URBAN FOREST SUSTAINABILITY GUIDE

A community guide to sustaining healthy street trees in the path of invasive species and climate change

INVASIVE SPECIES MANAGEMENT

SAINT LAWRENCE
EASTERN LAKE ONTARIO

SLELO PRISM Urban Forest Sustainability Guide

Foreword

Numerous studies have demonstrated that trees benefit the environment, human health and wellness, and the social, economic, and aesthetic aspects of our communities. Overall, there are an estimated 5.5 billion trees (39.4% tree cover) in urban communities nationally(1). Each of these communities having many components that must be considered to maintain their urban forests.

This guide is designed to help our communities sustain their urban forests by encouraging the following strategies: increased tree species diversity, planting climate adaptable trees, implementing proper pest management, planting the right trees in the right places, and selecting native rather than non-native tree species. Additional tools for sustaining your urban forest can be found at the SLELO PRISM website at sleloinvasives.org/urbanforestsustainability .

The St. Lawrence and Eastern Lake Ontario Partnership for Regional Invasive Species Management (SLELO PRISM) is a group of organizations whose mission is to protect native habitats, biodiversity, natural areas, parks and open space by using a collaborative and integrated approach to invasive species management. In response to concerns posed by communities within the SLELO region regarding the impacts of forests pests, SLELO partners have been working with state and county agencies, local organizations, municipalities and interested parties to pro-vide stakeholders with the information they will need to prepare for and manage invasive species including urban street trees. More information on the SLELO PRISM can be found here: sleloinvasives.org.

Integration with The New York State Urban and Community Forestry Program

The New York State Urban and Community Forestry, U&CF, Program is a partnership between the New York State Department of Environmental Conservation, forestry professionals, public and private individuals, and volunteer organizations who care about trees in urban settings. It supports and assists communities in comprehensive planning, management, and education to create healthy urban and community forests to enhance the quality of life for urban residents. Combined, the SLELO PRISM program and the U&CF program serves as a collaboration to promote healthier urban forests for the benefit of nature and people. More information on the U&CF program can be found here: www.dec.ny.gov/lands/4957.html

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THE IMPORTANCE OF TREES TO URBAN COMMUNITIES

Urban forests come in many different shapes and sizes. They include urban parks, street trees, landscaped boulevards, gardens, coastal boardwalks, open space and so on. Urban forests are a component of a city or town's green infrastructure on which communities, ie people, depend and provide critical benefits to people and wildlife.

Urban forests help to filter air and water, control storm water and conserve energy. They add beauty, form, and structure to urban design. Trees provide places to recreate, strengthen social cohesion, promote community revitalization, and add economic value to our communities. Additionally, several recent studies have identified a relationship between the natural environment and improved health.[2]

Healthy Trees Filter Air and Produce Oxygen

Trees improve air quality through removal of pollutants such as ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter. This reduction in pollutants has been calculated to have saved more than 850 lives a year and prevented 670,000 incidences of acute respiratory symptoms.[3]

Carbon dioxide that is emitted into our atmosphere from fossil fuel combustion, automobiles, home heating, etc., is collected by trees and used to make glucose (sugar) and water. Add sunlight and this completes the photosynthetic process whereby oxygen is released into the atmosphere. A mature sycamore tree, for example, produces about 100kg of oxygen per tree per year and an average adult person consumes about 740kg of oxygen per year roughly equating to every human requiring oxygen produced by seven or eight trees.[4]

Trees, Carbon, and Climate

In the United States the largest source of greenhouse gas emissions is from burning fossil fuels for electricity, heat, and transportation.[5] Carbon dioxide (CO_2) constitutes most of these emissions at 82%. Urban forests can mitigate some of these CO_2 climate changing emissions through sequestering atmospheric carbon from CO_2 into their tissues and by reducing fossil fuel-based energy used for heating/cooling.[6] The average U.S. City stores about 7.7 metric tonnes per hectare (3.43 US tons per acre). [7]

Trees and Stormwater

Often referred to as natural sponges, trees soak up water from the ground, filter it through biological processes, and then release cleaner water into the atmosphere. One large, healthy tree can absorb up to 100 gallons of water from the ground and discharge it into the atmosphere in a single day.[8] Trees also reduce stormwater runoff by capturing water along its leaves, stems, and trunk. Planting of trees over impervious surfaces can reduce surface runoff by up to 20%. Further reduction of runoff is achieved by its roots, which break up compacted soil, allowing for more water infiltration.[9]

Urban Heat Islands and Home Cooling

The term "heat island" describes developed areas that tend to be warmer than rural areas due primarily to heat absorbing structures such as pavement, concrete, brick and other construction materials. Heat islands can increase energy demand for cooling, elevate air pollution and greenhouse gas emissions, compromise human health, and impair water quality.[10] Trees in urban communities can reduce this heat island effect by providing shade and through evapotranspiration. Shaded surfaces have been found to be 20-45°F cooler than unshaded surfaces. Evapotranspiration is a release of water to the atmosphere from the tree canopy and results in a cooling effect, much like sweating. The combination of shade and evapotranspiration can reduce air temperature during the peak summer by 2–9°F.

Neighborhood Aesthetics and Property Values

A walk along a neighborhood street covered with healthy tree canopy feels much different than walking a street with few or no trees at all. Trees add landscape variation through different colors, textures, forms, and densities.[11] They also distract the eye from less attractive features such as parking lots, walls, and highways.[12] Having trees and other vegetation on a residential property adds up to 37% to its value.[13]

DEVELOPING A SUSTAINABLE URBAN FOREST

The development of a sustainable urban forest requires a group to manage the forest and rules for the community to follow. It also requires the establishment of an urban forest management plan and an urban forest preparedness plan.

Establishment of Tree Ordinance and Tree Board

To ensure that your urban forest is properly managed, a tree ordinance and tree board should be established. A tree ordinance provides legal authority for communities to conduct forestry programs, define municipal responsibility for public and private trees, pass regulations, and set minimum standards for management.

It may also include the establishment of a tree board. The tree ordinance should be individualized for your community but consulting other communities about their tree ordinance is still a good idea. A breakdown of basic components and examples of tree ordinances can be found at NYS DEC Urban Community and Forestry Website[14]

A tree board guides the management of community trees and may consists of municipal staff, citizens, and/or tree care professionals. The tree board is established through the tree ordinance or a separate ordinance. Some activities that board members may participate in include tree inventories, tree planting/removals, invasive species early detection surveys, education and outreach, and long-term urban forest health planning.

Tree City USA

The Tree City USA program provides direction, technical assistance, public attention, and national recognition for urban communities and is sponsored by the Arbor Day Foundation in cooperation with the USDA Forest Service and the NYS DEC Urban and Community Forestry Program. Creating a tree ordinance and board is half the requirements for membership. The other requirements are a community forestry program with an Annual Budget of at Least $2 Per Capita and an Arbor Day Observance and Proclamation. More information on membership can be found at the NYS DEC Urban and Community Forestry Program[14] and Arbor Day Foundation[15] websites.

URBAN FOREST MANAGEMENT PLAN

Creating an urban forest management plan involves getting to know your forest through inventory, both the good and bad elements. It also establishes the work plan and expenses required to sustain your forest.

Conducting a Tree Inventory

The first step to enhancing the sustainability of your urban forest is to conduct a tree inventory. A tree inventory is all about getting to know your urban forest, both the good and the bad. It provides the basic information required to make sound management and budgetary decisions. Information, such as types of trees, location, condition, pruning requirement, insect infestation, etc. can be gathered during these inventories. The need for tree plantings and removals can also be obtained. Having an arborist or urban forester on staff or contracted will be essential for the inventory and maintenance of your urban forest. The following tree inventory steps are in accordance with the ones proposed by Penn State Extension.[16]

Planning

Before doing anything, you need to assess what you need to know about your urban forest. Collecting information cost money and should be limited to what is required. A survey of practicing urban forest managers found the following variables to be the most useful: species (scientific name), size (dbh, height, crown width), condition (good, fair, poor or dead), location, presence of dead wood, weak forks,

cavities and over-head wires, and management needs (pruning or removal). Hazardous tree locations and available planting spaces will also need to be recorded during the inventory. It is also recommended that each tree be evaluated for signs of invasive and native pest infestation.

