ADAPTATIONS OF SOUTHEASTERN PIEDMONT PRAIRIE SPECIES: NEW PARADIGMS FOR DESIGNING AND PLANTING IN THE CONTEXT OF PUBLIC SPACES

by

JAMES WESLEY RYALS

(Under the Direction of Brad Davis)

ABSTRACT

This thesis explores the potential for novel assemblages of Piedmont prairie species using the designed plant community approach pioneered by professors James Hitchmough and Nigel Dunnett, along with key design principles outlined by Thomas Rainer and Claudia West as a framework for guiding selection and evaluation of Southeastern Piedmont Prairie species and their potential use in urban and suburban environments. Research has evolved as a response to four long-term problems that remain prevalent in urban parks authorities across the globe: (1) A significant decline in the funding of maintenance programs, (2) the erosion of horticultural vegetation maintenance skills within urban park authorities, (3) the loss of critical pollinator habitat and limited biodiversity, and (4) the need for a regionally specific understanding of natural plant assemblages.

Using new paradigms for designed plantings, an evaluation and design process has been developed by which hypernatural plant communities can be assembled and evaluated.

INDEX WORDS: sustainability, eco-acupuncture, natives, sustained performance, urban environment, ecological carrying capacity, pollinators, ecobeneficial, ruderal, resiliency

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by

JAMES WESLEY RYALS

BA, Georgia Southern University, 2004

BLA, University of Georgia, 2010

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

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by

JAMES WESLEY RYALS

Major Professor: Brad Davis
Committee: Dan Nadenicek
David Nichols
Thomas Rainer
Joe Smith

Electronic Version Approved:
Ron Walcott
Vice Provost for Graduate Education and Dean of the Graduate School
The University of Georgia
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DEDICATION

I would like to acknowledge those individuals involved who have contributed towards making my experiences here so memorable. First and foremost is my wife, whose tireless devotion has kept me grounded and focused. Your words of encouragement to "finish strong" have enabled me to be proud of my accomplishments here and have championed me to finish the course that I had started so many years ago. Additionally, I would like to dedicate this body of work to my son, Grayson. May it serve as a reminder to you that anything is possible with hard work and perseverance.

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CHAPTER 1

INTRODUCTION: NEW DIRECTIONS FOR CONSERVATION OF NATURE AND CULTURE

Pertinent Issues and Relevancy

Through great feats of engineering we have erected cities from swamps, tamed our mighty rivers, and cultivated the vast prairie regions of the country according to celebrated author and landscape architect, Thomas Rainer.[1] Such unprecedented human transformation of the environment has resulted in changes to our climate, land, oceans and biosphere at a magnitude and pace so rapid that a new geological epoch—the Anthropocene—dominated by human intervention, is gaining serious traction in various landscape-focused professions, including geography, landscape architecture, environmental planning, and ecology.[2] This stands in stark contrast to the accounts of early explorers, who encountered a continent teeming with a diversity of life, leading noted naturalist William Bartram to proclaim,

> *"My imagination thus wholly engaged in the contemplation of this magnificent landscape, infinitely varied, and without bound,*

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[1] Thomas Rainer and Claudia West, *Planting in a Post Wild World: Designing Plant Communities for Resilient Landscapes* (Portland, OR: Timber Press, 2015), 14.
[2] Jan Zalasiewicz et al., "The Anthropocene: A New Epoch of Geological Time?" *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 369, no. 1938 (2011), 835-841.

I was almost insensible or regardless of the charming objects

more within my reach…"[3]

The modern landscape appears dull in comparison to the species diversity and richness encountered by our forefathers, having been highly altered and reduced to a patchwork of isolated ecological fragments.[4] Indeed, "the primal wilderness of our ancestors is utterly gone,"[5] having been obliterated over the course of the past two centuries, and "to turn back the clock to the landscapes of 1600 is no longer possible."[6] Furthermore, ecological imperatives play out against the backdrop of this "post-wild" world[7] imposed by the increasing threats of climate change and the ever advancing invasion of exotic species.

The specter of landscape evolution and change presents profound challenges for managing and maintaining our landscapes. Ecosystem-level consequences of climate change are now well documented, altering ecosystem structure and function through rising temperatures, increased frequency and magnitude of extreme events, acceleration of hydrological cycles[8], and changes in

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[3] William Bartram and Mark Van Doren, *The Travels of William Bartram* (New York, NY: Dover Publications, 1928)., 273-274.
[4] Rainer and West, *Post-Wild*, 14.
[5] Ibid.
[6] Ibid.
[7] Ibid.
[8] Alan F. Hamlet et al., "Twentieth-Century Trends in Runoff, Evapotranspiration, and Soil Moisture in the Western United States," *Journal of Climate* 20, no. 8 (2007): 1469, doi:10.1175/JCLI4051.1.

seasonality.[9] Consequently, this has led to ecological impacts in animal and plant phenology[10] and induced shifts in the geographic distribution of plants and animals,[11] often which are irreversible. Moreover, climate change also threatens to undermine the very networks of community interaction, including predation and pollination, deemed critical components of ecosystem health.[12]

In October 2018, the Intergovernmental Panel on Climate Change (IPCC), a United Nations body tasked with assessing the science related to climate change, released a Special Report: Global Warming of 1.5 Degrees Celsius. The report, prepared by a diverse body of 91 authors and 133 contributing authors with representation across 40 countries, citing more than 6,000 peer-reviewed scientific studies and thousands of expert reviewers from across the globe, pointed to a bleak assessment of global average temperature change. Since the pre-industrial period, the report asserts, human activities are estimated to have increased Earth's global average temperature by approximately 1 degree Celsius with temperatures continuing to rise at a rate of 0.2 degrees Celsius on average every decade. If current trends hold, global warming is likely to reach 1.5

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[9] V. Masson-Delmotte et al., *IPCC, 2018: Summary for Policymakers. in: Global Warming of 1.5°C. an IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty* (Geneva, Switzerland: World Meteorological Organization,[2018]), 4.
[10] Camille Parmesan, "Ecological and Evolutionary Responses to Recent Climate Change," *Annual Review of Ecology, Evolution, and Systematics* 37 (2006): 641, doi:10.1146/annurev.ecolsys.37.091305.110100.
[11] Louis R. Iverson and Anantha M. Prasad, "Predicting Abundance of 80 Tree Species Following Climate Change in the Eastern United States," *Ecological Monographs* 68, no. 4 (1998): 475, 478, doi:10.2307/2657150.
[12] Sarah Gilman et al., "A Framework for Community Interactions Under Climate Change," *Trends in Ecology & Evolution* 25 (2010): 325-331, doi:10.1016/j.tree.2010.03.002.

degrees Celsius above pre-industrial levels, a crucial metric for gauging climate-related risks to both natural and human systems, between 2030 and 2052. Warming that has already entered Earth's atmosphere is not expected to dissipate for hundreds, if not thousands of years.[13] Rising temperatures from heat-trapping carbon and methane have led us to the precipice of a sixth mass extinction; the last of which occurred 66 million years ago and released 1-2 gigatonnes of CO_2, radically transforming the global environment and leading to the erasure of 76% of all species. Currently, global emissions of CO_2 amount to 30 gigatonnes per year. By 2050, melting permafrost is expected to release an additional 55 trillion kilograms of carbon into the atmosphere, equal to the predicted amount of total carbon emissions generated by the U.S. during the same time period.[14]

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[13] Masson-Delmotte et al., *IPCC, 2018*, 5.
[14] Alan Buis, "A Degree of Concern: Why Global Temperatures Matter," last modified Jul 19, accessed February, 19 2021, https://climate.nasa.gov/news/2878/a-degree-of-concern-why-global-temperatures-matter/.

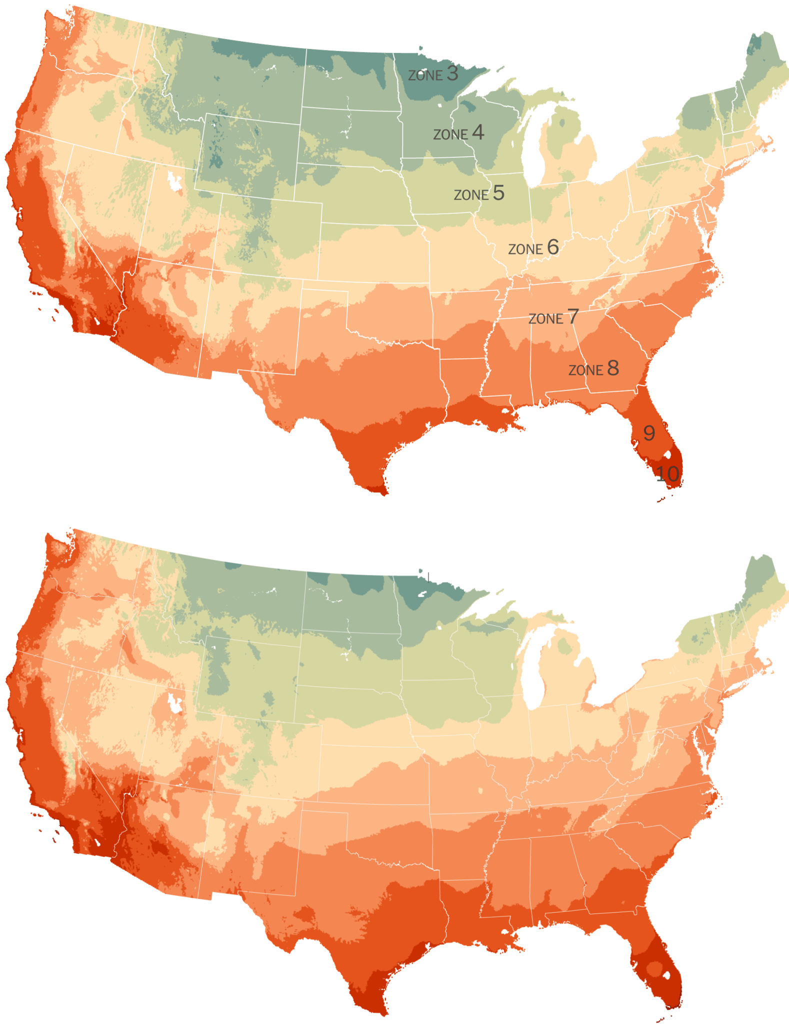

Figure 1.1: NOAA Plant Hardiness Zone Projections: 1981-2010 and 2011-2040

The biodiversity of the planet also remains under threat. The International Union for Conservation of Nature’s (IUCN) Red List of Threatened Species, the world's most comprehensive inventory of the global conservation status of biological species, includes 128,500 species with 35,500 species threatened with extinction. This amounts to 40% of amphibians, 34% of conifers, 33% of reef building corals, 26% of mammals and 14% of birds—28% of all assessed species.[15]

Figure 1.2: International Union for Conservation of Nature (IUCN): Red List of Threatened Species

What we as a society do now matters; the urgency with which the world addresses greenhouse gas emission now will influence the degree of future warming, in essence, determining "whether we'll be hit by a climate change hardball or a wiffle ball."[16] This, it is argued, necessitates a call to action and a reevaluation of landscape planning and design to develop adaptive strategies to buffer ecosystems against the uncertainties of extraordinary environmental change.[17] Though these challenges may seem insurmountable, there is cause for

[15] "Background and History," IUCN Red List of Threatened Species, accessed February, 21 2021, https://www.iucnredlist.org/about/background-history

[16] Buis, ""A Degree of Concern: Why Global Temperatures Matter," last modified Jul 19, accessed February, 2021, https://climate.nasa.gov/news/2878/a-degree-of-concern-why-global-temperatures-matter/.

[17] Martin Prominski, "Andscapes: Concepts of Nature and Culture for Landscape Architecture in the 'Anthropocene'," *Journal of Landscape Architecture* 9, no. 1 (2014), 6-19.

renewed optimism. We face a crossroads of critical importance, but one for which the profession of landscape architecture is uniquely suited.

Fifty years ago, historian Norman Newton in *Design on the Land*, could confidently define the practice of landscape architecture as "the art—or the science if preferred—of arranging land, together with the spaces and objects upon it, for safe, efficient, healthful, pleasant human use."[18] Such a definition is inadequate to describe the intricacies and complexities of practice today. We are now apt to view landscape architecture as an expanded discipline, "mediating between nature and culture."[19] According to John Beardsley, director of garden and landscape studies at Dumbarton Oaks, landscape architecture is "neither art nor science, but art *and* science; it fuses environmental design with biological and cultural ecology."[20] Furthermore, contemporary landscape architecture practice aims to provide more than a safe and harmonious environment; "it has become a forum for the articulation and enactment of individual and societal attitudes towards nature."[21]

Spearheaded by current societal and environmental movements, new approaches to landscape planning and design are beginning to emerge, regarding the context and conception of nature for reinvigorating public

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[18] Norman Newton, *Design on the Land* (Cambridge: Belknap Press of Harvard University Press, 1971), xxi.
[19] John Beardsley, "A Word for Landscape Architecture," *Harvard Design Magazine*, no. 12 (2000).
[20] Ibid.
[21] Ibid.

landscapes[22]: "adaptive ecological design,"[23] "designed plant communities,"[24] "designer ecology,"[25] "hypernatural design,"[26] and "restoration design"[27] are but a few of the related terms ascribed to these new types of approaches. Though each represents a different angle of inquiry and practice, at their core each fosters a reevaluation in design methodology and practice pertaining to the resiliency and ecological function of our landscapes, while still accounting for the aesthetic and functional needs of a variety of users. In doing so, these approaches open up vast opportunities for expanding the traditional canon of planting design in meaningful and constructive ways that render more diverse, resilient and ecologically-rich landscapes possible.

Additionally, practitioners are increasingly turning to the land fragments of our urban and suburban environments, revealing "territories of vast potential."[28] French landscape architect Gilles Clément refers to these fragments as the Third Landscape, "the sum of all the human-disturbed land through which natural processes still occur."[29] Included in this categorization are the difficult-to-characterize spaces such as "suburban yards, utility easements,

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[22] James Hitchmough and Nigel Dunnett, "Introduction to naturalistic planting in urban landscapes," in *The Dynamic Landscape: Ecology, Design, and Management of Naturalistic Urban Planting*, ed. James Hitchmough and Nigel Dunnett (Philadelphia: Taylor and Francis, 2014), 2.
[23] MaryCarol Hunter, "Using Ecological Theory to Guide Urban Planting Design: An Adaptation Strategy for Climate Change," *Landscape Journal* 30, no. 2-11 (2011), 189.
[24] Rainer and West, *Post-Wild*, 21.
[25] Nina-Marie Lister, "Sustainable Large Parks: Ecological Design Or Designer Ecology?" in *Large Parks*, ed. Julia Czerniak and George Hargreaves (New York: Princeton Architectural Press, 2007), 31-51.
[26] Bianca Maria Rinaldi. "Editorial: Hyper-landscapes." *Journal of Landscape Architecture*, (2014): 9:3, 4-5.
[27] Philip Juras, "The Presettlement Piedmont Savanna: A Model for Landscape Design and Management" University of Georgia, 1997), 65.
[28] Rainer and West, *Post-Wild*, 16.
[29] Ibid.

parking lots, road right of ways, and municipal drainage channels."[30] The impetus for this shift can be attested by practitioners and theorists grappling with urgent social and environmental demands, including issues pertaining to sustainability, habitat loss, climate change and sea level rise. Occurring at a time of dramatic climatic and social change, these shifts offer unitary approaches that can better bridge the gap between the natural and cultural divides of our modern context.[31] As landscape architect James Hitchmough has noted, "almost two centuries after the first phases of the industrial revolution drove a wedge between notions of nature and culture, there is an increasing desire to reconnect these forces in our minds."[32]

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[30] Ibid.
[31] Prominski, *Andscapes*, 6.
[32] Timber Press, February 28, 2017 "An interview with James Hitchmough," http://www.timberpress.com/blog/2017/02/an-interview-with-james-hitchmough/

CHAPTER 2

LITERATURE REVIEW

Concerning Nature and Culture

"The relationship between landscaping practices and the production of vital ecosystem services has created ethical issues never before faced by gardeners. Because the resources and services that support all humans come from functional landscapes, and function starts with plants, the planting and management choices we make at home impact our neighbors and indeed, our greater society as a whole. In essence, the relationships between plants and ecosystem function makes the ecological functionality in our landscapes a public resource, just like a reservoir, a river, and a national park. Unfortunately, this new reality is in direct conflict with Western culture's tradition of private land ownership." (Doug Tallamy and Rick Darke)[33]

When considering the issue of public perception of naturalistic-style plantings within the urban environment and how plantings might be structured in order to maximize receptibility, an exploration of the theoretical basis of landscape preference and perception seems in order. Underlying a predisposition for

[33] Rick Darke and Doug Tallamy, *The Living Landscape*, (Portland, OR: Timber Press, 2014) 119.

certain landscape types, two explanations have been put forward: 1) "we have an innate or biological response to landscape;" and 2) "responses to landscape are acquired through cultural background and personal development, to a greater or lesser degree."[34] At the center of this research, two often-quoted studies are presented: Jay Appleton's habitat theory (prospect-refuge theory) and Rachel and Stephen Kaplan's preference matrix, which argue in favor of bio-evolutionary origins as a basis for environmental preference. In *The Experience of Landscape*, Jay Appleton postulates that "aesthetic pleasure derives from the observer experiencing an environment favorable to the satisfaction of his biological needs."[35] Carried further, prospect-refuge asserts that, "because the ability to see without being seen is an intermediate step in the satisfaction of these needs, the capacity of an environment to ensure the achievement of this becomes a more immediate source of aesthetic satisfaction."[36] Thus, it is argued that a preponderance of savanna-like landscapes, indicative of sparse groupings of trees and shrubs set amongst an open ground plane in arrested succession, is owed in part to an evolutionary bias based on our ancestral origins on the African savanna.[37]

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[34] Anna Jorgensen, "The social and cultural context of ecological plantings," in *The Dynamic Landscape: Ecology, Design, and Management of Naturalistic Urban Planting*, ed. James Hitchmough and Nigel Dunnett (Philadelphia: Taylor and Francis, 2014), 295.
[35] Jay Appleton, *The Experience of Landscape* (London: Wiley, 1975), 73.
[36] Juras, *Presettlement Piedmont Savanna*, 9.
[37] Jorgensen, *ecological plantings*, 295.

Stephen and Rachel Kaplan's "preference matrix,"carries this evolutionary predisposition further, postulating that additional cognitive factors such as 'understanding' and 'exploration,' coupled with the experiential qualities of a landscape—coherence, complexity, legibility, and mystery—influence a preference for certain landscapes types. Kaplan's theory argues for an evolutionary bias in favor of savanna-like landscapes with an inherent preference for natural scenes that "contain views or vistas, plus elements such as curving sightlines," adding mystery or complexity to a landscape.[38]

Table 2.1: Kaplan's 'Preference Matrix'

	Understanding	Exploration
Immediate	Coherence	Complexity
Inferred/predicted	Legibility	Mystery

The field of psychology has also chimed in on the human-nature relationship. Within the human psyche lies an innate craving for *wildness*; a passionate longing to seek connections with the natural world and all living things. This phenomenon was first described by German-born psychoanalyst Erich Fromm as *biophilia*, "the passionate love of life and all that is alive."[39] The term was later popularised by E.O. Wilson, who insinuated that our tendency to focus on and affiliate with nature is imprinted on our subconscious, in part, at a basic genetic level. What might originate as a weak biological urge, Wilson surmised, could

[38] Jorgensen, *ecological plantings*, 297.
[39] "Biophilia Hypothesis," Encyclopedia Britannica, last modified June 25, accessed March, 2021, https://www.britannica.com/science/biophilia-hypothesis.

be nurtured and exercised through our exposure to and engagement with nature to foster deep emotional connections to the world around us.

For all but the last century, we as a species have been immersed in our natural surroundings. As author and garden designer Benjamin Vogt profoundly asserts, "what does urban life do, not only to our psyche but to our biology; when we are more cut off from nature, from daily interactions with wildness? And maybe more importantly; what happens to our ethical codes and our ability to perceive larger changes in our environment, from longer growing seasons to fewer songbirds and butterflies?"[40] Vogt is not alone in questioning the impacts resulting from lack of engagement and general alienation from nature on human development. The term *nature-deficit disorder*, first coined in 2005 by noted journalist and author Richard Louv, has now become a rallying cry for connecting children with nature. An ever expanding body of scientific evidence suggests that nature-deficit disorder "contributes to a diminished use of the senses, attention difficulties, conditions of obesity, and higher rates of emotional and physical illnesses."[41] Additionally, the ever increasing pull of technology, evident by our hyperconnected world of cell phones and GPS systems, also threatens to influence the ways we navigate and see the world around us. According to science journalist, M.R. O'Connor, neuroscience research is just beginning to

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[40] Benjamin Vogt, *A New Garden Ethic: Cultivating Defiant Compassion for an Uncertain Future* (Gabriola Island, CA: New Society Publishers, 2017), 4.
[41] Richard Louv, "What is Nature-Deficit Disorder?," last modified October 15, 2019, accessed May 18, 2021, http://richardlouv.com/blog/what-is-nature-deficit-disorder/.

shed light on the fault lines between the faith we place in our technological devices and the lack of skill or local knowledge, which manifests as atrophy in the hippocampus region of the brain.[42] O'Connor states, "[f]or our species alone, the hippocampus is the locus of autobiography, the narrative of the life we have lived till now. It is also the engine of our imagination: without it, people struggle to project themselves into the future, make predictions, or envision goals,"[43] raising important philosophical questions concerning our future and the risks of undermining our self-reliance and autonomy derived from our natural experiences.

