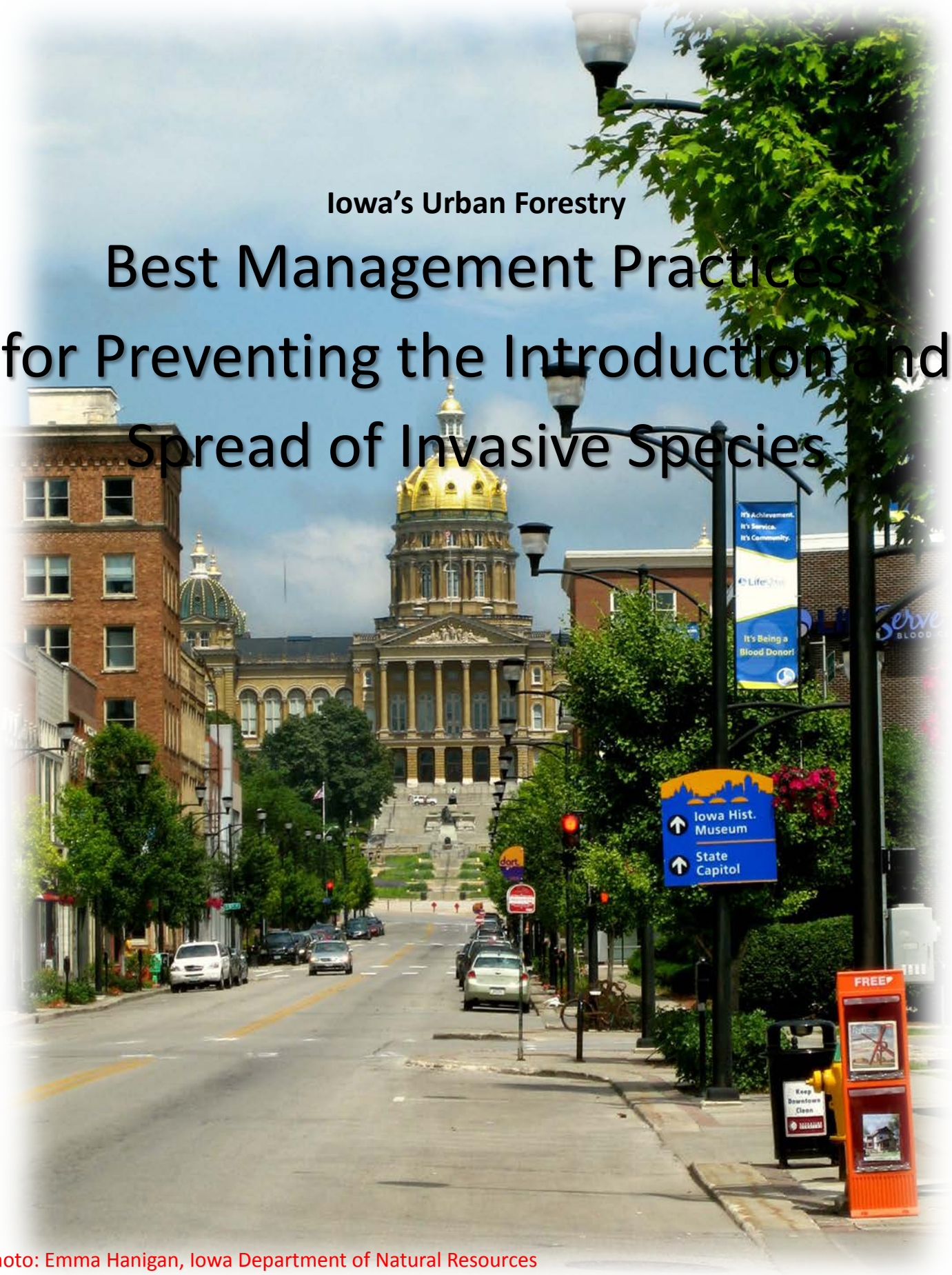
04/27/2017



Iowa's Urban Forestry

Best Management Practices for Preventing the Introduction and Spread of Invasive Species

Photo: Emma Hanigan, Iowa Department of Natural Resources

Table of Contents

Acknowledgements 1
Preface 3
Purpose and Scope Statements 4
How to use this Manual 5
Chapter 1: Introduction 6
Chapter 2: Elements of Invasive Species Management 13
Chapter 3: Planning 18
Chapter 4: Design 25
Chapter 5: Sales 28
Chapter 6: Planting and Installation 30
Chapter 7: Management/Maintenance 37
Chapter 8: Sanitation and Debris Disposal 45
Chapter 9: Monitoring and Research 49
Chapter 10: Education 52
Appendix A: Brief Overview of Control Methods 54
Appendix B: Monitoring 55
Appendix C: Terrestrial Invasive Plants in Iowa 59
Appendix D: Short List of Invasive Insects and Diseases for Iowa 60
Appendix E: Resources 61
Appendix F References 67
Appendix G: Glossary 70
Appendix H: List of BMPs 72

Acknowledgements

This effort was supported by many affected stakeholders who understood the importance of and the need for Urban Forestry Best Management Practices for Invasive Species. A special thanks to the Iowa Urban and Community Forestry Council and the Iowa Forest Advisory Council for dedicating their time, energy and resources to assist in developing this manual and the BMPs within. Their commitment and support for the future of Iowa's urban forests is evident through their many months of hard work and their continued leadership and advocacy.

A sincere thank you is owed to the Wisconsin Department of Natural Resources Division of Forestry and the USFS State and Private Forestry. Their dedication and foresight in the development of the Best Management Practices for Invasive Species for Forestry, Urban Forestry, Rights-of-Way, and Recreation set the stage for Iowa to follow. Their willingness to share materials and the thousands of staff and volunteer hours put in by a team of professionals not only made our job easier but set the standard!

04/27/2017

Advisory Committee Members

Paul Tauke
Iowa Department of Natural Resources
State Forester

Emma Bruemmer
Iowa Department of Natural Resources
Urban Forestry Program Leader
Iowa Urban and Community Forestry Council

Shane Donegan
Prairie Rivers RC&D
Urban Forestry Specialist

Tivon Feeley
Iowa Department of Natural Resources
Forest Health Program Leader
Iowa Forest Health Advisory Council

Patty Reisinger
Trees Forever,
Iowa Urban and Community Forestry Council

Ralph Conner
Iowa Arborist Association
Iowa Forest Health Advisory Council

Dr Jeff Iles
Iowa State University
Horticulture Department Chair
Iowa Urban and Community Forestry Council
Iowa Forest Health Advisory Council

Dennis McDougall
US Forest Service
Forest Stewardship Program Coordinator

Dr Laura Jesse
Iowa State University Extension Entomologist
Iowa Forest Health Advisory Council

Greg Heidebrink
Iowa Department of Natural Resources
District Forester

Preface

The Iowa Urban and Community Forestry Council and the Iowa Forest Health Advisory Council - comprising representatives of private and public forestry professionals, timber and forest product industries, conservation organizations, forestry schools, and other interested groups - targeted specific issues affecting forests in the state. Both Councils concluded that "*invasive exotic* [non-native] *species may present the greatest threat to the long-term health and sustainability of Iowa's forests*" and reached "*a clear consensus on the need for voluntary forestry/invasive best management practices and a commitment to a partnership-based process for creating them*." In response, the Councils created the Iowa Urban Forestry Best Management Practices for Invasive Species.

Purpose and Scope Statements

Purpose

Forest invasive species can pose a threat to Iowa's urban forests which provide important environmental, social and economic services such as reduced storm water run-off, improved air quality, energy conservation, improved public health, and increased property values. Urban forestry professionals and homeowners alike can play a role in reducing the impacts of invasive species by following the practices outlined in this manual. The goal is to provide guidance by incorporating invasive species considerations into routine urban forestry activities so as to prevent the introduction and slow the spread of invasive species.

Scope

The Best Management Practice (BMP) statements in this manual are intended to apply to a wide variety of urban forestry activities (including land use planning, landscape design, species selection, planting, maintenance, sanitation and debris disposal, and transportation) on urban forests comprised of all ownerships. The BMPs cover terrestrial plants, insects and diseases of the urban forest. The use of this manual is voluntary and non-regulatory.

Beyond the Scope

There are additional needs in invasive species management that are beyond the scope of this manual. These include non-regulatory efforts like additional BMP tracks including those that address traditional forestry, recreation, and utility and transportation corridor rights-of-way. Other efforts focus on regulatory programs at regional or national scales including quarantine and port of entry regulations that address movement of invasive species and infested material into and within the US and federal agency actions to strengthen inspection and management. The BMPs are not intended to provide species specific control and management recommendations.

How to use this Manual

Iowa's Urban Forestry Best Management Practices for Invasive Species provides voluntary Best Management Practices (BMPs) to aid in the prevention and management of invasive plants, insects, and diseases in and around Iowa's cities, towns, villages and other built environments. The BMPs identified in this manual are our best attempt to identify effective and realistic practices that can be integrated into routine urban forestry activities to limit the impact of invasive species.

This BMP manual was written for arborists, urban foresters, nursery growers and retailers, landscape architects, grounds managers, landscape contractors, and other urban forestry professionals. However, professionals and homeowners alike can play a role in helping to reduce the impacts of invasive species by following the practices outlined in this manual. Ultimately, everyone involved in the care and management of trees, shrubs, and other vegetation shares in the responsibility of preventing and controlling invasives. By taking reasonable and practical precautions today, we can help protect Iowa's urban forests and other lands into the future.

The manual recognizes a wide range of possible response options to any invasive species situation. Determining appropriate action in response to the large number of current and potential invasive species involves complex decisions that are context dependant. For that reason, practitioners applying BMPs need to be allowed a great deal of latitude to select strategies and responses appropriate for their circumstances. This manual does not give priority to any particular BMP. Practitioners will need to decide how best to prioritize and implement the BMPs for their particular situation. Response options will need to recognize the degree of threat posed by an invasive species, the objectives of the homeowner or client, the resources available (if any) for additional management activities, and the costs that will be borne by those implementing the BMPs.

The Manual is structured as in the following example:

→ BMP Statement: Invasive species BMPs are in bold font and are set off from the body of the document with an arrow. These statements are intended to describe voluntary practices that may reduce the impact of invasive species.

Considerations:

a. BMP Considerations are listed below the BMP Statement.
b. BMP Considerations were written to give more information about why the BMP is important.
c. BMP Considerations introduce items that could be used to address the BMP; they do not apply to every species or situation, and the user does not necessarily have to follow them to address the BMP (i.e., they are optional).
d. BMP Considerations may include details, suggestions, examples, and issues to consider about invasive species and applying the BMP.
e. See Appendices as directed for more information.

Chapter 1: Introduction

What are Invasive Species?

Invasive species are species that are not native to the ecosystem under consideration whose introduction causes or is likely to cause economic or environmental harm or harm to human health (National Invasive Species Council 2001, 2008). Essentially, invasive species are plants, animals, insects, and pathogens that are "out of place." A species is regarded as invasive if it has been introduced to a location, area, or region where it did not previously occur naturally (i.e. is not native), becomes capable of establishing a breeding population in the new location without further intervention by humans, and spreads widely throughout the new location.

Invasive species often exhibit aggressive reproductive qualities, such as rapid growth, abundant seed production, widespread seed dispersal, and vigorous vegetative spread. They are highly adaptable and are able to tolerate a wide range of environmental conditions. Invasive species often leave their predators, parasites, competitors and diseases behind in their native ecosystems without which they are better able to reproduce rapidly and out-compete native species. Species native to Iowa may also exhibit these same invasive qualities in particular environments.

Invasive species have been introduced to our state in a variety of ways. Some species initially introduced for beneficial reasons, later turned out to be invasive. Examples include Asian bush honeysuckle and purple loosestrife introduced for use as ornamental and landscape plants; reed canary grass introduced for forage and erosion control; garlic mustard introduced for use as a culinary herb; and gypsy moth introduced in an attempt to breed a hardier silkworm. Increases in domestic and international trade are resulting in an increasing rate of unintentional introductions. These include the Emerald Ash Borer and Asian Longhorned Beetle which likely arrived in the United States on solid wood packing material carried in cargo ships or airplanes from its native Asia.

Because most initial introductions occur in urban areas, the impacts of invasive species generally first occur in our urban forests. In turn, urban forests are often a source of invasive problems for our natural areas and rural landscapes.

> The term "**invasive disease**" is used throughout this document. Although diseases themselves are not technically invasive, the pathogens that cause plant diseases (including but not limited to fungi, bacteria, viruses and phytoplasmas) can be invasive when they infect a susceptible host and conditions are favorable for disease to develop.

04/27/2017

What is the Urban Forest and Urban Forestry?

The urban forest is comprised of all the trees, shrubs, groundcovers and associated vegetation, native and non-native, in and around a city, town or community in association with the buildings, infrastructure, soil, water, air, topography, animals and people. The urban forest includes landscaped private properties, trees along our streets, vegetation in our parks, trails, natural areas and more. Some of this vegetation was willfully planted and is carefully managed by the owners, while other vegetation is an accident of land-use decisions, economics, topography or neglect (Miller 1997). This mosaic or patchwork of highly altered landscapes spans properties, ownerships and jurisdictions.

The Urban Forest, Elkader, IA. Photo: Tivon Feeley Iowa Department of Natural Resources

Examples of the Urban Forest:

The state capitol grounds. Photo by DNR Stock Photo

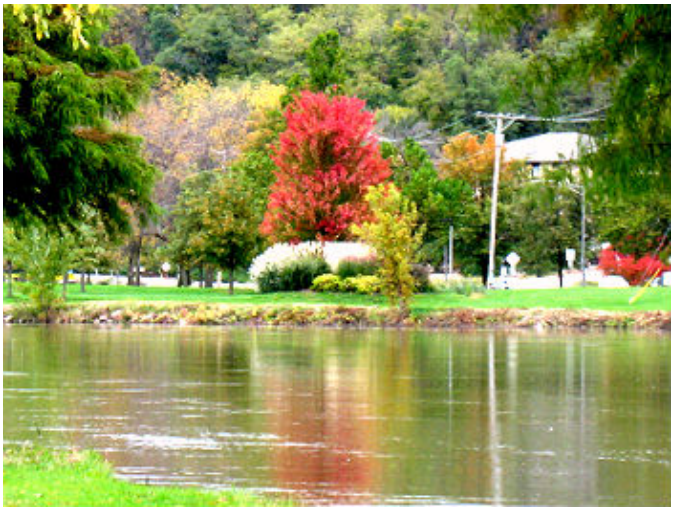
Parking lot University of Iowa. Photo: Mark Vitosh Iowa Department of Natural Resources

Des Moines River Photo: Emma Hanigan, Iowa Department of Natural Resources

Tree lined residential street. Photo: Emma Hanigan, Iowa Department of Natural Resources

Downtown Des Moines. Photo: Emma Hanigan, Iowa Department of Natural Resources

Downtown Iowa City. Photo: Mark Vitosh, Iowa Department of Natural Resources



Urban riverway, Iowa River Photo by Mark Vitosh

A rain garden planting. Photo: Helen Clamb , Iowa Department of Natural Resources

Urban Forestry is the art, science and technology of managing the urban forest landscape for the environmental, ecological, physiological, sociological, economic and aesthetic benefits that trees, shrubs, groundcovers and associated vegetation provide. This includes arboricultural practices as well as horticulture, gardening, landscaping and lawn care. Urban forest landscapes are best managed on various levels of scale because they come in all shapes and sizes and can span properties, ownerships and jurisdictions.

> Boundaries of the urban forest are *not solid.* The urban forest can include a subdivision surrounded by farm fields. Likewise, a residential yard on property out in the country can be considered part of the urban forest because it is managed as such. A forested area in the center of town is also considered part of the urban forest.

What impacts have Invasive Species had in the Urban Forest?

Invasive plants, insects and diseases can alter ecological relationships in our urban and community forests, as well as, negatively affect the economic, social and environmental benefits our urban and community forests provide.

Invasive species can displace, weaken or kill desirable plants resulting in loss of diversity, pose human health risks, degrade wildlife habitat, interfere with recreational activities, disrupt urban ecosystems, and divert millions of dollars for their control. In the United States, expenses associated with ecological damage and control of invasive species is estimated at $137 billion per year and increasing (Pimental et al. 2001). Invasives have left our communities with exorbitant control costs, decreased economic, environmental and social benefits, and decreased biodiversity.

The American elm (*Ulmus americana*) was once a major component of Iowa's residential and street tree populations until an Asian fungus (*Ophiostoma ulmi)* was introduced on European logs. The disease, coined Dutch elm disease, was spread by two beetle species, one European and one native, and by 1980 had killed the majority of elm trees. At one time, elms accounted for 50 to 60 percent of the total urban forest in many Iowa communities. Local governments, their residents and property owners bore the brunt of removal costs. The impact and economic loss caused by the Dutch elm disease epidemic has been huge; it lead to an estimated loss of 60 million trees in the United States, with a financial loss in the billions (Allison 1989).

Dead Elm due to Dutch elm disease. Photo: Joseph O'Brien, USDA Forest Service, Bugwood.org

Gypsy moth (*Lymantria dispar*), originally from Europe, Asia, and North Africa, was accidentally released in Massachusetts in 1867 in a failed attempt to raise a hardier silkworm. The larvae now defoliate approximately one million acres of oak and aspen forest annually from Maine to Virginia and west to Iowa. While gypsy moth has not caused significant tree mortality, it is an additional stressor that slows growth and often contributes to mortality in trees that have been weakened by previous defoliation or other stressors such as compaction and drought. In large numbers, they can become quite a nuisance for property owners. Additionally, some people can experience allergic reactions when they come in contact with the caterpillar's hair. Iowa has taken an aggressive stance to detect, control and slow the spread of the gypsy moth. In 2011 an estimated 1.2 million dollars has been spent on gypsy moth monitoring and mating disruption in Iowa, making it the state's largest treatment to date for this pest. It is expected that the gypsy moth populations will be slowed down by several years. However, the moths will establish themselves in Iowa's communities despite efforts to slow the spread.

Defoliation by gypsy moth. Photo by Tim Tigner, Virginia Department of Forestry, Bugwood.org.

Emerald Ash Borer larva. Photo: David Cappaert, Michigan State University, Bugwood.org

Emerald Ash Borer (EAB) is another serious invasive pest which was recently discovered in Iowa. Its arrival puts our state's 52 million forest ash and 3.1 million urban ash in peril. The larvae stage of the insect feeds under the bark of ash trees, cutting off the flow of water and nutrients. Infested trees gradually die over a 3-5 year period. About 15 percent of Iowa's street trees are ash, the loss of which would be devastating to many communities (Nowak 2010). Removal costs will again be borne by local governments and property owners. (For an up-to-date map showing EAB distribution go to http://www.iowadnr.gov/forestry/eab/index.html)

Invasive plants are a particular problem in the urban forest due to their ability to quickly colonize areas with high levels of disturbance. Our communities are full of opportunities for these plant invaders to establish themselves. Urban areas experience high use and development which leads to soil compaction, erosion and pollution. Invasive species are better able to take advantage of these conditions than our native species and can quickly populate disturbed sites.

Invasive shrubs such as common buckthorn have taken over parks, woodlands, open spaces and backyards throughout Iowa and the Midwest reducing the richness of desirable species. Common buckthorn (*Rhamnus cathartica*) spreads aggressively once introduced and has been shown to alter soil ecology, making control and restoration of infested sites difficult (Heneghan et al. 2006). It forms dense thickets that negatively impact the establishment of new plantings and makes accessing infested sites difficult (Frappier et al. 2003, 2004).

Invasive forbs are major problem in the urban forest. The invasive plant garlic mustard (*Alliaria petiolata*) is found in backyards, parks, and woodlands alike. It quickly reproduces and out-competes other forbs and seedlings in the area. Garlic mustard appears to suppress tree regeneration by disrupting beneficial associations between tree seedling roots and fungi (mycorrhizal associations), which may help explain its ability to invade undisturbed sites (Stinson et al. 2006).

Garlic mustard infestation. Photo: Tivon Feeley, Iowa Department of Natural Resources.

