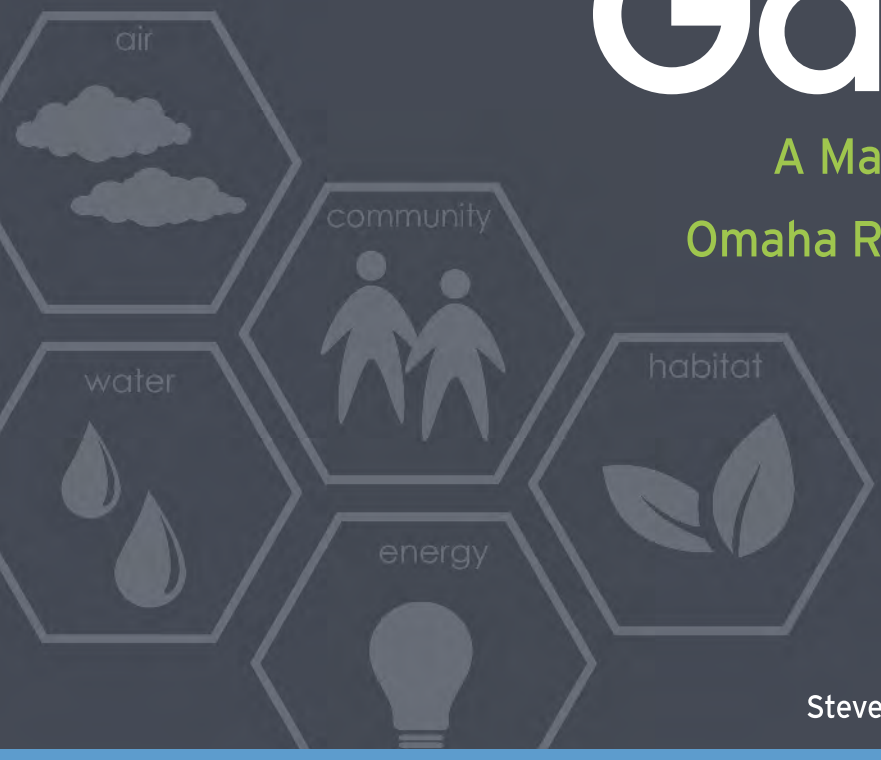
# Bioretention Gardens

## A Manual for Contractors in the Omaha Region to Design and Install Bioretention Gardens

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# Bioretention Gardens

## A Manual for Contractors in the Omaha Region to Design and Install Bioretention Gardens

### Preface

Green Infrastructure (GI) is an approach to water management that protects, restores or mimics the natural hydrology of an area by managing rain where it lands. GI incorporates both the natural environment as well as engineered systems that use soils, plants, and land features to preserve and/or mimic natural processes to absorb the impact of stormwater. GI can be applied on different scales – from a single property to a large watershed. On the site level, GI practices include bioretention gardens, permeable pavements, green roofs, and rainwater harvesting systems. At the largest scale, the preservation and restoration of natural landscapes such as forests, floodplains and wetlands are critical components of green infrastructure. Bioretention gardens are one of the most utilized GI practices in urban environments. They are called gardens because, in addition to their intended stormwater functions, they create attractive natural amenities for sites and for the surrounding community.

The design of bioretention gardens affects human welfare, health and safety, and that of the environment. These gardens will likely require the experience of a registered professional engineer and/or landscape architect. The design and installation of successful bioretention gardens require an interdisciplinary effort, integrating the skills and knowledge of engineers, landscape architects, earth scientists, and landscape plant and maintenance experts. This ensures that gardens will be functional, beautiful and maintainable.

This manual addresses the environmental conditions of eastern Nebraska and specifically the Omaha region. You will find information necessary for constructing bioretention gardens that are both functional and attractive.

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# Introduction

**Stormwater management in Eastern Nebraska can be frustrating.** Occasionally it rains so much it seems there will be no end to stormy weather. Other times there is too little water and every drop is precious. These extremes make rain gardens and bioretention gardens attractive options for managing stormwater.

Stormwater management is an issue that affects everyone in a community: residents, businesses, and even the local government. It's not unusual for streets to flood even during moderate rains, and the streams that drain our lands are quickly eroding and destroying property and creating hazards in our own backyards. These issues come from traditional stormwater management strategies that seek to move water off a site as efficiently as possible with little regard to downstream effect.

Omaha is part of the Papillion Creek Watershed and the associated Papillion Creek Watershed Partnership. The partnership requires stormwater management methods to provide for water quality control of the first half-inch of runoff from new and redeveloped projects that disturb 5,000 square feet or more of land. While this doesn't sound like much, it is this first half inch of rainfall that carries most of the pollutants, often called the first flush of runoff. In Omaha, 90% of all rain events are approximately one inch or less and accounts for a significant amount of annual runoff. Over time, water quality in our streams has degraded substantially as it becomes polluted with sediment and chemicals from our streets and lawns. As we look for stormwater pollution control methods, we find one way to combat damaging stormwater runoff and improve water quality is to construct bioretention gardens.

Bioretention gardens are stormwater best management practice, or BMP, designed and constructed to control, clean, and manage stormwater runoff. They protect our water resources and properties, and through the capture and infiltration of rainfall, they act to conserve water and allow it to return deep into the soil where it can be stored and used by plants later in the year.

## What is a Bioretention Garden?

Simply defined, a bioretention garden is a relatively shallow depression of nearly any size with amended soils, plants, and an underdrain system that ensures 100% drainage within 24-48 hours. Bioretention gardens are designed to protect our water resources by filtering stormwater through and into vegetation, soil and plant roots, and through a process called evapotranspiration. The word "garden" is important. In most places, bioretention gardens are highly visible on the landscape, so they should have aesthetic appeal in addition to being functional. To be successful, they require careful, combined management of water, soil, and plants from design to installation and beyond.

## Runoff Can Do Harm

Andy Szatko

Andy Szatko

**Typically, streams cannot handle the increase in volume and speed of stormwater runoff. Banks easily erode and create deep channels that threaten properties, are dangerous to people, and alter the natural environment significantly.**

Our climate can vary significantly from year to year, but it has a typical pattern. We experience cold winters, wet springs, and very warm and sometimes dry summers. Intense thunderstorms and heavy rains are common in the spring, and rainfall is common throughout the summer and fall.

We also have unique deep loess (wind blown) soil as the base of the region's topography of gently rolling hills. Loess soil is characterized by high silt content and is easily eroded if not protected by deep-rooted plants. When left unprotected, exposed soil erodes easily, especially in developed areas, and can have a significant impact on public safety and the environment.

While exotic or non-native well-trimmed grasses and flowers are considered acceptable in our yards, they can require a lot of water, fertilizer, and maintenance. The grasslands and hardwood forests that are native to Omaha's landscapes are rich, diverse ecological communities. The plants that were part of the original prairie have adapted to this environment and are well-suited for the extreme conditions that we experience here. These plants don't require fertilizers, and once established need very little water during their life cycles. In addition, native landscapes have beautiful, colorful grasses and flowers. Whether in a wild diverse mix or set in gardens, these plants have deep colors and vibrant flowers that rival many exotic species.

## Why Bioretention Gardens?

Other than the requirements for post-construction stormwater management in the watershed, why would someone want to include a bioretention garden in a development or open space plan? Here are a few reasons to consider:

- Bioretention gardens are a cost-effective way to manage and improve stormwater runoff.
- They collect, conserve, and improve water quality. The environmental benefits are many, including protecting streams from erosion, improving air quality, and helping to ease the "heat island" effect of urban areas.

- They add property value with their distinctive landscaping options. Studies show that properties that incorporate native landscaping strategies and green space sell sooner and for higher prices – and they retain their value for a longer period of time.
- Bioretention gardens and their surrounding landscape present a sense of place unique to Omaha's natural heritage.

## Cost Effectiveness

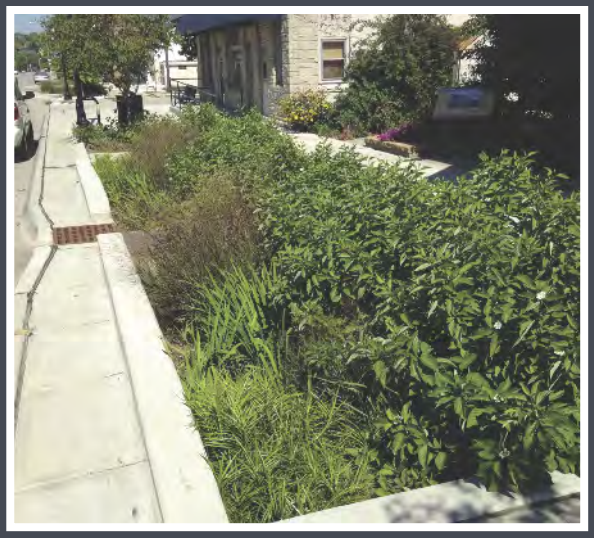
The true value of a bioretention garden is in its ability to control stormwater runoff and improve water quality. The cost of installing a bioretention garden will vary with the complexity of the design and construction requirements. A properly planned, built, and maintained bioretention garden will be attractive and self-sustaining, resulting in low long-term costs. Poor design, construction, or a lack of startup maintenance can result in a poorly functioning, undesirable structure that may need significant work or even eventual replacement.

## What's Next?

This manual provides design professionals, developers, contractors and landowners with important knowledge to help design, build and maintain a viable bioretention garden. Along with regional specific information, you will learn about site assessment, garden design, drainage and soil management, effective selection and use of plants, and the relative costs associated with bioretention implementation. As more bioretention gardens are implemented and information is gathered on their performance, our collective knowledge and aptitude for designing sustainable and beautiful landscapes will continue to improve and help protect our local environment for many years to come.

Andy Szatko

*Orchard Park street-side bioretention garden*



Andy Szatko

*Florence streetscape bioretention garden*

# The Landscape Environment

## Regional Landscape

Before development much of Omaha was upland tallgrass prairie or upland deciduous forest. Areas near the Missouri River and local creek drainages were covered with deciduous forests. Development and urbanization significantly changed landscape conditions, but the basic characteristics of native vegetation and soils remain and should be incorporated into regional bioretention garden design whenever possible. Incorporating the regional, native landscape into the bioretention garden design ties in the native heritage of the land with the functional beauty of the garden and a achieves a sense of place.

## Understanding Landscape Context

To be successful, the bioretention garden designer must have a full understanding of the particular landscape in which they are working. This manual can help with recommendations, but garden designers must ultimately look to onsite specific conditions. Vegetative, topographic, and soil conditions can vary dramatically, even across one property.

To design a successful bioretention garden, a full understanding of the landscape is the first step in the design process. An inventory and analysis of a site typically includes understanding the local landscape, microclimates including sun and wind patterns, topography and drainage patterns, soils, existing vegetation, maintenance considerations, location of utilities and the site's history.

When doing any type of landscaping, it's always better to work with the natural features of the current environment. If existing vegetation is present, it should be assessed for health, landscape role, and potential support of, or conflict with, a garden installation. For example, an existing tree canopy, or species of weeds growing in the area can impact the location, design, and maintenance of bioretention gardens.

Project goals and design concepts must work with these existing site conditions in order to provide a complete design that properly manages stormwater runoff entering it.  Designs can vary significantly from site to site. For example, a bioretention garden collecting water from parking lots and roof runoff from several locations will likely require a more detailed plan than one collecting water from a small, natural area.

## Local Landscape

The designer needs to consider the context of the garden in a given area. Neighborhoods or urban centers can often have a visual sense of place that dictates the unspoken acceptance of how formal or informal a landscape should appear. Bioretention gardens with curving edges, variable plant masses, and tall plants are

## Local Landscape Context

Ted Hartsig

*Undisturbed prairie*

Steve Rodie

*Residential home landscape with two rain gardens in a semi-formal layout*

Andy Szalko

*A roadside ditch unable to withstand the runoff being directed to it, creating multiple issues*

found in more informal areas. Straight edges, structured plant massing, and shorter plants are considered to be more formal. Complementing the surrounding landscape and meeting owner aesthetic desires is a very important consideration for the long-term acceptance of the garden.

## Microclimates

The microclimate of a landscape varies according to wind conditions, sun exposure, and shade. Observe the following when designing a bioretention garden:

- **Sunlight** - Sun and shade patterns move throughout the day and are affected by structures, existing trees. Sunlight varys from light to filtered to dark shade depending on the tree canopy shape and leaf type. The north side of a building normally has shaded conditions for most of the day, resulting in cooler temperatures and more moisture. Remember, in the summer months this shaded area can be significantly smaller.
- **Moisture** - Moisture affects the types of plant communities that can be established. Moisture conditions are dictated by the direction of the slope, whether drainage occurs high or low on the slope, whether the soil is well or poorly drained, and by the amount of sun exposure.
- **Exposure** - The direction of prevailing winds should be determined and relative wind exposure should be gauged onsite. For instance, will the garden location be on top of a hill? Is the site nestled in a neighborhood valley with large trees? Gardens installed on the north side of a structure or fence will have less exposure and drying from the wind than those open to the southeast.
- **Air Circulation** - A landscape with minimal air circulation will likely experience a higher level of plant diseases than an exposed location. Under less windy conditions, disease-resistant plants or specific cultivars will be necessary.

### Sense of Place

Andy Szatko

Andy Szatko

Andy Szatko

*Local site context will provide a basis for determining how the bioretention garden will look.*

## Beauty and Brains

IAMU - Kathleen Gibbons

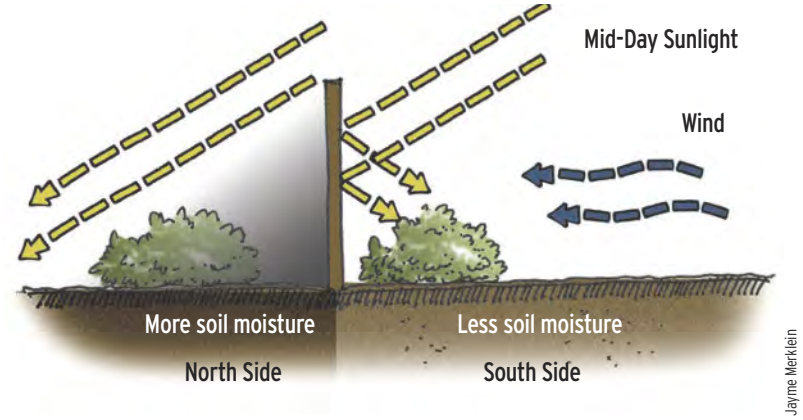
**The aesthetic character of a completed garden is just as important as its functional qualities. Successful designers will keep this in mind as they design the garden, select plants, and develop long-term management specifications.**

## Subtle Slopes

**It is recommended that all slopes be verified with a topographic survey using a laser level, string level, or other equipment. Slopes of one or two percent are very gradual, and extremely difficult to estimate accurately. The amount of slope, as well as its direction, can easily be miscalculated if it is not measured accurately.**

- **Tree Roots** - Planting gardens within the root zones of existing trees is not usually recommended due to the potential for tree root disturbance and changes to soil moisture. If a garden is near a tree, an understanding of sun and shade conditions is required to successfully match garden plants with growing conditions.

## Microclimate




Jayme Merklein

*Landscape position creates a microclimate that will dictate which plants will be successful there.*

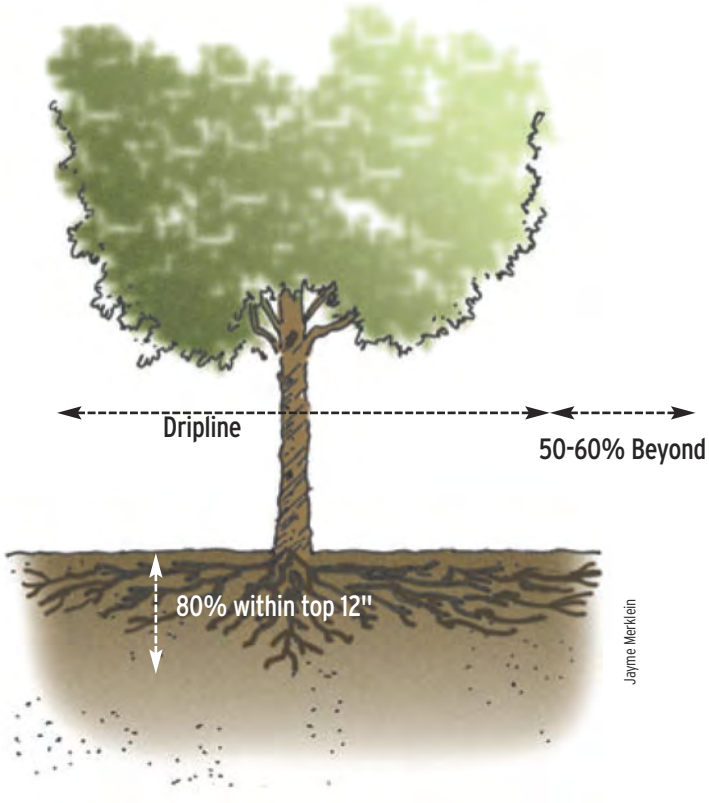
## Topography and Slopes

Understanding and managing the subtleties of a site's topography is not as simple as one might think. It is critical to identify and accurately document how quickly water flows and the path it flows on a given site. Bioretention gardens are not recommended on slopes steeper than 12% because the cutting and filling of soil becomes too difficult on steeper surfaces. Some sloping is necessary to direct water into the garden and overflow out of it. The following are recommended slopes to direct water into and out of gardens by surface type:

- 1% for smooth paved surface or pipe
- 2% for vegetated or rough surface i.e., turf or dry stream bed

## Existing Vegetation

If the potential garden location has existing vegetation, it should be assessed for compatibility with changes to soil moisture, grading of existing soils, and disturbance to roots. Most of a tree's roots occupy the top 6 to 12 inches of soil for ready access to moisture and oxygen. Excavation and root disturbances within and up to 50% beyond the drip line of a tree should be avoided when possible.




## Water - Soil - Plants: Working Together

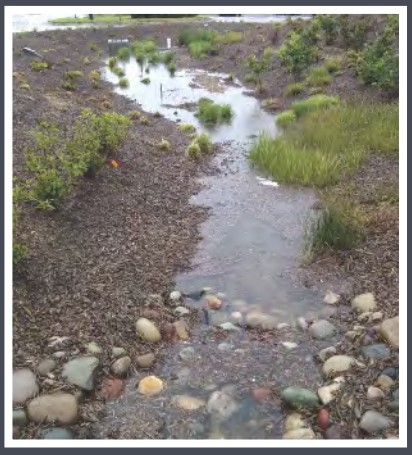
Understanding the connection between water, soil and plants is fundamental to the success of bioretention garden design. Overlooking or undervaluing these interconnected relationships can cause problems that can potentially lead to garden failure.

## Water

As stormwater runoff flows across surfaces, picking up various pollutants and collecting into pipes or swales, it becomes destructive to the downstream environment. However, when stormwater is collected in a bioretention garden, it is possible to manage these destructive forces and allow the water to soak and filter into the soil.

### Borrowing from Nature

**Take advantage of the plants already found in the area. A garden installed near a natural area may utilize the same plants and blend the two areas together. Plants such as Swamp Milkweed, Cardinal Flower and Golden Alexanders grow naturally along streams in the Omaha region, and are also recommended for bioretention garden planting.**



Andy Szatko

*Moisture will be greatest where water enters the bioretention garden and at the bottom.*

Andy Szatko

*Soil cores are being taken at the Orchard Park bioretention garden to better understand plant rooting and soils.*

## Important Facts About Water

- Water cannot soak into the ground and collects rapidly across paved surfaces.. This increases its volume and erosive power. For example, the typical one-inch rainfall over a one-half acre-sized parking lot will produce approximately 1,900 cubic feet of water. That's nearly 14,000 gallons, equivalent to what it takes to fill a swimming pool that's four-feet-deep and 24-feet in diameter.
- The pollutants that water picks up as it runs off paved and unpaved surfaces include sediments, salts, oils, greases, metals, pesticides, fertilizers, and more. These substances will pollute streams, rivers, and lakes if they are not removed from the stormwater.
- Water is a temperature modifier that cools air temperatures. To cool the air, water must go through the soil and then through plants (Marzluff, et al, 2008), a process called evapotranspiration.

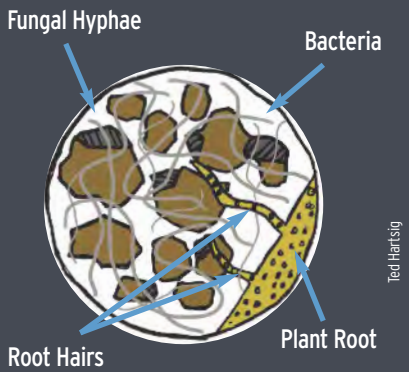
## Soil

Soil is the fundamental building block of a bioretention garden. It is a common misconception that the region's soil is full of clay and water cannot penetrate it effectively. This perception comes from land development that significantly alters the native soil and leaves behind soils high in clay content. Native plants to this region have an incredible ability to open pores with their deep roots and allow water to move deep into the ground.

## Important Facts About Soil

- Soil is more than just sand, silt, and clay. In fact, soil is a very active living system in which billions of microbes, fungi, plant roots and animals interact to create an environment that supports nearly all of the terrestrial life on earth. It is the organic aspect of soil that opens pores – even in clay – and allows water to infiltrate and be stored. This organic aspect also absorbs and holds nutrients to support plant growth while filtering pollutants from water that seeps into the ground.

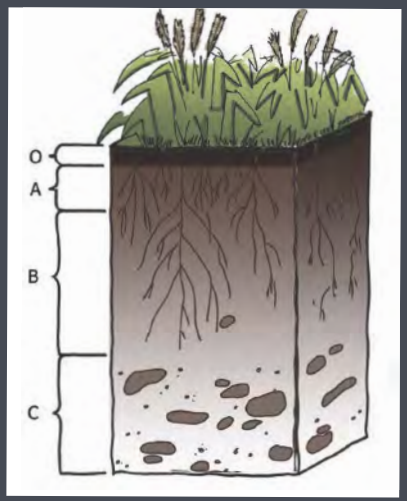
### Biology of Soil




Ted Hartsig

*The soil is a living organism. Soil fungi and bacteria help transport water and nutrients to plant roots, and help bind soil particles together to create rich, friable soil that rapidly absorbs water and supports plants.*

### Soil Profile




Jayme Merklein

**O:** Typically found in undisturbed native soils

**A:** Usually found in minimally-disturbed, or older soils in Omaha, 2 to 12+ inches

**B:** Ranges from a few to several feet thick in Omaha. Usually higher in clay content, lower organic matter, and usually mistaken for "topsoil" in urban areas

**C:** The C horizon is often deep in the soil profile, but is often exposed by development and excavation. May be high in clay and rocky material, low in organic matter

- Soil is chemically active. It holds chemicals that are essential for plant growth and can also filter chemical pollutants. The more clay and organic material there is in a soil, the more chemically active it is.

- Soil forms in layers, or horizons. In the Omaha region, because our soils formed in deep loess – often more than 30 to 40 feet deep, the horizontal layers are sometimes difficult to see. Loess is very high in silt. Over time, the silt broke down into smaller clay particles that moved deeper into the soil profile. The deeper subsoil is often very low in organic matter and high in clay, so it is difficult to work with. Unfortunately, this is the layer of soil that is often left after the land is developed.

- Tight, clayey soils are not made more porous or friable by adding sand. This essentially creates adobe. Clayey soils instead can be made more porous by mixing in organic matter, such as compost. By allowing the mixed soil and organic matter to grow together, peds – the friable, soft structures found in a rich, organic soil – will form.

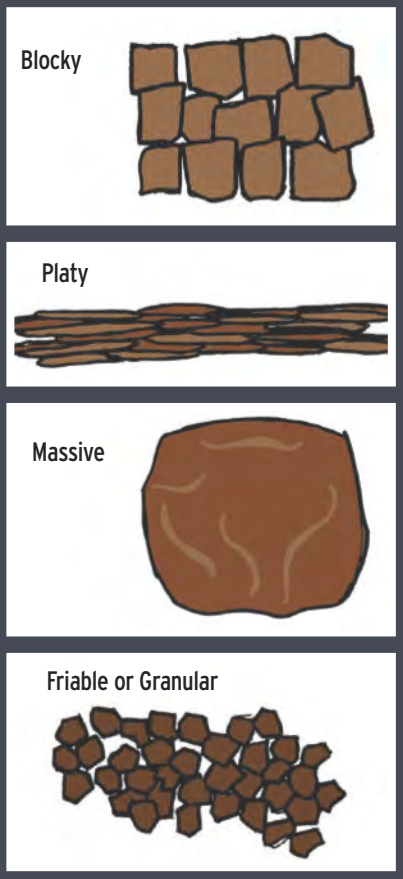
- A common mistake made in landscaping is to cover sandy, more porous soils with a soil that has a higher clay amount and smaller pores. Water will move into the clayey soil slowly and will not easily drain into the lower sandier soil layer. This is because pore size and diameter determine water movement in soil – the smaller the pore, the slower the movement. Layers of soil with differing textures will restrict water movement. As a result, the sandier subsoil gets little to no water and becomes very dry, while the clayey upper soil has a limited amount of available water to support plants. Plants in these areas suffer drought stress quickly and often die. Don't place a "planting soil mix" over sandier subsoil in a bioretention garden.

- When managing soil, structure is more important than texture. Soil structure is the condition of the soil, whether it is friable (easily broken, usually with large pores), platy (soil particles lay flat and stack on top of each other forming a barrier), blocky (soil "crumbs" that have angular edges), or massive (little to no structure, often becoming very hard when dry). Soil structure will often dictate more about how water moves into and through it than will soil texture.

## Know Your Soil

**Soil is a living organism. Soil fungi and bacteria help transport water and nutrients to the roots of plants and help bind soil particles together to create rich, friable soil that rapidly absorbs water and supports plants.**

## Soil Structure




*Soil structure will affect how water drains into it, and how roots will grow through it.*

### Plant Power

**Depending on the location and visibility of the bioretention garden, plants can easily make or break garden acceptance. Plant choices can lead to a garden being seen as a weed patch, or they can provide an attractive amenity.**

Andy Szatko

Andy Szatko

Andy Szatko

## Plants

Plants are the heart and soul of the bioretention garden. They play a significant role in the garden's function, while also enhancing the area's beauty and environmental value. Proper selection, planting and maintaining of plants is as important as other design aspects of the bioretention garden. Plants best suited for bioretention gardens typically have these characteristics:

- Are native or well-adapted perennials and shrubs as they are tolerant of our climate
- Have deep-root systems that improve infiltration of water over time
- Are tolerant of wet soil and short periods of ponding water as well as extended periods of dry conditions
- Provide extended periods of high seasonal interest (flowers, fruit, seasonal foliage color, winter structure and texture)
- Spread out but not invasive, plants filter water and hold soil in place better

Detailed information on selection and care of plants can be found in Chapters 5, 6, and 8.

## Important Facts About Native and Well-Adapted Plants

- Plants native to the area are adaptable to local climate extremes in temperature, moisture, and sun exposure. Once established, native plants use water very efficiently and need little fertilizer or other chemicals to grow.
- Plant roots can extend 15 feet or more into the soil. Deep roots help plants survive in drought and other difficult growing conditions, while creating additional pore space over time in the soil.
- Old, dying roots are replaced with new roots over time. This ongoing transition continually reinvigorates the root system while creating additional soil pore space for increased water infiltration and storage.