Our association with landscapes informs, perhaps even defines our attitudes to the world around us by offering first-hand experiences with *nature*. As referenced by Simon Schama's *Landscape and Memory*, "the founding fathers of modern environmentalism, Henry David Thoreau and John Muir, promised that 'in wildness is the preservation of the world.' The presumption was that the wilderness was out there, somewhere...and that it would be the antidote for the poisons of industrial society. But of course the healing wilderness was as much the product of culture's craving and culture's framing as any other imagined garden...The wilderness, after all, does not locate itself, does not name itself...Nor could the wilderness venerate itself. It needed hallowing visitations from New England preachers…, photographers…, painters in oil…, and painters

[42] "GPS and the Human Journey," last modified June 2019, accessed November 5, 2021, https://www.pbs.org/video/gps-and-the-human-journey-ew04dm/.
[43] Ibid.

in prose...to represent it as ...holy…"[44] To put it more succinctly, Schama postulates, there has existed a symbiotic relationship between humanity and nature throughout history that has been both beneficial and destructive. We see this in the impacts of the Industrial Revolution, which had transformative effects on both society and the world. Nature, through the landscape, has had transcending influence upon humanity. Thoreau's Walden and Muir's Yosemite, are not 'wilderness', but rather human constructs, idealized renditions of what wilderness should be. In turn, planting design and gardening design too bare the imprints of human dominion as both are informed and transformed by a view of nature.

In order to understand the receptibility of naturalistic design preferences within an urban context, it is beneficial to consider conventional design trends that have come to shape and define much of the urban greenspace fabric and which have informed maintenance—both in cities and suburbs—namely, "blocks of evergreen shrubs, mechanically cut on a regular basis to maintain artificial geometric shape, combined with mown grass and widely spaced trees."[45] Nature is often derided or kept at arm's length, a point underscored by the rampant and excessive use of herbicides. Coupled with this, an underlying shift

[44] James Golden, "Re-Imagining Nature - A Review of Planting in a Post-Wild World by Thomas Rainer and Claudia West," View from Federal Twist, last modified January 24, 2016, accessed June 24, 2021, https://federaltwist.com/blog/2016/01/24/re-imagining-nature-a-review-of-planting-in-a-post-wild-world-by-thomas-rainer-and-claudia-west.
[45] Hitchmough and Dunnett, *Introduction to Naturalistic Planting*, 2.

in socio-cultural dynamics and cultural perspectives has fostered a sense of detachment from place.

More recently, the receptibility of hypernaturalistic plantings seems evident when considering the expansion outside of traditional bounds such as private gardens and botanical collections onto high profile urban projects such as New York City's High Line, Chicago's Lurie Garden, or London's Olympic Park where they have been met with widespread acclaim. In the case of the widely celebrated High Line, the resulting design transformed the urban wildness of an abandoned elevated rail line, "beloved by many for its source of urban abandonment and natural reclamation,"[46] into an artful translation of natural plant communities. However, as Joan Nassauer's research has revealed, "novel landscape designs that improve ecological quality may not be appreciated or maintained if recognizable landscape language that communicates human intention is not part of the landscape."[47]

[46] Sean W. Dunlap, "Hypernatural Piedmont Prairies" University of Georgia, (2017), 46.
[47] Joan Iverson Nassauer, "Messy Ecosystems, Orderly Frames," Landscape Journal, 14(2): Fall 2007, 161.

Figure 2.1: The Highline. New York's fabled High Line serves as an important precedent for nature-inspired landscape design in an urban setting that reclaims a former elevated rail.

Yet despite our most earnest convictions and intentions, traditional garden practices so often remain disconnected from nature's mechanics.[48] Conventional garden design has long held visions that re-shape the landscape into static, man-made visions that require a great expenditure of resources to preserve the intended design integrity. Such practices can lead to perpetual disturbance to local ecologies that provides opportunities for weeds and unwanted species to gain a foothold. Additionally, lack of engagement in the process of landscape evolution and adaptation regards plants as mere "materials," objects with a purely aesthetic role.[49]

[48] Kelly D. Norris, *New Naturalism: Designing and Planting a Resilient, Ecologically Vibrant Home Garden* (China: Cool Springs Press, 2021), 9.
[49] Warren Byrd and Darrel Morrison, "A Century of Planting Design," *Landscape Architecture* 89, no. 11 (1999), 92-119. http://www.jstor.org/stable/44672198. 92-95.

Counter-productive horticultural practices include:[50]

- *Eliminating weeds by pulling them out, roots and all*
- *Fertilizing and irrigating to give a boost to established plantings*
- *Amending soil before planting by deep digging and adding organic matter, topsoil, and fertilizers*
- *Raising the pH of an acidic soil to make the nutrients it contains more readily available to plants*
- *Prolonging the life of desirable plants by any means available to preserve the beauty of the garden*

By contrast, neo-traditional horticultural practices—as noted by landscape architect and icon in the context of ecological landscape design, Larry Weaner—are shifting away from static stylization and wholly man-made visions onto the broader socio-cultural contexts within which the landscapes are originally embedded.[51] Views differ on how best to achieve results, but the general consensus favors approaches that demand "relatively low-maintenance costs, be as sustainable as possible, taxonomically diverse, demonstrate marked seasonal change, and support as much wildlife as possible."[52] These shifts in landscape planning and design provide a stark contrast to conventional

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[50] Weaner, Larry and Thomas Christopher, *Garden Revolution: How our landscape can be a source of environmental change*, Portland, OR: Timber Press, 2016, 16-17.
[51] Weaner, *Garden Revolution*, 13-14.
[52] Hitchmough and Dunnett, *Introduction to Naturalistic Planting*, 2.

agricultural-horticultural perspectives, which often include counterproductive measures.

Southeastern Piedmont Grasslands: History and Basis for Design Exploration

Temperate grasslands and their associated communities once accounted for much of the North American landscape, ranging from the far western chaparrals of California, to the oak savannas of the Midwest, and the subalpine parklands of the Rocky Mountains.[53] Following a common misconception that the Southeastern landscape was once dominated by expansive old growth forests prior to European settlement, Southeastern grasslands have been largely forgotten, a fact underscored by fabled tales of squirrels hopping from branch-to-branch without striking ground, stretching from the Atlantic coast to the Southeastern interior. Their absence from our collective memory denies us one of the most biodiverse regions in the country. Southeastern grasslands are more species rich with flora than tropical rainforests when comparisons are made at scales less than 100 square meters.[54] Indeed, the Coastal Plain alone accounts for one-third of all flora native to North America, most of which are associated with the longleaf pine savanna regime.[55]

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[53] Juras, *Presettlement Piedmont Savanna*, 4.
[54] Reed F. Noss, *Forgotten Grasslands of the South: Natural History and Conservation* (Washington, DC: Island Press, 2013), 94.
[55] Ibid.

Unlike the vast expanse of the Midwestern prairies, the majority of Southeastern grasslands are thought to have existed as a patchwork of small open pockets set amongst the oak forests once home to roaming herds of elk and buffalo,[56] though openings up to 25-miles across were documented.[57] Between 1540-1750, early European explorers and naturalists recounted observations of many open grasslands on their travels, though detailed information concerning species composition, scale or exact location is sparse. In most instances, only obscure references such as a single word or phrase in a passage, a place name on a map, or in the very rare occurrence, firsthand accounts by individuals such as longhunters,[58] are all that lend clues to their former presence.[59] However, where descriptions exist in detail, the aesthetic qualities of these landscapes are evident. In his travels throughout the southeastern landscape in the 1770s, including Georgia, noted naturalist William Bartram recounted an area west of the Chattahoochee river in the Alabama Piedmont and a location near present-day Gainesville, Florida with the following passages:

> "*…the ascents produce grand high forests, and the plains present to view a delightful varied landscape, consisting of extensive grassy fields, detached*

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[56] Jr Davis J. Eric et al., "Vascular Flora of Piedmont Prairies: Evidence from Several Prairie Remnants," *Castanea* 67, no. 1 (2002), 4.

[57] James Benson, "Characterization of Piedmont Prairie Sites in North and South Carolina" Clemson University, 2011), 2.

[58] Late 18th-century hunters, usually originating from North Carolina and Virginia, who made expeditions into the American frontier for extended periods of time in search of game. Their observations of the land prior to settlement lends invaluable information concerning the nature of Southeastern grasslands.

[59] Fran Chismar and Tom Knezick, *Meet the Southeastern Grasslands Initiative,* Dr. Dwayne Estes, Aug 2020 Pineland Nursery Podcast.

groves of high forest trees, and clumps of lower trees, evergreen shrubs and herbage; green knolls with serpentine, wavy glittering brooks coursing through green plains; and dark promontories, or obtuse projections of the side long acclivities, alternately advancing or receding on the verge of the illumined native fields, to the utmost extent of sight."[60]

"We left the magnificent savanna and its delightful groves, passing through a level, open airy pine forest, the stately trees scatteringly planted by nature, arising straight and erect from the green carpet, embellished with various grasses and flowering plants."[61]

Perhaps the most compelling description comes from Francis Bailey, describing Cumberland Mountain, Tennessee in the 1780s:

"The top of the mountain is...a vast upland prairie, covered with a most luxuriant growth of native grasses, pastured over as far as the eye could see, with numerous herds of deer, elk and buffalo, gamboling in playful security over these secluded plains…"[62]

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[60] Juras, *Presettlement Piedmont Savanna*, 21.
[61] Noss, *Forgotten Grasslands*, 1.
[62] D. Estes et al., *A Guide to Grasslands of the Mid-South* (Austin Peay State University and the Botanical Research Institute of Texas: Natural Resources Conservation Service, Tennessee Valley Authority, 2017), 2.

Figure 2.2: A "Savanna" in the Piedmont.
A French map from 1720 shows a "Savana" in the Piedmont along the eastern side of the Appalachian Mountains.

By the time trained naturalists arrived such as Augustine Gattinger (1825-1903), Charles T. Mohr (1824-1901), James Safford (1822-1907) and Joseph B. Killebrew (1831-1906), overgrazing, fire suppression, intensive agricultural practices and forest regeneration had taken a heavy toll.[63] As early as 1750, it

[63] Estes et al., *Guide to Grasslands*, 3.

has been theorised that the grasslands of Pennsylvania, Maryland, Delaware, New Jersey and parts of Virginia had been lost.[64] Twentieth century biologists and ecologists laid a good foundation concerning the distribution of historic Piedmont grasslands, but in the absence of historical record, information is not definitive.

There is a need for a standardized classification system as evidenced by such relatable terms as barren, prairie, meadow and grassland being used to describe similar ecosystems. The term grassland[65] is often used in reference to the Southeast, and has come to define a broad range of ecotypes and communities in which there is a dominant matrix of grasses, sedges and forbs with scattered to no canopy cover.[66] Falling under this categorization is a diverse assemblage

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[64] Chismar and Knezick, *Southeastern Grasslands Initiative*.
[65] Most cited literature sources use the term grasslands when describing the associated regimes of the Southeast, though related terminology is sometimes used, including savanna, barren or prairie. The differences between each typically relates to the amount of canopy cover. The term grassland will be used in reference to these types of communities in this report.
[66] Noss, *Forgotten Grasslands*, 7-8.

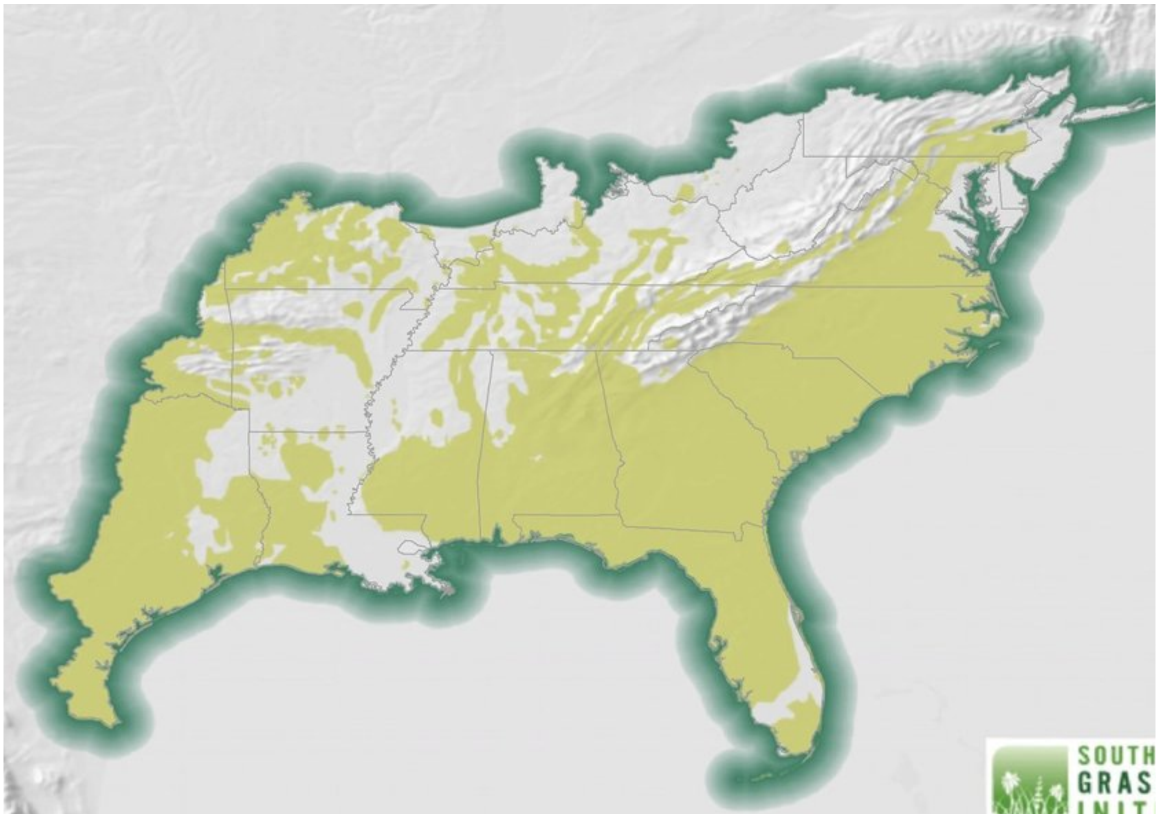

Figure 2.3: Historic distribution of Southeastern grasslands. Source: Southeastern Grasslands Initiative

of varied ecosystems across varying scales ranging from traditional associations such as prairies, savannas, barrens and balds to canebrakes, glades and open wetlands such as bogs, fens and meadows.[67] Notable Southeastern grassland communities of the modern Piedmont include the Black Belt and Jackson Prairies of Alabama and Mississippi, various savannas and flatwoods of the Atlantic Coastal Plain, Coastal prairies of the Gulf Coastal Plain, various glades and barrens found across most Southeastern states where limes, hardpan, shales and other non-Coastal Plain soil conditions are present.[68]

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[67] Estes et al., *Guide to Grasslands*, 2.
[68] Juras, *Presettlement Piedmont Savanna*, 4.

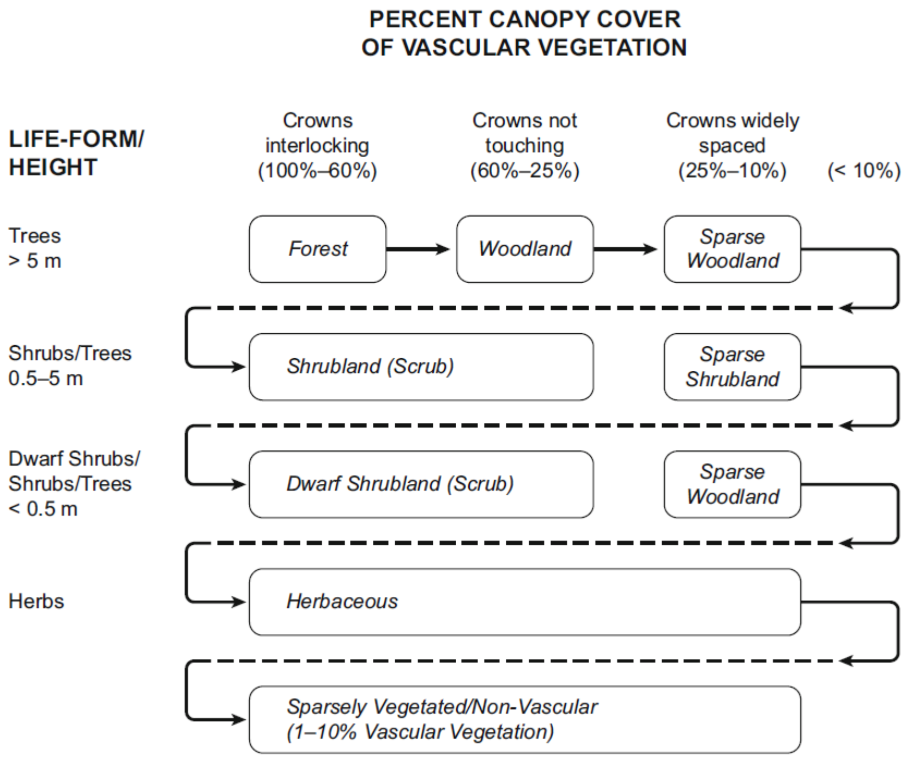

Figure 2.4: General categories of the Standardized National Vegetation Classification System.

It cannot be understated how important disturbance regimes are pertaining to the origins and persistence of Southeastern grasslands. According to Larry Barden, most upland sites of the Piedmont originated through both anthropogenic and non-anthropogenic means, while lowlands sites favored anthropogenic origins.[69] Despite the common assumption, there is still some conjecture concerning the extent to which human-created fires created grasslands of any substantial scale. The general consensus favors mutual causality between a combination of factors, aided by a period with drier climate, often with assistance from lightning-set fires, and maintained through herbivory,

[69] Noss, *Forgotten Grasslands*, 162.

human-created fires, and unique characteristics of soil properties and landform.[70] Edgar Transeau was the first to hypothesize that favorable climatic conditions, such as extended warm, dry periods allowed prairies of the Midwest to persist within a forest matrix. Recent evidence supports this with major eastward expansion of prairies noted during the Holocene Climatic Optimum, the most recent extended dry period to occur 5,000-9,000 years ago.

The importance of fire has been well-documented:

"*During the winter I first saw the tremendous fires caused by the burning of the dry grass. In many places, this grass was very thick and tall; and when perfectly dry, should it get on fire, the wind being high, the spectacle became truly sublime, especially at night. The flames...would sometimes burn the leaves on trees twenty or thirty feet in height. No one who ever witnessed one of these great fires would ever afterward be at a loss to account for the scarcity of timber in the barrens, as trees of all kinds, when small, were destroyed by them. Should a little twig or brush put up from the ground one season, it was sure to be burned the next. The Indians, in early times, used to set this grass on fire, when hunting, and killed great quantities of game as it fled before the flames.*"[71]

Reuben Ross, Montgomery County, Tennessee, circa 1812

Historic descriptions such as this noted late fall burning of large fields, falling outside of peak wildfire season and summer lightning activity, aiding the

[70] Noss, *Forgotten Grasslands*, 35.
[71] Estes et al., *Guide to Grasslands*, 10.

association of fire with Native American land use practices.[72] Fire is highly effective at controlling the habit and composition of vegetation, resetting natural succession tendencies by controlling woody growth and encouraging herbaceous ground cover under canopies and into open spaces.[73]

Figure 2.5: Controlled burn at Dunbar Cave State Park. Source: Tennessee Parks and Division of Natural Areas

Southeastern grasslands of the Piedmont are often associated with "flat convex and gently rolling uplands," located geologically "along the eastern interface between the Appalachian and Cumberland mountains and the Piedmont from Virginia south through Georgia in patches and bands."[74] Soil conditions, a direct result of the regional Piedmont geology, provide suitable environmental

[72] Juras, *Presettlement Piedmont Savanna*, 30.
[73] Juras, *Presettlement Piedmont Savanna*, 31-32.
[74] Cecil Frost and Steve Lindeman, "Rapid Assessment Reference Condition Model: Eastern Prairie Woodland Mosaic" 2005).

conditions favoring the development and persistence of grasslands—notably, soil moisture levels.[75] Unlike Midwestern prairies, which are found on deep, rich soil orders with high fertility and organic matter, Piedmont grasslands have originated on shallow, clayey soils, which are prone to drought conditions.[76] Of the six soil series recognized by the USDA Soil Taxonomy, two are most often associated with grasslands—alfisols and ultisols.

Ultisols are nutrient poor soils prone to drought conditions due to subsurface horizons of hardpan clay.[77] The tendency of shallow clay soils to dry out and harden during summer months serves to inhibit successional processes, thus limiting the tendency for forest emergence and enabling the stress-tolerant grassland species to persist.[78] Alfisols are nutrient rich soils which develop from metamorphosed igneous rock high in magnesium, iron, calcium and sodium—commonly referred to as mafic rock. Montmorillonite, a major clay present in alfisols, accounts for its high-shrink swell capacity. When dry, alfisols shrink and crack; when wet, the soil may swell to the point where moisture is unable to penetrate, causing a perched water table.[79]

Today Southeastern Grasslands exist as barely discernible remnants, relegated to disturbed sites such as roadsides, power line right-of-way, dry forest edges, and recently disturbed or burned areas.[80] By some estimates Southeastern

[75] Benson, *Characterization of Piedmont Prairie*, 4.
[76] Davis, Jr. et al, *Vascular Flora*, 3.
[77] Benson, *Characterization of Piedmont Prairie*, 4.
[78] Davis, Jr. et al, *Vascular Flora*, 3.
[79] Benson, *Characterization of Piedmont Prairie*, 4.
[80] Davis, Jr. et al, *Vascular Flora*, 1; Benson, *Characterization of Piedmont Prairie*, 4.

grasslands have declined by 90%, largely extirpated by 230+ years of land use changes including fire suppression, forest regeneration, infestation of invasive species and the loss of herbivory in the form of large grazers (bison) and browsers (elk).[81]

As mentioned previously, biodiversity in these landscapes has been characterized as extraordinarily high, often supporting large grazing mammals and associated predators, along with numerous bird species, small mammals, insects, and countless species of flora that are often found nowhere else.