Invasive species are now widespread across an increasing number of acres in the United States, posing threats to habitats and economies in areas as diverse as agriculture, forestry, urban forestry, livestock, fisheries, water bodies and recreation. Invasive species have spread to a wide range of ecosystems and now rank just behind habitat loss as the leading cause of native and rare species declines (Wilcove et al. 1998).

What can urban forestry practitioners, landscape and tree managers, governments, property owners and special interest groups do about invasive species?

Invasive species do not respect boundaries. Individual property owners, urban forestry practitioners, professionals, local, state and federal governments, and special interest groups all have a hand in the management of invasive species in our urban and community forests.

Managing existing invasive species infestations is difficult, expensive and often requires years of effort. For that reason, three of the most important invasive species concepts to consider include: preventing the occurrence, limiting the spread, and reducing impacts. Limiting the spread of invasive species means working to contain an infestation within a defined area. Preventive measures may include restricting activities and minimizing travel through infested areas, especially during times of seed production. Other practices like inspecting clothing and equipment may also limit the spread of invasives. In addition, do not move infested wood products (i.e.: firewood, logs, lumber). Following the voluntary BMPs outlined in *Iowa's Urban Forestry Best Management Practices* will help to prevent the introduction and limit the spread of invasive species. Reducing impacts implies that if control and containment methods fail to manage an infestation, a final option may be to reduce the impact on desirable species and the ecosystem. Through this method the focus shifts from managing invasive species populations to preserving desirable species.

Six elements for managing invasive species include:

- **Prevention–**An awareness of invasive species and an understanding of their mode of invasion are important aspects of planning.

- **Early Detection and Rapid Response–**Detecting new populations early and responding rapidly increases the likelihood of successful control while keeping costs down.

- **Control**–In many cases an invasive species may be too widespread and abundant to eradicate. In those cases, it may be cost-effective to slow the spread of the species through integrated control and management planning.

- **Monitoring–**The periodic inspection of target areas (e.g. travel corridors, access points, post-activity areas and areas with previously treated infestations) can lead to earlier detection and more successful treatment in the long run.

- **Restoration**–Invasive species are more likely to colonize sites that have been disturbed. The earlier a land manager can return the land to desirable vegetation or find ways to minimize site disturbance, the less vulnerable a site will be to invasion.

- **Communication and Education**–Educate yourself, employees, volunteers, clients, customers, and users about invasives. Inform invasive species specialists about new infestations and also about control methods undertaken and outcomes. This information may be useful for research projects.

Chapter 2: Elements of Invasive Species Management

In urban forest ecosystems we have a situation that is very different from traditional forested environments. A great diversity of vegetation, native and non-native, can be found in our communities. This includes landscaped private properties, trees along our streets, vegetation in our parks, trails, natural areas and more. Some of this vegetation was willfully planted and is carefully managed by the owners, while other vegetation is an accident of land-use decisions, economics, topography or neglect (Miller 1997). This mosaic or patchwork of highly altered landscapes spans properties, ownerships and jurisdictions. Invasive species do not respect boundaries. Individual property owners, urban forestry practitioners, professionals, local, state and federal governments and special interest groups all have a hand in the management of invasive species.

Invasive species management programs across the country have incorporated several common elements including: Prevention, Early Detection and Rapid Response, Control and Restoration. These elements serve as guiding principles of the National Invasive Species Management Plan and form the basis for the USDA-Forest Service Invasive Species Program. Elements of invasive species management include physical means, but they may also include legislative, education and planning components as well. These elements can help guide the actions of those who are concerned about invasive species within our urban forests. For example, these elements can assist homeowners and companies managing individual properties. Municipal tree managers may use the elements to manage invasives for an area that includes hundreds of different properties within their community. A multi-agency or multi-partner approach would be needed for even broader scales.

Prevention

An effective economical and ecologically sound approach to managing invasive species is to prevent their introduction in the first place. This manual addresses practices that attempt to prevent the introduction and spread of invasive species in Iowa's urban forests.

Resources are often limited for invasive species management. Once an invasive population becomes established the management can be expensive, and in many cases, eradication may be impossible. While it is still necessary to attempt to control the spread of established populations into non-infested areas, resources might be more efficiently utilized on proactive management that focuses on the prevention of new invasions.

Elements of prevention can include:

- Education and identification outreach and training
- Preventing the deliberate planting of invasives species
- Preventing the introduction of seeds/eggs/organisms into an area
- Developing local ordinances and state and federal legislation to address invasives
- Early detection and eradication of small populations of invasive species
- Periodically inspecting high-risk areas such as in and near travel corridors and access points
- Maintaining healthy and vigorous trees and other vegetation to best compete with invasive species
- Minimizing disturbance of desirable vegetation
- Mulching, revegetating or treating areas of bare soil
- Periodically evaluating the effectiveness of prevention efforts

When planning urban forestry projects that are in or near infested areas or will occur during peak transmission times, it may be beneficial to consider invasive species management as a part of project decisions in order to prevent the movement of invasive species.

Early Detection & Rapid Response

One of the most difficult aspects of managing invasive species is that they are usually widespread before they are recognized as harmful. Some species, like small insects or fungi, are so inconspicuous that populations can go unnoticed for many years after introduction. Others species are non-invasive at first, but become invasive later due to adaptation, because wildlife will begin to spread them (e.g. multiflora rose) or because population sizes reach the point where exponential growth allows them to increase rapidly.

The figure below illustrates this problem using a hypothetical population with a growth rate of 1.5x each generation. For the first 30 generations population growth is barely detectable; this is called the lag phase. After that, the species reaches a population threshold that allows for a rapid increase in the next ten generations – the exponential growth phase. Often a species is not recognized as invasive until it reaches the exponential phase, but by this point control is very difficult and eradication usually impossible. Gaining an advantage in controlling such species may require taking action during the lag phase, rather than assuming that these species will not become invasive in the future. Recognizing invasive characteristics and taking action early in the invasion process will make control efforts more effective and less costly.

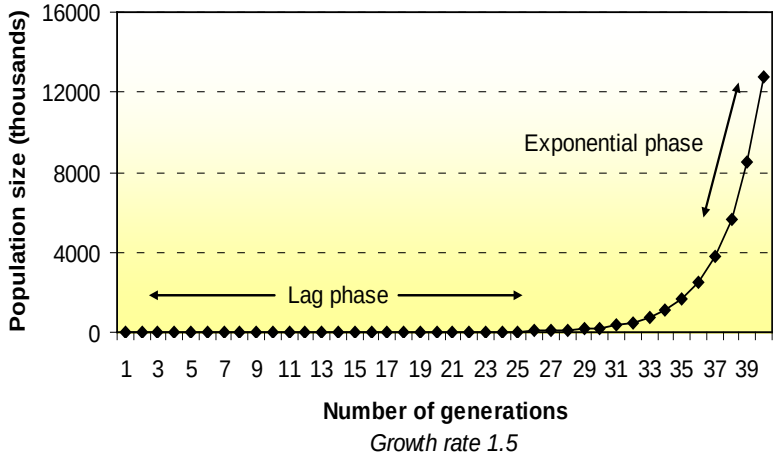


Figure 1. Population growth curve, illustrating the lag and exponential phases for a hypothetical population with a growth rate of 1.5x each generation. Population growth rates vary by species. A species with a growth rate higher than 1.5x (e.g. musk thistle, at 2.2x (Shea and Kelly 2004)) would have a shorter lag phase, and one with a lower growth rate (e.g. spotted knapweed, at 1.17x (Emery and Gross 2005)) would have a longer lag phase.

Even the best prevention efforts cannot stop all introductions. Early detection of incipient invasions and quick, coordinated responses are needed to eradicate or contain invasive species before they become too widespread and control becomes technically and/or financially impossible. Populations that are not addressed early may require costly ongoing control efforts.
-National Invasive Species Management Plan, 2001

It is widely agreed that exclusion is the most effective approach to the problem of invasive species. However, there is a similar consensus that in the current climate of trade and travel, more introductions are inevitable. Because the chances for eradication or control are greatest immediately after introduction, early detection and rapid response will be an important part of managing invasive species (Worall 2002).

Early Detection, as applied to invasive species, is a comprehensive, integrated system of active or passive surveillance to find new populations of invasive species as early as possible, when eradication and control are

still feasible and less costly. It may be targeted at: a.) areas where introductions are likely such as ports of entry, municipal campgrounds or natural areas that border residential properties, b.) areas with high ecological value to the urban forest where impacts are likely to be significant, and c.) vulnerable habitats or recently disturbed areas (Worall 2002).

Rapid response is a systematic effort to eradicate, control or contain invasive species while the infestation is still localized. It may be implemented in response to new introductions or to isolated infestations of a previously established species. Preliminary assessment and subsequent monitoring may be part of the response. It is most effective when based on a plan organized in advance so that the response is rapid and efficient (Worall 2002). Everyone involved in the response should understand the priority for this effort in a world with many and often conflicting priorities.

It is ultimately up to property owners and managers to stay vigilant and take action for invasives on their property. They must be ready and willing to alert the proper authorities in the case of regulated species, such as emerald ash borer, Asian longhorned and thousand cankers disease of walnut. Of course, federal, state, and local governments have a role to play in supporting the efforts of the private citizen, as well as, urban forestry practitioners who have a responsibility to educate and inform their clients, report findings and, if possible, offer solutions.

Control & Management

There are control strategies and control methods. The control strategies described below are: eradication, containment and reducing impacts. Control strategies are different approaches to addressing invasive species based on, for example, the size of an infestation, the source of infestation, the quality of the invaded site, the amount of resources available, etc.

Control methods are measures employed to carry out control strategies. They include manual, e.g. pulling and burning; mechanical, e.g. cutting and tilling; chemical, e.g. targeted pesticide use; biological, e.g. use of the fungus *Bacillus thuringiensis* (BT) for insect pests; and cultural methods, e.g. planting non-host tree species. Usually no one method is effective at controlling invasive species. To determine the best method or combination of methods to use, one should evaluate the site and the life cycle of the invasive species of concern.

When a combination of control methods is used it is referred to as integrated pest management (IPM). In the urban forest context integrated pest management of invasive species (plants, insects and diseases) can be defined as keeping their populations at tolerable levels (no economic or environmental harm) by the use of a variety of management strategies that are ecologically and economically efficient as well as socially acceptable.

Eradication is the elimination of the entire population of an invasive species in a defined geographical area. Site level eradication of some invasive populations can be an attainable goal if new introductions are detected early, resources are available and infestations are not large or pervasive. When limited resources or the degree of infestation rule out eradication, a more realistic management goal may be to slow the spread or reduce the impacts of invasive species.

Slowing the spread of invasive species, or containment, refers to the process or goal of containing an infestation within a defined geographical area (Moore 2005). Containment to a defined area can be very effective at limiting the regional spread of an invasive species. However, containing a species in a defined area requires constant attention and control of the species at the boundary of the defined area. Steps must be taken to prevent spread and new infestations must be located early so control measures can be implemented

quickly. Steps in a containment program may include inventory and prioritization of populations for treatment, restricting activities in certain areas or during certain times of year, inspecting and cleaning clothing and equipment to minimize species transport, and locating and controlling new infestations promptly. Successful containment can be costly and difficult to achieve.

Another strategy is to **reduce the impact of invasive species** on the local and regional urban forestry ecosystems to a level necessary to meet site management goals. At this level, the focus shifts from managing invasive species populations to managing the local and regional urban forestry ecosystems. Methods for reducing the impacts of well-established and widespread invasive species can include planting a diversity of tree species or planting species less susceptible to invasive insects and diseases. This strategy can be used in conjunction with the other strategies, especially for species known to be difficult to control.

Control strategies must strike a balance between the ecological impacts of allowing invasive species to spread and the economic realities of control methods. Not all control methods are practical, effective, economically feasible or environmentally sound for application in the urban environment. Control strategies should be integrated in ways that maximize management objectives while minimizing negative environmental impacts. Furthermore, control methods continue to develop based on ongoing research. Therefore, the most recent science should be consulted to determine an appropriate course of action.

Monitoring

Monitoring is the periodic inspection of sites to detect new invasions and evaluate the success of applied management plans and control measures. The early detection of new infestations in recently treated areas may make control measures more successful and may reduce costs.

Monitoring can be an informal process, or it can be highly formal. Most urban forestry managers will not need complex monitoring programs; monitoring should be kept as simple as possible and can be integrated with other urban forestry activities. Monitoring can be simplified by setting priorities, including identifying specific areas to visit, identifying specific species to monitor and using a list of prioritized target species likely to be encountered in an area (Colorado Natural Areas Program 2000). Target areas can include areas susceptible to invasion, such as transportation corridors and recently disturbed areas, and/or previous infestations that have undergone control measures. Target species can include those susceptible to specific invasive insects or diseases. Periodic visits to these areas and of these species will allow urban forestry managers to detect new invasions and assess the success of their control efforts.

Restoration

Restoration that establishes and maintains healthy plant communities may prevent invasive species infestations or prevent reoccurrence after invasive species removal. Urban forest restoration seeks to reestablish the ecological health of the urban forest by returning some of its structure and function lost through development, mismanagement or the neglect of time. Options for restoration sites include: yards, vacant lots, shopping centers, schoolyards, parks, industrial parks, brown fields and waterways (Duryea et al. 2000). Successful projects should have the support of the community and a well laid-out restoration plan. Examples include: eliminating mowing or leaf-raking in a park to re-establish a natural forest floor, planting non-invasive, site-appropriate species to decrease erosion or planting a rain garden in a residential yard. Additional benefits to urban forest restoration include improved storm-water management, increased wildlife habitat, and increased biodiversity. By returning the urban forest to a form which is more ecologically sustainable, it can contribute to a community instead of being a drain on its resources.

Communication and Education

We all have a stake in reducing the negative impacts of invasive species. The prevention and control of invasive species will require modifying behaviors, values and beliefs and changing the way decisions are made. A successful plan to address invasive species issues will depend on the understanding and acceptance of the magnitude and urgency of the invasive species problem and the actions needed to protect our valuable resources. A wide variety of education, outreach and training programs are needed to: raise awareness of the causes of establishment and consequences of invasive species, educate people about their management options, keep them abreast of the most current information, and help motivate them to take action.

Chapter 3: Planning

Invasive species introduction and spread can be minimized with proper planning. Long term costs can be decreased and resources can be used more effectively and efficiently when land use and activity planning take invasive species into account. This chapter is divided into these two major types of planning activities: land use planning and activity planning.

Land Use Planning

BMP 3.1: Know which invasive species affect or could affect your region and property.

BMP 3.2: Assess the extent of invasive species on and near the property by scouting and documenting infestations.

BMP 3.3: Assess current available resources and explore additional resources to prevent the introduction and manage the spread of invasive species.

BMP 3.4: Develop a plan for managing invasive species.

BMP 3.5: Provide training on identification, management, and prevention techniques of known invasive species to employees, contractors, volunteers, elected officials, owners, users, and the public.

Activity Planning

BMP 3.6: When planning for a specific management/maintenance activity, scout for invasive species both within and around the activity area.

BMP 3.7: Plan urban forest management/maintenance activities to limit the introduction and spread of invasive species.

BMP 3.8: Plan to monitor each site following management/maintenance activities; determine necessary treatments based on presence of invasive species.

BMP 3.9: As opportunities arise, interact with and engage researchers to further our understanding of invasives.

Land Use Planning

Land use planning is a conceptual process that can be done for any property. It may consist of ideas and approaches that are never committed to paper, or can result in a detailed written document. Land use planning is a good way to identify long-term goals, set priorities, develop a timeline and identify tools needed and available resources. It considers the rationale for various aspects of management and maintenance, including sustainability and providing services to its users. By evaluating the potential risk of invasive species on the property, one can develop a plan for managing those invasives; thus, helping achieve success for the overall management plan. Keep in mind that a good plan will be flexible and adaptive; for instance, priorities may change over time or impacts of invasion may be over- or under-estimated.

Invasive species and urban forest management

There are many types of managed urban forest lands, including residential properties, subdivisions, street easements, city parks, school grounds, golf courses, corporate campuses, cemeteries, public gardens or arboreta, zoos, natural areas and nature centers to name a few. Land managers may be the residents, owners, employees, contractors or even volunteers. They may or may not be trained in land management and landscape maintenance.

Land managers often find that their ability to meet site management goals and users' needs is inhibited, if not prevented, by the presence of invasive species. For example, invasive thorny shrubs may limit use by park

visitors; invasive insects and diseases can kill trees and other vegetation; and some invasive plants, such as wild parsnip and giant hogweed, may present health risks. Furthermore, invasive species control efforts may divert resources from other property management and development activities.

Land management and invasive species control efforts can become more complicated when users, equipment, and property staff inadvertently spread propagules from infested sites to uninfested sites. Failure to promptly address new infestations of invasive species can lead to a greater drain on future resources.

> **Propagule** (prŏp' ə gyool) = Any reproductive structure or part of an organism that can grow independently of its parent source. In plants, this may be a fruit, seed, bud, tuber, root, stem with rooting structures or shoot. In forest insects, this may be an egg, larva, pupa or adult. In forest diseases, this may be a spore, mycelial fragment (similar to roots) or a fruiting body.

→ BMP 3.1: Know which invasive species affect or could affect your region and property.

<u>Considerations:</u>

a. See Appendices C: Terrestrial Invasive Plants in Iowa and D: Short List of Invasive Insects and Diseases for Iowa.
b. Know which plant species on your property are susceptible to invasive insects and diseases.
c. Understand how invasive species impact your valued resources.

→ BMP 3.2: Assess the extent of invasive species on and near the property by scouting and documenting infestations.

<u>Considerations:</u>

Knowing which invasive species are present and their location is the first piece of information needed to evaluate threats. There are several steps to consider when scouting for invasive species:

a. Scout for invasive species at probable introduction sites such as access points (trails, roads, parking lots, rest stops, major ports of entry e.g. shipping ports and other examples), transportation corridors, new plantings, construction areas, other disturbed areas and stands of dead/dying/stressed trees, wood waste sites, wood product companies, greenways, drainage ways, waterways and elsewhere.
b. Identify specific management activities that will be occurring on and near the property in the short and long term. Scout for invasives both within and around those activity areas.
c. Document invasive species in a manner consistent with established effective record-keeping practices. (See *Appendix B: Monitoring* for examples.)
d. Confer with forest health specialists or other resource managers to identify forest health threats or invasive plant, insect or disease infestations of concern in the area.
e. Cooperate with partners especially when dealing with invasives on a broader geographical scale or when multi-agency issues are involved.

→ BMP 3.3: Assess current available resources and explore additional resources to prevent the introduction and manage the spread of invasive species.

<u>Considerations:</u>

a. Available resources include facilities, equipment, funding, knowledge base and human resources (both staff and volunteers).

b. Identify local and regional partners, such as neighborhood groups, with whom you may collaborate.
c. Identify individuals or groups with a primary focus on invasive species; if these are volunteers, provide staff support and ways to sustain their commitment.
d. Access information on grants, funding and supportive organizations.
e. Know which regulatory tools are available. For example, federal and state governments may utilize quarantines. Local Iowa governments have the authority to enact and enforce their own nuisance ordinances.

→ BMP 3.4: Develop a plan for managing invasive species.

Considerations:
The extent of the plan should take into consideration property size and management goals. An invasive species management plan may include some or all of the following elements, as appropriate:

a. Preventative measures to limit introductions of invasive species to the property.
b. Early detection of invasive species populations.
c. Measures for an assessment of invasive species threats (prioritization) that considers the impact of invasive species on the property and feasibility of control.
d. Goals for reducing impacts of invasive species present on the property. Sample goals might include:
   - Reduce abundance of host species [for insects and diseases] or habitat [for plants] by increasing vegetative diversity.
   - Revegetate disturbed areas with desirable, non-invasive plants and cover exposed soil with mulch in a timely manner to prevent the establishment of invasive species.
   - Use regular monitoring and early detection to identify and control small populations of invasive species.
   - Use appropriate methods to prevent the introduction of soil, seeds and propagules into uninfested areas (e.g. slow spread, reduce abundance, eradicate).
e. Methods for managing invasive species (e.g. manual, mechanical, chemical, biological and cultural). Keep in mind the resources you have available to control invasive species. Identify key staff and volunteers, budget, and equipment.
f. Methods for educating and informing users, staff, contractors and volunteers on invasive species including identification, impacts and prevention.
g. Discussions with neighbors and other land managers in your area. Consider cooperative projects and share your findings.

