ROADSIDE LANDSCAPE TYPOLOGIES:

A STUDY FOR SUSTAINABLE GEORGIA HIGHWAYS

by

MATTHEW JOHN QUIREY

(Under the Direction of Brad E. Davis)

ABSTRACT

This thesis defines the way that roadside landscapes can become a model of sustainable landscape design along the highways of the United States. The construction and maintenance of roads and roadsides has been recognized as a cause of habitat fragmentation and pollution. Increasing awareness of these negative effects on the environment has led to the creation of legislation and regulations that encourage environmentally sensitive planning and design, yet few state programs in Georgia exist involving this important public landscape. This study reviews the history of roadside landscape design as it has emerged in American history. Next, a review of selected state DOT programs, projects, and guidelines highlights innovative ideas across the United States. Then, roadside typologies are presented for an 18-mile section of Georgia I-85 highway associated with The Ray. Finally, ecological design recommendations are identified and illustrated for each roadside typology of the study area. These typologies can serve as a useful framework for piedmont roadsides across the Southeast United States.

INDEX WORDS: Landscape Architecture, Highway Design, Roadside Typologies, Sustainable Landscape, Right-Of-Way Vegetation

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MATTHEW JOHN QUIREY

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MATTHEW JOHN QUIREY

Major Professor: Brad E. Davis
Committee: David Nichols
Sonia Altizer
Allie Kelly

Electronic Version Approved:

Ron Walcott
Interim Dean of the Graduate School
The University of Georgia
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DEDICATION

"… A liking for this feature of the human landscape of America (the roadside) should not blind anyone to its frequent depravity and confusion and dirt. Its potentialities for trouble—aesthetic, social, economic—are as great as its potentialities for good, and indeed it is this ambidexterity which gives the highway and its margins so much significance and fascination. But how are we to tame this force unless we understand it and even develop a kind of love for it? We have not really tried to understand it as yet."

– J.B. Jackson, *Landscapes: Selected Writings of J. B. Jackson.*

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CHAPTER 1

INTRODUCTION

1.1 Description of Topic

My interest in roadside landscapes began as a child during annual family summer road trips. From visits to the Four Corners, Bryce Canyon, Arches and Zion National Parks in the west, the boundary waters of Minnesota in the north, the Great Smoky Mountains and Skyline Drive in Appalachia, as well as trips to visit family across the many parts of Texas, I spent many hours driving the interstate highways and smaller roads across the United States. Questions filled my head during those drives. Who designed these roads? Who takes care of them? What is their history? Answering those questions led to this research examination of roadside history.

It soon became obvious that roads are an integral part of our cultural history. The roadside landscapes viewed from those car windows each day are more than just grass or trees beside the highway, and billboards along the path. Roads and their landscapes have played a large role in shaping American life. As historian Hilaire Belloc once said, “The road moves and controls all history” (Raitz 1998, 363). Based on road-effect zones, 15-20% of the United States is ecologically impacted by roads (Forman and Alexander 1998, 207).

For much of the past, roads were simply viewed as a way to get from point A to point B. Since the creation of the Interstate Highway System, the roadside has been a space with various uses, restrictions, and design intents. When examining the historical context of the development of the highway system and adjacent roadsides in the United States, focus has been on the cultural value and assumptions of citizens and leaders. As cultural geographer J.B. Jackson would write, "the American highway landscape harbored enormous and largely uncharted potentialities for good" (Davis 2003, 65). From the founding of the United States, the new country sought to create its method of transportation and communication across the wide passages that composed its borders. From water transport to wagon trains to Pony Express mail delivery to railroads to automobiles, the new country struggled to expand ways to connect people and places. Roads improved from muddy trails to hard surface byways as the country grew, but leaders were more focused on the road surfaces than on the roadsides that accompanied them.

While the history of roadside design goes back to the earliest days of European settlement in North America, for the modern age, The Highway Beautification Act of 1965 ushered in a new focus on the use of roadside as designed space. The national dialogue began to include consideration of aesthetics and the environment. Before this act there were no federal rules regarding how the road and roadside could be designed and used.

Today, current emphasis has changed from a focus on transportation and communication to examining the use of these landscapes with a stronger interest toward ecological impacts, creation of wildlife habitat, and increased human well-being. We no longer consider if we can get to Los Angeles from Chicago safely or that the journey must be made by highway. However, we do consider whether that journey is aesthetically pleasing and environmentally friendly.

Much ecological study has shown us that humans are responsible for the environmental changes through pollution and fragmentation of habitat around us. Roads are a major cause of that habitat loss and degradation. To move forward we must acknowledge that roadside landscapes are an underutilized resource.

While both federal and state agencies have recommendations for improvements, since 1987 only 1% of their budgets has been set aside to do so. As of 1994 only 38 states have program level support for such plans (Roadside Use of Native Plants 2020). With careful analysis, ecological design planning, and thoughtful maintenance practices, roadside landscapes can become a stimulus for broader acceptance of sustainable design in the built environment for today and future generations.

1.2 Methods

This study will review the history of roadside landscape design as it has emerged in American history, tracing the impact of landscape architects in that process. Next, case studies will investigate the programs currently in place and examine successful roadside landscape design projects. Then, it will create typologies for an 18-mile section of Georgia I-85 highway associated with The Ray, a project designed to create a regenerative highway system. Typologies are by definition a classification based on type or category. This study will establish a conceptual framework for each type of landscape in the pilot study area. Finally, it will propose ecologically innovative design recommendations for each roadside typology. This can be used to help guide future highway landscape design by using innovation and best practices to create a safer and more sustainable roadside in Georgia.

1.3 Research Questions

1. What are current examples of ecologically innovative roadside design projects across the US?
2. What are recommendations for the 18-mile section of Georgia I-85 associated with the Ray?

1.4 Limitations

While there are 270,335 miles of highway in Georgia, this study will focus on an 18-mile section of I-85 surrounding The Ray project. The focus of this research is on sustainable roadsides and ecosystem services of landscapes, not public perceptions, or visual analysis of said landscapes.

CHAPTER 2

HISTORY OF ROADS AND ROADSIDES IN AMERICA

2.1 Early History Until 1861

When considering the modern highway, most begin with the Eisenhower years and the important legislation that created the modern interstate highway system. But the history of building roads can be traced back to George Washington and beyond. In Washington's first state of the Union address in 1778 he recommended that Congress "consider the need for facilitating the intercourse between distant parts of our country via due attention to the post office and the post roads" (Sky, 2). The oldest highway in America was a post road trail to deliver mail from New York City to Boston in 1673, eventually to be known as the Boston Post Road. Benjamin Franklin, the nation's first deputy postmaster, established a system of post roads to deliver mail in all thirteen colonies. Post road building would continue until the Revolutionary War (Kaszynski, 12).

The first hard surface road in the country, also the first toll road, was built from Philadelphia to Lancaster, Pennsylvania in 1794 by the Philadelphia and Lancaster Turnpike Company. In fact, in the early 1800s over 175 turnpike companies were created, constructing 3000 miles of road. (Kaszynski, 15). The first significant road was The National Road, also known as the Great National Turnpike. Approved as the first federally assisted highway, once completed it crossed six states: Maryland, Virginia, Pennsylvania, Ohio, Indiana, and Illinois. This act approved by Congress was signed by Benjamin Franklin and Thomas Jefferson. Both approved the act but personally thought there was no constitutional authority to fund such endeavors, opening a discussion into constitutional authority which would continue until 1893 (Sky, 18). This continued discussion led President Madison, in 1816, to recommend a constitutional amendment to give Congress the power to fund and build interstate roads which failed to pass (Williamson, 2).

By 1825 tolls did not cover repairs on the early toll roads, and road building by private companies was abandoned (Kaszynski, 16). In 1830 the invention of the steam engine led to the growth of railroads, thereby changing the means of long-distance transportation (Sky, 151). In 1835 under President Andrew Jackson the authority to administer road funding for the National Road was transferred to states through which it passed and federal appropriations ceased (Sky, ix).

From 1838 to 1893 the federal government had no funding interest in building roads. By 1852 due to political struggles, all construction halted on the National Road (Kaszynski, 15), a fact aided by the growth of railroads from 1850 through the 1890s (Sky, 151). Road usage again came to the attention of leaders in 1857 when Congress passed the Post Office Appropriations Act to offer subsidies for those carrying mail (Kaszynski, 1). This created a private mail system, the most well know being the Pony Express where riders carried mail across long distances until 1861. In 1844 the telegraph was invented, and by 1861 it ruled long distance communication (Kaszynski, 19). In broad terms the history of the road centers on the major factors of communication and commerce. However, the discussion of who should fund and maintain those routes for communication and commerce was the source of frequent and vocal debate. With the ending of the Post Road subsidy in 1861 and the dominance of the telegraph, interest in roads weakened.

2.2 Changing Priorities

The majority of people and the mail traveled by train during the 1860s-70s drastically reducing the interest in roads. In 1889 New Jersey allowed counties to issue bonds for the construction of roads, assessing a third of the cost to adjacent landowners (Kaszynski, 19). This was led in part by the Good Roads Movement to support the growing interest in bicycle riding. In 1892 the League of American Wheelmen petitioned the government for better road conditions for the riding clubs forming in cities (Kaszynski, 19).

The question of who pays for road building and maintenance was settled in March 27, 1893 when a landmark Supreme Court case Mononghela Navigation Company vs. The United States ruled "the power of Congress to regulate commerce carries with it the power over all means and instrumentality by which this commerce is carried on." Up until this point it was unclear if Congress had the power or responsibility to create and maintain roads; this ruling clearly stated that the federal government does indeed have that duty. This was followed in October 3, 1893, when the Agricultural Appropriations Bill included a $10,000 fund to study the feasibility of better roads (Kaszynski, 21).

2.3 The Automobile

Roads would forever gain more importance in 1893 when Frank Duryea drove the first American made automobile in Springfield, Illinois (Kaszynski, 23). Henry Ford built his first experimental car in a workshop behind his home in Detroit in 1896 marketed as Detroit Auto Works. After the formation of the Ford Motor Company, the first Ford car was assembled at the Mack Avenue plant in July 1903. By the early 1900s the automobile age begins (Kaszynski, 26). By 1905 roads and highways had become the dominant form of daily transportation, making roads an important asset of the built environment in America. By 1908 Ford had produced the highly successful Model T. In 1910 the first assembly line plant made it possible for the average family to own a car. From 1913-1920 the number of Americans owning a car grew from 1.3 million cars to 10 million cars. By 1914 automobiles outsold carriages (Jakle, 20).

2.4 Roads Gain Priority

Legislation creating free mail delivery in rural areas began in 1896 which forced even more pressure on existing roads. In 1907 the Supreme Court ruling on Wilson vs. Shaw stated that the constitution does grant Congress the authority to construct interstate roads. This was followed in 1912 by legislation to improve rural roads that would “get the farmers out of the mud” (Weingroff, 2001). By 1913 Congress approved $500,000 to improve postal roads, the largest appropriation in fifty years. In the same year the Lincoln Highway Association was formed to build the first east to west coast highway of over 3300 miles to be financed by private funds. (In 1935 it became US Interstate Highway 30).

Finally, in 1916 President Woodrow Wilson called for the first Federal Aid Road Act to fund grants to states to create and maintain interstate highways (Kaszynski, 53). This was focused on post roads (Sky, 154), forbade toll roads, and instituted the first federal gasoline tax to pay for construction and maintenance, a practice which continues today (Kaszynski, 53). The 1921 Federal Highway Act formally established a system of highways under federal control (Sky, 158), moving maintenance costs to the states (Bugge and Snow, 6).

The Great Depression increased the federal role in road construction through programs under Franklin Roosevelt such as the Civilian Conservation Corps (CCC) and the Public Works Administration (PWA). In 1935 PWA workers built 570,000 miles of rural road. For the first time, the federal government was the main source of funding and labor (Kaszynski, 90). On April 14,1941, Roosevelt appointed the National Interregional Highway Committee to study the possibility of creating a system of highways throughout the country, and they reported their results in January 1944. This report recognized four standards for roads: utility, safety, beauty, and economy (Bugge and Snow, 27). The Federal-Aid Highway Act of 1944 provided for a national system of interstate highways, not to exceed 40,000 miles. However, no funds were appropriated for such a system. Instead a funding formula was established for each state (Williamson, 7).

2.5 The Interstate System

It was during this period that Dwight Eisenhower, a young officer moving equipment across the US for World War II support, expressed his frustration with the quality of roads (Kaszynski, 136). He later stated in 1952 “the obsolescence of the nation’s highway system presents an appalling problem of waste, danger, and death” (Kaszynski, 163). Under his presidency The Federal-Aid Highway Act of 1952 was passed as the first law to allot $25 million for the interstate system on a 50% federal-50% state basis, but he felt it did not go far enough. In 1954 The Federal-Aid Highway bill authorized $175 million for 1956 and for 1957 with a 60-40 funding ratio. However, President Eisenhower would emphasize the importance of highways in a speech to Congress in 1955 in which he said:

> Our unity as a nation is sustained by free communication of thought and by easy transportation of people and goods. The ceaseless flow of information throughout the Republic is matched by individual and commercial movement over a vast system of interconnected highways … Together the uniting forces of communication and transportation systems are dynamic elements in the very name we bear—United States. Without them we would be a mere alliance of separate parts (Eisenhower 1955).

Finally, in 1956 The Federal-Aid Highway and Highway Revenue Act created sufficient funding for the interstate highway system to truly grow. This legislation provided $1 billion for 1957, $1.7 billion for 1958, and $2 billion for 1959 as well as establishing The Highway Trust Fund to provide a financing source for the system. Subsequently, tax revenues from fuel and road taxes have been directed to The Trust. Initial legislation set an expiration date for those funds to be deposited into The Trust in 1972, but later bills continued to extend that date (Williamson, 7-8).

The Federal-Aid Highway Act of 1959 extended the system into Alaska and Hawaii. The 1962 Act created comprehensive, coordinated transportation planning; the 1966 Act required each state to have a highways safety program and changed the name of the governing body to the Federal Highway Transportation Administration (FHWA) under the newly created Department of Transportation. In 1970 the federal share of non-interstate projects increased to 70% and also created the Special Bridge Replacement Program to inventory bridges on the national system, assigning them a priority for replacement (Williamson, 8).

1973 authorized funds to complete the system and to provide funding for bus lanes and highway traffic control devices. Fixed rail transit facilities were also included but funding was from the general fund rather than the trust fund. In 1976 for the first time funds were available for use for resurfacing, restoring, or rehabilitating existing highways. 1982 required emergency relief funds for bridge replacement. By 1987 the Surface Transportation and Uniform Relocation Assistance Act (STURAA) authorized appropriation from the Highway Trust Fund for highway assistance projects. It was vetoed by President Reagan, but the veto was overturned and emergency relief grants to the states increased from $30 million to $100 million as well as allowed a percentage to be used for highway planning (Williamson, 9).