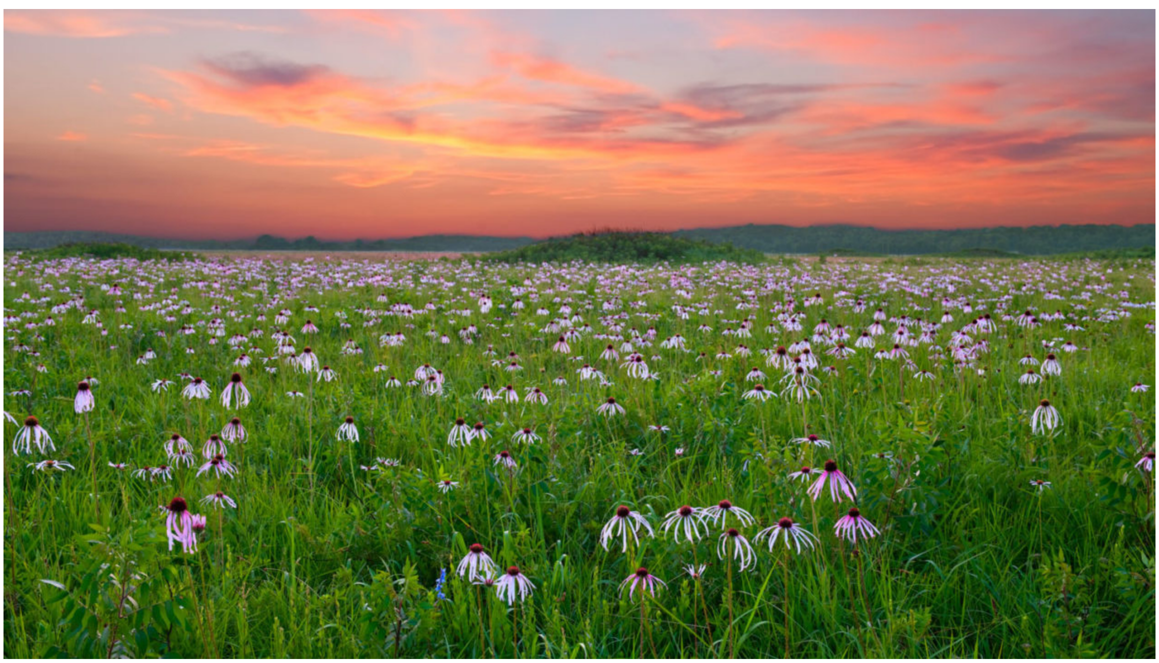

Figure 2.6: Cherokee Prairie Natural Area near Fort Smith, Arkansas. ***Source:*** William Dark Photography

[81] Estes et al., *Guide to Grasslands*, 3.

Theoretical Underpinnings

While the terminology may be new, the theoretical underpinnings of the ideas and methodologies are not without precedent. Nature-inspired garden styles and practices were well founded by the end of the nineteenth century, having been vigorously pursued across much of Europe and America by early adopters who were strongly influenced not only by aesthetics, but also ecological and cultural outcomes.[82] Spurred by a period of rapid urbanization wrought with fundamental social changes and unprecedented advancements in technology—now commonly referred to as the Second Industrial Revolution—designers increasingly turned to nature as an antidote to quell the various social, political and economic upheavals, and for extolling wholesome virtues pertaining to physical, moral and spiritual well-being.[83] Drawing upon the native landscape as a source of inspiration, early adoption mostly drew upon the middle-American prairie and Eurasian steppes as examples to emulate.

The origins of naturalistic plantings in America can be traced most directly to the Prairie Style landscape movement, a uniquely American contribution to garden design. First referenced in 1915 by Wilhelm Miller in the *Prairie Spirit in Landscape Gardening*, the style has been described as a celebration and embodiment of the Midwestern prairie landscape and its people, drawing upon

[82] Hitchmough and Dunnett, *Introduction to Naturalistic Planting*, 4.
[83] Jan Woudstra, "The Changing Nature of Ecology: A History of Ecological Planting (1800-1980)," in *The Dynamic Landscape: Ecology, Design, and Management of Naturalistic Urban Planting*, eds. James Hitchmough and Nigel Dunnett (Philadelphia: Taylor and Francis, 2014), 42.

the native flora of the region for inspiration with an overall emphasis on the expanse and open character of the prairie landscape. Key figures included O. C. Simonds (1855-1931), Jens Jensen (1860-1951) and Alfred Caldwell (1903-1998), of which Jensen is perhaps the movement's most influential and celebrated for his impassioned use of indigenous species, consideration of ecological processes and regard for a site's unique features and character.[84] After immigrating to America from Denmark in 1884, he eventually settled in the Chicago area at a time when the city was undergoing an unprecedented period of growth and vast industrialization. Jensen soon found work as a laborer for the city's Western Park Commission, quickly moving through the ranks of the park system where he was eventually appointed as superintendent of the 219-acre Humboldt Park in 1895. There he honed many of his most recognizable design principles, exploring new ideas and infusing the Prairie Style ideals within a conventional framework of garden design and planning. Ruminating on the general lack of season color in parks and gardens, Jensen writes,

I used to wonder why our parks and gardens were so poor in their fall colors, but gradually I came to understand that it was because they were in discord with the native landscape. With their foreign plants, they were nothing but out-of-doors museums; they represented a conglomeration of things purchased over the counter. Except for a few plants, their growing things had no coloring, or were

[84] "Biography of Jens Jensen," , accessed May 22, 2021, https://www.tclf.org/pioneer/jens-jensen.

not ripe for the change of foliage when the first frost threw it withered to the ground. They were an importation, unfitted to meet the struggle for life here, and hence doomed to destruction. Their expression was material, not spiritual; one of possession rather than of art. They did not belong." [85]

In 1913, he co-founded the Friends of Our Native Landscape with Henry Cowles, a pioneering ecologist of the time whose research of the Indiana Dunes environment along the southern shores of Lake Michigan became one of the first ecological studies in North America and was instrumental in describing the dynamics of plant succession.[86] Through their work, the Friends sought to preserve "examples of landscape types that are fast disappearing before the encroachments of industry."[87] Jensen believed the garden was an important asset to the surrounding community, referring to it as a "community garden," created for "those who have no other gardens except for their window sills."[88] In this manner, Jensen set himself apart from his peers for championing the humanizing power of parks for people and not merely artistic expressions for the elite. He would go on to design numerous parks as general superintendent of Chicago's Western Park District and private practitioner, amassing over 600

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[85] *The Native Landscape Reader*, ed. Robert E. Grese (Amherst: University of Massachusetts Press, 2011), 104.
[86] Victor Cassidy, "Henry Chandler Cowles: Ecologist, Teacher, Conservationist," *Chicago Wilderness,* Spring, 2007, 13-14.
[87] Cassidy, *Henry Chandler Cowles*, 14.
[88] "Art in the Parks: Historic Jens Jensen Formal Garden ," last modified Jul 19, accessed Aug 9, 2021, https://www.chicagoparksfoundation.org/seeinggreen/art-in-the-parks-historic-jens-jensen-formal-garden.

parks throughout his tenure, including Union Park, Columbus Park, and towards the end of his career, the famed Lincoln Memorial Gardens.

While the Prairie Style is rooted in the use of Midwestern indigenous species, it should be noted that Jensen and his contemporaries would often use non-native species in their designs, and viewed their works, not as pure restorations, but as embellishments and abstractions of nature. Not until 1936, did Jensen adopt a purely native approach through his work at the Lincoln Memorial Gardens in Springfield, Illinois. The garden serves as a living memorial to the past president, composed entirely of native plant communities drawn from the three states in which Lincoln resided: Illinois, Indiana and Kentucky.[89]

Unfortunately, the naturalistic approaches espoused by the movement never gained much traction outside of the Midwestern region and remained an undercurrent within the landscape architecture profession in the intervening decades between its inception and the present.[90] It is only within the last half century that interest in the movement has resurfaced again, following the environmental awakening of the 1960s and 1970s.[91]

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[89] TCLF, *Jens Jensen*.
[90] Darrel Morrison, "A Methodology for Ecological Landscape and Planting Design - Site Planning and Spatial Design," in *The Dynamic Landscape: Ecology, Design, and Management of Naturalistic Urban Planting*, eds. James Hitchmough and Nigel Dunnett (Philadelphia: Taylor and Francis, 2014), 116.
[91] Edith Roberts and Elsa Rehmann, "Foreword," in *American Plants for American Gardens*, ed. Darrel Morrison (Athens: University of Georgia Press, 1996), xi-xxviii.

While the adoption of naturalistic design approaches underwent a period of dormancy, science-based landscape management activities began in earnest starting in the 1930s, representing the first long-term systematic attempts at ecological restoration in America.[92] In their book *American Plants for American Gardens*, published in 1929, Edith A. Roberts and Elsa Rehmann were among the first to advocate for species selection based on underlying ecological concepts. The duo, a plant ecologist and a landscape architect respectively, promoted the use of native plant groupings based on naturally-occurring plant assemblages. Summarizing the underlying ecological knowledge guiding their work, landscape architect H. Stuart Ortloff, writes a few years later, "a better understanding of plant ecology opens up many new fields of endeavor, and allows us to correct many old mistakes that have endangered the success of our gardens. It is one of the guides to the selection of plants particularly suited for use in naturalistic plantings. If we are trying to catch the spirit of Nature in our work it is obviously important that we follow her principles of plant arrangement. The native plants have already grouped themselves together according to the conditions of soil, moisture, temperature, and exposure. Each given grouping of conditions will result in particular groups of plants being found together."[93] Subsequent leading voices included Aldo Leopold, an ecologist, forester and environmentalist, whose publication of *A Sand County Almanac* advocated for a moral responsibility to the natural world, or a *land ethic*. He writes,

[92] Dunlap, *Hypernatural Piedmont Prairies*, 28.
[93] Woudstra, *Changing Nature of Ecology*, 44.

"All ethics so far evolved rest upon a single premise: that the individual is a member of a community of interdependent parts...The land ethic simply enlarges the boundaries of the community to include soils, waters, plants and animals, or collectively: the land."[94]

According to Nina-Marie Lister, a leading voice in ecological design, aesthetics and design considerations have largely been left out of the broader ecological field, which is "principally concerned with the realistic emulation of ecological form, function, and where possible, process."[95] Subsequent generations of designers have sought to correct these impediments in order to reconcile the ecological function of landscapes with design.

Following the environmental awakening of the 60s and 70s, stirred by the environmental degradation expressed in Rachel Carson's *Silent Spring* (1963), culminating with the first Earth Day in 1970 and resulting in the passage of the Environmental Protections Act, innovations in ecologically based planting design experienced a revival within the landscape architecture community. Described by regional planner Lewis Mumford as an 'inspired ecologist,'[96] Ian McHarg, who's publication of *Design with Nature* (1969) subsequently led to a revival of

[94] Aldo Leopold and Charles Walsh Schwartz, *A Sand County Almanac. with Other Essays on Conservation from Round River.* (New York: Oxford University Press, 1966), 203-204.
[95] Lister, *Large Parks*, 40.
[96] Woudstra, *Changing Nature of Ecology*, 44.

ecological design within the profession as well, "is credited with reviving a nature-focused approach to landscape design."[97]

As a result, this period saw a range of naturalistic design approaches emerge for reconciling the artistic basis of landscape design with the environmental concerns of the ecological restoration community by advocating for both aesthetically-pleasing and ecologically-rich planting designs. Among the most prominent to emerge was the so-called "New American Garden" style created by the landscape design firm Oehme van Sweden in the late 1970s, which has been attributed as being stylistically similar and contemporaneous to the Dutch Wave and the New Perennial Movement in Europe, which used cohesive and visually-dramatic block plantings of perennials and grasses to artfully translate naturalistic vegetation.

The Cultural Landscape Foundation's description of the New American Garden style notes it as a direct successor to the Prairie Style:

"Inspired by Jen Jensen's approach to Prairie Style landscape architecture, the New American Garden Style is a metaphor for the American meadow. It reflects the beauty of the natural landscape, in all four seasons, liberating plant materials

[97] Dunlap, *Hypernatural Piedmont Prairies*, 30.

from forced and artificial forms, allowing them to seek a natural course as they weave a tapestry across the garden plane."[98]

A related but separate approach championed by landscape architect Darrel Morrison further strengthened the blending of artful landscape design practices with ecological restoration concepts, resulting in a "ecological landscape design,"[99] representing a merger of ecology with design. As a graduate student at the University of Wisconsin, Morrison encountered the natural beauty of the Curtis Prairie, seen as the first ecological restoration in the world, which fostered his passion for nature-inspired landscapes.[100] He describes his approach as "reintroducing and re-establishing of community-like assemblages of native species to sites which can reasonably be expected to sustain them, with the resultant vegetation demonstrating aesthetic and dynamic characteristics of the natural communities on which they are based."[101] His distillation of communities of native plants into artful translations of prairie, woodland, and coastal meadow has been explored through several exemplary designs at the Atlanta History Center, Brooklyn Botanical Garden, and Storm King Art Center. Addressing the complexity and innate artfulness of natural plant communities he writes, "there is

[98] "Biography of James Van Sweden," The Cultural Landscape Foundation, accessed Sept 12, 2021, https://www.tclf.org/pioneer/james-van-sweden.
[99] Margaret Roach, "Your Garden may be Pretty, but is it Ecologically Sound?," *New York Times*, Accessed Aug 11, 2021. https://www.nytimes.com/2021/08/11/realestate/your-garden-may-be-pretty-but-is-it-ecologically-sound.html.
[100] "Beauty of the Wild by Darrel Morrison ," last modified Jun 15, accessed Jun 18, 2021, https://ced.uga.edu/news_and_events/2021_darrel_morrison_book/.
[101] Morrison, "Design, Restoration, and Management," quoted in Juras, *Presettlement Piedmont Savanna*, 64.

sometimes a misperception that designing with native plant communities and natural processes is not sufficiently artful. In reality, it can be considered to be a new art form appropriate to the twenty-first century: 'ecological art', which is simultaneously aesthetically rich, ecologically sound, evocative of place and dynamic."[102] Perhaps where Morrison most differs from the field of ecological restoration is in his willingness to take liberties with species composition. Morrison notes that "[t]he abstraction of a native community in a designed landscape may include stylization in the sense of giving more legible form to the distribution of plants than usually occurs naturally, or incorporating a higher concentration of plants than might normally occur."[103]

Anchored in this context, the *designed plant community* approach is the most recent evolution in abstracted naturalistic planting design practices. However, the designed plant community approach breaks away from its predecessors by "promoting a shift from clumping and grouping plant varieties to mixing them in a way that occurs in nature. Discrete clumps are replaced with interplanted varieties to mixing them in a way that occurs in nature. Discrete clumps are replaced with interplanted varieties equipped by nature to live cheek by jowl."[104] The approach includes James Hitchmough, Nigel Dunnett, Thomas Rainer, Claudia West, and Kelly Norris as foremost proponents.

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[102] Morrison, *Methodology for Ecological Landscape*, 129.
[103] Morrison, *Methodology for Ecological Landscape*, 121.
[104] Adrian Higgins, "Why Manicured Lawns should Become a Thing of the Past," *The Washington Post*Dec 2, 2015.
https://www.washingtonpost.com/lifestyle/home/why-mulch-and-manicured-lawns-should-become-a-thing-of-the-past/2015/12/01/95e99344-8e0b-11e5-acff-673ae92ddd2b_story.html.

Understanding Plant Community Dynamics

According to modern ecological theory, adaptation and change over time are hallmarks of the criterion necessary for ecosystem health.[105] This alternative approach to landscape design based on gardening "first principles"[106] and age-old laws correct these impediments, and consequently, "turns the landscape from a consumer of resources into a source of environmental renewal: a nexus of stormwater absorption and purification, a sanctuary for indigenous wildlife, and a protector of biodiversity."[107] Thus, environmental goals of lasting resiliency and ecological functionality are achieved that are not dependent upon inputs to maintain the *status quo*.

James Hitchmough lays out the key attributes of sustainable planting design as such:[108]

- be well-fitted to a landscape, and hence robust, able to persist and possibly maintain their populations in perpetuity through self-seeding or vegetative means,
- be manageable in the long-term with relatively low inputs of resources, water, nutrients, carbon expenditures, and maintenance time,
- support as much native animal biodiversity as possible,

[105] Weaner and Christopher, *Garden Revolution*, 57.
[106] Weaner and Christopher, *Garden Revolution*, 13.
[107] Weaner and Christopher, *Garden Revolution*, 14.
[108] James Hitchmough, "Exotic Plants and Plantings in the Sustainable, Designed Urban Landscape," *Landscape and Urban Planning* 100 (2011), 380-382. doi:10.1016/j.landurbplan.2011.02.017.

- be attractive and meaningful to people,
- where appropriate, reflect or reinforce the character of a particular place.

The vocabulary of contemporary ecological science plays a fundamental role in shaping the approach to design and management of designed plant communities. Key Terminology pertaining to contemporary ecological science includes:

C-S-R Triangle Theory (J.P. Grime's Plant Strategy Theory) –
J. Phillip Grime's theory of life history strategies has emerged as a seminal work in gauging with remarkable predictability how a given species will respond to relative changes within their environment. The premise of the theory rests upon two fundamental sets of factors limiting a species growth and survival: *stress* and *disturbance* factors. Stress factors include limitations relating to physiological needs such as light exposure, temperature extremes and water or nutrient availability. Disturbance factors consist of external environmental forces such as grazing, cultivation, trampling and burning. Every habitat on Earth can be defined by

the relative combination of stress and disturbance.[109] Species can be broken down into three categories based upon their ability to respond to the aforementioned limiting factors.

Competitors (C-Strategists) naturally inhabit high-productivity environments where frequency and intensity of both stress and disturbance is low, a characteristic of environments with high nutrient loads, ample water supply and limited disturbance that might hinder growth. Competitor species excel via two strategies, including uptake of resources and growth rate, which they exploit to aggressively outcompete other species. Competitor species include the highly invasive japanese knotweed (*Reynoutria japonica*), along with the native common elderberry (*Sambucus nigra*)[110] Their presence in a landscape can tip the balance of a biodiverse ecosystem to low diversity with high density.[111]

Stress tolerators (S-Strategists) fall within the range of high-stress, low-disturbance environments. Stress-tolerant species tend to be long-lived evergreen, slow growers that flower infrequently with specialized physiologies and often protective tissues that make

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[109] Nigel Dunnett, "The Dynamic Nature of Plant Communities - Pattern and Process in Designed Plant Communities," in *The Dynamic Landscape: Ecology, Design, and Management of Naturalistic Urban Planting*, eds. James Hitchmough and Nigel Dunnett (Philadelphia: Taylor and Francis, 2014), 103.
[110] Travis Beck, *Principles of Ecological Landscape Design* (Washington: Island Press, 2013), 57.
[111] Beck, *Principles of Ecological Design*, 78.

them unpalatable to herbivores. Examples include sedum and olives.[112]

Disturbance tolerators or Ruderals appear in high-stress, high-disturbance environments. Ruderal species, while short-lived, thrive in response to predictable patterns of disturbance, investing resources into mechanisms that ensure a rapid recovery through colonization. Common weed species, such as lambsquarters (*Chenopodium album*), along with the annual California poppy (*Eschscholzia californica*) are examples.[113]

Grimes developed additional categories for intermediate species falling outside of the environmental extremes: competitive ruderals (cr), stress-tolerant ruderals (sr), stress-tolerant competitors (sc) and strategists combining traits from all three camps (csr).[114]

C-S-R theory sheds light into the ecological design process, highlighting a particular species ability to adapt, coexist or respond to physiological and environmental factors based upon fundamental trade-offs between devoting energy to growth, storage, defense, and reproduction. Coexistence is thus subject to

[112] Beck, *Principles of Ecological Design*, 78.
[113] Ibid.
[114] Ibid.

each species occupying a distinct ecological niche to which they are best suited within a community.[115]

Ecoregion – is a spatial framework for designating geographical areas with distinctively similar climatic conditions. Organizational structure accounts for biotic, abiotic, terrestrial and aquatic ecosystem components such as geology, landforms, soils, vegetation, climate, land use, wildlife, and hydrology. In terms of vegetation, ecoregions nurture particular assemblages or communities of plants. The U.S. Environmental Protection Agency has assembled detailed maps of the United States and Canada. A Roman numeral classification system is used to denote hierarchical levels of detail, whereby Level I represents the most generalized classification in the continental U.S., and Level IV includes the most detailed scale of 967 designated ecoregions. [116] A further breakdown of ecoregions includes the following[117]:

Level I - 12 ecoregions in the continental U.S.

Level II - 25 ecoregions in the continental U.S.

Level III - 105 ecoregions in the continental U.S.

Level IV - 967 ecoregions in the conterminous U.S.

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[115] Beck, *Principles of Ecological Design*, 78.
[116] Weaner and Christopher, *Garden Revolution*, 58.
[117] "Ecoregions," Environmental Protection Agency, accessed May 15, 2021, www.epa.gov/eco-research/ecoregions.