Who will do the inventory?

Either professionals or trained volunteers can do an inventory. A study by Bloniarz & Ryan[17] showed that trained volunteers performed urban forest inventories as well as professionals. The main difference is that volunteers typically require more training time to conduct the inventory accurately. It is advised that a person trained in hazardous trees assessment be the one to evaluate all trees for hazardous condition.

How will the data be recorded?

Data may be recorded using paper or a mobile computing device. Either method should have a format available to fill out for each tree evaluation. A separate GPS device should be used for recording the location of each tree when using a paper form or using a mobile computing device without GPS ability.

What additional resources/ equipment are required?

Vehicles, neighborhood maps (paper or digital), personnel to input/maintain inventory/create urban forest map, and funding must also be considered. Communities seeking financial assistance for the inventory may apply for urban and community grants offered annually by the New York Department of Environmental Conservation[18].

Implementation

Implementation should be completed when all trees are fully leaved (late spring to early fall). Each member will first be trained in accordance with their assigned task, whether it is measuring dbh, height, and crown width, or identifying the species of the trees. Teams may then be sent to designated neighborhoods to conduct the inventory. Upon completion of the inventory, data gathered will be inputted into a designated computer program and maps of urban forest created.

Compiling & Analyzing Data

After completion of the inventory, all data gathered will need to be compiled and summarized into one spreadsheet. This information will then need to be analyzed to assess urban tree composition, age structure, maintenance (pruning/removal), and planting requirements. Tree composition issues to be considered include urban forest diversity and percentage of native and non-native (non-invasive and invasive). A general guideline used to check for adequate diversity is called the 10-20-30 rule. To use this rule, a percentage of each species, genus, and family will need to be calculated. An increase in diversity is considered essential if your urban forest has more than 10% of any species, 20% of any genus, or 30% of any family. Age structure should be broken down by age classes by DBH (0”-8”, 9”-17”, 18”-24”, > 24”). Information to help you determine percentage of native, non-native non-invasive, and non-native invasive tree species can be found on the New York Flora Association website (native vs. non-native) and the New York Invasive Species (IS) Information website (lists non-native invasive tree species). In addition, a map should be created that includes the location and species type of all trees inventoried and if any tree is hazardous or invasive.

Maintenance & Costs

A work plan should be made that includes basic maintenance issues such as tree plantings and removals, pruning, and fertilizing. In addition, urban forest sustainability issues such as increasing species diversity, age structure, quantity of climate adaptable tree species, and, if necessary, pest management should be considered.

Urban forests also continue to change like any forest and need to be periodically re-inventoried to ensure their health. Inventories will no longer be significantly accurate after 5-10 years, so it is important that an inventory be conducted again within this period. This can be done as a whole forest inventory as the initial inventory was or in sections on an annual basis. Either way, annual health assessment should be conducted to limit the presence of hazard trees and to look for invasive pests and pathogens. A proposed budget that outlines the costs and benefits of the inventory and alterations will need to be created and submitted to your municipality.

One software program that can be used for both the inventory and cost benefit analysis is called iTree and was created by a USDA collaboration with many other organizations.

CREATING AN URBAN FOREST PREPAREDNESS PLAN

An urban forest preparedness plan is a proactive strategy for urban forest resilience to invasive pests, pathogens, and climate change. Its main components are urban forest risk assessment and urban forest health.

URBAN FOREST RISK ASSESSMENT

An urban forest risk assessment determines which invasive pests and pathogens will likely have a negative impact and how much that impact will cost. The effects of climate change on your forest can also be determined through a risk assessment. This knowledge allows for a pro-active approach to management.

Invasive Pest & Pathogen Infestation

During the early 20th century, the American elm was planted in large numbers throughout U.S. urban areas. By the 1930's, Dutch Elm Disease had started killing off these trees and by the 1970s, 40 million of these trees had died.[19] Many of these trees in the Midwest and northeast were replaced by maples and ashes.[20] In 2002, Emerald Ash Borer (EAB) was first discovered in southeastern Michigan. It has since killed tens of millions of ash trees across 30 states[21] with a total cost expected to reach $12.7 billion dollars by 2020.[22] Spotted lanternfly, a relative newcomer, was first discovered in 2014 in Pennsylvania and feeds on many different fruit, ornamental and woody trees including maples.[23] The history lesson to be learned from these events is that each tree species has invasive pests and pathogens that they are vulnerable to and 100% resistant trees don't exist. The invasive species for some of these trees may be in your area now, while others may be moving in soon, or have yet to arrive in the country. To fully understand the risk involved, a risk assessment of your urban forest should be completed. The first step in this assessment is to create a spreadsheet that lists all the species in your urban forest. With this information, an estimate of financial cost for tree removal, replacement, or pesticide treatment can be made. Financial loss in the form of lost ecosystem services can also be estimated.

The greatest advantage in having an urban forest risk assessment is the ability to take a proactive approach to mitigating the risk from invasive pests and pathogens. If funding for these events is added to the annual budget, the financial strain involved with a sudden loss in trees declines. In addition, the planting of tree species likely to be affected by invasive pests and pathogens in the near future can be eliminated or minimized. This will also serve to minimize the financial impact that an invasive pest or pathogen infestation may have on your community.

Climate Change Impact

From 1901 to 2011, the annual mean temperature of New England and northern New York has increased 2.4 °F and is predicted to increase 3-8°F by 2100. Greater winter precipitation and longer periods of drought in the summer are also predicted. These changes will negatively impact many of the northern and boreal tree species, while benefitting other tree species.[24] Knowing which of your urban trees should do well and which will probably do poorly in future conditions is critical to creating an urban forest risk assessment and for quality management. A good source for learning the climate change adaptability of common native tree species is the climate change atlas on the USDA Forest Service website.[25] This information should be added to your list of tree species as an additional assessment tool. With this tool, estimation of tree loss due to future climate incapability can be made and accounted for in future budget proposals. A shift to planting more climate adaptable tree species should also decrease future tree loss and save money. Adaptability of native trees will be discussed in a later section.

URBAN FOREST HEALTH

Maintaining urban forest health is about building resiliency into your forest. It starts with knowing the right tree for the right place. It continues with increased species and age diversity, avoiding high pest vulnerable tree species, and planting climate change adaptable tree species.

Planting Basics

Each tree species is adapted to the conditions where they naturally occur and will not likely thrive in areas that have much different conditions. Trees in an urban environment are often planted in a variety of locations such as sidewalks, parks, yards, around private and public businesses, and in small public spaces. To ensure the success of trees within this diverse environment, each location must be carefully matched with a tree species tolerant to its conditions and suitable to its location. Some of the environmental conditions to be considered at each site include the soil type, available sunlight, hardiness, and growing space. The right soil type for a tree is very important as it provides the nutrients, water, air, and organic matter required by them. Some of the factors to consider are texture, pH, salinity, and fertility. Texture is the relative content of sand, silt, clay in a soil and affects how much moisture the soil can hold and how fast water can move through it. Soil pH is a measure of acidity or alkalinity, while salinity is a measure of salt content. Soil fertility is a measure of the amount of important plant nutrients, such as nitrogen, phosphorus, and potassium, in a soil.

