

RETHINK SUBURBAN HOME LANDSCAPES:
BRINGING ECOLOGICAL VALUES INTO SUBURBAN LANDSCAPES IN THE
SOUTHEAST WITHOUT COMPROMISING THEIR CORE TRADITIONAL AESTHETICS

by

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(Under the Direction of Katherine Melcher)

ABSTRACT

Conventional suburban residential development in the southeast has a huge environmental impact. Their uniform landscape aesthetics contrasts with the “messy” appearance of typical ecological habitats. These aesthetics differences make bringing an ecological approach to suburban landscape challenging. In order to bring ecological values into suburban home landscapes without compromising their traditional aesthetics, this thesis explores the cultural history of American suburbs, their aesthetics, and ecological design approaches that can bring ecological design into suburban home landscapes. The research is primarily done by literature review and field study. In the end, a list of proposed design guidelines is given as a result of the research. A conceptual design of a suburban garden in Athens, GA is devised to showcase a possible outcome of implementing the design guidelines, and to test the conclusion of this thesis.

INDEX WORDS: landscape architecture, suburban subdivisions, ecological values, aesthetics

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CHAPTER 1

INTRODUCTION

1.1 Background Information

The first time I saw the suburbs of the Atlanta metro area was when I looked down through the window of an airplane landing at Atlanta Hartsfield-Jackson International Airport. An endless number of houses extended to the horizon. It's probably the most common landscape in southeast America, but it was definitely fresh and brand-new to a person like me, coming from China, the most populated country, where most people live in multi-story complexes in cities.

In comparison, the United States is called a "suburban nation," where over half of the American population lives in the suburbs (Kasinitz, 1995, p. 387). As a matter of fact, since the end of World War I, 85% of all new housing in the U.S. has been built in the suburbs (Zukin, 1991, p. 140). After World War II, from 1950 to 2010, the population doubled, but housing occupied almost five times as much land. Seven-eight percent of the newly developed land and almost 82 percent of the added population were located in suburbs outside central cities. The population density was almost cut in half from 5,319 persons per square mile in 1950 to 2,795 persons per square mile in 2010 (Rusk, 2013). Although the trend of suburbanization seems to be slightly reversed in the last decade (Bush, 2013; Davies, 2001; Gallagher, 2013; Rusk, 2013; Teaford, 2008), suburban subdivisions already occupy a great amount of land. Moreover, there is no guarantee how long such a reverse will last where suburban residents will relocate to urban areas. Therefore, a huge amount of land is still going to be occupied by suburban subdivisions with a significant environmental impact in the near future.

Human development interferes with natural processes and can sometimes lead to unpleasant consequences. The environmental impact from the suburban subdivisions, especially the ones designed without regard to their natural context, includes but is not limited to: forest fragmentation, reduced diversity of wildlife species, greater air pollution, loss of farmland and increased risk of flooding (Johnson, 2001; Radeloff, Hammer, & Stewart, 2005). Some of those impacts pose risks that could be immediately identified such as forest fragmentation (Johnson, 2001, p. 722), while others may not be fully known for years, for instance, reduced diversity of species. Additionally, some by-products of suburban development may cause further environmental hazards. For example, suburbanization transfers people and resources from inner-cities to distant suburbs, which causes disproportionate disinvestment in cities (Johnson, 2001). The lack of investment abandons some least-desirable areas within cities such as landfills and brownfields; the toxic and hazardous waste from those areas then begin to contaminate the soil and water.

To integrate natural processes in suburban landscapes requires the knowledge of those processes and new technologies. Over 110 years after the Garden City movement initiated by Sir Ebenezer Howard, we have a deeper understanding of the operation of natural processes and more advanced techniques, which allow us to rethink the design of suburban landscapes in an environmentally conscious manner.

On the other hand, the long-established, uniform appearance of suburban landscape in the southeast may resist such changes. “Single-family homes surrounded by more or less well-manicured lawns, resting in isolated pods” (Batchis, 2012, p. 2) is a very brief but accurate description of the suburban landscape. There have been attempts of bring nature into urban areas, such as the Garden City. However, the Garden City focused too much on the visual, and neglected,

to some extent, the underlying natural processes. It did not necessarily integrate nature with the city; instead it only integrated a natural-looking land with urban development. From a utilitarian standpoint, those natural-looking open spaces provide leisure space for citizens; the trees and vegetation infiltrate the polluted air, and the green space could provide habitat for birds and wildlife. However, from an ecological standpoint, many underlying natural processes are neglected. For instance, rainwater still runs into municipal drainage facilities and sewage still goes directly into water treatment plant. Besides, the benefit of creating wildlife habitat is also questionable since many plants are planted merely for their appearance. Therefore, “as they (garden cities) grow older and as urbanization spreads around them, they exhibit many of the same environmental problems as earlier cities.” (Spirn, 1984, p. 29)

The best way to incorporate ecological values into suburban development and therefore minimize their environmental impact is to “protect, restore and replicate” the natural processes (Calkins, 2011, p. 65), which in most cases also brings a disorderly appearance, far from the traditional aesthetics that has been pursued in suburban landscapes. Therefore, it is of great value to develop a new ecological suburban landscape design that is also aesthetically compatible with suburb’s long-established aesthetics.

1.2. The objective and the questions

The objective of this thesis is to find a way to mitigate the environmental impact of existing suburban subdivision landscapes in the southeast without compromising their core aesthetics. In other words, to devise an aesthetically-conscious way for an ecological transition of domestic gardens in southeastern suburbs.

In order to achieve this objective, the following questions need to be answered:

- a. What are the core aesthetics of suburban landscapes in the southeast US?

- b. What are the environment impacts of suburban subdivisions, and how can they be mitigated?
- c. How can we mitigate the environmental impacts in an aesthetic manner?

1.3. Premises, limitations and delimitations

1.3.1. Premises

This study is based on the following premises. The first premise is that there is a culturally –based aesthetic value of domestic landscapes that deeply influence suburban residents’ preferences for garden design, and that these values will not change in a short period of time. The second is that the ecological impacts of suburban subdivisions can be mitigated by redesigning domestic gardens and retrofitting existing subdivisions. The third is that there is a way to resolve differences between the long-established aesthetics and the disorderly appearance of nature to incorporate traditional aesthetics into environmentally-conscious design. The last premise is that suburban subdivisions will not be removed anytime soon, though their disadvantages have been criticized in a variety of ways. So it is still greatly meaningful to ecologically retrofit the existing subdivisions.

The first premise is explained in Chapter 4: Aesthetics; the second premise in Chapter 5: Ecological Values; and the third premise in Chapter 6: Proposed Design Guidelines. The last premise is explained in Chapter 3: American Suburbs.

1.3.2. Limitations

The first limitation is time. Due to the limited time I am able to work on this thesis, the approaches introduced and studied in this thesis may not be the best ones to achieve the objective. Moreover, new ecological design technologies and theories come out every week. By the time this thesis is published, some information in this paper may already be outdated.

The second limitation is the representativeness. Even though my research focuses on suburban landscapes in the southeast, primarily in the Piedmont ecoregion, the design guidelines provided in chapter 6 may not be applicable to every suburban household in this region. The Southeastern US, and even the Piedmont ecoregion is still a huge area. The soil type, vegetation type and water quality among other things can vary in a very short distance.

Moreover, even though a generally preferred style within suburban landscapes can be identified, a particular homeowner's preference could possibly be far from it. People from different cultural and ethnic backgrounds could have very different ideas about their gardens' appearance. So the result of my research is not universal. However, the research and findings of this thesis could still provide beneficial information to homeowners, designers, homeowners' associations, and government officials who intend to embrace nature in suburban landscapes.

1.3.3. Delimitations

The location of my research target—suburban landscapes—is confined to the Piedmont ecoregion in northern Georgia. The design guidelines and the design example given in the last chapter are based in Athens, Georgia.

The target for design is individual gardens in suburbs instead of the entire suburban subdivision. And there are two reasons for focusing on individual gardens. The first reason is that individual households constitute the subdivision. Without retrofitting the landscape design in individual gardens, the landscape of the subdivision cannot be changed. The second reason is that, balancing ecological values and aesthetics can be better addressed on a small scale, because people's aesthetics preference are based on what they can see in their houses or on the streets, not on the overall appearance of the entire the subdivision. In the chapter of ecological values, approaches and practices are selected in terms of their applicability of installation in suburban

subdivisions on the household level. Large equipment or technologies that require intensive maintenance or a large amount of land are out of the scope of this thesis.

Overall, the main body of this thesis lays a greater emphasis on landscape design among other issues that need to be addressed when retrofitting a domestic garden, such as landscape management. Landscape management is vital to maintain a functional ecological landscape, management-related subjects, such as maintenance and cost, will be discussed very briefly in certain sections. The absence of management topics does not suggest that they are not necessary. In fact, in some cases they might be more important than design. But for this thesis, time and effort are primarily contributed to design-related issues.

Another delimitation is the audience of this thesis's findings. The thesis is dedicated to the exploration of ecological values and aesthetics on a site level. And the research and the design guidelines in this thesis are intended to be a reference and guidance for individual homeowners. Although sometimes, on a larger scale, the planning agencies, HOA (Homeowners' Association), and the government can play a very important role in deciding the appearance of suburban landscapes by zoning and enforcing regulations, they are not part of the discussion.

1.4. The Importance of the Research

To begin with, the environmental impact of suburban subdivisions is large and it is urgent to minimize this impact. In the U.S., almost three quarters of the population in metro areas live in suburbs. With a much lower building density, suburban subdivisions occupy a huge amount of land. A large proportion of the suburban land is taken from prime farmland and forests. The ecological impact of suburban development without regard to natural habitat will be further discussed in Chapter 3: American Suburbs.

The new LEED certification system has taken architecture design to a new level of sustainability, but suburban landscapes are still largely designed without regard to ecological impact. Buildings may consume a lot of energy and generate toxic waste, but it is the conventional way of laying out the subdivisions and landscape design that damages primitive forests as well as wildlife habitats. Despite recent decrease in the construction of suburbs, existing suburbs are not going to disappear from the American landscape anytime soon. Therefore, it is necessary and urgent to devise a way to retrofit existing suburban landscapes to mitigate their environmental impacts. The research and design guidelines could also provide beneficial suggestions to new development projects.

On the other hand, historical research has explained the preferred appearance of landscapes in suburbs; sustainable design approaches have been implemented in architecture and landscape projects across the country; and attempts have been made to retrofit suburban subdivisions in a variety of ways. For instance, Joan Iverson Nassauer has revealed homeowners' preference of the traditional landscapes (manicured lawn and trimmed shrubs) and concluded that the traditional landscape of neatness suggests cues of care of their properties (Nassauer, 1993). Long before LEED certification system was established, designers and practitioners incorporated ecological values into their works. For example, drip irrigation has been installed in parks and plant nurseries to save potable water; double glazing windows has been installed in office and apartment buildings to reduce energy loss; and rain gardens have been built in many cities to increase infiltration and reduce stormwater runoff. However, few of these approaches were commonly implemented in suburban subdivisions. Plus, none of them tried to bring traditional suburban aesthetics into account.

The most relevant ecological practice focusing on suburbs is called conservation subdivision; the idea is to set aside open space around identified areas of high ecological value. This commonly happens in the first phase of a suburban subdivision project, rather than years after the houses are built. Retrofitting existing suburban subdivision by infill, smart growth or creating mixed-use districts is also under consideration and construction in some places (Dunham-Jones & Williamson, 2011). People are trying to save suburbs. But instead of retrofitting the existing infrastructure, these solutions generally aim to direct new growth and new construction to remediate certain social, transportation or economic issues. Therefore none of them could achieve the goal of retrofitting the existing suburban subdivisions in an ecological manner without superimposing a new look, which leaves it an important question to answer.

Being sensitive to traditional aesthetics may make it easier to bring nature back to suburban subdivisions without encountering resistance from local households. The previous approaches and ideas mentioned above tend to overlook aesthetics. According to my research, the objective of bringing ecological values into suburban landscapes in the southeast without compromising their core traditional aesthetics has never been carefully researched before. This is why it is meaningful to find a balance between traditional aesthetics and ecological design.

CHAPTER 2

METHODOLOGY

In order to find a way to bring ecological values into suburban landscapes in the southeast without compromising their core traditional aesthetics, the objective is broken down into three facets, suburban subdivisions in the southeast, aesthetics of the landscape, and ecological values. Through extensive literature review and research on best practices, a series of projective design guidelines are given as the conclusion of this thesis.

At the beginning of each chapter, the definition and the scope of each term will be defined, primarily through a synthesis of existing literature. In Chapter 3, to help acquire a full understanding of American suburbs, the history of American suburbs will be explored; findings of previous research will be studied; and several suburban subdivisions in Athens, GA will be investigated. Literature review is the primary method of research in this chapter. The method of field study is also utilized to help investigate the suburbs in Athens.

In Chapter 4, the preferred suburban landscape aesthetics will be identified and the reasons behind these celebrated appearances will be discussed. This chapter answers the question about the core traditional aesthetics of suburban landscapes in the southeast. The research will be done by literature review. Books and articles focusing garden design and the history of American suburbs are the main sources. Field study will be conducted in the suburbs of Athens, GA to help complement the theories from literature.

Chapter 5 is dedicated to finding the best solutions for bringing ecological values into suburban landscapes. Identifying the problem—the ecological impact of suburban landscape—is

the first step to respond to this objective, which will be done by studying reports, news and peer-reviewed articles. Current research and methods of environmentally sensitive design will be reviewed and evaluated in terms of their applicability to be installed in a typical suburban residence.

In Chapter 6, to devise the design guidelines for suburban home landscapes, which will be the conclusion of this thesis, all the research and findings from previous three chapters will be synthesized. To further explain the guidelines and to show how these guidelines can be implemented, a conceptual redesign of a suburban domestic garden in Athens, GA will be developed as an example. The design will then be evaluated by “The Guidelines and Performance Benchmarks”, a criteria established by Sustainable Sites Initiative (SITEStm) “for measuring site sustainability” ("Guidelines and Performance Benchmarks," 2009) (this criteria will be hereafter referred to as SITES). The evaluation will be followed by a reflection and discussion regarding the conceptual design and the design guidelines.

To conclude, literature review and field study are the primary methods to be used for answering the questions about suburban landscapes aesthetics and ecological values, which are the basis for devising the solution to balance them. Discussion and evaluation are used throughout the thesis to synthesize the information and to form new ideas.

CHAPTER 3

AMERICAN SUBURBS

This chapter is dedicated to the cultural history of American suburbs as a basis for further discussion on the aesthetics and ecological values of suburban subdivisions. First, the scope and meaning of suburbs and suburban landscapes are defined, followed by the identification of key features of suburban landscapes. The second section reveals the highs and lows of American suburbs from its birth to the 21st century, which helps explain the necessity and importance of retrofitting suburban landscapes without compromising their aesthetics.

3.1. Definition of Suburbs and the Scope of Suburban Landscape

Before American suburbs are further discussed, the definition of suburbs should be clarified. The definition of suburbs varies when perceived from different perspectives. Generally speaking, suburbs in the United States are recognized to be those places located between the central city limits and rural areas (Teaford, 2008). To be more specific, suburbia is that stretch of land beyond the city but still within a designated metropolitan area (Jindrich, 2012), which is also the definition agreed upon by Federal Census Bureau, who defines suburbs as “the zone within metropolitan areas but beyond central city limits.” (Teaford, 2008) Sub-types of suburban settlements, such as inner-ring suburbs, outer suburbs, exurbs on the rural-urban interface and edge cities (Jindrich, 2012), are identified in terms of their distance to the central city.

The term landscape in this thesis refers to a more specific target of front yards, especially in this chapter and in the discussion in Chapter 4: Aesthetics because of the delimitation of this thesis. In Chapter 6, however, the word landscape refers to backyard as well as the front yards,

since the design guidelines introduced in that chapter are intended to be applied to both front yards and back yards.

The components and general forms of suburban landscapes can be identified and summarized fairly clearly from a designer's perspective. Some of them are: "clustered housing subdivisions, shopping centers, office parks, and public buildings linked together by connector roads feeding into high-speed freeways." (Duany, Plater-Zyberk, & Speck, 2010, p. 5) Each of these components is strictly segregated from the others, although they are somehow connected by automobile transportation. Mixed-use areas are lacking. Almost all the residences are single-family houses, "surrounded at close quarters by more of the same" (Duany et al., 2010, p. 41). And those houses are "surrounded by more or less well-manicured lawns, resting in isolated pods of socioeconomically homogenous neighbors." (Batchis, 2012, p. 2) They are "a multitude of uniform, unidentifiable houses, lined up inflexibly, at uniform distances, on uniform roads" (Mumford, 1961, p. 486). Table 1 summarizes the key attributes of suburban subdivisions based on literature cited in this chapter and personal observation.

Table 1: Key Attributes of Suburban Subdivisions:

Location	Suburban subdivisions are located between the central city and rural area, but within metropolitan areas.
Residential Housing	Housing subdivisions/tract houses/single family houses look all the same. They are lined-up; have uniform setbacks; and are low-density.
Civic buildings / Public buildings	Civic buildings are not located in vicinity of residential houses or center of social life, if any; and they are surrounded by parking lots. Stores are usually located close to intersection or exit of highway.
Landscape	Well-manicured lawns, houses resting in isolated, small pods.

3.2. A Brief Introduction to American Suburbs

The central cities which emerged in the early 20th century, once the symbol and center of American life, are no longer central to the lives of most Americans (Teaford, 2008). By 2010, almost 68 percent of the population of 383 metropolitan areas in the US lived in suburbs. Equally as important, a majority of jobs in metro areas were located in suburbs as well (Rusk, 2013, 7). Nine of the twelve most famous and largest cities hit their twentieth-century population peaks in the 1950 census. That is when developers, bankers and businessmen made middle-class families an offer that they could not refuse: the American Dream (Rusk, 2013, 9). The following is a vivid description of what attracted the urban population to the suburbs in the 1950s:

“Sustained economic growth, cheap home mortgages, affordable automobiles, and federally subsidized highways—all touted on screens big and small—made that dream house with its own yard, quiet neighborhood, local school, and nearby shopping possible for millions of families. Compared with staying put in many city neighborhoods, suburbia was a bargain. Urban America became suburban America.” (Rusk, 2013, p. 9)

Apart from the economic circumstances and living conditions in the city back then, there were some deeper causes hidden behind the obvious. Leigh Gallagher argues in his book *The End of Suburbs* that the baby boomers and the popularity of automobiles helped fortify the notion of the suburban single-family house as the American dream (Gallagher, 2013). But the American Dream actually lies in the nation’s tradition of expansive freedom and mobility: “Suburbia reflects the desire of Americans over the decades to do it their own way (freedom and self-determination); Americans perceive suburban self-determination as a vital component of the nation’s heritage of

liberty” (Teaford, 2008, p. 220), which explains why suburban subdivisions are so popular in America from a cultural and social standpoint.

However, after a few decades, in suburbs of almost every metropolitan area, problems have emerged and the whole idea of suburbs has been scolded by city planners, landscape architects and critics in various ways. The homogenous look and the environmentally insensitive design are among the most urgent issues.

3.3. Summary

Suburbs once provided people in the U.S. a perfect alternative living environment as well as a dreamed lifestyle. But the traditional design of suburban subdivisions is currently going through a tough time of fitting people’s new needs for living environment in this country. Issues emerged in the past few decades are calling for a new solution for a more sustainable living condition. As mentioned in the first chapter, a lot of ideas have been put into practice to make suburbs more attractive for the new generation, such as infill and “smart growth”. However, private homeowner gardens are often left out in these new ideas, even though they occupy the largest amount of land in a suburban subdivision and can be easily changed as long as the homeowner wants to. This thesis is trying to fill the gap from an ecological standpoint.

CHAPTER 4

AESTHETICS

Now that we have an understanding of the need to transform suburban landscapes in an ecological way, it is time to come up with a plan to achieve this goal. The biggest obstacle to successfully accomplish the transformation is probably people's taste on how their gardens should look like. Aesthetics is "a set of ideas or opinions about beauty or art" (*Merriam-Webster's collegiate dictionary*, 2003). In this thesis, aesthetics refers to the visual cognition of beauty of the environment, which could be influenced by individual preferences but also have a shared cultural basis in reference to public landscapes (Duncan & Duncan, 2004). In other words, once established, aesthetics is resistant to swift changes.

In the second half of the twentieth century, a lot of things changed dramatically: the way people live, travel and communicate had all been changed, thanks to suburbanization, cars and computer technology. The housing construction boom, along with increasing house size, is also part of the change (Adams & Burchfield, 2013). This is also the time when suburban landscape became homogeneous. Surprisingly enough, compared to all the considerable changes in people's life, home garden design didn't change that much. In spite of many new concepts and products emerging in this era, for instance, edible landscapes, planting for wildlife, native plantings, and organic gardening, when it comes to the vast majority of suburban gardens, people still desired a perfect lawn (Adams & Burchfield, 2013). There must be a reason to explain people's persistence regarding their own garden designs. This chapter is dedicated to identifying the aesthetics of suburban home landscapes and explaining what lies within our heads.

On the other hand, from a design perspective, it is easier to accept people's persistence on aesthetics and take it into consideration rather than contradicting it. In other words, if a new design approach conforms to people's taste while accomplishing its ecological missions, the new design would be much easier to be accepted and eventually implemented.

As mentioned in the delimitation section of the first chapter, there are other factors that influence people's choice of retrofitting their gardens, such as maintenance and cost. But this thesis will focus on aesthetics since it is an important issue to address, especially for the design guidelines.

Aesthetics in this thesis refers to the visual cognition of beauty of the environment. This chapter starts with an exploration of the aesthetics of American landscape and a summary of characteristics of suburban garden landscapes. In the following sections, the traditional aesthetics of suburban landscapes is identified, summarized and explained from both historic and psychological perspectives. The front yard and the lawn are studied in two separate sub-section, since they are the most important and visible elements in suburban landscapes. In the last sub-section, psychological research is also taken into consideration. A concept called social contagion is introduced to help explain the uniformity of suburban landscapes.

4.1. Traditional Aesthetics of American Home Landscapes

The book *American Home Landscapes* introduces a series of garden styles of different time periods. Each of them has its own historic background, patterns, design details and favorite plant species. But despite differences in the decorative details, they look very similar to each other, since they share a lot of components and similar organization of those components (see Fig 4.1 – 4.2 for photos and master plans for reference). This observation is also supported by the author of this book in which he emphasizes the details of a garden design for “an appropriate period landscape.”

