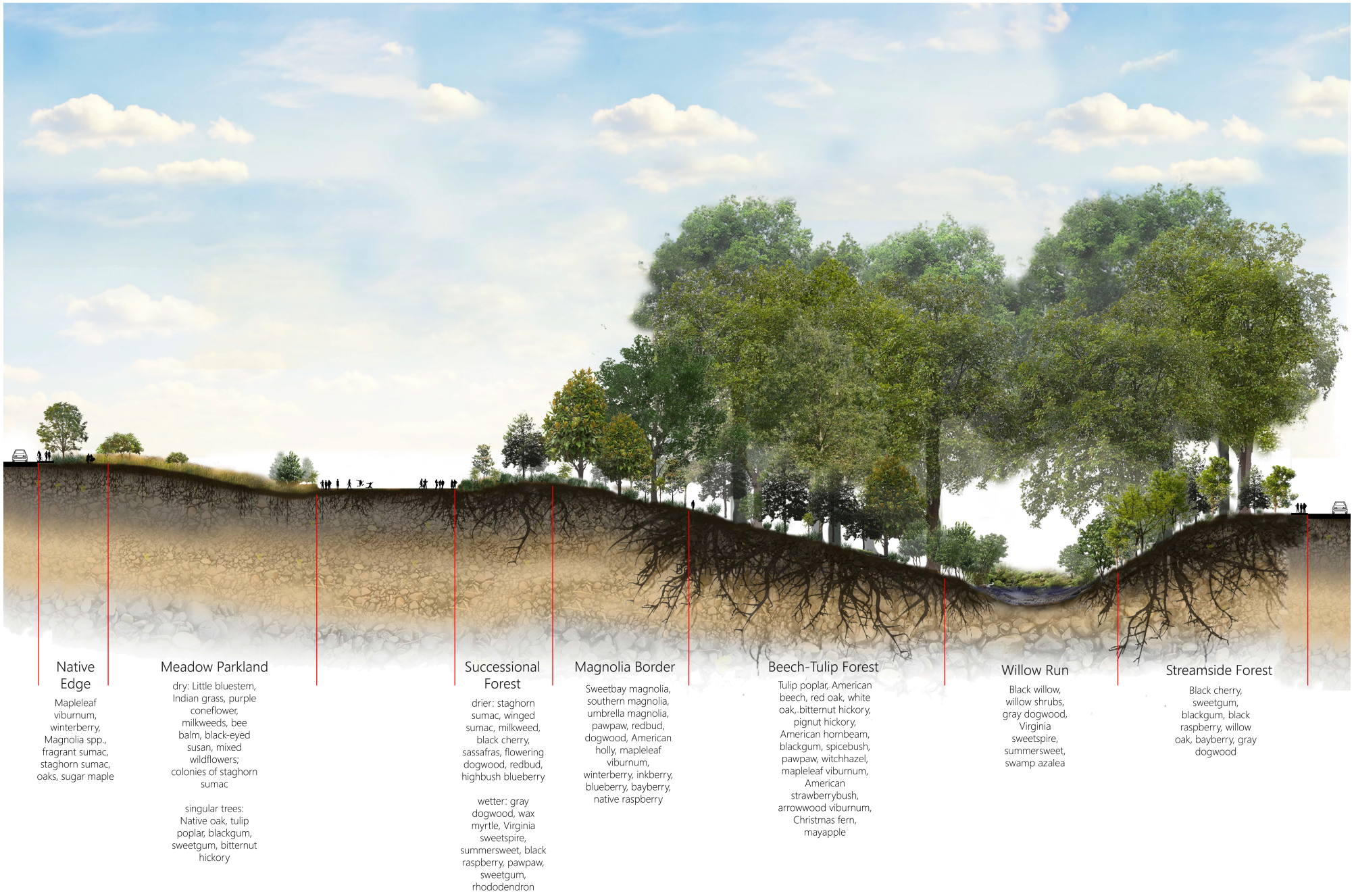
1. Conceptual Framework: Integrating vegetation dynamics theory into urban park design



