ABSTRACT

TRUEBLOOD, CLARA ENGLERT. An Invasive Species Assessment System for the North Carolina Horticultural Industry. (Under the direction Dr. Joseph C. Neal and Dr. Thomas G. Ranney).

While a small proportion of nonindigenous species successfully naturalize and even fewer become invasive, those that do may alter ecosystem processes and negatively impact native community composition. Many potentially invasive species were introduced and sold for horticultural purposes. The North Carolina Nursery and Landscape Association (NCNLA) has supported the development of an invasive assessment protocol designed to systematically assess the potential invasiveness of ornamental plants suspected to affect natural areas in the state. The North Carolina protocol incorporates and builds upon elements of existing assessment models to evaluate the potential invasiveness of plant species in accordance with regional environmental conditions. The ranking and scoring systems and qualitative and quantitative measurements of existing regional and national assessment models were compared to develop the framework for an assessment tool unique to North Carolina. The North Carolina assessment criteria are based on a framework of weighted sets of indices that evaluate and rate ecological impacts, potential for expanded distribution, management difficulty, and the economic value and benefits of non-native ornamental species. According to the combined weighted results, the model generates a recommendation for evaluated species ranging from 'unlikely to be invasive' to ‘invasive and not recommended for use.' The North Carolina invasive protocol is non-predictive and intended for species that are available in the horticultural trade. The assessment model incorporates a unique cost/benefit analysis and weighs economic benefits against the ecological risk of selling potentially invasive ornamental plants. An online survey of NCNLA members was designed to assess

the market value of potentially invasive plant species produced in the North Carolina nursery industry. We found that potentially invasive ornamental plant species have substantial value to the nursery industry in North Carolina. Total statewide wholesale value attributed to the 18 potentially invasive surveyed plants was estimated at roughly $206 million, or approximately 23.1% of state-wide industry sales. The assessment protocol was used to evaluate the invasiveness of 25 nonnative taxa. Three species, *Celastrus orbiculatus* (Oriental bittersweet), *Lonicera japonica* (Japanese honeysuckle), and *Vitex rotundifolia* (Beach Vitex) were categorized as highly invasive with severe environmental impacts, great potential for natural dispersion, and high management difficulty. Nine species were categorized as Moderately Weedy. All of the Moderately Weedy species are sold in the North Carolina nursery industry and either identified by land managers in North Carolina as potentially invasive plants or categorized as invasive species in other state assessments. Thirteen species were classified as Noninvasive with limited ecological impact, distribution and invasive potential, and management difficulty. The majority of the Noninvasive species are nonnative plants with very high economic value in the North Carolina nursery industry that have not been shown to invade natural areas. By modifying the criteria utilized in existing assessments and tailoring the model for the North Carolina horticultural trade, we have created an assessment system unique to the nursery industry that may be completed using resources available in North Carolina. The assessment results are intended to allow the NCNLA to advise their members regarding plants that are purported to be invasive.

An Invasive Species Assessment System for the North Carolina Horticultural Industry

by
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BIOGRAPHY

Clara Trueblood was born Clara Englert and grew up in Pittsburgh, Pennsylvania. She attended Ohio Wesleyan University for her undergraduate education and majored in zoology and environmental studies. After graduating in 2004, she worked briefly as an environmental educator for the Pittsburgh Zoo and Vermont Audubon. She later decided to move to Washington, D.C. and pursue a career working for the federal government. For nearly 3 years, she enjoyed working as a Science Policy Assistant for the National Science Board of the National Science Foundation (NSF). Her mentors and coworkers at NSF encouraged her to pursue graduate school. In August, 2007, she moved to Raleigh, North Carolina and began working towards her master's degree in Horticultural Science. After grad school, she plans to live in Pittsburgh once again with her new husband and pursue a career in plant and environmental science.

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SCOPE AND JUSTIFICATION

Plant invasiveness involves a wide range of ecological and economic consequences, but in general, invasive plants are species that establish and spread outside their native range or management area and degrade the environment (Mack et al. 2000). While a small proportion of nonindigenous species successfully naturalize and even fewer become invasive, those that do may alter ecosystem processes, including hydrology, sedimentation rates, fire regimes, and nutrient cycles, and negatively impact native community composition (Mack et al. 2000; Lehtonen 2001). In addition to acute environmental impacts, invasive plants present serious economic costs of at least $34.5 billion in agricultural losses and costs to contain invasive populations and remedy damage (Pimentel et el. 2005).

Many potentially invasive species that can cause environmental and economic consequences, including English ivy (*Hedera helix* L.) and Japanese honeysuckle (*Lonicera japonica* Thunb.), were introduced and sold for horticultural purposes (Mack et al. 2000; Burt 2007). Among potentially invasive woody plant species, it has been estimated that approximately 85% were introduced for landscaping and horticultural purposes (Reichard and White 2001). Reichard and White (2001) estimated that over 1,000 additional plants are potentially invasive and could cause new environmental impacts in the United States. With the persistent threat of potentially new invasive species, prevention and early detection provides the most efficient and economic approach to addressing invasive populations (Mack et al. 2000).

The US federal government has shown increasing interest in managing noxious weeds and invasive species. In 1999, President Clinton issued an Executive Order

(Executive Order 13112 of Feb 3, 1999) to create the interdepartmental National Invasive Species Council and coordinate efforts of federal agencies to prevent new introductions and reduce the spread of invasive species. The United States Department of Agriculture (USDA) Animal Plant Health Inspection Service (APHIS), which maintains the federal noxious weed list prohibiting listed species from entering the US, is considering whether to revise nursery stock regulations and take a more precautionary and restrictive approach (USDA 2007).

On a state level, the North Carolina Department of Agriculture and Consumer Services (NCDA&CS) Weed Regulatory Program works to eradicate, reduce, and prevent the spread of noxious weeds through control and quarantine measures. NCDA&CS maintains a list of noxious weeds, in addition to those identified by APHIS, that are regulated within the state.

Nursery professionals and the horticultural trade have recently introduced voluntary self-regulations to address the growing concern of invasive plant species (Missouri Botanical Garden for Plant Conservation). Following two botanical workshops examining the link between horticulture and ecology to prevent plant invasions, a Voluntary Code of Conduct for Nursery Professionals was established in 2002 to reduce the spread of invasive non-native species (http://www.centerforplantconservation.org/invasives/nurseryN.html). The American Nursery and Landscape Association (ANLA) and the North Carolina Nursery and Landscape Association (NCNLA) have endorsed these voluntary measures to assess invasive potential prior to distribution, identify regional invasive plants, develop alternative species or cultivars, encourage education programs to promote non-invasive plants, and with the agreement of nursery associations, government, academia, and conservation organizations, discontinue the

sale of specific invasive species in affected regions. In a study conducted at the University of California, Davis, researchers assessed the potential efficacy of self-regulation of nursery professionals to combat the spread of invasive species and found great potential for effective voluntary group initiatives (Burt et al. 2007). The NCNLA has also clarified key terms important in this project by adopting the following definitions:

Alien/Non-native Species: A species found outside their natural range boundaries as a result of human activity (Richardson et al. 2000)

Naturalized: A non-native species that establishes self-perpetuating populations (Richardson et al. 2000)

Invasive: A non-native species whose introduction causes or is likely to cause economic or environmental harm or harm to human health that outweighs any beneficial effects. This definition of invasive is based on The National Invasive Species Council's Invasive Species Definition Clarification and Guidance White Paper (2006).

According to the USDA Economic Research Service (2007), floriculture and nursery crops have been among the fastest growing components of the US agricultural economy, and North Carolina consistently ranks among the top 4 producers by state. The North Carolina Green Industry Council (2005) conducted an economic impact study of the green industry, which is composed of growers, producers, contractors, and retail centers in North Carolina, and determined that the green industry contributes $8.6 billion and 151, 982 jobs to the state economy. Among agricultural sectors in North Carolina, the nursery and floriculture industry captured the majority (29 percent) of total crop sales in 2007 with an estimated wholesale value of $890 million (North Carolina Agricultural Statistics 2008). As the horticultural

industry continues to grow, it becomes increasingly important to accurately assess the potential invasiveness of ornamental plants and avoid additional introductions or harmful establishments of escaped ornamentals. Lists of landscape plants to avoid have been developed by a variety of organizations, including exotic pest plant counsels, botanical gardens, and conservation groups but these collections, while well intended, are often based on anecdotal experience or observations, rather than scientific evidence. In addition, the criteria for categorizing species on these weed lists are often not well defined.

In contrast, a systematic assessment using an objective set of criteria could provide a more reliable evaluation and resolve conflicts. An assessment should be based on quantitative criteria and scientific documentation to avoid subjective or debatable conclusions and allow for transparency of the evaluations. In addition, the criteria must be replicable so that anyone correctly using the system would come to the same conclusion for a particular species in a specific region. A science-based assessment with transparent criteria may provide the necessary sound justification for categorizing or ranking a particular species as invasive. Recommendations for the limited sale and distribution of an invasive species may be more understandable when evaluating plants using a system developed specifically for North Carolina.

Several national and regional invasive assessment protocols have recently been developed to examine the potential invasiveness of plant species and the associated environmental impact of identified invasive species establishing or spreading in a natural area. NatureServe (Morse et al. 2004) has developed a general assessment model that may be regionally adapted to evaluate the impact of invasive plants on native ecosystems. Several

states, including Florida (Fox et al. 2005), California (Warner et al. 2003), Arizona (Northam et al. 2005) and Michigan (Schutzki et al. 2004) have developed their own risk assessment models for invasive plants. These efforts have been coordinated by state governments, universities, and exotic pest-plant councils.

Generally, weed risk assessments focus on two issues – in what regions will the species survive and what are the associated economic and environmental consequences (Kriticos and Randall 2001). Criteria and decision-making trees are based on a framework of weighted sets of indices to evaluate and rate ecological impacts, potential for expanded distribution, management difficulty, and the economic value of non-native species. Each protocol has its own scoring system, but from the combined weighted results, a particular recommendation is generated for each species ranging from 'not a problem,' to 'caution,' and finally to 'invasive and not recommended for use.' Most assessments share a common goal to minimize the number of species that are 'unknown' or 'in need of further evaluation.' Ideally, an assessment would incorporate as many quantitative evaluations as possible and require that all scores must be validated by scientific research results.

Considering the large economic contribution of the green industry (North Carolina Green Industry Council 2005), an invasive assessment system for North Carolina should consider the economic impact of selling potentially invasive ornamental plant species. In addition to evaluating the environmental consequences of invasive species, an assessment system uniquely tailored to the horticultural industry would include criteria that address the economic benefits of these potentially invasive ornamental plants. In this way, economic benefits could be weighed against the ecological risk of invasiveness.

Since the establishment and extent of an invasion is influenced by a range of conditions, including the current distribution in regional natural communities, a model unique to the environmental conditions of North Carolina would more effectively assess the potential invasiveness of plant species in natural areas. With a regional, science-based risk assessment protocol, ornamental plant species with a high potential for invasiveness may be reliably identified, reducing the risk to North Carolina natural areas and allowing the nursery industry to effectively evaluate measures of voluntary regulation to prevent the spread of invasive plants.

OBJECTIVES

Our main objectives were to: (1) create an objective, systematic tool for evaluating potentially invasive plants sold in the horticultural trade in North Carolina, (2) quantify, assess, and compare the regional level of invasiveness of plants commonly suspected to be invasive in North Carolina, and (3) identify research areas and data-gaps in invasive biology as it relates to the horticultural industry that require additional information. The assessment results are intended to allow the North Carolina Nursery and Landscape Association to advise their members regarding the sale and distribution of potentially invasive ornamental plants sold in the horticultural industry.

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Chapter 1

The development of an assessment protocol for potentially invasive plant species sold in the North Carolina horticultural trade

ABSTRACT

A systematic assessment protocol was developed to evaluate the potential invasiveness of plant species sold in the North Carolina nursery industry. Results from these assessments will provide objective criteria with which the North Carolina Nursery and Landscape Association (NCNLA) may advise their members regarding sale and marketing of plants that have been reported to be invasive. The North Carolina assessment is largely non-predictive and designed to assess both the environmental risks and overall benefits associated with potentially invasive ornamental plant species through a system of weighted criteria. The North Carolina assessment protocol was adapted from several existing invasive assessment models that have been developed by other states and environmental groups for the evaluation and categorization of potentially invasive plant species. The criteria of these state and national assessment systems were compared and integrated to develop an assessment tool specifically tailored for North Carolina. The North Carolina criteria are grouped into four sections: Ecological Impact, Distribution and Invasive Potential, Management Difficulty, and Benefits and Value. Eighteen ornamental plant species that have naturalized, at some level, in North Carolina were evaluated using the state-specific assessment and classified as invasive, moderately weedy, or noninvasive.

INTRODUCTION

The purpose of developing an invasive species assessment system for North Carolina is to provide the North Carolina Nursery and Landscape Association (NCNLA) with information to make better decisions regarding the sale and distribution of potentially invasive ornamental plant species sold in the North Carolina horticultural trade. The conclusions and recommendations of the assessment are intended to help prevent the spread of potentially invasive ornamental plant species and minimize environmental impacts within natural areas of North Carolina. Documentation, preferably from published peer-reviewed literature, is required to answer criteria and complete the North Carolina assessment. A science-based assessment with objective criteria, developed specifically for North Carolina, may help the nursery industry to justify the categorization and potentially limit the sale of species that have been identified as invasive plants.

The North Carolina assessment has been designed to evaluate potentially invasive plant species that affect natural areas. *Invasive species* are defined as non-native species whose introduction causes or is likely to cause economic or environmental harm or harm to human health that outweighs any benefits (NISC 2006). For the purpose of this assessment, *natural areas* have been defined as ecosystems that are primarily managed to be in a natural state. Areas immediately adjacent (<10 meters) to roads and trails are not considered natural areas in the North Carolina assessment. The North Carolina assessment is largely non-predictive and not intended to predict invasive attributes or prescreen species not currently utilized in the North Carolina horticultural trade; however, potential for further spread of existing species is considered.

The criteria for the North Carolina assessment protocol were adapted from several existing risk or invasive assessment models that have been developed by other states and environmental groups for the evaluation and categorization of potentially invasive plant species. The assessment tools that served as models in developing the North Carolina protocol have varying objectives and utilize a diversity of criteria, but each model is nonpredictive and largely science-based, meaning some kind of documentation is required to support each criterion that assesses species already present in the region. Researchers and plant pest advisory groups from several states, including Arizona, California, Florida, Indiana, and Michigan have developed assessment criteria and produced categorized lists of invasive non-native plants that have been identified as threats to natural areas within their states. Morse et al. (2004) developed an invasive assessment protocol for NatureServe, a non-profit environmental organization that may be modified for regional, state, or local areas.

Several states, including Arizona (Northam et al. 2005) and Indiana (IPSAWG 2005) have adapted existing assessment models to evaluate potentially invasive species. Northam et al. (2005) relied upon the criteria created in California by Warner et al. (2003) to develop an assessment tool for Arizona. The Indiana assessment tool (IPSAWG 2005) is largely derived from the Florida assessment written by Fox et al. (2005). In these cases, invasive plant working groups adapted assessment protocols from other states by looking to a single assessment as a model protocol. These groups have drawn upon existing criteria to evaluate potentially invasive species in their region for the purpose of providing management recommendations to agencies and organizations in their state. Rather than rely on one

existing model for the state assessment criteria, the North Carolina assessment incorporates elements of a variety of existing state and national assessments.

The ranking and scoring systems and qualitative and quantitative measurements of these existing assessment models were compared to develop the initial framework for an assessment tool unique to North Carolina. Support for the inclusion of criteria derived from available models was based upon the availability of documented support from peer-reviewed journal articles and current research regarding invasive biology and the link between horticulture and invasive plant introductions (Goodwin et al. 1999; Mack et al. 2000; Reichard and White 2001). Criteria selected for the North Carolina assessment are those that are likely to have information available for a variety of species.

The screening effectiveness of the draft invasive assessment model for North Carolina and the model's ability to discern damaging from innocuous non-native plants was tested by evaluating both known noxious weeds and nonindigenous species that are generally perceived to be noninvasive.

SELECTING SPECIES FOR THE ASSESSMENT

This model is non-predictive and designed to evaluate species that are already present in the horticultural trade in North Carolina. Fourteen ornamental plant species that have naturalized, at some level, in North Carolina were evaluated using the state-specific assessment. These potentially invasive species were identified by NCNLA members and North Carolina land managers in a prior survey. Plant species identified by other state assessments, such as the Florida protocol (Fox et al. 2005), as damaging invasive species and available in the horticultural industry in North Carolina were also examined using the North

Carolina model. Species were evaluated independently. Cultivars of species may be considered separately if they have been rigorously tested and determined to have unique non-invasive traits (e.g., seedlessness).

APPLYING THE CRITERIA

Criteria are presented as straightforward questions with a limited number of clearly defined yes-no or multiple-choice responses. For each main assessment question, the evaluator selects a response that corresponds to a particular point value. Numerical values assigned to criteria are for ranking purposes and to separate invasive from innocuous non-native species.

All supporting information must be documented on the species' Dataform and Score Sheet. If information is unavailable to answer a particular question, the response is marked as unknown. After supporting information has been reviewed, scores for each Index Category are determined. An overall score is compiled from the section scores.

DESCRIPTION OF THE CRITERIA

The North Carolina assessment protocol includes five yes-no screening questions and 21 weighted multiple-choice assessment questions grouped into four index categories that collectively measure the environmental risk and overall benefit of potentially invasive ornamental plant species (Table 1):

1. Ecological Impact (4 questions; 40% of final score)
2. Current Distribution and Potential for Expansion (5 questions; 40% of final score)
3. Management Difficulty (7 questions; 20% of final score)
4. Benefit and Value (5 questions; 15% of final score)

Table 1.1 Summary of the North Carolina Assessment System for Potentially Invasive Ornamental Plant Species

Introductory Screening Questions
i. Is this species listed on a federal or North Carolina noxious or prohibited plant list?
ii. Is this species sold in the horticultural trade in North Carolina?
iii. Is this species native to North Carolina?
iv. Is this species known or suspected to be present in natural areas within the four Physiographic Provinces (Blue Ridge Province, Piedmont Province, Inner Coastal Plain, Outer Coastal Plain) of North Carolina?
v. Is this a specific cultivar that has been rigorously tested and determined to be seedless and does not produce viable seeds or vegetative propagules that disperse widely under natural conditions?
Section 1. Ecological Impact (4 questions, 40% of rating)
1a. Impact on Ecosystem Processes and System-Wide Parameters (10 points)
1b. Impact on Plant Community Structure and Composition (20 points)
1c. Impact on Species of Special Concern or Threatened or Endangered Plants (5 points)
1d. Impact on Higher Trophic Levels (5 points)
Section 2. Current Distribution and Potential for Expansion (5 questions, 40% of rating)
2a. Local Range Expansion or Change in Abundance (7 points)
2b. Long-Distance Dispersal Potential (13 points)
2c. Reproductive Characteristics/Biological Character (8 points)
2d. Range of Communities in which Species is Invading (6 points)
2e. Similar Habitats Invaded Elsewhere (6 points)
Section 3. Management Difficulty (7 questions, 20% of rating)
3a. Herbicidal Control (5 points)
3b. Nonchemical Control (2 points)
3c. Necessity of Individual Treatments (2 points)
3d. Average Distribution Pattern (2 points)
3e. Likelihood of Reestablishment (2 points)
3f. Accessibility of Invaded Areas (2 points)
3g. Impact of Management on Native Species and the Environment (5 points)

Table 1.1 Continued

Section 4. Benefits and Value (5 questions)
4a. Estimated Wholesale Value for North Carolina (-7 points)
4b. Percentage of Wholesale Sales (-5 points)
4c. Ecosystem Services (-1 points)
4d. Wildlife Habitat (-1 points)
4e. Cultural and Social Benefits (-1 points)

Prescreening questions are designed to identify species eligible for assessment. To be eligible for assessment, a species must be a) currently not listed as a federal or state noxious weed (since those are already regulated by federal and state agencies), b) non-native, and c) sold in the horticultural trade in North Carolina, d) present or suspected to be present in natural areas in North Carolina, and e) not determined to be a non-invasive cultivar.

The criteria are divided among four sections: Ecological Impact, Distribution and Invasive Potential, Management Difficulty, and Benefits and Value. Scores from the Ecological Impact and Distribution and Invasive Potential sections weigh more heavily on the final recommendation due to the serious environmental implications associated with invasive species. Ecological Impact and Distribution and Invasive Potential are evaluated within natural areas and may be assessed separately in different geographic regions of North Carolina. The North Carolina assessment recognizes and considers the commercial value of selling potentially invasive ornamental plant species and the ecosystem services, wildlife habitat, and cultural benefits provided by some potentially invasive species. Scores from the Benefits and Value section are negative and subtract from the overall invasiveness rating and possible do not sell recommendation.

DERIVATION OF THE NORTH CAROLINA CRITERIA AND EVALUATION SYSTEM

- Introductory Screening Questions –

The North Carolina assessment begins with introductory screening questions to identify species that are eligible for assessment. The North Carolina assessment is designed to evaluate species that are a) currently not listed as a federal or state noxious weed, b) non-native and c) sold in the horticultural trade in North Carolina, d) present or suspected to be present in natural areas in North Carolina, and e) not a cultivar that is considered to be non-invasive.

The Florida (Fox et al. 2005), Indiana (IPSAWG, 2005), and Michigan (Schutzki et al. 2004) assessments include a prescreening section that automatically exempts a species from the assessment if it is listed on any federal or state noxious or prohibited plant lists. In addition, the Florida (Fox et al. 2005), Indiana (IPSAWG, 2005), and NatureServe (Morse et al. 2004) pre-screening questions identify species that currently invade natural or conservation areas of the state or region. These two screening questions were accepted for use in the NC assessment protocol. In addition, an exemption for a plant cultivar that has previously been demonstrated to be non-invasive was included. An example of such an exemption would be documented male and female sterility for a seed-propagated invasive species.

- Index Categories -

The North Carolina assessment includes four primary index categories: Ecological Impact, Current Distribution and Potential for Expansion, Management Difficulty, and Benefits and Value.

- Section 1. Ecological Impact

The purpose of the Ecological Impact section is to identify those species that alter ecosystem processes and plant community composition and impact endangered species and higher trophic levels in natural areas. This section is similar to that in existing models (Arizona: Northam et al. 2005; California: Warner et al. 2003; Florida: Fox et al. 2005; Indiana: IPSAWG, 2005; Michigan: Schutzki et al. 2004; NatureServe: Morse et al. 2004).

- Question 1a. Impact on Ecosystem Processes and System-Wide Parameters

The first question of the North Carolina assessment identifies whether a species substantially alters abiotic ecosystem processes and system-wide parameters in ways that may diminish the survival of native species. This section classifies the extent, ranging from severe, moderate, and mild, to negligible, that an invasive species alters abiotic processes, including fire frequency, erosion, sedimentation rates, hydrological regimes, nutrient and mineral dynamics, and light availability.

All models adapted for the North Carolina assessment examine the impact on abiotic ecosystem processes (Arizona: Northam et al. 2005; California: Warner et al. 2003; Florida: Fox et al. 2005; Indiana: IPSAWG, 2005; Michigan: Schutzki et al. 2004; NatureServe: Morse et al. 2004). The long-term alteration of ecosystem processes is a highly rated criterion among ecological impacts of invasion (Florida: Fox et al. 2005; Indiana: IPSAWG, 2005; Michigan: Schutzki et al. 2004).

- Question 1b. Impact on Plant Community Structure and Composition –

This criterion in the North Carolina assessment asks whether the species alters plant community, composition, or vegetation structure in natural areas. Evaluators identify whether

a species causes major, significant, minor, or no alteration in community composition. The highest number of points in this section is assigned to those species that cause major alterations in community composition (e.g., > 50% cover throughout one vegetation layer over multiple successional stages, results in the extirpation of one or more native species, reduces biodiversity).

The cumulative ecological impact of a species that invades and changes plant communities is considered heavily in existing models (Arizona: Northam et al. 2005; California: Warner et al. 2003; Florida: Fox et al. 2005; Indiana: IPSAWG, 2005; Michigan: Schutzki et al. 2004; NatureServe: Morse et al. 2004). Assessments evaluate the degree of alteration of plant community composition, structure, or interactions. Examples of severe impacts include formations of monocultural stands or patches, occlusion of a native canopy, significant reduction of native populations (Arizona: Northam et al. 2005; California: Warner et al. 2003; Michigan: Schutzki et al. 2004), coverage of at least 50% in the affected stratum (Florida: Fox et al. 2005; Indiana: IPSAWG, 2005). Within this section, evaluators may be asked to consider interactions that involve rare species or community types (Arizona: Northam et al. 2005; California: Warner et al. 2003). In the North Carolina assessment, there is a separate question (1c) to address the impact on species of special concern or threatened or endangered plants.

- Question 1c. Impact on Species of Special Concern or Threatened or Endangered Plants -

In other assessments, as part of the criterion examining the impact on plant community composition, structure, and interactions, evaluators are asked to consider

interactions that involve rare species or community types (Arizona: Northam et al. 2005; California: Warner et al. 2003; Michigan: Schutzki et al. 2004; NatureServe: Morse et al. 2004). In the Florida (Fox et al. 2005) and Indiana (IPSAWG 2005) assessments evaluators are asked to consider whether the species has negatively impacted Federal- or state-listed Species of Special Concern or Threatened or Endangered plants or animals. In the North Carolina assessment, similar to the Florida (Fox et al. 2005) and Indiana (IPSAWG, 2005) assessment, there is a separate question (1c) to address the important impact on species of special concern or threatened or endangered plants. Although impacts on threatened or endangered plants is of high concern, these situations are often very localized, and best addressed through management plants for specific natural areas were these plants exist, rather than state-wide recommendations.

- Question 1d. Impact on Higher Trophic Levels –

In the North Carolina assessment, this question regarding higher trophic levels identifies species that have a cumulative effect on other animals (nesting or foraging sites, habitat connectivity, migration corridors), act as a host plant or provide overwintering for insect pests that damage crop plants in North Carolina, and/or act as a host plant for insect pests that present a threat to human health.

In addition to the impacts on plant communities, the Arizona (Northam et al. 2005) and California (Warner et al. 2003) models consider how plant species affect animals and other organisms. Severe impacts include endangerment of native animal communities or the significant reduction in nesting or foraging sites, cover, or other critical resources.

- Section 2. Current Distribution and Potential for Expansion (Invasive Potential) –

The second section, Current Distribution and Potential for Expansion, evaluates the species' range in North Carolina, long-distance dispersal potential, reproductive traits associated with invasiveness, invaded natural communities, and similar habitats invaded elsewhere. The Distribution and Invasive Potential category of the North Carolina protocol was synthesized from a variety of categories developed by other assessment models. Existing assessments include a variety of sections that examine Invasive Potential (Arizona: Northam et al. 2005; California: Warner et al. 2003), Potential for Expansion (Florida: Fox et al. 2005, Indiana: IPSAWG, 2005), and Ecological Amplitude and Distribution (Arizona: Northam et al. 2005; California: Warner et al. 2003; Michigan: Schutzki et al. 2004; NatureServe: Morse et al. 2004). The North Carolina model combines likelihood for long-distance dispersal with the number of natural community types invaded to create one comprehensive section on current distribution and potential for expansion. Reproductive traits are considered in the Current Distribution and Potential for Expansion section, rather than throughout the assessment or with the Management Difficulty section (Florida: Fox et al. 2005), to improve clarity of invasive potential and avoid redundancy in the model.

- Question 2a. Local Range Expansion or Change in Abundance -

The North Carolina model examines whether the overall range or extent of the distribution of a species has increased within the state. The highest number of points is assigned in cases where the range of the species is increasingly rapidly. Existing models estimate the rate of spread within the range of the state or region as well (Arizona: Northam et al. 2005; California: Warner et al. 2003; NatureServe: Morse et al. 2004). As in the North

Carolina model, the selection choices are descriptive and qualitative estimates, ranging from widespread, increasingly rapidly (doubling in total range statewide in <10 years), increasing, but less rapidly, to stable, and declining (Arizona: Northam et al. 2005; California: Warner et al. 2003; NatureServe: Morse et al. 2004). Selection choices may also be quantitative and require distributional evidence that the species has been reported in more than two new discrete populations (at least 1 mile) in any 12 month period within the last 10 years (Florida: Fox et al. 2005).

- Question 2b. Long-Distance Dispersal Potential Within North Carolina –

The North Carolina model examines the likelihood for long-distance natural dispersal (> 1 km) and considers whether the species exhibits examples of long-distance dispersal mechanisms (e.g., seed disseminated by wind) or has been known to be distributed long distances via animals and abiotic mechanisms. Natural long-distance dispersal potential is evaluated by many existing models (Arizona: Northam et al. 2005; California: Warner et al. 2003; Michigan: Schutzki et al. 2004; NatureServe: Morse et al. 2004). Natural long-distance dispersal mechanisms include transport by animals or abiotic mechanisms that can move seed, roots, stems, or other propagules long distances (Arizona: Northam et al. 2005; California: Warner et al. 2003; Michigan: Schutzki et al. 2004). The likelihood of long-distance natural dispersal (> 1 km) is described in qualitative terms that include frequent, occasional, and rare (Arizona: Northam et al. 2005; California: Warner et al. 2003) or little to great potential for long-distance dispersal (Michigan: Schutzki et al. 2004).

