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## The Water Efficient Landscape

– a first guide for designing water-wise gardens in the piedmont region  
of North Carolina

Vatteneffektivitet i trädgården – en första guide över gestaltningen av  
vatteneffektiva trädgårdar i North Carolinas piedmont region

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**Abstract:**

Water efficiency in the landscape is becoming an increasingly pressing issue in the United States, as water shortages become more and more common. While awareness of water issues have increased over the last decades, landscape irrigation still constitutes a large percentage of household water consumption in the United States, and therefore reducing water use in the landscape is a vital step for conservation. North Carolina receives between 40" – 55" (1000mm-1400mm) of rain a year and has always been considered a water-rich state, however even with its abundant yearly rainfall, recent years have lead to water shortages.

Water-efficient gardening is the practice of landscaping with water conservation in mind. It includes xeriscaping and the idea of grouping plant material based on their water requirements, using plants that are well suited to the site conditions and require no supplemental irrigation, and increasing a soil's absorption rate and water retention. This paper explores the principles of xeriscaping and suggests suitable water-wise plants for residential landscapes in the piedmont region of North Carolina.

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# 1. Introduction

## Background

Although traditionally considered a water-rich state, North Carolina has experienced several extensive droughts over recent years. Over the past decade, drought during spring and summer months in the entire Southeast region of the United States has increased by 12-14%, and as the climate changes, it is expected that this trend will continue (Karl 2009). At the same time, the state's rapid population growth has increased the demand for water (Bass 2008). Together these changes have led to frequent shortages in water supply.

The average American household uses between 40% and 70% of its household water on outdoor use and landscaping (St Hilaire 2008). While some cities in North Carolina, such as Raleigh and Charlotte, already have restrictions on irrigation during droughts, extensive lawns and the use of shrubs and perennials unsuited to site conditions contribute to an unnecessary use of water that is unsustainable in the long run. In particular, irrigation of lawns contributes to a large use of water in the United States. With 4-9 millions hectares of land covered in turfgrass, Paul Robbins (2007) cites lawns as the largest irrigated crop in the country. With that in mind, even a small reduction of lawn areas and employing more water-wise practices in residential landscapes could make a big impact on water use in the United States.

Traditions and cultural norms concerning how a landscape should look, however, do not always foster a willingness to embrace alternative landscaping practices. Studies such as the one conducted by Lohr and Bummer (1992) show people's attachment to traditional lawn landscapes over more sustainable ones. Interestingly, this preference often arises more from societal expectations and pressure to conform to neighborhood norms rather than from personal ideals (Nassauer 2009). Furthermore, because North Carolina has been traditionally considered a water-rich state, some people don't consider water-efficiency in the landscape as being a relevant issue in the region (Bass 2008, Ward 2009). Xeriscaping, a term coined in Denver in the 1980's from the Greek word *xeros* ("dry"), to mean landscaping with water conservation in mind, has been employed in arid regions such as the southwest for decades, but is a relatively new concept on the east coast (Christopher 2011, Ward 2009).

## **Aim**

The purpose of this work is to examine the current landscaping and irrigation practices in the piedmont region of North Carolina and explore more water-efficient ways of designing residential landscapes. The goal is to show what kinds of plants gardeners and landscape designers can use to create water-wise gardens with aesthetic appeal. To reach this objective the thesis will answer the following questions:

- How can landscape designers conserve water in residential landscapes?
- What are the barriers that inhibit homeowners' interest in more water-efficient ways of landscaping?
- What plants are suitable for a low water use garden in the piedmont region of North Carolina?

## **Limitations**

This work concentrates on the principles of xeriscaping and water conservation in residential gardens. Because plant selection is so site-specific for water-efficiency, this paper includes planting suggestions for only one region of North Carolina. In order to limit the scope of this work, it does not include a complete design proposal, but is rather meant to be a theoretical discussion for how landscape designers can create water-efficient gardens that are aesthetically pleasing to homeowners.

## **Method and materials**

First and foremost, this work is a literature study. Since the subject matter concerns a region with a quite different climate than Sweden, many of the referenced books were obtained from the United States, while most of the articles and electronic publications were found through what was available at the SLU library.

Plant recommendations have been assembled with help from flora books and garden plant books, as well as online resources available from the Missouri Botanical Garden.

Results are shown through plant recommendations for the region based on their water requirements. Suggested plant combinations for different areas of the garden are also provided.

## 2. Geographical context

### The Region

North Carolina is situated on the mid-Atlantic coast of the United States. This paper focuses on the state's Piedmont region, which lies between the coastal plains to the east and the Blue Ridge Mountains to the west. Major cities are Raleigh, Charlotte, and Greensboro.



Image 2: State of North Carolina shown in red (digitally modified from Wikipedia Commons 2010)



Image 3: NC Piedmont shown in brown (Wikipedia Commons 2009)

On the USDA Plant Hardiness Map, the Piedmont is reclassified as zone 7b, with an average annual low between 5°F (-15°C) and 10°F (-12°C). Winter temperatures are frequently variable. On average temperatures drop to 10° or 15°F (-9° to -12°C) once, and it is not unusual for cold spells to be interspersed with days reaching up into the 60's (10°-15°C) even during the coldest months. Summers are hot and humid, with averages at 92°F (33°C) at midsummer in central North Carolina.

Average yearly rainfall in North Carolina is 40"-55" (1000 – 1400 mm). On average, summer is the wettest season, with the most rainfall occurring in July. Precipitation is variable however and frequently occurs in quick passing showers and thunderstorms with heavy rainfall. Dry spells of several weeks between storms are common in summer.

## **Environmental issues**

Even though North Carolina has always been considered a water-rich state with adequate rainfall, drought can have a severe impact on the region. Over half the state's water supply comes from aquifers at the Coastal Plains, but levels have been dropping steadily over the past century (EPA WaterSense 2010). As a result, salt water is seeping into the aquifers, making the water unusable. (EPA WaterSense 2010). North Carolinians are therefore becoming more and more dependent on surface waters, which depend on rainfall. The record setting droughts of 1998-2000 and 2007 resulted in disastrously low reservoir levels, and only through severe water restrictions and the return of rainfalls did the lakes not dry up completely.



Image 4: Jordan Lake, which supplies much of the Raleigh-Durham area with drinking water, during the record setting drought of 2007 (Keith 2007)

According to the U.S Global Change Research Program (2009), climate change will result in rising temperatures and increased rainfall in most of the eastern half of the country. However this increase in precipitation is expected to come increasingly intense storms, resulting in runoff toward the ocean before being collected in reservoirs (U.S. Global



Change Research Program 2009, EPA WaterSense 2010). Heavy storms will be offset by longer periods of drought in between (U.S. Global Research Program 2009). High sea levels will also increase the risk of further saltwater intrusion into the Coastal Plain aquifers (EPA WaterSense 2010).

At the same time, North Carolina is also one of the fastest growing states in the country. Between 2000 and 2009, the population increased by 17%, and the rate shows no sign of stopping as many people from other parts of the country relocate to North Carolina (EPA WaterSense 2010). This has led to an increase in water demand, even as our supply declines.

### **Residential landscapes and water use**

North Carolina's rapidly growing population has led to increased suburban sprawl throughout the state. Water demands increase as natural habitats and farmland are converted to residential areas. In the landscape, the greatest use of water is the lawn. While xeriscaping is not a new term in North Carolina, common practice does not seem to have caught up with education. According to a study, 68% of North Carolina's residents irrigate their lawns (Milesi et al. 2009). Residential turfgrass irrigation surpasses that used for agriculture (Milesi et al. 2009).



Image 5: Traditional suburban front yard (Pixabay 2012)



Image 6: Traditional rural home in North Carolina (Rayno 2005)

While the recent droughts of 1998-2000 and 2007 increased people's awareness of water issues in the state, there is still widespread use of excessive irrigation. One effect of the droughts was new, stricter water restriction rules that limit water use in many cities during dry summer weather, but adequate rainfall during recent years has perhaps falsely alleviated public worries. Even the usual amount of rainfall is not sustainable in the long term as long as North Carolina's population continues to grow. Bass (2008) states that water efficiency programs in North Carolina are not significant enough and cites one reason as being that environmental restrictions prevent new reservoirs from being built. Others say that financial barriers and fears of reduced revenues prevent North Carolina from developing more significant water-efficiency programs. (Ward 2009).

While there are many ways the state can become more water-efficient, landscape water use is particularly relevant because it constitutes such a large use of household water. With urban sprawl and population growth contributing to major decreases in water availability, small changes in residential landscaping practices can make a significant impact in better water efficiency, with or without laws to enforce these practices. Hiring professional landscape designers is common in North Carolina, particularly in the newer, exurban areas with large lots that are being built. Several studies have shown that some people misunderstand xeriscaping and water-efficiency and assume, for example, that xeriscape gardens are unattractive or limited to arid, desert landscapes (Nassauer 2009, Mustafa 2010, St. Hillaire 2008). Landscape designers have opportunities to educate the public through water-wise designs that also fit homeowners' aesthetic preferences.

### 3. The Water Efficient Landscape

This chapter discusses the general methods for water conservation in the landscape. Designers can refer to these principles when creating low water use gardens. More specific recommendations for the Piedmont region of North Carolina, and how these principles can be applied in a way to address people's aesthetic preferences when designing residential landscapes, will be discussed in chapters four and five.

#### **Xeriscaping**

Xeriscaping is the practice of landscaping with water conservation in mind. The word Xeriscape™ was coined in Denver in the 1980's from the Greek *xeros* "dry" + landscaping. The seven principles of xeriscaping are:

- Plan designs based on a thorough site analysis
- Limit turf areas and use regionally appropriate grasses
- Amend poor soils to increase water absorption and retention
- Mulch plantings to reduce evapotranspiration
- Select appropriate plant material adapted for the site conditions
- Use water-efficient irrigation systems
- Maintain landscapes appropriately

#### **Site analysis and design**

Careful examination of site conditions prior to design is the foundation of creating good xeriscape landscapes. Although this really is the base of all good design, designers can take extra consideration of microclimates, topography and drainage, and use the information to select the right plants for the right place. When designing lawns, the size and shape are of particular importance. Irregularly shaped lawns are more difficult to irrigate without wasting water, and xeriscape principles advocate designing lawns with the minimum size to fulfill the homeowners' needs. (Wade 2007).

Designers of xeriscapes can also think of different plants' water requirements when planning a composition. Plants can be grouped together in hydrozones, not merely based on their aesthetic compatibility but according to their water needs. Hydrozones can be for example high-water use plants or low-water use plants. This zoning of plants will reduce unnecessary irrigation to plants that do not need it. Thomas Christopher (2011) suggests using plants that require supplemental watering close to the house, where a maintained look is more important, while drought-resistant grasses and

perennials are better choices for less prominent areas of the landscape (Christopher 2011). However because house foundations in the Southeast often suffer from moisture problems, an alternative would be to place low-water use plants next to the foundation instead (Kelly 1991). Studies have also shown that dense plantings next to houses increases the risk for pest infestation, which can be a problem in the South (Kelly 1991).