- Plants provide habitat value, including food and cover for insects, birds and other wildlife.
- They are not considered invasive, although some native plants species can grow or spread aggressively under ideal environmental conditions. For example, well-behaved plants on a dry site may become aggressive when moved to a site with significantly more moisture.
- They help define our region and ecosystem. "Nebraska-style" landscapes, as defined by the University of Nebraska and the Nebraska Statewide Arboretum, can celebrate the diversity of prairie and river corridor vegetation and landform.

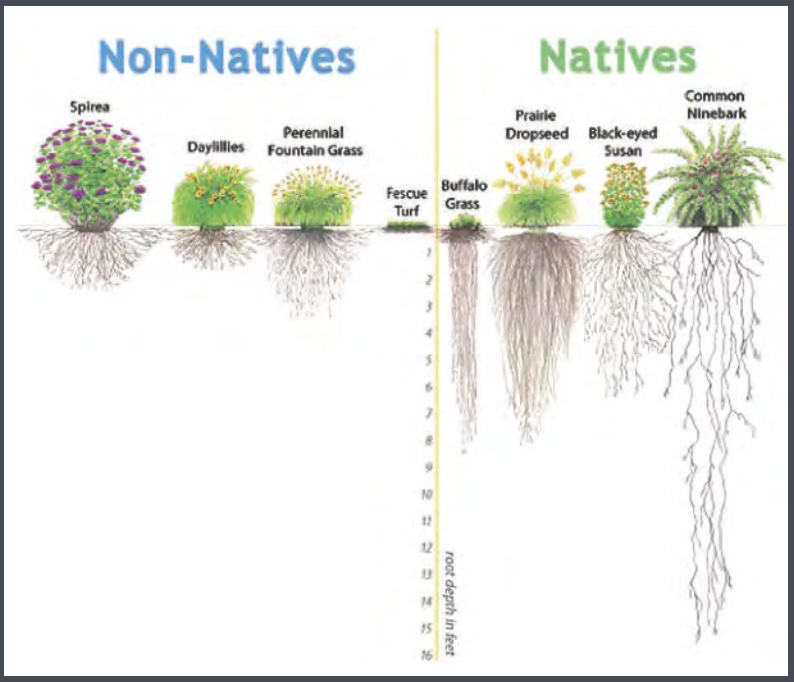
## Limitations to Native and Well-Adapted Plants

- Native plants can appear weedy, especially if relatively tall species are planted in areas where they are out of scale with surrounding plants or the size of the garden, or where plants lodge (flop over) onto adjacent plants or bed areas.
- The more informal "fuzzy" characteristic of native plants, when compared to more traditional, trimmed/sheared landscaping, can generate a visual contrast people may not enjoy.
- Soils in developed landscapes are typically compacted and often lack the organic matter of native soils. Although often very adaptable, native plants placed in "non-native" soils can experience limited planting success without proper management.

As summarized above, consideration and careful management of all three factors – water, soil and plants – are essential for the successful design of a bioretention garden.

### The Importance of Deep Rooting Plants

**Native Plants are not only preferred for bioretention gardens, they are essential for their success. Native plants have roots that extend deep into the soil (up to 15 or more feet). These roots open up the soil pores, improve soil structure and quality, and enhance water infiltration.**




http://www.marc.org/environment/Water/images/roots_diagram.gif

# Designing a Bioretention Garden

**With a better understanding of the benefits and influential factors associated with bioretention gardens, it's time to address the functions of design and construction.** Because bioretention gardens are typically part of commercial developments or larger public properties, planning and design of them should begin as early in the development process as possible. Once site characteristics have been well-documented, and a suitable location for the garden has been determined, the actual designing can begin. Keep two key design concepts in mind as you begin design: Low Impact Development (LID) and garden form and character.

## Low Impact Development (LID)

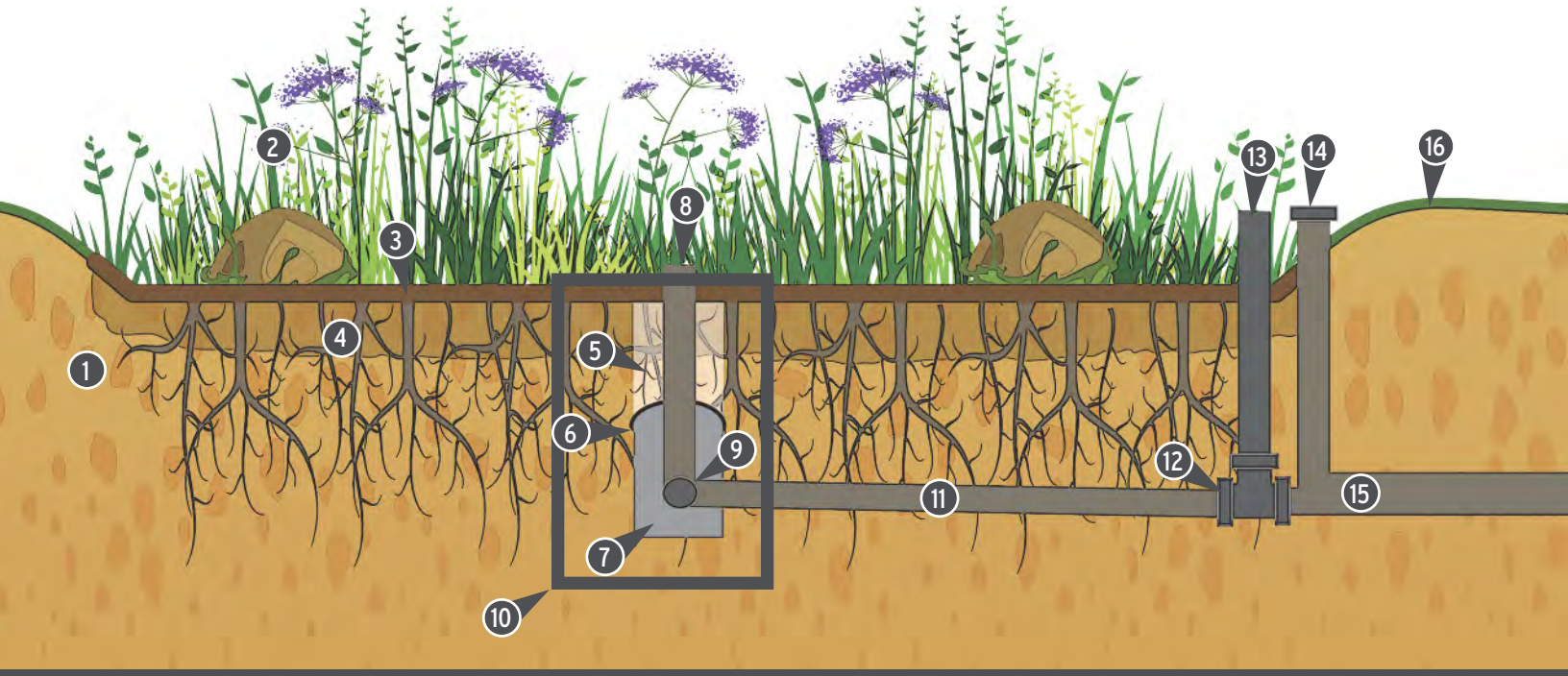
Low Impact Development (LID), a subset of Green Infrastructure, is an approach to land development (or re-development) that works with the local environment to manage stormwater as close to its source as possible. LID preserves and/or creates natural landscape features and practices that mimic natural processes, and as a result, effectively manages stormwater as a resource rather than a waste product.

Other types of LID practices other than bioretention gardens include green roofs, bioswales, rain barrels, and permeable pavements to name a few. By implementing LID principles and practices, water can be managed in a way that reduces the impact of built areas on the environment while providing numerous additional benefits.

Steve Rodie

Andy Scatko

## Components of a Bioretention Garden



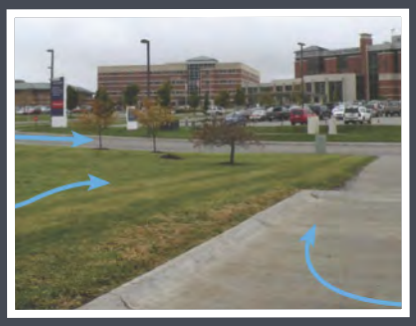

1. **Native Soil** - The existing soil on-site
2. **Native and Adaptive Plants** - Plants that are well-adapted to our climate
3. **Mulch** -Shredded hardwood mulch used to hold weeds down and moisture in
4. **Conditioned Soil** - As needed, compost is blended into the soil to help promote healthy plants
5. **Bioretention Soil Mix (BSM)** - A blend of fine sand and compost to support plant growth and infiltration downward
6. **Separation Layer** - Lightweight, open weave geotextile or equivalent that prevents soil from moving into the drainage rock
7. **Drainage Aggregate Layer** - Washed rock that allows water to enter the perforated underdrain
8. **Underdrain Cleanout** - Access to the underdrain to allow for maintenance if needed
9. **Perforated Underdrain** - Drain tile that collects filtered water
10. **Infiltration Cell** - Sized to allow stored water across the system to filter through in 24 hours
11. **Sloped Underdrain** - Solid drain tile that conveys excess water out of the system
12. **Valve** - Used to control the rate of flow out of the underdrain
13. **Riser Pipe** - Gives access to the valve to adjust the flow out of the system
14. **High Flow Structure** - Sized to allow large rain events to enter and flow into the storm drain pipe
15. **Storm Drain Pipe** - Conveys excess flows safely off-site
16. **Overflow** - As the system will always reach a point where it is full, this conveys the excess water to a controlled, desirable location

## Garden Form and Character

Traditionally accepted landscape attributes tend to focus on a formal and manicured appearance that require significant water, fertilizer, chemicals, and maintenance. Bioretention gardens are often described as being "fuzzy" looking due to the characteristics of the native plants and their layout. To accomplish a more manicured look, bioretention gardens can be designed with formal straight edges and planting patterns. They can also be kept neatly trimmed and deadheaded. However, these treatments can minimize some of the benefits of installing a bioretention garden. This doesn't necessarily mean that constructing a formal bioretention garden isn't possible, but careful consideration should be given so the garden and the surrounding landscape complement each other and don't clash. Two Strategies for Public Acceptance of Naturalistic Landscapes:

- **Intellectual Care** - To instill a deeper appreciation and acceptance of bioretention gardens, use signage or other strategies to educate property owners and passersby.
- **Vivid Care** – Blend elements of the adjoining landscape into the bioretention garden and vice versa. This will help unify the overall landscape aesthetic. In addition, when the entire landscape has a "fuzzy" appearance, consider a simple mowed or defined bed edge around the garden to indicate that it is being maintained and is supposed to look "fuzzy".

  *(Nassauer, J. (1997). Placing nature: culture and landscape ecology. Island Press.)*



Lisa Ulrich

## Steps for Designing a Successful Bioretention Garden

### 1. Choose a Location

"Location, location, location." Just as in real estate, the location of bioretention gardens is very important to its success. Water drainage is the primary factor for determining locations suitable for bioretention gardens as soils and plants can be easily adapted as needed.

The first step to understanding how stormwater will travel is to use the existing topography of the proposed location to identify its drainage areas. Water will drain to a point from all surrounding

Andy Szatko

### A Required Plan

**For most new developments or redevelopments, the City of Omaha, as part Papillion Creek Watershed Partnership, requires a Post Construction Stormwater Management Plan (PCSMP). The PCSMP includes the use of best management practices (BMP's) to address water quality and water quantity changes associated with development. Bioretention gardens are considered water quality BMP's, although depending on the size of the development, they may be able to store additional volumes associated with larger rain events.**

---

### The Math

**The first 0.5 inch of runoff will generate:**

- **1,815 cubic feet of water for one acre of area**
- **42 cubic feet of water for every 1,000 square feet of area**
- **4.2 cubic feet of water for every 100 square feet of area**

ground of higher elevation, so it's important to remember that drainage may come from adjoining properties and not just from your area of interest. Consider the full built-out condition of the contributing area around the bioretention garden to ensure it performs well as those areas are developed.

Bioretention gardens can be sized for a wide range of drainage areas, but the benefits and limitations of each location need to be considered. Small drainage areas only treat a limited quantity of stormwater and can add expense when they don't take advantage of economies of scale. It is generally accepted that keeping drainage areas small and incorporating multiple bioretention gardens will provide greater flexibility and versatility in choosing potential locations. Large drainage areas require large bioretention gardens that can be difficult to fit within a site. It is important to realize that the drainage area and available space will play a significant role in the bioretention garden size and location.

## 2. Determining the Size

There are a variety of ordinances across the country that require meeting certain sizing specifications, commonly referred to as the Water Quality Capture Volume (WQCV). The City of Omaha's post-construction stormwater ordinance defines the WQCV as a minimum one-half inch of runoff from the project area, regardless of the land use. When a project area is a defined area, there may be additional contributing areas that drain to the bioretention garden. To meet this ordinance, it is not necessary to include these outside areas when sizing the bioretention garden, but the additional runoff must be considered to make sure the designed garden is successful. Whenever possible, try to size the bioretention garden to capture one-half inch from the entire contributing area.

To determine the volume of one-half inch of stormwater runoff flowing to the bioretention garden, calculate the entire contributing area in square feet. Make sure you have accounted for any connected drainage pipes, culverts and roof downspouts. To determine the volume of one-half inch of runoff in cubic feet, divide the drainage area in square feet by 24.

Generally, bioretention gardens are sized to a depth of one foot, but will vary depending on available space, client desires, surrounding features, etc. Assuming a depth of one foot, the volume in cubic-feet will be approximately the same as the area measured in square feet. You can now determine if this size will fit into your potential location. If your area is too small, consider modifying storage depth or breaking it up into smaller bioretention gardens across the site.

## 3. Garden shape

The shape of the bioretention garden is chosen based on its location and what is pleasing to both the designer and property owner. Curves are good design element when considering the flow of bed lines and the plant groupings popular in many commercial, public, and residential landscapes. Garden edges adjacent to curb lines or paved surfaces generally are more appealing when they are straight or mimic those surfaces.

When designing a garden on or near slopes, keep the ratio of length to width at least 2:1, with the longer side running perpendicular to the slope where water enters the garden. This orientation maximizes the amount of water the garden can intercept and hold. A well-proportioned garden is typically easier to level than a long narrow garden, especially on a sloped site. As a rule-of-thumb, the garden width should not exceed 15 feet when placed on a slope of eight percent or greater. This will ensure the bioretention garden won't become too deep. If more width is needed on a steep slope, a series of stepped gardens can be designed to fit the slope while keeping the garden width at the proper proportion to the required garden depth.

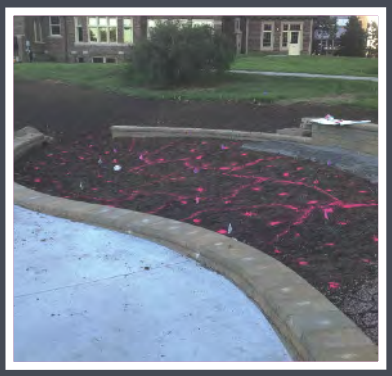
Regardless of garden shape or size, the landscape context should be considered. Extending plantings onto berms and beyond the physical limits of the bioretention garden will visually tie the garden into the surrounding landscape, and reduce the maintenance of leftover hardtop landscape areas.

Ted Hartsig

*Median in Country Club Neighborhood in Fall - Omaha*

Ted Hartsig

*Under the Sink in early Summer, 120th north of F Street*



Ted Hartsig

*UNO Welcome Center plants being laid out for planting*

Andy Szatko

*Creighton Prep infiltration cell construction*

Andy Szatko

*58th and Maple underdrain being installed*

Andy Szatko

*58th and Maple infiltration cell completed*

## 4. Size and Design the Infiltration Cell

The infiltration cell is where the water drains to the underdrain system and continues to slowly drain to a determined location. The size of the infiltration cell is based on allowing the full design volume to drain from the surface within 24 hours.

A Bioretention Soil Mix (BSM) is used in the infiltration cell to facilitate drainage into the underdrain system. A wide variety of BSMs are used across the country. Locally, it is commonly a mix of fine sand and compost, with typical compost amounts between 10-20% by volume. This BSM drains rapidly and retains sufficient moisture and nutrients to support plant growth. The infiltration rate for a BSM of 80% fine sand and 20% compost will typically be at least ten inches per hour. Using this rate for calculations, you can figure that in a 24-hour period 20 cubic feet of water will infiltrate through the BSM for every square foot of infiltration cell area. Therefore, the minimum size of the infiltration cell would occupy an area approximately equal to one-twentieth of the detention volume of the garden.

The small footprint for the infiltration cell this produces is problematic because it can easily be clogged by incoming sediment or minor imperfections. Final grading could result in pockets of water that cannot drain out of the cell. To ensure water from across the garden can drain and the potential for clogging is minimized, the infiltration cell should extend 90% across the bottom of the garden and with a minimum width of 12 inches. Calculate the size of the infiltration cell with these specifications. As long as it is greater than the minimum calculated size, the bioretention garden will drain. The larger the infiltration cell, the faster water will drain through the garden, so a valve or outflow control device will be needed.

The goal of a bioretention garden is to capture stormwater runoff, let it soak into the ground, and slowly release excess water over 24 hours. Having a valve or outflow control device on the underdrain gives ultimate control to manage flows leaving the garden over its life. A valve should be placed between the infiltration cell and the discharge point, with access to the valve preferably outside of the bioretention garden to allow for access when water is being stored. Common types of valves that perform well include slide-gates and curb-stops. A valve also allows for draw down for repairs or work in the garden during wet times of the year and for monitoring efforts to assess its performance.

The fine details of the infiltration cell can play a significant role in its performance. Recent monitoring efforts and experience with bioretention garden performance have reinforced this. These details are described below:

- Drainage aggregate used must be washed. Aggregate with significant fines or dirt can easily clog the underdrain and reduce effluent water quality.
- The drainage aggregate, at a minimum, should be four inches thick on all sides. A sleeve on the underdrain pipe is not recommended.
- Recycled concrete should not be used as drainage aggregate surrounding the underdrain.
- Perforations on underdrain – slotted underdrain pipes have been observed to clog easily, especially given a drainage aggregate that is not washed. It is recommended to use small diameter perforations on the bottom of the underdrain to minimize clogging.
- Underdrain material – It can be difficult to achieve a consistent, even slope when using flexible, corrugated pipe. Smooth walled, rigid pipe is recommended.
- Slope – the underdrain may have a 0.5% slope out of the garden.
- Clean-outs – are vertical risers that allow access to the underdrain for maintenance. Place clean-outs, at terminal ends of the underdrain and extend them above the surface of the garden. Do not install drainage rock around risers. Pipe used should be solid, have a threaded cap, and extend above the surface for access.
- Leak prevention – on the underdrain and on any utilities that cross the garden, an anti-seep collar is recommended to minimize water flowing around them, possibly towards structures.
- Geotextile – the use of geotextile is debated, but if used to separate the BSM from the drainage aggregate, ensure that it is arched upward and not flat in the profile of the cell. Geotextile has been observed to clog rapidly when laid flat over the drainage aggregate. Also use a light and open weave material and avoid thick, tight ones. Choking layers of different-sized aggregates is an alternative to using geotextile.
- Internal water storage – extending the drainage aggregate under the underdrain or install an upturned elbow creates storage where more volume can be stored. This also creates an anaerobic zone that promotes denitrification and improves effluent water quality. (See detail on page 26.)

In the past, Omaha recommended a 50 percent compost and 50 percent fine sand BMS, but recent research has indicated that BSM with a large percentage of compost can leach nutrients, such as nitrogen and phosphorous, particularly right after installation. Unlike traditional bioretention garden designs with BSM extending across the entire garden and up to four feet deep, the infiltration cell has a limited footprint and depth associated with it, and as a result has substantially lower amounts of total compost than traditional

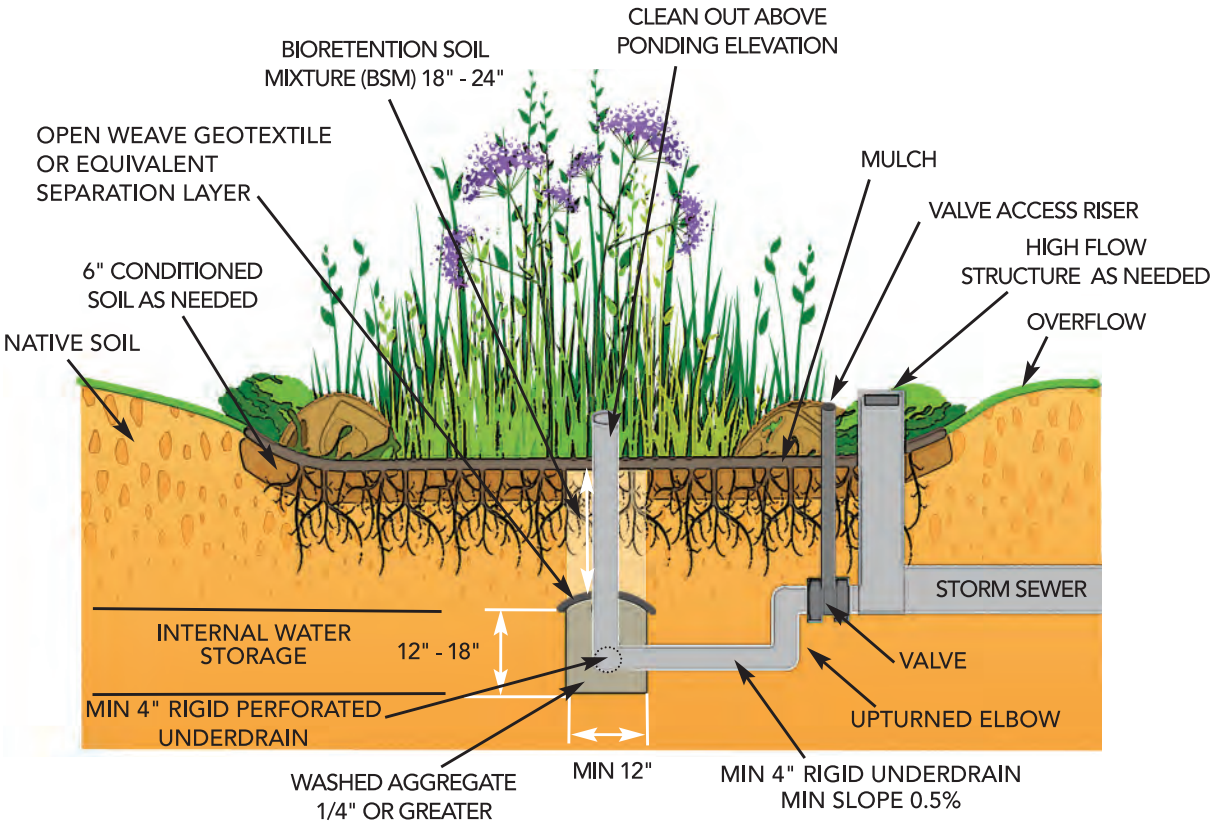
bioretention designs, reducing the potential for leaching. Monitoring and research efforts regionally and nationally are focusing these water quality aspects of bioretention performance. It is expected that bioretention gardens will evolve over time to adapt to these efforts and continue to provide beautiful, functional amenities to the local environment.

### Additional sizing considerations:

- Additional storage as part of the WQCV can be considered in the pore space of the infiltration cell. Multiply the volume of the infiltration cell by 20% to determine the approximate amount of space within the cell that is available for water storage.
- Bioretention gardens with a functioning underdrain will be able to drain within 24 hours. Because of this, the garden can be deeper and take up less space but still hold the same WQCV. Maximum ponded water depths in a bioretention garden should be based on what plants will tolerate, but in general should not exceed an average depth of two feet.

A detailed worksheet to walk you through the calculation process for sizing your bioretention garden is provided on page 28.

## Bioretention Garden - Upturned Elbow Detail



# Soil Management: Amended Soils and Native Soils


Andy Szatko


Andy Szatko


Jennifer McIntyre

Bioretention gardens are distinguished from rain gardens by their size and because bioretention gardens use amended soils and an underdrain to ensure the garden drains within 24 hours. Undisturbed, natural landscapes manage stormwater very well because of deep, thick roots opening macropores, which provide rapid infiltration of water into the soil. This takes time, however. Amended soils, typically dominated by sand and organic matter, readily facilitate infiltration of water into the bioretention garden, allowing it to achieve its function right away after construction.

Native soils remain an important part of the bioretention garden and are expected to both support the garden's plant life and promote infiltration of detained stormwater into the native soil. It is important that the native soil in the bioretention garden be of sufficient quality to achieve these functions. Sufficient quality means:

- Top soil should include approximately three to ten percent organic matter, a friable structure that is easily broken, and be at least two or more inches deep.
- The subsoil layers are not compacted and have generally good structure that is broken with little effort. The subsoil just below the topsoil layer should also have a reasonable amount of organic matter.
- The soil should be deep – at least three feet or more to rocky or slowly permeable layers. This condition is not difficult to find in the Omaha area.

It is also important to recognize the value of soil's organic matter, which provides the fuel for supporting soil microbial populations that are critical to the health and vigor of plants. Soil microbes – particularly fungi – help transport water and nutrients to plant roots to help them grow into stronger, healthier plants. Without sufficient organic matter, plants will suffer and take much longer to become established and healthy.

# Bioretention Sizing Worksheet

| | | |
|---|---|---|
| Designer: | Checked By: | Company: |
| Date: | Project: | Location: |

## Water Quality Capture Volume

**Step 1 - Contributing area to bioretention garden, $A_{ca}(sf^2)$** — **$A_{ca}(sf^2)$ =**

**Step 2 - Calculate the WQCV** — **$WQCV(ft^3)$ =**

$A_{ca}$*.5in*1/12 in = WQCV ($ft^3$)

## Infiltration Cell and Ponding Area

**Step 1 - Average ponding depth, $h_{avg}$ (ft)** — **$h_{avg}$ (ft) =**

$h_{avg}$ should be between .25 feet and 1.0 feet

**Step 2 - Required Ponding Area, $A_p$ ($ft^2$)** — **$A_p$ ($ft^2$) =**

$A_p$=WQCV/ $h_{avg}$

**Step 3 - Coefficient of permeability for infiltration cell, k(ft/day)** — **k (ft/day) =**

*Note: Using an 80% sand, 20% compost BSM, assume k = 10 ft/d*

**Step 4 - Infiltration cell depth, $d_{cell}$(ft)** — **$d_{cell}$(ft) =**

$d_{cell}$ should be between 1.5 feet and 3.0 feet

**Step 5 - Time required for WQCV to filter through the infiltration cell, $t_f$(days)** — **$t_f$ (days) =**

$t_f$ 1 day recommended, 2 day maximum

**Step 6 - Required infiltration cell surface area, $A_{min}$ ($ft^2$)** — **$A_{min}$ ($ft^2$) =**

$A_{min}$=WQCV / k*$t_f$

**Step 7 - Determine longest dimension of ponding area** — **$L_p$ (ft) =**

**Step 8 - Determine length of infiltration cell, $L_{cell}$ (ft)** — **$L_{cell}$ (ft) =**

$L_{cel}$ = 0.9 * $L_p$

**Step 9 - Determine width of infiltration cell** — **$w_{cell}$ (ft) =**

Minimum width of 1.0 feet

**Step 10 - Determine designed infiltration cell surface area** — **$A_{cell}$ =**

$L_{cell}$ * $w_{cell}$

**Step 11 - Infiltration cell volume ($V_{cell}$)** — **$V_{cell}$ ($ft^3$) =**

$V_{cell}$ = $A_{cell}$ * $d_{cell}$

# Keeping It All Together

Generally, people prefer a neat and tidy landscape. Research of natural settings has shown that preferred landscapes are most often those that make sense to the viewer and appear to have structure (Kaplan, R. et. al., 1998 ). This may explain why landscapes that use native plants are sometimes not utilized, especially if the plants are randomly mixed and placed in an otherwise manicured landscape. Helping viewers to look beyond the "fuzziness" of a native landscape to its diversity, habitat value and subtle beauty is important in successful garden acceptance. Helpful strategies may include:

- Grouping similar kinds of plants, using fewer varieties overall, and repeating masses that help unify the landscape character.
- Using flowering plants where practical, but acknowledge the wide variety and timeframe of seed heads that can visually range from "weedy" to very attractive. Sedges, rushes and grasses, may be more visually acceptable in some applications due to their more consistent grass-like texture through multiple seasons.
- Mix shrubs, grasses, sedges and flowers in patterns, making sure that garden edges are visually well-defined for a stronger structure and simpler maintenance.
- Spreading out plants so the mulch layer is more visible as a unifying ground texture to avoid an over-planted look. Although this "clean" look may be preferred by some, the open areas are more prone to weed development and mulch movement when the garden fills with runoff.
- Keeping plant heights scaled proportionally to the size of the garden and the height of the garden surroundings. Also use a low groundcover plant consistently around the garden edge to unify the character even when using a wide variety of other species.