→ BMP 3.5: Provide training on identification, management, and prevention techniques of known invasive species to employees, contractors, volunteers, elected officials, owners, users, and the public.

Considerations:
a. Encourage prevention as part of land management activities.
b. Post invasive species messages and prevention strategies at prominent locations on the property and surrounding community.
c. Use methods to reach a broad audience such as including invasives information in your local newspaper or community newsletter.

d. Provide information to your local representatives whose decisions influence invasive species management as well as to the community tree and park managers.
e. Provide information about where to report sightings of invasive species and locations of new infestations.
f. Post informational signs at locations where invasive species management efforts are being implemented; explain impacts, control methods and spread prevention strategies.
g. Present targeted messages during peak use seasons and peak seasons of biological importance ie. seed production, flowering.
h. Provide incentives for users, volunteers, and employees to support invasive species control and management goals; recognize those who contribute to these efforts.

Activity Planning

Once established, many invasive species can increase even as a result of well-intentioned management or maintenance activities. However, planning routine management and maintenance activities can help prevent or minimize the spread of invasive species. An *activity*, for purposes of this chapter, may include any practice that influences vegetation, soils or other habitat conditions such as planting and installation, pruning, mowing or tree removal.

Activity planning may occur on properties of all sizes, uses and types of ownership. Activity plans may be written documents; however, in many cases, activity planning is performed informally by land managers and not committed to paper. Recognizing that planning for activities is accomplished in a variety of ways, the goal of this chapter is to identify a set of steps and considerations that managers can utilize to prevent or minimize the spread of invasive species.

→ BMP 3.6: When planning for a specific management/maintenance activity, scout for invasive species both within and around the activity area.

Considerations:

a. Identify management/maintenance activities that will be occurring on and near the property in the short and long term.
b. Determine how management/maintenance activities may affect or may be affected by invasive species on and near the property.

→ BMP 3.7: Plan urban forest management/maintenance activities to limit the introduction and spread of invasive species. (*See also BMP 7.1*)

Considerations:

The planning phase is the time to consider whether special precautions for invasive species are needed and how they will affect the planned activity. The following BMP Considerations are examples of possible ways to address the BMP Statement.

a. Timing
   - Consider the need for invasive species control efforts, and determine whether those efforts should occur prior to, after or concurrent with the planned urban forest management/maintenance activity.

- If pre-treatment of invasive species is warranted, postpone activity until the infestation can be treated. Effective pre-treatments sometimes need to occur one to two years prior to the activity or even longer to deplete the seedbank.
- Consider practical seasonal timing options that minimize the risk of introducing or moving an invasive species. (See Figure 2.)
- Consider not carrying out an urban forest management/maintenance activity where spread of invasive species is likely.
- Prioritize and concentrate activities based on the most serious threat to make the most of limited human resources.

b. Boundaries
- Set up activity boundaries to exclude areas infested with invasive species that could be moved by equipment and workers.
- Make sure those involved in the activity are aware of the boundary locations and reasoning for their placement. Consider using signage so people not involved in the activity will be aware of the boundaries.
- Locate and use staging areas that are free of invasive plants to avoid spreading seeds and other viable plant parts.
- Sequence
- Consider options for the sequence of operations within the activity area and, where feasible, plan to enter areas infested with invasive species last.

c. Cleaning
- Plan for appropriate cleaning of workers and equipment to limit the introduction and spread of invasive species. Make prior arrangements for any cleaning that may be needed in conjunction with the activity. Consider the risks different types of equipment pose to introducing/spreading invasive species. (*See also Chapter 8: Sanitation and Debris Disposal*)

d. Compaction and Ground disturbance
- Where feasible, avoid creating soil and site conditions that promote invasive plant germination and establishment. Minimize soil disturbance to no more than needed to meet project objectives.
- Consider the impacts of different types of equipment and, where feasible, plan to use equipment that minimizes soil disturbance and compaction.
- Use erosion control techniques to help prevent movement of soil which may contain invasive plants and their propagules.
- Plan ahead of soil disturbing activities to have planting materials and ground covers ready to install to prevent invasion.
- Plan to remediate soil disturbance and compaction caused during projects to allow for establishment of desirable species.

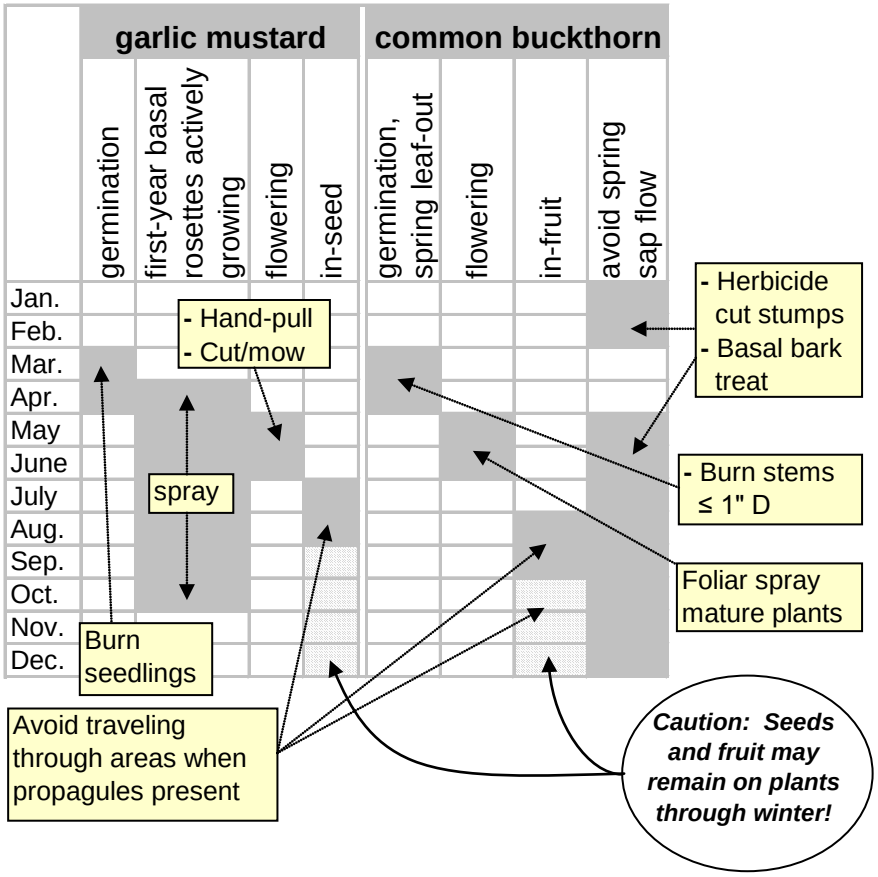


Figure 2. Identifying time windows for invasives species management. Time site preparation activities to avoid spreading invasive seeds and other propagules. The goal of this chart is to present basic planning concepts.

→ BMP 3.8: Plan to monitor each site following urban forestry management/maintenance activities; determine necessary treatments based on presence of invasive species. (*See also Chapter 9: Monitoring and Research*)

<u>Considerations:</u>

a. Conduct periodic inspections of each site following management/maintenance activities, anticipate responses of invasive species to activities and check for new infestations or the spread of existing populations. Inspect on an annual basis, at a minimum, for as long as there is an invasive problem.
b. Consider monitoring the entire property on a regular basis. This depends on the size and location of the property as well as the scale, extent and type of invasive species present.
c. Monitoring should be kept as simple as possible to meet invasive species management objectives. It can be integrated with other activities.
d. Determine appropriate control measures to respond to new infestations or spreading populations. Communicate these options with property owner ahead of time in case they don't want to use chemicals. You may need to allow time for other options.
e. While monitoring sites for known invasive species, land managers should be alert for emerging invasive threats such as the emerald ash borer.

→ BMP 3.9: As opportunities arise, interact with and engage researchers to further our understanding of invasives. (*See also BMP 9.6*)

Our understanding of invasive species ecology and prevention is increasing but still insufficient to contain or control invasives in many situations in which they occur. Our ability to predict what new species may become invasive and what landscape practices may provide habitat for these invasives is even more limited. Research conducted by universities and institutions is one source for learning about invasives. Researchers can also benefit by interacting with practitioners and discussing the emerging invasive species issues in the practice of urban forestry and landscaping.

Considerations:

a. Develop on-going communications and partnerships with area universities, colleges and institutions where the potential for research in matters of interest to urban forestry occur.
b. Consider the potential for cooperative research opportunities when undertaking new controls or practices for which little information is available.
c. Encourage research/testing of (new) urban landscape plants, either native or non-native, which exhibit tolerable levels of sterility and vegetative proliferation.
d. Researchers could be key partners in a monitoring program to help gauge which new plants, insects and diseases may become invasive and in which situations.

Chapter 4: Design

Good landscape design can result in a healthier, more aesthetically pleasing, more ecologically sound and more user friendly urban forest. The absence of a good design could actually contribute to invasive species infestations by intentionally introducing them or by ignoring existing invasive species populations and environmental site conditions. Planting species that are not appropriate for the site can lead to poor growth and less disease and insect resistance. Invasive species will often move in, taking advantage of such a situation. If invasive species are already present, this may influence the species used and the overall design.

BMP 4.1: Conduct a site assessment prior to site design.
BMP 4.2: Conduct an inventory for invasive species as part of a site assessment.
BMP 4.3: Do not include invasive species in planting designs.
BMP 4.4: Design using plant materials that are site appropriate and less susceptible to highly damaging/detrimental pests and diseases.
BMP 4.5: Design planting conditions that foster the establishment and health of plants.
BMP 4.6: Diversify the planting material within the context of your design.
BMP 4.7: Design with long-term management/maintenance in mind.

→ **BMP 4.1: Conduct a site assessment prior to site design.**

Considerations:

a. A site visit to conduct the assessment is necessary. Multiple site visits to conduct the assessment may be necessary depending upon the time of year, ground cover, climatic conditions etc.
b. Factors to consider include: existing hardscapes, below and above ground utilities, neighboring properties, soils, types of ecosystems, microclimate, topography, slope, aspect, hydrology, wildlife, cultural resources, land use, trees and other vegetation including invasive species and potential invaders.
c. Proper site assessment enables selection of vegetation appropriate for the site and therefore more resistant to insects and disease. It locates existing desirable species and conditions that may be utilized in the design. The process identifies areas of invasive species that may need to be treated before implementing a planting plan.

→ **BMP 4.2: Conduct an inventory for invasive species as part of a site assessment.** (*See also Chapter 9: Monitoring and Research*)

Considerations:

Knowing which invasive species are present, their location and extent is the first piece of information needed to evaluate threats. These are some steps to consider in inventorying invasive species:

a. The extent and intensity of inventories should be appropriate to the threat posed by the invasive species in or likely to be in the area and by the potential effects of development/design on the spread, release or control of those species.
b. Inventories for invasive insects and diseases should occur at likely introduction sites such as roads and trails, construction sites, new plantings and stands of dead/dying/stressed trees.
c. If possible, include adjacent properties in invasive species inventories.
d. Inventories could also include discussions with forest health specialists or other resource managers to identify invasive plants, insects or diseases of concern in the area as well as any other forest health threats.

e. Be aware of species that look very similar to invasive species.

→ **BMP 4.3: Do not include invasive species in planting designs.** (*See also BMPs 5.1 & 6.2*)

Considerations:

a. See *Appendix C: Terrestrial Invasive Plants in Iowa*.
b. Consider replacing existing invasive plants in the final planting design. Agencies, organizations and groups can have differing points of view about invasiveness of some species. This is natural considering invasiveness varies due to location, habitat type, disturbance history, urban versus rural locations, proximity to propagules, cultivar and varietal differences and many other factors. What may be invasive in one environment may not be invasive in another.

→ **BMP 4.4: Design using plant materials that are site appropriate and less susceptible to highly damaging/detrimental pests and diseases.** (*See also BMP 6.4*)

Considerations:

a. Site appropriate species are those that are suited to the climate, microclimate (includes wind and sun/shade) and soil type (pH, texture, moisture and drainage) where they are to be planted. In the urban environment, plant material must also be compatible with the hardscapes and maintenance needs.
b. Plant materials (including seeds/seed mixes) from similar hardiness zones or provenances are more likely to be adapted to local growing conditions. Avoid mail orders from sources outside your region unless the contents are guaranteed to be non-invasive.
c. Design with plants which may fulfill multiple needs, e.g. ecological, aesthetic, and wildlife.

Provenance (prov' *uh* n*uh* ns) = The geographic seed source (i.e. where the seed or seedling originated). Assures that the seed or seedling will be adaptable to the general climatic conditions of that geographic area.

Microclimate = The climate of small spaces, such as an inner city, a residential area, or a mountain valley. Microclimate includes: sun/shade, wind, temperature, and precipitation.

→ **BMP 4.5: Design planting conditions that foster the establishment and health of plants.**

Considerations:

a. Healthy vegetation is better able to withstand infestations, infections, and competition from invasive plants.
b. Minimize the amount and severity of soil disturbance to reduce introduction of invasive species to the site.
c. Preserve the existing soil structure if it is intact to foster plant establishment and health; otherwise consider the need for soil amendments.

→ **BMP 4.6: Diversify the planting material within the context of your design.** (*See also BMP 6.5*)

Considerations:

a. Increased species diversity may reduce the impacts of invasive insects or diseases.
b. A diversity of species may inhibit the spread of invasive insects and diseases.

c. For designs other than natural areas or turf grass, consider striving for a species diversity of no more than 20% in one family, no more than 10% in one genus and no more than 5% of any single species, including cultivars and varieties.
d. Consider the existing regional landscape and other designs in the region when diversifying your planting design.
e. Consider a long term planting strategy to increase age diversity. Increased age diversity may reduce the overall impacts if invasive insects or diseases prefer to attack trees of a certain age or size.
f. Consider plants that are hosts for beneficial insects and birds to improve their habitat and function.

→ **BMP 4.7 Design with long-term management/maintenance in mind.**

Considerations:

a. It may be prudent to delay planting or plant in stages to allow time for existing invasive species infestations to be treated prior to planting.
b. Be familiar with invasive species in your region and those that are on their way.
c. Recognize the duration, costs and funding for treatments for plants that are susceptible to invasive insects or diseases.

Chapter 5: Sales

Some of our worst plant invaders were introduced as ornamentals. Research has shown that 85% of woody invasive species in North America were introduced for the landscape trade (Reichard and Hamilton 1997, Snow 2002). The green industry is driven by consumer demand; people are always searching for the latest-and-greatest plants, and new plant introductions are key to the multi-billion dollar industry. Most introduced plants do not cause problems; however, those that do have significant economic and environmental costs. Therefore it is very important to educate the consumer about not using invasive plants and offer non-invasive alternatives.

When it comes to introduced invasive insects and diseases, the green industry is itself a victim. Stock infested or infected with invasive pests may need to be treated or destroyed, and the threat of pests can severely affect demand for host species. Once a big seller, sales of ash species have bottomed out with the increasing threat of emerald ash borer. It becomes even more important for green industry professionals to be vigilant about recognizing and responding to suspected invasive pest problems.

BMP 5.1: Do not purchase, sell or propagate known invasive plant species or their propagules.
BMP 5.2: Do not purchase or sell plant or landscape material you suspect may be infested or infected with invasive pests.
BMP 5.3: When available and appropriate, purchase, sell and propagate species, cultivars and varieties known to be less susceptible to invasive pests as alternatives to more susceptible ones.
BMP 5.4: Plant propagators, wholesalers and retailers should educate themselves and their customers about invasive plants and potential invasive insect and disease issues associated with host plant materials.

→ **BMP 5.1: Do not purchase, sell or propagate known invasive plant species or their propagules**. (*See also BMPs 4.3 & 6.2*)

Considerations:

a. See *Appendix C: Terrestrial Invasive Plants in Iowa.*
b. In general, lists on websites are updated more often than hard copy lists.
c. Agencies, organizations and groups often have differing points of view about which species are invasive. This is natural considering invasiveness varies due to location, habitat type, disturbance history, urban versus rural, proximity to propagules and many other factors. What may be invasive in one environment may not be invasive in another.
d. The United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) regulates the importing and exporting of plant, plant product and soil through the United States. Permits are required for the importation into the U.S. of regulated plants and plant products for consumption and propagation. APHIS does not generally regulate the movement of plants from one state to another, with the exception of parasitic plants, federal noxious weeds (which require a pest permit for interstate movement) and host plants regulated under specific domestic quarantines. The APHIS State Plant Health Director should be contacted to find out if a domestic quarantine applies to your plants.

→ **BMP 5.2: Do not purchase or sell plant or landscape material you suspect may be infested or infected with invasive pests.** (*See also BMP 6.3*)

Considerations:

a. See *Appendix D: Short List of Invasive Insects and Diseases for Iowa.*

b. See *Appendix E: Resources* Sections 3 and 4 for more information on invasive insects and diseases.
c. Inspect plant and landscape material for signs and symptoms of invasive species.
d. Be familiar with invasive plants and the signs and symptoms of invasive insects and diseases that affect or may affect your area.
e. Plants should be purchased only from Licensed Nurseries or from a dealer that has a Grower's License. The Iowa Department of Agriculture, Trade and Consumer Protection (IDALS) inspects and licenses nursery growers and certifies nursery stock to prevent the spread of pests. They also inspect sod to assure it is healthy and free of pests and disease before it is shipped to other states. Licenses assure the purchaser that these nurseries and dealers are in federal compliance and have obtained the proper Certificates necessary to ship outside of quarantined areas and out of state. Licenses are displayed for public view at all companies that are reputable nurseries.

→ **BMP 5.3: When available and appropriate, purchase, sell and propagate species, cultivars and varieties known to be less susceptible to invasive pests as alternatives to more susceptible ones.**

Considerations:

a. Examples of this are the elm cultivars which are less susceptible to Dutch elm disease than the standard American elm.
b. Educate buyers about these choices; this could be used as a marketing piece.
c. This should not preclude the use of certain species to achieve biodiversity (e.g. red oak which is susceptible to oak wilt disease).

→ **BMP 5.4: Plant propagators, wholesalers and retailers should educate themselves and their customers about invasive plants and potential invasive insect and disease issues associated with host plant materials.**

Considerations:

a. Plant propagators, wholesalers and retailers should provide guidance to their customers about the invasive potential of these species and where they should or should not be used.
b. Invasive potential should be assessed by the propagator or qualified experts using emerging risk assessment methods that consider plant characteristics and prior observations or experience with the plant elsewhere in the world.
c. Additional insights may be gained through on-going monitoring in the nursery for potential invasiveness.

Chapter 6: Planting and Installation

Planting and installation activities can introduce and spread invasive species. Disturbed ground provides opportunities for invasives to germinate. Plant and construction materials brought onto the site may be invasive or may harbor invasives. Equipment used for planting and installation activities, as well as boots and clothing of personnel, may carry invasives or their propagules.

BMP 6.1: Limit the introduction and spread of invasives during site preparation activities.
BMP 6.2: Do not plant invasive species.
BMP 6.3: Do not plant material that you suspect may be infested or infected with invasive pests.
BMP 6.4: Select plant materials that are site appropriate, healthy and less susceptible to highly damaging/detrimental pests and diseases.
BMP 6.5: Diversify the planting material within the context of your planting project.
BMP 6.6: Prepare site and plant trees according to current arboriculture industry standards for optimum tree health.
BMP 6.7: Reduce the introduction of pathogens and insects by avoiding unnecessary wounding of trees and other vegetation.
BMP 6.8: Avoid unnecessary soil disturbance.
BMP 6.9: Stabilize disturbed soils in a timely manner to prevent the establishment of invasive species.
BMP 6.10: Use landscape materials that are free of invasive species and their propagules.
BMP 6.11: Monitor sites following planting and installation activities; determine necessary treatments based on presence of invasive species.
BMP 6.12: Prior to relocating equipment, vehicles, and trailers, remove soil and debris from exterior surfaces by scraping, brushing, washing or using other methods to minimize the risk of transporting propagules.
BMP 6.13: Remove soil, seeds, vegetative matter and other debris from shoes, clothing and tools prior to leaving an area.