(Adams & Burchfield, 2013, p. 9) Most of the traditional styles share the same design “elements”, such as symmetrical shapes of planting or structures (with axis going through the geometrical center of the building or the site), trimmed shrubs as foundation planting, openness in front of the house, and fences surrounding the property to provide privacy. Modern landscape design trends that emerged in the late 20th century, such as minimalist landscapes (see Fig 4.3-4.4 for some images and plans of modern landscape design), however, never reached the general population (Adams & Burchfield, 2013).



Fig 4.1 Traditional garden design in different time periods

(Adams & Burchfield, 2013, pp. 61, 93, 178, 248)

(Top left: Hoboken, New Jersey, 1808; Top right: Nicholas William Stuyvesant, New York, 1857; Bottom left: “Typical suburban front yard” 1960 - 2000; Bottom right: Unknown, 1910)

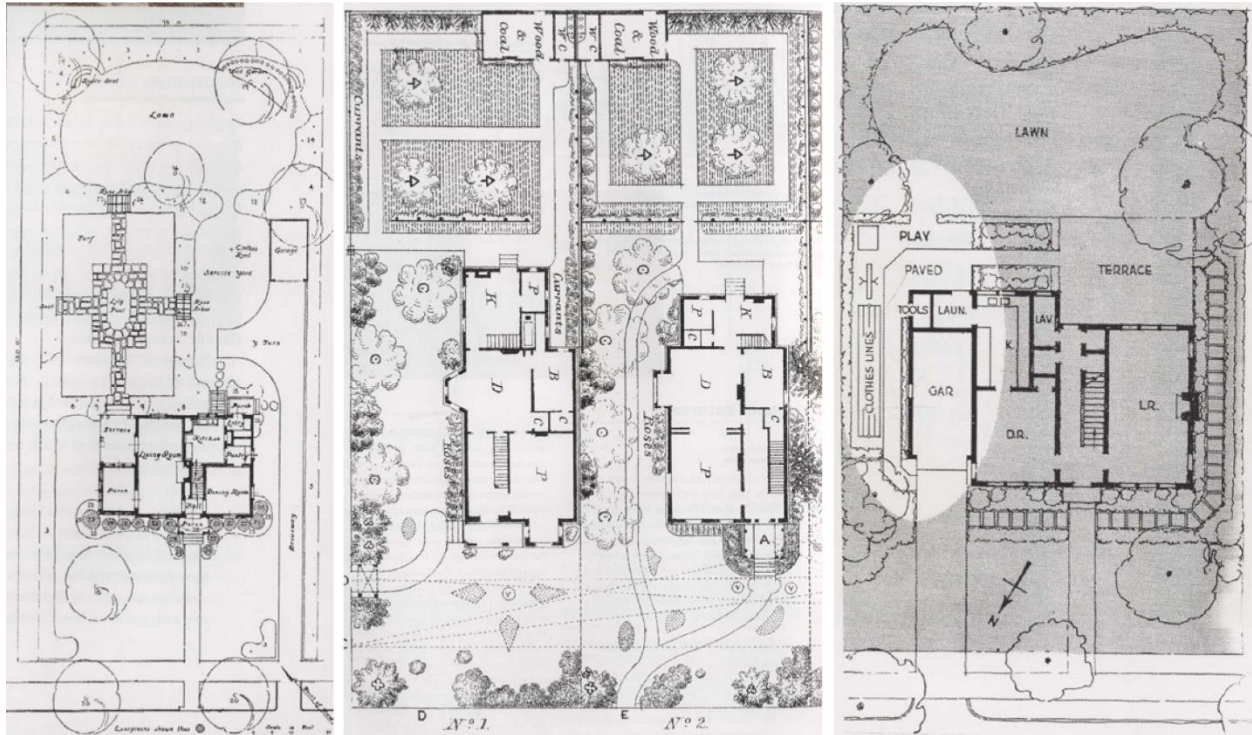


Fig 4.2 Plans of traditional garden design in different time periods

(Adams & Burchfield, 2013, pp. 138, 173, 220)

(From left to right: 1924, 1950, 1945)



Fig 4.3 Modern garden design (Colleu-Dumond & Lee, 2013, pp. 3, 165)

Left: Dan Kiley, Miller House Gardens, Columbus, IN, 1953; Right: Ron Herman, Ellison Residence, San Francisco, CA, 1961

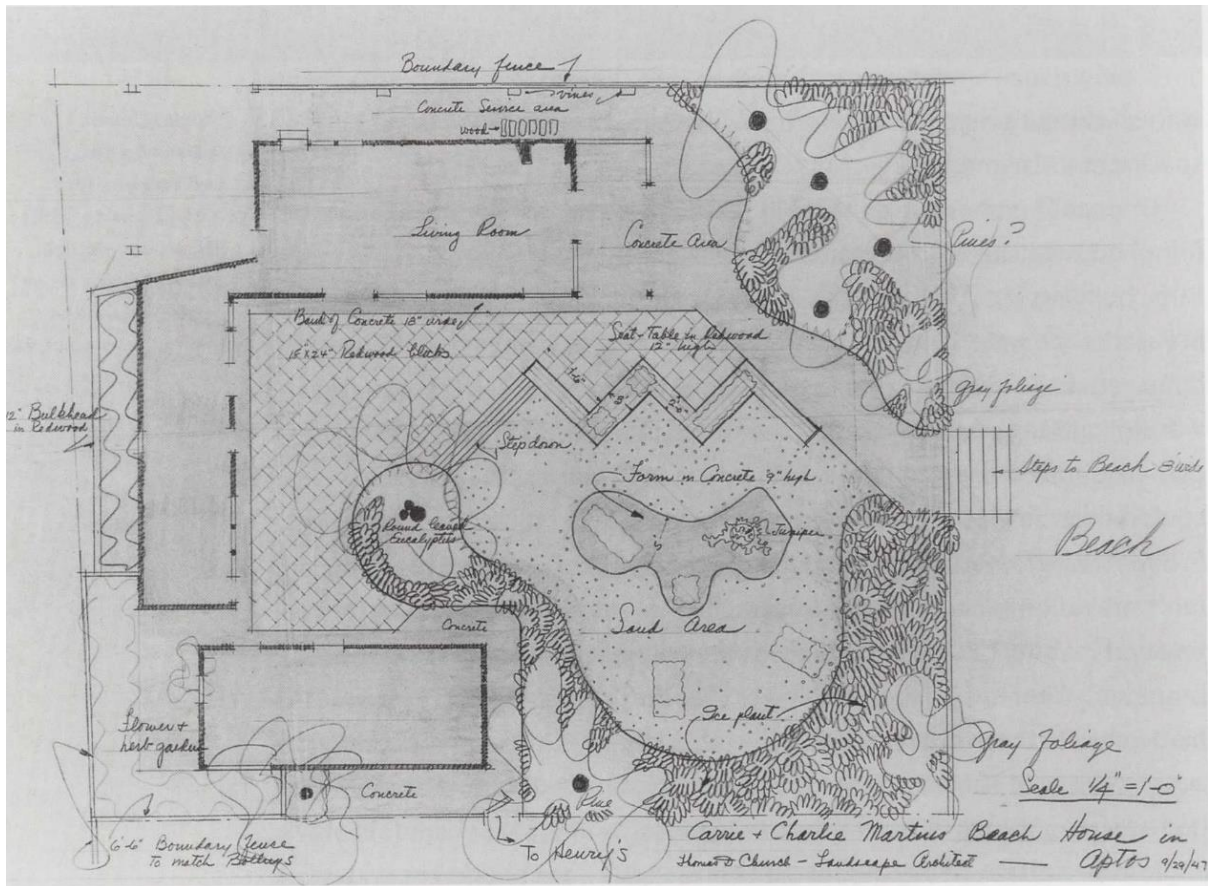


Fig 4.4 Plan for Martin Garden, Aptos, CA, 1947 (Waymark, 2003, p. 152)

From studying traditional garden designs in different time periods (master plans and photos) and field study in suburban neighborhoods in Athens, GA, I summarize a list of landscape aesthetic principles embedded in traditional gardens:

- (1) Simple geometries. Circles, rectangles, ovals and the combination of them are among the most frequently used shapes in traditional garden design. Simple geometries are used as planting areas, pavement areas, and sometimes the shapes of trimmed plants. Often times in the backyard, where the atmosphere is more relaxed, streamlined shapes are also widely used.

(2) Axis. Axis is essential in traditional garden design, especially in front yards. In many formal gardens, the walkway from streets to the house's front entrance is a physical axis in the landscape. In some cases, the axis is not physical, which, however, can be identified by the symmetrical arrangement of trees and other landscape amenities (see Fig 4.1 and 4.2).

(3) Lawn. A manicured lawn is an essential element of almost every garden, in front yards and backyards. Sometimes it is trimmed into a streamlined shape surrounded by shrubs and other vegetation. More often, the entire yard is dominated by lawn, with a few trees and shrubs on it.

(4) View. View from the house to the streets or from the sidewalk to the house is always clear at eye level. Trees, big shrubs are located near the edge to avoid blocking the view. In many cases, the vegetation planted near the edges also frames the view.

Suburban landscapes came with suburbanization and the suburban lifestyle. While the massive suburbanization started in as early as 1930s, the root of suburban life styles actually goes back to 18th century and possibly earlier.

In order to understand the essence of suburban landscapes, the history of them should first be understood. In the following section, I will explore the history of the landscape, in particular the front yard in suburban subdivisions from an aesthetics perspective.

Until the 18th century, most Americans lived in cities. Row houses were very popular in a big city such as New York City and those houses were “jammed together”; front and side yards were almost nonexistent, while the small rear yards were apt to be covered with black-alley dwellings (Jackson, 1985). Part of the reason was that, back in the days when Europeans first established their dwellings in the uncultivated new world, nature was wild and fearsome. Living

next to each other in cities provided a sense of safety. In the meantime, there was no easy way for people to travel long distances, and cities were probably the best places to make money.

However, the city was not always a paradise. In the United States, periodic outbreaks of plagues, such as smallpox, yellow fever, and cholera took heavy tolls. The compact living conditions were blamed as an obvious cause at that time, although today we would say a lack of proper sanitary measures was more likely the primary cause. As a result of this notion, when people no longer feared nature in the 19th century, thanks to modern technologies including automobiles, people began to seek the suburban lifestyle, as Kenneth T. Jackson described vividly in his book, “Scarcely a single suburban advertisement in the middle decades of the nineteenth century failed to contain the boast that residence among open space was healthier than life in cities.” (Jackson, 1985, p. 57)

On the other hand, in the 18th century, the zone of private life began to expand: “The emerging values of domesticity, privacy, and isolation reached fullest development in the United States.” (Jackson, 1985, p. 48) Architects designed single-family houses with much more complexity. Private spaces and public spaces under the same roof were strictly separated. The house became “a place of refuge, free from outside control” (Jackson, 1985, p. 47). In order to get a better sense of privacy and “domesticity”, the interior alone was not sufficient. So the landscape, essentially front yards and backyards, began to be considered as an inseparable part of the household’s territory of private life. As a result, after 1840, the preferred site for a middle-class household became “a semirural homestead”, and “the most conspicuous theme” of any architectural pattern books was private space (Jackson, 1985, pp. 56 - 57). And such standard had become “the paragon of middle-class housing, an investment that many people hoped would provide a ticket to higher status and wealth.” (Jackson, 1985)

However, when the “semirural” living style was introduced to America for the first time in the 19th century, there were no landscape design precedents for designers to emulate. This condition was soon ended by three great designers, Andrew Jackson Downing, Frank Law Olmsted and Calvert Vaux. A typical American residential landscape built around a manicured lawn was established by Downing’s work in the mid-nineteenth century (Lancaster & Goode, 1991). Their influence is still evident in the “visual composition of many American and Canadian suburbs”: “houses are set back from the street creating broad expanses of turf punctuated by trees and shrubs, resulting in park-like settings.” (Henderson, Perkins, & Nelischer, 1998, p. 136)

In my point of view, such common notions about how landscape should look helped intensify and consolidate the preferred landscape aesthetics in people’s mind, which could be passed to generation after generation, even if the environment changed over time.

4.2. Explanation of People’s Preference and the Uniformity of Suburban Landscapes

Some components of the popular suburban landscape clearly contribute to negative environmental impacts (details will be discussed in the next chapter). Residents must have chosen to maintain these landscape styles for centuries for specific reasons. This section is dedicated to explore those reasons.

This section is further divided into three sub-sections. The first two sub-sections focus on front yards and the lawn, two important and visible components of suburban home landscapes. The third one provides additional reasons to explain these two issues more thoroughly, from a historic and a psychological perspective.

4.2.1. The Formation and Characteristics of Front Yards

The setback from the street which didn’t exist until the 19th century created the front yard. The setback required a house to be set back from the street by a minimum distance (Henderson et

al., 1998). Since then, the yard, especially the front yard, started to be celebrated alongside with the detached houses. By 1870, “separateness had become essential to the identity of the suburban house.” (Jackson, 1985, p. 58) The gaps between houses were filled by yards. Yards were expected to be large and private, and act like “a transition from the public street to the very private house” (Jackson, 1985, p. 58).

Americans landscape design are deeply influenced by English picturesque landscape. The suburban landscape in the 19th century followed “a naturalistic or romantic approach, which was inspired by the English, with antecedents in the Orient.” (Jackson, 1985, p. 59) Such argument was also concurred by Lash and Urry: “The aesthetic attitude is closely linked to European romanticism in that both valorize lived particularity over abstracted generalization.” (Lash & Urry, 1994, p. 49) Perhaps the vast natural land had taught the Americans to appreciate the beauty of nature. English picturesque, which sought to use the existing terrain, with gently curving paths, irregular groupings of trees and shrubs and rustic pavilions, is no doubt the closest to what was surrounding the early Americans. This legacy continues today.

Another milestone was established when Frank A. Waugh outlined the three fundamental suburban landscape design principles in his *Book of Landscape Gardening* in 1926 (M. R. Smith, 1991; Waugh, 1926): “Firstly, foundation plantings were to be used to connect the house with the grounds and with other plantings. Secondly, the foundation plantings should soften the harsh architectural line of the house. And finally, the plantings should dress up the property and make it seem more cozy and homelike.” (Henderson et al., 1998, p. 137) Most significantly, the three principles established a standard for foundation plantings. These ideas controlled the design of suburban front yards, even today. Nature or natural processes were not mentioned within the three principles. Plantings are simply used as an ornament to beautify the house.

4.2.2. Lawn

Instead of enjoying hedges and wild flowers, which were also popular in Europe, Americans prefer the well-manicured lawn. The lawn became the “mark of suburban respectability” and “an object of great pride and enabled its owner to convey to passers-by an impression of wealth and social standing.” (Jackson, 1985, p. 59) In the U.S., lawns (private, public and sports turf) cover between 8 and 16 million ha (19.77 million acre and 39.53 million acre), far surpassing land coverage of major crops (Robbins, Polderman, & Birkenholtz, 2001). A study conducted by Nassauer in 1993 revealed that homeowners “generally preferred the traditional lawn”, in contrary to five other lawn alternatives, which contains a various proportion of naturally grown grass, shrubs and trees. However, “one scene in which half of the lawn had been replaced with native plants was found to be almost as equally attractive” (Fig 4.5), from which Nassauer came to the conclusion that “neatness suggests that a property is well cared for.” Another research conducted by Kaplan leads to a similar conclusion: the scene of spaced trees with a smooth ground, where the trees provide a clear focus and the setting seems to invite entry, seems to be highly desirable (Kaplan, Kaplan, & Ryan, 1998). On the contrary, “dense vegetation and obstructed views” seems to be low in preference (Kaplan et al., 1998). Neatness was best expressed through landscape designs providing visual cues of care (Nassauer, 1993). In other words, a design that appears to be neat and well cared for, with open views is more likely to be considered acceptable.



Conventional Front yard Design



50% Native Garden Front yard Design

Fig 4.5 Conventional Front Yard vs. 50% Native Plants Front Yard (Nassauer, 1993)

4.2.3. Additional Explanations and Facts

Additionally, suburban landscape preferences can also be explained by visual psychological studies. According to Gestalt psychology, “the first steps in visual perception, observed on humans, work like geometric grouping machines.” (Grompone von Gioi, Delon, & Morel, 2012, p. 266) Gestalt psychologists argue that perceptual experiences are intrinsically holistic and organized (Wagemans et al., 2012). Furthermore, phenomenological experiments have shown that the grouping laws (listed below) proposed by the Gestalt school are “purely geometric and mostly independent of any empirical knowledge.” (Grompone von Gioi et al., 2012, p. 266) Therefore such visual perceptions are independent of cultural background, family influence, or personal experience. In other words, the grouping laws are human nature. They are embedded in everyone’s mind and influence people’s preference for landscapes.

Note: The following grouping laws originate from K. Koffka’s work in 1935, but have been revised and consolidated by Herb Stevenson (Koffka, 1935; Stevenson, 2012):

1. The Principle of Similarity suggests that items that are similar tend to be grouped together regardless of whether the similarity or relationship actually exists (Fig 4.6-a).

2. The Principle of Pragnanz suggests that our sense of reality is organized to the simplest form possible by eliminating what is unfamiliar or does not seem to be useful (Fig 4.6-b).

3. The Principle of Proximity suggests that objects that are near to each other tend to be grouped together whether in a relationship or not (Fig4.6-c).

4. The Principle of Continuity indicates lines are seen as following the smoothest path, which suggests that we tend to develop lines of thought by following preconceived meaning-making (Fig 4.6-d).

5. The Principle of Closure suggests that objects that are grouped together are seen as a whole, such that things are grouped together to complete a whole that might not exist. We ourselves fill in the gaps (Stevenson, 2012). Closed areas seem to be self-sustaining, stable organizations (Koffka, 1935) (Fig 4.6-e).

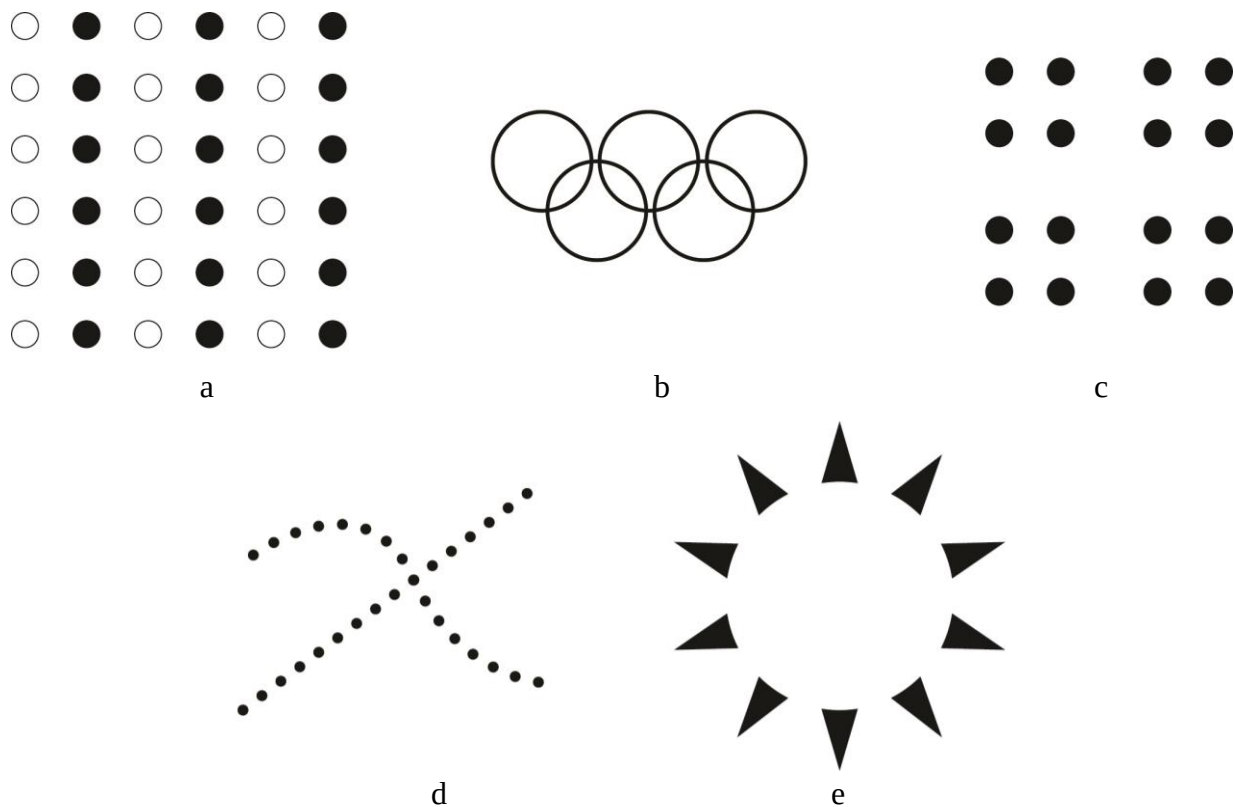


Fig 4.6 An illustration of Gestalt grouping laws

The grouping laws can be linked with design principles that were implemented in suburbs in the U.S., especially the traditional ones. The grouping laws could help explain the enduring popularity of these landscape aesthetic principles (see section 4.1 for reference). For instance, the principle of similarity and proximity can be found in front of the house. Shrubs are often pruned into spheres, and the same species are planted next to each other to form a group. Furthermore, the edges of both the drip line and the group of shrubs follow a smooth path, which corresponds to the principle of continuity (see Fig 4.7 for a labeled typical suburban house front yard).



Fig 4.7 A typical front yard of a modern suburban house

(Photo taken on the eastside of Athens, GA)

So far, I have pointed out several reasons and factors that explain, to some extent, how suburban front yards have evolved to their present appearance. Most of them date back to when suburban gardens first appeared. During that time, a few landscape design pioneers played a vital role in deciding the appearance of suburban gardens, and their influence remains today.

However, often the landscape of a suburban house is much simpler than traditional designs (see Fig 4.10). This happens more often in a newer suburban subdivision where homeowners, especially young ones where both the husband and wife work, may not be able to take care of their gardens or afford to pay professionals to do so. This situation leaves a lot of new suburban gardens

retaining their initial appearance, sometimes called the builder's package. Therefore the contractor's or the builder's package, an over-simplified version of traditional garden design, is also responsible for the homogeneity of front yards and backyards, especially in newer subdivisions (Adams & Burchfield, 2013). Typically, a low-end package consists of a shade tree, several shrubs, and a seeded lawn in the front yard; sometimes with a small patio, a privacy fence and more lawn in the backyard (see Fig 4.7 and Fig 4.8). This type of landscape is easy to manage and operations are simple. Landscape companies specialize in maintenance of this type of landscape for homeowners who lack the time and energy to take care of their gardens, which is all the more reason for the spread of the uniform landscape.





