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Vegetation Barrier Toolkit for Schools and Communities

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

ENVIRONMENTAL LAW & POLICY CENTER

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What's in This Toolkit?

Reducing exposure to air pollution near roadways is no easy task. Ideally, changes in laws and technologies would lead to vehicles that emit less air pollution. These types of changes take time, however. In addition, driving can also create other air pollutants such as particulate matter generated from the wear from tires and brakes and resuspension of road dust as vehicles travel along the road. Installing solid physical barriers next to major roadways and upgrading building heating, ventilation, and air-conditioning (HVAC) systems for better air pollutant removal are expensive activities and often cost-prohibitive. **Vegetation barriers are another approach for reducing the spread of air pollution from roadways to places where people spend time outdoors and into buildings.** The trees in vegetation barriers can provide other environmental benefits as well. Vegetation barriers can be more cost-effective compared to other air pollution mitigation techniques, although vegetation barrier benefits are usually not fully realized until several years after planting.

The goal of this toolkit is to take a community group step-by-step through the process of planning, creating, and caring for a vegetation barrier in addition to using vegetation barriers as part of science curricula. It includes the following components:

- **Getting Started** – Overview of what vegetation barriers are, how they work, and how to develop partnerships to create them.
- **Curriculum Toolkit for Educators** – Introduction to lesson plans for understanding air and soil quality at schools.
- **Planning and Planting Vegetation Barriers Guides** – Collection of guides about each step of the process of designing, planting, and caring for vegetation barriers.
- **Additional Resources** – Additional information about air quality, vegetation barriers, tree planting, soil, and more.
- **Project Budget Worksheet** – Tool to calculate the costs of planting a vegetation barrier using information from the guides and field sheets.
- **Field Sheets** – Handouts with checklists and tables for collecting observations during the vegetation barrier planning and planting process.
- **Vegetation Barrier Lesson Plans** – List of lesson plans that complement this toolkit.

The planning and planting guides and associated field sheets are designed to provide step-by-step instructions for a school or community group to plan, plant, and care for a vegetation barrier on their own. Tree-planting projects in urban environments can face many problems, however, and working with design and landscaping professionals may be a better strategy when facing issues such as, for example, buried construction material at a planting site. The toolkit's guides can still be a helpful resource to familiarize yourself with the vegetation barrier process.

While this toolkit and its list of plant species have been tailored for the Chicago metropolitan region, many of its recommendations are applicable to any place where community members want to improve air quality near roadways. Additionally, the tree-planting practices described in this toolkit may be relevant for many tree-planting projects.

Getting Started

What's a vegetation barrier?

Vegetation barriers are a collection of trees and shrubs that separate a source of pollution such as a highway from places where people live, learn, work, and play. When fully grown, a vegetation barrier looks a bit like a wall of plants that runs parallel to a roadway, rail yard, or other ground-level pollution sources. When plants with the right types of characteristics are put in the right places, they act as a living air filter or a diversion system. Air pollution can get stuck on the leaves and bark of the plants, while certain plants can absorb some air pollution inside their leaves through microscopic openings called stomata. Taller trees and thick bushes can also help divert the air pollutants up higher into the air, diluting the pollution and often lifting air contaminants above where people spend time.

Vegetation barriers may reduce people's exposure to vehicular air pollutants, including particulate matter, nitrous oxides, sulfur dioxide, and carbon monoxide. Decreasing people's exposure to these pollutants can reduce the likelihood that they will experience asthma, lung and heart disease, and cancer.[1, 2] Research shows that vegetation barriers have the potential to reduce downwind air pollutants by as much as 50%, depending on different factors.[3, 4] Plant characteristics and placement are especially important for a successful vegetation barrier. Poor choices of plant species and locations can have little effect on downwind air pollution and can even make it worse.[3, 4]

Planting vegetation barriers near schools, parks, or other community centers can both reduce air pollution and provide other benefits. When planted near roads, trees can also reduce the amount of noise or make it less noticeable. Adding plants to a landscape can help to improve mental health and well-being. Views of trees and vegetation can improve attention and memory. In addition, fully grown trees help the environment by capturing stormwater, reducing the urban heat island effect, and storing carbon dioxide, among many other benefits.[5] Vegetation barriers are also a great learning tool supporting science curricula when planted at schools.

It is important to keep in mind, however, that vegetation barriers may not be the best air pollution management tool for every location. Sometimes a narrower vegetation barrier next to a solid structure such as a wall may be able to reduce exposures to roadway pollutants. **Because vegetation barriers are living things, they take several years to grow large enough to be effective, and they require long-term care.**

The Planning and Planting Vegetation Barrier Guides are designed to help you determine if a vegetation barrier is right for your community and will walk you through the process of planning, planting, and caring for a vegetation barrier. The guides provide instructions for creating a barrier that is long and narrow, a bit like a wall, and made of trees

In the right location, a vegetation barrier can improve local air quality.

and shrubs. This design reflects our current best knowledge about vegetation barrier designs that can improve air quality. After reviewing the guides, making observations about your site, and deciding on your vegetation barrier, you can use the Project Budget Worksheet to estimate costs. In some cases, a project could be completed by a group of volunteers while in other situations, your group may need to work with professionals.

Trees can run into many problems growing near roads: soils that can't provide enough water, air, or nutrients; high temperatures; possible damage from human activities; and damage from pollution, to name a few. **Just like all other living things, trees will grow best when given a nurturing environment and the resources they need. The preparation and planting details in the guides may seem like extra work, but they will give your trees the best chances to survive and thrive as part of your vegetation barrier.** These instructions are based on the best science and practical knowledge about planting and caring for trees. Much of the information in the guides is applicable to other tree-planting projects as well. When we take care of trees, they take care of us.

Many of the guides have a companion field sheet that is meant to be printed and brought along when you are at the planting site or a garden center.

There are many phases to the process of completing a vegetation barrier, and the following guides will help walk you through the process:

- Learning about air quality challenges through community engagement and data collection (see the Appendix for lesson content about measuring air quality at a school or other outdoor area)
- Deciding to take action
- Finding an appropriate location for a vegetation barrier and potentially bringing in professional help (Guide #1)
- Taking a close look at the site to identify potential problems for tree planting (Guide #2)
- Determining landowners and getting permission and permits to plant on a property (Guide #3)
- Choosing a planting design (Guide #4)
- Evaluating the planting area's soil conditions (Guide #5)
- Selecting tree species (Guide #6)
- Purchasing trees from a garden center (Guide #7)
- Preparing the site for planting (Guide #8)
- Transporting, inspecting, and storing trees (Guide #9)
- Planting the trees (Guide #10)
- Adding mulch (Guide #11)
- Stabilizing the trees (Guide #12)
- Caring for the vegetation barrier after planting (Guide #13)

Cited sources

1. California Environmental Protection Agency Air Resources Board, 2005. Air Quality and Land Use Handbook: A Community Health Perspective. http://www.arb.ca.gov/ch/handbook.pdf. Accessed on 28 Jun 2021.
2. U.S. Environmental Protection Agency, 2016. Near-Source Air Pollution Research. http://www.epa.gov/air-research/near-source-air-pollution-research. Accessed on 28 Jun 2021.
3. Baldauf, R., 2017. Roadside vegetation design characteristics that can improve local, near-road air quality. Transportation research part D: Transport and environment, 52, pp.354-361.
4. Deshmukh, P., Isakov, V., Venkatram, A., Yang, B., Zhang, K.M., Logan, R. and Baldauf, R., 2019. The effects of roadside vegetation characteristics on local, near-road air quality. Air Quality, Atmosphere & Health, 12(3), pp.259-270.
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Partnerships are critical to success

A vegetation barrier is a substantial undertaking, and collaborating with a wide range of partners with specific expertise who can share the load is critical to your success. **Community support is needed for each of the phases, from gathering supporters all the way to maintenance.** It is important to make an inventory of potential partners and the roles they can play. Many hands make light work!

Consider hosting community gatherings and engagement opportunities at each of the phases of the vegetation barrier.

For instance, Phase 1: Learning about air quality challenges. This is a great opportunity to build interest in and get community support for your project. Host an event to provide an opportunity for community members to participate in air quality testing at the school and to learn why a vegetation barrier can have a significant health benefit for students and faculty. **Be sure to invite important partners who can help promote and support the project through a range of needs**, e.g., the mayor and trustees, principal, superintendent, parents, local service organizations, professionals (engineers, landscapers, landscape architects), community advocacy groups, businesses, the press, other elected officials, etc. Let them know what help is needed. Provide a list of needs so they can think about how they might be able to get involved. Get their contact information so you can follow up.

There is a wide range of potential partners. Some partners will help to build community support, others will help to identify funding opportunities, and still others will be able to provide in-kind contributions. The following are some examples.

Partnerships at the school are critical to facilitate the construction of a barrier—especially if the barrier is being placed on school property. The school can host meetings, identify potential partners, plan for maintenance of the barrier once complete, and provide funding assistance, among other activities. Key partners at the school include

- Superintendent
- Director of operations or facilities
- Principal
- Faculty (academic, clubs, and athletics)

- Associated after-school programs (including organizations that manage programs for schools)
- Facilities (maintenance, grounds staff, contractors)

A wide range of organizations and individuals within the community can help. They each have their own areas of expertise and talents. These include helping with fundraising, providing equipment and labor, planting and caring for the barrier, and communicating about the project. Potential partners are

- Parent-teacher organization
- Rotary Club
- Lions Club
- Garden clubs
- Scouts BSA or Girl Scouts
- Elected officials (local, regional, state, and national)
- Public works department
- Neighborhood groups
- Chamber of commerce
- Health clubs
- Hospitals and healthcare companies
- Transportation organizations
- Local corporations and businesses
- Local climate action group

There are likely some exceptional professionals and individuals in your community who would be willing to donate in-kind services or resources such as their time, equipment, or materials to help with the vegetation barrier:

- Engineering firms
- Landscaping contractors
- Architects
- Nurseries
- Grading companies
- Corporate volunteers
- Community group (adult and youth) volunteers

The construction of a vegetation barrier can be expensive. A number of organizations and individuals would likely be interested in helping to fund or fundraise for a vegetation barrier. Many may have established goals to support youth, education, giving back to the community, or improving the environment — all goals that are relevant to this project. It is important to think about how this project supports their goals — and present it to them that way — so they have a reason to support your goal of creating a vegetation barrier.

Departments within organizations will also have different goals that can fulfill your needs. For instance, a corporation's human resources department may be looking for opportunities for staff to provide service — volunteers. The marketing department may be looking for public relations opportunities — press and communications. The sustainability department may be looking to offset corporate impacts — funding.

Ultimately, a wide array of partnerships will result in broad interest and support for your project from inception through maintenance and monitoring. The stronger the partnerships, the stronger and more successful the project.

Examples of partners who might be able to provide services or direct funding assistance, or who may even be willing to run a fundraising campaign include

- Rotary Club
- Lions Club
- Local garden clubs and the Garden Club of America
- Local foundations
- Corporate neighbors
- Your school. A strategy may already be in place for fundraising, e.g., wrapping-paper sales, bake sales, raffles, etc. Check with your school to see what opportunities may be available.
- Individuals
- Regional, state, and national
  - State – Illinois Department of Transportation, Illinois Department of Natural Resources, Illinois Department of Health, Illinois Department of Education
  - Federal – Grants.gov
  - Associations – Illinois Education Association, Illinois Landscape Contractors Association, Illinois Green Industry Association, Illinois Society of Professional Engineers, Illinois Association of Landscape Architects, Illinois Arborist Association, Environmental Education Association of Illinois, etc.
  - Not-for-profits – Chicago Region Trees Initiative planting grants, Openlands Planters Grants, etc.
  - National organizations – Arbor Day Foundation, American Forests, One Tree Planted
- Health-related organizations
- Insurance companies
- Health clubs
- Drugstores
- Green industry
- Nurseries
- Garden centers
- Landscaping contractors
- Landscape design firms

Curriculum Toolkit for Educators

Understanding air quality and soil quality at your school site

Project overview for educators

Trees, hedges, shrubs, and other green spaces provide many benefits to individuals, especially where people work, learn, live, and play. From improving physical and mental health, to increasing students' attention and test scores, to supporting vibrant ecosystems, the benefits of greening the landscape provide lasting impacts to community members and key stakeholders.[1] Perhaps one of the most important benefits that trees provide is removing pollution, which causes significant health issues. Urban and suburban settings are more susceptible to pollution and less likely to have vast expanses of green spaces to counteract these factors.

Schools and businesses adjacent to high-traffic roadways are often subject to poor air and soil quality. Attempting to plant trees in soils of low quality will not solve the air quality issue as the trees will likely struggle and die before the barrier matures. Improving air and soil quality, especially near students or other vulnerable members of the population, is a critical human health issue. Vegetation barriers (trees/shrubs planted between the pollution source and the monitoring source) provide a mechanism to improve air and soil quality in these areas as the trees grow and develop over time.

The toolkit will support teachers and students as they conduct activities to understand what methods and species are the most successful at removing pollution. Their experiences and data collected will be used to help develop best practices that will be implemented at other schools around the country. The lesson sequence has been organized to allow teachers and students to understand air quality and make observations of air quality at their site, to understand how trees and vegetation can improve air quality over time, and then to develop mitigation plans and strategies that help improve these conditions. The document below outlines the education resources and components that would be part of this toolkit. The toolkit has been organized to provide schools and classrooms with tools to develop a vegetation barrier at their sites as well as to monitor air quality before and after installation.

Alignment with Next Generation Science Standards (NGSS)

Grades 3–5

- **3-LS4-4**. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
- **3-5-ETS1-2**. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- **5-ESS2-1**. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
- **5-ESS3-1**. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Grades 6–8

- **MS-LS2-4**. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- **MS-LS2-5**. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
- **MS-ESS3-3**. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- **MS-ETS1-1**. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Grades 9–12

- **HS-LS2-5**. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
- **HS-LS2-7**. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- **HS-ESS3-4**. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- **HS-ESS3-6**. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
- **HS-ETS1-2**. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Select activities have also been aligned to Common Core Reading and Language Standards:

- **RI.1**. Draw inferences from the text.
- **RI.2**. Determine the central idea or message of a text and supporting ideas.
- **RI.3**. Explain relationships, interactions, distinctions, and/or connections between ideas or concepts in a scientific text based on information or specific details in that text.
- **RI.4**. Determine the meaning of words or phrases in a text.
- **RI.10**. Read grade-level texts independently and proficiently.
- **L.4a**. Use context as a clue to the meaning of a word or phrase.
- **L.6**. Acquire and accurately use academic and domain-specific words and phrases.
- **SL.1**. Participate/engage effectively in collaborative group discussions.

Learning objectives

Students will be able to

- Trace pollutants (specifically air pollution) through the biosphere and geosphere.
- Understand the role of trees and their impacts to the ecosystem as well as impact on human health.
- Generate ideas to mitigate air pollution in their community.
- Explore and analyze the health of their urban ecosystem through data collection, monitoring, and investigation.
- Track and record air quality data for their surrounding school and school community. Data can be tracked over time from installation to subsequent years.
- Evaluate the success of the vegetation barrier on ecosystem services within their urban environment. (Evidence provided by monitoring data or other impact metrics, including community impact, school environment impact, etc.)

Curriculum outline and lesson progression

The lessons and activities outlined below are included as an appendix to this toolkit and are available separately from The Morton Arboretum's Education Department.

- **Setting the stage**
  - Introduction Activity: Anticipation Set, Find the Fiction, Air Quality Headlines Activity
  - Vocabulary Build: Vocabulary Story – Air Quality and Trees
- **Investigating the problem**
  - Observation: Measuring the Air Quality at Your Site, How to Use the Sensors, and Understanding Air Quality
    - Additional resources: United States Environmental Protection Agency Air Sensor Loaning Resource
  - Connect: Trees, Shrubs, and Air Quality – Science Notebook Activity
- **Designing a solution**
  - Action Planning Worksheet
  - Planning Your Vegetation Barrier
  - Investigating Soil on Your Schoolyard
  - Choosing the Trees for Your Barrier – Final Planning Activity
  - Bringing It All Together – Planting Design Proposal

Toolkit education loaning resources

In addition to the toolkit and guides, a bin of materials is available for loan to assist you with implementing this type of project for your community. The bin contains resources, equipment, and monitoring tools to help you create a

vegetation barrier to reduce air pollution. Several of the activities and lessons in this toolkit utilize these tools. The bin can be loaned for two weeks at a time and must be picked up from and returned to The Morton Arboretum. For more information, visit https://mortonarb.org/educators/classroom-items-for-loan/.

Bin contents

- Binder with printed toolkit and jump drive (digital content)
- Soil probes and/or shovels (qty: 3-5)
- Clipboard(s) (qty: 3-5)
- Large tape measure (qty: 3-5)
- AirBeam2 sensor (EPA Loaning Resource, quantity determined by educators during toolkit registration)
- Mobile device for sensor (EPA Loaning Resource, quantity determined by educators during toolkit registration)

Please note: *This toolkit contains the AirBeam2 sensor, and there are some considerations to understand with use of this sensor. Current particulate matter (PM) air sensors (sensors) most effectively detect particles within the size range of about 0.5-2.5 microns (um) in diameter. However, research has shown (for example, Lin et al., 2016[2]) that vegetation is most effective at removing very small particles (called ultrafine particles, smaller than 0.1um) and larger particles (called coarse particles, larger than 2.5um), which fall outside of this optimal measurement range with current air sensor technologies. Therefore, when using a PM sensor like the AirBeam2, we must realize that this sensor is not seeing the differences in the very small and larger particle concentrations, so we may likely not see the significant reductions in PM after the installation and maturation of a vegetation barrier using the AirBeam2 or other lower-cost sensors. Additionally, it is important to note that vegetation barriers may take a few years to establish and demonstrate significant changes to air quality measurements. School sites should consider including and adopting additional mitigation strategies (outlined in the "Action Planning Worksheet – Air Quality and Vegetation Barrier" activity).*

Additional resources and links

- **The Morton Arboretum Plant Clinic:** The Morton Arboretum's Plant Clinic is a leading source of science-based advice about trees, plants, and landscapes, helping gardeners and landscape professionals throughout the Chicago region and the world have healthy, attractive, well-chosen plants. Trained staff and volunteers are available by phone or by email to help with tree and plant selection, identifying and coping with pests and diseases, and other concerns.
- **The Morton Arboretum education resources**
  - **Virtual Curriculum Bundles (free):** These bundles are divided by grade level, and all activities are aligned to Next Generation Science Standards (NGSS) and, in some cases, Common Core State Standards, often including cross-curricular lessons and activities. The Virtual Bundles align to life science themes and come in three parts: introductory activities (to introduce the topic and domain-specific vocabulary), pre-recorded teaching videos, and concluding activities (to assess student learning). These bundles include teacher answer keys and standards-aligned rubrics (when necessary).
  - **Field trip programs (fee-based with potential grant opportunities):** Spark curiosity about science, nature, and art with one of the many programs available to school groups and classrooms at The Morton Arboretum.
  - **Classroom items for loan:** The Morton Arboretum has developed free loan resources for teachers to check out and implement in their classroom instruction. Each Discovery Bin contains materials, tools, and lessons to bring the new Next Generation Science Standards (NGSS) alive in your classroom. Bins are organized by grade-level and are aligned with our current field trip offerings. Check out a bin before or after your trip to extend your students' learning. These bins can be borrowed for up to two weeks at a time.

- **Guest speaker/outreach:** Schools planning a vegetation barrier for their site can also coordinate with The Morton Arboretum Education and Science Conservation departments to provide students, staff, and community members with a presentation on urban soils, urban trees, or other related topics for their barrier. These outreach events can take place virtually or in person and would be subject to staff availability during the planning process. For details contact The Morton Arboretum's Education Department.

