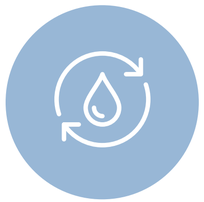
Reforestation

Invasive Species Eradication

Organic Landscape Care

Stream Restoration



Water Management

Composting

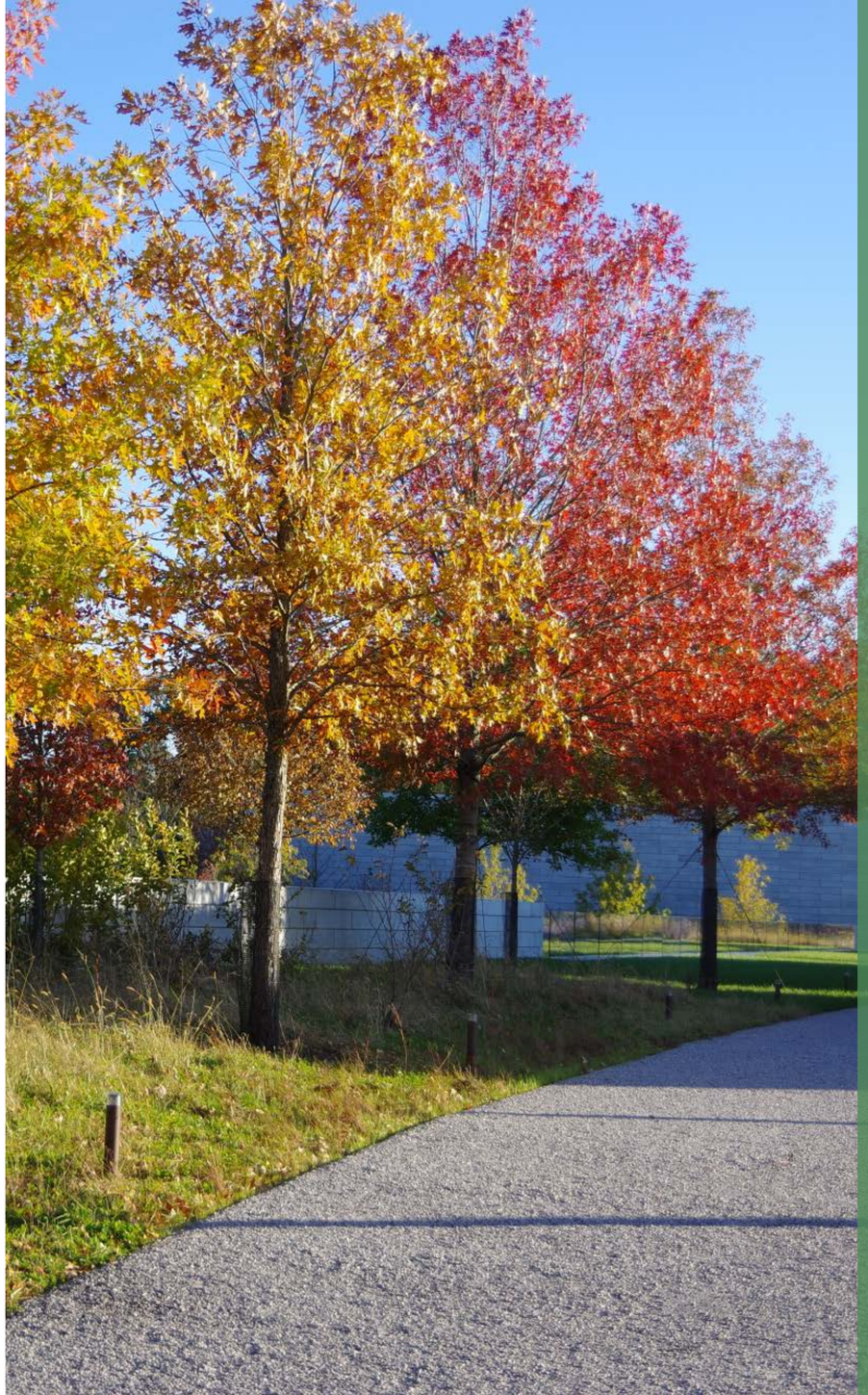
Recycling

Reforestation

re·for·est·a·tion: refers to the replanting of trees, “understory” vegetation such as shrubs, and ground cover flora on sites where previous plant life has been lost

Reforestation

Before its land was repurposed for suburban development, Potomac was deforested to become farmland servicing food crops and tobacco. Over the past decade as Glenstone expanded to nearly 300 acres, we have committed to the restoration of these original forests onsite—planting more than 8,000 native trees since opening to the public in 2006.



Right: Recently planted trees at Glenstone

Health Benefits of Trees

Referred to as the “lungs of the earth,” trees generate, moisten, and purify the air we breathe, releasing clean oxygen in a process known as photosynthesis. According to the Growing Air Foundation, over the course of a year, one acre of average-sized trees produces roughly the same amount of oxygen consumed annually by 18 people.[1]

Trees humidify the air by lifting water out of the ground and releasing it through their leaves. They also absorb various pollutants through holes in their leaves called stomates. For instance, the Spanish oak at the Gallery can lift an estimated 100 gallons of water out of the ground and discharge it into the air in a single day.

1 http://www.growingairfoundation.org/facts/

Environmental Benefits of Trees

Carbon dioxide (CO_2), though naturally occurring, is considered a dangerous greenhouse gas. Its concentration has increased in the atmosphere in the past 100 years due to cars and other industrial pollution. The planting of trees is seen as the best way to address this problem.[1] Trees mitigate CO_2 pollution by absorbing carbon into their wood fiber and releasing oxygen. An acre of trees absorbs enough CO_2 to offset the emissions of a car traveling 26,000 miles.[2] Our 8,000 newly planted trees are estimated to absorb approximately 500,000 pounds of CO_2 from the atmosphere each year.

1 National Research Council. 2010. *Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean*. Washington, DC: The National Academies Press. https://doi.org/10.17226/12904.
2 http://www.growingairfoundation.org/facts/

Right: One of the recently planted stands of trees at Glenstone

Environmental Benefits of Trees

Tree roots, which can grow up to three times the width of a tree's canopy, also do their part to stabilize soil and reduce erosion. Hundreds of trees were planted along the Greenbriar Branch and Sandy Branch streams, along with several smaller tributaries, as part of an ongoing restoration project aimed at reducing sediment pollution into the Potomac River.

Animals, including birds, mammals, amphibians, and insects depend on trees for shelter and habitat. At Glenstone, the stands of native birch trees at the Patio host dozens of species of butterflies and moths, and if you visit *FOREST (for a thousand years…)*, 2012, by Janet Cardiff and George Bures Miller, you may note colonies of ants at the base of the beech trees. Ants aggressively fight off other insects that might otherwise attack the trees.

Financial Benefits of Trees

Wood from trees provides raw material for an estimated 5,000 types of products worldwide.[1] However, trees provide a myriad of other financial benefits as well. For instance, one strategically placed, large tree could replace 10 standard air conditioners operating for 20 hours a day.[2] According to a recent study, trees planted in front of homes increase property values by 7-15%. Businesses also see an increase in sales when trees are planted in proximity to their storefront.[3] Evergreen trees that hold their needles year-round, such as the many pine groves in and around Glenstone, can block winds and reduce heating bills by 10-25%.[4]

1 http://www.biologyreference.com/Ve-Z/Wood-and-Wood-Products.html
2 http://www.growingairfoundation.org/facts/
3 https://www.thoughtco.com/how-much-oxygen-does-one-tree-produce-606785
4 https://articles.extension.org/pages/70092/tree-planting-for-lower-power-bills

Right: This fence along Glen Road was constructed from the lumber of native white oak trees, *Quercus alba*, that were felled during a 2012 derecho at Glenstone.

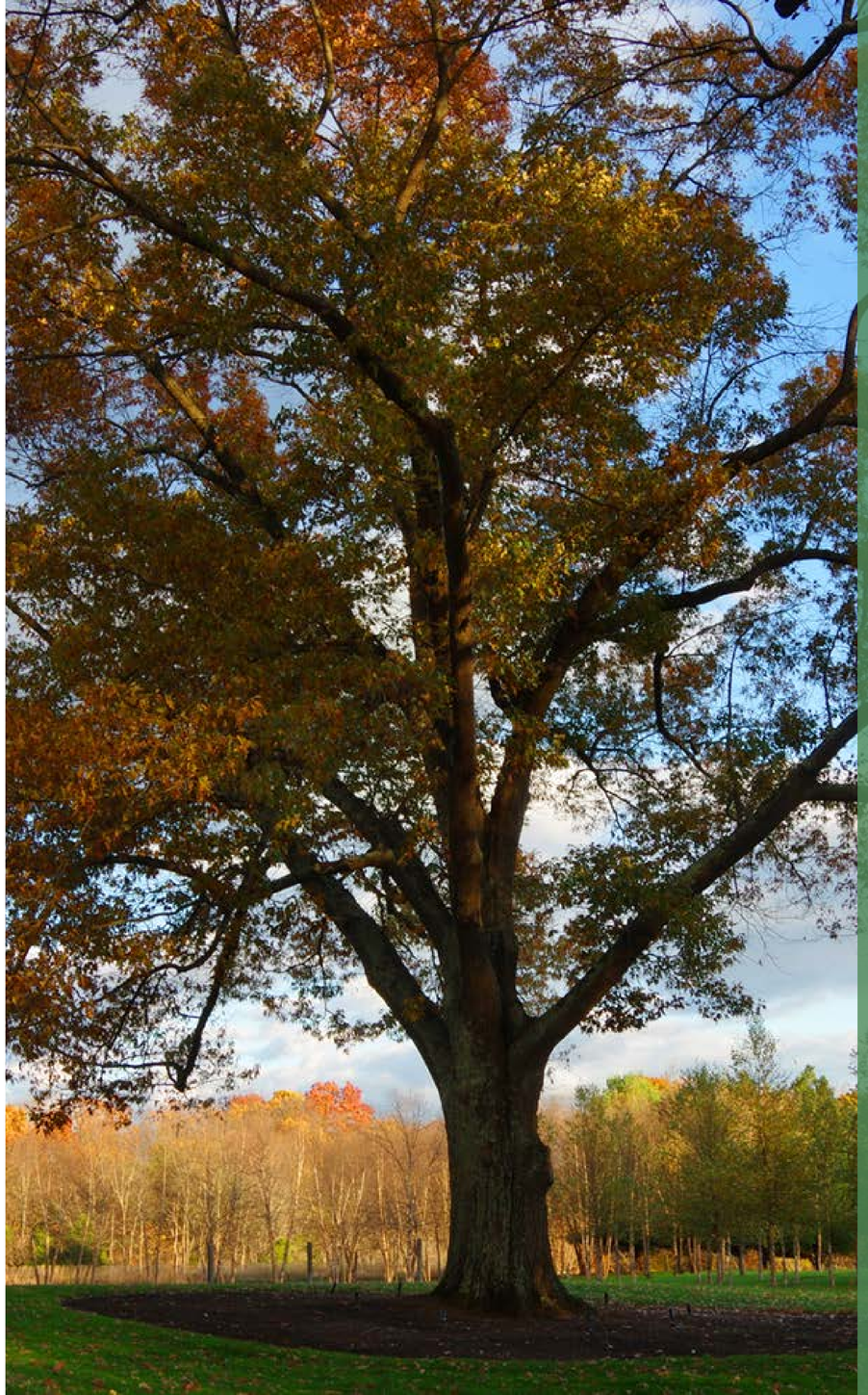
The Great Native Trees of Glenstone

Native species of plants, defined as anything growing on this continent prior to the arrival of European settlers, are naturally acclimated to a particular geographic region. Through observation, botanists conclude that native trees are generally more resilient and long-lived than those trees which originated on other continents.

The Gallery Spanish Oak

This tree has served as a cornerstone of the landscape at Glenstone since 2006. This *Quercus falcata* specimen, also known commonly as a Southern red oak, at 100 feet tall with a 104-foot canopy and 185-inch circumference, stands near the entrance to the Gallery and Richard Serra's sculpture *Sylvester*, 2001.

The Spanish oak thrives in full sun and relatively dry soil and is a low-maintenance tree for the Mid-Atlantic region.



The Boardwalk Tulip Poplar

Sited at the top of the Boardwalk and adjacent to the Greenbriar Branch stream, this tulip poplar, or *Liriodendron tulipifera*, is Glenstone's tallest tree, measuring 126 feet tall with a trunk circumference of 184 inches and a canopy which spans nearly 100 feet.

Tulip poplars are ideal trees for full-sun sites with plenty of room to grow. Their yellow tulip-shaped flowers reach peak bloom in May.

The Environmental Center Oak

This broad willow oak, or *Quercus phellos*, stands adjacent to the Environmental Center at 80 feet tall. Willow oaks, from the red oak family, are some of the most prolific trees at Glenstone.

Naturally resistant to infestations of insects and disease, these trees thrive in full sun and part shade. They are also popular street trees across the Mid-Atlantic but will often outgrow their sites over time.

The Arrival Sycamore

There are numerous native sycamores, or *Platanus occidentalis*, at Glenstone but perhaps the most notable marks the approach to the Pavilions. Prior to the expansion, in 2009 Glenstone opted to move this tree from its original location. Measuring 82 feet tall, this 60-to-70 year old tree is believed to be among the largest ever transplanted in Maryland.

The sycamore is an ideal shade tree for a moist soil location. In fact, there are several growing in the marsh at the base of Glenstone's Boardwalk.

Invasive Species Eradication

in·va·sive spe·cies: are plants, animals, or pathogens that are not native to the ecosystem under consideration and whose introduction causes (or is likely to cause) harm

Invasive Species Eradication

Exotic invasive weeds are plants from other continents that disrupt native ecosystems, catalyzing both environmental and economic consequences. Because these plants don't have regionally-specific insect or animal predators, they often outcompete or even suffocate native plants for space in fields and forests, thereby threatening the food chain of local plants, insects, and animals.

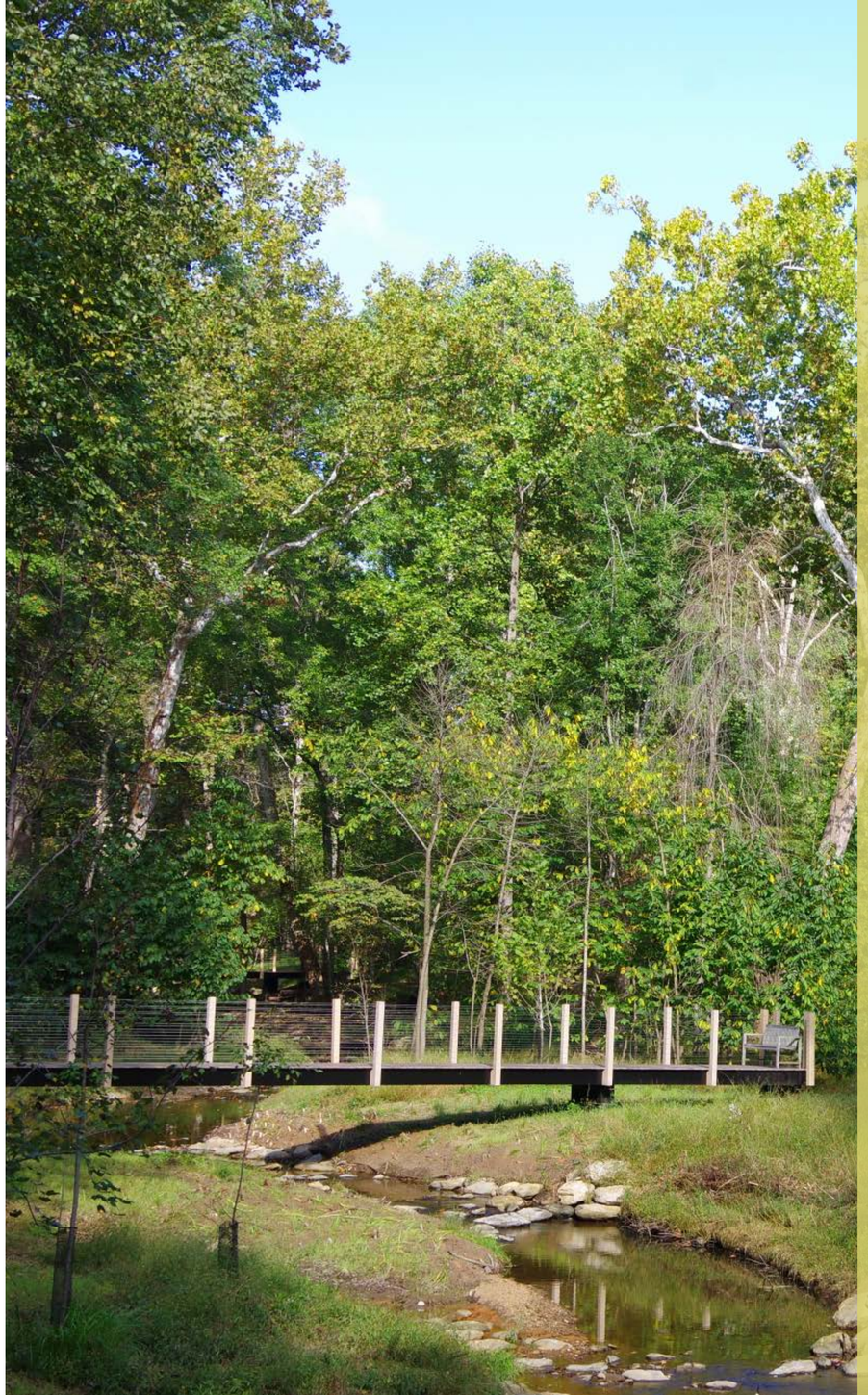
Managing this class of weeds is especially challenging at Glenstone due to our policy against using synthetic chemical weed-killers known to have toxic side effects.[1] This requires an ongoing commitment to removing and replacing exotic invasive weeds with native and non-native species.