The amount of nutrients, pH, and salinity can be obtained by use of a soil test kit or providing a sample to your county cooperative extension. Available sunlight for trees is described in terms of intolerant (full sun), intermediate (partial sun), or tolerant shade (shady) tolerance and should be matched carefully with conditions at a site. Hardiness is associated with typical temperature extremes of a given area during the year. The USDA has created a plant hardiness zone map[26] that assigns a number/letter code for each climate type in the United States. Make sure to know the hardiness zone of the area and a tree species hardiness preference before purchasing or planting any tree. A common motto in urban forestry is right tree, right place; so far, we have discussed the requirements and advice that apply just as well to a rural forest setting, but in an urban forest, right place takes on a deeper meaning. With an assortment of streets, buildings, power lines, statues, sidewalks, and other manmade construction, proper spacing becomes a very real issue. The solution to this problem is to plant trees that meet the height and width restrictions that come with a certain planting area. Different trees species have different height ranges and come in an assortment of shapes. In areas where height would become an issue, as with under powerlines, a shrub or small stature tree would be the most appropriate choice. In areas with width limitations, like sidewalks close to roads, a narrower form tree would make sense. Underground space also needs to be considered when selecting a tree species. Typically, a large tree will need 200-400 square feet of underground growing space for the root system, while a small tree will need 100-200 square feet of growing space for the root system.[27] Choosing the right tree for the right place ultimately saves the municipality money and time by avoiding unnecessary pruning and removal of poor health/dead trees and those growing outside their urban boundaries.[28] A great source of information concerning urban tree health is the New York State Department of Environmental Conservation ReLeaf program. It is a partnership of professional urban foresters and community members that offers courses in techniques of site and tree selection, along with planting and maintenance techniques. More information on this program can be found on page 17 of the guide and the NYS DEC Urban and Community Forestry website.[29]

Planting Native Trees

Another consideration when planting trees in the urban landscape is native vs. non-native. In this guide, we recommend planting native rather than non-native for several reasons. One reason is that native trees have co-evolved with native wildlife and better provide the food and shelter required for their survival. An example of this was found in a study by Narango, Tallamy, and Marra[30], in which non-native plants were found to support fewer arthropods than native plants and this led to a decrease in the number of Carolina chickadee young produced. This effect becomes of great concern when one considers that 130 million acres of U.S. forest is urban[31] and that the choice of native vs. non-native in this environment can have a serious impact on our native wildlife. Another reason to plant native trees is that they are adapted to the local climate and soil conditions. They are low maintenance! Native trees use less water, little to no fertilizer, little to no pesticides (developed their own defenses against many pests and diseases), and less pruning than non-native trees.[32] The principal of the right tree, in the right place applies perfectly for using native trees and should be seriously considered when making tree selection for your urban forest. A third reason to plant native trees is that they do not present a risk to the surrounding rural forests. While many non-native trees have not presented a problem, others, like

Norway Maple (*Acer platanoides*) and Tree-of-Heaven (*Ailanthus altissima*) are spreading into rural forests and outcompeting the native trees.[33,34] Evaluating the risk of spread potential is something that can be avoided by selecting native rather than non-native tree species.

Native Tree Suitability

Salinity: Salt spray from the roads can cause damage to the stems and buds of all trees and the needles of evergreen trees, while buildup of salt in the soil can damage the root system of these trees. Salt tolerance levels are often divided according to tree exposures to soil salts and to salt spray.[35] Soil salt and salt spray tolerance levels for the tree species on Table A is based on information from ten academic or government sources.[i] Salt tolerance levels varied among these sources and those stated in the table are in accordance with the majority. Please keep in mind that salt tolerance can vary within the same species and that data collected in different climates and soils may create differences in salt tolerance.[35]

Shade Tolerance: The amount of shade a tree can tolerate will determine how well it survives in any given location. The shade tolerance levels on Table A are in accordance with the USDA and splits tree species according to tolerant (shady), intermediate (partial sun), and intolerant (full sun) shade tolerance. The tolerance of these tree species to sun exposure may vary with the quality of the planting site and the age of the tree.[36]

Drought Tolerance: This is a measure of a tree species ability to tolerate periods of dry conditions. Tree species that only occur in low, poorly drained soils are considered to have no drought tolerance, while those that only occur in high, well drained soils are considered to have high drought tolerance. Trees found in between these extremes are considered to have low to medium drought tolerance.[37] The drought tolerance levels on Table A are in accordance with the USDA drought tolerance levels for each tree species.[38]

Optimum Soil pH range: This is a measure of the hydrogen concentration within a soil and ranges from 0, which is highly acidic to 14, which is highly alkaline with 7 being considered neutral. Each tree species survives best within a certain pH range and should be planted accordingly. Optimal soil pH levels on Table A are in accordance with the USDA minimum and maximum pH data for each species.[38]

Hardiness Zone: The USDA has divided the country into hardiness zones according to the annual minimum winter temperatures[26]. The distribution of each tree species corresponds with and is adapted to the climate in one or several of these zones. Table A provides the hardiness zones for each tree species.[39, 40, 41] Only tree species listed as being in your hardiness zone should be planted in your area. Be sure to know your hardiness zone prior to any planting. You should also try to purchase trees close to your area since climate tolerance can vary according to seed source.[42]

Climate Adaptability

The future climate is predicted to be warmer with greater precipitation in the winter and spring along with greater drought conditions in the summer.[43] To sustain the urban forest throughout these changes will require several strategies. Much of the following advice concerning adaptability was resourced from the Adaptation Workbook, which was created by the Northern Institute of Applied Climate Science[44] with partnership of the USDA, U.S. Forest Service and American Forests. Some recommended strategies include:

Increase Species and Age diversity: The urban forest will be stressed by climate change in many ways (floods, drought, increased temp., etc.). One way to make these forests less vulnerable is to promote species diversity. Diverse forests minimize the risk of substantial tree canopy and ecosystem service loss by distributing the risks among multiple species. That is, in droughty events, drought tolerant trees will keep the urban forest functioning, while in flood conditions, the flood tolerant trees will keep the urban forest functioning. This strategy also applies to the age structure of the urban forest. It is recommended that urban forests be evenly distributed among age classes since trees are more or less vulnerable to certain conditions at certain ages. For example, young trees generally do better during wind events, while older trees do better during long periods of drought. Age diversity can be increased through geographically dispersing, rather than congregating, your annual tree plantings and removals. Planting replacement trees in anticipation of mortality from a pest like emerald ash borer is also a good strategy for age diversification.

Select Trees that will Succeed in Present and Future Conditions: To further ensure the resilience of your urban forest to more extreme climate conditions, the natural tolerance levels of each tree species should be considered. Tree species that grow in a wide variety of conditions will most likely perform better than tree species that grow in a narrow range of conditions. Also, tree species located at the northern extent of their distribution are more likely to succeed than those located at the southern extent of their distribution. Tree species can also be selected for their tolerance to predicted climate change conditions at certain urban sites. For example, planting a tree species that is tolerant to flooding at a site predicted to experience more flood conditions. All dead and dying trees in the urban forest should be replaced with climate change resilient species rather than trees that are likely to do poorly in future climate conditions. Climate models that predict future tree species distribution and adaptability are available to assist municipalities in choosing the best trees to sustain the urban forest. A good source for these models is the climate change atlas on the USDA Forest Service website.[25] Another good source for finding climate adaptable tree species can be found in a study by Potter, Crane, and Hargrove. [45]

Invasive Pest & Pathogen Resilience

Vulnerability to Pest and Pathogens: In a study by Potter et al.[46], utilizing knowledge provided by experts in the U.S. Forest Service, species vulnerability to forest pest and pathogens was determined by considering the severity of each tree species major pests or pathogens, its sensitivity to these pests or pathogens and its ability to adapt to these pests or pathogens. Each tree species was then placed into a group according to its vulnerability to current pests and pathogens. New York tree species that were rated as having high insect and disease threat severity were white ash, green ash, black ash, eastern hemlock, and butternut. The following paragraphs will address these species and options to consider in your municipality. For information concerning the vulnerability ratings of other tree species, please see the link to the paper by Potter et al. at the bottom of the page.

Ash Trees and Emerald Ash Borer: The Emerald Ash Borer is a wood boring pest native to China, Mongolia, North Korea, South Korea, Japan, Taiwan, and the Russian Far East and was first discovered in the U.S. in southeastern Michigan in 2002. Since then, it has been found in 35 states, including New York, and has caused the destruction of tens of millions of ash trees.