Fig. 4.8 Three typical newer suburban houses' front yards (Photos taken in Athens, GA)

Another interesting fact about home landscapes is called “social contagion” (Hunter & Brown, 2012, p. 407). Hunter and Brown conducted a survey on the spatial occurrence of easement gardens (linear gardens along the street, outside of private properties, in contrary to regular turf within the property boundaries) in Ann Arbor, Michigan. The result of the survey indicates a spatial clustering of easement gardens: “the occurrence of easement gardens in proximity of other easement gardens.” (Hunter & Brown, 2012, p. 408) They argued that the social facilitation, the result of imitation, competition, status, advocacy, etc., accounted for such outcome. The idea of social facilitation has been published by previous works as well: “the form and content of urban gardens are influenced by those of close neighbors” (Zmyslony & Gagnon, 1998, p. 295); garden form can be influenced by social pressure to conform to neighborhood norms (Nassauer, Wang, & Dayrell, 2009). Simply put, the decision of the appearance of a resident’s garden is influenced deeply by nearby gardens, i.e. social contagions. This idea help explain the uniformity of suburban

landscapes by suggesting people's choice of home landscapes are influenced by their neighbors. In turn, this concept also suggests that a change in one garden could spread to nearby gardens, and eventually to the entire neighborhood, as in a chain reaction.

4.3. Summary

The traditional aesthetics of suburban home landscapes is explored and summarized in this chapter. Forms are visible and have an interaction with human being's mental activity (see section 4.2.3 for details), which enable them to be the most significant element of landscape aesthetics. Key features of conventional suburban landscape designs and the reasons of their long-term existence have been listed in this chapter. The key to maintaining the look of traditional suburban gardens is to conform to these widely acknowledged rules. It is hoped that then so the design will be more likely to be adopted by homeowners and landscape designers. The commonly used forms identified in suburban landscapes include:

- (1) An open view in the front yard, primarily accomplished by manicured lawn;
- (2) Trimmed shrubs at the foot of the house to soften the hard edges of the building;
- (3) Polygon-shaped or streamline-shaped planting areas, with a clean-cut edge to show the cues of care or neatness;
- (4) An axis is widely used in conventional garden design. In some cases, it is a physical element such as a foot path. Sometimes it is an invisible reference line that can be identified by the organization of trees and other landscape elements;
- (5) Recreational amenities in the backyard to provide a semi-private place for family gathering and outdoor entertainment;
- (6) One or two trees near the lawn area to provide shade and enrich the landscape;
- (7) Wood fences or hedges surrounding the backyard to reinforce privacy;

(8) Flowering or ornamental plants that bloom in different seasons.

Essentially, the traditional suburban landscape is an orderly, regularly maintained, clean landscape. However, it is not easy to find these principles in virgin forests in the southeast (Fig 4.9), or in a typical ecological design that does not concern aesthetics (Fig 4.10). The natural environment tends to look like or appear to be disordered but an undisturbed natural environment normally has the highest ecological values. Often times, to bring ecological values into garden design could also inevitably bring in the disordered and complex appearance.

The contrast between the two is the major concern when devising an ecological design for suburban home landscapes. The solution for balancing these two seemingly irreconcilable issues will be discussed in Chapter 6, after a discussion about the other end of the scale – ecological values in Chapter 5.



Fig 4.9 Preserved woods along the road of a suburban neighborhood in Athens, GA



Fig 4.10 The runoff management project, an ecological design,
on the west side of South Lumpkin St. in Athens, GA (Photo taken in May, 2014)

CHAPTER 5

ECOLOGICAL VALUES

In this chapter, ecological factors concerning current suburban subdivision design are addressed in the following categories; biodiversity, water, waste, energy and other minor issues. These issues together constitute the ecological values of the landscape. The chapter introduces each of these categories and explores issues related to each one.

The word “ecology” is defined by Merriam Webster dictionary as “a branch of science concerned with the interrelationship of organisms and their environments” (*Merriam-Webster's collegiate dictionary*, 2003). As a branch of science, ecology deals with a number of issues including biodiversity, habitat, biosphere, ecosystem and human ecology, to name a few. It is quite a broad concept for my thesis to address in depth. This thesis focuses on ecology within the context of suburban subdivision, and concerns mainly the ecological values and potential that are embedded in every household’s front and back yard. This ecological potential primarily refers to the capability of enhancing biodiversity and water conservation in a suburban setting. So biodiversity and water are the two primary issues that are addressed in this thesis.

5.1. General Introduction of Ecological Issues of Suburban Subdivisions and the Potential of Front Yards and Backyards

The Merriam Webster definition of ecology continues by saying ecology is “a science that deals with the relationships between groups of living things and their environments”. Ecology is an interdisciplinary field that deals with biodiversity, habitat, ecosystem and social ecology, among other issues. Its scope here is narrowed to the design of domestic gardens along with the

surrounding natural background. In this thesis, the research and the design primarily aimed for increasing the species diversity and maintaining a healthy ecosystem within an existing suburban subdivision, with the emphasis on each household's garden.

The subject of this chapter is to explore effective ways of using ecologically-friendly design, sometimes called sustainable design or environmentally-conscious design, in suburban landscapes.

The significance of gardens/front yards in terms of contributing to the ecosystem processes has been widely acknowledged (Cameron et al., 2012). For instance, domestic gardens have the potential to reduce energy consumption, minimize stormwater runoff and provide habitat for wildlife in urban environment. Since they constitute a large portion of urban green space (Gill et al., 2008; Goddard, Dougill, & Benton, 2010; Hunter & Brown, 2012), the potential of them for conservation and ecosystem function cannot be underestimated (Gaston, Warren, Thompson, & Smith, 2005; Sperling & Lortie, 2010).

Nevertheless, the role that domestic gardens play is highly dependent upon the design and the management of them (Cameron et al., 2012). Water pollution from inappropriate use of pesticides and fertilizers, greenhouse gas emissions due to the use of lawn mower, ecosystem disorder and excessive consumption of water from importing exotic plants are only some of the negative influences that a poorly designed garden could bring. Such garden management also costs billions of dollars annually, and requires countless person-hours of labor (Henderson et al., 1998) in the U.S.. Therefore, the question is how to design the garden in an ecologically conscious manner. As Nassauer pointed out, ecological design “calls for innovation, applied invention.” (Nassauer, 2012, p. 222) It is neither returning to natural order as much as possible, nor compromising between human desires and the limits of nature (Nassauer, 2012). Instead, it must

grow from our best knowledge of environmental processes, which could also synthesize societal functions with it, and is adaptable to future changes (Carpenter & Folke, 2006; Hill, 2009; Meinke et al., 2006; Nassauer, 2012).

5.2. Ecological Issues

This section explores two major issues—wildlife habitat/biodiversity and water—of ecological values. Waste and energy related issues are also discussed briefly. Within each category, the first few paragraphs identify the issue and the significance of addressing it in suburban home landscapes. After that, possible solutions are provided regarding that issue. Some of the solutions are well-developed and have been put into practice for a long time, while others may be relatively new and need further improvements.

5.2.1. Wildlife Habitat/Biodiversity

5.2.1.1. The Importance of Biodiversity

It has been widely acknowledged that biodiversity is one of the most important indicators of ecosystem health (Rapport, 1995; Tzoulas et al., 2007; Wasowski & Wasowski, 2004). The benefits of a highly diversified ecosystem include but are not limited to: a higher productivity, the stability of ecosystems, the efficiency of ecosystem functioning and the resilience to alien invaders (Bengtsson et al., 2002; M Loreau et al., 2002; M. Loreau et al., 2001; Naeem, H Åkansson, Lawton, Crawley, & Thompson, 1996; Tallamy, 2007; Tzoulas et al., 2007).

One of the design principles of conservation subdivision is to set aside open space around identified areas of high ecological value, as a means to ensure that the undeveloped land remains connected to preserve wildlife habitat (Freeman & Bell, 2011). However, most traditional suburban subdivisions, do not pay attention to such design principles. But these existing neighborhoods still have a chance to enhance biodiversity by recreating and reconnecting the

network of wildlife habitat. That chance lies in every homeowner's garden. Even for conservation subdivisions, such effort can be applied to the unprotected areas (developed land), since wildlife activity cannot be limited to human-designated protected areas. In fact, many threatened and protected species have significant populations beyond protected areas (IUCN, 2009).

The "Biodiversity in Urban Gardens in Sheffield" (BUGS) project which surveyed 61 domestic gardens in Sheffield, UK confirmed that private gardens, taken together, might reasonably be the most important natural reserve of UK (R. Smith, Gaston, Warren, & Thompson, 2006). Although small gardens can never replace species-rich semi-natural habitats, such as the protected areas around suburban development, they are nevertheless a useful complement (Cameron et al., 2012). Interestingly enough, people tend to assume wildlife habitats are located in remote places, e.g. natural reserves and national parks, but easily forget where they live every day in the past was the habitat of numerous animals and plants. The truth is that the preserves and parks set aside solely for the survival of wildlife are not "adequate to prevent the predicted loss species, and we have run out of the space required to make them big enough." (Tallamy, 2007, p. 31) Nonetheless, it is comforting that most species can live quite nicely with humans as long as their most basic ecological needs are met (Tallamy, 2007). The three basic needs of wildlife are described in the last paragraph of this section.

Biodiversity can be found in every tier of the food chain, from plants to insects, from birds to mammals, from fungus to aquatic animals. Depending upon various locations and climate zones, each tier needs a customized effort to be maintained. However, among all facets of biodiversity, native plants should be the first issue for us to take into account, not only because it is vital and fundamental to sustain the ecosystem, but also for the reason that it is an easy step to start with in gardens. Ecologically speaking, the ultimate source of energy that organisms consume is sunlight

and the only creature on this planet that can absorb sunlight and convert it into chemicals for other living beings to consume as food, is plants, with only a few exceptions. But either a simple lawn or a beautiful garden comprised of mostly popular exotic species, such as Japanese honeysuckle, cannot do the job very well, because only species that share an evolutionary history, which normally takes millions of years, can establish a relationship in local food chain (Wilson, 1987). Exotic species, invasive or not, is truly an issue that needs to be considered when trying to increase biodiversity of gardens. Since gardeners have always been drawn to exotic and unusual plants, gardens tend to have a large proportion of non-native plant species, selected genotypes (varieties), and accidental or intentionally bred hybrids (Cameron et al., 2012; R. M. Smith, Thompson, Hodgson, Warren, & Gaston, 2006).

In addition to native plants, insects are key for suburban ecosystems to fill the gap between plants and carnivores, and therefore connect the food chain. According to the theory of evolution: "...most insect herbivores can only eat plants with which they share an evolutionary history: our native insects will not be able to survive on alien plant species." (Wilson, 1987, pp. 344-345) Therefore, Edward Wilson described a land without insects as "a land without most forms of higher life" (Wilson, 1987, p. 346).

Pollination is the key to the reproduction of many plants, therefore it is "an essential part of a healthy ecosystem" (Webb, 2008, p. 1). Some plants are self-pollinated or wind-pollinated, but most of them depend on other organisms including insects, birds or bats. In Appendix II, plants that are attractive to local pollinators are labeled.

The survival of wildlife is dependent on three things, according to Douglas W. Tallamy: food, shelter, and nest sites. All of them can be provided by native plants. Tallamy also points out that unless we restore native plants to our suburban ecosystems, the future of biodiversity in the

United States is dim (Tallamy, 2007, p. 7). In a nutshell, “a healthy diversity of plants” is the foundation of a healthy ecosystem.

5.2.1.2. Wildlife-Friendly Garden

According to the National Wildlife Federation’s guidance for creating wildlife habitats, it is essential to provide the following components: food, water, cover and places to raise young. In the next few paragraphs, all four essential components will be briefly explained along with applicable solutions for them to be implemented in gardens.

(1) Food

Food is the basis for any organism to survive and thrive. Nectar, pollen, berries, seeds and nuts are among the most common food sources of wildlife. A selection of common native plants can easily provide all of the above.

(2) Water

Wildlife needs clean water for drinking, bathing and reproduction (NWF). A constant source of clean water for wildlife is vital. A bird bath is probably the easiest way to provide this source. Changing the water 2-3 times per week will prevent mosquitos from breeding in it during warm weather. Another solution is to build a pond, which can provide more than just water. A pond with some aquatic vegetation is also a habitat, a habitat that is attractive to amphibians, like toads and frogs.

(3) Cover

Wildlife also needs places to hide from people, predators and inclement weather. Shrubs and piles of brush can provide great cover places for wildlife with their bushy leaves and branches. A pond created for water resources can also provide cover for aquatic wildlife, such as fish and amphibians.

(4) Places to raise young

Wildlife also needs places to reproduce and raise the next generation, where they will be safe from predators, bad weather and human intervention. This can also be achieved by building cover for wildlife, through shrubs, ponds and piles of brushes.

In summary, there are three major approaches that can be implemented to achieve all the four basic needs of wildlife: native plants for food and cover, a pond for water source and habitat, a pile of brushes/dirt for cover and shelter.

5.2.2. Water

Water is the other major issue that can easily be addressed on a suburban lot. This section is divided into two sub sections. The first one addresses the significance of water conservation and the potential of a domestic garden to help achieve this objective. The second sub section briefly introduces a number of approaches, well-developed traditional ones and more recent ones based on new technologies.

5.2.2.1. A small step in the front yard is a big step towards water conservation

Water is city's life blood, a source of life, power, comfort and delight (Spirn, 1984). On a larger scale, attempts of floodwater storage, water restoration, and sewage treatment along with recreation have been made since "Frederick Law Olmsted created the Fens and the Riverway to combat the flooding and pollution problems of Boston's Back Bay tidal flats" (Spirn, 1984, p. 142). In contemporary landscape designs, new concepts and design techniques are put into practice to address water issues, such as rain gardens, detention ponds, and vegetated swales. These design approaches have demonstrated that water restoration can take place at a much smaller scale, for example, a domestic garden. "Gardens provide storm attenuation 'services' to the urban matrix," and vegetation "intercepts intense precipitation, holds water temporarily within their canopy thus

reducing peak flow and easing demand on urban drains.” (Xiao & McPherson, 2002, p. 132) Additionally, as pointed out earlier, the design and management of domestic gardens has a huge influence on water consumption and ecological footprints. A survey shows that on average, 30% of household water use is consumed within the garden, which rises to 50% during the summer (Domene & Saur í 2006). According to statistics provided by EPA, a twenty-five feet by forty-feet lawn requires 10,000 gallons each summer to stay green, and 12,000 gallons if the homeowner insists on a “bouncy, vibrant green” look (Wasowski & Wasowski, 2004, p. 33). There are about 65 million single-family homes in the country, according to U.S. census bureau, virtually all with lawns. Imagine the amount of water consumption for the lawn and how much water can be saved if the garden is designed differently. If a garden is designed with mulched flower beds and organic turf management, moisture evaporation will be minimized (Livesley et al., 2010) and water consumption can be reduced up to ten-fold (Morris & Bagby, 2008). Moreover, managing water on site, e.g. sustainable stormwater management or rainwater harvesting, could also improve aesthetics, provide wildlife habitat and be beneficial to plants by reducing soil erosion and maintaining appropriate soil moisture (Calkins, 2011, pp. 75, 76). This is a win-win for both nature and people.

5.2.2.2. On-site water management

An on-site water management system requires the management of both influent flow (water supply) and effluent flow (wastewater). The quantities and qualities of two flows should be considered equally. Influent flow includes tap water (potable water) and rainwater. Some examples of effluent flow are: stormwater runoff, toilet-flush water, laundry water, and kitchen wastewater. In succeeding paragraphs, each type of water will be discussed individually.

(1) Potable water:

Potable water consumption of a garden is largely determined by the design and management of it. As discussed in previous sections, a huge amount of valuable potable water has been used for irrigation. To reduce potable water use, there are two general solutions: to use potable water more efficiently, and to reduce the demand for potable water use.

For irrigation purposes in domestic gardens, there are a few management tips that can do a great job watering the plants while minimizing potable water consumption, without purchasing new equipment (Wasowski & Wasowski, 2004, pp. 34 - 35):

- a. Water the plants on the coolest parts of the day, preferably before sunrise;
- b. Water in two short cycles instead of one long one to reduce runoff. A far more efficient way is to use a drip irrigation or bubbler system;
- c. Water deeply, to a depth of four to six inches so the roots are encouraged to grow deeper, where it stays moist longer;
- d. Aerate the soil once a year for better water penetration;
- e. Use mulch around trees and shrubs to help maintain moisture in soil by slowing down the evaporation process;
- f. Check the watering or irrigation systems for leaks. A tiny leak can waste an incredible amount of water.

Another way to decrease the irrigation demand for potable water use is Xeriscaping, the dry landscaping, which is to use plants that can survive low amounts of rainfall (Wasowski & Wasowski, 2004, pp. 31, 33). This method is implemented in regions where fresh water is not easily accessible or reliable. But if Xeriscaping were implemented in a suburban garden in Georgia, even for a small area, it could greatly reduce potable water consumption for watering the garden. Planting indigenous species to replace exotic species and reducing the area of the lawn can also

considerably reduce the demand for irrigation water, because native plants are usually able to survive solely on rainwater while the lawn accounts for a majority of total water consumption.

Using reclaimed water as a substitute for irrigation is another way to reduce the demand for potable water. In high-density cities such as Beijing, Tokyo, Singapore, Canberra; countries like France, UK, Germany and Belgium; and certain states in the U.S. including California, municipal reclaimed water systems or site-scale recycled water reuse programs have been implemented for irrigation and flushing the toilet in order to reduce the rising demand for potable water (Bixio et al., 2006; Lazarova, Hills, & Birks, 2003; Maeda, Nakada, Kawamoto, & Ikeda, 1996; Yi, Jiao, Chen, & Chen, 2011). Reclaimed water, also known as intermediate water or non-potable recycled water, is wastewater that has been treated in a water treatment plant but is not clean enough for drinking purposes. However, implementing an entirely new civil infrastructure for wastewater treatment is almost impractical for suburban subdivisions in the southeast, as a result of financing problems caused by low density (see section 3.2 for more details). However, instead of sending water to treatment plants, relatively clean wastewater such as bath water, laundry water and kitchen water can be treated by fairly simple structures on site (details of on-site wastewater treatment will be discussed in a later section).

Rainwater is another good substitute for potable water in terms of watering the plants. Runoff from roofs is generally free from contaminants therefore a great source of irrigation water (Calkins, 2011, p. 112). Rainwater harvesting will be discussed in the following section.

(2) Rainwater (precipitation and runoff)

Traditional garden design ensures that rainwater goes away from the site as quickly as possible by carefully grading the land and perfecting the drainage system. However, such design approaches reduce or eliminate many phases of the natural water cycle, such as evaporation,

transpiration, groundwater recharge and interflow; and cause more runoff, stream flow and nonpoint pollution (Calkins, 2011). Compared to urban environments, suburban subdivisions have plenty of green spaces that can allow water to infiltrate and complete the natural water cycle. Furthermore, runoff from the roof and driveway can also be collected, treated and reused on site to reduce the negative influence of impervious surfaces.

In following paragraphs, five widely acknowledged stormwater management methods are introduced, then evaluated based on their applicability for suburban subdivisions in the southeast.

a. Rainwater harvesting

Rainwater harvesting is the collection, storage, and reuse of runoff from impervious surfaces (Calkins, 2011, p. 111). Runoff from relatively smooth and clean surface is generally free from hazardous contaminants, so it can be stored and reused for non-potable purposes with simple first-flush diversion and filtering. However, runoff from other surfaces, such as driveways, asphalt shingle roofs, may be conveying higher levels of pollutants, and is better to be infiltrated before reuse. A natural filter and infiltration process is the most cost-effective way to do the job. It is also aesthetically pleasing if designed properly. A 1000 square feet roof could collect 2093.28 gallons of rainwater during a one-year rainfall event, which is amount of water usage by a family of three for 7.6 days (data is from Georgia Stormwater Manual and the USGS website). Figure 5.1 illustrates a typical belowground cistern rainwater collection system.