- Question 2c. Reproductive Characteristics/Biological Character -

The North Carolina model summarizes reproductive attributes listed in other models to identify species that reproduce readily from seed in a variety of conditions, resprout after cutting, and fragment easily. Reproductive capacity is often used to identify a plant's invasive tendency, and species that have a high capacity to reproduce by seed and vegetative means are ranked highly in other models (Arizona: Northam et al. 2005; California: Warner et al. 2003; NatureServe: Morse et al. 2004; Michigan: Schutzki et al. 2004).

- Question 2d. Range of Communities in Which Species is Invading -

The North Carolina assessment identifies how many community groups or habitats are affected by a potentially invasive species. This question rates the number of primary natural community systems a species has invaded as an indication of the diversity of ecological types affected. The natural communities of North Carolina are characterized by plant and animal composition, topography, substrate, hydrology, and soil characteristics (Shafale and Weakley 1990). A list of the natural communities associated with each system is included with the model. Species that invade a wide range of communities (≥3 primary systems) receive the maximum number of points, since these species are likely to have wide environmental tolerances and broader impacts than species that are limited to a narrow range of communities (Fox et al. 2005).

Other models examine the number and proportion of different ecological types invaded within a state or region (Arizona: Northam et al. 2005; California: Warner et al. 2003; NatureServe: Morse et al. 2004) or range of communities and habitats in which a

species is invading (Florida: Fox et al. 2005; Indiana: IPSAWG, 2005). Community groups are defined by state departments of natural resources or state natural area inventories.

- Question 2e. Similar Habitats Invaded Elsewhere -

The North Carolina assessment examines whether a species has invaded a number of ecological types, in similar climates, elsewhere in the United States that exist in North Carolina and are as yet not invaded by this species. Natural communities are defined by Shafale and Weakley (1990) as in question 2d regarding the range of communities in which the species is invading.

The Arizona (Northam et al. 2005), California (Warner et al. 2003), and NatureServe (Morse et al. 2004) models estimate the likelihood of further spread within a state or region by considering whether the species has invaded ecological types in other states or countries that are similar to the invaded ecological types within the state or region of the assessment. In areas of the state where the plant has not invaded, the climate and availability of habitat types suitable for the growth of this species may also be considered (Florida: Fox et al. 2005).

- Section 3. Management Difficulty –

The third section, Management Difficulty, identifies species that are difficult to manage due to the time, money, and effort required to control infestations in natural areas. Other assessment models, including Florida (Fox et al. 2005), Indiana (IPSAWG 2005), Michigan (Schutzki et al. 2004), and NatureServe (Morse et al. 2004) include a section addressing Management Difficulty. These models include questions that specifically ask about the total costs of control per acre in the first year, the number of acres that would require management, and the number of discrete populations in managed areas. Since this

information is often difficult to obtain in published state-specific resources or entirely unavailable, the North Carolina model attempts to reflect the cost of managing invaded sites by considering the availability of control methods, need for individual treatments, average distribution in invaded areas, likelihood for reestablishment, and colonization of inaccessible areas.

- *Management Difficulty* –
- Question 3a. Herbicidal Control -

The North Carolina model considers whether a species is well-controlled by herbicides labeled for use in the invaded sites and allows the evaluator to select the degree and ease of herbicidal control, rather than simply selecting true or false for this criterion. The availability of effective herbicide treatments is considered by the Michigan (Schutzki et al. 2004) and Florida models (Fox et al. 2005) as well. In the Florida model, the availability of effective herbicide treatments is one of the most highly rated factors affecting management difficulty.

- Question 3b. Nonchemical Control -

The North Carolina assessment examines whether the species is well-controlled using nonchemical control methods, such as hand pulling, mowing, disking, grazing, flame, or biological control. The Michigan model (Schutzki et al. 2004) considers the effectiveness of nonchemical control methods in the management difficulty section as well.

- Question 3c. Necessity of Individual Treatments –

The North Carolina assessment considers whether individual treatments, chemical or nonchemical, are necessary to treat individual plants and manage this species. Points are

assigned when individual treatments (e.g., cut stem applications) are necessary, since this procedure increases time and labor costs, which are a measure of management difficulty.

- Question 3d. Average Distribution Pattern -

The North Carolina assessment examines the average distribution of the species and asks whether the distribution pattern is in a discrete patch formation or diffuse stands. Points are assigned for those species that are often distributed in diffuse stands, since this pattern may increase treatment time, labor costs, and management difficulty.

- Question 3e. Likelihood for Reestablishment -

This criterion estimates the likelihood for reestablishment of the species following management treatments. Other models (Florida: Fox et al. 2005; Indiana: IPSAWG, 2005; Michigan: Schutzki et al. 2004) consider the need for re-treatment or re-survey of an area due to recruitment from persistent seeds or vegetative structures, or by dispersal from outside the site, since this increases the level of management difficulty.

- Question 3f. Treatment in Inaccessible Areas -

The North Carolina assessment asks whether the species is found in inaccessible areas that cannot be reached or treated easily. The Florida (Fox et al. 2005) and NatureServe (Morse et al. 2004) models consider colonization of the species in inaccessible areas. Species that colonize areas that cannot be reached easily by surface vehicles or cannot easily be treated by an individual carrying a backpack sprayer or hand-held tool increase management difficulty.

- *Non-Target Impacts* –

- Question 3g. Nontarget Impacts –

The North Carolina assessment examines whether the management of the species negatively impacts native species and the environment. Species that are difficult to control without significant damage to native species may be widely dispersed, attached to native species, or easily mistaken for a native plant. Non-target management impacts are highly rated, and the Florida (Fox et al. 2005), Indiana (IPSAWG, 2005), Michigan (Schutzki et al. 2004), and NatureServe (Morse et al. 2004) models estimate damage to native species.

- Section 4. Benefit and Value –

The final section of the North Carolina protocol evaluates the benefits and value of potentially invasive ornamental plants and the benefits provided by potentially invasive species, including ecosystem services, wildlife habitat, and intrinsic cultural or social value. This Value and Benefits section allows the assessment to weigh the commercial value and benefits of a species against the ecological risk of potential invasiveness. Other state assessments, including Florida (Fox et al. 2005), Indiana (IPSAWG 2005), and Michigan (Schutzki et al. 2004) identify species with some significant economic value. Since species-level production and sales information is largely unavailable, the Florida (Fox et al. 2005) and Indiana (IPSAWG 2005) models estimate economic value based on sales from chain retail stores. The sale of high income species at retail stores is suspected to translate to grower sales within the state. The Economic Value sections of the Florida (Fox et al. 2005) and Indiana (IPSAWG 2005) models identifies whether a species has Low or High Economic Value, and numerical scores are not assigned to Economic Value criteria. In addition to

economic value, the Michigan model (Schutzki et al. 2004) considers the aesthetic, erosion control, and wildlife habitat value.

In the Benefits and Value section of the North Carolina assessment, species with high benefits and value are assigned negative point values that subtract from the overall invasiveness rating and may reduce the likelihood that the NCNLA recommend the limited use or sale of a species. Since state-level and species-specific data were unavailable for North Carolina, a short online grower survey was developed for NCNLA members to provide information on plant production and general sales. By addressing the value added to the state of North Carolina and the economic impact to the nursery industry, the North Carolina assessment uniquely addresses both the benefits and environmental risks associated with the sale of potentially invasive ornamental plant species.

- Question 4a. Estimated Wholesale Value for North Carolina -

The North Carolina assessment considers the estimated wholesale value of selling potentially invasive ornamental plants as a measure of economic and commercial value in the state. Point values assigned to criteria in this section are negative and subtract from the overall invasiveness scale and likelihood of not recommending a plant for sale.

The Florida (Fox et al. 2005) and Indiana (IPSAWG 2005) models incorporate a section on economic value, and these state assessments ask whether there are more than 10-20 commercial growers of this species state-wide. Rather than assigning point values for these criteria, the Florida (Fox et al. 2005) and Indiana (IPSAWG 2005) models designate a species as High or Low Value, according to the combined responses from this section.

- Question 4b. Percentage of Wholesale Sales –

Among producers that sell the plant, the North Carolina assessment examines the percentage of total sales attributed to the species. The Indiana model (IPSAWG 2005) asks whether more than five growers in the state rely on this species as more than 10% of their production. The Michigan model (Schutzki et al. 2004) considers whether the species constitutes more than 10% of the crop produced or sold by commercial growers that produce the plant in the state.

- Question 4c. Ecosystem Services -

The North Carolina assessment subtracts points from the overall rating if the species is currently used for erosion control, storm water management, phyto-remediation, bank stabilization, windbreaks, and/or modifying microclimates. The Florida (Fox et al. 2005) and Michigan (Schutzki et al. 2004) models also consider whether a species has economic value for forage, biomass, erosion control, or remediation purposes.

- Question 4e. Wildlife Habitat -

The North Carolina assessment considers whether the plant is currently used for wildlife management (food, cover, etc.). The Michigan model (Schutzki et al. 2004) considers whether the plant benefits wildlife conservation and habitat as well.

- Question 4f. Cultural and Social Benefits -

The North Carolina model considers whether this species provides unique cultural and social benefits that provide intrinsic value in the state. The Michigan model (Schutzki et al. 2004) includes contributions to recreation and leisure activities as part of the species' economic value.

- Overall Taxon Evaluation Scores and Recommendations –

The North Carolina model uses a straightforward scoring system, based on a total of 100 points. Numerical values assigned to criteria are for ranking purposes and to separate invasive from innocuous non-native species. According to the overall score combined from the four index categories, species may be classified as invasive, moderately weedy, or minimal concern.

Species that score highly, with an overall score between 67 to100 points, are considered invasive and may be recommended by the NCNLA for limited horticultural use in North Carolina. These species identified as invasive have relatively high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. Discontinued production and sale of these species in North Carolina should be recommended.

Moderately weedy species receive an overall score between 34 to 66 points and may be recommended for use in North Carolina with specific guidance to minimize escape or spread from cultivation. These moderately weedy species may naturalize in some areas, but have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. These plants should not be grown in close proximity to natural areas that have communities similar to those where this plant has been found to naturalize or near natural areas that have sensitive or threatened plants and/or natural communities. No recommendation for discontinued production or sale is warranted at this time for moderately weedy species, but less weedy alternatives are encouraged, particularly in locations near natural areas.

Species that score between 0 to 33 points are considered to be of minimal concern and may be recommended for use in North Carolina. These noninvasive exotic species have limited ecological impact, distribution and invasive potential, and management difficulty. Low-rated species may be locally problematic but biological/ecological traits limit their rate of invasion in natural areas.

When documented information is unavailable for a complete assessment, a species may designated as 'Evaluated but not listed.' These species may be potentially invasive in North Carolina, but additional information is necessary for further evaluation and conclusions.

All models (Arizona: Northam et al. 2005; California: Warner et al. 2003; Florida: Fox et al. 2005; Indiana: IPSAWG, 2005; Michigan: Schutzki et al. 2004; NatureServe: Morse et al. 2004) used to develop the North Carolina assessment separate overall taxa ranking scores into primary categories that may include rankings of Very High, High, Medium, and Low, based on the combined scores from a variety of index categories. Highly rated species have severe ecological impacts and high rates of dispersal, and when management difficulty is considered, are difficult to control. Taxa with an overall ranking of Medium have substantial ecological impacts, moderate to high rates of dispersal, establishment enhanced by disturbance, and limited distribution within a community range. Low rated species have minor ecological impacts, low rates of invasion, limited distribution, and when considered, low management difficulty. Additional categories may include Alert or Red Flag, which highlight species that may be classified in High or Medium categories if additional documentation regarding the environmental consequences are suspected but not available (Arizona: Northam et al. 2005; California: Warner et al. 2003). When adequate

information is missing in a species' evaluation, those taxa may be 'Evaluated but not listed' (Arizona: Northam et al. 2005; California: Warner et al. 2003).

The Index Scores and Low, Medium, High ratings produced in other assessment models may then be converted to Conclusions and Recommendations for the use of a particular species (Florida: Fox et al. 2005; Indiana: IPSAWG, 2005). Species that score highly may be eligible for a proposal for specified and limited use or may not be recommended for use in the state at all (Florida: Fox et al. 2005; Indiana: IPSAWG, 2005).

INTENDED OUTCOME OF THE NORTH CAROLINA ASSESSMENT PROTOCOL

The North Carolina assessment tool provides a uniform assessment to evaluate the invasiveness of ornamental plants and develop a categorized listing of invasive ornamental plant species. The classification process compiles information on impacts and benefits of each species and provides specific rankings along with citations. The assessment results are intended to allow the North Carolina Nursery and Landscape Association (NCNLA) to advise their members regarding plants that are found to be invasive. While the recommendations are advisory and non-regulatory, the assessment results may allow the NCNLA to: 1) educate their members regarding particular plants that present severe ecological impacts, 2) identify species that are potentially too invasive for sale in North Carolina, and 3) prioritize funding for the development of sterile noninvasive cultivars. The process of assessing invasiveness of ornamental plants within North Carolina may be strengthened with additional research in invasive biology as it relates to the horticultural industry. In particular, more information is needed regarding environmental impacts,

including the impact on abiotic ecosystem processes and plant community structure, and distribution within natural areas.

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Chapter 2

The North Carolina Invasive Species Assessment System

GENERAL DESCRIPTION OF THE CRITERIA

The assessment criteria have been adopted from current available invasive assessments (Fox et al. 2005; Morse et al. 2004; Schutzki et al. 2004; and Warner et al. 2003) and modified for use in the North Carolina horticultural trade. Criteria are those that are likely to have resources and information available for a variety of species. The model is largely non-predictive and not intended to predict invasive attributes or prescreen species not currently utilized in the North Carolina horticultural trade; however, potential for further spread of existing species is considered.

For each main assessment question, an evaluator selects a response that corresponds to a particular point value. If information is unavailable to answer a particular question, the response is recorded as unknown, and no points are assigned. Numerical values assigned to criteria are for ranking purposes and to separate invasive from innocuous non-native species.

The assessment is based on a total of 100 points. Scores for Economic Value (section 4) are negative and subtract from the overall invasiveness rating and possible "do not sell" recommendation. Ecological Impacts (section 1) and Distribution and Invasive Potential (section 2) are evaluated within natural areas and may be assessed specifically for different geographic regions of North Carolina (Figure 2.1).

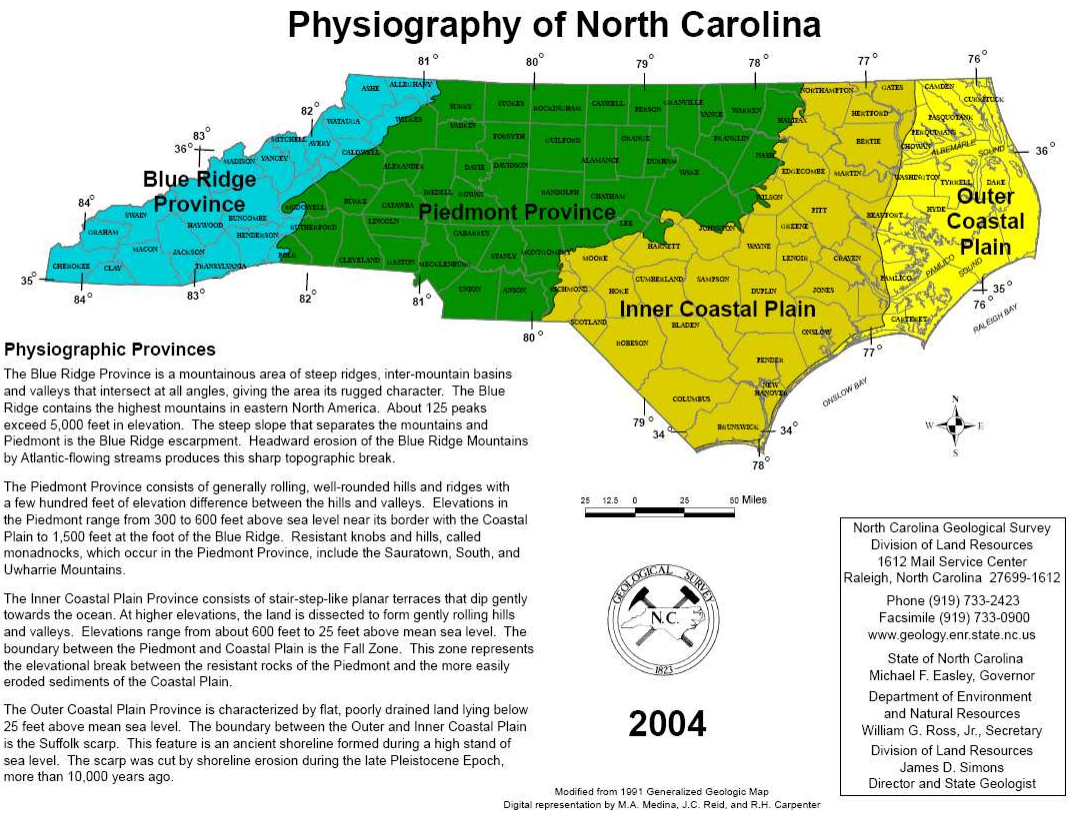

Figure 2.1 Physiography of North Carolina

Supporting information associated with the criteria will be recorded on the species' Dataform and Score Sheet (Table 2.1).

Table 2.1 Species Dataform and Scoresheet

Species Dataform and Scoresheet		
Species:		
Native range:		
Date evaluated:		
	Answer Choices	Response
Introductory Questions		
1. Current federal and state regulations	Y/N	
Comments:		
2. Occurrence in the horticultural trade	Y/N	
Comments:		
3. North Carolina nativity	Y/N	
Comments:		
4. Presence in natural areas	Y/N	
Comments:		
5. Non-invasive cultivars	Y/N	
Comments:		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	
Comments:		
1b. Impact on plant community structure	20	
Comments:		
1c. Impact on species of special concern	5	
Comments:		
1d. Impact on higher trophic levels	5	
Comments:		
Section 1. Subrank	***40***	
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	
Comments:		
2b. Long-distance dispersal potential	13	
Comments:		
2c. Reproductive characteristics	8	
Comments:		

Table 2.1 Continued

2d. Range of communities	6	
Comments:		
2e. Similar habitats invaded elsewhere	6	
Comments:		
Section 2. Subrank	***40***	
Section 3. Management Difficulty		
3a. Herbicidal control	5	
Comments:		
3b. Nonchemical control methods	2	
Comments:		
3c. Necessity of individual treatments	2	
Comments:		
3d. Average distribution	2	
Comments:		
3e. Likelihood for reestablishment	2	
Comments:		
3f. Accessibility of invaded areas	2	
Comments:		
3g. Impact on native species and environment	5	
Comments:		
Section 3. Subrank	***20***	
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	
Comments:		
4b. Percentage of total sales	-5	
Comments:		
4d. Ecosystem services	-1	
Comments:		
4e. Wildlife habitat	-1	
Comments:		
4f. Cultural and social benefits	-1	
Comments:		
Section 4. Subrank	***-15***	
Overall Score	**100**	
Overall Recommendation:		
Summary:		
References:		

INDEX CATEGORIES AND POINT VALUES

Table 2.2 Index categories and associated maximum point values in the North Carolina Invasive Species Assessment System

Index Category	Maximum Points
1. Ecological Impact	+40
2. Distribution and Invasive Potential	+40
3. Management Difficulty	+20
4. Benefits and Value	-15

OVERALL TAXON EVALUATION SCORES AND RECOMMENDATIONS

Highly invasive and not recommended for horticultural use: These species present relatively high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. (Overall Score: 67 – 100)

Moderately weedy and recommended for use with specific guidance: These species have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. These plants should not be grown in close proximity to natural areas that have communities similar to those where this plant has been found to naturalize or near natural areas that have sensitive or threatened plants and/or natural communities. (Overall Score: 34 – 66)

Noninvasive and recommended for use: These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)

Evaluated but not listed - These species may be potentially invasive, but additional information is necessary for further evaluation and conclusions.

KEY DEFINITIONS AND TERMS USED IN THE ASSESSMENT

Alien/Non-native Species: A species found outside their natural range as a result of human activity.

Naturalized: A non-native species that establishes self-perpetuating populations.

Invasive: According to the National Invasive Species Council (2006), invasive species are non-native species whose introduction causes or is likely to cause economic or environmental harm or harm to human health that outweighs any benefits.

Natural Areas: Ecosystems that are primarily managed to be in a natural state. Areas immediately adjacent (<10 meters) to roads and trails should not be included in assessments of natural areas.

Noxious Weed: According to the 1974 Federal Noxious Weed Act, a noxious weed is any plant in any stage of development, including parasitic plants whose presence whether direct or indirect, is detrimental to crops or other desirable plants, livestock, land, or other property, or is injurious to the public health. Noxious weeds are regulated by the federal government and state governments.

ENDANGERED, THREATENED, AND SPECIAL CONCERN SPECIES

In North Carolina, Endangered, Threatened, and Special Concern species have legally protected status in North Carolina through the North Carolina Plant Conservation Program (NC PCP), a unit of the North Carolina Department of Agriculture and Consumer Services. The NC PCP acts to maintain state lists of rare plant taxa, manage conservation programs, develop regulations, and issue permits concerning protected plants (Buchanan and Finnegan 2008). Endangered, threatened, and species of special concern are defined according to the

guidelines of the North Carolina Plant Protection and Conservation Act of 1979 (General Statutes, Article 19B, 106: 202.12_22).

North Carolina Species Status Definitions

Endangered: Any species of higher taxon of plant whose continued existence as a viable component of the State's flora is determined to be in jeopardy. Endangered species may not be removed from the wild except when a permit is obtained for research, propagation, or rescue which will enhance the survival of the species.

Threatened: Any resident species of plant which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Removal regulations are the same as for Endangered species.

Special Concern: Any species of plant in North Carolina which requires monitoring but which may be collected and sold under regulations adopted under the provisions of the Plant Protection and Conservation Act.

The North Carolina Natural Heritage Program maintains a database of state-level and federal legal status information (Buchanan and Finnegan 2008). Federally-listed Endangered and Threatened species and Species of Concern are defined according to the guidelines of the Endangered Species Act of 1973 (Section 3) and determined by the U.S. Fish and Wildlife Service (USFWS) and the U.S. National Marine Fisheries Services.

United States Species Status Definitions

Endangered: Taxa that are in danger of extinction throughout all or a significant portion of its range.

Threatened: Taxa that are likely to become endangered within the foreseeable future throughout all or a significant portion of the occupied range.

Species of Concern: A species under consideration for listing, for which there is insufficient information to support listing at this time. The USFWS works with the States and other private and public interests to assess their need for protection under the Endangered Species Act.

ASSESSMENT QUESTIONS

INTRODUCTORY SCREENING QUESTIONS

Complete the following five questions to determine whether a species should be evaluated. To be eligible for assessment, a species must be currently not listed as a federal or state noxious weed, non-native and sold in the horticultural trade in North Carolina, and present or suspected to be present in natural areas in North Carolina.

1. Current Federal and State Regulations

Is this species listed on a federal or North Carolina noxious or prohibited plant list?

Yes = Stop. If this species is listed as a noxious weed, do not evaluate. Instead, list this plant as an invasive species not recommended for use.

No = Continue with the assessment.

2. Occurrence in the Horticultural Trade

Is this species sold in the horticultural trade in North Carolina?

Yes = Continue with the assessment.

No = Stop. A species must be sold in the horticultural trade to be eligible for evaluation.

3. North Carolina Nativity

Is this species native to North Carolina?

Yes = Stop. A species must be non-native in North Carolina to be eligible for evaluation.

No = Continue with the assessment.

4. Presence in Natural Areas

Is this species known or suspected to be present in natural areas within any of the four Physiographic Provinces (Blue Ridge Province, Piedmont Province, Inner Coastal Plain, Outer Coastal Plain) of North Carolina? Counties contained in each Province are identified in Figure 2.1.

Yes = If this species is present in two or more nonadjacent provinces, assess this species on a state-wide level. However, if this species is present in natural areas in only one of the four province or two adjacent provinces, complete the assessment for this province or region only.

No = Stop. A species must be present or suspected to be present in natural areas to be to be eligible for evaluation. The assessment model is designed to evaluate horticultural species that may escape cultivation and invade undisturbed natural vegetation.

5. Non-Invasive Cultivars

Is this a specific cultivar that has been rigorously tested and determined to be seedless and does not produce viable seeds or vegetative propagules that disperse widely under natural conditions?

Yes = Stop. If the cultivar is considered to be non-invasive, this assessment is not relevant. Data and/or reviewed scientific publications must be provided to substantiate this claim.

No = Continue with the assessment.

SECTION 1. ECOLOGICAL IMPACT

Consider the known ecological impacts in natural areas where it is most prevalent (worst case) without, or before, any control effort.

1a. Impact on Ecosystem Processes and System-Wide Parameters – 10 points

Does this species substantially alter abiotic ecosystem processes and system-wide parameters in ways that may diminish the survival of native species?

Examples of abiotic processes include:

- Fire occurrence, frequency, and intensity
- Geomorphological changes such as erosion and sedimentation rates
- Hydrological regimes, including soil water table
- Nutrient and mineral dynamics, including salinity, alkalinity, and pH

- Light availability

_____Not known to impact ecosystem processes (**0 points**)

_____Influences ecosystem processes (e.g., has perceivable, but mild influence on soil nutrient availability) (**4 points**)

_____Significant alteration in ecosystem processes (e.g., increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl, alters nutrient and mineral dynamics to levels that favor non-native potentially invasive plants at the expense of native species) (**7 points**)

_____Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., changes fire regimes, plant reduces water level from open water or wetland system, changing habitats) (**10 points**)

1b. Impact on Plant Community Structure and Composition – 20 points

Does this species alter the plant community, composition, or vegetation structure?

_____No significant impact. Scattered presence, but no substantial effect on species composition or structure (**0 points**)

_____Minor effect on species composition or structure (e.g., found in patches, but represents <10% cover throughout any vegetation layer of any one successional state) **(5 points)**

_____Influences community composition. Wide spread (e.g., > 10% cover throughout one vegetation layer of at least one successional stage, reduces the number of individuals in one or more native plant species) (**10 points**)

_____Significantly alters community composition. Prevalent (e.g., > 25% cover throughout one vegetation layer over multiple successional stages, substantially reduces the number of individuals in one or more native plant populations) (**15 points**)

_____Causes major alterations in community composition (e.g., > 50% cover throughout one vegetation layer over multiple successional stages, results in the extirpation of one or more native species, reducing biodiversity) **(20 points)**

1c. Impact on Species of Special Concern or Threatened or Endangered Plants – 5 points

Does this species impact rare plants, species of special concern or threatened or endangered plants?

_____Not known to impact rare/endangered native plant species or unique plant communities. (**0 points**)

_____Co-habits with species of special concern, threatened, or endangered native plant species, but not known to have a direct impact on them. (**2 points**)

_____Known to inhabit vulnerable communities and displace or negatively impact species of special concern, threatened, or endangered native species. (**5 points**)

1d. Impacts on Higher Trophic Levels – 5 points

Does this species have a cumulative effect on animals (nesting or foraging sites, habitat connectivity, migration corridors), including pollinators? Does this species act as a host plant or provide overwintering for insect pests or pathogens that damage crop plants or native vegetation in North Carolina? Does this species act as a host plant for insect pests that present a threat to human health?

_____Not known to impact higher trophic levels (**0 points**)

_____May modify some animal behavior or health, reduces food, reproduction, or cover. (**1 point**)

_____Impacts animal species composition displaces certain species. May act as a host plant for insect pests or pathogens that damage crop plants or present a threat to human health (**3 points**)

_____Known to act as a host plant for insect pests or pathogens that damage crop plants, native species or present a threat to human health. (**5 points**)

SECTION 2. CURRENT DISTRIBUTION AND POTENTIAL FOR EXPANSION (INVASIVE POTENTIAL)

On a state level, an assessment is made for zones where the plant has and has not invaded.

2a. Local Range Expansion or Change in Abundance – 7 points

Is the overall range (extent of distribution) of this species increasing? Consider whether the range of the species is expanding, not is it filling in at higher infestation densities within its known range. Document any management activity that may be controlling the species.

_____ The range of this species had not increased over the past 10 years. **(0 points)**

_____ The range of this species has increased slightly over the past 10 years **(1 point)**

_____ The range of this species has moderately increased, but not doubled, over the past 10 years. **(4 points)**

_____ The range of this species is increasing rapidly and has doubled statewide in <10 years. **(7 points)**

2b. Long-Distance Dispersal Potential Within Region – 13 points

What is this species' potential for natural long-distance dispersal? Is this species spread by animals (including unintentionally by people) or abiotic mechanisms that can move seed, roots, stems, or other propagules over a long distance (> 1 km)?