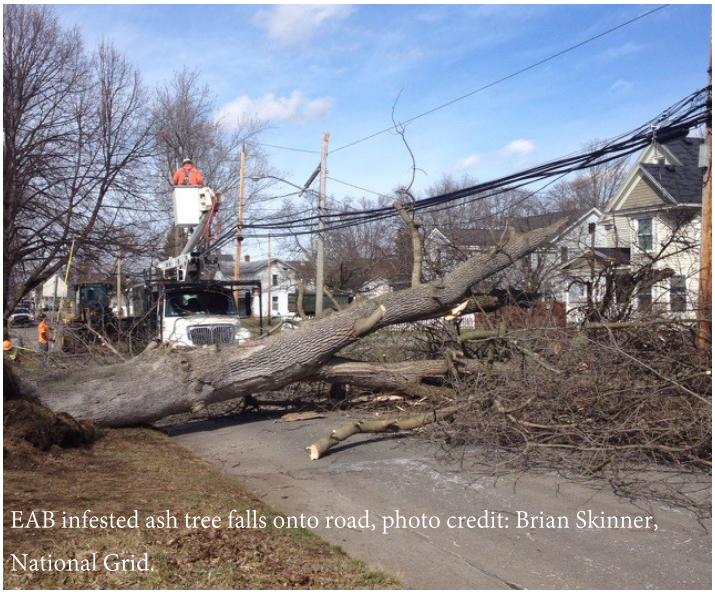
Adult beetles lay eggs in the bark which then hatch and feed on the vascular tissue within the bark of the tree, leading to the eventual death of the tree.[47] Signs and symptoms of the infestation includes: D-shaped holes on bark, S -shaped larval galleries under bark, dieback, yellowing, and browning of leaves, increased woodpecker activity, and "blonding" or large strips of bark falling off.[48] Current options to managing for Emerald Ash Borer include chemical treatment, tree removal, and doing nothing. *There are circumstances where all these options could be applied and are addressed as follows:*

Photo Credits: (left-right, top-bottom), emerald ash borer adult and larva, David Cappaert, Bugwood.org . EAB larval tunnels, Geoff McVey Forest Manager. Tree bark blonding, Mark Whitmore-Cornell.

Chemical Treatment: This is an option for ash trees that have special significance to the community. There are several chemical treatment options available to protect ash trees from EAB, but the success of treatments depends on multiple factors such as the time of year, proper application method, health of the tree, and the EAB infestation density.[49] These treatments can be expensive and vary in effectiveness[50] and will require reapplication. A good resource for chemical treatment options can be found on the Emerald Ash Borer Information Network.[51]

Tree Removal: This should be the option for trees that would become hazardous if infested by EAB and are not of special significance to the community. Trees are best cut down prior to infestation since infested trees become very brittle and difficult to remove safely.[52]

Do Nothing: In situations where the ash trees will not become a hazard, infested ash trees may be left alone. These trees may be monitored for resistance to EAB and if found to be resistant, used as part of a breeding program that could reintroduce ash trees to our rural and urban forests. Municipalities interested in monitoring some of their ash trees can contact the Ecological Research Institute, which is actively gathering information concerning resistant ash through its Monitoring and Managing Ash (MaMA) program.[53]



EAB infested ash tree falls onto road, photo credit: Brian Skinner, National Grid.

Eastern Hemlock and Hemlock Woolly Adelgid: Hemlock Woolly Adelgid (HWA) (*Adelges tsugae*) is a small aphid-like insect native to Asia that is now threatening eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*Tsuga caroliniana*). Signs of infestation include white woolly masses about one-quarter the size of a cotton swab on the underside of branches at the base of needles, needle loss and branch dieback, and gray-tinted needles, and lack of new growth in the spring signified by the absence of bright green needles at branch tips. HWA feed along the base of the needles and can kill a tree in 4 to 10 years.[54]

Current options to managing for hemlock woolly adelgid include chemical treatment, tree removal, biological treatment, and doing nothing. Each of these are addressed as follows:

Chemical Treatment: Individual trees can be treated with a systemic insecticide, but large groups of trees can become cost prohibitive. Imidacloprid and Dinotefuran have both been shown to have promising results. In combination they can ensure that a hemlock tree is HWA free for seven years [54].

Tree Removal: This should be the option for trees that would become hazardous if infested by HWA and where replacement would be preferred over chemical treatment.

Biological Treatment: Several HWA predators, including beetles and silverflies, are being tested for effectiveness in treating infested hemlocks on a large scale in New York. While more research is needed to assess long-term feasibility, studies have shown this to be a promising method of controlling HWA [54].

Do Nothing: In situations where the hemlock trees will not become a hazard, infested hemlock trees may be left alone.

Photo credits: (left-right, top-bottom), white woolly masses of HWA on hemlock needles, tree crown thinning due to HWA, graying hemlock due to HWA, all photos credited to the NYS Hemlock Initiative.

Dead hemlocks in the Pisgah National Forest in NC, photo credit, Steve Norman-U.S. Forest Service.

Butternut Canker Disease: Butternut Canker Disease was first reported on butternut (*Juglans cinerea*) trees in Wisconsin in 1967. It is caused by a fungus (*Sirococcus clavigignenti- juglandacearum*) that is thought to be from outside of North America. Symptoms of butternut canker are elongate, sunken areas that can be found throughout the tree, but commonly appear along the main stem of the tree. These cankers often have an inky black center and whitish margins and merge when in great numbers, girdling and killing the tree[55].

Butternut canker disease, photo credit: Tom Creswell, Purdue University, Bugwood.org

Since the 1980s, there has been a 58% decline in the butternut tree population across its U.S. range.[56] There is currently no known treatment for this condition.[57]

Management recommendations suggested by Ostry, Mielke, and Anderson[58] are as follows:

- Retain trees with more than 70 percent live crown and less than 20 percent of the combined circumference of the stem and root flares affected by cankers.
- Harvest dead or declining trees for wood value or maintain for their wildlife value.
- Retain trees free of cankers with at least 50 percent live crown and growing among diseased trees. These trees may be resistant and used for propagation by grafting or future breeding.

As with hemlocks and ashes, all butternuts that are in decline/dying that would become hazardous should be removed.

Urban Forest Sustainability to Future Pests and Pathogens: Climate change is predicted to allow movement of invasive pests and pathogens to areas that were once not suitable for successful colonization and breeding.[59] This will cause further stress and potential loss of ecosystem services within the urban environment. One way to mitigate this threat is to plant a diversity of tree species. This will decrease the chance that a single invasive species will eliminate the ecosystems services provided by the urban forest. Keeping age diversity also sustains the urban forest by limiting the number of declining older trees that would be more susceptible to invasive species [44]. Another way to mitigate the threat is to have an early detection/rapid response team actively pursuing and eradicating invasive species before they become a serious problem.[60] In some cases, application of insecticide or fungicide may be applied to vulnerable tree species to ensure ecosystem services are maintained [44]

- Habitat for some animals, particularly birds

ADDITIONAL URBAN FOREST CONSIDERATIONS

Creating a pocket park provides social, economic, and environmental benefits to areas that were previously serving no purpose. These parks require community involvement to get established and keep maintained, but are worth considering for any community.