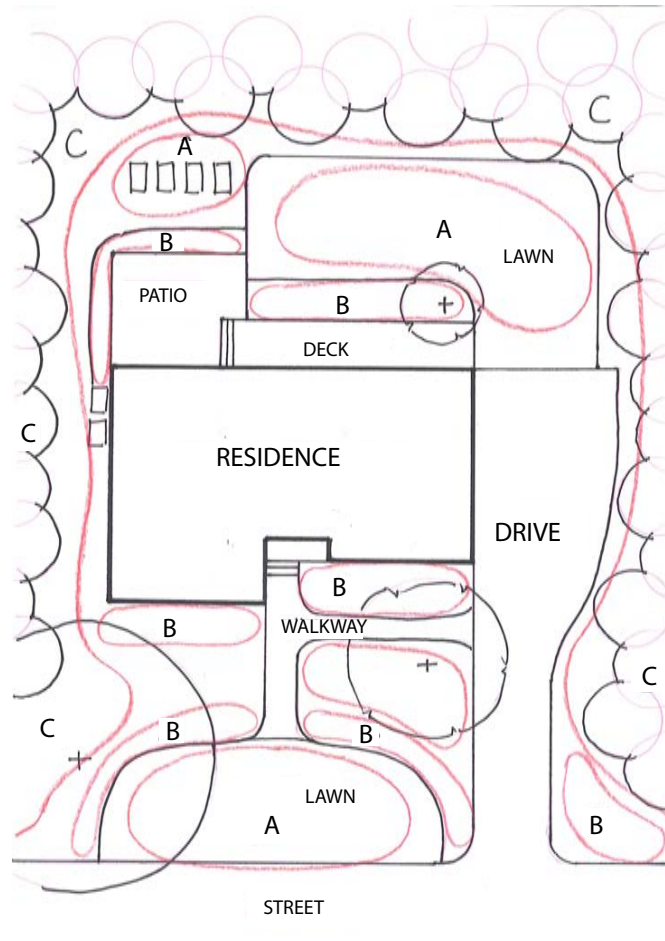


Image 7: Example of hydrozoning in a residential landscape. A: High water use (lawn and vegetable garden areas); B: Moderate water use (planting beds by house and in prominent spaces); C: Low to no water use (informal and naturalized planting areas). (Rayno 2014)



Image 8: This combination of banana (*Musa basjoo*) and miscanthus (*Miscanthus spp.*) is interesting from a pure design perspective but combines two plants with very different water requirements. The banana will need constant moisture during the summer, while the miscanthus is drought tolerant. (Rayno 2013).



Image 9: Carolina all-spice (*Calycanthus floridus*) and foamflower (*Tiarella cordifolia*) are both natives that have similar water and light requirements. (Rayno 2014)

### **Design of turf areas**

The lawn is considered by many to be the ideal home landscape in America (Pollan 1991, Henderson 1998). The lawn serves as a resting point for the eye, provides a place for recreation, and makes a statement of the homeowners' orderliness and responsibility (Greenlee 2011, Pollan 1991). This, however, does not mean that alternative designs cannot also fill these rolls (Greenlee 2011). Cries for the reduction of lawn areas and for new lawn alternatives have become a popular movement over recent years, thanks to the work of people like Rick Darke, John Greenlee and Neil Diboll, but a recent NASA study still places the nation's total turfgrass area at 40,411

square miles, the same area as the state of Kentucky (Greenlee 2011). Standard recommendations for weekly summertime irrigation of turf areas is 1" (25 mm) of water (Christopher 2011). Estimates put national landscape water use at 7 billion gallons every day (Christopher 2011). With so much residential landscape irrigation going to lawn areas – and in North Carolina 68% of homeowners irrigate their turfgrass (Milesi et al. 2009) – there is still a lot that can be done.

Traditional lawns not only consume too much of our water resources, but are bad for the environment in other ways as well. Michael Pollan (1991) calls lawns "nature under our boot." Lawns are overwatered, overfertilized, sprayed with pesticides, and mowing them pollutes our neighborhoods (Greenlee 2011). Aagesen (2004) suggests in the latest *Wild Ones handbook* that based on advice from the *National Coalition Against the Misuse of Pesticides* that if a lawn is given the typical pesticide and fertilization treatment, homeowners should "not walk barefoot on it; do not breathe near it; confine children, pets and toys inside; close windows." This might fulfill the lawn's purposes as something to rest one's eyes upon, but it is hardly a suitable environment for recreation.

One of the biggest problems with standard turfgrasses is that often the types used are not suited to the environment where they are planted. Kentucky bluegrass, for example, popular in many North Carolina turf blends, stops growing when temperatures exceed 75°F (Greenlee 2011). In North Carolina, where average highs surpass this five months of the year, irrigation would be needed to keep it green throughout the summer. Dry, hot weather will not kill it, however, and Bruneau (2008) recommends letting this grass grow brown to return in the autumn, as irrigation can increase disease problems. Warm-season grasses like zoysiagrass and bermudagrass grow well in the summer and are very drought-tolerant (Bruneau 2008) but because they go dormant through the winter and turn brown, are unpopular with some homeowners.

Choosing the most drought-tolerant species from the traditional species available is standard advice in xeriscape manuals. While it does reduce the need to water, I think that the truly sustainable landscape will take lawn design a step further. Zoysiagrass and bermudagrass are not self-maintaining. Bermudagrass grows quickly and requires frequent mowing to keep it at the recommended 1"-2" (2.5 – 5 cm); it also has high nitrogen fertilizer recommendations at 3-6 lb N/1000 sq ft/year (1.4 – 2.7 kg N/92m/year) (Bruneau 2008). Zoysia fares better with low to medium mowing frequency requirements, and fertilizer recommendations are 1-3 lb N/1000 sq ft/year (0.45-1.4kg N/92m/year), but is slow to establish and therefore more expensive to plant

(Bruneau 2008) – often deterring homeowners from selecting it. When possible should we not consider alternative ideas that fulfill the functions of a traditional lawn and are drought tolerant, but require no supplemental fertilizer or mowing?

### *Natural lawns and lawn alternatives*

A natural lawn uses untraditional grasses and sedges that naturally form a mat to create a lawn-like effect but without the environmental damage (Greenlee 2011). The idea is not a new one, but natural lawns are nevertheless unusual across the suburban landscape. Replacement of lawn areas with ornamental plantings are more common, although one study found that only 2% of single family homes had front yards with less than 40% turf (Henderson 1998). Difficult site issues such as steep slopes can encourage homeowners to plant something other than grass, but often these planting are predominately non-native ornamental shrubs and flowers (Henderson 1998). The lawn might be framed or broken up by plantings, but this does not usually reduce the desire for some lawn to remain, and thus natural lawns can be a good alternative.

Using low growing grasses and sedges as a base, and interspersing them with flowers and bulbs, the traditional lawn can become a meadow while keeping its function as a recreational area or resting point for the eye (Greenlee 2011). Some nurseries, such as Neil Diboll's nursery Prairie Nursery, in Wisconsin, specialize in "no-mow" seed mixes that require mowing just once or twice a year. This seed mix is intended for the northern parts of the country however and isn't adapted for the South. Grass-like plants such as *Liriope muscari* (liriope) and *Ophiopogon japonicas* (mondo grass) are also good potential alternative choices for lawns in North Carolina.





Image 10: Dwarf mondo grass (*Ophiopogon japonica* 'Nana') used as lawn alternative (Stewart 2013)

### **Soil preparation and mulching**

Two principles of xeriscaping are proper soil preparation before planting, and the mulching of plant beds afterwards. These practices are often cited as efficient ways to improve water absorption and water retention (Kelly 1991, Wade 2008). Since a soil's composition determines how well it holds water, the practice contends that by improving that composition to an ideal structure for plants, one becomes more water efficient (Kelly 1991, Wade 2008). Sandy soils with large pores drain water quickly, while the fine texture of clay soils retains water (Kelly 1991). Adding organic matter loosens up clay soils and aids in drainage, while mulching can help reduce transpiration from sandy, dry soils, and decrease runoff from clay soils by improving absorption (Kelly 1991, Wade 2008). Common advice is for the addition of 3" (7.5 cm) layer of organic mulch to significantly reduce evaporation from the soil (Kelly 1991, Wade 2008). The addition of organic mulch also has the added benefit of suppressing weed growth as well increasing the absorption rate of the soil, so there is less runoff (Kelly 1991, Wade 2008).





Image 11: Mulching with pine straw (Pedros 2006)

The question arises, however, as to how far a landscaper should go in changing the existing soil in the attempt to be more sustainable. Horticulturalists like John Greenlee advocate selecting plants to work with the soil that exists, rather than attempting to improve it (Greenlee 2011). Adding organic matter that will eventually decompose will not change the properties of the soil in the long run, but must be constantly mixed into the soil each year (Greenlee 2011). A more sustainable way of gardening is through working with the soil that exists instead of trying to change it (Greenlee 2011).

### **Right plant, right place**

Probably the single most important practice when designing for water-wise gardens is to use plants adapted to the site conditions. If a plant with high water requirements is desired in a garden with sandy, dry soil, the landscaper will either have to attempt to alter the site conditions through amending the soil, or replace the soil altogether. As stated earlier this is not uncommon practice in landscaping design, and is in fact standard advice in most gardening and xeriscaping resources. John Greenlee suggests that designers and gardeners chose plants that fit the site conditions, instead of altering the site to match the plants (Greenlee 2011). Barring situations with completely inhospitable or compacted soils caused by construction or other disturbances, avoiding expensive replacement of existing soil and instead focusing on appropriate plant material for the conditions can only lead to more sustainable plantings that require less maintenance and are healthier (Beck 2013). With this in mind, selections for plant lists in this work focus on not only drought tolerance, but on their ability to thrive in the clay soils of the North Carolina piedmont without soil amendments.

Since landscape irrigation is often restricted during summer droughts in North Carolina, it makes even more sense to select plants that can withstand droughts. Selecting the right plants can eliminate the need to water at all under normal conditions after a plant is established. (Adolphsen). But information on a plant's water requirements is sometimes difficult to find. One of the problems, Thomas Christopher states, is that the traditional climate zones only include information regarding temperature, not precipitation (Christopher 2011). The idea of zoning with water requirements in mind has only developed in the last few decades (Beck 2013), probably because until recently, water supplies were abundant and cheap enough that supplemental irrigation was easy (Beck 2013, Helfand 2006, Ward 2009).