Examples of natural long-distance dispersal mechanisms include:

- the species/fruit or seed is commonly consumed by birds or other animals that travel long distances (fleshy fruit, dispersed by birds)
- the species' fruits or seeds are sticky or burred and cling to feathers or hair of animals;
- the species has buoyant fruit, seeds, or other propagules that promote long-distance wind or water dispersal;

- the species, or parts of it, can detach and disperse seeds as the plants or plant parts are blown long distances.

_____ This species is not dispersed long distances. **(0 points)**

_____ This species exhibits low rates of long distance dispersal **(3 points)**

_____ This species exhibits examples of long-distance dispersal mechanisms. **(8 points)**

_____ This species exhibits examples of long-distance dispersal mechanisms and is known to be dispersed long distances. **(13 points)**

2c. Reproductive Characteristics/Biological Character – 8 points

Does this species have reproductive characteristics typical of invasive plant species? Check all that apply. Note any reproductive factors not listed that may suggest potential aggressiveness.

_____ Populations of this species reproduce readily by seed **(2 points)**

_____ Seeds germinate in a wide range of conditions (**2 points)**

_____ This species fragments easily and fragments can become established elsewhere. (**2 points)**

_____ This species resprouts readily when broken or cut. (**2 points)**

2d. Range of Communities in Which Species is Invading – 6 points

How many community groups or habitats does this species invade in North Carolina?

This question rates the number of primary natural community systems a species has invaded in North Carolina as an indication of the diversity of ecological types affected. Species that invade a variety of natural communities are more likely to have broad environmental tolerances and wide-ranging impacts compared with species that are restricted to a limited number of communities. The natural communities of North Carolina listed below are characterized by plant and animal composition, topography, substrate, hydrology, and soil characteristics (Shafale and Weakley 1990).

Complete Table 2.3 below by marking presence or absence of a species in each of the primary systems. A list of the natural communities associated with each system is included for your information.

If the species occurs only along the transportation corridor in any of the natural communities, it is not considered to have yet invaded these systems. However, it should be noted in the summary datasheet that the species has been found adjacent to the ecological type.

_____ This species invades a limited range of communities (1 primary system). **(2 points)**

_____ This species invades a moderate range of communities (2 primary systems). (**4 points)**

_____ This species invades a wide range of communities (≥3 primary systems). **(6 points)**

Table 2.3 Natural Communities of North Carolina, as defined by Shafale and Weakley (1990)

	Primary Systems	Natural Communities	Status
1	High mountain communities	Fraser fir forest, red spruce-fraser fir forest, grassy bald, heath bald, high elevation red oak forest, montane white oak forest, northern hardwoods forest, boulderfield forest	
2	Low elevation mesic forests	Rich cove forest, acidic cove forest, Canada hemlock forest, mesic mixed hardwood forest, basic mesic forest	
3	Low elevation dry and dry-mesic forest and woodlands	Carolina hemlock bluff, white pine forest, pine/oak heath, chestnut oak forest, piedmont forest, mountain oak-hickory forest, dry oak-hickory forest, dry-mesic oak-hickory forest, basic oak-hickory forest, xeric hardpan forest, piedmont longleaf pine forest	
4	Rock outcrop communities	High elevation rocky summit, high elevation granitic dome, low elevation rocky summit, low elevation granitic dome, montane acidic cliff, piedmont/coastal plain acidic cliff, piedmont/coastal plain heath bluff, montane or piedmont cliff, montane or piedmont calcareous cliff, coastal plain marl outcrop	
5	Communities of the coastal zone	Dune grass, maritime dry grassland, maritime shrub, maritime evergreen forest, maritime deciduous forest, coastal fringe evergreen forest, coastal fringe sandhill	
6	Sandy woodlands of the coastal plain	Mesic pine flatwoods, pine/scrub oak sandhill, xeric sandhill scrub	
7	River floodplains	Sand and mud bar, rocky bar and shore, coastal plain levee forest, cypress--gum swamp, coastal plain bottomland hardwoods, coastal plain small stream swamp, piedmont/mountain swamp forest, piedmont/mountain bottomland forest, floodplain pool, piedmont/low mountain alluvial forest, montane alluvial forest	
8	Nonalluvial wetlands of the mountains and Piedmont	Swamp forest-bog complex, Southern Appalachian bog, Southern Appalachian fen, high elevation seep, spray cliff, upland pool, upland depression swamp forest, hillside seepage bog, low elevation seep	

Table 2.3 Continued

9	Wet nonalluvial forests of the Coastal Plain	Wet Marl forest, nonriverine wet hardwood forest, nonriverine swamp forest	
10	Pocosin and peatland communities of the Coastal Plain	Low pocosin, high pocosin, pond pine woodland, peatland Atlantic white cedar forest, bay forest, streamhead pocosin, streamhead Atlantic white cedar forest,	
11	Wet savanna of the Coastal Plain	Wet pine flatwoods, pine savanna, sandhill seep	
12	Coastal Plain depressions and water bodies	Vernal pool, cypress savanna, small depression pond, natural lake shoreline	
13	Nontidal coastal fringe wetlands	Maritime wet grassland, maritime swamp forest, maritime shrub swamp, interdune pond, estuarine fringe loblolly pine forest	
14	Freshwater tidal wetlands	Tidal freshwater marsh, tidal cypress-gum swamp	
15	Estuarine system	Salt marsh, brackish marsh, salt flat, salt shrub	
16	Marine system	Upper beach	

2e. Similar Habitats Invaded Elsewhere – 6 points

Has the species invaded comparable habitat types elsewhere that exist in North Carolina, but which it has not yet invaded? Identify other areas where this species has been identified as a problem and consider whether this species has invaded ecological types in other states or countries outside its native range that are analogous to ecological types not yet invaded in North Carolina. It is helpful to complete Question 2d above before responding to this question. If a species has been shown to invade a community type in North Carolina, and it was documented above in Question 2d, it does not receive additional points here in Question 2e for invading the same community type in another state. No points are assigned here if a species invades elsewhere but only in ecological types that it has already invaded in North

Carolina. This information regarding suitable habitat-types is useful in determining the potential for additional spread within North Carolina.

_____ This species has not invaded comparable habitat types elsewhere. **(0 points)**

_____ This species has invaded 1 ecological type, in a similar climate, elsewhere that exists, but is not yet invaded in North Carolina **(2 points)**

_____ This species has invaded 2 ecological types, in similar climates, elsewhere that exist, but are not yet invaded in North Carolina. **(4 points)**

_____ This species has invaded 3 or more ecological types, in similar climates, elsewhere that exist, but are not yet invaded in North Carolina. **(6 points)**

SECTION 3. MANAGEMENT DIFFICULTY

This section addresses factors that increase the difficulty of management for potentially invasive species. Responses should be considered for areas without, or before, any efforts to control a species.

Management Difficulty

3a. Is this species well-controlled by herbicides labeled for use in the invaded sites? – 5 points

_____This species is well-controlled using herbicide applications. **(0 points)**

_____This species is well-controlled using a limited variety of herbicides applied at precise times of the year. Herbicide management must follow a strict protocol to be effective, and control is not consistent **(3 points)**

_____ This species is not well-controlled by herbicides registered for use in the invaded sites or this species has shown evidence of herbicide tolerance. **(5 points)**

3b. Are nonchemical control methods effective? – 2 points

_____ This species is well-controlled using nonchemical control methods such as hand-pulling, mowing, disking, grazing, flame or biological control **(0 points)**

_____ Nonchemical control methods provide moderate control of this species **(1 point)**

_____ Nonchemical control methods are not effective treatments for managing this species. (i.e., hand-pulled plants often break and resprout later, the invaded sites should not be disturbed, the invaded sites are too remote for weeding crews and volunteers to easily access the area) **(2 points)**

3c. Are individual treatments necessary? – 2 points

_____This species can be controlled broadly and individual plants treatments are not necessary.**(0 points)**

_____Individual plant treatments (e.g., cut stem applications) are necessary. **(2 points)**

3d. What is the average distribution pattern of this species? – 2 points

_____ The average distribution pattern of this species is a discrete patch formation **(0 points)**

_____ There is often variability in the distribution of this species **(1 point)**

_____ This species is often distributed in diffuse stands **(2 points)**

3e. What is the likelihood for reestablishment of this species following management treatments? – 2 points

Following the first year of control of this species, it would be expected that sites of former populations would require re-survey or re-treatment, due to recruitment from persistent seeds, spores, or vegetative structures, or by dispersal from outside the site:

_____ Re-treatments are generally not warranted; or regrowth not known. **(0 points)**

_____ Re-treatment may be made in 2 to 3 years, or spot treatments to limited re-growth over the next 2 to 5 years**. (1 point)**

_____ Annual re-treatment is necessary for 3 or more years, skipping a year of treatment may result in a return to the original infestation density. **(2 points)**

3f. Accessibility of Invaded Areas – 2 points

Is this species found in inaccessible areas?

_____ No. **(0 points)**

_____ Yes, and a limited area cannot be reached easily by vehicle or cannot easily be treated by an individual carrying a backpack sprayer or hand-held tool. **(1 point)**

_____ Yes, and much of the area cannot be reached easily by vehicle or cannot easily be treated by an individual carrying a backpack sprayer or hand-held tool. **(2 points)**

Non-Target Impacts

3g. Impacts of Management on Native Species and the Environment – 5 points

Does the management of this species negatively impact native species and the environment?

Species that are difficult to control without significant damage to native species may be:

- widely dispersed (i.e., does not occur within discrete clumps or monocultures);
- attached to native species (e.g., vine, epiphytes or parasite);
- easily mistaken for a native plant;
- significant soil disturbance would result from control measures.

_____ The management of this species does not negatively impact native species or the environment. **(0 points)**

_____ The management of this species may negatively impact native species or the environment. **(2 points)**

_____ The management of this species is known to negatively impact native species and the environment. **(5 points)**

SECTION 4. BENEFITS AND VALUE

This section weighs the economic, environmental, and social benefits of a species against the ecological risk of potential invasiveness. Negative point values subtract from the overall invasiveness scale and likelihood of not recommending a plant for sale.

4a. Estimated Wholesale Value in North Carolina

What is the estimated annual wholesale value attributed to this species?

_____ > $40 million **(-7 points)**

_____ > $30 million **(-6 points)**

_____ > $20 million **(-5 points)**

_____ > $10 million **(-4 points)**

_____ > $5 million **(-3 points)**

_____ > $1 million **(-2 points)**

_____ > $100,000 **(-1 point)**

4b. Percentage of Wholesale and/or Retail Sales

Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be:

_____ > 50% **(-5 points)**

_____ 26-50% **(-4 points)**

_____ 11-25% **(-3 points)**

_____ 6-10% **(-2 points)**

_____ 1-5% **(-1 point)**

4c. Ecosystem Services

This plant is currently used for erosion control, storm water management, phyto-remediation, bank stabilization, windbreaks, and/or modifying microclimates.

_____No **(0 points)**

_____Yes **(-1 point)**

4d. Wildlife Habitat

This plant is currently used for wildlife management (food, cover, etc.)

_____No **(0 points)**

_____Yes **(-1 point)**

4e. Cultural and Social Benefits.

This plant provides unique cultural and social benefits that provide intrinsic value.

_____No **(0 points)**

_____Yes **(-1 point)**

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Chapter 3

An estimate of the commercial value of potentially invasive nursery crops grown in North Carolina

ABSTRACT

Considering the large economic value of nursery crops, invasive plant assessment systems should ideally consider economic benefits along with environmental risks of selling potentially invasive ornamental plant species. Since state-level and species-specific economic data was unavailable for North Carolina, an online grower survey was developed to capture information on plant production and general sales of eighteen potentially invasive nursery crops. Thirty individuals completed the survey representing 4.3% ($37,927,250) of the wholesale value of the entire North Carolina nursery industry ($890 million) in 2007. The eighteen potentially invasive nursery crops examined in this study contributed an estimated $206 million annually, or 23.1% of state-wide wholesale sales. However, the economic value of specific crops varied considerably. *Celastrus orbiculatus* Thunb. (Oriental bittersweet) had an estimated state wide annual wholesale value of less than $6,000 state wide, while *Miscanthus sinensis* Andersson (Chinese silvergrass) exceeded $39,000,000. The results of this survey will be incorporated in species assessments using the North Carolina Invasive Species Assessment System.

INTRODUCTION

The impacts, both positive and negative, of growing non-native horticultural crops can be varied and complex. As presented in the Invasive Species Definition and Clarification and Guidance White Paper (NISC 2006), an invasive species is a non-native species whose

introduction causes or is likely to cause economic or environmental harm or harm to human health that outweighs any benefits. Adopting this concept requires a cost benefit analysis to adequately assess the impacts that potentially invasive plants may have.

The North Carolina Invasive Species Assessment System (Trueblood 2009) was developed to evaluate potentially invasive ornamental plant species that are currently found in natural areas within the state. In addition to environmental impacts, the North Carolina assessment considers the commercial value of potentially invasive ornamental plant species and the ecosystem services, wildlife habitat, and cultural benefits provided by some potentially invasive species. The Benefits and Value section of the North Carolina protocol allows the assessment to weigh the commercial value and benefits of a species against the ecological risk of potential invasiveness. Other state assessments, including Florida (Fox et al. 2005) and Michigan (Schutzki et al. 2004) also identify species with substantial economic value. Since species-level production and sales information were largely unavailable for the state, the Florida (Fox et al. 2005) model estimated economic value based on sales from chain retail stores. The sale of high income species at retail stores was suspected to translate to grower sales within the state. The Economic Value section of the Florida (Fox et al. 2005) model identifies whether a species has Low or High Economic Value, and numerical scores are not assigned to Economic Value criteria. In addition to economic value, the Michigan model (Schutzki et al. 2004) considered the aesthetic, erosion control, and wildlife habitat value. The economic impact and value-added section of the North Carolina model was inspired by the Florida (Fox et al. 2005) and Michigan models (Schutzki et al. 2004) that estimated the state-wide value of potentially invasive species. In the Benefits and Value

section of the North Carolina assessment, species that provide economic value and other benefits are assigned negative point values that subtract from the overall invasiveness rating and may reduce the likelihood that those plants are recommend limited or non-use.

According to the USDA Economic Research Service (2007), floriculture and nursery crops have been among the fastest growing components of the US agricultural economy, and North Carolina consistently ranks among the top 4 producers by state. The North Carolina Green Industry Council (2005) conducted an economic impact study of the green industry, which is composed of growers, producers, contractors, and retail centers in North Carolina, and determined that the green industry contributes $8.6 billion and 151, 982 jobs to the state economy. Among agricultural sectors in North Carolina, the nursery and floriculture industry captured the majority (29 percent) of total crop sales in 2007 with an estimated wholesale value of $890 million (North Carolina Agricultural Statistics 2008).

Wirth et al. (2004) recently conducted an impact study to evaluate the economic value of potentially invasive ornamental plant species on a state-wide level in Florida. These researchers assessed the economic impact of 14 potentially invasive landscape plant species designated as invasive by the Florida Exotic Pest Plant Council, but which have significant economic value according to the Florida Nurserymen and Growers Association (Wirth et al. 2004). The survey design and data analysis developed by Wirth et al. (2004) provided a template for the North Carolina economic impact survey.

Considering the large economic contribution of the nursery industry (North Carolina Agricultural Statistics 2005), an invasive assessment system for North Carolina should ideally consider the economic impact of selling potentially invasive ornamental plant species.

The objective of this project was to assess the commercial value of potentially invasive nursery crops grown in North Carolina.

METHODS

A brief survey comprised of 24 questions was developed and posted online through the North Carolina State University College of Agriculture and Life Sciences. The link to the online survey was distributed to 881 North Carolina Nursery and Landscape Association (NCNLA) members via e-mail in March 2009. A reminder/thank you e-mail was sent to each NCNLA member in April 2009. The survey was publicized through a presentation to growers at a NCNLA trade show in January 2009 and an article in the November/December 2008 edition of the NCNLA trade publication, Nursery Notes.

Survey questions included multiple choice responses regarding estimated total annual sales attributed to 21 species (Appendix A1). The survey addressed sales at the species level and cultivars were not considered separately. In addition, the survey asked growers to classify their business as a wholesale and/or retail nursery and provide some general information, including the total gross value in sales for nursery crops from 2008. All responses were strictly anonymous and used for this NCSU research project only.

Twenty-one taxa were included in the survey. Of the 21 taxa, 18 species were potentially invasive plant species that have naturalized, at some level, in North Carolina. Three nonnative taxa that are generally presumed to be noninvasive were included for comparison purposes and include *Camellia spp*. (Camellia), *Rhododendron subgenus Tsutsii spp*. (evergreen azaleas), and Liriope ssp. and or Ophiopogon spp. (Lily-Turf/Mondo Grass) species. The potentially invasive species were identified by NCNLA members and North

Carolina land managers in a prior survey. Plant species identified by other state assessments, such as the Florida protocol (Fox et al. 2005), as damaging invasive species and available in the horticultural industry in North Carolina were also examined using the North Carolina model and included with the survey.

Estimated wholesale value for each species per respondent was calculated based on the midpoint of response ranges. Estimated statewide wholesale value for each species was calculated from mean sales percentages for each species, divided by the total sales captured by the survey ($37,927,250), and multiplied by the wholesale value of the entire nursery industry ($890 million, North Carolina Agricultural Statistics 2008).

RESULTS

Survey response rate. Of the 881 NCNLA members that received the link to the online survey, 30 individuals completed the survey for a response rate of 3.4%. Of the 30 respondents, 29 provided information regarding the total gross value in sales for nursery crops from 2008. Table 3.1 shows the distribution of reported total annual sales for responding NCNLA members compared with the distribution in the 2007 Census of Agriculture (USDA 2009). The survey covered a greater percentage of larger farms compared to smaller producers and included >6% of the 3 largest sales categories. These larger operations may be more stable and account for a greater proportion of the products sold.

Table 3.1. Distribution of reported total annual sales for responding NCNLA members compared with the distribution of the 2007 Census of Agriculture

Reported annual sales*	Respondents	Nursery, greenhouse, floriculture, and sod farms in the 2007 census	Survey coverage of census population
≥ $1 million	10	124	8.1
$500,000 – $999,999	5	80	6.3
$200,000 – $499,000	8	114	7.0
$100,000 – $199,999	2	285	0.7
$40,000 –$99,999	0	158	0.0
$10,000 – $39,999	3	703	0.4
$2,500 – $9,999	1	549	0.2
$1 – $2,499	0	304	0.0

*The sales categories used in the 2009 NCNLA survey and the 2007 Census of Agriculture are similar but not identical.

Current nursery sales. About 80% of responding nurseries indicated that they sell at least one of the 18 potentially invasive species. The percent of respondents who grow each species is shown in Table 3.2, with the total estimated annual sales and estimated mean annual sales attributed to each. *Miscanthus sinensis* (Chinese silvergrass), *Liriope* and/or *Ophiopogon* species, *Buddleja davidii* (Butterfly bush), and *Nandina domestica* (Heavenly bamboo) are some of the most commonly grown taxa among responding nurseries. Estimated mean annual sales of $100,000 or more may be attributed to *Camellia*, *M. sinensis*, and *Liriope* and/or *Ophiopogon* species.

Table 3.2 Number of respondents that sell each species, total estimated annual sales, and estimated mean annual sales attributed to each species for those respondents.

Taxa	Number of respondents who sell species	Estimated total annual sales ($)	Estimated mean annual sales ($)
Albizia julibrissin	3	7,996	2,665
Berberis thunbergii	15	687,093	45,806
Buddleja davidii	16	445,216	29,681
Camellia	14	1,761,470	125,819

Table 3.2 Continued

Celastrus orbiculatus	1	250	250*
Elaeagnus pungens and/or *E. x ebbingei*	8	82,608	10,326
Euonymus alatus	13	222,494	17,115
Evergreen azaleas	14	1,238,313	88,451
Hedera helix	10	339,119	33,912
Ligustrum japonicum	9	622,595	69,177
Ligustrum sinensis	10	372,483	37,248
M*ahonia bealei*	12	503,869	41,989
Miscanthus sinensis	17	1,674,117	98,478
Nandina domestica	16	1,149,080	71,818
Liriope and/or *Ophiopogon*	17	1,756,093	103,300
Pyrus calleryana	7	161,606	23,087
Spiraea japonica and/or *S. x bumalda*	15	583,608	38,907
Ulmus parvifolia	9	568,333	63,148
Vinca minor	12	875,854	72,988
Vitex rotundifolia	1	100,000	100,000*
Wisteria floribunda and/or *W. sinensis*	8	363,998	45,500

*Only one respondent sells this species.

The estimated percentage of total annual sales attributed to each species is shown in Table 3.3. Growers reported that sales of these species account for a wide range of their total annual sales. *Celastrus orbiculatus* (Chinese bittersweet) and *Vitex rotundifolia* (Beach Vitex), two species regulated as noxious weeds in North Carolina, account for a very small percentage, <1%, of total annual sales and were sold by two respondents. Among respondents, the majority of taxa contribute up to 5% of total annual sales. Five growers indicated that the sale of *Miscanthus sinensis, Ligustrum japonicum* (Japanese privet), *Liriope* and/or *Ophiopogon* species, and *Nandina domestica* made up 26 to 50% of total annual sales.

Table 3.3 Number of respondents with reported estimated percentages of total annual sales attributed to each species

Taxa	< 1%	1 – 5%	6 – 10%	11 - 25%	26-50%	Total
Albizia julibrissin	2	1	0	0	0	3
Berberis thunbergii	4	9	0	1	0	14
Buddleja davidii	8	8	0	0	0	16
Camellia	3	8	2	1	0	14
Celastrus orbiculatus	1	0	0	0	0	1
Elaeagnus pungens and/or *E. x ebbingei*	5	3	0	0	0	8
Euonymus alatus	10	2	1	0	0	13
Evergreen azaleas	4	7	2	1	0	14
Hedera helix	7	1	2	0	0	10
Ligustrum japonicum	1	6	1	0	1	9
Ligustrum sinensis	5	4	0	1	0	10
M*ahonia bealei*	7	5	0	0	0	12
Miscanthus sinensis	13	2	0	0	2	17
Nandina domestica	3	10	2	0	1	16
Liriope and/or *Ophiopogon*	4	10	0	2	1	17
Pyrus calleryana	5	2	0	0	0	7
Spiraea japonica and/or *S. x bumalda*	6	8	1	0	0	15
Ulmus parvifolia	2	5	1	1	0	9
Vinca minor	7	3	1	1	0	12
Vitex rotundifolia	1	0	0	0	0	1
Wisteria floribunda and/or *W. sinensis*	6	2	0	0	0	8

Estimated annual statewide wholesale value. The entire survey captured approximately 4.3% ($37,927,250) of the wholesale value of the entire nursery ($890 million) in 2007 (North Carolina Agricultural Statistics 2008). The total state-wide wholesale value for all species included in the survey was estimated at $317 million. The estimated wholesale value of the 18 potentially invasive species was $206 million. Table 3.4 shows the estimated wholesale value and percentage of the total state-wide nursery sales attributed to

each species for North Carolina. Total economic output impact is greatest for *Camellia* and *Liriope* and/or *Ophiopogon* species at about $41 million each. Among potentially invasive species, total economic impact is greatest for *Miscanthus sinensis* (Chinese silvergrass) at $39 million, followed by *Nandina domestica* (Heavenly bamboo) at $27 million and *Vinca minor* (Common periwinkle) at $21 million. Sales of *Albizia julibrissin* (Mimosa), *Celastrus orbiculatus* (Chinese bittersweet), *Elaeagnus pungens* and/or *E. x ebbingei* (Thorny elaeagnus), *Euonymus alatus* (Burning bush), *Pyrus calleryana* (Callery pear), and *Vitex rotundifolia* (Beach vitex) account for less than 1% of total state-wide nursery sales. The combined sales of all 21 species account for about 35.6% of total industry sales in North Carolina, with 23.1% of sales from the 18 potentially invasive species.

Table 3.4 Estimated annual statewide wholesale values attributed to 21 nonnative species, including 18 potentially invasive species, in North Carolina

Taxa	**Estimated state-wide wholesale value ($)**	**Species % of total state-wide nursery sales**
Albizia julibrissin	187,600	<1
Berberis thunbergii	16,123,300	1.8
Buddleja davidii	10,447,400	1.2
Camellia	41,334,600	4.6
Celastrus orbiculatus	5,900	<1
Elaeagnus pungens and/or *E. x ebbingei*	1,938,4500	<1
Euonymus alatus	5,221,000	<1
Evergreen azaleas	29,058,200	3.3
Hedera helix	7,957,800	1.0
Ligustrum japonicum	14,609,800	1.6
Ligustrum sinensis	8,740,700	1.0
M*ahonia bealei*	11,823,800	1.3
Miscanthus sinensis	39,284,800	4.4
Nandina domestica	26,964,300	3.0
Liriope and/or *Ophiopogon*	41,208,400	4.6
Pyrus calleryana	3,792,200	<1

Table 3.4 Continued

Spiraea japonica and/or *S. x bumalda*	13,694,900	1.5
Ulmus parvifolia	13,336,500	1.5
Vinca minor	20,552,800	2.3
Vitex rotundifolia	2,346,600	<1
Wisteria floribunda and/or *W. sinensis*	8,541,600	1.0
Total sales	317,170,800	35.6

DISCUSSION

The 18 potentially invasive ornamental plant species examined in this study have substantial value to the nursery industry in North Carolina. Total statewide sales attributed to these potentially invasive plants are estimated to be about $206 million, or 23.1% of state-wide industry sales. The economic value of these crops should be considered along with the environmental risks of selling these potentially invasive plants in North Carolina.

The data generated by this survey of North Carolina Nursery and Landscape Association (NCNLA) members is being used to evaluate species using the North Carolina Invasive Species Assessment System. The North Carolina protocol incorporates a unique component to address the economic value of potentially invasive plant species and directly includes the economic rating, in the form of negative point values, as a factor in the overall recommendation for a species. With the survey data, the economic benefits of a species can be weighed against the ecological risk of potential invasiveness.

However, the response rate for this survey was lower than expected, and our economic impact values are only a general estimate of the production and percentage of total annual sales attributed to potentially invasive ornamental species. The economic impact of

potentially invasive ornamental plants in North Carolina could be better understood with greater survey response rates and additional economic data.

With a low response rate, there is a risk that the wholesale value associated with each species may be overestimated. While the survey response rate was lower than expected, the survey included a greater percentage of large, high-value producers that may account for a greater proportion of the products sold in the state and enhance the survey coverage.

The survey results, and in turn, the North Carolina Invasive Species Assessment System, could be strengthened with increased responses from NCNLA members. In addition, the geographic distribution of sales across the state was not considered in the survey. As Wirth et al. (2004) demonstrated, the geographic clustering of sales may cause limitations on the sale of certain invasive species to differentially affect regions of North Carolina.

Wirth et al. (2004) indicated that economic impact results may not necessarily translate to economic losses for the nursery industry, since consumers may purchase alternative plants to replace any that may be phased-out. Research regarding the development of sterile cultivars or suitable replacements for especially valuable potentially invasive species would be desirable.

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Chapter 4

Results of the North Carolina Invasive Species Assessment System and Individual Species Evaluations

The potential invasiveness of 25 taxa was assessed using the North Carolina Assessment System for Potentially Invasive Plant Species Sold in the North Carolina Horticultural Trade.

Table 4.1 Highly invasive species and associated assessment point values

Taxa	Total assessment points
Vitex rotundifolia (Beach vitex)	81*
Lonicera japonica (Japanese honeysuckle)	75
Celastrus orbiculatus (Oriental bittersweet)	71

*Environmental impacts associated with this species have been documented in coastal areas of North Carolina.

Three species were categorized as Highly Invasive. These plants are invasive and may not be recommended for horticultural use in North Carolina. As defined by the National Invasive Species Council (2006), the economic or environmental harm or harm to human health attributed to invasive species outweighs any beneficial effects associated with these species. These species present relatively high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. Highly ranked species received an overall score of 67 – 100 points in the North Carolina assessment.

Table 4.2 Moderately weedy species and associated assessment point values.

Taxa	Total assessment points
Ligustrum sinense (Chinese privet)	66
Berberis thunbergii (Japanese barberry)	61
Hedera helix (English ivy)	49
Pyrus calleryana (Callery pear)	43
Mahonia bealei (Leatherleaf mahonia)	42
Euonymus alatus (Burning bush)	41
Wisteria floribunda and/or W. sinensis (Japanese and/or Chinese wisteria)	37
Nandina domestica (Nandina, Heavenly bamboo)	35
Ligustrum japonicum (Japanese privet)	34

Nine species were categorized as Moderately Weedy. According to the Assessment results, these species are not considered by definition to be invasive, since the economic or environmental harm associated with these species has not been shown to outweigh any beneficial effects associated with these plants. Moderately weedy species have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. Moderately weedy plants may be recommended for horticultural use with specific guidance. These plants should not be grown in close proximity to natural areas that have communities similar to those where this plant has been found to naturalize or near natural areas that have sensitive or threatened plants and/or natural communities. In areas where these species have been found to be problematic, alternative plants may be recommended. Moderately ranked species received an overall score of 34 - 66 points in the North Carolina assessment.