Benefits of Pocket Parks

A pocket park is a small, usually ¼ acre or less in size, open space in an urban area which serves much of the same function as a city park. These are often created in vacant lots by community groups, private entities or foundations for the benefit of the neighborhood.(61) They may be used as event spaces, play areas, places to relax or meet friends, or for lunch breaks. Some basic requirements include: 1) within 5-10 minutes walking distance 2) accessible by foot and bike 3) serve 500-100 people, and 4) attempt to accommodate the needs of all the neighborhood. (62) Each pocket park should also include enough diverse, climate adaptable trees to eventually create a canopy in the park. This will enhance the resiliency of the urban forest in the wake of climate change and invasive species. The benefits of these parks may include[61]:

- Improving the overall ecology of cities through decreased driving to bigger parks
- Reduced pollution, traffic, and consumption of resources such as oil
- Renovation of run-down areas
- Increased amount of permeable surface (reduce run-off)
- Increased physical activity and lowered stress
- Reduction in criminal activity(63)
- Increase in ecosystem services associated with trees in the urban environment

The first step in creating a pocket park is to get the community commitment to creating it. This will require community discussion and agreement as to the expected benefits. It will also require that the community is involved with initiating and designing the park. A steering committee should be created to establish clear roles and responsibility for each person. This committee will need access to all information, resources, and services required for the project. Funding sources for the park may come from private or public sources and will need to be considered for short-term construction and long-term maintenance. Services required will include water, mulch, fencing, and garbage collection and will need to come from city or other service providers. A community-based or community assisting organization(s) should partner with this project to ensure long-term support and resources when needed.(64)

COMMUNITY SCIENCE, EDUCATION, AND OUTREACH

One way to increase urban forest sustainability is to get the public involved in the community science, education and outreach component of your program. Community science (CS) is "the practice of public participation and collaboration in scientific research to increase scientific knowledge".[65] Community science (CS) enables participants with the ability to explore their curiosity and contribute their talents to science through a wide range of programming.[66]

To achieve a higher level of programmatic involvement, CS programs may require a public outreach and education campaign emphasizing the value of urban trees and urban forest ecosystems to their community's sustainability and resiliency.[67] This may be done through multiple media outlets such as municipal websites, social media, newsletters, or local television. Briefings and meetings should be conducted with local organizations such as schools, nonprofits, and community groups. Participation in local events through signage, presentations or displays can also be effective at increasing community awareness of the program. It is important to note that a lead contact should be delegated for the public to work with to create a more effective program.

As community scientists are recruited in your community, participants would require an initial training on expectations and urban forest tasks, such as forest inventories, pruning, planting, and invasive pest and pathogen presence/absence surveys.

Training methods and their effectiveness in your community may vary but could include webinars, in-person classes or field-based workshops that are geared toward varying skill levels. Tasks performed by these volunteers should be conducted, when possible, within their neighborhoods and with their participation and consideration beginning in the planning process.[65]

Motivations of a participant's involvement can vary and their skills should be well understood. An individual's interest and participation may range from in-depth scientific work or assisting in the recruitment of other volunteers, conducting community outreach or by monitoring specific areas through a "adopt-a-tree" type program. CS programs can help to reduce constraints that hinder the success of an urban forestry program, which include local knowledge, time and budget limitations, and personnel capacity.

Community science may provide for a more successful and sustainable urban forestry initiative, but extensive effort should go into the initial development of the recruitment, training and retention aspects of the program. By developing a better understanding of the community's goal for a more sustainable and resilient urban forest, and growing the program around that, the result is a higher level of support and participation in the program.

NEW YORK URBAN & COMMUNITY FORESTRY PROGRAM

The New York State Urban and Community Forestry, U&CF, Program[68] is a partnership between DEC forestry professionals, public and private individuals, and volunteer organizations who care about trees in urban settings. It supports and assists communities in comprehensive planning, management, and education to create healthy urban and community forests to enhance the quality of life for urban residents. Funding for this program is provided in part by the State of New York and the U.S. Forest Service.

The NYS Urban and Community Forestry Program provides technical assistance to communities through local DEC Urban Foresters and ReLeaf volunteers. Additional financial assistance is available from the State through competitive cost-share grants. Technical assistance includes presentations, training workshops, brochures, booklets, information on our website, and helpful links to other U&CF related websites.

This reimbursement grant program focusses on partnerships, volunteers, community groups, professionals and outreach and education because these are components of strong and sustainable community forestry programs. Eligible project categories include tree inventories, management plans, tree planting, maintenance, and education programming for those who care for community trees.

Grant funds are available from the NYS Environmental Protection Fund and are managed and allocated by the Department of Environmental Conservation (DEC). Grant proposals are evaluated for cost effectiveness, projected benefits, use of recommended standards in implementation, community outreach and education, local support, and regional impact. Appropriate consideration is given to under-served neighborhoods, as well as environmental issues that could be addressed with green solutions. DEC foresters can provide technical assistance to applicants and assist with tree lists for planting grants.

URBAN FOREST SUSTAINABILITY TEMPLATES

The following templates list the basic steps required in creating an urban forest management plan and urban forest preparedness plan. A detailed explanation for each step can be found in the appropriate section of the guide.

Urban Forest Management Plan

1. Conduct Tree Inventory

   Include the following:

   - Species (scientific name, family)
   - Size (dbh, height, crown width)
   - Condition (good, fair, poor or dead)
   - Location (GPS coordinates)
   - Presence of Dead Wood, Weak Forks, Cavities and Over-Head Wires
   - Management Needs (pruning or removal)
   - If it Presents a Hazard to the Community (hazard tree)

2. Compile and Analyze Data

   - Summarize Data into One Spreadsheet
   - Create Map of Urban Forest (if possible)
   - Calculate Urban Forest Diversity (10, 20, 30 Rule)
   - Calculate Percentage of Native vs. Non-Native, Non-Invasive (NN(NI)) vs. Non-Native, Invasive (NN(I)) Tree Species
   - Calculate Percentage of Age Classes by DBH (0”-8”, 9”-17”, 18”-24”, > 24”)

3. Develop a Maintenance Plan for Hazardous Trees, Pruning, Fertilization, etc.

4. Include Maintenance Costs in Annual Budget Request

Urban Forest Preparedness Plan

1. Urban Forest Risk Assessment

   A. Risk from Pests/Pathogens

   1. Determine Pest/Pathogen Threats for each Tree Species

   2. Determine Management Options for each Threat

      - Do Nothing
      - Chemical Treatment
      - Biological Treatment (if available)
      - Tree Removal/Tree Replacement
      - Combination Chemical Treatment/Biological Treatment/Tree Removal

   3. Determine Cost of Each Management Option for Each Threat

   4. Select Best Option for Your Community for Each Threat

1. Urban Forest Risk Assessment (continued)

   B. Risk from Climate Change

      1. Determine Climate Change Adaptability for Each Tree Species

      2. Determine Management Option for Each Threat

         - Do Nothing (same management practice/tree selection)
         - Remove Dying/Dead/Poor Condition Trees and replace with Climate Change Adaptable Tree Species

      3. Determine Cost of Each Management Option for Each Threat

      4. Select Best Option for Your Community for Each Threat

   C. Integrate Risk Plan into Annual Budget Request

      1. Prioritize your Risks According to Their Likelihood

      2. Account for the Greatest Risks in Your Annual Budget Request

2. Urban Forest Health

   A. Create Yearly Planting Plan That:

      - Increases Tree Species Diversity
      - Includes Climate Adaptable Trees
      - Increase Age Class Diversity
      - Avoids Planting Trees with Known Invasive Pests or Pathogens (i.e. eastern hemlock, ash trees)
      - Plants Native Tree Species When Possible (Increases Food and Habitat for Native Wildlife)