When analyzing a site's average yearly precipitation, it is also important to consider the seasonality of that precipitation (Beck 2013). When the rain falls and how much at a time, is equally important when determining good plant choices. North Carolina, for example, receives between 40-55" (1000-1400 mm) of rain yearly but often that rain falls in singular heavy storms, with long dry spells in between. Furthermore the heavy clay soils typical of the Piedmont have a low absorption rate, resulting in a lot of runoff.

The usual advice for dealing with the clay soils like those typical of the Piedmont is heavy organic soil amendments (Kelly 1991, Wade 2008). By looking at native flora however we can explore some options for plantings that do not require as much backbreaking attempts to adjust the soil composition. In particular many trees and shrubs can be planted without any soil amendment. *Calycanthus floridus* and *Callicarpa americana* are two drought-tolerant natives that are also valuable to the residential landscape (Missouri Botanical Garden n.d.). Many native perennials are also suited to clay soils. For example *Rudbeckia fulgida* and *Coreopsis verticillata* are both very tolerant of drought and have long bloom times (Missouri Botanical Garden n.d.).



Image 12: Red clay soil in the NC Piedmont (Lindbo 2004)

Perhaps because of their suitability to our native soils and climate, exotic garden plants are sometimes judged as unsustainable choices. Native plant purists claim that native plants are always best, while others, like Rick Darke recognize that our residential landscapes rarely resemble the original environment before building – the soil has been changed and disrupted, climate patterns are affected by buildings and urban microclimates – and native plants sometimes do not thrive there. Choosing plants that fit the site conditions, whatever those conditions are, is the best way to plant a sustainable landscape, and as long as the plants are not invasive, if they have a value and are well suited to the environment they should be used. See chapter 6 for appropriate plant selections for the North Carolina Piedmont.

### **Irrigation techniques**

Even employing the sustainable practices discussed above, it is usually impossible to completely avoid watering a residential landscape. New plantings require irrigation to ensure good establishment, and even well established landscapes can occasionally need supplemental water to thrive. Wescoat's article, *The 'duties of water' with respect to planting*, discusses the responsibilities of watering landscape plants, for example, during times of drought (Wescoat 2013). Mature existing trees and shrubs have aesthetic and sentimental value, but a long and persistent drought can single-handedly wipe out a large area of vegetation, even a xeric one, if it is not irrigated. (Wescoat 2013).

Irrigation in home landscapes, however, is often used too recklessly. The U.S. Environmental Protection Agency estimates that 50% of water used for landscape irrigation is wasted due to overwatering and inefficiency. (U.S. Environmental Protection Agency 2014).

Overwatering landscape plants is not only wasteful of resources, but can also weaken a plant's ability to survive drought when water restrictions might be in place. Frequent irrigation with small amounts of water promotes shallow roots that are less able to reach accessible water deep in the soil during dry spells (Adolphsen 2006). Thomas Christopher points out several other negative consequences of overwatering: runoff leaches nutrients from the soil, spreads disease, promotes excess growth that draws pests to the garden, and provides an moist environment where weeds can thrive (Christopher 2011).

When irrigation is necessary, more efficient techniques can reduce the amount of water wastage. Sprinkler systems that spray water into the air tend to waste a lot of water through evaporation and inaccurately aimed sprays (Adolphsen 2006). Handwatering is extremely efficient, but labor-intensive. However this can be a very efficient choice when supplemental water is needed during times of drought (Adolphsen 2006). Irrigation for landscapes is usually the first to be prohibited during drought anyway (Wescoat 2013), and often handwatering is the only option under water restrictions.

Drip irrigation and field pipe systems are also efficient alternatives to sprinklers. According to Adolphsen drip irrigation uses 30%-50% less water than sprinkler systems and have lower installations costs as well (Adolphsen 2006). Field pipe systems are recommended when irrigation is only needed for plant establishment, and there is no long-term irrigation plan for the landscape. These systems are not permanent but placed on top of the soil, and can be removed once plantings are established (Adolphsen 2006).

Drip irrigation, field pipe systems, and handwatering are not suited to the irrigation of turf areas, however, but it is turf that often receives the most irrigation in the landscape. According to a report, Americans irrigate between 40% and 80% of turf areas. (Milesi et al. 2009). Overwatering can be avoided by following the recommendations available for different turf types. Tables published by the North Carolina State University Cooperation Extension Office provide information for various grass types and their water requirements (Bruneau 2008). Dry weather rarely kills grass, however, and the question of lawn irrigation in the South can be debated. The most

water-efficient choice, perhaps, is to accept that cool season turf-grasses, like Kentucky bluegrass, will turn brown in the summer during dry spells. Replacing traditional turf with native grasses or meadow plantings further diminishes the need for irrigation completely and should be considered more often.

### **Water saving maintenance practices**

Studies have shown that gardens incorporating all seven principles of xeriscaping reduce maintenance labor, such as weeding and irrigation, by up to 50 percent (Kelly 1991). Although no garden is maintenance free, certain practices can reduce excessive maintenance and water needs.

#### *Fertilization*

Over fertilizing plants will lead to a surge of growth and increase in water need that would be undesirable during the hot summer months, so fertilizing the proper recommended amount and using slow-release fertilizers can help minimize this. (Wade 2007).

#### *Pruning*

Shearing plants promotes new growth and therefore higher water intake to support that growth. Thinning shrubs by cutting branches to a side branch or bud instead is less stressful on plants and gives the plant a more natural look. (Wade 2007).

#### *Turf management*

Bruneau (2008) recommends mowing turf often enough that no more than 50 percent of leaf tissue is cut away. Cutting too frequently leads to more stress on the plant and increase in water intake (Wade 2007). Turfgrass should also be cut to the height recommended for the species. Cutting turf higher promotes deeper root system and increases the ability of the turf to withstand drought. (Wade 2008).

Table over recommended mowing heights for common turfgrass types (Bruneau 2008)

Name	Recommended mowing height
Bermudagrass ( <i>Cynodon dactylon</i> )	0.75"-2" (2cm-5cm)
Centipedegrass ( <i>Eremochloa ophiuroides</i> )	1" – 1.5" (2.5cm-4cm)
Kentucky bluegrass /tall fescue/ fine fescue mix ( <i>Poa pratensis</i> / <i>Festuca arundinacea</i> / <i>Festuca</i> spp.)	2.5"-3.5" (6cm-9cm)
St. Augustinegrass ( <i>Stenotaphrum secundatum</i> )	2.5"-4" (6cm-10cm)
Zoysiagrass ( <i>Zoysia matrella</i> )	0.75"-2" (2cm-5cm)

### *Weeding*

Keeping plant beds weeded also has an effect on water use. Ornamentals and weeds compete for water during drought, so keeping unwanted plants out of planting beds reduces competition for water (Wade 2008).

### *Water management under drought*

During droughts irrigation may be needed to insure certain plants survival. Wade (2008) recommends evaluating the worth of different plants and irrigating based on that. Annuals are not worth a lot of money and can be easily replaced, while trees and shrubs are harder to replace. Mulch plants to reduce evaporation from the soil and water plants thoroughly at a rate of 60 gallons/100 square feet (227l/9m<sup>2</sup>) every two weeks (Wade 2008). During severe droughts all watering may be restricted but cutting back trees and shrubs by 1/3 will reduce evapotranspiration and increase a plant's chance of survival (Wade 2008).

## 4. Cultural Norms and Traditions

Many studies have been conducted that examine people's perception to designed landscapes and their responses to nature in urban environments (Nassauer 2009, St Hilaire 2008, Lohr and Bummer 1992, Lewis 1996). Nassauer (2009) suggests that people's preferences are often linked to cultural norms and traditions. Although some studies have shown that many people rate ecological landscapes as equally attractive as traditional ones (Lohr and Bummer 1992, St Hilaire 2008), what other people think can have a significant influence on how homeowners decide to landscape their property (Nassauer 2009). The traditional neat and well-maintained lawn, for example, stems from an ideology of responsibility and community (Pollan 1991). Possibly because of this deep-rooted cultural tradition, alternative and ecologically designed landscapes are sometimes perceived as uncared for or unattractive (Nassauer 2009).

Concern over property values can also affect how people perceive alternative landscape designs. According to St Hilaire (2008), the Council for Tree and Landscape Appraisers reveal that a home's landscaping amounts to about 20% of the property's market value. This can further dissuade homeowners to install alternative landscapes that might be unattractive for future buyers (Nassauer 2009). It is therefore important that water-efficient landscapes are aesthetically attractive to the general public in order for them to be more readily adopted by homeowners.

In this chapter I will discuss the history of residential landscaping traditions in the United States, in particular the prevailing culture of water-thirsty lawns, and explore some of the research that has been conducted on how people aesthetically perceive water-efficient and ecologically designed landscapes.

### Traditional residential landscapes

In America, residential landscapes are referred to as 'yards' rather than 'gardens.' The definition of a *yard* is a 'the ground that immediately adjoins or surrounds a house,' while a *garden* is 'a plot of ground, usually near a house, where flowers, shrubs, vegetables, fruits, or herbs are cultivated' (Random House Webster's College Dictionary 2001). Perhaps it is not surprising that there is no mention of plants in the definition of yard: the traditional lawn landscapes of American front yards are devoid of everything but grass, constantly clipped so it never flowers, along with a few shrubs along the foundation of the house.

The front yard and back yard of residential landscapes are often treated quite differently. While the back yard gives owners more freedom to design according to their own preferences, the front yard holds the spirit of a semi-public space, and there is frequently pressure to maintain the front yard according to other people's expectations (Nassauer 2009, Mustafa 2010).

A number of books have been written on the history and cultural meaning of the American lawn over recent years. Virginia Scott Jenkins' *The Lawn: a history of an American Obsession* (1994) traces the history of the lawn's development in America, questions its environmental impact, and explores other alternatives. Paul Robbins' *Lawn People* explores the cultural and political aspects of the traditional lawn, and debates what the real reasons people continue to maintain lawns even when they feel ambiguous about them from an environmental perspective. Michael Pollan's essay "Why Mow?" (1991), relates the pressure felt by many homeowners' to maintain a well-kept lawn in American suburbia, equating the responsibility with being a good citizen. Lastly, F. Herbert Bormann's book, *Redesigning the American Lawn* (1993), focuses on the environmental costs of the lawns and promotes new alternative replacements. All these books are interesting reads for those interested in exploring the subject more deeply.