- **Extension Master Gardener programs (United States Department of Agriculture)**
  - Find your local Extension Master Gardener program from each of the 50 states for more support. These trained professionals and volunteers recommend university and research-based information through the Cooperative Extension System.
- **United States Environmental Protection Agency (U.S. EPA)**
  - **Air Quality Sensor Loaning Program:** The EPA has developed a series of lessons and loaning resources for libraries and education institutions to provide community members and youth with access to air quality monitoring tools and sensors.
  - **Measuring Air Quality Improvements from Vegetation Barriers:** This is a set of lesson plans designed to complement U.S. EPA's Air Quality Sensor Loaning Program. Lesson plans include classroom and field activities that utilize mobile air quality sensors.
  - **Environmental Resources for Educators:** U.S. EPA has curated a collection of lesson plans and classroom activities on a wide range of environmental topics, including air pollution.
  - **EPA's Best Practices for Reducing Near-Road Pollution at Schools:** This publication can help school communities identify strategies for reducing traffic-related pollution exposure at schools located downwind from heavily traveled roadways (such as highways), along corridors with significant trucking traffic, or near other traffic or vehicular pollution sources. Many of these strategies are already being used by schools across the country to reduce exposure to traffic-related air pollution.
  - **Idle-Free Schools Toolkit for a Healthy School Environment:** The Idle-Free Schools Toolkit includes information needed to run an effective idling reduction campaign at a school to reduce student exposure to toxic vehicle exhaust. The toolkit also provides the resources to make this a student-run science or community involvement project, providing students with the opportunity to learn how to run a public-service campaign while expanding their science and math skills.
  - **Air Quality Flag Program.** As part of this program, each day the school/organization raises a flag that corresponds to how clean or polluted the air is. The color of the flag matches EPA's Air Quality Index (AQI): green, yellow, orange, red, and purple. On unhealthy days, the school/organization can use this information to adjust physical activities to help reduce exposure to air pollution while still keeping people active.
- **Environmental Law & Policy Center (ELPC)**
  - **Air Quality Monitoring Program.** ELPC's program loans residents handheld air quality monitors to assess street by street (particulate matter) PM2.5 levels, empowering community members to become vocal advocates for clean air policy and enforcement. Using AirBeams, people collect data around their neighborhoods and local areas of concern. From ELPC's website, residents can access PM2.5 datasheets and downloadable maps, gain the attention of policymakers on air quality injustice, and seek solutions such as vegetation barriers and fleet electrification to mitigate neighborhood PM2.5 levels.

Cited sources

1. Turner-Skoff, J.B., Cavender, N. 2019. The benefits of trees for livable and sustainable communities. Plants People Planet. 1:323-335.
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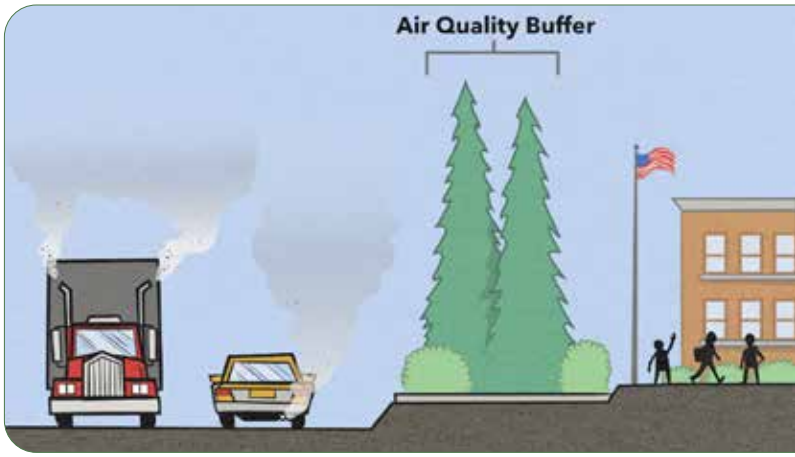
GUIDE #1

What's the Best Place for a Vegetation Barrier?

To reduce air pollution, a vegetation barrier will be most effective if it is downwind of and close and parallel to a ground-level source of pollution, such as a busy roadway. This way, the wall of trees or shrubs intercepts the wind that would bring polluted air onto a site. The methods described in these guides are typically used for open areas. While vegetation barriers can be designed for streets between crowded buildings in cities, those conditions are much more complex and consequently more challenging to ensure the vegetation barrier will work effectively.[1]

Vegetation barriers are generally made of a few rows of trees and/or shrubs. These plants grow to form a living wall or hedge that can trap air pollutants or direct polluted air away from the area you want to protect. Vegetation barriers planted near an actual wall or solid fence also provide effective air pollution improvements. As the plants grow, their branches should be close enough so the barrier does not have any gaps near the ground or between the trees. Gaps in the vegetation barrier can act like a funnel for air pollutants and let them through to the other side. The vegetation barrier can also be more than functional: You can add more decorative plants around and below the barrier. (See the Additional Plants to Complement Vegetation Barriers section.)

If there are already some trees or large plants between the road and the area you want to protect, it is preferable NOT to remove those plants to make a new barrier. Those plants are probably providing other benefits and are already mature. If you have existing trees where you think a vegetation barrier should go, it could be helpful to work with an arborist to determine if those trees are healthy and should be saved. If you do want to keep existing trees at your site, you can add vegetation barrier species around existing planted areas to enhance its ability to improve air quality.



Vegetation barriers should be planted between the source of ground-level air pollution, such as a road, and the area you want to protect, such as a playground.

Think about where you might want to put a vegetation barrier; this is your planting area. Take a walk around your site and look at it with an online map. Use your observations to answer the questions in Field Sheet #1.

If you answered "Yes" to all of the questions in Field Sheet #1, proceed to Guide #2 to start making measurements that will help you figure out if your planting area has enough space to grow vegetation barrier trees and shrubs. If your location doesn't have a good place for a vegetation barrier, the Additional Resources section can direct you to other practices that can help improve local air quality.

If you answer "No" to question #4, a vegetation barrier could still be planted in some circumstances. In this case, the vegetation barrier should be higher than the pollution source to be effective. For example, imagine a planting area that is 7 feet lower than a nearby highway. The vegetation barriers would need to grow at least 23 feet tall so that the trees extend 16 feet higher than the road.

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GUIDE #2

Do You Have Enough Space for a Vegetation Barrier?

For trees and shrubs to grow to their fullest potential, they need lots of space both above and below ground. When trees that are supposed to grow large are planted in small spaces, their roots can lift or crack sidewalks, their branches can get tangled in overhead wires, and they may not grow very well because there isn't enough soil to provide the water and resources they need. Additionally, trees and shrubs need to be planted far enough away from major roads so that they do not cause safety issues such as blocking drivers' views or road signs.[1]

This guide will help you determine if there is enough space at your site to grow vegetation barrier trees that will be big enough to block and filter air pollution from nearby roads. Some of the guide's questions can best be answered by walking around the site while others may be easier to determine using online maps. Record all of your observations in Field Sheet #2.

Pay careful attention to your potential vegetation barrier planting site to make sure your trees will have enough sunlight, won't grow into utility lines and below-ground pipes, and won't be too close to sidewalks and roads.

Light level

Observe how much sunlight your planting location receives each day. Different tree species need different amounts of light to thrive. This information will help you choose the best tree species for your barrier in Guide #4. Look for things like buildings and other trees that may cast shade on your future vegetation barrier.

Planting area

Trees need space for their roots to spread out. Trees in vegetation barriers need plenty of high-quality soil so they can grow to their fullest potential. In addition, for a vegetation barrier to be most effective it should be about 30 feet wide and be longer than the area it is trying to protect; an extra 162 feet long is ideal. Measure the length of the planting area parallel to the road or other air pollution source. Measure the width of the planting area perpendicular to the air pollution source.

Utility lines

Trees may be short when we plant them, but as they grow we don't want their branches to get tangled in overhead wires. Be sure to look up and check for overhead wires above your planting area.

Below-ground infrastructure

It's important to make sure there aren't any buried utilities like sewer pipes or gas lines underneath or near your planting site. Knowing the location of underground utilities will help prevent them from being damaged during the planting process. Plus, if those buried utilities need repair work in the future, your vegetation barrier might be removed or damaged.

In Chicago, you can avoid this situation by calling 811 or 312-744-7000 to request that utility companies come and mark the location of underground infrastructure on your property. This marking service will be completed within 48 hours of placing the request. Outside of Chicago you can call JULIE or 800-892-0123. Outside of Illinois, use USIC (U.S. Infrastructure Company, www.usicllc.com) at 317-575-7800.

Sidewalks and roads

When trees are planted in planting pits or strips between sidewalks and roads, their roots will eventually try to grow underneath the pavement to find more water and nutrients. Over time this can cause pavement to be lifted out of place or crack. Since the vegetation barrier needs medium to large trees, it is best to make sure there will be at least 10 feet of space between the trunk of the tree and any sidewalks, roads, or parking lots to minimize potential impacts to pavement. Other shrubs and plants you add to your vegetation barrier can be closer to the pavement without worrying about damage.

In the summer, hard surfaces like roads, parking lots, buildings, and sound barriers (hardscape) can increase local temperatures. This can harm trees if they don't have enough water in the soil.

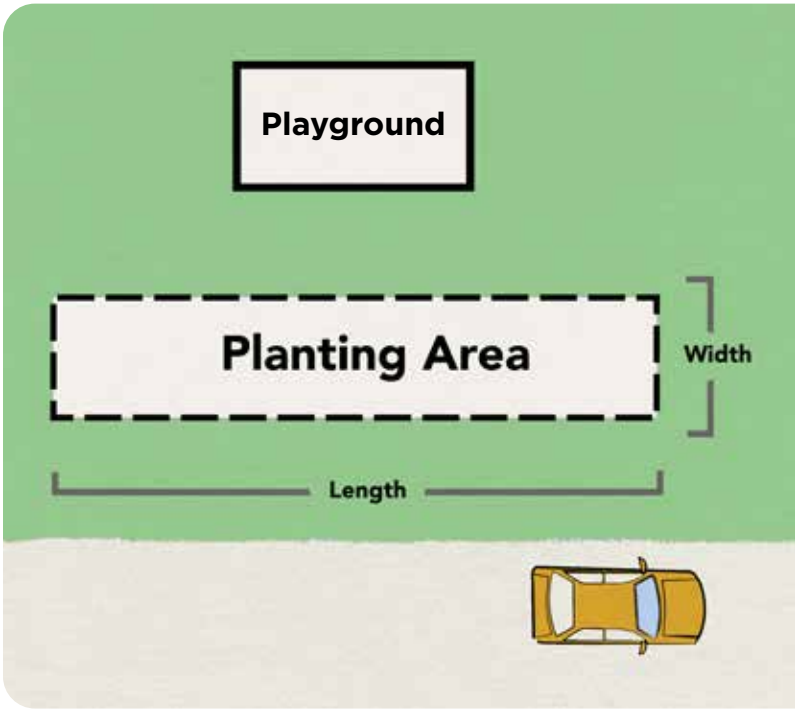
Trees planted near roads and sidewalks can also be damaged by road salts in the winter in places where it snows. This is especially bad when salty water from the road or sidewalk flows into the soil where the trees are growing.

The planting area should also not be located within the clear zone of a highway — an area where trees cannot be planted in order to maintain a safe driving environment. Clear zones are generally about 30 feet wide, although this distance can vary by location, and you should check with your local highway agency to confirm the clear zone location. You should also check to make sure that when trees are fully grown they will not prevent drivers from being able to see signs or see around a curve or corner. Most towns and cities have rules about the distance between plants, roads, and signs for safety.

Hills and low areas

The height of your planting area compared to the rest of the property can affect how wet or dry the soil around the vegetation barrier will get. The soil on top of hills or sloped ground tends to get pretty dry while the soil in depressions or low-lying areas tends to get very wet. Tree species that make good vegetation barriers in the Chicago region don't like soil that stays wet for a long time.

Record your measurements and observations about the potential vegetation barrier planting area in Field Sheet #2, and use that information to answer the related questions. If the answer to any of the questions is "Yes," then this location is likely not a good spot for a vegetation barrier; further investigation and consultation with a professional landscape architect or engineer may be needed. The Additional Resources section can direct you to other practices that can help improve local air quality.



Cited sources
1. Baldauf, R. Recommendations for Constructing Roadside Vegetation Barriers to Improve Near-Road Air Quality. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-16/072, 2016. https://cfpub.epa.gov/si/si_public_record_report.

GUIDE #3

Getting Landowner Permission and Permits

Once you've identified the best location for the vegetation barrier, you need to find out who owns that property and determine how to get permission to plant on it. In some cases, such as highway property, your organization may not be the group that actually plants the vegetation barrier, but you will play an important role in planning and championing the project.

Potential landowners:

- Board of education
- County, city, or town
- Parks department
- State department of transportation
- Federal Highway Administration

When asking for permission to plant a vegetation barrier, be prepared to answer the following questions:

- What is a vegetation barrier?
- Where exactly will the barrier go?
- How big will the barrier be and how many trees will be planted?
- How will this project be paid for?
- Who will plant and then maintain the barrier?
- Could this project create new problems such as limited visibility?

GUIDE #4

Choosing a Planting Design

Several different designs for vegetation barriers can reduce air pollution. The design you choose will be influenced by your amount of planting space, available species, and budget. It often takes a few tries to choose the best landscape design. It is OK to choose a design now and then adjust it later as your project develops.

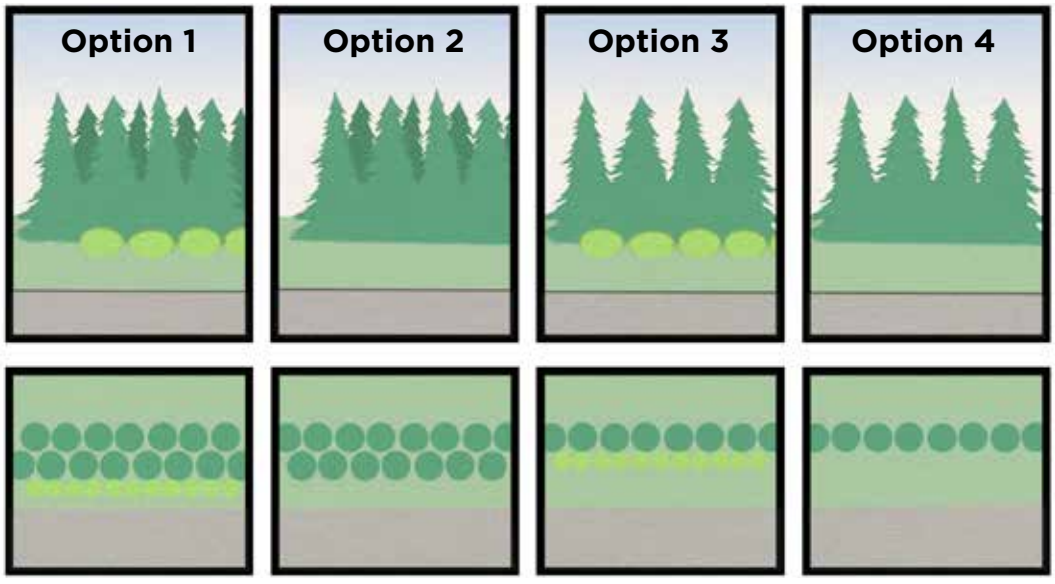
An ideal vegetation barrier should be about 32 feet wide, about 162 feet longer than the area you want to protect, and grow to at least 16 feet tall.[1] Such a barrier could be made of three rows of plants. Two rows are made of trees or shrubs that can grow at least 16 feet tall (although taller is better). A third row is made of shorter shrubs that will block any gaps that form between the ground and the lowest branches of the trees. The plants in each row should be staggered from each other to limit the formation of gaps between plants.

If you have less than 32 feet of planting width, other design options include using two rows of trees without shrubs, a single row of trees and a row of shrubs, or just a single row of trees or tall shrubs to form a hedge. Keep in mind that the wider the barrier, the better it can improve air quality.

Vegetation barriers can also be planted behind noise barrier walls or solid fences to help improve air quality as well. Noise barriers alone are able to improve air quality, but a combined solid structure barrier (such as a noise barrier) with a vegetation barrier may provide the most benefits for the reduction of near-road air pollutants such as particulate matter. In this situation, the plants need to grow taller than the noise barrier to provide additional benefits.[1]

Use the measurements of your planting area from Guide #2 to determine which option will fit in your site.

	Yes...	No...
Is your planting area at least 32 feet wide?	Option 1	Option 2, 3, or 4



The planting area should be a long rectangular shape and extend beyond the area you want to protect from ground-level air pollution. Measure planting area length parallel to the road and width perpendicular to the road.

Cited sources

1. U.S. Environmental Protection Agency, 2016. Near-Source Air Pollution Research. http://www.epa.gov/air-research/near-source-air-pollution-research. Accessed on 28 Jun 2021.

GUIDE #5

Get to Know Your Soil

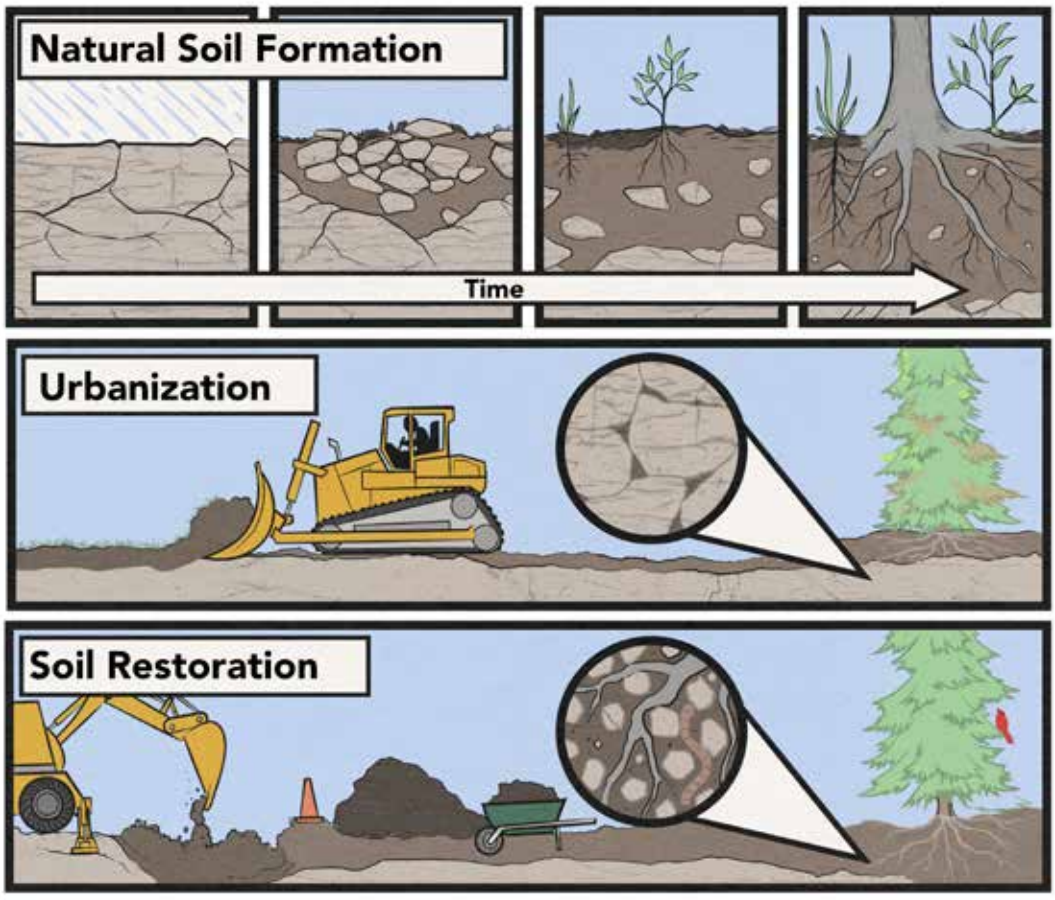
If you want to grow healthy trees and plants, you need healthy soil. Trees and other plants get water and essential nutrients from soil and rely on soil to hold them in place. This guide provides background about soil and helps you check for several common soil problems that can be found near roadways and other places affected by construction. Use Field Guide #5 to record your observations about the planting area soil.

Background: Healthy trees need healthy soil

Healthy and happy trees start with healthy soil. Soil is a collection of tiny rock and mineral particles, organic matter, water, and air. Soils are unique: They vary from place to place, and they are constantly changing over time. Soil is fundamental for the growth of plants on land. It helps store and filter water, breaks down dead materials and wastes so their nutrients can be reused, and is a home for many creatures. Ideally soil is about 5% organic matter (the remains and wastes of plants and animals) and 45% tiny rock fragments. The rest is empty space between the solid pieces that can be filled with the air and water plants and soil critters need to live.

Have you ever wondered where soil comes from? The answer is not a bag from the hardware store. In nature, soil forms slowly over time as weather, plants, animals, and microbes break rocks into smaller and smaller particles and add organic matter. In some parts of the world, it can take 100 years to form an inch of rich, organic topsoil.

Unfortunately, removing or damaging good-quality soil can happen quickly. Construction activities usually remove topsoil — an upper layer of soil that can be rich in nutrients and good for plant growth.



Soil forms from bare rock over very long periods of time with the help of microbes, insects, fungi, plants, and animals. Construction severely changes soil by removing topsoil rich in organic matter and compacting the soil. Soil restoration can improve the condition of soil after construction so it is more suitable for growing trees and other plants.

Soils are also damaged when vehicles or heavy materials pack down or compress the soil, a process called compaction. With some soils, people simply walking the same path over and over can compact them. Compaction pushes the solid parts of the soil close together and destroys the empty spaces that hold air and water. After compaction, the soil can't hold or move as much air and water, making it difficult for plant roots, microbes, and other soil residents to live there. Sometimes the soil becomes so tough that it is impossible for roots to push their way through it.