1 https://www.scientificamerican.com/article/weed-whacking-herbicide-p/w

Right: Before Glenstone's eradication project launched in 2015, Japanese stiltgrass covered nearly 80% of the forest floor.

Native Species

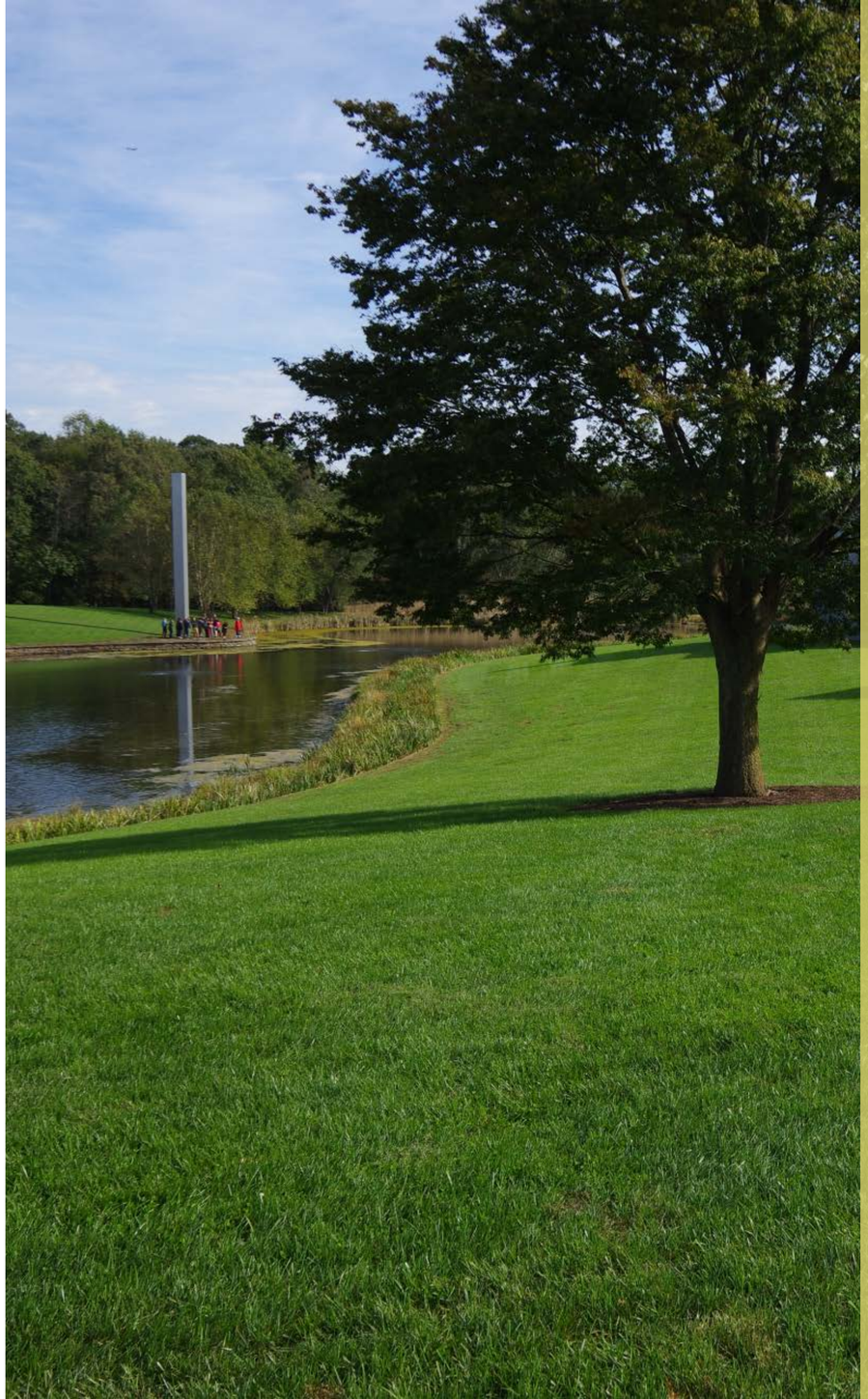
A native plant is a plant that has been growing in a particular geographic region without human intervention for hundreds of years. Native plants almost always have corresponding insects and animals that depend on them as an important food source.



Right: Large native sycamores grow in wet areas such as the Greenbriar Branch stream.

Non-native Species

Sometimes called alien or exotic species, these plants were generally introduced to a new location by humans, either intentionally or accidentally, after originating in other areas. Not all non-native species have negative impacts; hundreds of these plants have great benefits in forestry, horticulture, medicine, and agriculture. An example of a highly beneficial non-native plant is the turf-type tall fescue, which originated in Europe, and is the primary species of lawn grass for much of the Mid-Atlantic, including here at Glenstone.



Right: In full sun lawn areas, Glenstone plants turf-type tall fescue, a non-native species.

Plant Identification

The first step in dealing with exotic invasive weeds is identification. Many federal, state, and local organizations publish lists of known invasive species for each region. For a comprehensive list of invasive plants presented by the Center for Invasive Species and Ecosystem Health, visit www.invasive.org.

Right: In 2003, Glenstone launched an understory research project to determine which plants would outcompete invasive weeds. Ferns and sedges were among the best options for our climate.

Replacement Plants

Eradicating invasives is only part of the battle in landscape management. A plan should also include identifying plants that will replace the weeds once they are removed. Today, any bare soil in the Mid-Atlantic region will almost always favor invasive weeds over desirable native species.

When selecting replacement plants, it is important to take the following into consideration:

- Light conditions
- Soil type and any modifications to soil, within reason
- Soil moisture and water sources for irrigation
- Likelihood of predation
- Plant growth rate and ability to compete with other species

Right: *Carex pensylvanica* is used at Glenstone as a grass-replacement groundcover as it competes favorably with Japanese stiltgrass in sunny locations.

Weed Removal At Glenstone

When a homeowner or organization eliminates harmful synthetic chemical weed-killers, there is no single solution that can eradicate invasive weeds. At Glenstone we employ a multi-pronged approach that can be adapted for practice elsewhere. As with any weed eradication techniques, it is important to replant the area with an appropriate native species at the right time, typically spring or fall.

Right: This area was infested with invasive weeds such as barberry prior to our restoration project in 2017.

Weed Removal At Glenstone

Hand-pulling: In some cases where weeds are in a concentrated area and are not widespread, hand-pulling weeds may be the best and most efficient option. Keep in mind, however, that hand-pulling a weed and not removing all of its roots in the process may lead to a greater problem when the plant re-sprouts from leftover roots.

Right: When extracting weeds from the soil, it's important to get as much of the root system as possible.

Weed Removal At Glenstone

Spraying: There are many natural weedkillers that can be used in place of harmful synthetic weedkillers, including horticultural vinegars, citrus-based acids, and fatty acids. Many of these options require several applications if weeds are mature. It is important to remember that these are non-selective herbicides, meaning that they are toxic to all plants, so users should exercise care in targeting weeds.

Right: Organic substances such as horticultural vinegar can be sprayed directly onto weeds, which will typically die back within a day or two.

Weed Removal At Glenstone

Flaming: Propane torches can be used in small areas but are less practical for larger plant invasions. The intense heat will instantly kill small seedlings after a second of exposure to flame. Larger plants take longer to kill. Although it is always important to be careful around an open flame, these tools can be especially dangerous in summer when mulch and dry leaves can easily serve as tinder for fire.

Weed Removal At Glenstone

Weed whacking: After a season of testing numerous research plots onsite, we concluded that mechanical cutting with a line trimmer (also known as a weed whacker) offers the most efficient approach to eradicating Japanese stiltgrass. Timing is important: cutting plants before they set seed each year reduces their future population. Space is also a consideration: it is difficult to target with weed whackers, which can cause unintended damage to beneficial plants.

Weed Removal At Glenstone

Tarping: Covering weedy areas with a rubber tarp is an efficient way to suffocate and eliminate weeds—weeds typically die within a month.

Organic Landscape Care

or·gan·ic land·scape care: a natural system of plant and soil maintenance avoiding synthetic chemical fertilizers and pesticides in favor of observation, testing, and use of products derived from plant and animal byproducts

Organic Landscape Care

In 2010, Glenstone began one of its first sustainability initiatives when the grounds team stopped using synthetic chemical fertilizers and pesticides, marking the beginning of our natural approach to the outdoor program.

Beyond a straightforward swap of chemicals for organics, our manifesto represents an entirely different approach to landscape management.

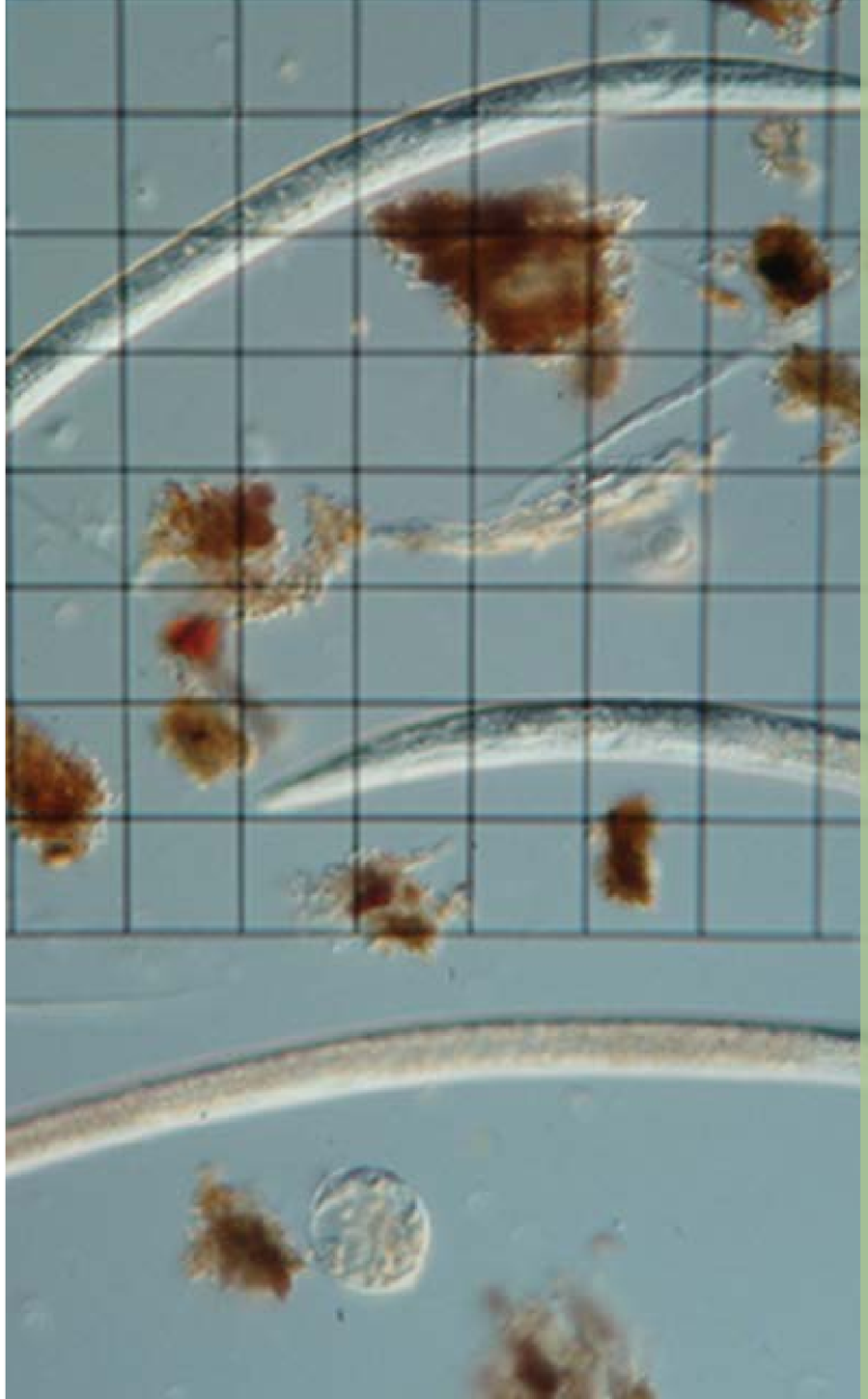
Close Observation of Soil

An essential component of the natural system, healthy soil teems with life-sustaining organisms including organic bacteria, protozoa, nematodes, and mushroom-like fungal material.[1] These organisms naturally feed the plants by digesting and excreting material, similar to the way cow manure fertilizes fields.

At Glenstone, we leverage this natural system by feeding the soil with only organic materials such as compost and compost tea, grass clippings, pine straw and organic fertilizers derived from fish, alfalfa, or other plant or animal-derived substances. These organic materials become a component of the soil, helping it to become self-sustaining and less prone to erosion and nutrient runoff than it would be with use of synthetic chemical products.