The lawn's origins can be traced back to England. Yet while American landscaping ideals have been greatly influenced by English traditions (Beck 2013), much of what gives our residential landscapes their particular aesthetic is actually a reaction against traditional European norms. In England, lawns were for manor houses and estates – that is, for the wealthy. Originally "lawns" in America were nothing more than native grasses that would have been grazed by livestock (Adolphsen 2006). Pollan (1991) writes humorously of Englishman William Cobbet's visit to America in the mid-nineteenth century, during which he was appalled by the prevailing "white trash" style of garden – home landscapes were practical spaces for farm equipment and animals, not used for ornamental gardening at all. It was only through the influence of designers like Frederick Law Olmstead that the neat and orderly lawn landscape we see today became popular (Adolphsen 2006, Henderson 1998). Frederick Law Olmstead was responsible for designing one of the first suburban neighborhoods in 1868. Under his direction the standard setback of houses from the road that we know today was created. Previously, houses were usually placed directly in front of the road. Olmstead also proscribed lawns as standard for the newly created front yards that resulted from the setback. These lawns would connect with all the neighboring lawns, "creating the impression that all lived together in a single park" (Pollan 1991).



The invention of the lawn mower during the mid-nineteenth century also made it easier for middle class homeowners to maintain lawns (Henderson 1998). The lawn was no longer a luxury for the wealthy, as in England, but was something anyone could obtain (Henderson 1998). Thus the lawn developed a democratic side as well. Running continuously through neighborhoods without interruption, it proclaimed community and equality of the residents (Pollan 1991).

Interestingly, the lawn does not just proclaim solidarity with one's neighbors, but also provides a medium by which to display one's own success. While in Europe it is normal to see front gardens hedged in from passersby, in America this is unusual. "Curb appeal" – or how a house is viewed from the street - is an important feature for most people when it comes to their front yard (Nassauer 2009). Neat, well-maintained lawns show that the homeowner is responsible and successful, that he cares about his property and its value, and in turn that he cares about the value of the whole community (Pollan 1991). The lawn, being an open stretch uninhibited by tall vegetation, also opens a full view to the house, and sets the house, in some sense, upon a stage (Pollan 1991). Frank Scott's influential book on suburban landscape design from the 19<sup>th</sup> century, which had a significant impact on how residential gardens look today, states: "It is unchristian to hedge from the sight of others the beauties of nature which it has been our good fortune to create or secure" (Scott 1870).

This typical continuous park-like stretch of grass uninhibited by hedges designed by Olmstead continues in many suburban neighborhoods today, and it has several consequences. If one person does not mow their lawn and lets the weeds grow, it is more of an affront to the neighbor than if there is no barrier (Pollan 1991). One's yard, in some sense, also belongs to the neighborhood (Pollan 1991). An unkempt front yard decreases property value, which in turn affects the property value of one's neighbors (Nassauer 2009). In many suburban and exurban neighborhood there are strict rules over the maintenance of one's lawn. With all this in mind, it isn't surprising that writers like Pollan equate maintaining one's lawn with civic responsibility (Pollan 1991).

### **Perception toward water-efficient landscapes**

There have been many studies over the years that have researched people's perceptions to landscapes and in particular ecologically designed ones (Gobster et al. 2007, Nassauer 2009, Mustafa 2010, St. Hilaire 2008, Lohr and Bummer 1992, Henderson 1998). Given that it is frequently the case that only severe situations of

water shortages and droughts motivate homeowners to redesign their landscapes in a water-efficient manner (St Hilaire 2008), it is of interest to the designer to understand why this is and explore how water-efficient landscapes might be designed better to make them more attractive.

There are often misconceptions over what a xeriscape is. Some tend to associate it with barren desert landscapes or as a design concept only relevant to the western part of the country (St. Hilaire 2008). However, the word is also sometimes used colloquially for any ecologically designed landscape that takes consideration of the physical site conditions (Mustafa 2010). This definition could be used in a broad range of situations that go far beyond the scope of a 'dry-landscape.'



Image 13: Xeriscape garden in Southern California (Downtowngal 2014)



Image 14: Xeriscape planting in Colorado (Carolannie 2007)

The results of studies measuring the public's perception of water-efficient landscapes are somewhat contradictory. While several studies conclude that homeowners do not always think water-efficient landscapes are attractive (Lohr and Bummer 1992, St.

Hilaire 2008, Nassauer 2009), other studies have shown that people generally prefer a more natural style of gardening, and that when shown pictures of traditional and alternative landscapes, they are found equally attractive (Henderson 1998, Mustafa 2010).

What is interesting is that many times when homeowners do prefer alternative landscapes from an aesthetic point of view, they do not always install them (Mustafa 2010). Pressures to conform to neighborhood norms, economic expenses in installing a new landscape, and the time involved for establishment, are often cited as some of the reasons (Mustafa 2010). Grass is fast and cheap to install, while the design of a xeriscape is complicated, time consuming, and often requires help from a landscape designer, which people may or may not be able to afford (Mustafa 2010).

What is it that makes a homeowner view water-efficient landscape designs as attractive? Gobster et al. (2007) debate whether education can influence whether a person sees a landscape as attractive or not. Their study showed that increased knowledge of the ecological function of a landscape increased a person's aesthetic appreciation of it. The debate remains, however, over whether ecological appreciation is really the same as aesthetic appreciation, and if it is important (Gobster et al. 2007).

Although the public's aesthetic appreciation is perhaps less important in large-scale ecological restoration projects, in the residential landscape, at least, attractiveness is of the utmost importance. One of the reasons people often don't prefer ecologically designed landscapes is the perception that they appear messy or uncared for (Nassauer 2009). This "care" aspect of the landscape is extremely important particularly in the front yard due to the public quality of the space (Nassauer 2009). The well-maintained lawn serves this function, and even if homeowners are aware of and interested in more ecologically sound landscape designs, they are unlikely to install them if they do not serve the same function (Henderson 1998).

Paul Robbins (2007) writes in *Lawn People* that contrary to his expectations, his 3-year study showed that the people who regularly fertilized, irrigated, and sprayed their lawns with pesticides were more likely to understand the environmental consequences of their actions than people who did not use chemicals. Mustafa's (2010) study on perceptions of water-efficient landscapes in Florida expands on Robbin's ideas and discusses in depth the ambivalence homeowners often feel for their lawns, despite Florida's severe water shortages. Despite often-cited financial arguments against installing xeriscapes, the study showed that education had a larger impact than

economics on whether homeowner's installed xeriscapes or not (Mustafa 2007). Nevertheless, Robbin's (2007) study showed that although people often are aware of more ecologically sound practices, they do not practice them anyway.

Henderson's (1998) study surveyed the prevalence of lawn-alternatives in residential areas in Ontario and found less than two percent had front landscapes that were planted with 40% or less lawn. The study concluded that the reasons for this were time and money, and also suggested that a lack of availability of for example plug plants for meadow plantings, dissuaded landscape designers from designing alternative residential landscapes (Henderson 1998). Henderson's (1998) study also found that most of the alternative landscapes contained mostly exotics, not natives, and suggest that an increase in ecological awareness might be a good first step toward changing people's perceptions to home landscapes.

## 5. Design

In *The New American Garden*, Thomas Christopher states that gardeners can reduce water consumption in the landscape by at least 75% just by following more sustainable practices (Christopher 2011). However as discussed in the previous chapter, people's preference for traditional landscapes, whether from personal aesthetic ideals or from community pressure, and the perception of more sustainable alternatives as being unattractive can hinder the adoption of more water-efficient practices. How can landscape designers influence homeowners' perception of water-efficient landscapes and design them in a way that is both sustainable and aesthetically attractive?

### **Tidiness**

The desire for a garden, in particular the front garden, to look well maintained and tidy is one of the biggest obstacles preventing homeowners from installing more water-efficient landscapes (Nassauer 2009, Henderson 1998). This no doubt stems from the fact that many water-wise landscapes often utilize meadows and native plantings that are more "natural" and "wild" than the traditional formality of the front garden, and this is sometimes confused with messiness and lack of care (Nassauer 2009, Henderson 1998). But there is no reason why native plants and even meadows cannot be designed with a more formal aesthetic when it is desired. For example, mixing meadow inspired plantings with evergreen topiary or hedges gives an interesting contrast in composition. The topiary and hedges could provide structure and winter interest to a planting that otherwise might appear uncared for by some homeowners.

Some xeriscape designs like to focus on natives, but there are many drought-tolerant exotics that are equally suited to the residential landscape. In particular evergreens are important to the residential garden, but there are not many existing evergreen natives (Darke 2011). Many exotic hollies and junipers, and boxwoods are drought tolerant and well suited to the conditions of North Carolina's climate (Evans n.d.). Evergreens provide winter interest, screening, and a formal, maintained look. By mixing both natives and appropriate exotics, it is easier to maintain a formal design aesthetic. There are also many native Piedmont plants that are very showy and ornamental, and suitable for both naturalized areas as well as more tidy perennial borders (Mellichamp 2014).



Image 15: This classic combination of exotics crape myrtle (*Lagerstroemia indica*) and evergreen lilyturf (*Liriope muscari*) is drought tolerant, formal and has multi-season interest (Rayno 2014).

### **Better lawn alternatives**

Since a large percentage of landscape water use goes to lawn areas (Greenlee 2011, Milesi et al. 2009), lawn alternatives are a good way to increase water conservation. Some options fulfill the same functions as the traditional lawn better than others. Meadow plantings do not provide space for recreation and could be perceived as less “tidy.” Planting with groundcovers like dwarf mondo grass (*Ophiopogon japonica*) or liriope (*Liriope muscari*), particularly in less sunny areas, are potential grass-similar options that could be used more in the Piedmont as an alternative to turf. Other groundcovers like brass buttons (*Leptinella squalida*), creeping Jenny (*Lysimachia nummularia*), creeping thyme (*Thymus spp.*), or bugleweed (*Ajuga reptans*), could be explored more as well (Brickell 2004). Another idea is to mix different species to provide longer a flowering period and biodiversity (Greenlee 2011).





Image 16: Low growing ornamental grasses as an alternative to lawn (Burton 2010).

### **Low maintenance**

People tend to want low-maintenance gardens, but the way landscaping is traditionally done is high labor intensive (Kelly 1991, Wade 2007). Lawn requires mowing and possibly irrigation and fertilizer, while well-tended, orderly flowerbeds are time consuming with weeding, mulching, and possibly bedding out annuals. Although many people who may hire landscape designers may also use contractors to maintain their landscape, low maintenance is still often desirable from an economic point of view (Mustafa 2010). Xeriscape designs require less labor than the traditional perennial border (Kelly 1991, Wade 2007). Reducing the lawn or replacing it with an alternative will require less time and resources to maintain in the long run, even if it is more expensive and time consuming to install (Mustafa 2010, Greenlee 2011).