Table 4.3 Noninvasive species and associated assessment point values.

Taxa	Total assessment points
Elaeagnus pungens Thunb. and *Elaeagnus x ebbingei* (Thorny elaeagnus)	33
Spiraea japonica and/or *S. x bumalda* (Japanese spiraea)	33
Albizia julibrissin (Mimosa)	31
Ulmus parvifolia (Chinese elm, Lacebark elm)	31
Buddleja davidii (Butterfly-bush)	26
Vinca minor (Common periwinkle)	26
Miscanthus sinensis (Chinese silvergrass)	18
Magnolia stellata Maxim. (Star magnolia)	12
Ginkgo biloba L. (Ginkgo, Maidenhair tree)	4
Styrax japonicus Siebold and Zucc. (Japanese snowbell)	4
Camellia japonica L. (Camellia)	-1
Evergreen azaleas	-2
Ophiopogon japonicus Ker-Gawl. and *Liriope* species (Mondo grass, lily turf, liriope)	-5

Thirteen species were categorized as Noninvasive. These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. Some species, such as *B. davidii*, may exhibit environmental impacts in other parts of the U.S., but they have not been shown to negatively affect natural areas in North Carolina. Low ranked species received an overall score of 0 – 33 in the North Carolina assessment. Negative point values are associated with noninvasive species with extremely high economic value in North Carolina.

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Table 4.4 Species Dataform and Scoresheet for *Albizia julibrissin* Durazzini (Mimosa, Silktree).

Species Dataform and Scoresheet		
***Albizia julibrissin* Durazzini (Mimosa, silktree)**		
Native range: Asia Date evaluated: March 17, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Appears on several invasive species lists (not laws) in the Southeastern U.S., including Georgia (Top ten listed), South Carolina (Significant threat), Florida (General list), and Tennessee (Rank 1, Severe threat), Kentucky (Significant threat), Virginia (Medium invasiveness), and the National Forest Service (Category 1, species known to be invasive and persistent) (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments:		
3. North Carolina nativity	Y/N	N
Comments: Native to tropical Asia (Weakley 2008)		
4. Presence in natural areas	Y/N	Y
Comments: Found in disturbed areas and suburban woodlots(Weakley 2008). Naturalized along road-sides throughout southeastern United States (Pitman 2008). Generally not found in natural areas.		
5. Non-invasive cultivars	Y/N	N
Comments:		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: No known impacts on abiotic ecosystem processes.		
1b. Impact on plant community structure	20	5
Comments: Generally a pioneer species that is intolerant of shade (Pagad 2005). Dense stands of mimosa, usually along roads or disturbed areas, can significantly reduce sunlight and available nutrients for native plants (Demers et al. 2008). Mimosa can become a serious competitor along riparian areas where seeds are easily transported (Pagad 2005).		
1c. Impact on species of special concern	5	0
Comments: Strong competitor to native trees and shrubs (Demers et al. 2008), but impacts on species of special concern are unknown.		
1d. Impact on higher trophic levels	5	0
Comments: No known impacts on higher trophic levels.		
Section 1. Subrank	***40***	***5***

Table 4.4 Continued

Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	1
Comments: "Becoming a serious weed" (Weakley 2008).		
2b. Long-distance dispersal potential	13	8
Comments: Seed spread from nearby ornamental plantings allows for vigorous establishment in other areas (Demers et al. 2008). Seeds may be spread by water or wildlife that ingest the seeds (IFAS 2008). Fruits are flat and in pods. Problematic along waterways where seeds easily transported by water (IFAS 2008).		
2c. Reproductive characteristics	8	6
Comments: Reproduces both vegetatively and by seed (Demers et al. 2008). Germination is limited by hardseededness, but no additional dormancy factors are involved (Pitman 2008). Re-sprouts quickly if damaged, cut, or top-killed (Demers et al. 2008). Produces large seed crops (Demers et al. 2008). Produces root suckers (Demers et al. 2008). Seeds may be spread by water or wildlife that ingest the seeds (IFAS 2008).		
2d. Range of communities	6	0
Comments: Shade intolerant and seldom found in forests with full canopy cover (Pagad 2005).		
2e. Similar habitats invaded elsewhere	6	0
Comments:		
Section 2. Subrank	***40***	***15***
Section 3. Management Difficulty		
3a. Herbicidal control	5	3
Comments: Herbicides available for mimosa control include Garlon 4, Garlon 3A, Accord, and Transline (Demers et al. 2008). Chemical treatments are most effective if applied when seeds are present on the tree (Demers et al. 2008).		
3b. Nonchemical control methods	2	2
Comments: Plants resprout quickly if damaged, cut, or top-killed (Demers et al. 2008). Chemical treatments are necessary for full control (Demers et al. 2008). No known biological control agents (IFAS 2008).		
3c. Necessity of individual treatments	2	2
Comments: The majority of effective treatment methods using herbicides include basal-bark, cut stem, hack-n-squirt, and stem injections, but foliar applications are also effective (Demers et al. 2008).		
3d. Average distribution	2	1
Comments: Mimosa is a small to medium sized tree that may form dense stands (Demers et al. 2008).		
3e. Likelihood for reestablishment	2	2
Comments: Plants resprout quickly if cut and may grow up to 3 feet in a single growing season (Demers et al. 2008). Seeds may remain dormant for many years (IFAS 2008).		

Table 4.4 Continued

3f. Accessibility of invaded areas	2	1
Comments: Often found along streamside and riparian areas (Pagad 2005) which may be difficult to reach.		
3g. Impact on native species and environment	5	2
Comments: Herbicides may damage or kill nontarget plants.		
Section 3. Subrank	***20***	***13***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-1
Comments: The annual estimated wholesale value attributed to this species is $187,600 (Trueblood 2009).		
4b. Percentage of total sales	-5	-1
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 1-5% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-2***
Overall Score	**100**	**31**
Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)		
Summary: *Albizia julibrissin* (Mimosa) is noninvasive in North Carolina and may be recommended for horticultural use by the North Carolina Nursery and Landscape Association. Mimosa rarely invades natural areas. This species is shade intolerant and naturalizes primarily along roadsides and other disturbed areas. Mimosa has minimal ecological impacts in natural areas. Seeds may be spread from ornamental plantings. The difficulty of managing mimosa is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of mimosa. This species has low economic value to the nursery industry.		

Table 4.4 Continued

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Table 4.5 Species Dataform and Scoresheet for *Berberis thunbergii* DC. (Japanese barberry).

Species Dataform and Scoresheet		
***Berberis thunbergii* DC. (Japanese barberry)**		
Native range: Japan Date evaluated: May 28, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Sale of prohibited in Massachusetts and New Hampshire (Lubell et al. 2008). Appears on several invasive species lists (not laws) in the Southeastern U.S., including Tennessee (Rank 2, Significant threat), Kentucky (Rank b, Significant threat), Virginia (Rank b, Medium invasiveness), and the National Forest Service (Category 1, species known to be invasive and persistent) (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
3. North Carolina nativity	Y/N	N
Comments: Native to Japan (Weakley 2008)		
4. Presence in natural areas	Y/N	Y
Comments: Japanese barberry infestations may occur in undisturbed closed-canopy forests (Ehrenfeld 1997).		
5. Non-invasive cultivars	Y/N	N
Comments: Some ornamental Japanese barberry genotypes have reduced fruit and seed production and limited fecundity (Lubell et al. 2008). Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	4
Comments: Alters soil chemistry (raises soil pH and nitrification) and microbial communities of deciduous forests in New Jersey (Ehrenfeld et al. 2001). Impacts soil ecosystem, nitrogen cycling, soil biota, soil structure, and function (Kourtev 2002). Reduces litter layer (Kourtev 2002).		
1b. Impact on plant community structure and composition	20	15
Comments: Japanese barberry may limit tree regeneration and herbaceous plants in the forest understory (Ward et al. 2009). *Berberis thunbergii* has the ability to outcompete native species in the understory (Xu et al. 2007). Biomass of co-occurring species is suppressed by Japanese barberry (Silander and Klepeis 1999).		
1c. Impact on species of special concern	5	2

Table 4.5 Continued

Comments: May displace native flora (Lubell et al. 2008). In eastern deciduous forests, Japanese barberry has replaced the native blueberries (*Vaccinium* spp.) normally found in the forest understory (Kourtev 2002). In North Carolina, *Vaccinium macrocarpon* (Cranberry) and *V. virgatum* (Small-flower blueberry) are significantly rare (Franklin 2004).		
1d. Impact on higher trophic levels	5	3
Comments: Impacts earth worm populations (Ehrenfeld at al. 2001). Barberry-infested forests have especially high populations of blacklegged ticks (*Ixodes scapularis*) that are the major vectors for several diseases, including Lyme disease (Ward et al. 2009).		
Section 1. Subrank	***40***	***24***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	4
Comments: Found in mountains, piedmont and coastal plain of NC (Weakley 2008). In New England, there has been a slow increase in the frequency with which Japanese barberry has been observed in mature forest (Ehrenfeld 1997).		
2b. Long-distance dispersal potential	13	13
Comments: Japanese barberry produces large numbers of bird dispersed fruits that allow the plant to effectively spread across the landscape (Silander and Klepeis 1999). Seed contained within berries spread by birds and small rodents (Lubell et al. 2008). Japanese barberry infestations may occur in areas distant from disturbed or open areas, sometimes up to 100 m into undisturbed forest (Ehrenfeld 1997). Songbirds, white-tail deer (*Odocoileus virginianus*), wild turkeys (*Meleagris gallopavo*) and grouse (*Bonasa ubmellus*) may utilize and distribute the berries (Ehrenfeld 1997).		
2c. Reproductive characteristics	8	6
Comments: Plants thrive under a variety of light and soil moisture conditions and reproduce readily from seed (Silander and Klepeis 1999). Produces large number of seeds that have a high germination rate (Swearingen 2005). Branches that are in contact with the ground root freely at nodes and facilitate vegetative spread (Swearingen 2005). Root fragments regenerate to form new plants (Swearingen 2005).		
2d. Range of communities	6	4 (Unknown)
Comments: Rich forests, old fields in North Carolina, uncommon (Weakley 2008).		
2e. Similar habitats invaded elsewhere	6	4
Comments: Forms dense stands in canopy forests, open woodlands, wetlands, pastures, and meadows in New England and northern states in the Southeast U.S. (Swearingen 2005). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests, low elevation dry and dry-mesic forest and woodlands		
Section 2. Subrank	***40***	***31***
Section 3. Management Difficulty		
3a. Herbicidal control	5	3

Table 4.5 Continued

Comments: Herbicides, including glyphosate and triclopyr, applied mid-to-late season following an initial pre or early-season mechanical (cutting), prescribed fire, or directed flame treatment provide effective control in a single growing season (Ward et al. 2009). Glyphosate applied in early spring at first leaf-out is an effective chemical control option (Silander and Klepeis 1999).		
3b. Nonchemical control methods	2	2
Comments: Manual control methods must be combined with herbicide applications in moderate to heavy infestations (Swearingen 2005). Initial pre- or early-season mechanical (cutting), prescribed fire, or directed flame treatments applied prior to herbicide treatments of glyphosate or triclopyr provide effective control of dense infestations (Ward et al. 2009). In dense infestations where Japanese barberry plants are waist high or taller, medium (drum chopper) or heavy (bulldozer) equipment is necessary (Ward et al. 2009). However, medium and heavy equipment may be limited by terrain, forest density, and operator experience (Ward et al. 2009). No biological control organisms are available (Swearingen 2005).		
3c. Necessity of individual treatments	2	2
Comments: Root wrenching and herbicide applications to cut stems are effective, but labor intensive (Ward et al. 2009).		
3d. Average distribution	2	1
Comments: Dense stands may form in the forest understory (Ward et al. 2009). Distribution patters may be sparse, moderate, or dense populations (Ehrenfeld 1997).		
3e. Likelihood of reestablishment	2	2
Comments: Seed spread by birds and small rodents (Lubell et al. 2008) and may be reintroduced to treated area. Nearly all Barberry clumps treated once with mechanical control methods or prescribed fire had new sprouts by the end of the growing season (Ward et al. 2009).		
3f. Accessibility of invaded areas	2	1
Comments: Japanese barberry is capable of invading closed canopy forests (Ehrenfeld 1997). Extensive patches of Japanese barberry have been documented to exist within the forest interior in protected forest areas in New York (Ehrenfeld 1997).		
3g. Impact on native species and environment	5	2
Comments: The nonselective herbicides glyphosate and triclopyr must be applied carefully to individual plants to avoid impacting non-target native plants (Swearingen 2005).		
Section 3. Subrank	***20***	***13***
Section 4. Economic Value		
4a. Estimated wholesale value in North Carolina	-7	-4
Comments: The estimated wholesale value attributed to Japanese barberry in North Carolina is $16,123,300 (Trueblood 2009).		
4b. Percentage of total sales	-5	-3

Table 4.5 Continued

Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be: 11-25% (Trueblood 2009).		
4c. Ecosystem services	-1	0
4d. Wildlife habitat	-1	0
4e. Cultural and social benefits	-1	0
Section 4. Subrank	***-15***	***-7***
Overall Score	**100**	**61**
Overall Recommendation: Moderately weedy and recommended for use with specific guidance – These species have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. These plants should not be grown in close proximity to natural areas that have communities similar to those where this plant has been found to naturalize or near natural areas that have sensitive or threatened plants and/or natural communities. (Overall Score: 34 – 66)		
Summary: *Berberis thunbergii* (Japanese barberry) is moderately weedy and recommended for horticultural use in North Carolina with specific guidance. Japanese barberry may suppress herbaceous plants in the forest understory and outcompete native species. Japanese barberry has high long-distance dispersal potential and may invade additional natural areas. The difficulty of managing Japanese barberry is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of this species. Japanese barberry is economically valuable to the nursery industry. Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications. Use of seedless cultivars would be desirable when they become available.		

Table 4.5 Continued

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Table 4.6 Species Dataform and Scoresheet for *Buddleja davidii* Franch. (syn. *Buddleia davidii*) Butterfly-bush

Species Dataform and Scoresheet		
***Buddleja davidii* Franch. (syn. Buddleia davidii) Butterfly-bush**		
Native range: China Date evaluated: March 19, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Appears on invasive species or noxious weed lists in the Pacific Northwest (Tallent-Halsell and Watt 2009). *Buddleja davidii* is listed as a class "B" noxious weed by the Oregon Department of Agriculture and the Washington State Noxious Weed Control Board (Tallent-Halsell and Watt 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Grown for ornamental properties and ability to attract butterflies (Weakley 2008).		
3. North Carolina nativity	Y/N	N
Comments: Native to China (Weakley 2008).		
4. Presence in natural areas	Y/N	Y
Comments: Readily establishes in disturbed sites (Tallent-Halsell and Watt 2009). Weedy in a variety of habitats including coastal forest edges, stream and river banks (USDA Forest Service 2005) and disturbed places (Weakley 2008). Colonizes disturbed sites along roads, river banks, and railways (Ebeling et al. 2008). Invasive along roadsides, abandoned railroads, rural dumps (USDA Forest Service 2005). Problematic in riparian areas in Oregon and Washington (Tallent-Halsell and Watt 2009). Generally not found in natural areas in North Carolina.		
5. Non-invasive cultivars	Y/N	N
Comments:		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	5
Comments: *Buddleja davidii* impacts soil nutrients by accumulating P, N, and organic matter, but the long-term effects of these alterations on successional trajectories are unknown (Bellingham et al. 2005). *Buddleja davidii* appears to be a better competitor for limited resources early in primary succession but is eventually replaced by native shrubs (Bellingham et al. 2005).		
1b. Impact on plant community structure	20	0

Table 4.6 Continued

Comments: Dense infestations may compete with native species, especially along streams and river banks (Brunel 2006). Monospecific stands may restrict access to waterways (Brunel 2006). Thrives in nutrient poor soils and quickly grows into dense thickets (Thomas et al. 2008). Grows rapidly to suppress and displace native pioneer plants (Anisko and Im 2001). Most dense infestations observed within first ten years of colonization, since plants have a fairly short lifespan (Brunel 2006). Primarily a shade intolerant pioneer species that is mostly found along roadsides, railroad tracks, and other disturbed sites. Over time, *Buddleja* is typically outcompeted through natural succession.		
1c. Impact on species of special concern	5	0
Comments: Unknown impacts on species of special concern.		
1d. Impact on higher trophic levels	5	0
Comments: Unknown impacts on higher trophic levels.		
Section 1. Subrank	***40***	***5***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	0
Comments:		
2b. Long-distance dispersal potential	13	8
Comments: Wind-dispersed seeds (Bellingham et al. 2005). Seeds are small and long-winged and dispersed by wind and water (Ebeling et al. 2008).		
2c. Reproductive characteristics	8	6
Comments: *Buddleja davidii* produces a very large number of seeds, and a single plant can produce up to several million seeds (Ebeling et al. 2008). Seeds are wind and water dispersed (Ebeling et al. 2008). Resprouts vigorously after damage (Ebeling et al. 2008). Seeds germinate readily at high rates (Ebeling et al. 2008). Basal and stem sprouts allow the shrub to recover after the original stems have been damaged (Anisko and Im 2001). Propagated by cuttings or by seed (Starr et al. 2003). Seedlings have superficial roots and are easily carried away in floods (Brunel 2006). Propagated along rivers by stem cuttings (Brunel 2006).		
2d. Range of communities	6	2
Comments: Thrives in fairly dry conditions (USDA Forest Service 2005). Roots may perish in wet soil (USDA Forest Service 2005). Invasive in a variety of habitats including coastal forest edges, stream and river banks (USDA Forest Service 2005). Natural communities of North Carolina (Shafale and Weakley 1990) = river floodplains.		
2e. Similar habitats invaded elsewhere	6	0
Comments:		
Section 2. Subrank	***40***	***16***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0

Table 4.6 Continued

Comments: Plants should be cut and treated with glyphosate or triclopyr (USDA Forest Service 2005).		
3b. Nonchemical control methods	2	2
Comments: Small seedlings may be hand-picked (USDA Forest Service 2005). Goats eat this plant and can treat infested areas over 3-4 year time span (USDA Forest Service 2005). Cut plants will resprout (Starr et al. 2005). Hand-picking seedlings may result in increased soil disturbance and facilitate recolonization, so disturbance at invaded sites should be minimized (Starr et al. 2005). Biological control options are being explored in New Zealand (Starr et al. 2005).		
3c. Necessity of individual treatments	2	2
Comments: Herbicides should be applied to cut stems (USDA Forest Service 2005). Herbicides must be applied repeatedly to individual stems (Tallent-Halsell and Watt 2009).		
3d. Average distribution	2	1
Comments: May form dense infestations and monospecific stands (Brunel 2006).		
3e. Likelihood for reestablishment	2	2
Comments: Easily recovers after damage (Thomas et al. 2008). Cut plants will resprout (Starr et al. 2003). Seeds remain dormant in soil for many years (Washington State Noxious Weed Control Board). *Buddleja davidii* can regenerate and spread from buried stems, stumps, and cut debris, following removal attempts (Tallent-Halsell and Watt 2009).		
3f. Accessibility of invaded areas	2	1
Comments: Often colonizes river and stream banks (Brunel 2006) that may be difficult to access.		
3g. Impact on native species and environment	5	2
Comments: The nonselective herbicides glyphosate and triclopyr may impact non-target species. Grazing is also a nonselective treatment.		
Section 3. Subrank	***20***	***10***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-4
Comments: The annual estimated wholesale value attributed to this species is $10,447,400 (Trueblood 2009).		
4b. Percentage of total sales	-5	-1
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 1-5% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-5***

Table 4.6 Continued

Overall Score	**100**	**26**
Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)		
Summary: *Buddleja davidii* (Butterfly-bush) is noninvasive in North Carolina and may be recommended for horticultural use by the North Carolina Nursery and Landscape Association. *Buddleja davidii* is a shade intolerant pioneer species that may be eliminated through natural plant succession. *Buddleja davidii* readily colonizes disturbed areas, and it is rarely found in natural areas. While environmental impacts associated with *Buddleja davidii* have been documented in the Pacific Northwest, *B. davidii* has not been shown to have negative ecological impacts in natural areas in North Carolina. *Buddleja davidii* is economically valuable to the nursery industry in North Carolina.		
References:		

Anisko, T. and U. Im. (2001) Beware of Butterfly bush. American Nurseryman 194: 46-50.

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Ebeling, S.K., Hensen, I., and H. Auge. (2008) The invasive shrub *Buddleja davidii* performs better in its introduced range. Diversity and Distributions 14: 225-233.

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Table 4.6 Continued

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USDA Forest Service. (2005) Weed of the Week: Butterfly Bush. WOW 09-27-05. Newton Square, PA (http://www.na.fs.fed.us/fhp/invasive_plants/weeds/butterfly_bush.pdf) Accessed: March 19, 2009.

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Table 4.7 Species Dataform and Scoresheet for *Camellia japonica* L. (Camellia)

Species Dataform and Scoresheet		
***Camellia japonica* L. (Camellia)**		
Native range: China and Japan Date evaluated: March 9, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments:		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Frequently cultivated and popular ornamental plant.		
3. North Carolina nativity	Y/N	N
Comments: Native to China and Japan (Weakley 2008).		
4. Presence in natural areas	Y/N	N
Comments: Sometimes persistent around old home sites (Weakley 2008).		
5. Non-invasive cultivars	Y/N	Y
Comments: Assessment indicates that *C. japonica* is noninvasive in North Carolina.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: No known abiotic ecosystem impacts.		
1b. Impact on plant community structure	20	5
Comments: Successful understory plants in deciduous forests (Reiley, 2001). *Camellia japonica* is slow-growing, but in grouped plantings, they create an effective screen (Gilman, 1999).		
1c. Impact on species of special concern	5	0
Comments: No known impact on species of special concern or threatened or endangered plants.		
1d. Impact on higher trophic levels	5	0
Comments: No known impact on higher trophic levels.		
Section 1. Subrank	***40***	***5***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	0
Comments: No known expansion into natural areas.		
2b. Long-distance dispersal potential	13	0
Comments: This species is not dispersed naturally long distances.		
2c. Reproductive characteristics	8	2

Table 4.7 Continued

Comments: Fruits are dry and hard, not fleshy (Gilman 1999). Propagation is by seed or cuttings (Gilman 1999).		
2d. Range of communities	6	0
Comments: May be planted nearly throughout North Carolina (Gilman 1999).		
2e. Similar habitats invaded elsewhere	6	0
Comments: Sensitivity to frost and freezing restricts the range of Camellia species to the Southeast and the Pacific Coast (Reiley 2001).		
Section 2. Subrank	***40***	***2***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: Herbicides will damage *C. japonica*, especially if applied to the leaves (Reiley 2001)		
3b. Nonchemical control methods	2	0
Comments: Digging around Camellia species will damage shallow root systems (Reiley 2001)		
3c. Necessity of individual treatments	2	2
Comments: Large shrubs or small trees (Reiley 2001) would require individual treatments.		
3d. Average distribution	2	0
Comments:		
3e. Likelihood for reestablishment	2	0
Comments:		
3f. Accessibility of invaded areas	2	0
Comments: Not know to invade natural areas.		
3g. Impact on native species and environment	5	0
Comments:		
Section 3. Subrank	***20***	***2***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-7
Comments: The estimated wholesale value of Camellia species to the North Carolina nursery industry is > $40 million (Trueblood 2009).		
4b. Percentage of total sales	-5	-3
Comments: Among producers that sell Camellia species, the highest percentage of total sales attributed to this species from any one grower in the state is estimated to be 11-25% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0

Table 4.7 Continued

Comments:		
Section 4. Subrank	***-15***	***-10***
Overall Score	**100**	**-1**
Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)		
Summary: *Camellia japonica* (Camellia) is noninvasive in North Carolina and may be recommended for horticultural use by the North Carolina Nursery and Landscape Association. Camellia species are not known to invade natural areas in North Carolina. They have little to no negative ecosystem impacts, low potential for long-distance dispersal, and may be easily removed from the landscape. Camellia species have extremely high economic value for the nursery industry in North Carolina.		
References: Gilman, E.F. (1999) Camellia japonica Fact Sheet FPS-97. Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Science, University of Florida. (http://hort.ufl.edu/shrubs/CAMJAPA.PDF) Accessed: March 9, 2009. Reiley, H. E. (2001) Azaleas, Camellias, and Rhododendrons. Des Moines, IA: The Scotts Company. Trueblood, C.E. (2009) Chapter 3. An estimate of the commercial value of potentially invasive ornamental nursery crops grown in North Carolina. In An Invasive Species Assessment System for the North Carolina Horticultural Industry, a thesis submitted to the Graduate Faculty of North Carolina State University. North Carolina State University, Raleigh, NC. Weakley, A.S. "Flora of the Carolinas, Virginia, Georgia, northern Florida, and surrounding areas." University of North Carolina. Working draft. 7 April 2008.		

Table 4.8 Species Dataform and Scoresheet for *Celastrus orbiculatus* Thunb. (Oriental bittersweet)

Species Dataform and Scoresheet		
***Celastrus orbiculatus* Thunb. (Oriental bittersweet)**		
Native range: Eastern Asia Date evaluated: November 4, 2008		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	Y
Comments: "Class C" State Noxious Weed (NCDA).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Grown and sold in Western North Carolina.		
3. North Carolina nativity	Y/N	N
Comments: Native to temperate eastern Asia (Dreyer 1987).		
4. Presence in natural areas	Y/N	Y
Comments: Oriental bittersweet is most prevalent in disturbed gap and edge environments, but may invade and colonize relatively undisturbed forests (Ellsworth 2004, Patterson 1973)		
5. Non-invasive cultivars	Y/N	N
Comments:		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	4
Comments: Light availability is the major abiotic condition impacted by oriental bittersweet. Overgrowth of vines may reduce light availability and shade young seedlings (McNab 1987). Dense stands of oriental bittersweet reduce light intensity, alter light quality, and may exclude other plants (Patterson 1973). Oriental bittersweet has little to no effect on soil moisture and soil minerals and does not produce toxic or inhibitory substances (Patterson 1973). It is possible that vines may act as a ladder fuel that may enhance canopy burn (USDA Forest Service 2006).		
1b. Impact on plant community structure	20	20
Comments: Dense uncontrolled infestations of oriental bittersweet could cause severe forest degradation (Ellsworth et al. 2004). Vines may overtop native vegetation, girdle and damage trees and stems, suppress the regeneration of native vegetation, shade existing vegetation, and add additional weight to trees, making them more susceptible to mechanical breakage and ice damage (Ellsworth 2004).		
1c. Impact on species of special concern	5	5

Table 4.8 Continued

Comments: Oriental bittersweet has a wider range of ecological tolerances (Leicht-Young et al. 2007) than the native American bittersweet (*Celastrus scandens*). American bittersweet is not listed as a threatened or endangered species in North Carolina, but it is categorized in NC as a significantly rare species (NC Natural Heritage Program 2004).		
1d. Impact on higher trophic levels	5	0
Comments: Oriental bittersweet is not known to impact other animals.		
Section 1. Subrank	***40***	***29***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	4
Comments: Oriental bittersweet is expanding its range across North Carolina, but at lower rate of expansion compared with other known invasive plants, such as Japanese honeysuckle (Merriam 2003). The rate of spread across the state is approximately a 3 percent increase in the number of counties reporting occurrences per year (Merriam 2003). Oriental bittersweet has been shown to be increasing in range in other parts of the United States as well, particularly in the Northeastern US, due to its ability to colonize a wide range of environments (Leicht-Young 2007).		
2b. Long-distance dispersal potential	13	13
Comments: Seeds are dispersed by birds and mammals throughout the fall, winter, and early spring (Ellsworth et al. 2004).		
2c. Reproductive characteristics	8	6
Comments: Seeds are able to germinate in a range of light conditions, including partial and dense shade (Patterson 1974). Orange arillate fruits are dispersed by birds (Patterson 1974). This species exhibits rapid growth rates in both full and partial sun (Dreyer 1987). Rootsuckers proliferate rapidly under a range of conditions (Dryer 1987).		
2d. Range of communities	6	4
Comments: Thickets, roadsides, forests, alluvial woods (Weakley 2008). NC Primary Systems (Shafale and Weakley 1990) = Low elevation mesic forests, river floodplains		
2e. Similar habitats invaded elsewhere	6	4
Comments: Beaches are also susceptible to invasion (NatureServe Explorer), including coastal areas and salt marsh edges (Plant Conservation Alliance). Upland meadows and cove hardwood stands may also be susceptible to invasion (NatureServe Explorer).		
Section 2. Subrank	***40***	***31***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: Cut stem applications of glyphosate and triclopyr are effective (McNab 2002).		
3b. Nonchemical control methods	2	2
Comments: Hand pulling and clipping are effective, but hand-pulled sprouts often break and resprout later (McNab 2002).		