   B. Include Planting Requirements in Your Annual Budget Request

   C. Recalculate Diversity, Native/NN(NI)/NN(I), and Age Class Percentages During Each Inventory

Table A: Native Tree Suitability

Scientific Name	Common Name	Soil Salt Tolerance	Salt Spray Tolerance	Shade Tolerance	Drought Tolerance	pH range	Hardiness Zone
Acer rubrum	red maple	S	S	Intermediate	Medium	4.7-7.3	3-9
Acer saccharum	sugar maple	S to M	S	Tolerant	Medium	3.7-7.9	3-8
Amelanchier arborea	common serviceberry	S	S to M	Tolerant	Low	4.8-7.5	4-9
Amelanchier canadensis	Canadian serviceberry	S to M	S to M	Intermediate	Low	5.5 to 7.5	4-8
Amelanchier laevis	shadbush	S	S to M	Tolerant	Medium	4.8-7.0	4-8
Betula alleghaniensis	yellow birch	S to M	S	Intermediate	Medium	4.0-8.0	3-7
Betula lenta	sweet birch	S to M	S	Intolerant	Medium	3.6-6.8	3-7
Betula nigra	river birch	S to M	S	Intolerant	Low	3.0-6.5	4-9
Betula papyrifera	paper birch	S to M	S	Intolerant	Low	4.2-7.4	2-6
Betula populifolia	gray birch	S to M	T	Intermediate	Medium	3.5-6.5	3-6
Carpinus caroliniana	American hornbeam	S	S	Tolerant	Low	4.0-7.4	3-9
Carya cordiformis	bitternut hickory	S	S	Intolerant	High	4.8-7.4	4-9
Carya glabra	pignut hickory	S	S	Intermediate	High	4.8-7.3	4-9
Carya ovata	shagbark hickory	S	S	Intermediate	Medium	4.0-7.3	4-8
Celtis occidentalis	hackberry	S to M	S to M	Tolerant	High	6.0-7.8	2-9
Diospyros virginiana	common persimmon	S	S to M	Tolerant	Medium	4.7-7.5	4-9
Gymnocladus dioicus	Kentucky coffeetree	M to T	M to T	Intolerant	Medium	6.0-8.0	3-8
Ilex opaca	American holly	M to T	T	Tolerant	Medium	4.5-7.0	5-9
Juglans nigra	black walnut	S to M	S to M	Intolerant	Low	4.6-8.2	4-9
Juniperus virginiana	eastern redcedar	M to T	S to M	Intermediate	High	4.7-8.0	2-9
Liquidambar styraciflua	sweetgum	S to M	S to M	Intolerant	Low	4.5-7.0	5-9
Liriodendron tulipifera	yellow poplar	S	S	Intolerant	Low	4.5-6.5	4-9
Magnolia acuminata	cucumber tree	S	S	Intermediate	None	5.2-7.0	3-8
Magnolia virginiana	northern sweetbay	S	S	Intermediate	None	5.0-6.9	5-10
Nyssa sylvatica	blackgum	M	M	Tolerant	Low	4.5-6.0	3-9
Ostrya virginiana	eastern hop hornbeam	S	S	Tolerant	Medium	4.2-7.6	3-9
Picea glauca	white spruce	S to M	S to M	Intermediate	High	4.0-8.2	2-6
Pinus rigida	pitch pine	S	S*	Intolerant	Medium	3.5-5.1	4-7
Pinus strobus	white pine	S	S	Intermediate	None	4.0-6.5	3-8
Platanus occidentalis	American sycamore	S	S to M	Intermediate	Low	4.9-6.5	4-9
Prunus serotina	black cherry	M to T	S to M	Intolerant	Medium	4.0-7.5	3-9
Prunus virginiana	chokecherry	M*	M	Intolerant	Medium	5.2-8.4	2-7
Quercus alba	white oak	M to T	S to M	Intermediate	Medium	4.5-6.8	3-9
Quercus bicolor	swamp white oak	S to M	S to M	Intermediate	Low	4.3-6.5	3-8
Quercus coccinea	scarlet oak	T*	S	Intolerant	Medium	4.5-6.9	4-9
Quercus macrocarpa	bur oak	M to T	S	Intermediate	High	4.5-7.5	3-8
Quercus muehlenbergii	chinkapin oak	S	S	Intolerant	High	5.0-8.0	5-7
Quercus palustris	pin oak	S	S to M	Intolerant	Low	4.5-6.5	4-8
Quercus rubra	red oak	M to T	S	Intermediate	Low	4.3-7.3	4-8
Quercus velutina	black oak	S	S	Intermediate	Low	4.5-6.5	3-9
Sassafras albidum	sassafras	S*	M*	Intolerant	High	4.5-7.3	4-9
Thuja occidentalis	northern white cedar	M	S to M	Intermediate	Low	5.2-7.0	2-7
Tilia americana	basswood	S	S	Tolerant	Low	4.5-7.5	2-8
* based on one report							

REFERENCES

(1) Nowak, D. J., & Greenfield, E. J. (2018). US urban forest statistics, values, and projections. Journal of Forestry, 116(2), 164-177. https://www.fs.fed.us/nrs/pubs/jrnl/2018/nrs_2018_Nowak_003.pdf

(2) Donovan, G. H., Butry, D. T., Michael, Y. L., Prestemon, J. P., Liebhold, A. M., Gatziolis, D., & Mao, M. Y. (2013). The relationship between trees and human health: evidence from the spread of the emerald ash borer. American journal of preventive medicine, 44(2), 139-145. https://www.ncbi.nlm.nih.gov/pubmed/23332329

(3) Nowak, D. J. & Greenfield E. (2015). Trees improve human health and well-being in many ways. Northern Research Station Research Review No. 26, April 2015. https://www.fs.fed.us/nrs/news/review/review-vol26.pdf

(4) Villazon, L. (2020). How many trees does it take to produce oxygen for one person?. BBC Science Focus. https://www.sciencefocus.com/planet-earth/how-many-trees-does-it-take-to-produce-oxygen-for-one-person/

(5) United States Environmental Protection Agency (2020). Greenhouse Gas Emissions. https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

(6) Nowak, D. J., Hoehn, R. E. III, Crane, D. E., Stevens, J. C., Walton, J. T. (2007). Assessing urban forest effects and values, New York City's urban forest. Resour. Bull. NRS-9. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 22 p. https://www.milliontreesnyc.org/downloads/pdf/ufore_study.pdf

(7) Nowak, D. J., Greenfield, E. J., Hoehn, R. E., & Lapoint, E. (2013). Carbon storage and sequestration by trees in urban and community areas of the United States. Environmental pollution, 178, 229-236. https://www.fs.fed.us/nrs/pubs/jrnl/2013/nrs_2013_nowak_001.pdf

(8) International Society of Arboriculture (2019). Fun Facts About Trees. https://www.treesaregood.org/funfacts

(9) Kuehler, E., Hathaway, J., & Tirpak, A. (2017). Quantifying the benefits of urban forest systems as a component of the green infrastructure storm-water treatment network. Ecohydrology, 10(3), e1813. https://www.srs.fs.usda.gov/pubs/ja/2017/ja_2017_kuehler_001.pdf

(10) United State Environmental Protection Agency (2020). Heat Island Effect. https://www.epa.gov/heat-islands

(11) Tyrväinen, L., Pauleit, S., Seeland, K., & de Vries, S. (2005). Benefits and uses of urban forests and trees. In Urban forests and trees (pp. 81-114). Springer, Berlin, Heidelberg. Benefits and Uses of Urban Forest and Trees

(12) Tree Canada (2018). Compendium of Best Urban Forest Management Practices, Chapter 3. Benefits of Urban Forests. https://treecanada.ca/resources/canadian-urban-forest-compendium/3-benefits-of-urban-forests/

(13) Foster, J., Lowe, A., & Winkelman, S. (2011). The value of green infrastructure for urban climate adaptation. Center for Clean Air Policy, 750 (1), 1-52. http://ccap.org/assets/The-Value-of-Green-Infrastructure-for-Urban-Climate-Adaptation_CCAP-Feb-2011.pdf

(14) New York Department of Environmental Conservation (2020). Tree Ordinances. https://www.dec.ny.gov/lands/4957.html

(15) Arbor Day Foundation (2020). Tree City USA. https://www.arborday.org/programs/treecityusa/?Trackingid=404

(16) Penn State Extension (2015). Conducting a Community Tree Inventory. https://extension.psu.edu/conducting-a-community-tree-inventory

(17) Bloniarz, D. V., & Ryan, H. D. P. (1996). The use of volunteer initiatives in conducting urban forest resource inventories. Journal of Arboriculture, 22, 75-82. https://pdfs.semanticscholar.org/aed5/d2192919b8cfd23bb7395678f78834b260ab.pdf

(18) New York State Department of Environmental Conservation (2020). Urban and Community Forestry Grants. https://www.dec.ny.gov/lands/5285.html

(19) United States Department of Agriculture, U.S. Forest Service, Northern Research Station (2011). U.S. Forest Service, Northern Research Station, Launches Website for Reporting American Elm. https://www.nrs.fs.fed.us/news/release/American-elm-reporting