2. Conceptual timeline of planting design typologies



3. Illustrative section of planting design typologies, with some recommended plant species



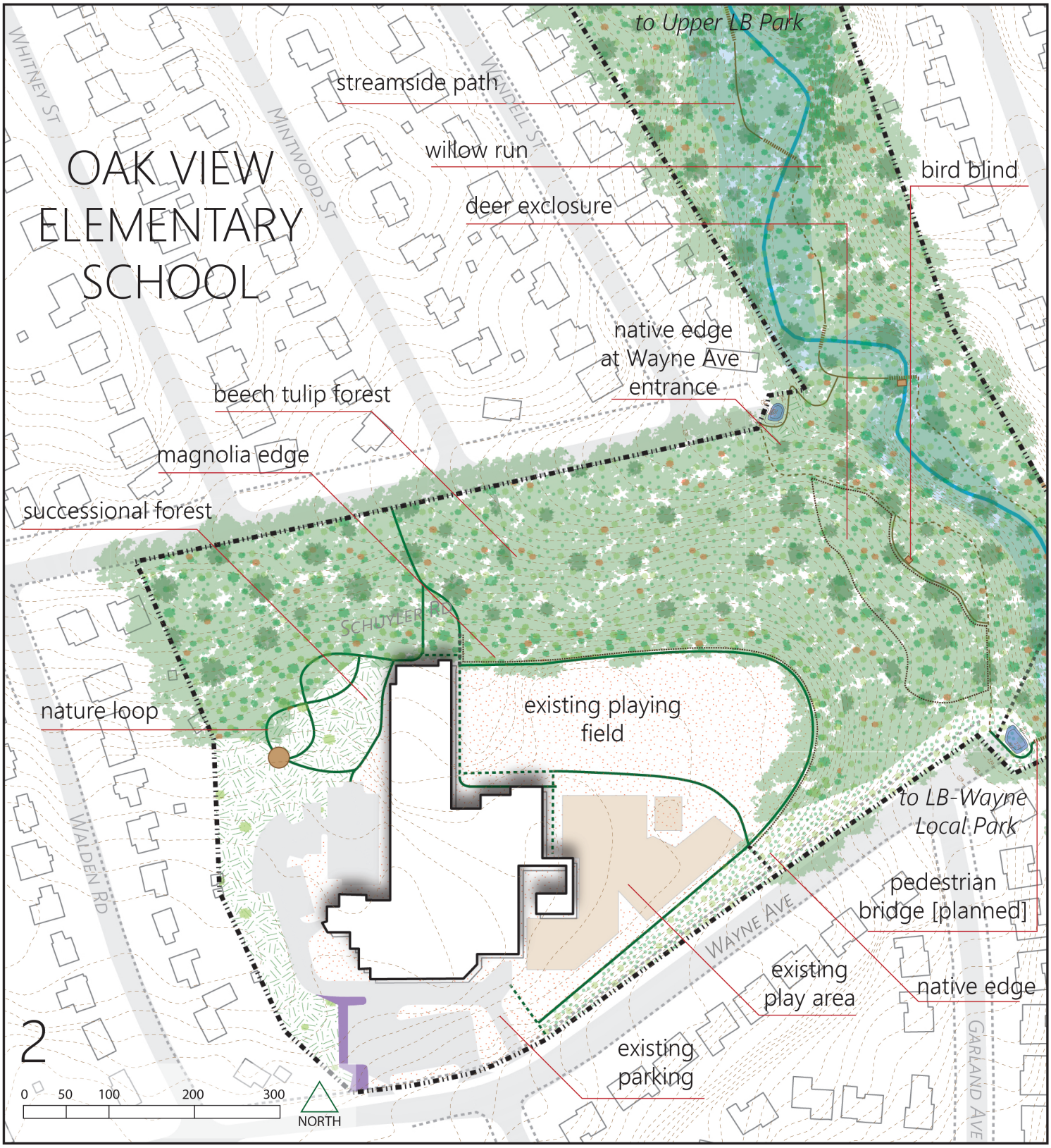
4. Concept Plan: Upper Long Branch Neighborhood Park