Ecotype – Plants have evolved to grow in particular climatic and microclimatic environments, forming distinct variants within a particular species over thousands of years of natural selection, each displaying true genetic differences. A study conducted in the 1940s by a trio of scientists in California—Jens Clausen, David Keck and William Hiesey—analyzed growth and reproduction characteristics of the common yarrow (*Achillea millefolium*), one of the most widely distributed plants in the Northern hemisphere, across three wide ranging environments. The study revealed surprisingly dissimilar results between each of the isolated populations. When found growing in the seasonally arid interior foothills, yarrow has developed thin gray foliage and goes dormant during the summer. When growing amongst conifers in the open meadows on the slopes of the Sierra Nevada, it possesses greener foliage, is mid in stature, slow to mature and has winter dormancy. Above the timberline, it is frost-resistant, short in stature and early to flower following a long winter dormancy. When the researchers grew out seeds collected from the various locations, genetic differences persisted. Collectively, the results highlight a species' unique adaptability to its local environment in regards to its growth, reproduction and overall fitness, relative to other plants of the same species.[118]

Generalist versus Specialist Species – As some plants prefer or even require specific growing conditions in order to flourish, considerations regarding adaptability to a set of environmental conditions or habitats should be primary when making species selections. Species favoring highly selective environmental conditions are referred to as specialists. Lady slipper orchids are one such example which favors a well-defined set of environmental conditions, notably semi-open woodlands with deep humus and well-drained, acidic soil. The species is also highly dependent upon a specific soil-borne fungus, *Rhizoctonia mycorrhizae*, that is essential for its long-term survivability. Conversely, generalist species are readily adaptable to a wide range of conditions. Pioneer species and aggressive ornamentals fit this category.[119]

Habitat – can be determined by both a place and a set of environmental conditions where a given plant species naturally inhabits. Habitats may be further distinguished by a certain set of physical conditions, such as soil type, range of temperatures,

[118] Beck, *Principles of Ecological Design*, 23.
[119] Weaner and Christopher, *Garden Revolution*, 68.

amount of moisture available, and intensity of sunlight. For instance, a species native to a woodland habitat may only occupy open woodland conditions where soil conditions are dry and acidic with intermittent sunlight throughout the day.[120] Horticulturalists and savvy gardeners have long understood the importance of provenance, or the geographic location, when sourcing genetic material, especially in regards to wide-ranging species such as yarrow. By sourcing plants from conditions similar to where the ultimate design or restoration is set to reside, plants are more likely to perform well within their new environment. An ecotype-focused approach to plant selection lens an additional layer of specificity.[121]

Microhabitat – variations within a habitat, including topography, moisture levels, sunlight or other features that modify and influence environmental conditions. Take, for example, a north-facing slope is likely to be consistently cooler than adjacent south- or west-facing slopes that receive more intense sunlight

Native – specifies whether a species historically inhabits a specific ecoregion

[120] Weaner and Christopher, *Garden Revolution*, 59.
[121] Beck, *Principles of Ecological Design*, 24.

Niche – Unlike animals, plants must compete for the same essential resources, often acquiring them through very similar means. Thus in order to coexist with other species in ecologically stable communities without eliminating one another through competitive exclusion, plants must inhabit distinct ecological niches and efficiently partition available resources. Research studies undertaken by Jonathan Silvertown, professor of evolutionary ecology at the University of Edinburgh, revealed niche associations present within plant communities follow a range of factors, including "light gradients, canopy height, rooting depth, hydrologic gradients, exploitation of different sources of nitrogen and association with different soil microbes" with variability depending on the type of community and the environment in which it is embedded.[122] An analysis of a typical multi-layered woodland setting, for example, presents a valuable study concerning how species may coexist by taking advantage of varying light levels. At the far end of the spectrum are canopy trees, highly efficient at and most dependent upon intercepting direct sunlight. Unless an opening in the canopy presents itself or other conditions are favorable, seeds and seedlings from canopy species may persist in a suspended state for extended periods of

[122] Beck, *Principles of Ecological Design*, 72.

time. Resting beneath the upper canopy are understory trees and shrubs that tolerate intermediate levels of light. As the species will never grow taller than the upper canopy, they are not direct competitors for sunlight. Lastly, occupying the woodland floor, are herbaceous forbs, sedges and ferns able to withstand low light conditions.[123] When extrapolated to account for a design featuring naturalistic plantings, ecosystem stability can be maximized when considering the spatial niche favored by each selected species. If a niche is left unoccupied, infiltration by aggressive or otherwise opportunistic species may undermine an intended design, creating opportunities for other invaders.[124]

The Plant Community as a Design Tool

Worldwide distribution of natural vegetation is determined by a species' own unique tolerance to ecological conditions, both physical and within a given ecosystem. Species with similar tolerances form into identifiable assemblages or communities, possessing similar floristic and structural characteristics. Vegetation classification systems, at the broadest scale, consist of biogeographic regions or ecozones that are further broken into major world biomes or habitats, including tropical forest, temperate grassland, coniferous forest, temperate forest, and

[123] Beck, *Principles of Ecological Landscape Design*, 23.
[124] Weaner and Christopher, *Garden Revolution*, 65.

polar tundra. Classification of ecological systems form the basis for understanding community composition, structure and function.

The idea of planting design as an assemblage or community of associated species has its most distant origin in the ideas and discoveries of intrepid early nineteenth century explorer-naturalists. A leading figure of this period included Alexander von Humboldt, whose contributions to the fields of ecology and geoscience fundamentally altered the perception of the natural world. It is through these early travels that Humboldt first recognized the relative predictability in how certain plant species formed repeating assemblages or communities, and that specific communities of species varied depending on their geographic region of origin. Furthermore, it was noted that species within communities had naturally evolved through natural selection, adaptability, and evolution over time to tolerate specific environmental conditions.
Richard Hansen and Friedrich Stahl's landmark work, *Die Stauden und ihre Lebensbereich (Perennials and their Garden Habits)* first published in 1991, greatly advanced the understanding of the ecological requirements of perennials rather than focusing purely on the aesthetic merits of height, flowering sense and color. James Golden reflects on their work as "an outgrowth of decades of research growing perennials in controlled conditions, and containing detailed information on a vast number of plants and their appropriate habitats, was very influential on contemporary thinking, and paved the way to

new directions in garden design, among them the naturalistic "new perennials" movement epitomized by Piet Oudolf and other designers."[125]

While stylistically aligned with other garden movements such as the Dutch New Wave and New American Garden style, the designed plant community approach generally places species in matrix-like arrangements rather than clearly discernible blocks and groups with species concentration varying throughout a composition.

Once viewed strictly in terms of ecological science, the plant community has emerged as a central approach in modern landscape planning and design for artfully capturing and translating the visual character of natural vegetation, while remaining foundationally rooted in an understanding of contemporary ecological science for guiding species selection, arrangement and management.[126] As mentioned prior, conventional garden design practices and agricultural-horticultural perspectives favor approaches and practices which show little regard for how plants grow and behave ecologically in gardens—how species socialize, reproduce and spread, compete for space and so on. An in-depth understanding of these types of issues and conditions holds

[125] View from federal twist, Feb 21, 2013, https://federaltwist.com/blog/2013/02/21/ecological-disruption-has-travis-beck-been-in-my-garden.
[126] James Hitchmough, *Sowing Beauty : Designing Flowering Meadows from Seed* (Portland, OR: Timber Press, 2017), 12.

considerable implications for the design and management of naturalistic-style plantings if long-term sustainability is to be achieved.

Drawing upon a variety of interdisciplinary perspectives, the central thrust in this work has been to apply lessons derived from an understanding of contemporary ecological science[127] and restoration ecology.[128] Designed plant communities provide a framework for "reintroducing and re-establishing community-like assemblages of native species to sites which can reasonably be expected to sustain them, with the resultant vegetation demonstrating aesthetic and dynamic characteristics of the natural communities on which they are based."[129] Furthermore, plant communities "serve as functional workhorses, performing valuable ecological services that far surpass conventional plantings" with an "end result that is exquisitely tied to a particular site,"[130] and which "show a high level of compatibility and so remain relatively stable with little maintenance."[131]

Research reveals that approaches put forth by the designed plant community are not new, but support a layering of knowledge over time that has made informed decisions regarding species selection much more obtainable. A deep

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[127] J. P. Grime, *Plant Strategies, Vegetation Processes and Ecosystem Properties* (New York, NY: Wiley, 2001), 748.
[128] J. O. Luken, *Directing Ecological Succession* (London: Chapman and Hall, 1990), 251.
[129] Morrison, "Design, Restoration, and Management," quoted in Juras, *Presettlement Piedmont Savanna*, 64.
[130] Rainer and West, *Post-Wild World*, 20.
[131] Piet Oudolf and Noel Kingsbury, *Planting Design: Gardens in Time and Space* (Portland, OR: Timber Press, 2005), 25.

knowledge of how plants socialize is fundamental to designing resilient plant communities.

CHAPTER 3

METHODOLOGY AND APPLICATION

Research Foundations

This thesis offers a regional response to four long-term problems plaguing landscape and planting design: (1) A significant decline in the funding of maintenance programs, (2) the erosion of horticultural vegetation maintenance skills within urban parks authorities, (3) the loss of critical pollinator habitat and limited biodiversity, and (4) the need for a regionally specific understanding of natural plant assemblages. These four factors have contributed to an ongoing simplification of urban parks and green spaces, whereby herbaceous plants and shrubs have been effectively "edited out" over time, resulting in monocultures of mown grass and trees.

Inserted into this context, the urban ecosystem offers a huge diversity of planting opportunities, many of which lie outside the canon of traditional designed plantings. Challenges within urban environments necessitate that planting solutions include inexpensive installation methods, and can be maintained within the unique growing conditions of urban ecosystems, often which include a minimal resource environment and extremely varied growing conditions.

Design Goals

The design intent is to develop a hypernatural plant community using historic Southeastern Piedmont prairie communities as a source of inspiration. Presently there is limited guidance concerning the successful establishment of designed plant communities in the Southeast utilizing the Southeastern Piedmont prairie as a primary source of inspiration. The study area extends from Mideastern Alabama into Central Virginia as illustrated below. The species rich, floristic composition of the Southeastern Piedmont prairie affords ample opportunity for design exploration, while also serving to showcase an association of species which in the past have largely received little attention in regards to creative plant selection or combination.

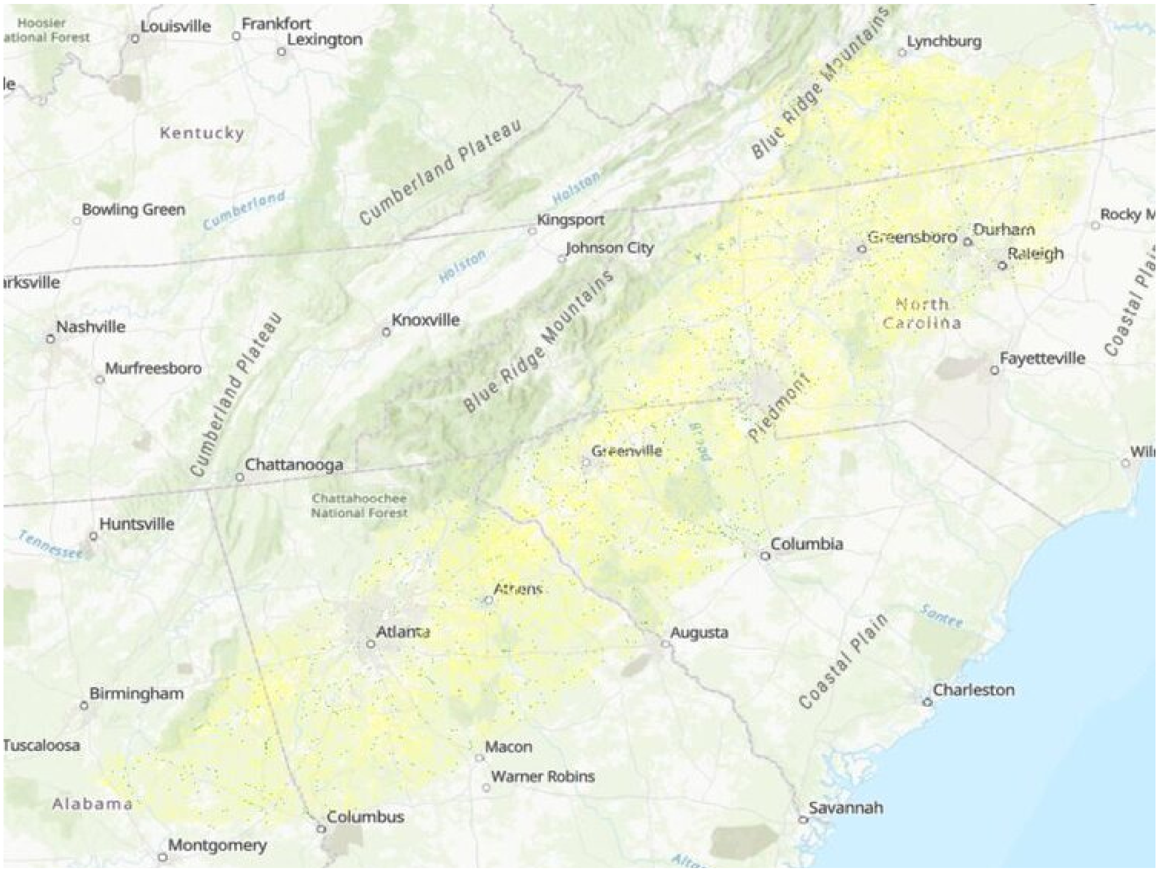

Figure 3.1: Distribution of Southeastern Piedmont Prairies. *Source:* Southeastern Grasslands Initiative

Design Approach

The designed plant community serves as a proven model for guiding species selection and evaluation concerning multiple populations of species and their associated interactions to one another. The design approach for this study is largely aligned with the key principles of designed plant communities laid out by Thomas Rainer and Claudia West,[132] which are: (1) Related Populations, not Isolated Individuals, (2) Stress as an Asset, (3) Cover the Ground Densely by Vertically Layering Plants, (4) Make it Attractive and Legible, and (5)

[132] Rainer and West, *Post-Wild World*, 43-61.

Management, not Maintenance. These principles are addressed further in relation to an evaluation of the key characteristics pertaining to species selection.

This chapter outlines an evaluation and design process by which hypernatural plant communities can be assembled and evaluated that is framed and rooted in an in-depth understanding of plant dynamics and natural processes that shape, define and inform species selection. Guidelines and specific aspects of native plant community design developed by James Hitchmough and Nigel Dunnet, along with key design principles outlined by Thomas Ranier and Claudia West, provide the primary framework and much of the specific information in this application. An open grassland ecotype of average soil moisture serves as a basis for design exploration, using species drawn from the Southeastern Piedmont prairie, including both familiar and lesser-known species that are worthy of receiving greater attention. A series of tables and diagrams illuminate the design process by offering comparisons between species using a range of ecological and design criteria for guiding plant selections. Through a series of refinements, a final list of species is presented, reflecting a cumulative assessment of all traits across selected species for the target group in order to best gauge suitability and ecological fitness within the designated plant community. The resulting composition reflects a species palette that is both fully functional and ecologically resilient, while balancing cultural aspirations of color, form and texture.

Generally speaking, plant communities consist of plants that are adapted to the same habitat or which commonly associate together within a given habitat. This foundation highlights a key principle of designed plant communites: *related populations, not isolated individuals*. Adopting a biogeographic approach to species selection, whereby species are drawn from parallel geographies, it is argued, increases the likelihood of creating designed plant communities that are resilient as species should be broadly compatible with one another in terms of growth rates, tolerances of environmental conditions, and management regimes.[133] Drawing species from similar biomes yields another beneficial effect in terms of limiting the collective amount of species from which to select and evaluate.

It is worth reiterating that designed plant communities reflect an artful translation of naturalistic plant communities, and do not constitute a purely ecological approach aimed at restoration. While designed plant communities mimic the spatial and structural form of semi-natural vegetation, a balance is struck between natural and cultural aspirations. Specifically related to prairie flora, Nassauer notes that "prairie plants with small flowers tend to be misunderstood for weeds"[134] and that "if restorations or gardens include an

[133] Hitchmough, *Sowing Beauty*, 113.
[134] Nassauer, *Messy Ecosystems, Orderly Frames*, 168.

‘unnaturally high’ proportion of plants with larger, brighter flowers, at least in the first few seasons, people are more likely to find them attractive.”[135] Differing too from conventional herbaceous plantings is the development of an extended, full seasonality of growth and bloom. Furthermore, naturalistic plantings consist of a greater diversity of species in much higher densities than conventional herbaceous plantings, providing effective cover for weed suppression early in the growing season when plantings composed strictly of blocks or singular species are just beginning to fill in.

While the catalog of projects using a designed plant community approach is currently limited for high profile urban projects, the approach is gaining traction to great effect as the dazzling floriferous displays of the Queen Elizabeth II Olympic Park in London can attest. Designed by English garden designer Sarah Price in collaboration with professors James Hitchmough and Nigel Dunnett for the 2012 Olympic Games, several gardens were designed to emulate natural associations of species from across the globe, including the North American prairie. Establishment was largely achieved through sowing of species *in situ*. A more regional precedent can be found at the recently unveiled Arboretum at Penn State’s Pollinator and Bird garden designed by Phyto Studio and Didier Design Studio using principally plugs.

[135] Nassauer, *Messy Ecosystems, Orderly Frames*, 168.

Figure 3.2: The 2012 London Olympic Gardens designed by Sarah Price and Professor James Hitchmough. The gardens featured a section of gardens that were inspired by the grassland communities of North America. Several selected species are directly associated with the Piedmont prairie regime, including Rudbeckia, Aster, Helianthus and Solidago species.[136]

[136] "Olympic Gardens: North America," Sarah Price Landscapes, accessed Sept 22, 2021, https://www.sarahpricelandscapes.com/public-olympic-gardens-north-america.

Figure 3.3: Perennial combinations at the 2012 London Olympic Gardens.

Figure 3.4: Perennial combinations at the 2012 London Olympic Gardens.


Figure 3.5: Perennial combinations at the 2012 London Olympic Gardens.

Species Selection

Initial species selections were drawn from a multitude of sources, including NatureServe[137] and the Georgia Department of Natural Resources,[138] with additional selections gathered from well-regarded sources such as Philip Juras, [139] Heather Alley,[140]James Hitchmough,[141] and E. Davis, Jr. et. al.[142]. From this initial list of hundreds of species of forbs and grasses associated with the Southeastern Piedmont prairie ecoregion, evaluations were conducted comparing the suitability of 68 species (55 forbs and 13 grasses) to the target ecotype with additional design criteria based on their optimal growing conditions, structural habit, height and spread, bloom color, bloom duration, and habitat value. In this manner, adjudication of planting decisions were not solely based on any preconceived aesthetics or style of companionship. From these series of evaluations, a final list of species was assembled, reflecting 15 forbs and five grasses (75% forbs to 25% grasses). This distribution ratio favoring forbs to grasses is in keeping with James Hitchmough's design premise that in order for naturalistic plantings to be received by the average layperson, "plant communities must be designed and managed to be visually dramatic at some

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137 https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860351/Schizachyrium_tenerum_-_Aristida_beyrichiana_-_Manfreda_virginica_Grassland_Shrubland_Divisionhttps://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.731002/Andropogon_gerardii_-_Bouteloua_curtipendula_-_Echinacea_simulata_Coosa_Valley_Barren_Grassland

138 https://georgiawildlife.com/sites/default/files/wrd/pdf/rare-data/natural_communities_thumbnail_accounts.pdf

139 Juras, *Presettlement Piedmont Savanna*, 85-90.

140 Alley, Heather. email correspondence, June 2021.

141 Hitchmough, *Sowing Beauty*, 86-91

142 Davis, Jr. et al., *Vascular flora*, 6-11.

point in their lifecycle."[143] By comparison, a 2003 study conducted by Hitchmough and Marcus de la fleur included a composition of 15 prairie forbs and two prairie grasses.[144] By favoring a greater diversity of forbs to grasses, it is hoped that the desired result would achieve a "longer succession of bloom, more diversity of texture, and longer-lasting groundcover."[145]

Evaluation Criteria and Metrics

Evaluation criteria and metrics for guiding species selection largely builds upon the great body of work undertaken by James Hitchmough and Nigel Dunnett at the Department of Landscape Architecture, University of Sheffield, England, that has been conducted over the course of the past thirty years. The duo, assisted by numerous graduate assistants, has been instrumental in developing new paradigms for planting design and management strategies conceived for public spaces. By applying sound ecological principles to planting design, their research strategies have yielded various plant communities adapted to very specific physical, ecological, cultural, and aesthetic contexts in which they are embedded. In particular, their work has promoted diverse assemblages of species consisting of herbaceous species of forbs, grasses, and geophytes. Their research, while not rooted or derived from any one particular theory, has

[143] James Hitchmough, "New Approaches to Ecologically Based, Designed Urban Plant Communities in Britain: Do these have any Relevance in the United States?" *Cities and the Environment* 1, no. 2 (2008), 5. https://digitalcommons.lmu.edu/cgi/viewcontent.cgi?article=1019&context=cate.
[144] James Hitchmough, Marcus de la Fleur and Catherine Findlay, "Establishing North American Prairie Vegetation in Urban Parks in Northern England: Part 1. Effect of Sowing Season, Sowing Rate and Soil Type," *Landscape and Urban Planning* 66, no. 2 (2004), 79.
[145] Rainer and West, *Post-Wild World*, 47.

resulted in pragmatic approaches for developing and establishing designed plant communities with long-term management in mind, including a commitment to a low expenditure of resources for maximizing long-term survivability.[146] What is more surprising is that the visually dramatic results of their work have not been achieved through the extensive amelioration of growing conditions to bring site conditions back to a "normative" range, but rather through sowing carefully tailored seed mixes to fit prevailing site conditions.

As previously noted, coexistence within wild plant communities is a direct result of features and functions that act cumulatively and complementarily, allowing species to exploit different ecological niches in order to minimize competitiveness between their neighbors. Plants exploit niche opportunities through an array of functional features, including but not limited to, rooting mass, aboveground structure, time of flowering, ability to fix nitrogen, and growth cycle.[147] Understanding this cumulative impact of characteristics and traits of individual species and their associated adaptations, tolerances and behaviours is crucial to developing resilient plant communities and adapting strategies to fit specific design conditions. This section sheds light on some of the most essential traits and characteristics to consider when evaluating species and the methodology used in this study for making informed selections.