Steve Rodie

Steve Rodie

*Massing of plants across large project areas creates a sense of order and character, often resulting in greater public acceptance. Left: Orchard Park Right: Creighton Prep*

Andy Szatko

*Flagstone pre-treatment with V-notch weirs in Saddle Hills Neighborhood*

Andy Szatko

*Stainless steel 'curb-well' in Florence Streetscape*

Andy Szatko

*Soft weirs at Under the Sink*

## 5. Directing water in and out of the garden

All bioretention gardens must have a designated inlet and outlet. This fundamental design consideration addresses how water will enter, exit, and/or bypass your garden.

All of the drainage areas incorporated into the garden design should have a pathway directing it into the bioretention garden. This may require minor grading, curb cuts or underground pipes. Use caution in assuming drainage patterns where slopes are minimal. It doesn't take much to alter flow pattern, especially on pavement. If the curb cut doesn't go deep enough, it can be enough to push flows right past it, especially during lower intensity rain events. Also, practices that keep water flowing on vegetated surfaces can improve filtering of runoff, increase infiltration and provide simpler maintenance.

**Pre-treatment:** There are a variety of designs, but in general pre-treatment is a depression or structure that allows sediment and other debris to filter out of the runoff before entering the bioretention garden. Some examples include a vegetated forebay or swale, shallow sump structures, and baffles. Pre-treatment will also slow the velocity of water as it enters a bioretention garden, protecting the garden from erosion damage.

**Inlets:** Inlet design has three main characteristics: size, location, and energy dissipation. The size of the inlet will dictate how much water can flow into the garden. If it is too small, water could back up or bypass the garden. If sized too large, it could unnecessarily raise costs or pose maintenance issues in and around the garden. Location of the inlet should be placed where it will intercept the greatest amount of water from the contributing area. This is especially important when working in flat areas where slopes change slightly over the course of construction.

Energy dissipation is essential for the success of the garden. When water enters through a pipe or swale, it has significant speed that will easily erode the garden and shift mulch around. Energy dissipation is usually incorporated into the pre-treatment of the garden, but can take a variety of shapes. Common examples include cobble stone or rip rap, vegetation reinforcement mats, or sump structures.

**Outlets:** It is important that the design for your bioretention garden provides an avenue for excess water to escape or bypass the garden. If water is constantly flowing through the bioretention garden, it is considered an **inline system**. If water bypasses the garden once it has reached capacity, it is considered an **offline system**. Outlet structures must be designed to safely pass the two-year, 24-hour storm if it is designed as an inline bioretention garden. These structures, such as soft weirs or high-flow structures, will direct overflow water to a preferred flow path that will deter erosion, flooding, or other problems that may occur from too much runoff.

Excess stormwater runoff can also be diverted away from the garden instead of actively flowing through it, thereby creating an offline bioretention garden. This can be accomplished by creating backwater conditions that prevent runoff from entering once a certain ponding elevation has been achieved. This approach can minimize the stress on plants, reduce mulch displacement, and provide the ability to block flows completely from entering and allowing maintenance operations to occur. This could also be useful during construction as flows can be diverted away from the garden until construction is complete or plants are established.

Efforts to limit the amount of flow out of the bioretention garden during the two-year, 24-hour storm event may serve as a guideline for sizing your outlet structure. Simple calculations using the approach discussed in Chapter 2 of the Omaha Regional Stormwater Design Manual can be performed to determine the existing peak flow from your garden's drainage area. Having determined this target flow, the area available for water to exit the garden may be selected to match this flow rate.

For example, if your existing two-year peak discharge is 1.5 cubic-foot-per-second (cfs), you might select a pipe outlet that is six inches in diameter (assuming an average velocity through the pipe of eight feet per second) based on the equation:

**Q=vA, where v is the average velocity (ft/sec) and A is the cross sectional area (ft2)**

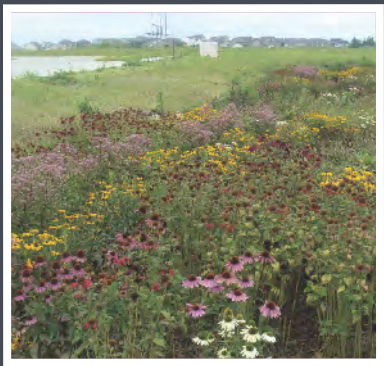
*Non-pipe or more complicated outlets can use Manning's Equation and the procedures found in Chapter 5 of the Omaha Regional Stormwater Design Manual to estimate velocity.*

Under no conditions should bioretention gardens be subjected to detained water greater than what the selected plants can handle. Remember, a post-construction stormwater management plan is usually comprised of several components all working together to treat the WQCV and maintain the two-year peak flow. Individual bioretention gardens can be easily modeled to determine their effect on the two-year peak flow, but they are often part of a system to manage stormwater across a site.

Similar to inlet energy dissipation, the potential for erosion due to water velocities over three feet per second is an important design consideration. Selected vegetation, inlet/outlet slope, and size must be designed in accordance with the open-channel design guidance found in Chapter 5 of the Omaha Regional Stormwater Design Manual. All other outlet types, such as concrete or sheet pile, must be adequately designed to protect the garden and receiving drainage ways or streams from erosion.

### Not Too Many, Not too Few

**By limiting the number of plant species in the bioretention garden relative to it's size, you can highlight the selected species and provide more order to the garden structure.**



Andy Szatko

Andy Szatko

## 6. Create the planting plan

A native plant is defined as a plant species that lives or grows naturally in a particular region without direct or indirect human intervention (Lady Bird Johnson Wildflower Center, 2009). Most plants considered native to a particular location or habitat have been around for centuries. Over time, plants can alter their natural range due to changes in climate, land use, and other factors. Plants native to a location or setting do not necessarily grow in all areas within the defined location. Instead they adapt and adjust to the conditions best suited for their long-term survival.

The most important thing about native plants is the value they bring to garden function and beauty. Native plants thrive because of deep rooting that enhances soil infiltration, habitat value, and a local sense of place. Many adapted non-native plants also can thrive, although the ultimate combined value of adapted plants is not as well documented as native ones.

This manual presents a wide variety of plants that have proven to be reliable choices for planting in gardens throughout the region. The tables and plant summaries found in the Appendix provide specific information for each plant, helping you choose plants that best respond to various environmental conditions. Using this information and communicating it to the property owner will aid in the success of the bioretention garden

## Plant Selection and Placement

Proper plant selection is key. Use the following principles to ensure that the bioretention garden is beautiful for many years to come.

- Preferences and tolerances for soil moisture, sun exposure, soil texture, and pollutants
- Aesthetic characteristics: foliage, form, and multi-season interest
- Habitat value
- Plant height
- Plant scale

## Preferences and Tolerances

Select plants for their preferred - or at least tolerated conditions. Since garden conditions can vary dramatically between locations, seasons and over time, plants that will adapt to change will perform best. For example, selecting plants for bioretention gardens solely on a preference for wet conditions will likely lead to poor plant health or even failure when gardens experience weeks of drought - not an uncommon occurrence in Omaha. The following factors are noted for all plants in the back of the manual, using this information will help create a successful, long-term garden.

**Soil moisture** – Plant species that tolerate wet soil conditions and inundation for short periods of time should be placed at the bottom of the garden. Species that tolerate or prefer dry conditions should be placed on berms and the landscape surrounding the garden. Plants that are best suited to average soil moisture conditions are best placed on garden sides.

**Sun/shade** – Many plants require much more sun than shade. Few plants prefer full dense shade and the ones that do typically come from a woodland origin. Among regionally native plants, full-sun types are typically prairie species that require six hours of direct sunlight each day. Some prairie species, especially those that remain short and grow under the tall prairie grasses, will tolerate partial shade conditions. Most plants require at least a couple hours of filtered, early, or afternoon sun for flowering and quality vegetation. Morning sun is often preferred by plants. Shade in the afternoon can minimize heat or full-sun damage to plants that are not adapted to harsh, dry conditions.

**Soil texture and structure** – These soil characteristics greatly influence plant health and vigor. Many plant species are adaptable to average soil textures, such as silt loam, found in Omaha. However, many post-construction soils that have poor structure will be more of a problem for plants than texture tolerance, since all plants will struggle in soils devoid of pore spaces.

Steve Rodie

Steve Rodie


Steve Rodie


Steve Rodie


Steve Rodie


Steve Rodie

**Chemicals and salt** – Many gardens are used to filter runoff from paved surfaces. Salt, oil, grease, pesticides and fertilizers can all be washed into gardens. Salt use in the winter can be significant and in areas receiving runoff from roads and parking lots, plants that are salt tolerant should be used.

## Aesthetic Characteristics

The most common plants for bioretention gardens are those that flower. They are chosen because of their size, color, and smell. Although these factors are very important for overall garden visual appeal, there are a variety of other characteristics to consider in the selection process, including:

- **Foliage texture and color** – Flowers can be striking, but tend to last a relatively short time. Foliage texture (coarse-large leaves vs. fine-small leaves) tends to be an underappreciated component of plant selection. Contrasts between textures provide aesthetic value to a garden. Colored foliage may last the entire growing season. It should be used to accent garden areas or focus views. Fall color changes, although more limited in time, are a heralded component of the fall season. Many perennials and grasses (geranium and little bluestem, for example) exhibit dramatic fall color changes that rival many woody plants.

- **Form** – Selecting plants for specific forms or shapes can have a dramatic affect on garden character. Form varies from upright (feather reedgrass and gayfeather) to vase-shaped or arching (butterfly bush) to flat and layered (low sedges and purple poppy mallow).

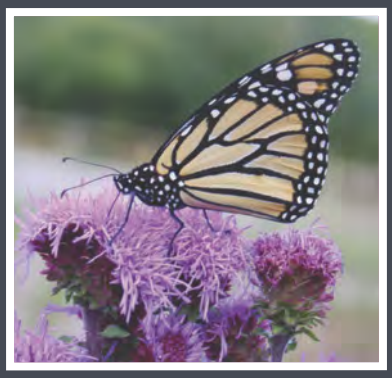
- **Multi-Season Interest** – When possible, select plants that have long-lasting visual appeal. Some plants have relatively long flowering periods (spiderwort) or follow flowering with highly ornamental fruit (dwarf false indigo). Attractive fruit or seeds/seed heads that persist all winter (many grasses, asters, goldenrods and sedums) extend garden beauty through the entire winter while providing habitat value. Also, consider plants that hold their foliage well and retain

their foliage along the full height of the plant so they don't appear leggy or weedy. Plants with poor or lost foliage may be successfully mixed with other plants to hide bare stems as the growing season progresses.

## Habitat Value

Bioretention gardens offer an added benefit by providing habitat value for butterflies, birds, and insects that fill important roles in regional ecology. Native plants are particularly valuable in this role, and when adapted, can also be utilized as food sources and cover. Cardinal flower and blue lobelia attracts hummingbirds, while coneflowers bring in finches. A wide variety of butterflies are drawn in by gayfeather, asters, and milkweed.

Steve Rodie



Steve Rodie

## Plant Heights

When determining plant heights, the major viewpoints of the garden should be taken into account. A garden that is viewed from all directions will look and function best with the tall plants in the middle and shorter plants towards the edges. The tallest plants may be placed in the center of the garden for a more symmetrical look. If the garden is large enough, they may be placed in multiple locations to create a vertical rhythm of varying heights in the garden center.

Gardens that are viewed from one side only should have the majority of the taller plants towards the rear of the garden. Taller plants may be placed closer to the garden middle to create additional interest. Use a range of medium to short plants to fill in the middle and front of the garden. Occasionally placing a taller plant in front of shorter plants can create interest without blocking garden views.

## Plant Scale

It is crucial to select plants that fit the physical and visual parameters of the garden. One of the most important elements is plant height relative to your garden area. Plants that grow too tall for a garden will be out of scale in a small garden. Some flower species and many grasses tend to flop over when mature or when grown in moisture-rich soil. Plants that grow very wide and take up significant garden space are not appropriate for a small garden as it can look overgrown and can limit the overall variety of plants. For small and medium-sized

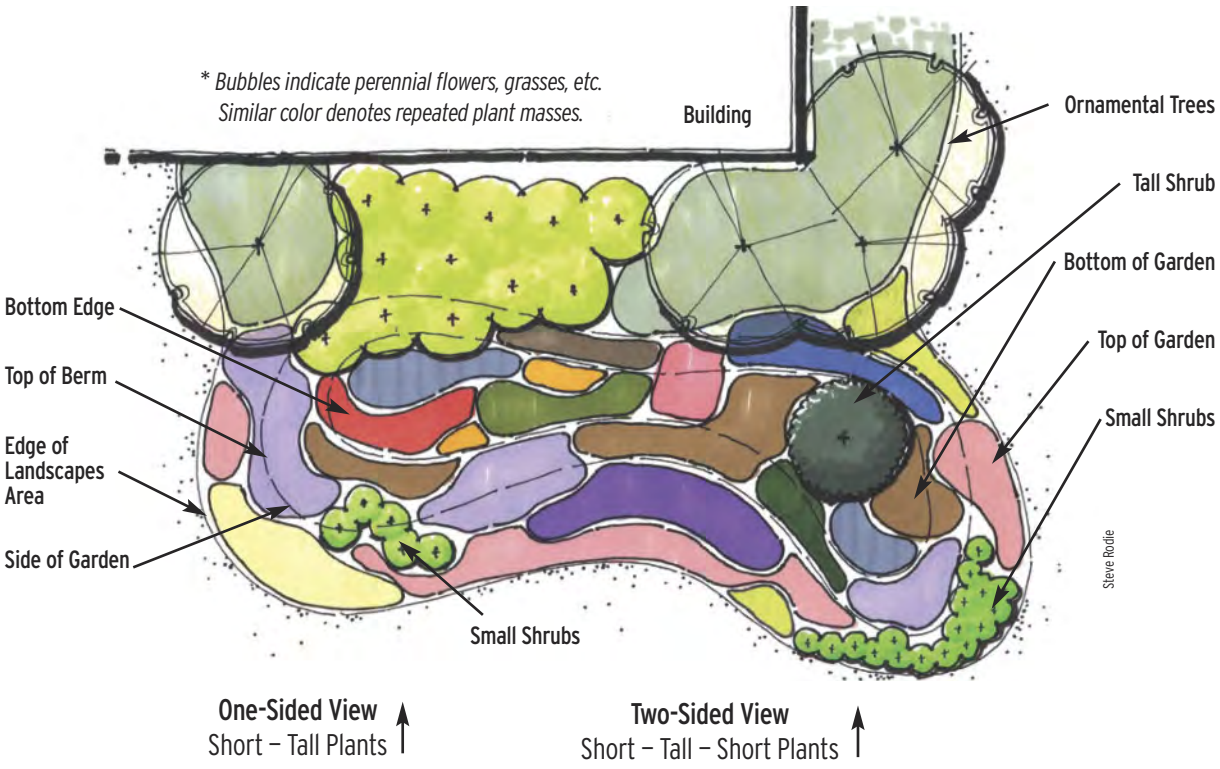
gardens, limiting plants to three to four feet in height will minimize the potential weedy character associated with tall plants. In larger gardens and in gardens that have a tall backdrop (in front of a tall retaining wall, for example), taller plants may be warranted. In these situations, locate tall plants in the middle or back of the garden, and surround them with medium-sized plants to visually integrate them into the garden as well as structurally support them so that flopping problems are reduced.

## Basic Design Principles

While proper plant selection is key, using solid design principles will ensure that the bioretention garden is beautiful for many years to come. Here is a list of those principles.

- Massing
- Garden composition
- Repetition
- Accent and focus
- Plant types

The design below summarizes many of the basic design principles, including plant massing, "lacing" plant masses together, repeated use of selected plants, planting for context beyond the top of the berm, and locating plants to coincide with specific soil conditions.



## Plant Mass

Many garden plants look best if planted in masses. Consider the following guidelines:

- Limit the number of species of plants used in the garden. This will help simplify maintenance and create clean lines as they fill in over time.
- Select a variety of plants with contrasting textures, sizes, bloom colors and timing. This creates a strong visual interest throughout all seasons.
- Consider the mature size of the plant and space them appropriately. Provide adequate space for plants that sucker or spread easily by seed and limit their placement adjacent to plants that are easily overwhelmed.

## Garden Composition

Garden composition should highlight the aesthetic qualities of individual and grouped plants, and should strengthen the overall design theme. Plants which have unique forms (weeping or strongly irregular, for example) are best planted individually so the form can be appreciated. Plants with an upright or rounded form can be grouped effectively. In some cases, the plant groupings exhibit textures and shapes far more interesting than if plants are positioned as individuals.

Formal designs are strengthened by masses with relatively straight and/or strictly proportioned shapes and masses that are butted together. Informal designs are reinforced with masses that are laced together. Additionally, plantings are strengthened when plant masses are varied in their width and contain curves along their length.

Andy Szatko

*Palm Sedge at inlet*

Andy Szatko

*Karl Foerster Reed Grass with Arctic Fire Dogwood*

Andy Szatko

*Seeded native grass and forbs in bioswale*

### Repetition

If only one principle in this list is followed, it should be repetition. Repeating plants as individuals or masses, or repeating specific visual plant characteristics within a garden is a simple principle, but it helps to:

- Visually unify the garden.
- Heighten the accent potential for unique plants with less competition between variable colors, textures, etc.
- Lower maintenance variability.

For example, the texture and seasonal color of little bluestem tends to be subtle but can be woven throughout a garden. Or, several different species of gayfeather or iris might be used to vary flower colors and seasonal bloom, while unifying the garden with a consistent upright form or fine leaf texture.

## Accent and Focus

Every garden should combine plants that provide structure, color and interest. But not every plant needs to serve every role, and there should be a sense of accent or focus in specific garden areas. Addressing this principle will enhance the sense of garden unity while attracting viewer attention where it is intended. Although gardens that contain a majority of flowers are typically admired for their dramatic color and variety, a garden that combines one of everything may not appear coherent, and can seem too complex. Structure is also important to creating an accent or focus, and can include evergreen plants (junipers in full sun, yews in shade). Plants such as tall sedums and many grasses can maintain a garden presence through the winter months.

## Plant Types

Small to medium-sized gardens should generally be planted with perennials and grasses. Shrubs can take up a large space in a garden, significantly reducing garden plant variety. Woody shrubs have an important role in gardens that are large enough to incorporate them. They provide year-round structure, and many provide habitat value and multi-season ornamental interest.

Trees are typically not utilized for bioretention gardens for a variety of reasons. Generally, the plants in a bioretention garden require significant sun exposure. As a trees mature, environmental conditions can change significantly and there is only a limited selection of trees tolerant of ponding and that can establish strong root systems around adjacent structures.


WELCOME CENTER

# Constructing the Bioretention Garden

**With the bioretention garden plan in place, it is now time to build it.** As a developer, builder, or contractor the process of moving soil, grading and shaping a site is nothing new. Some of the procedures for building a bioretention garden may be new, however. This chapter addresses the key elements of successful bioretention garden construction.

## Building the Structure of the Bioretention Garden

In site design and landscape construction, the tendency is to build up landscape beds. This results in water running off the landscape rather than soaking into it. With green infrastructure, such as bioretention gardens, the direction gardens are built tends to be downward to allow water to soak in.. As you begin the construction of the bioretention garden, take care to follow these steps:

1. Stake the garden area
2. Excavate the garden and establish final grades
3. Condition the in-situ soils as needed
4. Install the infiltration cell and high flow structure as needed
5. Install additional features such as pretreatment, curbs, signs, etc.
6. Perform a quality control review of the bioretention garden structure

## 1. Stake the garden area

Staking should include the garden perimeter, grade, pre-treatment and location of the underdrain. Make sure you file a locate request with Nebraska811 at least 2 business days prior to beginning any excavation project to have all the underground utilities marked. Also, check with the property owner to see if there are other private utilities located in the area, including irrigation lines or private gas lines.

Once the garden is staked and utilities marked, develop your plan for access into and through the site to avoid unnecessary compaction of the soil and make the project easier to complete.

## 2. Excavate the garden and establish final grades

Use light excavation equipment that is easy to maneuver in tight places and doesn't exert too much force or weight onto the soil during the placement and removal of excavated soils and debris. Work from the inside of the bioretention garden toward the outside. Once the bioretention garden is excavated, limit traffic into and through it to avoid compaction.

## Step-by-Step Guide

Ted Hartsig

*Stake bioretention garden prior to excavation.*


Ted Hartsig

*During excavation, check depths, slopes, and avoid soil compaction.*

Ted Hartsig

*When excavation and soil placement is complete, begin soil preparation for planting.*

Ted Hartsig

*Use marking paint to define planting boundaries.*

Ted Hartsig

*Erosion control and maintenance is essential during and after planting.*

Ted Hartsig

*First year maintenance assures aesthetic and functional performance.*

Avoid compaction of the adjacent soils and vegetation. The project becomes much easier when you do not have to restore disturbed areas. Compaction in and around your garden can stress plants, greatly extend the time needed to establish roots, and limit the potential infiltration into the soils.

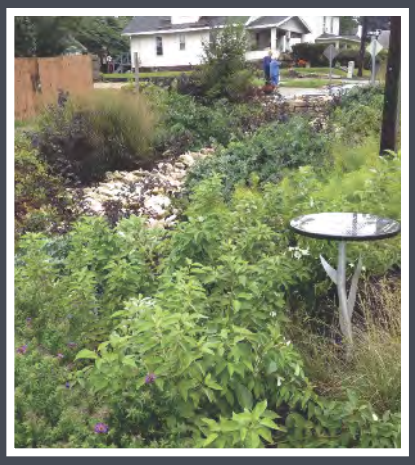
Do not work in the bioretention garden if the soils are saturated as this can result in smearing of soils or excess compaction that limits infiltration into the existing soils. It is highly recommended to keep the bioretention garden offline (keep flows from entering) while under construction. This will significantly improve the installation and reduce time and costs.

## 3. Condition the in-situ soils as needed

A good planting or seedbed will significantly improve the success of bioretention garden plants. Often the soil in development sites has been significantly damaged and/or stripped of its topsoil, resulting in very clayey, often dense and compacted subsoil. Most plants do not establish well in these types of growing environments, allowing weeds to thrive and harm the function and look of the garden.

Soils can vary greatly from site to site, so getting a soil test can provide important insights into your particular site. If you are using native plants, it is not recommended to add fertilizer to the soil. Native plants typically do not need excessive amounts of nutrients. They will obtain most of what they need from the decomposition of organic matter, and adding fertilizer will only promote weed growth. Generally, if the soil is very light brown or yellowish-brown colored, it probably does not have enough organic material. Compost is the most common amendment used to improve soils, so conditioning the soil with compost will be described for this step.

To condition the soil, apply your compost evenly over the garden area, typically 1-2 inches in depth. Avoid slopes greater than 10% as these areas are prone to slough off. Working from the inside and bottom of the bioretention garden, begin to work the compost into the in-situ soil to a minimum depth of 6". Once the compost and soil have been incorporated, take a tile or round-point shovel and randomly dig small potholes in the bottom of the garden, going deeper than the conditioned soil. This is an easy step to take to help promote



Andy Szatko

Andy Szatko

infiltration across the garden because when equipment like a tiller blade hits the in-situ soil, it can smear and create a layer that limits water infiltration below the tilled area. The pot-holing will help to break that smooth layer between the tilled and un-tilled soil and allow for better rooting and infiltration.

## 4. Install the infiltration cell and high flow structure

Install the infiltration cell after soil conditioning has been completed. This avoids issues if the installation crew inadvertently tills across the infiltration cell and blends the BSM with the in-situ soils. With significant clay and silty soils in developed areas, this can greatly reduce infiltration rates and result in a failed system. This has been observed on multiple projects.

Excavate trenches for the underdrain system. Scarify the bottom and sides to help prevent smearing of the soil and promote infiltration. Install the washed aggregate into the trench to the specified depth. Lay out the drain pipe on the aggregate and ensure proper slopes have been established. Install the clean-outs, valve, anti-seep collars, and high flow structure as needed at this time. If there is an upturned elbow, establish and verify joints and elevations. Make certain all joints are tight and sealed, then continue to install aggregate over the drain pipe, and mound the top of it when final elevation has been reached.

If a geotextile separation material is used, use an open weave material and ensure it is arched upward to minimize clogging. Do not return the geotextile up the sides of the trench as this is unnecessary and will restrict water movement. Backfill trenches with the BSM as designed, and make sure proper compaction is achieved to minimize settling. Install protection for the infiltration cell as needed to protect it from sediment deposits that may occur before final planting and mulching occurs.

### Underdrain Placement

Andy Szatko

*Place perforations downward onto drainage rock below*

Andy Szatko

*Mound drainage rock and separation layer upward*

## 5. Install additional features

Features, such as the pre-treatment, curbs, signs, etc., can vary significantly between projects and will depend greatly on site context to determine installation time. Pre-treatment features should be properly protected once installed. If possible, block these features to prevent flows from entering during construction.

## 6. Perform a quality control review of the bioretention garden structure

When all structural components of the bioretention garden have been built, it is a good practice to review them so the garden will operate as designed. Quality control review will help to provide as-built plans for the project, as most projects have changes that occur in the field that would best be remembered if documented.