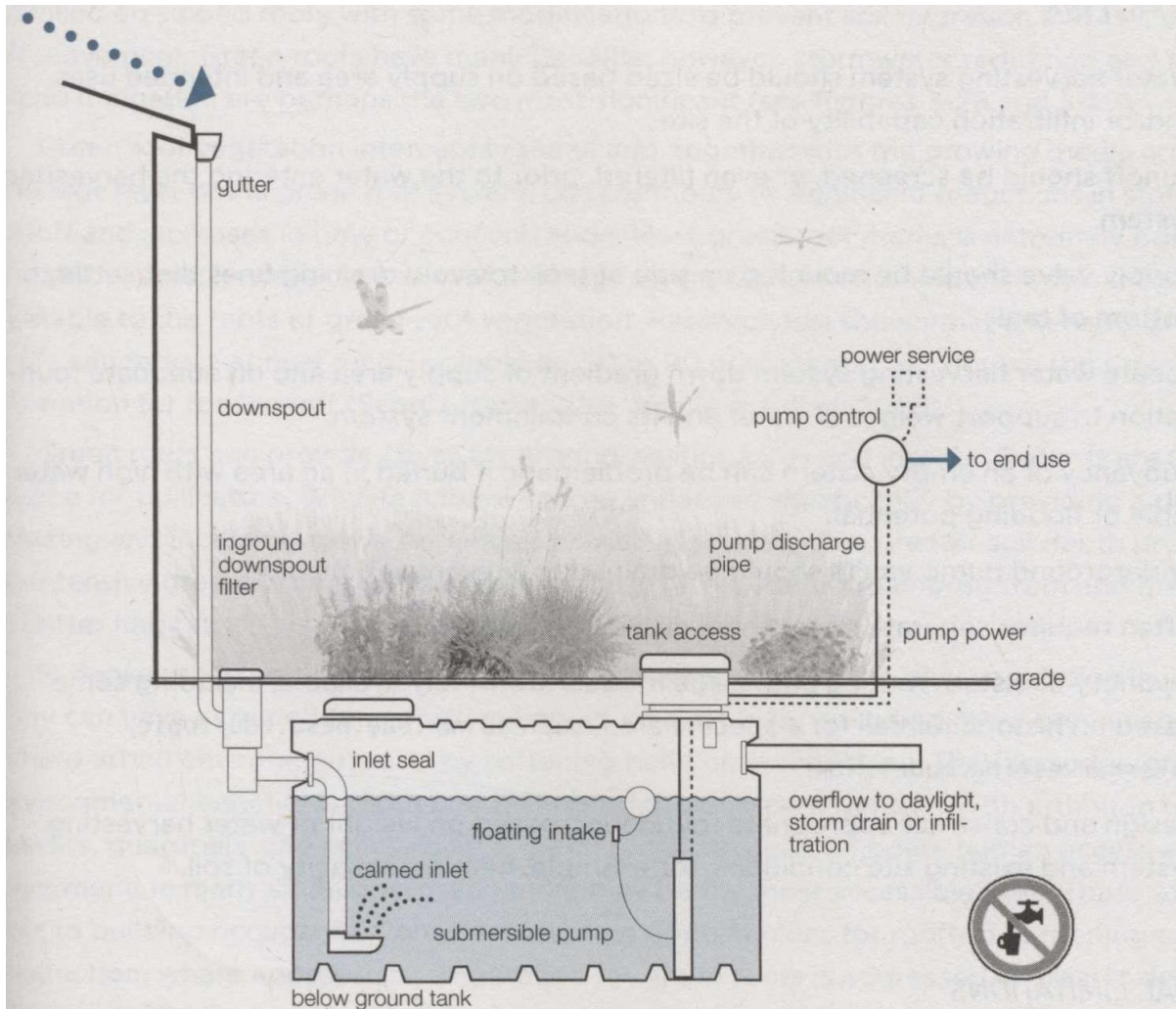


Figure 5.1 Below ground rainwater collection system (Calkins, 2011, p. 113)

b. Rain Garden

A rain garden is a small, shallow depressed area that encourages water to briefly pond and infiltrate within a day (Calkins, 2011, p. 121). Rain gardens have drawn great attentions in the 21st century because they are “aesthetically pleasing, simple to build, and can be very effective when infiltration is focused to maximize recharge.” (Morzaria-Luna, Veltman, Cutforth, & Schaepe, 2004, p. 1054) An ideal situation is that small, frequently occurring rain gardens distribute throughout a site to emulate natural conditions, in which multiple depressions from sinkholes and wildlife burrows create microcatchments that store and infiltrate surface runoff. Indigenous plant

species that are capable of withstanding temporary inundation and also periods of drought should be selected to be planted in rain gardens. Such plants can be found in floodplains where many species are well adapted to similar conditions.

c. Bioretention Areas

Bioretention areas are shallow, upland stormwater basins that use vegetation and highly permeable soils to filter and infiltrate runoff (Calkins, 2011, p. 123). Quite similar to rain gardens, bioretention areas are most effective when small ones are distributed throughout the site and utilized to capture and treat contaminated runoff from impervious sites as close to the source as possible. What distinguishes bioretention areas from rain gardens is that the design of the former often includes an overflow pipe tied into storm drain in case of flooding from bigger storm events. Bioretention areas are functional, flexible, attractive and cost effective (Calkins, 2011, p. 123).

Figure 5.2 is an illustration of a typical bioretention area.

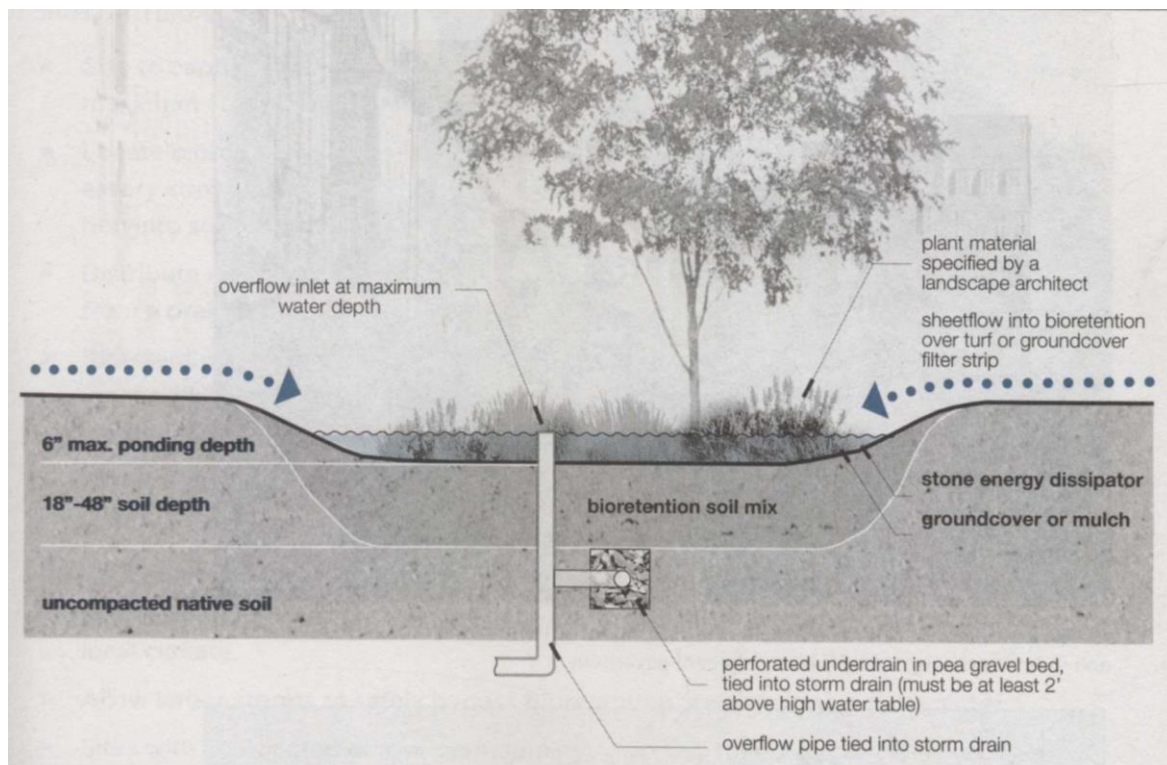


Fig 5.2 A typical bioretention section (Calkins, 2011, p. 125)

Summary:

Rainwater harvesting, rain gardens, and bioretention areas are three most applicable water management approaches for suburban households. They are effective, visually pleasing, and can be a variety of sizes. There are other options for stormwater management, such as vegetated swales and bioswales with micropools. However, due to their function of conveying water from one place to another and the large area they require, they are not suitable to be implemented in domestic gardens.

Although the three methods are listed here separately, they are actually different approaches to serve the same goal of water conservation and stormwater infiltration. Depending on the size of the site, annual precipitation, soil porosity and public accessibility, certain approaches are more appropriate than others. In other words the best solution for a specific site varies. However, combining and linking various methods (Morzaria-Luna et al., 2004), works better than using one solution or multiple solutions separately. Moreover, certain steps in the wastewater treatment process (see the following section for details), in some cases, can be combined with these bioretention processes, which can increase the efficiency of the whole system. Issues regarding the combination of the two systems will be discussed in depth in chapter 6.

(3) Wastewater

Suburban residents produce wastewater every day. Every drop of water flushed down the drain goes to sewage pipes, goes through a treatment facility, and eventually ends up in a natural water body. Toilet flushing water, bathing water, kitchen water, and laundry water are probably the most common ones among all kinds of wastewater people produce on a daily basis. Although the centralized wastewater treatment plant achieves a high standard of sanitation for cities; the decentralization, also known as localization, of wastewater treatment is gaining popularity today

(Rose, 1996; van Roon, 2007, p. 439). The most sustainable way to treat wastewater is to treat it at its sources, where it is produced, because this way avoids “the cost of transporting water to a central facility and then returning the reclaimed water to another location” (Levine & Asano, 2004, p. 204). This is especially true in the suburban US, where low density development further increases the amount of investment for infrastructure.

Household wastewater that “contains less suspended solids and nitrogen than a typical domestic sewage” (Lazarova et al., 2003, p. 71) is labeled as greywater. It basically includes all household-generated wastewater excluding toilet water, which is normally called blackwater. To be specific, greywater can include wastewater from bath tubs, bathroom tanks, and showers (“light grey”), and may also include wastewater from laundry facilities, dishwaters and even kitchen sinks (“dark grey”) (Lazarova et al., 2003, p. 69). Because greywater normally contains fewer pollutants, it needs less effort to be treated to a safe level. Such properties make greywater treatment preferable to blackwater treatment on site in suburban subdivisions, since land coverage and budget are two primary limitations for facilities. Major pollutants contained in greywater, such as TSS (Total Suspended Solids), COD (Chemical Oxygen Demand), BOD (Biochemical Oxygen Demand), ammonia and TKN (Total Kjeldahl Nitrogen) can be greatly reduced by certain local wastewater treatment methods (Lazarova et al., 2003). Therefore greywater is the target of the following discussion of on-site wastewater treatment and reuse on site.

Post-treatment wastewater is called reclaimed water or recycled water. A more accurate definition of reclaimed water, according to Levine and Asano, is “the end product of wastewater reclamation that meets water quality requirements for biodegradable materials, suspended matter and pathogens.” (Levine & Asano, 2004, p. 203) In most cases, the effluent from treatment facilities is not safe enough for drinking. However, non-potable reclaimed water has a lot of

valuable uses on other occasions, such as agricultural irrigation, landscape irrigation, flushing toilet and industrial reuse (Maeda et al., 1996; Rose, 1996; Yi et al., 2011). For a typical suburban resident, reclaimed water can be used for flushing toilets, garden irrigation and even laundry.

Although actual results may vary depending on seasons, facility types, the polluted level of graywater and other factors; generally speaking, on-site wastewater treatment and reuse in households is a very successful approach to conserve water and supports a sustainable design (Bixio et al., 2006; Lazarova et al., 2003; Levine & Asano, 2004).

The fundamental premise of wastewater treatment is to remove pollutants from water, for the most part, through physical, chemical, and biological processes (Levine & Asano, 2004). A wide variety of treatment technologies have been used to achieve that goal. They are generally divided into three levels of treatment: primary, secondary and tertiary treatment, based on the effluent water quality. Primary treatment is also called primary sedimentation, since sedimentation is the major process of this level. The effluent after secondary treatment may be clean enough to be reused for irrigation and toilet flushing purposes. Tertiary treatment further removes pollutants from water. The effluent of tertiary treatment is safe enough to be discharged into natural water bodies.

In following paragraphs, five wastewater treatment technologies that have already been put in operation are briefly introduced and then evaluated based on their applicability for suburban subdivisions.

a. Constructed wetlands (secondary treatment)

Constructed wetlands are “treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality” (EPA, 2004). They are one of the wastewater treatment technologies that have been proven efficient in

the 1990s (Kivaisi, 2001, p. 545). Constructed wetlands are frequently built by “excavating, backfilling, grading, diking and installing water control structures to establish desired hydraulic flow patterns... wetland vegetation is then planted or allowed to establish naturally” (EPA, 2004, p. 1) (see Fig 5.3 for a schematic diagram of constructed wetlands). This is how it works: water slows down as it flows through constructed wetlands; suspended solids become trapped by wetland vegetation while other contaminants become less dissolvable forms that are taken up by plants. Wastewater treatment is accomplished through “an integrated combination of biological, physical, and chemical interactions among the plants, the substrata, and the inherent microbial community.” (Ayaz & Akça, 2001, p. 190) Evidence has shown that concentrations of COD (chemical oxygen demand), TOC (total organic carbon), nitrogen, suspended solids and phosphorus are greatly reduced to safe level for uses including landscape irrigation (Ayaz & Akça, 2001). Although constructed wetlands are praised for their low cost and low maintenance, they require a large area, which limits their application in suburban subdivisions (Ayaz & Akça, 2001; Kivaisi, 2001).

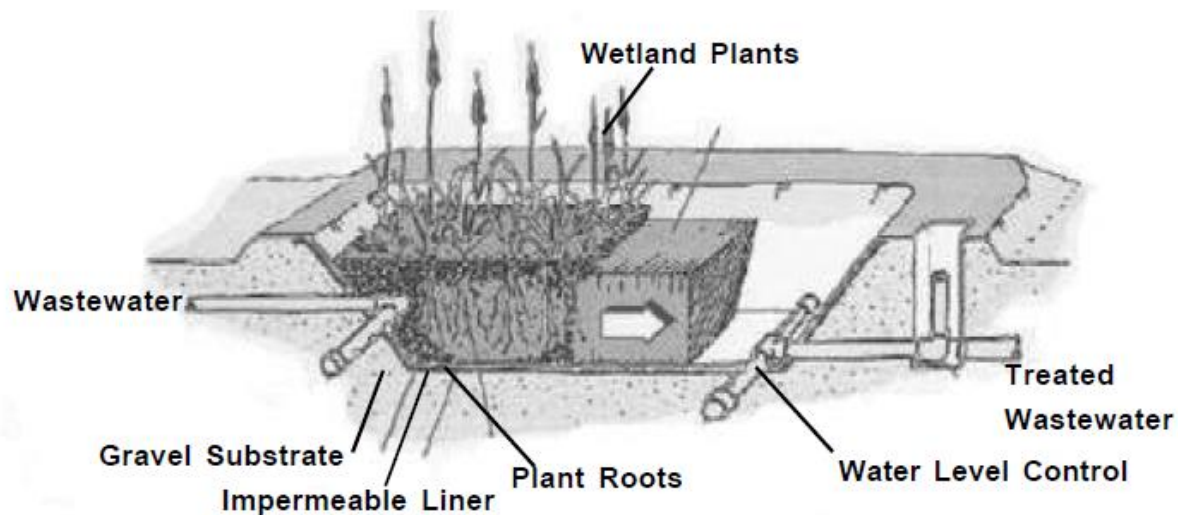


Figure 5.3 A schematic diagram of Constructed Wetland (EPA, 2004)

b. The Living Machine (EPA, 2002) (Primary + Secondary Treatment)

The Living Machine is “an emerging wastewater treatment technology that utilizes a series of tanks, which support vegetation and a variety of other organisms” (EPA, 2002). It is branded as “the most efficient & cost effective ecological solution for treating and reusing wastewater” by one of its manufactures, The Living Machine®. It not only incorporates the basic wastewater treatment process such as sedimentation, filtration, adsorption and clarification; but also uses plants and animals to achieve the treatment goals and maintains an aesthetically pleasing appearance, which are rarely seen in other solutions.

The treatment process of living machine consists of six principle components (see Fig 5.4 below), in process order: (1) an anaerobic reactor, (2) an anoxic tank, (3) a closed aerobic reactor, (4) open aerobic reactors, (5) a clarifier, and (6) “ecological fluidized beds” (EFBs).

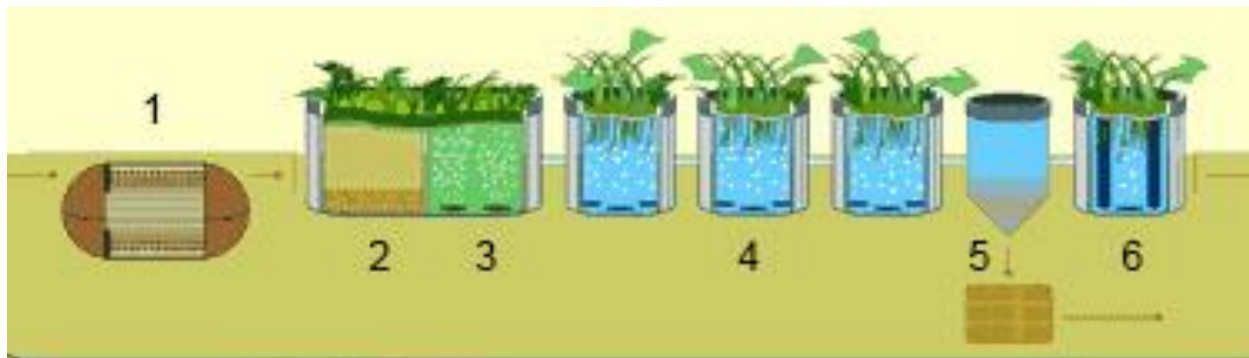


Fig 5.4 Process Diagram of Living Machine (EPA, 2002, p. 2)

Firstly, wastewater enters the anaerobic reactor (1), which acts as a primary sedimentation basin. Secondly, in the anoxic tank (2), a significant portion of BOD will be removed by floc-forming microorganisms living in this tank. A coarse bubble diffuser is constantly operating inside the tank to maintain the dissolved oxygen level below 0.4 mg/L. And an additional growth medium is placed in a compartment to facilitate growth of bacteria and microorganisms. Then the water enters the closed aerobic reactor (3), of which the main purpose is “to reduce the dissolved wastewater BOD to low levels, to remove further odorous gases, and to stimulate nitrification”

(EPA, 2002, p. 3). Next, the treated water flows into multiple open aerobic reactors (4) where BOD is reduced again and the process of nitrification is completed. After that, the remaining solids floating in the treated wastewater settle and are separated from the water in the clarifier. The surface of the clarifier (5) is often covered with duckweed to prevent algae from growing. Finally, water enters the ecological fluidized beds (EFBs, 6), polishing filters that implement the final treatment. Normally, one to three of them are used in series to reduce BOD, TSS and nutrients to meet final effluent criteria. The effluent is suitable to be reused for landscape irrigation, toilet flushing, vehicle washing, etc.

c. Anaerobic sewage treatment / Biogas Reactor (Seghezzo, Zeeman, van Lier, Hamelers, & Lettinga, 1998) (Primary treatment + Secondary treatment)

Anaerobic treatment is a sewage treatment process which relies mostly on a bacterial process called anaerobic digestion that is carried out in the absence of oxygen. The upflow anaerobic sludge blanket (UASB) reactor is one of the proved effective solutions of anaerobic treatment. Lucas Seghezzo introduced and reviewed anaerobic sewage treatment thoroughly with emphasis on UASB (Fig. 5.5) (Seghezzo et al., 1998). According to his article, UASB has been “extensively used for the treatment of several types of wastewater” (Lettinga, 1995; Seghezzo et al., 1998, p. 178). The mechanism is simple. Firstly, sewage goes into the tank from the bottom. Then the accumulation of incoming suspended solids and bacterial growth forms the sludge bed, where all the biological processes take place. The upflow anaerobic system allows a thorough contact of the active sludge with the contaminants therefore making it a highly efficient system in ways of treating sewage and generating biogas. Less space and reactor volume is required. However, “the effluent from UASB reactors usually needs further treatment, in order to remove remnant organic matter, nutrients and pathogens.” (Seghezzo et al., 1998, p. 178) Further treatment

can be accomplished in aerobic systems, e.g., stabilization ponds and activated sludge plants. Also, the treatment efficiency can be improved by using two- or three-stage UASB reactors and proper post-treatment methods. This process has been applied to treat sewage from small-size communities in Brazil (Vieira, Carvalho, Barijan, & Rech, 1994).

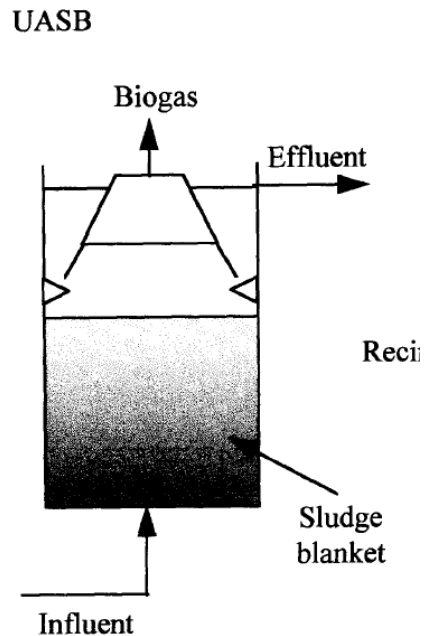


Fig 5.5 Schematic diagram of UASB reactor (Seghezzo et al., 1998, p. 178)

d. Septic system with Textile filter system (Primary treatment + secondary treatment)

Septic tanks are one of the simplest, oldest, and most widely used wastewater treatment processes (McCarty, 1982). The tank creates an anaerobic bacterial environment which decomposes or mineralizes the pollutants. In addition, the septic system with textile filter system comprises “a septic tank with an effluent filter vault, a textile filter, and a shallow pressure-dosed soil absorption system.” (as shown in Figure 5.6) (Bradley, Daigger, Rubin, & Tchobanoglous, 2002, p. 92) Greywater flows into the septic tank first, where settleable solids and floating material are removed. An effluent filter vault is attached to the tank to retain residual solids that have not

settled or floated to the surface within the tank. Then the effluent from the septic tank is treated using a textile filter (a bed of loosely placed textile material cut into 2-inches squares). Here the water is treated biologically as it passes through the filter bed and a portion of the flow is recirculated to optimize treatment performance. The treated effluent is distributed through “either a pressure-dosed shallow trench system or a drip irrigation system” to allow the soil absorb the water eventually. The final effluent is proved to be qualified for subsurface landscape irrigation (Bradley et al., 2002).

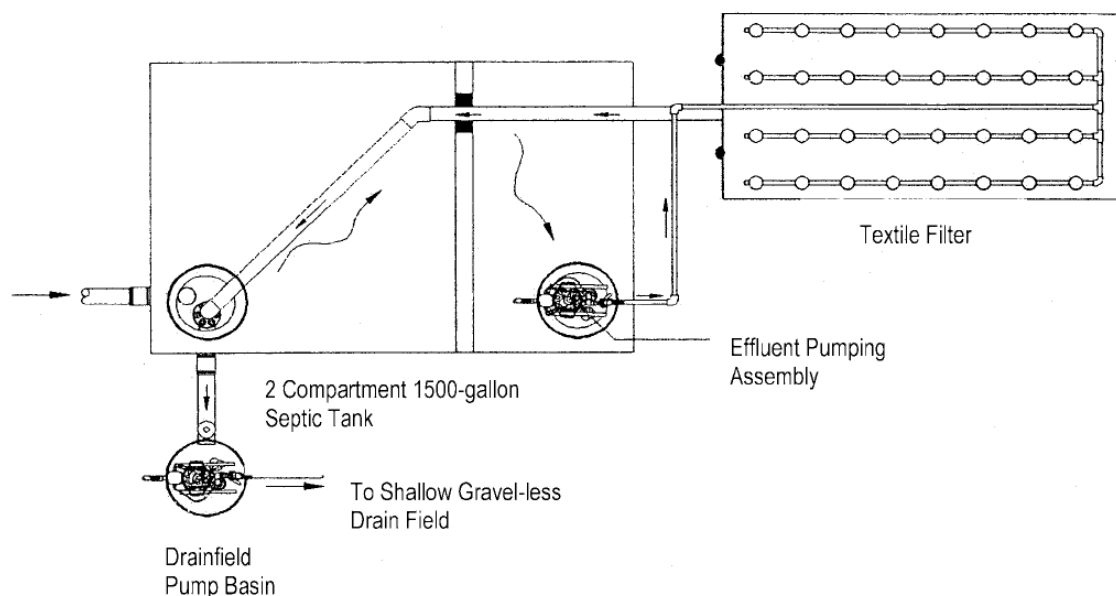


Figure 5.6 Septic system with textile filter system (Bradley et al., 2002, p. 92)

In Table 2, pros and cons of the four technologies are analyzed and given credits based on how satisfied they meet the standards of being implemented in suburban gardens: 2 credits for most satisfied, 1 for medium satisfied and 0 for least satisfied. For example, if a technology takes a big patch of land but the cost is very low, it will get a 0 for its size and a 2 for the cost.