→ **BMP 6.1: Limit the introduction and spread of invasives during site preparation activities.**

Site preparation methods should be determined by site conditions and site preparation objectives. Site preparation can be accomplished by mechanical or chemical methods or with the use of fire. Often these methods are used in conjunction to control competing vegetation.

Site preparation methods may involve disturbing the soil bed by removing existing vegetation and exposing soil to create a favorable growing environment for trees or other desirable vegetation. It is important to keep in mind that the majority of site preparation methods will create conditions favorable to invasive plant colonization. New invasive species may become established and existing populations may spread.

<u>Considerations:</u>

a. In areas where invasive species are known to be present, including in the seed bank, it may be necessary to treat invasives as part of the site preparation process. Keep in mind it is almost always easier to treat invasives before an area is planted to its desired vegetation.
b. Spot application of herbicides or fire (with the use of a weed torch) may reduce the impact to non-target plants.
c. One goal of site preparation might be to promote invasive plant species germination or growth from the existing soil seedbank or root system—then treating—in order to eliminate some of the seedbank competition before planting desired vegetation.

d. While ground disturbance may be necessary to aid the germination and establishment of desirable vegetation (especially when planting by seed), it should not extend beyond the area where revegetation is desired.
e. Some seed planting may be accomplished by methods requiring little to no soil disturbance (e.g. no till drilling or broadcast seeding prairie in late autumn before first snow.)
f. Avoid damaging branches, stems or roots of trees and other vegetation to be retained in the landscape during mechanical site preparation. Reference *American Standards for Tree Care Operations – Management of Trees and Shrubs During Site Planning (ANSI A300 Part 5)*
g. Time site preparation activities to avoid spreading invasive seeds and other propagules. (See Figure 3.)
h. Inspecting areas at highest risk of invasion following soil disturbance activities may help to detect new invasions.

Soil seedbank = the collective name for the store of unsprouted seeds in the soil. For example, although most seeds sprout in the first few years after they fall onto the soil, some spotted knapweed seeds last 10 years in the soil before they sprout.

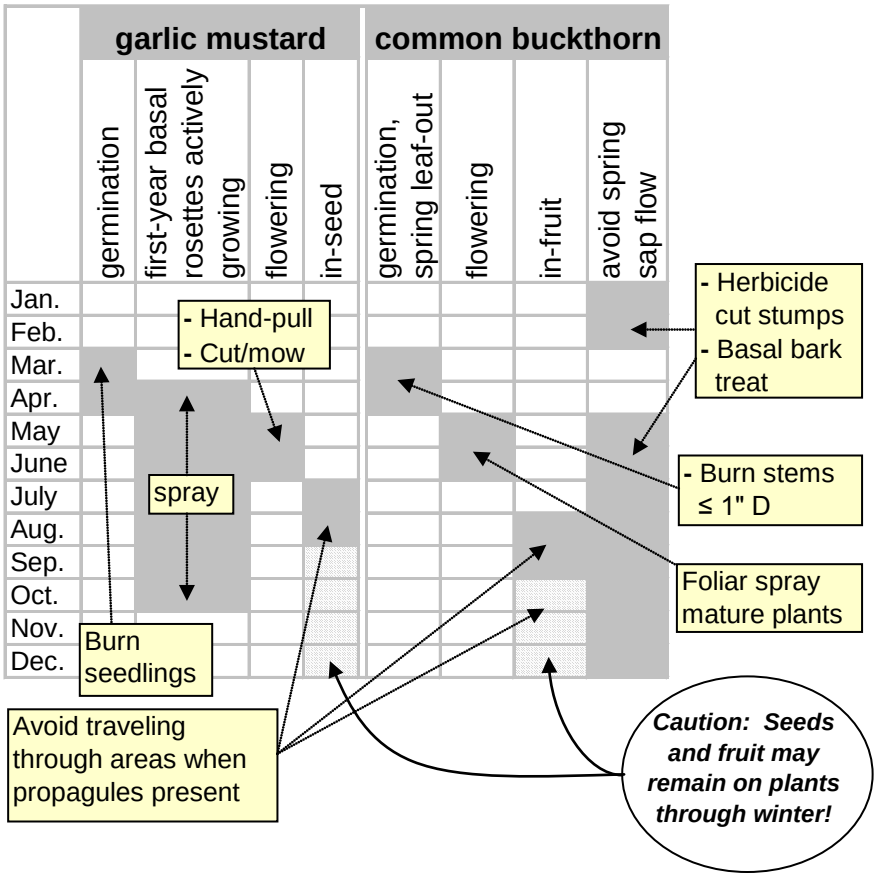


Figure 2. Identifying time windows for invasives species management. Time site preparation activities to avoid spreading invasive seeds and other propagules. The goal of this chart is to present basic planning concepts.

→ **BMP 6.2: Do not plant invasive species.** (*See also BMP 4.3*)

Considerations:

a. See *Appendix C: Terrestrial Invasive Plants in Iowa*.
b. See *Appendix E: Resources* Section 2 for plants to use as an alternative to invasives.

c. In general, lists on websites are updated more often than hard copy lists.
d. Agencies, organizations and groups often have differing points of view about which species are invasive. This is natural considering invasiveness varies due to location, habitat type, disturbance history, urban versus rural locations, proximity to propagules and many other factors. What may be invasive in one environment may not be invasive in another.
e. The United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) regulates the importing and exporting of plant, plant product and soil through the United States. Permits are required for the importation into the U.S. of regulated plants and plant products for consumption and propagation. APHIS does not generally regulate the movement of plants from one state to another, with the exception of parasitic plants, federal noxious weeds (which require a pest permit for interstate movement) and host plants regulated under specific domestic quarantines. The APHIS State Plant Health Director should be contacted to find out if a domestic quarantine applies to your plants.

→ **BMP 6.3: Do not plant material that you suspect may be infested or infected with invasive pests.** (*See also BMP 5.2*)

Considerations:

a. See *Appendix D: Short List of Invasive Insects and Diseases for Iowa*.
b. See *Appendix E: Resources* Sections 3 and 4 for more information on invasive insects and diseases.
c. Inspect plant and landscape material for signs and symptoms of invasive species.
d. Be familiar with invasive plants and the signs and symptoms of invasive insects and diseases that affect or may affect your area.
e. Plants should be purchased only from Licensed Nurseries or from a dealer that has a Grower's License. The Iowa Department of Agriculture, Trade and Consumer Protection (IDALS) inspects and licenses nursery growers and certifies nursery stock to prevent the spread of pests. They also inspect sod to assure it is healthy and free of pests and disease before it is shipped to other states. Licenses assure the purchaser that these nurseries and dealers are in federal compliance and have obtained the proper Certificates necessary to ship outside of quarantined areas and out of state. Licenses are displayed for public view at all companies that are reputable nurseries.
f. A purchasing contract from the vendor supplying stock may help insure pest free materials if it is specified in the contract.
g. Recognize that invasives may inhabit the soil associated with nursery stock, e.g. invasive plant propagules, specific invasive insect stages, invasive diseases and even non-native earthworms.

→ **BMP 6.4: Select plant materials that are site appropriate, healthy and less susceptible to highly damaging/detrimental pests and diseases.** (*See also BMP 4.4*)

Considerations:

a. Healthy trees are less susceptible to insect and disease outbreaks than stressed trees.
b. Site appropriate species are those that are suited to the climate, microclimate (includes wind and sun/shade) and soil type (pH, texture, moisture and drainage) where they are to be planted. In the urban environment, plant material must also be compatible with the hardscapes and maintenance needs.
c. Plant materials (including seeds/seed mixes) from similar hardiness zones or provenances are more likely to be adapted to local growing conditions. Avoid mail orders from sources outside your region unless the contents are guaranteed to be non-invasive.

d. Examine stock before planting—be sure it is not diseased, infested with insects or mislabeled. All plant material shall conform to American Standards for Nursery Stock (ANSI Z60.1). (Note: It is not common for stock to be diseased. However, a disease like gall rust could easily be identified, and those plants could be culled.)
e. Some trees and other vegetation are host species or alternative hosts for native diseases and insects. If the potential for damage is low, this should not preclude their use. If the potential for damage is a concern, consider using resistant varieties or a completely different species.
f. Plant species that fulfill multiple needs, e.g. ecological, aesthetic and wildlife.

Provenance (prov' *uh nuh* ns) = The geographic seed source (i.e. where the seed or seedling originated). Assures that the seed or seedling will be adaptable to the general climatic conditions of that geographic area.

Microclimate = The climate of small spaces, such as an inner city, a residential area, or a mountain valley. Microclimate includes: sun/shade, wind, temperature, and precipitation.

→ **BMP 6.5: Diversify the planting material within the context of your planting project.** (*See also BMP 4.6*)

Considerations:

a. Increased species diversity may reduce the impacts of invasive insects or diseases.
b. A diversity of species may inhibit the spread of invasive insects and diseases.
c. For designs other than natural areas or turf grass, consider striving for a species diversity of no more 20% in one family, no more than 10% in one genus and no more than 5% of any single species, including cultivars and varieties.
d. Consider the existing regional landscape and other designs in the region when diversifying your planting design.
e. Consider a long term planting strategy to increase age diversity. Increased age diversity may reduce the overall impacts if invasive insects or diseases prefer to attack trees of a certain age or size.
f. Consider plants that are hosts for beneficial insects and birds to improve their habitat and function.

→ **BMP 6.6: Prepare site and plant trees according to current arboriculture industry standards for optimum tree health.**

Considerations:

a. Proper site preparation can lead to healthier trees which may be better able to withstand infestations, infections and competition from invasive plants.
b. Selecting a tree to a site that meets the tree's optimum growing conditions will assist the tree in having a less stressful environment and thus, better able to become established in the landscape.
c. Avoid using soils known to be contaminated by herbicide residue or by salt and oil from vehicles and roadways for a better planting medium.
d. See American Standards for Tree Care Operations- Transplanting (ANSI A300 Part 6) and its companion publication Best Management Practices: Tree Planting from the International Society of Arboriculture.

→ **BMP 6.7: Reduce the introduction of pathogens and insects by avoiding unnecessary wounding of trees and other vegetation.** (*See also BMP 7.4*)

Pathogen (păth'ə-jən) = An agent that causes disease, especially a living microorganism such as a bacterium or fungus.

Considerations:

a. Avoid wounding during periods of high risk transmission. Refer to current Iowa Department of Natural Resources and ISU Extension research and literature for specifics, for example, oak wilt and Dutch elm disease. Be sure to check your local ordinances first; local ordinances may use more restrictive dates than the state recommends.
b. Erect barriers to protect existing trees and other vegetation from injury during planting and installation activities occurring in the same general area. See *American Standards for Tree Care Operations – Management of Trees and Shrubs During Site Planning (ANSI A300 Part 5)*.

→ **BMP 6.8: Avoid unnecessary soil disturbance.** (*See also BMP 7.7*)

Considerations:

a. Ground disturbance may uproot existing vegetation and expose soil, creating a seedbed for invasive plants that can overwhelm desirable vegetation.
b. Topsoil may be lost to wind or water erosion; local ordinances for silt fencing and other erosion control practices may apply.
c. Soil disturbance, when combined with aggressive follow-up control measures, may be used to control invasive species within infested areas by depleting the seed bank.
d. Disking or tillage operations may propagate invasive plants that spread by rhizomes, root fragments or seed and should, therefore, be used cautiously.
e. After a soil disturbance, encourage prompt regeneration of desirable vegetation or cover exposed soil with a layer of mulch to reduce germination or introduction of invasive plants.
f. After a soil disturbance, monitor the area and treat new invasive plant infestations.
g. Check with the Iowa Department of Natural Resources as well as your local government to see if your project's soil disturbance requires any erosion permits or erosion control practices such as silt fencing.

→ **BMP 6.9: Stabilize disturbed soils in a timely manner to prevent the establishment of invasive species.** (*See also BMP 7.8*)

Considerations:

a. After a soil disturbance, encourage prompt regeneration of desirable vegetation or cover exposed soil with a layer of mulch to reduce germination or introduction of invasive plants.
b. Stabilizing disturbed soils includes: revegetating, mulching (straw, wood, leaf), the use of biologs or erosion matting, etc.
c. A non-persistent cover crop like annual rye or oats can be used to temporarily stabilize the soil and discouraging the establishment of invasive species.
d. Use weed-free oat or wheat straw where available; "marsh hay" may contain reed canary grass.
e. In areas where invasive species are known to be in the seed bank, treat invasives before revegetating.

f. You may purposely not plant a disturbed area if your goal is to promote invasive plant species germination from the existing seedbank—then treating it—in order to eliminate some of the invasive seedbank.
g. Inspecting areas at highest risk of invasion following soil disturbance activities may help to detect new invasions.

→ **BMP 6.10: Use landscape materials that are free of invasive species and their propagules.** (*See also BMPs 7.6. and 8.7*)

Propagule (prŏp' ə gyool) = Any reproductive structure or part of an organism that can grow independently of its parent source. In plants, this may be a fruit, seed, bud, tuber, root, stem with rooting structures or shoot. In forest insects, this may be an egg, larva, pupa or adult. In forest diseases, this may be a spore, mycelial fragment (similar to roots) or a fruiting body.

Considerations:

a. Landscape materials include: fill, top soil, soil amendments, compost, erosion control materials, stone and mulch.
b. Knowing the source of landscape materials may help you avoid infested source material.
c. Treat infested source material to render invasive species as non-viable prior to its use.
d. Stockpile displaced topsoil for future use on the same site in an invasives free area. Be aware that if the topsoil is piled too deep, advantageous fungi may be destroyed. This effect varies by soil type, climate and other factors.
e. Keep stockpiled material free of invasive species.
f. Use weed-free oat or wheat straw where available; "marsh hay" may contain reed canary grass.
g. Avoid contaminants such as salt, oil and herbicide residue for a better planting medium.
h. Consider reusing or recycling landscape materials on site to avoid potentially transporting invasives.

→ **BMP 6.11: Monitor sites following planting and installation activities; determine necessary treatments based on presence of invasive species.**

Considerations:

a. Anticipate responses of invasive species to planting and installation activities and check for new infestations or the spread of existing populations.
b. Determine appropriate control measures to respond to new infestations or spreading populations.
c. Monitoring should be kept as simple as possible to meet invasive species management objectives.

→ **BMP 6.12: Prior to relocating equipment, vehicles, and trailers, remove soil and debris from exterior surfaces by scraping, brushing, washing or using other methods to minimize the risk of transporting propagules.** (*See also BMPs 7.11 & 8.1*)

Equipment cleaning

Invasive species can spread by equipment used in urban forestry, landscaping and maintenance activities, as well as by the workers themselves. Seeds, plant parts, and fungal spores can move in soil or mud in undercarriages, tire tread and on other areas of equipment. Insects in all life stages can also be moved by equipment. Mud and debris stuck to boots, clothing or tools can also transport invasive plant material, insects

and disease. Invasive species covered under this BMP include plants (fruit, seed, bud, tuber, root, etc.), insects (egg, larvae, pupae, overwintering adults, etc.) or diseases (fungi, bacteria, viruses, etc.).

For purposes of these BMPs:

- "equipment" refers to off-road, rubber-tired and tracked equipment including mowers, skid steers, bucket loaders, dozers, graders, chippers and other construction equipment.
- "relocating" refers to moving off the work site OR moving within the work site from an infested to a non-infested area.
- "disposal" refers to methods to dispose of invasive species which can include burning, treating and containment, i.e. bagging. (*See also Chapter 8: Sanitation and Debris Disposal.*)

Considerations:

a. Equipment should be free of invasives when it arrives at the work site.
b. Clean equipment after operating in an area with invasive species and before relocating to an area free of invasives. Cleaning would occur before leaving the project site, at the site of infestation.
c. Preferred locations for equipment cleaning areas are those where:
    - Equipment is unloaded and loaded.
    - Invasives are less likely to spread from cleaned equipment (e.g. a blacktopped parking lot). Collect, bag and dispose of properly. (*See also BMP 8.5*)
    - Invasive species are already established.
    - Monitoring can be conducted at a later date.
d. To limit the spread of invasives downstream, do not clean equipment, vehicles or trailers in or near waterways or storm sewers.
e. Contain or filter wash water on-site, if possible.

→ **BMP 6.13: Remove soil, seeds, vegetative matter and other debris from shoes, clothing and tools prior to leaving an area.** (*See also BMPs 7.12 & 8.2*)

Considerations:

a. Preferred locations for cleaning your person are those where:
    - Equipment is cleaned.
    - Invasives are less likely to spread (e.g. a blacktopped parking lot). Collect, bag and dispose of properly. (*See also BMP 8.5*)
    - Invasive species are already established.
b. Check places like hoods, pockets, seams and Velcro fasteners.

Chapter 7: Management/Maintenance

Proper care is essential for maintaining and improving the health of our urban and community forests. Routine maintenance and/or management helps to maximize the benefits they provide and minimize the costs associated with their management. However, these activities often unknowingly introduce and spread invasive species. Maintenance/management activities include, but are not limited to: pruning, removals, mulching, watering, fertilizing and lawn care.

BMP 7.1: Plan management/maintenance activities to limit the introduction and spread of invasive species.
BMP 7.2: When working in an area infested or previously infested with invasives, utilize monitoring surveys and control records for the property prior to the current work being conducted.
BMP 7.3: Minimize the movement of invasive species to non-infested areas during management/maintenance activities.
BMP 7.4: Reduce the introduction of pathogens and insects by avoiding unnecessary wounding of trees and other vegetation.
BMP 7.5: Perform activities in a way that promotes healthy plants.
BMP 7.6: Use landscape materials that are free of invasive species and their propagules.
BMP 7.7: Avoid unnecessary soil disturbance.
BMP 7.8: Stabilize disturbed soils in a timely manner to prevent the establishment of invasive species.
BMP 7.9: Keep records of activities that could affect invasives.
BMP 7.10: If possible, monitor recent work sites for invasive species.
BMP 7.11: Prior to relocating equipment, vehicles, and trailers, remove soil and debris from exterior surfaces by scraping, brushing, washing or using other methods to minimize the risk of transporting propagules.
BMP 7.12: Remove soil, seeds, vegetative matter and other debris from shoes, clothing and tools prior to leaving an area.
BMP 7.13: Properly treat or dispose of invasive species or materials that may harbor invasive propagules, insects or diseases.
BMP 7.14: If pre- or post-activity invasive species control treatments are planned, ensure they are applied within the appropriate time window and environmental conditions.

→ **BMP 7.1: Plan management/maintenance activities to limit the introduction and spread of invasive species.** (*See also BMP 3.7*)

Considerations:
The planning phase is the time to consider whether special precautions for invasive species are needed and how they will affect the planned activity. The following BMP Considerations are examples of possible ways to address the BMP Statement.

a. Timing
   - Consider the need for invasive species control efforts, and determine whether those efforts should occur prior to, after or concurrent with the planned urban forest management/maintenance activity.
   - If pre-treatment of invasive species is warranted, postpone activity until the infestation can be treated. Effective pre-treatments sometimes need to occur one to two years prior to the activity or even longer to deplete the seedbank.
   - Consider practical seasonal timing options that minimize the risk of introducing or moving an invasive species. (See Figure 2.)