Bioretention garden success occurs when design and installation teams work together and communicate effectively with one another. Simple details, such as the elevation of a pretreatment system, very often have not been followed and the result is poor capture of runoff and stressing of one part of a garden. Bioretention gardens provide a function just as a sewer pipe or street does – their performance relies on following all details in the plans.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*The 'curb-well' pre-treatment in this project was installed too high, creating backwater conditions that allow flows to bypass the garden, especially in low-flow events. The 'curb-well' should be installed with V-notch weirs or level with the pavement.*

### Tips for Success

- **If possible, design all side slopes in the bioretention garden to be equal to or less than a 3:1 ratio**
- **Try to make the shape of the bioretention garden as natural as possible by contouring the garden into the surrounding landscape.**
- **Minimize the removal and/or re-grading of surrounding soils and landscape to retain as much of the natural landscape and drainage as possible.**
- **Use erosion and sediment control measures to keep sediment from surrounding areas from moving into the BSM. If possible, the bioretention garden should be constructed after other major site work is completed to minimize sedimentation from within the garden.**
- **Don't block the inlet or outlet of the bioretention garden by placing soil or other material in the drainage path.**
- **Be certain that the subsurface drain pipes discharge to a well-drained area away from buildings.**

# Lessons Learned Design and Construction

There are lessons to learn from every design and construction of a bioretention garden. Some items in design and construction that should be noted:

1. Layers of rock, filter fabric, and large underdrain pipe systems that extend across the entire flat bottom of a bioretention garden defeat the purpose of using native plants for promoting infiltration of water deep into the soil. The roots of the native plants will have great difficulty penetrating these layers, which limits the ability of the garden to improve infiltration over time and to provide a suitable environment for plant health. Limiting the footprint of the infiltration cell will allow ample room for plants to establish deep roots into the in-situ soils.
2. The infiltration cell of a bioretention garden is typically filled with a BSM, which can vary greatly per designer and region. In Omaha, Lincoln, and Kansas City, experiences have shown BSM that contains topsoil will generally limit infiltration. The type of topsoil used in the mix is critical as texture can vary greatly between sources. Utilizing a BSM with a high percentage of sand and some compost works very well. Monitoring is ongoing to evaluate various BSM compositions, but currently 80% sand to 20% compost is commonly used.
3. Installation of the infiltration cell should occur last to avoid potential clogging from rain events or construction activities. If the soils around the infiltration cell will be tilled and amended, this should be completed before the infiltration cell's installation.
4. BSMs are being asked to serve many roles in a bioretention garden, including pollutant removal, plant establishment, and flow regulation. The valve on the underdrain is a critical piece that allows flexibility in the design and operation of the bioretention garden. Flow regulation with the valve also provides monitoring and adaptation over time.
5. Placement of the BSM into the infiltration cell should be completed in lifts that are individually compacted. It's important to properly compact the mix so it doesn't settle within a few days and leave a depression in the bioretention garden.

Andy Szatko

*Dirty road gravel with slotted corrugated drainage pipe that clogged rapidly*

Andy Szatko

*In-situ soil high in clay was tilled into the top 2 inches of the infiltration cell, clogging it right away*

# Planting the Bioretention Garden

**No matter how good the design, no matter how well chosen the plants, garden failure can result from improper planting and establishment.** By adhering to correct techniques and procedures, healthy garden establishment can be expected.

## Choosing Plants by Size and Condition

Proper selection of plants was covered in Chapter 3, but it also includes plant size and condition at the time of planting. Project budgets will often dictate a smaller initial plant size, but given establishment costs, maintenance commitments and anticipated visual impacts, the least expensive choice isn't always the best choice.

## Seeding

Seeding can be a cost-effective method for creating large gardens. Refer to the listing of seed sources in Chapter 8 for information about the specific seed mixes available. Seeding has some significant limitations however, including:

- Improper seed bed preparation or lack of pre-planting weed treatments can result in excessive weed growth
- It can be difficult to determine garden plants from weed seedlings
- Plant establishment can occur relatively slowly with seedlings. It takes native plants around one to two years to establish their root structure before they expand foliage and bear flowers or fruit
- Seeds have a very low survival rate if the garden is taking on flows. They can also move easily, creating bare areas and inconsistent plant cover.

If you are using seed, drilling is typically preferred to broadcasting in order to establish good seed-soil contact and minimize seed loss due to water or wind erosion. In either case, purchase seed from a reliable source and use a high-quality pure live seed (PLS). If broadcasting, prepare a firm seedbed with a friable surface, and place or rake the seed evenly into the soil, not more than one-half inch deep. Make sure there is good soil-seed contact by rolling or lightly compacting the soil. Place approximately one inch of straw mulch or erosion mat over the surface to protect against erosion and excess drying. Use caution with straw as weed seeds in the straw can create a significant maintenance problem.

## Sod

Sod provides instant coverage of a bioretention garden and is relatively easy to install. Benefits of using sod include immediate visual effect and soil protection, which limits the potential for erosion. Limitations of sod include having fewer plant choices, slower plant establishment compared to potted plants, and difficult establishment if receiving flows right away. If the garden is receiving flows upon installation, it is recommended to fully open the valve to limit stress on the sod until it is established and tolerant of longer inundation periods. In addition to common turfgrass sod, there are nurseries experimenting with a variety of bioretention garden plants to create a native plant sod. This may be a cost-effective, intermediate step between less expensive seeding and relatively expensive potted plant installation when native and adapted plants are desired over turfgrass.

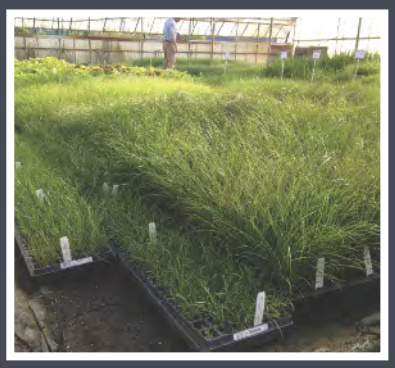
## Potted Plants

Plugs and pots come in a variety of sizes, from deep cell-plugs to more established gallon sized potted plants. Deep cell-plugs, plants in pots shaped deep and narrow to drive root growth downward, are a cost-effective option for live plants. They can significantly enhance early plant health and establishment. In general, larger potted plants provide greater instant aesthetic appeal, are tall enough to limit stresses from initial inundation, and can be more tolerant of irregular irrigation during establishment. Factors to consider when selecting potted plant size include:

- Soil conditions
- Growth rate and vigor of the plant
- Time of year
- Irrigation requirements
- Availability

Small plants are initially more cost effective, but issues like excessive weed growth can quickly arise if proper maintenance is not provided during establishment. Plants should be vigorous with well developed roots that are not root-bound. Root-bound plants may be acceptable if not overgrown in the pot. If root-bound, soil balls should be scored or broken along the edges of the root mass to encourage new rooting during planting.


Steve Rodie


Andy Szatko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## Plant Layout and Spacing

Plant layout and spacing should correspond to specific garden conditions and plant widths as described in the plant tables in the appendix. As in all plant installations, plant locations will need to be adjusted to constructed site dimensions and conditions. Planting density can be tightened for more immediate effect. Overplanting, however, can create plant health or maintenance issues due to overcrowding when plants mature. Planting density can also be decreased for more cost-effective planting, especially when using plants that naturally self-seed or spread through rhizomes. Plants that are spread out too much can lead to mulch displacement, erosion, and excessive weeds. In all cases, an accurately designed planting plan should form the basis for initial plant quantities and for a successful garden.

## Planting, Fertilizing, Initial Watering

Avoid soil compaction when planting and maintaining plants. Methods to minimize compaction include:

- Planting in the middle of the garden and working toward the edges
- Keeping equipment/foot traffic on planks, plywood or other support
- When mulching, working from the garden edges inward by walking on the mulch as you work towards the center

Fertilizing native plants is not recommended since it will likely enhance more weed growth than native plant growth. The garden likely already contains compost or other amendments as determined during the design and installation phases. When planting, keep plant roots moist and dig holes deep and wide enough to provide adequate backfill and full extension of root systems. Thoroughly water the plant after firming the backfill around it. Watering should help establish good soil-root contact and minimize air pockets.

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# Care and Maintenance: Ensuring Success

## Managing Expectations: Patience is a Requirement

A successful bioretention garden can be beneficial for pollutant removal, infiltration, flow regulation, sustaining plant performance and providing a pleasing aesthetic to the local environment. However, the native plants selected for the bioretention system are often unfamiliar to most people. This can lead to misunderstandings involving the look, function, and maintenance of the garden. As with any landscape project, its performance is a direct result of the care that is put into it. Patience and knowledge is required to gain a full understanding of how the bioretention garden operates.

Maintenance for bioretention gardens is normally the property owner's responsibility. It includes many of the same duties you would expect for other typical landscapes, including weeding, litter removal, and cutting back of vegetation as needed. This can be done by the owner or can be incorporated into conventional grounds maintenance contracts for the overall property.

A nursery, landscape company, or land management professional should be consulted periodically to see that all needs of the bioretention garden are met. Some elements that may need professional maintenance include inlets and outlets, berms, and overall plant health. Use these professionals to complete more difficult or specialized work, because if the work is not done properly the first time, the entire garden may become compromised and have ongoing issues.  Some problems are often not obvious to the untrained eye.

## The First Few Weeks

During the first few weeks after planting, it will be necessary to care for the bioretention garden in much the same way as any type of garden. Common maintenance activities include:

- Regular watering
- Removal of weeds, especially before they go to seed
- Spreading displaced mulch caused by excess water flows
- Replace plants as needed. Note whether they died as a result of being planted in the wrong location, because of poor maintenance, because they were damaged, or as the result of disease.
- Removal of trash and sediment

After a couple of months, the bioretention garden will finally begin to look and function as designed. Still, many native plants take time to grow. If the garden is seeded, a portion of the seed may remain dormant until the next year before germinating. The seeds that do begin to grow, along with the plants that were installed,

## Weeds Will Grow

**There's no doubt about it. Especially if the garden has been seeded, invasive plants from seeds that were dormant in the soil or that are brought in will sprout and begin to grow very quickly. Being able to recognize and pull the weeds is necessary to keep the garden healthy and beautiful. Doing this will allow the desired plants to fully establish within the garden and limit future weed establishment.**

Nina Cudahy

Nina Cudahy

work to develop their root systems first, making them hardy and strong. Even if the top part of the plant appears to be stunted, it is likely to grow with time. After the plants have been established and during the first and second season, remember these key points.

- **Grasses can be slow to start.** There will be competition from other grasses, such as fescue, rye, Johnson, barnyard, and crabgrass. Eliminate them promptly to allow desired grasses to thoroughly establish across the garden.
- **Remove weeds before they form seed heads. T**his will limit their re-seeding in the garden.
- **Plants should receive proper irrigation.** Their roots are not completely formed, so they will need to receive water periodically throughout the first year if sufficient rainfall does not occur. They may need watering during the second year if weather conditions are excessively dry. Native and adapted plants are accustomed to the drier conditions of the prairie, so reduce irrigation as needed as they mature.
- **Mulch the garden as needed.** Only mulch when it is needed to cover bare areas. Too much mulch can reduce the amount of water the garden can hold, clog outlet structures, or limit growth of desired plants. As the garden fills in with plants, mulch will likely not be needed. A good tip is to establish bed edges around the bioretention garden and apply a layer of new mulch that will give it a clean look and let people know the garden is being maintained. (See photo on page 57.)
- **Warm season native plants will go dormant in the early to late fall**. Some grasses will retain their color while others will become pale brown.
- **Wait to cut the bioretention garden back until early spring.** During the winter, the plants provide visual interest in the landscape and food for wildlife. If you do not want to attract a wide variety of birds or wildlife, it is best to cut the garden back and remove dead plant material from the garden.

- **Be mindful of local wildlife.** Deer and rabbits can cause significant damage to a garden's plants. Voles are also common and can seriously damage root systems. Where wildlife damage is expected to be significant select plants that animals don't prefer.

Each bioretention garden needs its own long-term plan for operations and maintenance. Plans should include maintenance of bioretention components and seasonal care. Use the following as a general guide to conduct maintenance for your bioretention garden. An inspection sheet is also included as a resource.

## Component Maintenance

**Inlets –** Inlets for runoff entering the garden may be a single pipe, a swale, or there may be none at all if flows enter from all directions. The inlet type will determine specific maintenance needs, but generally, maintenance includes:

- Checking for erosion around the inlet and promptly repairing as needed.
- Checking for obstructions such as trash, excessive vegetation, or sediment build-up and removing as needed.
- Examining surrounding areas to make sure runoff flow is directed to the inlet and not bypassing it. Modify inlets as needed.

**Pretreatments –** Pre-treatments serve to remove sediment and calm flows as they enter the garden. They come in a variety of forms, including structural sumps, small depressions, and vegetated swales. The pre-treatment type will determine specific maintenance needs, but maintenance typically includes:

- Checking for erosion around the pre-treatment and promptly repairing as needed.
- Removing accumulated sediment and debris.
- Checking for any damage to the structure and promptly repairing as needed.

Andy Szatko

### Sooner than Later

*Making regular observations of bioretention gardens helps catch issues early. If not addressed promptly, they can quickly become significant efforts to repair.*

Andy Szatko

*Example of a pretreatment manhole that captures floatable debris and sediment*

Andy Szatko

*Remove mulch from structure. When possible, use dome grates, they are less likely to be obstructed than flat ones.*

Andy Szatko

*Layer of sediment that has built up over mulch layer. Best to remove when conditions are dry.*

Andy Szatko

*Newly planted bioretention garden with three varieties of sedges planted 12 inches on center*

**Outlets –** Outlets may consist of hard weir structures (ex. concrete walls), soft weir structures (ex. depressions in the berm), or riser structures. The outlet structure will determine specific maintenance needs, but maintenance typically includes:

- Checking the outlet for erosion and promptly repairing as needed.
- Checking for obstructions such as trash, excessive vegetation, or sediment build-up and removing as needed.
- Examining surrounding areas to make sure runoff flow is directed to appropriate areas.

**Stormwater Ponding Area –** Maintenance for the area of the garden that stores stormwater runoff includes:

- Removing excess sediment build-up. Make sure the garden maintains a flat bottom after sediment removal.
- Removing dead plants and thin vegetation as needed.
- Redistributing mulch that has been displaced by water.
- Repairing erosion or damage from animals.
- Examining for infiltration of detained water. Assess if BSM has been clogged with sediment and address as needed. Consult designer and/or installer if necessary.

**Vegetation –** A primary component of the bioretention garden, vegetation will continually change throughout the seasons. Maintenance includes:

- Inspecting for dead, stressed, or damaged vegetation. It's highly recommended to determine the cause and address the problem before replacing with new plants.
- Thinning overgrown or dominating vegetation as needed to maintain the desired look of the garden. This is an opportunity to use thinned plants as starters in other gardens.
- Inspecting for the presence of weeds and managing them promptly before they go to seed. Use care when removing weeds, as pulling or spraying larger weeds could damage surrounding plants.
- Cut down vegetation and trim shrubs in early spring and remove debris from the garden.

## Seasonal Maintenance

### Short-Term: Year One

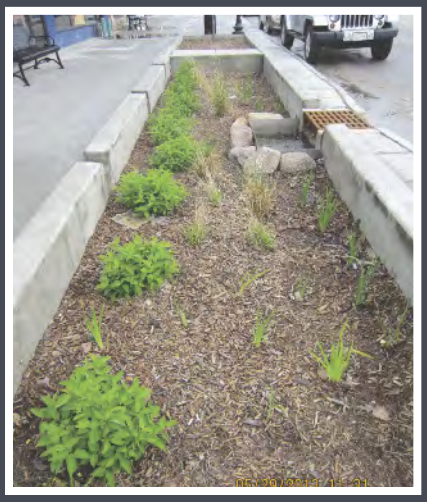
- It is important to remember that native plants have not fully matured to their full aesthetic and functional BMP value during their first year. Roots have not sufficiently developed enough to withstand long dry periods and water infiltration may be limited based on site conditions.
- In the absence of rain, water seedlings and young plants at least weekly during the first two to three months. After that and through the summer months, water bi-weekly when there is insufficient rainfall.
- Monitor the bioretention cell for growth of weeds and eliminate weeds as soon as possible. If possible, spot apply herbicide to undesirable vegetation periodically throughout the first year.
- Inspect the bioretention garden after significant rainfalls to check its condition. Redistribute mulch as needed when displaced by stormwater flow. Look for vegetation that may be stressed from extended ponding of water.
- Remove sediment that accumulates in the garden. With sediment removal, some plant and/or mulch maintenance may be necessary.
- Check for erosion damage both inside the garden and around the berm, at inlets, and outlets. Repair erosion damage promptly.
- Regularly inspect vegetation health and vigor. Address issues as needed and replace dead plants if necessary.

### Mid-Term: Years Two and Three

- Mow or cut back vegetation from the garden in early spring each year to facilitate new plant growth. Do not mow lower than six inches above the ground. Remove any plant debris.

Andy Szatko

*After the vegetation is cut back and removed, re-establish bed edge and install about one foot area of mulch to provide a clean look*



Andy Szatko

*Plants emerging in spring after being planted prior season.*

- Monitor for the growth of weeds. Eliminate weeds as soon as possible. Spot apply herbicide to weeds and undesirable vegetation periodically throughout years two and three.
- Until second-year growth is established, inspect the garden after each significant rainfall. Redistribute mulch if it becomes displaced by stormwater flow, remove trash, and look for vegetation that may be stressed from extended ponding of water.
- Determine if water is draining as desired. If not (water is ponding for greater than 24 hours, for example), determine if there is a noticeable cause (sediment covering infiltration cell, clogged underdrain, or valve is fully closed) or consult with the designer, installer, or a knowledgeable professional to determine possible reasons and solutions to the problem.
- Check for erosion damage in the garden and repair as soon as possible.
- Inspect for and remove sediment that accumulates in the garden. With sediment removal, some plant and/or mulch maintenance may be necessary. Examine plant condition and replace if necessary.
- Complete annual inspections of the bioretention garden's condition during the second half of the growing season to assess vegetation condition. If vegetation becomes overgrown, thin or prune excess plants. Replace dead plants if necessary.

**Long-Term Year Four and Beyond**

- Cut back or mow dead vegetation from the bioretention garden in early spring of each year to facilitate new plant growth. Remove any plant debris. Do not cut back lower than six inches above the ground.
- Monitor the garden for growth of invasive weed species two to three times during each year. Eliminate invasive plants as soon as possible. Pull the weed and as much of it's roots as possible or do a spot application of herbicide as needed.
- Regularly maintain pre-treatment.
- Inspect the garden at a minimum annually or more frequently for sediment accumulation, erosion, and structural issues with the garden's components. Address any issues as soon as possible.

# The Cost of a Bioretention Garden

**The function of bioretention gardens is well-proven, and they provide outstanding amenitites for the communities where they are built. But what are the costs?**

## Design and Construction Costs

Costs associated with bioretention gardens can vary greatly between projects because of variations in design goals, complexity of design and construction, site location and conditions, associated amenities, size, access and materials. A general discussion on costs is the focus for this chapter and detailed cost information is not included. Costs will be shared through presentations and project fact sheets as more is learned. Bioretention gardens are still relatively new to designers and construction professionals, and lack of familiarity can result in unnecessarily large pipes or excavations to ensure the system functions properly. This can add unnecessary costs. For construction, a contractor new to building bioretention gardens may increase labor hours out. As contractors, designers, and owners all gain more experience with bioretention gardens, these issues will be less of a factor, improve costs overall.

The cost of materials and the level of maintenance that is required during the first two years after the garden installation play a significant role in costs. These factors can shift over the course of several subsequent seasons. Keep up on current prices in your area to adapt. In general, however, the costs of bioretention gardens are comparable to, if not less than, conventional methods of stormwater management, particularly in terms of removing pollutants from the first half-inch of runoff.

There are a variety of cost metrics that are discussed within the industry, including cost per square foot and per cubic foot of water quality capture volume. Data and various calculators of costs are becoming more widely available. When looking at these resources, be sure to qualify the data and methods being used to make sure they accurately reflect the approach to bioretention gardens described in this manual. In general, it is recommended that a cost estimate include the following elements:

- Excavation/Grading
- Bioretention Soil Mix (BSM)
- Underdrain Pipe
- Valve
- Washed Underdrain Aggregate
- High Flow Structure (if applicable)
- Erosion Control Materials
- Seed and/or Live Plants
- Compost (Soil Conditioning)
- Mulch

Andy Szatko

## Cost of Maintenance

Like other managed landscapes, bioretention gardens require regular maintenance to prolong their use as an attractive, functioning stormwater management amenities. Maintenance levels will be highest during the first year following installation. With time, gardens will become increasingly self-sustainable, resulting in lower maintenance costs.

Most cost studies for bioretention systems show that approximately 7% to 10% of the original construction costs are needed for maintenance during the first two to three years after construction. Beyond that, maintenance tasks become focused on removal of weeds, thinning overgrowth of vegetation, and annual mowing. This commonly equates to annual labor costs of less than 5% of the original construction costs.

## Cost vs. Performance

The investment in the quality of maintenance provided ultimately pays dividends through the lifespan of the bioretention garden. The following advice below are based on many experiences within the Omaha area.

- Attention to construction details is very important for a successful bioretention system. Be careful not to over-excavate basins, compact soils, or use alternative materials without consulting the designer as these features could substantially affect the performance and growth of the garden. Keep the design professional involved during construction to address any concerns that may arise.
- Using live plants up front can save on maintenance costs. Using live plants improves plant survival rate and helps to identify weeds.
- Maintenance is important. If the function and aesthetic of the garden is not maintained, the garden may become undesirable to the landowner or the community, potentially leading to its removal. Design, build, and maintain the bioretention garden as a long-term component of the landscape.

# Bioretention Garden Plants

**There is a broad range of plants suitable for use in bioretention gardens within the Omaha region.** This chapter includes a series of tables that summarize plants by type and intended use in the garden, as well as individual plant summaries and images, section contributors, and references.

Plant availability can change from year to year so no single plant list should be considered as all-inclusive. The list found here gives a starting point for creative selection and use of plants for green infrastructure projects. For future reference, visit OmahaStormwater.org or water.unl.edu/stormwater for supplemental information to this list.

## The following points have been considered for the plants listed in this section:

- Nebraska and regionally native plants comprise the bulk of the list due to the inherent benefits associated with their use. Plants that are native to the local environment greatly improve overall plant success, and as a result, improve project success.
- Adapted non-invasive, non-native plants that have proven themselves in regional green infrastructure projects are included to broaden plant diversity and availability. Plants with these first two points are referred to as Native or Ecologically Well-Adapted Non-Invasive Plants (NEWANIP) in the City of Omaha's Environmental Element.
- Cultivars and hybrids with specific ornamental characteristics, growth habits, and disease or drought resistances are commonly available for many plant species on the list. Selecting and breeding plants for specific characteristics may lessen genetic diversity, but attributes such as compact habit or disease resistance may be worth considering when expectations for garden aesthetics must be met. Do not assume similar growth habits between different cultivars or hybrids, as they can vary significantly.
- Consideration for the plant's tolerance for water inundation in the garden is critical and needs to be noted during the design stage.

## Here are general tips to help ensure a successful bioretention garden:

- Shrub use should be carefully considered to ensure they blend in well with the function and look of the garden. Where space allows, they should be used to complement forbs and grass masses, frame and provide backdrops for gardens, and provide food and cover for wildlife.

- Garden locations beyond the top of berms do not require plants adapted to inundation so other well-suited landscape plants may be considered for selection. Always remember to consider soil conditions and maintenance requirements of the project when making planting choices.

This plant list includes forbs, grasses, sedges, rushes, and shrubs. Designers should consider all plant attributes and be sure to choose the right plant for the right location in the garden. Doing so will enhance seasonal interest and garden structure. Plants listed in this guide are generally available regionally. Less commonly known species should still be attainable through well-known physical and online sources. Many native plants are becoming more readily available due to increased interest and demand. It is anticipated that this plant guide will become an online resource in the future; visit OmahaStormwater.org for details.

The following plant table has been developed to help you design your garden. The table includes the following information:

- **Common and Scientific Names** – Common names are easiest for public reference but scientific names are critical to ensure that plant selection and ordering is accurate.

- **Regional Native Status** – All listed states have been verified through the USDA Plant Database and the Flora of Nebraska, 2007. The region includes Nebraska, South Dakota, Minnesota, Iowa, Illinois, Missouri, Kansas, Wyoming, and Colorado. This list assigns native status based on plant species, which does not technically include cultivars or hybrids.

- **Exposure** – Full sun means a minimum of six to eight hours of sunlight per day. Part shade is three to six hours of direct sunlight per day or filtered sunlight all day. Full shade is less than three hours of direct sunlight per day.

- **Soil Type** – Categories include sand, loam, or clay. For use as a general factor in plant selection and indicator of plant adaptability to poor soil conditions.

- **Soil Moisture** – Ranges from wet to dry. For use as a general classification to match plants to conditions.

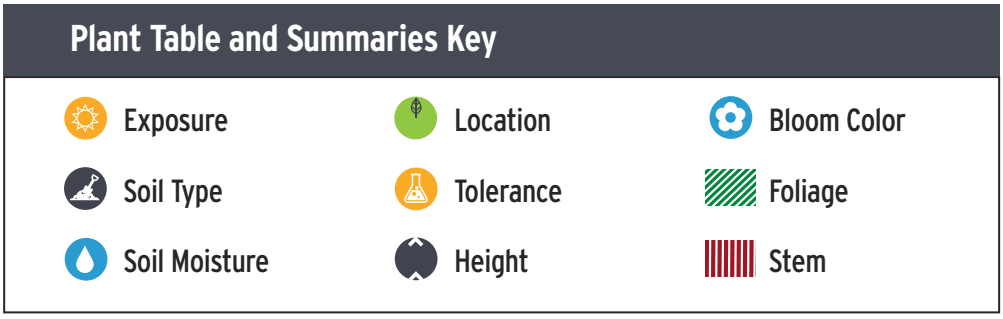
- **Recommended Garden Location** – Correlates to soil moisture information and ability to tolerate standing water in the garden. Ponding duration can vary widely. Plants recommended for garden sides may also be adaptable to bottom areas of the garden where water naturally infiltrates quickly.

- **Approximate Mature Height** – Plants are listed by categories ranging from groundcover to more than 60 inches for perennials and grasses, and from 2 to 3 feet to more than 15 feet for shrubs.
- **Bloom and Seasonal Interest** – Average bloom times and approximate colors for forbs are noted by month. Grasses, sedges, and rushes are noted for their growing periods as well as fall and winter interest., fall and winter interest. Shrubs are noted for flower season, fall color and winter interest.

## Plant Summaries and Images

Information summaries and thumbnail images are provided for many plants. The summaries include the following categories and are intended to supplement the table information for more specific plant selection criteria:

- **Form** – Relative shape
- **Foliage** – Color, type, and overall texture
- **Flowers** – Color, size, shape, fragrance and average bloom season
- **Height and Spread** – Average size height and width of mature plants
- **Garden Exposure and Location** – Range of sun and shade conditions as well as designation of garden location relative to soil moisture and inundation tolerance. This includes the bottom of garden, sides of garden, or top of berm surrounding garden, which includes outside of water storage basin.
- **Comments and Cautions** – Additional information based on personal experiences of manual authors and contributors. In particular, carefully consider whether to use plants that lean or may be too tall for small gardens, or tend to appear weedy, aggressive or invasive.
- **Alternative Species and Cultivars** – Provides additional choices in plants that fill similar garden roles, expand flower colors or have special characteristics, may be easier to locate in the trade, etc.