Table 2: Pros and Cons of Five Wastewater Treatment Technologies

	Constructed Wetlands	Living Machine	Biogas Reactor	Septic System	Notes
Size*	0	0	2	1	Large/0 Medium/1 Small/2
Effluent safety level	2	2	0	2	Low/0 Medium/1 High/2
Efficiency	1	2	2	1	Low/0 Medium/1 High/2
Aesthetic quality	2	2	0	1	Low/0 Medium/1 High/2
Cost	2	1	2	1	High/0 Medium/1 Low/2
Tech level / maintenance	2	2	1	1	High/0 Medium/1 Low/2
Total Credits	9	9	7	7	Range: 0 ~ 12

Note:

***Size:** Size is the space that the wastewater treatment technology generally occupies. Compared to a typical suburban subdivision lot size, the method that can be easily installed in the backyard will be considered a satisfying small size. Anything that cannot function without occupying a bigger area than a typical lot will be conceived as large. Medium size will be anything in between. If an installment can be put underground for the most part, it will be treated as small size as well.

Conclusion: Constructed wetlands and the living machine have the most credits among the five technologies. However, we cannot come to the conclusion that either one of them is the best for any household or suburban subdivision to treat their wastewater. Failing to achieve at least a medium credit for certain factors could remove the treatment method from the list. For instance, having zero credit for size, constructed wetlands or living machines might not fit on a single family household lot, even though they both get 9 credits in total. However, they can still be implemented to serve multiple homes or an entire subdivision. Therefore, the decision has to be made on a case-by-case basis. The chart can be very helpful to decision-making by providing general characteristics of those five technologies.

5.2.3. Waste

The world faces increasingly serious environmental problems as a result of increasing amount of waste (Hara, Furutani, Murakami, Palijon, & Yokohari, 2011, p. 1213; Sterner & Bartelings, 1999). Currently, there are three major ways of waste treatment (primarily refers to solid waste): landfill, incineration and recycling. In a fast-developing metropolitan area like Beijing, the municipal solid waste management system (for the most part, landfill) has been challenged to cope with the increasing demand of waste disposal (Wang & Wang, 2013). Landfill is also the most popular way for treating solid waste in the U.S. Although land is relatively abundant in America, the increasing consumption of goods had led to a perceived localized crisis of landfill space shortage in the 1980s (Subramanian, 2000). To increase the efficiency of waste disposal is one of the goals of any sustainable growth. Similar to wastewater treatment, the most sustainable way to achieve this goal is to treat it at its source, in this case, the suburban subdivisions.

However, solid waste management is a lot more complicated than wastewater treatment for households', therefore, the waste is better to be sent to municipal facility for advanced treatment (sometimes called MSWM – Municipal Solid Waste Management). Even landfills—the most common way for waste disposal—are not as simple as they sounds. A proper landfill site in the U.S. requires composite liner, leachate collection and removal systems, and groundwater monitoring system, to name a few. However, on household level, there are still things can be done, such as organic waste recycle.

Compost is the organic matter that has been decomposed and recycled into a soil amendment. The process is called composting. A large portion of household kitchen waste is organic matter that can be easily composted at home to make compost for the garden or to be sold to farms for reuse. Therefore, it is feasible to “simultaneously achieve waste reduction and the promotion of urban farming” by reusing compost from residential areas (Hara et al., 2011, p. 1213; Sterner & Bartelings, 1999).

5.2.4. Energy

Buildings account for 20%-40% of the total energy consumption in most developed countries (P érez-Lombard, Ortiz, & Pout, 2008, p. 395). Growth in population, increasing demand for interior comfort levels and rising time spent indoors assure an “upward trend in energy demand” of the buildings (P érez-Lombard et al., 2008, p. 394). Therefore, one of the primary goals of ecological designs is to reduce the energy consumption. To reduce the consumption of energy is to reduce the demand of fuel, coal or other raw materials that are used for producing energy, which further helps protect the environment in the long run. In addition to the design of the building itself, appropriate landscape design can also reduce energy consumption: US data suggests that strategic positioning of plants (Strategic planting) could reduce domestic buildings' energy

consumption by 20–40% (Akbari, Kurn, Bretz, & Hanford, 1997). A wide range of vegetation has the potential to improve cooling through planting next to a building in summer (Cameron et al., 2012, p. 130). In winter, vegetation around houses reduces the velocity of air over buildings (wind break), removing draughts and minimizing temperature differences between existing and incoming air (McPherson, Herrington, & Heisler, 1988).

5.2.5. Miscellaneous Issues

(1) Carbon Storage

It is suggested that an average of $2.5 \times 10^3 \text{ g} \cdot \text{m}^{-2}$ of carbon is stored in domestic gardens with 83% in soil (to 600 mm depth), 16% in trees and shrubs and only 0.6% on average in grass and herbaceous plants (Jo & McPherson, 1995). Such data indicates that the design and management of a domestic garden can strongly affect the amount of carbon storage. Gardens that incorporate naturally grown trees or meadow, implement low-maintenance landscapes, or permaculture practices are likely to have the least impact in terms of CO₂ release (Pouyat, Groffman, Yesilonis, & Hernandez, 2002). However, the carbon stored in vegetation and soil can be easily offset by use of petrol-powered mowers, which releases 1.5-fold the carbon sequestered by the lawn itself (Jo & McPherson, 1995).

(2) Chemicals

Primary fertilizers and pesticides have widespread use (74% of all homeowners) in the U.S. (Robbins et al., 2001). Local by-laws in the U.S. even encourage the use of garden chemicals and promote intensive management, potentially to increase property values (Robbins et al., 2001). If fertilizers have to be used to maintain the landscape, a better alternative is to use composted organic matter rather than chemical ones, because compost offers a lower carbon cost for supplementing nitrogen than using an inorganic nitrogen fertilizer, for example, NH₄NO₃

(Lillywhite & Rahn, 2008). As stated in the waste section, domestic organic waste can be a great source of compost to fertilize garden plants. Since garden pesticides are significant contributors to America's nonpoint source water pollution, the replacement of them also reduces water pollution.

5.3. Summary

Ecological values are discussed in this chapter in a wide range of categories.

The first aspect of ecological values is biodiversity. Wildlife, like some other terms mentioned in this thesis, is a very broad term. Birds, mammals, fish, insects and amphibians are all wildlife. But not all of them are able to easily take advantage of a small garden behind a house. Moreover, there are plenty of them that homeowners are normally not happy to see in their own backyards (see section 7.2 for details about unwelcomed animals). Therefore, backyard wildlife primarily refers to birds, amphibians, some insects (bees, butterflies and dragonflies, for instance) and small mammals in this thesis. In southeastern America, wildlife habitat has been largely fragmented into small patches due to suburban development (see Fig 7.13 for reference), highway construction, plantation and farms. Suburban subdivisions have the potential to reconnect those patches through redesigned wildlife-friendly gardens, so that they are not barriers for wildlife anymore. This way, suburban subdivisions become a part of the habitat, though in a human-controlled way.

In summary, there are three major approaches that can be implemented to achieve all the four basic needs of wildlife: native plants for food and cover, a pond for water source and habitat, a pile of brushes/dirt for cover and shelter. Among them, plants are the basis for animals to survive. Native plant species with fruits or flowers that are attractive to wildlife are top priority to be used in garden designs. More species means a more diverse food supply, which attracts more wildlife

species. A more complicated food web also adds to the garden's stability, therefore reduces the chance of the garden being consumed by only a few species.

Biodiversity, water, waste, energy and other issues discussed in this chapter together constitute the ecological values of the landscape. Biodiversity and water are two major issues. Waste is recognized as a minor issue since the technologies that solid waste treatment and recycle process require are beyond what a suburban home can offer. Energy, on the other hand, is also considered minor because most energy is consumed indoors. So it is out of the scope of this thesis. The approaches described in this chapter have the potential to greatly minimize suburban subdivisions' environmental impact and bring ecological values into them. However, aesthetics is normally not considered in these ecological design approaches. In next chapter, the key of this thesis—finding a way to bring ecological values into suburban subdivisions while maintaining their traditional aesthetics—will be explored.

CHAPTER 6

PROPOSED DESIGN GUIDELINES

The first section of this chapter summarizes the key elements of the previous discussion about aesthetics and ecological values. Based on that, it explores the potential design approaches of balancing these two issues. Then the second section presents a series of recommended guidelines for suburban subdivision garden design which is provided for homeowners and garden designers to follow should they wish to enhance the ecological values of their gardens while maintaining core traditional aesthetics.

6.1. Design Approaches of Balancing Aesthetics and Ecological Values

Table 3 below summarizes the key elements from the discussion of both aesthetics and ecological values.

Table 3 Summary of Key Elements from Chapter 4 and Chapter 5

Aesthetics		Ecological Values	
		Categories	Approaches
Key features of traditional suburban home landscapes	1. An open view in the front yard, primarily accomplished by lawn	Wildlife habitat / Biodiversity	1. Native plants 2. Pond or bird bath 3. Pile of brushes
	2. Trimmed shrubs		
	3. Polygon or streamlined planting or paved areas	Water	1. Irrigation tips 2. Stormwater management 3. Wastewater treatment and reuse
	4. Axis		
	5. A few trees to provide shade		
	6. Fences or hedges to reinforce privacy	Waste	1. Composting
		Energy	1. Strategic planting

The following two sub sections are dedicated to incorporating ecological values into the conventional aesthetics of suburban landscapes. The first section focuses on how to celebrate traditional aesthetics in suburban gardens by maintaining the core principles in an ecologically-conscious manner. The second section brings specific issues of ecological values into consideration and discusses how to embed them into the traditional forms.

6.1.1. Aesthetics and Forms

In order to increase the ecological value while conforming to the key principles listed above, there are some design techniques or tricks that can be used to create a neat-looking garden or an illusion of a conventional looking garden:

(1) The open view in front of the house can still be maintained without a large lawn area. The lawn can be reduced and located in front of the house entrance in the front yard. Naturally grown grass or groundcover, flowering shrubs and shade trees can fill the remaining space without a messy appearance if carefully-designed.

(2) Naturally-grown (untrimmed) plants can be planted in a designated area with a clear edge. The edges can be maintained through regular maintenance. Bricks or other decorative materials can also be placed on edges to emphasize them. Planting areas should be a simple shape, such as a circle or a quadrangle, or a simple streamlined shape, to show neatness, even though the plants are not trimmed.

(3) Some facilities that are installed for ecological purposes, such as a cistern or a septic tank, can be installed underground or partially underground, and surrounded by plants to be hidden from the public viewers.

(4) For the remaining lawn, grass species that are more adapted to indigenous climate should be used instead of exotic ones. Habiturf (Austin, 2014), a new technology of ecological turf, can be applied to replace the conventional lawn. Habiturf will be discussed in a later section.

6.1.2. Ecological Values

This section further explains how to bring ecological values into design in a way that is suitable for suburban subdivision gardens. Specific design guidelines to incorporate these values are to be given in the next section.

The best way to create a native plant garden is to imitate nature's own design. There are three major issues that need to be considered when converting a traditional garden:

The first issue is the selection of plants. While the definition of native plants is still under debate academically, a list of widely-acknowledged plants that have been present for thousands of years is relatively easy to acquire. Appendix II is a list of native plants for garden design in Georgia, preferably in the Piedmont ecoregion (see Fig 6.1 for details), compiled and selected from various resources. These plants are also attractive to wildlife, according to a study conducted by the Georgia Fish and Wildlife department. It is also strongly recommended that plants within different families should be equally considered, for the sake of both biodiversity and visual enjoyment. More species generally help create a higher level of biodiversity. Even more so for a wide range of plants in a variety of families.

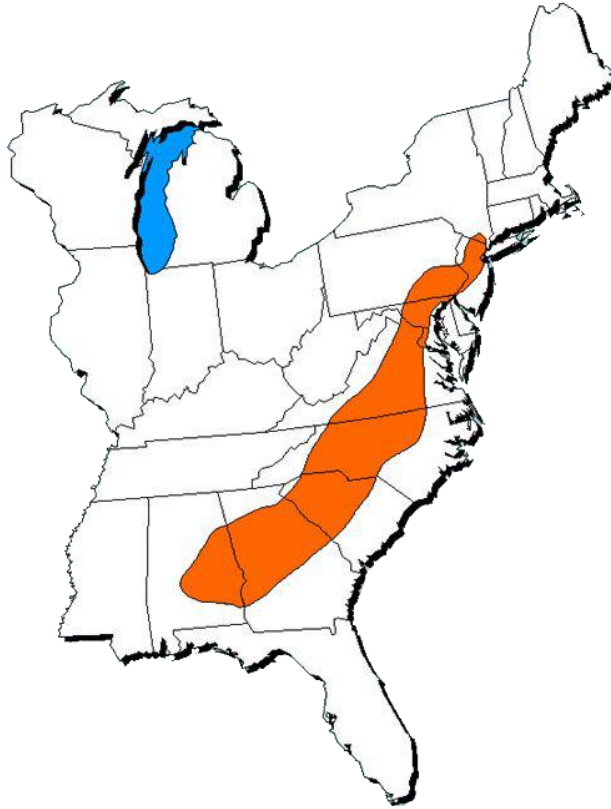


Fig 6.1 Piedmont Ecoregion (highlighted in orange)

The second approach is to imitate the vertical structure of natural woods “by using ground cover, shrub, understory, and canopy species.” (Tallamy, 2007, p. 119) Although a landscape with only grass and specimen trees has been proved to be more aesthetically attractive (see section 4.2.2 for reference), a combination of plants in various heights can create multiple types of habitats for considerably more species, which eventually enhance the biodiversity and ecological values of the landscape.

The last issue, which is also the key to maintain the landscape, is management. Some exotic species need extra care to survive while others adapt to an environment so well they become invasive. Sometimes invasive species are so persistent and fast-growing they cannot be eliminated in one attempt. They will keep coming back from the seeds hidden in the soil or from outside your garden (Wasowski & Wasowski, 2004). Except for this, the management work of a native plant

garden is actually much easier than that of a traditional garden because natives are well adapted to survive in indigenous region. The leaf litter can be reused as “free mulch, free fertilizer, free weed control, free soil amendments” (Tallamy, 2007, pp. 111,116), as long as they are kept in place, or piled in a restricted area with a neat edge to look tidy.

A “side-benefit” of native plants is, since they are typically well adapted to local environment, they usually thrive on their own, so that they do not need “toxic herbicides or pre-emergent herbicides that can make your skin itch and your eyes water” to thrive (Wasowski & Wasowski, 1994, p. XI). However, in order to maintain a lush appearance, organic fertilizers, instead of chemical ones, are recommended to help achieve this goal. Mass-produced chemicals could kill wildlife species and may be retained in the soil for years.

On the other hand, residents and gardeners may worry about the appearance of their plants if too many insects are attracted to nest in the gardens. Will they eat up the plants and make the garden look bad? Good news is that evidence suggests “as much as 10 percent of the foliage in a garden can be damaged by insects before the average gardener even notices.” (Sadof & Raupp, 1996, pp. 203 - 226) Besides, native predators will keep the amount of insects at a reasonable number once a balanced ecosystem is established.

The lawn, an essential and necessary element of every household garden, will remain as an important piece of the new landscape. However, many of the most popular lawn species we use today, for instance, Bermudagrass, Centipedegrass and Zoysiagrass are actually exotic species originated in Middle East, Southern China and East Asia, respectively. These lawn species need to be replaced by native species to lower their environmental impacts (high water consumption, the use of pesticide and fertilizer). The Wildflower Center at University of Texas in Austin has done a great job regarding this issue. The Habitutm is an ecological lawn that is one of the results

of their research on native plants, which has been proved to be effective towards “Less Mowing, Less Water and Less Weeding” (Austin, 2014; Simmons, Bertelsen, Windhager, & Zafian, 2011). Although the products are specifically designed for the west, north and central Texas, the idea has no limitation regarding the location. The core idea of Habiturf is to develop a mixture of native grass species that have almost identical shaped leaves, well adapted to local climate and have a high tolerance on sun-shade condition. However, such effort has not been made in Georgia, according to my research in early 2014. In fact, Bermudagrass, Centipedegrass and Zoysiagrass are still labeled as the “right grass” to plant for domestic gardens in Georgia among other recommended turf grass species in a publication provided by College of Agricultural and Environmental Sciences at the University of Georgia (Landry, 2010). Although the development of such a mixture is outside the scope of this thesis, I provide a list of native grass species that could be good as lawn grasses in the “Lawn Substitutes (native grass species)” section in Appendix II. Buffalograss and Feather fingergrass are among the most common ones.

Last, if a house happens to be next to any ecological corridor (see section 7.1 for an example), the owner would have more opportunities and responsibilities to bring nature into the garden, because the garden is the frontline for the wildlife to expand their territories and for us to show our hospitality. Increased connectivity can eventually create a green web. The idea of green web is explained in the next paragraph.

Many modern suburban subdivision layouts leave the original land cover, mostly woods, in northern Georgia, in isolated islands, while concrete, shingled roof and mowed lawn become the dominant land cover. The idea of green web is to reverse this land pattern. By cultivating wildlife habitat in every household’s backyard, connecting them to the adjacent existing forest, and by planting street trees to cover the concrete roads, it is possible to rebuild a largely connected

wildlife habitat in the suburbs (See Fig 6.2, 6.3). In this vision, in turn, the houses and concrete structures become islands.

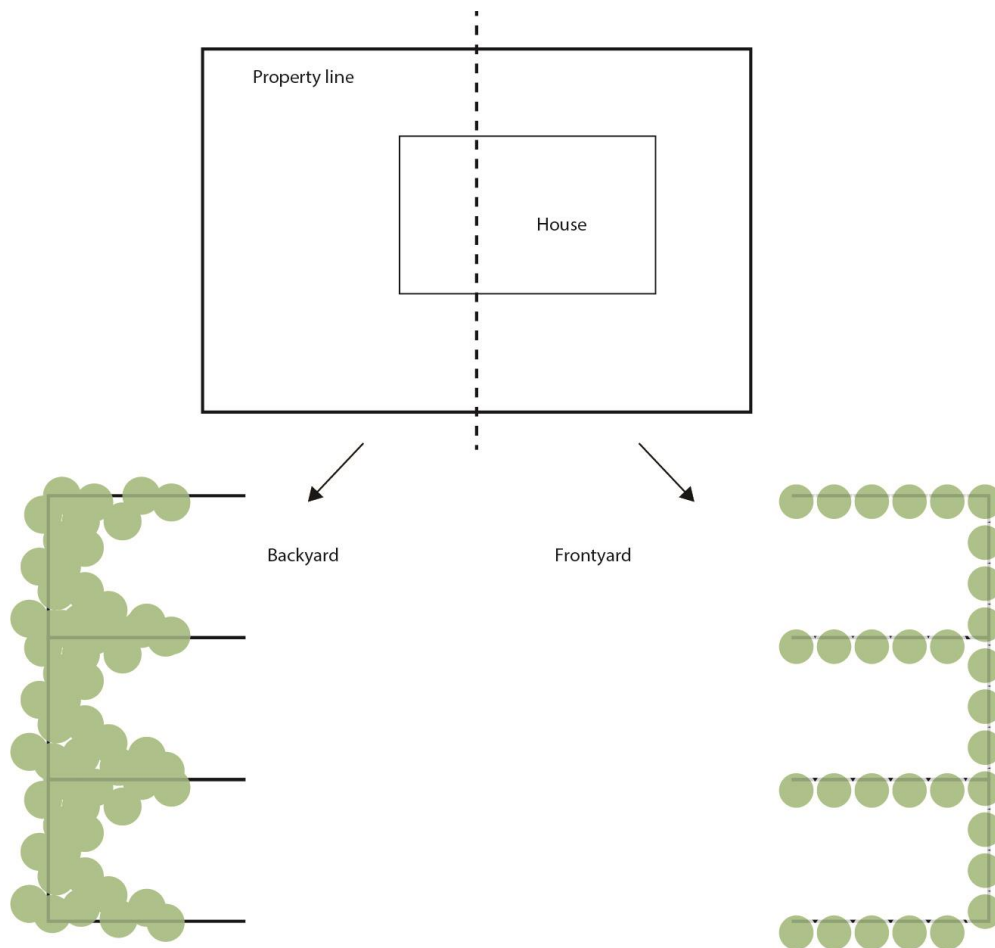


Fig 6.2 Green web diagram I (Front yards and backyards)

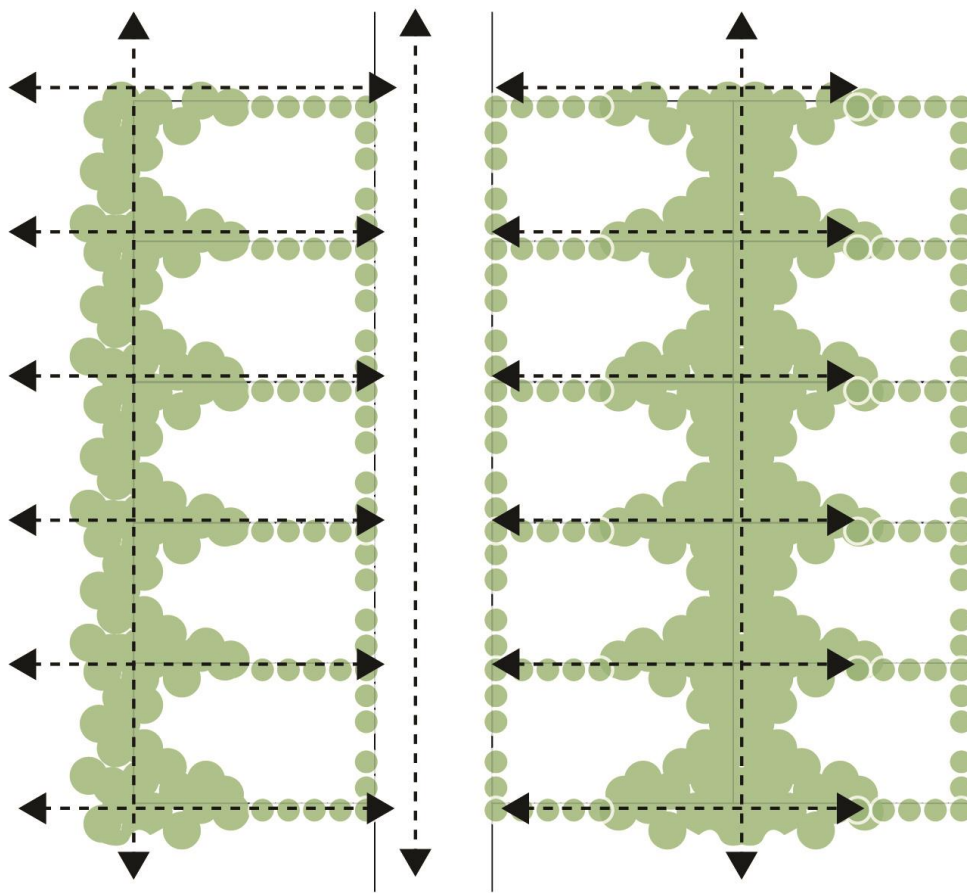


Fig 6.3 Green web diagram II

6.2. Guidelines for Designing Suburban Subdivision Gardens

The following eleven guidelines are designed to help homeowners and garden designers to create a visually pleasing garden with high ecological values. The guidelines are intended to provide beneficial suggestions to suburban homeowners nationwide. However, since some of the research and field studies are done in the southeast, especially in northern Georgia, these guidelines are expected to be more appropriate to be implemented in the southeast. The text within the parenthesis next to the title of each guideline indicates the related ecological issue.