[146] Hitchmough, *New Approaches Plant Communities*, 2.
[147] Norris, *New Naturalism*, 26.

Selecting species according to ecological fitness, while favoring species which share common traits and characteristics, responds to what has come to be one of the fundamental tenets of the designed plant community approach—right plant, right place.[148] Put succinctly, species should be *well-fitted* to the environment in which they are to be used, thus reducing a need for resource-intensive or drastic site manipulation. As Nigel Dunnett elucidates, "plants are the great interpreters of site conditions and accurately reflect and mirror what might be minute changes in the soil type, topography, climate and management."[149]

Hitchmough lays out the essential ecological traits of herbaceous perennials that render them compatible with other species as such:[150]

1) Capacity to Produce Seed;
2) Ability of Seed to Germinate and Establish Seedlings;
3) Palatability of Seedlings and Adults to Herbivores;
4) Capacity to Form Seed Banks in the Soil;
5) Capacity to Thrust Shoots through Leaf Litter and Overtopping Plant Canopies;
6) Capacity to make Vegetative Spread via Above Ground Shoots;
7) Capacity to make Aboveground Spread from Shoots on the Roots;
8) Capacity to Tolerate Low Light Levels;

148 Dunnett, *Dynamic Nature of Communities*, 98.
149 Ibid.
150 Hitchmough, *Sowing Beauty*, 49.

9) Capacity to Tolerate Extreme Moisture Levels;

10) Capacity for Longevity

Physiological Characteristics

Growth and reproduction strategies, foliage form, structural habit, and other physiological characteristics of species all serve as important reference frames from which to assess the suitability of a species to its environment. As mentioned previously, information pertaining to Southeastern Piedmont prairie species is currently limited and sourcing information relevant to the Georgia piedmont proved to be elusive. The North Carolina State University Cooperative Extension office provided the greatest benefit for sourcing information relevant to this region. Cultural conditions, structural habit, foliage form, habitat value, bloom color, bloom duration, and seed type were all discussed in detail for most of the 68 referenced species. Other useful sources of information included the Ladybird Johnson Wildflower Center,[151] the Missouri Botanical Garden,[152] and Prairie Nursery.[153] Where literature was lacking concerning a species' preferred growing conditions or tolerances, guidance on foliage form and structural habit outlined by James Hitchmough provided reliable information for gauging soil moisture preferences or light level tolerances. For example, smaller leaves are typically associated with species adapted to high-light environments, and can

[151] "Native Plants Database," Lady Bird Johnson Wildflower Center, accessed Sept 12, 2021, https://www.wildflower.org/plants/.
[152] "Plant Finder," , accessed Sept 12, 2021, http://www.missouribotanicalgarden.org/plantfinder/plantfindersearch.aspx.
[153] "Wildflowers," Prairie Nursery, accessed Sept 12, 2021, https://www.prairienursery.com/.

usually withstand some degree of soil moisture stress. The opposite is usually true for species possessing larger leaves, which favor shade and higher moisture levels. Larger, thicker leaves can be an indicator of species which are adapted to dryer conditions. The same is true for species possessing, pubescence, or the fine covering of down or soft short hairs atop the surface of a leaf. The foliage form of a species is also another important indicator of growing conditions. For example, flat leaf rosettes are associated with low productivity soils and open sunny habitats.[154] Winter hardiness, moisture level preferences, and light level tolerances served as a primary baseline for eliminating species during an initial round of evaluations, leaving an association of species favoring similar growing conditions.

However, winter hardiness, moisture-level preferences, and light-level tolerances alone are not a reliable threshold for making informed decisions regarding species selection. Plants survive by virtue of their cumulative ability to respond to three strategies previously outlined under Grime's Plant Strategy Theory: (1) ability to compete for resources (competitors), (2) ability to withstand stress (stress-tolerators), and (3) ability to overcome disturbance (ruderals), albeit to varying degrees within each category. An understanding of how a species relates to each of these three strategies has direct and relevant application to achieving a well-balanced, communal association of species. For example, in

[154] Hitchmough, *Sowing Beauty*, 39.

order to counter the colonizing tendencies of warm season, tall competitor species such as *Andropogon gerardii* (big bluestem) and *Sorghastrum nutans* (Indiangrass), associated species must be able to withstand lower light levels or invest in accelerated growth and reproduction before the grasses have a chance to gain a foothold later in the season. Alternatively, the opportunistic qualities and accelerated growth cycles of ruderal species enable them to serve as effective groundcovers.

Table 3.1: C-S-R Traits in Plants[155] [156]

Trait	Representative Characteristics
Competitive Traits:	large leaves large canopy allelochemical production large root spread (i.e. stoloniferous or rhizomatous) colonizing tendencies
Stress-tolerant Traits:	investment in biomass mechanical defenses (i.e. thorns) chemical defenses slow growth deep taproots fleshy, succulent leaves candices
Ruderal Traits:	opportunists short life cycle overwintering structures high seed/spore dispersal ability to persist in the seedbank rapid growth

[155] Jennifer L. Wood and Ashley E. Franks, "Understanding Microbiomes through Trait-Based Ecology ," *Microbiology Australia* 39, no. 1, 54.
[156] Norris, *New Naturalism*, 21.

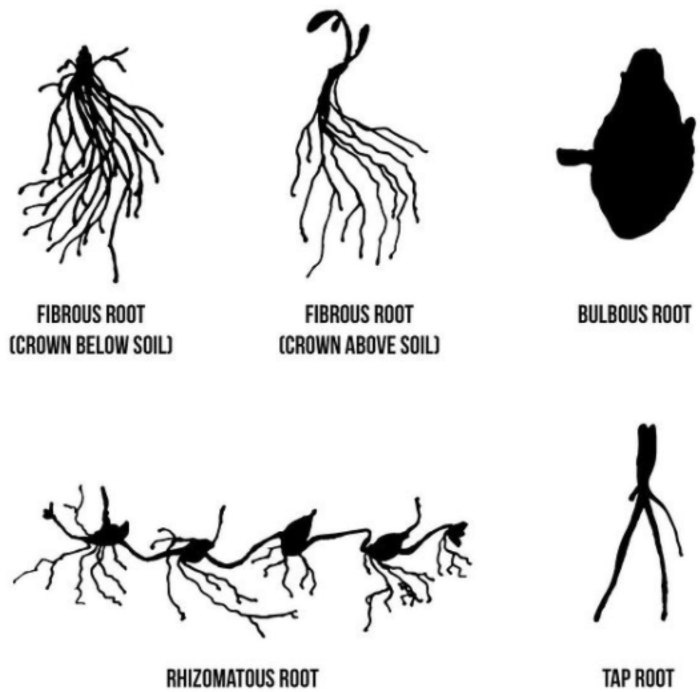

Figure 3.6: Root Type Classifications. *Source:* Prairie Moon Nursery

Vegetative Layering Characteristics

Secondary evaluations of species concentrated on design characteristics such as structural habit, texture, bloom color, and bloom duration. In order to achieve a well-layered composition and to maximize ecological function, species selections were drawn from a range of sizes and spreads, thus responding to the key principle of designed plant communities: *cover the ground densely by vertically layering plants*. Structural layering has been arranged into three broad categories for evaluation: ground layer, middle canopy, and an upper emergent layer. By comparison, Rainer and West divide vegetative layering into four broad categories: functional (ground), design (middle canopy), structural (upper emergent), and a fourth seasonal theme layer that is interwoven throughout a composition to maximize visual interest throughout the year. The primary differences between the two classifications being that Hitchmough is largely writing in reference to seeded plant communities, whereas Rainer and West have tailored their approach to include plugs in their designs. The mature height of referenced species, along with growth rate, and tolerances for varied light conditions were used to gauge where a species might fall under the designated layering classification of ground layer, middle canopy or upper emergent. Breakdowns for vegetation height included low (6"-18”), medium (18"- 36") and high (36” - 72”+). Spring-blooming species, which tend to fade or undergo dormancy following their bloom period, are effectively masked by the emergent growth of later blooming species. As such, ground layer species need to possess some degree of shade tolerance if they are to persist in a multi-layered composition.

LAYERS OF A DESIGNED PLANT COMMUNITY

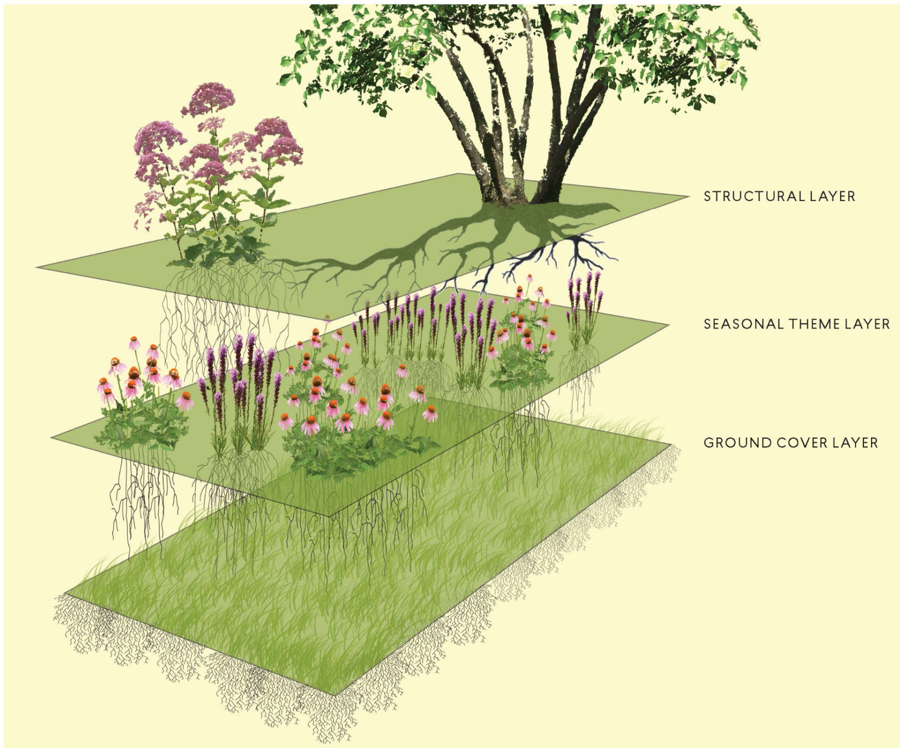

Figure 3.7: Layers of a Designed Plant Community
Adapted from *Planting in a Post-Wild World* by Thomas Rainer and Claudia West.

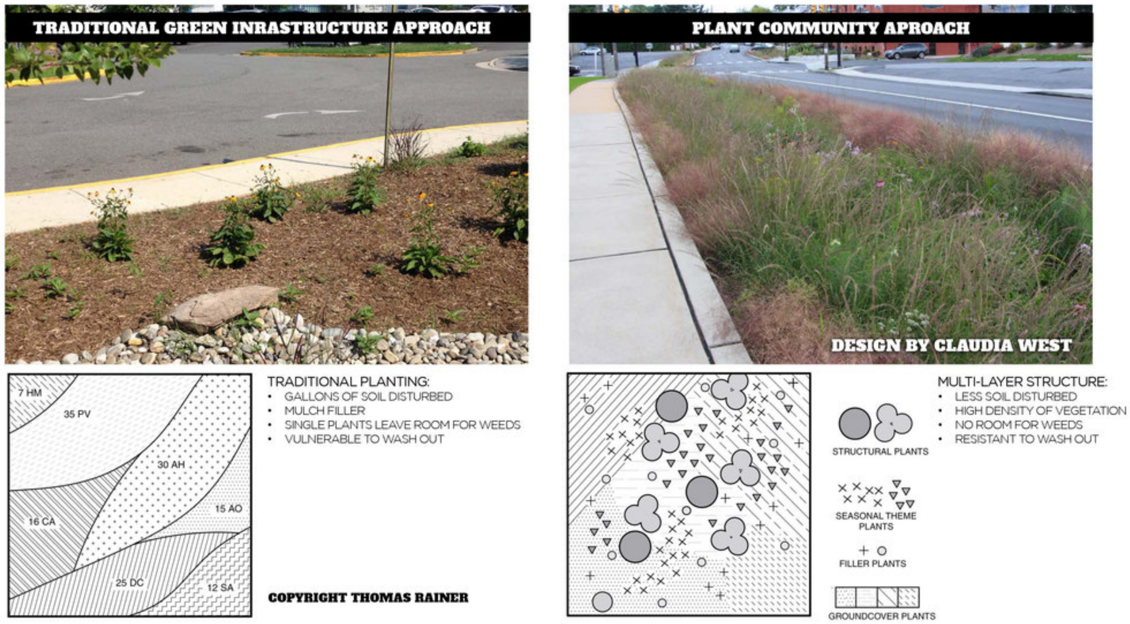

Figure 3.8: Traditional Planting versus Multi-layered Planting Approach. ***Source***: ***Planting in a Post-Wild World*** by Thomas Rainer and Claudia West.

Floristic Characteristics

While aesthetic considerations such as bloom color and form can contribute to the overall acceptance of designed plant communities, it is important to incorporate species with a range of bloom durations in order to accommodate a full season of color across the entirety of the growing season. This follows another key principle of designed plant communities: *Make it Attractive and Legible*. Species evaluations concluded that many summer-blooming species possessed yellow blooms, whereas late summer and early fall species possessed purple blooms. Such considerations are important when considering how a composition of species might transform throughout the growing season.

Wildlife Value

While the visual display of species is important for achieving cultural aspirations, it is important to remember the associations between plant and animal species. Plants have coevolved with organisms to form dynamic and intricate webs of life. While there can be an aversion to cosmetic damage to plants caused by insects and mammals, studies have shown that herbivores tend to consume no more than 20% of total net primary production in a growing season.[157] The capacity of a landscape to support the greatest amount of biodiversity is most directly achieved through concentrations of plant populations that maximize species diversity.[158] Additionally, a multi-layered and well-structured composition of species provides for a variety of habitat types. Evaluation criteria assessing wildlife value focused on host species for pollinators, and the ability to attract beneficial insects, birds and small mammals.

Seed Sources and Species Availability

In addition to evaluating plant characteristics, seed sources and species availability were also considered when selecting species. The procurement of seed typically involves two methods: the seed industry associated with restoration ecology or the horticultural seed industry supplying nursery growers. The total pool of herbaceous plant species currently sold commercially as bulk seed is estimated to be around 5,000 species with associated seed strains,

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[157] Norris, *New Naturalism*, 32.
[158] Hitchmough, *Sowing Beauty*, 135.

amounting to less than two percent of the world's total flora.[159] While professional engagement with Southeastern Piedmont prairies has increased substantially over the last two decades, including efforts currently being undertaken to catalogue and assemble seed collections from remnant ecosystems across the Southeast, only a slim catalogue of species are presently available in the horticultural trade. However, as demand has risen for more regionally-adapted seed sources, especially in regards to local genotypes, seed collection and seed banking initiatives have increased. One such effort is being undertaken by the Southeastern Grasslands Initiative (SGI), who, in partnership with the Seeds of Success (SOS) Program and Roundstone Native Seed, is embarking on a mission to "collect wildland native seed to serve as source material for restoration projects for restoring and supporting resilient ecosystems."[160] Additionally, SGI is developing an authoritative lists of trees, shrubs, woody vines, herbaceous vines, forbs, grasses, sedges, rushes, ferns, and fern allies that should be given priority for ecological restoration or landscape architecture projects within" each of the major Level IV ecoregions across the Southeast.[161]

[159] Hitchmough, *Sowing Beauty*, 168.
[160] "Seedbanking," Seedbanking, accessed Aug 2, 2021, https://www.segrasslands.org/seedbanking.
[161] "Seedlists by Ecoregion for Native Grassland Restoration and Re-Creation," Seedlists by Ecoregion, accessed Aug 2, 2021, https://www.segrasslands.org/seed-lists-by-ecoregion.

Application: The Designed Plant Community

A model plant community comprised of species adapted to open, sunny sites with moderate moisture content and well-drained soils serves as the basis for this design application. Proposed species possess a range of tolerances and traits that are best suited to a variety of harsh urban conditions, including highway right-of-ways and urban parks where resources for maintaining selections may be limited and self-sustaining populations of species are needed. Species selection has focused on achieving a diversity of traits, enabling multiple species to coexist at relatively high densities by occupying different niches. Such intense competition amongst species is favored in order to reduce vigor or suppress avenues through which alien or undesirable species might take hold, drastically reducing the expenditure of resources needed to maintain plantings over time. Intense competition also lessens the impact to the overall composition from the loss of an individual plant or grouping as openings are quickly filled in by other desirable species. The resulting design reflects a novel association of species that are not strictly drawn from any particular Piedmont prairie community, but rather from the region as a whole.

It is important to note that species do not often neatly fit within each of the respective growth strategy categories: competitor (c), stress-tolerator (s), and ruderal (r), but may exhibit traits from each to varying degrees. *Asclepias syriaca* (common milkweed) is one such example that does not neatly align with a single classification. Its stems exude a white sticky sap when cut, a chemical defense trait indicative of stress-tolerators, and it possesses a deep taproot. However, seed is produced at high rates, a trait often associated with ruderal species. Because common milkweed exhibits traits mostly aligned with that of a stress-tolerator, it would be given a stress-ruderal (sr) classification.

The distribution of competitive species, to stress-tolerators, to ruderals draws from precedents set by Nigel Dunnet,[162] Thomas Rainier and Claudia West,[163] and Kelly Norris[164] whereby a high concentration of groundcover species (40%-50% of the total composition) is preferred to cover the ground in order to minimize weed pressure from undesirable species. These foundational workhorses also serve as living mulch, replacing the burdensome tasks of mulching and weeding that are needed with traditional gardens.

Many ruderal species provide structure and bloom early in the season when other species are beginning to emerge from dormancy. Species in this category include daisy fleabane (*Erigeron strigosus*), which offers a profusion of white daisy-like blooms in early April. As these species have an accelerated growth cycle, they typically fade out by mid-summer but are replaced by the growth of later blooming species. Other selected species fitting a ruderal classification are

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[162] Wolfram Kircher et al., "Development of Randomly Mixed Perennial Plantings and Application Approaches for Planting Design," (2006), 117.
[163] Rainer and West, *Post-Wild World*, 153, 172
[164] Norris, *New Naturalism*, 60.

large scullcap (r), partridge pea (sr), prairie phlox (csr), black-eyed susan (sr), splitbeard bluestem (sr) virginia wildrye (r), and little bluestem (sr).

Stress-tolerators provide much of the structure for the mid-canopy of the composition. Devoting much of their energy to biomass, growth rates can be slow, but species within this category often possess traits that enable them to withstand pressure from ruderal groundcovers early in the season by (1) possessing thick shoots that enable them to push through dense foliage such as *Baptisia australis va. Aberrans* (eastern prairie blue wild indigo), (2) maintaining evergreen basal growth as a means of accelerating their growth cycle such as *Symphyotrichum laeve* (smooth blue aster), or (3) by producing chemical defenses to lessen palatability to herbivores such as *Hypericum sphaerocarpum* (round-fruited st. john's wort). Soil moisture and drainage preferences did factor into exclusions of several species, including *Antennaria plantaginifolia* (pussy-toes), which has a tendency to perform poorly if soil conditions or drainage are not optimal. *Gaura filipes* (slenderstalk beeblossom) has a tendency to flower less on productive soils, whereas *Euthamia graminifolia* (grass-leaved goldenrod) may become overly aggressive if sufficient environmental stresses are not present.

Structural species account for approximately 10-15% of the total community in order to provide seasonal thematic elements and architectural scaffolding for other species in order to preserve legibility of the composition throughout the growing season. The upper emergent layer tends to be comprised of late summer or autumnal blooming species. Species within this category included *Ratibida pinnata* (grey headed coneflower) and *Silphium astericus* (starry rosinweed).

As bloom is most dramatic during summer months, fall blooming and seasonally dramatic species such as asters, goldenrod and grasses have been added to extend the bloom duration and provide exuberant fall color when other species have begun to fade. Species with visually dramatic floriferous displays were also selected, including *Phlox pilosa* (prairie phlox), *Scutellaria integrifolia* (large scullcap), *Symphyotrichum laeve* (smooth blue aster), and *Solidago speciosa var. erecta* (showy goldenrod).

Several species have been selected for their ability to serve as host species for butterflies and their associations with native bee populations. Research has shown where aster species can serve as invaluable insectaries, harboring populations of beneficial insects, including mantids, spiders, beetles, lacewings, parasitic wasps, sawflies and dragonflies.[165] These species have been added in order to maintain a balance in the pressures exerted by herbivory. The hollow stems of species such as *Silphium astericus* (starry rosinweed) can also provide

[165] Norris, *New Naturalism*, 32.

nesting opportunities for solitary bee species, while their upturned leaves hold small reservoirs of water for supporting small mammals. Maintaining a healthy population of lepidoptera is also critical for supporting songbird populations. According to Professor Doug Tallamy, a leading entomologist at the University of Delaware, between 6,000 and 9,000 caterpillars are needed in order to rear a clutch of chickadees (up to 13 eggs).[166]

Of the total number of species assessed, approximately 15% are not commercially available as seed or are not available in sufficient quantities. However, evaluation criteria is limited and can not speak to the nuances of a particular site, and thus specific design objectives and site constraints would dictate a refinement to the listed species where appropriate. A full vetting of species is needed with field trials in order to best gauge species performance over time. However, the testing period can be quite extensive. For example, Hitchmough conducted field trials for 10+ years in order to fully vet species before incorporating them into specific design applications. For actual site applications, species selection should be refined as necessary to account for the size of a site and the intended design goals. A thorough inventory and analysis of the site to be designed, taking account of characteristics such as soil type, steepness of terrain, solar orientation, views and existing vegetation, is a typical first step in the design process in order to match species selections to site

[166] John Magee and Alonso Abugattas, *Dr. Doug Tallamy on the Nature of Oaks,* Doug Tallamy, Podcast, May 15, 2021 Native Plant Podcast.

characteristics and constraints. Field observations of reference communities that closely approximate the intended site conditions, where present, can provide critical opportunities for analyzing species distribution, assessing species according to dominant, prevalent and 'visual essence' species. For the final assessment, a percentage of each species needs to be considered and the sowing method (i.e. plugs or seed) identified before proceeding with implementation.