## Herbaceous Plants

| Plant Names | | Native Status | Exposure | | | Soil Type | | | Soil Moisture | | | | Salt Tolerance | Location | | | Approximate Height | | | | | | | Bloom and/or Interest Season | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common Name | Botanical Name | Species Regionally Native (by State) | Full Sun | Part-Shade | Shade | Sand | Loam | Clay | Wet | Moist | Average | Dry | Moderate to High Salt Tolerance | Bottom | Sides | Top of Berm | Groundcover | 6" - 12" | 12" - 24" | 24" - 36" | 36" - 48" | 48" - 72" | 6' - 10' | 10' - 15' | March | April | May | June | July | August | September | October | November | Dec. - Feb. |
| common yarrow | Achillea millefolium | NE | x | x | | x | x | | | | x | x | x | | x | x | x | | x | x | | | | | | | | | | | | | | |
| Paprika yarrow, Terracotta yarrow | Achillea hybrids and cultivars | | x | x | | x | x | | | | x | x | x | | x | x | | | x | | | | | | | | | VARIES | | | | | | |
| leadplant | Amorpha canescens | NE | x | | | x | x | x | | | x | x | | | x | x | | | | x | | | | | | | | | | | | | | |
| fragrant false indigo | Amorpha nana | NE | x | | | x | x | | | | x | x | | | x | x | | | | x | | | | | | | | | | | | | | |
| Arkansas amsonia | Amsonia hubrichtii | | x | x | | | x | x | | x | x | x | | | x | x | | | | x | | | | | | | | | | | | | | |
| shining bluestar | Amsonia illustris | KS, MO | x | x | | | x | x | | x | x | x | | | x | x | | | x | x | | | | | | | | | | | | | | |
| windflower | Anemone canadensis | NE | x | x | | x | x | | x | x | | | | x | x | | x | | x | | | | | | | | | | | | | | | |
| American columbine | Aquilegia canadensis | NE | | x | x | | x | | | x | x | | x | | x | x | | | x | | | | | | | | | VARIES | | | | | | |
| hybrid columbine | Aquilegia hybrids | | x | x | | | x | | | x | x | | | | x | x | | | x | | | | | | | | | VARIES | | | | | | |
| spikenard | Aralia racemosa | NE | | x | x | | x | | | x | x | | | | x | | | | | | | x | | | | | | | | | | | | |
| pale Indian plantain | Arnoglossum atriplicifolium | NE | x | x | | x | x | x | x | x | | | | x | x | | | | | | x | x | | | | | | | | | | | | |
| white goat's beard | Aruncus dioicus | IA | | x | x | | x | | x | x | x | | | x | x | x | | | | | | x | | | | | | | | | | | | |
| wild ginger | Asarum canadense | NE | | x | x | | x | | | x | x | | | | x | x | x | x | | | | | | | | | | | | | | | | |
| swamp milkweed | Asclepias incarnata | NE | x | x | | x | x | x | x | x | x | | | x | | | | | | | x | | | | | | | | | | | | | |
| butterfly milkweed | Asclepias tuberosa | NE | x | x | | x | x | x | | | x | x | | | x | x | | | | x | | | | | | | | | | | | | | |
| Wood's aster series | Aster dumosus 'Wood's Blue,' 'Pink,' and 'Purple' | NE | x | x | | | x | x | | x | x | x | | | x | x | | x | | | | | | | | | | | VARIES | | | | | |
| Chinese astilbe | Astilbe chinensis var. pumila | | | x | x | | x | | | x | x | | x | x | x | | x | | x | | | | | | | | | | | | | | | |
| lady fern | Athyrium filix-femina | NE | | x | x | | x | | x | x | x | | | x | x | | | | | x | | | | | | | | | | | | | | | |
| Lady in Red lady fern | Athyrium filix-femina 'Lady in Red' | | | x | x | | x | | x | x | x | | | x | x | | | | | x | | | | | | | | | | | | | | |
| blue false indigo | Baptisia australis | NE | x | x | | | x | x | | x | x | x | x | x | x | x | | | | | x | | | | | | | | | | | | | | |
| dwarf blue false indigo | Baptisia australis var. minor | NE | x | x | | | x | x | x | x | x | x | x | x | x | x | | | | x | | | | | | | | | | | | | | | |
| boltonia | Boltonia asteroides | MO | x | x | | | x | x | | x | x | x | | | x | x | | | | | | x | | | | | | | | | | | | | |
| Snowbank boltonia | Boltonia asteroides 'Snowbank' | | x | x | | | x | x | | x | x | x | | | x | x | | | | | | x | | | | | | | | | | | | | |
| Jim Crockett boltonia | Boltonia asteroides var. lasquimata 'Masbolimket' | | x | | | | x | x | | x | x | x | | | x | x | | | x | | | | | | | | | | | | | | | |
| purple poppy mallow | Callirhoe involucrata | NE | x | | | x | x | | | | x | x | | | | x | x | x | | | | | | | | | | | | | | | | | |
| turtlehead | Chelone glabra | IA, MO | x | x | x | | x | x | x | x | x | | | x | x | | | | | x | | | | | | | | | | | | | | | |
| Hot Lips turtlehead | Chelone lyonii 'Hot Lips' | | x | x | x | | x | x | x | x | x | | | x | x | | | | | x | | | | | | | | | | | | | | |
| threadleaf coreopsis | Coreopsis verticillata | | x | x | | | x | | | x | x | | | | x | x | | | x | x | | | | | | | | | | | | | | |
| purple prairie clover | Dalea purpurea | NE | x | | | x | x | | | | x | x | | | | x | | | x | | | | | | | | | | | | | | | |
| Stephanie purple prairie clover | Dalea purpurea 'Stephanie' | | x | | | x | x | | | | x | x | | | | x | | | x | | | | | | | | | | | | | | | |
| narrow-leaf coneflower | Echinacea angustifolia | NE | x | | | x | x | x | | | x | x | | | | x | | | x | x | | | | | | | | | | | | | | |
| purple coneflower | Echinacea purpurea | IA, KS | x | x | | x | x | x | | x | x | x | | | x | x | | | | x | x | | | | | | | | | | | | | | |
| Phantom joe pye weed | Eupatorium 'Phantom' | | x | x | | x | x | x | | x | x | | | x | x | | | | | | x | | | | | | | | | | | | | |
| Little Joe joe pye weed | Eutrochium dubium 'Little Joe' | | x | x | | x | x | x | | x | x | | | x | x | | | | | | x | | | | | | | | | | | | | |
| sweet joe pye weed | Eutrochium purpureum | NE | | x | x | | x | x | | x | x | | | x | x | | | | | | | x | | | | | | | | | | | | |

## Herbaceous Plants cont.

| Plant Names | | Native Status | Exposure | | | Soil Type | | | Soil Moisture | | | | | Location | | | | Approximate Height | | | | | | | Bloom and/or Interest Season | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common Name | Botanical Name | Species Regionally Native (by State) | Full Sun | Part-Shade | Shade | Sand | Loam | Clay | Wet | Moist | Average | Dry | Moderate to High Salt Tolerance | Bottom | Sides | Top of Berm | Groundcover | 6" - 12" | 12" - 24" | 24" - 36" | 36" - 48" | 48" - 72" | 6' - 10' | 10' - 15' | March | April | May | June | July | August | September | October | November | Dec. - Feb. |
| Gateway spotted joe pye weed | Eutrochium purpureum subsp. maculatum 'Gateway' | NE | x | x | | | x | x | x | x | x | | | x | x | | | | | | | x | | | | | | | | ✿ | ✿ | | | | |
| queen-of-the-prairie | Filipendula rubra | IA | x | x | | | x | x | x | x | x | | | x | | | | | | | | x | | | | | | | ✿ | ✿ | | | | | |
| blanket flower | Gaillardia aristata | NE | x | | | x | x | | | | x | x | x | | x | x | | | x | | | | | | | | | | ✿ | ✿ | ✿ | | | | |
| Oranges 'n Lemons blanket flower | Gaillardia aristata `Oranges 'n Lemons' | | x | | | x | x | | | | x | x | x | | x | x | | | x | | | | | | | | | | ✿ | ✿ | ✿ | | | | |
| blanket flower hybrids and cultivars | Gaillardia grandiflora | | x | | | x | x | x | | | x | | x | | x | x | | | x | | | | | | | | | ✿ | ✿ | ✿ | ✿ | | | | |
| wild geranium | Geranium maculatum | NE | | x | x | x | x | x | | x | x | x | | | x | | | | x | | | | | | | | ✿ | ✿ | | | | | | | |
| bloody cranesbill | Geranium sanguineum | | | x | x | | x | x | | x | x | x | | | x | | x | | x | | | | | | | | ✿ | ✿ | | | | | | | |
| Alpenglow bloody cranesbill | Geranium sanguineum 'Alpenglow' | | | x | x | | x | x | | x | x | x | | | x | | | | x | | | | | | | | ✿ | ✿ | | | | | | | |
| sneezeweed | Helenium autumnale | NE | x | x | | | x | x | x | x | x | | x | x | x | | | | | | x | x | | | | | | | ✿ | ✿ | ✿ | ✿ | | | |
| Mardi Gras sneezeweed | Helenium 'Mardi Gras' | | x | x | | | x | x | x | x | x | | | x | x | | | | | x | | | | | | | | ✿ | ✿ | ✿ | ✿ | | | |
| Wyndley sneezeweed | Helenium 'Wyndley' | | x | x | | | x | x | x | x | x | | | x | x | | | | | x | | | | | | | | ✿ | ✿ | ✿ | ✿ | | | |
| ox-eye daisy | Heliopsis helianthoides | NE | x | x | | x | x | x | | x | x | | x | x | x | | | | | | x | x | | | | | | | ✿ | ✿ | ✿ | | | | |
| Summer Nights ox-eye daisy | Heliopsis helianthoides 'Summer Nights' | | x | x | | | x | x | x | x | | | | x | x | | | | | | x | x | | | | | | | ✿ | ✿ | ✿ | | | | |
| daylily | Hemerocallis (various species and hybrids) | | x | x | x | | x | x | | x | x | x | x | | x | x | x | | x | x | | | | | | | VARIES | ✿ | ✿ | ✿ | ✿ | ✿ | | | |
| rose mallow, hardy hibiscus | Hibiscus moscheutos | KS, MO | x | x | | | x | x | x | x | x | | x | x | x | x | | | | | x | x | | | | | | | ✿ | ✿ | ✿ | ✿ | | | |
| Disco Belle, Luna series rose mallow | Hibiscus moscheutos cultivars and hybrids | | x | x | | | x | x | x | x | x | | x | x | x | x | | | | | x | x | | | | | | | VARIES | ✿ | ✿ | ✿ | | | |
| hosta | Hosta (various species and hybrids) | | | x | x | x | x | x | | x | x | x | x | | x | x | | x | x | x | | | | | | | | VARIES | ✿ | ✿ | ✿ | ✿ | | | |
| Siberian iris | Iris sibirica | | x | x | | | x | x | | x | x | | x | | x | x | | | | x | | | | | | | ✿ | ✿ | | | | | | | |
| Caesar's Brother Siberian iris | Iris sibirica 'Caesar's Brother' | | x | x | | | x | x | | x | x | | x | | x | x | | | | x | | | | | | | ✿ | ✿ | | | | | | | |
| blue flag iris | Iris versicolor | MN | x | x | | | x | x | x | x | x | | x | x | | | | | | x | | | | | | | ✿ | ✿ | ✿ | | | | | | |
| meadow blazing star | Liatris ligulistylis | WY, CO | x | x | | | x | x | | x | x | | | | x | | | | | | x | | | | | | | | | ✿ | ✿ | ✿ | | | |
| prairie blazing star | Liatris pycnostachya | NE | x | | | x | x | x | x | x | | | | x | x | | | | | | x | | | | | | | | | ✿ | ✿ | ✿ | | | |
| dense blazing star | Liatris spicata | MO | x | | | x | x | x | | x | | | | x | x | x | | | | x | | | | | | | | ✿ | ✿ | ✿ | ✿ | | | | |
| Kobold dense blazing star | Liatris spicata 'Kobold' | | x | | | x | x | x | | x | | | | x | x | x | | | x | x | | | | | | | | ✿ | ✿ | ✿ | ✿ | | | | |
| cardinal flower | Lobelia cardinalis | NE | | x | x | | x | x | x | x | | | | x | | | | | | x | | | | | | | | | ✿ | ✿ | ✿ | | | | |
| great blue lobelia | Lobelia siphilitica | NE | x | x | | x | x | x | x | x | x | | x | x | x | | | | | x | | | | | | | | | ✿ | ✿ | ✿ | ✿ | | | |
| ostrich fern | Matteuccia struthiopteris | NE | | x | x | | x | x | x | x | | | | x | | | | | | x | | | | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | | |
| moneyflower | Mimulus ringens | NE | x | x | | x | x | x | x | x | | | | x | x | | | | x | x | | | | | | | | ✿ | ✿ | ✿ | ✿ | | | | |
| bee balm | Monarda didyma | IA | x | x | | | x | x | x | x | x | | | x | x | | | | | x | x | | | | | | | | ✿ | ✿ | | | | | |
| Jacob Kline, Raspberry Crush, others | Monarda didyma cultivars | | x | x | | | x | x | x | x | x | | | x | x | | | | | x | x | x | | | | | | | VARIES | ✿ | | | | | |
| wild bergamot | Monarda fistulosa | NE | x | x | | x | x | x | x | x | x | x | | x | x | | | | | | x | | | | | | | | ✿ | ✿ | ✿ | | | | |
| sundrops | Oenothera fruticosa | MO | x | | | | x | x | x | x | x | | | | x | | x | | x | | | | | | | | | | ✿ | ✿ | | | | | |
| Missouri primrose | Oenothera macrocarpa | MO | x | | | | x | x | | x | x | x | | | x | x | | x | | | | | | | | | | ✿ | ✿ | ✿ | ✿ | | | | |
| cinnamon fern | Osmunda cinnamomea | IA | | x | x | | x | x | x | x | x | | | x | | | | | | | x | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | | |
| smooth beardtongue, penstemon | Penstemon digitalis | NE | x | x | | x | x | x | | x | x | x | | | x | x | | | x | | | | | | | | | ✿ | ✿ | | | | | |

## Herbaceous Plants cont.

| Plant Names | | Native Status | Exposure | | | Soil Type | | | Soil Moisture | | | | | Location | | | | Approximate Height | | | | | | | Bloom and/or Interest Season | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common Name | Botanical Name | Species Regionally Native (by State) | Full Sun | Part-Shade | Shade | Sand | Loam | Clay | Wet | Moist | Average | Dry | Moderate to High Salt Tolerance | Bottom | Sides | Top of Berm | Groundcover | 6" - 12" | 12" - 24" | 24" - 36" | 36" - 48" | 48" - 72" | 6' - 10' | 10' - 15' | March | April | May | June | July | August | September | October | November | Dec. - Feb. |
| prairie phlox | Phlox pilosa | NE | x | x | | x | x | | | x | x | | | | x | x | | | x | | | | | | | | | | | | | | | |
| obedient plant | Physostegia virginiana | NE | x | x | | | x | x | | x | x | | | | x | x | | | | x | | | | | | | | | | | | | | |
| Vivid, Miss Manners | Physostegia virginiana cultivars | | x | x | | | x | x | x | x | x | | | | x | x | | | | x | | | | | | | | | | | | | | |
| Solomon's seal | Polygonatum biflorum | NE | | x | x | | x | | x | x | x | x | | | x | | x | | | x | | | | | | | | | | | | | | |
| variegated Solomon's seal | Polygonatum multiflorum 'Variegatum' | | | x | x | | x | | x | x | x | x | | | x | x | x | | x | | | | | | | | | | | | | | | |
| Virginia mountain mint | Pycnanthemum virginianum | NE | x | x | | x | x | | | x | x | x | x | x | x | x | | | x | | | | | | | | | | | | | | | |
| gray headed prairie coneflower | Ratibida pinnata | NE | x | x | | x | x | x | | x | x | | | | x | | | | | | x | | | | | | | | | | | | | |
| Goldsturm rudbeckia | Rudbeckia fulgida var. sullivantii 'Goldsturm' | MO | x | x | | x | x | x | | x | x | | x | | x | | | | | x | | | | | | | | | | | | | | |
| goldenglow | Rudbeckia laciniata | NE | x | x | | x | x | x | x | x | | | x | x | x | x | | | | | x | x | | | | | | | | | | | | |
| Herbstonne goldenglow | Rudbeckia laciniata 'Herbstonne' | | x | x | | x | x | x | x | x | | | x | x | x | x | | | | | x | x | | | | | | | | | | | | |
| wild petunia | Ruellia humilis | NE | x | | | x | x | x | | | x | x | | | x | x | x | x | | | | | | | | | | | | | | | | |
| meadow sage | Salvia nemorosa | NE | x | x | | | x | x | | | x | | | | x | x | | | x | | | | | | | | | | | | | | | |
| Caradonna, Purple Rain | Salvia cultivars and hybrids | | x | x | | | x | x | | | x | | | | x | x | | | x | | | | | | | | | | | | | | | |
| stonecrop sedum | Sedum (groundcover hybrids and cultivars) | | x | x | | x | x | x | | x | x | x | | | x | x | x | x | | | | | | | | | VARIES | | | | | | | |
| showy sedum | Sedum (tall hybrids and cultivars) | | x | x | | x | x | x | | x | x | x | | | x | x | | | x | x | | | | | | | | | | | | | | |
| cup plant, rosinweed | Silphium integrifolium | NE | x | x | | x | x | x | | x | x | | | x | x | x | | | | | | x | x | | | | | | | | | | | | |
| Golden Baby, Little Lemon, Crown of Rays | Solidago spp. cultivars | | x | x | | | x | x | | x | x | x | | | x | x | | | x | x | | | | | | | | | | | | | | |
| Riddell's goldenrod | Solidago riddellii | IA, SD | x | x | | x | x | x | x | x | x | | | | x | | | | | x | | | | | | | | | | | | | | |
| Fireworks goldenrod | Solidago rugosa 'Fireworks' | MO | x | x | | | x | x | x | x | x | x | | | x | x | | | | | x | | | | | | | | | | | | | |
| showy goldenrod | Solidago speciosa | NE | x | x | | x | x | x | | x | x | | | | x | | | | | x | | | | | | | | | | | | | | |
| heath aster | Symphyotrichum ericoides | NE | x | | | x | x | | | | x | x | | | | x | | | x | x | | | | | | | | | | | | | | |
| New England aster | Symphyotrichum novae-angliae | NE | x | x | | | x | x | | x | x | | | | x | x | | | | x | x | | | | | | | | | | | | | | |
| aromatic aster | Symphyotrichum oblongifolium | NE | x | x | | x | x | | | | x | x | | | x | x | | | x | x | | | | | | | | | | | | | | |
| October Skies aromatic aster | Symphyotrichum oblongifolium 'October Skies' | | x | x | | x | x | x | | | x | x | | | x | x | | | | x | | | | | | | | | | | | | | |
| tall purple rue | Thalictrum dasycarpum | NE | | x | x | x | x | | x | x | | | | x | x | | | | | | x | x | | | | | | | | | | | | |
| prairie spiderwort | Tradescantia bracteata | NE | x | | | | x | x | | x | x | | | | x | | | | x | | | | | | | | | | | | | | | |
| Ohio spiderwort | Tradescantia ohioensis | NE | x | x | | x | x | x | | x | x | | | x | x | | | | x | | | | | | | | | | | | | | | |
| Sweet Kate, Concord Grape | Tradescantia hybrids and cultivars | | x | x | | x | x | x | | x | x | | | x | x | | | | x | | | | | | | | | | | | | | | |
| blue vervain | Verbena hastata | NE | x | x | | | x | x | x | x | x | | | x | x | | | | x | | | | | | | | | | | | | | | |
| common ironweed | Vernonia fasciculata | NE | x | x | | x | x | x | x | x | x | | | x | x | | | | | | x | | | | | | | | | | | | | |
| Culver's root | Veronicastrum virginicum | NE | x | x | | | x | x | x | x | x | | | x | x | | | | | | | x | | | | | | | | | | | | |
| barren strawberry | Waldsteinia fragarioides | MN | x | x | x | | x | x | | | x | | x | | | x | x | x | | | | | | | | | | | | | | | | |
| heart-leaved meadow parsnip | Zizia aptera | IA, SD | x | x | | | x | | | x | x | | x | | x | | | | x | | | | | | | | | | | | | | | |

## Grasses, Sedges and Rushes

| Plant Names | | Native Status | Exposure | | | Soil Type | | | Soil Mosture | | | | | Location | | | | Approximate Height | | | | | | | Bloom and/or Interest Season | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common Name | Botanical Name | Species Regionally Native (by State) | Full Sun | Part-Shade | Shade | Sand | Loam | Clay | Wet | Moist | Average | Dry | Moderate to High Salt Tolerance | Bottom | Sides | Top of Berm | Groundcover | 6" - 12" | 12" - 24" | 24" - 36" | 36" - 48" | 48" - 72" | 6' - 10' | 10' - 15' | March | April | May | June | July | August | September | October | November | Dec. - Feb. |
| big bluestem | Andropogon gerardii | NE | x | x | | x | x | x | | x | x | x | x | x | x | x | | | | | | x | | | | | | | | | | | | |
| bushy bluestem | Andropogon glomeratus | IL | x | | | | x | x | x | x | | | x | x | x | | | | | | | x | | | | | | | | | | | | |
| sideoats grama | Bouteloua curtipendula | NE | x | | | x | x | x | | | x | x | x | | x | x | | | | x | | | | | | | | | | | | | | |
| blue grama | Bouteloua gracilis | NE | x | | | x | x | x | | | x | x | | | | x | | | x | | | | | | | | | | | | | | | |
| feather reed grass | Calamagrostis acutifora | | x | x | | x | x | x | | x | x | x | x | | x | x | | | | | | x | | | | | | | | | | | | |
| Karl Foerster, Overdam, Avalanche | Calamagrostis acutifora cultivars | | x | x | | x | x | x | | x | x | x | x | | x | x | | | | | x | | | | | | | | | | | | | |
| Korean feather reed grass | Calamagrostis brachytricha | | x | x | | x | x | x | x | x | x | | x | x | x | | | | | | x | | | | | | | | | | | | | |
| bluejoint grass | Calamagrostis canadensis | NE | x | x | x | | x | x | x | x | | | x | x | x | | | | | | | x | | | | | | | | | | | | | |
| yellowfruit or large yellow fox sedge | Carex annectens | NE | x | x | | | x | x | x | x | | | | x | x | | | | | x | | | | | | | | | | | | | | | |
| prairie or copper-shouldered sedge | Carex bicknellii | NE | x | x | | x | x | x | x | x | x | | | x | x | x | | | | x | | | | | | | | | | | | | | | |
| shortbeak or plains oval sedge | Carex brevior | NE | x | x | x | x | x | x | x | x | x | x | | x | x | x | | | x | | | | | | | | | | | | | | | | |
| bottlebrush sedge | Carex comosa | NE | x | x | | | x | | x | x | | | | x | | | | | x | | | | | | | | | | | | | | | | |
| fringed sedge | Carex crinita | IA | x | x | x | | x | | x | x | x | | | x | | | | | | x | | | | | | | | | | | | | | | |
| Gray's sedge | Carex grayii | IA, KS | x | x | x | | x | x | x | x | | | x | x | x | | | | | x | | | | | | | | | | | | | | | |
| bottlebrush sedge | Carex hystericina | NE | x | x | | | x | x | x | x | | | | x | x | | | | | x | | | | | | | | | | | | | | | |
| Ice Dance, Old Gold | Carex morrowii cultivars | | | x | x | | x | x | x | x | x | | | x | x | | | | x | | | | | | | | | | | | | | | | |
| palm sedge | Carex muskingumensis | IA, KS | x | x | x | | x | x | | x | x | | x | x | x | | x | | x | | | | | | | | | | | | | | | | |
| rosy sedge | Carex rosea | NE | x | x | x | | x | x | x | x | x | | | x | x | x | | x | | | | | | | | | | | | | | | | | |
| broom sedge | Carex scoparia | NE | x | | | | x | | x | x | | | x | x | | | | | x | | | | | | | | | | | | | | | | |
| Sprengel's sedge | Carex sprengelii | NE | x | x | | | x | | x | x | x | | | x | x | x | | | | x | | | | | | | | | | | | | | | |
| common fox sedge | Carex stipata | NE | x | x | x | | x | | x | x | | | x | x | x | | | | | x | | | | | | | | | | | | | | | |
| tussock sedge | Carex stricta | NE | x | x | | | x | | x | x | | | | x | x | | | | | | | | | | | | | | | | | | | | |
| Texas sedge | Carex texensis | NE | | x | x | | x | | x | x | x | | | x | x | x | x | | | | | | | | | | | | | | | | | | |
| brown fox sedge | Carex vulpinoidea | NE | x | x | | | x | | x | x | x | | x | x | x | | | | | x | | | | | | | | | | | | | | | |
| spikerush | Eleocharis palustris | NE | x | x | | | x | x | x | x | | | | x | | | | | | | x | | | | | | | | | | | | | | |
| Baltic rush | Juncus balticus | NE | x | | | | x | x | x | x | x | | | x | x | | | | x | | | | | | | | | | | | | | | | |
| common rush | Juncus effusus | NE | x | x | | | x | x | x | x | x | | x | x | | | | | x | | | | | | | | | | | | | | | | |
| path rush | Juncus tenuis | NE | x | x | | | x | x | x | x | | | | x | x | | | x | | | | | | | | | | | | | | | | | |
| switchgrass | Panicum virgatum | NE | x | x | | | x | x | x | x | x | | x | x | x | x | | | | | | x | | | | | | | | | | | | | |
| Northwind, Heavy Metal, Cheyenne | Panicum virgatum cultivars | | x | x | | | x | x | x | x | x | | x | x | x | x | | | | | | x | | | | | | | | | | | | | |
| little bluestem | Schizachyrium scoparium | NE | x | x | | x | x | x | | | x | x | x | | x | x | | | | x | | | | | | | | | | | | | | | |
| Blaze, Blue Heaven | Schizachyrium scoparium cultivars | | x | x | | x | x | x | | | x | x | x | | x | x | | | | x | x | | | | | | | | | | | | | | |
| Indian grass | Sorghastrum nutans | NE | x | x | | x | x | x | | x | x | x | | x | x | x | | | | | | x | | | | | | | | | | | | | |
| Sioux Blue, Indian Steel | Sorghastrum nutans cultivars | | x | x | | x | x | x | | x | x | x | | x | x | | | | | | | x | | | | | | | | | | | | | |
| prairie dropseed | Sporobolus heterolepis | NE | x | x | | x | x | x | | | x | x | | | x | x | | | x | x | | | | | | | | | | | | | | | |