1 https://www.peoplepoweredmachines.com/faq-environment.htm

Right: Glenstone's soil under magnification



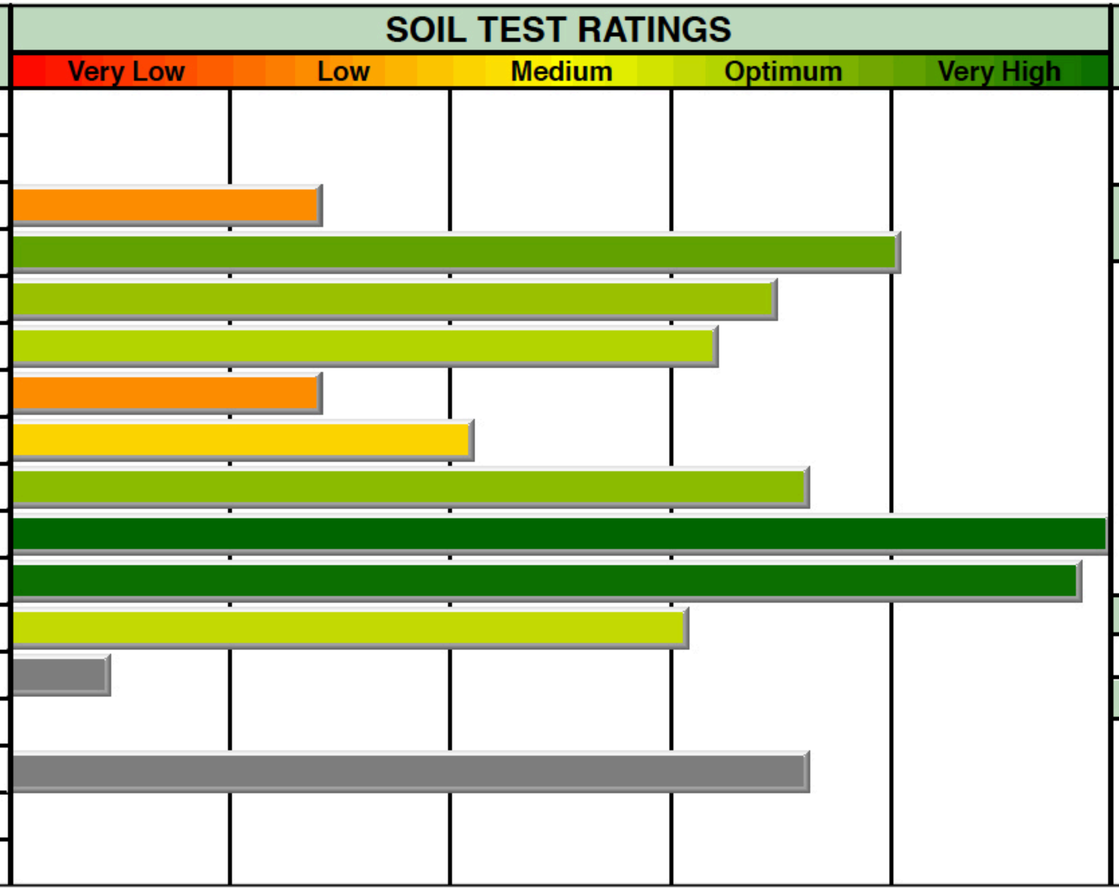
Testing

Even as professional landscapers, the Glenstone grounds team sends out soil samples annually to determine if we have the proper levels of nutrients, soil pH, and organic matter. This helps us make informed decisions about the addition of any soil additives such as lime, sulphur, compost, or nutrients such as nitrogen, phosphorus, or potassium which bring soil to its optimal levels. In addition, excess nutrients, in addition to wasting money, can also become runoff polluting waterways.

When sending samples to the soil lab, it is important to note the location of its collection. In most cases, grass and trees don’t thrive in like soil conditions, so tailoring a plan to the plants the soil is serving will yield best results.

Sample Soil Test Results

Test	Results
Soil pH	7.3
Buffer pH	
Phosphorus (P)	19 ppm
Potassium (K)	172 ppm
Calcium (Ca)	1546 ppm
Magnesium (Mg)	204 ppm
Sulfur (S)	12 ppm
Boron (B)	0.6 ppm
Copper (Cu)	2.6 ppm
Iron (Fe)	211 ppm
Manganese (Mn)	95 ppm
Zinc (Zn)	3.7 ppm
Sodium (Na)	15 ppm
Soluble Salts	
Organic Matter	6.4 % ENR 150
Nitrate Nitrogen	



Calculated Cation Exchange Capacity	
9.9 meq/100g	
Calculated Cation Saturation	
%K	4.5
%Ca	78.1
%Mg	17.2
%H	0.0
Hmeq	0.0
%Na	0.7
K : Mg Ratio	
0.24	
Ca : Mg Ratio	
4.54	

Above: Glenstone sample soil test from 2017 indicates an optimal organic matter result of 6.4%.

Selecting the Right Limestone

Garden and agricultural centers sell many different types of limestone as soil amendments to help raise the pH of acidic soils closer to neutral at 7.0. The most commonly available product is dolomitic lime, which contains two-parts calcium to one-part magnesium. At Glenstone, we use high-calcium limestone because it contains less magnesium, which can cause weeds to grow. Our goal is a seven-to-one ratio of calcium-to-magnesium in the soil, which helps to reduce populations of weeds, especially dandelions.

In scenarios when a soil pH is already 7.0 or higher but the soil still needs more calcium to offset the magnesium, it's best to add gypsum — about 20 pounds per 1,000 square feet of lawn—and test the soil again the following year.

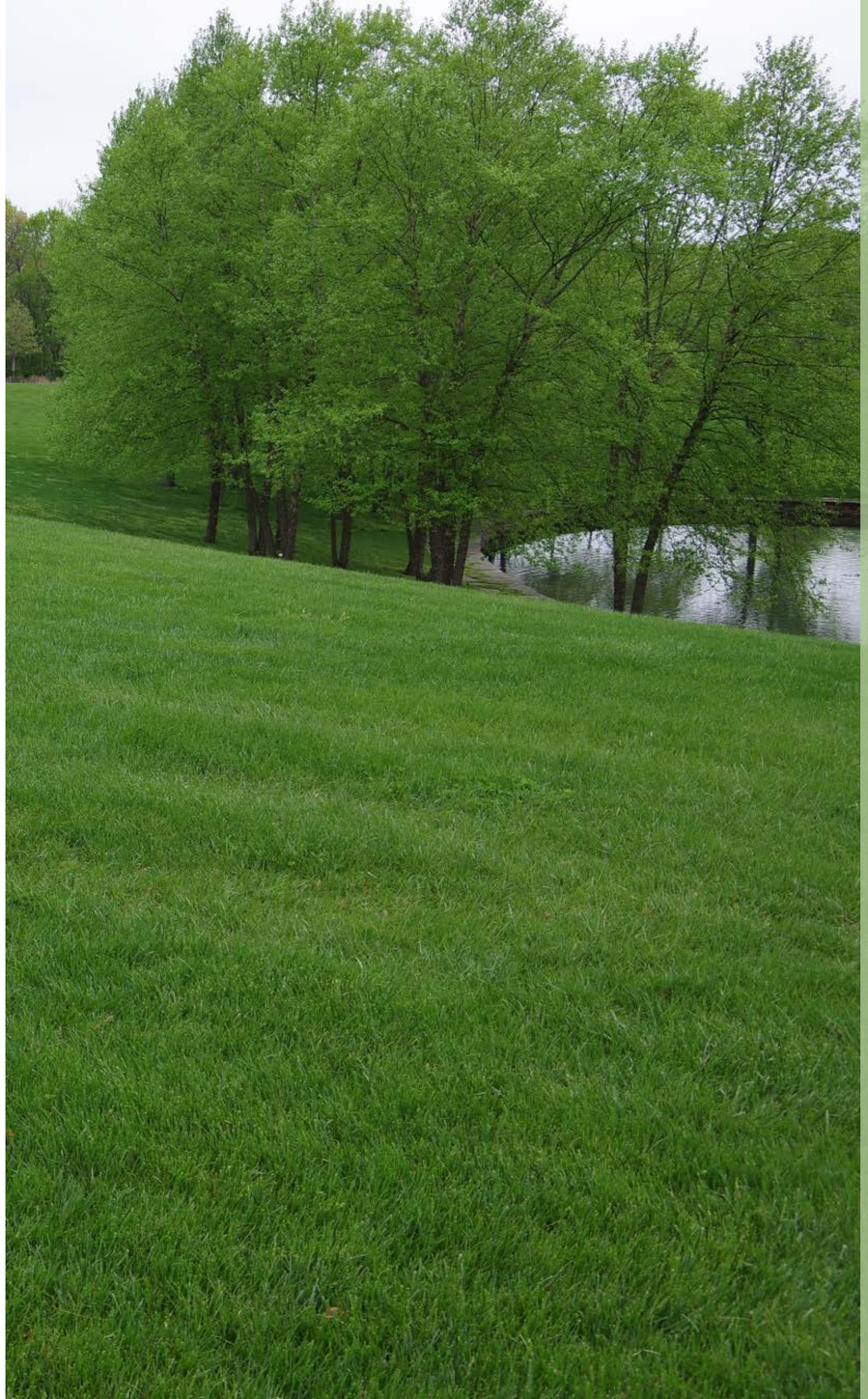
Right: Gypsum contains roughly 50% calcium and can be used in place of high-calcium limestone.

Know Your Lawn

While lawns may appear alike from a distance, they are typically comprised of several different species of grasses that thrive based on the point in the season, the light conditions, the amount of fertilizer applied, and the degree of foot traffic. Seed companies also proactively cross-breed species each year to create new varieties, known as cultivars, that have desired traits including:

- Better heat or moisture tolerance
- Slower growing to reduce mowing requirements
- Resistance to insect and disease infestation
- Deeper green coloring

Here at Glenstone, we primarily utilize turf-type tall fescue, or *Festuca arundinacea*, in full sun and chewings red fescue, or *Festuca rubra*, in shade.



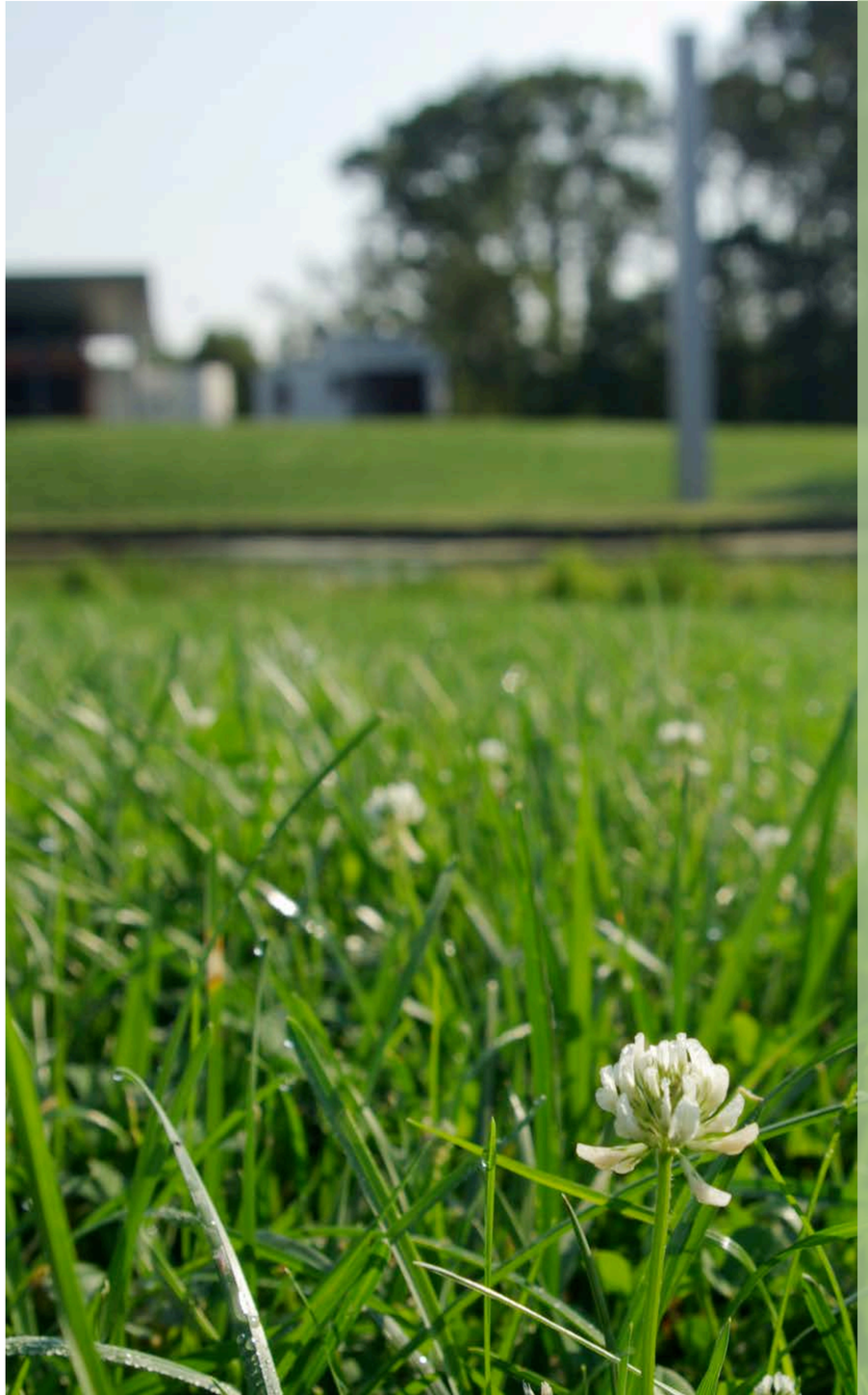
Right: This lawn at Glenstone, in full sun, is planted with turf-type tall fescue.

Clover

Brought to North America by the first settlers from Europe as a food crop for humans and animals, clover soon naturalized in most American landscapes.[1] Once celebrated for its ability to convert atmospheric nitrogen into fertilizer in the soil, clover seed was included in most grass seed mixes prior to the mid-1970s. In subsequent decades, however, clover was identified as a weed by synthetic chemical companies.[2]

1 https://forages.oregonstate.edu/nfgc/eo/onlineforagecurriculum/instructormaterials/availabletopics/introduction/history
2 R. Milton Carleton (1957) *A New Way to Kill Weeds*. Arco Publishing Company, N.Y.

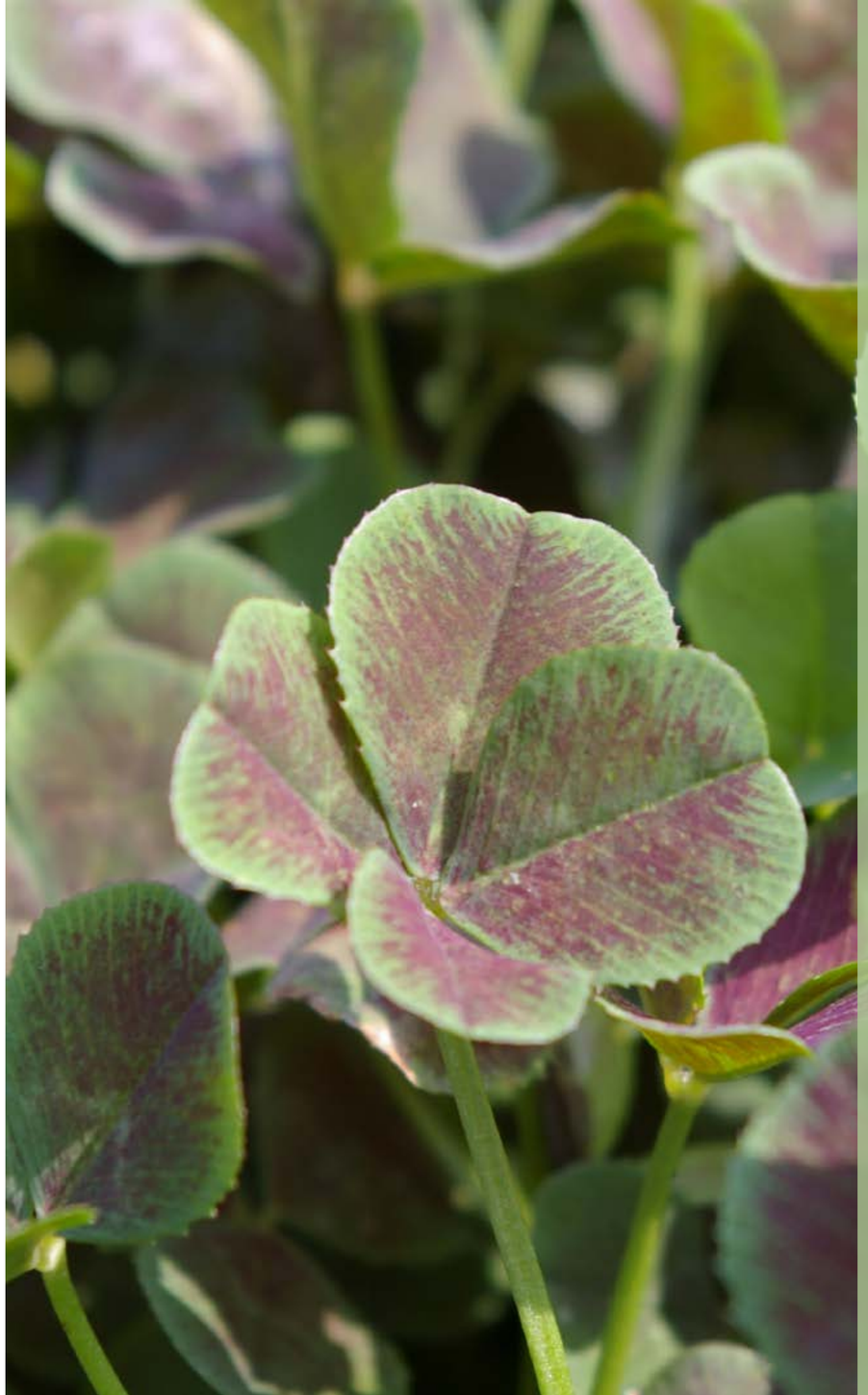
Right: Clover is an integral part of Glenstone's healthy lawn ecosystem.