Compacted soil conditions are not nurturing environments for trees and other plants. Over time this stress can stunt growth and potentially kill a tree because it can't get enough water, air, and nutrients from the soil. Ideally, we prevent soils from being damaged from compaction during construction. But when we do encounter poor-quality compacted soils in places where we want to put trees and other plants, there are ways to help improve the condition of the soil. Taking the time to help restore soil that has been damaged will create a better growing environment for your new plants so they can survive and thrive in their new home.

Soil Test #1 – Soil profile assessment and drainage

Soil profile assessment: *About 10 minutes per hole*
Soil drainage: *About 15 minutes to set up each hole; wait times could range from 30 minutes to several hours. These two tests can be done together.*

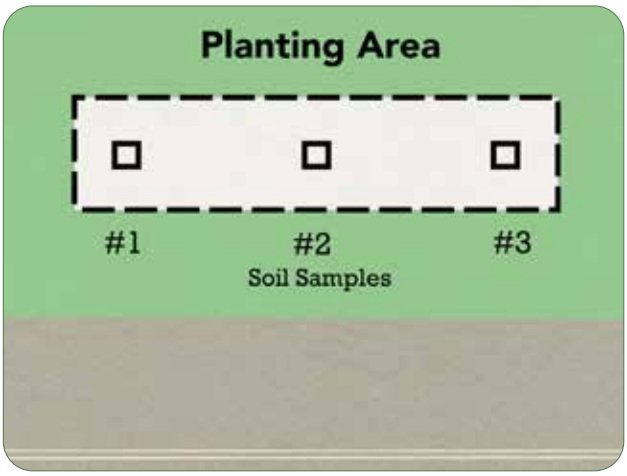
The characteristics of soil change the deeper you dig. When you dig a hole, you might notice different layers of soil, much like a layer cake. This is called the soil profile. These changes can be gradual and hard to detect or abrupt and drastic. If your soil has very distinct boundaries between layers, restrictions in water flow and root penetration may be an issue.

Soil water is a lot like Goldilocks and the Three Bears: Most trees, including the ones that make good vegetation barriers, don't want too much or too little water in the soil. They need soil water to be just right.

Soil drainage tells us how slowly or how quickly water moves out of the soil. A soil that drains slowly stays very wet for days after it rains (think puddles and mud). For many tree species, this means there is too much water around their roots and not enough air. A soil that drains very quickly will be dry again soon after it rains. This can be a problem for many tree species because there will not be enough water for the tree roots, especially during the hot, dry spells of Chicago's summers. This will be even more of a problem as climate change affects the frequency and severity of droughts in the Chicago region.

The soil profile on the left came from a forest soil while the profile on the right came from an area affected by construction. Notice the distinct layers in the profile on the right that can affect how water moves through soil and how plant roots can grow. (Image credit: Bryant Scharenbroch)

To learn about your planting area's soil profile and drainage, you'll dig three holes — one in the middle of your planting area and one at each end. These will become your three sample locations. First, you'll dig a small, narrow hole to look at the soil profile. Then you can make the hole bigger for the drainage test.



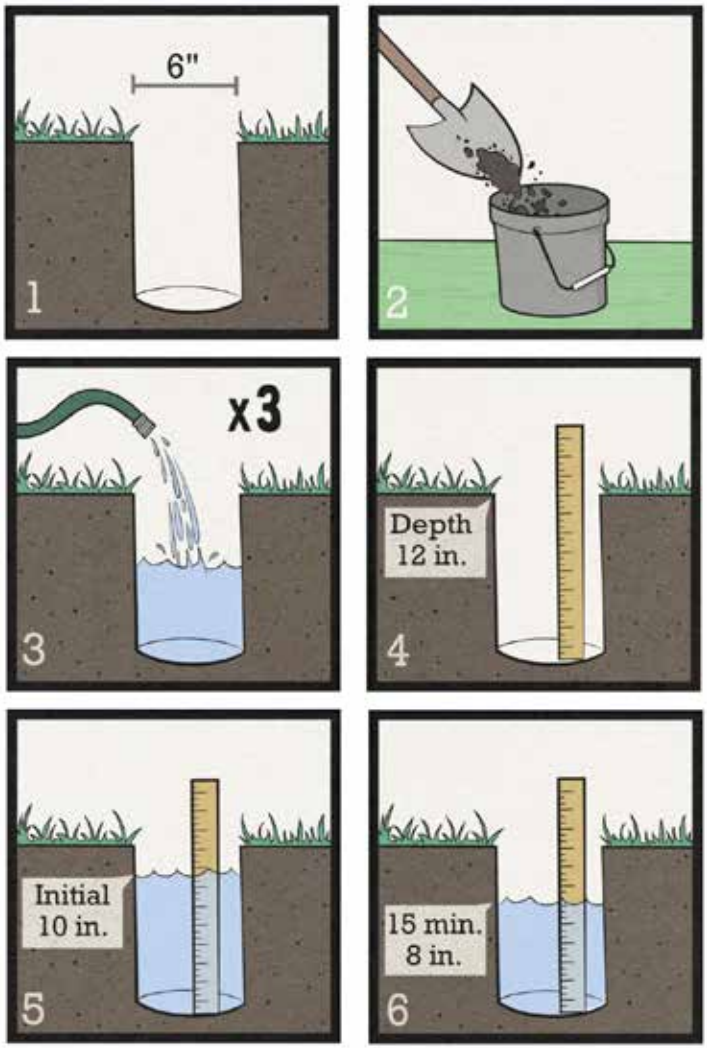
Choose three locations from the middle and both ends of your planting area to collect soil samples.

Note: *It can be tricky to find the best day to work with soil. If it rained recently, the soil might be too muddy and difficult to work with. If it has not rained lately and the soil has become extremely dry, it can require a lot of effort to get your shovel into the ground. If you need to work with soil that is very dry, consider pouring a large bucket of water on the area where you will be working. Wait a few hours and then try digging.*

To look at the soil profile,

1. Use a round-bottom shovel to remove an intact chunk of soil. Dig straight down to the full depth of the blade, then remove the shovel.
2. Rotate the shovel 180 degrees and do the same 2-3 inches from the first slice. This should allow a slice of soil to be removed as shown in Figure: Soil profile. This is a great way to examine the top 6-12 inches of the soil profile. Record your observations in Field Sheet #5.

Use the following steps to measure how slowly or how quickly water drains in your planting area. Record your observations in Field Sheet #5.



1) Begin your drainage test by digging a hole about 6 inches wide and 12 inches deep. Save that soil for other soil tests. 2) Fill the hole with water, then let it drain three times to get the soil completely wet. 3) Use a ruler to measure the depth of the hole. 4) Fill the hole with water and measure the starting depth. 5) Wait 15 minutes, then measure the water depth again. Record your measurements in Field Sheet #5.

1. At each sample location, dig a hole about 12 inches deep and at least 6 inches wide. You can dig your hole with a shovel, hand trowel, or a bulb-planting tool.

   a. Save some of the soil you remove from the hole for the next test. When you are digging each hole, save about a cup of soil from near the bottom of each hole and put that in a spare bucket or other container. You'll use that for the next two tests.

2. Fill the hole with water to thoroughly wet surrounding soil and wait for that water to completely drain out of the hole. Repeat twice. This may take a while, depending on your soil.
3. Use a ruler to measure the depth of your hole. You may find it helpful to place a clipboard on the ground next to the hole to serve as a reference level for your ruler. Record the number under the depth of hole column in Field Sheet #5. This number will help you reposition your ruler when you take measurements in the following steps. One person may need to hold the ruler in place because it may float when you add more water.
4. Fill the entire hole with water and write down the height of water in the initial water height column in the table below.
5. Wait 15 minutes and measure the height of the water again. Make sure the ruler is touching the bottom of the hole and matches your original depth measurement. Add the water height measurement to the 15-min. water height section of the table.

Poor drainage – less than 4 inches per hour
Moderate drainage – 4 to 8 inches per hour
Excessive drainage – more than 8 inches per hour

Soil samples

Mix the soil that you dug out of the drainage test holes into a single bucket. Remove any large objects like stones or plant roots. You will use this soil to measure soil texture, pH, and organic matter. You can either send your soil to a soil-testing lab or do the tests yourself, following the instructions for Soil Tests #3–#4. The advantage to sending your soil to a testing lab is that you can feel confident in the accuracy of the results, although this may cost $30 to $60 plus shipping, depending on the tests you request.

If you do choose to send your soil sample to a professional laboratory, we recommend requesting the following tests, at a minimum:

- pH
- Organic matter

Other soil information that would be nice, but not necessary, includes nutrients such as phosphorus, potassium, calcium, and magnesium, as well as cation exchange capacity (CEC). These are often offered in a single soil-test package.

The University of Illinois maintains a list of regional testing labs. Each lab has its own instructions about preparing the soil for shipping (https://web.extension.illinois.edu/soiltest/).

Soil Test #2 – Soil texture

Approximately 10–15 minutes if your soil sample was already collected

Soil consists mainly of tiny rock fragments — soil particles. Soil particles come in three sizes: sand (large, gritty), silt (medium, floury), and clay (very small, sticky). The relative amount of sand, silt, and clay together defines the soil texture. Soil texture affects how well water moves through the soil and how well the soil holds onto nutrients, as well as other properties. Information about soil texture can help you make decisions about choosing vegetation barrier species later on.

While there are many ways to see what kind of texture your soil has, the simplest method is called hand-texturing, or the texture-by-feel method. To use the hand-texturing method, you will need a handful of soil and some water. The soil sample should be wet enough so that it feels like play dough. Using this soil, follow the flow chart instructions at the end of this guide.

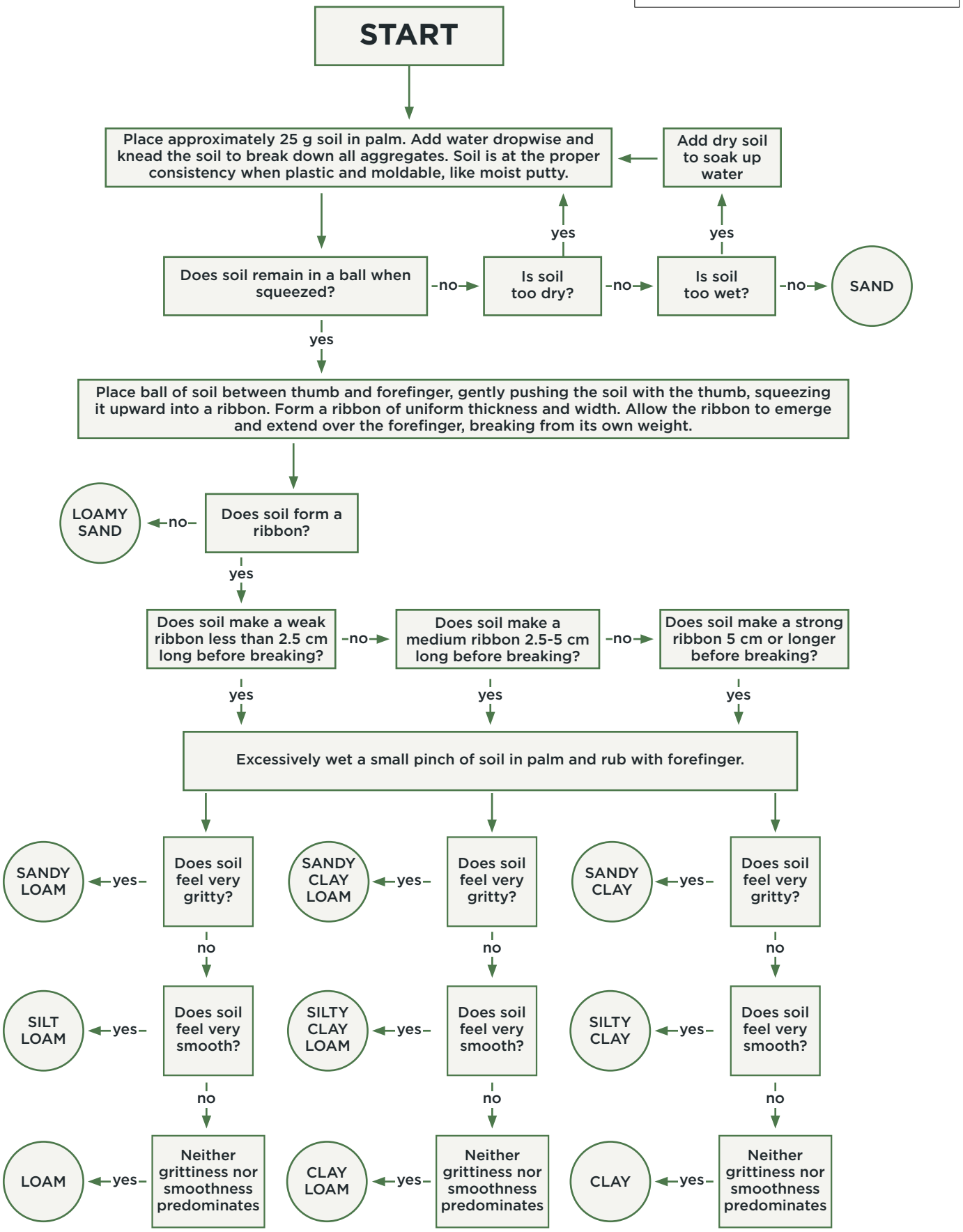
This instructional video demonstrates how to use the chart and method: https://youtube/lOyaBxj767s

This instructional video shows what each step in the flow chart looks like: https://youtube/GWZwbVJCNec.

Record your soil texture in Field Sheet #5.

Soil Texture Flow Chart

Credit: Natural Resources Conservation Service, "Guide to Texture by Feel."



Soil Test #3 – Organic matter

Approximately 10–15 minutes if the soil sample has already been collected

Organic matter is a sponge-like material in the soil that used to be part of a living thing. This includes things such as dead leaves, animal and insect waste, bacteria, fungi, and much more. Organic matter is an important part of the soil's recycling system and can supply living things with important nutrients so they can grow. Organic matter also makes soil a little lighter and fluffier (lower bulk density), which makes it easier for plants and other living things to thrive there. Organic matter also helps water stay in soil longer so it doesn't completely dry out between rainy days.

The best soils for growing trees are made of about 4%-6% organic matter. Soil organic matter can be measured in many ways. For soils in Illinois, one easy way to estimate organic matter is by looking at the color of the soil. Darker-colored soils typically have more organic matter.

Hold a moist piece of soil in the sunlight and next to the soil color chart to estimate how much organic material is in the soil sample. (Image Credit: NRCS "Soil Color")

To estimate your planting area's soil organic matter, take a small handful of your soil sample and get it wet so it feels damp like a kitchen sponge. A squirt bottle can be helpful for this. Hold the wet soil in the sunlight and then match it to the closest color in the chart in Field Sheet #5.

Soil color	Munsell soil value	Organic matter (%)
	<2	>10
	3	5-10
	4	3-4
	5	1-2
	>5	<1

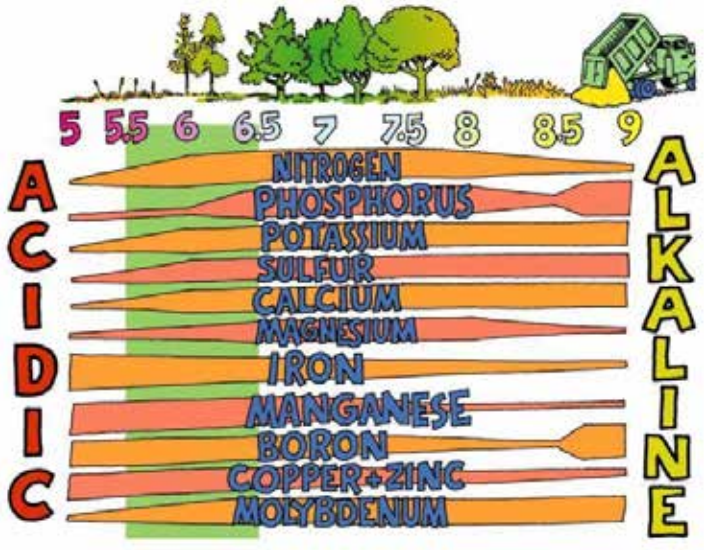
Simplified soil color chart for estimating organic matter content of soils from Illinois. (Credit: Bryant Scharenbroch)

Soil Test #4 – pH

Approximately 10–15 minutes if soil sample has already been collected, depending on the brand of soil test

Soils vary in pH: Some are more acidic, some are neutral, and others are basic. Some tree species are very picky about pH because it affects how easily they can get nutrients out of the soil.

One way to measure soil pH is by using an inexpensive at-home gardening or lawn test kit, which can be found at local hardware stores or online. Generally, these kits work by mixing some of your soil sample with water in a tube or cup, and then adding a powder or liquid that causes your mixture to turn a different color. That color then tells you the soil's pH. Probe-type soil pH meters produce less reliable results. After following your test kit's instructions, record pH in Field Sheet #5.



Soil pH tells us how acidic or basic a soil is and affects how easily plants can absorb nutrients such as potassium (K) from the soil. (Image credit: International Society of Arboriculture)

Soil Test #5 – Soil compaction

Approximately 5 minutes per sample location

Compacted soil is very dense and tough; it may even feel a little like a rock when it is very dry. When soil is severely compacted by vehicle or foot traffic, it is difficult for plant roots to penetrate it to access water, nutrients, and air. Good planting soil is less dense and feels crumbly, like cake or cookie crumbs.

The simplest way to see if your planting-area soil is too compacted is to use a wire, such as a metal coat hanger that you've bent apart using pliers and wire cutters as needed, or a soil probe (available for loan from The Morton Arboretum Education Department). If using the wire approach, take about 15 to 20 inches of your wire and use about 4 inches of it to make a looped handle. When the soil is neither very wet (puddles or muddy) nor very dry (almost dusty) follow these steps at your three sample locations.

1. Hold the wire by the loop or the soil probe by the handle.
2. Attempt to push the wire or probe into the soil using only slight pressure.
   – If you get struck trying to push the wire probe and you hear a scraping or scratching noise, you may have hit a rock. Pull the wire out and try again at a different location. If you noticed a lot of gravel in your soil drainage and profile tests, then it may not be possible to accurately do the compaction test.
3. Record the depth of penetration in Field Sheet #5.
4. Repeat at two other sampling locations.

Test if your soil is compacted by 1) making a wire probe about 12 inches long, 2) pushing the probe into the soil as far as it can go, and 3) measure the depth you were able to push the probe into the soil. Record your measurements on Field Sheet #5.

If any of your soil compaction test results were severe or moderate, your planting area will likely benefit from the soil restoration process described in Guide #8. If you encountered too much gravel or rock in the soil to complete the compaction test, use information from other soil tests to determine if your planting area would benefit from soil restoration.

GUIDE #6

Choosing the Right Trees for Your Site

There are tens of thousands of tree species in the world, each adapted to live in a specific habitat with different conditions. Some trees like to live in places with a lot of sunshine, others prefer very little sun. Many trees cannot survive in places that are flooded for most of the year, but some species are well-adapted to waterlogged soils.

The recommendations in this guide have been tailored to the Chicago metropolitan region located in U.S. Department of Agriculture (USDA) Hardiness Zones 5 and 6. If you're planting a vegetation barrier in another part of the United States, consider reaching out to your local cooperative extension office or state urban forester for species recommendations or see this toolkit's Additional Resources section.

The list of tree species in this guide has narrowed down the hundreds of trees that can grow in the Chicago region to just a few species that would be ideal for a vegetation barrier. These species have several key characteristics:

- Tolerant of Chicago winters (hardiness zones 5 or 6, where typical winter temperatures can range from -20° to 0°F)
- Evergreen needles stay on their branches all year long. This means these trees can help reduce air pollution year-round, not just in the spring, summer, and fall, like deciduous trees.
- Moderately tolerant of soil conditions that you are likely to encounter around Chicago
- Moderately tolerant of deicing salts that get blown onto their needles, though less tolerant of high levels of deicing salt in the soil
- Moderate growth rates that help your barrier reach a functional size sooner
- Minimum mature height of 16 feet
- Low pollen and biogenic volatile organic compound (bVOCs) production. Tree pollen can cause allergies for some people while tree-produced bVOCs can also contribute to air pollution. bVOCs can react with air pollutants from other sources, such as vehicles powered by fossil fuels.

In some cases, there may not be any evergreen species that are appropriate for a particular vegetation barrier project's planting conditions. We've included a list of deciduous species, which lose their leaves in the winter but have characteristics such as hairy leaves, which can also make effective vegetation barriers. The only drawback is they will offer fewer benefits in the winter. Deciduous species may also need more pruning to grow a strong structure.