Table 4.8 Continued

3c. Necessity of individual treatments	2	2
Comments: Cut-stem application of herbicide effective (Webster, 2007). Oriental bittersweet is often mistaken for American bittersweet (*C. scandens*), a rare native vine, and herbicides may affect nontarget vegetation (McNab 2002).		
3d. Average distribution	2	1
Comments: There is often variability in the distribution of this species.		
3e. Likelihood for reestablishment	2	2
Comments: Hand-pulled sprouts often break and resprout later. Great amount of seed produced, dispersed by birds, mammals, and humans (Dreyer 1987). Difficult to manage in forests that are subject to frequent natural or managed disturbance that may open the forest canopy and allow frequent growth of seedlings (McNab 2002). Persistent vegetative structures proliferate rapidly under wide variety of conditions (Dreyer 1987). Seeds remain viable for several years and management techniques must be continued for several years (SE-EPPC)		
3f. Accessibility of invaded areas	2	0
Comments: Invaded areas are primarily along forest margins.		
3g. Impact on native species and environment	5	5
Comments: Oriental bittersweet is often mistaken for *C. scandens* (American bittersweet), a rare native vine, and herbicides may affect nontarget vegetation (Mc Nab 2002, Dreyer 1987).		
Section 3. Subrank	***20***	***12***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	0
Comments: The estimated wholesale value for the North Carolina nursery industry is approximately $5,900 (Trueblood 2009).		
4b. Percentage of total sales	-5	0
Comments: Among producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be <1% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	-1
Comments: Collected and sold in western NC crafts trade.		
Section 4. Subrank	***-15***	***-1***
Overall Score	**100**	**71**

Table 4.8 Continued

Overall Recommendation: Highly invasive and not recommended for horticultural use – These species present relatively high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. (Overall Score: 67 – 100)
Summary: *Celastrus orbiculatus* (Oriental bittersweet) is highly invasive in North Carolina and may not be recommended for horticultural use by the North Carolina Nursery and Landscape Association. Oriental bittersweet severely impacts plant community structure by displacing and outcompeting native vegetation. There is great potential for the additional invasion of oriental bittersweet within natural areas. The difficulty of managing Oriental bittersweet is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of oriental bittersweet. Oriental bittersweet has low economic value to the nursery industry, but it does have unique cultural and social benefits in western North Carolina.
References:

Dreyer, G.D. (2003) Element Stewardship Abstract for *Celastrus orbiculata*. The Nature Conservancy. Arlington, Virginia.

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Leicht-Young, S.A., Silander, J.A., and A.M. Latimer. 2007. Comparative performance of invasive and native *Celastrus* species across environmental gradients. Oecologia 154: 273-282.

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Table 4.8 Continued

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Weakley, A.S. "Flora of the Carolinas, Virginia, Georgia, northern Florida, and surrounding areas." University of North Carolina. Working draft. 7 April 2008.

Table 4.9 Species Dataform and Scoresheet for *Elaeagnus pungens* Thunb. and *Elaeagnus x ebbingei* (Thorny elaeagnus)

Species Dataform and Scoresheet		
***Elaeagnus pungens* Thunb. and *Elaeagnus x ebbingei* (Thorny elaeagnus)**		
Native range: Japan Date evaluated: March 19, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Appears on several invasive species lists (not laws) in the Southeastern U.S., including South Carolina (Rank a, Significant threat), Florida (Category II,, increased frequency but not altering plant community), and Tennessee (Rank 1, Severe threat), Virginia (Rank c, Low invasiveness), and the National Forest Service (Category 2, species suspected to be invasive) (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Used as a landscape plant, often grown as an evergreen hedge and barrier (IFAS 2008).		
3. North Carolina nativity	Y/N	N
Comments: Native to Japan (Weakley 2008).		
4. Presence in natural areas	Y/N	Y
Comments: Forests and woodlands in suburban areas (Weakley 2008). Invades natural areas throughout the southeastern United States (Invasive.org 2009). May move into natural areas and outcompete native plants for light (Walther 2005).		
5. Non-invasive cultivars	Y/N	Y
Comments: Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: Not known to impact ecosystem processes.		
1b. Impact on plant community structure	20	5
Comments: Has potential to displace native species and change community structure by growing over and shading out other plants (IFAS 2008). May move into natural areas and outcompete native plants for light (Walther 2005).		
1c. Impact on species of special concern	5	0
Comments: No known impacts on species of special concern.		
1d. Impact on higher trophic levels	5	0
Comments: No known impacts on higher trophic levels.		
Section 1. Subrank	***40***	***5***

Table 4. 9 Continued

Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	0
Comments:		
2b. Long-distance dispersal potential	13	13
Comments: Fruits are round drupes (IFAS 2008) spread by birds (Weakley 2008). Seeds dispersed by birds and animals long distances into forests (Miller 2003).		
2c. Reproductive characteristics	8	6
Comments: Fast growing, able to thrive in a variety of environmental conditions (IFAS 2008). Reproduction by seed and stem sprouts (IFAS 2008).		
2d. Range of communities	6	4
Comments: Can tolerate a variety of environmental conditions, including shade, drought, and salt (IFAS 2008).		
2e. Similar habitats invaded elsewhere	6	0
Comments:		
Section 2. Subrank	***40***	***23***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: Chemical treatment options include glyphosate and triclopyr (IFAS 2008). Can be controlled with herbicides (Walther 2005).		
3b. Nonchemical control methods	2	1
Comments: Aggressive tillage or mowing are nonchemical control options (IFAS 2008). No known biological control agents (IFAS 2008).		
3c. Necessity of individual treatments	2	2
Comments: Large stems may require cut-stem applications of herbicides (IFAS 2008).		
3d. Average distribution	2	2
Comments: Primarily a shrub but may also take on a climbing growth form (IFAS 2008). Often found as escaped single plants or scattered individuals both in open and under forest shade (Miller 2003).		
3e. Likelihood for reestablishment	2	1
Comments: Spread by birds (Weakley 2008), which may facilitate reestablishment in treated areas.		
3f. Accessibility of invaded areas	2	1
Comments: Often found as escaped single plants or scattered individuals both in open and under forest shade (Miller 2003).		
3g. Impact on native species and environment	5	2
Comments: Nontarget plants may be killed or injured by root uptake of herbicides (Miller 2003).		
Section 3. Subrank	***20***	***9***

Table 4.9 Continued

Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-2
Comments: The annual estimated wholesale value attributed to this species is $1,938,4500 (Trueblood 2009).		
4b. Percentage of total sales	-5	-1
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 1-5% (Trueblood 2009).		
4d. Ecosystem services	-1	-1
Comments: Salt tolerant and used for erosion control in coastal areas.		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-4***
Overall Score	**100**	**33**
Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)		
Summary: *Elaeagnus pungens* Thunb. and closely related *Elaeagnus x ebbingei* (Thorny elaeagnus) is noninvasive in North Carolina and may be recommended for horticultural use by the North Carolina Nursery and Landscape Association. The potential ecological impacts associated with thorny elaeagnus are largely unknown, and additional information is required to complete a more conclusive assessment of this species. There is potential for the natural dispersion of thorny elaeagnus. The difficulty of managing thorny elaeagnus is low to moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of this species. Thorny elaeagnus is economically valuable to the nursery industry. Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications. Use of seedless cultivars would be desirable when they become available.		

Table 4.9 Continued

References:

Invasive.org: Center for Invasive Species and Ecosystem Health (2009) *Elaeagnus pungens* Thunb. (Thorny olive) The University of Georgia

Invasive.org: The Bugwood Network, USDA Forest Service, and USDA APHIS PPQ. (2009a) Invasive Plants of the Thirteen Southern States. (http://www.invasive.org/south/seweeds.cfm) Accessed: March 24, 2009.

Miller, J.H. (2003) Nonnative invasive plants of southern forests: a field guide for identification and control. Gen. Tech. Rep. SRS-62. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 93 p

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Weakley, A.S. "Flora of the Carolinas, Virginia, Georgia, northern Florida, and surrounding areas." University of North Carolina. Working draft. 7 April 2008.

Table 4.10 Species Dataform and Scoresheet for *Euonymus alatus* Thunb. (Burning bush, Winged euonymus)

Species Dataform and Scoresheet		
***Euonymus alatus* Thunb. (Burning bush, winged euonymus)**		
Native range: Eastern Asia Date evaluated: March 24, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Appears on several invasive species lists (not laws) in the Southeastern U.S., including South Carolina (Watch), Tennessee (Significant threat), Kentucky (Severe threat), Virginia (Low invasiveness), and the USFS Forest Inventory and Analysis and State Monitoring for Invasive Plants (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments:		
3. North Carolina nativity	Y/N	N
Comments: Native of eastern Asia (Weakley 2008).		
4. Presence in natural areas	Y/N	Y
Comments: Invades natural areas (Ebinger 1983).		
5. Non-invasive cultivars	Y/N	N
Comments: Chen et al. (2006) have studied the development of transgenic sterile cultivars of *Euonymus alatus*. Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: Unknown impacts on abiotic ecosystem processes.		
1b. Impact on plant community structure	20	10
Comments: The dense fibrous root system of *E. alatus* prevents the establishment of native species (Chen et al. 2006). Dense thickets may shade out native herbs and displace native shrubs (Martin, 2006). This species has established populations in a mature second growth forest that dominate the understory (Ebinger 1983).		
1c. Impact on species of special concern	5	0
Comments: Unknown impacts on species of special concern.		
1d. Impact on higher trophic levels	5	0
Comments: Unknown impacts on higher trophic levels.		
Section 1. Subrank	***40***	***10***
Section 2. Current Distribution and Potential for Expansion		

Table 4.10 Continued

2a. Local range expansion	7	0
Comments:		
2b. Long-distance dispersal potential	13	13
Comments: Seeds dispersed long distances by birds and water (Chen et al. 2006). Seeds are dispersed by birds (Martin 2006).		
2c. Reproductive characteristics	8	8
Comments: Seeds germinate readily from bird-dispersed fruits (Martin 2006). A mature plant may produce up to 50,000 seeds that are dispersed by birds and water and germinate readily (Chen et al. 2006). Expands through vegetative reproduction (Swearingen et al. 2002). Grows well in a variety of environmental conditions, including different soil types, pH levels, and full shade (Martin 2006).		
2d. Range of communities	6	0
Comments: The range of affected communities in North Carolina is unknown.		
2e. Similar habitats invaded elsewhere	6	6
Comments: *Euonymus alatus* has established populations in a mature white oak upland forest and an open second growth lowland forest in Illinois (Ebinger 1983). Populations have been found growing in ravines in valley floor forests and glacial drift hill prairies (Martin, 2006). Escaped cultivation in Connecticut, Virginia, Pennsylvania, and Illinois, possibly into woodland areas and coastal scrubland (Martin, 2006). Comparable Natural Communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests, low elevation dry and dry-mesic forest and woodlands, and communities of the coastal zone)		
Section 2. Subrank	***40***	***27***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: Cut stumps may be painted with glyphosate (Martin 2006). Glyphosate and triclopyr may be applied to cut shrubs (Swearingen et al. 2002).		
3b. Nonchemical control methods	2	1
Comments: Seedlings can be hand-pulled and large plants may be cut but regrowth may need to be repeatedly cut back (Martin 2006).		
3c. Necessity of individual treatments	2	2
Comments: Herbicides should be applied to cut stumps immediately after cutting (Martin 2006). Herbicides should be applied to shrubs that have been cut to the ground (Swearingen et al. 2002).		
3d. Average distribution	2	1
Comments: Populations of this species may dominate an area of the forest understory or consist of a few large shrubs and numerous seedlings (Ebinger 1983).		
3e. Likelihood for reestablishment	2	2

Table 4.10 Continued

Comments: This species produces a high number of seeds that are dispersed by birds (Martin 2006), which may allow reestablishment in a treated area. Regrowth from treated shrubs should be repeatedly cut back (Swearingen 2002). Treatments of cutting and herbicide application may require a five-year commitment for control (NatureServe 2008).		
3f. Accessibility of invaded areas	2	1
Comments: Inaccessible areas may be colonized, since seeds are dispersed by birds and the species is highly shade-tolerant (Martin 2006).		
3g. Impact on native species and environment	5	2
Comments: The nonselective herbicides glyphosate and triclopyr may impact non-target species.		
Section 3. Subrank	***20***	***9***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-3
Comments: The annual estimated wholesale value attributed to this species is $5,221,000 (Trueblood 2009).		
4b. Percentage of total sales	-5	-2
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 6-10% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-5***
Overall Score	**100**	**41**
Overall Recommendation: Moderately weedy and recommended for use with specific guidance – These species have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. These plants should not be grown in close proximity to natural areas that have communities similar to those where this plant has been found to naturalize or near natural areas that have sensitive or threatened plants and/or natural communities. (Overall Score: 34 – 66)		

Table 4.10 Continued

Summary: *Euonymus alatus* (Burning bush) is moderately weedy in North Carolina and may be recommended for horticultural use with specific guidance by the North Carolina Nursery and Landscape Association. The ecological impacts of *Euonymus alatus* are largely unknown, but dense thickets of this species may shade out native herbs and displace native vegetation. There is potential for the additional invasion of burning bush to natural areas due to the high potential for natural dispersal. The difficulty of managing *E. alatus* is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of this species. *Euonymus alatus* is economically valuable to the nursery industry.
References:

The Bugwood Network, USDA Forest Service, and USDA APHIS PPQ. (2009) Invasive Plants of the Thirteen Southern States. (http://www.invasive.org/south/seweeds.cfm) Accessed: March 24, 2009.

Chen, Y., Lu, L., Duan, H., Deng, W., McAvoy, R., Smith, W., Thammina, C., Von Bodman, S., Li, Y., Ye, D.and Zhao, D. (2006). Biotech approach to neutralize the invasiveness of burning bush (*Euonymus alatus*), a progress report on development of its genetic transformation system and functional analysis of sterile genes. Proceedings of the International Symposium on Asian Plants with Unique Horticultural Potential: Seoul, Korea.

Ebinger, J.E. (1983) Exotic shrubs: A potential problem in natural area management in Illinois. Natural Areas Journal 1: 3-6.

Martin, T. (2006) Weed Alert - *Euonymus alatus*. The Nature Conservancy. (http://tncinvasives.ucdavis.edu/alert/alrteuon.html) Accessed: March 24, 2009.

NatureServe (2008) Comprehensive Report Species - *Euonymus alatus*. (http://www.natureserve.org/explorer/servlet/NatureServe?searchName=Euonymus%20alata) Accessed: March 24, 2009.

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Swearingen, J., K. Reshetiloff, B. Slattery, and S. Zwicker. (2002) Plant Invaders of Mid-Atlantic Natural Areas. National Park Service and U.S. Fish & Wildlife Service, Washington, D.C. 82 pp. (http://www.nps.gov/plants/alien/pubs/midatlantic/toc.htm) Accessed: March 24, 2009.

Table 4.10 Continued

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Weakley, A.S. "Flora of the Carolinas, Virginia, Georgia, northern Florida, and surrounding areas." University of North Carolina. Working draft. 7 April 2008.

Table 4.11 Species Dataform and Scoresheet for Evergreen azaleas

Species Dataform and Scoresheet		
Evergreen azaleas		
Native range: Asia Date evaluated: March 9, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments:		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Popular ornamental plant. The estimated annual wholesale value attributed to evergreen azaleas in North Carolina is approximately $29,058,200.		
3. North Carolina nativity	Y/N	N
Comments: Most evergreen azaleas originated in Japan (Reily 2001).		
4. Presence in natural areas	Y/N	N
Comments: Not known to invade natural areas.		
5. Non-invasive cultivars	Y/N	Y
Comments: Assessment indicates that evergreen azaleas are noninvasive in North Carolina.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: No known impact on abiotic ecosystem processes.		
1b. Impact on plant community structure	20	0
Comments: No known impact on plant community structure.		
1c. Impact on species of special concern	5	0
Comments: No known impact on species of special concern or threatened or endangered plants.		
1d. Impact on higher trophic levels	5	0
Comments: No known impact on higher trophic levels.		
Section 1. Subrank	***40***	***0***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	0
Comments:		
2b. Long-distance dispersal potential	13	0
Comments: Not known to naturally disperse long distances.		
2c. Reproductive characteristics	8	4

Table 4.11 Continued

Comments: Evergreen azalea cuttings root well from wood taken throughout the year (timing is not critical) (Reiley 2001). Azaleas set many tiny seeds in elongated pods. Fresh seed has a 90% germination rate at a temperature of 65° to 70° F (Reiley 2001).		
2d. Range of communities	6	0
Comments: Evergreen azaleas grow well along most of the East Coast (Reiley, 2001), but are not generally found in natural areas		
2e. Similar habitats invaded elsewhere	6	0
Comments: There are hundreds of Evergreen azalea cultivars that vary in hardiness (tolerance to low winter temperatures). Depending on the cultivar, evergreen azaleas can survive in USDA Zones 5b to 9 (Niemiera, 2009).		
Section 2. Subrank	***40***	***4***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: Herbicides will damage azaleas (Reiley 2001).		
3b. Nonchemical control methods	2	0
Comments: Digging around azaleas will damage shallow root systems (Reiley 2001).		
3c. Necessity of individual treatments	2	2
Comments: Shrubs (Reiley 2001) would require individual treatments.		
3d. Average distribution	2	0
Comments:		
3e. Likelihood for reestablishment	2	0
Comments:		
3f. Accessibility of invaded areas	2	0
Comments:		
3g. Impact on native species and environment	5	0
Comments:		
Section 3. Subrank	***20***	***2***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-5
Comments: The estimated annual wholesale value attributed to evergreen azaleas is approximately $29,058,200 (Trueblood 2009).		
4b. Percentage of total sales	-5	-3
Comments: The highest percentage of total sales attributed to this species from any one grower in North Carolina is estimated to be 11-25% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0

Table 4.11 Continued

Comments:		
Section 4. Subrank	***-15***	***-8***
Overall Score	**100**	**-2**
Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)		
Summary: Evergreen azaleas are noninvasive in North Carolina and may be recommended for horticultural use by the North Carolina Nursery and Landscape Association. These species are not known to invade natural areas in North Carolina. These species have little to no negative ecosystem impacts, low potential for long-distance dispersal, and may be easily removed from the landscape. They have extremely high economic value to the North Carolina nursery industry.		
References:		

Niemiera, A.X. (2009) Evergreen Azalea (Rhododendron species) Virginia Cooperative Extension. (http://www.ext.vt.edu/pubs/np/2901-1035.pdf) Accessed: March 9, 2009.

Reiley, H. E. (2001) Azaleas, Camellias, and Rhododendrons. Des Moines, IA: The Scotts Company.

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Weakley, A.S. "Flora of the Carolinas, Virginia, Georgia, northern Florida, and surrounding areas." University of North Carolina. Working draft. 7 April 2008.

Table 4.12 Species Dataform and Scoresheet for *Ginkgo biloba* L. (Ginkgo, Maidenhair tree)

Species Dataform and Scoresheet		
***Ginkgo biloba* L. (Ginkgo, Maidenhair tree)**		
Native range: China Date evaluated: March 10, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments:		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Frequently planted in North Carolina (Weakley 2008).		
3. North Carolina nativity	Y/N	N
Comments: Native to China (Weakley 2008).		
4. Presence in natural areas	Y/N	N
Comments: Rarely escaped to suburban woodlands and yards, weakly naturalized (Weakley 2008).		
5. Non-invasive cultivars	Y/N	Y
Comments: Assessment indicates that *G. biloba* is noninvasive in North Carolina.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: No known impact on abiotic ecosystem processes.		
1b. Impact on plant community structure	20	0
Comments: No known impact on plant community structure.		
1c. Impact on species of special concern	5	0
Comments: No known impact on species of special concern or threatened or endangered plants.		
1d. Impact on higher trophic levels	5	0
Comments: No known impact on higher trophic levels.		
Section 1. Subrank	***40***	***0***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	0
Comments:		
2b. Long-distance dispersal potential	13	0
Comments: Not known to naturally disperse long distances.		
2c. Reproductive characteristics	8	2

Table 4.12 Continued

Comments: Probably no longer exists in truly wild state (McAlister 1981). Produces large fruits with seeds surrounded by thick seed coat (Del Tredici 2000). In North Carolina, Ginkgo seeds are shed in late summer or early fall and germinate in mid to late spring (Del Tredici 2000). Plants may be vegetatively propagated (Del Tredici 2000).		
2d. Range of communities	6	0
Comments: Cultivated throughout temperate zones for ornamental purposes (Del Tredici 2000). Ginkgo grows rapidly within USDA hardiness zones 6-8 within North Carolina (Del Tredici 2000).		
2e. Similar habitats invaded elsewhere	6	0
Comments:		
Section 2. Subrank	***40***	***2***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments:		
3b. Nonchemical control methods	2	0
Comments:		
3c. Necessity of individual treatments	2	2
Comments: Large trees of 20 - 40 meters tall (Del Tredici 2000) would require individual treatments.		
3d. Average distribution	2	0
Comments:		
3e. Likelihood for reestablishment	2	0
Comments:		
3f. Accessibility of invaded areas	2	0
Comments:		
3g. Impact on native species and environment	5	0
Comments:		
Section 3. Subrank	***20***	***2***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	0
Comments: Unknown.		
4b. Percentage of total sales	-5	0
Comments: Unknown.		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		

Table 4.12 Continued

Section 4. Subrank	***-15***	***0***
Overall Score	**100**	**4**
Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)		
Summary: *Ginkgo biloba* (Ginkgo) is noninvasive in North Carolina and may be recommended for horticultural use by the North Carolina Nursery and Landscape Association. Ginkgo is not known to invade natural areas in North Carolina. This species has little to no negative ecosystem impacts, low potential for long-distance dispersal, and may be easily removed from the landscape. Selection and planting of male trees eliminates undesirable fruit and any potential for reseeding.		
References:		

Del Tredici, P. (2000). The evolution, ecology, and cultivation of Ginkgo biloba. In T. A. Van Beek (Ed.), Ginkgo Biloba (pp. 7-23). Amsterdam: Harwood Academic Publishers.

McAlister, E.J. (1981) Notes on the fertilisation of the seed of the Maidenhair tree (Ginkgo biloba L.). Australian Institute of Horticulture, Inc. 3:16-18.

Van Beek, T. A. (2000). Introduction. In T. A. Van Beek (Ed.), Ginkgo Biloba (pp. 1-7). Amsterdam: Harwood Academic Publishers.

Weakley, A.S. "Flora of the Carolinas, Virginia, Georgia, northern Florida, and surrounding areas." University of North Carolina. Working draft. 7 April 2008.

Table 4.13 Species Dataform and Scoresheet for *Hedera helix* L (English ivy)

Dataform and Scoresheet		
***Hedera helix* L (English ivy)**		
Native range: Europe Date evaluated: March 25, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Appears on several invasive species lists (not laws) in the Southeastern U.S., including Georgia (Important), South Carolina (Watch), Tennessee (Rank 1, Severe threat), Kentucky (Significant threat), Virginia (Medium invasiveness), USFS Policy (Category 2, species suspected to be invasive) and the USFS Forest Inventory and Analysis and State Monitoring for Invasive Plants (Invasive.org 2009). Listed as a Class C noxious weed in Washington (Washington State Noxious Weed Control Board 2007) and Class B noxious weed in Oregon (Oregon Dept. of Agriculture, Plant Division).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Popular ornamental vine with hundreds of cultivars (Remaley 2003).		
3. North Carolina nativity	Y/N	N
Comments: Native to Europe (Weakley 2008).		
4. Presence in natural areas	Y/N	Y
Comments: Persistent, established, and spreading around old home sites and in suburban woodlands in the Coastal Plain, Piedmont, and Mountains of North Carolina (Weakley 2008). Populations exists in many natural areas throughout the U.S. (Remaley 2003). Invades disturbed and undisturbed forests (Swearingen and Diedrich 2006).		
5. Non-invasive cultivars	Y/N	N
Comments: Hundreds of cultivars exist that vary greatly in habit, leaf size, lobing, and marbling (Weakley 2008).		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: Unknown impact on abiotic ecosystem processes.		
1b. Impact on plant community structure	20	15
Comments: Suppresses the growth of native herbs (Thomas 1980). Capable of shading and killing overstory and understory trees as well as small trees (Thomas 1980). Covers forest floor and may suppress the growth of native herbs and woody seedlings and compete with trees for light (Clarke et al. 2006). Additional weight of vines may increase storm damage to trees (Clarke et al. 2006).		
1c. Impact on species of special concern	5	0
Comments: Unknown impact on species of special concern.		
1d. Impact on higher trophic levels	5	0

Table 4.13 Continued

Comments: Unknown impact on higher trophic levels.		
Section 1. Subrank	***40***	***15***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	1
Comments: Persistent, established, and spreading around old home sites and in suburban woodlands in the Coastal Plain, Piedmont, and Mountains of North Carolina (Weakley 2008).		
2b. Long-distance dispersal potential	13	13
Comments: Dispersed long distances and to new areas by birds that consume the fruits (Swearingen and Diedrich 2006).		
2c. Reproductive characteristics	8	8
Comments: Propagates readily from cuttings of young shoots (Gilman 1999). Rootlets sprout from leaf nodes and allow spread and climbing (Remaley 2003). Spreads vegetatively and new plants can become established from cut or broken stems (Swearingen and Diedrich 2006). Dispersed long distances and to new areas by birds that consume the fruits (Swearingen and Diedrich 2006).		
2d. Range of communities	6	4
Comments: Grows well in moist, successional deciduous woods in the Southeast (Remaley 2003). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests, river floodplains.		
2e. Similar habitats invaded elsewhere	6	4
Comments: Invades woodlands, forest edges, coastal areas, salt marsh edges (Swearingen and Diedrich 2006). Occurs in coastland, estuarine habitats, natural forests, riparian zones, and wetlands (ISSG 2005). Natural communities of North Carolina (Shafale and Weakley 1990) = Communities of the coastal zone and estuarine systems.		
Section 2. Subrank	***40***	***30***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: Glyphosate and triclopyr are effective herbicides to treat English ivy (Remaley 2003).		
3b. Nonchemical control methods	2	1
Comments: Very small populations may be cut back and hand-pulled (Remaley 2003). No biological controls are available (Swearingen and Diedrich 2006). Mulching may be effective for small infestations but must be maintained for at least two growing seasons (Swearingen and Diedrich 2006).		
3c. Necessity of individual treatments	2	2

Table 4.13 Continued

Comments: Herbicides should be applied to cut stems or through a foliar spray to control large populations (Remaley 2003). The most effective management approach involves a combination of cutting followed by herbicide application (Swearingen and Diedrich 2006).		
3d. Average distribution	2	1
Comments: Vines may be growing on trees or distributed as a dense ground cover (Swearingen and Diedrich 2006).		
3e. Likelihood for reestablishment	2	2
Comments: Vines must be cut back often, and severed vines will continue to resprout until the root stores are exhausted (Remaley 2003). If any part of the root system remains intact after treatment, the vine will resprout (Remaley 2003).		
3f. Accessibility of invaded areas	2	1
Comments: Dispersed long distances and to new areas by birds that consume the fruits (Swearingen and Diedrich 2006).		
3g. Impact on native species and environment	5	2
Comments: The nonselective herbicides glyphosate and triclopyr may kill non-target partially sprayed species (Remaley 2003).		
Section 3. Subrank	***20***	***9***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-3
Comments: The annual estimated wholesale value attributed to this species is $7,957,800 (Trueblood 2009).		
4b. Percentage of total sales	-5	-2
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 6-10% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-5***
Overall Score	**100**	**49**
Overall Recommendation: Moderately weedy and recommended for use with specific guidance – These species have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. These plants should not be grown in close proximity to natural areas that have communities similar to those where this plant has been found to naturalize or near natural areas that have sensitive or threatened plants and/or natural communities. (Overall Score: 34 – 66)		

Table 4.13 Continued

Summary: *Hedera helix* (English ivy) is moderately weedy in North Carolina and may be recommended for horticultural use with specific guidance by the North Carolina Nursery and Landscape Association. The ecological impacts of *H. helix* are largely unknown, but dense infestations of this species may suppress the growth of native herbs and woody seedlings. There is great potential for the additional invasion of English ivy to natural areas due to the high potential for natural dispersal. The difficulty of managing *H. helix* is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of this species. *Hedera helix* is economically valuable to the nursery industry.