## Shrubs and Small Trees

| Plant Names | | Native Status | Exposure | | | Soil Type | | | Soil Mosture | | | | | Location | | | | Approximate Height | | | | | | | Bloom and/or Interest Season | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common Name | Botanical Name | Species Regionally Native (by State) | Full Sun | Part-Shade | Shade | Sand | Loam | Clay | Wet | Moist | Average | Dry | Moderate to High Salt Tolerance | Bottom | Sides | Top of Berm | Groundcover | 6" - 12" | 12" - 24" | 24" - 36" | 36" - 48" | 48" - 72" | 6' - 10' | 10' - 15' | March | April | May | June | July | August | September | October | November | Dec. - Feb. |
| red chokeberry | Aronia arbutifolia | | x | x | | | x | x | x | x | x | | x | x | x | x | | | | | | x | x | | | | | | | | | | | |
| Erecta, Brilliantissima | Aronia arbutifolia cultivars | | x | x | | | x | x | x | x | x | | x | x | x | x | | | | | x | x | | | | | | | | | | | | |
| black chokeberry | Aronia melanocarpa | IA | x | x | | | x | x | | x | x | x | x | x | x | x | | | | | x | x | | | | | | | | | | | | |
| Iroquois Beauty, Viking, Autumn Magic | Aronia melanocarpa cultivars | | x | x | | | x | x | | x | x | x | x | x | x | x | | | | | x | x | | | | | | | | | | | | |
| buttonbush | Cephalanthus occidentalis | NE | x | x | | | x | x | x | x | x | | | x | x | x | | | | | | | x | x | | | | | | | | | | | |
| Sugarshack buttonbush | Cephalanthus occidentalis 'Sugarshack' | | x | x | | | x | x | x | x | x | | | x | x | x | | | | | | x | | | | | | | | | | | | |
| redtwig dogwood, redosier dogwood | Cornus sericea | NE | x | x | | x | x | x | x | x | x | x | | x | x | x | | | | | | x | x | | | | | | | | | | | | |
| Isanti, Arctic Fire, Firedance | Cornus sericea cultivars | | x | x | | x | x | x | x | x | x | x | | x | x | x | | | | | x | x | x | | | | | | | | | | | | |
| American hazelnut | Corylus americana | NE | x | x | | | x | x | | x | x | x | | | x | x | | | | | | | | x | | | | | | | | | | | |
| dwarf bush honeysuckle | Diervilla lonicera | IA | x | x | x | x | x | x | | x | x | x | | | x | x | | | | | x | | | | | | | | | | | | | | |
| southern bush honeysuckle | Diervilla sessilifolia | | x | x | x | | x | x | x | x | x | | | x | x | | | | | | x | | | | | | | | | | | | | |
| Butterfly, Copper | Diervilla spp. cultivars | | x | x | x | | x | x | x | x | x | | | x | x | | | | | | x | | | | | | | | | | | | | |
| smooth hydrangea | Hydrangea arborescens | IA, KS | | x | x | x | x | x | | x | x | | x | x | x | | | | | | x | | | | | | | | | | | | | |
| Annabelle, White Dome | Hydrangea arborescens cultivars | | | x | x | x | x | x | | x | x | | x | x | x | | | | | | | | | | | | | | | | | | | |
| Virginia sweetspire | Itea virginica | MO | x | x | x | | x | x | x | x | x | | x | x | x | | | | | | x | x | | | | | | | | | | | | | |
| Henry, Little Henry, Merlot | Itea virginica cultivars | | x | x | x | | x | x | x | x | x | | x | x | x | | | | | | x | x | | | | | | | | | | | | | |
| ninebark | Physocarpus opulifolius | NE | x | x | | | x | x | | x | x | x | | | x | x | | | | | | | x | | | | | | | | | | | | |
| Diablo, Summer Wine, Coppertina | Physocarpus opulifolius cultivars | | x | x | | | x | x | | x | x | x | | | x | x | | | | | | x | x | | | | | | | | | | | | |
| shrub rose | Rosa cultivars | | x | x | | x | x | x | | x | x | x | x | | x | x | | | | | x | x | | | | | | | | | | | | | |
| dwarf blue arctic willow | Salix purpurea 'Nana' | IA | x | | | x | x | x | | x | x | | x | x | x | x | | | | | | x | | | | | | | | | | | | | |
| elderberry | Sambucus canadensis | NE | x | x | | x | x | x | | x | x | | x | x | x | x | | | | | | | | x | | | | | | | | | | | |
| Ural false spirea | Sorbaria sorbifolia | IA | x | x | | | x | x | | x | x | x | | | x | x | | | | | | x | | | | | | | | | | | | | |
| white meadowsweet | Spiraea alba | SD, IA | x | x | | | x | x | | x | x | | x | x | x | | | | | | x | | | | | | | | | | | | | | |
| arrowwood viburnum | Viburnum dentatum | IA | x | x | | | x | x | x | x | x | | x | x | x | x | | | | | | | x | x | | | | | | | | | | | |
| Blue Muffin, Autumn Jazz | Viburnum dentatum cultivars | | x | x | | | x | x | x | x | x | | x | x | x | x | | | | | | | x | x | | | | | | | | | | | |
| American cranberrybush | Viburnum opulus var. americanum | NE | x | x | | | x | x | | x | x | | x | | x | x | | | | | | | | x | x | | | | | | | | | | |
| Hahs, Wentworth, Red Wing | Vib. opulus var. americanum cultivars | | x | x | | | x | x | | x | x | | x | | x | x | | | | | | | | x | x | | | | | | | | | | |
| blackhaw viburnum | Viburnum prunifolium | IA | x | x | | | x | x | | x | x | | x | | x | x | | | | | | | | | x | | | | | | | | | | |

## Achillea millefolium
common yarrow

Full Sun | Part Shade | Top | Side | Height: 24" | Spread: 36"

**Form:** spreading mounds of low mat-like foliage; flowers on stalks above foliage

**Foliage:** bright green to slightly gray or dusty green; finely divided; fine texture; leaves to 12" long

**Flowers:** flat heads up to 4" across; millefolium white; cultivar colors range from white to pink, rose, yellow, gold, red or orange; June -Sept.

**Comments and Cautions:** straight species can spread aggressively by rhizomes; use cultivars and other species to lessen spreading

**Additional Species and Cultivars:** millefolium cultivars ('paprika,' 'summer pastels,' 'terra cotta,' and 'anqelique'); hybrid cultivars ('coronation gold,''moonshine')

## Amorpha canescens
leadplant

Full Sun | Top | Side | Height: 36" | Spread: 36"

**Form:** small, semi-woody to woody, irregular

**Foliage:** fine-textured, compound leaves with small silvery green leaflets

**Flowers:** racemes 2 to 4 inches long, blue to red-violet, fragrant; June-July

**Comments and Cautions:** cut back to within 6 inches of base in early spring to encourage full growth; extensive deep roots enhance drought adaptability

## Amorpha nana
fragrant false indigo, dwarf wild indigo

Full Sun | Top | Side | Height: 12-36" | Spread: 24-36"

**Form:** compact erect shrub; semi-woody to woody

**Foliage:** fine-textured, compound green leaves

**Flowers:** dense racemes of purple pea-like flowers; fragrant; June-July

**Comments and Cautions:** drought-resistant; known for fragrant flowers; rabbits may cause winter damage

## Amsonia hubrichtii
arkansas amsonia

Full Sun | Part Shade | Top | Side | Height: 30" | Spread: 30"

**Form:** open upright vase

**Foliage:** very fine, needle-like leaves; excellent yellow fall color

**Flowers:** light blue, star-shaped; April-May

**Comments and Cautions:** deep root system holds soil; spreads readily but not aggressively; cut back after flowering

## Amsonia illustris
shining bluestar

Full Sun · Part Shade · Top · Side · Height 36" · Spread 36"

**Form:** erect to mounded

**Foliage:** shiny thick leathery leaves; excellent yellow fall color

**Flowers:** light blue, star-shaped; April to May

**Comments and Cautions:** deep root system holds soil; spreads readily but not aggressively; cut back after flowering

**Additional Species and Cultivars:** A. ciliata, A. tabernaemontana var. tabernaemontana

## Anemone canadensis
windflower

Full Sun · Part Shade · Side · Bottom · Height 12-24" · Spread 24-36"

**Form:** spreading low foliage; flowers on stalks above foliage

**Foliage:** deeply lobed basal leaves; whorled 3- to 5-parted leaves on flower stems

**Flowers:** white 2-inch diameter flowers; May-June

**Comments and Cautions:** will spread aggressively by underground rhizomes to form colonies under good growing conditions; effective groundcover

## Aquilegia canadensis
American columbine

Full Sun · Part Shade · Top · Side · Height 24" · Spread 24"

**Form:** rounded mound of basal foliage; flower stems erect, branching

**Foliage:** gray-green; compound leaves; medium texture

**Flowers:** nodding yellow (sepals) and red (spurs) blooms; April-June

**Comments and Cautions:** very vigorous and easily grown but short-lived; can spread quickly by reseeding and will hybridize with other columbines; hybrids and cultivars also appropriate

**Additional Species and Cultivars:** A. canadensis 'Corbett;' A. caerulea Rocky Mountain columbine; 'Dragonfly' hybrids, 'Music' hybrids, 'Songbird'

## Aralia racemosa
spikenard

Part Shade · Shade · Side · Height 48" · Spread 36"

**Form:** Large, spreading

**Foliage:** compound leaves, bold texture

**Flowers:** large white plumes in July-August followed by clusters of dark purple fruit

**Comments and Cautions:** slowly spreads by underground rhizomes; highly organic soil beneficial

## Arnoglossum atriplicifolium
pale Indian plantain

Full Sun | Part Shade | Side | Bottom | Height: 36-72" | Spread: 24-36"

**Form:** upright

**Foliage:** thick, leathery, coarsely toothed basal leaves; stems and lower leaf surfaces covered with whitish bloom

**Flowers:** tiny, white, tubular-shaped, in flat-topped clusters; August-September

**Comments and Cautions:** will self-seed under good growing conditions; significant bee attractor

**Additional Species and Cultivars:** Cacalia suaveolens (false Indian plantain) is native to Iowa, adapted to similar garden conditions

## Aruncus dioicus
goat's beard

Full Sun | Part Shade | Top | Side | Bottom | Height: 48" | Spread: 48"

**Form:** rounded, shrub-like

**Foliage:** compound leaves; dark green; feathery bold texture

**Flowers:** small, cream-colored, in dense spikes up to 12" long

**Comments and Cautions:** use as backdrop or specimen plant, low moisture combined with wind and sun will cause foliage to burn

**Additional Species and Cultivars:** 'Child of Two Worlds;' 'Kneiffii' is a smaller cultivar

## Asarum canadense
wild ginger

Part Shade | Shade | Top | Side | Height: 6" | Spread: 24"

**Form:** spreading groundcover; rhizomatous

**Foliage:** dull green, heart-shaped to kidney-shaped, hugging the ground; bold texture

**Flowers:** urn-shaped, brownish purple; under the leaves and not showy; April-May

**Comments and Cautions:** tolerant of dry conditions in shade once established

## Asclepias incarnata
swamp milkweed

Full Sun | Part Shade | Bottom | Height: 48" | Spread: 48"

**Form:** tall, rather open habit, usually unbranched except in upper part of stems

**Foliage:** dark green, narrow leaves with pointed tips; medium texture; milky sap when stems are broken, but not to the same extent as common milkweed

**Flowers:** Rounded terminal clusters 4" to 5" across; flowers dusty pink to rose, with the "skirt" darker pink, lightly fragrant; July-August

**Comments and Cautions:** excellent for attracting butterflies; will self-seed

**Additional Species and Cultivars**: 'Cinderella,' 'Ice Ballet'

## Asclepias tuberosa
butterfly milkweed

Full Sun | Full Sun | Top | Side | Height: 18-24" | Spread: 18"

**Form**: mounding upright to rounded, deep-rooted

**Foliage**: fine texture

**Flowers**: orange, flat-topped clusters followed by boat-shaped pods; June-August

**Comments and Cautions:** will not tolerate wet soils; excellent habitat plant with deep taproot and hardy once established; tends to emerge late in spring; susceptible to aphids; wonderful attractant for pollinators

## Aster dumosus 'Wood's Blue,' 'Wood's Pink,' 'Wood's Purple'
Wood's aster series

Full Sun | Part Shade | Top | Side | Height: 12" | Spread: 18"

**Form**: compact rounded plants

**Foliage**: dark green; fine texture

**Flowers**: masses of single daisy-like flowers in blue, pink, purple; September-October

**Comments and Cautions:** excellent disease resistance (especially powdery mildew)

**Additional Species and Cultivars:** A. novae-angliae, New England Aster; 'Purple Dome,' 'Alma Potschke,' and 'September Ruby'; taller cultivars can be pinched or sheared to encourage branching and reduce height

## Astilbe chinensis var. pumila
dwarf Chinese astilbe

Part Shade | Shade | Sides | Bottom | Height: 12-15" | Spread: 12-15"

**Form**: low rounded mound; spreads slowly by stolons

**Foliage**: compound leaves, fine-textured; deep green with russet tones on margins and undersides

**Flowers**: conical, fluffy pink panicles in July-August; ornamental through fall if seed heads are allowed to remain

**Comments and Cautions:** excellent groundcover; best astilbe for drought tolerance, but performs poorly if allowed to dry out

**Additional Species and Cultivars:** A. chinensis 'Visions in Pink,' 'Visions in Red'

## Athyrium filix-femina
lady fern

Part Shade | Shade | Side | Bottom | Height: 24-30" | Spread: 12-30"

**Form**: mounding, vigorous; spreads very slowly by rhizomes

**Foliage**: deciduous; lacy lance-shaped leaves; fine-textured

**Height/Spread:** reaches largest size in consistently moist, shady soil

**Comments and Cautions:** relatively easy fern to grow, but slow to establish; tolerant of variable soil conditions; prefers high organic soils

**Additional Species and Cultivars:** A. filix-femina var. angustum 'Lady in Red;' smaller, more upright form with deep red stems

## Baptisia australis
blue false indigo

Full Sun · Part Shade · Top · Side · Bottom · Height: 24-48" · Spread: 48"

**Form**: woody base; bushy and upright to rounded

**Foliage**: compound leaves, blue-green to green changing to silver-dark gray in late fall and persisting through winter; medium texture

**Flowers**: indigo blue, pea-like on terminal spikes, May-June; followed by showy persistent gray-black seed pods

**Comments and Cautions:** effective in naturalized settings; extremely deep fleshy taproot makes relocation difficult; slow to establish

**Additional Species and Cultivars:** Baptisia australis var. minor, smaller in all its parts to a height and spread of 24 to 36 inches

## Boltonia asteroides
boltonia

Full Sun · Part Shade · Top · Sides · Height: 48" · Spread: 48-60"

**Form**: strongly upright and slightly rounded; dense mass of self-supporting stems

**Foliage**: narrow gray-green leaves; medium-fine texture

**Flowers**: white, 1-inch "daisies" cover plant late August-September; attracts butterflies

**Comments and Cautions:** No staking required to hold form into winter

**Additional Species and Cultivars:** 'Snowbank,' more compact, heavier flowering; Boltonia asteroides var. latisquama 'Jim Crockett,' compact to a height and spread of 24 inches and pale violet flowers with yellow discs from June through September

## Callirhoe involucrata
purple poppy-mallow, wine cups

Full Sun · Top · Height: 12" · Spread: 36"

**Form**: sprawling groundcover

**Foliage**: dissected leaves on stems up to 3 feet long

**Flowers**: bright magenta, cup-shaped blooms with white centers; very showy; June-September

**Comments and Cautions:** excellent for hot dry areas; shear or mow plants to rejuvenate tired foliage; avoid disturbing taproot

## Chelone glabra
turtlehead

Full Sun · Part Shade · Shade · Side · Bottom · Height: 24-48" · Spread: 18"

**Form**: dense and upright

**Foliage**: dark green shiny leaves, almost leathery

**Flowers**: terminal clusters of white tubular flowers resembling turtle heads; August-October

**Comments and Cautions:** attracts hummingbirds and butterflies; highly organic soil with good moisture is beneficial

**Additional Species and Cultivars:** C. lyonii 'Hot Lips,' smaller, more compact plant with deep pink flowers

## Coreopsis verticillata
threadleaf coreopsis

Full Sun | Part Shade | Top | Side | Height: 18-24" | Spread: 30"

**Form:** upright, spreading by stolons to form large dense colonies

**Foliage:** threadlike, dark green; fine texture

**Flowers:** bright yellow notched rays and yellow disc; loose bunches; June-August

**Comments and Cautions:** drought tolerant and carefree once established; sandy to loamy soil promotes spread; shear after blooming

**Additional Species and Cultivars:** 'Zagreb,' 'Golden Showers' are tallest and strongest cultivars

## Dalea purpurea
purple prairie clover

Full Sun | Top | Height: 24" | Spread: 24"

**Form**: clustered, branched stems; upright vase shape

**Foliage**: tiny, feathery, compound leaves; dense but fine texture

**Flowers**: tiny, red-violet to hot pink clustered in a hoop or donut shape; flowers open from base to tip for long season interest; June-August

**Comments and Cautions:** deep taproot and extremely drought tolerant; requires excellent drainage, should be located in relatively dry locations

**Additional Species and Cultivars:** 'Stephanie' more compact, greater flower production

## Echinacea angustifolia
narrow-leaved coneflower

Full Sun | Top | Height: 18" | Spread: 36"

**Form**: narrowly upright; flower heads carried on single stems

**Foliage**: oblong leaves covered with stiff hairs; medium-bold texture

**Flowers**: pale purple to pink; small number of drooping petals surround dark cone; June-August

**Comments and Cautions:** upright stems show to advantage among grasses; cones provide winter bird food

## Echinacea purpurea
purple coneflower

Full Sun | Part Shade | Top | Side | Height: 24-48" | Spread: 24"

**Form**: basal mound of foliage; flowers on erect individual stalks

**Foliage**: rough-surfaced bright to dark green leaves; variable size

**Flowers**: purple-pink rays held flat around large brown-orange disk

**Comments and Cautions:** late season foliage may look rough but can be removed; reseeds and spreads readily; cones provide winter bird food

**Additional Species and Cultivars:** wide range of cultivars and hybrids with variable heights and bloom colors; orange and yellow hybrids have limited life span and hardiness

## Eupatorium "Phantom"

phantom joe pye weed

Full Sun | Part Shade | Side | Bottom | Height: 24-48" | Spread: 12-24"

**Form**:clump-forming

**Foliage**: dark green leaves in whorls

**Flowers**: terminal, dome-shaped compound inflorescence; mid-summer to early fall; seed heads may persist into winter

**Comments and Cautions:** attractive to butterflies; hybrid cross between Eupatorium maculatum 'Atropurpureum' and Eupatorium rugosum

## Eutrochium dubium 'Little Joe'

Little Joe pye weed

Full Sun | Part Shade | Side | Bottom | Height: 36-48" | Spread: 24-36"

**Form**: rounded to upright compact mound

**Foliage**: serrated dark green leaves whorled around stems; medium texture

**Flowers**: tiny mauve purple flowers in flat-topped inflorescences; August-September

**Comments and Cautions:** attractive to butterflies; compact form well-suited to smaller gardens; more open, less upright habit in full shade

## Eutrochium purpureum

sweet joe pye weed

Part Shade | Shade | Side | Bottom | Height: 48-72" | Spread: 48"

**Form**: erect, mound-forming

**Foliage**: serrated whorled dark green leaves; bold texture

**Flowers**: tiny pinkish-purple flowers; vanilla-scented; in large compound inflorescences; July-September

**Comments and Cautions:** very attractive to butterflies; needs lots of space; good for back or center of larger gardens; can be cut back by one-third to reduce height and encourage branching

**Additional Species and Cultivars:** 'Little Red' more compact, 36 to 48 inches tall, better for small gardens

## Eutrochium purpureum subsp. maculatum 'Gateway'

Gateway spotted joe pye weed

Full Sun | Part Shade | Side | Bottom | Height: 48-60" | Spread: 48"

**Form**: erect, mound-forming

**Foliage**: dark green whorled leaves on red stems

**Flowers**: tiny rose-pink flowers in 12- to 18-inch terminal inflorescences; July-September; seed heads persist into winter

**Comments and Cautions:** very attractive to butterflies; best for larger gardens or as a tall backdrop; tolerates more moisture than E. purpureum species (sweet joe pye weed)

## Filipendula rubra
queen-of-the-prairie

Full Sun | Part Shade | Bottom | Height: 60-84" | Spread: 36"

**Form:** rounded, flowering stems are upright and slightly arching, seeds to form colonies

**Foliage:** compound, divided, deep green; medium texture

**Flowers:** small, pink fragrant; in large terminal plumes; May-June

**Comments and Cautions:** consistently moist soils keep foliage looking good; staking usually not needed

## Gaillardia grandiflora
gaillardia hybrids and cultivars

Full Sun | Top | Side | Height: 12-24" | Spread: 12-24"

**Form**: rounded basal mounds of foliage; upright flowering stems

**Foliage**: gray-green leaves, lobed and covered with short hairs

**Flowers**: 3 to 4 inches composite flowers, rays banded with yellow, orange, red; June-September

**Comments and Cautions:** root rot potential in poorly drained soil; tends to be short-lived and should be allowed to reseed

**Additional Species and Cultivars:** G. aristata, blanket flower, is native to dry sites in the west; 'Baby Cole,' 'Bijou,' 'Fanfare,' 'Arizona Sun'

## Geranium maculatum
wild geranium

Part Shade | Shade | Side | Height: 18-24" | Spread: 18"

**Form**: mounding

**Foliage**: palmately lobed leaves, dark green; medium to bold texture

**Flowers**: 1 inch wide, pink to purple, five-petaled; April-May

**Comments and Cautions:** can spread aggressively through rhizomes; useful for naturalizing

## Geranium sanguineum
bloody cranesbill

Part Shade | Shade | Side | Height: 18" | Spread: 18-36"

**Form**: mounded, spreading

**Foliage**: small palmately lobed leaves, dark green turning red in fall; fine texture

**Flowers**: 1 inch wide, magenta, five-petaled; May-June with some rebloom

**Comments and Cautions:** spreads slowly and can produce seedlings; fairly drought tolerant once established

**Additional Species and Cultivars**: 'New Hampshire,' 'Alpenglow'

## Helenium autumnale
Helen's flower, sneezeweed

Full Sun | Part Shade | Side | Bottom | Height: 36-60" | Spread: 30"

**Form**: erect, mound-forming; stems unbranched

**Foliage**: dark green; medium texture

**Flowers**: compound, with small notched yellow rays and a round, dull, yellow raised disk; July-October

**Comments and Cautions:** stake or cage plants to reduce flopping; shorter, more compact hybrids and cultivars with greater bloom color variety are available; maintain consistent moisture

**Additional Species and Cultivars:** Most are hybrids; 'Rotgold,' 'Rubinzwerg,' 'Wyndley,' 'Mardi Gras'

## Heliopsis helianthoides
ox-eye daisy

Full Sun | Part Shade | Side | Bottom | Height: 36-60" | Spread: 24-36"

**Form**: mound-forming, upright

**Foliage**: dark green, serrated leaves; bold texture

**Flowers**: daisy-like, 2 to 3 inches in diameter; yellow rays, brown centers; June-August

**Comments and Cautions:** species can reseed aggressively; plants require support if shade is excessive; aphids can be a problem

**Additional Species and Cultivars:** 'Summer Sun' and 'Summer Nights' recommended cultivars for better flower production; 'Summer Nights' has dark red-brown stems

## Hemerocallis spp. (many cultivars)
daylily

Full Sun | Part Shade | Shade | Top | Side | Height: 6-36" | Spread: 60"

**Form**: low and spreading; arching mounds; groundcover

**Foliage**: long linear leaves; bright green; medium texture

**Flowers**: highly variable in bloom time and color; some fragrant; May-October; depending on selection, some are repeat bloomers

**Comments and Cautions:** foliage works for spreading groundcover and can be mowed to produce new leaves in midsummer; no winter interest

**Additional Species and Cultivars:** dozens of cultivars and hybrids available; consider length and season of bloom (choose different cultivars to extend bloom time), ability to re-bloom, fragrance, and height

## Hibiscus moscheutos
rose mallow, hardy hibiscus

Full Sun | Part Shade | Top | Side | Bottom | Height: 36-60" | Spread: 24-36"

**Form**: broad and rounded; shrub-like

**Foliage**: lobed leaves up to 10 inches long; very bold texture

**Flowers**: up to 12 inches wide, overlapping petals; color range includes pinks, reds, white, yellow; July-October

**Comments and Cautions:** cut back only in late spring to protect crown in winter and encourage dense basal growth; flowers last only a day but are profuse; avoid windy locations

**Additional Species and Cultivars:** 'Disco Belle White,' 'Disco Belle Rosy Red,' 'Kopper King,' 'Luna' series, 'Plum Krazy,' 'Fireball,' 'Pink Cloud'

## Hosta spp. (many cultivars)
hosta

Part Shade | Shade | Top | Side | Height: 6-36" | Spread: 6-60"

**Form**: mounded to arching; flower stems above foliage

**Foliage**: long petioles, smooth or wavy margins; small and pointed to very large and rounded; green, chartreuse, variegated

**Flowers**: bell-shaped, white to lavender, variable size on leafless stems; many fragrant; June-September depending on selection

**Comments and Cautions:** some cultivars may tolerate sun if adequate moisture is present; most hostas are best planted in part shade to shade

**Additional Species and Cultivars:** dozens of cultivars and hybrids available; choices for naturalized, spreading plantings include H. lancifolia 'Francee,' 'Ground Master'

## Iris sibirica
Siberian iris

Full Sun | Part Shade | Top | Side | Height: 24-36" | Spread: 24-36"

**Form**: upright mounds

**Foliage**: swordlike narrow green leaves; effective yellow fall color; medium texture

**Flowers**: three standards and three falls held on stems above foliage; purple to blue with yellow and white cultivars; May-June

**Comments and Cautions:** nice foliage after bloom; less susceptible to borers and rot than tall bearded iris; divide in spring

**Additional Species and Cultivars:** 'Caesar's Brother,' 'Butter and Sugar'

## Iris versicolor
blue flag iris

Full Sun | Part Shade | Bottom | Height: 24-30" | Spread: 24-30"

**Form**: mound-forming, arching and upright

**Foliage**: blue-green narrow leaves

**Flowers**: violet-blue with white and yellow markings; May-July

**Comments and Cautions:** best grown in moist soil; will slowly naturalize

## Liatris ligulistylis
meadow blazing star

Full Sun | Part Shade | Side | Height: 12-36" | Spread: 12-24"

**Form**: upright and mound-forming

**Foliage**: basal tufts of narrow green leaves; medium texture

**Flowers**: fluffy, thistle-like, deep rose-purple flowers on columnar inflorescences; flowers open at same time within the flower head; July-September

**Comments and Cautions:** excellent for butterflies and birds; tends to flop and may need staking; can be difficult to establish

## Liatris pycnostachya
prairie blazing star

Full Sun | Side | Bottom | 36-48" Height | 18" Spread

**Form**: mounded foliage, upright and curved flower stems

**Foliage**: narrow leaves, mostly at base of plant; medium texture

**Flowers**: fluffy, deep, rose-purple flowers crowded on dense spikes; bloom top to bottom; July-August

**Comments and Cautions:** tallest *Liatris* species, tends to flop and may need staking

**Additional Species and Cultivars:** L. lancifolia (lanceleaf blazing star) grows 24 to 36 inches tall; adapted to wet ditches and sand-loam soil; difficult to find in trade

## Liatris spicata
dense blazing star

Full Sun | Top | Side | Bottom | 24-36" Height | 18" Spread

**Form**: mounded foliage; upright flower spikes

**Foliage**: narrow dark green linear leaves; medium-fine texture

**Flowers**: small magenta flowers on stems up to 18 inches; bloom top to bottom; July-September; seed heads effective into fall

**Comments and Cautions:** cultivars longer-blooming and/or more compact than the species; best performing Liatris in moist soils; slow to establish

**Additional Species and Cultivars:** 'Floristan White,' 'Floristan Violet,' 'Kobold'

## Lobelia cardinalis
cardinal flower

Part Shade | Shade | Bottom | 24-36" Height | 24" Spread

**Form**: open, upright mounds of foliage

**Foliage**: dark green leaves; bold texture

**Flowers**: clustered, deep red tubular flowers on vertical stems; July-September

**Comments and Cautions:** can be relatively short-lived; must have consistent moisture; attractive to hummingbirds and butterfies