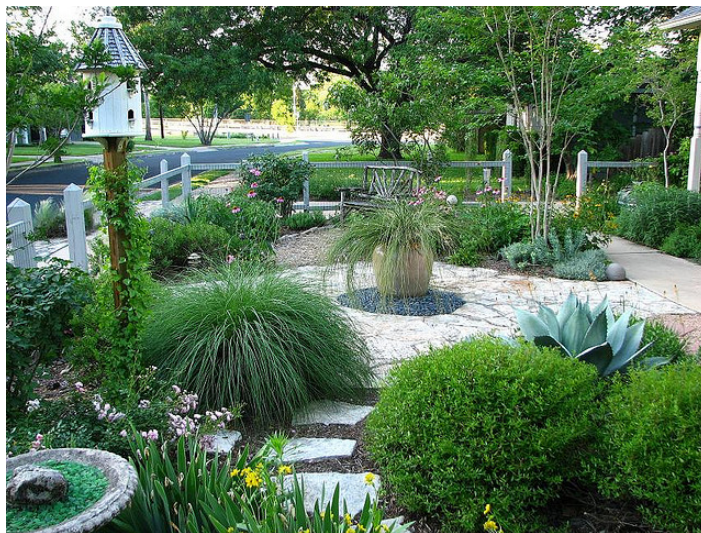


Image 17: Drought tolerant, low maintenance plants replace the lawn in this front garden in Austin, Texas (Harris 2008).

## **Education**

Education has been linked to people's perceptions of a landscape's aesthetic attractiveness (Gobster et. al 2007). Since aesthetics is so important in the residential landscape, it is especially important that water-efficient landscapes also remain attractive (Nassauer 2009). Landscape designers have the opportunity of showing new options to homeowners and educating them on the benefits of alternative designs. Gobster et al. (2007) suggests that one reason people do not appreciate the wilder landscape designs is that they do not understand the ecological benefits they provide. Providing information to homeowners about the reduction in water use and increase in biodiversity provided by multi-species alternative designs may alter a person's aesthetic value of that landscape (Gobster et al. 2007).

Showing homeowners pictures of alternatively designed landscapes with information about the installation costs, time involved, and maintenance costs in comparison to a traditional design may help them compare their options better. Designers could also have information about the ecological benefits of alternative designs available for their clients to read when discussing design options. If there are any drought-resistant or sustainably designed gardens in the area, the designer and client could visit it together and discuss what the client likes and doesn't like.



## 6. Water-wise plants for the North Carolina Piedmont

All the species in the following plant lists are drought tolerant, which is defined here as tolerating less than 1" (25mm) of water every two weeks during the peak summer season. Several books and online sources have been used as sources. I am particularly indebted to *Native Plants of the Southeast*, by Larry Mellichamp, which contains comprehensive, thorough descriptions of native plants in the Southeast region of the United States. Albert E. Radford's *Manual of the Vascular Flora of the Carolinas*, provided more botanical information about where the native plants listed here are naturally adapted in North Carolina. *Waterwise Plants for Sustainable Gardens*, by Lauren and Scott Ogden, has been an aid in selecting non-native plants adapted to a wide range of moisture conditions. I have also used the Missouri Botanical Garden's online Plant Finder, which provides more in-depth descriptions of how landscape plants react under various moisture and nutrient conditions than the book sources used.

Plants have been selected based on the following conditions:

- Will thrive through peak summer months with just 1" (25mm) of water every two weeks, and less than 1" during cooler seasons
- Will thrive under ordinary, moist conditions as well as the temporarily dry conditions as described above
- Are adapted to the clay-dominant soils of North Carolina and requires little to no soil amendment, and no fertilizer

For the plants to be considered capable of thriving under the moisture conditions described above, it is assumed the planting has been mulched with 2"-4" (5-10cm) of organic material, such as triple shredded hardwood or leaf mulch, in order to reduce evaporation from the soil and increase absorption of rainfall. Since North Carolina's climate can be both wet and dry, it is important to choose plants that tolerate a wide range of moisture conditions. For that reason, the majority of the plants selected for these lists are native to North Carolina because they are already adapted to the fluctuation of wet and dry.

\* = native to North Carolina

## Trees and shrubs

### *Abelia x grandiflora* (glossy abelia)



DESCRIPTION: A small shrub with white to pink flowers throughout the summer and glossy leaves that are evergreen in the Southeast. Mature height is 4' (1.2m). Attractive to butterflies, bees and hummingbirds (Ogden 2011).

HABITAT: Grows best in average moisture, nutrient rich and well-drained soils in full to part sun (Missouri Botanical Garden n.d.).

OTHER: Common cultivars in North Carolina are 'Canyon Creek' (pink flowers) and 'Kaleidoscope' (yellow and green variegated

foliage, red/orange fall color, and white flowers).

### *Aesculus parviflora* (bottlebrush buckeye)\*



DESCRIPTION: A multi-stemmed deciduous shrub reaching 12' (3.6m) tall and 15' (4.5m) wide. White showy flowers in spring to summer. Attractive to butterflies. Brown nutlike fruits in late summer (Mellichamp 2014).

HABITAT: Woodland native of the Southeast. Grows best in average moisture well-drained soils, preferably rich loams, in part shade to shade. After established it is moderately drought tolerant (Missouri Botanical Garden n.d.).

### *Aralia spinosa* (devil's walking stick)\*



DESCRIPTION: A deciduous tree that grows 10'-20' (3m-6m). Has small white flowers in summer that are attractive to insects, and purple black berries in fall. Trunk and branches are very spiny. (Mellichamp 2014).

HABITAT: Native to upland and low woods throughout North Carolina (Radford 1968). This tree can grow in both moist and dry soils, preferably well drained and in sun or part sun. (Mellichamp 2014).

### *Callicarpa americana* (beautyberry)\*



DESCRIPTION: Deciduous shrub reaching 10' (3m) in height. Small, inconspicuous pink flowers in summer, with showy purple berries in fall. Attractive to birds. (Mellichamp 2014).

HABITAT: A woodland native in the Southeast, this plant prefers rich moist to dry soils, either clay or sand, with lots of organic matter. Full sun or part shade. Very low maintenance after establishment (Mellichamp 2014, Missouri Botanical Garden n.d.).

OTHER: Common cultivars in North Carolina are 'Issai' (heavy fruiting, purple berries), 'Duet' (variegated foliage, white berries), 'Early Amethyst' (early fruiting).

*Calycanthus floridus* (Carolina all-spice)\*



DESCRIPTION: A deciduous shrub, 8'-10' (2.5m-3m) tall. Showy maroon flowers that have a spicy scent bloom in spring. Yellow fall color.

HABITAT: Native to moist to dry woodlands Virginia to Florida. (Mellichamp 2014). Grows best in average moisture well-drained soils, preferably rich loams, in full sun to part shade. Tolerates clay soils (Missouri Botanical Garden n.d.).

*Caryopteris x clandonensis* (blue mist spirea)



DESCRIPTION: A rounded, deciduous shrub that grows 3'-4' (1m-1.2m). Gray-green foliage. Blue fragrant flowers in late summer. Attractive to bees. (Ogden 2011).

HABITAT: Grows best in medium moisture, well-drained soils, but tolerates moderate drought. Prefers loam and full sun. Will not tolerate wet soil (Missouri Botanical Garden n.d.). Cultivars with

yellow foliage are not as drought tolerant as green-leaved forms (Ogden 2011).

OTHER: The most common cultivar is 'Longwood Blue', growing 4' (1.2m) tall and has reliable, profuse blooming. (Missouri Botanical Garden n.d.).

*Ceanothus americanus* (New Jersey tea)\*



DESCRIPTION: A compact deciduous shrub 3'-4' (1m – 1.2m) tall with long-flowering white blooms in summer (Mellichamp 2014). Flower are attractive to butterflies and hummingbirds. (Missouri Botanical Garden n.d.).

HABITAT: Native to dry woods, roadsides and rocky areas in North Carolina (Radford 1968). It is easy to grow in dry to moist well-drained soil in sun to part shade, although it can be difficult to establish. Once established however it is very drought tolerant because it has deep, woody roots. It prefers sandy loam or rocky soil. (Missouri Botanical Garden n.d.).

*Chionanthus virginicus* (fringe-tree)\*



DESCRIPTION: A small deciduous tree that grows 12'-20' (3.6m-6m) tall. Has white fringe-like flowers in drooping clusters in spring. (Missouri Botanical Garden n.d.).

HABITAT: This small native tree is common throughout North Carolina in dry woods and savannahs (Radford 1968). It grows best in average moisture, nutrient rich, well-drained soils in full sun to part shade. Once established, it tolerates moderate drought, but will need irrigation during severe droughts. (Missouri Botanical Garden n.d.).

*Fothergilla gardenii* (dwarf fothergilla)\*



DESCRIPTION: A small deciduous shrub, reaching 2'-5' (-0.6m-1.5m) tall. Good year round appeal with showy white brush-like flowers in spring, consistently green summer foliage, bright fall color. (Mellichamp 2014).

HABITAT: Native to the coastal plains of North Carolina south to Florida. This plant prefers average moisture organically rich acidic soils, but once established will tolerate moderate drought. Grows best in sun to part

shade. Flowering is best in full sun. (Missouri Botanical Garden n.d.).

OTHER: Cultivar 'Blue Mist' has blue-green summer foliage; 'Mount Airy,' a hybrid between *F. gardenia* and the larger fothergilla *F. major* has profuse flowers and consistent fall color. (Missouri Botanical Garden n.d.).

*Hydrangea quercifolia* (oakleaf hydrangea) \*



DESCRIPTION: A deciduous shrub reaching 4'-8' (1.2m-2.4m) in height. Large lobed foliage with purple-red fall color. Showy white flowers in early summer (Mellichamp 2014).

HABITAT: This plant is native to dry wooded ravines and moist forests in the Southeast (Mellichamp 2014). It grows best in average moisture soils that are organically rich and well-drained soils (Missouri Botanical Garden n.d.). Prefers part

shade and will become less drought tolerant in full sun (Mellichamp 2014).

### *Ilex glabra* (inkberry holly)



DESCRIPTION: An evergreen shrub, 6'-8' tall with inconspicuous white flowers in summer. Black berries in fall. Good foundation plant. (Mellichamp 2014).

HABITAT: Native to sandy savannahs and pineland, mostly in the coastal plain of North Carolina (Mellichamp 2014). Tolerates a wide range of soils, both heavy and light, but prefers average moisture, acidic soils in full sun to part shade (Missouri Botanical Garden n.d.)

OTHER: Cultivars 'Shamrock' and 'Compacta' have a more compact habit than the straight species (Missouri Botanical Garden n.d.).