References:

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Table 4.14 Species Dataform and Scoresheet for *Ligustrum japonicum* Thunb. (Japanese privet)

Species Dataform and Scoresheet		
***Ligustrum japonicum* Thunb. (Japanese privet)**		
Native range: Japan, Korea Date evaluated: March 31, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Appears on several invasive species lists (not laws) in the Southeastern U.S., including South Carolina (Severe threat), Tennessee (Rank 2, Significant threat), and USFS Policy (Category 1, species known to be invasive and persistent) (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Widely planted as an ornamental plant (Miller 2003).		
3. North Carolina nativity	Y/N	N
Comments: Native to Japan and Korea (Weakley 2008).		
4. Presence in natural areas	Y/N	Y
Comments: Escapes into natural areas in southern U.S. (Munger 2003). However, Japanese privet has not naturalized in North Carolina to the extent that it has in more southern states.		
5. Non-invasive cultivars	Y/N	N
Comments:		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: Unknown impact on abiotic ecosystem processes.		
1b. Impact on plant community structure	20	5
Comments: Commonly forms dense thickets and out-competes native species (Swearingen et al. 2002). May escape cultivation, establish monospecific stands, and quickly degrade native communities (Munger 2003). Outcompetes native woody species (Munger 2003).		
1c. Impact on species of special concern	5	0
Comments: Unknown impact on species of special concern.		
1d. Impact on higher trophic levels	5	0
Comments: Unknown impact on higher trophic levels.		
Section 1. Subrank	***40***	***5***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	0
Comments: Occurs primarily in the southeastern U.S. (Munger 2003).		
2b. Long-distance dispersal potential	13	13

Table 4.14 Continued

Comments: Produces an abundance of fleshy berries that are consumed by birds (Gilman and Watson 1993).		
2c. Reproductive characteristics	8	6
Comments: Produces an abundance of fleshy berries that are consumed by birds (Gilman and Watson 1993). Seeds may germinate where they fall (Gilman and Watson 1993). Propagated by seed or cuttings (Gilman and Watson 1993). Spread by rootsprouts and bird- and animal-dispersed seeds (Miller 2003). Plants propagate themselves prolifically from seed, readily reseeds, and cuttings are easily rooted (Scheper 2005). Reproduces from root or stump sprouts (Munger 2003). Grows in full sun and partial shade, tolerant of a range of soil types, not salt-tolerant (Gilman and Watson 1993).		
2d. Range of communities	6	4
Comments: Invades lowland and upland habitats in southern forests, but usually more prevalent in lowland areas (Miller 2003). Occurs in mesic habitats (Munger 2003). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests, low elevation dry and dry-mesic forest and woodlands.		
2e. Similar habitats invaded elsewhere	6	2
Comments: Grows in full sun and partial shade, tolerant of a range of soil types, not salt-tolerant (Gilman and Watson 1993). May invade floodplains, forests, wetlands, and fields (Swearingen et al. 2002). Invades intermittent stream bed and mesic woodland habitats in Texas (Munger 2003). Natural communities of North Carolina (Shafale and Weakley 1990) = River floodplains		
Section 2. Subrank	***40***	***25***
Section 3. Management Difficulty		
3a. Herbicidal control	5	3
Comments: Glyphosate herbicides are effective treatment methods (Miller 2003). Imazapyr is effective when applied to cut stumps, and glyphosate is effective when applied at bud break or soon after (Munger 2003).		
3b. Nonchemical control methods	2	1
Comments: Small infestations may be mowed, but stems should be cut back at least once per growing season to control the spread of privet (Remaley 2003). Young seedlings may be hand-pulled (Remaley 2003). There are no known biological controls for privet (Remaley 2003).		
3c. Necessity of individual treatments	2	2
Comments: Large stems should be cut and immediately treated with herbicide solution (Miller 2003).		
3d. Average distribution	2	1
Comments: Single plants (shrub, hedge, or small tree) or thicket-forming (Miller 2003).		
3e. Likelihood for reestablishment	2	2

Table 4.14 Continued

Comments: Stems must be cut at least once each growing season to prevent reestablishment (Remaley 2003). Japanese privet produces an abundance of seeds that are dispersed by birds, which allows the plant to naturalize over a wide area (Scheper 2005) and possibly become reestablished.		
3f. Accessibility of invaded areas	2	1
Comments: Produces an abundance of fleshy berries that are consumed by birds (Gilman and Watson 1993). Seeds may germinate where they fall (Gilman and Watson 1993). Shade tolerant (Miller 2003) and may spread to areas that are difficult to access.		
3g. Impact on native species and environment	5	2
Comments: Nontarget plants may be killed or injured by root uptake of herbicides (Miller 2003).		
Section 3. Subrank	***20***	***12***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-4
Comments: The annual estimated wholesale value attributed to this species is $14,609,800 (Trueblood 2009).		
4b. Percentage of total sales	-5	-4
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 26-50% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-8***
Overall Score	**100**	**34**
Overall Recommendation: Moderately weedy and recommended for use with specific guidance – These species have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. These plants should not be grown in close proximity to natural areas that have communities similar to those where this plant has been found to naturalize or near natural areas that have sensitive or threatened plants and/or natural communities. (Overall Score: 34 – 66)		

Table 4.14 Continued

Summary: *Ligustrum japonicum* (Japanese privet) is moderately weedy in North Carolina and may be recommended for horticultural use with specific guidance by the North Carolina Nursery and Landscape Association. The ecological impacts of *L. japonicum* are largely unknown, but this species may escape cultivation and form dense thickets that degrade native communities. Japanese privet has not naturalized in North Carolina to the extent that it has in more southern states. There is great potential for the additional invasion of Japanese privet to natural areas due to the high potential for natural dispersal. The difficulty of managing *L. japonicum* is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of this species. *Ligustrum japonicum* is extremely economically valuable to the nursery industry.
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Table 4.15 Species Dataform and Scoresheet for *Ligustrum sinense* Lour. (Chinese privet)

Species Dataform and Scoresheet		
***Ligustrum sinense* Lour. (Chinese privet)**		
Native range: China Date evaluated: March 3, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. **Current federal and state regulations**	Y/N	N
Appears on several invasive species lists (not laws) in the Southeastern U.S., including Mississippi (General list), Georgia (Top ten listed), South Carolina (Rank a, Severe threat), Florida (Category 1, altering plant community), Tennessee (Rank a, Severe threat), Kentucky (Significant threat), Virginia (Rank c, Low invasiveness), and the National Forest Service (Category 1, species known to be invasive and persistent) (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Introduced from China in 1852 for horticultural use and still used in landscaping (Merriam 2002).		
3. North Carolina nativity	Y/N	N
Native of China (Weakley 2008)		
4. Presence in natural areas	Y/N	Y
Invades both edge and interior of woodland habitats in the southeastern United States (Morris et al. 2002). Colonizes moist forests, especially alluvial bottomlands, in North Carolina (Weakley 2008). Over the past 70 years, Chinese privet has rapidly engulfed southern wetlands (Weakley 2008).		
5. Non-invasive cultivars	Y/N	N
Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	7
The greatest threat posed by *L. sinense* is large-scale ecosystem modification by outcompeting (for light) and displacing native vegetation (Urbatsch 2000). May limit hardwood regeneration, wildlife habitat, and biodiversity (Harrington and Miller 2005).		
1b. Impact on plant community structure and composition	20	20
Suppresses native vegetation as one of the most serious weeds in North Carolina (Weakley 2008). Forms dense thickets (Morris et al. 2002, Urbatsch 2000). Provides additional layer of understory vegetation and dominates the understories of mesic forest habitat in southeastern U.S. (Harrington and Miller 2005). May displace shrub layer in woodlands (Batcher 2000).		

Table 4.15 Continued

1c. Impact on species of special concern	5	5
Chinese privet is one exotic species that has threatened the Schweintz's sunflower (*Helianthus schweinitzii*) in the piedmont, an endangered species in North Carolina (Urbatsch 2000). Chinese privet is one aggressive weed species that when unmanaged, out shades Schweintz's sunflower (Weakley and Houk 1994). Outcompetes many kinds of native vegetation (Batcher, 2000).		
1d. Impact on higher trophic levels	5	0
Not known to impact higher trophic levels.		
Section 1. Subrank	***40***	***32***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	4
Moderate rate of spread across North Carolina - 5.4% increase in counties reporting occurrences per year (Merriam 2003). Continues to invade bottomland and upland forests in the Southeast (Harrington and Miller 2005). Distribution across southeastern U.S. experienced exponential growth between 1950-1980 (Harrington and Miller 2005). Over the past 70 years, Chinese privet has rapidly engulfed southern wetlands (Weakley 2008).		
2b. Long-distance dispersal potential	13	13
Seeds spread by birds and animals (Harrington and Miller 2005, Batcher 2000). Flooding and water transport may be major seed-carrying mechanism, since the species is often distributed along rivers and streams (Merriam 2003).		
2c. Reproductive characteristics	8	6
Seeds germinate readily without cold stratification (Harrington and Miller 2005). Grows from seed, root and stump sprouts (Batcher 2000). Produces large number of viable seeds that are readily dispersed by birds and have high germination rates in a wide variety of environmental conditions (Batcher 2000). Plants mature rapidly and produce prolific amount of seeds, spreads vegetatively by root suckers (Urbatsch 2000).		
2d. Range of communities	6	6
Moist forests, alluvial bottomlands, southern wetlands in North Carolina (Weakley 2008). NC Primary Systems (Shafale and Weakley 1990) = Low elevation mesic forests, river floodplains, nonalluvial wetlands of the mountains and Piedmont		
2e. Similar habitats invaded elsewhere	6	2
Chinese privet grows in red cedar and hardwood forests around cedar glades in Tennessee (Morris et al. 2002) and has been reported in oak-hickory pine forest and longleaf pine forest habitats in Alabama (Batcher 2000). *Ligustrum spp.* colonize floodplains, woodlands, bogs, wetlands, old fields, calcareous glades and barrens, and mesic hardwood forests in North America (Batcher 2000). NC Primary Systems (Shafale and Weakley 1990) = Low elevation dry and dry-mesic forest and woodlands		
Section 2. Subrank	***40***	***31***
Section 3. Management Difficulty		

Table 4.15 Continued

3a. Herbicidal control	5	0
Low rates of glyphosate effective when applied in spring or fall, lower control with summer application (Harrington and Miller 2005).		
3b. Nonchemical control methods	2	1
Manual uprooting of plants provides less control than glyphosate application (Harrington and Miller 2005). Mowing or cutting will control the spread of *L. sinense* but may not eradicate it (Batcher 2000). No known biological controls (Urbatsh).		
3c. Necessity of individual treatments	2	2
Shrub or small trees, grows to about 9 m tall, multiple stems, abundant production of root sprouts (Harrington and Miller 2005). Plants may be cut back for cut-stem application, or herbicides may be applied using a backpack sprayer (Harrington and Miller 2005). Herbicides may be applied using a foliar spray method where risk to desirable species is limited, or using cut stump control methods when individual shrubs must be treated to limit nontarget impacts (Batcher 2000).		
3d. Average distribution	2	1
Variability of stands, either isolated or stand-grown (Harrington and Miller, 2005).		
3e. Likelihood of reestablishment	2	2
Abundant regeneration possible from root sprouts (Harrington and Miller 2005). High likelihood of continued dispersal of seeds into treated area (Batcher 2000). Eradication is difficult due to high reproductive capacity by seed and vegetative propagation (Urbatsch 2000).		
3f. Accessibility of invaded areas	2	2
Seeds spread by birds, shade tolerant and able to spread under dense forest canopies (Harrington and Miller 2005, Batcher 2000).		
3g. Impact on native species and environment	5	2
Herbicide applications may impact non-target species (Batcher 2000). Glyphosate and triclopyr have no soil activity at registered rates and if applied as a directed foliar application, present little risk to associated vegetation (Harrington and Miller 2005).		
Section 3. Subrank	***20***	***10***
Section 4. Benefits and Value		
4a. Estimated Wholesale Value in North Carolina	-7	-3
The estimated annual wholesale value attributed to Chinese privet is $8,740,700 in North Carolina (Trueblood 2009).		
4b. Percentage of total sales	-5	-3
Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be: 11-25% (Trueblood 2009).		
4c. Ecosystem services	-1	0
4d. Wildlife habitat	-1	-1

Table 4.15 Continued

Important component of winter deer forage (Stromayer et al., 1998)		
4e. Cultural and social benefits	-1	0
Section 4. Subrank	***-15***	***-7***
Overall Score and Recommendation	**100**	**66**
Overall Recommendation: (Medium) Moderately weedy and recommended for use with specific guidance – These species have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. These plants should not be grown in close proximity to natural areas that have communities similar to those where this plant has been found to naturalize or near natural areas that have sensitive or threatened plants and/or natural communities. (Overall Score: 34 – 66)		
Summary: *Ligustrum sinense* (Chinese privet) ranks highly in the assessment system, and may be categorized as moderately weedy to highly invasive in North Carolina. In the assessment, Chinese privet scores one point below the highly invasive category. Chinese privet has high ecological impact and distribution and invasive potential, along with high economic value in the horticultural industry. Chinese privet impacts ecosystems by displacing and outcompeting native vegetation. There is great potential for the additional invasion of Chinese privet within natural areas. The difficulty of managing Chinese privet is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of Chinese privet. Chinese privet is economically valuable to the nursery industry and benefits wildlife habitat. Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications. Use of seedless cultivars would be desirable when they become available.		
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Table 4.16 Species Dataform and Scoresheet for *Lonicera japonica* Thunberg (Japanese honeysuckle)

Species Dataform and Scoresheet		
***Lonicera japonica* Thunberg (Japanese honeysuckle)**		
Native range: Eastern Asia Date evaluated: February 20, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments:		
2. Occurrence in the horticultural trade	Y/N	N
Comments:		
3. North Carolina nativity	Y/N	N
Comments: Native to Japan, Korea, and eastern China (Larson et al. 2007)		
4. Presence in natural areas	Y/N	Y
Comments: In North Carolina, *L. japonica* extends further into forest interior than other non-native species (Larson et al., 2007).		
5. Non-invasive cultivars	Y/N	NN
Comments:		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	10
Comments: Changes the structure of woodlands by outcompeting native vegetation for light and below-ground resources (Larson et al. 2007). Vines overtop existing vegetation and produce a more open habitat (Larson et al. 2007). Serious infestations that suppress dominant species may convert part of a forest to an open vine-dominated community (Larson et al. 2007). Allelopathic effect on trees and herbs may contribute to rapid development of *L. japonica* populations (Larson et al. 2007).		
1b. Impact on plant community structure	20	20
Comments: Shade and drought tolerant, most aggressive when growing in fertile soils and full sunlight, and may smother young trees (Regehr and Frey 1988). Grows up and past saplings, blocking light, and killing herbs, shrubs, and saplings (Hardt 1986). In severe infestations, it can produce a dense mat of vines and prevent regrowth of forest stands (Hardt 1986). Overtops existing vegetation, topples shrubs and small trees (Larson et al. 2007). Understory of vines can suppress growth of canopy trees (Larson et al. 2007). *Lonicera japonica* forms a new ground layer that may suppress the reproduction of overstory dominant trees and kill saplings and shrubs (Larson et al. 1997).		
1c. Impact on species of special concern	5	2

Table 4.16 Continued

Comments: Outcompetes native vegetation by vigorous above and below-ground competition and prevents nearly all plants from surviving beneath its dense canopy (Nuzzo 1997).		
1d. Impact on higher trophic levels	5	3
Comments: Forest understory bird populations can be affected in forest communities disturbed by Japanese honeysuckle (Yates et al. 2004, Nuzzo 1997). May act as host for insect pests and contribute to over-wintering populations of crop-damaging larvae, including two-spotted spider mite (*Tetranychus urticae* Koch) that re-invade corn and peanut in the spring in North Carolina (Larson et al. 2007).		
Section 1. Subrank	***40***	***35***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	4
Comments: Rate of spread across North Carolina suspected to be highest among non-native species (Merriam, 2003). Now nearly ubiquitous in North Carolina (Weakley 2008).		
2b. Long-distance dispersal potential	13	13
Comments: Fruit is a pulpy berry dispersed by birds and small mammals (Larson et al. 2007).		
2c. Reproductive characteristics	8	6
Comments: Japanese honeysuckle reproduces rapidly both vegetatively and sexually. Lateral branches that spread along the ground can root at nodes and sprout (Hardt 1986). Spreads extensively vegetatively by above-ground runners and below ground rhizomes (Larson et al. 2007). Semi-evergreen in the Southeastern U.S. and able to photosynthesize during early spring and late fall (Larson et al. 2007). Fruit is a pulpy berry dispersed by birds and small mammals (Larson et al. 2007).		
2d. Range of communities	6	6
Comments: Common in the Piedmont, Coastal Plain, and in mesic habitats (Weakley 2008). Found in range of habitats, including old fields, thickets, open woodlands, mature woodlands, bottomlands, maple and oak forests (Larson et al. 2007), dry-mesic to wet-mesic upland forest areas and floodplain forests (Nuzzo 1997). Does not survive well in coastal pine barrens and spruce and fir-dominated communities (Larson et al. 2007). These systems may correspond to the natural communities of North Carolina (Shafale and Weakley 1990): Low elevation mesic forests, low elevation dry and dry-mesic forest and woodlands, river floodplains, wet nonalluvial forests of the Coastal Plain.		
2e. Similar habitats invaded elsewhere	6	0
Comments: Has already invaded a large proportion of the state and multiple primary systems in North Carolina.		
Section 2. Subrank	***40***	***29***
Section 3. Management Difficulty		
3a. Herbicidal control	5	3

Table 4.16 Continued

Comments: Controlled with 1.5% glyphosate applied in December or 1.5% dichlorprop plus 2,4-D applied after the first freezing temperatures in the fall (Regehr and Frey 1988).		
3b. Nonchemical control methods	2	2
Comments: Removal of the above ground portions of a *L. japonica* plant stimulates dense regrowth, and cut material can easily take root on or off site (Nuzzo 1997). Mowing may slow vegetative spread but increase stem density (Nuzzo 1997). Disking is effective but environmentally damaging, and hand-pulling has limited effectiveness for controlling *L. japonica* (Nuzzo 1997).		
3c. Necessity of individual treatments	2	0
Comments: Herbicides may be applied broadly to *L. japonica* infestations (Regehr and Frey 1988).		
3d. Average distribution	2	1
Comments: Japanese honeysuckle growth is "loose and rangy," reaching in all directions (Hardt 1986). Vines spread horizontally and vertically, and each vine has numerous long vegetative runners (Nuzzo 1997).		
3e. Likelihood for reestablishment	2	1
Comments: Regrowth depends on time of herbicide application. 30 MAT with 1.5% glyphosate applied in December, most plots showed excellent control (Regehr and Frey 1988). Honeysuckle treated with dichlorprop plus 2,4-D in October showed occasional regrowth, but honeysuckle treated with the same chemical combination in December largely recovered due to bud regrowth and was not well-controlled in the long-term (Regehr and Frey 1988). Responds rapidly to disturbance and may be present for long periods of time in the understory of closed-canopy forests (Larson et al. 2007). Young small plants are difficult to locate and may go unnoticed (Nuzzo 1997). Treated areas must be reassessed at the end of the second growing season (Nuzz 1997).		
3f. Accessibility of invaded areas	2	2
Comments: In North Carolina, *L. japonica* extends further into forest interior than other non-native species (Larson et al., 2007).		
3g. Impact on native species and environment	5	2
Comments: Glyphosate or dichlorprop plus 2,4-D resulted in minor to moderate injury of trees in management area (Regehr and Frey, 1988). Easily distinguished from other North America *Lonicera* spp. by its leaves and berries (Larson et al., 2007)		
Section 3. Subrank	***20***	***11***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	0
Comments:		
4b. Percentage of total sales	-5	0
Comments:		
4d. Ecosystem services	-1	0
Comments:		

Table 4.16 Continued

4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***0***
Overall Score	**100**	**75**
Overall Recommendation: Highly invasive and not recommended for horticultural use – These species present relatively high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. (Overall Score: 67 – 100)		
Summary: *Lonicera japonica* (Japanese honeysuckle) is highly invasive in North Carolina and may not be recommended for horticultural use by the North Carolina Nursery and Landscape Association. Japanese honeysuckle seriously impacts ecosystem processes and plant community structure. There is great potential for the natural dispersion of Japanese honeysuckle throughout North Carolina. The difficulty of managing Japanese honeysuckle is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of Japanese honeysuckle. Japanese honeysuckle has little to no economic value for the nursery industry.		
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Table 4.17 Species Dataform and Scoresheet for *Magnolia stellata* Maxim. (Star magnolia)

Species Dataform and Scoresheet		
***Magnolia stellata* Maxim. (Star magnolia)**		
Native range: Japan Date evaluated: March 11, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments:		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Popular cultivated magnolia species.		
3. North Carolina nativity	Y/N	N
Comments: Native to the Tokai region of Japan (Hirayama et al. 2005).		
4. Presence in natural areas	Y/N	N
Comments: Not known to invade natural areas.		
5. Non-invasive cultivars	Y/N	Y
Comments: Assessment indicates that *M. stellata* is noninvasive in North Carolina.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: No known impact on abiotic ecosystem processes.		
1b. Impact on plant community structure	20	0
Comments: No known impact on plant community structure.		
1c. Impact on species of special concern	5	0
Comments: No known impact on species of special concern or threatened or endangered plants.		
1d. Impact on higher trophic levels	5	0
Comments: No known impact on higher trophic levels.		
Section 1. Subrank	***40***	***0***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	0
Comments:		
2b. Long-distance dispersal potential	13	8
Comments: Seeds are large and associated with a fleshy aril (Watanabe et al. 2002). Seeds spread by birds, mammals, and heavy rains (Shi et al. 2002).		
2c. Reproductive characteristics	8	2
Comments: Propagated from seed and vegetative cuttings (Shi et al. 2002).		
2d. Range of communities	6	0

Table 4.17 Continued

Comments:		
2e. Similar habitats invaded elsewhere	6	0
Comments: Found in wetlands in Japan (Hirayama et al. 2005).		
Section 2. Subrank	***40***	***10***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments:		
3b. Nonchemical control methods	2	0
Comments:		
3c. Necessity of individual treatments	2	2
Comments: Tree, up to 10 m in height, often with multiple stems (Hirayama et al. 2005) would require individual treatments.		
3d. Average distribution	2	0
Comments:		
3e. Likelihood for reestablishment	2	0
Comments:		
3f. Accessibility of invaded areas	2	0
Comments:		
3g. Impact on native species and environment	5	0
Comments:		
Section 3. Subrank	***20***	***2***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	0
Comments: Unknown.		
4b. Percentage of total sales	-5	0
Comments: Unknown.		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***0***
Overall Score	**100**	**12**
Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas.		

Table 4.17 Continued

Summary: *Magnolia stellata* (Star magnolia) is noninvasive in North Carolina and may be recommended for horticultural use by the North Carolina Nursery and Landscape Association. *Magnolia stellata* is not known to invade natural areas in North Carolina. This species has little to no negative ecosystem impacts, low to moderate potential for long-distance dispersal, and may be easily removed from the landscape.
References:

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Table 4.18 Species Dataform and Scoresheet for *Mahonia bealei* (Fortune) Carr. (Leatherleaf Mahonia)

Species Dataform and Scoresheet		
***Mahonia bealei* (Fortune) Carr. (Leatherleaf Mahonia)**		
Native range: China Date evaluated: April 2, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Appears on several invasive species lists (not laws) in the Southeastern U.S., including South Carolina (Significant threat) and Tennessee (Rank 2, Significant threat) (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Popular ornamental plant in the Southeastern United States (Allen et al. 2006).		
3. North Carolina nativity	Y/N	N
Comments: Native of China (Weakley 2008).		
4. Presence in natural areas	Y/N	Y
Comments: In deciduous forests in suburban areas, spread from plantings in North Carolina (Weakley 2008). Naturalizing widely in the southeastern United States (Weakley 2008).		
5. Non-invasive cultivars	Y/N	N
Comments: Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	4
Comments: Woody shrubs, like *M. bealei*, that invade forest areas may create a shift in under- and mid-story composition that may in turn alter primary production, nutrient cycling, and carbon storage (Allen et al. 2006).		
1b. Impact on plant community structure	20	10
Comments: Invades the forest under- and mid-story and produces dense populations and canopy cover in these layers (Allen et al. 2006).		
1c. Impact on species of special concern	5	0
Comments: Unknown impact on species of special concern.		
1d. Impact on higher trophic levels	5	0
Comments: Unknown impact on higher trophic levels.		
Section 1. Subrank	***40***	***14***
Section 2. Current Distribution and Potential for Expansion		

Table 4.18 Continued

2a. Local range expansion	7	4
Comments: Naturalizing widely in the southeastern United States (Weakley 2008). Likely to continue to spread in the Southeastern U.S. (Allen et al. 2006). Rapid population growth of *M. bealei* can be expected in the Southeastern U.S. (Allen et al. 2006).		
2b. Long-distance dispersal potential	13	13
Comments: Fruits consumed by birds (Gilman 1999). Spread from plantings in North Carolina (Weakley 2008).		
2c. Reproductive characteristics	8	6
Comments: *Mahonia bealei* can grow well in very low light conditions (Allen et al. 2006). Reproduces by seed and clonal ramets (Allen et al. 2006). Fleshy fruits consumed by birds (Gilman 1999). Seeds from bird-dispersed seeds can immediately germinate (Miller and Manning 2008).		
2d. Range of communities	6	2
Comments: Occurs in bottomland forests in North Carolina (Cook 2009). Natural communities of North Carolina (Shafale and Weakley 1990) = River floodplains		
2e. Similar habitats invaded elsewhere	6	4
Comments: Invades woodlands in the southern United States (Invasive.org 2009b). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests, low elevation dry and dry-mesic forest and woodlands.		
Section 2. Subrank	***40***	***24***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: A glyphosate herbicide or Garlon 3A may be applied in a cut stem treatment or foliar application (Miller and Manning 2008).		
3b. Nonchemical control methods	2	2
Comments: Herbicide application is the recommended control procedure (Miller and Manning 2008).		
3c. Necessity of individual treatments	2	2
Comments: Large stems or tall individuals should be cut and treated with herbicides (Miller and Manning 2008).		
3d. Average distribution	2	1
Comments: Shrub, up to 4 m tall, density of invasion is variable (Allen et al. 2006).		
3e. Likelihood for reestablishment	2	1
Comments: Fleshy fruits consumed by birds (Gilman 1999), which may reestablish populations.		
3f. Accessibility of invaded areas	2	1
Comments: In a study by Allen et al. (2006) in South Carolina, *M. bealei* distribution was not restricted to the edge of woodlots and populations were found approximately 60 m from the edge. Fleshy fruits consumed by birds (Gilman 1999), which may facilitate dispersion to inaccessible areas.		

Table 4.18 Continued

3g. Impact on native species and environment	5	2
Comments: Nontarget plants may be killed or injured by root uptake of herbicides (Miller and Manning 2008).		
Section 3. Subrank	***20***	***9***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-4
Comments: The annual estimated wholesale value attributed to this species is $11,823,800 (Trueblood 2009).		
4b. Percentage of total sales	-5	-1
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 1-5% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-5***
Overall Score	**100**	**42**
Overall Recommendation: Moderately weedy and recommended for use with specific guidance – These species have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. These plants should not be grown in close proximity to natural areas that have communities similar to those where this plant has been found to naturalize or near natural areas that have sensitive or threatened plants and/or natural communities. (Overall Score: 34 – 66)		
Summary: *Mahonia bealei* (Leatherleaf mahonia) is moderately weedy in North Carolina and may be recommended for horticultural use with specific guidance by the North Carolina Nursery and Landscape Association. The ecological impacts of *Mahonia bealei* are largely unknown, but dense thickets of this species may shade out native herbs and displace native vegetation. There is potential for the additional invasion of Leatherleaf mahonia to natural areas due to the high potential for natural dispersal from ornamental plantings. The difficulty of managing *M. bealei* is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of this species. *Mahonia bealei* is economically valuable to the nursery industry. Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications. Use of seedless cultivars would be desirable when they become available.		