Some of the species on the following list are not naturally occurring in Illinois or North America but have characteristics that make them well-suited for a vegetation barrier. It is important to plant tree species that are native to Illinois in other locations with more favorable growing conditions because these species benefit wildlife such as birds and insects found in Illinois. Planting native flowers and shrubs near your vegetation barrier is a great way to provide food and habitat to beneficial insects while your barrier's trees help to improve air quality.

Tree species selection

First, use your observations from Field Sheets #2 and #3 to answer the first set of questions in Field Sheet #6 and identify any species that should definitely not be used in your barrier. Next, use information on Field Sheets #2 and #3 to further narrow your species options based on the "Best Conditions" column in the Species Options Table in Field Sheet #6. You might also adjust your species list based on the availability of species in your local nurseries. The Additional Plants to Complement Vegetation Barriers section provides a list of shorter shrub species you can choose from if your vegetation barrier will have a row of shrubs.

Here are four evergreen tree species that are well suited to be planted in vegetation barriers in the Chicago region. See the Preferred Evergreen Tree Species Options section at the back of this guide for additional options.

Norway spruce

Black Hills spruce

Chinese juniper *by University of Michigan School of Environment and Sustainability, Creative Commons Attribution 2.0 Generic (CC BY 2.0) via flickr.com*

Eastern red cedar *by CIAT, Creative Commons Attribution-NonCommercial-ShareAlike 2.0 Generic (CC BY-NC-SA 2.0) via flickr.com*

You may find it simpler to design a barrier where each row is made of the same species so all of your trees can be the same distance apart. If you want to put different species in the same row, try to choose species that will be similarly sized at maturity. In other situations, planting many types of tree species is a good thing. For vegetation barriers, limiting the number of species can help grow a more uniform green wall for improving air quality.

If you'd also like to include shorter shrubs and flowering plants around your vegetation barrier, Appendix – Shrub and Flower Selection provides a guide for choosing additional plants for your site.

Tree quantity

Different tree species have different heights and widths when they grow to maturity. It is important to plant the vegetation barrier trees at the correct distance from each other. This way there will be no space between the trees' branches that could let air pollution through. At the same time, it prevents trees from being too close and crowded together.

Once you've selected your species, determine how many trees your site will need by finding the spacing of your chosen species in the Evergreen or Deciduous Tables. Add this information to the Tree Quantity Calculation Table in Field Guide #6. Then take the vegetation barrier length from Field Sheet #2 and divide it by spacing. Then multiply that number by the number of rows to determine the quantity of trees your barrier will need.

GUIDE #7

Choosing Nursery Trees

Nurseries grow and sell trees several ways. Trees can be purchased as bare root with no soil, in a container, or as a loose ball of soil wrapped in burlap and a wire basket (balled-and-burlapped or B&B). Each type has advantages and disadvantages.

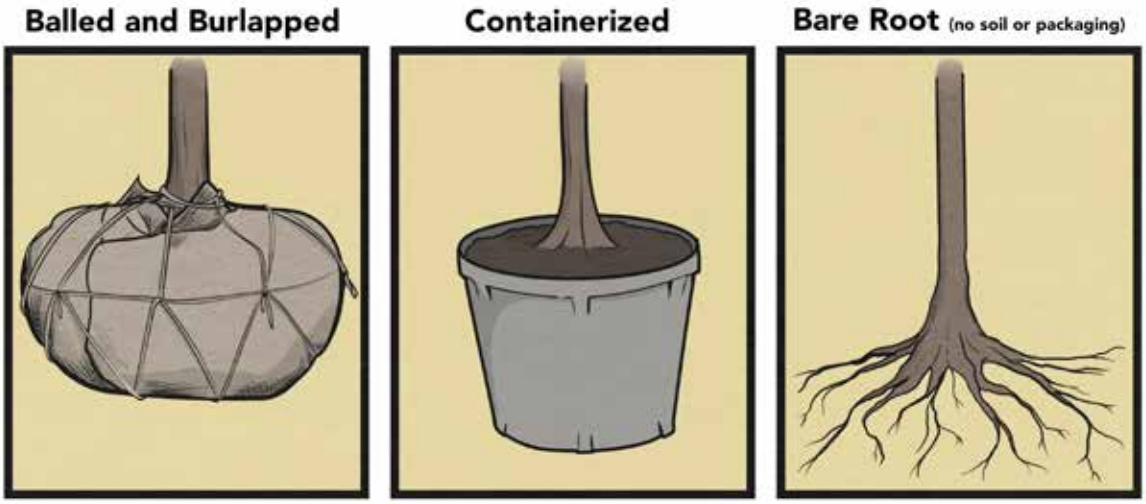
We recommend purchasing container-grown trees because they can be purchased in smaller sizes and consequently will be less expensive and easier to transport. The instructions in the toolkit guides assume this is the type of tree you'll use at your planting site. If you choose to select bare root or balled-and-burlapped trees, you can contact The Morton Arboretum's Plant Clinic to learn more about how to plant these trees (Additional Resources).

Trees can also be purchased in many sizes. One challenge of planting any size tree is that it needs time to grow its roots into the soil of its new home. This is called the establishment period. Until the roots are established and spread out, the tree usually needs to be irrigated because its small root system can't access enough water. There are advantages and disadvantages to purchasing large and small trees.

For a vegetation barrier project, we recommend purchasing trees between 4 and 6 feet tall. Avoid:

- Smaller than 4 feet tall in the nursery because these will take more time to reach maturity.
- Larger than 6 feet tall, unless you'll be working with professionals or you have equipment to easily move large, heavy trees around a site.

Bring Field Sheet #8 to the nursery with you to help you choose the best-quality trees for your vegetation barrier. Purchasing good-quality healthy trees will get your project off to a good start. See the Additional Resources section for more information about choosing nursery trees.



Trees can be purchased from nurseries or garden centers wrapped in burlap and a wire basket (balled-and-burlapped), growing in a container (e.g,. pot or bag), or bare root without any soil.

Small trees from nursery	Large trees from nursery
Advantages: • Shorter establishment time • Less expensive Disadvantages: • May take longer to grow into a mature vegetation barrier	Advantages: • May take less time to grow into a mature vegetation barrier Disadvantages: • Longer establishment time • More expensive

Check the tree above ground

✓ Tree is not much larger or smaller than pot

✓ Fairly straight and central leader (single main trunk)

✗ Avoid brown spots

✗ Avoid roots wrapping around the trunk

Trees should have one dominant, upright branch called a central leader. This will help the tree grow into a good shape.

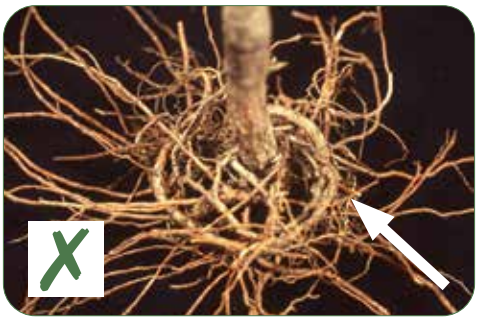
Avoid purchasing trees with discolored needles or leaves.

Roots should be growing away from the tree or shrub trunk like spokes of a tire. Roots should not be wrapping or circling around the trunk because this will cause problems in the future.

Check the tree roots

✓ If you move away some soil, roots near the soil surface spread out like spokes of a wheel from the trunk

✗ Avoid excessive circling roots. (Instructions for handling smaller circling roots in container-grown trees can be found in Guide #10.)



Trees grown in containers can have large wood roots that wrap around the perimeter of the container in any direction. If these circling roots are not removed before planting, they will stay in place and can eventually choke the tree as it grows. (Photo credit: Gary Watson)

GUIDE #8

Improving Soil Conditions

Your soil testing results from Guide #3 can help you determine if your soil needs to be improved before planting trees. Construction activities change the condition of soil and make it difficult for plants to grow. Such soils are usually compacted and have very little organic matter. These conditions can go unnoticed for a long time and can seriously reduce the health of trees.

If your planting site is moderately compacted and/or has low organic matter, your trees will thank you if you decompact the soil and add an organic amendment before you plant. Research has shown that using decompaction and organic amendments together can greatly improve tree survival and growth in places with poor quality soil.[1, 2, 3]

If you answered "Yes" to question #1 or #2, your soil is severely compacted or may have a buried layer of debris that may restrict root growth and water movement. In this case, your planting area will benefit from the assistance of landscaping or tree-care professionals to improve the soil before planting. See the Additional Resources section to learn more about restoring severely compacted soil.

If you answered "Yes" to questions #3 or #4, your soil may also benefit from a surface decompaction process that is not as intensive as the process needed for severely compacted soils. In these situations, good site preparation can make the difference between a new tree just staying alive and a new tree thriving and growing to its fullest potential. The rest of this guide and Field Sheet #8 provide instructions for surface decompaction with common gardening tools, although this process can also be performed by landscaping professionals using mechanical equipment.

If you answer "No" to all of the questions, you can skip the rest of this section and move on to the next guide.

	Yes	No
1. Did your wire probe penetrate less than 4 inches into the soil? (severely compacted)		
2. When looking at the soil profile, was there a buried layer of hard, compacted materials or construction debris?		
3. Did your wire probe penetrate between 4 and 12 inches into the soil? (moderately compacted)		
4. Does your soil have less than 5% organic matter?		

Restoring soil with surface decompaction overview

The decompaction process takes soil that was stuck together in one giant chunk and breaks it into smaller pieces, called aggregates. Mixing an organic amendment in between these smaller pieces helps to prevent the small pieces from collapsing and reforming into one massive solid layer again.

Plants grow better in soil that forms small clumps called aggregates. Construction activities often cause aggregates to break apart but soil restoration can improve the structure of the soil.

The many methods for decompacting soil involve different types of equipment and varying amounts of effort. Below, we provide instructions for decompacting on a budget using people power and/or a garden tiller. If you are able to access a backhoe or tractor with a ripping attachment, the restoring soil websites in the Additional Resources section provide instructions for using those tools.

Sourcing organic amendments

Soil organic amendments are any materials made from once-living things such as compost. When decompacting soil, organic amendments should do two things: 1) make the soil lighter or fluffier (having a lower bulk density), and 2) add nutrients to the soil. These are good not only for plants but also for all the other living things in the soil. When added to mineral soils, organic matter also acts like a sponge to help retain water.

There are many types of organic amendments. For this type of project it is important to use material that has enough nutrients, is not too acidic or too basic, and has a low amount of salt and other potentially harmful elements. We strongly recommend the following types of materials for your project:

- Exceptional Quality (EQ) Compost
- Compost made from vegetation waste

EQ Compost is a product created by the Chicago Metropolitan Wastewater Reclamation District (MWRD) that composts plant wastes such as grass clippings and dead leaves with treated sewage sludge. The final product is good for soil restoration and meets rigorous safety standards. And this product is available free to schools, nonprofit organizations, and residents in the Chicago region. You can learn more about EQ Compost and order it here: https://mwrd.org/eq-compost.

Vegetation-waste compost (also called municipal compost) can be obtained from county and municipal sources or landscaping material providers. Make sure your compost product has the characteristics listed below. You can request this type of information from a compost supplier to make sure the product will be beneficial for your vegetation barrier.

- Mature compost (assessed based on respiration levels)
- Moisture content between 40% and 50%
- Organic matter content (based on loss on ignition test) at least 30%
- Carbon-to-nitrogen ratio should be between 10:1 and 25:1.
- Soluble salts (of a saturated paste) less than 4 mS/cm.

Organic amendment quantity

Landscaping materials are generally sold by volume, usually in units of cubic yards. One cubic yard is approximately 40 5-gallon buckets.

Use your measurements of the planting area and the formula below to calculate how much EQ Compost or other organic amendment you should order using Field Guide #8. This calculation assumes you'll spread a 4-inch layer of amendment over your planting area before mixing it into the soil.

Surface decompaction by hand

Preparation

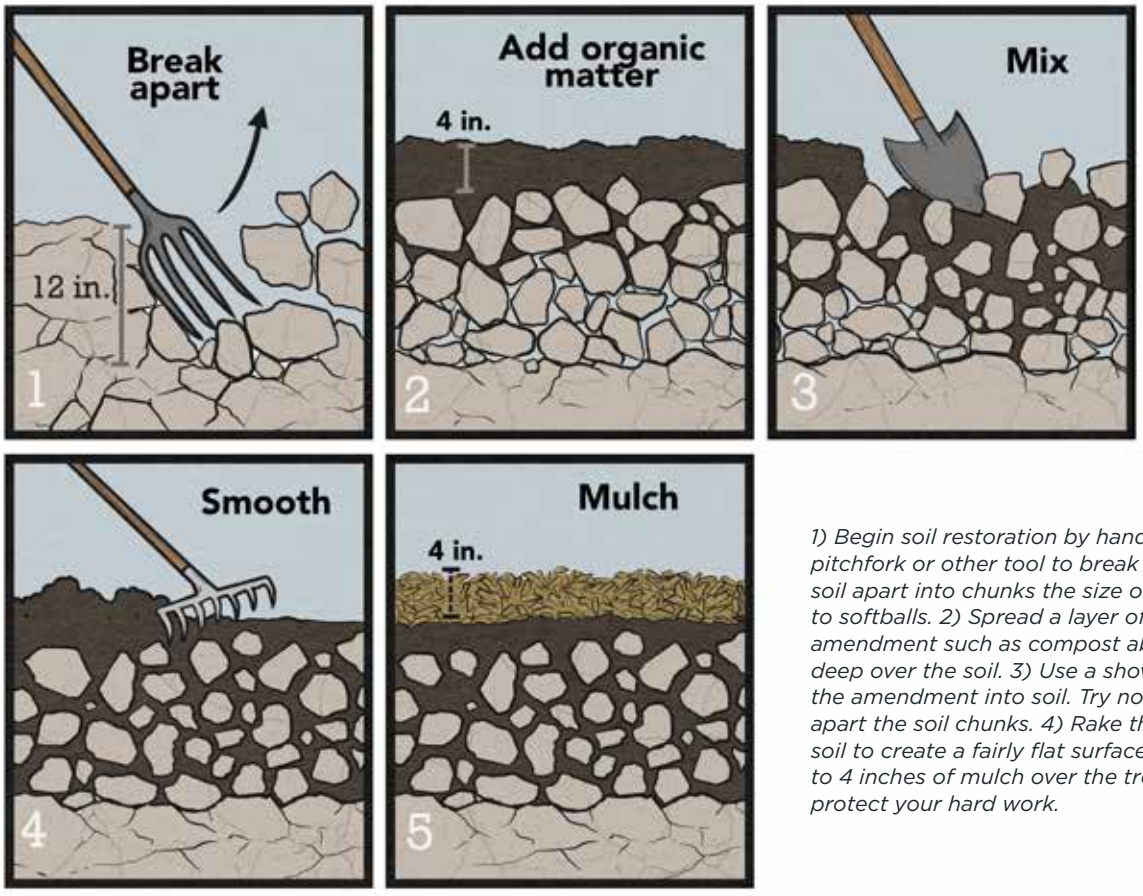
- Confirm that there are no underground utilities in your planting area (see Guide #2) before you start digging.
- Use stakes, traffic cones, or other objects to mark the area that needs to be treated.
- Call your friends! Decompaction by hand is a lot of physical work, so the more people, the merrier. Make sure you have enough shovels and forks for everyone.
- Planning events around weather is tricky. To get the best results, DO NOT attempt to decompact the soil when it is very muddy (if soil is sticking to your shoes when you walk on it). But if the soil is too dry (almost dusty), it will be difficult to dig.
- If this is your first time using this technique, try a practice section before the event to make sure you have a process that is good for your site and the right equipment.

Process

Step 1: Turn the soil. Start by pushing a spading fork as deep as you can into the soil. Then move it back and forth to loosen the soil a little bit. Then push on the fork to pry pieces of the soil apart. This should pop large chunks of soil out of the ground. Step backward and repeat until you have a large area of loosened soil.

- Note: You may find using a shovel easier or more effective for this process. Try different tools to see what works best for your soil.
- A rototiller could also be used for this process, but take care not to grind the soil too finely. A variety of large aggregates between the size of a golf ball or softball are good to maintain within the top few inches of finished soil, so do not break these mega-aggregates.
- This step will start to restore air pockets into the soil so that water can move through the soil and it will be easier for roots as well as soil critters to grow.
- If grass is covering your planting area, you can 1) remove the sod to be used in a different location using a sod cutter, or 2) bury the grass as you are turning the soil.

Step 2: Add the compost. Next, spread your organic amendment about 4 inches deep over the surface of the turned soil. It doesn't need to be perfect since you'll be mixing it into the soil.



1) Begin soil restoration by hand by using a pitchfork or other tool to break compacted soil apart into chunks the size of golf balls to softballs. 2) Spread a layer of an organic amendment such as compost about 4 inches deep over the soil. 3) Use a shovel to mix the amendment into soil. Try not to break apart the soil chunks. 4) Rake the amended soil to create a fairly flat surface. 5) Add 3 to 4 inches of mulch over the treated soil to protect your hard work.

Step 3: Mix in the compost. Use shovels to mix the compost into the soil that you turned up. You want the compost to fill in the spaces between the larger chunks of soil. Do your best to get the compost mixed in at least 12 inches deep.

- This step will help prevent the soil from collapsing back on itself after you've turned it. This will help get more air and water into the soil. In addition, the compost will provide food for soil critters, both big and small, that will continue your work of making healthier soil.
- IMPORTANT: Don't let your hard work of restoring the soil go to waste by driving vehicles or putting other heavy equipment on your planting area. This will just recompact the soil.

Step 4: Level the soil. Use metal rakes to smooth the soil and break up any large lumps so that you have a fairly even surface. No need to aim for perfection, but large soil lumps or holes might be tripping hazards later, and it is easiest to fix that problem now.

Step 5: Spread the wood chips or other mulch material such as straw (Guide #10 – Adding Mulch). Use metal rakes to spread a layer of mulch over the surface of your planting area.

Cited sources

1. Layman, R.M., S.D. Day, D.K. Mitchell, Y. Chen, J.R. Harris, and W.L. Daniels. 2016. Below ground matters: urban soil rehabilitation increases tree canopy and speeds establishment. Urban Forestry and Urban Greening. 16:25-35.
2. McGrath, D., and J. Henry. 2016. Organic amendments decrease bulk density and improve tree establishment and growth in roadside plantings. Urban Forestry and Urban Greening. 20(1):120-127.
3. Oldfield, E.E., A.J. Felson, D.S. Novem Auyeung, T.W. Crowther, N.F. Sonti, T. Harada, D.S. Maynard, N.W. Sokol, M.S. Ashton, R.J. Warren II, R.A. Hallett, and M.A. Bradford. 2015. Growing the urban forest: tree performance in response to biotic and abiotic land management. Restoration Ecology. 23(5):707-718.

GUIDE #9

Tree Transport, Inspection, and Storage

Careful preparation for the movement of trees is critical to ensure that your trees arrive in good condition. If your trees are being delivered by a nursery or landscaper, be prepared to inspect them upon arrival so you can reject and return to the nursery any trees that arrive in poor condition. Record any rejections on official shipping documents.

When your trees arrive at the planting site, if they are not being planted in the next 24 hours, check the potting soil moisture. If the soil seems dry, water the trees. Continue to water daily if the trees have to be stored at your site prior to planting.

These instructions assume you are using container-grown trees. For instructions about bare-root or ball-and-burlap trees, contact The Morton Arboretum Plant Clinic.

Transportation and handling

Proper transportation and handling include the following steps:

- Trees are covered (e.g., with tarps) or are inside a closed vehicle during transport. This prevents the trees from drying out during the drive.
- Trees are handled by carrying the container, not the branches or trunk.
- Trunks are protected during movement to minimize breaking branches or damaging the trunk.
- Container soil moisture is maintained at an adequate level (soil should feel like a damp sponge, not too wet and not too dry).

Inspection at delivery

When the trees are delivered and before the delivery truck leaves, inspect the trees using this checklist:

❏ Leaf size, color, and appearance are appropriate to the time of year and stage of growth

❏ No signs of prolonged moisture stress or overwatering (wilted or dead leaves)

❏ No evidence of dead, diseased, or seriously injured branches

❏ Container soil should be moist throughout

Storing container-grown trees

Ideally, trees should be planted within 36 hours of delivery. When that is not possible, use the following checklist to ensure tree health and quality are maintained:

❏ Check soil moisture daily (and irrigate as required).

❏ Store trees in a partially shady area if possible; this will help reduce the likelihood that they will dry out.

GUIDE #10

Tree Planting

Finally! It is time for the most exciting part of the project: planting your trees in the new home you've carefully prepared for them. Following the instructions in this guide will set your trees up for success.

Most of the steps in this guide benefit the roots of your trees to give them the best possible start in your new vegetation barrier. Roots provide trees with water, nutrients, and stability. They also help the tree stay in place and grow tall. Healthy trees need healthy roots.