5. Upper Long Branch Stream Valley Boardwalk



6. Concept Plan: Oak View Elementary School



7. Beech Tulip Forest Path with Deer Exclosure



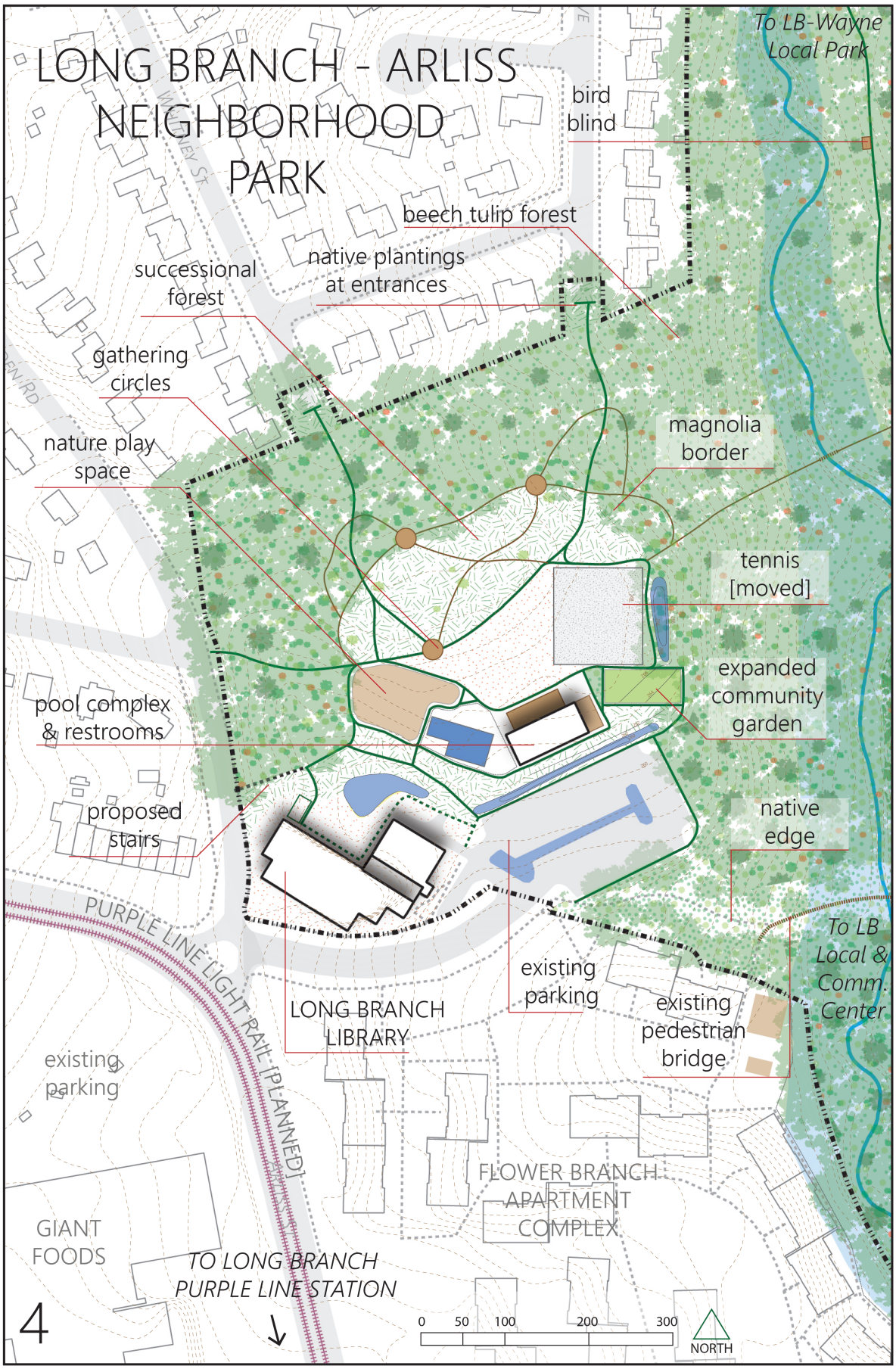
8. Concept Plan: Long Branch-Wayne Local Park