In 1991 the Intermodal Surface Transportation and Equity Act (ISTEA) declared that its appropriations were the last to be used for completion of the interstate system. It also established the Surface Transportation Program which allowed spending on roads and projects many had previously seen as below the federal level of responsibility and allowed states more flexibility in transferring highway funds. 1998 saw the passage of the Transportation Equity Act for the 21st Century (TEA-21). It reauthorized funding streams for the Highway Trust until 2005 to include $218 billion 1998-2003. It also guaranteed each state at least 90.5% of its contribution to the highway trust fund. Perhaps most importantly, it ensured that highways spending is directly proportional to highway revenues. 2005 saw the passage of the Safe, Accountable, Efficient, Transportation Equity Act (SAETA) which extended the guarantees of TEA-21 until 2009. It broadened the state's ability to use toll roads as part of the interstate system (Williamson, 9-10).

While TEA-21 expired officially in 2009, it was extended nine times before the next transportation bill was passed. The Moving Ahead for Progress in the 21st Century (MAP-21) was signed into law in 2012. It provided $105 billion for 2013 and 2014 emphasizing a performance-based system. MAP-21 was followed by the current bill, Fixing America's Surface Transportation (FAST) which became law in 2015 and provides $305 billion in funding until 2020. It was the first transportation bill to provide funding for freight projects (Williamson, 11).

2.6 History of Roads in Georgia

Road building in Georgia began in 1755 while still a British colony by dividing the land area into nine districts and appointing surveyors to lay out and maintain roads which were built by local citizens and supported by local taxation. After the American Revolution more attention was given to the necessity for roads, but they were still built by labor from local citizens with their own tools. Not until 1829 was there general support for the improvement of roads. The state General Assembly appropriated $70,000 for the purchase of 200 slaves for the purpose of building roads. Support for this program waned since it was largely used near larger cities, moving instead to the use of toll roads built by private contractors until the Civil War (GDOT, “The Early Days”).

The first progressive move toward state highways began in 1891 when the state General Assembly authorized county commissioners to levy a two mil tax to buy mules and machinery and to employ labor at regular wages. This system helped to maintain existing roads but did little to build new ones. For Georgia, meaningful change would come from the federal government when the Federal Aid Road Act of 1916 became law as a legacy of the national Good Roads movement that signaled the role the automobile would play in the future. Perhaps the most significant provision of the new law was that no federal money would be distributed to the states except by legislative approval through their respective highway department. Therefore, on August 18, 1919, the General Assembly created the Highway State Highway Board (GDOT, “The Early Years”).

The very first Highway Commissioners were an interesting combination including the Prison Commissioner, the State Geologist, the Dean of the College of Engineering of the State University, and the Professor of Highways Engineering at the Georgia School of Technology. By 1920 the commission had hired a State Highway Engineer, a Chief Draftsman, and three assistant engineers. State funding for the staff was from motor vehicle tag fees. The General Assembly appropriated no funds for road construction, leaving the work of raising the 50-50 match for federal funds to the county whose job it was to build the roads with approval from the State

Engineer and his staff. By 1920 Georgia's share of federal highway funds was $238,000 (GDOT, "The Early Days).

The Highway Department was reorganized in 1937, 1941 and in 1943 when the board was replaced with a State Highway Director and a 12- man commission. By 1950 that organizational structure was replaced with a 3-man board elected by the General Assembly (GDOT, "Some Facts on Georgia Roads"). In 1963, the State Highway board was once again changed to a director and a 10-member board. Finally, in 1972 the Highway Department became the Georgia Department of Transportation (GDOT). Today GDOT is by a 14-person transportation board elected by the General Assembly.

2.7 Highway Beautification

Was the Highway Beautification Act of 1965 the first real look at the roadside from an aesthetic point of view? It could be said it was the first serious look at the national legislative level. However, much earlier projects considered the roadside landscape as part of the design intent. While most were parkways which have limited access as compared to highways, they serve as examples where practical use, natural ecology and aesthetic factors were all considered. Perhaps the earliest example of thoughtful design was the Bronx River Parkway begun in 1907. The Bronx River Commission recognized that the Parkway would have to accommodate traffic but desired that it would do so while it displayed "the principal interesting features without despoiling it … Painstaking attention was paid to the landscaping along the Parkway" (Bronx River Parkway, 2017).

As early as 1926 Massachusetts and Pennsylvania had undertaken highway beautification programs, and in 1931 California set principles for highway beautification (Bugge and Snow, 6-

7). In Georgia, in the early 1930s the Highway Department of Georgia named Landscape Architect Hubert Bond Owens to improve the function and appearance of roadside development projects. These included the removal of illegal signs, planting of trees and grass, and widening shoulders. Mr. Owens stated he was responsible "for enhancement of the overall landscape design of the roadsides and improvement of their scenic quality" (Owens, 4).

In Georgia beautification efforts began in 1928 along selected roadways thanks to the pressure from groups such as Garden Clubs, United Daughters of the Confederacy, Daughters of the American Revolution, Federation of Women's Clubs, and the Georgia Automobile Association. The Landscaping Office was created in 1945 to supervise design construction and maintenance to include planting trees and grasses and fertilizing slopes to prevent erosion. In 1966 a Landscape Design Section was added employing three landscape architects and a draftsman. In 1974, Rosalind Carter along with the Garden Clubs of America established the Wildflower Program which planted 10,000 miles of roadways by 1994 (GDOT, Timeline).

2.8 The Role of Landscape Architects

How did landscape architects fit into this discussion of roadside landscapes? Reviewing the journal Landscape Architecture revealed that many prominent landscape architects weighed in on roadside design in the early years of highway design in America. In April 1924, Jens Jensen published an article entitled "Roadside Planting" and argued:

> All roadside plantings should be determined based on the country and its native vegetation through which the road lines its way. In this way the roadside planting will become a part of the general landscape and enhance the beauty of its surroundings as far as this is possible for a highway to do. A period of great cultural advancement is always measured by the vision and the outlook for the future. Roadside plantings belong to such a period. It is pioneer work with us, but it is a part and a very important part of a great cultural movement of our people (Jensen, 187).

In April 1930, J.P. Hillsbury wrote an article entitled “Highway Plantings” focused on “the present widespread interest in highway beautification” advocating for a systematic statewide approach to highway plantings. In July 1930, Frederick Law Olmsted (celebrating the 20th anniversary of the journal) in his summary of the developing profession included “designing and building of roads” in the list of activities in which landscape architects are involved (Olmsted, 287). In that same July 1930 piece, Warren Manning wrote, “America is just waking up to the importance of making its travel ways avenues of beauty” (Manning, 323). And in January 1931, Frank Waugh wrote “Ecology of Roadsides”, a twelve-page article with photos and diagrams (Waugh, Ecology, 81).

Given the importance of ecology and its role in landscape architecture, in April 1931, Waugh returned with “Natural Plant Groups” (Waugh, 169). P.H. Elwood Jr., Iowa State College, wrote a five-page article “Planning Highway Landscapes” stating “we are rapidly becoming a nation known for its fine highways.” Calling for intelligent study he adds, “Much study is involved the proper planning of the most appropriate, attractive and permanently valuable planting. No set plan or pattern works if our highways are to be really in harmony with the surrounding landscape” (Elwood, 180).

Then there is a twenty-six-year gap in articles written in the journal until October 1957, when a three-page article entitled “Highway Aesthetics” appears by Newton B. Drury. In it he focuses on roadsides within the National Park Service but generally states that “highway aesthetics cannot be achieved to its fullest extent without adequate space or land upon which to develop an ultimate goal. Fullest consideration must therefore be given to the acquiring of sufficient right-of-ways…” (Drury, 31).

In the spring of 1960, an ASLA report “Delays and Expansion-The interstate Highway Program” was published in the journal. Interestingly, it recommends well designed plantings for interchanges, contouring/grading plans, planting design for medians, maintenance, and training for the landscape architect to place him or herself in positions of technical leadership. All of those issues and concerns continue today in the discussion about landscape architects and highway planning. Discussions in the past centered more on aesthetics related to billboards and wayside development but did consider ecological and sustainable roadside plantings as well (170).

Frank Waugh was indeed ahead of his time and visionary in seeing the issues to be faced when he wrote in 1931:

> Now the LA is very especially interested in roads, trails, paths, and their bordering plantations. He is forever making roads and paths. Either these are designed purposefully to illustrate the beauty of existing plant groups or the plantings are subsequent to the road and our design with direct reference to the aspect which they present not toward those that use the road. In either case the relation between the roadway and the plantings is vital and must engage the LA most thoughtful consideration. Yet the point seems to be often overlooked that the roadway itself becomes an ecological agent to a very important degree (Waugh, Ecology, 92).

CHAPTER 3

ROADS AND THE ENVIRONMENT

3.1 Introduction

As sources of transportation, roads are a critical part of our national culture. But roads and surrounding roadsides are much more than a way to get from point A to point B. With over 4 million miles of paved roadways and associated roadsides in the US, "it is important to view them as sustainable places rather than leftover spaces" (NRC, 2005). Roadsides, the area adjacent to roads, make up 45% of this total (Forman, 2004). The roadside connects the roadway to the surrounding environment and has an important role in protecting the larger ecosystem ("An integrated Approach, ix). As J. Baird Callicot, environmental ethicist, has stated:

> When Aldo Leopold formulated his now famous land ethic half a century ago, few people realized the utility, beauty, and intrinsic value of roadsides. Economics controlled the use and management of roadsides with little attention to the roadside environment. The time has come for us to recognize that the land ethic applies to our roadsides no less than to our wilderness areas.

Considering roadsides as valuable space includes both aesthetic and environmental considerations. Sustainable and aesthetically pleasing roadsides not only take into account the preservation of the natural environment but also the economic and social needs of stakeholders (Texas DOT, 2009). Roadsides must be utilized for the most positive effect on the environment and the economy. They are in fact an important factor in the nation's biological heritage. By definition they are not wilderness or wildlife areas. However, in many places, they remain the only safe harbor for many native plants and songbirds.

3.2 Habitat Fragmentation

The largest single threat to biological diversity worldwide is the outright destruction of habitat, along with habitat alteration and fragmentation of large habitats into smaller patches (Meffe et al. 1997). While any change in land use can create fragmentation, roads are a major contributor to such habitat fragmentation because “they divide large landscapes into smaller patches and convert interior habitat into edge habitat” (Watson, 3). While roadside ecosystems provide habitat for native wildlife (McCleery et al. 2015), refuge for rare native plants (Forman et al. 2003, Forman and McDonald 2007, Brown and Sawyer 2012), and create buffer zones between developed areas and sensitive ecosystems like wetlands by filtering pollutants from stormwater runoff (Rammohan 2006), roads and roadway activities are also a major cause of landscape fragmentation, habitat loss, and non-point source pollutants (US EPA 1990, Laurance et al, 2014). By fragmenting natural areas, wildlife populations are limited in their ability to move from one area to another (Burgess and Sharpe, 1984). In effect, the road creates a barrier. As dispersal corridors for plants, invasive species are more easily dispersed than natives (Bernes et al., 2017).

Today ecological study has shown us that humans are responsible for the environmental changes through pollution and degradation/fragmentation of habitat around us. Much research focuses on the road effect zone - the area from the edge of the road over which ecological changes can be detected (Forman and Alexander, 207). Obviously, this is the area where roadside plantings largely reside and allow the road to be a primary agent for ecological change as described by Waugh in 1931.

3.3 Habitat Restoration

Today many roadsides are "undermanaged, underutilized, and undervalued for their ecological functions" (Wiggington and Meyerson, 2016). In fact, animal and plant populations along roadsides are highly dependent on how the roadside is managed (Forman, 1998). While studies show that vegetation is the most critical factor influencing erosion and filters chemical pollutants and sediments (Forman et al. 2003), vegetation management along roadsides most often consisted of mowing and spraying with herbicides. Fortunately, increased emphasis on the ecological impacts of those practices has begun to be re-evaluated by state DOTs. For example, studies have shown that management practices that limited and/or timed mowing successfully increased beneficial species (Wojcik and Buchmann, 2012).

The ecological implications of roadside plantings began to receive national attention through a framework designed by the state of Iowa in 1988 known as Integrated Roadside Vegetation Management (IRVM). It is designed to encourage stable self-sustaining vegetation with limited use of mowing and herbicides. It is achieved through techniques encouraging self-sustaining native plant communities that naturally discourage the establishment of unwanted plant species and begins with good soils management, planting design, and revegetation (Chapter 9, 2017). These practices increase the beauty, utility, and economy of the roadside. With sustainable integrated management strategies, roadsides can create habitat, lower management costs, and reduce fragmentation (Wiggington and Meyerson, 2016).

Other federal programs called for better management of roadside vegetation. For example, the Surface Transportation and Uniform Relocation Assistance Act (STURAA) in 1987 required that 1% of the landscape budget for a federally funded highway be devoted to planting native wildflowers. In 1999 President Clinton signed an Executive Order on invasive plants that focused on prevention and control as well as follow up with native species.

3.4 Pollinator Habitat

Additionally, roadside plantings can serve as a resource to increase pollinator habitat that is critical to our food supply and to the health of ecosystems. Yet globally pollinators are declining largely due to habitat loss. Honey bee populations have declined by as much as 29% annually in recent years. Native bees have shared similar losses of 25% (Hatfield et al, 2014). With as much as 85% of all flowering plants dependent on pollination for survival, it is critical that steps be taken to help reverse the decline in pollinator populations (Ollerton et al. 2011). Additionally, pollinators are estimated to provide as much as $27 billion in crop pollination services in the U.S. each year or about one-in-three mouthfuls of food and drink that we consume (Farmers Can “Bee” a Friend to Pollinators, 2018).

By increasing native species planted along roadsides, bee communities have shown to benefit from increased habitat (Hopwood, 2008). The Federal Highway Administration has recognized the need to manage roadsides with pollinator friendly plantings. This includes protecting existing habitat by limiting mowing and herbicide application as well as planting programs to extend or introduce habitat with native species (Pollinators and Roadsides, 1-3).

3.5 Carbon Sequestration

Global climate change is an environmental issue faced around the world. Most scientists believe that its primary cause is the increasing amounts of carbon dioxide (CO2) and other greenhouse gases (GHGs) emitted into the atmosphere, which trap heat and lead to a rise in the earth's surface temperatures. The main human activity that produces CO_2 is the combustion of fossil fuels primarily through transportation. Therefore, transportation corridors are being considered by using right-of-ways (ROWs) for carbon sequestration, that is reducing the carbon footprint with roadside planting. A 2013 study by the Western Transportation Institute at Montana State University found that eight federal land management agencies collectively manage over 300,000 miles of roadway and had the potential to capture and store 8 million metric tons of carbon annually (Ament, Robert et al.,2013). The Federal Highway Administration has determined that there are 5 million acres of right-of-way managed along 163,000 miles of roadways nationwide. These lands store an estimated 100 million tons of carbon at 4 million tons per year. While this is a naturally occurring process, management of these lands have the potential to increase and accelerate carbon sequestration and thereby address climate change (Romig et al.,78).