When to plant

Spring is a great time to plant trees and shrubs because the long growing season gives roots time to grow into the new soil before winter. Fall can also be a good time to plant, but be sure to plant 6 weeks before the ground is expected to freeze. If you are planting during the summer, you will need to be very diligent with irrigation.

Corrective pruning for roots before planting

Eliminating root defects can greatly improve the establishment and health of trees. Nursery-produced trees can have many root defects, most of which can be fixed. Correcting the deformities at the time of planting is one of the best ways to achieve a successful project.

Remove the tree and its root ball (roots and soil) from its container. Notice if any roots have grown along the container wall so that they almost form a circle around the tree or are pointing downward. These roots are going to keep growing in this circle pattern and could actually choke or girdle the tree as its stem grows bigger. We want to encourage the roots to grow outward from the tree, like the spokes of a wheel, so those roots can find plenty of water and nutrients for the tree. Roots that grow outward from the trunk instead of in a tight circle pattern also help to keep the tree stable.

Circling roots

This might seem drastic, but the best way to help the roots grow in the right direction is to cut off the circling roots. Don't worry, there are plenty of other roots in the middle of the root ball that will start growing in the correct direction.

- Use a sharp saw to trim off the outer $^1/_2$ to 1 inch of soil and roots from the root ball. A pair of bypass pruners can also be used to cut woody roots that are not pointing away from the tree.
- To check for circling roots closer to the trunk, knock off soil from the top of the root ball until you find the place where the first large root and stem are connected. If you find a root that is growing or starting to grow in a circle, use your hand pruners to cut it off. If left alone, eventually that circling root will strangle the trunk and kill the tree.
  - DO NOT hack roots off with a shovel blade. Make clean cuts with pruners or a sharpened saw.

Tree or shrub roots that are growing in a circle, up or down because of the container wall should be removed with bypass pruners or a sharp saw prior to planting. This will encourage new roots to grow outward from the plant instead of continuing to grow in the direction of the container wall. (Photo credit right: Alison O'Connor, Creative Commons Attribution-Noncommercial 3.0 License via bugwood.org)

Planting-hole depth

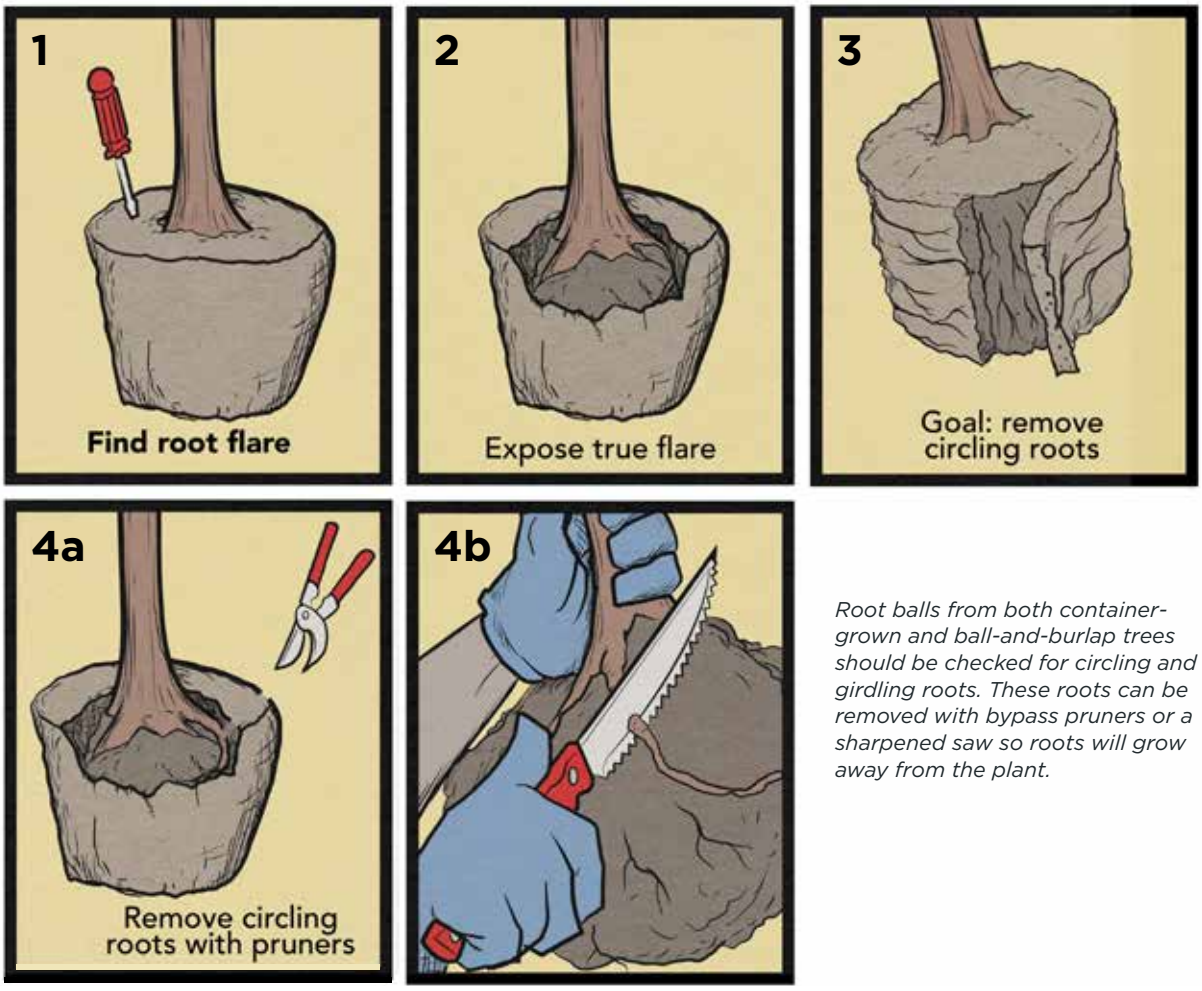
Your tree needs a hole that is not too deep yet not too shallow. Too deep and roots will have trouble getting enough oxygen. Too shallow and the roots might dry out or get too hot in the summer.

- If your planting area is already covered in wood chips or straw (mulch) to prevent erosion, rake the mulch out of the way to dig the planting hole. Mulch is most useful on top of the soil, not buried within it.
- For all of your trees: Knock off soil from the top of the root ball to find the top-most structural root. You may notice that near the root the stem bulges and then gets thinner as you move up. This is called the root flare, and it should be at the surface of the soil. Don't be fooled by false roots. These are called adventitious roots, and they are a product of being too deep throughout production.
- Measure the height from the top of the root flare to the bottom of the root ball. This will be your planting-hole depth.
- Note: It is better that the planting hole is slightly shallower than the depth of the root ball rather than deeper than the root ball. Often the tree will sink down a little over time. Planting a tree too deeply can stunt growth by limiting root access to oxygen and harming bark on the tree trunk.
- If your tree spacing is close enough, it may be easier to dig a long trench rather than individual planting holes.

Planting-hole width

Digging out a wide planting hole will also help encourage the roots to grow outward from the tree so they can find more water and nutrients.

- Dig a saucer-shaped planting hole with inward sloping sides.
- The planting hole should be two to three times the diameter of the container in which the tree had been growing.

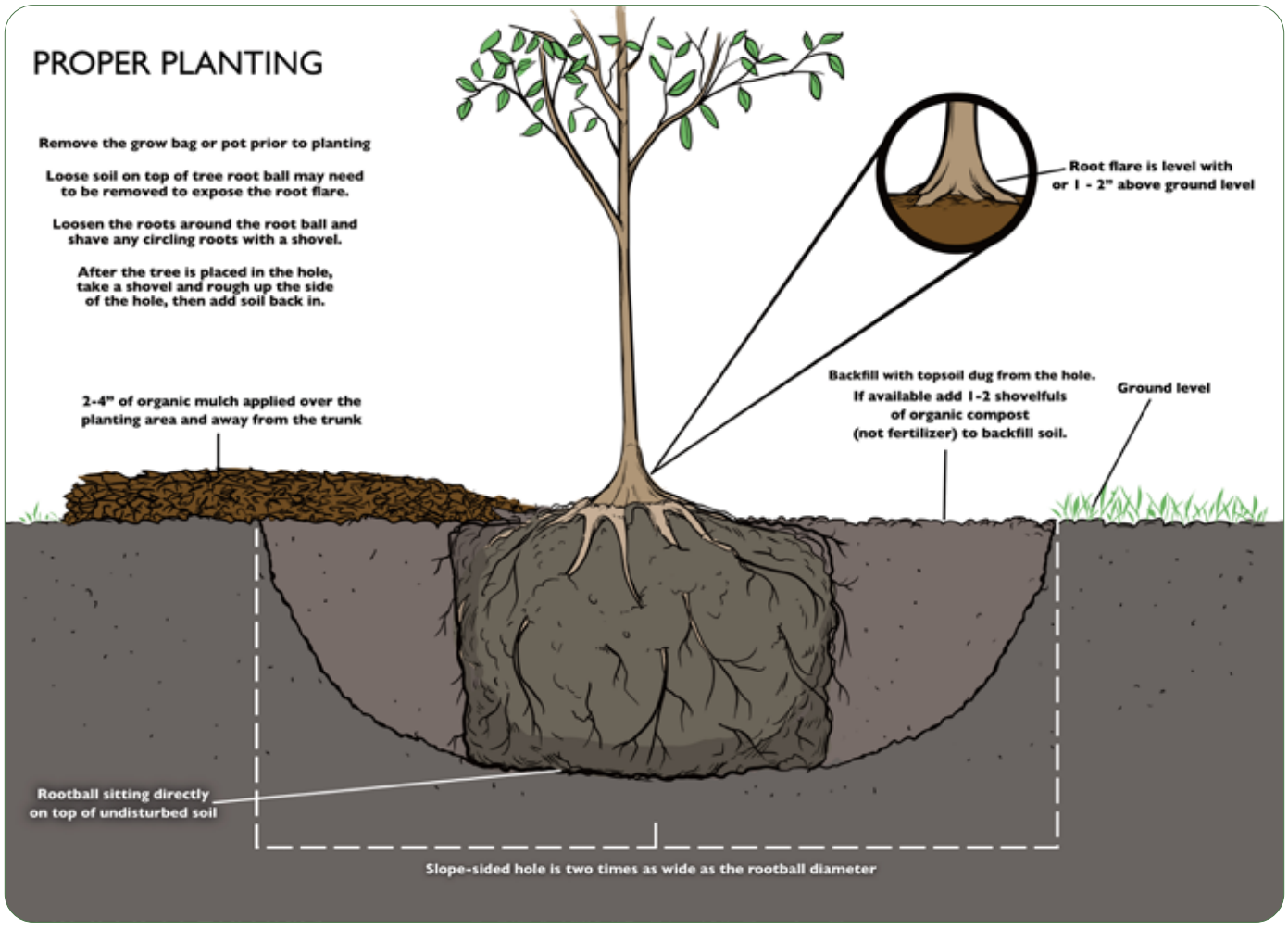


Root balls from both container-grown and ball-and-burlap trees should be checked for circling and girdling roots. These roots can be removed with bypass pruners or a sharpened saw so roots will grow away from the plant.

Planting the tree

- Start by scratching the walls of the planting hole to eliminate the possibility of restricting root growth. Sometimes when digging, the sides get glazed from the force of the shovel blade. This could reduce the roots' ability to grow away from the tree and eventually cause them to circle back around the trunk. You can also scratch the wall after the tree is placed in the hole but before the soil is added.
- Place the tree in the hole. All trees should be placed on a firm, undisturbed soil base at the bottom of the hole. If the hole is dug too deeply, add more soil and tamp firmly. When you put the tree's root ball in the hole, the root flare should be level with the surface of the ground. Use a shovel handle to confirm proper elevation by laying it across the root and existing edge of the planting hole.
- Fill the hole about halfway with soil. Gently press down on the soil, then add a bucket of water to the hole to help the soil settle in. You may find it helpful to have one person hold the tree upright while another person adds the soil.
- Finish filling the hole with soil. Again, gently press down on the soil and add a bucket of water so that the ground and tree are stable.
- Remove all plant identification tags, ribbons, trunk protection, or packing from the nursery. Eventually these will fall off on their own and become litter or strangle the tree if they do not degrade in time.

Dig the planting hole deep enough so the topmost root is very close to the soil surface. The planting hole should be twice the diameter of the container.



GUIDE #11

Mulching

Mulches are materials spread over soil to improve conditions for plant growth. One commonly used type of mulch is wood chips or wood mulch, spread around the base of trees. Tree leaves and straw are other examples of mulch. Wood chip mulch does several important jobs. It keeps your soil and compost from getting washed away by the rain. It helps the soil retain the right amount of moisture to grow healthy tree roots. It keeps the soil from getting too hot in the summer. And as wood chips slowly decompose, they feed the soil critters that provide nutrients to plants and maintain good soil structure. Mulch also helps prevent lawn mowers and weed whackers from getting too close and damaging the tree trunk.

There are two options for applying mulch to your new vegetation barrier trees:

- Option 1: Spread a circle of mulch around each individual tree. This may be easier if your trees are spaced far apart and the grass is still intact because you did not use a decompaction process.
- Option 2: Use mulch to create a single long planting bed around all the planted trees (or possibly two long planting beds if you have two rows of trees). Having a bed of mulch between the trees saves the trouble of having to mow in between the new trees. You can also add other plants such as flowers that attract bees and butterflies in between the young trees in a long planting bed.

Wood chips can be purchased from a landscaping supplier or may be available free or at a discounted price from local tree-care companies or municipalities. Programs such as Chipdrop could also help you obtain free or discounted wood chips.

Mulch quantity

Option 1: Circles of mulch around each tree
Use the Mulch Quantity Table in Field Sheet #11 to determine the amount of mulch needed for your project. This calculation assumes you will spread the mulch about 2 to 3 inches deep in a circle with a 3- to 4-foot diameter around each tree. The mulch ring should be at least the same diameter as the planting hole.

Option 2: Long planting bed
Use the Mulch Quantity Table in Field Sheet #11 to determine the amount of mulch needed for your project. This calculation assumes you will spread the mulch about 2 to 3 inches deep in a long planting bed that contains the vegetation barrier trees.

Adding mulch

Grass preparation
If you would like to use the mulch to create a single long planting bed and you did not need to use a decompaction process, there will likely still be grass in between your tree-planting holes. You will need to remove or kill grass prior to placing the mulch; otherwise the grass will just grow through the mulch.

The following instructions describe a simple and cost-effective way to smother the grass prior to mulching. Other options for grass removal include using a sod cutter to remove the turf or killing the grass with a broad spectrum herbicide. Note that a broad spectrum herbicide must be used well before tree planting to prevent damage to the new trees. Follow herbicide instructions carefully.

- Use a measuring tape to measure and mark the location and dimensions of your planting bed.
- Check the area to be cut for sticks, stones, or other objects that could poke a hole through the covering material.
- If using landscaping fabric, follow the product instructions to cover the entire planting area.
- If using newspaper or other similar material, spread a layer of newspaper about 10 pages deep over a portion of your planting area. Make sure the newspaper pieces overlap each other to prevent grass from growing between gaps. It can be helpful to spray the newspaper with water to help it stay in place while spreading the mulch.

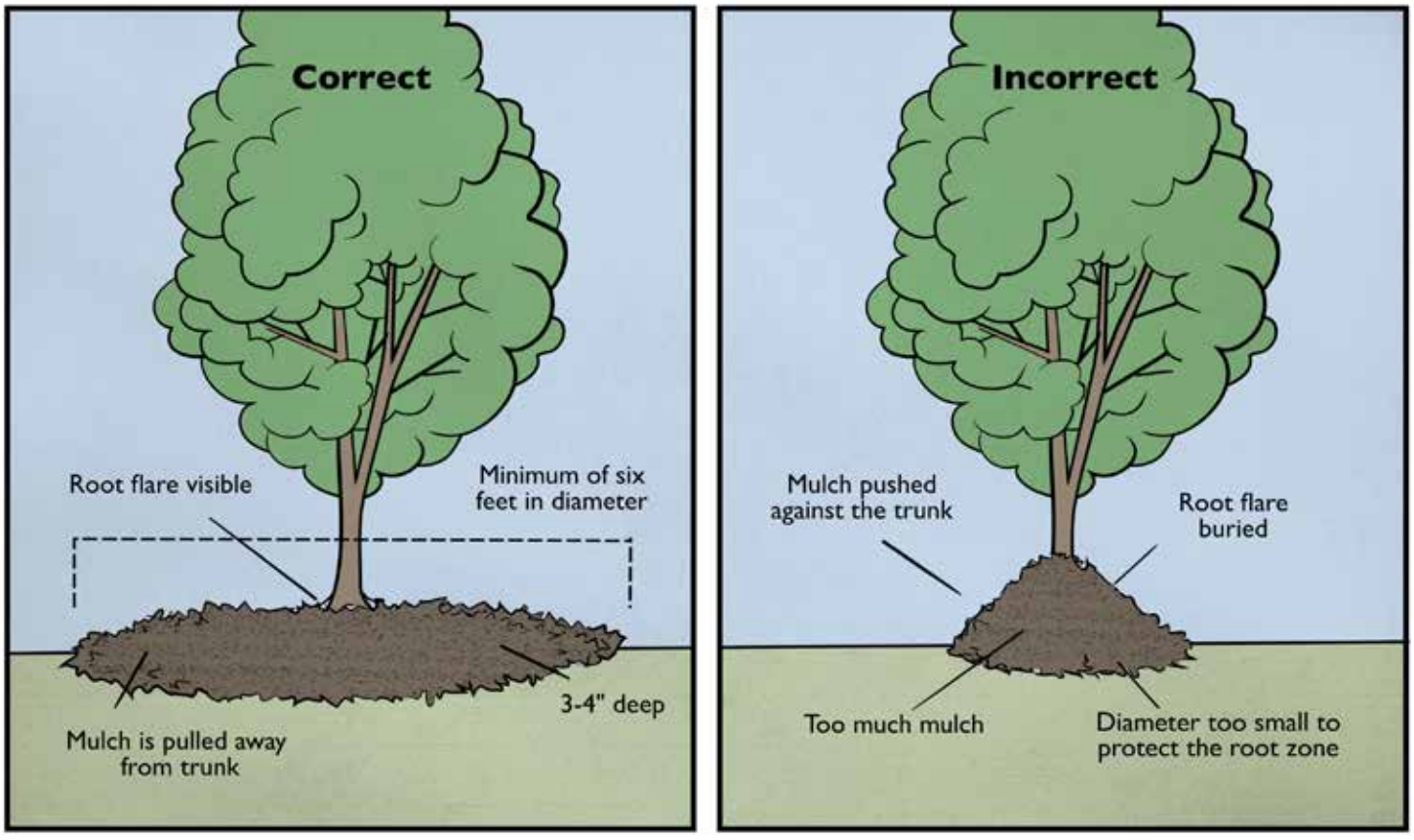
- If using cardboard, cover the planting area with cardboard pieces, making sure the pieces overlap to prevent grass from growing through the cracks.
- Cover the landscaping fabric, newspaper, or cardboard with 2 to 3 inches of mulch.

One way to remove turf from a planting area is to smother it with cardboard or newspaper and then cover it with mulch.

Spreading mulch

After your trees have been planted, place your mulch (wood chips, leaves, or straw) in a ring around the tree or across the entire planting bed.

- Use a metal rake to push mulch back over the planting holes after they have been filled in with soil.
- Rake the mulch so it is about 2 to 3 inches deep.
- IMPORTANT! There should be NO mulch touching the trunk of the tree. We want mulch to keep the soil moist, but if mulch is resting on the trunk of the tree it can keep the bark wet for long periods of time and cause damage to the trunk. Aim to create a donut shape of mulch around the tree to prevent mulch from mounding on the trunk.



Mulch such as wood chips, straw, or leaves should be placed in a ring around the trunk of the tree. Make sure the mulch does not touch the trunk of the tree.

GUIDE #12

Tree Stabilization

Staking trees can help prevent your new trees from leaning or tilting before their root systems establish. If you have planted any of the recommended vegetation barrier evergreen tree or shrub species that are between 4 and 6 feet tall, staking is likely unnecessary because these trees have branches low to the ground and should be fairly stable. However, if your planting site is highly exposed to a lot of wind or you are choosing to plant deciduous trees, which are more top-heavy, staking may be helpful for the first year after planting.

IMPORTANT: All stabilization supports should be removed between 12 and 14 months after planting. Otherwise the supports will start to interfere with tree growth. If you can't guarantee that stabilization supports will be removed in a timely manner, it is probably better not to use them.