- Consider not carrying out an urban forest management/maintenance activity where spread of invasive species is likely.
- Prioritize and concentrate activities based on the most serious threat to make the most of limited human resources.

b. Boundaries
- Set up activity boundaries to exclude areas infested with invasive species that could be moved by equipment and workers.
- Make sure those involved in the activity are aware of the boundary locations and reasoning for their placement. Consider using signage so people not involved in the activity will be aware of the boundaries.
- Locate and use staging areas that are free of invasive plants to avoid spreading seeds and other viable plant parts.

c. Sequence
- Consider options for the sequence of operations within the activity area and, where feasible, plan to enter areas infested with invasive species last.

d. Cleaning
- Plan for appropriate cleaning of workers and equipment to limit the introduction and spread of invasive species. Make prior arrangements for any cleaning that may be needed in conjunction with the activity. Consider the risks different types of equipment pose to introducing/spreading invasive species. (*See also Chapter 8: Sanitation and Debris Disposal*)

e. Compaction and Ground disturbance
- Where feasible, avoid creating soil and site conditions that promote invasive plant germination and establishment. Minimize soil disturbance to no more than needed to meet project objectives.
- Consider the impacts of different types of equipment and, where feasible, plan to use equipment that minimizes soil disturbance and compaction.
- Use erosion control techniques to help prevent movement of soil which may contain invasive plants and their propagules.
- Plan ahead of soil disturbing activities to have planting materials and ground covers ready to install to prevent invasion.
- Plan to remediate soil disturbance and compaction caused during projects to allow for establishment of desirable species.

→ **BMP 7.2: When working in an area infested or previously infested with invasives, utilize monitoring surveys and control records for the property prior to the current work being conducted.**

<u>Considerations:</u>

a. This can help you plan the sequencing of operations so that you're working from non-infested to infested areas.
b. This will also let you know whether or not previous invasives management techniques have been working and what you could do to achieve better success.

→ **BMP 7.3: Minimize the movement of invasive species to non-infested areas during management/maintenance activities.**

Considerations:

a. Locate and use staging areas that are free of invasive plants to avoid spreading seeds and other viable plant parts.
b. Set up activity boundaries to exclude areas with an invasive species infestation that could easily be disturbed by equipment, workers or users.
c. Clean equipment before moving from infested to non-infested areas.
d. Carry out work under conditions that minimize the risk of spread, e.g. frozen ground, snow cover, absence of seeds/propagules, etc. (See Figure 2.)
e. Exclude infested areas from equipment travel corridors.
f. Disinfect pruning equipment between cuts when pruning out diseased portions of plants.
g. Take measures to minimize the spread of pests when management cannot occur at optimal times. For example, immediately paint wounds on oak trees when they must be pruned during the active oak wilt season.
h. Check for compliance with local ordinances when conducting maintenance activities and when disposing of debris that is infested or infected with invasive species.

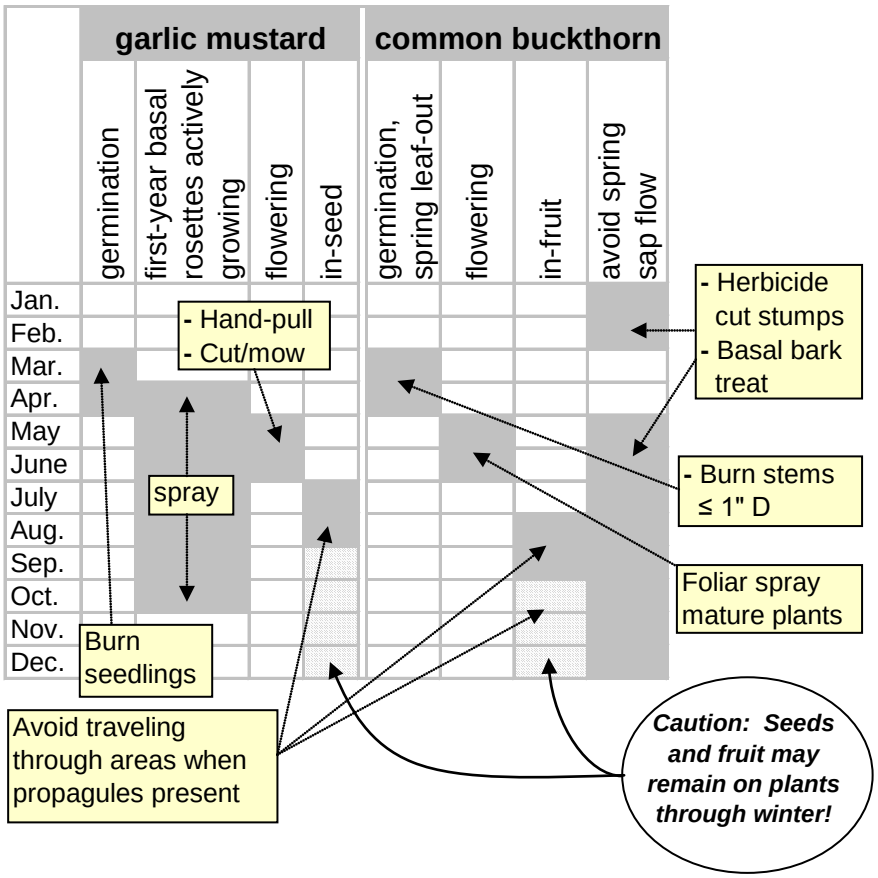


Figure 2. Identifying time windows for invasives species management. Time site preparation activities to avoid spreading invasive seeds and other propagules. The goal of this chart is to present basic planning concepts.

→ **BMP 7.4: Reduce the introduction of pathogens and insects by avoiding unnecessary wounding of trees and other vegetation.** (*See also BMP 6.7*)

Pathogen (păth'ə-jən) = An agent that causes disease, especially a living microorganism such as a bacterium or fungus.

Considerations:

a. Avoid wounding during periods of high risk transmission. Refer to current Iowa Department of Natural Resources and ISU Extension research and literature for specifics, for example, oak wilt and Dutch elm disease. Be sure to check your local ordinances first; local ordinances may use more restrictive dates than the state recommends.
b. Erect barriers to protect existing trees and other vegetation from injury during planting and installation activities occurring in the same general area. See *American Standards for Tree Care Operations – Management of Trees and Shrubs During Site Planning (ANSI A300 Part 5).*

→ **BMP 7.5: Perform activities in a way that promotes healthy plants.**

Considerations:

a. Healthy plants are better able to survive and compete against invasive plants, insects and diseases.
b. Follow ANSI (American National Standards Institute) A300 Standards for Tree Care Operations. For example follow proper pruning, watering, mulching, fertilizing, etc.

→ **BMP 7.6: Use landscape materials that are free of invasive species and their propagules.** (*See also BMPs 6.9. and 8.7*)

Propagule (prŏp' ə gyool) = Any reproductive structure or part of an organism that can grow independently of its parent source. In plants, this may be a fruit, seed, bud, tuber, root, stem with rooting structures or shoot. In forest insects, this may be an egg, larva, pupa or adult. In forest diseases, this may be a spore, mycelial fragment (similar to roots) or a fruiting body.

Considerations:

a. Landscape materials include: fill, top soil, soil amendments, compost, erosion control materials, stone and mulch.
b. Knowing the source of landscape materials may help you avoid infested source material.
c. Treat infested source material to render invasive species as non-viable prior to its use.
d. Stockpile displaced topsoil for future use on the same site in an invasives free area. Be aware that if the topsoil is piled too deep, advantageous fungi may be destroyed. This effect varies by soil type, climate and other factors.
e. Keep stockpiled material free of invasive species.
f. Use weed-free oat or wheat straw where available; "marsh hay" may contain reed canary grass.
g. Avoid contaminants such as salt, oil and herbicide residue for a better planting medium.
h. Consider reusing or recycling landscape materials on site to avoid potentially transporting invasives.

→ **BMP 7.7: Avoid unnecessary soil disturbance.** (*See also BMP 6.8*)

Considerations:

a. Ground disturbance may uproot existing vegetation and expose soil, creating a seedbed for invasive plants that can overwhelm desirable vegetation.

b. Topsoil may be lost to wind or water erosion; local ordinances for silt fencing and other erosion control practices may apply.
c. Soil disturbance, when combined with aggressive follow-up control measures, may be used to control invasive species within infested areas by depleting the seed bank.
d. Disking or tillage operations may propagate invasive plants that spread by rhizomes, root fragments or seed and should, therefore, be used cautiously.
e. After a soil disturbance, encourage prompt regeneration of desirable vegetation or cover exposed soil with a layer of mulch to reduce germination or introduction of invasive plants.
f. After a soil disturbance, monitor the area and treat new invasive plant infestations.
g. Check with the Iowa Department of Natural Resources as well as your local government to see if your project's soil disturbance requires any erosion permits or erosion control practices such as silt fencing.

→ **BMP 7.8: Stabilize disturbed soils in a timely manner to prevent the establishment of invasive species.** (*See also BMP 6.9*)

Considerations:

a. After a soil disturbance, encourage prompt regeneration of desirable vegetation or cover exposed soil with a layer of mulch to reduce germination or introduction of invasive plants.
b. Stabilizing disturbed soils includes: revegetating, mulching (straw, wood, leaf), the use of biologs or erosion matting, etc.
c. A non-persistent cover crop like annual rye or oats can be used to temporarily stabilize the soil and discouraging the establishment of invasive species.
d. Use weed-free oat or wheat straw where available; "marsh hay" may contain reed canary grass.
e. In areas where invasive species are known to be in the seed bank, treat invasives before revegetating.
f. You may purposely not plant a disturbed area if your goal is to promote invasive plant species germination from the existing seedbank—then treating it—in order to eliminate some of the invasive seedbank.
g. Inspecting areas at highest risk of invasion following soil disturbance activities may help to detect new invasions.

→ **BMP 7.9: Keep records of activities that could affect invasives.** (*See also Chapter 9: Monitoring and Research*)

Considerations:

a. This BMP refers to records of maintenance activities such as pruning, removals, mulching, watering, fertilizing and lawn care. It does not refer to records of invasive control techniques, although that may be part of the maintenance activities. If invasive species control techniques are part of the activities, consider using monitoring methods specific to infestations.
b. Record keeping should be consistent with your current management/maintenance recording methods.
c. Records should be complete and accurate.
d. Records should be easily accessible for future reference.
e. Examples of information to include in your records are: times, places, activities and maps.
f. See *Appendix B: Monitoring* for examples of recording sheets.

→ **BMP 7.10: If possible, monitor recent work sites for invasive species.** (*See also BMP 9.3*)

Considerations:

a. Conduct periodic inspections of each site following management/maintenance activities.
b. Anticipate responses of invasive species to activities and check for new infestations, infections or the spread of existing populations during the appropriate life stage timing for the specific invasive in question.
c. Determine appropriate control measures to respond to new infestations or spreading populations.
d. If it is not possible to conduct follow-up monitoring (e.g. business hired for one job), then it becomes an opportunity to educate the customer on the need for monitoring and possible follow-up on their part.

Equipment cleaning

Invasive species can spread by equipment used in urban forestry, landscaping and maintenance activities, as well as by the workers themselves. Seeds, plant parts, and fungal spores can move in soil or mud in undercarriages, tire tread and on other areas of equipment. Insects in all life stages can also be moved by equipment. Mud and debris stuck to boots, clothing or tools can also transport invasive plant material, insects and disease. Invasive species covered under this BMP include plants (fruit, seed, bud, tuber, root, etc.), insects (egg, larvae, pupae, overwintering adults, etc.) or diseases (fungi, bacteria, viruses, etc.).

For purposes of these BMPs:

- "equipment" refers to off-road, rubber-tired and tracked equipment including mowers, skid steers, bucket loaders, dozers, graders, chippers and other construction equipment.
- "relocating" refers to moving off the work site OR moving within the work site from an infested to a non-infested area.
- "disposal" refers to methods to dispose of invasive species which can include burning, treating and containment, i.e. bagging. (*See also Chapter 8: Sanitation and Debris Disposal.*)

→ **BMP 7.11: Prior to relocating equipment, vehicles, and trailers, remove soil and debris from exterior surfaces by scraping, brushing, washing or using other methods to minimize the risk of transporting propagules.** (*See also BMPs 6.12 & 8.1*)

Considerations:

a. Equipment should be free of invasives when it arrives at the work site.
b. Clean equipment after operating in an area with invasive species and before relocating to an area free of invasives. Cleaning should occur before leaving the project site, at the site of infestation.
c. Preferred locations for equipment cleaning areas are those where:
    - Equipment is unloaded and loaded.
    - Invasives are less likely to spread from cleaned equipment (e.g. a blacktopped parking lot). Collect, bag and dispose of properly. (*See also BMP 8.5*)
    - Invasive species are already established.
    - Monitoring can be conducted at a later date.
d. To limit the spread of invasives downstream, do not clean equipment, vehicles or trailers in or near waterways or storm sewers.
e. Contain or filter wash water on-site, if possible.

→ **BMP 7.12: Remove soil, seeds, vegetative matter and other debris from shoes, clothing and tools prior to leaving an area.** (*See also BMPs 6.13 & 8.2*)

Considerations:

a. Preferred locations for cleaning your person are those where:
   - Equipment is cleaned.
   - Invasives are less likely to spread (e.g. a blacktopped parking lot). Collect, bag and dispose of properly. (*See also BMP 8.5*)
   - Invasive species are already established.
b. Check places like hoods, pockets, seams and Velcro fasteners.

→ **BMP 7.13: Properly treat or dispose of invasive species or materials that may harbor invasive propagules, insects or diseases.** (*See also BMP 8.5*)

Considerations:

a. Place plant materials in a sturdy clear plastic bag labeled "Invasive plants – please landfill" and dispose of as you would with regular garbage. For more information, contact the IA DNR's Bureau of Waste Management.
b. Materials may be disposed of in piles. Locate the pile in an area that facilitates easy monitoring and control if infestations spread from the pile.
c. Materials may be burned. Regulations and permits may apply. For more information, contact the IA DNR Bureau of Waste Management and the IA DNR Bureau of Air Management.
d. Materials may be buried. Burial depth is specific to the invasive. An average minimum depth would be three feet, but some invasives need to be buried even deeper. For example, Japanese knotweed can grow through five feet of soil. Be aware that if you later dig into this soil you may be exposing propagules.
e. Materials might be utilized for value added products e.g. fuel, furniture, etc.
f. Chipping woody debris may kill invasive pests if chipped to a size specific to the target insect. However, wood chips may still contain other invasive propagules that may spread if the chips are used in an area other than from where they originated.
g. Material taken from sites that contain invasive plants should not be used away from the site of infestation until all viable plant material is destroyed. Material from areas containing invasive plants may be reused within the exact limits of the infestation.
h. Any excavated material that contains viable plant material and is not reused within the limits of the infestation should be stockpiled on an impervious surface until viable plant material is destroyed (Perron 2008).
i. Do not dump yard waste in parklands, natural areas and waterways.
j. Do not home compost invasive species or their propagules. Backyard compost piles and bins do not reliably generate enough heat for a long enough period of time to destroy weed seeds.
k. If possible, use invasive control options that don't create waste. For example, use a basal bark treatment on woody invasives which kills the invasive as it is left in place instead of a cut stump treatment which creates woody debris.

→ **BMP 7.14: If pre- or post-activity invasive species control treatments are planned, ensure they are applied within the appropriate time window and environmental conditions.**

Considerations:

a. Consider life history of target invasive species in relation to seasonal timing of control methods. (See Figure 2.)
b. The party responsible for creating activity plans should be responsible for planning pre- or post-activity invasive species treatments.
c. Allow time and resources for post-activity follow-up control measures, due to persistent seedbank, resprouting and other factors.
d. Allow enough time for control prior to activity.
e. Determine appropriate control measures to respond to new infestations or spreading populations. Communicate these options with property owner ahead of time in case they don't want to use chemicals. You may need to allow time for other options.
f. Environmental conditions are very important for the proper application of herbicides; rain, sun, temperature and wind can all affect the application's effectiveness. Federal law requires the applicator to always follow label instructions.

Chapter 8: Sanitation and Debris Disposal

The spread of invasive species has been perpetuated by the improper disposal of invasives and invasive propagules. Inadequate sanitation procedures of equipment used or located in an area that includes invasives only compounds the problem. Most often, improper disposal and sanitation results from a lack of knowledge about invasive species and the damage they cause, rather than from intentional means. The spread of invasives and new introductions can be reduced by properly disposing of debris and by using effective sanitation procedures.

BMP 8.1: Prior to relocating equipment, vehicles, and trailers, remove soil and debris from exterior surfaces by scraping, brushing, washing or using other methods to minimize the risk of transporting propagules.
BMP 8.2: Remove soil, seeds, vegetative matter and other debris from shoes, clothing and tools prior to leaving an area.
BMP 8.3: Minimize the offsite transport of invasives and materials that may contain invasives.
BMP 8.4: When necessary to transport invasives and materials that may contain invasives off site, cover or otherwise contain those materials.
BMP 8.5: Properly treat or dispose of invasive species or materials that may harbor invasive propagules, insects or diseases.
BMP 8.6: Allow compost piles to heat to appropriate temperatures and times and with proper procedures to reduce the viability of invasives contained within.
BMP 8.7: Avoid the use of wood chips and compost that may contain invasive propagules.

Equipment cleaning

Invasive species can spread by equipment used in urban forestry, landscaping and maintenance activities, as well as by the workers themselves. Seeds, plant parts, and fungal spores can move in soil or mud in undercarriages, tire tread and on other areas of equipment. Insects in all life stages can also be moved by equipment. Mud and debris stuck to boots, clothing or tools can also transport invasive plant material, insects and disease. Invasive species covered under this BMP include plants (fruit, seed, bud, tuber, root, etc.), insects (egg, larvae, pupae, overwintering adults, etc.) or diseases (fungi, bacteria, viruses, etc.).

For purposes of these BMPs:

- "equipment" refers to off-road, rubber-tired and tracked equipment including mowers, skid steers, bucket loaders, dozers, graders, chippers and other construction equipment.
- "relocating" refers to moving off the work site OR moving within the work site from an infested to a non-infested area.
- "disposal" refers to methods to dispose of invasive species which can include burning, treating and containment, i.e. bagging. (*See also Chapter 8: Sanitation and Debris Disposal.*)

→ **BMP 8.1: Prior to relocating equipment, vehicles, and trailers, remove soil and debris from exterior surfaces by scraping, brushing, washing or using other methods to minimize the risk of transporting propagules.** (*See also BMPs 6.12 & 7.11*)

<u>Considerations:</u>

a. Equipment should be free of invasives when it arrives at the work site.
b. Clean equipment after operating in an area with invasive species and before relocating to an area free of invasives. Cleaning should occur before leaving the project site, at the site of infestation.
c. Preferred locations for equipment cleaning areas are those where:

- Equipment is unloaded and loaded.
- Invasives are less likely to spread from cleaned equipment (e.g. a blacktopped parking lot). Collect, bag and dispose of properly. (*See also BMP 8.5*)
- Invasive species are already established.
- Monitoring can be conducted at a later date.

d. To limit the spread of invasives downstream, do not clean equipment, vehicles or trailers in or near waterways or storm sewers.
e. Contain or filter wash water on-site, if possible.

→ **BMP 8.2: Remove soil, seeds, vegetative matter and other debris from shoes, clothing and tools prior to leaving an area.** (*See also BMPs 6.13 & 7.12*)

Considerations:

f. Preferred locations for cleaning your person are those where:
   - Equipment is cleaned.
   - Invasives are less likely to spread (e.g. a blacktopped parking lot). Collect, bag and dispose of properly. (*See also BMP 8.5*)
   - Invasive species are already established.
g. Check places like hoods, pockets, seams and Velcro fasteners.

Long-range Transport

Movement of invasive species occurs naturally in a wide variety of ways. Some species of plants, insects and fungi have very small reproductive propagules that can be moved long distances by wind, water and animals, without the influence of human activity.

Be aware of all state and federal quarantine rules related to transportation of regulated articles out of a quarantined area.

Regulatory Considerations

It is a violation of state and federal laws to transport designated regulated articles outside of a quarantined area. USDA Animal Plant Health Inspection Service (APHIS) and the Iowa Department of Agriculture and Land Stewardship (IDALS) are responsible for designating quarantined areas, determining what materials will be regulated and enforcing the quarantines. Movement of regulated articles may be allowed under certain circumstances; details of exceptions are provided in a compliance agreement, which is issued by USDA APHIS and/or IDALS. Additionally, be aware of county and municipal ordinances related to the transportation of invasive materials.