(1) Plant native plants. (Biodiversity)

Plant native plants and use as many species as possible. Be careful when selecting them. Get information on local soil type and vegetation type before selecting the plants. Each native plant species has its favorite soil and microclimate, even though they are all well adapted to the local environment. Choosing the right plants can also help further lower the cost of maintenance. In Appendix II, a list of native plant species in northern Georgia is selected for homeowners and designers to choose from. The ability of attracting wildlife is also taken into account for the selection. In addition, birds, amphibians and small mammals that are native to this region or frequently visit people's backyards are listed in Appendix I.

(2) Pay attention to the context. (Biodiversity)

The tiny wildlife habitat created in the backyard is more resilient to external changes and can attract more wildlife species if it fits in the environment. Soil types, vegetation types and topography change in a fairly short distance. Such context information should be considered when determining the arrangement of design elements, the target wildlife to attract and the plant species to grow. Therefore it is important to understand the context prior to the design phase.

(3) Design the planting carefully. (Biodiversity and Energy)

Before planting trees or shrubs, draw a plan first. Delineate planting areas using circles, quadrangles or streamlined shapes. Big and tall trees should be located near the edges while grass and small plants in the center to ensure an open view from the house, especially in front yards. Planting dense vegetation in the upwind direction of the house while planting big and tall trees in the south to shade the house could conserve energy consumption. It is also recommended to draw an axis through the center of the building front. Organizing the design in a symmetrical way is a good method to maintain traditional aesthetics. See Fig 6.4 below.

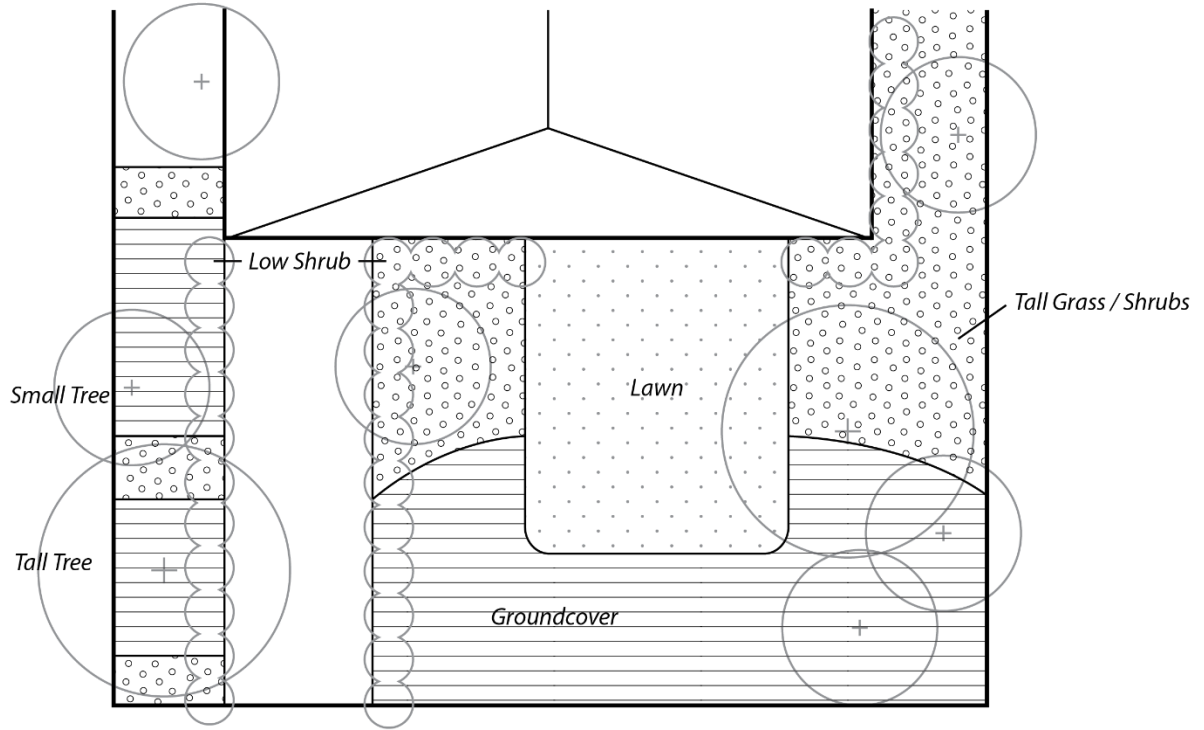


Fig 6.4 An example of garden design with simple geometries

(4) Pay attention to the structure of the planting design. (Biodiversity)

Plant tall trees, small trees, tall shrubs, low shrubs, groundcovers, vines and water plants to create a diverse habitat for different wildlife species. See Fig 6.5 below.



Fig 6.5 The structure of a planting design to create a more diverse habitat

(5) Design water-related facilities and landscape amenities. (Water)

Determine the location and size of the wet pond, rain garden, detention pond and wastewater treatment facilities, if any, when you have a general idea of what the garden looks like. Some water-resistant fabric underneath the pond will keep water from leaking too quickly, so that a constant water level can be maintained. Plant shrubs and other plants around the pond. Use the dirt from digging the pond to create a mound. This not only creates a change of terrain to enrich visual experience, but also provides a more diverse environment for plants and wildlife species. See Fig 6.6 below.

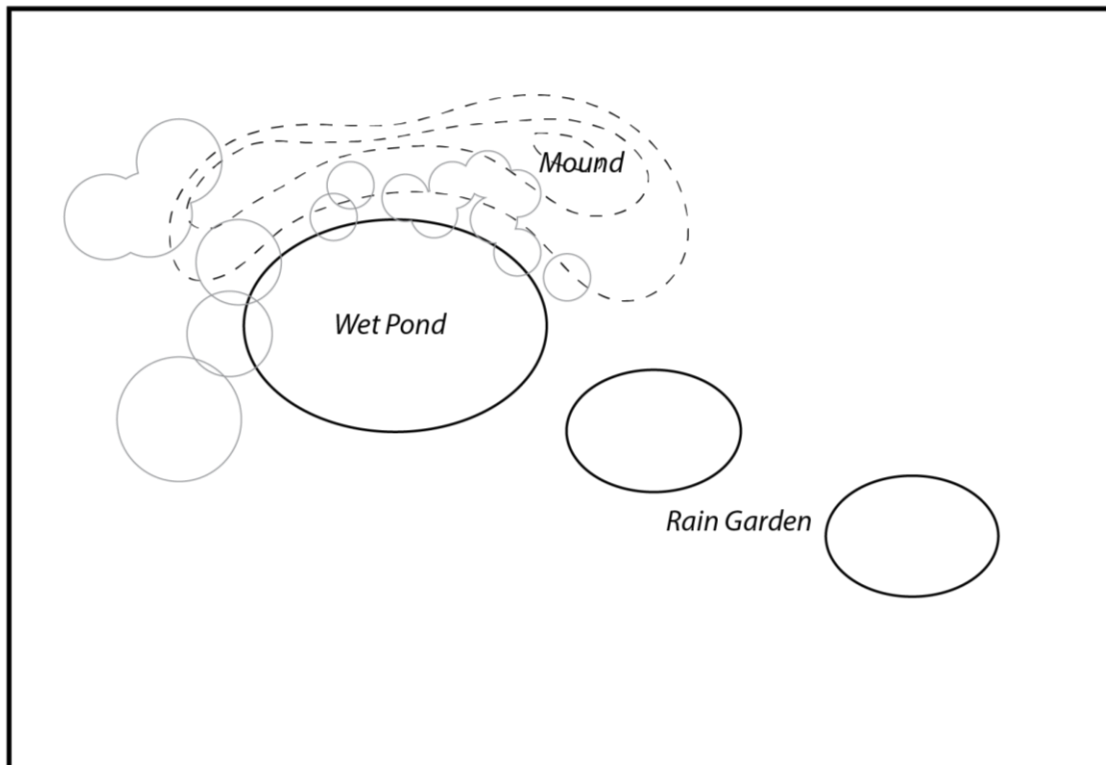


Fig 6.6 Wet pond, mound, and vegetation

(6) Create a water circulation system. (Water)

The diagram (Fig 6.7) below demonstrates a complete water circulation system for a suburban home. A homeowner can choose from the components, depending on site limitations, local policies and personal preferences. But implementing more components means achieving a higher level of water conservation, stormwater runoff control, wastewater treatment, and increasing biodiversity altogether. When building a wet pond, install a water-resistant liner to slow down leakage. If a wet pond is not practical, bird baths are a good alternative to provide water for wildlife.

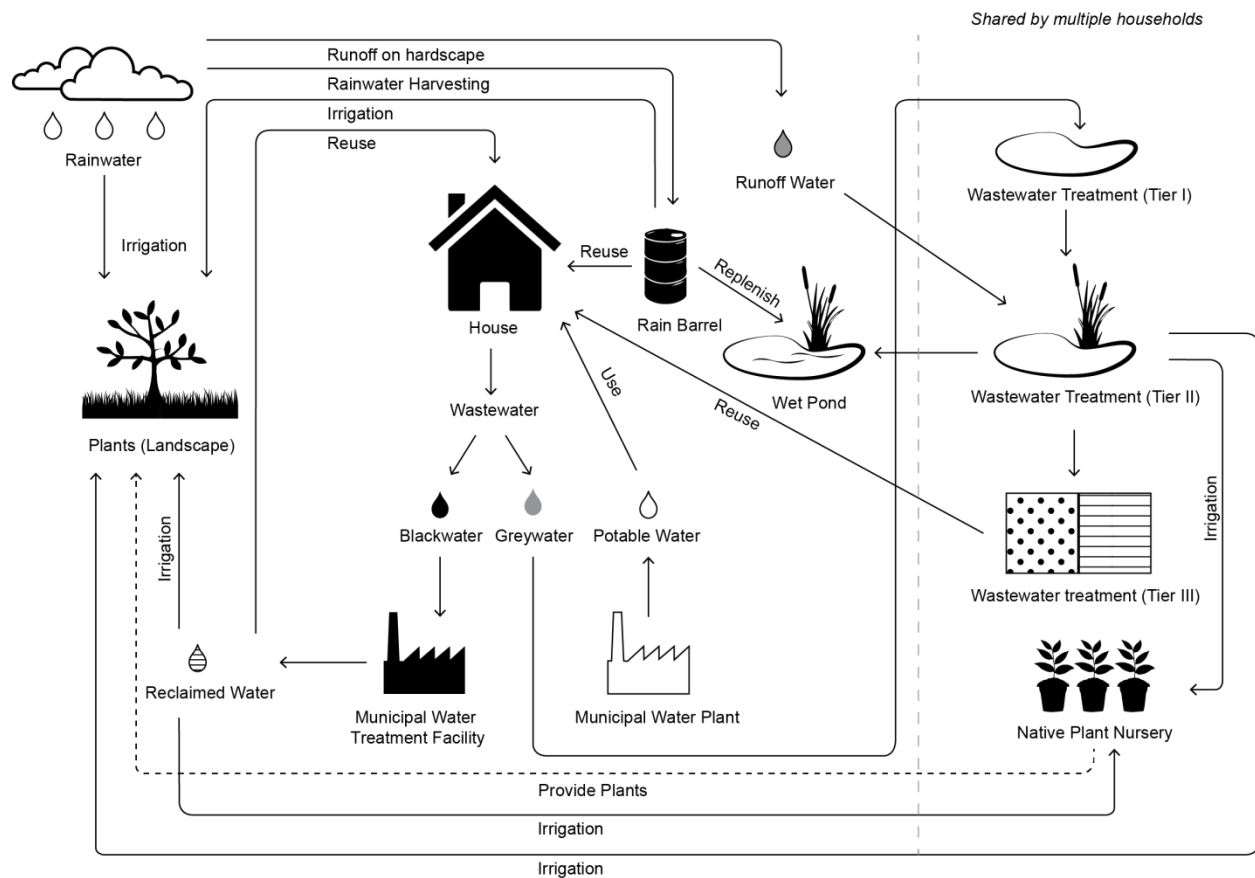


Fig 6.7 Water circulation diagram (Dashed line is not related to water)

Note: This diagram illustrates the relationship of six types of water: rainwater, runoff water, potable water, greywater, blackwater and reclaimed water. On the left side of the dashed line, all the processes happen or can be implemented in a suburban household garden. The processes on the right side, however, may be more suitable and practical to be implemented outside the property line and shared by multiple households within the community.

(7) Contact a local plant nursery or farm for native plants seedlings. (Biodiversity)

If seedlings are not available, build a native plant nursery to service the entire neighborhood. Water reclaimed from household's secondary wastewater treatment can be used for irrigation in nursery, while the nursery provides plants for gardens (See Fig 6.7 above), since native plants sold by many seed companies are often limited.

(8) Construct a feeder and a fenced brush pile. (Biodiversity)

A simple feeder is one of the easiest way to attract birds. Also, find a place in the backyard to pile branches, leaves and any other debris from cleaning and maintenance of front yards or back yards. For a clean look, the pile of brushes can be restricted to a fenced area. This works as wildlife “cover”.

(9) Use multiple native grass species for the lawn (Habiturf). (Biodiversity)

Since the lawn remains an essential part and the focal point of the front yard, it needs to be upgraded to minimize the environmental impacts. Appendix II provides several native grass species that require little care and almost no chemical products to maintain its growth and appearance. The photo below is an example of replacing turf grass with groundcovers/low shrubs. This method can be used when the vegetated area is not intended to be accessible.



Fig 6.8 Using groundcovers/low shrubs to replace turf as land cover plants (APLD, 2012, p. 25)

(10) Compost the organic waste. (Biodiversity and Waste)

Put a barrel or other appropriate container in the backyard for composting. Kitchen waste, branches and other organic waste can all be placed in a composting system for decomposition. The compost can be used as a soil amendment.

(11) Seek help from an experienced landscape architect or a cooperative extension agent.

(N/A)

Finally, since each site is different, the design may not be done by simply following the guidelines, and many issues may occur when putting all of them together, often times you would feel overwhelmed by all those procedures. If this is the case for you, contact a local landscape architect to assist you.

CHAPTER 7

CONCEPTUAL DESIGN

In this chapter, a conceptual design of a private garden in Athens, GA is devised to show how the findings and design guidelines can be implemented into practice. Due to the limitations of this thesis, the design is intended to test the issues within the coexistence of ecology-oriented design and traditional aesthetics, rather than to provide precise construction details or calculations about how the ecological solutions discussed in former chapters are implemented into the landscape.

The first section introduces background information of Athens Clarke County, a typical southeastern city where the conceptual design is located. It first explains why Athens is chosen as site location, then introduces its geographical, climatic, vegetation, wildlife and economic information, which are all critical to help create an ecological landscape.

Following the second section of conceptual design, the third section evaluates the design by calculating the score this design could achieve based on SITES, an established criteria for sustainable development. This chapter ends with a reflective discussion regarding the guidelines as well as the design.

7.1. Background Information of Southeastern America

Due to Athens Clarke County's proximity to Atlanta, one of the largest and continually growing metropolitan areas in America, life in Athens is gradually becoming more connected with the big city. As a matter of fact, Athens-Clarke County has been counted as a part of the Atlanta—Athens-Clarke—Sandy Springs Combined Statistical Area, with its economic, cultural and

demographic core of Atlanta Metropolitan Area, which is defined by United States Office of Management and Budget, OMB. CSA (Combined Statistical Area) is defined by OMB as an aggregate of adjacent Core Based Statistical Areas (CBSAs) that are linked by commuting ties.

The demand for bringing ecological values into suburban landscapes, is particularly urgent in the Metropolitan Atlanta region, which is undergoing “a prolonged period of unprecedented population growth and rapid urban and suburban development” (Gregory & Bryant, 2003, p. 1). Geographically, Metro Atlanta is located in the piedmont ecoregion (Fig 7.1). A study done by Jerry A. Griffith from the University of Southern Mississippi showed “an increase in forest fragmentation and a loss of forest cover” after 1980s in this region (Fig. 7.2) (Griffith, Stehman, & Loveland, 2003, p. 572). Such landscape trends call for attention to the environmental impacts of suburban development, which supports the importance of this thesis from another perspective.

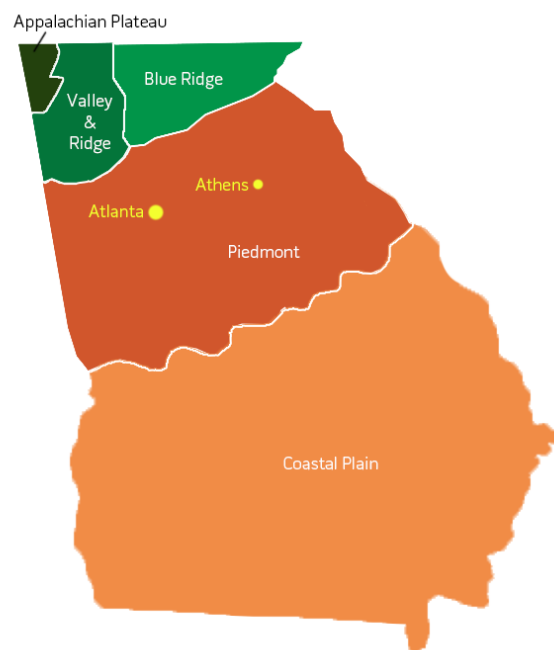


Fig. 7.1 Ecoregions of Georgia, USA

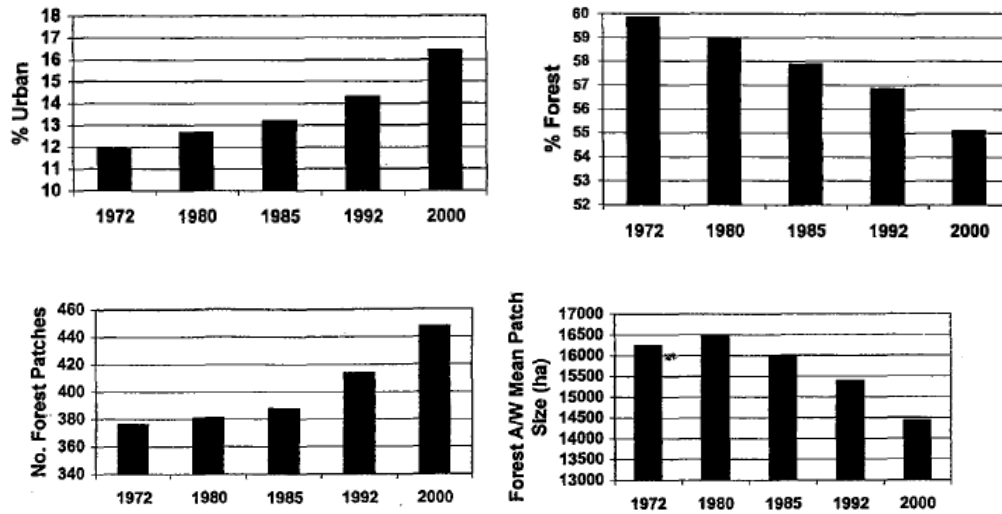


Fig. 7.2 The forest fragmentation and urban expansion of Piedmont ecoregion from 1972 to 2000 (Griffith et al., 2003, p. 580)

According to 2012 USDA Plant Hardiness Zone Map, northern Georgia belongs to Zone 8a (See Fig 7.3 below). The average annual extreme minimum temperature is from 10 to 15 F (-12.2 to -9.4 C). The climate of Georgia, humid subtropical climate, indicates mild winters and hot summers. After millions of years of evolution, the climate and the geography together create a unique ecosystem, with many native plant and wildlife species that are well adapted to this region.



Fig 7.3 2012 USDA Plant Hardiness Zone Map of Georgia (USDA, 2012)

7.2. A Conceptual Design

The selected site is located at 607 Trellis Ct, Carrington Plantation, Athens, GA.

Carrington Plantation is a community of about 200 homes, located in the southeast portion of Athens-Clarke County, about 5 miles from downtown Athens. The aerial photo below shows the location of Carrington plantation and its layout. It is a typical suburban subdivision in the southeast, with three entrances on both sides connected to main roads, surrounded by woodland and other subdivisions.