### *Ilex vomitoria* (yaupon holly)\*



DESCRIPTION: An evergreen shrub reaching 20' (6m) tall. Flowers in late spring; red berries in fall – winter. Used commonly in foundation plantings or as a hedge. If growing for berries, make sure to plant a male form, for example 'Schillings,' to insure pollination. (Mellichamp 2014).

HABITAT: Native to the coastal forests of the Carolinas (Mellichamp 2014). *Ilex vomitoria* is the most drought resistant of the hollies, growing in its native habitat in both dry and wet soils. Grows well in both sun and shade. (Missouri Botanical Garden n.d.).

OTHER: Dwarf cultivars 'Nana' and 'Schillings' only reach 4'-5' ft (1.2-1.5m), are very drought tolerant, dense, and slow growing. (Mellichamp 2014). 'Bordeaux' has crimson new foliage in spring.

### *Juniperus virginiana* (eastern red cedar)\*



DESCRIPTION: A pyramidal evergreen tree growing up to 50' (15m) tall. In winter, its blue fleshy cones are attractive to birds (Mellichamp 2014). Good for screening and foundation plantings in the landscape (Missouri Botanical Garden n.d.).

HABITAT: This tree is very common throughout Eastern North America, and somewhat underused in the landscape because it is so common (Ogden 2011). It is easy to grow in dry to moist well-drained soils in full sun, and is the best drought-tolerant conifer native to Eastern North America. Deer tolerant. (Missouri Botanical Garden n.d.).



OTHER: There are many cultivars of *J. virginiana*. A few common ones are 'Burkii', which has a columnar form with blue foliage, and 'Grey Owl', a dwarf hybrid reaching just 3' x 6' (1m x 2m) with gray foliage. (Mellichamp 2014).

### *Lagerstroemia indica* (crape myrtle)



DESCRIPTION: A multi-stemmed small tree, 15'-25' (4.5-7.5m) tall. Has showy white, pink or red flowers in summer. Some cultivars have exfoliating bark with winter interest. Many cultivars have bright fall foliage. (Missouri Botanical Garden n.d.).

HABITAT: Though a native of Asia, crape myrtle is one of the most popular ornamental trees in the South. It is well

adapted to the clay soils of the NC Piedmont, as well as very drought tolerant. It grows best in well-drained soil in full sun (Missouri Botanical Garden n.d.)

OTHER: There are dozens of cultivars of crape myrtle in many colors and with different degrees of peeling bark. Some popular ones in North Carolina are: 'Natchez' (a hybrid between *L. indica* and *L. fauriei* with white flowers and exfoliating bark, bright red fall color), 'Muskogee' (lavender-pink flowers), 'Dynamite' (red flowers).

### *Osmanthus fragrans* (fragrant olive)



DESCRIPTION: An evergreen shrub reaching 10'-15' (3m-4.5m) in height with very fragrant white flowers in spring (Missouri Botanical Garden n.d.).

HABITAT: Grows best in average moisture well-drained soils in sun to part shade. Prefers afternoon shade in hot climates.

Tolerates heavy clays (Missouri Botanical Garden n.d.).

OTHER: Related species *Osmanthus heterophyllus* (false holly), is also drought tolerant and has similar site condition needs.

### *Rhododendron calendulaceum* (flame azalea)\*



DESCRIPTION: A deciduous shrub reaching 4'-8' (1.2m-2.4m). Showy yellow-orange flowers in spring. Colorful fall foliage ranging from yellow-orange to red-purple.

HABITAT: This plant is a common native in the mountains of North Carolina. Prefers organically rich, well-drained soils in part shade to sun. Needs acidic soil to thrive. Very drought tolerant plant that will go dormant during severe droughts and

drop its leaves to survive. (Mellichamp 2014).

OTHER: There are sixteen native species of deciduous azaleas in the Southeast, all of which are drought tolerant. A few other species suitable for Piedmont gardens are *R. austrinum* (Florida azalea) and *R. arborescens* (Sweet azalea). (Mellichamp 2014).

## Perennials and Groundcovers

### *Achillea millefolium* (common yarrow)



DESCRIPTION: A mat-forming perennial with fern-like leaves and white flowers in summer. Mature height is 2 – 3 feet. *A. millefolium* spreads a lot so it is best in naturalized areas of the landscape. It is deer tolerant and attractive to butterflies. (Missouri Botanical Garden)

HABITAT: This European and Asian plant was introduced to North America during colonial times and has become naturalized throughout the country. The straight species is common on roadsides, waste areas, and lawns, and is generally considered a weed, but many cultivars are popular as garden plants. It is a very drought tolerant plant that grows best in dry, well-drained sandy loam soils in full sun. If grown in rich soils, the stems tend to flop. (Missouri Botanical Garden)

OTHER: Common cultivars available in North Carolina are ‘Paprika’ (dark red flowers), ‘Terra Cotta’ (reddish-orange flowers), and the hybrid ‘Coronation Gold’ (yellow flowers).

### *Allium cernuum* (nodding onion)\*



DESCRIPTION: A spreading bulb with pink to white blooms in summer, reaching 12” in height. The flowers are showy umbels that nod, as the common name suggests. During the summer it often goes dormant but will return again in the spring. When using this plant in designed landscapes it is best in naturalized areas or meadows because it spreads by bulbs (Mellichamp 2014). It is deer tolerant and attractive to bees.

HABITAT: This plant is commonly found growing wild in the NC Piedmont in meadows and open woods (Radford 1968). It thrives naturally in a wide range of moisture conditions, from moist to dry, but does not tolerate overwatering and prefers a well-drained soil. It grows best in sun (Mellichamp 2014).

### *Amsonia ciliata* (sandhills bluestar)\*

DESCRIPTION: A clumping perennial with pale blue flowers in mid spring. Mature height is 2 – 3 feet. Yellow fall color. Deer tolerant and attractive to butterflies.

HABITAT: This plant is not common in the Piedmont region of North Carolina but is native to the coastal plains of the state, where it grows in sandhills, woodland and scrubland. (Radford 1968). It prefers dry, sandy soils that get regular moisture but drain quickly. Soil is preferably acidic. *A. ciliata* grows best in full sun. Some shade will give a longer bloom period, but may result in leggier plants that flop over. (Missouri Botanical Garden n.d.).

*Amsonia tabernaemontana* (common bluestar)\*



DESCRIPTION: A clumping perennial with showy star-shaped blue flowers in early spring. It reaches 2-3 feet at maturity. The flowering period is short but the leaves hold up well all summer even during hot weather (Mellichamp 2014).

HABITAT: This plant is native to mixed deciduous forests, wooded slopes, and bottomlands throughout the Southeast, but in North Carolina it occurs predominately in the Piedmont region (Radford 1968). It prefers moist, well drained loamy soils in full sun but can take some shade and tolerates moderate drought (Missouri Botanical Garden n.d., Mellichamp 2014).

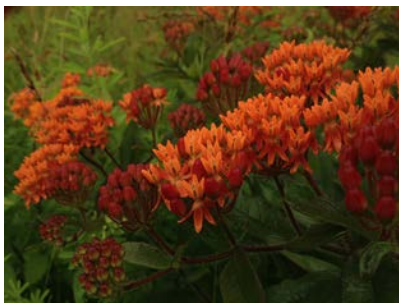
*Aquilegia canadensis* (eastern columbine)



DESCRIPTION: A semi-evergreen, clumping perennial that reaches 1'-3' (30cm-90cm) in height when blooming. Showy red flowers with yellow center in spring. (Mellichamp 2014).

HABITAT: Native to woodlands and rocky outcrops throughout the Southeast (Mellichamp 2014). Prefers average moisture, well drained soils in full sun to part shade. Prefers some dappled shade, especially to make it more drought tolerant. Grows best in soil that is organically rich and moist (Missouri Botanical Garden n.d.).

*Asclepias tuberosa* (butterfly weed)\*



DESCRIPTION: A clumping perennial with showy orange flowers that bloom from late spring through summer. Mature height is 1 – 2 feet. *A. tuberosa* has a deep taproot, which makes it very drought-tolerant, but it can be slow to establish and is difficult to transplant. It is deer resistant and attractive to butterflies. In particular, it is important to Monarch butterflies which lay their eggs on the leaves in late summer. (Mellichamp 2014, Missouri Botanical Garden)

HABITAT: *A. tuberosa* is native throughout the state, occurring in dry fields, wood edges, and roadsides. (Radford 1968). It grows in both moist and dry soils but must have a soil that is very well drained, and thrives best in poor soil. Overwatering and rich soils lead to crown rot. It prefers sun or part sun. (Missouri Botanical Garden).



*Aster x frikartii* (Frikart's aster)



DESCRIPTION: A hybrid between *A. amellus* and *A. thomsonii*.

Lavender-blue blooms summer – fall. Attractive to butterflies.

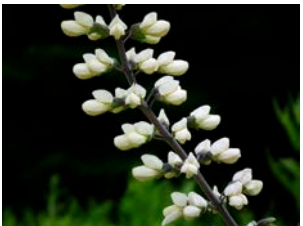
(Missouri Botanical Garden n.d.).

HABITAT: Prefers well-drained soils with average moisture but is also quite drought tolerant. It will not tolerate wet winter soils. Clay soils are ok as long as they are well-drained. Grows best in sun to part

shade. (Missouri Botanical Garden n.d.).

Other: Cultivar 'Mönch' (3' ht, lavender-blue flowers)

*Baptisia alba* (false indigo)\*



DESCRIPTION: A clumping perennial with white pea-like flowers in late spring, 3'-4' tall. Large mounded habit that looks fresh all summer. (Mellichamp 2014).

HABITAT: Native to woodland and open woodland areas in parts of North Carolina, although it is more common in the Midwest (Radford 1968). Prefers well-drained soils, and will tolerate dry soils as well as

seasonally wet soils. A deep root system makes it particularly resistant to drought. Suitable for meadows, specimen plantings and rain gardens. (Missouri Botanical Garden n.d.)

OTHER: Other native species of false indigo suitable for residential landscape are *B. australis*, with blue flowers, and *B. tinctoria*, with yellow flowers. The latter has flowers which are smaller than other species so is best for naturalized areas and native gardens rather than specimen plantings. (Missouri Botanical Garden n.d.).

*Coreopsis verticillata* (threadleaf coreopsis)\*



DESCRIPTION: A clumping perennial with yellow blooms in summer to fall. Foliage is palmate and threadlike. Mature height is 1 – 2 feet. The straight species may spread somewhat aggressively through seed and rhizomes, but cultivars exist that are more compact growers that spread less. It is deer tolerant and attractive to butterflies.