Clover

At Glenstone, clover is considered a primary lawn plant with additional benefits including:

- Low growth and in need of little mowing
- Evergreen even in the coldest climates
- Drought-tolerant, requiring little if any supplemental water once established
- Masks the presence of weeds in the lawn
- Resistant to insects and diseases, especially white grubs which can become a major lawn nemesis



Right: A four-leaf clover at Glenstone

Compost

At Glenstone, we apply compost almost everywhere in the landscape. We produce our own compost from food scraps and landscape debris combined with bulk purchases from sources in Maryland and Virginia. When planting trees, we incorporate compost into the planting holes at a roughly a two-to-one ratio of soil-to-compost and when starting a landscape from scratch, we incorporate compost into the soil at the same ratio across the entire area. When renovating established landscapes, such as existing lawns, we top-dress with compost once or twice a year to elevate the organic matter to our desired level of 5% to 7% of the soil by weight.

Right: Top-dressing of compost at Glenstone

Weeds

Plants and soils naturally have a symbiotic relationship. Our focus at Glenstone is to create soil conditions where grasses, rather than weeds, are encouraged to grow on the lawns, and trees are encouraged to grow in the forest. Unfortunately, for a category of weeds known as exotic invasive species, improving the soil conditions may not eradicate weeds. The best strategy in that case is diligence.

Right: Soils that need calcium are ideal for large dandelion populations.

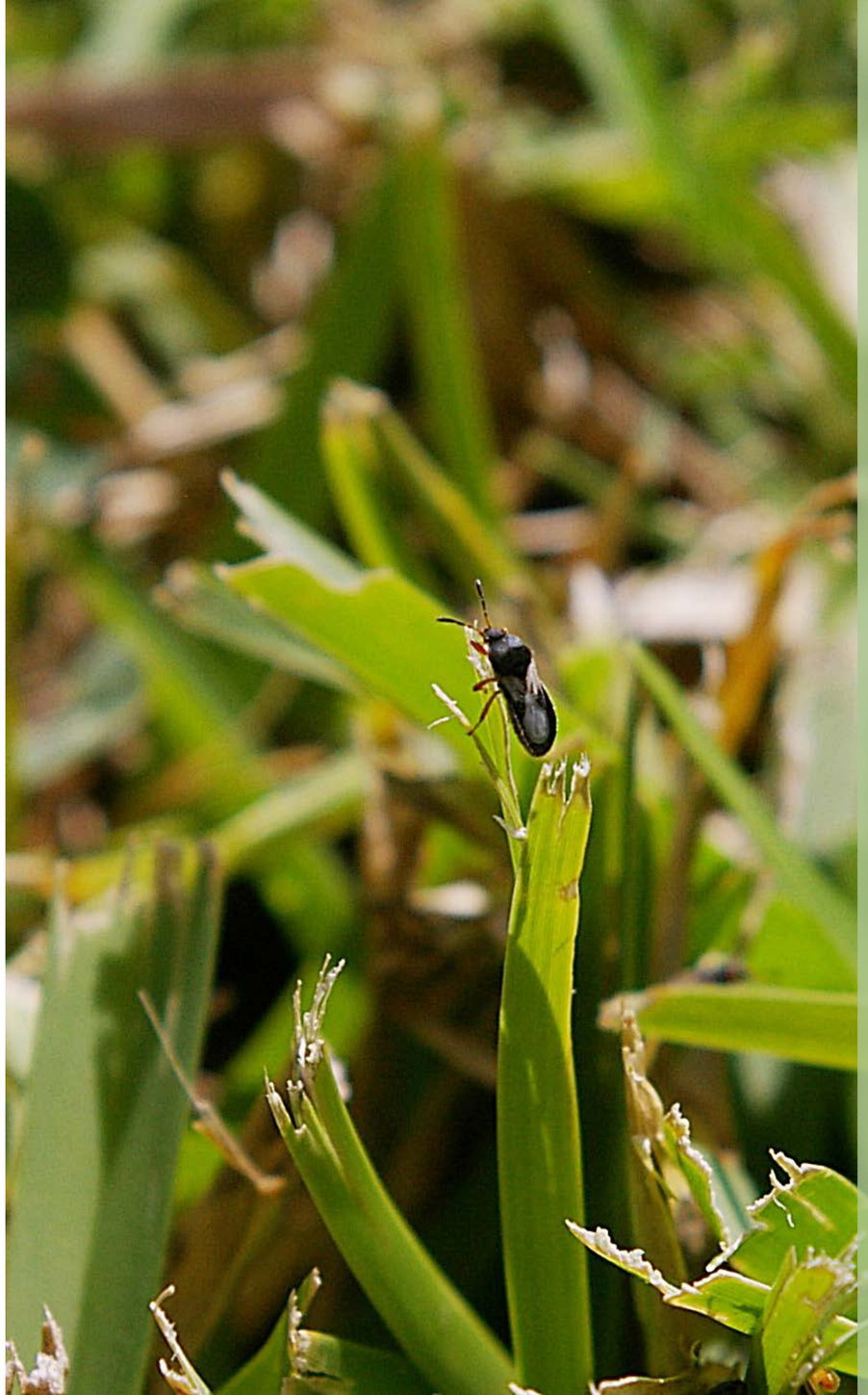
Insects

While plants need insects for pollination they can also be preyed upon by other insects, especially if the plants are unhealthy. According to USDA scientist Phil Callahan, insects see through an infrared system of navigation that allows them to sense weaknesses in plants, allowing them to attack weak plants first.[1]

At Glenstone, when we see certain bugs, we know to look for corresponding plant conditions. For instance, wet conditions attract chinchbugs on lawns, dry conditions bring beetles to pine trees, and plants which don’t have enough nutrients attract a variety of insect species.

1 Jenkins, Virginia Scott & Smithsonian Institution (1994). *The Lawn: A History of an American Obsession*. Smithsonian Institution Press, Washington, D.C.

Right: A chinchbug preys on excessively moist turf



Grass Clippings

A first step toward a natural landscape program at Glenstone was to stop bagging grass clippings. By leaving them on our lawn to decompose, the clippings quickly return nutrients to the soil, essentially creating its own fertilizer. Incidentally, clippings should not be confused with lawn thatch, which is a layer of decaying grass and root tissue that can build up in a lawn that receives too much fertilizer. A heavy thatch layer of a half inch or more should be raked away. Glenstone has not had a thatch issue on its lawn since the organic program commenced in 2010; the soil organisms that occur naturally feed on the thatch and keep it to a minimum.

Right: Grass clippings left to decompose

Irrigation

Before starting our organic landscape program, we used our lawn irrigation system daily. In recent years, with the introduction of organic landscape practices, the system is only turned on during the most severe droughts. By adding compost to the landscape over the years we have increased the soil's inherent water-holding capacity. When we do run the water, we soak the soil deeply, teaching the plants' roots to grow downward in search of moisture rather than waiting near the surface for water.

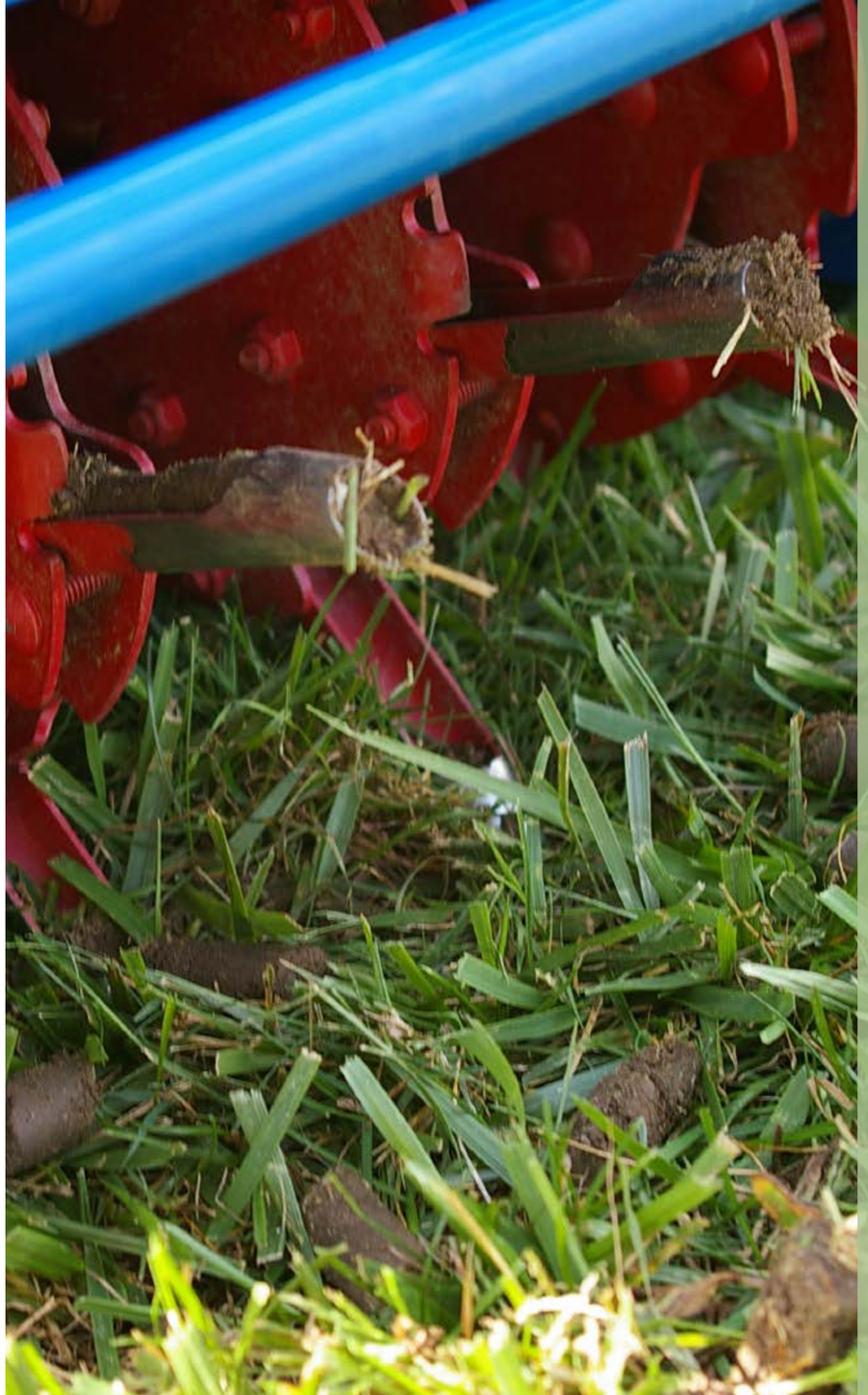
Two other watering tips:

- Use programmable timers so the irrigation only comes on when you want it to and override the timer during periods of rain.
- Choose native plants that are regionally appropriate; these typically have lower water requirements than plants imported from other continents.

Right: Watering midday with uncalibrated spray heads should be avoided

Aeration

Recognizing the natural lifecycle of soil, Glenstone reduces excess lawn compaction by discouraging its staff and guests from parking on the lawn. Because heavy mowers must drive on the lawn, however, we cut core plugs of soil and grass out of the lawn twice yearly. The process, known as aeration, reduces compaction and allows water, air, and nutrients to get down to the roots of the grasses more efficiently. We have found that fall is the best time due to less competition from weed seeds, but spring aeration may be best in severely compacted areas.



Right: Aeration at Glenstone

Mowing Essentials

Though a mowing program isn't necessarily unique to an organic lawn vs. a lawn maintained with synthetic chemicals, how you mow will determine the success of either program.

Here are a few suggestions for mowing:

- Fertilize by letting grass clippings fall on the lawn, the cut grass contains nutrients that will return to the soil as it biodegrades
- Keep your mower blades sharp — sharpen after every eight-to-twelve hours of use to improve the health of the grass and fuel efficiency of the mower

Right: This lawn was cut with a dull mower blade which tears grass instead of cutting it

Mowing Essentials

Here are a few more suggestions for mowing:

- Never cut more than one-third off the length of your grass at any time
- Never cut the lawn lower than four inches, especially in the heat of summer when soil can dry out quickly
- Don’t mow in summer unless there’s rain in the short-term forecast; lawns suffer when mowed in the heat of the summer, especially with no water to assist in their recovery

Right: The mower blade should be set at four inches which is typically the highest setting on the mower.

Understanding Organic Fertilizer

Synthetic chemical fertilizer is mostly water soluble, and, as a result, dissolves and is partially absorbed by the plant—quickly making it greener. Part of the fertilizer is typically wasted through water runoff or vaporization. Organic fertilizer does not get absorbed the same way, but rather feeds soil organisms first. Once minerals in the fertilizer are eaten, digested, and excreted by soil organisms they subsequently become mineralized and available to be absorbed by the plants. This additional step of mineralization takes time, especially if the underlying soil isn't optimal at the outset.

Anyone transitioning to organics from synthetic chemicals should anticipate a year-long transition period. Liquid organic fertilizers are generally faster acting than granular organic products or compost; Glenstone utilizes a combination of both in its programs.