Table 3.2: A Dry, Open Piedmont Prairie Designed Plant Community

Forbs

Botanical Name	Common Name
Baptisia australis var. Aberrans	Eastern Prairie Blue Wild Indigo
Chamaecrista fasciculata	Partridge Pea
Erigeron strigosus	Daisy Fleabane
Packera anonyma	Small's Ragwort
Penstemon laevigatus	Eastern Beardtongue
Phlox pilosa	Prairie Phlox
Pycnanthemum tenuifolium	Narrow-leaf Mountain Mint
Ratibida pinnata	Grey Headed Coneflower
Rudbeckia hirta	Black-eyed Susan
Scutellaria integrifolia	Large Scullcap
Silphium astericus	Starry Rosinweed
Solidago speciosa var. erecta	Showy Goldenrod
Symphyotrichum ericoides	Heath Aster
Symphyotrichum georgianum	Georgia Aster
Symphyotrichum laeve	Smooth Blue Aster

Grasses

Agrostis perennans	Autumn Bentgrass
Andropogon ternarius	Splitbeard Bluestem
Elymus virginicus	Virginia Wildrye
Eragrostis spectabilis	Purple Lovegrass
Schizachyrium scoparium	Little Bluestem

Application: A Conceptual Design Framework

Shifting beyond the theoretical basis of species selection and evaluation onto an implementable site design requires an informed understanding of the specific site conditions that are most suitable to a designated plant community if lasting resiliency is to be achieved.

For the proposed plant community, suitable applications could include the following within the urban or suburban environs:

- planted meadows in combination with sowing
- narrow beds along fencelines and marginal plantings
- traffic islands or highway right of way
- school yards or suburban lots where a reduction in lawn is desired

A turf replacement in a typical school yard has been selected as a case study for design exploration in order to test a possible arrangement of species. In the absence of an actual site, a 10-meter by 10-meter site has been selected to showcase the proposed arrangement of species using plug and seed density rates of 10-plugs/m² and 100/m² respectively as recommended by James Hitchmough.[167] For this application, plugs have been principally used with overseeding of quick-establishing forbs and grasses in order to achieve the fastest rate of ground coverage. Species quantity and distribution largely follows

[167] James Hitchmough, "Naturalistic Herbaceous Vegetation for Urban Landscapes," in *The Dynamic Landscape: Ecology, Design, and Management of Naturalistic Urban Planting*, eds. James Hitchmough and Nigel Dunnett (Philadelphia: Taylor and Francis, 2014), 132.

the classification of perennials and recommended proportions outlined by Nigel Dunnett et al. below. Within the previously proposed designed plant community, a few of the tallest, most dynamic species have been omitted or substituted for shorter, more stable selections in order to maximize public perception of the designed landscape. Considerations for site preparation, installation and management will be discussed briefly as a basis for future design exploration.

Table 3.3: Classification of Perennials[168]

Category	Definition	Recommended proportion of plants
Dominant species: structure plants, framework plants	Forming the structural framework of the planting, e.g. grasses, large-leaved perennials or upright plants; mainly C-, C-S or S-Strategists.	5-15%
Companion plants	Recurring, stabilizing elements which define the visual character of the planting and emphasize the structure plants. Long lived plants; mainly C-, C-S or S-Strategists.	30-40%
Ground cover plants	Usually small perennials of up to 30 cm height which must be used in larger numbers, usually as a carpet between gaps between plants of the first two categories; mainly C-, C-S or S-Strategists.	≥50%
Filler plants	Short lived plants, responsible for a quick cover and visual display in the first one to three years. Quick in growth and spreading	5-10%

[168] Kircher et al., *Mixed Perennial Plantings*, 117.

generatively, but weak in
competition, declining while
substituted by the dominant,
companion and ground cover
plants; R-, R-S or C-R-Strategists.

Evaluations of suitable sites should consider the prevailing soil conditions in order to determine if remediation efforts are needed. As previously noted, Southeastern Piedmont Prairie species require lean, unproductive soils to look their best and to perform well over time. If conditions favor productive soils, such as many urban park environments, soil replacement may be needed in order to create an optimal growing environment. Subsequently, alterations to the designed plant community may be necessary in order to bring the species mix more in tune with site conditions.

During installation, it is important to limit the extent of disturbance to the area being planted as much as possible in order to minimize the potential invasion from weed species. Most weed species are hemophiles, meaning they "thrive in habitats disturbed by humans."[169] Depending on the nature of the site to be planted, a variety of weed removal techniques may be deployed, which are presented in more detail in the table below. If heavy equipment is used during construction, steps will need to be made to remedy soil compaction before planting can occur. While tilling may be a preferred method when dealing with

[169] Rainer and West, *Post-Wild World*, 196.

compaction, "it can compound soil problems" by "collaps[ing] many of the pore spaces in soil, ultimately causing soils to settle."[170] According to Rainer,

"Preparing a site for planting is all about setting the stage so that natural processes of root growth and soil building take place. It is about understanding soil as a living partner with plants, not some inert material that we must break into submission. It is also about managing competition early, sheltering your plants from the mob of aggressive species waiting to colonize disturbed ground. Neglecting this process will compound site problems later on."[171]

Table 3.4: Weed Removal Techniques[172]

Weed Removal Tools	Materials	Benefits and Challenges
Smothering	recycled paper and cardboard organic mulch (bark, wood chips, compost) clean topsoil	difficult in enhancement planting ideal for container planting, not seeding safe to use around existing trees and shrubs if thin layer is applied little impact on soil health because rain and air pass through materials
Spraying	organic herbicides traditional herbicides	for enhancement planting (spot-spraying) or new planting some herbicides can be harmful to people and the environment
Mechanical Removal	hand weeding machinery (brush hog, string trimmer)	for enhancement planting manual or with machines causes high levels of disturbance
Burning	propane burner	for enhancement planting

[170] Rainer and West, *Post-Wild World*, 201-202.
[171] Rainer and West, *Post-Wild World*, 203.
[172] Rainer and West, *Post-Wild World*, 200.

	drip torch	burned debris makes plant essential nutrients available immediately for other plants selectively reduces pressure from fire-intolerant species like cool season grasses and winter weeds
Cover Cropping	seed	requires long lead times cover crops can be part of the future design can enrich and improve soil (legumes enrich soil with nitrogen) temporary solutions to bridge time between site preparation and planting

In order to maintain a dense coverage of species, a cover crop has been added to the mix to hold back initial weed colonization before plantings have a chance to gain a foothold. Alternatives for mulching layers or cover cropping may include sand mulch or granite fines. A study conducted by Hitchmough and de la Fleur concluded that the "most important factor in long-term success proved to be the use of a 50mm deep sand mulch which greatly reduced weed competition in the first growing season" by creating a hostile environment through which weed seed germination was greatly limited.[173]

Management strategies follow the last key principle of designed plant communities: *Management, Not Maintenance*. Designed plant communities,

[173] James Hitchmough and Marcus de la Fleur, "Establishing North American Prairie Vegetation in Urban Parks in Northern England: Effect of Management and Soil Type on Long-Term Community Development," *Landscape and Urban Planning* 78 (2006), 386-397. doi:10.1016/j.landurbplan.2005.11.005.

while requiring less expenditure of resources than conventional plantings, do still demand a range of strategies to assist with the preservation of the design intent and legibility of the landscape over time, necessitating that the designer be actively engaged throughout the design, implementation and management processes. Management practices generally are tailored to fit three broad phases of establishment: *plant establishment phase*, *landscape establishment phase*, and *post-establishment phase*.[174] Management goals are generally aligned with "keep[ing] orderly frames clean and neat"[175] and preserving the legibility of the layers, lessening in intensity as a landscape matures. Additionally, as many Southeastern Piedmont Prairie species are S-Strategists, disturbance is key to their long-term success. This can be replicated in the landscape through mechanical means of weeding or by a weed torch where prescribed burning is prohibited. To assist in the establishment of the designed plant community, management recommendations require that the landscape be mown in early summer during the first growing season in order to lessen competition from competitive early species.

[174] Rainer and West, *Post-Wild World*, 235.
[175] Rainer and West, *Post-Wild World*, 224.

Table 3.5: Schoolyard Plant Schedule (10-meter by 10-meter)

Plugs (10-plugs/m²)

Quantity	Species Name	Classification
50	*Baptisia australis var. Aberrans* / Eastern Prairie Blue Wild Indigo	I
200	*Bouteloua curtipendula* / Sideoats Grama	III
100	*Eragrostis spectabilis* / Purple Lovegrass	III
50	*Erigeron strigosus* / Daisy Fleabane	IV
100	*Phlox pilosa / Prairie Phlox*	II
100	*Pycnanthemum tenuifolium* / Narrow-leaf Mountain Mint	II
250	*Schizachyrium scoparium* 'Standing Ovation' / Standing Ovation Little Bluestem	I/III
50	*Scutellaria integrifolia* / Large Skullcap	II
50	*Silphium astericus* /Starry Rosinweed	I
50	*Solidago sphacelata* 'Golden Fleece' / Golden Fleece Goldenrod	II

Total Plants: 1,000 Plugs

Seeded Cover Crop (100/m²)

50,000 *Agrostis perennans* / Autumn Bentgrass

50,000 *Elymus virginicus* / Virginia Wildrye

Targeted Management Activities: Sown cover crop in Spring, Mow landscape in early Summer and again in the late Fall to a height of 4-6" during the first full season of growth,[176] use weed torch to spot treat for weed species as needed

[176] "Wildflower Meadows: Let's Get Real," last modified Dec 2012, accessed Aug 22, 2021, https://lweanerassociates.com/wildflower-meadows-lets-get-real/#:~:text=By%20mowing%20the%20meadow%20every,enough%20light%20for%20strong%20establishment.

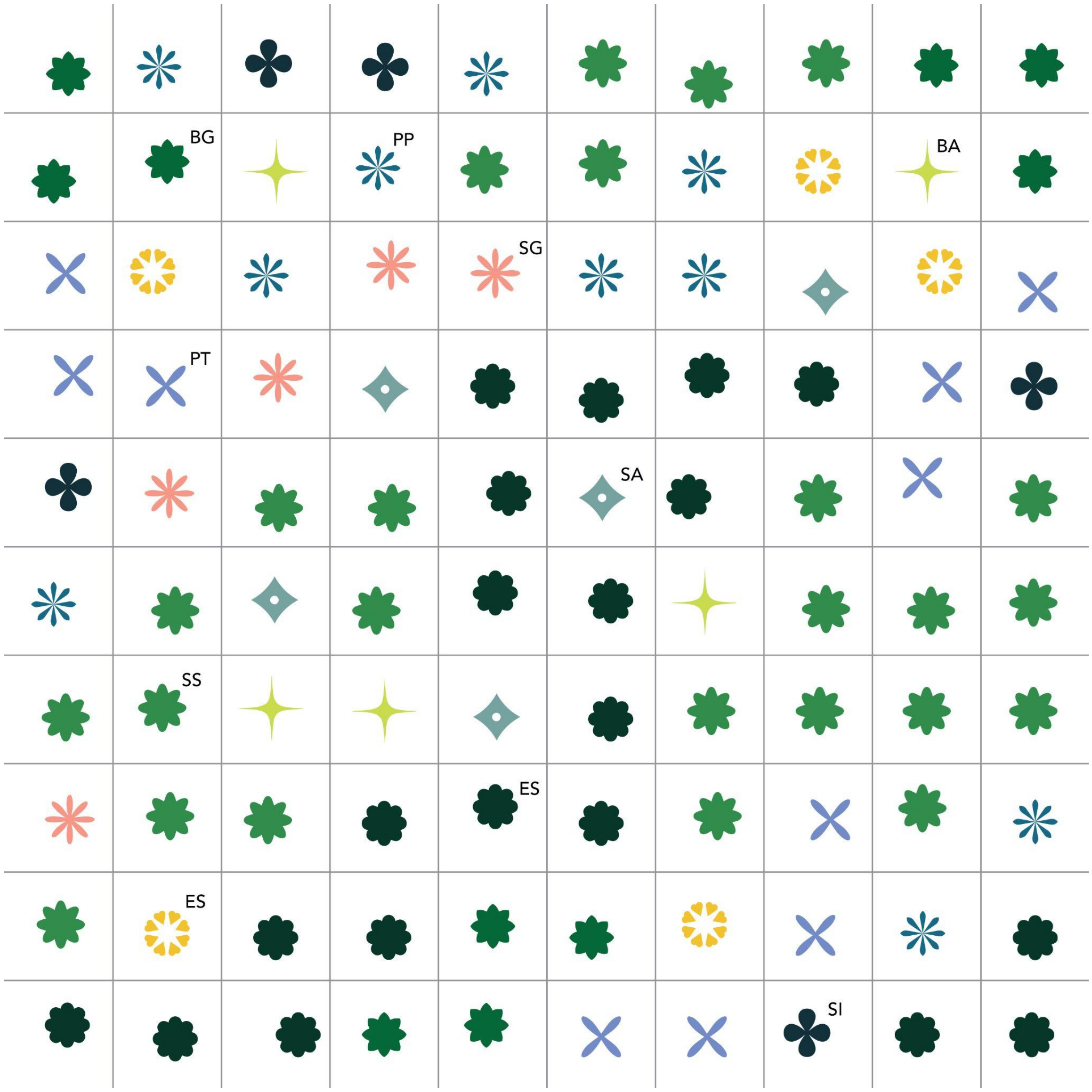

Figure 3.9: 10m² x 10m² Schoolyard Planting Plan (each symbol represents 10 plugs)

Plant Legend

Baptisia australis var. Aberrans / Eastern Prairie Blue Wild Indigo - BA

Bouteloua curtipendula / Sideoats Grama - BG

Eragrostis spectabilis / Purple Lovegrass - ES

Erigeron strigosus / Daisy Fleabane - ES

Phlox pilosa / Prairie Phlox - PP

Pycnanthemum tenuifolium / Narrow-leaf Mountain Mint - PT

Schizachyrium scoparium 'Standing Ovation' / Standing Ovation

Little Bluestem - SS

Scutellaria integrifolia / Large Skullcap - SI

Silphium astericus / Starry Rosinweed - SA

Solidago sphacelata 'Golden Fleece' / Golden Fleece Goldenrod - SG

CHAPTER 4

CONCLUSION

This thesis demonstrates the value of hypernatural designed plant communities, and identifies a process for selecting and evaluating species inspired by the rich, floristic composition of Southeastern Piedmont prairies. This thesis has used a systematic evaluation of the ecological and design criteria for 68 species of forbs and grasses native to the Piedmont of the Southeast. These analyses begin to reveal the complexity in selecting individual species for combination in layered mixes. Beyond initial selection, study is needed of plant interactions and changes in performance and visual quality that may result based on unique combinations and local site influences. Each species is evaluated in light of the four established problems facing public parks and land: (1) A significant decline in the funding of maintenance programs, (2) the erosion of horticultural vegetation maintenance skills within urban parks authorities, (3) the loss of critical pollinator habitat and limited biodiversity, (4) the need for regionally specific understanding of natural plant assemblages as well as fit within the strategies identified by Rainer and West (1) Related Populations, not Isolated Individuals, (2) Stress as an Asset, (3) Cover the Ground Densely by Vertically Layering Plants, (4) Make it Attractive and Legible, and (5) Management, not

Maintenance. These evaluation tools pave the way towards more informed seed mix formulation and application, where further study and refinement over time can take place.

The opportunities and benefits afforded by hypernatural plant communities are timely as we grasp with the uncertainties presented by unparalleled environmental change associated with the Anthropocene era. The resiliency and ecological function of hypernaturalistic designed plant communities provides ample opportunity for incorporating resilient and biodiverse plantings in the public realm by turning our landscapes from consumers of resources into sources of environmental renewal.

Future Research Goals and Objectives

A 5-year study completed in 2021 by Professor Brad Davis and several graduate students sought to identify best practices in relation to the effects of species selection, rate of sowing, and management regimes on the establishment of hypernatural piedmont prairie communities.[177] The study resulted in a grant funded partnership with The Ray and GDOT, and the successful establishment of nine plots, totaling 15,000 square feet (0.34 acres) along the Ray, an innovative solar-powered 18-mile stretch of interstate I-85 in Troup County, Georgia. The trial tested several installation methods using finely-crushed granite, sawdust,

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[177] Dunlap, *Hypernatural Piedmont Prairies*, 79.

and Georgia clay soil.[178] This study has an opportunity to serve as a basis for future research initiatives concerning the ability to test long-term effects for resiliency of species, invasiveness or aggressive potential. In his field trials, Hitchmough required 10+ years to design and evaluate each designed plant community before incorporating the mixes into designed applications.

While the research presented in this thesis is targeted at sunny open sites on the piedmont, this evaluation process may be used to smartly predict new mixes for a variety of soils, slopes, and site conditions, including shade, presence of tree canopy, or more xeric environments. By defining a more focused testing and evaluation process for implementation, findings suggest there is a higher chance of success, without fumbling in the dark and testing possibly hundreds of seed combinations without any real understanding of what will lead to success and acceptance.

Future research is prioritized as follows:

- Conduct field trials for the specified species community in order to assess long-term species sociability and performance.

[178] "Georgia DOT, UGA and the Ray Break Ground on Latest Meadow-Research Installation ," last modified Feb 11,2021, accessed Oct 4, 2021, https://theray.org/2021/02/11/georgia-dot-uga-and-the-ray-break-ground-on-latest-meadow-research-installation/.

- Identify new plant community assemblages using the criteria identified in this thesis for other environmental conditions, including mesic or sloping environments.
- Identify other suitable locations for implementation of designed plant communities such as The Ray.

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APPENDIX

Southeastern Piedmont Prairie Species Evaluations

Southeastern Piedmont Prairie Species: Soil Classification

SPECIES		SOIL CLASSIFICATION		
BOTANICAL NAME	COMMON NAME	UNPRODUCTIVE, DRY SOILS	INTERMEDIATE SOILS	PRODUCTIVE, MOIST TO WET SOILS
HERBACEOUS PERENNIALS				
Agalinis purpurea	Purple False-Foxglove*			X
Allium cernuum	Nodding Wild Onion		X	X
Amorpha schwerinii	Schwerin's Indigo-bush	X	X	
Antennaria plantaginifolia	Woman's Tobacco/Pussy-toes	X	X	
Asclepias tuberosa	Butterfly-Weed	X	X	
Asclepias verticillata	Whorled Milkweed	X		
Baptisia australis var. Aberrans	Eastern Prairie Blue Wild Indigo		X	X
Chamaecrista fasciculata	Partridge Pea		X	X
Chrysogonum virginianum	Green-and-Gold		X	X
Coreopsis grandiflora	Largeflower Tickseed	X	X	
Coreopsis verticillata	Threadleaf Coreopsis	X	X	tendency to flop
Desmodium strictum	Pine Barren Tick Trefoil		some dry tolerance	X
Echinacea laevigata	Smooth Purple Coneflower	X	X	
Echinacea simulata	Wavyleaf Purple Coneflower	X	X	
Erigeron strigosus	Daisy Fleabane	X	some dry tolerance	
Eryngium yuccifolium	Rattlesnake Master		X	X
Eupatorium rotundifolium	Roundleaf Thoroughwort	X	X	
Euthamia graminifolia	Grass-leaved Goldenrod	tolerance once established	X	aggressive tendency
Gaura filipes	Slenderstalk Beeblossom	X	X	greater biomass, less flowering
Helenium autumnale	Sneezeweed		X	wet soil tolerance
Helianthus smithii	Smith's sunflower		some dry tolerance	X
Houstonia purpurea	Woodland Bluet		some dry tolerance	X
Hypericum sphaerocarpum	Round-fruited St. John's Wort	X	X	
Lespedeza virginica	Virginia Bush-clover	X	X	
Liatris aspera	Rough Blazing Star	X		
Lotus unifoliolatus var. helleri	Carolina Birdsfoot-trefoil*	X	X	
Oenothera fruticosa	Narrowleaf Evening Primrose			moderately fertile tolerance
Oligoneuron album	Upland White Goldenrod	X	X	moisture tolerance if well-drained
Oligoneuron rigidum	Stiff Goldenrod	X	X	
Onosmodium virginianum	Wild Job's Tears	X	X	
Packera anonyma	Small's Ragwort	summer preference	X	winter preference
Parthenium integrifolium	Wild Quinine	drought tolerance	X	wet soil tolerance
Penstemon australis	Southern Beardtongue**	X		
Penstemon laevigatus	Eastern Smooth Beardtongue		some dry tolerance	X
Phlox pilosa	Prairie Phlox		tolerance with mulch	X
Physostegia virginiana	Obedient Plant		X	aggressive tendency