(20) Poland, T. M., & McCullough, D. G. (2006). Emerald ash borer: invasion of the urban forest and the threat to North America's ash resource. *Journal of Forestry*, *104*(3), 118-124. https://www.nrs.fs.fed.us/pubs/jrnl/2006/nc_2006_Poland_003.pdf

(21) United States Department of Agriculture, Animal and Plant Health Inspection Service (2020). Emerald Ash Borer Beetle. https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/the-threat/emerald-ash-borer/emerald-ash-borer-beetle

(22) Cary Institute of Ecosystem Studies (2019). Tree-SMART Trade. https://www.caryinstitute.org/science/tree-smart-trade

(23) United States Department of Agriculture, Animal and Plant Health Inspection Service (2020). Spotted Lanternfly. https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/slf/spotted-lanternfly

REFERENCES

(24) Janowiak, M. K., D'Amato, A. W., Swanston, C. W., Iverson, L., Thompson, F. R., Dijak, W. D., ... & Brandt, L. A. (2018). New England and northern New York forest ecosystem vulnerability assessment and synthesis: a report from the New England Climate Change Response Framework project. Gen. Tech. Rep. NRS-173. Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station. 234 p., 173, 1-234. https://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs173.pdf

(25) United State Department of Agriculture, U.S. Forest Service (2020). Climate Change Atlas. https://www.fs.fed.us/nrs/atlas/

(26) United States Department of Agriculture, Agricultural Research Service (2020). USDA Plant Hardiness Zone Map. https://planthardiness.ars.usda.gov/PHZMWeb/Default.aspx

(27) Georgia Forestry Commission (2020). Community Tree Planting and Establishment Guidelines. http://www.gfc.state.ga.us/community-forests/ask-the-arborist/CommunityTreePlantingandEstablishmentGuidelinesPrintVersion.pdf

(28) The University of Tennessee Agricultural Extension Service, SP 511-15M -7/98R12-4910-11-001-99 (2020). SP511 Plant the Right Tree in the Right Place. Available online: http://trace.tennessee.edu/utk_agexfores/46

(29) New York State Department of Environmental Conservation (2020). New York ReLeaf. https://www.dec.ny.gov/lands/5307.html

(30) Narango, D. L., Tallamy, D. W., & Marra, P. P. (2018). Nonnative plants reduce population growth of an insectivorous bird. Proceedings of the National Academy of Sciences, 115(45), 11549-11554. https://www.pnas.org/content/pnas/115/45/11549.full.pdf

(31) United States Department of Agriculture, U.S. Forest Service (2020a). Urban Forests. https://www.fs.usda.gov/managing-land/urban-forests

(32) New York State Department of Environmental Conservation (2020). Sustainable Landscaping. https://www.dec.ny.gov/public/44290.html

(33) Munger, Gregory T. 2003. Acer platanoides. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). https://www.fs.fed.us/database/feis/plants/tree/acepla/all.html

(34) Fryer, Janet L. 2010. *Ailanthus altissima.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratry (Producer). https://www.fs.fed.us/database/feis/plants/tree/ailalt/all.html

(35) Beckerman, J. & Lerner, B. R., Purdue Extension, Purdue University (2009). ID-412-W Salt Damage in Landscape Plants. https://www.extension.purdue.edu/extmedia/ID/ID-412-W.pdf

(36) Martin, J. & Gower, T., UW Extension, University of Wisconsin-Madison (1996). Forestry Facts No. 79, Tolerance of Tree Species. https://erc.cals.wisc.edu/woodlandinfo/files/2017/09/FEM_079.pdf

(37) United States Department of Agriculture, Natural Resources Conservation Service (2020). Conservation Plant Characteristics Data Definitions. https://plants.usda.gov/charinfo.html

(38) United States Department of Agriculture, Natural Resources Conservation Service (2020b). Characteristics. https://plants.usda.gov/characteristics.html

(39) Missouri Botanical Garden (2020). Missouri Botanical Garden Website. http://www.missouribotanicalgarden.org/

(40) The Morton Arboretum (2020). The Morton Arboretum Website. https://www.mortonarb.org/

(41) North Carolina State Extension (2020). North Carolina Extension Gardener Plant Toolbox, *Pinus Rigida.* https://plants.ces.ncsu.edu/plants/pinus-rigida/

(42) Perry, L., Department of Plant and Soil Science, University of Vermont Extension (2003). Plant Hardiness. http://pss.uvm.edu/ppp/pubs/oh54.htm

(43) United States Environmental Protection Agency (2017). Climate Change Impacts: Climate Impacts in the Northeast. https://archive.epa.gov/epa/climate-impacts/climate-impacts-northeast.html

(44) Northern Institute of Applied Climate Science (2020). Adaptation Workbook: Adaptation Strategies and Approaches (Urban). https://adaptationworkbook.org/niacs-strategies/urban#strategy-305

(45) Potter, K. M., Crane, B. S., & Hargrove, W. W. (2017). A United States national prioritization framework for tree species vulnerability to climate change. New forests, 48(2), 275-300. https://www.srs.fs.usda.gov/pubs/ja/2017/ja_2017_hargrove_001.pdf. Supplementary Material: https://link.springer.com/article/10.1007%2Fs11056-017-9569-5

(46) Potter, K. M., Escanferla, M. E., Jetton, R. M., Man, G., & Crane, B. S. (2019). Prioritizing the conservation needs of United States tree species: Evaluating vulnerability to forest insect and disease threats. Global Ecology and Conservation, 18, e00622. https://www.sciencedirect.com/science/article/pii/S2351989418304864

REFERENCES

(47) United States Department of Agriculture, Animal and Plant Health Inspection Service (2020). Emerald Ash Borer Beetle. https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/emerald-ash-borer

(48) New York State Department of Environmental Conservation (2020). Emerald Ash Borer (EAB). https://www.dec.ny.gov/animals/7253.html

(49) Herms D. A., McCullough D. G., Clifford C. S., Smitley D. R., Miller F. D., Cranshaw W. (2019). Insecticide options for protecting ash trees from emerald ash borer. North Central IPM Center Bulletin. 3rd Edition. 16pp. http://www.emeraldashborer.info/documents/Multistate_EAB_Insecticide_Fact_Sheet.pdf

(50) New York State Department of Environmental Conservation (2020). Emerald Ash Borer Recommendations and Resources. https://www.dec.ny.gov/animals/45409.html

(51) Emerald Ash Borer Information Network (2019). Homepage. http://www.emeraldashborer.info/

(52) Purdue Extension (2019). Avoid Deadly Risk of Dying Ash Trees with Timely Tree Removal. Available online: https://www.purdue.edu/fnr/extension/__trashed/

(53) Ecological Research Institute (2020). Monitoring and Managing Ash (MaMA). http://www.monitoringash.org/

(54) New York State Department of Environmental Conservation (2020). Hemlock Woolly Adelgid. https://www.dec.ny.gov/animals/7250.html

(55) Woeste, K., Farlee, L., Ostry, M., McKenna, J., & Weeks, S. (2009). A forest manager's guide to butternut. Northern Journal of Applied Forestry, 26(1), 9-14. https://www.nrs.fs.fed.us/pubs/jrnl/2009/nrs_2009_woeste_001.pdf

(56) Morin, R. S., Gottschalk, K. W., Ostry, M. E., & Liebhold, A. M. (2018). Regional patterns of declining butternut (Juglans cinerea L.) suggest site characteristics for restoration. *Ecology and evolution*, *8*(1), 546-559. https://www.fs.fed.us/nrs/pubs/jrnl/2017/nrs_2017_morin_002.pdf

(57) Schultz, J. (2003). Conservation Assessment for Butternut or White Walnut (Juglans Cinerea) L: USDA Forest Service, Eastern Region. Hiawatha National Forest. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm91_054130.pdf

(58) Ostry, M. E., Mielke, M. E., & Anderson, R. L. (1996). How to identify butternut canker and manage butternut trees. https://www.fs.usda.gov/naspf/sites/default/files/naspf/pdf/92 06howtoidentifybutternutcankermanagebutternuttrees_20180710_508.pdf