HABITAT: Native to the lower Piedmont and inner Coastal Plain regions of North Carolina, where it occurs in upland woods and dry pine woods. (Radford 1968). It prefers well drained acidic soils with dry to medium moisture and full sun. In particular it grows well in sandy or rocky soils, while rich, moist soils will produce sprawling plants and often leads to crown rot. (Missouri Botanical Garden)

OTHER: Commonly available cultivars in North Carolina are 'Moonbeam' (a sterile cultivar that won't self-sow, pale yellow blooms), 'Golden Gain' (compact, bushing cultivar with bright yellow blooms that does not spread as aggressively as the species).

### *Echinacea purpurea* (purple coneflower)\*



DESCRIPTION: Perennial with pale purple flowers in summer. Better heat and drought tolerance than *E. purpurea*. 2' – 3' tall. Deer tolerant. Attractive to butterflies. (Missouri Botanical Garden n.d.).

HABITAT: A rare native to North Carolina, occurring in woodland and roadsides, and is more common in the prairies and savannahs of the Midwest (Radford 1968). It is very adaptable to a wide range of soil, light and moisture conditions, tolerating dry to moist soils, sun to part shade, and poor soils. It tolerates heat, humidity and drought well, and will grow in clay and rocky soils, which makes it a good choice for the Piedmont. (Missouri Botanical Garden).

OTHER: *E. pallida* is also a good species of coneflower for the Piedmont, equally drought tolerant and tolerant of clay soils, but with paler flowers.

### *Eryngium yuccifolium* (rattlesnake master)\*



DESCRIPTION: Usually grown for its ornamental yucca-like leaves. Has showy white to pale green blooms in summer; 3-4ft (.9m-1.2m) tall. (Missouri Botanical Garden n.d.).

HABITAT: Naturally occurring in open woods and roadsides in the Piedmont, where the soil is acidic clay or sandy (Radford 1968). *Eryngium* grows best in dry to average moisture soils in full sun. Prefers sandy, dry soils but will tolerate seasonal flooding. Doesn't like soils that are too rich in nutrients, which will result in sprawling, flopping plants. Taproot makes it very drought tolerant. (Missouri Botanical Garden n.d.).

OTHER: Other species of *Eryngium* are also good for drought-tolerant gardens: *E. planum* (1.5-2.5ft/50-75cm tall, with purple flowers); *E. amethystinum* (compact form with later-blooms and silver veined foliage) (Odgen 2011).

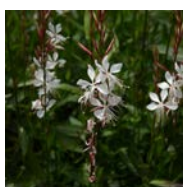
### *Eurybia divaricatus* / syn. *Aster divaricatus* (woodland aster)\*



DESCRIPTION: Evergreen perennial, 6"-24" (15-60cm) tall. White daisy-like flowers in late summer. Useful as a groundcover in woodland gardens (Mellichamp 2014).

HABITAT: Native woodland plant in NC Piedmont and Mountain regions (Radford 1968). It grows well in dry to medium moisture, well-drained soils, in part shade to heavy shade. (Missouri Botanical Garden n.d.).

### *Gaura lindheimeri* (gaura)



DESCRIPTION: A clumping perennial with white to pink flowers late summer – fall. 3'-5' (0.9,-1.5m) height. (Missouri Botanical Garden n.d.)

HABITAT: Gaura grows best in sandy to loamy, well-drained soils in full sun. Prefers poor soil and will grow leggy and flop in rich soils (Missouri Botanical Garden n.d.)

OTHER: Many cultivars of gaura are easily available: 'Whirling Butterflies' (white flowers, 2'ht), 'Ballerina Rose' (pink flowers, 1'ht), 'Crimson Butterflies' (pink flowers, crimson foliage, 2'ht)

### *Geranium macrorrhizum* (cranesbill)



DESCRIPTION: Low growing, semi-evergreen perennial, 12" (30cm) tall. Purple-pink flowers in early summer. Red leaf color in fall. Deer resistant. Attractive to butterflies. (Missouri Botanical Garden n.d.).

HABITAT: Easy to grow perennial that thrives in both dry and moist well-drained soil in full sun to part shade. This is the most heat and humid tolerant geranium for the South. It's thick rhizomes make this plant survive drought well. (Missouri Botanical Garden n.d.).

### *Glandularia canadensis*/Verbena canadensis (rose verbena)



DESCRIPTION: A low growing, clumping perennial with pink blooms in summer. Reaches 18" (45cm) in height. A fast growing groundcover that is attractive to butterflies.

HABITAT: A native to the plains of the United States, where it grows in prairies and fields, rose verbena grows best in dry to moist soils that are well-drained. It does not tolerate wet soil and prefers full sun (Missouri Botanical Garden n.d.)

OTHER: Many cultivars with various color blooms are available: 'Annie' (lilac flowers), 'Miss Anne' (white flowers), 'Homestead Purple' (rich purple flowers).

### *Heuchera americana* (coral bells)\*



DESCRIPTION: Evergreen perennial, 12"-18" (30-45cm) tall. With flowers that are inconspicuous and bloom from spring to summer, this plant is grown more for its leaves, which are round and variegated with green, silver and purple color (Mellichamp 2014).

HABITAT: Native to rich woods and rock outcrops in the piedmont and mountain regions of North Carolina (Radford 1968). *Heuchera americana* prefers humus-rich soils that are well drained. It grows best in part shade in the South (Missouri Botanical Garden n.d.).

### *Iris cristata* (dwarf crested iris)



DESCRIPTION: 3"-6" (7.5-15cm) tall. Showy blue-lavender flowers with white, yellow and pink markings in spring. (Mellichamp 2014). Deer tolerant (Missouri Botanical Garden n.d.).

HABITAT: Native to moist woods and roadsides in the upper southeast (Mellichamp 2014). Prefers average moisture, well-drained soils that are organically rich. Will grow in full sun or shade, but is best in part shade. If in full sun it needs consistent moisture and thus loses some of its drought tolerance. (Missouri Botanical Garden n.d.).

### *Liriope muscari* (lilyturf)



DESCRIPTION: Asian species grown widely in the Southeast as a groundcover. Evergreen grass-like foliage and purple blooms in late summer. 12"-18"ht. Deer tolerant (Missouri Botanical Garden n.d.).

HABITAT: Grows best in average to dry well-drained soils; very tolerant. Will grow in sun to part shade (Missouri Botanical Garden n.d.)

OTHER: Common cultivars are 'Variegata,' with variegated foliage, purple blooms, 1' (30cm) height; 'Big Blue', with violet flowers, 1' (30cm) height.

### *Ophiopogon japonicus* (mondo grass)



DESCRIPTION: A low growing Asian species grown widely in the Southeast as a groundcover. Evergreen grass-like foliage. The straight species is 1' (30cm) tall but smaller cultivars are usually used. (Missouri Botanical Garden n.d.).

HABITAT: Grows best in average moisture soils in part shade to shade.

(Missouri Botanical Garden n.d.).

OTHER: Cultivar 'Nigrescens' has dark purple-black foliage; 'Nana' is a dwarf cultivar that reaches 1"-2" (2.5cm-5cm).

### *Phlox nivalis* (trailing phlox)\*



DESCRIPTION: An evergreen mat-forming perennial with showy pink blooms in spring. Grows well on slopes and is good for erosion control. Suitable alternative for lawn mixed with grass and can tolerate occasional mowing (Mellichamp 2014). Deer tolerant and attractive to butterflies (Missouri Botanical Garden n.d.).

HABITAT: Native to dry woodland and rock outcrops in the Carolinas south to Alabama (Mellichamp 2014). It grows best in organically rich well-drained soils in full sun. Tolerant of average to dry moisture soils and is very heat tolerant (Missouri Botanical Garden n.d.).

OTHER: The related species *Phlox subulata*, native further west to the mountain regions of North Carolina and into the Northeast, is another good drought-tolerant phlox, good as a ground cover. It has shorter leaves than *P. nivalis* and is available in a wide range of colors (Mellichamp 2014).



*Rudbeckia fulgida* (black eyed susan)\*



DESCRIPTION: A clumping perennial reaching 2'-4' (0.6m-1.2m) in height. Yellow blooms in summer to fall. Deer tolerant. Attractive to butterflies (Missouri Botanical Garden n.d.).

HABITAT: Native throughout the Southeast in open woods and meadows (Mellichamp 2014). It grows best in dry to medium moisture well-drained soil in full sun to dappled shade. It has very good heat

tolerance and can grow well in clay soils (Missouri Botanical Garden n.d.).

CULTIVARS: The German cultivar 'Goldsturm' is not as tolerant of the hot humid summers of North Carolina, even though it is one of the most common cultivars available: 'Early Bird Gold' and 'Little Goldstar' are shorter but more heat-tolerant (Mellichamp 2014).

*Ruellia caroliniensis* (Carolina wild-petunia)\*



DESCRIPTION: An attractive perennial wildflower growing 6"-12" (15cm-30cm) in height. Showy light blue flowers that bloom all summer. Self sows and only suitable for more naturalized areas (Mellichamp 2014).

HABITAT: Native to dry and moist woodlands throughout the Southeast United States. It prefers moist, well-drained soils in shade

to part shade (Mellichamp 2014).

*Sedum ternatum* (mountain stonecrop)\*



DESCRIPTION: An evergreen perennial with low, creeping habit. Showy white blooms in late spring. (Mellichamp 2014). Deer tolerant. Attractive to butterflies. Good groundcover for woodland areas (Missouri Botanical Garden n.d.).

HABITAT: Native in the Piedmont and mountain regions of North Carolina in rocky woods and cliffs. It prefers dry to moist well-drained soil in shade or part shade. (Mellichamp 2014).

*Silene virginica* (fire-pink)\*



DESCRIPTION: Short-lived perennial reaching 1'-2' (30-60cm) tall. Showy red flowers in spring to early summer. Attractive to hummingbirds and butterflies (Mellichamp 2014).

HABITAT: Grows well in dry to medium moisture well-drained soils in shade to part shade. Sandy and clay soils are both tolerated. (Missouri Botanical Garden n.d.).

*Sisyrinchium angustifolium* (blue eyed grass)\*



DESCRIPTION: A clumping grass-like plant in the Iris family. Showy blue flowers in spring to summer. Reaches 6"-12" (30cm-60cm) in height. Good naturalizing groundcover with profuse blooming. Best used in masses (Mellichamp 2014).

HABITAT: Native to moist meadows and woodlands in the southeast (Radford 1968). It grows well in moist to dry soils that are well drained, in full sun to part sun. Once established it is moderately drought tolerant. (Mellichamp 2014).

OTHER: This plant has potential to be used as an alternative to lawn, mixed with other wildflowers.

*Solidago odora* (licorice goldenrod)\*



DESCRIPTION: A clumping perennial with bright yellow blooms summer – fall. 2'-3' (60-90cm) tall. Crushed leaves smell like anise. (Mellichamp 2014). Attractive to bees and butterflies. Deer resistant. Self seeds so best in naturalized areas of the garden. (Missouri Botanical Garden).