Table 4.18 Continued

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Table 4.19 Species Dataform and Scoresheet for *Miscanthus sinensis* Anderson (Chinese silvergrass)

Species Dataform and Scoresheet		
***Miscanthus sinensis* Anderson (Chinese silvergrass)**		
Native range: Eastern Asia Date evaluated: April 2, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Appears on several invasive species lists (not laws) in the Southeastern U.S., including Georgia (Important), South Carolina (Significant threat), Tennessee (Rank 2, Significant threat), Kentucky (Severe threat), Virginia (Low invasiveness), and the U.S. Forest Service Policy (Category 2, Species suspected to be invasive (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Popular ornamental grass (Hockenberry Meyer 2004).		
3. North Carolina nativity	Y/N	N
Comments: Native to Eastern Asia (Weakley 2008).		
4. Presence in natural areas	Y/N	Unknown
Comments: Naturalized in 3 counties (Buncombe, Madison, and Henderson) in western North Carolina (Zone 6) (Hockenberry Meyer 2008) along roadsides and in pastures. Common along roadsides (Weakley 2008), but is unclear if *M. sinensis* is found in natural areas in North Carolina. *Miscanthus sinensis* is a pioneer, early successional species that is very shade intolerant and quickly shaded out as natural succession progresses.		
5. Non-invasive cultivars	Y/N	Y
Comments: Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications. *Miscanthus* x *giganteus* is a sterile triploid hybrid (Jorgensen and Muhs 2001)		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	4
Comments: Monocultural stands can alter native ecosystems and delay reforestation (Hockenberry Meyer 2008). Highly flammable and a wildland fire hazard (Miller 2003). May alter fire regime (Remaley 2003), but it is unclear if *M. sinensis* is present in natural areas of North Carolina.		
1b. Impact on plant community structure	20	0
Comments: Aggressive, spreading plant with invasive potential (Gilman 1999). Forms extensive infestations (Miller 2003).		
1c. Impact on species of special concern	5	0
Comments: Unknown impacts on species of special concern.		
1d. Impact on higher trophic levels	5	0

Table 4.19 Continued

Comments: Unknown impacts on higher trophic levels.		
Section 1. Subrank	***40***	***4***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	4
Comments: Becoming aggressively weedy in North Carolina (Weakley 2008).		
2b. Long-distance dispersal potential	13	3
Comments: *Miscanthus sinensis* sets a significant amount of airborne seed (Hockenberry Meyer 2003). Generally spread along roadsides and woodland borders (Wilson and Knox 2006). Interstate highways in western North Carolina provide a corridor for the spread of airborne seeds of Miscanthus (Hockenberry 2008).		
2c. Reproductive characteristics	8	6
Comments: Adaptable to a wide range of environmental conditions (Wilson and Knox 2006). Wind-pollinated and capable of seeding (Wilson and Knox 2006). While seed viability varies by cultivar and location, Wilson and Knox (2006) found that the total averaged germination among cultivars was between 42-66% in Florida. Viable seedlings are readily produced in mild climates, including Zone 6 of western North Carolina (Hockenberry Meyer 2004). Heavy seed set (Hockenberry Meyer 2004, Ogura and Yura 2008). *Miscanthus sinensis* sets a significant amount of airborne seed (Hockenberry Meyer 2003).		
2d. Range of communities	6	0
Comments: Colonizes a variety of sites but grows best in moist well-drained areas. Invades shores of reservoirs, roadsides, and old fields in the Southeastern United States (Remaley 2003). However, *M. sinensis* appears to occur only along the transportation corridors in any of the natural communities of North Carolina, so it is not considered to have yet invaded these systems. *Miscanthus sinensis* may be found adjacent to the ecological type, Low elevation mesic forests (Shafale and Weakley 1990).		
2e. Similar habitats invaded elsewhere	6	0
Comments: In addition to Western North Carolina, *Miscanthus sinensis* has naturalized in southeastern Pennsylvania, the Washington, D.C. area, and Iowa (Hockenberry Meyer 2003), but the affected ecological types are unknown.		
Section 2. Subrank	***40***	***13***
Section 3. Management Difficulty		
3a. Herbicidal control	5	3
Comments: To treat with herbicides, the previous year's growth should be removed by cutting the plant back to the ground. After the new growth is approximately 12" tall in mid spring or early summer, plants may be treated with glyphosate (Hockenberry Meyer 2003). An adequate amount of actively growing foliage should be present for effective herbicide treatments (Hockenberry Meyer 2003).		
3b. Nonchemical control methods	2	1

Table 4.19 Continued

Comments: Hand pulling is ineffective due to the large root system and ability to resprout from root fragments (Remaley 2003). Regular mowing can reduce the growth of *M. sinensis* and eventually kill it (Hockenberry Meyer 2008). However, mowing or burning *M. sinensis* when plants are dormant in winter or early spring may increase plant growth (Hockenberry Meyer 2008).		
3c. Necessity of individual treatments	2	2
Comments: Plants should be cut back and allowed to grow approximately 12" before treating with glyphosate (Hockenberry Meyer 2003).		
3d. Average distribution	2	1
Comments: Dense infestations may form monocultural stands (Hockenberry Meyer 2008).		
3e. Likelihood of reestablishment	2	1
Comments: Mowing must be repeated, sometimes for several years, if a seed bank has been established (Hockenberry Meyer 2003).		
3f. Accessibility of invaded areas	2	1
Comments: Readily naturalizes in areas long distances from its planting (Wilson and Knox 2006).		
3g. Impact on native species and environment	5	2
Comments: Nontarget plants may be killed or injured by root uptake (Miller 2003).		
Section 3. Subrank	***20***	***11***
Section 4. Benefits and Value		
4a. Estimated Wholesale Value in North Carolina	-7	-6
Comments: The estimated wholesale value attributed to M. sinensis is $39,284,800 in North Carolina (Trueblood 2009).		
4b. Percentage of total sales	-5	-4
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be: 26-50%. (Trueblood 2009).		
4c. Ecosystem services	-1	0
4d. Wildlife habitat	-1	0
4e. Cultural and social benefits	-1	0
Section 4. Subrank	***-15***	***-10***
Overall Score	**100**	**18**
Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)		

Table 4.19 Continued

Summary: *Miscanthus sinensis* (Chinese silvergrass) is noninvasive in North Carolina and may be recommended for use by the North Carolina Nursery and Landscape Association. While *M. sinensis* has naturalized in at least 3 counties (Buncombe, Madison, and Henderson) in western North Carolina (Hockenberry Meyer 2008). However, the infestations are found along roadsides and in pastures, rather than natural areas. Because *Miscanthus sinensis* is a pioneer, early successional species that is very shade intolerant, it is typically outcompeted over time and rarely found in natural areas. Weakley (2008) indicated that *M. sinensis* is becoming aggressively weedy in North Carolina, and other states in the southeastern U.S. have included Chinese silvergrass on state listings of invasive species (Invasive.org 2009), so additional monitoring of the distribution, spread, and environmental impacts in North Carolina would be prudent. Some cultivars of *Miscanthus* are sterile, e.g., *M.* x *giganteus*. Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications. Use of seedless cultivars would be desirable when they become available. The species appears to have very high economic value in the North Carolina nursery industry.

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Table 4.19 Continued

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Table 4.20 Species Dataform and Scoresheet for *Nandina domestica* Thunb. (Nandina, Heavenly bamboo)

Species Dataform and Scoresheet		
***Nandina domestica* Thunb. (Nandina, Heavenly bamboo)**		
Native range: China Date evaluated: April 6, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Appears on several invasive species lists (not laws) in the Southeastern U.S., including Georgia (Important), South Carolina (Significant threat), Florida (Category I altering plant community), Tennessee (Rank 2, Significant threat), and the USFS Policy (Category 2, Species suspected to be invasive) (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Widely planted in the Piedmont and Coastal Plain of North Carolina (Weakley 2008). Planted in traffic islands and many kinds of landscape and commercial applications (Scheper 2008).		
3. North Carolina nativity	Y/N	N
Comments: Native to China (Weakley 2008).		
4. Presence in natural areas	Y/N	Y
Comments: Increasingly escaping and naturalizing in North Carolina (Weakley 2008).		
5. Non-invasive cultivars	Y/N	Y/N
Comments: Cultivars, including Nana, Harbour Dwarf, and Firepower, have been developed that produce little or no seed (Langeland and Craddock Burks 2008).		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: Unknown impact on abiotic ecosystem processes.		
1b. Impact on plant community structure	20	10
Comments: Shade tolerant and establishes under forest canopies and near forest edges (Miller 2003). Displaces native species and disrupts plant communities (USDA Forest Service 2006). Forms dense thickets that displaces native vegetation (UF/IFAS 2008). Actively disrupts plant communities (Scheper 2008).		
1c. Impact on species of special concern	5	2
Comments: Displaces native vegetation, including endangered plant species, in Florida (Langeland and Craddock Burks 2008).		
1d. Impact on higher trophic levels	5	0
Comments: Unknown impact on higher trophic levels.		
Section 1. Subrank	***40***	***12***

Table 4.20 Continued

Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	4
Comments: Increasingly escaping and naturalizing in North Carolina (Weakley 2008).		
2b. Long-distance dispersal potential	13	13
Comments: Produces fleshy fruit, spread by animal-dispersed seeds (Miller 2003).		
2c. Reproductive characteristics	8	6
Comments: Produces fleshy fruit, spread by animal-dispersed seeds (Miller 2003). Colonizes vegetatively through root sprouts (Miller 2003). Spreads by root suckers and rhizomes (IF/IFAS 2008). Grows in both moist and dry areas (Langeland and Craddock Burks 2008) and shaded and open areas (USDA Forest Service 2006). Cut roots readily re-sprout (USDA Forest Service 2006).		
2d. Range of communities	6	2
Comments: Forests and woodlands in suburban areas in North Carolina (Weakley 2008). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests.		
2e. Similar habitats invaded elsewhere	6	2
Comments: Grows under forest canopies and near forest edges in full sun to shade, but does not grow well in sand (USDA Forest Service 2006). Invaded woodlands, floodplains, conservation areas, secondary woodlands in Florida (Langeland and Craddock Burks 2008). Natural communities of North Carolina (Shafale and Weakley 1990) = River floodplains.		
Section 2. Subrank	***40***	***22***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: Glyphosate and triclopyr herbicides provide effective control (Miller 2003).		
3b. Nonchemical control methods	2	2
Comments: Difficult to remove manually because small pieces of root may re-sprout (USDA Forest Service 2006). No known biological control agents (UF/IFAS 2008).		
3c. Necessity of individual treatments	2	2
Comments: Large stems should be cut and immediately treated (Miller 2003). Fruit should be collected from the treated area and destroyed (Miller 2003).		
3d. Average distribution	2	1
Comments: May forms dense thickets (UF/IFAS 2008).		
3e. Likelihood for reestablishment	2	2
Comments: Retreatment may be necessary to reduce population densities (USDA Forts Service 2006). Fruits dispersed by animals and birds and root sprouts may recolonize an area (Miller 2003).		
3f. Accessibility of invaded areas	2	1

Table 4.20 Continued

Comments: Mature plants found far from cultivation areas in the southeastern United States (Langeland and Craddock Burks 2008). Animals and birds disperse seeds (Miller 2003) which may be transported to areas not easily accessed for management.		
3g. Impact on native species and environment	5	2
Comments: Nontarget plants may be killed or injured by root uptake of herbicides (Miller 2003).		
Section 3. Subrank	***20***	***10***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-5
Comments: The annual estimated wholesale value attributed to this species is $26,964,300 (Trueblood 2009).		
4b. Percentage of total sales	-5	-4
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 26-50% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-9***
Overall Score	**100**	**35**
Overall Recommendation: Moderately weedy and recommended for use with specific guidance – These species have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. These plants should not be grown in close proximity to natural areas that have communities similar to those where this plant has been found to naturalize or near natural areas that have sensitive or threatened plants and/or natural communities. (Overall Score: 34 – 66)		
Summary: *Nandina domestica* (Nandina, Heavenly bamboo) is moderately weedy in North Carolina and may be recommended for horticultural use with specific guidance by the North Carolina Nursery and Landscape Association. Nandina is increasingly escaping and naturalizing in North Carolina The ecological impacts of *N. domestica* are largely unknown, but dense thickets of this species may shade out native herbs and displace native vegetation. There is potential for the additional invasion of Nandina to natural areas due to the high potential for natural dispersal from ornamental plantings. The difficulty of managing Nandina is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of this species. *Nandina domestica* has extremely high economic value to the nursery industry.		

Table 4.20 Continued

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Table 4.21 Species Dataform and Scoresheet for *Ophiopogon japonicus* Ker-Gawl. and *Liriope* species (Mondo grass, lily turf, liriope)

Species Dataform and Scoresheet		
***Ophiopogon japonicus* Ker-Gawl. and *Liriope* species (Mondo grass, lily turf, liriope)**		
Native range: Japan Date evaluated: March 10, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments:		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Popular ornamental ground cover.		
3. North Carolina nativity	Y/N	N
Comments: Native to Japan (Shimomura and Kondo 2000).		
4. Presence in natural areas	Y/N	N
Comments: Not known to invade natural areas in North Carolina.		
5. Non-invasive cultivars	Y/N	Y
Comments: Assessment indicates that *O. japonicus* and *Liriope* species are noninvasive in North Carolina.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	4
Comments: *Ophiopogon japonicus* produces plant growth inhibitors and has potential allelopathic activity (Iqbal et al. 2004).		
1b. Impact on plant community structure	20	0
Comments: No known impact on plant community structure.		
1c. Impact on species of special concern	5	0
Comments: No known impact on species of special concern or threatened or endangered plants.		
1d. Impact on higher trophic levels	5	0
Comments: No known impact on higher trophic levels.		
Section 1. Subrank	***40***	***4***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	0
Comments:		
2b. Long-distance dispersal potential	13	0
Comments: Not known to naturally disperse long distances.		
2c. Reproductive characteristics	8	2

Table 4.21 Continued

Comments: Propagates vegetatively (Shimomura and Kondo, 2000).		
2d. Range of communities	6	0
Comments:		
2e. Similar habitats invaded elsewhere	6	0
Comments:		
Section 2. Subrank	***40***	***2***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments:		
3b. Nonchemical control methods	2	0
Comments:		
3c. Necessity of individual treatments	2	0
Comments:		
3d. Average distribution	2	0
Comments: Groundcover (Shimomura and Kondo, 2000) may be controlled broadly		
3e. Likelihood for reestablishment	2	0
Comments:		
3f. Accessibility of invaded areas	2	0
Comments:		
3g. Impact on native species and environment	5	0
Comments:		
Section 3. Subrank	***20***	***0***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-7
Comments: The estimated state-wide wholesale value attributed to this species is approximately $41,208,400 (Trueblood 2009).		
4b. Percentage of total sales	-5	-4
Comments: The highest percentage of total sales attributed to this species from any one grower in North Carolina is estimated to be 26-50% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-11***
Overall Score	**100**	**-5**

Table 4.21 Continued

Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)
Summary: *Ophiopogon japonicus* and *Liriope* species are noninvasive in North Carolina and may be recommended for horticultural use by the North Carolina Nursery and Landscape Association. These species are not known to invade natural areas in North Carolina. These species have little to no negative ecosystem impacts, low potential for long-distance dispersal, and may be easily removed from the landscape. They have extremely high economic value to the North Carolina nursery industry.
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Table 4.22 Species Dataform and Scoresheet for *Pyrus calleryana* Decne. (Callery pear)

Species Dataform and Scoresheet		
***Pyrus calleryana* Decne. (Callery pear)**		
Native range: China Date evaluated: April 7, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	Y
Comments: Appears on the South Carolina invasive species list (not law) as a species to watch (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Commonly cultivated (Weakley 2008).		
3. North Carolina nativity	Y/N	N
Comments: Native of China (Weakley 2008).		
4. Presence in natural areas	Y/N	Y
Comments: Rare in natural areas. Commonly naturalized along roadsides and old fields in North Carolina (Weakley 2008). Impact on natural areas and undisturbed woods less understood and documented than the impact in marginal areas, including fence rows, fallow fields, railroad beds, and the edges of disturbed woodlands (Vincent 2005). Recently spread into natural areas (Culley and Hardiman 2007).		
5. Non-invasive cultivars	Y/N	N
Comments: *Pyrus calleryana* cross-pollinates with other pear species and produces fertile progeny (Vincent 2005). Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: Unknown impact on abiotic ecosystem processes.		
1b. Impact on plant community structure	20	5
Comments: May establish large thorny thickets (Vincent 2005). May form dense, monocultural stands in open areas outside of a closed canopy (Culley and Hardiman 2007). May impede the establishment of late- to middle-stage successional species in disturbed or open sites (Culley and Hardiman 2007). Invades and degrades newly restored wetland prairies (Culley and Hardiman 2007).		
1c. Impact on species of special concern	5	0
Comments: Unknown impact on species of special concern.		
1d. Impact on higher trophic levels	5	0
Comments: Unknown impact on higher trophic levels.		
Section 1. Subrank	***40***	***5***

Table 4.22 Continued

Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	7
Comments: Range is expanding along roadsides and fields (not natural areas) in North Carolina (Weakley 2008). Highly naturalized in Maryland and Northern Virginia, indicating that *P. calleryana* may become a serious pest in North Carolina as well (Weakley 2008). Rapidly becoming naturalized in the eastern United States (Vincent 2005).		
2b. Long-distance dispersal potential	13	13
Comments: Birds readily eat the fruits, spreading the seeds (Vincent 2005).		
2c. Reproductive characteristics	8	6
Comments: Reproduces readily in the wild (Vincent 2005). Fruits are bird-dispersed (Vincent 2005). Highly adaptable and tolerant of a wide range of environmental conditions, including low pH, high pH, wet soils, dry soils, sandy soils, and clay soils (Vincent 2005). Exhibits weedy and invasive characteristics, including rapid growth, early and abundant flowering, and wide tolerance to a variety of environmental conditions (Culley and Hardiman 2007). Populations may become established by seed and root sprouts (White et al. 2005). Readily resprouts when cut (White et al. 2005).		
2d. Range of communities	6	0
Comments: Naturalizes in fields, roadsides, and disturbed areas from North Carolina northward (Weakley 2008). Rare in natural communities in N.C.		
2e. Similar habitats invaded elsewhere	6	2
Comments: May be problematic in pine reforestations in Arkansas (Vincent 2005). Invasive in grasslands and open woodlands in Illinois (White et al. 2005). Natural communities of North Carolina (Shafale and Weakley 2008) = Low elevation dry and dry-mesic forest and woodlands.		
Section 2. Subrank	***40***	***28***
Section 3. Management Difficulty		
3a. Herbicidal control	5	3
Comments: After trees have been cut, glyphosate or triclopyr herbicides may be applied immediately to the freshly cut trunk (Culley and Hardiman 2007).		
3b. Nonchemical control methods	2	2
Comments: Mowing of small trees is ineffective due to prolific sprouting from any remaining trunk or root systems (Culley and Hardiman 2007). Few, if any, natural controls (Vincent 2005).		
3c. Necessity of individual treatments	2	2
Comments: Herbicide applications should be made to trunks of trees that have been cut down (Culley and Hardiman 2007).		
3d. Average distribution	2	1

Table 4.22 Continued

Comments: Callery pear is a tree 10-20 m tall (Vincent 2005). In some areas, large thickets of trees of various ages and sizes have been observed (Vincent 2005).		
3e. Likelihood for reestablishment	2	2
Comments: Extensive long-lasting seed bank allows seedlings to repopulate an area (Culley and Hardiman 2007). Fruits are bird-dispersed (Vincent 2005) and may be reintroduced to a treated area.		
3f. Accessibility of invaded areas	2	1
Comments: Fruits are bird-dispersed (Vincent 2005) and may be spread to areas difficult to access for management. However, *P. calleryana* prefers full sunlight and has a low shade tolerance, which prevents the species from establishing in the understory of a closed canopy cover (Culley and Hardiman 2007).		
3g. Impact on native species and environment	5	2
Comments: Glyphosate and triclopyr herbicide applications may impact non-target species.		
Section 3. Subrank	***20***	***13***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-2
Comments: The annual estimated wholesale value attributed to this species is $3,792,200 (Trueblood 2009).		
4b. Percentage of total sales	-5	-1
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 1-5% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-3***
Overall Score	**100**	**43**
Overall Recommendation: Moderately weedy and recommended for use with specific guidance – These species have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. These plants should not be grown in close proximity to natural areas that have communities similar to those where this plant has been found to naturalize or near natural areas that have sensitive or threatened plants and/or natural communities. (Overall Score: 34 – 66)		
Summary: *Pyrus calleryana* (Callery pear) is moderately weedy in North Carolina and may be recommended for horticultural use with specific guidance by the North Carolina Nursery and Landscape Association. *Pyrus calleryana* is commonly naturalized along roadsides and old fields in North Carolina, and the ecological impacts on natural areas has		

Table 4.22 Continued

not been well-documented. However, *P. calleryana* is highly naturalized in Maryland and Northern Virginia, and may become a more serious weedy species in North Carolina. *Pyrus calleryana* may establish large thorny thickets that impede the establishment of late- to middle-stage successional species in disturbed or open sites and degrade newly restored wetland areas. There is potential for the additional invasion of Callery pear, possibly to natural areas due to the high potential for natural dispersal. However, *P. calleryana* prefers full sunlight and has a low shade tolerance, which prevents the species from establishing in the understory of a closed canopy cover and is generally an early successional species that is outcompeted over time. Management of *P. calleryana* may be costly considering the time and labor required to effectively treat stands of this species. *Pyrus calleryana* is economically valuable to the nursery industry. Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications. Use of seedless cultivars would be desirable when they become available.

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Table 4.23 Species Dataform and Scoresheet for *Spiraea japonica* L. and/or *Spiraea* x *bumalda* Burven [*S. albiflora* x *japonica*] (Japanese Spiraea)

Species Dataform and Scoresheet		
***Spiraea japonica* L. and/or *Spiraea* x *bumalda* Burven [*S. albiflora* x *japonica*] (Japanese Spiraea)**		
Native range: Japan and China Date evaluated: April 7, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Appears on several invasive species lists (not laws) in the Southeastern U.S., including Tennessee (Rank 1 Severe threat), Kentucky (Significant threat), Virginia (Medium invasiveness), and U.S. Forest Service Policy (Category 2, Species suspected to be invasive) (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Cultivated (Weakley 2008).		
3. North Carolina nativity	Y/N	N
Comments: Native of Japan and China (Weakley 2008).		
4. Presence in natural areas	Y/N	Y
Comments: Establishes quickly in disturbed areas and spreads to adjacent woodlands (Remaley 2003).		
5. Non-invasive cultivars	Y/N	N
Comments: Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: Unknown impact on abiotic ecosystem processes.		
1b. Impact on plant community structure	20	5
Comments: Dense growth displaces native herbs and shrubs (Swearingen et al. 2002). Grows rapidly to produce dense stands that outcompete native vegetation (Duever 2003).		
1c. Impact on species of special concern	5	0
Comments: Unknown impact on species of special concern.		
1d. Impact on higher trophic levels	5	0
Comments: Unknown impact on higher trophic levels.		
Section 1. Subrank	***40***	***5***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	0

Table 4.23 Continued

Comments:		
2b. Long-distance dispersal potential	13	13
Comments: Seeds can be dispersed by water (Swearingen et al. 2002). Water-dispersed seeds deposited along streambanks (Duever 2003).		
2c. Reproductive characteristics	8	6
Comments: Tolerates a wide range of environmental conditions (Swearingen et al. 2002). Produces a large number of water-dispersed seeds (Swearingen et al. 2002). Propagated by sucker division and cuttings (Duever 2003).		
2d. Range of communities	6	0
Comments: Roadsides, woodland borders, old home-sites in the Mountains and Piedmont of North Carolina (Weakley 2008). Range of specific community types unknown.		
2e. Similar habitats invaded elsewhere	6	6
Comments: Invades fields, forests, stream and river edges in the Mid-Atlantic United States (Swearingen et al. 2002). Invades stream margins, mesic forest edges and openings, and old fields (Duever 2003). Natural communities of North Carolina (Shafale and Weakley 1990) = River floodplains, low elevation mesic forests, low elevation dry and dry-mesic forest and woodlands.		
Section 2. Subrank	***40***	***25***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: A glyphosate or triclopyr herbicide solution may be applied to large thickets of Japanese spiraea (Remaley 2005).		
3b. Nonchemical control methods	2	1
Comments: Cutting may be effective for small populations, and repeated cutting or mowing will control the spread of Japanese spiraea but not eradicate it (Swearingen et al. 2002). Stems should be cut close to the ground, prior to seed production, at least once per growing season (Remaley 2005).		
3c. Necessity of individual treatments	2	2
Comments: Individual stems should be cut as close to the ground level as possible prior to seed production (Remaley 2005). In areas where foliar application is not appropriate, herbicides may be applied in a cut stump method (Invasive.org 2003).		
3d. Average distribution	2	1
Comments: Depending on the cultivar, plants may be tall or short growing forms (Duever 2003). May establish dense stands (Duever 2003).		
3e. Likelihood for reestablishment	2	2
Comments: Stems may resprout after cutting or mowing, so repeated cutting will be necessary over the long-term (Duever 2003). Japanese spiraea produces an abundance of seeds that remain viable in the soil for many years (Duever 2003). Stems should be cut back at least once per growing season (Remaley 2005).		
3f. Accessibility of invaded areas	2	1

Table 4.23 Continued

Comments: Seeds are dispersed by water and able to germinate in a wide range of soil and light conditions (Swearingen et al. 2002), so individuals may establish in areas difficult to access for treatment.		
3g. Impact on native species and environment	5	2
Comments: Herbicides may have an effect on non-target vegetation (Remaley 2005).		
Section 3. Subrank	***20***	***9***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-4
Comments: The annual estimated wholesale value attributed to this species is $13,694,900 (Trueblood 2009).		
4b. Percentage of total sales	-5	-2
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 6-10% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-6***
Overall Score	**100**	**33**
Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)		
Summary: *Spiraea japonica* and/or *S. x bumalda* (Japanese spiraea) is noninvasive in North Carolina and may be recommended for horticultural use with specific guidance by the North Carolina Nursery and Landscape Association. However, Japanese spiraea was only one point away from being classified as moderately weedy in the assessment. The ecological impacts of Japanese spiraea in natural areas are largely unknown, but dense stands may displace native herbs and shrubs. There is potential for the additional invasion of Japanese spiraea to natural areas due to the high potential for natural dispersal of the seeds via water. The difficulty of managing Japanese spiraea is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of this species. Japanese spiraea is economically valuable to the nursery industry. Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications. Use of seedless cultivars would be desirable when they become available.		

Table 4.23 Continued

References:

Duever, L.C. (2003) Spiraea japonica. FloriData. Tallahassee, Florida. (http://www.floridata.com/ref/S/spir_jap.cfm) Accessed: April 7, 2009.

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Remaley, T. (2005) Fact Sheet: Japanese Spiraea. Plant Conservation Alliance's Alien Plant Working Group. (http://www.nps.gov/plants/alien/fact/spja1.htm) Accessed: April 7, 2009.

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Table 4.24 Species Dataform and Scoresheet for *Styrax japonicus* Siebold and Zucc. (Japanese snowbell)

Species Dataform and Scoresheet		
***Styrax japonicus* Siebold and Zucc. (Japanese snowbell)**		
Native range: China, Japan, Korea Date evaluated: March 12, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments:		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Grown for horticultural use (Gilman and Watson 1994).		
3. North Carolina nativity	Y/N	N
Comments: Native to China, Japan, and Korea (Brand 2001).		
4. Presence in natural areas	Y/N	N
Comments: Not known to widely escape cultivation (Seiler et al. 2008). Tree has little, if any, invasive potential (Gilman and Watson 1994).		
5. Non-invasive cultivars	Y/N	Y
Comments: Assessment indicates that evergreen azaleas are noninvasive in North Carolina.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: No known impact on abiotic ecosystem processes.		
1b. Impact on plant community structure	20	0
Comments: No known impact on plant community structure.		
1c. Impact on species of special concern	5	0
Comments: No known impact on species of special concern or threatened or endangered plants.		
1d. Impact on higher trophic levels	5	0
Comments: No known impact on higher trophic levels.		
Section 1. Subrank	***40***	***0***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	0
Comments:		
2b. Long-distance dispersal potential	13	0
Comments: Fruit does not attract wildlife (Gilman and Watson 1994)		
2c. Reproductive characteristics	8	2

Table 4.24 Continued

Comments: Produces dry rounded drupes (Brand 2001). Propagated by softwood cuttings and seed (Brand 2001). Seeds exhibit a double dormancy but will eventually germinate (Gilman and Watson 1994). Low probability of reseeding in natural areas.		
2d. Range of communities	6	0
Comments: Potential planting range extends throughout North Carolina (Gilman and Watson 1994)		
2e. Similar habitats invaded elsewhere	6	0
Comments:		
Section 2. Subrank	***40***	***2***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments:		
3b. Nonchemical control methods	2	0
Comments:		
3c. Necessity of individual treatments	2	2
Comments: Small tree, 20 - 30 feet in height, (Gilman and Watson 1994) would require individual treatments		
3d. Average distribution	2	0
Comments:		
3e. Likelihood for reestablishment	2	0
Comments:		
3f. Accessibility of invaded areas	2	0
Comments:		
3g. Impact on native species and environment	5	0
Comments:		
Section 3. Subrank	***20***	***2***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	0
Comments: Unknown estimated wholesale value.		
4b. Percentage of total sales	-5	0
Comments: Unknown percentage of total sales.		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***0***

Table 4.24 Continued

Overall Score	**100**	**4**
Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)		
Summary: *Styrax japonicus* (Japanese snowbell) is noninvasive in North Carolina and may be recommended for horticultural use by the North Carolina Nursery and Landscape Association. These species are not known to invade natural areas in North Carolina. These species have little to no negative ecosystem impacts, low potential for long-distance dispersal, and may be easily removed from the landscape. The economic value to the North Carolina nursery industry is unknown.		
References:		

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Table 4.25 Species Dataform and Scoresheet for *Ulmus parvifolia* Jacq (Chinese elm, Lacebark elm)

Species Dataform and Scoresheet		
***Ulmus parvifolia* Jacq (Chinese elm, Lacebark elm)**		
Native range: China and Japan Date evaluated: April 14, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments:		
2. Occurrence in the horticultural trade	Y/N	Y
Comments:		
3. North Carolina nativity	Y/N	N
Comments: Native to China and Japan (Weakley 2008).		
4. Presence in natural areas	Y/N	Y
Comments: Chinese elm escapes from plantings and invades native plant communities (USDA Forest Service 2005).		
5. Non-invasive cultivars	Y/N	N
Comments:		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	4
Comments: Aggressive root systems consume water, nutrients, and space in native plant communities (USDA Forest Service 2005).		
1b. Impact on plant community structure	20	10
Comments: Invades native plant communities (USDA Forest Service 2005). Seedlings are especially aggressive and invasive (SD/ASLA and CNPS 2008).		
1c. Impact on species of special concern	5	0
Comments: Unknown impact on species of special concern.		
1d. Impact on higher trophic levels	5	0
Comments: Unknown impact on higher trophic levels.		
Section 1. Subrank	***40***	***14***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	0
Comments:		
2b. Long-distance dispersal potential	13	8
Comments: Fruit does not attract wildlife (Gilman and Watson 1994). Seeds are winged and wind-dispersed (USDA Forest Service 2005).		