Right: This organic fertilizer is a combination of chicken manure, chicken feathers, alfalfa and bone meal

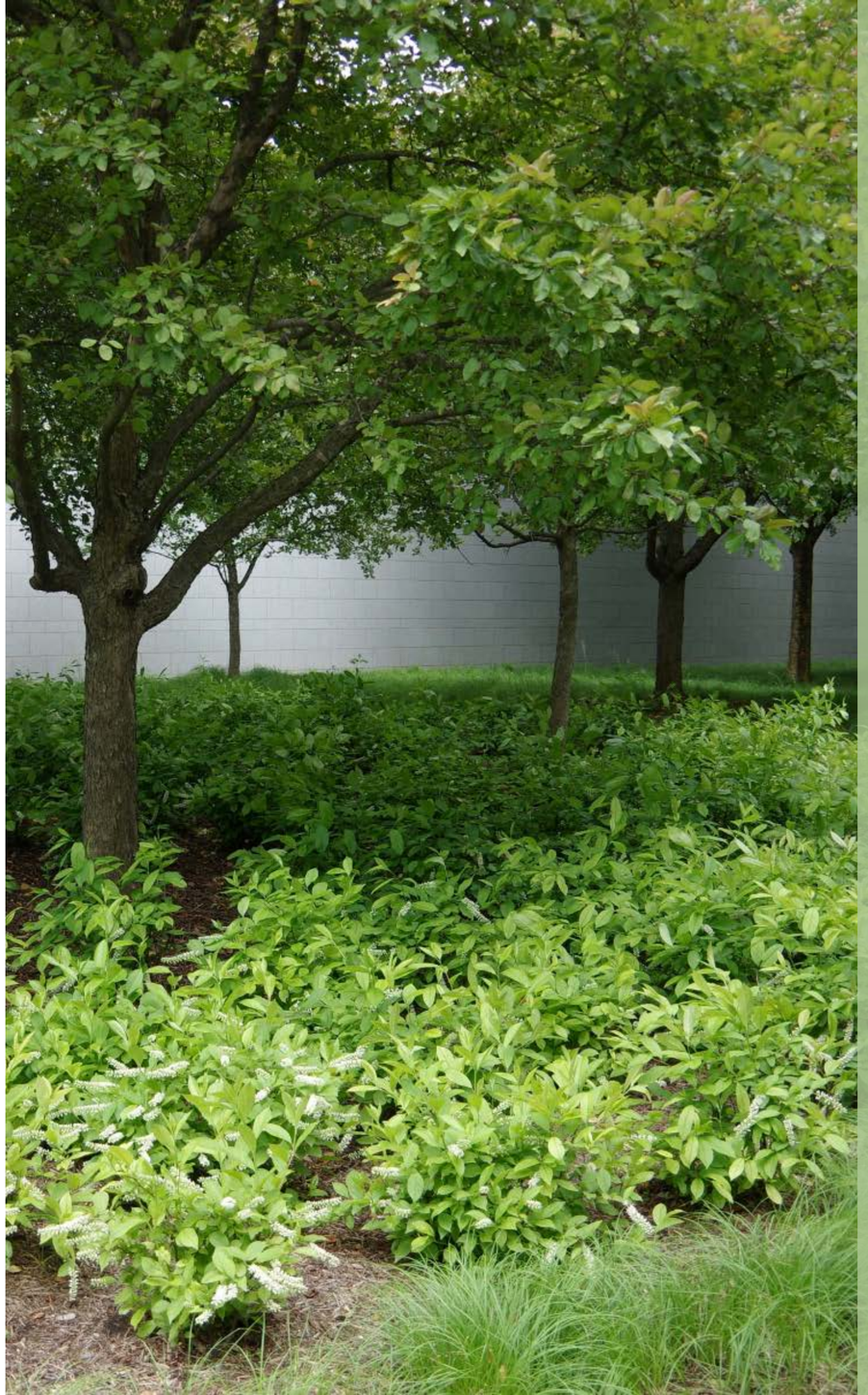
Consider Lawn Alternatives

Over the past 50 years, a landscaped lawn has become the American paradigm.[1] In many cases, however, grass may not be the ideal plant for any given landscape situation depending on:

- Intended use, such as foot traffic
- The amount of sunlight or shade
- The projected rainfall or availability of irrigation
- Aesthetic considerations

1 Jenkins, Virginia Scott & Smithsonian Institution (1994). *The Lawn: A History of an American Obsession*. Smithsonian Institution Press, Washington, D.C.

Right: Itea ‘Little Henry’ is used as a reliable turf replacement plant at Glenstone

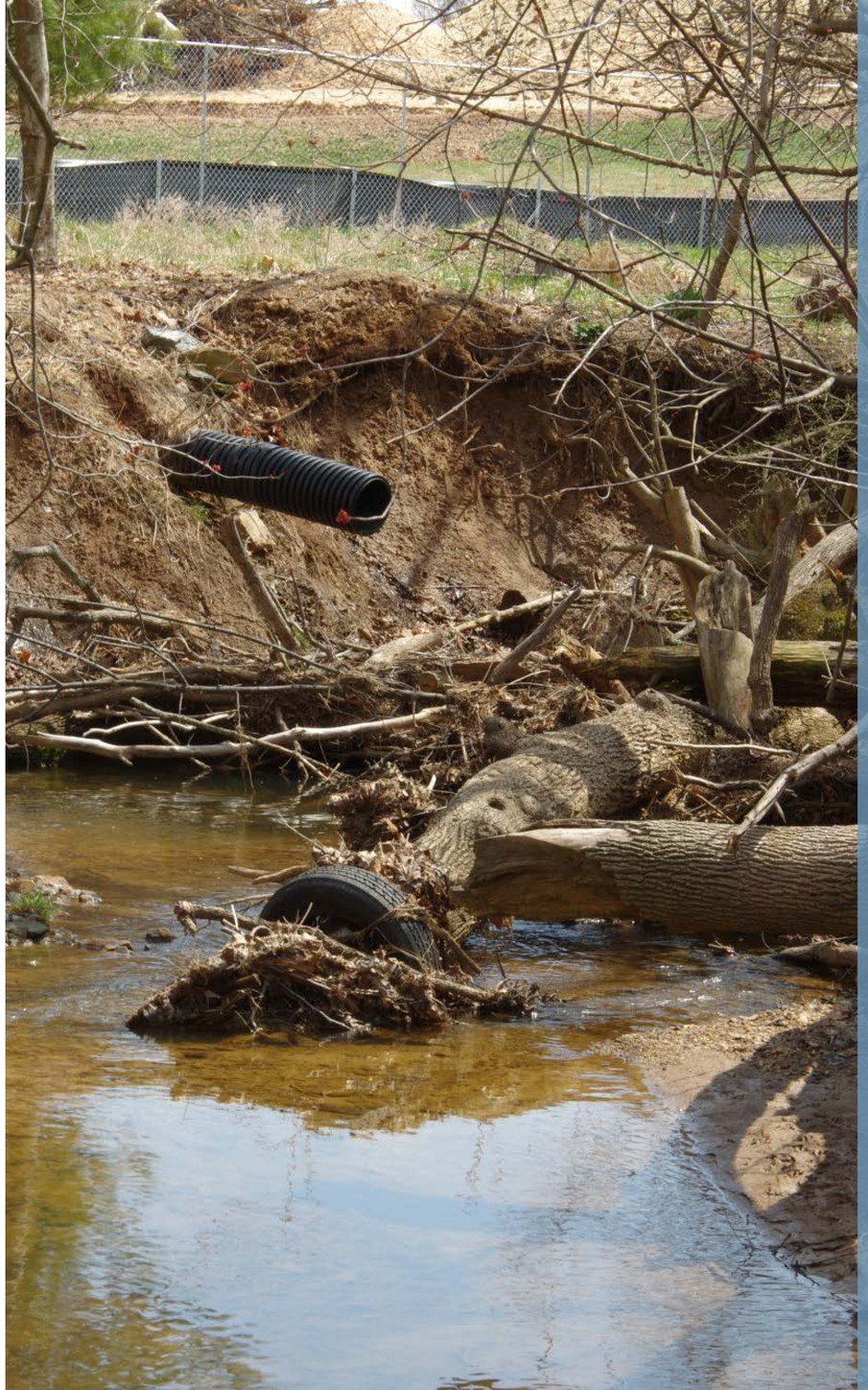


Stream Restoration

stream res·tor·a·tion: a series of design and construction processes intended to reduce soil erosion along the edges of streams and tributaries

Stream Restoration at Glenstone

Across America, suburban development has caused concentrated stormwater runoff to degrade stream and river networks. As a result, decayed waterways suffer from excess amounts of sediment—a blend of sand, silt, clay, and organic material—which is deposited into our rivers and, ultimately, oceans. Too much sediment makes water muddy, consequently threatening populations of fish, insects and amphibians.



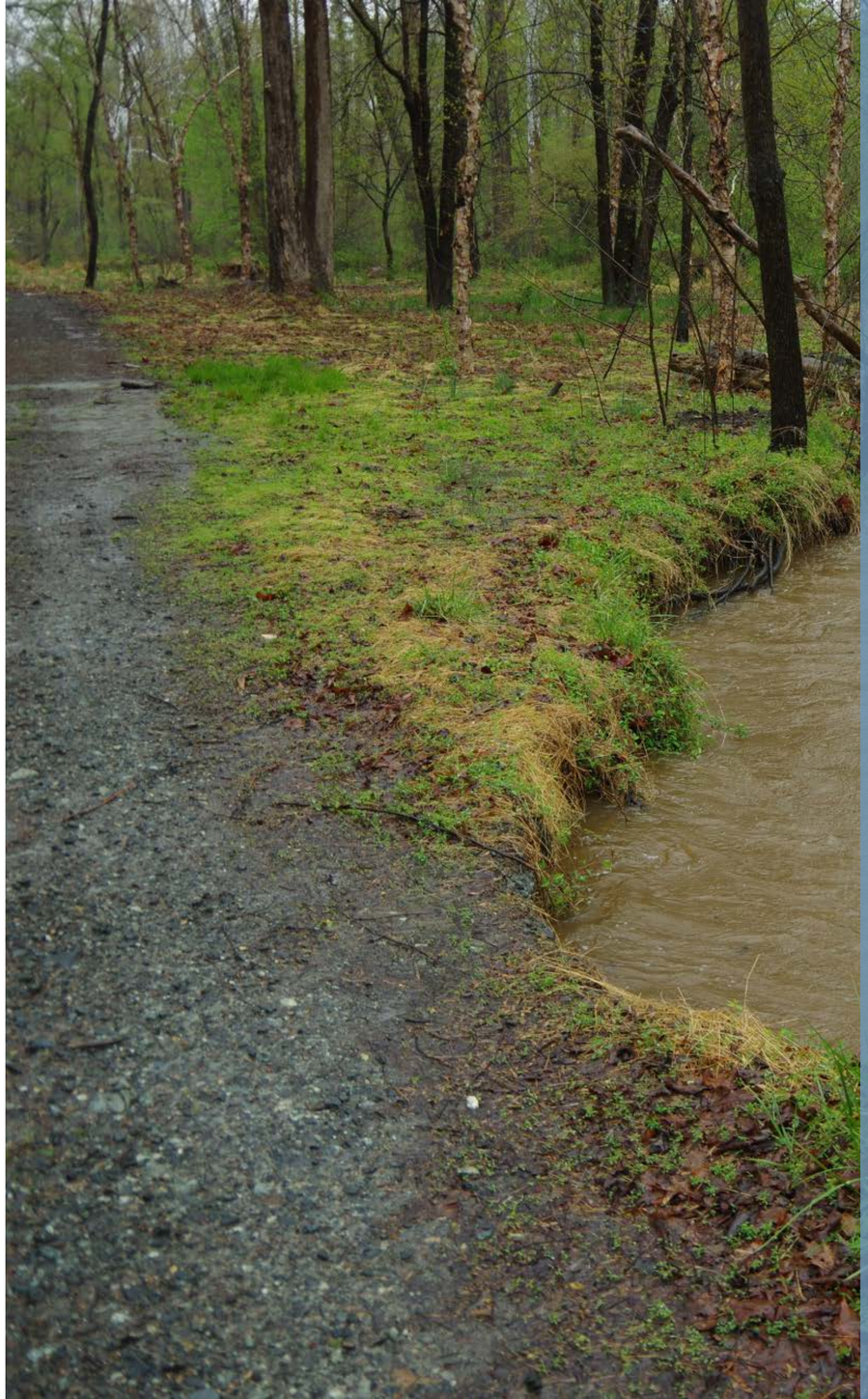
Right: The Sandy Branch Stream at Glenstone in 2017. Prior to our restoration project, more than eight feet of soil had eroded away from the protruding culvert.

Stream Restoration at Glenstone

In 2014, Glenstone launched its plan to restore the two tributaries in its landscape that connect to the Potomac River, once named America's most endangered river.[1] These two tributaries, the Greenbriar Branch and Sandy Branch streams, were classified in poor condition due to sediment pollution and lack of species diversity. Had they not been restored, both could have presented safety issues in addition to environmental concerns.

1 https://www.treehugger.com/clean-water/americas-most-endangered-rivers-2012.html

Right: Prior to the stream restoration efforts, heavy rains were beginning to undercut the woodland trail that runs alongside the Greenbriar Branch stream.



Stream Restoration at Glenstone

After consulting with several experts, Glenstone began working with Dr. David Rosgen, the nation's leading authority in natural stream and river restoration. After Dr. Rosgen's team completed the restoration design and permitting process with the county, state, and federal governments, the stream re-construction began in November 2015.

Right: Dr. Rosgen at Glenstone

Stream Restoration at Glenstone

To restore our streams, we repurposed soil and stone collected from the excavation at the Pavilions site. These stones are used to hold soil in place along the stream banks and offer a gradual connection of the regraded areas to the flood plains. During this process, exotic invasive plants and dead or decaying trees are also identified and removed, and subsequently replanted with regionally appropriate native trees, shrubs, ferns, and grasses.

Right: This stone was excavated from the Glenstone landscape during construction and was subsequently repurposed for stream restoration.

Stream Restoration at Glenstone

According to Dr. Rosgen's projections for the restoration, a vast amount of sediment—measuring in the hundreds of tons—will likely be prevented from reaching the Potomac River. In addition to the return of wildlife habitat and aquatic organisms, improved water quality is another anticipated benefit.

The project, set to be completed in 2020, will help Montgomery County achieve a significant portion of the federal government's annual requirements for its restoration obligations.

Right: The Greenbriar Branch Stream in 2018, after restoration

Techniques to Slow Stream Flow

According to Dr. Rosgen, all rivers and streams are impacted by eight variables: slope, width, depth, water velocity and discharge, boundary roughness, the size of sediment transported, and the concentration of sediment. He has developed numerous techniques to address these issues, with the goal of slowing the water flow and reducing instability and destruction.[1]

1 Rosgen, D. L. (1996). *Applied River Morphology*. Pagosa Springs, CO: Wildland Hydrology.

Techniques to Slow Stream Flow

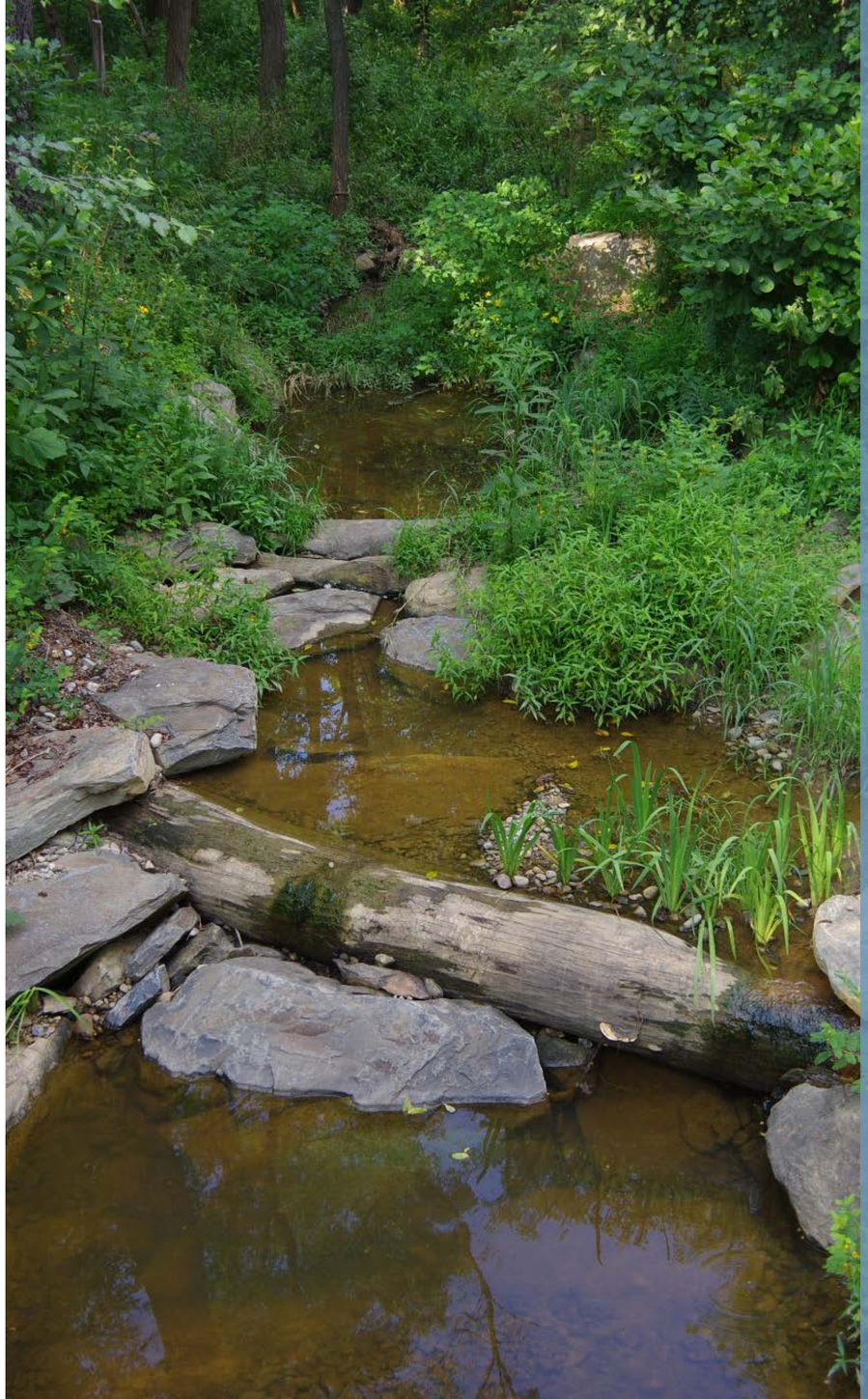
J-Hooks: Constructed with strategically placed lines of boulders along the outer curve of a stream bank, boulders are curved into a hook which directs water away from the vulnerable bank.