Pycnanthemum tenuifolium	Narrow-leaf Mountain Mint	drought tolerance	X	wet soil tolerance
Ratibida pinnata	Grey Headed Coneflower	adaptable	X	moist soil tolerance
Rudbeckia fulgida	Orange Coneflower	tolerance once established		X
Ruellia caroliniensis	Carolina Wild Petunia	X	X	X
Rudbeckia hirta	Black-eyed Susan	drought tolerance	X	
Salvia lyrata	Lyreleaf Sage	drought tolerance	X	flooding tolerance
Scutellaria integrifolia	Large Scullcap		some dry tolerance	X
Scutellaria parvula var. Missouriensis	Small Scullcap	X	X	
Senna marilandica	Wild Senna		X	
Silphium astericus	Starry Rosinweed	drought tolerance	X	X
Silphium trifoliatum var. Latifolium	Whorled Rosinweed		X	
Solidago speciosa var. erecta	Showy Goldenrod		some dry tolerance	X
Symphyotrichum dumosum var. dumosum	Bushy Aster		some dry tolerance	X
Symphyotrichum ericoides	Heath Aster	X	X	
Symphyotrichum georgianum	Georgia aster		some dry tolerance	X
Symphyotrichum laeve var. Concinnum	Narrow-leaved Smooth Aster	X	X	
Symphyotrichum laevia	Smooth Blue Aster	tolerance once established	some dry tolerance	X
Tradescantia ohiensis	Ohio Spiderwort		X	X
Vernonia noveboracensis	New York Ironweed		X	flooding tolerance

*Denotes annual species **Denotes short-lived species

GRASSES				
Agrostis perennans	Autumn Bentgrass	X	X	
Andropogon gerardii	Big Bluestem			X
Andropogon ternarius	Splitbeard Bluestem	X	X	
Andropogon virginicus	Broomsedge	X	X	flooding tolerance
Bouteloua curtipendula	Sideoats Grama	X	X	
Danthonia spicata	Poverty Oat Grass	X	X	
Elymus virginicus	Virginia Wildrye		X	X
Eragrostis spectabilis	Purple Lovegrass	X	X	
Panicum anceps	Beaked Panicgrass		X	X
Panicum virgatum	Switchgrass	drought tolerance	X	flooding tolerance
Schizachyrium scoparium	Little Bluestem	X	X	
Sorghastrum nutans	Indian Grass	drought tolerance	X	
Sporobolus heterolepis	Prairie Dropseed	drought tolerance	X	

Southeastern Piedmont Prairie Species: Growth Strategies

SPECIES		GROWTH STRATEGIES		
BOTANICAL NAME	COMMON NAME	COMPETITOR	STRESS-TOLERATOR	RUDERAL
HERBACEOUS PERENNIALS				
Agalinis purpurea	Purple False-Foxglove*			X
Allium cernuum	Nodding Wild Onion		X	X
Amorpha schwerinii	Schwerin's Indigo-bush	X	X	
Antennaria plantaginifolia	Woman's Tobacco/Pussy-toes		X	
Asclepias tuberosa	Butterfly-Weed		X	X
Asclepias verticillata	Whorled Milkweed		X	X
Baptisia australis var. Aberrans	Eastern Prairie Blue Wild Indigo		X	X
Chamaecrista fasciculata	Partridge Pea		X	X
Chrysogonum virginianum	Green-and-Gold			X
Coreopsis grandiflora	Largeflower Tickseed		X	X

Coreopsis verticillata	Threadleaf Coreopsis		X	
Desmodium strictum	Pine Barren Tick Trefoil		X	X
Echinacea laevigata	Smooth Purple Coneflower		X	X
Echinacea simulata	Wavyleaf Purple Coneflower		X	X
Erigeron strigosus	Daisy Fleabane	X		X
Eryngium yuccifolium	Rattlesnake Master		X	X
Eupatorium rotundifolium	Roundleaf Thoroughwort			X
Euthamia graminifolia	Grass-leaved Goldenrod			X
Gaura filipes	Slenderstalk Beeblossom		X	X
Helenium autumnale	Sneezeweed		X	
Helianthus smithii	Smith's sunflower		X	X
Houstonia purpurea	Woodland Bluet		X	
Hypericum sphaerocarpum	Round-fruited St. John's Wort		X	
Lespedeza virginica	Virginia Bush-clover		X	X
Liatris aspera	Rough Blazing Star		X	X
Lotus unifoliolatus var. helleri	Carolina Birdsfoot-trefoil*			X
Oenothera fruticosa	Narrowleaf Evening Primrose			X
Oligoneuron album	Upland White Goldenrod			X
Oligoneuron rigidum	Stiff Goldenrod			X
Onosmodium virginianum	Wild Job's Tears		X	
Packera anonyma	Small's Ragwort		X	
Parthenium integrifolium	Wild Quinine		X	
Penstemon australis	Southern Beardtongue**		X	X
Penstemon laevigatus	Eastern Smooth Beardtongue		X	X
Phlox pilosa	Prairie Phlox	X	X	X
Physostegia virginiana	Obedient Plant	X	X	
Pycnanthemum tenuifolium	Narrow-leaf Mountain Mint	X	X	
Ratibida pinnata	Grey Headed Coneflower		X	X
Rudbeckia fulgida	Orange Coneflower		X	X
Ruellia caroliniensis	Carolina Wild Petunia		X	X
Rudbeckia hirta	Black-eyed Susan		X	X
Salvia lyrata	Lyreleaf Sage		X	X
Scutellaria integrifolia	Large Scullcap			X
Scutellaria parvula var. Missouriensis	Small Scullcap			X
Senna marilandica	Wild Senna	X		X
Silphium asteriscus	Starry Rosinweed	X		X
Silphium trifoliatum var. Latifolium	Whorled Rosinweed	X		X
Solidago speciosa var. erecta	Showy Goldenrod		X	X
Symphyotrichum dumosum var. dumosum	Bushy Aster		X	X
Symphyotrichum ericoides	Heath Aster		X	X
Symphyotrichum georgianum	Georgia aster		X	X
Symphyotrichum laeve var. Concinnum	Narrow-leaved Smooth Aster		X	X
Symphyotrichum laevia	Smooth Blue Aster		X	X
Tradescantia ohiensis	Ohio Spiderwort		X	X
Vernonia noveboracensis	New York Ironweed	X	X	

*Denotes annual species **Denotes short-lived species

GRASSES				
Agrostis perennans	Autumn Bentgrass		X	
Andropogon gerardii	Big Bluestem			
Andropogon ternarius	Splitbeard Bluestem		X	X

Andropogon virginicus	Broomsedge			X
Bouteloua curtipendula	Sideoats Grama		X	
Danthonia spicata	Poverty Oat Grass		X	
Elymus virginicus	Virginia Wildrye			
Eragrostis spectabilis	Purple Lovegrass		X	
Panicum anceps	Beaked Panicgrass		X	
Panicum virgatum	Switchgrass	X	X	
Schizachyrium scoparium	Little Bluestem		X	X
Sorghastrum nutans	Indian Grass	X	X	X
Sporobolus heterolepis	Prairie Dropseed		X	

Southeastern Piedmont Prairie Species: Light Conditions

SPECIES		LIGHT CONDITIONS		
BOTANICAL NAME	COMMON NAME	FULL SUN	SEMI-SHADE	DENSE SHADE
HERBACEOUS PERENNIALS				
Agalinis purpurea	Purple False-Foxglove*	X	X	X
Allium cernuum	Nodding Wild Onion	X		
Amorpha schwerinii	Schwerin's Indigo-bush	X	X	
Antennaria plantaginifolia	Woman's Tobacco/Pussy-toes	X	X	
Asclepias tuberosa	Butterfly-Weed	X		
Asclepias verticillata	Whorled Milkweed	X	X	
Baptisia australis var. Aberrans	Eastern Prairie Blue Wild Indigo	X		
Chamaecrista fasciculata	Partridge Pea	X	X	
Chrysogonum virginianum	Green-and-Gold	consistently moist	X	X
Coreopsis grandiflora	Largeflower Tickseed		X	
Coreopsis verticillata	Threadleaf Coreopsis	X	X	
Desmodium strictum	Pine Barren Tick Trefoil	X	X	X
Echinacea laevigata	Smooth Purple Coneflower	X	X	
Echinacea simulata	Wavyleaf Purple Coneflower	X	X	
Erigeron strigosus	Daisy Fleabane	X	X	
Eryngium yuccifolium	Rattlesnake Master	X		
Eupatorium rotundifolium	Roundleaf Thoroughwort	X		
Euthamia graminifolia	Grass-leaved Goldenrod	X		
Gaura filipes	Slenderstalk Beeblossom	X	X	
Helenium autumnale	Sneezeweed	X	X	
Helianthus smithii	Smith's sunflower	X	X	
Houstonia purpurea	Woodland Bluet	X	X	
Hypericum sphaerocarpum	Round-fruited St. John’s Wort	X	X	
Lespedeza virginica	Virginia Bush-clover		X	X
Liatris aspera	Rough Blazing Star	X	X	
Lotus unifoliolatus var. helleri	Carolina Birdsfoot-trefoil*		X	
Oenothera fruticosa	Narrowleaf Evening Primrose	X	X	
Oligoneuron album	Upland White Goldenrod	X	tolerance	
Oligoneuron rigidum	Stiff Goldenrod	X		
Onosmodium virginianum	Wild Job’s Tears	X		
Packera anonyma	Small’s Ragwort	X	X	
Parthenium integrifolium	Wild Quinine	X	X	
Penstemon australis	Southern Beardtongue**	X	X	
Penstemon laevigatus	Eastern Smooth Beardtongue	X		X
Phlox pilosa	Prairie Phlox	X	X	

Physostegia virginiana	Obedient Plant	X	X	
Pycnanthemum tenuifolium	Narrow-leaf Mountain Mint	X		
Ratibida pinnata	Grey Headed Coneflower	X	X	
Rudbeckia fulgida	Orange Coneflower	X	tolerance	
Ruellia caroliniensis	Carolina Wild Petunia		X	
Rudbeckia hirta	Black-eyed Susan	X	X	
Salvia lyrata	Lyreleaf Sage	X	X	X
Scutellaria integrifolia	Large Scullcap	X		
Scutellaria parvula var. Missouriensis	Small Scullcap	X	X	
Senna marilandica	Wild Senna	X		
Silphium astericus	Starry Rosinweed	X	X	X
Silphium trifoliatum var. Latifolium	Whorled Rosinweed	X		
Solidago speciosa var. erecta	Showy Goldenrod	X		
Symphyotrichum dumosum var. dumosum	Bushy Aster	X		
Symphyotrichum ericoides	Heath Aster	X		
Symphyotrichum georgianum	Georgia aster	X	X	
Symphyotrichum laeve var. Concinnum	Narrow-leaved Smooth Aster	X		
Symphyotrichum laevia	Smooth Blue Aster	X	X	
Tradescantia ohiensis	Ohio Spiderwort	X	X	blooms not as profuse
Vernonia noveboracensis	New York Ironweed	X	X	

*Denotes annual species **Denotes short-lived species

GRASSES				
Agrostis perennans	Autumn Bentgrass	X	X	
Andropogon gerardii	Big Bluestem	X		
Andropogon ternarius	Splitbeard Bluestem	X	X	
Andropogon virginicus	Broomsedge	X	X	
Bouteloua curtipendula	Sideoats Grama	X		
Danthonia spicata	Poverty Oat Grass	X	X	
Elymus virginicus	Virginia Wildrye	X	X	
Eragrostis spectabilis	Purple Lovegrass	X		
Panicum anceps	Beaked Panicgrass	X	X	
Panicum virgatum	Switchgrass	X	plants tend to flop	
Schizachyrium scoparium	Little Bluestem	X		
Sorghastrum nutans	Indian Grass	X		
Sporobolus heterolepis	Prairie Dropseed	X	X	

Southeastern Piedmont Prairie Species: Height

SPECIES		HEIGHT		
BOTANICAL NAME	COMMON NAME	LOW (6"-18")	MEDIUM (18"- 36")	TALL (36"- 72"+)
HERBACEOUS PERENNIALS				
Agalinis purpurea	Purple False-Foxglove*			X
Allium cernuum	Nodding Wild Onion	X	X	
Amorpha schwerinii	Schwerin's Indigo-bush			X
Antennaria plantaginifolia	Woman's Tobacco/Pussy-toes	X		
Asclepias tuberosa	Butterfly-Weed		X	
Asclepias verticillata	Whorled Milkweed		X	
Baptisia australis var. Aberrans	Eastern Prairie Blue Wild Indigo		X	
Chamaecrista fasciculata	Partridge Pea	X		
Chrysogonum virginianum	Green-and-Gold	X		
Coreopsis grandiflora	Largeflower Tickseed		X	

Coreopsis verticillata	Threadleaf Coreopsis		X	
Desmodium strictum	Pine Barren Tick Trefoil		X	
Echinacea laevigata	Smooth Purple Coneflower		X	
Echinacea simulata	Wavyleaf Purple Coneflower		X	
Erigeron strigosus	Daisy Fleabane		X	
Eryngium yuccifolium	Rattlesnake Master			X
Eupatorium rotundifolium	Roundleaf Thoroughwort		X	
Euthamia graminifolia	Grass-leaved Goldenrod		X	
Gaura filipes	Slenderstalk Beeblossom		X	X
Helenium autumnale	Sneezeweed			X
Helianthus smithii	Smith's sunflower			X
Houstonia purpurea	Woodland Bluet	X		
Hypericum sphaerocarpum	Round-fruited St. John’s Wort		X	
Lespedeza virginica	Virginia Bush-clover			X
Liatris aspera	Rough Blazing Star			X
Lotus unifoliolatus var. helleri	Carolina Birdsfoot-trefoil*		X	
Oenothera fruticosa	Narrowleaf Evening Primrose	X		
Oligoneuron album	Upland White Goldenrod		lower end of range	
Oligoneuron rigidum	Stiff Goldenrod			X
Onosmodium virginianum	Wild Job’s Tears		lower end of range	
Packera anonyma	Small’s Ragwort		lower end of range	
Parthenium integrifolium	Wild Quinine		X	
Penstemon australis	Southern Beardtongue**		X	
Penstemon laevigatus	Eastern Smooth Beardtongue		X	
Phlox pilosa	Prairie Phlox		X	
Physostegia virginiana	Obedient Plant			lower end of range
Pycnanthemum tenuifolium	Narrow-leaf Mountain Mint		X	
Ratibida pinnata	Grey Headed Coneflower			X
Rudbeckia fulgida	Orange Coneflower		X	
Ruellia caroliniensis	Carolina Wild Petunia		X	
Rudbeckia hirta	Black-eyed Susan			lower end of range
Salvia lyrata	Lyreleaf Sage	X		
Scutellaria integrifolia	Large Scullcap	X		
Scutellaria parvula var. Missouriensis	Small Scullcap	X		
Senna marilandica	Wild Senna			X
Silphium astericus	Starry Rosinweed		X	X
Silphium trifoliatum var. Latifolium	Whorled Rosinweed			X
Solidago speciosa var. erecta	Showy Goldenrod		X	
Symphyotrichum dumosum var. dumosum	Bushy Aster		X	
Symphyotrichum ericoides	Heath Aster		X	X
Symphyotrichum georgianum	Georgia aster		X	
Symphyotrichum laeve var. Concinnum	Narrow-leaved Smooth Aster		X	
Symphyotrichum laevia	Smooth Blue Aster		X	X
Tradescantia ohiensis	Ohio Spiderwort		X	
Vernonia noveboracensis	New York Ironweed			X

*Denotes annual species **Denotes short-lived species

GRASSES				
Agrostis perennans	Autumn Bentgrass		X	
Andropogon gerardii	Big Bluestem			X
Andropogon ternarius	Splitbeard Bluestem		X	
Andropogon virginicus	Broomsedge			lower end of range
Bouteloua curtipendula	Sideoats Grama	X		
Danthonia spicata	Poverty Oat Grass	X		
Elymus virginicus	Virginia Wildrye			lower end of range
Eragrostis spectabilis	Purple Lovegrass	X		
Panicum anceps	Beaked Panicgrass			lower end of

				range
Panicum virgatum	Switchgrass			X
Schizachyrium scoparium	Little Bluestem		X	
Sorghastrum nutans	Indian Grass			X
Sporobolus heterolepis	Prairie Dropseed		X	

Southeastern Piedmont Prairie Species: Layer Classification

SPECIES		LAYER CLASSIFICATION		
BOTANICAL NAME	COMMON NAME	GROUND LAYER	MIDDLE CANOPY	UPPER EMERGENT
HERBACEOUS PERENNIALS				
Agalinis purpurea	Purple False-Foxglove*			X
Allium cernuum	Nodding Wild Onion		X	
Amorpha schwerinii	Schwerin's Indigo-bush			X
Antennaria plantaginifolia	Woman's Tobacco/Pussy-toes	X		
Asclepias tuberosa	Butterfly-Weed		X	
Asclepias verticillata	Whorled Milkweed		X	
Baptisia australis var. Aberrans	Eastern Prairie Blue Wild Indigo		X	
Chamaecrista fasciculata	Partridge Pea	X		
Chrysogonum virginianum	Green-and-Gold	X		
Coreopsis grandiflora	Largeflower Tickseed		X	
Coreopsis verticillata	Threadleaf Coreopsis		X	
Desmodium strictum	Pine Barren Tick Trefoil		X	
Echinacea laevigata	Smooth Purple Coneflower		X	
Echinacea simulata	Wavyleaf Purple Coneflower		X	
Erigeron strigosus	Daisy Fleabane		X	
Eryngium yuccifolium	Rattlesnake Master			X
Eupatorium rotundifolium	Roundleaf Thoroughwort		X	
Euthamia graminifolia	Grass-leaved Goldenrod		X	
Gaura filipes	Slenderstalk Beeblossom		X	X
Helenium autumnale	Sneezeweed			
Helianthus smithii	Smith's sunflower			X
Houstonia purpurea	Woodland Bluet	X		
Hypericum sphaerocarpum	Round-fruited St. John's Wort		X	
Lespedeza virginica	Virginia Bush-clover			X
Liatris aspera	Rough Blazing Star			X
Lotus unifoliolatus var. helleri	Carolina Birdsfoot-trefoil*		X	
Oenothera fruticosa	Narrowleaf Evening Primrose	X		
Oligoneuron album	Upland White Goldenrod			
Oligoneuron rigidum	Stiff Goldenrod			X
Onosmodium virginianum	Wild Job's Tears		X	
Packera anonyma	Small's Ragwort		X	
Parthenium integrifolium	Wild Quinine		X	
Penstemon australis	Southern Beardtongue**		X	
Penstemon laevigatus	Eastern Smooth Beardtongue		X	
Phlox pilosa	Prairie Phlox		X	
Physostegia virginiana	Obedient Plant			X
Pycnanthemum tenuifolium	Narrow-leaf Mountain Mint		X	
Ratibida pinnata	Grey Headed Coneflower			X
Rudbeckia fulgida	Orange Coneflower		X	
Ruellia caroliniensis	Carolina Wild Petunia		X	
Rudbeckia hirta	Black-eyed Susan			X
Salvia lyrata	Lyreleaf Sage	X		
Scutellaria integrifolia	Large Scullcap	X		
Scutellaria parvula var. Missouriensis	Small Scullcap	X		
Senna marilandica	Wild Senna			X
Silphium astericus	Starry Rosinweed			

Silphium trifoliatum var. Latifolium	Whorled Rosinweed			X
Solidago speciosa var. erecta	Showy Goldenrod		X	
Symphyotrichum dumosum var. dumosum	Bushy Aster		X	
Symphyotrichum ericoides	Heath Aster		X	
Symphyotrichum georgianum	Georgia aster		X	
Symphyotrichum laeve var. Concinnum	Narrow-leaved Smooth Aster		X	
Symphyotrichum laevia	Smooth Blue Aster		X	
Tradescantia ohiensis	Ohio Spiderwort		X	
Vernonia noveboracensis	New York Ironweed			X

*Denotes annual species **Denotes short-lived species

GRASSES				
Agrostis perennans	Autumn Bentgrass		X	
Andropogon gerardii	Big Bluestem			X
Andropogon ternarius	Splitbeard Bluestem		X	
Andropogon virginicus	Broomsedge			X
Bouteloua curtipendula	Sideoats Grama	X		
Danthonia spicata	Poverty Oat Grass	X		
Elymus virginicus	Virginia Wildrye			X
Eragrostis spectabilis	Purple Lovegrass	X		
Panicum anceps	Beaked Panicgrass			X
Panicum virgatum	Switchgrass			X
Schizachyrium scoparium	Little Bluestem		X	
Sorghastrum nutans	Indian Grass			X
Sporobolus heterolepis	Prairie Dropseed		X	

Southeastern Piedmont Prairie Species: Foliage Form

SPECIES		FOLIAGE FORM					
BOTANICAL NAME	COMMON NAME	PROSTRATE	BASAL	ROSETTE	MOUND	SEMI-ERECT	ERECT
HERBACEOUS PERENNIALS							
Agalinis purpurea	Purple False-Foxglove*	X					X
Allium cernuum	Nodding Wild Onion		X				
Amorpha schwerinii	Schwerin's Indigo-bush					X	
Antennaria plantaginifolia	Woman's Tobacco/Pussy-toes			basal rosette			
Asclepias tuberosa	Butterfly-Weed					X	
Asclepias verticillata	Whorled Milkweed					X	
Baptisia australis var. Aberrans	Eastern Prairie Blue Wild Indigo				X		
Chamaecrista fasciculata	Partridge Pea	X					in flower
Chrysogonum virginianum	Green-and-Gold	spreading					
Coreopsis grandiflora	Largeflower Tickseed				X		in flower
Coreopsis verticillata	Threadleaf Coreopsis				X		X
Desmodium strictum	Pine Barren Ticktrefoil						X
Echinacea laevigata	Smooth Purple Coneflower				X		
Echinacea simulata	Wavyleaf Purple Coneflower				X		
Erigeron strigosus	Daisy Fleabane				X		
Eryngium yuccifolium	Rattlesnake Master			erect rosette			
Eupatorium rotundifolium	Roundleaf Thoroughwort						X
Euthamia graminifolia	Grass-leaved Goldenrod						X
Gaura filipes	Slenderstalk Beeblossum				X		
Helenium autumnale	Sneezeweed				X		in flower
Helianthus smithii	Smith's sunflower					X	
Houstonia purpurea	Woodland Bluet				X		
Hypericum sphaerocarpum	Round-fruited St. John's Wort					X	