**Additional Species and Cultivars:** L. 'Monet Moment;' magenta late summer-fall bloom; grows 24 to 36 inches; well-adapted to moist/dry location; hybrid lobelia generally longer lived than species

## Lobelia siphilitica
great blue lobelia

Full Sun | Part Shade | Side | Bottom | 24-36" Height | 24" Spread

**Form**: rounded to upright; mound-forming

**Foliage**: finely toothed, light green leaves; medium texture

**Flowers**: showy blue tubular flowers in dense racemes; July-September

**Comments and Cautions:** may be short-lived under stressed conditions; must have consistent moisture

## Matteuccia struthiopteris
ostrich fern

Part Shade | Shade | Bottom | Height: 36-72" | Spread: 60-96"

**Form**: mound-forming, upright and arching; spreads by rhizomes

**Foliage**: medium green, dissected, and feathery fronds; medium-fine texture

**Flowers**: n/a

**Comments and Cautions:** foliage quality declines over summer; maintain consistent moisture; goes dormant in early fall

## Mimulus ringens
monkey flower

Full Sun | Part Shade | Side | Bottom | Height: 12-36" | Spread: 9-12"

**Form:** rhizomatous growth habit; erect square stems

**Foliage:** oblong sharply-toothed leaves

**Flowers**: in pairs, each flower to 1" long; lilac-purple, two-lipped (resemble snapdragon or face of a smiling monkey); bloom June to September

**Comments and Cautions:** best in part shade; used for naturalizing

## Monarda didyma
bee balm

Full Sun | Part Shade | Side | Bottom | Height: 36" | Spread: inf

**Form**: upright, spreads by aggressive stolons to form large colonies

**Foliage**: bright green, toothed, and aromatic; powdery mildew can be a problem on straight species; medium-bold texture

**Flowers**: tubular, two-lipped flowers up to 2 inches long in dense clusters; colors include pink, purple, red, and white

**Comments and Cautions:** select cultivars with mildew resistance and provide good air circulation; some may spread less aggressively; attractive to hummingbirds

**Additional Species and Cultivars:** M. didyma 'Jacob Cline,' 'Marshall's Delight,' 'Petite Pink;''Petite Delight,' M. fistulosa, wild bergamot

## Oenothera fruticosa
sundrops

Full Sun | Side | Height: 12-18" | Spread: 12-24"

**Form**: Upright; clustered unbranched stems

**Foliage**: dull green, lance-shaped leaves

**Flowers**: bright yellow, four-petaled flowers bloom during day; June-July

**Comments and Cautions:** can spread rapidly but typically not invasive; can attract birds

## Oenothera macrocarpa
Missouri evening primrose

Full Sun | Top | Side | 12" Height | 12-24" Spread

**Form:** sprawling and spreading

**Foliage:** narrow silver-green leaves with ruby-red stems throughout growing season

**Flowers**: 3 to 5 inches across, solitary, mildly fragrant, bright yellow, open for one day; spring to late summer bloom followed by showy winged seed pods 2 to 3 inches long

**Comments and Cautions**: may self-seed in optimum growing conditions; has been shown to be highly adaptable in both dry and wet soils

**Additional Species and Cultivars:** 'Comanche Campfire'

## Osmunda cinnamomea
cinnamon fern

Part Shade | Shade | Bottom | 36" Height | 36" Spread

**Form**: upright and arching; will form colonies

**Foliage**: bright green; finely divided fronds; fine texture; may turn golden in moist summers; rough and brown by August in drought conditions

**Flowers**: n/a

**Comments and Cautions:** tolerant of wide variety of soils; highly organic soil is beneficial

## Penstemon digitalis
smooth beardtongue, penstemon

Full Sun | Part Shade | Top | Side | 18-30" Height | 18" Spread

**Form:** rosette of foliage; vertical flower stems

**Foliage:** thick, oblong leaves; medium texture, evergreen to semi-evergreen

**Flowers:** two-lipped, white to pink, tubular; seed heads are dark brown and showy; May-June

**Comments and Cautions:** good drainage promotes longevity; reseeds easily

**Additional Species and Cultivars:** 'Husker Red,' 'Dark Towers' have deep red-purple foliage

## Phlox pilosa
prairie phlox

Full Sun | Part Shade | Top | Side | 18" Height | 24" Spread

**Form**: weakly spreading groundcover; colonizes by underground stolons

**Foliage**: dark green linear leaves; fine-textured

**Flowers**: 1 inch wide, pale pink to lavender petals with tubular center; very fragrant; April-May, and sporadic rebloom

**Comments and Cautions:** higher drought-resistance than other phlox

**Additional Species and Cultivars:** 'Eco Happy Traveler' is more compact, stronger bloomer

## Physostegia virginiana
obedient plant

Full Sun | Part Shade | Top | Side | Height: 36-48" | Spread: 24-36"

**Form**: upright habit, spreads

**Foliage**: sharp-toothed narrow leaves

**Flowers**: pinkish tubular flowers; July-September

**Comments and Cautions:** can be an aggressive spreader and tends to flop, especially in high fertility soils; can be cut back for denser habit

**Additional Species and Cultivars:** 'Miss Manners' has a clumping habit and pure white flowers; 'Vivid' has rosy-pink flowers and a compact form

## Polygonatum biflorum
solomon's seal

Part Shade | Shade | Top | Side | Height: 24-36" | Spread: 24"

**Form**: unbranched arching stems, colonizes from rhizomes

**Foliage**: bright green leaves in flattened pattern on stems; yellow fall color; medium texture

**Flowers**: small, bell-shaped, white-green; hang under leaves; April-May, followed by blue-black berries

**Comments and Cautions:** long-lived once established; competes with tree roots

## Polygonatum multiflorum 'Variegatum'
variegated Solomon's seal

Part Shade | Shade | Top | Side | Height: 24" | Spread: 24"

**Form**: unbranched arching stems, colonizes from rhizomes

**Foliage**: bright green leaves with white edges in flattened pattern on stems; yellow fall color; medium texture

**Flowers**: small, bell-shaped, white-green; hang under leaves; April-May, followed by blue-black berries

**Comments and Cautions:** long-lived once established; competes with tree roots

## Pycnanthemum virginianum
virginia mountain mint

Full Sun | Part Shade | Top | Side | Bottom | Height: 24-36" | Spread: 18"

**Form**: erect to rounded, bushy

**Foliage**: narrow, tapered leaves; fine texture

**Flowers**: profuse flat-topped clusters of small white flowers; July-September

**Comments and Cautions:** mint-like fragrance from crushed foliage and flowers; excellent for attracting pollinators; can withstand drought

**Additional Species and Cultivars:** P. tenuifolium

## Ratibida pinnata
grayheaded prairie coneflower

Full Sun | Part Shade | Side | Height: 36-60" | Spread: 24"

**Form**: upright, narrow, and sparse

**Foliage**: pinnately divided leaves; bold texture

**Flowers**: bright yellow, drooping rays; gray raised disk; June-August

**Comments and Cautions:** best massed or combined with grasses due to sparse habit of individual plants; tallest plants may need support

## Rudbeckia fulgida var. sullivantii 'Goldsturm'
goldsturm rudbeckia

Full Sun | Part Shade | Side | Height: 24-36" | Spread: 36"

**Form**: upright and mound-forming; spreads by rhizomes

**Foliage**: dark green foliage, rough-surfaced; medium-bold texture

**Flowers**: daisy-like with yellow-orange rays and round dark brown center discs; June-September

**Comments and Cautions:** foliage diseases possible if soil is too wet or air circulation is poor

## Rudbeckia laciniata (R. nitida)
goldenglow, green-head coneflower

Full Sun | Part Shade | Top | Side | Bottom | Height: 36-72" | Spread: 36"

**Form**: rounded mounds of foliage; upright and weakly vase-shaped in bloom

**Foliage**: large, dull green leaves, mitten-shaped lobes; bold texture

**Flowers**: limp yellow rays, raised green disc; July-September

**Comments and Cautions:** pinch back for bushier plants to reduce height; plants rarely need support; tolerates heat but not drought

**Additional Species and Cultivars:** 'Goldquelle,' 'Herbstonne'

## Ruellia humilis
wild petunia

Full Sun | Top | Side | Height: 9" | Spread: 18"

**Form**: open, spreading mound; groundcover

**Foliage**: bright green leaves, purplish stems and petioles; medium-fine texture

**Flowers**: small, petunia-like, violet-blue; each lasts one day; June-August

**Comments and Cautions:** reseeds prolifically; deep root system; nearly maintenance-free groundcover on difficult sites; can be very aggressive

## Salvia nemorosa
meadow sage

Full Sun | Part Shade | Top | Side | Height: 18-24" | Spread: 12-18"

**Form**: mounded foliage, upright flower stems

**Foliage**: dull gray-green leaves; medium texture

**Flowers**: spike-like racemes of violet-blue flowers; May-August if deadheaded

**Comments and Cautions:** long-blooming if deadheaded; wide variety of hybrids and cultivars; attractive to pollinators

**Additional Species and Cultivars:** 'Cardonna,' 'Marcus,' 'Purple Rain,' S. x *sylvestris* 'Mainacht'

## Sedum (groundcover hybrids and cultivars)
stonecrop, sedum

Full Sun | Part Shade | Top | Upper Side | Height: 3-6" | Spread: 12-24"

**Form**: low, sprawling, or creeping groundcover

**Foliage**: small, thick succulent leaves; variable colors and sizes; fine texture

**Flowers**: small, star-shaped; size and shape of inflorescences varies; white, pink, yellow; late spring through late summer

**Comments and Cautions:** best massed and used as groundcover in drier areas

**Additional Species and Cultivars:** S. acre, S. sexangulare, S. kamschaticum, many others

## Sedum spp. (tall hybrids and cultivars)
showy sedum

Full Sun | Part Shade | Top | Side | Height: 18-24" | Spread: 18-30"

**Form**: upright to mounded

**Foliage**: medium leaves; thick and succulent; bright green, blue-green, variegated, purple; medium-bold texture

**Flowers**: star-shaped; inflorescences vary in shape and size; colors include white, pink, red, bronze

**Comments and Cautions:** highly drought tolerant; may flop in too much shade or moisture

**Additional Species and Cultivars:** S. telephium, 'Autumn Fire,' 'Carmen,' 'Frosty Fire,' 'Abbeydore,' many others

## Silphium integrifolium
cup plant, rosinweed

Full Sun | Part Shade | Top | Side | Bottom | Height: 48-72" | Spread: 24-36"

**Form**: upright

**Foliage**: medium green; leaves vary in size, bold texture

**Flowers**: yellow rays and disks resemble small sunflowers; in clusters; July-September

**Comments and Cautions:** tolerates drought once established; naturalizes by reseeding; resinous, gummy sap

## Solidago spp. cultivars
goldenrod

Full Sun | Part Shade | Top | Side | Height: 18-24" | Spread: 18-24"

**Form**: upright arching stems, many have rhizomes that form colonies

**Foliage**: dark green, sharply toothed; medium texture

**Flowers**: tiny yellow flowers in curving, plume-shaped inflorescence; July-September

**Comments and Cautions:** select shorter, dense cultivars to reduce flopping; excellent plants for attracting pollinators

**Additional Species and Cultivars:** 'Golden Baby,' 'Cloth of Gold,' 'Crown of Rays,' 'Little Lemon,' 'Wichita Mountains'

## Solidago riddellii
Riddell's goldenrod

Full Sun | Part Shade | Side | Height: 24-36" | Spread: 18-24"

**Form**: upright, will spread to form colonies

**Foliage**: dark green; medium texture

**Flowers**: tiny, bright yellow flowers in dense flat-topped inflorescences; September-October

**Comments and Cautions:** relatively late-blooming; unusual goldenrod; not tolerant of any dry condition

## Solidago rugosa 'Fireworks'
Fireworks goldenrod

Full Sun | Part Shade | Top | Side | Height: 48" | Spread: 24"

**Form**: upright, will spread slowly to form colonies

**Foliage**: green; medium texture

**Flowers**: open flat sprays of tiny bright yellow flowers like a shower of sparks; late August-October

**Comments and Cautions:** tolerates moist to dry soils; one of the latest to bloom; attractive to bees and butterflies

## Solidago speciosa
showy goldenrod

Full Sun | Part Shade | Side | Height: 24-36" | Spread: 24-36"

**Form**: upright, will spread to form colonies

**Foliage**: green; medium texture

**Flowers**: tiny, bright yellow flowers in club-shaped clusters; August-October

**Comments and Cautions:** very showy flower; attracts bees and butterflies

## Symphyotrichum ericoides
heath aster

Full Sun | Top | 12-36" Height | 18" Spread

**Form:** bushy, compact with many stems

**Foliage:** long narrow leaves

**Flowers:** daisy-like, white with yellow centers; September-October

**Comments and Cautions**: attractive to butterflies; mildew-resistant

## Symphyotrichum novae-angliae
New England aster

Full Sun | Top | Side | 36-48" Height | 24-36" Spread

**Form:** clump-forming; upright

**Foliage:** rough, hairy leaves and stems

**Flowers**: 1.5" wide, bright purple or light lavender petal-like ray flowers surrounding a central yellow disk; blooms August-September

**Comments and Cautions:** may self-seed in optimum growing conditions; can flop if allowed to grown to full height; prolific late summer/early fall blooms; species susceptible to powdery mildew; recommend cultivars for shorter, more compact habit and disease resistance

**Additional Species and Cultivars:** 'Purple Dome'; 'Alma Potschke', Kickin Series cultivars

## Symphyotrichum oblongifolium
aromatic aster

Full Sun | Part Shade | Top | Side | 12-36" Height | 12-36" Spread

**Form:** bushy, compact, rounded; spreads slowly by rhizomes to form large mounds

**Foliage**: small oblong leaves, blue-green to gray-green, covered with short hairs and fragrant when crushed

**Flowers**: small, daisy-like; violet-blue with yellow center; September-October

**Comments and Cautions:** attractive to butterflies; rarely needs attention; excellent mildew resistance

**Additional Species and Cultivars:** 'October Skies,' a shorter cultivar; *A. laevis* fall-blooming, violet rays with yellow centers

## Thalictrum dasycarpum
meadow rue

Part Shade | Shade | Side | Bottom | 36-48" Height | 36-48" Spread

**Form**: dense, mound-forming

**Foliage**: fine-textured foliage, medium green

**Flowers**: sprays of tiny purplish-white flowers; May-July

**Comments and Cautions:** intolerant of hot sun and dry soils; may flop and need staking

## Tradescantia bracteata
prairie spiderwort

Full Sun | Side | 12-18" Height | 18" Spread

**Form**: compact, mound-forming

**Foliage**: dark green, grass-like leaves; grooved; medium texture

**Flowers**: rose to purple, three petals and three sepals; each lasts one day; May-July

**Comment and Cautions:** foliage declines after flowering, cut back for new growth and later flowering

**Additional Species and Cultivars:** many T. x andersonii hybrids for rain gardens, including 'Concord Grape,' 'Purple Dome,' 'Sweet Kate,' 'Blue and Gold'

## Tradescantia ohioensis
Ohio spiderwort

Full Sun | Part Shade | Side | Bottom | 24-36" Height | 18-24" Spread

**Form**: mounded to slightly arching

**Foliage**: blue-green, arching grass-like leaves; can sprawl by late summer;medium texture

**Flowers**: open clusters with three rounded petals and three sepals, blue to rose; each lasts one day; May-July

**Comments and Cautions:** can self-seed and become aggressive

## Verbena hastata
blue vervain

Full Sun | Part Shade | Side | Bottom | 24-48" Height | 12-30" Spread

**Form**: mounded and upright; slowly forms colonies

**Foliage**: sharply toothed green leaves up to 6 inches long

**Flowers**: purplish-blue small flowers on slender spikes; July-September

**Comments and Cautions:** spreads slowly by rhizomes and self-seeding; attracts butterflies

## Vernonia fasciculata
common ironweed

Full Sun | Part Shade | Side | Bottom | 24-48" Height | 12-24" Spread

**Form**: erect, fibrous stems

**Foliage**: smooth narrow leaves with serrated edges; medium texture

**Flowers**: small, fluffy, purple flowers in clustered heads; July-September

**Comments and Cautions:** can reseed; cut back in late spring to reduce height; attractive to butterflies

## Veronicastrum virginicum
Culver's root

Full Sun | Part Shade | Side | Bottom | Height: 48-60" | Spread: 24-48"

**Form**: upright to slightly vase-shaped

**Foliage**: narrow whorled leaves; medium-bold texture

**Flowers**: tiny, white, tube-shaped flowers in slender spikes; bloom from top down; June-August

**Comments and Cautions:** may flop and require support; may be too large for small gardens; maintain consistent soil moisture

## Waldsteinia fragarioides
barren strawberry

Full Sun | Part Shade | Shade | Top | Height: 3-6" | Spread: 12"

**Form**: mat-forming groundcover spreads by rhizomes

**Foliage**: small-toothed leaflets; fine texture

**Flowers**: small, yellow, five-petaled flowers on separate stems; April-June; fruits resemble small strawberries

**Comments and Cautions:** use for shade groundcover; non-native W. ternata species is more aggressive and considered invasive

## Zizia aptera
meadow parsnip, heart-leaved alexanders

Full Sun | Part Shade | Side | Height: 12-30" | Spread: 12-18"

**Form**: upright, mounded

**Foliage**: heart-shaped basal leaves, divided stem leaves

**Flowers**: tiny yellow flowers in flat-topped clusters resembling carrot flowers on tall stems; May

**Comments and Cautions:** tends to be short-lived; foliage declines in summer

**Additional Species and Cultivars:** Z. aurea (golden alexander) adapted to sun and part shade; grows in small colonies; compound leaves with toothed leaflets and tiny yellow flowers; workhorse plant for some gardens

## Andropogon gerardii
big bluestem

Full Sun | Part Shade | Top | Side | Bottom | 96" Height | 36" Spread

**Form**: mound-forming; upright; warm-season native prairie grass

**Foliage**: green to green-blue; excellent coppery, orange-red fall color

**Flowers**: terminal, red at emergence; inflorescence resembles turkey's foot

**Comments and Cautions:** can flop; best away from manicured edges; slower to establish; may self-seed

**Additional Species and Cultivars:** 'Pawnee,' 'Silver Sunrise' (a hybrid with distinct banding on stems)

## Andropogon glomeratus
bushy bluestem

Full Sun | Side | Bottom | 36-72" Height | 24-36" Spread

**Form:** clump-forming

**Foliage:** flattened blue-green leaf blades; coppery-orange fall color persists into winter

**Flowers:** club-shaped flowers and bushy inflorescences; showy; September bloom

**Comments and Cautions:** generally intolerant of dry soils; can aggressively self-seed in optimum growing conditions

## Bouteloua curtipendula
sideoats grama

Full Sun | Top | Side | 36" Height | 18" Spread

**Form**: warm-season native prairie grass; mound-forming with arching flower stems

**Foliage**: light green to blue-green; fine texture

**Flowers**: slender arching stems hold individual spikelets in June-July; seed resembles small oats, mostly arranged on one side of stem

**Comments and Cautions:** very drought tolerant; seeds are fairly persistent

**Additional Species and Cultivars:** 'Trailway'

## Bouteloua gracilis
blue grama

Full Sun | Top | 12-15" Height | 15" Spread

**Form**: warm-season native prairie bunchgrass

**Foliage**: slender, slightly curled leaves, blue-green color; tan fall color; fine texture

**Flowers**: thin wiry stems hold flowers and seeds above foliage; inflorescence resembles small comb or moustache; turning to straw in fall and fairly persistent

**Comments and Cautions:** will self-seed to form low maintenance turf

**Additional Species and Cultivars:** 'Hachita'

## Calamagrostis acutiflora
feather reed grass

Full Sun | Part Shade | Top | Side | Height: 48-60" | Spread: 18-30"

**Form**: cool-season grass; mounds of foliage and vertical flower stems

**Foliage**: bright green; emerges early spring; light tan through winter; medium texture

**Flowers**: June; vertical inflorescence to 12 inches on long stems; tight narrow seed heads; sterile seeds; persistent into mid-winter

**Comments and Cautions:** upright, long-standing ornamental grass; the straight species is rarely available in the trade; divide every 3 to 4 years

**Additional Species and Cultivars:** 'Karl Foerster' is a commonly available hybrid; 'Overdam,' 'Avalanche' are variegated; C. brachytricha is fall-blooming and not as hardy; C. stricta (slimstem reedgrass) grows 12 to 36 inches; adapted to wet sandy soils

## Calamagrostis brachytricha
Korean feather reed grass

Full Sun | Part Shade | Side | Bottom | Height: 36-48" | Spread: 24-36"

**Form:** clump-form, slowly spreading

**Foliage:** mounded, narrow stiff green leaves

**Flowers:** pinkish tinged plumes late summer; appear above foliage to 4'

**Comments and Cautions:** does well in heavy clay soils; prefers moist soil

## Calamagrostis canadensis
bluejoint grass

Full Sun | Part Shade | Shade | Side | Bottom | Height: 24-60" | Spread: 24-36"

**Form:** clump-forming; grows from rhizomes and can form a coarse sod

**Foliage:** numerous slender stems

**Flowers:** nodding branched inflorescence; purplish turning to tan

**Comments and Cautions:** stands up well in winter; frequently found with sedges in natural settings; can spread aggressively; broad pH tolerance; resembles reed canary grass

## Carex annectens
yellowfruit large (yellow fox) sedge

Full Sun | Part Shade | Side | Bottom | Height: 12-36" | Spread: 12-24"

**Form:** dense clumping

**Foliage:** narrow grass-like leaves to 24" long

**Flowers:** green/yellow/brown spikes in late spring

**Comments and Cautions:** best massed for foliage in moist/wet areas; effective accent; will naturalize

## Carex bicknellii
prairie (copper-shouldered) sedge

Full Sun | Part Shade | Top | Side | Bottom | Height: 18-36" | Spread: 18-24"

**Form:** clump-forming; can colonize

**Foliage:** narrow and grass-like

**Flowers:** yellowish green, insignificant, April to July; on stalks up to 36" long; seed heads not showy

**Comments and Cautions:** relatively tolerant of variable soil moisture (dry to wet)**;** foliage may die back during hot, dry summers; can naturalize

## Carex brevior
shortbeak (plains oval) sedge

Full Sun | Part Shade | Shade | Top | Side | Bottom | Height: 12-24" | Spread: 15-18"

**Form:** short rhizomes forming tufts and clumps

**Foliage:** narrow and grass-like; fine-textured

**Flowers:** April to July; seeds are unique flat discs, tan when mature

**Comments and Cautions:** active growth spring and fall during cooler temperatures; adaptable to all conditions (especially dry and/or disturbed)

## Carex comosa
longhair sedge

Full Sun | Part Shade | Bottom | Height: 24-48" | Spread: 24-48"

**Form**: erect, dense growth

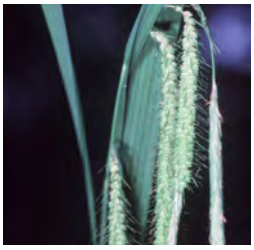
**Foliage**: narrow light green leaves; medium-fine texture

**Flowers**: insignificant; fruit a nutlet that is showy and bristly

**Comments and Cautions:** also known as bottlebrush sedge; may be difficult to find

## Carex crinita
fringed sedge

Full Sun | Part Shade | Bottom | Height: 24-48" | Spread: 24-48"



**Form**: mound-forming

**Foliage**: grass-like, bright green, medium-fine texture

**Flowers**: insignificant; pendulous seed heads provide habitat value for birds

**Garden Exposure and Location**: full sun to part shade; bottom

**Comments and Cautions:** also known as nodding or caterpillar sedge; may be difficult to find

## Carex grayii
gray's sedge

Full Sun | Part Shade | Shade | Side | Bottom | Height: 24-36" | Spread: 24"

**Form:** clump-forming

**Foliage:** semi-evergreen to evergreen; grass-like

**Flowers:** May-August; interesting showy spiked clustered seed heads; green turning brownish gray and persistent into winter

**Comments and Cautions:** adequate moisture required in full sun

## Carex hystericina
bottlebrush (porcupine) sedge

Full Sun | Part Shade | Side | Bottom | Height: 24-36" | Spread: 24-36"

**Form:** tuft-forming; rhizomatous colonies

**Foliage:** narrow, grass-like

**Flowers:** May-July; green prickly spikelets turning brown

**Comments and Cautions:** almost always naturally occurs in wetlands; growth during cool seasons, dormant when hot; seed valued by wetland birds

## Carex morrowii cultivars
Ice Dance, Old Gold

Part Shade | Shade | Side | Bottom | Height: 10-12" | Spread: 12-24"

**Form**: mounding and spreading slowly to form open colonies

**Foliage**: narrow, with a distinct V-shape; dark green with white edges; evergreen to semi-evergreen; medium-fine texture

**Flowers**: insignificant; May; seed heads rarely produced

**Comments and Cautions:** not native; needs protection from drying winds in winter and consistent moisture

**Additional Species and Cultivars:** Other Japanese sedge cultivars include 'Old Gold' and 'Variegata'

## Carex muskingumensis
palm sedge, muskingum sedge

Full Sun | Part Shade | Shade | Side | Bottom | Height: 18-24" | Spread: 24"

**Form**: mounded, dense, clump-forming; spreads by rhizomes and seed; groundcover

**Foliage**: light green, grass-like leaves; yellow after frost; medium-fine texture

**Flowers**: insignificant; arching tan seed heads persist through summer

**Comments and Cautions:** will flop in full shade; performs best with consistent moisture; not widely available commercially

## Carex rosea
rosy sedge

Full Sun | Part Shade | Shade | Top | Side | Bottom | 6-12" Height | 6-12" Spread

**Form:** thick clumps; short rhizomes may form sod

**Foliage:** very fine-texture; softly-arching, grass-like leaves

**Flowers:** spikes of reddish flowers/seed heads in May-June

**Comments and Cautions:** valued for use in dry shade; adaptable to wet and dry conditions; cool-season growth

## Carex scoparia
broom sedge

Full Sun | Bottom | 18-30" Height | 18-30" Spread

**Form**: tight bunching; vertical

**Foliage**: alternate narrow leaves; bright green; medium-fine texture

**Flowers**: insignificant; 1-inch spikelets

**Comments and Cautions:** also known as pointed broom sedge; not widely available commercially

## Carex sprengelii
sprengel's (long-beaked) sedge

Full Sun | Part Shade | Top | Side | Bottom | 18-36" Height | 18-24" Spread

**Form:** clumping

**Foliage:** fine, grass-like

**Flowers:** June-August

**Comments and Cautions:** native to woodlands

## Carex stipata
common fox sedge

Full Sun | Part Shade | Shade | Side | Bottom | 24-36" Height | 24-36" Spread

**Form**: slender, open tufts or bunches

**Foliage**: grass-like; blades tend to arch and flop; medium-fine texture

**Flowers**: clusters of brown seed capsules

**Comments and Cautions:** also known as awlfruit or owlfruit sedge

## Carex stricta
tussock sedge

Full Sun | Part Shade | Side | Bottom | Height: 12-36" | Spread: 12-24"

**Form:** rhizomatous to clump-forming

**Foliage:** evergreen; narrow and grass-like

**Flowers:** reddish-brown blooms May-June; not showy

**Comments and Cautions:** forms tussocks (clumps) in wet conditions; spreading into large colonies under drier conditions; good groundcover for light shade areas

## Carex texensis
Texas sedge

Part Shade | Shade | Top | Side | Bottom | Height: 3-6" | Spread: 12-18"