3.6 Resilient Roadsides

Roadsides can be created as not only sustainable but resilient. The concept of resiliency in landscape was first used by ecologist Aldo Leopold in 1949 when he said, “Land health is the capacity for self-renewal in the soils, waters, plants, and animals that collectively comprise the land. Conservation is our effort to understand and preserve this capacity” (Leopold, 1949). In view of the ecological threats inherent in landscape design, it is important to focus on creating designs that are robust enough to persist and adapt in areas where ecological change is certain to happen. Choosing roadside plantings that are sustainable and resilient plans appropriately for the future of climate change.

CHAPTER 4

SELECTED INNOVATIVE ROADSIDES LANDSCAPE PROJECTS

4.1 Introduction

Roadsides can be productive ecologically as discussed above as well as productive and economically beneficial. Numerous states are conducting research projects that highlight this as summarized in the innovative projects below.

4.2 Projects Centered on Biofuel Production

North Carolina—2010 Biofuel Roadside Planting Program

The aim of this program is to use roadside areas to produce biofuels that will run their fleet of vehicles. Beginning in 2009, researchers planted four canola crops in fall 2009, in Duplin, Wake, Rutherford and Surry counties. After those crops were harvested in spring 2010, sunflowers were planted in Rutherford and Surry counties, and safflowers in Wake and Duplin Counties. Those harvests took place in fall 2010. Results showed the first year was a success. A total of 108 gallons of oil were processed from 2,900 pounds of plot-grown canola, similar to agricultural settings with canola as the best result. Sunflower performance was marginal. The cost to produce the crops was very similar to agriculture production, but it helps the state save money in a number of ways, from lowering mowing costs to reducing the need to import biodiesel from other states. It also helps beautify the state's highways system.

Since 2006 by using biofuels, the department of transportation estimates they have saved four million gallons of fossil fuel. (Hilton, 1-3). Based on GIS analysis, North Carolina has identified 14,962 miles of eligible right-of-way suitable for this program (BAE, 2011).

Utah—Freeways to Fuel

This program proposed developing sustainable crops to allow biofuel feedstock production on non-traditional lands. Canola and Safflower plots were established in 2007 and 2008 along four corridors of Utah I-15. Due to harsh climate of above average temperatures and below average precipitation, no measurable yield was observed in control plots. Therefore, oilseed crops along these roadsides was not economical and the program was discontinued (Whitesides and Hanks, 2011).

Illinois—New Bioways for Highways

This program proposes roadside harvesting of biomass from three native species: Kanlow switchgrass, Illinois big bluestem, and Rumsey Indiangrass beginning with a 10-acre test plot in Madison County. This biomass would then be pelletized to provide heat for Illinois Department of Transportation garages and the biomass boiler at the University of Illinois Energy Farm. They estimate $2 million could be generated from mowing Illinois roadsides and harvesting the biomass for biofuel production (Illinois, 2017).

Nevada—Gumweed to Bio-crude

Begun in 2017 with a $500,000 grant from the US Department of Agriculture, this project studies Curly top gumweed which grows native on Nevada's right-of-ways and does not compete with land used for crops for animal feed or ethanol. Because it grows in arid conditions it is an attractive option in biofuel production.

The plant is a biennial and produces the thick hydrocarbon emulsion just prior to flowering on the second year of growth. It is deep rooted, and amenable to capturing water that has penetrated deeply into the ground. Harvested twice a year, potential roadsides could produce up to 200 gallons per acre (Improving production, 2019).

4.3 Projects Centered on Solar Production

Massachusetts—Renewable Roadsides

This program involves the installation of solar panels on right-of-ways to produce electric power for roadside operations. Begun in 2013, it is a public-private partnership between Massachusetts Department of Transportation and Amerseco, a publicly traded energy utility responsible for the construction, operation, and maintenance of the sites. 60 potential sites were identified. Ameresco will lease the publicly owned land from MDOT which produces $100,000 in income for the state. MDOT has contracted to buy all the generated electricity at a specially negotiated rate that allows them to export excess energy back into the grid.

The first phase of the project came online and began producing power in April of 2015. The first sites to go live were adjacent to stretches of the Massachusetts turnpike, or I-90, in Framingham and Natick. Those four sites are already producing over 2 million kilowatt-hours (kWh) of electricity, which is enough to power almost 500 homes. They are also reducing the state's annual carbon emissions by two million pounds. The next group of installations went online by the end of 2015 and doubled the amount of solar energy that the state was able to produce. Most of the new solar farms line the far western end of I-90, but one of the largest of the projects is planned for an area off I-95 in Salisbury.

By 2018 eight developed sites had produced 10,750 megawatt hours of electricity to save the state more than $1 million. Over 20 years the state estimates a savings of $15 million (MacCormack, 2015).

Maryland—DOT-wide Solar Program

In 2018 Maryland DOT announced plans for 35 solar sites on right-of-ways within 18 months. Just as with Massachusetts, this will be a public-private partnership where a private contractor will lease land from the state and be responsible for the construction and maintenance of the sites. The initial contract will be for 5 years. The state will agree to purchase all electricity produced at a negotiated rate. They project electricity cost savings of 30-40% with the sites producing 46,000 megawatt hours per year (Hodges and Plovnik, 2019).

Oregon—Solar Highway

On December 19, 2008, the nation's first solar highway project started feeding clean, renewable energy into the electricity grid on December 19, 2008. The 104-kilowatt (dc) ground-mounted solar array, made up of 594 solar panels, is situated at the interchange of Interstate 5 and Interstate 205 south of Portland, Oregon, and offsets over one-third of the energy needed for freeway illumination at the site. The project is a public-private partnership between ODOT and Portland General Electric. The project sits on the ROW but is owned by Portland General Electric who built and operates the facility. Solar energy produced feeds into the grid during the day and lights the interchanges at night through a Solar Power Purchase Agreement.

The Blalock Solar Station, a second installation was completed on January 17, 2012 Adjacent to farm fields and a safety rest area. It is a1.75dc Megawatt solar array at the French Prairie Safety Rest Area, south of Wilsonville on Interstate 5 in unincorporated Clackamas County. The rest area is about 7miles south of the Demonstration Project on Interstate 5. The 6,994-panel array sits on seven acres of ODOT property, producing approximately 1.97 million kilowatt-hours of clean, renewable energy annually (Oregon Solar Highway Program 2011).

4.4 Projects Centered on Carbon Sequestration

New Mexico—Slowing Climate Change

This project began in 2011 to evaluate the potential to increase carbon sequestration along right-of-ways by managing vegetation. After identifying the amounts of carbon present in 8 sites, researchers were able to determine that small increases in grass production produced a significant increase in carbon sequestration. By planting specific nitrogen rich species, by raising the height of mowers, and by using soil imprinting vegetation appears to have increased carbon sequestration potential (Romig et al, 78).

4.5 Projects Centered on Habitat Restoration

Iowa—Set the table for monarchs

Realizing that vegetation management practices were not healthy for the monarchs passing through their state, the staff at the University of Northern Iowa's Tallgrass Prairie Center began propagating milkweed and collecting its seed for planting along Iowa's highways. In cooperation with the state DOT and the Monarch Joint Venture biologists, the center began providing seed, assistance, and training in 1989. Since then 78 counties in Iowa and surrounding states have helped restore 10,000 acres of roadside to natural vegetation (Galea et al, 2016).

Illinois DOT

Recognizing the monarch butterfly is at risk of being declared endangered, with a population that has declined by 80 percent over the last 10 years, the state of Illinois DOT has initiated new mowing standards beginning in May 2017. Roadsides will only be mowed 15 feet from the roadway in order to protect milkweed which is the primary food source for monarch caterpillars.

Monarch Highway

This is a collaborative project by six states along the I-35 corridor which serves as the central flyway for monarch migration: Minnesota, Iowa, Missouri, Kansas, and Texas. The project aims to promote awareness of monarchs and other pollinators and assist individual state efforts to enhance vegetation management practices. Such practices include promoting habitat in their rights of way by undertaking studies on the quality of habitat and presence of pollinators in their roadsides, updating signage, educating the public through rest area demonstration gardens, planting milkweed (for monarch breeding) and wildflowers (for feeding), and participating in their respective state pollinator conservation plans.

Ohio—Pollinator Habitat Initiative (OPHI)

Begun in 2016, OPHI recognizes that bees and other pollinators are critical to maintaining vegetation communities that provide food and shelter for humans and wildlife.

When considering the need to slow the decline of pollinators, Ohio DOT recognized roadsides had the potential to convert low-diversity, frequently mowed areas dominated by cool-season grasses to high-diversity wildflower and grass habitats that provide much needed foraging, breeding, and nesting habitat for pollinators. They did a statewide analysis using GIS data of existing right-of-ways identifying characteristics suitable for pollinator habitat, such as sun exposure, typography, and soil composition. Seed mixes and plant selection were carefully evaluated, and sites were prepared considering maintenance requirements. Mowing schedules and limited herbicide use were also planned based on life cycles and nesting seasons.

Careful evaluation of the program is ongoing for three years in order to document the success and/or impact in reaching the goals of the project "to develop a statewide initiative to protect pollinators by establishing and maintaining pollinator habitat along roadways within ODOT rights-of-way (ROWs) throughout the state" (ODOT Statewide Pollinator Habitat Program Restoration Guide, 2016).

CHAPTER 5

SITE ANALYSIS OF THE RAY AND PROPOSED LANDSCAPE TYPOLOGIES

5.1 Ray History and Current Programs

This project began in July 2014 when Georgia named the portion of highway I-85 between exits 2 and 18 in western Georgia (Figure 1) after Ray C. Anderson (1934-2011), chairman of Interface® and a national spokesman for industrial sustainability. His continuing quest was "What is your company doing for the environment?" Upon his death, his family formed a foundation to honor his memory. That foundation created The Ray as an independent, non-profit to turn this section of highway into a global model for safe, sustainable, and regenerative transportation. The work began with a $2.5 million grant and continues today with an additional $2 million in funding for transportation projects designed to reduce pollution, generate resources, restore ecosystems and habitat, and to empower all to a symbiotic relationship with the environment (The Ray.org)

In partnership with GDOT, FHWA, Georgia Public Service (GPS), Georgia Power Commission (GPC), Hannah Solar, KIA, and the University of Georgia (UGA), The Ray is implementing the following projects:

<u>Solar Panels</u>

In August 2018 Georgia will be the third state in the nation to utilize the grassy shoulder of an interstate highway, called the right-of-way (ROW), to generate solar energy. This unique project will pilot the use of native flowering plants as ground cover in test plots within the solar array, making Georgia the first in the nation to pilot pollinator-friendly, right-of-way solar. Power produced will provide electricity.

Solar Highway

At the West Point Visitor Information Center, the Ray is starting with Wattway, approximately 538 square feet of solar panels laid down on the road's surface. Durable enough to withstand the traffic from tens of thousands of vehicles a year, the photovoltaic pavers are thin and skid-resistant, and can be installed over existing pavement, so there is no need to tear up roads. Wattway provides electricity to the visitor center but has the potential to feed it back to the grid or to other sources.

Solar powered car charging stations

At the Visitor center welcoming visitors as they enter Georgia from Alabama, there are charging stations for electric vehicles, sponsored by Kia Motors, which has a manufacturing plant in nearby West Point. The stations are currently powered by pole-mounted photovoltaic solar panels, and vehicle owners can power up their electric cars free of charge.

Exit 6-Land Laboratory

1. A perennial Wheat (Kernza) has been planted to test for its use in soil retention and carbon sequestration. Using a 900 square feet test plot, The Ray is partnering with the Land Institute in Salina, Kansas and the University of Georgia College of Environmental Design (UGA CED) to experiment with this perennial wheat grass to determine its suitability in the SE and the highways' right-of-way.
2. Piedmont prairie flowering meadow research using native perennials of the SE is a series of test plots to determine establishment methods without irrigation, soil

amendments, or similar inputs. The goal is to establish a protocol that can be scaled using existing GDOT protocols and contractors.

3. Slope stabilization - Projects involve hydro seeding of native plants on steep bare slopes. The goal is to highlight nontraditional native plants that are appropriate for this common roadside typology.
4. Pollinator Garden - In conjunction with the Chattahoochee Nature Center, Georgia Conservancy, Kia Motors and GDOT, in 2016 The Ray installed a 7,000 square foot pollinator garden at the Georgia Visitor Center at The Ray. The first of its kind at any Georgia DOT facility, the pollinator garden is a perfect habitat for honeybees and butterflies. It also helps to show visitors what's possible when highways are reimagined in a way that is more sustainable and healthier for all species.
5. Bioswales - The most effective way of trapping the largest variety of pollutants, bioswales are shallow drainage ditches filled with vegetation or compost, commonly switchgrass, to create a flow path to slow water movement during rainstorms. This design helps deposit silt and capture particulate pollutants, including heavy metals, rubber, and oil. In 2016 The Ray partnered with Georgia DOT and their roadside maintenance staff, contractors, and landscape architects to determine the optimal number, size, and placement of bioswales needed on this stretch of highway. The goal is to successfully clean water runoff and mitigate pollution, all with native Georgia plant species.

Figure 1 Map of The Ray (The Ray 2020)

Piedmont Prairie Wildflower Meadow Research

For the past five years Professor Brad Davis, UGA CED has been researching the establishment of Piedmont prairie wildflower meadows by seeding. This installation method shows promise in roadside landscapes and other challenging areas limited by lack of irrigation and budgetary constraints. Wildflower meadows have long been desired for their aesthetic and ecological benefits but are often expensive and time consuming to establish and maintain. This is because they are most often planted with plugs or whole plants which are expensive to purchase and laborious to install and establish. Similar to other landscape plantings with an environmental focus i.e. rain gardens, bioswales, etc., another challenge is perception and lack of public acceptance of the plantings as they are often seen as weedy, ugly or an eyesore. The ecological benefit and intentional design is often not understood by the general public which leads to their removal.

In the spring of 2015 Professor Davis working with graduate student Sean Dunlap started a pilot study of Piedmont prairie perennial wildflower meadows at the UGArden in Athens, Ga. Two custom seed mixes were tested with two different installation methods and maintenance practices. Seed mixes can be found in Appendix A and B. Installation methods included seeding onto bare Georgia clay or seeding into a layer of granite fines. Management practices compared were of mowing versus burning annually. The research methods were tested in 24 8'x8' plots. This work is a modification and replication of the research of Prof. James Hitchmough at the University of Sheffield UK. His many years of research culminated in the book Sowing Beauty and led Prof. Davis and his graduate students to test those ideas in the state of Georgia.