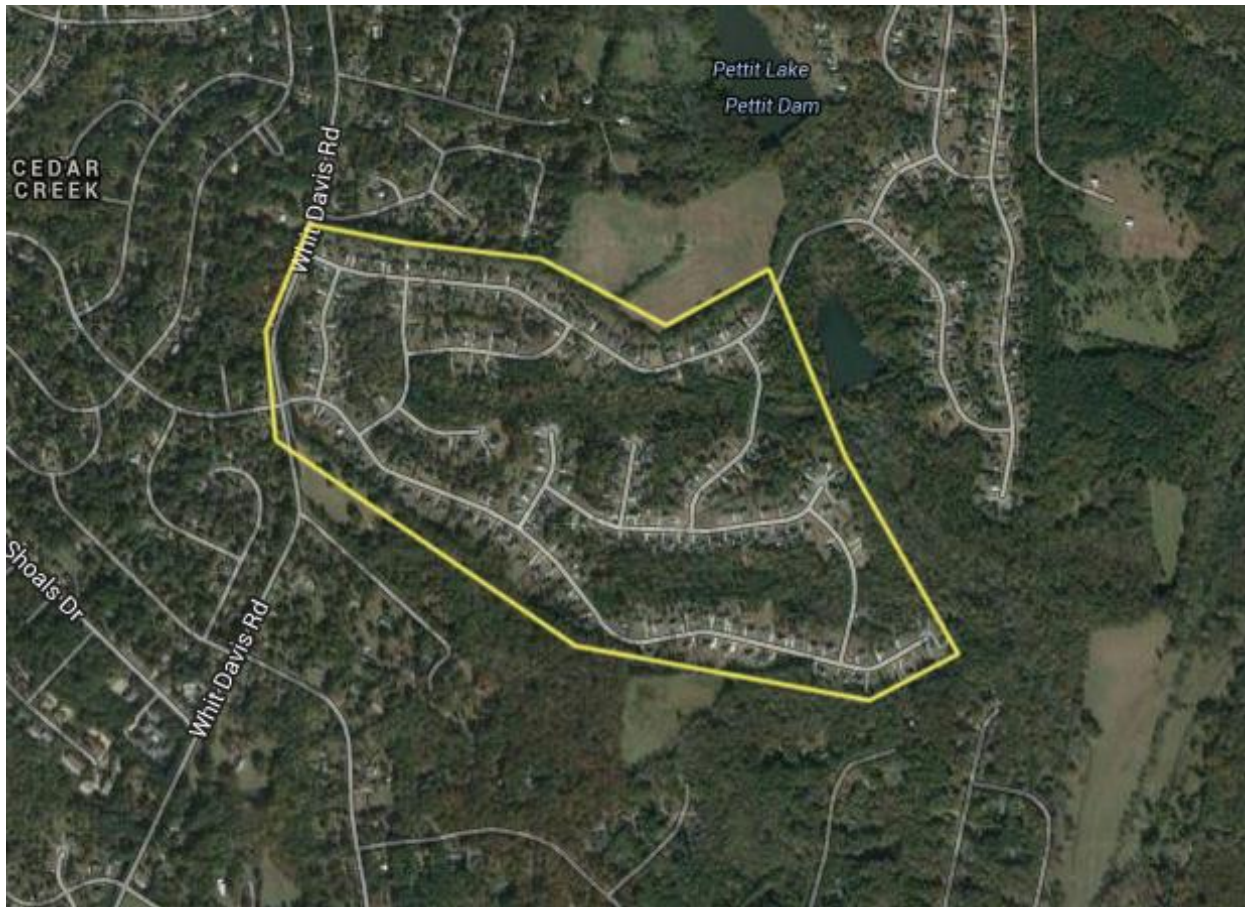


Fig 7.4 An overview of Carrington Plantation (Source: Google Earth)

Within Carrington Plantation, 607 Trellis Ct was chosen as the site to implement the design guidelines. In this neighborhood, each lot is very similar to each other, partially because it is a relatively new subdivision. 607 Trellis Ct was chosen because the yard retains much of its original condition from when the developer delivered the house to the owner, which makes it easier to implement new ideas. The aerial photo below (Fig 7.5) shows the site (within the yellow boundary). It has a house standing in the southeastern half of the site, with a driveway connected to the road. A storage structure is located at the other end of the site, close to the existing woods. The foundation planting, or the builder's package, is very simple. It contains: nine shrubs at the base of the front wall, trimmed into cubicles; one Magnolia tree in the front lawn; and three evergreen tree saplings to the east side of the house. A small piece of the backyard is occupied by

fully-grown trees, which may have been protected during construction. The rest of the site is covered with mowed lawn.



Fig 7.5 Site View (Source: Google Earth)



Fig 7.6 The front view of the house at 607 Trellis Ct, Athens, GA

7.2.1. Site Analysis

(1) Context Analysis – Soil

Fig 7.7 uses data from GIS to show the existing soil types of this area. It is clear that the soil type can change in a very short distance. The primary soil types of the site are CZB3 and CYC2. CZB3 refers to the soil of Cecil sandy clay loam, 2 to 6 percent slopes, severely eroded. CYC2 refers to the soil of Cecil sandy loam, 6 to 10 percent slopes, eroded. Soil types are one of the concerns when selecting the right plants for landscaping. It is best to identify the soil type before making the decision of which plants to grow. Plants that are poorly adapted to the soil could cost more to survive and maintain a healthy look.

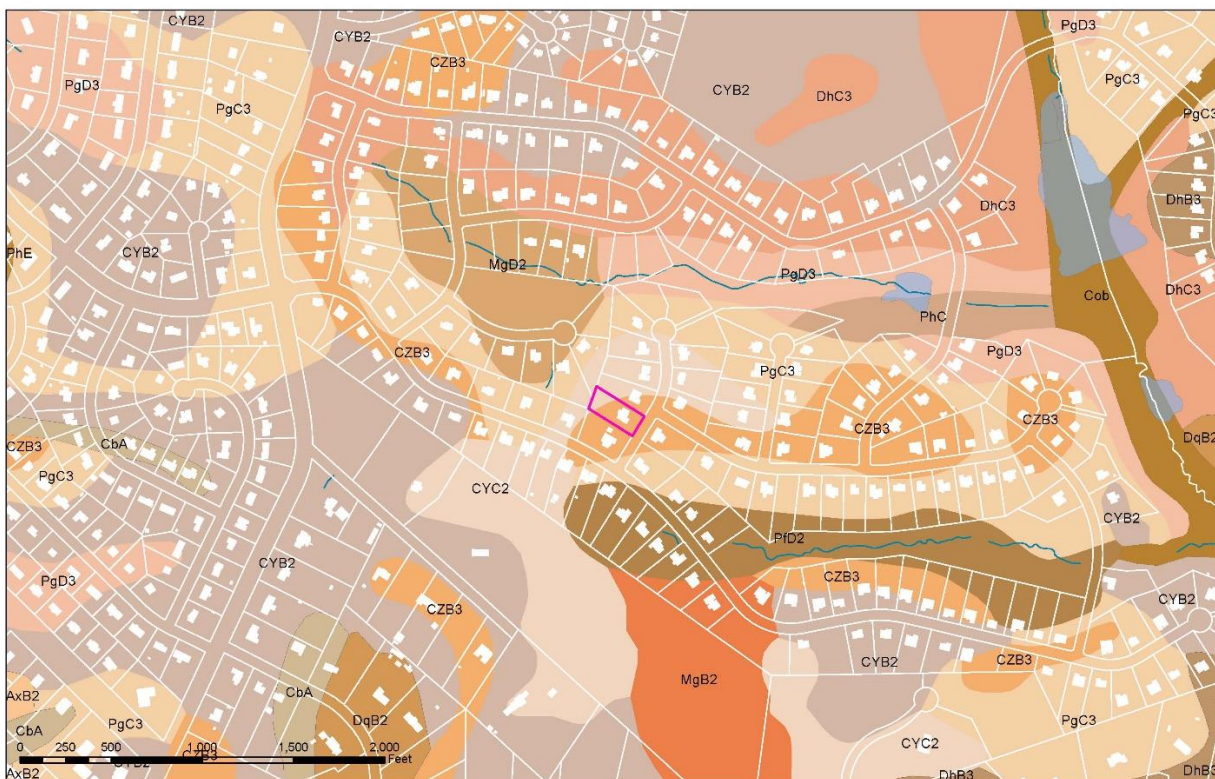


Fig 7.7 Soil type

(2) Context Analysis – Vegetation Type

The vegetation type map above shows the vegetation type of this area prior to construction of the suburb. Three major vegetation types within Carrington Plantation are light pine, hardwood and kudzu. Kudzu, a commonly known invasive species, occupies a lot of land along the streams. Therefore, preferred vegetation types that are to be restored are hardwood and light pines.



Fig 7.8 Vegetation type

(3) Site Analysis

The site analysis below shows a few basic features of this site, which will be the basis for design.



Fig 7.9 Site Analysis

a. Axis. One of the important features of traditional gardens is simple geometries and the axis which the organization of landscape elements are based upon. Within this site, two axis are drawn to align with the geometric centerline of the house and the barn. These two axis will be the reference lines for design.

b. Slope. The land elevation is higher at the side adjacent to the road and lower at the other end. The landform should be considered when designing the rainwater harvesting system, as rainwater flows from high to low land.

c. Front window view. Keeping an open view in front of the window plays an important role in designing a traditional looking garden.

d. Existing vegetation. Fortunately, the planning of Carrington Plantation did not eliminate every patch of original forest, which brings the opportunity for the household garden to connect to the larger patch of forest outside the subdivision (see Fig 7.13 for reference).

7.2.2. Design Plan and Renderings

The conceptual design (Fig 7.10) is an example showing one way to bring ecological values into suburban subdivisions without compromising their core traditional aesthetics. The purpose of the design is not only to showcase a possible outcome of implementing the design guidelines, but also to test the conclusion of this thesis through evaluation and reflection regarding the design.

The design is devised to maintain a traditional look while bringing in ecological values and providing necessary landscape amenities to the residents, but in different ways for front yards and backyards. In the front yard, the lawn is minimized into a pear-shaped area in front of the house to ensure an open view. Low shrubs and groundcovers replace the rest of the lawn to lower water consumption and to increase the plant diversity. Their heights also ensure the open view in the front yard, while the clear-defined edges convey the cues of care. Two lines of trees are planted

on either side of the front yard, with one line within the property and the other line in the yard next door. This way, one homeowner only needs to take care of one line of trees while getting the benefit of both of them. Street trees are planted along the sidewalk, but the ones right in front of the lawn are omitted to keep the open view.

In the backyard, on the other hand, a more complex system is established. There are four layers of vegetation with two systems embedded. The four layers are, from the edge to the center, natural woods, shrubs, groundcovers and lawn (Habiturf). See Fig 7.12 for a visual reference of the four layers. The two systems are rainwater harvesting system and runoff control system. The gradual height change from woods to turf is a transition from natural wildlife habitat to human-dominated outdoor activity area. It also encloses the backyard, providing a sense of space and privacy. The wet pond provides more diverse habitat conditions to attract different species. A cistern located next to the house collects rainwater from the roof. Collected rainwater can be used indoors (flushing the toilet) or outdoors (irrigation). The volume of cistern can be calculated through the equations below. The number in enclosed parentheses refers to actual size of this site. A 5000 gallon cistern is about the size of 5 compact cars, which may be too large for a domestic garden. Instead, it is recommended to use a 2500 gallon below-grade cistern for this household. A family of three consumes 2500 gallon water in 9.5 days, on average, according to USGS.

Cistern size = Catchment area (2408 ft²) × 1-year 24-hour Rainfall depth (3.36 in) × Conversion factor (0.623) = 5040 gal (*Georgia Stormwater Management Manual*, 2001)

A swale runs along the edge of the groundcover, conveying runoff through several small-sized rain gardens (detention ponds) until reaching the wet pond (retention pond).



Fig 7.10 Conceptual design (Plan view)



Fig 7.11 Front view: Existing vs. Proposed Rendering

The front view rendering (Fig 7.11) illustrates how a simple design could achieve the goal of increasing ecological values while maintaining the traditional look. The original lawn is reduced to a pear-shaped area in front of the house entrance (along the axis, the centerline of the house) and replaced by Habiturf. Shrubs are planted at regular distance, on both sides of the axis.

Groundcovers fill the rest of the yard. Trees on both edges provide shade as well as a frame of view. All of the new vegetation provides habitat and foods for birds, insects, small mammals and amphibians, while the careful arrangement of which helps maintain a clean look to be more easily accepted.



Fig 7.12 Backyard: existing aerial photo vs. proposed design rendering

The backyard rendering (Fig 7.12) illustrates a wildlife-friendly backyard. The lawn in the center provides space for family gathering and children play. From the center to the edges, the height of vegetation increases from lawn, groundcover, low shrubs to shrubs and trees. The edges of each “layer” is clearly defined by placing bricks or regular maintenance. Three species are listed for each type of plants in the graphic as examples. More species are available in Appendix II. Species that are attractive to general wildlife species, birds, and pollinators are labeled for reference. Diverse plants are the basis for establishing a healthy ecosystem.

In the far back where the view is blocked by the plants, the garden is connected to the existing woods. To the left of the storage room, a rain garden and a wet pond is located between groundcover area and shrubs/small trees area. They are not only visually pleasing landscape amenities but also function as runoff infiltration ponds.

7.3. Evaluation and Reflection

(1) Evaluation by SITES

The only two established criteria concerning ecological design are SITES (see Appendix III for details) and EcoHomes, according to my research. SITES targets many different types of construction sites while EcoHomes only targets residential neighborhoods. However, SITES was eventually chosen over EcoHomes for this thesis because SITES addresses ecological issues more comprehensively than EcoHomes. And EcoHomes criterion are actually devised for multi-home subdivisions and complexes, rather than single-family home sites. But the fact is, neither of them is perfect for an ecological retrofitting project of a single household garden. Sustainable Sites Initiative (SITES) program is an interdisciplinary effort to promote sustainable land development and management practices that apply to sites with and without buildings ("Guidelines and Performance Benchmarks," 2009). It is a 250-point rating system, which reflects the Initiative's

Guiding Principles. All the points are organized into nine sections: site selection, pre-design assessment and planning, site design—water, soil and vegetation, materials selection, human health and well-being, construction, operations and maintenance, monitoring and innovation. Each section is divided into prerequisites and credits. SITES rating system is expected to “establish and encourage sustainable practices in landscape design, construction, operations, and maintenance” (“Guidelines and Performance Benchmarks,” 2009, p. 2). It is also a very powerful tool to assess the sustainability value of a design in a lot of ways. Ecological values are an important component of sustainability. It is used to provide a more objective measure of ecological values discussed in the guidelines. Evaluating the design by SITES helps test the design guidelines and provide new directions of research in the future.

A garden designed by following all the design guidelines provided in section 6.2 and by implementing appropriate ecological solutions provided in section 5.2, can achieve a maximum of 100 points in SITES rating system, using the conceptual design as an example.

The requirements of each section will not be fully described in this thesis, however a list of each credit and a brief explanation of how those credits are achieved in the design is offered in Appendix III. Prerequisites are omitted since they are not worth any points and this is only a hypothetical evaluation, although the prerequisites are mandatory as a baseline in order to achieve any credits. To be concise and clear, an achieved credits distribution table (Table 4) is displayed below. The categories of site design – water and site design – soil and vegetation are selected as relevant categories because the design guidelines mainly address issues of these two categories. Credits earned for these categories are calculated separately.

Table 4 Scoreboard for SITES rating system

	<i>Section</i>	<i>Credits Available</i>	<i>Credits achieved</i>
1	Site selection	21	0
2	Pre-Design Assessment and Planning	4	4
3	Site Design—Water	44	27
4	Site Design—Soil and Vegetation	51	41
5	Site Design—Materials Selection	36	13
6	Site Design—Human Health and Well-Being	32	7
7	Construction	21	0
8	Operations and Maintenance	23	0
9	Monitoring and Innovation	18	8
	<i>Total</i>	250	100 (40%)
	<i>Total (relevant categories: 3,4)</i>	95	68 (71.58%)

Earning a score of 71.58% in relevant categories proves this design did a good job bringing ecological values into the site.

As mentioned above, though better than EcoHomes, SITES is not a perfect criteria to evaluate the garden design for a suburban household because it is not specifically developed for it. Scores of different sites are not comparable to each other since they have completely different characteristics including their sizes and the natural context. LEED (Leadership in Energy and Environmental Design) is a rating system designed for sustainable buildings. It has been tailored in a variety of ways to target different types of buildings, such as offices, houses, schools and hospitals. If the guidelines and performance benchmarks of SITES could be further developed

for different types of sites, such as a house yard, a public park or an urban green space, SITES would be a more powerful evaluation tool for sustainable sites.

(2) Design Reflection

The design shows one way to implement the guidelines. The geometry in the front yard and the clear planting area edges of the backyard are results of conforming to the traditional aesthetics, while bringing in ecological values. Maintenance of vegetation is expected to be kept at the lowest level. The rainwater management system built in the backyard is only a startup for the water circulation system described in the guidelines. Wastewater treatment is not included.

The primary objective of the thesis is to bring ecological values into suburban landscapes without compromising their core traditional aesthetics, which is how the research is carried out and why this thesis is organized this way. When it comes to physically implementing the design guidelines, practical issues will occur and there are too many of them to be predicted in this thesis. Three major ones are listed below to complement the design guidelines and to inspire new thoughts and further research, but there could be other issues that have been missed.

a. Green web and wildlife habitat connectivity.



Fig 7.13 An analysis of natural habitat connection (the yellow circle highlights the design site)

Wildlife habitat connection is “green web” (see section 6.1.2 for reference) in a larger context (Fig 7.13). Such connectivity issue is the main research target of landscape ecology, since habitat and ecosystem fragmentation are one of the main causes of the decline in biodiversity (Marsh, 2005, p. 430). Studies in island biogeography revealed that the larger that area of an island (or its terrestrial counterpart, a patch of wildlife habitat) and the closer the distance is between neighboring islands, the higher the species diversity is. Continuous vegetation (patch) is highlighted by transparent red marker in this aerial photo. Although the original forest is largely fragmented due to suburban subdivision development, relatively big and continuous woods still exist and have the potential to be connected to green islands within subdivisions. The site, due to its proximity to a stream (light blue line), has the opportunity to be connected to a major green branch directly and allow wildlife expand their territory.

b. Time. Time refers to two things here. The first is the time it takes for plants to grow. According to the guidelines provided by Wildflower center at University of Texas Austin, Habiturf is fully established after three to four months. Shrubs and trees need much more time to grow into full height. Within the growing time of the plants, homeownership may change, which could result in the change of landscape design due to different personal preference. So the habitat may not be successfully established. The second one is the time it takes for people’s mindset to change. One successfully-established garden could have a huge influence on its neighbors, however, because of social contagion (see section 4.4 for reference), it could still take years for a community to follow this new style.

c. Unwelcomed animals. Although people usually express their fondness of wildlife, they may not want certain species in their backyards. Birds and small mammals are among the welcomed ones. However, unwelcomed wildlife species, such as mosquitos, snakes, spiders, and

sometimes deer could also be attracted to the newly designed backyards. Certain precautions should be taken to prevent those species from getting too close to the house, for instance, drying the wet pond monthly to kill the wrigglers of mosquitos. An eight feet high deer fence along the edge of the neighborhood could effectively prevent deer from entering and eating up all the plants.

Despite the limitations, the design guidelines could greatly increase ecological values of suburban domestic gardens, while maintaining the traditional aesthetics.

CHAPTER 8

CONCLUSION

To achieve the objective of “finding a way to mitigate the environmental impact of suburban subdivision landscapes in the southeast without compromising their core aesthetics,” there are many issues to consider and study. I broke them down into three categories, American suburbs, aesthetics and ecological values. The research of American suburbs helped me understand how the landscape of American suburbs turned out the way it is today. In the chapter of aesthetics, I explored some of the theories about people’s taste by studying peer-reviewed articles, books and reports on history, culture, psychology and geography. In the next chapter on ecological values, I identified the environmental impacts that current suburban landscapes impose and then searched for possible solutions to mitigate such impacts. The design chapter proposed a series of design guidelines, which could minimize the environmental impacts while not contradicting traditional preferences.

To establish the general traditional aesthetic principles is not easy, since aesthetics is a subjective matter and existing research on suburban home landscapes is very limited. To find a way to balance the two core concepts: ecological values and aesthetics is not easy, either. But they are not the most difficult parts of this thesis. The biggest challenge is to transform theories into a practical and applicable solution to achieve the objective. Ecological values are based on scientific research. To bring the newest concepts into consideration and to embed new findings into design, I have to fully understand them first, which is not an easy task for a landscape architect. On the contrary, aesthetics is subjective. “Any landscape is composed not only of what lies before our

eyes but what lies within our heads,” (Meinig, 1979, pp. 33 - 34) just like the old saying of Shakespeare, “There are a thousand Hamlets in a thousand people's eyes.” Personal preference, in particular, is such a delicate and erratic matter to deal with, while guidelines have to speak for the general public. An applicable solution cannot be devised before an appropriate compromise between the two is made. Moreover, there is no perfect way to evaluate the design. As mentioned in section 7.3, SITES is chosen over EcoHomes because it addresses ecological issues more comprehensively. But neither of them is perfect for the design in this thesis.

The design guidelines are originally devised as a reference for homeowners so they are expected to be implemented on a household garden level. However, some issues that are discussed in this thesis indicate the design guidelines’ influence on a larger scale. For one thing, components on the right side of the dashed line in the water circulation diagram (Fig 6.7), such as tier-two wastewater treatment and local plant nursery are intended to be implemented on a community level. Some wastewater treatment facilities can occupy a large area and often require a continuous inflow to work properly. A plant nursery has the same issue of large areas. Elements such as these work better and provide better service to multiple households on a community level.

The green web idea is also being considered on a larger scale. If most households in a subdivision follow these guidelines to design their gardens, a better wildlife habitat connectivity can be established.

The design guidelines can also have a widespread influence, beyond the boundary of one household garden or the whole subdivision, if they are adopted or referenced by planners, local homeowner associations and local governments. As a matter of fact, they could play a significant role in the ecological transition of suburban landscapes. Suburban subdivision planners and developers determine the layout of a neighborhood. If they have preserved as much virgin

vegetation as they possibly could in the first place, it will be an easier job for homeowners to create a diverse wildlife habitat in the backyard and connect it to the larger context, since undisturbed vegetation is the best habitat for local wildlife. Plus, the plants outside of the property lines can only be saved in the early planning phase of the development, which normally does not involve any individual resident.