9. Meadow Parkland at Long Branch-Wayne Local Park



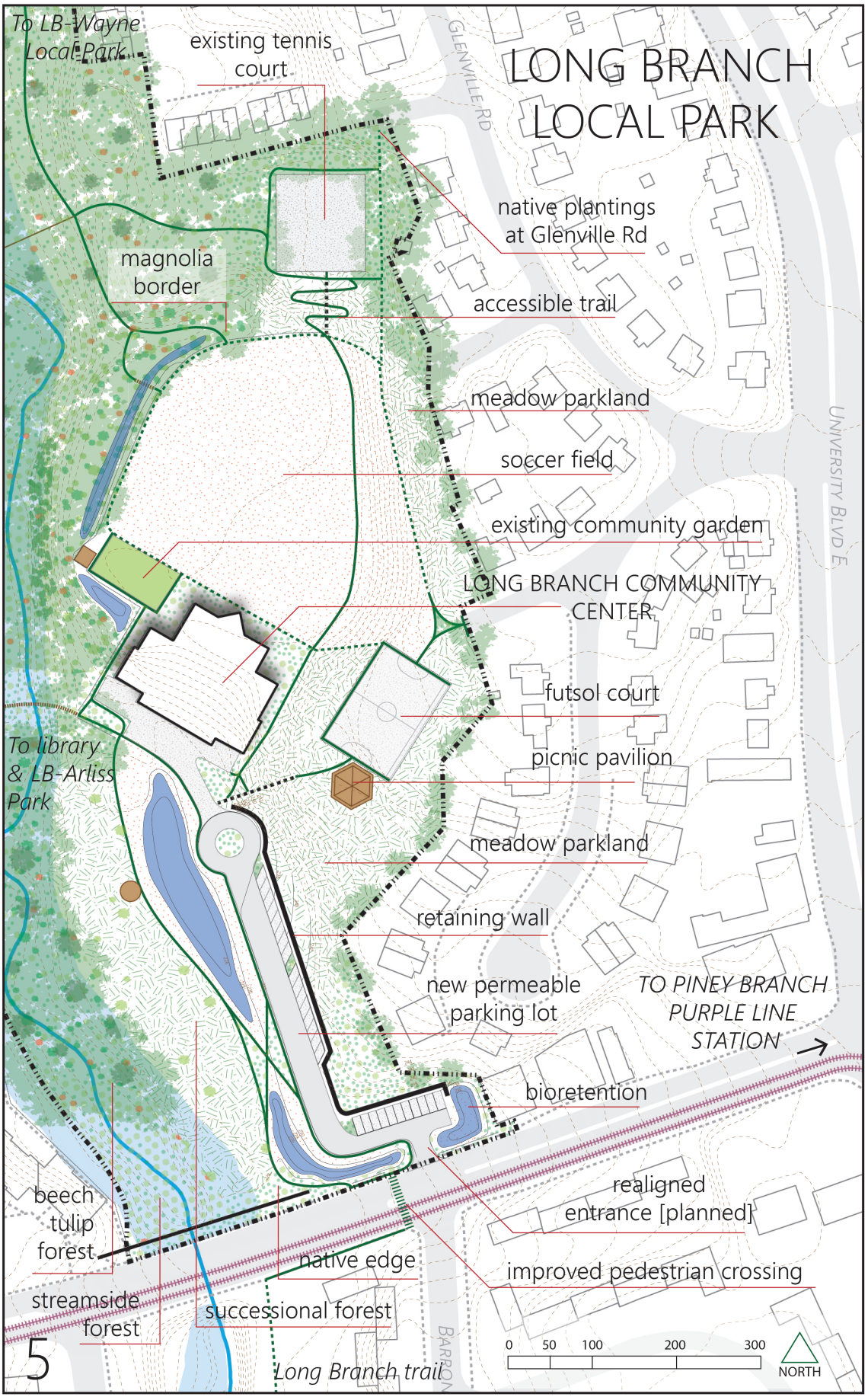
10. Concept Plan: Long Branch-Arliss Neighborhood Park



11: Long Branch-Arliss Neighborhood Park Recreation Complex



12. Concept Plan: Long Branch Local Park



13: Magnolia Border at Long Branch Local Park



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