Prof Hitchmough often used perennial flowers from the SE United States along with others that are found in arid locations across the world. Hitchmough's approach is also different from others in its concept of the meadow having "flower power" and the recognition that the general public responds more positively to the flowering aspect of the meadow versus the tall grassy aspect of the meadow. Most wildflower mixes are comprised of grasses and forbes (flowering plants) with an 80% grass to 20% forbes composition. Hitchmough reverses that percentage with 80% forbes and 20% grasses with the goal of having flowering plants for as long as possible throughout the growing season. This is done by selecting species that flower early, middle, and late in the growing season and making sure the mix contains species that are low growing (0-12 inches), medium (12-24 inches) and tall (24 +). His primary method of installation is direct sowing a custom seed mix into a layer of coarse sand or a layer of granite fines. This allows the wildflowers time to establish themselves while the layer of sand acts as a weed barrier to the undesirable plants that would re-establish themselves in bare soil (Hitchmough, 2017).

With positive results from the initial planting at the UGArden Prof. Davis working with graduate student Matthew Quirey expanded the study to a 1.8-acre planting at The Ray in partnership with GDOT and The Georgia Garden Club. The 1.8-acre planting is located at Exit 6 on I-85 in SW Georgia. There are three different plots of 1.0-acre, 0.6-acres, and 0.2-acres. A custom UGA mix was sourced from two seed companies and tested alongside a GDOT mix. These mixes are identified in Appendix C. The 0.2-acre plot was given a treatment of two inches of granite fines in half of the site. Three different seed mixes were then evenly planted, half on granite fines and half on bare Georgia clay in January 2020. This site will be monitored for the next three growing seasons. The next phase will test the same maintenance ideas from the UGArden and Hitchmough with the hope of expanding plantings along Georgia highways.

This meadow research aims to showcase the many native flowering perennial plants of the SE to improve the aesthetic, ecological and financial sustainability of Georgia highways. Georgia is home to some of the most diverse plant communities in North America. A long growing season and steady rainfall allow them to grow anything successfully. Agriculture is the number one industry in the state of Georgia. There is a robust timber industry for lumber and paper pulp. Southern white pine can often be found growing in roadside ditches alongside other common weeds. This creates unique challenges for roadside management in Georgia. Pine trees and other woody species must be managed in the ROW clear zone. Current practices are regular mowing two to eight times per growing season. This meadow research hopes to address the needs of the ROW by managing pine trees and woody species and also reducing mowing, thus providing aesthetic, ecological and financial benefits.

5.2 Site Analysis of The Ray

Region of the state

The Ray is located in Troup County (Figure 2) in western central Georgia's Piedmont region which lies between the Blue Ridge Mountains and the Upper Coastal Plain (Appendix D). In the 2010 census the population was 67,044. The county's west boundary is coterminous with the Georgia/Alabama state line.

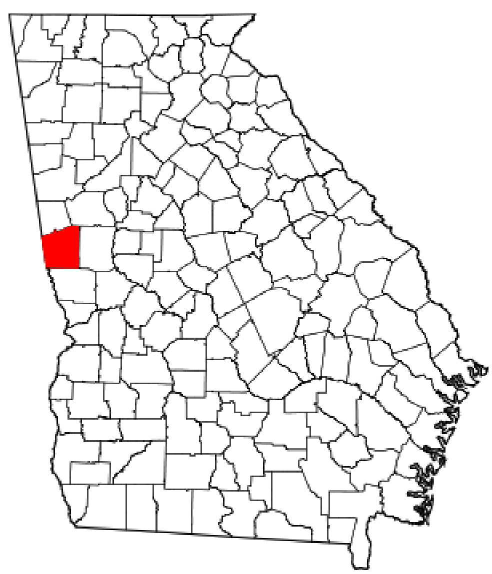

Figure 2 Troup County, GA (Wikipedia 2020)

Weather Data

Troup county averages 52.76 inches of precipitation per year with an average temperature of 61.9 degrees. Humidity averages 71.97 and days of sunshine are 241 per year (Appendix E). The Ray is located in zone 8a of the USDA Hardiness Zones Map (Appendix F). (http://usa.com/troup-coounty-ga-htm).

Waterways

Troup County and The Ray are located in the middle of the Chattahoochee River-Lake Harding Sub-basin of the ACF River basin (Apalachicola-Chattahoochee-Flint). A map is located in Appendix G. There are also eight lakes found in close proximity to The Ray: Hanks, Malloy, Ridley, Bryant, Murphy, Harrell, and West Point. Three streams include Panther Creek, Blue John Creek, and Long Cane Creek.

Existing plant species

The Ray is a typical highway site with grasses and Georgia pine forest. Located in the Piedmont Ecoregion which lies between the northern mountains and the southern plains, it occupies the middle of the state of Georgia and is known for its red clay soil and abundant rainfall.

Structures

Bridges - There are 4 bridges/interchanges off I-85 within the study area: Highway 109 which provides the northernmost entrance into La Grange, Highway 27 which provides the second La Grange exit and is the gateway exit for Callaway Gardens and Resort, Highway 219 coming south from La Grange downtown area, and Exit 6 which is the Kia Parkway. Other structures include the Georgia Visitor Information Center at West Point.

Safety and Design Requirements

Clear Zones - The Roadside Design Guide defines a clear zone as:

> The total roadside border area, starting at the edge of the travel way, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. Desired minimum width depends on traffic volumes and speeds and the roadside geometry. Simply stated, it is an unobstructed, relatively flat area that allows a driver to stop safely or regain control of a vehicle that leaves the traveled way (FHWA Design).

Based on FHWA guidelines, the recommended Clear Zone ranges are based on a width of 30-32’ for flat level terrain adjacent to a straight section of a 60-mph highway with an average daily traffic of 6000 vehicles (FHWA Safety).

Sight distance - Normally, stopping sight distance is considered the first consideration in roadway design. However, on interstate highways Decision Sight Distance is of greater importance. Decision Sight Distance is defined as “the distance traversed while recognizing an object or hazard, plotting an avoidance course and making the necessary maneuvers “(Geometric Design).

Using the FHWA AASHTO Green Book guidelines, GDOT recognizes that:

> Decision Sight Distance is the distance needed for a driver to detect an unexpected or difficult to perceive information source or condition in a roadway environment that may be visually cluttered, recognize the condition or its potential threat, select an appropriate speed and path, and initiate and complete the maneuver safely and efficiently. Examples of locations where Decision Sight Distance should be considered are: multiphase at-grade intersections, six-lane roadways with at-grade intersections, interchanges, ramp terminals on through roadways, lane drops and areas of concentrated traffic demand where there is likely to be more visual demands and heavier weaving maneuvers (GDOT Design Policy Manual).

Cultural and historic features

The history of Troup County began officially in 1825 when the United States negotiated a treaty with the Creek Indians. This treaty gave Georgia governor Michael Troup the power to create five counties from the territory, one of which was named for him--hence Troup County. In 1827 Troup county was opened for settlement. La Grange was named the county seat in 1828, West Point was incorporated in 1832, and Hogansville in 1870. Troup county would become known as a center for trade and commerce. La Grange was named for the French and American hero General Marquis de Lafayette whose travels had brought him to Georgia at which point he commented to Governor Troup on the similarity to his French estate.

Until the Civil War, the county was home to a strong agricultural economy primarily based on cotton with 50% of the population being slaves who worked the fields. In the 1850s the Atlanta and West Point Railroad passed through LaGrange. The town was also home to three institutions of higher learning, including LaGrange College, the first privately funded college in Georgia. After the Civil War, Troup county was rebuilt as a strong economic force, and by the turn of the century became home to a growing textile industry. Between 1900 and 1930 fifteen mills were in production in the area.

After the Civil War, many houses were accompanied by gardens and the city of La Grange referred to as “a city of gardens”. Perhaps the most famous was the landscape at Ferrell Gardens established by Blount and Sarah Ferrell built on old cotton terraces. The gardens were purchased by Fuller Callaway Sr and became the site of his Hills and Dales estate which includes an Italianate style villa and extensive grounds. La Grange was built on cotton and the textile industry continues today (Wood, 2008 and La Grange Chamber of Commerce).

5.3 Landscape Typologies of The Ray

By definition, a typology is a "study of or analysis or classification based on types or categories" (Webster). How then are roads and their surrounding roadsides best categorized in order to propose design guidelines for the 18-mile section of Georgia I-85 known as The Ray? Generally, roads are first categorized by location as urban, suburban, or rural.

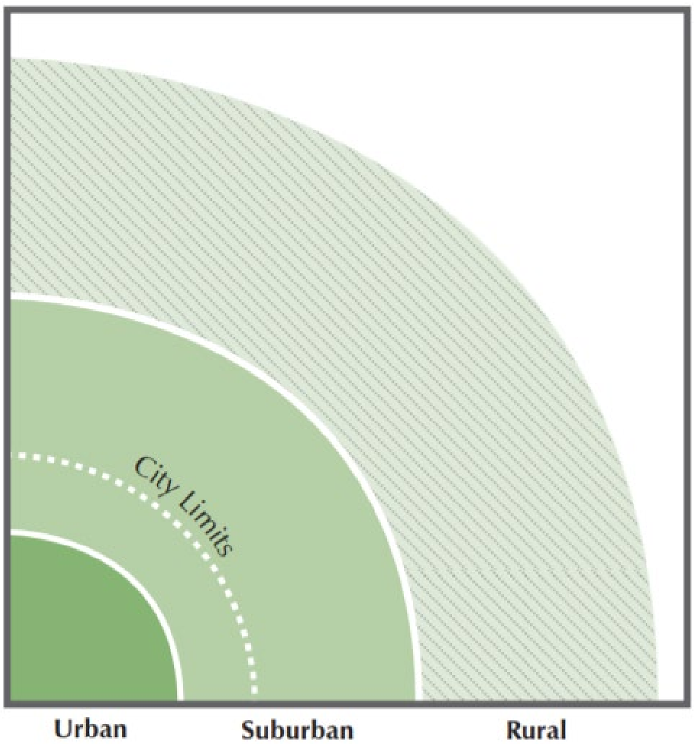

Figure 3 Location of Landscape Classification Types (TNDOT Landscape Design Guidelines 2010)

Eight factors contribute to determining the classifications within those broad categories (Camp et al. Tennessee Landscape Design Guide, 2010):

1. Population density
2. Location
3. Development patterns
4. Land use
5. Natural features
6. Transportation options
7. Utilities and signage
8. Unique characteristics

Once the eight factors have been considered for urban, suburban, or rural roads, all three can be divided into operational zones and non-operational zones. Operational zones contain the roadway and shoulder to allow routine maintenance and areas for motorists to safely leave the roadway. Non-operational zones are the right-of-way where roadside vegetation grows and provide a buffer for ecosystems as well as drainage and stormwater management (WSDOT Maintenance Manual M 51-01.10 Page 6-5 March 2020).

When reviewing state DOT policies and manuals, language centers on land use categories or types and their relevant functions within the roadside landscape in order to provide guidance for planning and management of those resources. Washington and Tennessee DOTs provided the most succinct analysis.

The Washington DOT uses the following categories (WSDOT Maintenance Manual M 51-01.10 March 2020):

Roadside Land Use // WSDOT Categories

1. Operational Right-of-Way (ROW)
2. Non-operational Right-of-Way (ROW)
3. Formal Landscape
4. Resource Conservation Areas
5. Environmental Mitigation Sites

Having established the five categories of land use, they apply four functions to each category (WSDOT Maintenance Manual M 51-01.10 March 2020):

WSDOT Roadside Functional Categories

1. Operational

2. Environmental
3. Visual
4. Auxiliary

Tennessee DOT uses types to identify and categorize their roadside landscapes (Camp et al. Tennessee Landscape Design Guide, 2010):

1. Interchanges (clover leaf)
2. ROW
3. Intersections
4. Highway Facilities
    a. Rest Areas and Welcome Centers
    b. Truck Weigh Stations
    c. Maintenance Facilities
5. Unique Landscape
    a. Scenic Roads
    b. Gateways
    c. Streetscapes

Based on a summary of the WSDOT and TDOT approaches to roadside landscape design and maintenance, this study proposes the following typologies:

Proposed Typologies for The Ray

1. Right-of-Way (ROW)
2. Medians

3. Streams and Wetlands
4. Interchanges
5. Behind the Guardrail
6. Gateways

Functional Zones for Each Typology

A. Operational
B. Environmental
C. Transition / Buffer

Modifying the WSDOT approach allows for each typology to have multiple functions. This approach recognizes the variety of landscape types and functions of The Ray, while allowing for a concise description of the roadside landscape that can be wildly different in the 18-mile study area.

CHAPTER 6

Design Recommendations for The Ray

6.1 Introduction

The 18-mile corridor of The Ray along I-85 in southwest Georgia has been broken into the following typologies. Design recommendations are proposed for each topology and functional zone below.