→ **BMP 8.3: Minimize the offsite transport of invasives and materials that may contain invasives.**

Considerations:

a. Consider storing and reusing excavated materials, such as soil, on the same site. Use proper topsoil storage techniques to help ensure survival of advantageous fungi and microbes (e.g. beneficial organisms found in topsoil may die if the soil is piled to high which affects oxygen and temperature levels.) Treat infested excavated material to remove invasive species prior to reuse.
b. Consider using invasive control options that don't create waste, and thus, don't require the removal and transport of debris. For example, use a basal bark treatment on woody invasives

which kills the invasive as it is left in place instead of a cut stump treatment which creates woody debris.

c. Consider leaving invasive material and pests within the area of infestation (e.g. pile invasive brush at a site within the infested area).
d. Time the removals of invasive plants so the removals will occur when there are the fewest propagules present (e.g. invasive brush removal and transport should occur after the fruit has dropped).

→ **BMP 8.4: When necessary to transport invasives and materials that may contain invasives off site, cover or otherwise contain those materials.**

Considerations:

a. Materials may include but are not limited to: woody debris, propagules and soil.
b. Be aware of all state and federal quarantine rules related to the transportation of regulated articles out of a quarantine area. Secure compliance agreements for moving this material out of quarantined areas when necessary.
c. Be aware of local ordinances related to the transportation of invasive materials.
d. Covering and containment are not necessary if invasive propagules are not present. For example, bush honeysuckle debris would not need to be covered if it's removed when fruits are not present.

→ **BMP 8.5: Properly treat or dispose of invasive species or materials that may harbor invasive propagules, insects or diseases.** (*See also BMP 7.13*)

Considerations:

a. Place plant materials in a sturdy clear plastic bag labeled "Invasive plants – please landfill" and dispose of as you would with regular garbage.. For more information, contact the IA DNR's Bureau of Waste Management.
b. Materials may be disposed of in piles. Locate the pile in an area that facilitates easy monitoring and control if infestations spread from the pile.
c. Materials may be burned. Regulations and permits may apply. For more information, contact the IA DNR Bureau of Waste Management and the IA DNR Bureau of Air Quality.
d. Materials may be buried. Burial depth is specific to the invasive. An average minimum depth would be three feet, but some invasives need to be buried even deeper. For example, Japanese knotweed can grow through five feet of soil. Be aware that if you later dig into this soil you may be exposing propagules.
e. Materials might be utilized for value added products e.g. fuel, furniture, etc.
f. Chipping woody debris may kill invasive pests if chipped to a size specific to the target insect. However, wood chips may still contain other invasive propagules that may spread if the chips are used in an area other than from where they originated.
g. Material taken from sites that contain invasive plants should not be used away from the site of infestation until all viable plant material is destroyed. Material from areas containing invasive plants may be reused within the exact limits of the infestation.
h. Any excavated material that contains viable plant material and is not reused within the limits of the infestation should be stockpiled on an impervious surface until viable plant material is destroyed (Perron 2008).
i. Do not dump yard waste in parklands, natural areas and waterways.

j. Do not home compost invasive species or their propagules. Backyard compost piles and bins do not reliably generate enough heat for a long enough period of time to destroy weed seeds.
k. If possible, use invasive control options that don't create waste. For example, use a basal bark treatment on woody invasives which kills the invasive as it is left in place instead of a cut stump treatment which creates woody debris.

→ **BMP 8.6: Allow compost piles to heat to appropriate temperatures and times and with proper procedures to reduce the viability of invasives contained within.**

Considerations:

a. For in-vessel or static aerated pile composting, maintain a temperature of 131 – 170 °F for 3 consecutive days.
b. For windrow composting, maintain a temperature of 131 – 170 °F for 15 days during which, the compost is to be turned a minimum of five times.
c. Legumes or other hard coated seeds will likely not be destroyed during composting.
d. Backyard compost piles and bins do not reliably generate enough heat for a long enough period of time to destroy weed seeds.
e. Consider landfilling debris containing invasives instead of composting it. Place plant materials in a sturdy clear plastic bag labeled "Invasive plants – please landfill" and dispose of as you would with regular garbage. For more information, please contact the IA DNR's Bureau of Waste Management.

→ **BMP 8.7: Avoid the use of wood chips and compost that may contain invasive propagules.** (*See also BMPs 6.10. and 7.6*)

Considerations:

a. Woodchips and compost suspected of containing invasive materials should be used in a manner that will minimize the reintroduction of propagules back into the environment (e.g. Don't use woodchips containing buckthorn fruit in wooded areas that will not be chemically treated.)
b. Knowing the source of woodchips and compost may help you avoid infested material.
c. Notify the public that wood chips and compost could harbor invasive species. They may need to monitor and treat if used.
d. If material is used that may contain invasive propagules, monitor the site and treat if necessary.

Chapter 9: Monitoring and Research

Monitoring is the periodic inspection of post-activity sites to detect new invasions and evaluate the success of invasive species management plans and control measures. It records specific information in a constant manner over time to help better understand the invasive and its management. Scouting refers to an inspection to locate invasive species. Research is crucial to further our understanding of invasives, future invasives and ways to control them. Both monitoring and scouting provide opportunities to cooperate with universities, groups or individuals who are conducting research.

Monitoring and scouting can be informal processes, or they can be highly formal. While powerful tools like Geographic Positioning Systems (GPS), Geographic Information Systems (GIS) and computer software do exist to aid these processes, efforts should be kept as simple as possible to meet invasive species management objectives. The ability to perform monitoring or scouting depends on who is doing it, the extent of the property and the resources available. For example, property managers may be better equipped to scout and monitor a property on a regular basis. Those hired to carry out a one-time job may not be able to follow-up with monitoring.

BMP 9.1: Create an invasive species monitoring plan for properties under your management.
BMP 9.2: Assess the extent of invasive species on and near the property by scouting, locating and documenting infestations.
BMP 9.3: Monitor sites under your management following management/maintenance activities; determine necessary follow-up based on presence of invasive species.
BMP 9.4: Keep records when scouting and monitoring.
BMP 9.5: Report new infestations of known invasive species to the appropriate authority.
BMP 9.6: As opportunities arise, interact with and engage researchers to further our understanding of invasives.

→ **BMP 9.1: Create an invasive species monitoring plan for properties under your management.**

Considerations:

a. Integrate monitoring with other general management activities that occur on the property.
b. Consider monitoring the entire property on a regular basis. Methods will depend on the size and location of the property, as well as the scale, extent and type of invasive species present.
c. Periodically inspect high risk areas for introductions.
d. Organize monitoring/inventory/scouting work to begin in non-infested areas and work towards the infested areas.
e. Utilize any available history of the property's prior invasions.
f. Consider long term management when creating a monitoring plan.
g. Take surrounding properties into consideration.
h. Discuss the plan with neighboring property managers and consider cooperative projects with them.
i. If it is not possible to conduct follow-up monitoring (e.g. business hired for one job), then it becomes an opportunity to educate the customer on the need for monitoring and possible follow-up on their part.

→ **BMP 9.2: Assess the extent of invasive species on and near the property by scouting, locating and documenting infestations.**

Knowing which invasive species are present and their locations, is the first piece of information needed to evaluate threats.

Considerations:

a. Scout for invasive species at probable introduction sites such as access points (trails, roads, parking lots, rest stops, major ports of entry, etc…), new plantings, construction areas, other disturbed areas, area of dead/dying/stressed trees and other vegetation, greenways, drainage ways, corridors, adjacent properties and more.
b. Organize monitoring/inventory/scouting work to begin in non-infested areas and work towards the infested areas.
c. Keep assessments as simple as possible to meet invasive species management objectives.
d. Document invasive species in a manner consistent with established effective record-keeping practices.
e. Mapping is a very a useful tool for documenting and monitoring infestations.
f. When scouting it may be useful to bring a GPS or compass, flagging ribbon, sample bags or plant press, map or air photo, pens, camera and a clipboard.
g. While assessing sites for invasive species, land managers should be alert for emerging invasive threats such as the emerald ash borer.
h. Identify potential future invaders during scouting or monitoring procedures.
i. Confer with forest health specialists or other resource managers to identify forest health threats or invasive plant, insect or disease infestations of concern in the area.
j. Cooperate with partners, especially when dealing with invasives on a broader geographical scale or when multi-agency issues are involved.
k. When planning for a specific management or maintenance activities: Identify activities that will be occurring on and near the property in the short and long term. Scout for invasive species both within and around the activity area. Determine how those activities will affect and will be affected by invasive species on and near the property.

→ **BMP 9.3: Monitor sites under your management following management/maintenance activities; determine necessary follow-up based on presence of invasive species.** (*See also 7.10*)

Considerations:

a. Conduct periodic inspections of each site following management/maintenance activities.
b. Inspect on an annual basis, at a minimum, as long as there is an invasive problem.
c. Consider monitoring the entire property on a regular basis. This depends on the size and location of the property, as well as the scale, extent and type of invasive species present.
d. Anticipate responses of invasive species to activities and check for new infestations, infections or the spread of existing populations during the appropriate life stage timing for the specific invasive in question.
e. Monitor sites not only for known invasive species, but also emerging invasive threats such as the emerald ash borer.
f. Keep monitoring as simple as possible to meet invasive species management objectives; integrate with other activities.
g. Determine appropriate control measures to respond to new infestations or spreading populations; evaluate them for their efficiency and impact.
h. If it is not possible to conduct follow-up monitoring (e.g. business hired for one job), then it becomes an opportunity to educate the customer on the need for monitoring and possible follow-up on their part.

→ **BMP 9.4: Keep records when scouting and monitoring.**

Considerations:

a. Include information about the current infestation, as well as, areas on the fringe of the infestation, areas heavily used, disturbed areas and other areas you suspect may be invaded by invasive species.
b. Consider the use of mapping as a tool for recording and monitoring infestations.
c. Be consistent with your monitoring methods.
d. Be complete; they should be easily understood by another person.
e. Have them easily accessible for future reference.
f. See *Appendix B: Monitoring* for example recording sheets.

→ **BMP 9.5: Report new infestations of known invasive species to the appropriate authority.**

Considerations:

a. Alert the property owners and others involved in its management.
b. Report infestations of target species (species that are new to Iowa) to the DNR Forest Health Program Leader.

→ **BMP 9.6: As opportunities arise, interact with and engage researchers to further our understanding of invasives.** (*See also BMP 3.9*)

Our understanding of invasive species ecology and prevention is increasing but still insufficient to contain or control invasives in many situations in which they occur. Our ability to predict what new species may become invasive and what landscape practices may provide habitat for these invasives is even more limited. Research conducted by universities and institutions is one source for learning about invasives. Researchers can also benefit by interacting with practitioners and discussing the emerging invasive species issues in the practice of urban forestry and landscaping.

Considerations:

a. Develop on-going communications and partnerships with area universities, colleges and institutions where the potential for research in matters of interest to urban forestry occur.
b. Consider the potential for cooperative research opportunities when undertaking new controls or practices for which little information is available.
c. Encourage research/testing of (new) urban landscape plants, either native or non-native, which exhibit tolerable levels of sterility and vegetative proliferation.
d. Researchers could be key partners in a monitoring program to help gauge which new plants, insects and diseases may become invasive and in which situations.

Chapter 10: Education

The greatest instrument in the prevention and control of invasive species is education. It creates an awareness and understanding of invasive species issues. This is essential to the foundation of partnerships between property owners, urban forestry practitioners, local, state and federal governments, special interest groups and the public, all of whom have an investment and a role to play in the management of invasive species.

BMP 10.1: Educate yourself about invasive species.
BMP 10.2: Educate employees and volunteers about invasive species.
BMP 10.3: Educate clients, customers and users about invasive species.
BMP 10.4: Educate public officials and other decision makers about invasive species.

→ **BMP 10.1: Educate yourself about invasive species.**

Considerations:

a. Keep current with the changing information on invasive species.
b. Keep up to date with your professional accreditations and certifications.
c. See *Appendix E: Resources* Section 14 for a list of on-going educational opportunities.
d. Pass your knowledge onto others.

→ **BMP 10.2: Educate employees and volunteers about invasive species.**

Considerations:

a. Include information about identification, impacts, prevention and management in your organization's training programs and materials.
b. Instruct your employees and volunteers on the practical use of the Urban Forestry Best Management Practices for Invasive Species and evaluate their implementation.
c. Effectively seal (e.g. in plastic) any potential propagules, insects or diseases that you intend to use as educational "props."
d. Encourage employees to pursue or continue with professional accreditations and certifications.
e. Encourage employees to seek additional invasives information. (See *Appendix E: Resources* Section 14 for a list of on-going educational opportunities.)
f. Encourage employees to pass their knowledge onto others.

→ **BMP 10.3: Educate clients, customers and users about invasive species.**

Considerations:

a. Include information about identification, impacts, prevention and management in your organization's newsletters, marketing materials and face-to-face meetings.
b. Instruct clients, customers and users on the practical use of the Urban Forestry BMPs for Invasive Species.
c. Effectively seal (e.g. in plastic) any potential propagules, insects or diseases that you intend to use as educational "props."
d. Encourage clients, customers and users to seek additional invasives information. (See *Appendix E: Resources* Section 14 for a list of on-going educational opportunities.)
e. Encourage clients, customers and users to pass their knowledge onto others.

f. Work with faculty and other educators to inform students, Master Gardeners and industry about the Urban Forestry Best Management Practices for Invasive Species.

→ **BMP 10.4: Educate public officials and other decision makers about invasive species.**

Considerations:

a. Educate public officials and decision makers as to the role they play and the benefits to their constituents by preventing the introduction and spread of invasive species.
b. Include information about identification, impacts, prevention and management.
c. Coordinate education efforts with the municipal Weed Commissioner.
d. Effectively seal (e.g. in plastic) any potential propagules, insects or diseases that you intend to use as educational "props."
e. Encourage public officials and decision makers to seek additional invasives information. (See *Appendix E: Resources* Section 14 for a list of on-going educational opportunities.)
f. Encourage municipalities to make invasives information available to the public.

Appendix A: Brief Overview of Control Methods

Manual control techniques include activities such as hand-pulling, digging, flooding, mulching, burning, removal of alternate hosts and manual destruction or removal of nests, egg masses or other life stages. These techniques work best on small populations or in areas where chemicals or motorized equipment cannot be used. Manual control efforts must be persistent and several treatments may be needed to reduce or eliminate the target population. If infestations are too pervasive, manual control may become very labor intensive, and thus, not economically feasible.

Mechanical control techniques include mowing, girdling, cutting, chopping, tilling, hoeing, and constructing barriers using tools or machines. These techniques are most useful in areas with large infestations where the landscape does not create safety or equipment issues. Repeated mowing or cutting of invasive plants can weaken the population by depleting root reserves and preventing flowering; however, mechanical control is typically most effective when used in conjunction with herbicide treatments. If infestations are small, the cost of mechanical control is usually relatively low, and when combined with other treatments, it can be very effective. However, cutting large populations of woody invasive plants can become labor and resource intensive.

Chemical control refers to the use of pesticides, and for all practical purposes, some invasive organisms cannot be controlled without the use of pesticides. There are many kinds of herbicides, insecticides and fungicides. Not all of them will be appropriate for every situation. The choice of pesticide depends on the species, stage of growth, the presence of desirable species that may be affected, the proximity of water resources and environmental conditions. Pesticides must always be applied in accordance with the label. Property owners should possess the proper equipment and the knowledge to safely apply chemicals or hire a licensed applicator. Proper personal protection gear should be used, and materials to contain spills should be kept close by. There may be instances when chemical control is inappropriate or simply not allowed. Densely populated urban areas, adjacent property owners and local ordinances are just a few examples of things that can affect chemical control plans.

Biological control refers to the use of animals, fungi or diseases to control invasive populations. Control organisms usually come from the native range of the target species, and require a period of study to ensure they will remain specific to the target population and will not harm other species. Biological control typically does not eliminate the invasive species and it usually takes several years to show results. Biological control has been effective for some species such as the *Galerucella* beetle which has been used with some success to control purple loosestrife (*Lythrum salicaria*), and Btk, *Entomophaga maimaiga* and the nuclear polyhedral virus for gypsy moth control.

Cultural Control is the manipulation of urban forest composition, growing conditions and tree health to control invasive species or limit their effects if invasion occurs. Trees and other vegetation that are potentially susceptible host species can be reduced as an urban forest component, thus limiting outbreaks of insects and disease-causing organisms. Alternately, species that are resistant to invasive insects and diseases may be planted instead of nonresistant species. Our urban forests include native and non-native plant species. Creating or selecting proper planting locations for them is another illustration of cultural control. For example, plants that spread aggressively by rhizomes would be best planted in a contained area. Minimizing stress to a plant through actions such as mulching, watering or fertilizing often enables it to better withstand and outcompete invasive infestations. Another example of a cultural control activity is maintaining a level of canopy closure that impedes shade intolerant invasive species. See *Appendix E: Resources* Section 13 for information about the proper management of trees shrubs and other vegetation.

Appendix B: Monitoring

The following are examples of data sheets for inventorying, monitoring, and managing invasive species. The Midwest Invasive Plant Network keeps a list of data sheet examples at http://www.mipn.org/edrrdataforms/. Urban forestry practitioners need to use the data sheet that works best for their situation.

INVASIVE SPECIES INVENTORY FIELD REPORT FORM

Observation Date: _____

Name: _____ Association: _____

Address: _____ City: _____ State: _____ Zip: _____

Phone: _____ Email: _____

Species Information - Name and Locations

Common Name: _____ Scientific (if known): _____

Locality Name (lake or twnshp): _____ County: _____

Site address (if any): _____ City: _____ Zip: _____

Property Ownership (i.e, Private, county, state, federal, etc.): _____

Provide one or more of the following location methods below:

PLS: ¼ ¼ Sec _____ ¼ Sec _____ Sec _____ Twp _____ Range _____

GPS: X Coordinate (Lat./Easting): _____

Y Coordinate (Long./Northing): _____

Number of individuals observed (Check one): ☐ < 20 ☐ 20 - 99 ☐ 100 - 999 ☐ < 1000

Distribution of infestation: ☐ occurs singly ☐ scattered pockets ☐ continuous/extensive

Size of infested area (acres): ☐ < 1 ☐ 1 - 5 ☐ 5 - 10 ☐ 10 - 50 ☐ > 50

Diagram: Show roads, nearest intersections, distances, compass direction and rough outline in invasive species population.

(Attached diagram if filling out form digitally.)

Verbal directions (if PLS/GPS information unavailable):

Mail form to: Minnesota Department of Natural Resources
Division of Forestry
Attn: Invasive Species Specialist
500 Lafayette Rd
St. Paul, MN 55155-4025

Email to: susan.burks @ dnr.state.mn.us

For more information visit:
http://files.dnr.state.mn.us/assistance/backyard/treecare/forest_health/invasivereportform.pdf

Setting Objectives for Invasive Species*	**Weighted Score****
Current Extent of the Species***	
1. Species present in early stage or emerging satellite populations	5
2. Species present in large infestations and still expanding rapidly	3
3. Species present in large infestations and no longer expanding	1
	Score :

Current and Potential Impacts	
1. Species that alter ecosystem processes	5
2. Species that out-compete native vegetation without disturbance, but not #1	3
3. Species that only out-compete with native vegetation following disturbance	1
	Score :

Value of Habitats Affected	
1. Infestations occurring in high quality, high diversity or otherwise significant habitats	5
2. Infestations occurring in already de-graded, low-diversity, or less significant sites	2
	Score :

Feasibility of Control and Successful Outcomes	
1. Species likely to be controlled or eradicated with available methods and resources	5
2. Species difficult to control or eradicate with available resources and methods	3
3. Species unlikely to be controlled with available resources and methods	1
	Score :

Score - 15-20: Consider "Zero Tolerance" (Eradication) Objective	**ZT**	Total Score :
Score 9-14: Consider "Acceptable Threshold" Objective	**AT**	
Score 5-8: Consider "Slow the Spread" Objective	**SS**	

*Adapted from "Site Weed Management Plan Template" by Mandy Tu of The Nature Conservancy's Wildland Invasive Species Program. For the complete document see: http://tncweeds.ucdavis.edu/products/plans/WeedTemp.rtf

**Managers should select the condition that best describes their situation for each of the 4 criteria areas. The scoring ranges and associated objectives are recommended and managers may need to consider other information in setting objectives.