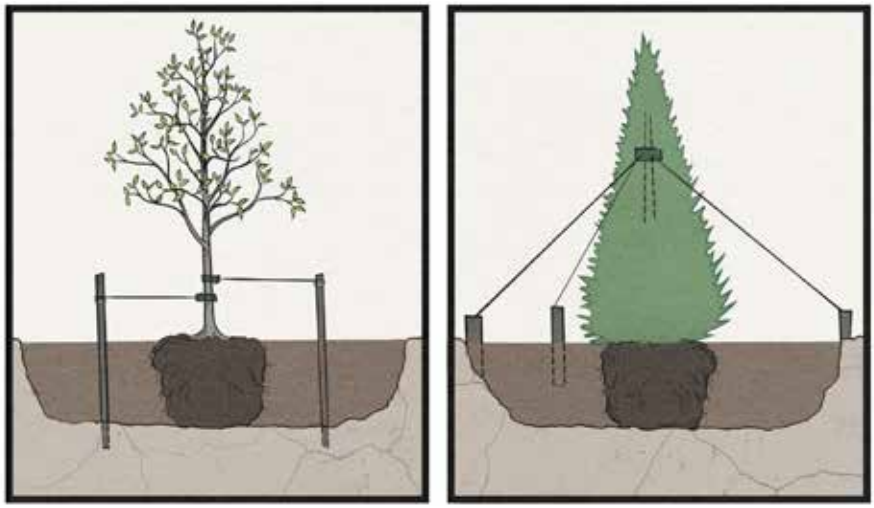
If your vegetation barrier will be made of evergreen trees and stabilization is necessary, then you need to use a guying system to support the trees. If you are using deciduous trees, you will stake the trees instead.

Guying process (preferred for evergreens)

- Drive three wood support stakes (2 x 2 x 18 inches) into the ground outside the planting hole, evenly spacing them around the hole.
- Starting at the first stake, attach one end of the tie or webbing to the stake. Loop the other end of the tie around the tree's trunk, at less than two-thirds the height of the tree. Then attach the loose end of the tie to the stake, completing the loop.
- Repeat the process for the other two stakes.
- The ties do not need to be perfectly tight but they should not be extremely slack and loose either. You should be able to wiggle the trunk a little. Your main goal is to prevent the tree from getting completely blown over.

Staking process (preferred for deciduous trees)

- Because wind generally blows from west to east in the Chicago region, place the first stake on the western side of the tree.
- Place the second stake opposite the first stake.
- Drive the stakes into undisturbed soil outside of the root ball until stakes are secure.
- Use the ties or webbing to connect the tree and the stakes. The ties should be no more than two-thirds up the height of the tree, still allowing for trunk movement.
- The ties do not need to be perfectly tight but they should not be extremely slack and loose either. You should be able to wiggle the trunk a little. Your main goal is to prevent the tree from getting completely blown over.



Deciduous trees may benefit from two tall stakes with fabric ties attached no more than two-thirds the way up the trunk. Evergreen trees may benefit from three small stakes with fabric ties attached less than two-thirds the way up the trunk. All staking material must be removed 12 to 14 months after planting to avoid damaging the tree trunk.

GUIDE #13

Long-Term Tree Care

Congratulations! You've planted a vegetation barrier. Just like other living things, your new trees will need care and attention to thrive in their new home, especially for the next two to three years. During this time period, called the establishment phase, the trees will begin to grow their root systems out into the soil of your planting site. You will likely not notice too much above-ground growth during this time, as the trees' resources are focused below-ground. Until the tree has a lot of roots growing into its new soil, it will need extra water.

Irrigation

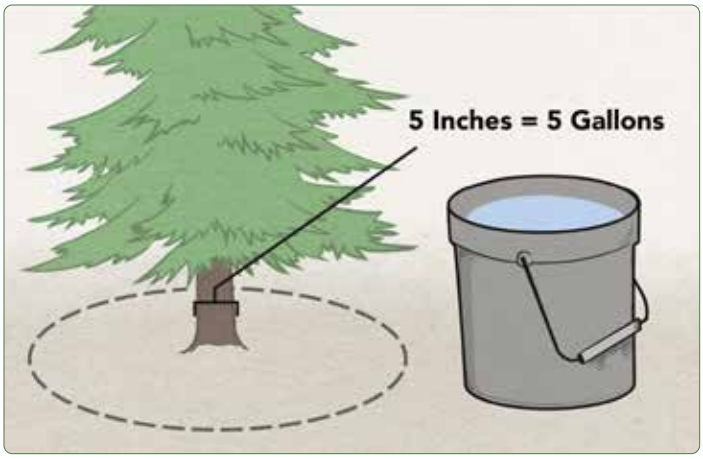
The following irrigation guidelines were developed for the Chicago metropolitan region. For other parts of the United States, contact your local cooperative extension office to get care recommendations specific to your region.

Supplemental watering with irrigation is recommended for all new plantings for at least the first two growing seasons. It is important to consider if existing irrigation (e.g., lawn irrigation) will affect the watering or irrigation planning for newly planted trees.

Scheduling irrigation:

- In the first few months following planting, check newly planted shrubs and trees often because the potting soil around their roots can dry out quickly. Apply water as needed.
- After the first 12 weeks, water your trees weekly between May and September for the next two years.
- Keep in mind that trees will experience greater water stress during periods of drought or low rainfall and may need extra watering during very hot or very dry weather.

The width or diameter of the tree trunk can be used to roughly estimate how much water to apply when irrigating using the Irrigation Water Quantity Table in Field Guide #13.



Each vegetation barrier tree will need 1 gallon of water per inch of tree trunk diameter per week.

There are several methods you can use to water your trees, from simple to more complicated and expensive:

- Hose and buckets. Water can be sprayed from a hose directly on the soil around the tree or by filling buckets with water that are then brought to the tree. This approach works best if your planting area is located near a hose hookup. It is cheaper but labor intensive.
- Portable water tank (also called a water buffalo tank). This is a large tank that can hold anywhere from 300 to 500 gallons of water in a vehicle like a pickup truck. This approach can help bring water to a location not near a water source.
- Sprinklers. A set of sprinklers can be set out in your planting area weekly to water your trees. This method requires close proximity to a water source.
- Drip irrigation or soaker tubes. Drip irrigation systems are essentially leaky hoses that apply water directly to the soil. These hoses can be spread out in the planting area at the beginning of the growing season but would need to be brought indoors before winter. When it is time to irrigate, the drip irrigation hoses get connected to your water source, which is left on for a period of time until your trees are sufficiently watered.

- Note: It is important to do a weekly finger test for each tree to make certain the water leaving the soaker hose is reaching the end of the line.

Regardless of how you irrigate, make sure to apply water to the roots around the trunk within the dripline of the tree, which is the area directly underneath the tips of the branches.

Weeding

While mulch can slow the growth of weeds, you will likely find it necessary to periodically remove weedy plants that have started to grow in your vegetation barrier. Weed removal options include:

- Hand-pulling weeds
- Applying a pre-emergent herbicide in the spring to inhibit weed growth. If you are using a pre-emergent herbicide, make sure it is compatible with evergreen trees and any other smaller decorative plants you have added to your barrier.

We strongly recommend avoiding the use of a weed whacker around the vegetation barrier trees because of the potential for the weed whacker to accidentally damage the trunk of the tree. Damaging the tree trunk leaves a permanent scar on the tree and reduces its ability to move water and nutrients from the roots to the leaves.

Pruning

For your vegetation barrier, it is important NOT to remove lower branches (a process called limbing up). The trees and shrubs need their lower branches so they can form a complete "wall" of greenery from the ground to the tops of the tree.

If you are using any deciduous tree species, structural pruning when trees are young is an important way to grow trees that are less likely to be damaged by wind or bad weather as they mature. Shrubs can also benefit from pruning as they age to encourage new growth and keep the branches within the confines of the planting area.

Avoid removing lower trees limbs as shown in this photo. *It is important that the branches and leaves of your vegetation barrier trees reach all the way to ground.*

Sometimes pruning can be necessary to remove a broken or damaged branch to help the tree recover faster from damage. You can learn more about pruning from The Morton Arboretum Plant Clinic.

Root maintenance

As the trees mature, be certain to keep an eye on the root flare. If you see a stem starting to girdle the roots or roots that want to grow back toward the stem, corrective root pruning should be made before the root grows too thick.

Tree-Care Schedule

Month	Year 1	Year 2	Every year
April			Check trees for winter damage (broken branches, large dead patches)
May	❑ Water weekly	❑ Water weekly	Option: Apply a pre-emergent herbicide
June	❑ Water weekly ❑ Remove weeds	❑ Water weekly ❑ Remove weeds	❑ Water as needed during dry periods
July	❑ Water weekly	❑ Water weekly	❑ Water as needed during dry periods
August	❑ Water weekly ❑ Remove weeds	❑ Water weekly ❑ Remove weeds	❑ Water as needed during dry periods
September	❑ Water weekly	❑ Water weekly	
October	❑ Water weekly ❑ Remove staking if used (Guide #9)	❑ Water weekly	

Additional Resources

Other approaches for improving local air quality

- Community Assessment of Freeway Exposure and Health (CAFEH) "Improving Health in Communities Near Highways"
  https://sites.tufts.edu/cafeh/files/2011/10/CAFEH-Report-Final-2-26-15-hi-res1.pdf
- U.S. Environmental Protection Agency 2021 "Best Practices for Reducing Near-Road Pollution Exposures at Schools"
  https://www.epa.gov/mobile-source-pollution/how-mobile-source-pollution-affects-your-health#best-practices-for-schools

Vegetation barriers

- U.S. Environmental Protection Agency 2016 "Recommendations for Constructing Roadside Vegetation Barriers to Improve Near-Road Air Quality"
  https://www.epa.gov/air-research/recommendations-constructing-roadside-vegetation-barriers-improve-near-road-air-quality
- Community Action to Promote Healthy Environments (CA-PHE) "Vegetation Buffer Toolkit. Using Trees to Improve Air Quality in Detroit."
  https://caphedetroit.sph.umich.edu/information-air-quality/buffer-toolkit/
- U.S. Forest Service. "6.3 Air Quality Buffers." Conservation Buffers
  https://www.fs.usda.gov/nac/buffers/guidelines/6_aesthetics/3.html

Tree and gardening questions

- The Morton Arboretum Plant Clinic, 630-719-2424,
  plantclinic@mortonarb.org, https://www.mortonarb.org/trees-plants/tree-and-plant-advice/plant-clinic
- Cook County Cooperative Extension Horticulture Program
  https://extension.illinois.edu/cook/horticulture
- How to find a certified arborist
  https://www.treesaregood.org/findanarborist/arboristsearch
- The Arbor Day Foundation
  https://www.arborday.org/trees/?utm_source=Arborday.org&utm_medium=Top_Menu&utm_campaign=Main_Menu&utm_term=Trees&utm_content=trees
- The Cornell Urban Horticulture Institute
  https://blogs.cornell.edu/urbanhort/
- Cooperative Extension Master Gardener List https://mastergardener.extension.org/

Species selection

- i-Tree Species (helpful for identifying species good for air pollution reduction)
  https://species.itreetools.org/
- The Morton Arboretum Tree and Plant Selector (includes hardiness zones 2-11)

  https://mortonarb.org/plant-and-protect/trees-and-plants
- Missouri Botanical Garden Plant Finder (includes hardiness zones 1-12)
  http://www.missouribotanicalgarden.org/plantfinder/plantfindersearch.aspx
- Cornell Woody Plants Database (includes hardiness zones 3-7)
  http://woodyplants.cals.cornell.edu/plant/search

Choosing nursery stock

- The Cornell Horticultural Institute
  https://www.youtube.com/watch?v=_OirhsCKxWw

Restoring severely compacted soil

- Soil Profile Rebuilding
  https://www.urbanforestry.frec.vt.edu/SRES/
- Urban Tree Foundation (includes sample specifications)
  http://www.urbantree.org/details_specs.shtml
- The Ontario Landscape Tree Planting Guide
  https://www.vinelandresearch.com/case-study/the-ontario-landscape-tree-planting-guide/

Sourcing compost and other organic amendments

- U.S. Composting Council
  https://www.compostingcouncil.org/
- Biosolids Resources
  http://biosolidsresources.org/OE/

Additional Plants to Complement Vegetation Barriers

After you've planted the trees or large shrubs for your vegetation barrier, you may notice that you have extra room for shorter plants, especially while the new trees are young. One option is to incorporate some pollinator-friendly plants to make your barrier more colorful and attractive to beneficial insects. Another option is to add shorter shrubs on one side of the barrier to help plug any spaces that may form between the tree branches and the ground that could let air pollutants pass through.

Pollinator-friendly plants

This list includes annual and perennial flowering plants that grow well in full sun. They can benefit pollinators by providing nectar, pollen, shelter, and food for pollinator larvae such as caterpillars. This list was compiled by the Illinois Department of Natural Resources (https://www2.illinois.gov/dnr/education/Pages/SHAGOptionalPlantList.aspx).

Common name	Scientific name	Flower color	Mature height	Space requirements
azure aster	*Symphyotrichum oolentangiense*	blue	2–3 feet	1 foot
black-eyed Susan	*Rudbeckia hirta*	yellow	1–3 feet	1 foot
blue vervain	*Verbena hastata*	blue	3–6 feet	1 foot
brown-eyed Susan	*Rudbeckia triloba*	yellow	2–5 feet	2 feet
butterfly weed	*Asclepias tuberosa*	orange	2–3 feet	1.5 feet
Canada milk vetch	*Astragalus canadensis*	yellow	2–3 feet	1 foot
common boneset	*Eupatorium perfoliatum*	white	3–4 feet	1 foot
common ironweed	*Vernonia fasciculata*	purple	4–6 feet	2 feet
common mountain mint	*Pycnanthemum virginianum*	white	1–3 feet	1 foot
compass plant	*Silphium laciniatum*	yellow	3–10 feet	2 feet
Culver's root	*Veronicastrum virginicum*	white	3–6 feet	1.5 feet
cup plant	*Silphium perfoliatum*	yellow	3–10 feet	2 feet
downy sunflower	*Helianthus mollis*	yellow	2–4 feet	2 feet
foxglove beardtongue	*Penstemon digitalis*	white	2–3 feet	1 foot
golden Alexander	*Zizia aurea*	yellow	2–3 feet	1 foot
great blue lobelia	*Lobelia siphilitica*	blue	1–4 feet	1 foot
hairy white aster	*Symphyotrichum pilosum*	white	2–4 feet	1 foot
hoary vervain	*Verbena stricta*	purple	2–4 feet	1 foot
horsemint	*Monarda punctata*	green-yellow	1–2 feet	1 foot
Indian plantain	*Arnoglossum atriplicifolium*	white	3–6 feet	2 feet
leadplant	*Amorpha canescens*	purple	3–5 feet	1 foot
marsh blazing star	*Liatris spicata*	purple	3–6 feet	1 foot
New England aster	*Symphyotrichum novae-angliae*	purple	3–6 feet	1.5 feet

Common name	Scientific name	Flower color	Mature height	Space requirements
New Jersey tea	*Ceanothus americanus*	white	3–4 feet	3 feet
nodding wild onion	*Allium cernuum*	white	1–2 feet	1 foot
Ohio goldenrod	*Oligoneuron ohioense*	yellow	3–4 feet	2 feet
Ohio spiderwort	*Tradescantia ohiensis*	purple	2–4 feet	1 foot
ox-eye sunflower	*Heliopsis helianthoides*	yellow	3–6 feet	1 foot
pale coneflower	*Echinacea pallida*	purple	3–5 feet	1 foot
prairie blazing star	*Liatris pycnostachya*	purple	3–5 feet	1 foot
prairie dock	*Silphium terebinthinaceum*	yellow	3–10 feet	2 feet
prairie dropseed	*Sporobolus heterolepis*	red-gold	2–4 feet	2 feet
prairie milkweed	*Asclepias sullivantii*	pink-white	3–5 feet	1 foot
purple coneflower	*Echinacea purpurea*	purple	3–4 feet	1 foot
purple prairie clover	*Dalea purpurea*	purple	1–2 feet	1 foot
rattlesnake master	*Eryngium yuccifolium*	white	3–5 feet	1 foot
rosinweed	*Silphium integrifolium*	yellow	2–6 feet	2 feet
rough blazing star	*Liatris aspera*	red-purple	2–5 feet	1 foot
round-headed bush clover	*Lespedeza capitata*	white	3–5 feet	1 foot
sand coreopsis	*Coreopsis lanceolata*	yellow	1–2 feet	1 foot
shooting star	*Dodecatheon meadia*	white	1–2 feet	1 foot
showy goldenrod	*Solidago speciosa*	yellow	1–3 feet	1 foot
showy tick trefoil	*Desmodium canadense*	purple	3–5 feet	1 foot
slender mountain mint	*Pycnanthemum tenuifolium*	white	1–3 feet	2 feet
smooth aster	*Symphyotrichum laeve*	blue	2–4 feet	1 foot
Solomon's seal	*Polygonatum commutatum*	green-yellow	1–3 feet	1 foot
stiff aster	*Lonactis linariifolius*	purple	1–2 feet	1 foot
stiff goldenrod	*Oligoneuron rigidum*	yellow	3–5 feet	1 foot
swamp milkweed	*Asclepias incarnata*	pink	3–5 feet	2 feet
sweet black-eyed Susan	*Rudbeckia subtomentosa*	yellow	4–6 feet	1 foot
western sunflower	*Helianthus occidentalis*	yellow	3 feet	1 foot
white wild indigo	*Baptisia alba*	white	3–5 feet	3 feet
wild bergamot	*Monarda fistulosa*	purple	2–5 feet	2 feet
wild petunia	*Ruellia humilis*	purple	1–2 feet	1 foot
wild quinine	*Parthenium integrifolium*	white	3–5 feet	2 feet
wild senna	*Senna hebecarpa*	yellow	4–6 feet	2 feet
yellow coneflower	*Ratibida pinnata*	yellow	3–6 feet	1.5 feet
yellow sneezeweed	*Helenium autumnale*	yellow	4–5 feet	1 foot

Short shrubs tolerant of roadsides

The following list of shrubs are adapted for USDA Hardiness Zones 5 and 6 and partial to full sun (four or more hours of sunlight each day), are native to North America, and are tolerant of road salt. These shrubs also have comparatively low allergen potential (OPALs score less than 5[1]). You can search for other shrub characteristics using The Morton Arboretum's Tree and Plant Database (https://mortonarb.org/plant-and-protect/trees-and-plants).

Evergreen Shrubs

Common name	Scientific name	Mature height	Space requirements
Anglojap yew	*Taxus* x *media*	8–40 feet	3–5 feet
Bayberry	*Myrica pensylvanica*	5–10 feet	2–4 feet
Eastern arborvitae	*Thuja occidentalis*	6–60 feet	3–5 feet
Eastern hemlock	*Tsuga canadensis*	40–70 feet	3–5 feet
Giant arborviate	*Thuja plicata*	20–50 feet	3–5 feet
Inkberry	*Ilex glabra*	5–8 feet	2–4 feet
Japanese yew	*Taxus cuspidata*	5–40 feet	3–5 feet
Scarlet firethorn	*Pyracantha coccinea*	10–15 feet	3–5 feet

Deciduous Shrubs

Common name	Scientific name	Mature height	Space requirements
Alpine currant	*Ribes alpinum*	3–6 feet	2–4 feet
Black raspberry	*Rubus occidentalis*	3–6 feet	1–3 feet
Black-haw	*Viburnun prunifolium*	8–15 feet	3–5 feet
Bridalwreath spirea	*Spirea prunifolia*	5–8 feet	2–4 feet
Bush-honeysuckle	*Diervilla lonicera*	3–5 feet	2–4 feet
Buttonbush	*Cephalanthus occidentalis*	5–12 feet	2–4 feet
Clove currant	*Ribes odoratum*	6–8 feet	2–4 feet
Common flowering quince	*Chaenomeles speciosa*	6–10 feet	2–4 feet
Common lilac	*Syringa vulgaris*	6–12 feet	2–4 feet
Common ninebark	*Physocarpus opulifolius*	6–10 feet	2–4 feet
Common witch-hazel	*Hamamelis virginiana*	15–25 feet	3–5 feet
Doublefile viburnum	*Viburnum plicatum tomentosum 'Mariesii'*	8–10 feet	4–6 feet
Fragrant sumac	*Rhus aromatica*	2–5 feet	1–3 feet
Hedge cotoneaster	*Cotoneaster lucida*	5–10 feet	2–4 feet
Manchurian lilacs	*Syringa pubescens* subsp.	5–8 feet	2–4 feet
Meadowsweet	*Spirea alba*	3–8 feet	1–3 feet
Purple basket willow	*Salix purpurea*	8–10 feet	2–4 feet
Purple chokeberry	*Aronia prunifolia*	6–12 feet	3–5 feet
Pussy willow	*Salix discolor*	15–25 feet	3–5 feet
Red chokeberry	*Aronia arbutifolia*	5–10 feet	2–4 feet
Red-osier dogwood	*Cornus sericea*	5–10 feet	1–3 feet
Sargent's crabapple	*Malus sargentii*	6–10 feet	2–4 feet
Siebolds shrub-ginseng	*Eleutherococcus sieboldianus*	8–10 feet	2–4 feet
Smooth arrowwood viburnum	*Viburnum dentatum*	6–10 feet	2–4 feet
Smooth wild rose	*Rosa blanda*	3–5 feet	2–4 feet
Spreading cotoneaster	*Cotoneaster divaricatus*	5–8 feet	2–4 feet
Vernal witch-hazel	*Hamamelis vernalis*	6–10 feet	2–4 feet
Wild plum	*Prunus americana*	10–25 feet	3–5 feet

Cited sources
1. Ogren, 2015. The Allergy Fighting Garden. 10-Speed Press, Berkeley, California.