Log Vanes: Trunks of hardwood trees with the root ball intact that are set into the bank to hold the structure in place. The trunk is placed upstream at a 20-degree angle from the bank and slightly downhill so that the water is forced to run uphill, which dissipates the energy before it cascades over the side of the log and back into the main stream channel.

Right: A log vane at Glenstone

Techniques to Slow the Stream Flow

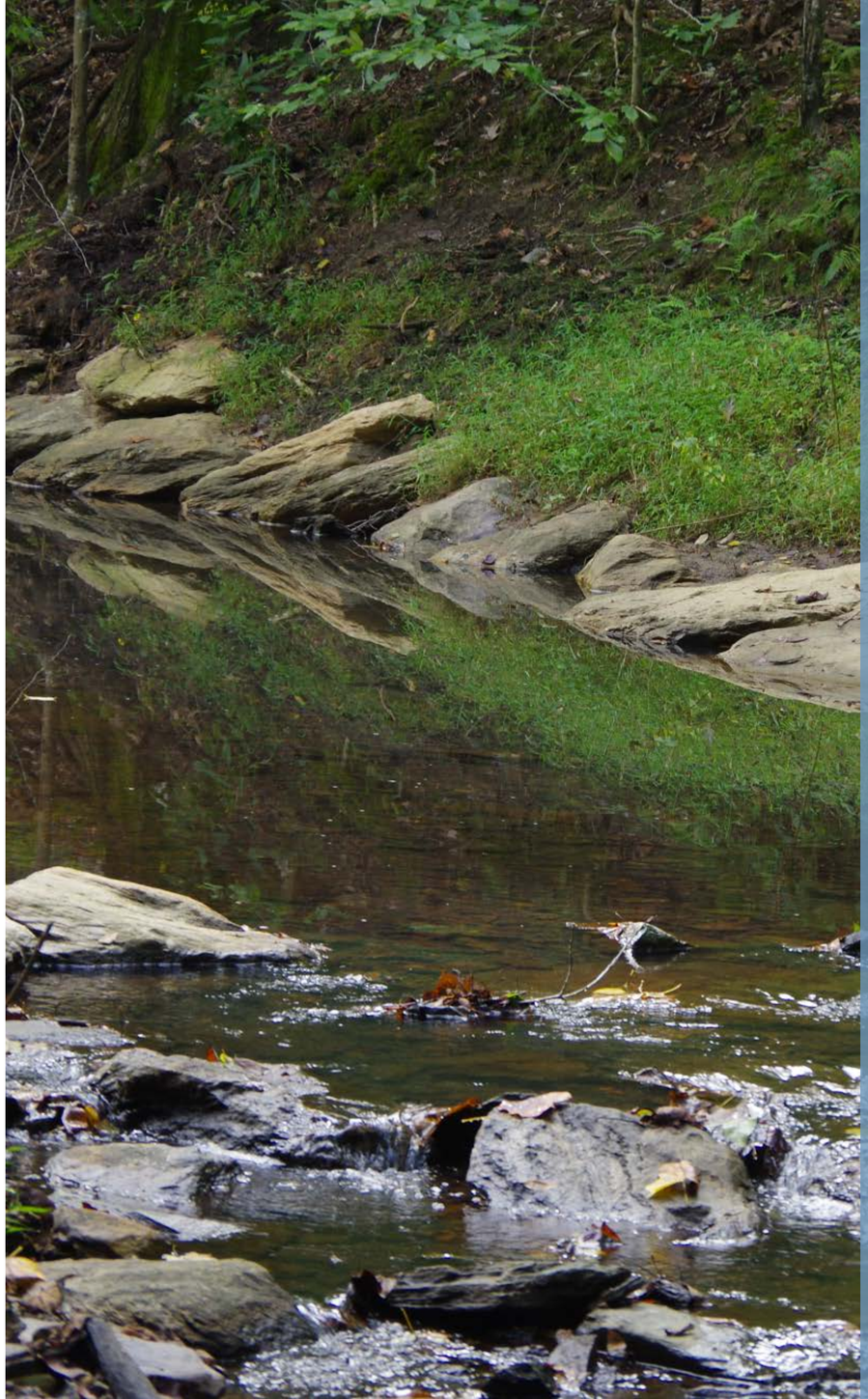
Log-Boulder Step Pools: Used in areas where there is a significant elevation change as the water runs downhill, these structures are dammed pools that collect water. When the highest pool in the stream fills to capacity, the water cascades over a log dam that is placed on the downhill side of the pool and flows downstream to the next log-boulder step pool. This process happens in succession until the water reaches the calmer waters of a nearly level stream. These pools hold onto the water, allowing it to seep into the water table below and provide important sustenance for trees and wildlife.



Right: A log-boulder step pool visible from the upstream side of the Arrival Bridge

Techniques to Slow the Stream Flow

Riffles and Pools: The main channel of a healthy stream is characterized by areas of shallow water (riffles) and deeper water (pools). From the shore, these areas are discernable by the amount of visible surface friction, or waves, that occur as the water flows downstream. In riffles, the rocks of the stream bed constantly filter sediment out of the water. The deeper pools hold onto the water and dissipate the energy of the stream, so that the water is less likely to cause erosion or further damage downstream.



Right: A riffle coming out of a pool at the Greenbriar Branch Stream

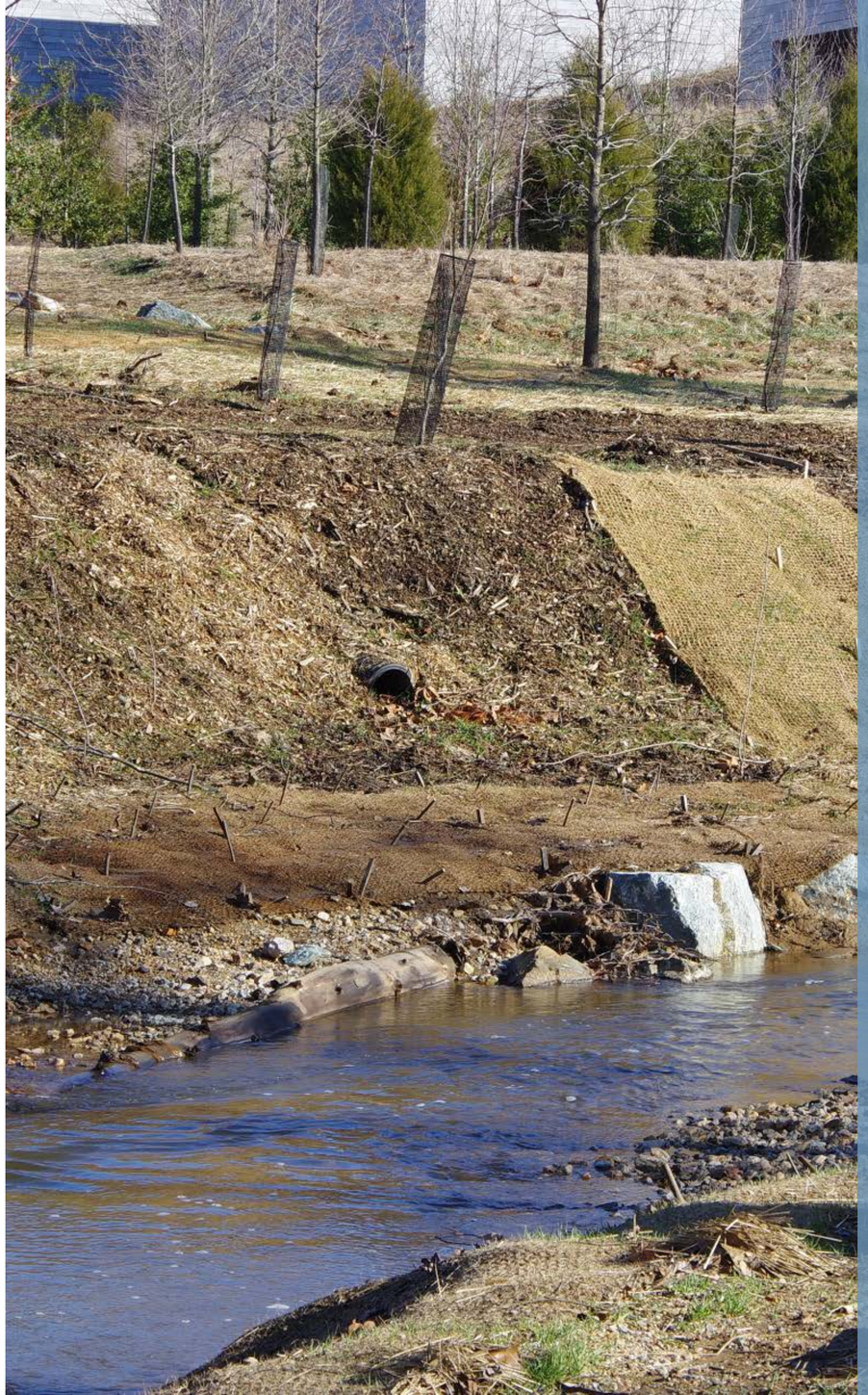
Managing Stormwater Runoff

Rainwater causes billions of dollars of damage every year. Each time it rains, water tumbles onto the ground and needs to go somewhere, as not all rainwater soaks into the ground. This water, known as stormwater runoff, picks up dirt, oils, pesticides, fertilizers and myriad forms of other pollution and eventually winds up in streams, rivers, and oceans.

Right: Nearly 50% of the Pavilions roof is covered in native meadows and lawn which is designed to absorb stormwater runoff

Managing Stormwater Runoff

Glenstone protects streams and minimizes the impact of stormwater through numerous water management measures, including downspouts that lead to underground storage tanks known as cisterns. The Glenstone landscape leading to each stream was also contoured to include rain gardens and bogs, green roofs, and acres of meadows and forests in order to better mitigate the concentrated water flow that storms bring.



Right: The grading along the Sandy Branch stream bank is intended to reconnect the stream to the flood plane.

Managing Stormwater Runoff

What follows is a list of pointers to alleviate the impact of stormwater runoff on rivers and streams:

- **Downspouts:** Make sure the flow from downspouts does not escape freely onto paved areas and run directly into storm drains. Lawns and gardens are better destinations to absorb the water.
- **Storm drains:** Keep clear of debris and avoid dumping anything other than clean water anywhere near the drain.
- **Mowing:** Try to keep your lawn at least 3.5 to 4 inches in height, which reduces the need for watering and increases absorption of rain water. Leave grass clippings on your lawn, which will biodegrade and become free fertilizer. Sweep clippings on your sidewalks and driveway onto your lawn rather than hosing them down.

Managing Stormwater Runoff

- **Driveways:** Make sure to clean off any spills of oil and other chemicals.
- **Car Washing:** Don’t allow soapy water to flow off your property and into a storm drain.
- **Plants:** Install plants wherever water congregates or flows to help absorb water and reduce runoff.
- **Catch Basins:** Build these below downspouts to trap sediment, debris, contaminants, and pollutants so that they cannot enter drainage pipes.
- **Permeable Pavers:** An alternative to traditional paving methods for driveways, walkways and patios, these are typically honeycombed 3D grid-cellular systems, made of plastic and other materials, that naturally filter stormwater and reduce runoff that can pollute waterways.

Managing Stormwater Runoff

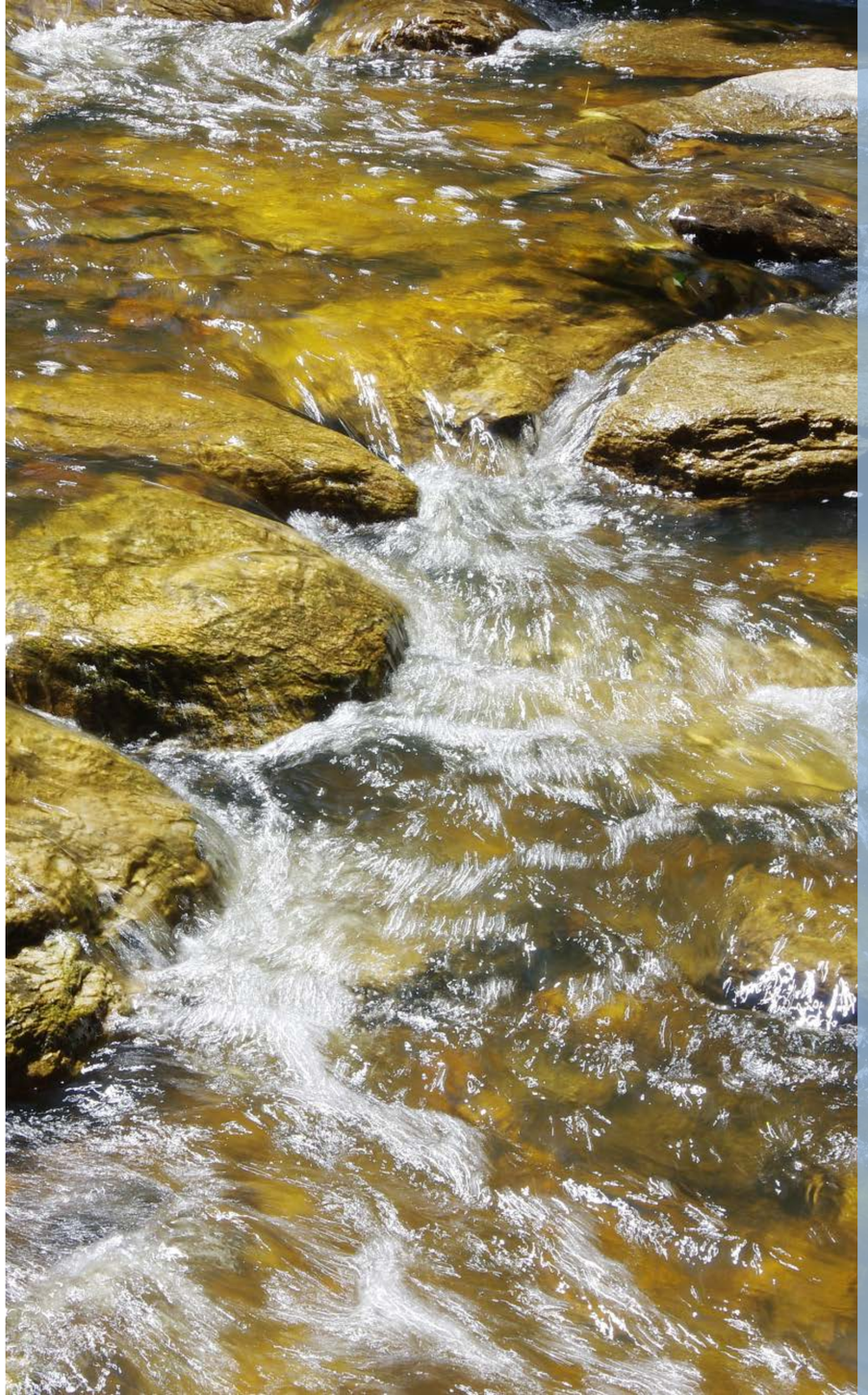
- **Rain Gardens:** These are typically depressions in the landscape designed to attract water flow and planted with appropriate species of plants that can handle both wet conditions during rain as well as drier periods.
- **Green Roofs:** These absorb heat and insulate from cold to increase both heating and cooling efficiencies. They also improve stormwater management and water quality by reducing runoff, while sequestering atmospheric carbon into the soil and providing habitat for wildlife.