***On larger properties consider creating multiple management units to reflect different conditions and levels of infestation.

Fort McCoy Wildlife Program

Treatment Action Data Sheet **Grid #_____**

		Plant Phenology						Chemical Action															Additives									Base of Solution					Equipment						Method									
Species Initials (See Back)***	Date	Early Growth	Pre-flower	Peak Flower	Post-flower	Fall Flush	Dormant	Glyphosate**	2-4,D LV4	2,4 – D Amine	Milestone	Transline	Tordon K	Plateau	Triclopyr 3SL	Triclopyr 4E	Habitat	Element 3A	Element 4	Oust	Escort	Overdrive	L I 700	Dye	Silkin	Liberate	Level 7	Preference	Attach	Choice Weather	MSO	H2O	B.O. LT	B.O. EC	Dilient Blue	Dilient Blue XLT	Backpack	Wick	Truck Boom	Truck Gun	Polaris Boom	Polaris Hand Gu	Foliar	Basal Bark	Cut-stump	Total Amt. Sol. Used in **GAL.**	Total Amt. Herb. Used in **OZ**	Conc. Of Herb. (%)	Hours	# people	Total Hours	Initials*	Record #
SK	6/18/07		x								x													x		x						x					x						x			10		1/4	2	2	4	JD	
SK	6/19/07		x								x													x		x						x					x						x			2		1/4	1	2	2	JD	
SK	6/20/07		x								x													x		x						x					x						x			12		1/4	1	2	2	JD	

Under Comments, List: date, type of glyphosate**, note on average patch desity (high, med., low), brief weather description (temp., precip., cloud cover, humidity, time of day and any other pertinent info.), Print or write neatly, be precise, but short. If Biological Control is implemented, mention specific species used.

***Initials-Name-State Cert. #**	**Comments:**
JD - John Doe - 012345	6-18-07 Coudy, mid-80's, wind 0-5mph
JS - Jane Smith - 012345	6-19-07 Spot sprayed, 90°, sunny, Site looks better than last year.
	6-20-07 Spot sprayed, 90°, sunny, Revisit site in one week.

Species Initials***

AO-Autumn Olive	CM-Common Mullen	HS- Honeysuckle	RC-Reed Canary Grass
BfT-Birdsfoot Trefoil	CoT-Common Teasel	JB-Jap. Barberry	SC-Sweet Clover
BL-Black Locust	CS-Cypress Spurge	JK-Jap. Knotweed	SJ-St. Johns Wort
BT-Bull Thistle	CT-Cutleaf Teasel	LS-Leafy Spurge	SK-Spotted Knapweed
CaT-Canada Thistle	CV- Cow/Crown Vetch	MFR-Multiflora Rose	SPS-Siberian Pea Shrub
CB-Common Buckthorn	GB-Glossy Bucktorn	MS-Musk Thistle	TA-Tansy
CE-Chinese Elm	GM-Garlic Mustard	PL- Purple Loosestrife	WP-Wild Parsnip

For more information visit: http://www.mccoy.army.mil/

Appendix C: Terrestrial Invasive Plants in Iowa

There exists both formal and informal invasive plant lists for the state of Iowa and the surrounding region. Among these, no two lists are the same, in part because the agencies, organizations and groups who created them can have differing points of view about the invasiveness of some species. This is natural considering invasiveness varies due to location, habitat type, disturbance history, urban versus rural locations, proximity to propagules and many other factors. In short, what may be invasive in one environment may not be invasive in another.

Because no individual list will be able to meet the needs of every Urban Forestry practitioner in Iowa, we have put together a list of invasive plant lists pertinent to our region and have attempted to explain how they were compiled so that the user can decide for themselves which list best meets their needs.

Keep in mind that lists are continually being updated as new invasive plant species appear in Iowa and as additional research is being reported. It is important to remember that regardless if a particular species is included in a list, implementation of the BMPs should be effective at preventing or slowing the spread of any species.

Lists:

Iowa Department of Natural Resources (DNR)—Invasive Forest Plant Species:
http://www.iowadnr.gov/Conservation/Forestry/Forest-Health/Invasive-Plants

Iowa's Invasive and Noxious Weed List: http://plants.usda.gov/java/noxious?rptType=State&statefips=19

Iowa's Noxious Weed Law: http://www.weeds.iastate.edu/reference/weedlaw.htm

USGS Searchable Nonindigenous List: http://nas.er.usgs.gov/queries/StateSearch.aspx

Appendix D: Short List of Invasive Insects and Diseases for Iowa

The lists below are provided for educational purposes for use in conjunction with the BMPs. The lists represent insects and diseases, native or non-native, that are the most destructive or threatening to Iowa's urban forests. Species are listed in alphabetical order; they are not listed in order of priority. These species may already be present in our state or they have the potential to be here in the near future. The lists may be updated as new invasive species appear in or threaten Iowa.

Invasive Insects		
Common Name	Scientific Name	Preferred Host Species
European gypsy moth	**Lymantria dispar (European race)**	hardwoods; oaks preferred
Japanese beetle	**Popillia japonica**	many hosts
Emerald ash borer	**Agrilis planipennis**	all species of ash (Fraxinus spp.)
Asian longhorned beetle	**Anopliphora glabripennis**	hardwoods; maples preferred
Sirex woodwasp	**Sirex noctilio**	pines
Asian gypsy moth	**Lymantria dispar (Asian race)**	hardwoods & conifers
Thousand Cankers Disease of Black Walnut	**Geosmethia morbida (pathogen) and Pityophthorus juglandis (insect)**	black walnut
Invasive Diseases		
Disease Name	Scientific Name of Pathogen	Preferred Host Species
Diplodia shoot blight	Diplodia pinea	pines; red, scots, jack & Austrian preferred
Cytospora canker	Cytospora kunzei var. piceae	Norway & Colorado blue spruce preferred
Oak wilt	Ceratocystis fagacearum	oaks; red/black family preferred
White pine blister rust	**Cronartium ribicola**	5-needled pines
Dutch elm disease	Ophiostoma ulmi, O. novo-ulmi	American elm most susceptible
Fireblight	Erwinia amylovora	rose, apple, pear, and other rosaceous plants
Sudden oak death	**Phytophthora ramorum**	many hosts
Butternut canker	**Sirococcus clavigignenti-juglandacearum**	butternut
Bur Oak Blight	**Tubakia spp.**	Bur oak
Species in bold were assessed by Species Assessment Groups comprised of experts in their respective fields and stake-holder groups. The Species Assessment Groups were asked to review literature summaries and to make recommendations to the Iowa Council on Invasive		

Note: The term "**invasive disease**" is used throughout this document. Although diseases themselves are not technically invasive, the pathogens that cause plant diseases (including but not limited to fungi, bacteria, viruses and phytoplasmas) can be invasive when they infect a susceptible host and conditions are favorable for disease to develop.

Appendix E: Resources

1. Invasive Plants
2. Plants to Use as an Alternative to Invasives
3. Invasive Insects and Diseases
4. Invasive Insects and Diseases Lists
5. All Invasives
6. General Invasive Plant Management
7. Cooperative Weed Management Areas (CWMAs)
8. Biocontrol
9. Herbicide
10. Prescribed fire
11. Early Detection and Rapid Response
12. Prioritizing Management
13. General Sites of Interest
14. Educational Opportunities and Events

1. Invasive Plants (*See also All Invasives*)**:**

Center for Invasive Plant Management (CIPM): http://www.weedcenter.org/; this web site provides information on invasive plant identification, biology, and impacts of invasive species. It also includes links to a resource guide, weed control methods, and invasive plant management online textbook.

USDA National Invasive Species Information Center: http://www.invasivespeciesinfo.gov/unitedstates/ia.shtml; this web site provides information on invasive plant identification, biology, and impacts of invasive species.

Iowa Department of Natural Resources Invasive Forest Plants: http://www.iowadnr.gov/Conservation/Forestry/Forest-Health/Invasive-Plants; this web site provides information on invasive plant identification, biology, and impacts of invasive species.

Midwest Invasive Plant Network (MIPN): http://www.mipn.org/; this organization's mission is to reduce the impact of invasive plant species in the Midwest. The web site provides information on prevention, early detection and rapid response, control and management, education, research, and more.

Plant Conservation Alliance (PCA), Weeds Gone Wild, Alien Plant Invaders of Natural Areas: https://www.nps.gov/plants/alien/; this web site provides a list of invasive plants in the US, background information on the threats and impacts of invasive species, fact sheets, and relevant links.

*USDA Forest Service Forest Invasive Plants: http://na.fs.fed.us/spfo/invasiveplants/states/ia.asp; t*his web site provides information on invasive plant identification, biology, and impacts of invasive species.

2. Plants to Use as an Alternative to Invasives:

Iowa Native Plant Society: http://iowanativeplants.org/index.php

Iowa Living Roadways: http://www.iowadot.gov/lrtf/

Meijer & The Nature Conservancy's Recommended Non-Invasives List: http://www.nature.org/wherewework/northamerica/states/michigan/files/meijer_plant_list.pdf

Landscape Alternatives for Invasive Plants of the Midwest: http://mipn.org/MIPN%20redraft2.pdf; Lists the invasive and its alternatives

3. **Invasive Insects and Diseases** (*See also All Invasives*)**:**
Iowa Department of Agriculture and Land Stewardship (IDALS): http://www.iowatreepests.com/; IDALS is responsible for the prevention, introduction and spread of plant pests. This webpage provides information on specific pests, rules, and firewood restrictions.

Iowa Department of Natural Resources Forest Health Overview and Reports: http://www.iowadnr.gov/Conservation/Forestry/Forest-Health

Emerald Ash Borer: What you need to know: http://www.emeraldashborer.info/; this web site is part of a multi-state effort to provide the latest information about EAB to the public.

Iowa Department of Natural Resources Resource Kit: http://www.iowadnr.gov/eab

The Exotic Forest Pest Information System for North America: http://www.invasive.org/species/list.cfm?id=5; this web site contains a database of invasive insects, mites, and diseases with background information for each pest.

U S Department of Agriculture (USDA) Animal Plant Health Inspection Service (APHIS): https://www.aphis.usda.gov/aphis/ourfocus/planthealth; APHIS safeguards agriculture and natural resources from the risks associated with the entry, establishment, or spread of animal and plant pests. The site has links to information on specific plant pests, pest detection and identification information, and plant protection and quarantine manuals.

US Department of Agriculture (USDA) Forest Service - North Central Research Station: Emerging Forest Insect Pests: http://www.nrs.fs.fed.us/units/invasivesecology/; the North Central Research Station web site provides information on exotic forest insects, describes current research, and features publications and maps for a 20-state region spanning the Midwest and Northeast.

Iowa Gypsy Moth: http://www.extension.iastate.edu/psep/GypsyMoth.html; the Iowa Gypsy Moth site has information on predicting defoliation, management options, identification, and life cycle.

4. **Invasive Insects and Diseases Lists:**
USDA Forest Service Invasive Species Program Web pages: http://www.fs.fed.us/invasivespecies/speciesprofiles/index.shtml

USDA Forest Service North Central Research Station: http://www.nrs.fs.fed.us/units/invasivesecology/

The Nature Conservancy's Invasive Species Initiative Regional List of Pests, 2004: http://www.invasive.org/gist/products/gallery/regionlist.html; scroll down to Midwest region, but note that this covers from MI to ND, south to TX.

5. **All Invasives:**

National Invasive Species Council's Definition of Invasive Species: http://www.invasivespeciesinfo.gov/docs/council/isacdef.pdf

National Invasive Species Management Plan: https://www.doi.gov/invasivespecies/management-plan

The Nature Conservancy (TNC), Global Invasive Species Team: http://tncinvasives.ucdavis.edu/; this web site is no longer maintained by the Nature Conservancy but it is archived on various other web sites. It provides many resources designed to help conservationists deal most effectively with invasive species. It provides links to an introduction on invasive species management, planning and strategy, control methods, photo archive and more.

USDA Forest Service Invasive Species Program: http://www.fs.fed.us/invasivespecies/; this web site serves as a portal to Forest Service invasive species information and related management and research activities across the agency and with partners. The program's goal is to reduce, minimize, or eliminate the potential for introduction, establishment, spread, and impact of invasive species across all landscapes and ownerships.

6. **General Invasive Plant Management:**

Center for Invasive Plant Management (CIPM)—Weed Control Methods: http://www.weedcenter.org/management/control.html; the Weed Control Methods web page offers information and links on the following control techniques: biocontrol, grazing, herbicides, mechanical, and prescribed burning.

Department of Conservation and Natural Resources Invasive Exotic Plant Tutorial for Natural Land Managers. Invasive Exotic Plants in Pennsylvania List: http://www.dcnr.state.pa.us/forestry/invasivetutorial/List.htm; although this site is for Pennsylvania most of the species featured are also invasive in Iowa. The site provides links to fact sheets and management and control recommendations.

Garlic mustard (Alliaria petiolata) - Guide for identifying and controlling: http://wildones.org/download/garlicmustard.pdf

Illinois Nature Preserve Management Guidelines: https://www.dnr.illinois.gov/INPC/Pages/INPCManagementGuidelines.aspx; the information presented gives guidance to landowners, managers, custodians and stewards of sites in the Illinois Nature Preserve Programs on control methods for common invasives.

Invasive Plants of the Upper Midwest by Elizabeth J. Czarapata. This book is a comprehensive, fully-illustrated guide to the identification and control of invasive plant species.

Plant Conservation Alliance - Alien Plant Invaders of Natural Areas: https://www.nps.gov/plants/alien/factmain.htm; this web site features illustrated, easy-to-read fact sheets on select invasive plants with native ranges, plant descriptions, ecological threats, US distributions and habitats, background of introductions, plant reproduction and dispersal, management approaches, alternative native plants, and other useful information.

Shaw Nature Reserve Native Landscaping Manual - Chapter Three-Control and Identification of Invasive Species: A Management Guide for Missouri: http://www.missouribotanicalgarden.org/Portals/0/Shaw%20Nature%20Reserve/PDFs/horticulture/NLM%

20Ch3.pdf; this manual describes mechanical and chemical control methods and revegetation. It provides good illustrations of management.

The Nature Conservancy (TNC)—Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas: http://www.invasive.org/gist/handbook.html; the handbook provides detailed information on the use of manual and mechanical techniques, grazing, prescribed fire, biocontrol, and herbicides for use in controlling invasive species in natural areas.

USDA Forest Service Invasive Species Program—Control and Management: http://www.fs.fed.us/invasivespecies/controlmgmt/index.shtml; this page provides links for more information on research, management planning, forest service activities, and pest-specific control and management.

US Forest Service—Dangerous Travelers: Controlling Invasive Plants along America's Roadsides (Video): http://www.fs.fed.us/invasivespecies/prevention/dangeroustravelers.shtml; The video outlines the best management practices that road crews should be following in their day-to-day operations. This is the first in a series on "Best Management Practices for Invasive Species Prevention." The video can also be ordered on DVD by contacting: USDA Forest Service; San Dimas Technology and Development Center; 444 East Bonita Avenue; San Dimas, CA 91773; (909) 599-1267

7. **Cooperative Weed Management Areas (CWMAs):**
A Cooperative Weed Management Area is a partnership of federal, state and local government agencies, tribes, individuals, and other interested groups that manage invasive plants in a defined geographic area. CWMAs are local organizations that provide a mechanism for sharing invasive plant management resources across jurisdictional boundaries in order to achieve widespread invasive plant prevention and control. CWMAs operate under a formal agreement to ensure long-term, on-going resource-sharing and collaboration.

- *Midwest Invasive Plant Network:* http://www.mipn.org/cwma-resources/; a local Midwest resource for starting a CWMA.
- *Center for Invasive Plant Management:* http://www.weedcenter.org/; information and resources on how to start a CWMA.

8. **Biocontrol:**
Invasive Plants of the Eastern US - Biological Control of Invasive Plants in the Eastern United States. (USDA Forest Service Publication FHTET-2002-04, 413 p.): http://www.invasive.org/weedcd/pdfs/biocontrol.pdf; this web site serves as a reference guide for field workers and land managers concerning the historical and current status of the biological control of select invasive plants in the eastern United States.

Cornell University. Biological Control: A Guide to Natural Enemies in North America: http://vivo.cornell.edu/display/individual15600; this web site provides photographs and descriptions of biocontrol agents of insect, disease and weed pests in North America.

9. **Herbicide:**
Iowa State University Integrated Pest Management: http://www.ipm.iastate.edu/; a list of integrated way to control various pests.

Herbicide safety information—Material Data Safety (MDS) sheets and product labels: http://www.cdms.net/Label-Database

The Nature Conservancy (TNC)—Safe Herbicide Handling in Natural Areas: A Guide for Land Stewards and Volunteer Stewards: http://www.invasive.org/gist/products/library/herbsafe.pdf

The Nature Conservancy (TNC)—Upkeep and Maintenance of Herbicide Equipment: A guide for natural area stewards: http://www.invasive.org/gist/products/library/herbupkeep.pdf

10. **Prescribed fire:**
California Invasive Plant Council—The Use of Fire as a Tool for Controlling Invasive Plants: http://www.cal-ipc.org/ip/management/UseofFire.pdf; this document contains information on the following: planning and implementing prescribed burns, control of invasive plants with prescribed fire, using prescribed burning in integrated strategies, effects of fire on plant communities, and effects of fire on chemical, physical, and biotic properties of soil.

Center for Invasive Plant Management (CIPM)—Fire As a Tool For Controlling Nonnative Invasive Plants: http://www.weedcenter.org/store/docs/burning_weeds.pdf; this review focuses on the intentional use of fire, alone or integrated with other methods, to control exotic plants in North America.

The Nature Conservancy (TNC)—Fire Management Manual: http://www.tncfiremanual.org/index.htm; the manual serves as the Conservancy's guiding document on all aspects of wildland fire management.

USDA Forest Service—Fire Effects Information System (FEIS): http://www.feis-crs.org/feis/; FEIS features a searchable database that summarizes and synthesizes research about living organisms in the United States —their biology, ecology, and relationship to fire.

11. **Early Detection and Rapid Response:**
iMapInvasives: Geotracking invasive exotic species: http://www.imapinvasives.org/; a consortium developed an on-line GIS-based invasive species mapping tool designed to aid in Early Detection and Rapid Response efforts. The site allows one to display maps and query by invasive species or contributing organization. Currently the site has only sample plant data for the state of New York. Long-term goals for the site include seeking participation of additional states and/or provinces.

Midwest Invasive Plant Network (MIPN)—Early Detection and Rapid Response: http://www.mipn.org/edrr/

National Biological Information Infrastructure (NBII). National Framework for Early Detection, Rapid Assessment, and Rapid Response to Invasive Species: http://www.invasive.org/edrr/; this framework includes seven main components: 1) identification and validation, 2) reporting, 3) expert verification, 4) occurrence databases, 5) rapid assessment, 6) planning, 7) rapid response.

The North American Weed Management Association: http://www.nawma.org/ The North American Weed Association has developed a data collection standard for invasive plant monitoring in the western United States and it has been adopted by several federal agencies, including US Forest Service and the National Park Service. At the home page, scroll down to "Mapping Standards" link.

USDA Forest Service. The Early Warning System for Forest Health Threats in the United States: http://www.fs.fed.us/foresthealth/publications/EWS_final_draft.pdf; this is a monitoring framework for early detection and response to environmental threats (e.g. insects, diseases, invasive species, and fire) to forest lands. The framework is based on the following steps: 1) identify potential threats, 2) detect actual threats, 3) assess impacts, and 4) respond.

12. Prioritizing Management:

NatureServe - An Invasive Species Assessment Protocol: Evaluating Non-Native Plants for Their Impacts on Biodiversity: http://www.natureserve.org/library/invasiveSpeciesAssessmentProtocol.pdf; the Invasive Species Assessment Protocol was developed as a tool for assessing, categorizing, and listing non-native invasive vascular plants according to their impact on biodiversity in a large area such as a nation, state or province, or ecological region. This protocol is designed to make the process of assessing and listing invasive plants objective and systematic.