The HOA (Homeowner's Association, a corporation formed by a real estate developer) often has a legal right to make and enforce rules for the properties in its jurisdiction. They have the opportunity to adopt the design guidelines into their rules or publicize the ideas to the residents. Similarly, a local government could bring the basic ideas into local regulations and set up rewards for those who achieve a better performance as an encouragement. They could have a much bigger influence than individuals implementing these guidelines.

Due to the limitations of this thesis, some issues that are relevant to design and design implementation are not studied. Various physical issues are not taken into consideration, such as construction details, maintenance, costs, and technical calculations. In reality, when redesigning a domestic garden, there are influential factors other than aesthetics and ecological values. State laws and local regulations, neighborhood guidelines, and the potential opposition from neighbors are only a few of them. All these issues are significant factors that a homeowner should consider if he plans to bring the new design into his own home. Often times, some of those issues are among the major incentives for household to change their yard designs. Extra rainwater harvesting and wastewater treatment system generates additional cost for installing and maintaining them, but they could lower the potable water consumption, thus lower water bills. Native plants often require less care than exotic species, but they could cost more than routine garden plants since currently they are often more difficult to be acquired. So it is hard to estimate whether the new design will

cost more money or labor. Therefore, there is still a lot of research and study to be done before applying these theories into practice.

Although the benefits and significance of the ecological transition have been discussed extensively in the first few chapters, they may not be easily understood and accepted by homeowners. Moreover, the benefits are mostly environmental benefits, which might not have a large influence on changing people's mindset, let alone to say such changes could also bring obvious initial costs and maintenance costs (see section 6.5 for details). Considering this issue, this thesis explored how to make a design that is more acceptable so it is easier to be adopted. But the design alone does not guarantee that the change will be successfully accepted and put into practice by everyone. Strategies and approaches concerning this matter, however, is out of the scope of this thesis.

A vast amount of land in the southeast is consumed by suburban subdivision development while most of these development do not pay much attention to the original land cover or the existing wildlife habitat. Therefore, restoring ecological values back to the land through individual homeowners would help conserve natural habitat and to minimize the suburban subdivision's environmental impact. The research and the design guidelines in this thesis are a first step towards achieving this goal.

To restate the importance of the research and the results, bringing ecological values into suburban landscapes can be one of the most important components of sustainable development, a system that involves all kinds of human activity and influences every one of us. However, the intrinsic disorderliness of ecological approaches contrast with suburban homeowners' aesthetic preferences. By exploring cultural history of American suburbs/suburban landscapes as well as human being's inherent psychological perceptions, I have a better understanding of the mechanism

behind people's choice. Considering all the three factors, a new way of transforming suburban landscapes can then possibly be developed to bring in ecological values but not contradict people's preferences.

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APPENDIX I

BACKYARD WILDLIFE SPECIES IN GEORGIA

The following wildlife species are selected because they are native to northern Georgia; they have been seen in human-dominated places such as backyards; and they are not rare or endangered species. Therefore these wildlife species are expected to be seen if a homeowner wishes to implement the design guidelines.

Resource:

http://www.enature.com/fieldguides/view_default.asp?rgn=ga_232&allSpecies=y

http://www.wildsidegardens.com/franklin/birds/birds_of_georgia.html

<http://quizlet.com/17543860/common-birds-in-ga-flash-cards/>

http://www.georgiabackyardnature.com/georgia_backyard_nature/birds/

<http://georgiawildlife.com/georgiahummingbirds>

Table 5: Backyard Wildlife Species in Georgia

Group	Latin name	Common name
Birds	<i>Melanerpes carolinus</i>	Red-bellied Woodpecker
	<i>Baeolophus bicolor</i>	Tufted Titmouse
	<i>Poecile carolinensis</i>	Carolina Chickadee
	<i>Haemorhous mexicanus</i>	House Finch
	<i>Dumetella carolinensis</i>	Gray Catbird
	<i>Passer domesticus</i>	House Sparrow
	<i>Cyanocitta cristata</i>	Blue Jay

	<i>Sialia sialis</i>	Eastern Bluebird
	<i>Selasphorus calliope</i>	Calliope hummingbird
	<i>Cardinalis cardinalis</i>	Northern Cardinal
	<i>Turdus migratorius</i>	American Robin
	<i>Toxostoma rufum</i>	Brown Thrasher
Amphibians	<i>Anaxyrus americanus</i>	American toad
	<i>Bufo fowleri</i>	Fowler's toad
	<i>Acris crepitans</i>	Cricket frog
	<i>Hyla versicolor</i>	Gray treefrog
	<i>Pseudacris crucifer</i>	Spring peeper
	<i>Pseudacris feriarum</i>	Upland chorus frog
	<i>Gastrophryne carolinensis</i>	Eastern narrowmouth toad
	<i>Lithobates catesbeianus</i>	American Bullfrog
	<i>Lithobates sylvaticus</i>	Wood frog
	<i>Ambystoma maculatum</i>	Spotted salamander
	<i>Notophthalmus viridescens</i>	Eastern newt

APPENDIX II

NATIVE PLANTS FOR GARDEN DESIGN IN NORTHERN GEORGIA

The following plant species are selected because they meet one or more of the following criterion:

- (1) Native plants in northern Georgia;
- (2) Commonly-seen in natural habitat;
- (3) Have fruits or flowers that are attractive to wildlife species;
- (4) Trees are not too tall (could be a problem for a small site).

* Plants that are commonly seen and attractive to native wildlife species, according to USDA.

** Plants that provide food or cover for birds.

*** Plants that are attractive to pollinators (butterflies, bees or wasps).

Sources:

Lady Bird Johnson Wildflower center at the University of Texas of Austin: Native plant database (<http://www.wildflower.org/plants/>)

(Cowell, 1998; Tallamy, 2007; Wasowski & Wasowski, 1994; Webb, 2008; Westerfield, 2012)

Table 6: Native Plants for Garden Design in Northern Georgia

Group	Latin name	Common name
Evergreen trees	<i>Ilex opaca</i> **	American Holly
	<i>Juniperus virginiana</i> **	Eastern red cedar
	<i>Magnolia grandiflora</i> **,***	Southern Magnolia

	<i>Pinus echinata</i>	Shortleaf Pine
	<i>Tsuga canadensis</i>	Eastern Hemlock
	<i>Ilex vomitoria</i> **,***	Yaupon holly
	<i>Illicium floridanum</i> ***	Florida anise
	<i>Myrica cerifera</i> **,***	Wax myrtle
	<i>Osmanthus americanus</i>	Devilwood
Deciduous trees	<i>Acer barbatum</i>	Southern sugar maple
	<i>Acer rubrum</i> **	Red maple
	<i>Betula nigra</i> **	River birch
	<i>Fraxinus Americana</i>	White Ash
	<i>Liquidambar styraciflua</i> **	Sweetgum
	<i>Magnolia virginiana</i> **	Sweetbay Swampbay
	<i>Nyssa salvatika</i> **	Blackgum
	<i>Quercus alba</i> **	White oak
	<i>Quercus phellos</i> **	Willow oak
	<i>Quercus stellate</i> **	Post oak
	<i>Tilia americana</i>	Basswood
	<i>Aesculus pavia</i>	Scarlet buckeye
	<i>Carpinus caroliniana</i>	Musclewood
	<i>Aralia spinosa</i>	Devil's walkingstick
	<i>Cercis canadensis</i> ***	Redbud
	<i>Cornus florida</i> **	Flowering dogwood
	<i>Diospyros virginiana</i>	Eastern persimmon
	<i>Hamamelis virginiana</i>	Witchhazel

	<i>Ilex decidua</i>	Possumhaw
	<i>Oxydendrum arboreum</i>	Sourwood
	<i>Viburnum obovatum</i> **	Walter's viburnum
Evergreen shrubs, used as screening	<i>Agarista populifolia</i>	Agarista
	<i>Ilex glabra</i>	Inkberry
	<i>Myrica heterophylla</i>	Southern bayberry
	<i>Rhododendron maximum</i>	Rosebay rhododendron
Flowering and fruiting shrubs:	<i>Aesculus parviflora</i> ***	Bottlebrush buckeye
	<i>Callicarpa americana</i> ***	American beautyberry
	<i>Calycanthus floridus</i>	Sweetshrub
	<i>Clethra alnifolia</i> ***	Clethra
	<i>Euronymus americanus</i>	Strawberrybush
	<i>Hydrangea quercifolia</i>	Oakleaf hydrangea
	<i>Lindera benzoin</i> ***	Spicebush
	<i>Rhododendron canescens</i> *	Piedmont azalea
	<i>Rhododendron trutsuji</i> *	Azalea
	<i>Styrax Americana</i>	American snowball
	<i>Viburnum dentatum</i> **	Arrowwood
Vines	<i>Bignonia capreolata</i>	Crossvine
	<i>Gelsemium sempervirens</i>	Carolina jessamine
	<i>Clematis crispa</i>	Curly clematis
	<i>Decumaria Barbara</i>	Decumaria
	<i>Lonicera sempervirens</i> *	Coral honeysuckle
	<i>Parthenocissus quinquefolia</i>	Virginia creeper

	<i>Campsis radicans</i> *	Trumpet vine
Groundcovers & Low Shrubs & Ferns (foundation planting)	<i>Leucothoe axillaris</i>	Coastal leucothoe
	<i>Lyonia lucida</i>	Fetterbush
	<i>Rhododendron minus</i> var. <i>minus</i>	Dwarf rhododendron
	<i>Vaccinium darrowii</i> **	Evergreen blueberry
	<i>Yucca aloifolia</i>	Aloe yucca
	<i>Hydrangea arborescens</i>	Wild hydrangea
	<i>Itea virginica</i> ***	Itea, Virginia willow
	<i>Viburnum acerifolium</i> **	Mapleleaf viburnum
	<i>Antennaria plantaginifolia</i>	Pussytoes
	<i>Galax urceolata</i>	Galax
	<i>Hexastylis arifolia</i>	Heartleaf
	<i>Mitchella repens</i>	Partridgeberry
	<i>Polytrichum commune</i>	Haircup moss
	<i>Salvia lyrata</i> *	Lyreleaf sage
	<i>Smilax pumila</i>	Dwarf smilax
	<i>Pachysandra procumbens</i>	Allegheny spurge
	<i>Uvularia sessilifolia</i>	Spreading bellwort
	<i>Dryopteris marginalis</i>	Marginal fern
	<i>Onoclea sensibilis</i>	Sensitive fern
	<i>Licotiana</i> *	Flowering tobacco
	<i>Asclepias</i> spp.***	Milkweeds
Flowers	<i>Aquilegia canadensis</i>	Wild red columbine
	<i>Iris cristata</i>	Dwarf iris

	<i>Isopyrum bitermatum</i>	Isopyrum
	<i>Phlox divaricate</i> *	Blue phlox
	<i>Podophyllum peltatum</i>	Mayapple
	<i>Silena virginica</i>	Fire pink
	<i>Zephyranthes atamasco</i>	Atamasco lily
	<i>Monarda didyma/fistulosa</i> *	Bee balm
	<i>Hibiscus</i> *	Hibiscus
	<i>Impatiens</i>	Impatiens
Ornamental Grasses:	<i>Andropogon ternarius</i>	Splitbeard bluestem
	<i>Chasmanthium latifolium</i>	Uniola latifolia
	<i>Muhlenbergia capillaris</i>	Pink Muhly
	<i>Panicum virgatum</i>	Switchgrass
	<i>Scirpus cyperinus</i>	Woolgrass
Lawn substitutes (Native lawn species)	<i>Bouteloua dactyloides</i>	Buffalograss
	<i>Cenchrus spinifex</i>	Field Sandspur
	<i>Chloris virgata</i>	Feather fingergrass
	<i>Cyperus squarrosus</i>	Bearded flatsedge
Aquatic plants	<i>Nelumbo lutea</i>	American Lotus
	<i>Nymphaea odorata</i>	Fragrant waterlily
	<i>Orontium aquaticum</i>	Goldenclub
	<i>Pontederia cordata</i>	Pickereelweed
	<i>Saururus cernuus</i>	Lizard's tail, water dragon

APPENDIX III

EXPLANATION FOR SITES RATING SYSTEM

Resource: All requirements and descriptions of SITES are cited from “Guidelines and Performance Benchmarks 2009”.

Note: The digit on the left side of the slash mark is the number of credits that the design can achieve and the possible points is on the right side of the slash mark.

(1) Site selection, 21 possible points

Credit 1.5: Select brownfields or greyfields for redevelopment **0/10**

No credits achieved. The house is not located on brownfields or greyfields.

Credit 1.6: Select sites within existing communities **0/6**

No credits achieved. Although the site is within an existing community, it does not meet the requirement of “locate project near existing neighborhood shops, services, and facilities in operation.” (p.28)

Credit 1.7: Select sites that encourage non-motorized transportation and use of public transit **0/5**

No credits achieved. Although the site is located in a pedestrian-friendly neighborhood (sidewalks are on both sides of the streets), it does not meet the requirement of “continuous sidewalks that span 8 blocks in each direction” or “a street with bicycle lanes”.

(2) Pre-Design Assessment and Planning, 4 possible point

Credit 2.3: Engage users and other stakeholders in site design **4/4**

In an actual design process, the homeowner may need assistance from a professional

designer, but he is the one to decide how the garden looks like. So the user is positively engaged in every phase of the process.

(3) Site Design—Water, 44 possible points

Credit 3.2: Reduce potable water use for landscape irrigation by 75 percent or more from established baseline. **3/5**

The proposed design could achieve the requirement of “use no potable water, or other natural surface or subsurface water resources, for landscape irrigation beyond the establishment phase,” because a successful implementation of water circulation system, including rainwater harvesting and greywater reuse can substitute the use of potable water (see details in section 6.3 design guidelines). On the other hand, native plants also demand less water.

Credit 3.3: Protect and restore riparian, wetland, and shoreline buffers. **3/8**

The site is located near a relatively undisturbed stream corridor (see 6.4.1 Site Analysis for reference). And one of the goals of the design is to connect to the habitat that has been preserved along the stream corridor. Although this site is not directly connected to the corridor, all the other sites that are next to the stream have the potential to contribute to expanding the stream buffer from less than 100 feet (existing) to more than 100 feet.

Credit 3.4: Rehabilitate lost streams, wetlands, and shorelines. **0/5**

No credits achieved. This credit only applies to “sites with streams, wetlands, or shorelines that have been artificially modified”, which is not a property this site has.

Credit 3.5: Manage stormwater on site. **7/10**

The water-related techniques in the design, such as the wet pond, rainwater harvesting system and rain garden, aim to manage stormwater on site. An estimate of 60 percent improvement could be achieved to get 7 points out of 10. 10 points is for 90 percent improvement.

Credit 3.6: Protect and enhance on-site water resources and receiving water quality. **8/8**

The water circulation system (see design guidelines for reference), if successfully implemented, can achieve more than “95 percent of average annual volume of runoff discharged from the developed portion of the site receives stormwater treatment for pollutants of concern” (p.78), the requirement for achieving 8 points.

Credit 3.7: Design rainwater/stormwater features to provide a landscape amenity. **2/3**

2 credits are achieved because about “75 percent of the rainwater/stormwater features on site are designed as amenities and are visible and accessible from the high-use portions of the site.” (p.82) Some water features described in design guidelines are located off site, such as greywater treatment facility.

Credit 3.8: Maintain water features to conserve water and other resources. **4/4**

The water features, including the wet pond and rain gardens, are all replenished by grey water treatment, rainwater harvesting and other non-potable water sources. So it meets the requirement of “100 percent of annual make-up water for water feature(s) comes from sustainable water sources.” (p.85)

(4) Site Design—Soil and vegetation, 51 possible points

Credit 4.4: Minimize soil disturbance in design and construction. **6/6**

The design guidelines aim to restore native plant species back to the garden, which is why the soil and vegetation are analyzed in the pre-design phase (site analysis). Theoretically, the original soil will not be disturbed, so the design meets the requirement of “on all areas of healthy soils or soils with minimal soil disturbance as identified in the site assessment... limit disturbance...”

Credit 4.5: Preserve all vegetation designated as special status. **5/5**

The design does not harm any existing trees or special vegetation designated as special status by local, state, or federal entities. Almost all the plants that are replaced are grasses from the existing lawn.

Credit 4.6: Preserve or restore appropriate plant biomass on site. **8/8**

The design transforms the existing “builder’s package”, largely lawn, to a landscape that is comprised of trees, understories and groundcovers. It achieves the most credit possible by meeting the requirement of “Preserve or restore vegetation biomass on site to a level appropriate to the site’s region.” (p.101 – 105)

Credit 4.7: Use native plants. **4/4**

The design meets the requirement of “100 percent of the site vegetated area is composed of native plants.” (p.109)

Credit 4.8: Preserve plant communities native to the ecoregion. **6/6**

This credit applies to “existing native plant communities as identified in the site assessment in which evidence of human disturbance is minimal and exotic and invasive plants make up less than 25 percent of the total area.” All the existing native plants (light pine and hardwoods) near the edge of the site are preserved, so it meets the requirement of this credit.

Credit 4.9: Restore plant communities native to the ecoregion. **4/4**

The existing plant communities are mostly made up by manicured grasses with a small amount of original woods on the edge (see site analysis for reference). The design restores native plant species back to the site, so it meets the requirement of this credit, “Restore native plant communities to comprise at least 75 percent of the site vegetated area.” (p.114)

Credit 4.10: Use vegetation to minimize building heating requirements. **2/4**

Trees and dense shrubs are planted on the north-west portion of the backyard, which

function as “a windbreak to protect the building from the prevailing winter wind” (p.116). Due to site limitation, it cannot meet the requirement of locating the windbreak at least 60 feet from the building wall. Therefore it achieves half the points.

Credit 4.11: Use vegetation to minimize building cooling requirements. **3/5**

Trees and other vegetation are planted on every edge of the site, including the south side so that most of the site are shaded in the daytime. So it meets the requirement of “Use vegetation or vegetated structures to shade 60 percent of the surface area of west, southwest,

southeast, and east walls and 60 percent of total roof area within 10 years of installation.” (p.118)

Credit 4.12: Reduce urban heat island effects. **3/5**

Existing lawn on site is replaced by groundcovers, shrubs and trees, so it could achieve the requirement of “reducing urban heat island effects for 30 percent of all site hardscape and structures,” (p.120) because lawn or turf grass has the most contribution to urban heat island effect.

Credit 4.13: Reduce the risk of catastrophic wildfire. **0/3**

No credits are achieved because Firewise Construction Checklist is not part of the concern of the design guidelines.

(5) Site Design—Materials Selection 36 possible points

Credit 5.2: Maintain on-site structures, hardscape, and landscape amenities. **4/4**

All the existing structures, hardscapes and amenities (storage room and patio) are preserved and unchanged. So it meets the requirement of “maintaining in their existing form 95 percent of the surface area of existing structures, hardscape, and landscape amenities on site.”

(p.125)

Credit 5.3: Design for deconstruction and disassembly. **0/4**

No credit is achieved because the design guidelines does not take construction-related issues into account.

Credit 5.4: Reuse salvaged materials and plants. 0/4

The proposed design does not generate materials that can be salvaged or reused because the only material that is generated is turf grasses. So it does not achieve any credits under this category.

Credit 5.5: Use recycled content materials. 0/4

No credit is achieved because the design or design guidelines does not take material-related issues into consideration. It does not meet the requirement of “use materials with recycled content such that the sum of post-consumer recycled content plus one-half of the pre-consumer content constitutes at least 20 percent of the total value of the materials in the project.” (p.130)

Credit 5.6: Use certified wood. 0/4

The requirement of using certified wood is not mentioned in the design or design guidelines.

Credit 5.7: Use regional materials. 6/6

All the plants used in the design are native plants coming from local nursery or community-based nursery, so the design meets the requirement of “90 percent of all materials, plants, and soils are sourced within the distances specified above.” (p.133)

Credit 5.8: Use adhesives, sealants, paints, and coatings with reduced VOC emissions.
0/2

Not relevant.

Credit 5.9: Support sustainable practices in plant production. 3/3

This credit requires the plant provider qualified as sustainable practices (see details on p.136 of the guidelines and performance benchmarks 2009). This could be achieved if qualified providers are chosen by the homeowners as their providers.

Credit 5.10: Support sustainable practices in materials manufacturing. 0/6

Not relevant.

(6) Site Design—Human Health and Well-Being 32 possible points

Credit 6.1: Promote equitable site development. 0/3

This credit aims to ensure that the project provides economic or social benefits to the local community during its construction, which is not relevant to the design or the design guidelines.

Credit 6.2: Promote equitable site use. 0/4

The site is a private garden so it is able to provide any public services as required by this credit, “provide events” or “Provide an on-site facility or desirable amenity that was identified as a community need during meetings with local community groups.” (p.144)

Credit 6.3: Promote sustainability awareness and education. 0/4

No credit is achieved because the design or guidelines does not meet the requirement of “Provide a minimum of three educational or interpretive elements.” (p.146) However, the appearance of the garden will have an positive influence on the neighborhood (see section 4.4 for reference).

Credit 6.4: Protect and maintain unique cultural and historical places. 0/4

Not relevant.

Credit 6.5: Provide for optimum site accessibility, safety, and wayfinding. 0/3

Not relevant.

Credit 6.6: Provide opportunities for outdoor physical activity. **0/5**

The site is not a public space so it cannot allow or welcome any “potential users” from outside.

Credit 6.7: Provide views of vegetation and quiet outdoor spaces for mental restoration.

4/4

The patio and the lawn in the backyard provides opportunities for “views of vegetation and access to quiet outdoor space(s) on site to optimize mental health benefits of site users,” (p.161) which is the requirement for this credit.

Credit 6.8: Provide outdoor spaces for social interaction. **3/3**

The lawn can be used as outdoor gathering spaces, so it meets the requirement of “provide outdoor spaces that support and encourage social interaction.” (p.165)

Credit 6.9: Reduce light pollution. **0/2**

The design or guidelines does not address any light-related issues.

(7) Construction **0/21**

This whole category is not relevant because the design or guidelines does not address any construction-related issues.

(8) Operations and Maintenance **0/23**

This whole category is not relevant because the design or guidelines does not address any operation or maintenance-related issues.

(9) Monitoring and Innovation 18 possible points

Credit 9.1: Monitor performance of sustainable design practices. **0/10**

The design or guidelines does not address any monitoring-related issues.

Credit 9.2: Innovation in site design. **8/8**

The design guidelines are based on the research carried in this thesis and have never been implemented before. So it could qualify for the requirement of innovative sustainable practices.