Lespedeza virginica	Virginia Bush-clover					X	
Liatris aspera	Rough Blazing Star				X		
Lotus unifoliolatus var. helleri	Carolina Birdsfoot-trefoil*					X	
Oenothera fruticosa	Narrowleaf Evening-primrose			X			in flower
Oligoneuron album	Upland White Goldenrod				X		
Oligoneuron rigidum	Stiff Goldenrod		X				in flower
Onosmodium virginianum	Wild Job's Tears					X	
Packera anonyma	Small's Ragwort		X				in flower
Parthenium integrifolium	Wild Quinine			basal rosette			
Penstemon australis	Southern Beardtongue**			basal rosette			
Penstemon laevigatus	Eastern Smooth Beardtongue			basal rosette			
Phlox pilosa	Prairie Phlox					X	
Physostegia virginiana	Obedient Plant						X
Pycnanthemum tenuifolium	Narrow-leaf Mountain Mint						X
Ratibida pinnata	Grey Headed Coneflower						X
Rudbeckia fulgida	Orange Coneflower			X			
Ruellia caroliniensis	Carolina Wild Petunia						X
Rudbeckia hirta	Black-eyed Susan			basal rosette			in flower
Salvia lyrata	Lyreleaf Sage		X				
Scutellaria integrifolia	Large Scullcap						X
Scutellaria parvula var. Missouriensis	Small Scullcap						X
Senna marilandica	Wild Senna					X	
Silphium astericus	Starry Rosinweed					X	
Silphium trifoliatum var. Latifolium	Whorled Rosinweed		X				
Solidago speciosa var. erecta	Showy Goldenrod		X				
Symphyotrichum dumosum var. dumosum	Bushy Aster					X	
Symphyotrichum ericoides	Heath Aster						X
Symphyotrichum georgianum	Georgia aster						X
Symphyotrichum laeve var. Concinnum	Narrow-leaved Smooth Aster						X
Symphyotrichum laevia	Smooth Blue Aster						X
Tradescantia ohiensis	Ohio Spiderwort				X		
Vernonia noveboracensis	New York Ironweed						X

*Denotes annual species **Denotes short-lived species

GRASSES							
Agrostis perennans	Autumn Bentgrass				rhizomatous		
Andropogon gerardii	Big Bluestem				X		X
Andropogon ternarius	Splitbeard Bluestem				X		X
Andropogon virginicus	Broomsedge				X		X
Bouteloua curtipendula	Sideoats Grama				X		
Danthonia spicata	Poverty Oat Grass				X		
Elymus virginicus	Virginia Wildrye				rhizomatous		X
Eragrostis spectabilis	Purple Lovegrass				rhizomatous		
Panicum anceps	Beaked Panicgrass				rhizomatous		
Panicum virgatum	Switchgrass				X		X
Schizachyrium scoparium	Little Bluestem				X	X	
Sorghastrum nutans	Indian Grass				X		X
Sporobolus heterolepis	Prairie Dropseed				X		

Southeastern Piedmont Prairie Species: Flower Color

SPECIES		FLOWER COLOR
BOTANICAL NAME	COMMON NAME	
HERBACEOUS PERENNIALS		
Agalinis purpurea	Purple False-Foxglove*	pink
Allium cernuum	Nodding Wild Onion	pink/white
Amorpha schwerinii	Schwerin's Indigo-bush	purple
Antennaria plantaginifolia	Woman's Tobacco/Pussy-toes	white
Asclepias tuberosa	Butterfly-Weed	orange/yellow
Asclepias verticillata	Whorled Milkweed	white/green
Baptisia australis var. Aberrans	Eastern Prairie Blue Wild Indigo	blue
Chamaecrista fasciculata	Partridge Pea	yellow
Chrysogonum virginianum	Green-and-Gold	yellow
Coreopsis grandiflora	Largeflower Tickseed	yellow
Coreopsis verticillata	Threadleaf Coreopsis	yellow
Desmodium strictum	Pine Barren Tick Trefoil	purple/lavender
Echinacea laevigata	Smooth Purple Coneflower	pink/purple
Echinacea simulata	Wavyleaf Purple Coneflower	pink/purple
Erigeron strigosus	Daisy Fleabane	white/yellow
Eryngium yuccifolium	Rattlesnake Master	white
Eupatorium rotundifolium	Roundleaf Thoroughwort	white
Euthamia graminifolia	Grass-leaved Goldenrod	yellow
Gaura filipes	Slenderstalk Beeblossom	white
Helenium autumnale	Sneezeweed	yellow
Helianthus smithii	Smith's sunflower	yellow
Houstonia purpurea	Woodland Bluet	lavender/blue
Hypericum sphaerocarpum	Round-fruited St. John's Wort	yellow
Lespedeza virginica	Virginia Bush-clover	purple/lavender
Liatris aspera	Rough Blazing Star	purple/lavender
Lotus unifoliolatus var. helleri	Carolina Birdsfoot-trefoil*	salmon pink
Oenothera fruticosa	Narrowleaf Evening Primrose	yellow
Oligoneuron album	Upland White Goldenrod	white
Oligoneuron rigidum	Stiff Goldenrod	yellow
Onosmodium virginianum	Wild Job's Tears	orange/yellow
Packera anonyma	Small's Ragwort	yellow
Parthenium integrifolium	Wild Quinine	white
Penstemon australis	Southern Beardtongue**	pink/white
Penstemon laevigatus	Eastern Smooth Beardtongue	white
Phlox pilosa	Prairie Phlox	pink
Physostegia virginiana	Obedient Plant	purple/lavender
Pycnanthemum tenuifolium	Narrow-leaf Mountain Mint	white
Ratibida pinnata	Grey Headed Coneflower	yellow
Rudbeckia fulgida	Orange Coneflower	yellow
Ruellia caroliniensis	Carolina Wild Petunia	light purple
Rudbeckia hirta	Black-eyed Susan	yellow
Salvia lyrata	Lyreleaf Sage	lavender
Scutellaria integrifolia	Large Scullcap	blue
Scutellaria parvula var. Missouriensis	Small Scullcap	blue/purple
Senna marilandica	Wild Senna	yellow
Silphium astericus	Starry Rosinweed	yellow
Silphium trifoliatum var. Latifolium	Whorled Rosinweed	yellow
Solidago speciosa var. erecta	Showy Goldenrod	yellow
Symphyotrichum dumosum var. dumosum	Bushy Aster	purple/lavender
Symphyotrichum ericoides	Heath Aster	white
Symphyotrichum georgianum	Georgia aster	blue/purple
Symphyotrichum laeve var. Concinnum	Narrow-leaved Smooth Aster	purple/blue
Symphyotrichum laevia	Smooth Blue Aster	purple/blue

Tradescantia ohiensis	Ohio Spiderwort	blue/purple
Vernonia noveboracensis	New York Ironweed	purple/lavender

*Denotes annual species **Denotes short-lived species

GRASSES		
Agrostis perennans	Autumn Bentgrass	light green/yellow
Andropogon gerardii	Big Bluestem	copper/red
Andropogon ternarius	Splitbeard Bluestem	copper/red
Andropogon virginicus	Broomsedge	bright orange
Bouteloua curtipendula	Sideoats Grama	purple/lavender
Danthonia spicata	Poverty Oat Grass	light green
Elymus virginicus	Virginia Wildrye	blue/green
Eragrostis spectabilis	Purple Lovegrass	red/purple
Panicum anceps	Beaked Panicgrass	light green
Panicum virgatum	Switchgrass	red/burgundy
Schizachyrium scoparium	Little Bluestem	purple/bronze
Sorghastrum nutans	Indian Grass	bronze/chestnut
Sporobolus heterolepis	Prairie Dropseed	pink/brown/copper

Southeastern Piedmont Prairie Species: Flowering Duration

SPECIES		FLOWERING DURATION											
BOTANICAL NAME	COMMON NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
HERBACEOUS PERENNIALS													
Agalinis purpurea	Purple False-Foxglove*							■	■	■	■	■	
Allium cernuum	Nodding Wild Onion						■	■	■				
Amorpha schwerinii	Schwerin's Indigo-bush				■	■	■						
Antennaria plantaginifolia	Woman's Tobacco/Pussy-toes					■	■						
Asclepias tuberosa	Butterfly-Weed					■	■	■	■	■			
Asclepias verticillata	Whorled Milkweed					■	■	■	■	■			
Baptisia australis var. Aberrans	Eastern Prairie Blue Wild Indigo					■							
Chamaecrista fasciculata	Partridge Pea						■	■	■	■	■		
Chrysogonum virginianum	Green-and-Gold			■	■								
Coreopsis grandiflora	Largeflower Tickseed					■	■						
Coreopsis verticillata	Threadleaf Coreopsis					■	■	■					
Desmodium strictum	Pine Barren Tick Trefoil							■	■				
Echinacea laevigata	Smooth Purple Coneflower					■	■	■					
Echinacea simulata	Wavyleaf Purple Coneflower						■	■	■				
Erigeron strigosus	Daisy Fleabane				■	■							
Eryngium yuccifolium	Rattlesnake Master					■	■	■	■				
Eupatorium rotundifolium	Roundleaf Thoroughwort							■	■	■	■		
Euthamia graminifolia	Grass-leaved Goldenrod							■	■	■			
Gaura filipes	Slenderstalk Beeblossom						■	■	■	■	■		
Helenium autumnale	Sneezeweed								■	■	■		
Helianthus smithii	Smith's sunflower								■	■	■		

Houstonia purpurea	Woodland Bluet					■	■						
Hypericum sphaerocarpum	Round-fruited St. John's Wort							■	■				
Lespedeza virginica	Virginia Bush-clover							■	■	■			
Liatris aspera	Rough Blazing Star								■	■	■		
Lotus unifoliolatus var. helleri	Carolina Birdsfoot-trefoil*							■	■	■			
Oenothera fruticosa	Narrowleaf Evening Primrose				■	■	■	■	■				
Oligoneuron album	Upland White Goldenrod								■	■	■		
Oligoneuron rigidum	Stiff Goldenrod								■	■			
Onosmodium virginianum	Wild Job's Tears						■	■					
Packera anonyma	Small's Ragwort				■								
Parthenium integrifolium	Wild Quinine					■	■	■	■	■			
Penstemon australis	Southern Beardtongue**					■	■	■					
Penstemon laevigatus	Eastern Smooth Beardtongue					■	■	■					
Phlox pilosa	Prairie Phlox					■	■	■					
Physostegia virginiana	Obedient Plant								■	■	■		
Pycnanthemum tenuifolium	Narrow-leaf Mountain Mint						■	■	■				
Ratibida pinnata	Grey Headed Coneflower						■	■	■				
Rudbeckia fulgida	Orange Coneflower								■	■	■		
Ruellia caroliniensis	Carolina Wild Petunia					■	■	■	■	■			
Rudbeckia hirta	Black-eyed Susan					■	■	■					
Salvia lyrata	Lyreleaf Sage				■	■							
Scutellaria integrifolia	Large Scullcap					■	■	■					
Scutellaria parvula var. Missouriensis	Small Scullcap					■	■	■					
Senna marilandica	Wild Senna							■	■				
Silphium astericus	Starry Rosinweed						■	■	■	■			
Silphium trifoliatum var. Latifolium	Whorled Rosinweed							■	■	■			
Solidago speciosa var. erecta	Showy Goldenrod								■	■	■		
Symphyotrichum dumosum var. dumosum	Bushy Aster								■	■	■	■	
Symphyotrichum ericoides	Heath Aster								■	■	■		
Symphyotrichum georgianum	Georgia aster										■	■	
Symphyotrichum laeve var. Concinnum	Narrow-leaved Smooth Aster									■	■		
Symphyotrichum laevia	Smooth Blue Aster									■	■	■	
Tradescantia ohiensis	Ohio Spiderwort				■	■	■	■					
Vernonia noveboracensis	New York Ironweed							■	■	■			

*Denotes annual species **Denotes short-lived species

GRASSES													
Agrostis perennans	Autumn Bentgrass									■	■		

Andropogon gerardii	Big Bluestem							■	■	■	■		
Andropogon ternarius	Splitbeard Bluestem									■	■		
Andropogon virginicus	Broomsedge									■	■	■	
Bouteloua curtipendula	Sideoats Grama						■	■	■				
Danthonia spicata	Poverty Oat Grass				■	■							
Elymus virginicus	Virginia Wildrye							■	■	■	■		
Eragrostis spectabilis	Purple Lovegrass								■	■	■		
Panicum anceps	Beaked Panicgrass							■	■	■	■		
Panicum virgatum	Switchgrass						■	■	■	■	■		
Schizachyrium scoparium	Little Bluestem								■	■	■		
Sorghastrum nutans	Indian Grass								■	■	■		
Sporobolus heterolepis	Prairie Dropseed								■	■	■		

Southeastern Piedmont Prairie Species: Wildlife Value

SPECIES		WILDLIFE VALUE
BOTANICAL NAME	COMMON NAME	SPECIES SUPPORTED
HERBACEOUS PERENNIALS		
Agalinis purpurea	Purple False-Foxglove*	Common Buckeye (Junonia coenia), Leaf-cutting bees (Megachile spp.), Syrphid flies
Allium cernuum	Nodding Wild Onion	Hairstreak (Theclinae), attracts songbirds and hummingbirds
Amorpha schwerinii	Schwerin's Indigo-bush	Species undefined, known to support bees
Antennaria plantaginifolia	Woman's Tobacco/Pussy-toes	American Lady (Vanessa virginiensis)
Asclepias tuberosa	Butterfly-Weed	Monarch, Gray Hairstreak, Queen, and Milkweed Tussock Moth
Asclepias verticillata	Whorled Milkweed	Monarch, numerous species of bees and butterflies
Baptisia australis var. Aberrans	Eastern Prairie Blue Wild Indigo	Wild Indigo Dustywing
Chamaecrista fasciculata	Partridge Pea	Cloudless Sulphur (Phoebis sennae), Sleepy Orange (Eurema nicippe), seeds consumed by numerous songbirds, quail and wild turkey
Chrysogonum virginianum	Green-and-Gold	Attracts bees and butterflies, seeds eaten by songbirds
Coreopsis grandiflora	Largeflower Tickseed	Attracts bees and butterflies, seeds eaten by songbirds
Coreopsis verticillata	Threadleaf Coreopsis	Seeds eaten by songbirds
Desmodium strictum	Pine Barren Tick Trefoil	Leaf-cutting bees, seeds grazed by large mammals and songbirds
Echinacea laevigata	Smooth Purple Coneflower	Wavy-lined Emerald (Synchlora aerata), attracts bees and butterflies; seeds eaten by songbirds
Echinacea simulata	Wavyleaf Purple Coneflower	Attracts numerous species of bees, butterflies, moths and beetles; seeds grazed by small mammals and songbirds
Erigeron strigosus	Daisy Fleabane	Attracts numerous species of bees, butterflies, wasps, and hummingbirds
Eryngium yuccifolium	Rattlesnake Master	Attracts numerous species of bees, butterflies and wasps
Eupatorium rotundifolium	Roundleaf Thoroughwort	Attracts numerous species of native bees
Euthamia graminifolia	Grass-leaved Goldenrod	Native bees, wasps, butterflies, moths, beetles and pollinating flies; deer and rabbits graze foliage; seeds eaten by songbirds
Gaura filipes	Slenderstalk Beeblossom	Attracts numerous species of bees and butterflies
Helenium autumnale	Sneezeweed	Attracts bees and butterflies
Helianthus smithii	Smith's sunflower	Species undefined
Houstonia purpurea	Woodland Bluet	Species undefined
Hypericum sphaerocarpum	Round-fruited St. John's Wort	Gray Hairstreak (Strymon melinus), Gray Half-Spot (Nedra ramosula), Long-tongued bees, Sweat bees, Syrphid flies
Lespedeza virginica	Virginia Bush-clover	Eastern Tailed-Blue (Everes comyntas); seeds important food source for bobwhite quail
Liatris aspera	Rough Blazing Star	Tiger Swallowtail, Clouded Sulphur, Orange Sulphur, Gray Hairstreak, Aphrodite Fritillary, Painted Lady, Red Admiral, Wood Nymph
Lotus unifoliolatus var. helleri	Carolina Birdsfoot-trefoil*	Species undefined
Oenothera fruticosa	Narrowleaf Evening Primrose	Long-horned bees, Sweat bees; seeds eaten by songbirds

Oligoneuron album	Upland White Goldenrod	Attracts numerous species of bees and butterflies
Oligoneuron rigidum	Stiff Goldenrod	Attracts numerous species of bees and butterflies
Onosmodium virginianum	Wild Job's Tears	Species undefined
Packera anonyma	Small's Ragwort	Cuckoo bees, Halictid bees, Andrenid bees, Syrphid flies, skippers, and beetles
Parthenium integrifolium	Wild Quinine	Sweat bees, little carpenter bees, mining bees, yellow-faced bees, soldier flies, syrphid flies, and tachnid flies
Penstemon australis	Southern Beardtongue**	Mason bees and hummingbirds
Penstemon laevigatus	Eastern Smooth Beardtongue	Common Buckeye (Junonia coenia), attracts numerous species of bees, butterflies and hummingbirds
Phlox pilosa	Prairie Phlox	American Painted Lady, Sulfur, and Swallowtail, numerous species of bees including bumblebees, little carpenter bees, cuckoo bees
Physostegia virginiana	Obedient Plant	Attracts numerous species of bees, butterflies and hummingbirds
Pycnanthemum tenuifolium	Narrow-leaf Mountain Mint	Wavy-lined Emerald (Synchlora aerata), attracts numerous pollinators, including sweat bees, butterflies, and wasps
Ratibida pinnata	Grey Headed Coneflower	Silvery Checkerspot (Chlosyne nycteis); seeds eaten by American goldfinches
Rudbeckia fulgida	Orange Coneflower	Wavy-lined Emerald (Synchlora aerata) and to Silvery Checkerspot (Chlosyne nycteis); seeds eaten by American goldfinches
Ruellia caroliniensis	Carolina Wild Petunia	Common Buckeye (Junonia coenia)
Rudbeckia hirta	Black-eyed Susan	Wavy-lined Emerald (Synchlora aerata) and to Silvery Checkerspot (Chlosyne nycteis), seeds grazed by American goldfinches
Salvia lyrata	Lyreleaf Sage	Attracts numerous species of bees, butterflies and hummingbirds
Scutellaria integrifolia	Large Scullcap	Gulf fritillary, Spicebush swallowtail and Eastern black swallowtail, attracts numerous species of bees, butterflies, flies and wasps
Scutellaria parvula var. Missouriensis	Small Scullcap	Skullcap Skeletonizer Moth (Prochoreutis inflatella), mason bees, little carpenter bees, sweat bees, leaf beetles, shiny flea beetle
Senna marilandica	Wild Senna	Sleepy Orange (Urema nicippe), Orange-barred Sulfur (Phoebis philea), and Cloudless Sulfur (Phoebis sennae)
Silphium asteriscus	Starry Rosinweed	Attracts numerous species of bees and butterflies; seeds are eaten by songbirds
Silphium trifoliatum var. Latifolium	Whorled Rosinweed	Attracts numerous species of bees and butterflies; seeds are eaten by songbirds
Solidago speciosa var. erecta	Showy Goldenrod	Wavy-lined Emerald (Synchlora aerata)
Symphyotrichum dumosum var. dumosum	Bushy Aster	Numerous miner bee species, plasterer bees
Symphyotrichum ericoides	Heath Aster	Attracts numerous species of bees and butterflies
Symphyotrichum georgianum	Georgia aster	Numerous miner bee species (Andrena (Callandrena s.l.) spp.)
Symphyotrichum laeve var. Concinnum	Narrow-leaved Smooth Aster	Pearl Crescent, numerous miner bee species (Andrena (Callandrena s.l.) spp.); birds and small mammals graze seeds
Symphyotrichum laeve	Smooth Blue Aster	Pearl Crescent, numerous miner bee species (Andrena (Callandrena s.l.) spp.); birds and small mammals graze seeds
Tradescantia ohiensis	Ohio Spiderwort	Attracts numerous species of bees
Vernonia noveboracensis	New York Ironweed	Long-horned bees; seeds eaten by songbirds

*Denotes annual species

**Denotes short-lived species

GRASSES		
Agrostis perennans	Autumn Bentgrass	Species undefined
Andropogon gerardii	Big Bluestem	Common Wood-Nymph (Cercyonis pegala) and various skipper species
Andropogon ternarius	Splitbeard Bluestem	Common Wood-Nymph (Cercyonis pegala), seeds eaten by songbirds and small mammals
Andropogon virginicus	Broomsedge	Common Wood-Nymph (Cercyonis pegala) and various skipper species
Bouteloua curtipendula	Sideoats Grama	Green Skipper butterfly and Dotted Skipper butterfly; provides denning and nesting material; foliage grazed by small mammals
Danthonia spicata	Poverty Oat Grass	Species undefined
Elymus virginicus	Virginia Wildrye	Provides shelter to small mammals and insects, provides denning and nesting material, Branded Skippers and Satyrs
Eragrostis spectabilis	Purple Lovegrass	Panicles used for nesting, support insects, Grass Moth,
Panicum anceps	Beaked Panicgrass	Species undefined
Panicum virgatum	Switchgrass	Common Wood-Nymph (Cercyonis pegala); seeds are eaten by songbirds and small mammals
Schizachyrium scoparium	Little Bluestem	Common Wood-Nymph (Cercyonis pegala)
Sorghastrum nutans	Indian Grass	Pepper-and-Salt Skipper butterfly; seeds eaten by birds and small mammals; food source for various grasshopper species
Sporobolus heterolepis	Prairie Dropseed	Seeds eaten by songbirds; foliage grazed by deer and bison