Animal and Plant Health Inspection Service (APHIS) - Weed-Initiated Pest Risk Guidelines for Qualitative Assessments: https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra.pdf; this document provides a template for conducting pest risk analysis: initiating the process by identifying a pest that may qualify as a quarantined pest, and/or pathways that may allow introduction or spread of a quarantine pest; and assessing pest risk (determining which pests are quarantine pests, characterized in terms of likelihood of entry, establishment, spread, and economic importance.)

13. General Sites of Interest:

American Nursery and Landscape Association. http://www.anla.org/ This website provides education, research, public relations, and representation services to members of the nursery and landscape industry.

International Society of Arboriculture: http://www.isa-arbor.com/home.aspx; this is a worldwide professional organization dedicated to fostering a greater appreciation for trees and to promoting research, technology, and the professional practice of arboriculture.

Trees are Good. International Society of Arboriculture: http://www.treesaregood.com/; this site helps to educate the general public about the importance and value of proper tree care.

Iowa Arborist Association: http://www.iowaarboristassociation.org/; this is a large organization of commercial, municipal, utility and academic arborists whose members serve Iowa by providing private and public arboriculture services.

Trees Forever: http://www.treesforever.org/; this organization is dedicated to sustaining urban forestry.

14. Educational Opportunities and Events:

International Society of Arboriculture: http://www.isa-arbor.com/home.aspx

Appendix F References

Allison, RB. 1989. Tree Diseases in Iowa's Urban Forests. *Iowa Academy Review* (36)1.

Best Management Practices for Land Managers. Long Island Weed Management Area. http://www.invasive.org/gist/products/wma/li-managers.pdf

Chornesky, EA, AM Bartuska, GH Aplet, KO Britton, J Cummings-Carlson, FW Davis, J Eskow, DR Gordon, KW Gottschalk, RA Haack, AJ Hansen, RN Mack, FJ Rahel, MA Shannon, LA Wainger and TB Wigley. 2005. Science priorities for reducing the threat of invasive species to sustainable forestry. *BioScience* 55(4): 335-348.

Colorado Natural Areas Program. 2000. Creating an Integrated Weed Management Plan: A Handbook for Owners and Managers of Lands with Natural Values. In *Caring for the Land Series,* Volume IV.

Czarapata, EJ. 2005. Invasive Plants of the Upper Midwest: An Illustrated Guide to Their Identification and Control. University of Iowa Press. Madison, WI.

Duryea, ML, EK Binelli, and LV Korhnak. 2000. *Restoring the Urban Forest Ecosystem*. CD-ROM. School of Forest Resources and Conservation, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

Elzinga, CL, DW Salzer, and JW Willoughby. 1998. *Measuring and Monitoring Plant Populations.* Technical Reference 1730-1. Bureau of Land Management, National Business Center, Denver CO.

Environmental Protection Agency. Code of Federal regulations, Title 40, Protection of the Environment, Criteria for Classification of Solid Waste Disposal Facilities and Practices. 40 CFR Part 257 Appendix II, Section B. http://www.epa.gov/epawaste/wycd/tribal/pdftxt/40cfr257.pdf pg 23

Executive Summary of the National Invasive Species Plan. http://www.invasivespeciesinfo.gov/council/nmp.shtml

Frappier, B, RT Eckert, and TD Lee. 2003. Potential impacts of the invasive exotic shrub *Rhamnus frangula* L. (glossy buckthorn) on forests of southern New Hampshire. *Northeastern Naturalist*. 10(3):277-296.

Frappier, B, RT Eckert, and TD Lee. 2004. Experimental removal of the non-indigenous shrub *Rhamnus frangula* L. (glossy buckthorn): effects on native herbs and woody seedlings. *Northeastern Naturalist*. 11(3):333-342.

Global Invasive Species Programme. http://www.gisp.org/ecology/strategies.asp

Harrington, RA and RR Kujawski. 2003. Invasive plants and the green industry. *Journal of Arboriculture* 29(1): 42-48.

Harris, RW et al. Arboriculture: Integrated Management of Landscape Trees, Shrubs, and Vines. 3rd edition, Prentice-Hall, Inc. 1999.

Heneghan, L, C Rauschenberg, F Fatemi, and M Workman. 2004. European buckthorn (*Rhamnus cathartica*) and its effects on some ecosystem properties in an urban woodland. *Ecological Restoration*. 22(4):275-280.

Heneghan, L, F Fatemi, L Umek, K Grady, K Fagen, and M Workman. 2006. The invasive shrub European buckthorn (*Rhamnus cathartica*, L.) alters soil properties in Midwestern US woodlands. *Applied Soil Ecology*. 32:142-148.

Hodkinson, DJ and K Thompson. 1997. Plant dispersal: the role of man. *Journal of Applied Ecology* 34: 1484-1496.

Hulme, PE. 2006. Beyond control: wider implications for the management of biological invasions. *Journal of Applied Ecology* 43: 835-847.

Humble, LM and EA Allen. 2004. *Alien Invaders: Non-indigenous species in urban forests.* 6th Canadian Urban Forest Conference, Kelowna, BC.

Kolar, CS and DM Lodge. 2001. Progress in invasion biology: predicting invaders. *Trends in Ecology & Evolution* 16(4): 199-204.

Kostichka, CJ and WN Cannon Jr. 1984. Costs of Dutch elm disease management in Iowa communities. *Journal of Arboriculture* 10(9).

LaGro Jr. JA. 2001. Site Analysis: Linking program and concept in land planning and design. John Wiley and Sons, Inc. New York

Leung, B, DM Lodge, D Finnoff, JF Shogren, MA Lewis, and G Lamberti. 2002. An ounce of prevention or a pound of cure: bioeconomic risk analysis of invasive species. *Proceedings of the Royal Society – Biological Sciences* 269: 2407-2413.

Lodge, DM, S Williams, HJ MacIsaac, KR Hayes, B Leung, S Reichard, RN Mack, PB Moyle, M Smith, DA Andow, JT Carlton and A McMichael. 2006. Biological invasions: Recommendations for US Policy and Management. *Ecological Applications* 16(6): 2035-2054.

Mack, RN, D Simberloff, WM Lonsdale, H Evans, M Clout, and FA Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. *Ecological Applications* 10(3): 689-710.

Miller, RW. 1997. *Urban Forestry: Planning and managing urban green spaces.* 2nd Edition. Prentice Hall, New Jersey. 210 pp.

National Invasive Species Council. 2001. *Meeting the Invasive Species Challenge: National Invasive Species Management Plan.* 80 pp. https://www.invasivespeciesinfo.gov/docs/council/mpfinal.pdf

National Invasive Species Council. 2008. *2008-2012 National Invasive Species Management Plan.* 35 pp. https://www.invasivespeciesinfo.gov/council/mp2008.pdf

National Strategy and Implementation Plan for Invasive Species Management. 2004. United States Department of Agriculture: Forest Service.

Nowak, DJ and EJ Greenfield. 2010. Urban Community Forests of the North Central West Region. *Northern Research Technical Report NRS-56.*

Perron, C. 2008. *Best Management Practices for Roadside Invasive Plants.* New Hampshire Department of Transportation.

Pimentel, D, S McNair, J Janecka, J Wightman, C Simmonds, C O'Connell, E Wong, L Russel, J Zern, T Aquino, and T Tsomondo. 2001. Economic and environmental threats of alien plant, animal, and microbe invasions. *Agriculture, Ecosystems & Environment* (84) 1: 1-20.

Reichard, SH and CW Hamilton. 1997. Predicting invasions of woody plants introduced into North America. *Conservation Biology.* 11: 193-203.

Simberloff, D, IM Parker, and PN Windle. 2005. Introduced species policy, management, and future research needs. *Frontiers in Ecology and the Environment* 3(1): 12-20.

Smith, LL 2005. Invasive Exotic Plant Management Tutorial for Natural Lands Managers. Mid-Atlantic Exotic Pest Plant Council, Inc.

Snow, K 2002. Working with the horticultural industry to limit invasive species introductions. *Conservation in Practice.* 3(1): 33-36.

Society for Ecological Restoration International Science & Policy Working Group. 2004. *The SER International Primer on Ecological Restoration.* http://www.ser.org/ & Tucson: Society for Ecological Restoration International.

Spear, RJ. *The Great Gypsy moth War*. Amherst & Boston: University of Massachusetts Press, 2005.

Stinson KA, SA Campbell, JR Powell, BEWolfe, RM Callaway, et al. 2006. Invasive plant suppresses the growth of native tree seedlings by disrupting belowground mutualisms. *PLoS Biology*. 4(5):e140.

The Dictionary of Forestry. 1998. Helms, J A. (ed.). Society of American Foresters, Bethesda, Maryland. 210 p.

Ticehurst, M and S Finley. 1988. An urban forest integrated pest management program for gypsy moth: an example. *Journal of Arboriculture*. 14(7): 172-175.

Urban Forestry Services. *Forestry Facts #3: Controlling Invasive Plants.* Toronto Parks and Recreation. http://www.toronto.ca/trees.

Voluntary codes of conduct for nursery professionals. http://www.centerforplantconservation.org/invasives/

Wilcove, DS, D Rothstein, J Dubow, A Phillips, and E Loso. 1998. Quantifying threats to imperiled species in the United States. *Bioscience*. 48: 607-615.

Wisconsin Department of Natural Resources. Iowa Administrative Code, Chapter NR 502, Solid Waste Storage, Transportation, Transfer, Incineration, Air Curtain Destructors, Processing, Wood Burning, Composting and Municipal Solid Waste Combustors. Chapter NR 502.12(10)(h). http://docs.legis.wisconsin.gov/code/admin_code/nr/500/502/12/10/h pg 16.

Worall, J. 2002. Review of Systems for Early Detection and Rapid Response. USDA Forest Service: Forest Health Protection.

Appendix G: Glossary

Control: To reduce the impact of a pest to a level necessary to meet site management goals.

Cooperative Weed Management Area (CWMA): A formal partnership of federal, state and local government agencies, tribes, individuals, and other interested groups that share resources to manage invasive plants in a defined geographic area.

Cultivar: A cultivated variety of a plant. Cannot be reproduced without human assistance. Usually propagated asexually (cloned). Compare to variety....

Early Detection: An integrated system of active or passive surveillance to find new populations of invasive species, as early as possible while their population is low, when eradication and control are still feasible and less costly. It may be targeted at: a) areas where introductions are likely, such as access points and travel corridors, b) areas with high ecological value where impacts are likely to be significant, and c) vulnerable habitats or recently disturbed areas.

Ecosystem: The complex of a community of organisms and its environment.

Invasive Disease: Although diseases themselves are not technically invasive, the pathogens that cause plant diseases (including but not limited to fungi, bacteria, viruses and phytoplasmas) can be invasive when they infect a susceptible host and conditions are favorable for disease to develop.

Invasive Species: A species that is not native to the ecosystem under consideration whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Integrated Pest Management: To reduce the impact of destructive agents by the planned use of a variety of preventive, suppressive or regulatory tactics and strategies that are ecologically and economically efficient and socially acceptable.

Introduction: The intentional or unintentional escape, release, dissemination or placement of a species into an ecosystem as a result of human activity.

Inventory: The collection of data about the number, condition and distribution of trees and other vegetation in order to manage the resource.

Microclimate: The climate of small spaces, such as an inner city, a residential area or a mountain valley. Microclimate includes: sun/shade, wind, temperature and precipitation.

Monitoring: The periodic inspection of post-activity sites to detect new invasions and evaluate the success of invasive species management plans and control measures.

Native species: With respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.

Pathogen: An agent that causes disease, especially a living microorganism such as a bacterium or fungus.

Prevention: The prescriptions or strategies used to discourage the presence or spread of pests.

Propagule: Any reproductive structure or part of an organism that can grow independently of its parent source. In plants, this may be a fruit, seed, bud, tuber, root, stem with rooting structures or shoot. In insects, this may be an egg, larva, pupa or adult. In diseases, this may be a spore, mycelial fragment (similar to roots) or a fruiting body.

Provenance: The geographic seed source (i.e. where the seed or seedling originated). Assures that the seed or seedling will be adaptable to the general climatic conditions of that geographic area.

Rapid Response: A systematic effort to contain, control or eradicate invasive species while the infestation is still localized. It may be implemented in response to new introductions or to isolated infestations of a previously established species. Preliminary assessment and subsequent monitoring may be part of the response. It is most effective when based on a plan organized in advance so that the response is rapid and efficient.

Reforestation: The reestablishment of forest cover either naturally (e.g. natural seeding, coppice, root suckers) or artificially (e.g. planting or direct seeding).

Restoration: The process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed.

Revegetation: The reestablishment and development of vegetation.

Soil seedbank: The collective name for the store of unsprouted seeds in the soil. For example, although most seeds sprout in the first few years after they fall onto the soil, spotted knapweed seeds can last 10 years in the soil before they sprout.

Species: A group of organisms, all of which have a high degree of physical and genetic similarity, generally interbreed only among themselves and show persistent differences from members of allied groups of organisms.

Urban Forest: All the trees, shrubs, groundcovers and associated vegetation in and around a city, village or town in association with the buildings, infrastructure, soil, water, air, topography, animals and people.

Urban Forestry: The art, science and technology of managing the urban forest landscape for the environmental, ecological, physiological, sociological, economic and aesthetic benefits trees, shrubs, groundcovers, and associated vegetation provide.

Variety: A naturally occurring subdivision of a species having a distinct difference and breeding true to that difference. Compare to cultivar....

Weed Commissioner: A position which a municipality or county may appoint as having responsibility over noxious weeds and other duties as assigned by the entity.

Appendix H: List of BMPs

Chapter 3 Planning:

Land Use Planning

BMP 3.1: Know which invasive species affect or could affect your region and property.

BMP 3.2: Assess the extent of invasive species on and near the property by scouting and documenting infestations.

BMP 3.3: Assess current available resources and explore additional resources to prevent the introduction and manage the spread of invasive species.

BMP 3.4: Develop a plan for managing invasive species.

BMP 3.5: Provide training on identification, management, and prevention techniques of known invasive species to employees, contractors, volunteers, elected officials, owners, users, and the public.

Activity Planning

BMP 3.6: When planning for a specific management/maintenance activity, scout for invasive species both within and around the activity area.

BMP 3.7: Plan urban forest management/maintenance activities to limit the introduction and spread of invasive species.

BMP 3.8: Plan to monitor each site following management and maintenance activities; determine necessary treatments based on presence of invasive species.

BMP 3.9: As opportunities arise, interact with and engage researchers to further our understanding of invasives.

Chapter 4 Design:

BMP 4.1: Conduct a site assessment prior to site design.

BMP 4.2: Conduct an inventory for invasive species as part of a site assessment.

BMP 4.3: Do not include invasive species in planting designs.

BMP 4.4: Design using plant materials that are site appropriate and less susceptible to highly damaging/detrimental pests and diseases.

BMP 4.5: Design planting conditions that foster the establishment and health of plants.

BMP 4.6: Diversify the planting material within the context of your design.

BMP 4.7: Design with long-term management/maintenance in mind.

Chapter 5 Sales:

BMP 5.1: Do not purchase, sell or propagate known invasive plant species or their propagules.

BMP 5.2: Do not purchase or sell plant or landscape material you suspect may be infested or infected with invasive pests.

BMP 5.3: When available and appropriate, purchase, sell and propagate species, cultivars and varieties known to be less susceptible to invasive pests as alternatives to more susceptible ones.

BMP 5.4: Plant propagators, wholesalers and retailers should educate themselves and their customers about invasive plants and potential invasive insect and disease issues associated with host plant materials.

Chapter 6 Planting and Installation:

BMP 6.1: Limit the introduction and spread of invasives during site preparation activities.

BMP 6.2: Do not plant invasive species.

BMP 6.3: Do not plant material that you suspect may be infested or infected with invasive pests.

BMP 6.4: Select plant materials that are site appropriate, healthy and less susceptible to highly damaging/detrimental pests and diseases.

BMP 6.5: Diversify the planting material within the context of your planting project.

BMP 6.6: Prepare site and plant trees according to current arboriculture industry standards for optimum tree health.

BMP 6.7: Reduce the introduction of pathogens and insects by avoiding unnecessary wounding of trees and other vegetation.

BMP 6.8: Avoid unnecessary soil disturbance.

BMP 6.9: Stabilize disturbed soils in a timely manner to prevent the establishment of invasive species.

BMP 6.10: Use landscape materials that are free of invasive species and their propagules.

BMP 6.11: Monitor sites following planting and installation activities; determine necessary treatments based on presence of invasive species.

BMP 6.12: Prior to relocating equipment, vehicles, and trailers, remove soil and debris from exterior surfaces by scraping, brushing, washing or using other methods to minimize the risk of transporting propagules.

BMP 6.13: Remove soil, seeds, vegetative matter and other debris from shoes, clothing and tools prior to leaving an area.

Chapter 7 Management/Maintenance:

BMP 7.1: Plan management/maintenance activities to limit the introduction and spread of invasive species.

BMP 7.2: When working in an area infested or previously infested with invasives, utilize monitoring surveys and control records for the property prior to the current work being conducted.

BMP 7.3: Minimize the movement of invasive species to non-infested areas during management/maintenance activities.

BMP 7.4: Reduce the introduction of pathogens and insects by avoiding unnecessary wounding of trees and other vegetation.

BMP 7.5: Perform activities in a way that promotes healthy plants.

BMP 7.6: Use landscape materials that are free of invasive species and their propagules.

BMP 7.7: Avoid unnecessary soil disturbance.

BMP 7.8: Stabilize disturbed soils in a timely manner to prevent the establishment of invasive species.

BMP 7.9: Keep records of activities that could affect invasives.

BMP 7.10: If possible, monitor recent work sites for invasive species.

BMP 7.11: Prior to relocating equipment, vehicles, and trailers, remove soil and debris from exterior surfaces by scraping, brushing, washing or using other methods to minimize the risk of transporting propagules.

BMP 7.12: Remove soil, seeds, vegetative matter and other debris from shoes, clothing and tools prior to leaving an area.

BMP 7.13: Properly treat or dispose of invasive species or materials that may harbor invasive propagules, insects or diseases.

BMP 7.14: If pre- or post-activity invasive species control treatments are planned, ensure they are applied within the appropriate time window and environmental conditions.

Chapter 8 Sanitation and Debris Disposal:

BMP 8.1: Prior to relocating equipment, vehicles, and trailers, remove soil and debris from exterior surfaces by scraping, brushing, washing or using other methods to minimize the risk of transporting propagules.

BMP 8.2: Remove soil, seeds, vegetative matter and other debris from shoes, clothing and tools prior to leaving an area.

BMP 8.3: Minimize the offsite transport of invasives and materials that may contain invasives.

BMP 8.4: When necessary to transport invasives and materials that may contain invasives off site, cover or otherwise contain those materials.

BMP 8.5: Properly treat or dispose of invasive species or materials that may harbor invasive propagules, insects or diseases.

BMP 8.6: Allow compost piles to heat to appropriate temperatures and times and with proper procedures to reduce the viability of invasives contained within.

BMP 8.7: Avoid the use of wood chips and compost that may contain invasive propagules.

Chapter 9 Monitoring and Research:

BMP 9.1: Create an invasive species monitoring plan for properties under your management.

BMP 9.2: Assess the extent of invasive species on and near the property by scouting, locating and documenting infestations.

BMP 9.3: Monitor sites under your management following management/maintenance activities; determine necessary follow-up based on presence of invasive species.

BMP 9.4: Keep records when scouting and monitoring.

BMP 9.5: Report new infestations of known invasive species to the appropriate authority.

BMP 9.6: As opportunities arise, interact with and engage researchers to further our understanding of invasives.

Chapter 10 Education:

BMP 10.1: Educate yourself about invasive species.

BMP 10.2: Educate employees and volunteers about invasive species.

BMP 10.3: Educate clients, customers and users about invasive species.

BMP 10.4: Educate public officials and other decision makers about invasive species.