6.2 Proposed Typologies for the Ray

1. Right-of-Way (ROW)
2. Medians
3. Streams and Wetlands
4. Interchanges
5. Behind the Guardrail
6. Gateways

6.3 Proposed Functional Zones for Each Typology

A. Operational

B. Environmental

C. Transition / Buffer

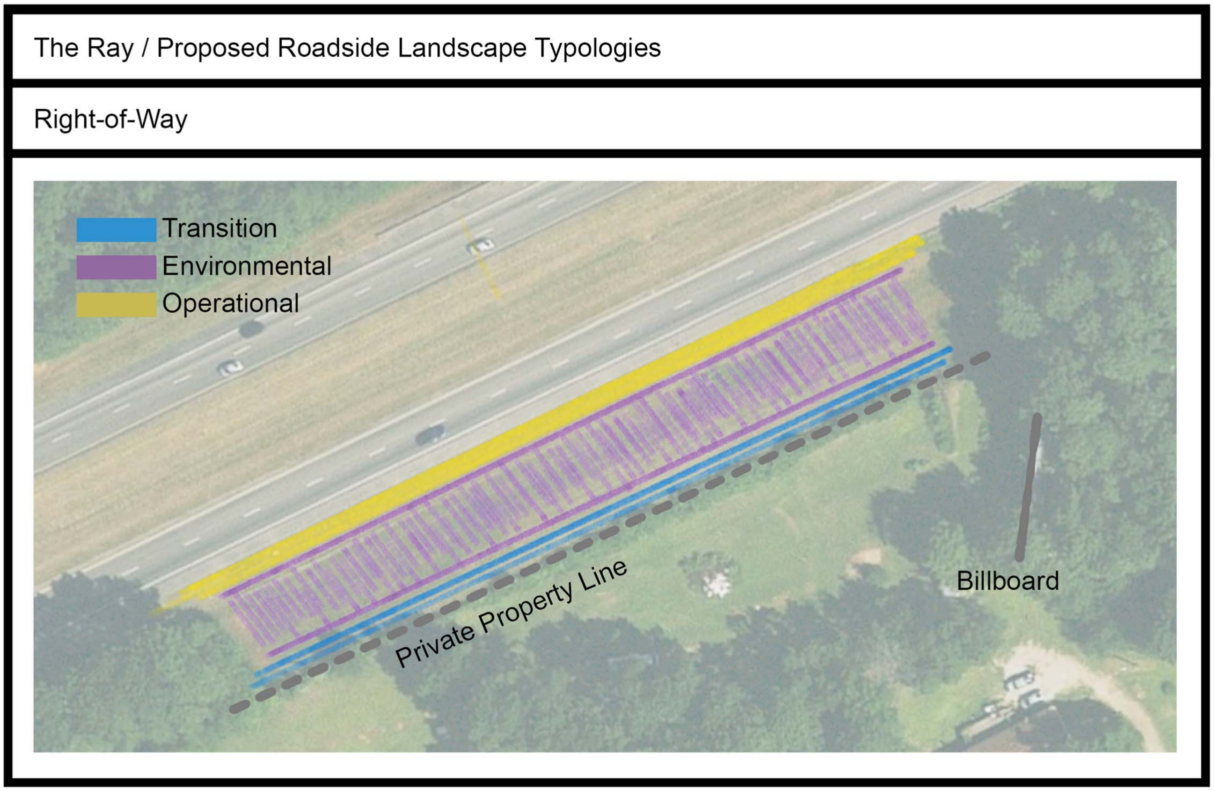

Figure 4 Right-of-Way Typology Diagram

6.4 Right-of-Way (ROW)

<u>Zone A / Operational Zone</u>

The first fifteen feet of the right-of-way will be mown at regular intervals throughout the growing season. This is often referred to as "strip mowing" in many DOT manuals. Mowing height can be set at 4-8 inches depending on terrain and existing plant species. Maintaining a clean edge along the roadside adjacent to the pavement is important for many reasons:

- It meets the requirements of the "designed clear zone" as required by FWHA regulations.
- It gives an "orderly frame" as described by Nassauer which is helpful for maintaining positive public perceptions (Nassauer 1995).
- It allows for water to safely run off the pavement surface.

From 15-35 feet (depending on the width of the ROW) the operational zone can be planted with a number of plant species to meet a number of goals. Plantings in this area will be no taller than 24 inches and will be grasses or forbes only:

- This continues to meet the requirements of the "designed clear zone"
- Reduces mowing while adding to the beauty and ecological benefits of the ROW

Zone B / Environmental

This area begins 30-50 away from the outside through lane as described by FWHA regulations and definition of the "design clear zone". This area can be planted with a variety of different plant species to meet a number of goals but will focus on improving the environmental impact and ecological benefits of the roadside ROW. Possible planting strategies include but are not limited to:

- Pollinator meadows
- Native plant seed production
- Canola or other biodiesel crops
- Plantings for carbon sequestration
- Crops for hay or other productive fiber production goals

Zone C / Transition / Buffer Zone

The edge of the ROW ends at the border of state-owned land and adjacent public lands. The buffer zone is 5-15 feet wide at this border where certain maintenance activities take place:

- Where applicable, tree clearing, and regular mowing takes place to keep viewsheds open to billboards or other areas designated to be kept clear.

Zone C / Transition / Buffer Zone (Cont.)

- Maintenance of fencing may require clearing activities (mowing, string-trimming, etc.) that are unique to this zone.

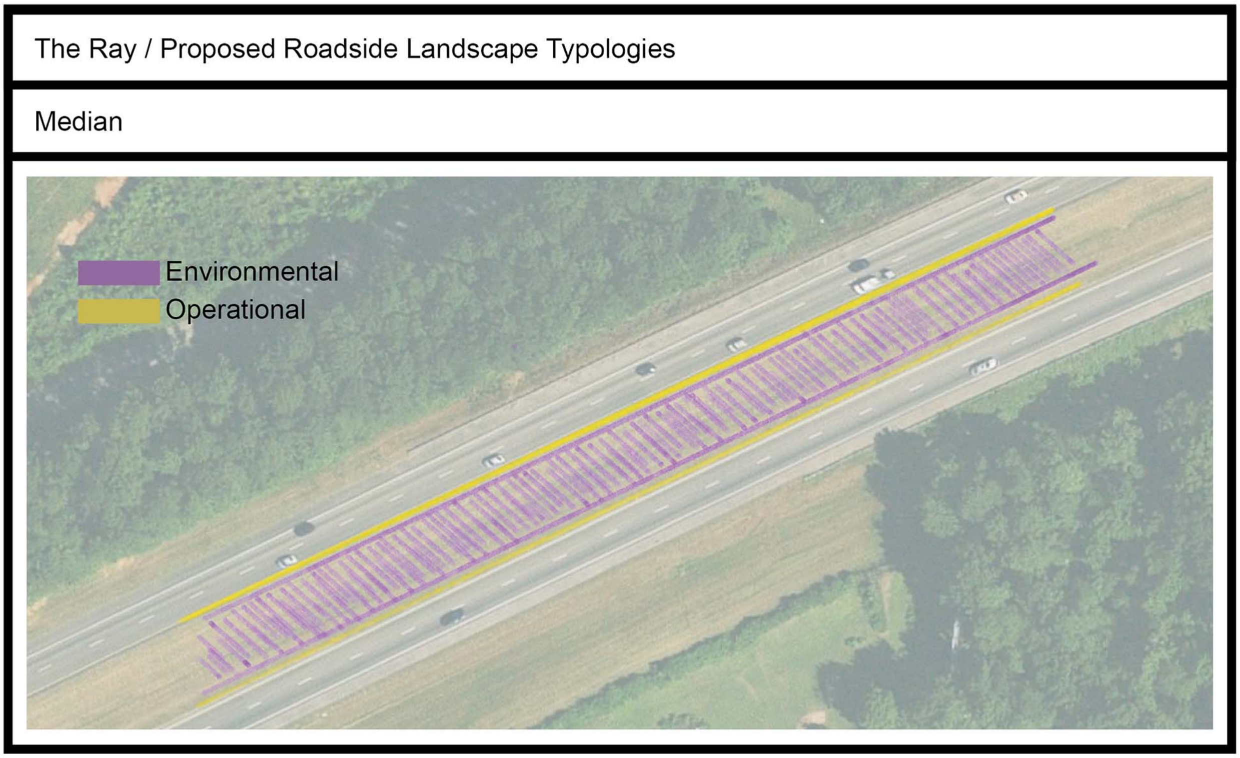

Figure 5 Median Typology Diagram

6.5 Medians

Along the 18-mile corridor of The Ray, the majority of the median is less than 50 feet wide. The goal of reducing mowing and improving ecological benefits can still take place in this typology but in different ways than in the ROW typology.

Zone A / Operational Zone

Similar to other typologies, “strip mowing” may take place along the first 5-15 feet adjacent to the roadway. Mowing height can be set at 4-8 inches depending on terrain and existing plant species. Maintaining a clean edge along the roadside adjacent to the pavement is important for many reasons:

- It meets the requirements of the “designed clear zone” as required by FWHA regulations.
- It gives an “orderly frame” as described by Nassauer which is helpful for maintaining positive public perceptions (Nassauer 1995).
- It allows for water to safely run off the pavement surface.

But in this typology, a mown edge may not be necessary if planted with native grasses or forbs that do not grow taller than 18 inches. Creative approaches can be used to plant in the designed clear zone in a way that reduces mowing to once per year and also creates a pleasing effect without the need to mow regularly.

Zone B / Environmental Zone

In this typology the environmental zone comprises the majority of the area and will overlap with the operational zone when possible. Environmental plantings and goals can be taken all the way to the roadway edge and still adhering to the designed clear zone guidelines.

Given the proximity to the roadway, this area cannot be planted with trees or shrubs because of safety concerns. But similar to the ROW, this typology can execute a number of possible project types:

- Pollinator meadows

Zone B / Environmental Zone (Cont.)

- Native plant seed production
- Canola or other biodiesel crops
- Plantings for carbon sequestration
- Crops for hay or other productive fiber production goals

Zone C / Transition / Buffer Zone

This typology is not adjacent to private land, but it can connect with the typology "Behind the Guardrail." It is important to connect various planting approaches and goals in the median in a pleasing way with as smooth of transitions as possible.

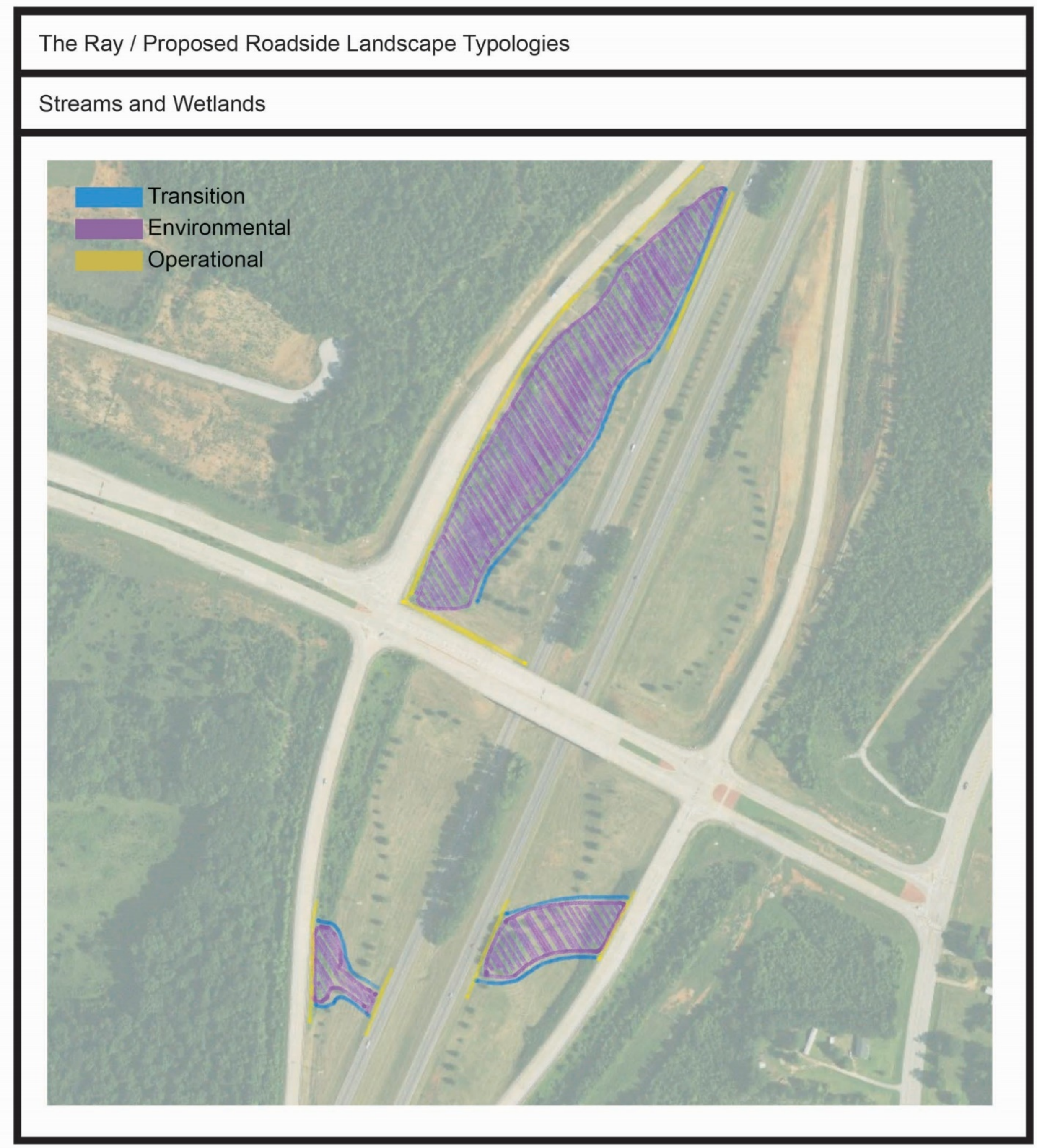

Figure 6 Streams and Wetlands Typology Diagram

6.6 Streams and Wetlands

Zone A / Operational Zone

If this typology is near the roadway, a mown strip will occur adjacent to the roadway for 5-15 feet. This is to ensure the design clear zone is maintained according to FWHA regulations.

Zone B / Environmental Zone

This area focuses on maintaining the plantings in an ecologically friendly way. Too often waterways have been impaired by road construction. The goal is to restore them as best as possible to improve water quality and habitat. Possible activities include:

- Bioswales
- Managed wetlands
- Removing concrete embankments to slow the movement of water and allow for slow soil infiltration

It is important to monitor these areas for invasive species and remove them before they naturalize. Depending on the proximity of the roadway and the designed clear zone, tree removal might also be necessary for safety.

Zone C / Transition / Buffer Zone

Where this topology connects to adjacent private land, it is important to consider the surrounding plant communities to connect with them in the best possible way. This is also the buffer zone where invasive species might enter the area.