**Form:** rhizomatous; grows in mat-like clumps

**Foliage:** fine-textured, grass-like; semi-evergreen

**Flowers:** small green spikes in May

**Comments and Cautions:** a good shade groundcover for naturalizing; adaptable to full sun with irrigation

## Carex vulpinoidea
brown fox sedge

Full Sun | Part Shade | Side | Bottom | Height: 12-24" | Spread: 12-24"

**Form**: dense mounds or clumps

**Foliage**: grass-like, arching; bright green; fine texture

**Flowers**: golden-colored seed heads effective May-July

**Comments and Cautions:** may be weedy and can spread rapidly

## Eleocharis palustris
spikerush

Full Sun | Part Shade | Bottom | Height: 24-48" | Spread: 12-24"

**Form:** spreads by rhizomes

**Foliage:** leafless green stems grow from base of plant

**Flowers:** greenish-brown, inconspicuous spikelets on stems, June-September; yellow-brown seed heads

**Comments and Cautions:** may self-seed

## Juncus balticus
baltic rush

Full Sun | Side | Bottom | Height: 24" | Spread: 18-24"

**Form:** rhizomatous; dense growth

**Foliage:** tall wiry stems; bladeless leaves at plant base

**Flowers:** panicles in May-July; brown capsule fruit

**Comments and Cautions:** typical in wet spring/dry fall conditions; highly tolerant of soil moisture conditions and drought

## Juncus effusus
common rush, soft rush

Full Sun | Part Shade | Bottom | Height: 18-36" | Spread: 18-36"

**Form**: clump-forming and spreading by rhizomes and seed

**Foliage**: cylindrical, dark green stems; no actual leaves; yellow in fall before frost; fine texture

**Flowers**: insignificant small, greenish-brown, scaly; July-September

**Comments and Cautions:** can be somewhat aggressive in good growing conditions; restrict root zone to control spread

**Additional Species and Cultivars:** J. effusus 'Spiralis,' spiral rush, is widely available but not well-suited to large naturalized plantings

## Juncus tenuis
path rush

Full Sun | Part Shade | Side | Bottom | Height: 6-18" | Spread: 6-18"

**Form**: mounded or tufted with arching flower stems

**Foliage**: narrow, bright green, grass-like leaves in basal tufts; turns brown with frost; fine texture

**Flowers**: not significant; small greenish or brownish flowers in dense spikes or heads; May-July

**Comments and Cautions:** may naturalize readily and become weedy; more tolerant of drought and compaction than other rushes

## Panicum virgatum
switchgrass

Full Sun | Part Shade | Top | Side | Bottom | Height: 48-60" | Spread: 36-48"

**Form**: broad dense upright mounds; warm season native; spreads by rhizomes and seed

**Foliage**: bright green to blue-green; medium texture

**Flowers**: airy, cloudlike panicles above foliage; red, silver, white, or blue appearance; July-August; panicles persist into fall

**Comments and Cautions:** can reseed aggressively; consider planting after establishment of other garden plants to help limit spreading; may flop in rich soils

**Additional Species and Cultivars:** 'North Wind,' 'Shenandoah,' 'Rehbraun,' 'Prairie Fire,' 'Cloud Nine,' 'Dallas Blues,''Cheyenne'

## Schizachyrium scoparium
little bluestem

Full Sun | Part Shade | Top | Side | Height: 24-36" | Spread: 18-36"

**Form**: clump-forming warm-season native grass; upright to somewhat vase-shaped

**Foliage**: narrow, thin blue-green to gray-green leaves; excellent orange, red, gold, or tan fall color; medium-fine texture

**Flowers**: reddish racemes at ends of slender peduncles; September; seed heads fluffy, white, and curled; remain through winter months

**Comments and Cautions:** excellent drought-tolerant plant; will flop in shade or too much moisture; cut back by half in late spring to reduce flopping; spreads by seed to form dense stands

**Additional Species and Cultivars:** 'Blaze,' 'The Blues,' 'Blue Heaven'

## Sorghastrum nutans
indiangrass

Full Sun | Part Shade | Top | Side | Bottom | Height: 48-84" | Spread: 48"

**Form**: clump-forming warm season native grass; broadly upright; blooms rise above foliage

**Foliage**: green, rough-textured leaves; yellow to gold fall color; medium texture

**Flowers**: copper-colored panicles open August-September; bright yellow pollen sacs evident; copper-tan seed heads remain through winter

**Comments and Cautions:** will self-seed; shorter cultivars available

**Additional Species and Cultivars:** 'Indian Steel,' 'Sioux Blue'

## Sporobolus heterolepis
prairie dropseed

Full Sun | Part Shade | Top | Side | Height: 15-18" | Spread: 24"

**Form**: mounded, slightly arching, and vase-shaped; warm-season native prairie grass

**Foliage**: very fine, light green leaves; fall color can be brilliant orange to tan; foliage persists through winter; fine texture

**Flowers**: open panicles, 2 to 5 inches long on slender stalks; vanilla-scented; August-September; delicate seed heads

**Comments and Cautions:** extremely drought tolerant once established; may take years to bloom

## Aronia arbutifolia
red chokeberry

Full Sun | Part Shade | Top | Side | Bottom | Height: 6-10' | Spread: 3-6'

**Form**: vase-shaped; may sucker to form colonies

**Foliage**: glossy green leaves; red fall color; medium texture

**Flowers**: small; white to pale pink in open clusters; May

**Fruit**: abundant glossy bright red fruit persistent into winter; showy on some cultivars

**Comments and Cautions:** best fruit production in full sun; remove root suckers to control spread

**Additional Species and Cultivars:** 'Elegantissima' more compact than species, with better fall color and larger, more numerous fruit; 'Erecta' has an upright habit

## Aronia melanocarpa
black chokeberry

Full Sun | Part Shade | Top | Side | Bottom | Height: 5-6' | Spread: 4-5'

**Form**: rounded; may sucker to form colonies in good growing conditions

**Foliage**: glossy green leaves; red fall color; medium texture

**Flowers**: small; white to pale pink in open clusters; May

**Fruit**: blackish-blue, berry-like fruit persistent into winter; showy on some cultivars; edible

**Comments and Cautions:** best fruit production in full sun

**Additional Species and Cultivars:** 'Morton' (Iroquois Beauty) and 'Autumn Magic' are compact selections; 'Viking' and 'Nero' have showy large fruit; var. elata is larger by several feet

## Cephalanthus occidentalis
buttonbush

Full Sun | Part Shade | Top | Side | Bottom | Height: 5-10' | Spread: 4-8'

**Form**: open and rounded

**Foliage**: large glossy green leaves; bold texture

**Flowers**: tiny white flowers packed into 1-inch round flower heads; fragrant; June-July

**Fruit**: rounded, stalked balls, persistent through winter

**Comments and Cautions:** attracts bees and butterflies

**Additional Species and Cultivars:** 'Sputnik' is a compact form, 'Sugarshack' (compact, 4 to 6' ht.)

## Cornus sericea
redtwig dogwood

Full Sun | Part Shade | Top | Side | Bottom | Height: 6-10' | Spread: 6-10'

**Form**: upright, multi-stemmed, and spreading or suckering; stoloniferous red stems provide winter interest

**Foliage**: smooth green leaves with distinct veins; reddish-purple to yellow fall color; medium texture

**Flowers**: small white flowers in flat-topped clusters; May-June and intermittently through summer

**Fruit**: whitish to purple drupe fruit clusters in late summer, taken readily by birds

**Comments and Cautions:** bird habitat value; multi-season interest; best stem color produced on new stems; cultivars are smaller, more dense, or variegated; some disease and insect issues

**Additional Species and Cultivars:** 'Isanti,' 4 to 6 feet and finer texture; 'Allemans,' compact and dense; 'Cardinal,' large with brilliant red winter twigs; 'Farrow' (Arctic Fire), 3 to 4 feet, 'Firedance' (compact, 3 to 4' ht.)

## Corylus americana
American hazelnut


**Form**: rounded; suckering to form spreading colonies

**Foliage**: medium to large, toothed, dark green leaves; good fall color potential; bold texture

**Flowers**: showy male catkins, tiny female flowers in April

**Fruit**: nut in papery husk; late summer into fall

**Comments and Cautions:** high habitat value; tough and interesting plant

## Diervilla lonicera
Northern bush honeysuckle


**Form**: mounded; suckering to form loose colonies

**Foliage**: dark green leaves; yellow to red fall color; medium texture

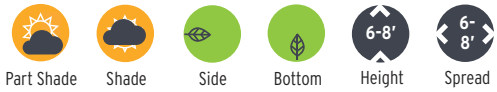
**Flowers**: small, bell-shaped, fragrant flowers, yellow changing to orange; June-August

**Fruit**: brown, not showy

**Comments and Cautions:** can be relatively short-lived but rejuvenates by suckering

**Additional Species and Cultivars:** 'Copper' grows to 3' x 3'; D. sessilifolia 'Butterfly,' Butterfly southern bush honeysuckle, profuse yellow flowers, grows to 3'-6' height and width.

## Hydrangea arborescens
smooth hydrangea




**Form**: rounded; erect, usually unbranched stems that sucker to form colonies

**Foliage**: large, dull green leaves with pointed tips; bold texture

**Flowers**: symmetrical rounded heads 4 to 6 inches across; buds are chartreuse, opening to small white fertile flowers and persisting through winter; June-September

**Fruit**: none

**Comments and Cautions:** species has been all but replaced by showy cultivars but reversion often occurs; cut close to ground each spring for best flowering and foliage

**Additional Species and Cultivars:** 'Annabelle,' with round heads 8 to 12 inches across; 3 to 5 feet by 5 feet or more; 'Dardom' (White Dome) with showy sterile flowers sprinkled into domes of fertile flowers; 3 to 5 feet; 'Invincibelle Spirit,' deep pink

## Itea virginica
Virginia sweetspire

Full Sun | Part Shade | Shade | Side | Bottom | Height: 3' | Spread: 5'

**Form**: arching, somewhat rounded; suckering roots form loose colonies

**Foliage**: dark green leathery leaves; dark red fall color lasts into November; medium texture

**Flowers**: drooping, elongated clusters of tiny, white, fragrant flowers; June-July

**Fruit**: not showy

**Comments and Cautions:** will naturalize in ideal conditions; may be chlorotic in alkaline soils; cultivars have better flowering and fall color than species

**Additional Species and Cultivars:** 'Henry's Garnet,' 'Merlot;' 'Sprich' (Little Henry) is a dwarf

## Physocarpus opulifolius
ninebark

Full Sun | Part Shade | Top | Side | Height: 5-8' | Spread: 4-6'

**Form**: rounded to vase-shaped, and broadly spreading with exfoliating bark; species has rather coarse appearance

**Foliage**: dull green leaves with large marginal teeth; medium texture

**Flowers**: small white to pink flowers in flat clusters; May-June

**Fruit**: reddish seed capsule clusters late summer into fall

**Comments and Cautions:** very hardy and deep-rooted; can be rejuvenated by cutting to ground

**Additional Species and Cultivars:** 'Monlo' (Diablo), 'Summer Wine,' 'Copper Glow,' and 'Coppertina' all have various shades of deep wine-red or red-copper foliage and are less prone to suckering than the speces; 'Nanus' is dwarf

## Rosa cultivars
shrub rose

Full Sun | Part Shade | Top | Side | Height: 2-5' | Spread: 2-5'

**Form**: highly variable, groundcover to large rounded or arching shrub

**Foliage**: compound leaves, shiny, leathery, or rough; potential for fall color

**Flowers**: highly variable in structure, color, bloom season, and fragrance

**Fruit**: variable fruit (hips) size, color, and persistence

**Comments and Cautions:** select disease-resistant hardy cultivars; not tolerant of poor drainage

## Salix purpurea 'Nana'
dwarf purpleosier willow

Full Sun | Side | Bottom | Height: 3-6' | Spread: 3-6'

**Form**: compact, rounded; fine-textured, dense, pale purple to silver winter twigs

**Foliage**: narrow blue-green leaves; fine texture

**Flowers**: showy grayish-white catkins in early spring before foliage; April-May

**Fruit:** not showy

**Comments and Cautions:** susceptible to many disease and insect problems, especially if drought-stressed; works well in a naturalistic setting; not long-lived

## Sambucus canadensis
elderberry

Full Sun | Part Shade | Top | Side | Bottom | Height: 5-10' | Spread: 5-10'

**Form**: rounded and suckering to form large colonies; coarse plant with thick, mostly unbranched, weak stems

**Foliage**: bright green compound leaves; bold texture

**Flowers**: small, fragrant, white flowers in large flat clusters; June-July

**Fruit**: small, edible, purple berry-like fruit in large clusters; late summer through fall

**Comments and Cautions:** high habitat value (flowers, fruit); produces better flowers and fruit in full sun; spreads by seed

**Additional Species and Cultivars:** 'Laciniata,' cut foliage and smaller habit; 'Aurea,' gold foliage

## Sorbaria sorbifolia
Ural false spirea, sorbaria

Full Sun | Part Shade | Top | Side | Height: 4-6' | Spread: 6'

**Form:** upright, semi-woody or suffrutescent; suckering rapidly or form indefinite colonies

**Foliage:** compound, doubly serrate, almost fernlike bright green leaves; medium texture

**Flowers:** small white flowers in 10-inch long pointed panicles; June-July and sporadically throughout summer

**Fruit:** not effective

**Comments and Cautions:** extremely effective for erosion control; showy during growing season; cut to ground in early spring

**Additional Species and Cultivars:** 'Sem' is a dwarf selection that grows with less suckering

## Spiraea alba
white meadowsweet

Full Sun | Part Shade | Side | Bottom | Height: 4' | Spread: 4'

**Form**: upright, numerous unbranched stems; mounded overall form

**Foliage**: narrow-toothed green leaves; medium-fine texture

**Flowers**: cone-shaped terminal clusters of tiny white flowers; June-August

**Fruit**: small pod-shaped follicles; late summer into fall

**Comments and Cautions:** more adaptable to wet soil than other spireas; do not allow to dry out

## Viburnum dentatum
Arrowwood viburnum

Full Sun | Part Shade | Top | Side | Bottom | Height: 5-8' | Spread: 5-8'

**Form**: upright, rounded to vase-shaped, multi-stemmed; may sucker weakly

**Foliage**: shiny green leaves, distinctly toothed; good fall color potential

**Flowers**: flat-topped clusters of small white flowers; no fragrance; May-June

**Fruit:** blue-black, berry-like fruit clusters late summer; rapidly taken by birds

**Comments and Cautions:** use cultivars for best fruiting, size, and fall color

**Additional Species and Cultivars:** 'Autumn Jazz,' fall color, good fruit set; 'Blue Muffin,' compact habit, dense fruit; many others

## Viburnum opulus var. americanum (V. trilobum)

American cranberrybush


**Form**: upright, rounded, spreading; may sucker or root from prostrate stems

**Foliage**: lobed green leaves; red to yellow fall color; medium texture

**Flowers**: showy flat-topped flower structures composed of tiny white fertile flowers surrounded by large sterile flowers; May-June

**Fruit**: clusters of edible red drupe fruit; very showy in late summer through fall

**Comments and Cautions:** generally fewer problems than with European cranberrybush (*V. opulus*); cultivars valuable for compact growth and prolific fruiting

**Additional Species and Cultivars:** 'Wentworth,' 'Hahs,' 'JN Select' (Red Wing)

## Viburnum prunifolium

blackhaw viburnum


**Form**: upright, multi-stemmed shrub or small tree

**Foliage**: glossy dark green leaves; reddish purple fall color

**Flowers**: small white flowers in flat-topped clusters, non-fragrant; May-June

**Fruit**: showy, edible, blue-black, berry-like fruit; persists fall into winter

**Comments and Cautions:** may sucker in ideal conditions; excellent plant for larger gardens

**Additional Species and Cultivars:** 'Summer Magic,' foliage emerges with bronze edge; *V. rufidulum*, rusty blackhaw or southern blackhaw

## Photo Citations

Achillea millefolium ..... Steven N. Rodie
Amorpha canesiens ..... Steven N. Rodie
Amorpha nana ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Amsonia hubrichtii ..... Courtesy Missouri Botanical Garden PlantFinder
Anemone canadensis ..... Mrs. W.D. Bransford, Lady Bird Johnson Wildflower Center
Andropogon glomeratus ..... Robert H. Mohlenbrock, @ USDA-NRCS PLANTS Database/ USDA SCS. 1989. Midwest wetland flora: Field office illustrated guide to plant species. Midwest National Technical Center, Lincoln
Aronia arbutifolia ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Arnoglossum atriplicifolium ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Asarum canadense ..... Albert Vick, Lady Bird Johnson Wildflower Center
Aster dumosus 'Wood's Blue' (Pink and Purple) ..... Weston Nurseries, www.WestonNurseries.com
Astilbe chinensis 'Pumila' ..... Steven N. Rodie
Athyrium filix-femina ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Baptisia australis ..... Steven N. Rodie
Boltonia asteroides ..... Steven N. Rodie
Bouteloua curtipendula ..... Steven N. Rodie
Bouteloua gracilis ..... Steven N. Rodie
Calamagrostis acutifora ..... Steven N. Rodie
Calamagrostis brachytricha ..... Courtesy Nebraska Statewide Arboretum
Calamagrostis canadensis ..... Robert H. Mohlenbrock, @ USDA-NRCS PLANTS Database/ USDA SCS. 1989. Midwest wetland flora: Field office illustrated guide to plant species. Midwest National Technical Center, Lincoln
Callirhoe involucrata ..... Steven N. Rodie
Carex bicknellii ..... Photo by John Hilty, Illinois Wildflowers
Carex comosa ..... Robert H. Mohlenbrock, @ USDA-NRCS PLANTS Database/ USDA SCS. 1989. Midwest wetland flora: Field office illustrated guide to plant species. Midwest National Technical Center, Lincoln
Carex crinita ..... Robert H. Mohlenbrock, @ USDA-NRCS PLANTS Database/ USDA SCS. 1989. Midwest wetland flora: Field office illustrated guide to plant species. Midwest National Technical Center, Lincoln
Carex grayi ..... Photo by John Hilty, Illinois Wildflowers
Carex hystericina ..... Photo by John Hilty, Illinois Wildflowers
Carex morrowii ..... Courtesy Missouri Botanical Garden PlantFinder
Carex muskingumensis ..... Courtesy Missouri Botanical Garden PlantFinder
Carex scoparia ..... Robert H. Mohlenbrock, @ USDA-NRCS PLANTS Database/ USDA SCS. 1989. Midwest wetland flora: Field office illustrated guide to plant species. Midwest National Technical Center, Lincoln.
Carex sprengelii ..... Courtesy Nebraska Statewide Arboretum
Carex stipata ..... Robert H. Mohlenbrock, @ USDA-NRCS PLANTS Database/ USDA SCS. 1989. Midwest wetland flora: Field office illustrated guide to plant species. Midwest National Technical Center, Lincoln
Carex stricta ..... Photo by John Hilty, Illinois Wildflowers
Carex texensis ..... Courtesy Nebraska Statewide Arboretum
Carex rosea ..... Courtesy Nebraska Statewide Arboretum
Carex vulpinoidea ..... Robert H. Mohlenbrock, @ USDA-NRCS PLANTS Database/ USDA SCS. 1989. Midwest wetland flora: Field office illustrated guide to plant species. Midwest National Technical Center, Lincoln
Cephalanthus occidentalis ..... Courtesy Missouri Botanical Garden PlantFinder
Chelone glabra ..... Steven N. Rodie
Coreopsis verticillata ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
CenterCornus sericea 'Isanti' ..... Courtesy Missouri Botanical GardenPlantFinder
Corylus americana ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Dalea purpurea ..... Mrs. W. D. Bransford, Lady Bird Johnson Wildflower Center
Diervilla lonicera ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Diervilla sessilifolia ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Echinacea angustifolia ..... Steven N. Rodie
Echinacea purpurea ..... Steven N. Rodie
Eleocharis palustris ..... Robert H. Mohlenbrock, @ USDA-NRCS PLANTS Database/ USDA SCS. 1989. Midwest wetland flora: Field office illustrated guide to plant species. Midwest National Technical Center, Lincoln
Eupatorium dubium 'Little Joe' ..... Steven N. Rodie
Eupatorium 'Phantom' ..... Weston Nurseries, www.WestonNurseries.com
Eupatorium purpureum ..... George Bruso, Lady Bird Johnson Wildflower Center
Eupatorium purpureum subsp. maculatum ..... Courtesy Missouri Botanical Garden PlantFinder
Filipendula rubra ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Gaillardia xgrandiflora ..... Courtesy Missouri Botanical Garden PlantFinder
Geranium maculatum ..... Mrs. W. D. Bransford, Lady Bird Johnson Wildflower Center
Geranium sanguineum ..... Courtesy Missouri Botanical Garden PlantFinder
Helenium autumnale ..... Steven N. Rodie
Heliopsis helianthoides ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Hemerocallis (various species and hybrids) Steven N. Rodie
Hibiscus moscheutos ..... Courtesy Missouri Botanical Garden PlantFinder
Hosta (various species and hybrids) ..... Steven N. Rodie
Hydrangea arborescens 'Annabelle' ..... Steven N. Rodie
Iris sibirica ..... Steven N. Rodie
Iris versicolor ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower CenterItea virginica ..... Steven N. Rodie
Juncus balticus ..... Robert H. Mohlenbrock, Robert H. Mohlenbrock, hosted by the USDA-NRCS PLANTS Database / USDA NRCS. 1995. Northeast wetland flora: Field office guide to plant species. Northeast National Technical Center, Chester
Juncus effusus ..... Courtesy Missouri Botanical Garden PlantFinder
Juncus tenuis ..... Robert H. Mohlenbrock, @ USDA-NRCS PLANTS Database/ USDA SCS. 1989. Midwest wetland flora: Field office illustrated guide to plant species. Midwest National Technical Center, Lincoln
Liatris ligulistylis ..... Bernie Bengston, Lady Bird Johnson Wildflower Center
Liatris pycnostachya ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center

Liatris spicata ..... Stefan Bloodworth, Lady Bird Johnson Wildflower Center
Lobelia cardinalis ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Lobelia siphilitica ..... Steven N. Rodie
Matteuccia struthiopteris ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Mimulus ringens ..... Photo by John Hilty, Illinois Wildflowers
Monarda didyma ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Oenothera fruticosa ..... Albert F. W. Vick, Lady Bird Johnson Wildflower Center
Oenothera macrocarpa ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Osmunda cinnamomea ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Panicum virgatum ..... Steven N. Rodie
Penstemon digitalis ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Phlox pilosa ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Physocarpus opulifolius ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Physostegia virginiana ..... Stephan Bloodworth, Lady Bird Johnson Wildflower Center
Polygonatum biflorum ..... Steven N. Rodie
Polygonatum multiflorum 'Variegatum' ..... Courtesy Missouri Botanical Garden PlantFinder
Pycnanthemum virginianum ..... Steven N. Rodie
Ratibida pinnata ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Rosa cultivars ..... Steven N. Rodie
Rudbeckia fulgida var. sullivantii 'Goldsturm' ..... Steven N. Rodie
Rudbeckia laciniata (nitida) ..... Steven N. Rodie
Ruellia humilis ..... Sandy Smith, Lady Bird Johnson Wildflower Center
Salix purpurea 'Nana' ..... Courtesy Missouri Botanical Garden PlantFinder
Salvia nemorosa ..... Courtesy Missouri Botanical Garden PlantFinder
Sambucus canadensis ..... Joseph A. Marcus, Lady Bird Johnson Wildflower Center
Schizachyrium scoparium ..... Steven N. Rodie
Sedum (groundcover hybrids and cultivars) ..... Steven N. Rodie
Sedum (tall hybrids and cultivars) ..... Steven N. Rodie
Silphium integrifolium ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Solidago cultivars ..... Steven N. Rodie
Solidago riddellii ..... Courtesy Missouri Botanical Garden PlantFinder
Solidago rugosa 'Fireworks' ..... Steven N. Rodie
Solidago speciosa ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Sorbaria sorbifolia ..... Courtesy Missouri Botanical Garden PlantFinder
Sorghastrum nutans ..... Steven N. Rodie
Spiraea alba ..... Mrs. W. D. Bransford, Lady Bird Johnson Wildflower Center
Sporobolus heterolepis ..... Steven N. Rodie
Symphyotrichum oblongifolius ..... Courtesy Missouri Botanical Garden PlantFinder
Symphyotrichum novae-angliae ..... Jennifer Anderson, hosted by the USDA-NRCS PLANTS Database
Thalictrum dasycarpum ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Tradescantia bracteata ..... Mrs. W. D. Bransford, Lady Bird Johnson Wildflower Center
Tradescantia ohioensis ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Verbena hasta ..... Mariann Watkins, Lady Bird Johnson Wildflower Center
Vernonia fasciculata ..... Steven N. Rodie
Veronicastrum virginicum ..... Steven N. Rodie
Viburnum dentatum ..... Courtesy Missouri Botanical Garden PlantFinder
Viburnum opulus var. americanum ..... Courtesy Missouri Botanical Garden PlantFinder
Viburnum prunifolium ..... Courtesy Missouri Botanical Garden PlantFinder
Waldsteinia fragarioides ..... George Bruso, Lady Bird Johnson Wildflower Center
Zizia aptera ..... Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center
Front Cover ..... Andy Szatko
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Pages 4 ..... Steven N. Rodie
Pages 18 ..... Steven N. Rodie
Pages 40 ..... Steven N. Rodie
Pages 48 ..... Steven N. Rodie
Pages 52 ..... Steven N. Rodie
Pages 60 ..... Andy Szatko
Pages 64 ..... Steven N. Rodie

## Plant Information Resources

**University of Nebraska–Lincoln NebGuides**

Available online at extension.unl.edu/publications; applicable information includes:

- G1759, Stormwater Management: Plant Selection for Rain Gardens in Nebraska
- G1060, Black Spot of Roses (recommended disease-resistant roses for Nebraska)
- G1074, Wildflowers for the Home Landscape: Perennials for Sunny Sites

**Publications**

- Flora of the Great Plains by Robert B. Kaul, Steven Rolfsmeier, and David Sutherland, published by University Press of Kansas, 2007.
- The Blue Thumb Guide to Raingardens–Design and Installation for Homeowners in the Upper Midwest by David Dods, Rusty Schmidt, and Dan Shaw, published by Waterdrop Innovations, LLC, 2007.

**Wildlife damage prevention information**

- Voles: www.icwdm.org/wildlife/voles.asp
- Deer: www.icwdm.org/wildlife/deer.asp
- Rabbits: www.icwdm.org/wildlife/rabbit.asp

**Plant Database websites**

- USDA (plants.usda.gov)
  Missouri Botanical Garden (www.mobot.org)
- Lady Bird Johnson Wildflower Center (www.wildflower.org)

# Form, Function, Benefits

Simply defined, a bioretention garden is a shallow, man-made depression of nearly any size that uses amended soils and a sub-drain system to collect stormwater runoff and conveys it slowly to the nearest outflow or channel.

Bioretention gardens add beauty and function regardless of location – whether it be a park or parking lot. It is the management of water, soil and plants that gives us a beautiful amenity and proven method for controlling stormwater flow where it's needed most.

This manual provides guidance for siting, designing, building, and maintaining bioretention gardens that are specific to the Omaha region, bringing new strategies and ideas for building beautiful gardens that will be successful in Omaha for generations to come.

OMAHA STORMWATER PROGRAM

Environmental Quality Control