HABITAT: Native to dry woods, savannahs and pinelands throughout North Carolina (Radford 1968). Grows well in dry to average moisture soils, including clay soils, preferably in full sun but tolerates some shade. (Missouri Botanical Garden).

OTHER: Hybrid 'Goldkind' has a long bloom period and is shorter than most other goldenrods at 1.5'-2' (45-60cm)

## Ornamental Grasses

### *Andropogon gerardii* (big blue-stem)\*



DESCRIPTION: An upright ornamental grass with a clumping habit, 5-8ft tall. Foliage is blue-green in summer, red-brown in fall and has stiff flower spikes in late summer (Mellichamp 2014).

HABITAT: Native to dry woods, fields and savannahs throughout the state (Radford 1968). Prefers sites in full sun, but can tolerate a range of soil moisture conditions, from dry to moist. Prefers well-

drained, poor soils, while rich fertile soils may make the plant topple. *A. gerardii*'s extensive root system can make it difficult to establish but afterwards is extremely drought tolerant (Missouri Botanical Garden n.d.).

### *Carex pensylvanica* (Pennsylvania sedge)\*



DESCRIPTION: Clumping ornamental grass with delicate green leaves that turn yellow in fall. Flowers are inconspicuous, in spring. (Mellichamp 2014).

HABITAT: This species native to dry and moist woodlands. Often it is found growing under oaks where the soil is dry. It is one of the best sedges to tolerate dry soil and does best in part shade to shade.

Prefers loose loams. It will also tolerate wet soil and is suitable for rain gardens if they are not too sunny. Can also be used as a lawn alternative [see Lawn Alternatives below] (Missouri Botanical Garden n.d.).

### *Festuca glauca* (blue fescue)



DESCRIPTION: Low growing, semi-evergreen ornamental grass with blue-green foliage. Short lived and requires frequent division. Buff-colored seed heads in fall (Missouri Botanical Garden n.d.).

HABITAT: Grows well in dry to medium moisture well-drained soils. Will grow in clay soils as long as they are drained well. Prefers full sun for best foliage color.

OTHER: 'Siskiyou Blue', a hybrid between *F. glauca* and *F. idahoensis*, is longer lived and does not self seed as much as *F. glauca*.

### *Muhlenbergia capillaris* (pink muhly grass)\*



DESCRIPTION: Ornamental grass with clumping habit, reaching 3ft (90cm). Pink fall blooms that last into winter. (Mellichamp 2014).

HABITAT: Native to dry woods and savannahs, mostly in the piedmont and coastal regions of North Carolina (Radford 1968). Grows well in a wide range of moisture conditions, from average to dry. Prefers well-drained soils; sandy and rocky soils are best. Does best in full sun. (Missouri Botanical Garden n.d.).



*Schizachyrium scoparium* (little bluestem)\*



DESCRIPTION: Ornamental grass with clumping habit, reaching 3-4ft (90-120cm). Foliage is blue-green, turning red during the fall and winter. Delicate, plumed flowers in late summer (Mellichamp 2014).

HABITAT: *S. scoparium* is a very tolerant plant native to dry woods, rich fertile prairies in the Southeast. It grows well in average to dry soils in a wide range of soil conditions. Prefers full sun (Missouri Botanical Garden n.d.).

## Ferns

*Polystichum acrostichoides* (Christmas fern)\*



DESCRIPTION: An evergreen clumping fern, reaching 1'-2' (30cm-60cm) in height (Mellichamp 2014).

HABITAT: A native that grows in dry and moist woodlands throughout the Southeast. Prefers organically rich, dry to moist soils in part shade to full shade. Needs well-drained soils to prevent crown rot (Missouri Botanical Garden n.d.).

## 7. Drought-tolerant combinations for residential landscapes

The following are some suggested combinations for various site conditions that might occur in the residential landscape. All plants listed here are best adapted to ordinary moisture conditions but tolerate moderate drought under the conditions as described in chapter 6. Plants have been selected based on their compatibility to the site conditions, as well as bloom time, flower color, foliage, shape and habit.

### A planting in shade

- Calycanthus floridus* (Carolina spice bush)
- Ilex vomitoria* 'Bordeaux' (yaupon holly)
- Polystichum acrostichoides* (Christmas fern)
- Silene virginica* (fire-pink)
- Ophiopogon japonicus* 'Nigrescens' (mondo grass)

The evergreen holly, Christmas ferns, and dark-leaved mondo grass give structure in this planting during the winter, while in the spring and early summer, Carolina spice bush and fire-pink bloom in crimson and red.

### A planting for part-shade

- Chionanthus virginicus* (fringe-tree)
- Hydrangea quercifolia* (oak-leaf hydrangea)
- Eurybia divaricatus* (woodland aster)
- Carex pensylvanica* (Pennsylvania sedge)
- Heuchera americana* (coral bells)
- Geranium macrorrhizum* (cranesbill)

This planting looks best in spring when the cranesbill, coral bells, and fringe-tree bloom together. The hydrangea blooms follow in summer, to be replaced by the white flowers of the woodland aster.

### A planting in part-shade under existing pines (acidic soil)

- Fothergilla gardenii* (dwarf fothergilla)
- Rhododendron* spp. (deciduous azaleas)
  - Rhododendron calendulaceum*
  - Rhododendron arborescens*
- Amsonia ciliata* (sandhills bluestar)
- Aquilegia canadensis* (columbine)

A beautiful combination of native plants with spring blooming in white, red and blue.

### **A foundation planting in part-shade**

- Hydrangea quercifolia* (oak-leaf hydrangea)
- Ilex glabra* 'Shamrock' (inkberry holly)
- Abelia x grandiflora* 'Rose Creek' (glossy abelia)
- Ophiopogon japonicus* (mondo grass)

The hydrangea is the focal point of this foundation planting. Evergreens inkberry holly, glossy abelia, and mondo grass are planted in front of windows in three layers to give year round interest.

### **A formal planting in sun**

- Ilex vomitoria* 'Nana' (dwarf yaupon holly)
- Liriope muscari* 'Big Blue' (lilyturf)
- Lagerstroemia indica* 'Dynamite' (crape myrtle)

This combination consists of landscape plants that are already heavily used in North Carolina, but are very drought tolerant and give a formal look.

### **A naturalistic perennial border in full sun**

- Schizachyrium scoparius* 'The Blues' (little blue stem)
- Andropogon gerardii* (big blue stem)
- Asclepias tuberosa* (butterfly weed)
- Rudbeckia fulgida* (black-eyed susan)
- Achillea millefolium* 'Coronation Gold' (yarrow)

This bright prairie-inspired border combines yellow and orange summer-blooming perennials with ornamental grasses.

### **A mixed border in full sun**

- Caryopteris x clandonensis* 'Longwood Blue' (blue mist spirea)
- Callicarpa americana* (beautybush)
- Muhlenbergia capillaris* (pink muhly grass)
- Gaura lindheimeri* (gaura)
- Echinacea purpurea* (coneflower)

This naturalistic border has multi-season interest. Coneflower and blue mist spirea bloom through the summer, while in the fall pink muhly grass and gaura bloom together alongside the ripening purple berries of beautybush.

## 8. Discussion

North Carolina receives a large amount of rainfall each year, with an average of 45"-55" (1000-1400mm), but a rapidly growing population and the effects of a changing climate have led to several severe water shortages over recent years. Since the state's population growth shows no sign of changing, and climate change research shows that the effects we have already been experiences will only intensify in the future, water conservation is an important issue in the state and in the entire country. With predictions that certain parts of the U.S. may run out of water completely in the coming decades, even states with sufficient water need to be managing and collecting the excess in a sustainable manner.

As water conservation grows as an important issue in the United States, how relevant is cutting back on residential landscape water use? Unlike public spaces, private residential gardens place greater importance on aesthetics, which may not always be in line with conservation measures, but they also offer individuals a way to personally take part in water conservation. Since residential landscapes consist of a large area of our cities and suburban communities, water conservation in the landscape can have a meaningful impact on water usage, even though a single residential garden might seem insignificant in the grand scheme of things.

The purpose of this thesis was to explore how landscape designers can design more water efficient gardens, both technically through appropriate plant choices and best management practices, and through overcoming potential aesthetic barriers. The subject of water use in the landscape is wide and there is potential for a deeper, more focused study on many areas just touched on in this paper, but as a first guide for landscape designers, this work has discussed various techniques designers can use when designing gardens, and how they can use them in a way that might be more aesthetically pleasing for homeowners.

Despite the wealth of information written on water conservation in landscape design, using literature as the sole method of this work has been limiting in a few ways. Much that is written concerning residential landscapes is basic and aimed toward homeowners, while many academic articles are more scientific than design-oriented. With so much material it also has been hard to draw the line to what is relevant to this work.

During the research for this thesis, I've found some information about xeriscape gardens to be vague and contradictory. The term xeriscape, despite having been around since the 1980's, incorporates a wide range of meanings for many people, and even after writing this thesis, seems difficult to define. The seven principles of xeriscaping are not really that innovative when looked at alone, and could be considered simply good horticultural practices rather than ecological. I've found it hard to find information about designing residential gardens that really pushes beyond these principles.

The lack of published information containing in-depth ecological information of plants and their requirements has been a subject I've thought a lot about during my education at Alnarp, and is one of the reasons why I wanted to write this thesis. Assembling plant lists has therefore been the biggest challenge of this work. No books I've found contain thorough descriptions of the water needs for individual plants, and because this thesis focuses on a small region of the United States, it has been hard to find plant information directed toward this particular climate and soil conditions. Interviews with people who have more personal experience with the plants and climate in North Carolina would have been a helpful supplement, and there is a lot of opportunity to develop the lists provided here further.

Literature that addresses aesthetic barriers to water-efficient gardens has been the richest material used in this work, and could be a thesis in itself. I've only been able to touch on the cultural and psychological background to designed landscapes, and how it can affect the adoption of more water-efficient designs, but my research has shown that residential landscape designers have a lot of opportunities through education to overcome these barriers. My conclusion is that educator is the most important role landscape designers have when creating water-efficient landscapes, if any really significant change in practices at the residential level is going to happen. At the same time, this raises several ethical issues. To what extent does a designer have the right to try to get a homeowner to install a water-efficient garden as opposed to a conventional one? Can they and should they try to alter someone's aesthetic preferences? Finally, should designers create gardens they know to be unsustainable if that is what the homeowner wants? I think it is up to individual designers themselves to find a balance between the ecological/scientific and the aesthetic, but hopefully this work has been an inspiration for those interested in ways of designing gardens that use less water while remaining aesthetically true to more traditional garden styles in North Carolina.

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