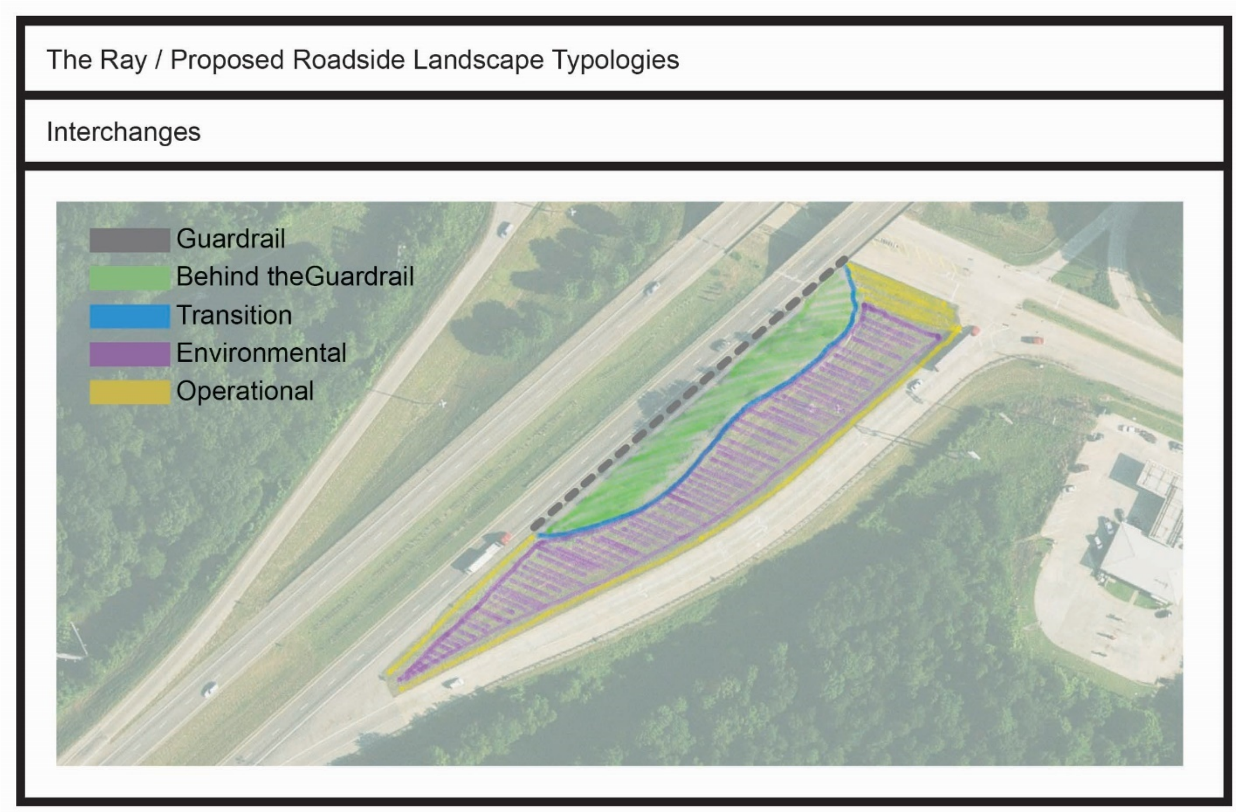

Figure 7 Interchange Typology Diagram

6.7 Interchanges

Zone A / Operational Zone

Similar to other typologies, “strip mowing” may take place along the first 5-15 feet adjacent to the roadway. Mowing height can be set at 4-8 inches depending on terrain and existing plant species.

Zone B / Environmental Zone

This typology offers more diversity in the landscape than any other typology. Interchanges often have both large very flat areas and steep bridge embankments. It can be home to the most dry areas of the roadside and the wettest. These areas provide some of the most interesting opportunities for creative solutions in integrated roadside vegetation management (IRVM). Accessing the large flat areas between the on/off ramps and the main roadway offer both challenges and opportunities. Possible planting strategies include but are not limited to:

- Pollinator meadows
- Native plant seed production
- Canola or other biodiesel crops
- Plantings for carbon sequestration
- Crops for hay or other productive fiber production goals
- Roadside solar (outside of the designed clear zone with safety fencing)

Zone C / Transition / Buffer Zone

The edge of the interchange ends at the border of state-owned land and adjacent public lands. The buffer zone is 5-15 feet wide at this border where certain maintenance activities take place:

- Where applicable, tree clearing and regular mowing takes place to keep viewsheds open for line-of-sight requirement at intersections and signage.
- Maintenance programs in partnership with municipalities or businesses to provide a more frequent level of care.

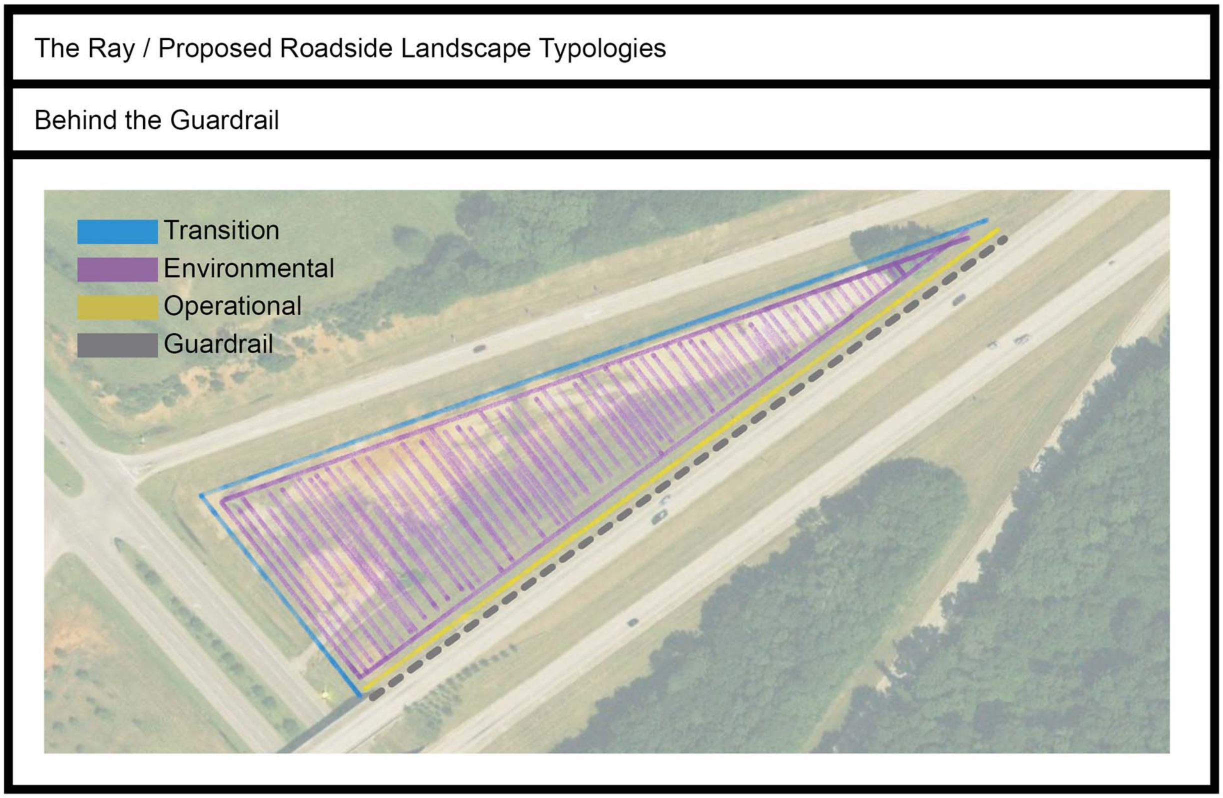

Figure 8 Behind the Guardrail Typology Diagram

6.8 Behind the Guardrail

Because this typology does not have the same designed clear zone requirements, it is the only typology that can have permanent structures, trees, or shrubs in close proximity to the roadway.

<u>Zone A / Operational Zone</u>

Similar to other typologies, “strip mowing” may take place along the first 5-15 feet adjacent to the roadway. Mowing height can be set at 4-8 inches depending on terrain and existing plant species. But most often the area adjacent to the roadway is managed with string trimmers.

Zone B / Environmental Zone

This is the area behind the guardrail. Since it has the most protection, this is the ideal location for:

- Roadside solar
- Plantings of trees and shrubs

Zone C / Transition / Buffer Zone

This area often connects with other typologies. It is important to have as smooth of a transition between plantings as possible.

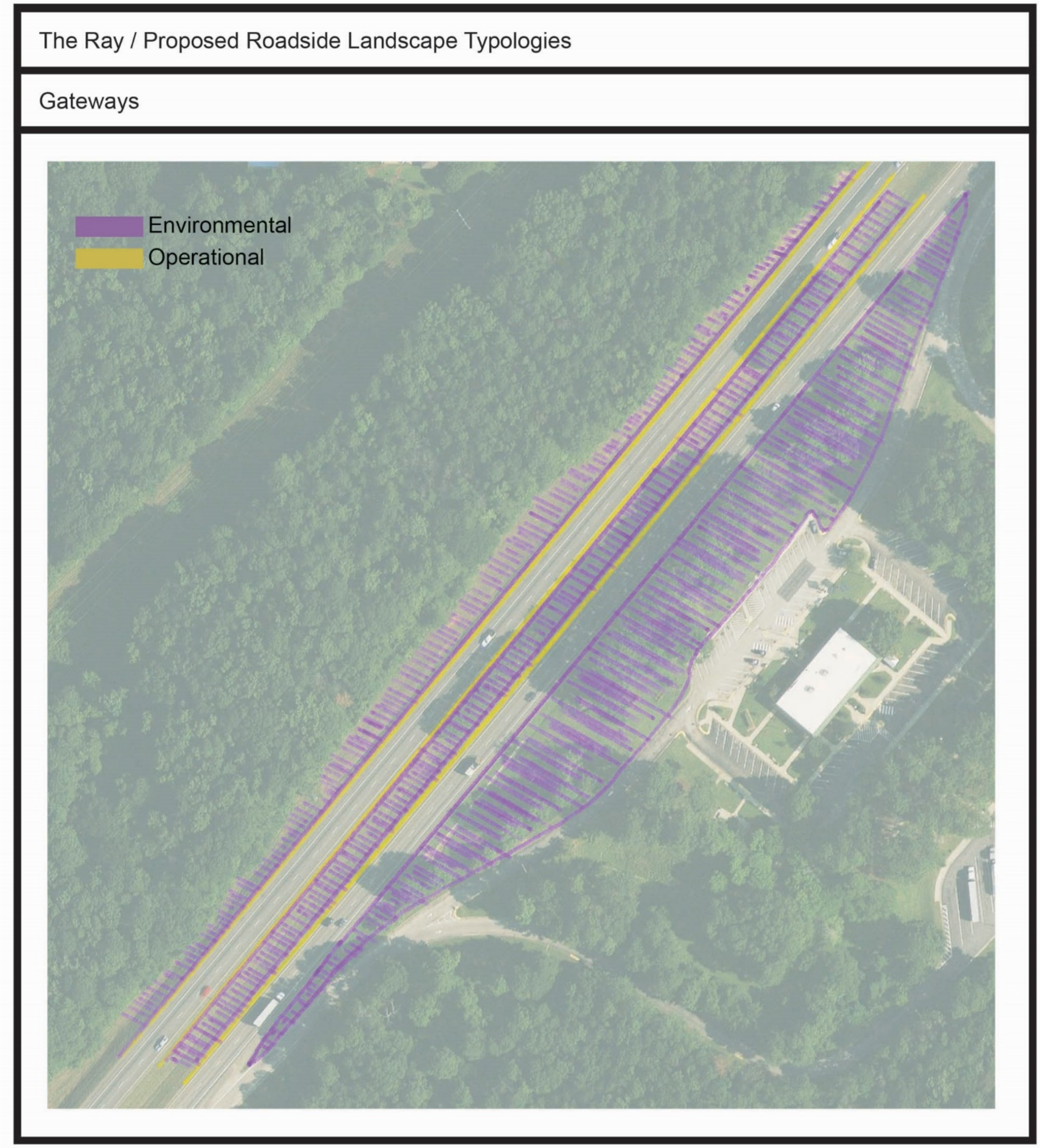

Figure 9 Gateways Typology Diagram

6.9 Gateways

The main goal of the gateway typology is to showcase native plants of Georgia and create an inviting, beautiful, and sustainable landscape. Gateways are found at the two ends of The Ray, at Exit 14, and at the Georgia Visitor Information Center.

Zone A / Operational Zone

Similar to other typologies, the first 5-15 feet adjacent to the roadway will be mown at regular intervals throughout the growing season. This is often referred to as "strip mowing" in many DOT manuals. Mowing height can be set at 4-8 inches depending on terrain and existing plant species. Maintaining a clean edge along the roadside adjacent to the pavement is important for many reasons:

- It meets the requirements of the "designed clear zone" as required by FWHA regulations.
- It gives an "orderly frame" as described by Nassauer which is helpful for maintaining positive public perceptions (Nassauer 1995).
- It allows for water to safely run off the pavement surface.

Zone B / Environmental Zone

The main goal of the gateway typology is to showcase native plants of Georgia and create an inviting, beautiful, and sustainable landscape.

Zone C / Transition / Buffer Zone

This area often connects with other typologies. It is important to have as smooth of a transition between plantings as possible.

CHAPTER 7

Summary and Discussion

This study began on the basis that today current emphasis has changed from a focus on transportation and communication to examining the use of roadside landscapes with a stronger interest toward ecological impacts, creation of wildlife habitat, and increased human well-being. Confidently, these typologies and design recommendations are a step in that direction. In the state of Georgia, The Ray and its projects and initiatives are already working to create "a net zero highway" with the focus of multiple functions and benefits to both people and the environment for beauty and aesthetics as well as the budget. It should be clear that mowing the grass is not good enough and may actually have detrimental impacts on the environment, local food growing operations, water quality and the economy.

Currently the state of Georgia spends $44 million annually on mowing and litter pickup. Roadsides are mowed from two to eight times per year depending on their conditions and location. Any reduction in mowing will give immediate benefits of lower costs and carbon emissions. But budget considerations on vegetation management are not the only considerations. Both timing and frequency have ecological consequence for native plants, animals, and pollinators. States such as Minnesota and Wisconsin have designed mowing schedules to protect nesting birds (MN) and butterfly habitat (WS) (Foreman et al. 2003). Targeted mowing produces the maximum benefits for all (Ries et al., 2001). If safety and aesthetic goals can still be met with reduced mowing requirements, financial means could be used in more productive ways. Moving away from traditional mowing takes study and planning.

Another factor in reducing mowing also involves helping the public understand the benefits associated with a more sustainable management approach since roadside mowing has been the accepted standard across the United States from the beginning of our history. Since 1969 the National Environmental Policy Act (NEPA) has called on Federal Agencies to:

> Use all practical means to: fulfill the responsibilities of each generation as trustee of the environment for succeeding generations; assure for all Americans safe, healthful, productive and aesthetically and culturally pleasing surroundings; and preserve important historic, cultural, and natural aspects of our national heritage, and maintain, whenever possible an environment which supports diversity, and a variety of individual choice.

That standard has not translated to an environmental view of roadside vegetation. As one researcher stated, "Without knowledge of the intrinsic values associated with this atypical, and oftentimes, less manicured aesthetic, public response is frequently critical (Lucey and Barton, 2010). Projects like The Ray assist in spreading the word to change perceptions about the roadside.

One such project in Georgia has had some years to change perception. The Georgia Wildflower Program along its highways began in 1972 when Virginia Callaway of The Georgia Garden Clubs and then first lady Roselyn Carter began an initiative to improve the visual impact along roadsides with wildflowers. In the last fourteen years over 2700 acres have been planted. Supported with funding from the Wildflower Tag program, limited plant diversity with species of Cosmos and Daffodils did not produce the perennial meadows that provide long term ecological support for pollinators and wildlife habitat. Only recently has GDOT begun to plant pollinator meadows with emphasis on milkweed for monarch migration and bioswales for perennial native grasses to reduce pollution runoff. Time will tell if this "New Aesthetic" will have broader impact across the state (DeGrace 2019). The cooperation of GDOT with The Ray provides an opportunity to test the best mix of native plants to give the greatest aesthetic, ecological and financial results for Georgia roadsides.