Water Management

wa·ter man·age·ment: a system which uses water as a limited but necessary resource to irrigate trees, shrubs and groundcover

Water Management at Glenstone

Situated on a rural site relying on ground wells, Glenstone adheres to an intensive stormwater collection plan for both site irrigation and fire protection.



Right: One of the goals of water management is keeping streams clear and free of sediment

Water Management at Glenstone

In addition to several aboveground ponds that serve as reservoirs, Glenstone relies on three underground concrete cisterns holding nearly one million gallons of water combined with five large-capacity fire suppression tanks. These measures reduce Glenstone's dependency on the water resources shared by its surrounding community.

Glenstone's campus-wide irrigation system, embedded in mulch and understory, reduces evapotranspiration and stormwater runoff. All buildings are equipped with water-efficient toilets, faucets and other fixtures, as well as state-of-the-art heating and cooling systems which optimize Glenstone's energy efficiency.

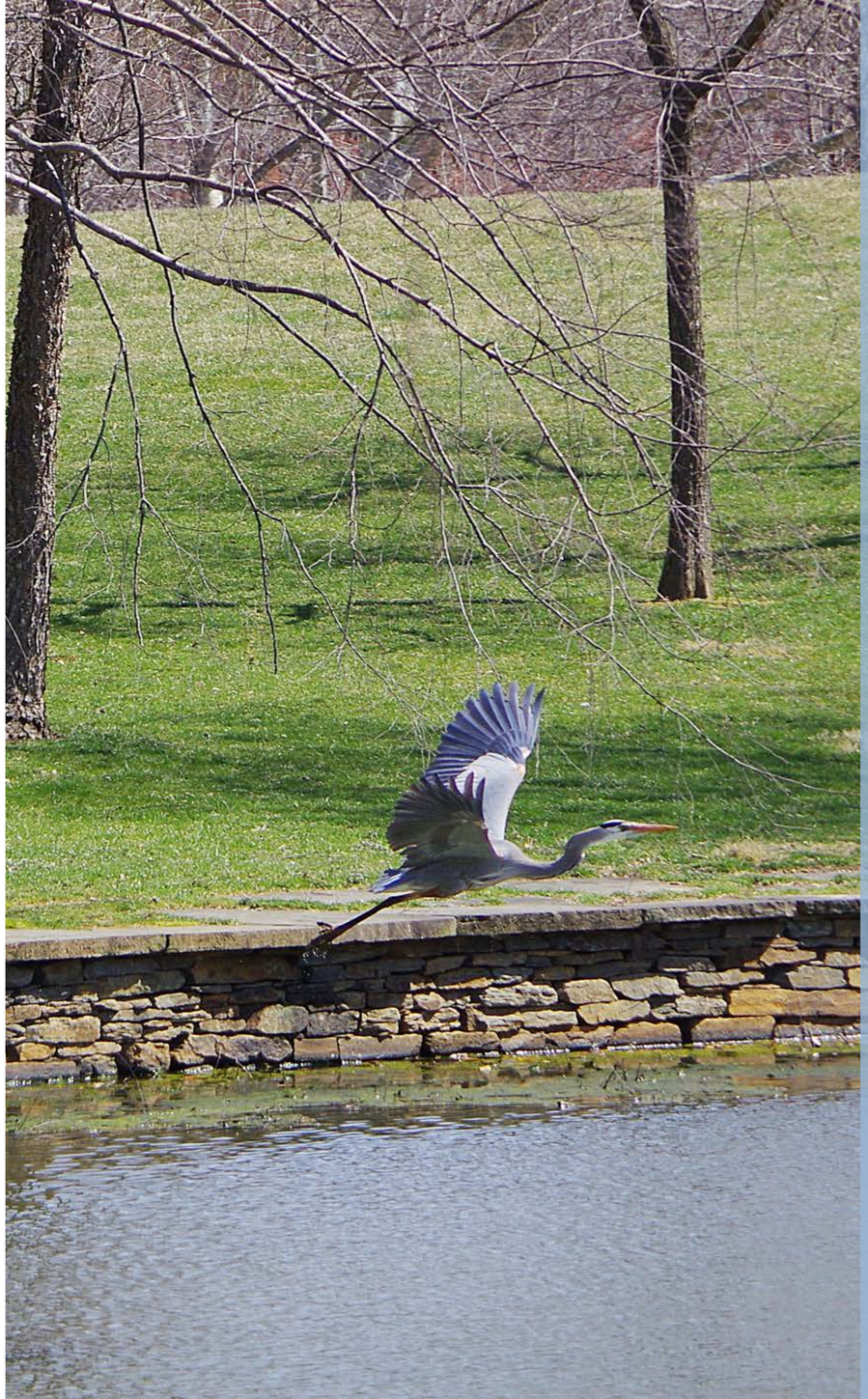
Right: Drip irrigation lines encircle nearly all of the 8,000 newly planted trees during Glenstone's expansion

Ponds

Collecting rainwater runoff from nearby buildings, the ponds on Glenstone's property provide more than one million gallons of water for irrigation and assist in reducing sediment which reaches the Potomac River.

Constructing and managing ponds, however, poses its own challenges. Bodies of water that don't have appropriate circulation can become stagnant, allowing for algae growth. Ponds are also vulnerable to weeds, especially aquatic invasive species such as milfoil, duckweed, and hydrilla, which threaten native species.

Water also attracts wildlife, which can be both positive and negative. We constantly seek solutions to keep away the Canada geese, deer, and muskrats which wreak havoc on Glenstone's lawns.



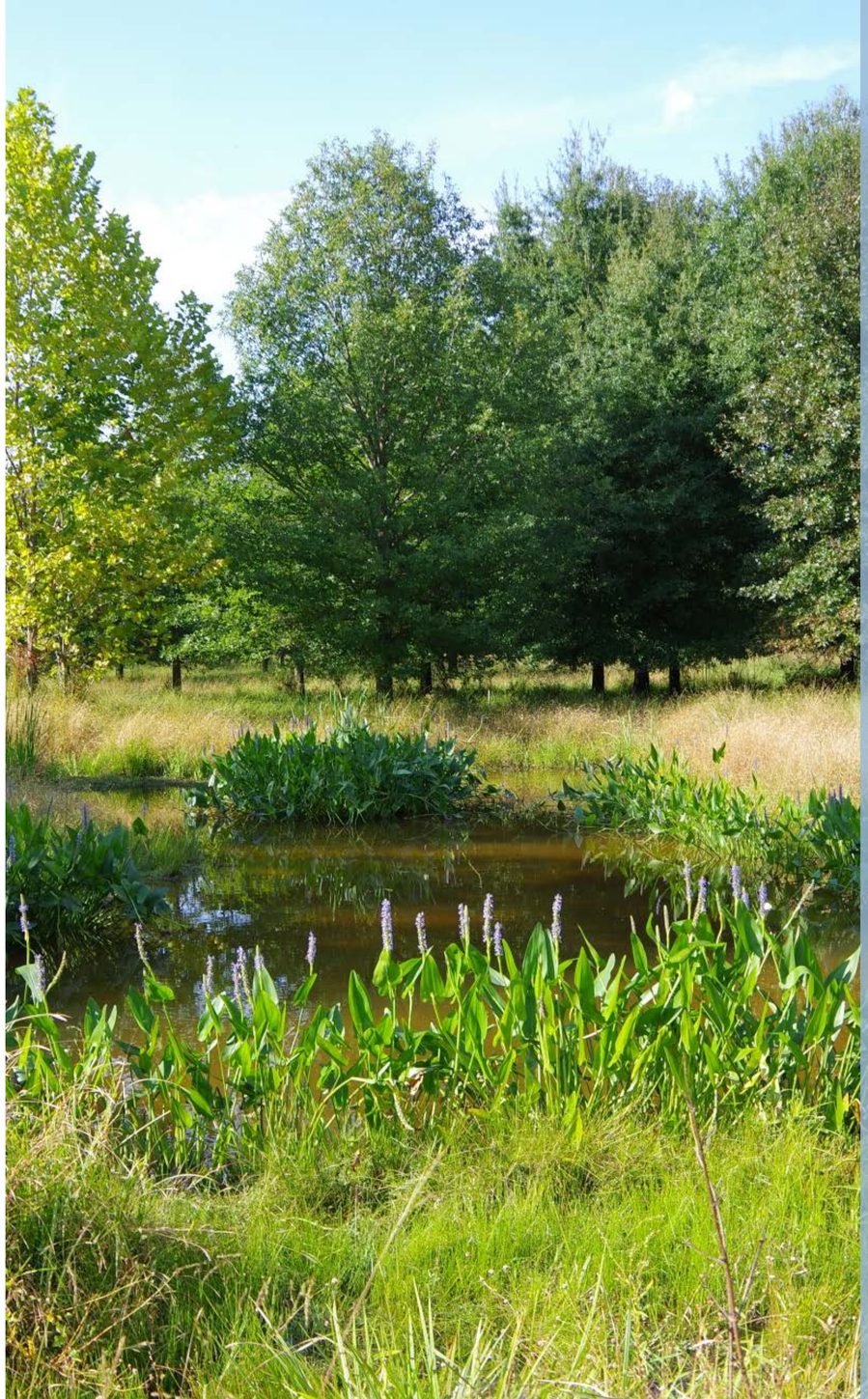
Right: The great blue heron, affectionately named "The Admiral" at Glenstone

Wetlands

Wetlands are areas that buffer dry land from open water. According to the Environmental Protection Agency, wetlands host and shelter more than one-third of America's threatened and endangered species including songbirds, waterfowl, shellfish and mammals.[1] Any intrusion of sediment, fertilizers, pesticides or heavy equipment into a wetland threatens its fragile ecological stability.

Because Glenstone includes the Sandy Branch and Greenbriar Branch streams, we have several acres of wetlands that, in addition to shelter to animals, offer flood, bio-filtration, and pollution control. Because of these benefits, Glenstone stewards our land by enhancing and extending the wetlands wherever possible. We have also carefully avoided wetland impacts during building construction projects.

1 https://www.epa.gov/wetlands/why-are-wetlands-important



Right: This wetland buffers the Sandy Branch stream to the west of the Arrival Hall

Bioponds/Rain Gardens

Similar to wetlands in their function, bioponds and rain gardens are found in low areas in the landscape. Bioponds are a manmade solution to managing stormwater runoff, particularly water from roofs and impervious paved areas such as parking lots.

The key to a successful biopond is its subsoil, which should include very porous soil installed over a layer of well-draining gravel, alongside a selection of plants which can withstand extreme wet and dry conditions. To avoid water carving potentially destructive paths during periods of heavy rainfall, homeowners should consider an outlet or overflow valve.[1]

1 https://www.montgomerycountymd.gov/water/rainscapes/

Right: This biopond, just below the main Sycamore parking grove, is planted with sedges and other plant species that can withstand occasional deluges of water.

Cisterns

At Glenstone, we constructed three underground cisterns to serve as additional water sources. These are especially critical during droughts, which are an annual occurrence in this part of the country.

These cisterns allow Glenstone to be both good stewards of water as well as good neighbors. The amount of water required to irrigate nearly 8,000 newly planted trees and understory plants can exceed 20,000 to 30,000 gallons per day. With nearly one million gallons of water in our cisterns, we can be self-sustaining for long periods of time without tapping into the groundwater shared by the surrounding community.

Right: The largest cistern at Glenstone holds nearly 600,000 gallons of water

Stormwater Outfalls

Successfully managing stormwater runoff is a key component to making cities, towns and neighborhoods habitable. Here at Glenstone, where we are bounded by wetlands, streams, and a large culvert that brings stormwater from an abutting property, we fortified our outfalls to slow and filter water before it reaches wetlands and streams. The top of the outfall, or headwall, is always cast in concrete to hold the head of the culvert in place. Immediately below the headwall is a plunge pool that can gather and slow water, along with any debris and excess sediment so that any water that does travel to the wetlands and streams is as clean as possible.

Right: Most of Glenstone's concrete headwalls and outfalls are reinforced with natural stone to slow the impact of the stormwater. This is one of our outfalls prior to reinforcement.

Stormwater Outfalls

Outfall boulders and stones vary in size in order to hold soil in place and filter water and also hold pockets of soil in place for appropriate native wetland plants to grow. When fully mature, these plants will nearly obscure the boulders and offer further water filtration.

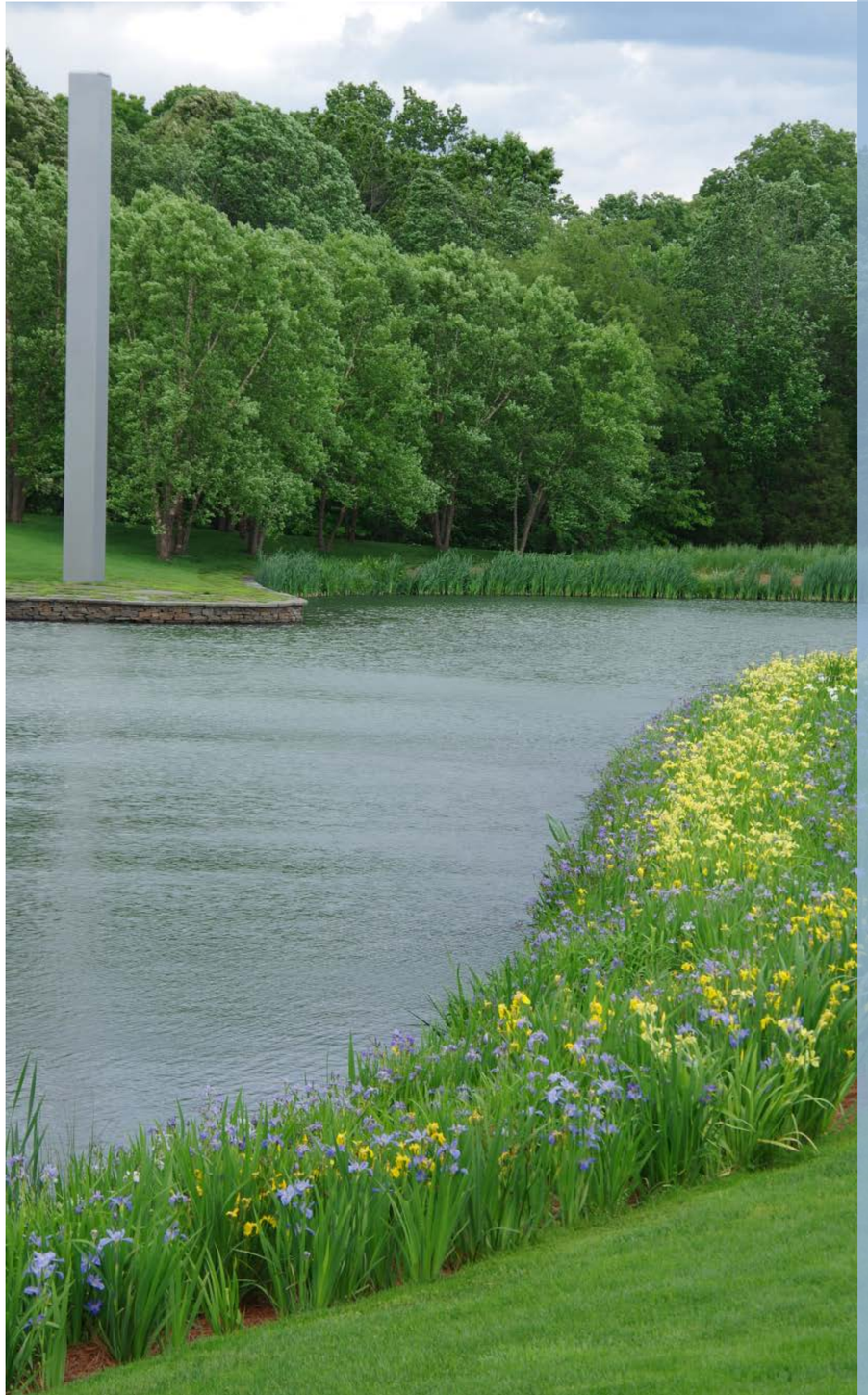
Right: An outfall after placement of stone

Buffer Plantings

While unobstructed views of a pond, lake, stream, or river are beautiful, they offer little protection from fertilizers, pesticides, grass clippings and other contaminants gaining access to the water. Plantings offer dual benefits, functioning both as a buffer and a filter.