Project Budget Worksheet

The following is a list of budget considerations. Additional categories may be needed and some may not be required.

Project component	Quantity	Unit cost	Total
Engineering site inspection (preliminary review for unknown challenges, etc.)			
Design (engineer, landscape architect, other)			
Easements			
Permits and fees			
Site control (fencing, traffic realignment, etc.)			
Materials removal (parking lot, driveway, etc.)			
Utility relocation			
Grading			
Soil remediation (removal, amendments, etc.)			
Plant material			
Mulch			
Site restoration			
Labor			
Maintenance			
Equipment rental			
Tools (if installed in-house or with volunteers)			
Meeting resources (refreshments, facilities, etc.)			
Communications			
Coordination			
Other			
Total			

Field Sheets

The following field sheets are designed for you to print and bring to your planting site to record your observations and measurements. They also contain checklists for supplies and explain each step of the planning and planting process.

FIELD SHEET #1

What's the Best Place for a Vegetation Barrier?

Bring this field sheet with you to your potential vegetation barrier location.

Materials

- Field Sheet #1
- Pen or pencil
- Phone or separate camera (can be helpful to take pictures of areas you think could be a good space for a vegetation barrier)

Estimated time

1 hour

Observations

While walking around the area you want to shield from ground-level pollution, use your observations to answer the questions in the table below. Using online maps and aerial photos can also help you answer these questions.

Is your potential vegetation barrier planting area....	**Yes**	**No**
1. Parallel and downwind to a ground-level pollution source such as a busy road?		
2. Separating the source of ground-level air pollution from areas where people spend time outside?		
3. Longer than the area you want to protect?		
4. At the same elevation or above the pollution source?		
5. Not located in between two pollution sources such as a busy roadway and a side street where cars and buses idle? (This situation can trap air pollution on the side of the vegetation barrier where people are located.)		

Other notes:

FIELD SHEET #2

Do You Have Enough Space for a Vegetation Barrier?

Bring this field sheet with you to your potential vegetation barrier location.

Materials

- Field Sheet #2
- Pen or pencil
- Phone or separate camera (can be helpful to take pictures of areas you think could be a good space for a vegetation barrier)
- Tape measure

Estimated time

2-3 hours

Observations

When visiting your potential vegatative barrier planting area, record your measurements and observations below. Then use that information to answer the related questions. Remember that once fully grown, the vegetation barrier should be at least 20 feet tall and could be up to 30 feet wide.

If the answer to any of the following questions is "Yes," then this location is likely not a good spot for a vegetation barrier or further investigation is needed. The Additional Resources section can direct you to other practices that can help improve local air quality.

Amount of **sunlight** for planting area	❏ Full sunlight – more than 6 hours of direct sunlight ❏ Partial shade – 4 to 6 hours of direct sunlight ❏ Full shade – less than 4 hours of direct sunlight	Is the planting site in full shade?	❏ Yes ❏ No
Length and width of **planting area**	Length: _____ feet Width: _____ feet	Is the planting area width less than 30 feet?	❏ Yes ❏ No
Location of **overhead utility** lines on property	Notes:	Are there utility wires above the planting site?	❏ Yes ❏ No
Distance between planting area to **underground utilities**	_____ feet	Is there buried infrastructure within 10 feet of your planting area?	❏ Yes ❏ No

Distance to nearest **sidewalk or road**	_____ feet	Are there sidewalks, roads, or other pavement within 10 feet of where tree trunks will be planted?	❏ Yes ❏ No
The planting site is on	❏ Flat ground ❏ The top of a hill ❏ A low-lying area that sometimes holds water	Is the planting area in a low-lying area that is sometimes filled with water or puddles?	❏ Yes ❏ No
Distance from planting area to **highway**	_____ feet	Would a vegetation barrier be located within the clear zone of a highway? (Usually 30 feet from highway, but could be more, depending on site)	❏ Yes ❏ No
Distance between planting area and **nearest road**	_____ feet	Would the vegetation barrier obstruct a driver's view of the road and signs?	❏ Yes ❏ No
Type of plants growing at the site	Notes:	Are mature trees already growing at the site? If so, you may need to adjust your design. An arborist can help you assess the quality or condition of existing trees.	❏ Yes ❏ No
Presence of **bare soil**	Notes:	Are there places on the ground where no plants are growing and there is only bare soil? This may indicate severely compacted soil.	❏ Yes ❏ No
Location of the nearest **water spigot**	Notes:	Does the site have a water source? If not, you will need a plan to bring water to the site to irrigate the trees in their first few years (see Guide #11).	❏ Yes ❏ No
Visibility of areas where people walk, play, etc.	Notes:	Will the barrier obstruct visibility in an area that may make people feel unsafe? Perceptions about safety should be discussed with the community	❏ Yes ❏ No

FIELD SHEET #5

Get to Know Your Soil

Bring this field sheet with you to your potential vegetation barrier location.

Materials for all soil tests

- Field Sheet #5
- Pen or pencil
- Phone or separate camera
- Tape measure or yardstick that can get wet
- Shovel/soil auger
- Water source and bucket/hose
- Resealable plastic sandwich bags
- Permanent marker
- Wire probe (description below)
- Squirt or spray bottle (optional)

Soil Test #1 – Soil profile assessment and drainage

Record your observations about each soil profile you remove.

	Sample #1	**Sample #2**	**Sample #3**
Example	Soil is brown, deeper soil is darker. Grass roots grow about 10 cm deep. Soil forms larger clumps 10-20 cm deep.	Top 10 cm of soil is brown, forms large dense clumps. 10-20 cm is light tan color, mostly sand and gravel.	Soil is loose and sandy and does not have clumps. There is a gravel layer starting 15 cm down.
Observations (number of soil layers, colors, gravel, smell, other notes)			
Causes for concern: gray soils, buried human-made materials such as asphalt, rotten smell			

Record your measurements of the soil drainage test. Remember to save the soil from your drainage holes in a bucket for the other soil tests.

Poor drainage – less than 4 inches per hour
Moderate drainage – 4 to 8 inches per hour
Excessive drainage – more than 8 inches per hour

Sample location	Depth of hole	Initial water height	15 min. water height	Change (initial minus 15 min.)	Convert to 1 hour (x 4)	Drainage
Example	12 in.	10 in.	8 in.	10-8 = 2 in.	2 in. x 4 = 8 in. per hour	Moderate
#1						
#2						
#3						

Soil Test #2 – Soil texture

Soil texture type determined by the texture-by-feel method (for example, "silty loam").

Soil texture	Category	Notes
• Sand	Coarse	Water flows through very quickly Difficult to compact Not good at holding nutrients
• Loamy sand		
• Sandy loam		
• Sandy clay loam	Medium	Water flows through at moderate speed Somewhat easy to compact Good at holding nutrients
• Loam		
• Silt loam		
• Silt		
• Silty clay loam	Fine	Water flows through very slowly (poor drainage) Easy to compact Very good at holding nutrients
• Clay loam		
• Sandy clay		
• Silty clay		
• Clay		

Soil Test #3 – Organic matter

Estimate the amount of organic matter by matching your soil sample color to the chart below.

Soil color	Organic matter	Soil sample
	>10%	•
	5%–10%	•
	3%–4%	•
	1%–2%	•
	<1%	•

Soil Test #4 – pH

Record the results of your soil pH test here: _____

Soil Test #5 – Soil compaction

After each penetration test, check off if a sample location had severe, moderate, or acceptable soil compaction.

How deep did the wire go?	Soil compaction	Sample location #1	Sample location #2	Sample location #3
Less than 4 inches	Severe	•	•	•
4 to 12 inches	Moderate	•	•	•
More than 12 inches	Acceptable	•	•	•

FIELD SHEET #6

Choosing the Right Trees for Your Site

Tree Species Selection

This guide will help you use the information from Field Sheets #2 and #3 to choose the best species for growing a vegetation barrier at your site. First, use your answers to these questions to remove trees from the vegetation barrier tree species list in the species list table. You can also use the information from Field Sheets #2 and #3 to further narrow down your species options.

Measurement question	AVOID
Is pH higher than 8? Yes _____ No _____ If yes and soil is not treated	The soil pH is too high, so avoid: ✕ All vegetation barrier tree species
Is drainage less than 4 inches per hour? Yes _____ No _____ If yes and soil is not treated...	The soil will hold too much water, so avoid: ✕ All vegetation barrier tree species
Is drainage greater than 8 inches per hour? Yes _____ No _____ If yes...	The soil will not hold enough water, so avoid: ✕ Norway spruce ✕ Black Hills spruce
Is the planting site less than 15 feet from a roadway? Yes _____ No _____ If yes...	Road salt could affect the air and soil around the planting site, so avoid: ✕ Norway spruce ✕ Black Hills spruce
Is the site in full shade? Yes _____ No _____ If yes ...	There is not enough sunlight at this site, so avoid: ✕ All vegetation barrier tree species
Is the site in partial shade? Yes _____ No _____ If yes ...	There is a moderate amount of sunlight at this site, so avoid: ✕ Chinese juniper ✕ Eastern red cedar

Preferred Evergreen Tree Species Options

Species	Full-grown size and growth rate	Spacing	Best conditions	Notes	Good for your site?
Balsam fir *Abies balsamea*	H: 40–75 feet W: 20–25 feet Slow	10–12 feet	pH: AC-ALK Light: FS to PSH Drought: MT Waterlogging: T Prefers acidic, moist, well drained soil	Native to North America	
Black Hills spruce *Picea glauca* v. *densata*	H: 20–40 feet W: 10–15 feet Slow to moderate	5–7 feet	pH: AC-ALK Light: FS to SH Drought: MT Waterlogging: S Prefers consistently moist, well-drained soil (medium texture)	Native to North America Avoid cultivars with dwarf shapes	
Blue spruce *Picea pungens*	H: 30–60 feet W: 10–20 feet Slow	5–7 feet	pH: AC-ALK Light: FS Drought: T Waterlogging: S Salt tolerant Prefers alkaline, clay soil, dry sites	Native to North America Can experience fungal challenges when older and when spaced too closely	
Chinese juniper *Juniperus chinensis*	H: 50–60 feet W: 15–20 feet Slow	7–9 feet (Fairview, Hetzii Columnaris, Keteleeri, Perfecta)	pH: AC-NE Light: FS Drought: T Waterlogging: S Prefers consistently moist, well-drained soil (medium texture); tolerates dry periods and alkaline soils	Non-native Female cultivars prefered as male plants have high allergen potential*: • Fairview • Hetzii Columnaris • Keteleeri • Perfecta	
Common juniper *Juniperus communis*	H: 5–25 feet W: 2–10 feet Slow	3–5 feet	pH: AC-ALK Light: FS Drought: T Waterlogging: S Prefers moist, well drained soil, tolerates alkaline soil	Native to North America	

pH: **ALK**-Alkaline **AC**-Acidic **N**-Neutral
Light: **S**-Sun **FS**-Full sun **PSH**-Part shade **FSH**-Full shade
Drought OR Waterlogging: **S**-Sensitive **MS**-Moderately sensitive **T**-Tolerant **LT**-Low tolerant **MT**-Moderately tolerant **IN**-Intolerant

Species	Full-grown size and growth rate	Spacing	Best conditions	Notes	Good for your site?
Douglas fir *Pseudotsuga menziesii*	H: 40–80 feet W: 12–20 feet Moderate	6–8 feet	pH: AC-ALK Light: FS to SH Drought: MT Waterlogging: S Salt tolerant Prefers moist, well drained soil, tolerates alkaline soil	Native to North America	
Eastern arborvitae *Thuja occidentalis*	H: 40–60 feet W: 10–15 feet Moderate	5–7 feet	pH: AC-ALK Light: FS to PSH Drought: IN Waterlogging: S Moderately salt tolerant Prefers alkaline, moist, well drained soil	Native to North America Broad size ranges based on different cultivars	
Eastern red cedar *Juniperus virginiana*	H: 40–50 feet W: 8–20 feet Moderate	4–6 ft (Emerald Sentinel, Canaertii)	pH: AC-ALK Light: FS Drought: T Waterlogging: S Prefers consistently moist, well-drained soil (medium texture)	Native to North America Female cultivars*: • Emerald Sentinel • Canaertii	
Giant arborvitae *Thuja plicata*	H: 50–70 feet W; 15–25 feet Slow	7–9 feet	pH: AC-N Light: FS to PSH Drought: MT Waterlogging: MS Prefers moist, well drained soils, tolerates alkaline, dry soils	Native to North America High allergen score, very benefical for pollutant removal characteristics	
Limber pine *Pinus flexilis*	H: 30-50 feet W: 15-35 feet Slow	7-9 feet	pH: AC-ALK Light: FS to PSH Drought: MT Waterlogging: MT Low salt tolerance Prefers moist, well drained soils, tolerates alkaline, dry soils	Native to North America	

pH: **ALK**-Alkaline **AC**-Acidic **N**-Neutral
Light: **S**-Sun **FS**-Full sun **PSH**-Part shade **FSH**-Full shade
Drought OR Waterlogging: **S**-Sensitive **MS**-Moderately sensitive **T**-Tolerant **LT**-Low tolerant **MT**-Moderately tolerant **IN**-Intolerant

Species	Full-grown size and growth rate	Spacing	Best conditions	Notes	Good for your site?
Norway spruce *Picea abies*	H: 40–60 feet W: 25–30 feet Moderate to fast	10–12 feet (narrow cultivar)	pH: AC-ALK Light: FS to SH Drought: MS Waterlogging: MS Prefers consistently moist, well-drained soil (medium texture)	Non-native Avoid cultivars with weeping or dwarf shapes Narrow cultivars: • Cupressiana	
Oriental arborvitae *Platycladus orientalis*	H: 15–25 feet W: 10–15 feet Slow	5–7 feet	pH: AC-N Light: FS Drought: T Waterlogging: S Prefers moist, well drained soils, tolerates alkaline and dry sites	Non-native	
White fir *Abies concolor*	H: 30–50 feet W: 15–20 feet Slow	7–9 feet	pH: AC-ALK Light: FS to PSH Drought: T Waterlogging: S Low salt tolerance Prefers moist, sandy, well drained soil, tolerates alkaline soil	Native to North America	

pH: **ALK**-Alkaline **AC**-Acidic **N**-Neutral
Light: **S**-Sun **FS**-Full sun **PSH**-Part shade **FSH**-Full shade
Drought OR Waterlogging: **S**-Sensitive **MS**-Moderately sensitive **T**-Tolerant **LT**-Low tolerant **MT**-Moderately tolerant **IN**-Intolerant

* A cultivar is a variety of a species that has been bred for specific characteristics. If your vegetation barrier will be near a location where people spend time outside, we strongly recommend choosing a female cultivar of Chinese juniper or eastern red cedar because these trees will not produce pollen that can make allergies worse. All spruce trees produce pollen because they do not have separate male and female trees, but spruce pollen is less allergenic compared to pollen from other tree species.[1]

Preferred Evergreen Shrub Species Options

Species	Full-grown size and growth rate	Spacing	Best conditions	Notes	Good for your site?
Anglo-Japanese yew *Taxus* x *media*	H: 8–40 feet W: 5–30 feet Slow	3–5 feet	pH: AC-ALK Light: S to PSH Drought: LT Waterlogging: LT Prefers moist, well, drained soil	Non-native	
Bayberry *Myrica pensylvanica*	H: 5–10 feet Colony forming Moderate	2–4 feet	pH: AC Light: S to PSH Drought: LT Waterlogging: MT Salt tolerant Moist to dry, degraded, near-road	Native to North America This is a semi-evergreen at best, mostly deciduous in zone 5	
Eastern arborvitae *Thuja occidentalis*	H: 6–60 feet W: 3–15 feet Slow to moderate	3–5 feet	pH: AC-ALK Light: FS to PSH Drought: IN Waterlogging: S Moderate salt tolerance Prefers alkaline, moist, well drained soil	Native to North America Broad size ranges based on different cultivars	
Eastern hemlock *Tsuga canadensis*	H: 40–70 feet W: 25–35 feet Moderate	3–5 feet	pH: AC Light: FS to PSH Drought: LT Waterlogging: MT Moist, well drained, not clayey soil	Native to North America Tolerates shade but will be thinner	
Giant arborvitae *Thuja plicata*	H: 20–50 feet W: 15–20 feet Moderate	3–5 feet	pH: AC-ALK Light: S to PSH Drought: MT Waterlogging: LT Moist, well-drained soil	Native to North America	

pH: **ALK**-Alkaline **AC**-Acidic **N**-Neutral
Light: **S**-Sun **FS**-Full sun **PSH**-Part shade **FSH**-Full shade
Drought OR Waterlogging: **S**-Sensitive **MS**-Moderately sensitive **T**-Tolerant **LT**-Low tolerant **MT**-Moderately tolerant **IN**-Intolerant

Species	Full-grown size and growth rate	Spacing	Best conditions	Notes	Good for your site?
Inkberry *Ilex glabra*	H: 5–8 feet W: 5–8 feet Slow	2–4 feet	pH: AC Light: S to FSH Drought: LT Waterlogging: MT Moist, well-drained, clay soil	Non-native	
Japanese yew *Taxus cuspidata*	H: 5–40 feet W: 5–40 feet Moderate	3–5 feet	pH: AC-N Light: S to FSH Drought: LT Waterlogging: LT Salt tolerant Sandy, well-drained soil	Non-native Pollutant tolerant	
Scarlet firethorn *Pyracantha coccinea*	H: 10–15 feet W: 10–15 feet Fast	3–5 feet	pH: AC-N Light: S to PSH Drought: MT Waterlogging: LT Moderate salt tolerance All, tolerate clay soil	Non-native Semi-evergreen in zone 5	

pH: **ALK**-Alkaline **AC**-Acidic **N**-Neutral
Light: **S**-Sun **FS**-Full sun **PSH**-Part shade **FSH**-Full shade
Drought OR Waterlogging: **S**-Sensitive **MS**-Moderately sensitive **T**-Tolerant **LT**-Low tolerant **MT**-Moderately tolerant **IN**-Intolerant

Deciduous Species Options – For use if evergreen species are not appropriate for a site

Species	Full-grown size and growth rate	Spacing	Best conditions	Notes	Good for your site?
Alpine currant *Ribes alpinum*	H: 3–6 feet W: 6–7 feet Medium	2–4 feet	pH: ALK Light: FS to FSH Drought: M Waterlogging: MT Salt tolerant	Non-native	
American bladdernut *Staphylea trifolia*	H: 8–15 feet W: 10–15 feet Fast	2–4 feet	pH: ALK Light: S to FSH Drought: MT Waterlogging: MT	Native to North America	
American hazelnut *Corylus americana*	H: 5–8 feet W: 4–6 feet colony forming Medium	2–4 feet	pH: ALK Light: S to PSH Drought: MT Waterlogging: LT	Native to North America	
Black chokeberry *Aronia melanocarpa*	H: 6–12 feet W:8–10 feet Slow	3–5 feet	pH: AC-ALK Light: S to PSH Drought: LT Waterlogging: T	Native to North America	
Black raspberry *Rubus occidentalis*	H: 3–6 feet W: 4–8 feet colony forming Fast	1–3 feet	pH: AC-ALK Light: S to FSH Drought: LT Waterlogging: MT	Native to North America	
Black-haw *Viburnum prunifolium*	H: 8–15 feet W: 8–12 feet Medium to slow	3–5 feet	pH: ALK Light: S to PSH Drought: MT Waterlogging: LT	Native to North America	
Bridalwreath spirea *Spiraea punifolia*	H: 5–8 feet W: 6–8 feet Medium	2–4 feet	pH: ALK Light: FS to PSH Drought: MT Waterlogging: LT Salt tolerant	Non-native	

pH: **ALK**-Alkaline **AC**-Acidic **N**-Neutral
Light: **S**-Sun **FS**-Full sun **PSH**-Part shade **FSH**-Full shade
Drought OR Waterlogging: **S**-Sensitive **MS**-Moderately sensitive **T**-Tolerant **LT**-Low tolerant **MT**-Moderately tolerant