However, further study is needed to determine how The Ray and this 18-mile study area can be expanded to the rest of I-85 and the Georgia highway system. Site specific interventions are great but corridor scale, big picture thinking is necessary to make substantive changes in the management of roadside landscapes along America's highways. Time will tell if the “living vegetative lab” that The Ray envisions will produce “innovative land management strategies to inform decisions around the state” (GDOT, UGA, and The Ray, February 2020).

These typologies should be able to expand to other Georgia highways but are in no sense comprehensive. Replicating the study in another highway environment would determine if these typologies are exhaustive. Further research is also needed on the ecological implications of wildflower meadows on the roadside. As with any landscape project monitoring and evaluation are the best measures for success to see if a good idea truly meets its goal. Ecological monitoring of the plants, insects, and small mammals can show if implementing these roadside typology recommendations truly have ecological benefits or if they are purely aesthetic changes that make humans feel better.

There are a plethora of design guides, IRVM manuals, wildflower, and pollinator proposals from the FHWA already in existence. In reality, there does not seem to be broad acceptance or use across the United States and in the state of Georgia. For example, GDOT has a comprehensive context sensitive design manual (CSD), a process the guide defines as “a revolutionary change from a tradition of focusing almost exclusively on engineering to an approach that balances safety and mobility with a community’s values and environmental preservation” (CSD Manual, GDOT,12/29/16). Those are lofty words accompanied by strong guiding principles that include: Interdisciplinary Teams, Community and Stakeholder Focus, Environmental Sensitivity in Design, Design Flexibility in Reaching Solutions, and the acknowledgement that Context-Sensitive Solutions is a Process. If roadside management is to change to meet those lofty goals it will indeed take a reimagining of the use of roadside landscapes.

Perhaps projects like The Ray can best be seen as true innovators for the future by comparing them to innovations from the past. Early in the history of road building in the United States General EG Harrison, head of the Office of Public Inquiries (OPI) pushed for the public to support better road building techniques that would provide a better quality experience for the user. He built the first "Object Lesson Road" in nearly every state east of the Rocky Mountains using new materials and techniques that created a better and safer road (Longfellow, FHWA, 2017.) Today, The Ray is pioneering another "Object Lesson Road", this one with the intention of providing a better-quality experience for the user and the environment.

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APPENDIX

MEADOW MIX A

Low

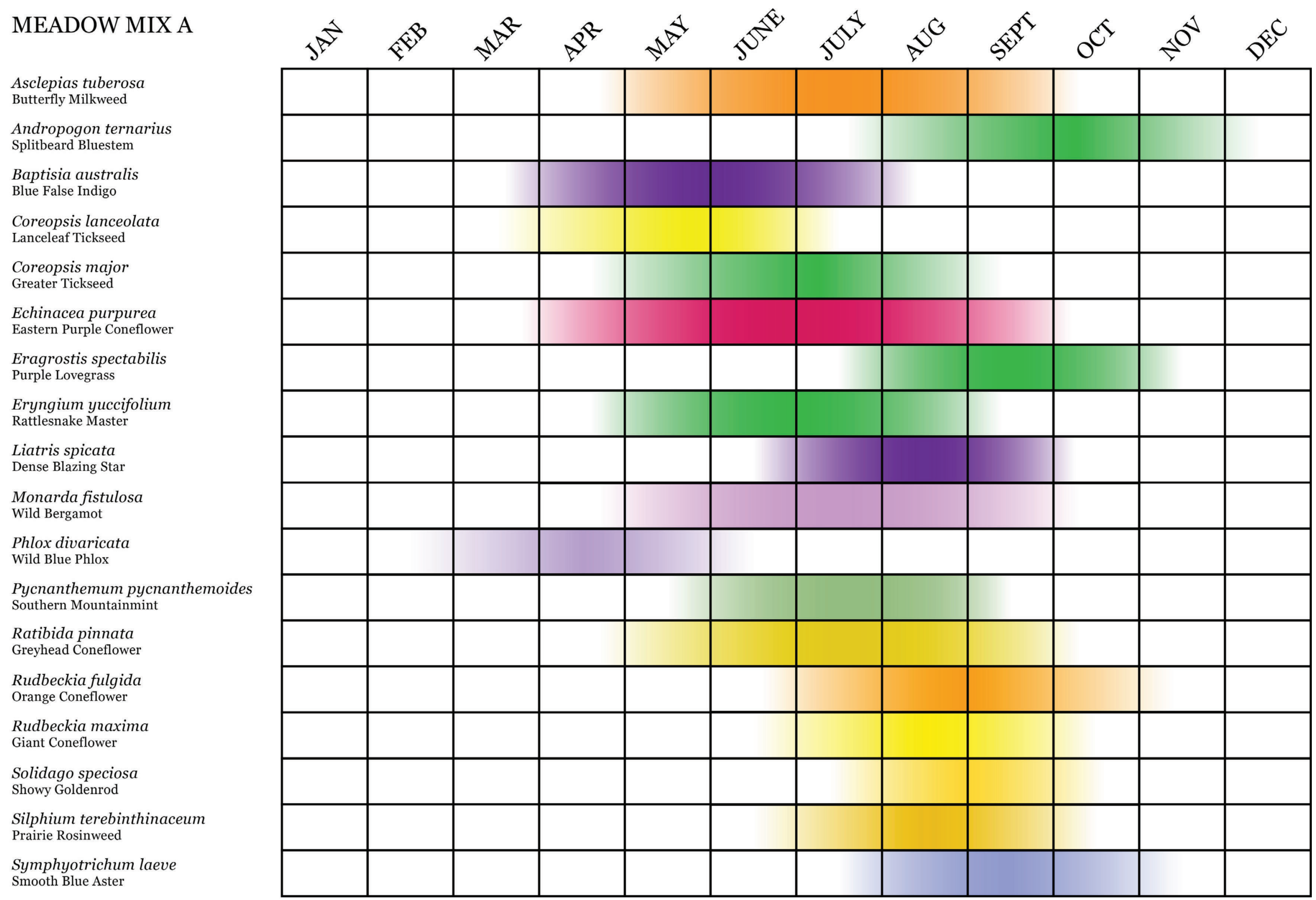
Asclepias tuberosa Butterfly Milkweed	1-2
Coreopsis lanceolata Lanceleaf Tickseed	1-2
Coreopsis major Greater Tickseed	1-3
Eragrostis spectabilis Purple Lovegrass	1-2
Phlox divaricata Wild Blue Phlox	1-2
Rudbeckia fulgida Orange Coneflower	1-3

Medium / Mounding

Andropogon ternarius Splitbeard Bluestem	2-4
Baptisia australis Blue False Indigo	3-5
Monarda fistulosa Wild Bergamot	2-5
Pycnanthemum pycnanthemoides Southern Mountainmint	2-6
Symphyotrichum laeve Smooth Blue Aster	2-4

Tall / Upright

Echinacea purpurea Eastern Purple Coneflower	2-5
Eryngium yuccifolium Rattlesnake Master	3-5
Liatris spicata Dense Blazing Star	2-4
Ratibida pinnata Greyhead Coneflower	3-5
Rudbeckia maxima Giant Coneflower	3-6
Silphium terebinthinaceum Prairie Rosinweed	3-8
Solidago speciosa Showy Goldenrod	1-5



MEADOW MIX B

Low

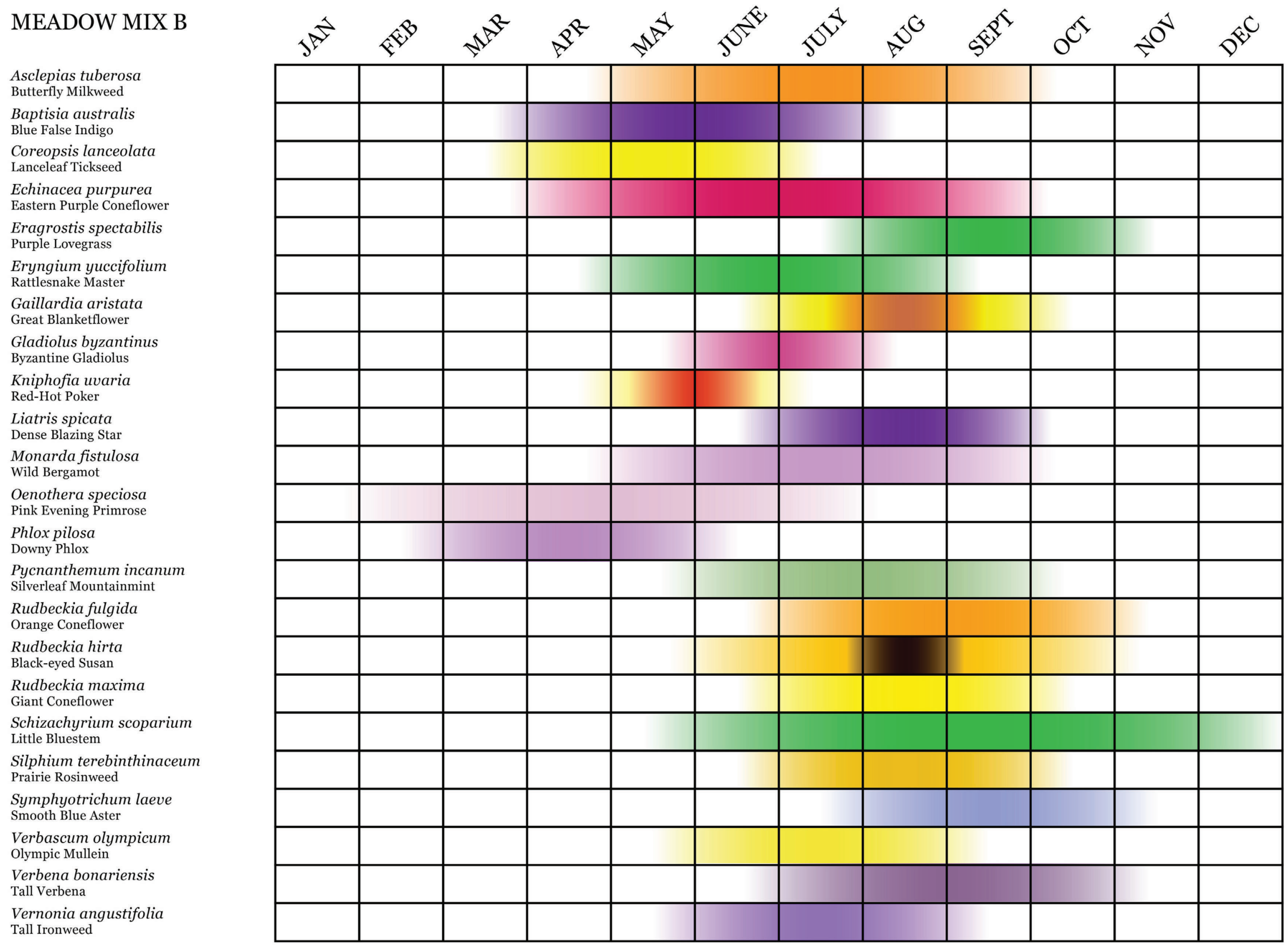
Asclepias tuberosa Butterfly Milkweed	1-2
Coreopsis lanceolata Lanceleaf Tickseed	1-2
Eragrostis spectabilis Purple Lovegrass	1-2
Gladiolus byzantinus Byzantine Gladiolus	1-2
Oenothera speciosa Pink Evening Primrose	1-2
Phlox pilosa Downy Phlox	1-2
Rudbeckia fulgida Orange Coneflower	1-3
Rudbeckia hirta Black-eyed Susan	1-2
Schizachyrium scoparium Little Bluestem	1-2

Medium / Mounding

Baptisia australis Blue False Indigo	3-5
Gaillardia aristata Great Blanketflower	2-4
Monarda fistulosa Wild Bergamot	2-5
Pycnanthemum incanum Silverleaf Mountainmint	3-6
Symphyotrichum laeve Smooth Blue Aster	2-4
Verbena bonariensis Tall Verbena	2-4
Vernonia angustifolia Tall Ironweed	3-5

Tall / Upright

Echinacea purpurea Eastern Purple Coneflower	2-5
Eryngium yuccifolium Rattlesnake Master	3-5
Kniphofia uvaria Red-Hot Poker	3-4
Liatris spicata Dense Blazing Star	2-4
Rudbeckia maxima Giant Coneflower	3-6
Silphium terebinthinaceum Prairie Rosinweed	3-8
Verbascum olympicum Olympic Mullein	5-9



The Ray / Exit 6 / Phase 1

These three mixes were installed by GDOT on January 28, 2020 for the first phase of meadow research at The Ray.

The Mix A and Mix B in the following pages are the mixes tested by Prof. Davis and his graduate students at UGArden in Athens, GA. They served as a foundation for the research at Exit 6 / The Ray.

GDOT MIX /
From Garrett Wildflower Seed Farm

	Common Name
1	Spotted Beebalm
2	White Clover - Ladino
3	Partridge Pea (fasciculata)
4	Narrow-leaved Sunflower
5	Lance-leaved Coreopsis
6	Plains Coreopsis
7	Large Flower Coreopsis
8	Goldenmane Coreopsis
9	Black-eyed Susan
10	Bur-marigold