(59) Hellmann, J. J., Byers, J. E., Bierwagen, B. G., & Dukes, J. S. (2008). Five potential consequences of climate change for invasive species. Conservation biology, 22(3), 534-543. https://www.researchgate.net/profile/James_Byers/publication/5279379_Five_Potential_Consequences_of_Climate Change_for_Invasive_Species/links/ 5a27fe77aca27 27dd88508fd/Five-Potential-Consequences-of-Climate-Change-for-Invasive-Species.pdf

(60) Burgiel, S. W., & Hall, T. (2014). Bioinvasions in a Changing World: A Resource on Invasive Species-Climate Change Interactions for Conservation and Natural Resource Management. https://www.doi.gov/sites/doi.gov/files/uploads/bioinvasions_in_a_changing_world_2014.pdf

(61) Blake, A. (n.d.). Pocket Parks. https://depts.washington.edu/open2100/pdf/2_OpenSpaceTypes/Open_Space_Types/pocket_parks.pdf

(62) National Recreation and Park Association (2020). Creating Mini-Parks for Increased Physical Activity. Available online: https://www.nrpa.org/contentassets/f768428a39aa4035ae55b2aaff372617/pocket-parks.pdf

(63) Branas, C. C., Cheney, R. A., MacDonald, J. M., Tam, V. W., Jackson, T. D., & Ten Have, T. R. (2011). A difference-in-differences analysis of health, safety, and greening vacant

(64) urban space. American journal of epidemiology, 174(11), 1296-1306. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3224254/

(65) National Urban and Community Forestry Advisory Council (NUCFAC) (2000). Neighborhood Open Space Management: A Report on Greening Strategies in Baltimore and Six Other Cities. https://www.csu.edu/cerc/documents/NeighborhoodOpenSpaceManagement-AReportonGreeningStrategiesinBaltimoreandSixOtherCitiesSprin.pdf

(66) National Geographic (2020). Resource Library | Encyclopedic Entry: Citizen Science. https://www.nationalgeographic.org/encyclopedia/citizen-science/

(67) United States Environmental Protection Agency (2020). Citizen Science for Environmental Protection. https://www.epa.gov/citizen-science

(68) United States Department of Agriculture, U.S. Forest Service (2020). Urban and Community Forestry Program. https://www.fs.usda.gov/managing-land/urban-forests/ucf

REFERENCES

Salt Tolerance References

(i) Bassuk, N., Curtis, D. F., Marranca, B. Z., & Neal, B. (2009). Recommended Urban Trees: Site Assessment and Tree Selection for Stress Tolerance. Cornell University, Urban Horticulture Institute. http://www.hort.cornell.edu/uhi/outreach/recurbtree/pdfs/~recurbtrees.pdf

Beckerman, J. & Lerner, B. R., Purdue Extension, Purdue University (2009). ID-412-W Salt Damage in Landscape Plants. https://www.extension.purdue.edu/extmedia/ID/ID-412-W.pdf

Cornell University (2020). Woody Plants Database. http:// woodyplants.cals.cornell.edu/home

Johnson, G. R. & Sucoff, E. (1995). Minimizing De-Icing Salt Injury to Trees. Department of Forest Resources, University of Minnesota Extension Service, University of Minnesota. https://conservancy.umn.edu/bitstream/handle/11299/93996/1/1413.pdf

Miyamoto S., Martinez I., Padilla, M., Portillo, A., & Ornelas, D. 2004. Landscape Plant Lists for Salt Tolerance Assessment, by Agricultural Research and Extension Center of El Paso, Texas Agricultural Experiment Station, Texas A&M University System; report, 12 p. https://www.plantanswers.com/Landscape_Plant_Lists_for_Salt_Tolerance_Assessment.pdf

The Morton Arboretum (2020). The Morton Arboretum Website. https://www.mortonarb.org/

The University of Maine Cooperative Extension (2020). Tolerance of Trees and Shrubs to Salts in Soil. https://extension.umaine.edu/gardening/manual/tolerance-trees-shrubs-salts-soil/

University of Florida (2020). Environmental Horticulture: 680 Tree Fact Sheets. https://hort.ifas.ufl.edu/database/trees/trees_common.shtml

University of Massachusetts Amherst (2020). Road Salt and Trees. https://www.umass.edu/urbantree factsheets/ 18roadsalttrees.html

University of Nebraska-Lincoln School of Natural Resources: Regional & Community Forestry (2020). Tree & Shrub Identification. https://trees.unl.edu/identification/idbyname.aspx

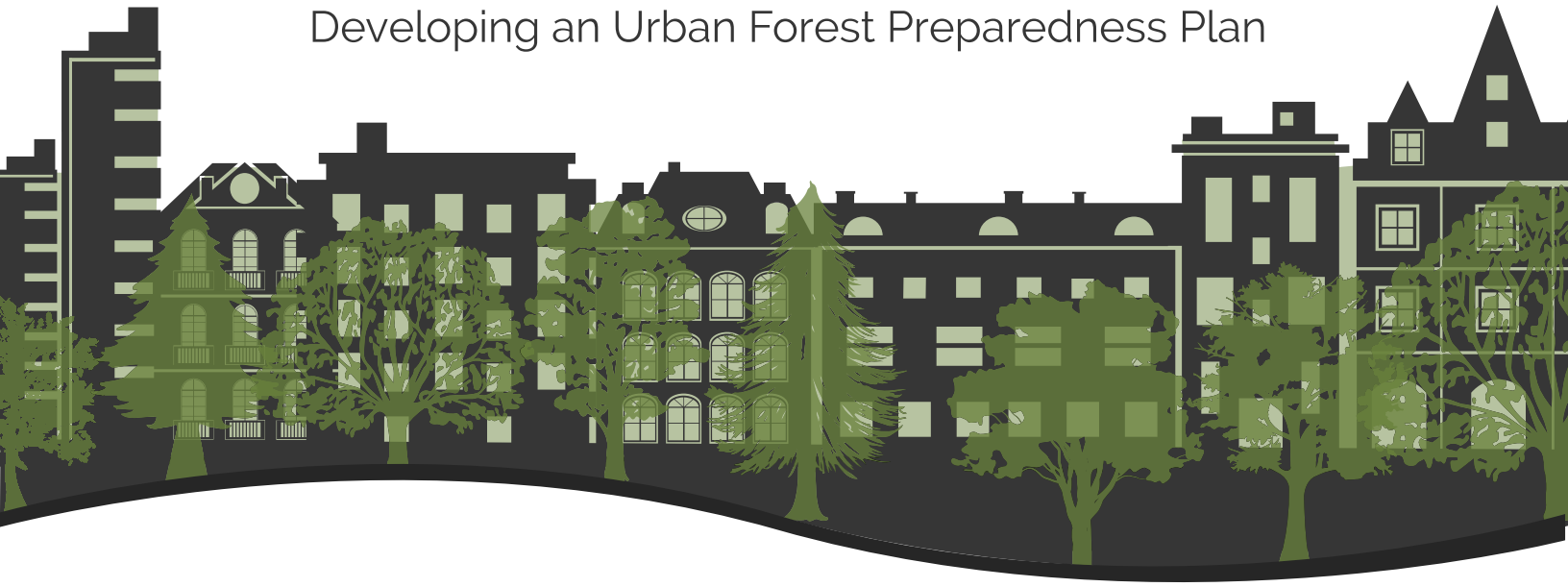
Wu, L. & Dodge, L. (2005). Landscape Plant Salt Tolerance Selection Guide for Recycled Water Irrigation, A Special Report for the Elvenia J. Slosson Endowment Fund, University of California, Davis; article, 40 p. http://slosson.ucdavis.edu/files/215300.pdf

URBAN FOREST SUSTAINABILITY

This guide is designed to help our communities sustain their urban forests by encouraging the following strategies: increased tree species diversity, planting climate adaptable trees, implementing proper pest management, planting the right trees in the right places, and selecting native rather than non-native tree species.

Guide Features:

Conducting a Tree Inventory
Completing an Urban Forest Risk Assessment
Maintaining Forest Health
Developing an Urban Forest Preparedness Plan



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