Species	Full-grown size and growth rate	Spacing	Best conditions	Notes	Good for your site?
Bush-honeysuckle *Diervilla lonicera*	H: 3–5 feet W: 3–5 feet Fast	2–4 feet	pH: AC Light: S to PSH Drought: T Waterlogging: LT	Native to North America	
Buttonbush *Cephalanthus occidentalis*	H: 5–12 feet W: 12–18 feet Medium	2–4 feet	pH: ALK Light: S to PSH Drought: ML Waterlogging: T	Native to North America Needs moist soil	
Clover currant *Ribes odoratum*	H: 5–12 feet W: 6–8 feet Medium	2–4 feet	pH: ALK Light: S to PSH Drought: T Waterlogging: LT	Native to North America	
Common flowering quince *Chaenomeles speciosa*	H: 6–10 feet 6–10 feet Medium	2–4 feet	pH: AC-ALK Light: S to PSH Drought: T Waterlogging: M	Non-native	
Common lilac *Syringa vulgaris*	H: 6–12 feet W: 5–8 feet Medium	2–4 feet	pH: AC-ALK Light: FS Drought: T Waterlogging: M Salt tolerant	Non-native	
Common ninebark *Physocarpus opulifolius*	H: 6–10 feet W: 6–10 feet Medium	2–4 feet	pH: AC-ALK Light: S to PSH Drought: M Waterlogging: T Salt tolerant	Native to North America	
Common witch-hazel *Hamamelis virginiana*	H: 15–25 feet (can be trained shorter) W; 15–20 feet Medium	3–5 feet	pH: ALK Light: S to FSH Drought: LT Waterlogging: M Salt tolerant	Native to North America	
Double viburnum *Viburnum plicatum tomentosum 'Mariesii'*	H: 8–10 feet W: 8–10 feet Medium	4–6 feet	pH: AC-ALK Light: S to PSH Drought: M Waterlogging: M	Non-native	

pH: **ALK**-Alkaline **AC**-Acidic **N**-Neutral
Light: **S**-Sun **FS**-Full sun **PSH**-Part shade **FSH**-Full shade
Drought OR Waterlogging: **S**-Sensitive **MS**-Moderately sensitive **T**-Tolerant **LT**-Low tolerant **MT**-Moderately tolerant

Species	Full-grown size and growth rate	Spacing	Best conditions	Notes	Good for your site?
Fragrant sumac *Rhus aromatica*	H: 2–5 feet W: 5–10 feet Medium to slow	1–3 feet	pH: AC-ALK Light: FS to PSH Drought: T Waterlogging: M Salt tolerant	Native to North America	
Hedge cotoneaster *Cotoneaster lucida*	H: 5–10 feet W: 8–10 feet Medium	2–4 feet	pH: ALK Light: S to PSH Drought: T Waterlogging: M Salt tolerant	Non-native	
Manchurian lilacs *Syringa pubescens* subsp.	H: 5–8 feet W: 5–7 feet Medium	2–4 feet	pH: ALK Light: S to PSH Drought: LT Waterlogging: LT Salt tolerant	Non-native	
Meadowsweet *Spiraea alba*	H: 3–8 feet W: 3–4 feet colony forming Medium	1–3 feet	pH:AC-N Light: FS to PSH Drought: LT Waterlogging: T	Native to North America	
Purple basket willow *Salix purpurea*	H: 8–10 feet W: 8–10 feet Fast	2–4 feet	pH: ALK Light: S to PSH Drought: MT Waterlogging: M	Non-native	
Pussy willow *Salix discolor*	H: 15–25 feet W: 12–15 feet Fast	3–5 feet	pH: ALK Light: FS Drought: LT Waterlogging: T	Native to North America	
Red chokeberry *Aronia arbutifolia*	H: 5–10 feet W: 3–5 feet Slow	2–4 feet	pH: AC-ALK Light: S to PSH Drought: LT Waterlogging: M	Native to North America	
Red-osier dogwood *Cornus sericea*	H: 5–10 feet W: 7–10 feet Fast	1–3 feet	pH: ALK Light: FS to PSH Drought: M Waterlogging: T	Native to North America	

pH: **ALK**-Alkaline **AC**-Acidic **N**-Neutral
Light: **S**-Sun **FS**-Full sun **PSH**-Part shade **FSH**-Full shade
Drought OR Waterlogging: **S**-Sensitive **MS**-Moderately sensitive **T**-Tolerant **LT**-Low tolerant **MT**-Moderately tolerant

Species	Full-grown size and growth rate	Spacing	Best conditions	Notes	Good for your site?
Sargent's crabapple *Malus sargentii*	H: 6-10 feet W: 6-12 feet Medium	2-4 feet	pH: AC-ALK Light: S Drought: M Waterlogging: M	Non-native	
Siebolds shrub-ginseng *Eleutherococcus sieboldianus*	H: 8-10 feet W: 8-10 feet Medium	2-4 feet	pH: AC-ALK Light: S to PSH Drought: LT Waterlogging: LT Salt tolerant	Non-native	
Smooth arrowwood viburnum *Viburnum dentatum*	H: 6–10 feet W: 6–12 feet Medium to fast	2–4 feet	pH: AC Light: S to PSH Drought: M Waterlogging: M Salt tolerant	Native to North America	
Smooth wild rose *Rosa blanda*	H: 3–5 feet W: 3–5 feet colony forming Fast	2–4 feet	pH: ALK Light: FS Drought: M Waterlogging: M	Native to North America	
Spreading cotoneaster *Cotoneaster divaricatus*	H: 5–8 feet W: 5–8 feet Medium	2–4 feet	pH: ALK Light: S to PSH Drought: M Waterlogging: LT Salt tolerant	Non-native	
Vernal witch-hazel *Hamamelis vernalis*	H: 6–10 feet W: 10–15 feet Medium	2–4 feet	pH: ALK Light: S to PSH Drought: M Waterlogging: M	Native to North America	
Wild plum *Prunus americana*	H: 10–25 feet W: 15–25 feet colony forming Medium	3–5 feet	pH: ALK Light: FS to PSH Drought: M Waterlogging: M	Native to North America	

pH: **ALK**-Alkaline **AC**-Acidic **N**-Neutral
Light: **S**-Sun **FS**-Full sun **PSH**-Part shade **FSH**-Full shade
Drought OR Waterlogging: **S**-Sensitive **MS**-Moderately sensitive **T**-Tolerant **LT**-Low tolerant **MT**-Moderately tolerant

* A cultivar is a variety of a species that has been bred for specific characteristics. If your vegetation barrier will be near a location where people spend time outside, we strongly recommend choosing a female cultivar of Chinese juniper or eastern red cedar because these trees will not produce pollen that can make allergies worse. All spruce trees produce pollen because they do not have separate male and female trees, but spruce pollen is less allergenic compared to pollen from other tree species.[1]

Tree quantity

Once you've selected your species, determine how many trees your site will need by finding the spacing of your chosen species in the Evergreen or Deciduous Tables. Then take the vegetation barrier length from Field Sheet #2 and divide it by spacing. If you will be using Design Option 2 (Guide #2) with two rows of trees, multiply that number by two to determine the quantity of trees your barrier will need.

Tree Quantity Calculation

Vegetation barrier length	**÷ Spacing**	**× Rows**	**= Quantity of trees**
Example: 300 feet	÷ 5 feet (Black Hills spruce)	× 2	= 120
	÷	×	=

Cited sources
1. Ogren, 2015. The Allergy Fighting Garden. 10-Speed Press, Berkeley, California.

FIELD SHEET #7

Choosing Nursery Trees

Bring this field sheet with you when shopping for nursery trees.

Materials

- Phone (camera)
- Clipboard/note paper and pen
- List of best species and quantity needed for your site (Field Sheet #6)

Checklist

Above-ground condition

- Tree is not much larger or smaller than its container
- Fairly straight and central leader (single main trunk)
- Few to no brown spots
- No root wrapping around the trunk

Below-ground condition

- Roots spread out from trunk like spokes of a wheel
- Few circling roots wrapping around root ball

FIELD SHEET #8

Improving Soil Conditions

Use this guide to determine how much organic amendment to order and then bring the guide into the field when you are ready to improve your soil.

Calculate the amount of organic amendment to order

Use your measurements of the planting area and the formula below to calculate how much EQ Compost you should order. This calculation assumes you'll spread a 4-inch layer of amendment over your planting area before mixing it into the soil.

Vegetation barrier length (feet)	**× Vegetation barrier width (feet)**	**÷ 81 (conversion factor)**	**= Volume of compost (cubic yards)**
Example: 300 feet	× 30 feet	÷ 81	= 111 cubic yards
	×	÷ 81	=

Materials needed for surface decompaction by hand

- Organic amendment (see previous section to determine the amount you need)
- Shovels
- Spading forks (also called garden forks)
- Metal rakes (this tool is needed to smooth out the ground and spread mulch)
- 5-gallon buckets or wheelbarrows for moving amendments
- Straw or wood chip mulch to cover planting area to prevent soil from getting washed away
- Optional–rototiller that can till at least 12 inches deep

Surface decompaction by hand

Preparation

- Confirm that there are not underground utilities in your planting area (see Guide #2) before you start digging.
- Use stakes, traffic cones, or other objects to mark the area that needs to be treated.
- Call your friends! Decompaction by hand is a lot of physical work, so the more people the merrier. Make sure you have enough shovels and forks for everyone.
- Planning events around weather is tricky. To get the best results, DO NOT attempt to decompact the soil when it is very muddy (if soil is sticking to your shoes when you walk on it). But if the soil is too dry (almost dusty), then it will be very difficult to dig.
- If this is your first time using this technique, try a practice section before the event to make sure you have a process that is good for your site and the right equipment.

Process

Guide #8 describes the surface decompaction process in more detail.

- Step 1: Turn the soil. Start by pushing a spading fork as deep as you can into the soil. Then move it back and forth to loosen the soil a little bit. Then push on the fork to pry pieces of the soil apart. This should pop large chunks of soil out of the ground. Step backward and repeat until you have a large area of loosened soil. A rototiller could also be used for this process.
- Step 2: Add the compost about 4 inches deep over the surface of the turned soil.
- Step 3: Mix in the compost.
- Step 4: Level the soil.
- Step 5: Spread the wood chips (Guide #10 – Mulching).

FIELD SHEET #9

Tree Transport, Inspection, and Storage

Bring this field sheet along when your trees are delivered to the planting site.

Materials

- A record of trees ordered
- Water source and hose
- A partially shady area for storing trees prior to planting if storing for more than 36 hours

Inspection at delivery

When the trees are delivered and before the delivery truck leaves, inspect the trees using this checklist:

- ❏ Leaf size, color, and appearance are appropriate to the time of year and stage of growth.
- ❏ No signs of prolonged moisture stress or overwatering (wilted or dead leaves)
- ❏ No evidence of dead, diseased, or seriously injured branches
- ❏ Container soil should be moist throughout.

Storing container-grown trees

Ideally, trees should be planted within 36 hours of delivery. When that is not possible, use the following checklist to ensure tree health and quality are maintained.

- ❏ Check soil moisture daily (and irrigate as required).
- ❏ Trees are stored in a partially shady area if possible; this will help reduce the likelihood that they will dry out.

FIELD SHEET #10

Tree Planting

Bring this field sheet with you to your tree-planting day.

Materials

- Bypass hand pruners with sharpened blades
- Hand saw
- Measuring tape
- Shovels/equipment for digging
- Pitch fork (optional for moving mulch)
- Metal rigid rakes
- Water source (hose and/or buckets)

Corrective pruning for roots before planting

- Use a sharp saw to trim off the outer $^1/_2$ to 1 inch of soil and roots from the root ball. A pair of bypass pruners can also be used to cut woody roots that are not pointing away from the tree.
- To check for circling roots closer to the trunk, knock off soil from the top of the root ball until you find the place where the first large root and stem are connected. If you find a root that is growing or starting to grow in a circle, use your hand pruners to cut it off. If left alone, eventually that circling root will strangle the trunk and kill the tree.
- DO NOT hack roots off with a shovel blade. Make clean cuts with pruners or a sharpened saw.

Tree-planting process

- Planting hole depth = the distance from the bottom of the root ball (the soil and roots held together within the planting container) to the top-most large root. It is better that the planting hole is slightly shallower than the depth of the root ball rather than deeper than the root ball.
- Planting hole width = a saucer-shaped planting hole with sloping sides that is two to three times the diameter of the tree's container. For example, if your tree's container is 1 foot in diameter, then the planting hole should be at least 2 feet wide.
- You can dig individual holes for each tree, or if the trees need to be spaced closely together (such as 5-foot spacing), it may be simpler to dig one long trench to plant the trees in.
- Rough up the walls of the planting hole to eliminate the possibility of it restricting root growth into existing soil. This can also be done after the tree is placed in the hole but before the soil is added.
- Place the tree in the hole. All trees should be placed on a firm, undisturbed soil base at the bottom of the hole. If the hole is dug too deeply, add additional soil and tamp firm. When you put the tree's root ball in the hole, the root flare should be level with the surface of the ground. Use a shovel handle to confirm proper elevation by laying it across the root and existing edge of the planting hole.
- Fill the hole about halfway with soil. Gently press down on the soil, then add a bucket of water to the hole to help the soil settle in. You may find it helpful to have one person hold the tree upright while another person adds the soil.
- Finish filling the hole with soil. Again, gently press down on the soil and add a bucket of water so that the ground and tree are stable. The soil should be firm enough so that the tree can stand upright on its own.
- Remove all plant identification tags, ribbons, trunk protection, or packing from the nursery. Eventually these will fall off on their own and become litter or strangle the tree.

FIELD SHEET #11

Mulching

Bring this field sheet on your tree-planting day.

Materials

- Mulch (wood chips, leaves, or straw)
- Rigid rakes

For long planting beds:

- Stakes (wooden or metal), other objects, or spray paint to mark edge of planting bed
- Measuring tape

If smothering grass under planting beds:

- Landscaping fabric and pins/stakes (if not included with the product), or
- Newspaper (do not use glossy newspaper), or
- Cardboard (remove any tape or staples from cardboard first)

Mulch quantity

Option 1: Circles of mulch around each tree
This calculation assumes you will spread the mulch about 2 to 3 inches deep in circles with a 3- to 4-foot diameter around the trees. Each mulch ring should be at least the same diameter as the planting hole.

Quantity trees	**× Volume mulch per tree (cubic yards)**	**= Total volume of mulch (cubic yards)**
Example: 50	× 0.1 cubic yards	= 5 cubic yards
	× 0.1 cubic yards	=

Option 2: Long planting bed
This calculation assumes you will spread the mulch about 2 to 3 inches deep in a long planting bed that contains the vegetation barrier trees.

Vegetation barrier length (feet)	**× Vegetation barrier width (feet)**	**÷ 108 (conversion factor)**	**= Volume of compost (cubic yards)**
Example: 100 feet	× 10 feet	÷ 108	= 10 cubic yards
	×	÷ 108	=

Adding mulch

Prepare planting bed by smothering grass
Use this process if there is still grass between planting holes that you would like covered with mulch. You will need to remove or kill grass prior to placing the mulch; otherwise the grass will just grow through the mulch. The grass could also be removed manually or with an herbicide.

- Use a measuring tape to measure and mark the location and dimensions of your planting bed.
- Check the area to be cut for sticks, stones, or other objects that could poke a hole through the covering material.
- If using landscaping fabric, follow the product instructions to cover the entire planting area.
- If using newspaper, spread a layer of newspaper about 10 pages deep over a portion of your planting area. Make sure the newspaper pieces overlap each other to prevent grass from growing between gaps. It can be helpful to spray the newspaper with water to help it stay in place while spreading the mulch.
- If using cardboard, cover the planting area with cardboard pieces, making sure the pieces overlap to prevent grass from growing through the cracks.
- Cover the landscaping fabric, newspaper, or cardboard with 2 to 3 inches of mulch.

Spread mulch
After your trees have been planted, place your mulch (wood chips, leaves, or straw) in a ring around the tree or across the entire planting bed.

- Use a metal rake to push mulch back over the planting holes after they have been filled back in with soil.
- Rake the mulch so it is about 2 to 3 inches deep.
- IMPORTANT! There should be NO mulch touching the trunk of the tree. We want mulch to keep the soil moist, but if mulch is resting on the trunk of the tree this can keep the bark wet for long periods of time and cause damage to the trunk. Aim to create a donut shape of mulch around the tree to prevent mulch from mounding on the trunk.

FIELD SHEET #12

Tree Stabilization

Bring this field sheet on your tree-planting day.

If your vegetation barrier trees are between 4 and 6 feet tall and NOT in a very windy area, temporary stabilization is likely unnecessary.

IMPORTANT: All stabilization supports should be removed between 12 and 14 months after planting. Otherwise the supports will start to interfere with tree growth. If you can't guarantee that stabilization supports will be removed in a timely manner, it is probably better not to use them at all.

Materials

- 2 x 2-inch wooden stakes
- Three 18-inch-long stakes for guying each evergreen OR
- Two 6-foot-long stakes for staking each deciduous tree
- Smooth, broad (> 2.5 cm wide), pliable ties or webbing (biodegradable options include folded denim, coco rope)
- Scissors for cutting ties
- Hammer or mallet

Guying process (preferred for evergreens)

- Drive three wood support stakes (2 x 2 x 18 inches) into the ground outside the planting hole, evenly spacing them around the hole.
- Starting at the first stake, attach one end of the tie or webbing to the stake. Loop the other end of the tie around the tree's trunk at less than two-thirds the height of the tree. Then attach the loose end of the tie to the stake, completing the loop.
- Repeat the process for the other two stakes.
- The ties do not need to be perfectly tight, but they should not be extremely slack and loose either. You should be able to wiggle the trunk a little. Your main goal is to prevent the tree from getting completely blown over.

Staking process (preferred for deciduous trees)

- Because wind generally blows from west to east in the Chicago region, place the first stake on the western side of the tree.
- Place the second stake opposite the first stake.
- Drive the stakes into undisturbed soil outside of the root ball until stakes are secure.
- Use the ties or webbing to connect the tree and the stakes. The ties should be no more than two-thirds up the height of the tree, still allowing for trunk movement.
- The ties do not need to be perfectly tight but they should not be extremely slack and loose either. You should be able to wiggle the trunk a little. Your main goal is to prevent the tree from getting completely blown over.

FIELD SHEET #13

Long-Term Tree Care

Keep this field sheet handy as you check on your trees as they grow.

Irrigation water quantity

The width or diameter of the tree trunk can be used to roughly estimate how much water to apply when irrigating.

Tree trunk diameter (measure about 6 inches above the ground)	× 1	= Volume of water (gallons) per tree
Example: 2 inches	×	= 2 gallons
	×	=

Irrigation schedule

- In the first few months following planting, check newly planted shrubs and trees often because the potting soil around their roots can dry out quickly. Apply water as needed.
- After the first 12 weeks, water your trees weekly between May and September for the next two years.
- Keep in mind that trees will experience greater water stress during periods of drought or low rainfall periods and may need extra watering during very hot or dry weather.

Month	Year 1	Year 2	Every year
April			Check trees for winter damage (broken branches, large dead patches)
May	❑ Water weekly	❑ Water weekly	Option: Apply a pre-emergent herbicide
June	❑ Water weekly ❑ Remove weeds	❑ Water weekly ❑ Remove weeds	❑ Water as needed during dry periods
July	❑ Water weekly	❑ Water weekly	❑ Water as needed during dry periods
August	❑ Water weekly ❑ Remove weeds	❑ Water weekly ❑ Remove weeds	❑ Water as needed during dry periods
September	❑ Water weekly	❑ Water weekly	
October	❑ Water weekly ❑ Remove staking if used (Guide #12)	❑ Water weekly	

Lesson Plans

The following set of lesson plans using problem-based learning and citizen science approaches are available from The Morton Arboretum's Education Department in both PDF and Word document forms. Materials such as portable air quality sensors can also be available for classrooms to borrow. Connect with The Morton Arboretum's Education Department at registrar-ed@mortonarb.org.

Curriculum outline and lesson progression (Strategy-based: problem-Based learning & citizen science)

- **Setting the stage**
  - Introduction Activity – Anticipation Set- Find the Fiction – Air Quality Headlines Activity
  - Vocabulary Build: Vocabulary Story – Air Quality and Trees
- **Investigating the problem**
  - Observation: Measuring the Air Quality at Your Site, How to Use the Sensors, and Understanding Air Quality.
    - ♦ Additional resources: U.S. Environmental Protection Agency (Air Sensor Loaning Resource) (only available as an appendix in toolkit's printed resource)
  - Connect: Trees, Shrubs and Air Quality – Science Notebook Activity
- **Designing a solution**
  - Action Planning Worksheet
  - Planning Your Vegetation Buffer
  - Investigating Soil on Your Schoolyard
  - Choosing the Trees for Your Barrier – Final Planning Activity
  - Bringing It All Together – Planting Design Proposal

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