Phase 1 UGA Mix /
From Roundstone Native Seed Farm

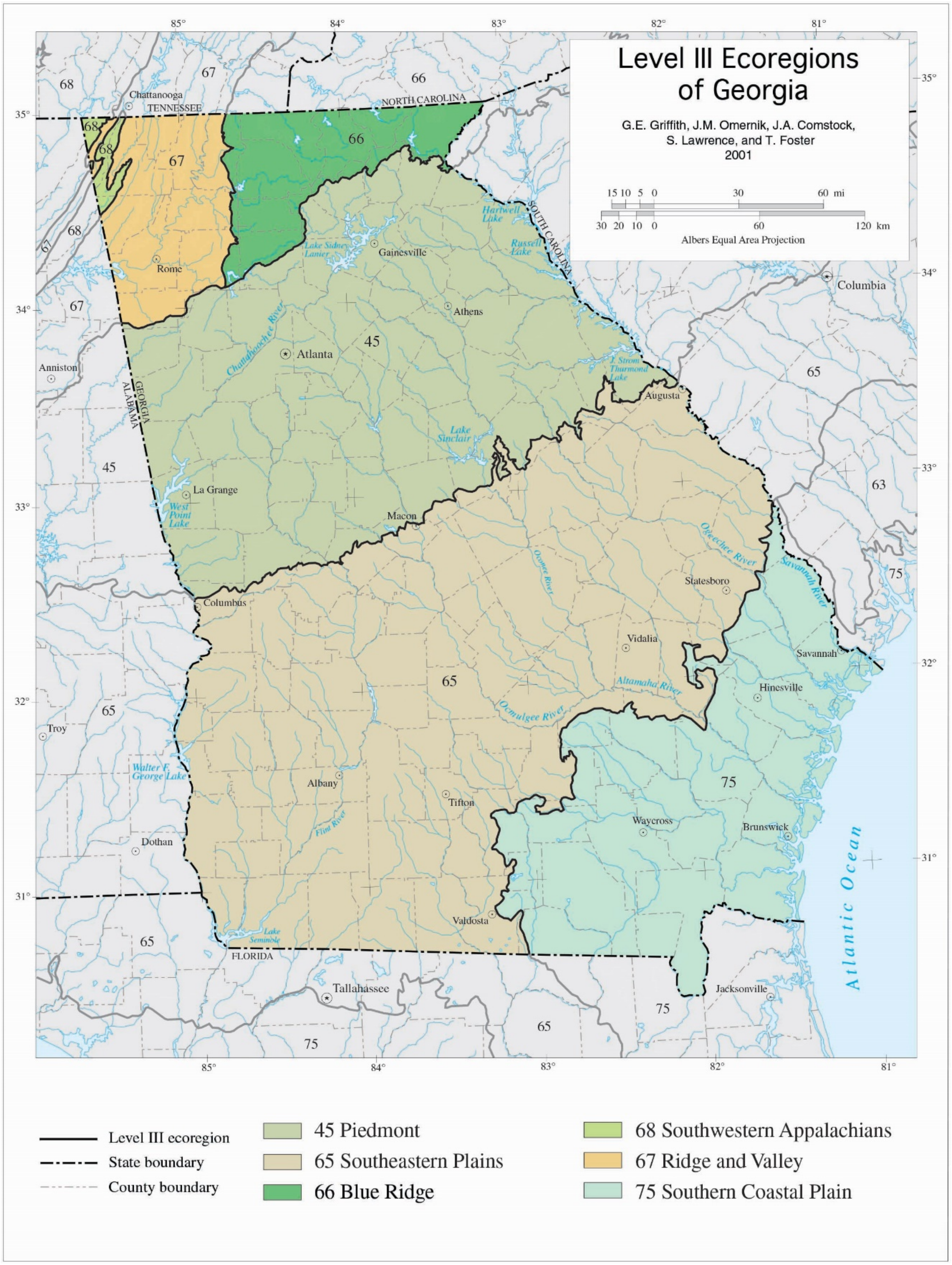
	Common Name
1	Smooth Aster
2	Butterfly Milkweed
3	Splitbeard Bluestem
4	Blue False Indigo
5	Lance-leaved Coreopsis
6	Large Flower Coreopsis
7	Pale Purple Coneflower
8	Purple Coneflower
9	Purple Lovegrass
10	Rattlesnake Master
11	Blanketflower
12	Indian Blanket
13	Blazing Star
14	Bergamot
15	Showy Evening Primrose
16	Few Flower Blazing Star
17	Hairy Mountain Mint
18	Greyheaded Coneflower
19	Orange Coneflower
20	Cutleaf Coneflower
21	Showy Goldenrod
22	Prairie Dock
23	Mullein

Phase 1 UGA Mix /
From Jelitto Perennial Seeds

	Common Name
1	Smooth Aster
2	Butterfly Milkweed
3	Splitbeard Bluestem
4	Blue False Indigo
5	Lance-leaved Coreopsis
6	Large Flower Coreopsis
7	Pale Purple Coneflower
8	Purple Coneflower
9	Purple Lovegrass
10	Rattlesnake Master
11	Blanketflower
12	Indian Blanket
13	Red-hot Poker
14	Blazing Star
15	Bergamot
16	Showy Evening Primrose
17	Prairie Phlox
18	Hairy Mountain Mint
19	Greyheaded Coneflower
20	Giant Coneflower
21	Showy Goldenrod
22	Prairie Dock
23	Mullein
24	Tall Verbena

* only found in this mix

APPENDIX D



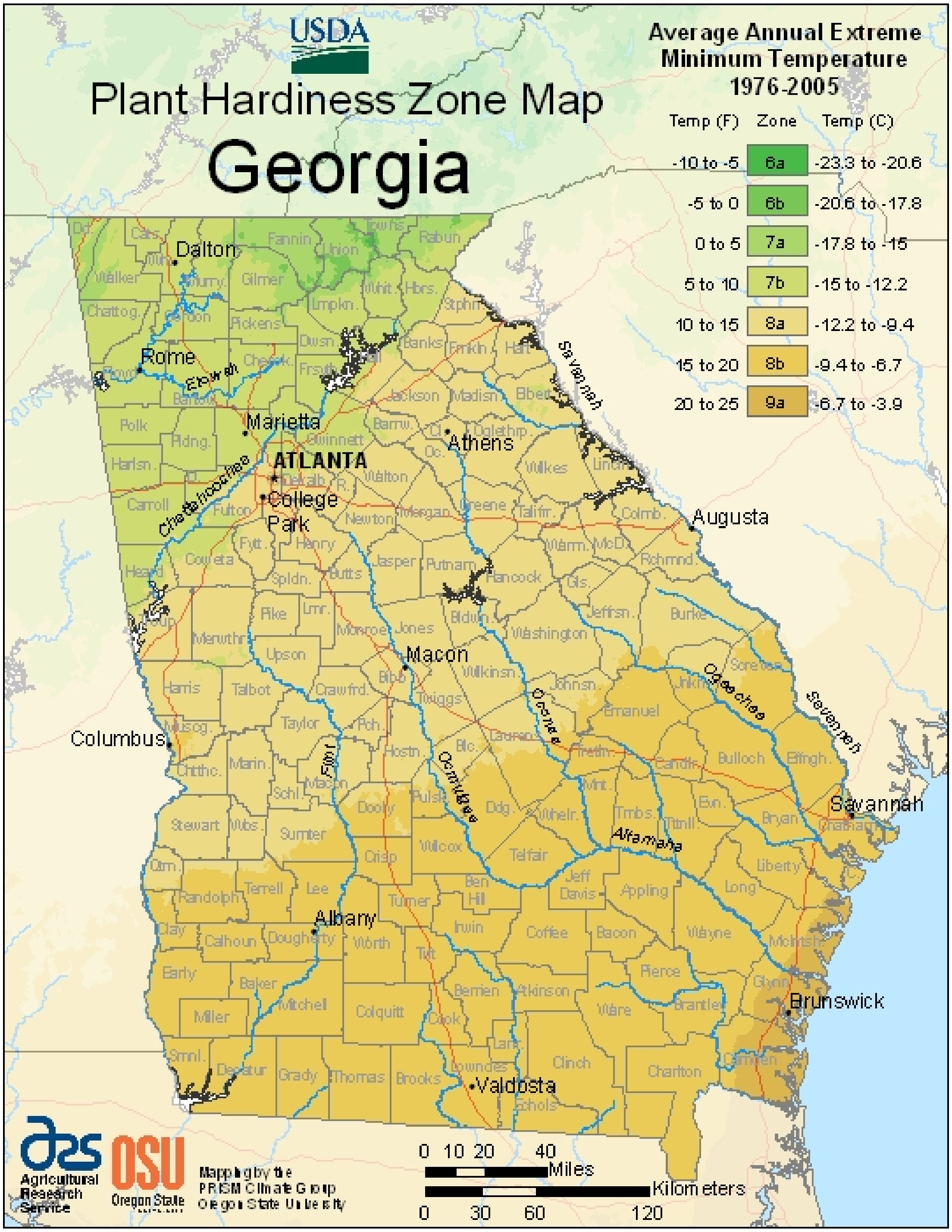
Level III Ecoregions of Georgia
G.E. Griffith, J.M. Omernik, J.A. Comstock, S. Lawrence, and T. Foster
2001
Albers Equal Area Projection
Atlantic Ocean
Level III ecoregion
State boundary
County boundary
45 Piedmont
65 Southeastern Plains
66 Blue Ridge
68 Southwestern Appalachians
67 Ridge and Valley
75 Southern Coastal Plain

APPENDIX E

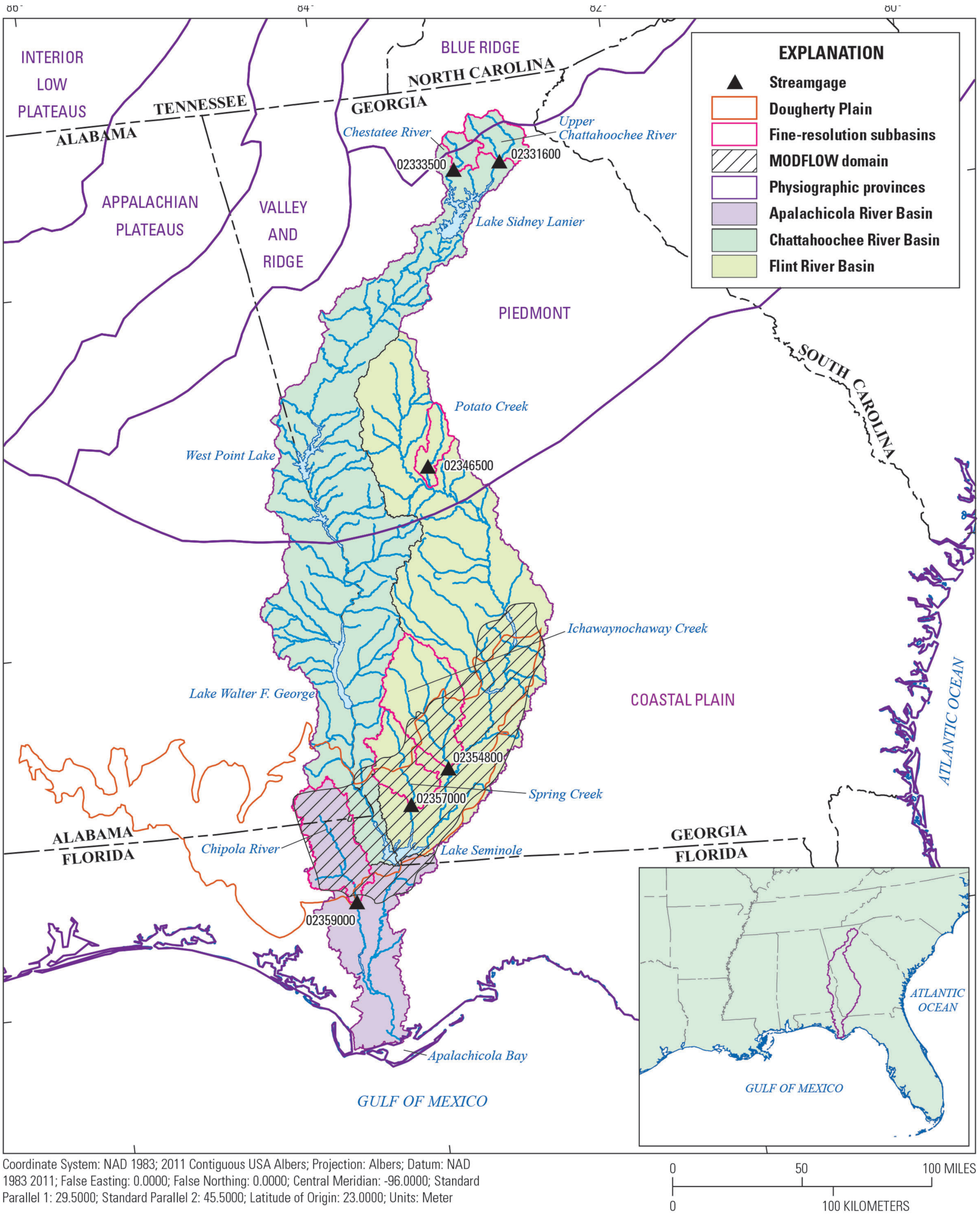
Weather Data for Troup County, GA						
Monthly Averages						
Month	**Jan.**	**Feb.**	**March**	**April**	**May**	**June**
Avg. Temperature	53/37	58/41	65/46	74/54	82/61	89/68
Avg. Wind Speed	8 mph	8 mph	7 mph	7 mph	6 mph	5 mph
Avg. Precipitation	1.9 in	2.2 in.	1.9 in	1.6 in	1.6 in	2.1 in
Avg. Humidity	73%	76%	75%	72%	73%	74%
Avg. Cloud Cover	42%	46%	43%	35%	32%	31%
Barometric Pressure	30.6 in	30.6 in	30.6 in	30.5 in	30.5 in	30.5 in
Avg. Dry Days	19	16	16	17	16	10
Avg. Precip. Days	10	10	13	11	13	16
Avg. Snow Days	1	1	0	0	0	0
Avg. Fog Days	7	8	9	9	9	10
Avg. UV Index	3	4	4	5	6	7
Avg. Hours of Sun	185	186	215	253	314	319

Weather Data for Troup County, GA						
Monthly Averages						
Month	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Avg. Temperature	90/71	89/70	85/65	75/55	63/45	56/41
Avg. Wind Speed	5 mph	5 mph	5 mph	6 mph	7 mph	7 mph
Avg. Precipitation	3.0 in	3.0 in.	1.6 in	1.3 in	1.8 in	2.6 in
Avg. Humidity	74%	75%	74%	71%	72%	78%
Avg. Cloud Cover	33%	34%	33%	32%	35%	47%
Barometric Pressure	30.5 in	30.5 in	30.5 in	30.5 in	30.6 in	30.6 in
Avg. Dry Days	9	10	15	22	20	18
Avg. Precip. Days	20	18	12	8	8	11
Avg. Snow Days	0	0	0	0	0	0
Avg. Fog Days	8	9	9	7	6	7
Avg. UV Index	6	6	5	4	4	3
Avg. Hours of Sun	329	286	255	225	173	155

APPENDIX F


USDA
Plant Hardiness Zone Map
Georgia
Average Annual Extreme Minimum Temperature 1976-2005
Temp (F) Zone Temp (C)
-10 to -5 6a -23.3 to -20.6
-5 to 0 6b -20.6 to -17.8
0 to 5 7a -17.8 to -15
5 to 10 7b -15 to -12.2
10 to 15 8a -12.2 to -9.4
15 to 20 8b -9.4 to -6.7
20 to 25 9a -6.7 to -3.9
Dalton
Rome
Marietta
ATLANTA
College Park
Athens
Augusta
Macon
Columbus
Savannah
Albany
Brunswick
Valdosta
Etowah
Chattahoochee
Savannah
Ogeechee
Oconee
Ocmulgee
Flint
Altamaha
0 10 20 40 Miles
0 30 60 120 Kilometers
Agricultural Research Service
OSU Oregon State
Mapping by the PRISM Climate Group Oregon State University

APPENDIX G - Location, Hydrology, and Physiography of the Apalachicola-Chattahoochee-Flint River Basin



Coordinate System: NAD 1983; 2011 Contiguous USA Albers; Projection: Albers; Datum: NAD 1983 2011; False Easting: 0.0000; False Northing: 0.0000; Central Meridian: -96.0000; Standard Parallel 1: 29.5000; Standard Parallel 2: 45.5000; Latitude of Origin: 23.0000; Units: Meter