At Glenstone, we selected buffer plants to include a native palette of trees and shrubs as well as understory plants and native grasses which limit erosion and sediment and protect against contaminants entering the water.

In areas where water is constantly moving, such as along the edge of streams or outfalls, it can be challenging for plants to establish themselves. In those cases, we install jute matting, a biodegradable plant-based netting that grasses and other plants can grow through. Within a year of being installed, the jute will dissolve into the soil.



Right: The Gallery pond at Glenstone

Irrigation

In order for plants to thrive in an environment, a reliable source of water is needed. Responsible irrigation begins with consideration of the water source, including any equipment such as timers, pumps, spray heads, and drip tube delivery system. At Glenstone, we rely on more than 100 miles of drip irrigation tubes buried beneath mulch, as well as timers and soil gauges. Additionally, our technicians hand-probe the soil to ensure that the root zone of any given plant is adequately saturated.

Right: Irrigation installation at Glenstone

Irrigation Takeaways

Homeowners should remember the basics when irrigating a landscape:

- Whenever possible, water in the early morning.
- Apply water deeply once (or, at most, twice) a week to train roots to grow downward for hydration rather than remaining just below the surface of the soil, which can dry plants out in summer heat.

Right: A horticulturalist sprays Compost Tea at Glenstone

Downspouts and Gutters

Attached to almost every structure, downspouts and gutters are some of the best ways to manage stormwater. When they are directed onto a lawn or planting bed or into rain barrels, cisterns, or containment areas, water is put to good use rather than adding to runoff that can create contamination and flooding downstream.

At Glenstone, we carefully reviewed the runoff from every impervious surface on the property. For instance, on the roof of the Pavilions, storm drains lead to pipes that carry rainwater to our cisterns. And even at Andy Goldsworthy's *Clay Houses (Boulder-Room-Holes)*, 2007 rain gutters catch water flowing off the roofs and pipe it beneath the Woodland Trail to alleviate potential erosion.

Right: Storm drain at Glenstone

Lawn Management

According to recent studies,[1] lawns consume up to two-thirds of the available drinking water in many regions of the country during the growing season. In an effort to mitigate this environmental impact, many municipalities offer financial incentives for property owners who remove turfgrass and install native plants and other low-water planting strategies for their landscapes.

Since we began our organic lawncare practices in 2010 Glenstone has reduced the mown areas of the campus by more than two thirds, cutting down our mown lawn from 16 acres to 5 acres. As you walk through the Gallery side of campus, many areas of the grounds once covered in lawn are now covered with Pennsylvania sedge, *Carex pensylvanica*, creeping red fescue, *Festuca rubra*, or meadows of native wildflowers and grasses.

1 https://www.sciencedaily.com/releases/2011/04/110421104512.htm

Right: Creeping red fescue is a fine-bladed grass that grows well in partially shaded areas of the Glenstone campus.

Lawn Management at Home

Below are a few of the Glenstone lawncare strategies that can be replicated at home:

- Raise mower blades to four inches so that the taller blades of grass will better shade the surface of the soil and reduce the evaporation of water; this technique will also reduce weed pressure compared to mowing at lower heights.
- Sharpen mower blades after every eight-to-twelve hours of use to maintain a sharp edge that cuts rather than tears the grass.
- Reduce the frequency of mowing, especially in July through September.
- Eliminate the use of synthetic chemical fertilizers and leave grass clippings on the lawn to decompose and return their nutrients to the soil.

Right: The lawn at Glenstone

Permeable Pavers and Asphalt

Increasingly utilized as surface management systems, permeable pavers and asphalt offer an alternative to traditional paving methods for driveways, walkways, and patios. The permeable systems absorb water rather than repel it by catching precipitation and surface runoff, storing it in a sand-filled reservoir, and slowly releasing the water into the soil below or discharging it through a layer of gravel known as a drain tile.

Abutting a large forested hillside that meets the junction of the Greenbriar Branch and Sandy Branch streams, the staff parking grove at Glenstone features more than a half-acre of permeable asphalt. Beneath the asphalt is an underground grid-cellular system that naturally filters stormwater and reduces runoff that could damage and pollute waterways.

It is important to note that permeable systems require recurring maintenance on their surface. The pores of the concrete or asphalt need to be cleaned regularly which can be done with a vacuum machine that can be rented or contracted.

Green Roofs

Among the many benefits of green roofs are their reduction of stormwater runoff, providing wildlife habitat, reduction of the need for heating and cooling, and sequestration of carbon in soil.

To take advantage of the benefits that green roofs afford, Thomas Phifer, architect of the Pavilions, fully integrated his design for the building into the surrounding earth. With the native wildflower meadow rolling over the steel and concrete building, approximately 48% of the structure is covered in a green roof. This design allows the Pavilions to absorb hundreds of thousands of gallons of stormwater each year that otherwise might overburden or damage the ecosystem.

Composting

Compost is a natural material which can be added to soil to help plants grow by absorbing water and releasing important nutrients into its surroundings.

Composting may seem intimidating, but anyone can compost. According to the Environmental Protection Agency, food scraps and yard waste together make up about 30% of American waste.[1] Practicing composting is an environmentally friendly alternative to placing these materials in plastic bags and sending them to landfills where they release methane, a potent and toxic greenhouse gas.

1 https://www.epa.gov/recycle/composting-home

Composting Basics

At its most basic level, composting is simply facilitating the decomposition of natural materials. Sources of carbon and nitrogen combine with air and water, along with the microscopic biology that is found in naturally occurring healthy soil and heats and biodegrades raw materials. The carbons, often called the “browns,” include materials such as dead leaves, branches and twigs. The nitrogen-rich sources, called the “greens,” include materials such as grass clippings, vegetable wastes, fruit scraps, coffee grounds and animal manures. Indeed, almost anything that used to be alive can be used in composting.

Right: The brown components of compost

Composting Basics

Your compost, whether piled outdoors or contained indoors, should contain roughly an equal amount of co-mingled browns-to-greens by weight (not volume). It's important to continue to turn the pile over time to add air and keep it moist. You can track your progress by monitoring the pile's temperature: it should be between 130-150 degrees Fahrenheit for several days in a row. If the pile isn't heating, you may not have enough greens to counterbalance the browns. On the other hand, if your pile is starting to smell rotten or anaerobic, you may not have enough brown material to absorb the nitrogen from the greens. You can catalyze the composting process by adding a handful of previously finished compost or commercially available compost starters that contain soil biology. When the materials are finished decomposing — meaning they're ready for use as compost and incorporation into the soil — the resulting brown material shouldn't look anything like the original inputs; rather, it should look like fine, fluffy soil, not warm to the touch, and smell earthy rather than pungent or alcoholic. This process typically takes 30 to 60 days.

How Compost Helps the Soil

One method to rejuvenate overused soil is to incorporate compost material into lawncare maintenance. The most obvious soil benefit comes from the addition of organic matter, since finished compost tends to be composed of about 50% organic matter by weight.[1] Soils are comprised of six primary components—sand, silt, clay, air, water, and organic matter—with organic matter the primary support and sustenance of life.[2]

Healthy lawn soil should be composed of roughly 5% to 7% organic matter.[3] When Glenstone began testing its lawns in 2010, the soil contained less than 2% organic content. Through diligent application of compost over the course of several years, our lawns have little use for additional fertilizer. However, we do continue to test soil annually to confirm our organic matter content continues to be at its optimal level.

1 https://umaine.edu/soiltestinglab/wp-content/uploads/sites/227/2016/07/Compost-Report-Interpretation-Guide.pdf
2 http://www.fao.org/docrep/009/a0100e/a0100e02.htm
3 Tukey, Paul. (2007) *The Organic Lawn Care Manual: A Natural Low-Maintenance System for a Beautiful, Safe Lawn*. Storey Publishing, Boston, MA.

How Compost Helps the Soil

Adding compost to soil helps plants absorb nutrients more efficiently by balancing pH levels, which is a measure of acidity and alkalinity.[1] Finished quality compost should have a neutral pH of approximately 7.0. This can be tested with a pH probe, or by a soil lab.

Compost also aids in the absorption of water, both by increasing the pore space in the soil and by cation exchange capacity, a definable number that predicts how well soil can maintain water and nutrients.[2] We have found that our need for lawn irrigation has dropped by at least 90% since our compost program began in 2010.

1 https://www.planetnatural.com/composting-101/soil-science/compost-soil/
2 https://www.planetnatural.com/composting-101/soil-science/compost-soil/

Right: These compost tumblers, ideal for home use, are about the size of a 30-gallon trash can

How Compost Helps the Soil

Adding compost to landscape soil also improves its structure and texture. The compost improves soil structure by helping it bind with particles of sand, silt and clay that better support the weight of foot traffic and lawn mowers, etc. Compost improves soil texture by making clay soils more airy with better drainage, and conversely improves the water-holding capacity of sandy soils. To note: If too much compost is added to soil at once, the result may be a surface that is too spongy to support foot traffic or a mower.

Compost Tea

Compost tea, also known as liquid biological amendment, is made—as the name implies— much like the beverage. When the tea is sprayed onto a plant or drenched into the soil, those nutrients help plants grow, resist disease, and outperform plants that have not been treated with the tea. However, it is important to note that a number of factors including time, temperature, and the properties of the compost will impact the tea's effectiveness.

Right: These brewing machines allow us to brew finished compost tea in about 30 hours

Compost Tea

At Glenstone, we brew and apply our own compost tea via specialized brewing machines at our Environmental Center. These machines have modernized the process by gently agitating compost with air to speed the extraction of nutrients and living organisms from the compost, which is suspended in a bag inside 250-gallon tanks. After approximately 30 hours of brewing, the resulting tea is applied across the Glenstone landscape through a campus-wide irrigation system and specially retrofitted portable spray equipment which allows the liquid's biology to pass through without being harmed. Whereas chemical sprays are typically applied in low-volume, high-pressure equipment, compost tea is best applied in higher volumes (about 50 gallons per acre) under low pressure. This keeps bacteria, protozoa, nematodes and other microorganisms intact as they come in contact with soil.

Right: Our Irrigation Technician applies compost tea to the lawn outside the Gallery

Composting at Glenstone

Since our composting efforts began in 2013 we have designated a composting yard at the Environmental Center, open to visitors. To date, our composting program has diverted more than 15,000 pounds of food from the waste stream while generating hundreds of cubic yards of compost that is applied as a soil enhancement across our grounds.

Right: From 2010 to 2016, Glenstone top-dressed the lawn with compost to build the organic matter in the soil.

Compost Tea at Home

Compost tea is available for sale in various forms at garden centers. With a short shelf life as a living, breathing product, it should be used within a day of purchase or brewing.

There are also numerous devices for sale for home brewing, ranging in price from $50 to more than $500. Homeowners can also construct their own unit with a five-gallon drywall-style bucket and a small aquarium-sized aerator to agitate the compost and keep the water from becoming stagnant. The resulting tea can be applied with a watering can, or with a standard hose-end sprayer.

To brew compost tea, homeowners should start with a pound of compost per gallon of water and “brew” it for about 36 hours at 60 degrees, 30 hours at 70 degrees, or 24 hours at 80 degrees (or higher). Adding a tablespoon of molasses per gallon of water will increase the bacteria content of the compost tea, which is generally beneficial to the grass.

Right: This five-gallon size is an ideal home-scale tea brewing machine

Recycling

re·cyc·ling: is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products

Reduce, Re-Use, & Recycle

Driven by Glenstone's long-term vision to be a leader in sustainability practices coupled with Montgomery County's mandate to reduce, re-use, and recycle all possible materials, we have developed a robust program to minimize trash and wasteful practices throughout the property.

When Montgomery County announced its goal in 2013 to recycle 70% of office materials by 2020, Glenstone set its goal instead to achieve this milestone within the calendar year. In order to do so, we began weekly measurements of inputs and outputs, and established additional metrics of Materials Used Per Person (MUPP) and Trash Out Per Person (TOPP).

Reduce, Re-Use, & Recycle

We also began to consider other sources of material onsite that could be recycled, reduced, or re-used and developed a 12-step trash reduction program based on Montgomery County's requirement that businesses and non-profit organizations separate materials into three categories:

- Mixed Paper
- Co-Mingled (cans and bottles)
- Scrap Metals

Reduce, Re-Use, & Recycle

We identified additional opportunities to recycle:

- Construction Debris
- Food Composting
- Landscape Materials
- Electronics
- Batteries
- Hazardous Materials
- Soft Plastics & Shopping Bags
- Floor Sweepings

And stressed that throwing something in the trash needed to be the 12th step—an absolute last resort.

Reduce, Re-Use, & Recycle

Within the year, we had met our goal to recycle 70% of office materials. In keeping with our core value of continuous improvement, however, we eventually raised our goal to 80%.

Today, our TOPP (Trash Out Per Person) is approximately one pound per person per week and our MUPP (Materials Used Per Person) is approximately three pounds per person.

We weigh materials daily and remind staff weekly about our goal and current standing. Each new staff member is also required to complete a recycling orientation program within one month of their hiring date.

Home/Business Applications

- Provide containers, signage, and education to make it easy for associates to participate in our recycling program.
- Establish a Recycling Bay where bins for each of the 12 steps in the trash diversion program can be located.
- Discourage all paper printing and invoicing and rely on electronic devices such as laptops, cell phones, smart screens, email, etc. as much as possible.
- Set the default to double-sided on copy machines when printing is necessary.
- For internal printing, when necessary, utilize paper that is previously printed on one side.

Home/Business Applications

- Use continuous circulation envelopes to route internal mail to staff when email is not an option.
- Reduce print subscriptions to magazines, newsletters, trade journals, and newspapers, and subscribe to electronic versions instead.
- Re-use difficult-to-recycle materials such as Styrofoam, binders, folders, packing supplies, etc., or donate them to art classes in the community.
- Recycle toner and ink cartridges.
- Replace disposable kitchenware in lunch rooms with reusable or compostable options, and utilize refillable containers for salt, pepper, sugar, etc. to avoid individual packets.

Home/Business Applications

- Re-use or donate electronics and provide opportunities for associates to recycle their home electronics.
- Look for EPEAT-registered (Electronic Product Environmental Assessment Tool) electronic products.
- Select US Green Building Council-approved materials for cabinets and fixtures and other office amenities.

Home/Business Applications

- When ordering catered food, select caterers who provide reusable or recyclable kitchenware, and use locally grown, and preferably organic food that is sustainably harvested.
- Aim to use toiletries, paper towels, tissues, and toilet paper that are comprised of 100% post-consumer recycled material, and compost paper towels.
- Stock bathrooms with biodegradable soaps without antibacterial agents in reusable containers.

Right: Compostable paper towels are utilized in all staff and guest bathrooms at Glenstone

Home/Business Applications

- Set thresholds for recycled and chlorine content of all paper, letterhead, and envelopes. In general, aim to utilize paper with a minimum of 30% recycled content and avoid chlorine in paper wherever possible, as it is a known environmental polluter.
- Review all Material Safety Data Sheets and eliminate most products that include synthetic chemicals and those with high toxicity quotients.
- Carefully select waste and recycling contractors and audit the destination of all materials.
- Recycle plastic shopping bags and other soft plastics and work with companies who repurpose them for their products.

Home/Business Applications

- Form a Green Team that meets regularly to inform and reinforce sustainability policies and initiatives.
- Conduct monthly waste assessments and share results with staff.
- Designate a purchasing coordinator on staff to avoid duplicate orders and multiple trips to and from the store.

Right: The Green Team at Glenstone