Table 4.25 Continued

2c. Reproductive characteristics	8	6
Comments: Propagated from seed and cuttings (Christman 2006). Grows in most soil types, full sun, and partial shade (Christman 2006). Produces an abundance of seeds (SD/ASLA and CNPS 2008). May resprout from rootsuckers (Gilman and Watson 1994).		
2d. Range of communities	6	0
Comments:		
2e. Similar habitats invaded elsewhere	6	2
Comments: May invade wetlands and riparian areas (SD/ASLA and CNPS 2008). Natural communities of North Carolina (Shafale and Weakley 1990) = River floodplains.		
Section 2. Subrank	***40***	***16***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: Effectively controlled with triclopyr and imazapyr herbicides (USDA Forest Service 2005).		
3b. Nonchemical control methods	2	2
Comments: Small plants may be hand-pulled, but all roots must be removed (USDA Forest Service 2005). Rootsuckers may emerge and would need to be pruned (Gilman and Watson 1994). Large trees are difficult and expensive to remove.		
3c. Necessity of individual treatments	2	2
Comments: Trees may reach heights of 80 feet, but is often seen at 40 to 50 feet (Gilman and Watson 1994). Trees should be treated using stem injections or cut-treat methods (USDA Forest Service 2005). Seedlings and saplings may be treated with basal and foliar sprays (USDA Forest Service 2005).		
3d. Average distribution	2	1
Comments: There is variability in the distribution of this species.		
3e. Likelihood for reestablishment	2	1
Comments: The root system includes several large-diameter roots that may grow great distances from the trunk (Gilman and Watson 1994). Rootsuckers may emerge and would need to be pruned (Gilman and Watson 1994). Seeds are wind-dispersed (USDA Forest Service 2005) and may allow an invasive population to reestablish in a treated area.		
3f. Accessibility of invaded areas	2	0
Comments:		
3g. Impact on native species and environment	5	2
Comments: Herbicide applications may affect non-target species.		
Section 3. Subrank	***20***	***8***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-4
Comments: The annual estimated wholesale value attributed to this species is $13,336,500 (Trueblood 2009).		

Table 4.25 Continued

4b. Percentage of total sales	-5	-3
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 11-25% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-7***
Overall Score	**100**	**31**
Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)		
Summary: *Ulmus parvifolia* (Chinese elm, Lacebark elm) is noninvasive in North Carolina and may be recommended for horticultural use by the North Carolina Nursery and Landscape Association. The ecological impacts of *Ulmus parvifolia* are largely unknown, but seedlings are especially aggressive and invasive in native plant communities. There is potential for the additional invasion of *U. parvifolia* to natural areas due to the wind-dispersal of seeds from ornamental plantings. The difficulty of managing *U. parvifolia* is low to moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of this species. *Ulmus parvifolia* is economically valuable to the nursery industry.		

Table 4.25 Continued

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USDA Forest Service. (2005) Weed of the Week - Chinese Elm, *Ulmus parvifolia*. WOW 04-18-05. Forest Health Staff, Newtown Square, Pennsylvania. (http://www.na.fs.fed.us/fhp/invasive_plants/weeds/chinese-elm.pdf) Accessed: April 14, 2009.

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Table 4.26 Species Dataform and Scoresheet for *Vinca minor* L. (Common periwinkle)

Species Dataform and Scoresheet		
***Vinca minor* L. (Common periwinkle)**		
Native range: Europe Date evaluated: April 14, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Appears on several invasive species lists (not laws) in the Southeastern U.S., including South Carolina (Watch), Tennessee (Rank 2, Significant threat), Kentucky (Significant threat), and Virginia (Low invasiveness) (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Commonly planted in shade gardens and valued in landscaping (Darcy and Burkart 2002).		
3. North Carolina nativity	Y/N	N
Comments: Native of Europe (Weakley 2008).		
4. Presence in natural areas	Y/N	Y
Comments: Persistent and spreading from cultivation in North Carolina (Weakley 2008). Escapes cultivation and invades natural areas in the Mid-Atlantic United States (Swearingen et al. 2002).		
5. Non-invasive cultivars	Y/N	N
Comments:		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	5
Comments: *Vinca minor* may have an allelopathic effect on root growth of native species (Darcy and Burkart 2002).		
1b. Impact on plant community structure	20	15
Comments: *Vinca minor* reduces seedling recruitment, and over time, the increased spread of *V. minor* prevents the replacement of canopy trees and may alter forest succession (Darcy and Burkart 2002). Reduces the recruitment of native tree seedlings by outshading plants on the forest floor (Bultman and DeWitt 2008). *Vinca minor* has a significant negative impact on woody seedlings (Darcy and Burkart 2002). *Vinca minor* forms a dense monotypic evergreen groundcover that displaces native plants (Swearingen et al. 2002).		
1c. Impact on species of special concern	5	0
Comments: Threatens native plants and communities, including native wildflowers (Swearingen et al. 2002). Specific affected species unknown.		
1d. Impact on higher trophic levels	5	1

Table 4.26 Continued

Comments: Infestations of *Vinca minor* alter the assemblage of forest floor spiders, which may have important impacts on forest ecosystem processes including nutrient cycling, decomposition, and mineralization (Bultman and DeWitt 2008).		
Section 1. Subrank	***40***	***21***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	1
Comments: Persistent and spreading from cultivation in North Carolina (Weakley 2008).		
2b. Long-distance dispersal potential	13	0
Comments: Spreads only by vegetative means (Swearingen et al. 2002). Other than planting, it may spread a few inches a year.		
2c. Reproductive characteristics	8	2
Comments: Propagates through vegetative reproduction (Darcy and Burkart 2002). Spreads by vegetative means (Swearingen et al. 2002). Seed viability not reported (Miller 2003).		
2d. Range of communities	6	2
Comments: Forms extensive infestations in open to dense canopied forests in the southeastern United States (Miller 2003). Invades riparian forest areas in North Carolina (Vidra et al. 2006). Natural communities of North Carolina (Shafale and Weakley 1990) = River floodplains		
2e. Similar habitats invaded elsewhere	6	2
Comments: Bultman and DeWitt (2008) studied the effects of *Vinca minor* invasion in a mature forest dominated by American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), and black maple (*Acer nigrum*) in Michigan. Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation dry and dry-mesic forest and woodlands.		
Section 2. Subrank	***40***	***7***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: A glyphosate herbicide may be applied to cut plants (Swearingen et al. 2002). Glyphosate or triclopyr herbicides provide effective control (Miller 2003).		
3b. Nonchemical control methods	2	1
Comments: *Vinca minor* may be removed by digging and mowing, but all parts of the plant must be removed (Swearingen et al. 2002).		
3c. Necessity of individual treatments	2	0
Comments: Dense patches may be treated with herbicide applications.		
3d. Average distribution	2	0
Comments: May establish dense patches in mature forests (Darcy and Burkart 2002).		
3e. Likelihood for reestablishment	2	2
Comments: All plant parts must be removed for effective control (Swearingen et al. 2002).		

Table 4.26 Continued

3f. Accessibility of invaded areas	2	1
Comments: *Vinca minor* may form extensive mats under forest canopies (Miller 2003) that may be difficult to easily access.		
3g. Impact on native species and environment	5	2
Comments: Nontarget plants may be injured or killed by root uptake of herbicides (Miller 2003).		
Section 3. Subrank	***20***	***6***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-5
Comments: The annual estimated wholesale value attributed to this species is $20,552,800 (Trueblood 2009).		
4b. Percentage of total sales	-5	-3
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 11-25% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-8***
Overall Score	**100**	**26**
Overall Recommendation: Noninvasive and recommended for use – These species have limited ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. They may be locally problematic but their reproductive biology and other traits limit their rate of invasion to natural areas. (Overall Score: 0 – 33)		
Summary: *Vinca minor* (Common periwinkle) is noninvasive in North Carolina and may be recommended for horticultural use by the North Carolina Nursery and Landscape Association. *Vinca minor* rarely produces seeds and generally spreads slowly from ornamental plantings. While *V. minor* is rarely found in natural areas in North Carolina, this species may have serious ecological impacts in localized areas. Dense patches of *Vinca minor* reduce seedling recruitment, displace native plants, and over time, the increased spread of *V. minor* may alter forest succession. *Vinca minor* has low long-distance dispersal potential and spreads only by vegetative means. The difficulty of managing *V. minor* is low. *Vinca minor* has high economic value to the nursery industry.		

Table 4.26 Continued

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Invasive.org: The Bugwood Network, USDA Forest Service, and USDA APHIS PPQ. (2009) Invasive Plants of the Thirteen Southern States. (http://www.invasive.org/south/seweeds.cfm) Accessed: March 24, 2009.

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Table 4.27 Species Dataform and Scoresheet for *Vitex rotundifolia* L. f. (Beach Vitex)

Species Dataform and Scoresheet		
***Vitex rotundifolia* L. f. (Beach Vitex)**		
Native range: Eastern Asia Date evaluated: February 26, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	Y
Comments: Class B state noxious weed in North Carolina (NCDA).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Introduced in the mid 1980s as an ornamental and for dune stabilization (Westbrooks and Madsen 2006)		
3. North Carolina nativity	Y/N	N
Comments: Native to Eastern Asia.		
4. Presence in natural areas	Y/N	Y
Comments: Coastal areas of North Carolina.		
5. Non-invasive cultivars	Y/N	N
Comments:		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	10
Comments: Beach vitex produces a chemical that prevents the establishment of sea oats and other native species (Tibbetts 2007). Produces substance that reduces soil moisture and soil's capacity to absorb water (Tibbetts 2007). Waxy leaves create a coating in the leaf litter that further reduces soil moisture absorption (Tibbetts 2007). In the long-term, Beach vitex could disrupt the beach ecosystem (Tibbetts 2007).		
1b. Impact on plant community structure	20	20
Comments: Forms monocultures that completely crowd out native dune plants [Sea oats (*Uniola paniculata*)] and federally endangered sea beach amaranth (*Amaranthus pumilus*) (Westbooks and Madsen, 2006). Outcompetes and inhibits establishment of native species by blocking light (Smith 208).		
1c. Impact on species of special concern	5	5
Comments: Impacts native dune vegetation and federally endangered sea beach amaranth (*Amaranthus pumilus*) (Westbrooks and Madsen, 2006)		
1d. Impact on higher trophic levels	5	5
Comments: Tangles of vegetation alter sea turtle nesting areas (Carolinas Beach Vitex Task Force). Degrades sea turtle habitat with dense foliage and impenetrable, wiry roots (Westbrooks and Madsen 2006).		
Section 1. Subrank	***40***	***40***

Table 4.27 Continued

Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	1
Comments: Occupies a fairly small amount of land, approximately 17 acres, along the coast of North Carolina and South Carolina (Westbrooks and Madsen 2006). In North Carolina, Beach vitex has been documented in New Hanover, Pender, and Onslow Counties (Westbrooks and Madsen 2006).		
2b. Long-distance dispersal potential	13	13
Comments: Viable seeds and vegetative runners spread easily by near shore waves and currents (Westbrooks and Madsen 2006). Storms may wash seeds and shoots great distances (Smith 2008)		
2c. Reproductive characteristics	8	8
Comments: Prolific seed producer, produces vegetative runners, roots at leaf nodes (Westbrooks and Madsen 2006). Produces dry bluish purple berries. Fragments easily and fragments may become established elsewhere.		
2d. Range of communities	6	6
Comments: Coastal dunes (Weakley, 2008). Salt marshes (Carolina Beach Vitex Task Force) = Communities of the coastal zone, Estuarine system, and Marine system (Shafale and Weakley, 1990). Has not naturalized areas of North Carolina beyond the Coastal Plain.		
2e. Similar habitats invaded elsewhere	6	2
Comments: High habitat suitability and expected to grow in at least 5 U.S. hardiness zones (Westbrooks and Madsen 2006). Occupies small percentage of potential ecological range in the U.S. and could grow well in coastal communities throughout the southeastern U.S. (Westbrooks and Madsen 2006).		
Section 2. Subrank	***40***	***30***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: Controlled with glyphosate after cutting-back to the stump (Smith 2008).		
3b. Nonchemical control methods	2	2
Comments: Young seedlings should be removed by hand-pulling (Smith 2008). Seeds and broken shoot fragments that may easily regenerate the plant must be removed entirely from management area (Smith 2008).		
3c. Necessity of individual treatments	2	2
Comments: Plants may be controlled with cut-stem applications of glyphosate after being cut back as close to the ground as possible (Smith 2008).		
3d. Average distribution	2	0
Comments: Monoculture (Smith 2008).		
3e. Likelihood for reestablishment	2	2

Table 4.27 Continued

Comments: Seeds and vegetative runners spread easily by near shore waves and currents (Westbrooks and Madsen 2006). Cut and treated stumps must be monitored monthly for re-sprouting and necessary retreatment (Smith 2008).		
3f. Accessibility of invaded areas	2	2
Comments: Removal of plants in many areas requires landowner permission (SC Native Plant Society)		
3g. Impact on native species and environment	5	5
Comments: Removing plants by herbicides or hand-pulling may disturb fragile beach dune ecosystems (SC Native Plant Society). Native dune species should be re-established following management techniques (Smith 2008).		
Section 3. Subrank	***20***	***13***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-2
Comments: The annual estimated wholesale value attributed to this species is $2,346,600 (Trueblood 2009).		
4b. Percentage of total sales	-5	0
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be <1% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments: Planted for dune stabilization but spread aggressively as an invasive species (Weakley 2008). Beach vitex lacks the fibrous root system of native plants that are better-suited for erosion control (Carolinas Beach Vitex Task Force). Economic value in dune stabilization outweighed by economic cost in the lost value and marketing of ocean front properties and negative impact on multi-million dollar federal beach renourishment projects (Westbrooks and Madsen 2006)		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-2***
Overall Score	**100**	**81**
Overall Recommendation: Highly invasive in coastal areas and not recommended for horticultural use in coastal areas – These species present relatively high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. (Overall Score: 67 – 100)		

Table 4.27 Continued

Summary: *Vitex rotundifolia* (Beach vitex) is highly invasive in coastal areas of North Carolina and may not be recommended for horticultural use by the North Carolina Nursery and Landscape Association in coastal areas. Beach Vitex has some of the most severe environmental impacts among all species examined in the assessment process, but these impacts are limited to coastal areas. Beach Vitex seriously impacts ecosystem processes, plant community structure, native plant species, and higher trophic levels in coastal areas of North Carolina. Beach Vitex has high invasive potential on the coast. The difficulty of managing Beach Vitex is moderate to high considering the availability of control methods and time and labor required to effectively treat this species. Beach Vitex has low economic value to the nursery industry.

References:

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Table 4.28 Species Dataform and Scoresheet for *Wisteria sinensis* (Sims) DC and/or *Wisteria floribunda* (Willd.) DC (Chinese and/or Japanese wisteria)

Species Dataform and Scoresheet		
***Wisteria sinensis* (Sims) DC and/or *Wisteria floribunda* (Willd.) DC (Chinese and/or Japanese wisteria)**		
Native range: China and Japan Date evaluated: April 14, 2009		
	Answer Choices	**Response**
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Comments: Appears on several invasive species lists (not laws) in the Southeastern U.S., including South Carolina (Severe threat), Tennessee (Rank 2, Significant threat), and the USFS Policy (Category 2, Species suspected to be invasive) (Invasive.org 2009). Virginia has listed Japanese Wisteria as a plant with Low invasiveness and Chinese Wisteria as a plant with Medium invasiveness. Chinese wisteria appears on invasive species lists from Georgia (Top ten) and Florida (Category II increased frequency but not altering plant community).		
2. Occurrence in the horticultural trade	Y/N	Y
Comments: Commonly cultivated (Weakley 2008).		
3. North Carolina nativity	Y/N	N
Comments: Native to China and Japan (Weakley 2008).		
4. Presence in natural areas	Y/N	Y
Comments: Escaped to urban, suburban, and rural forests and woodlands in North Carolina (Weakley 2008). Exotic Wisteria may successfully invade natural habitats throughout the United States (Trusty et al. 2007a). Distributed along roadsides throughout the Southeastern U.S. (Trusty et al. 2007a). Common along forest edges, roadsides, ditches, and rights-of-way (Remaley 2005).		
5. Non-invasive cultivars	Y/N	N
Comments:		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	0
Comments: Unknown impact on abiotic ecosystem processes.		
1b. Impact on plant community structure	20	15
Comments: Infestations of Wisteria strangle or shade-out native trees and shrubs (Trusty et al. 2007b). Few or no other plant species are found in dense thickets of Wisteria (Trusty et al. 2007b). Exotic Wisteria displaces native herbs, vines, shrubs and trees (Swearingen et al. 2002). Wisteria may climb and kill trees, which opens the forest canopy and increases light levels on the forest floor (Swearingen et al. 2002).		
1c. Impact on species of special concern	5	0

Table 4.28 Continued

Comments: Unknown impact on species of special concern.		
1d. Impact on higher trophic levels	5	0
Comments: Unknown impact on higher trophic levels.		
Section 1. Subrank	***40***	***15***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	1
Comments: Wisteria continues to spread in the southeastern United States in an ongoing invasion of watersheds and managed forests (Trusty et al. 2007b).		
2b. Long-distance dispersal potential	13	8
Comments: Wisteria seeds may be carried great distances in water (Swearingen et al. 2002). Large seeds are water-dispersed along riparian areas and not animal-dispersed (Miller 2003).		
2c. Reproductive characteristics	8	6
Comments: Easily propagated, grows vigorously (Trusty et al. 2007a). Propagated from cuttings and seed (Trusty et al. 2007b). Regenerates after being cut (Trusty et al. 2007b). Shade tolerant and capable of growing in a variety of soil and moisture types (Trusty et al. 2007b). Runners root at nodes (Miller 2003).		
2d. Range of communities	6	2
Comments: Escaped to urban, suburban, and rural forests and woodlands in North Carolina (Weakley 2008). Distributed in natural and managed forests, and riparian areas throughout the Southeastern U.S. (Trusty et al. 2007a). Natural communities of North Carolina (Shafale and Weakley 1990) = River floodplains		
2e. Similar habitats invaded elsewhere	6	0
Comments:		
Section 2. Subrank	***40***	***17***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Comments: Systemic herbicides, such as triclopyr may be effective for large infestations (Swearingen et al. 2002). Systemic herbicides, such as glyphosate or triclopyr may be applied to the cross sections of vines that are established around native plants or where they have grown into the canopy (Remaley 2005).		
3b. Nonchemical control methods	2	1
Comments: Small infestations may be cut (Swearingen et al. 2002). Small populations of cut or trailing vines may be cut back as close to the root collar as possible, but this technique is labor intensive and must be repeated until root stores are depleted (Remaley 2005).		
3c. Necessity of individual treatments	2	2

Table 4.28 Continued

Comments: In areas where vines have become established around desirable native vegetation or climbed into the canopy, stems should be cut close to ground level and treated with herbicides in a cut stump application (Remaley 2005). Stump treatments should precede foliar applications to avoid damage to surrounding native plants (Remaley 2005).		
3d. Average distribution	2	1
Comments: Wisteria may form dense thickets (Trusty et al. 2007b).		
3e. Likelihood for reestablishment	2	2
Comments: Regenerates after being cut (Trusty et al. 2007b). Wisteria will resprout after cutting if root stores are left intact (Remaley 2005)		
3f. Accessibility of invaded areas	2	1
Comments: Wisteria is shade tolerant and may be widespread in forested habitats (Trusty et al. 2007b).		
3g. Impact on native species and environment	5	2
Comments: Resembles American wisteria (*Wisteria frutescens*) and trumpet creeper (*Campsis radicans*) (Swearingen et al. 2002). Nontarget plants may be harmed or killed by herbicides (Miller 2003).		
Section 3. Subrank	***20***	***9***
Section 4. Benefits and Value		
4a. Estimated wholesale value	-7	-3
Comments: The annual estimated wholesale value attributed to this species is $8,541,600 (Trueblood 2009).		
4b. Percentage of total sales	-5	-1
Comments: Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be 1-5% (Trueblood 2009).		
4d. Ecosystem services	-1	0
Comments:		
4e. Wildlife habitat	-1	0
Comments:		
4f. Cultural and social benefits	-1	0
Comments:		
Section 4. Subrank	***-15***	***-4***
Overall Score	**100**	**37**

Table 4.28 Continued

Overall Recommendation: Moderately weedy and recommended for use with specific guidance – These species have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value. These plants should not be grown in close proximity to natural areas that have communities similar to those where this plant has been found to naturalize or near natural areas that have sensitive or threatened plants and/or natural communities. (Overall Score: 34 – 66)
Summary: *Wisteria floribunda and/or W. sinensis* (Japanese and/or Chinese wisteria) is moderately weedy in North Carolina and may be recommended for horticultural use with specific guidance by the North Carolina Nursery and Landscape Association. Exotic wisteria affects urban, suburban, and rural forests and woodlands in North Carolina. In the Southeastern U.S., exotic Wisteria is distributed in natural and managed forests, especially in riparian areas, and spreads from ornamental plantings. The ecological impacts of exotic Wisteria are largely unknown, but dense thickets of this species may shade out native herbs and shrubs and displace native vegetation. Wisteria may climb and kill trees, which opens the forest canopy and increases light levels on the forest floor. The difficulty of managing Wisteria is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of this species. *Wisteria floribunda and W. sinensis* are economically valuable to the nursery industry.
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Chapter 5

A comparison of invasive plant assessment systems using the test species, *Berberis thunbergii* (Japanese barberry), *Ligustrum sinense* (Chinese privet), and *Miscanthus sinensis* (Chinese silvergrass) in North Carolina

ABSTRACT

The potential invasiveness of three species, *Ligustrum sinense* (Chinese privet), *Berberis thunbergii* (Japanese barberry), and *Miscanthus sinensis* (Chinese silvergrass) was examined in North Carolina using the criteria of existing invasive assessment systems from California, Florida, Michigan, NatureServe, and North Carolina. Each species was evaluated within North Carolina. The assessment systems generated similar rankings and overall conclusions regarding the potential invasiveness of the test species. However, the North Carolina Invasive Species Assessment System generally had fewer unknown responses, provided more specific details on the range of natural communities where these plants are found in North Carolina, and included data on commercial value for North Carolina. The continued development and refinement of state-specific assessment systems will provide more detailed and relevant information regarding potential invasiveness in natural areas within regions.

INTRODUCTION

Five different assessment systems were utilized and compared to evaluate the potential invasiveness of three species, *Ligustrum sinense* Lour. (Chinese privet), *Berberis thunbergii* DC (Japanese barberry), and *Miscanthus sinensis* Andersson (Chinese silvergrass)

in North Carolina. The North Carolina Invasive Species Assessment System (Trueblood et al. 2009a) was adopted and modified from existing assessment systems developed by researchers and plant pest advisory groups in California (Warner et al. 2003), Michigan (Schutzki 2004), Florida (Fox et al. 2005), and by the nonprofit organization, NatureServe (Morse et al. 2004). The California Exotic Pest Plant Council and Southwest Vegetation Management Association developed a set of criteria for use in California, Arizona, and Nevada to support categorized lists of invasive plants affecting wildlands (Warner et al. 2003). The Michigan Invasive Plant Council developed an assessment system to evaluate the environmental impact of invasive species in natural areas, managed landscapes, and agricultural production fields within Michigan (Schutzki 2004). The Florida model was developed by Fox et al. (2005) to develop categorized lists of non-native plants that invade natural areas of Florida. The NatureServe model was developed by Morse et al. (2004) to assess and categorize non-native invasive plants according to their ecological impacts in a large geographical region.

Other states have recently adapted available invasive assessment tools to address regional conservation objectives and environmental conditions. Northam et al. (2005) used the criteria developed in California by Warner et al. (2003) to categorize invasive nonnative plants that threaten wildlands in Arizona. While the criteria are entirely derived from the California model, Northam et al. (2005) supplemented the original criteria with unique user guidelines and notes to assist Arizona plant evaluators. The Indiana Invasive Plant Species Assessment Working Group (IPSAWG 2005) adopted the Florida model (Fox et al. 2005) and criteria for use in Indiana.

Although all of the models are designed to identify and rank invasive species, the specific approaches, questions, categories, formats, and emphases vary considerably (Trueblood 2009b). The objective of this project was to compare selected assessment systems by evaluating a set of species and examining the conclusions and recommendations generated by each protocol.

METHODS

The potential invasiveness of three escaped ornamental species in North Carolina were evaluated using the criteria of the North Carolina, Florida, California, Michigan, and NatureServe invasive assessment systems. The species selected for evaluation, *Ligustrum sinense* (Chinese privet), *Berberis thunbergii* (Japanese barberry), and *Miscanthus sinensis* (Chinese silvergrass), have been found to naturalize in NC and other regions (Invasive.org 2009). Evaluations for each of the test species were based on data and assessments completed within North Carolina. Supporting information from scientific literature, online databases, books, and other resources was collected and documented. For each assessment question, a response was selected that corresponds with a particular point value or alphabetical ranking. If information was unavailable to answer a particular question, the response was marked as unknown. After supporting information was reviewed, scores for each criterion were determined, and an overall score was compiled from composite section scores.

RESULTS

The purpose, intended scale of application, and criteria of the selected assessment protocols are summarized in Tables 5.1 and 5.2.

Table 5.1 Purpose and intended scale of application of selected assessment systems

Name of System	Purpose	Scale
California Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands (Warner et al. 2003)	Develop categorized lists for use by land managers, environmental consultants, and legislators of invasive plant species affecting wildlands in CA, AZ, and NV.	State
Florida IFAS Assessment of the Status of Non-Native Plants in Florida's Natural Areas (Fox et al. 2005)	Categorize non-native plants in natural areas in FL for use in IFAS Extension publications	State
Michigan Plant Invasiveness Assessment System (Schutzki et al. 2004)	Provide evaluation information for the Michigan Invasive Plant Council (MIPC) and MIPC recommended action plans	State
NatureServe: An Invasive Species Assessment Protocol (Morse et al. 2001)	Assess and categorize non-native species in conservation areas	National or state
North Carolina Invasive Species Assessment System (Trueblood et al. 2009a)	Assess the potential invasiveness of ornamental plants suspected to affect natural areas in the state and provide information to the NC Nursery and Landscape Association	State

Table 5.2 Components and primary criteria of selected assessment systems

Assessment Components	California (Warner et al. 2003)	Florida (Fox et al. 2005)	Michigan (Schutzki et al. 2004)	NatureServe (Morse et al. 2001)	North Carolina (Trueblood et al. 2009a)
Ecological impacts					
Abiotic processes	Yes	Yes	Yes	Yes	Yes
Community structure	Yes	Yes	Yes	Yes	Yes
Higher tropic levels	Yes	No	No	No	Yes
Endangered species	No	Yes	Yes	Yes	Yes
Hybridization	Yes	Yes	No	No	No
Invasive Potential or Current Distribution					
Role of Disturbance	Yes	No	No	No	No
Rate of Invasion	Yes	Yes	Yes	Yes	Yes
Reproductive potential	Yes	Yes	Yes	Yes	Yes
Human-caused dispersal	Yes	No	Yes	Yes	Yes
Natural dispersal	Yes	Yes	Yes	Yes	Yes
Range of communities	No	Yes	Yes	Yes	Yes
Other regions invaded	Yes	Yes	Yes	Yes	Yes
Management Difficulty					
Herbicide availability	No	Yes	Yes	Yes	Yes
Manual control	No	No	Yes	Yes	Yes
Retreatment or time required for management	No	No	Yes	Yes	Yes
Impact on native species	No	Yes	Yes	Yes	Yes

Table 5.2 Continued

Specific estimated cost	No	Yes	No	No	No[1]
Restoration requirements	No	Yes	No	No	No
Accessibility	No	Yes	No	Yes	Yes
Number or distribution of populations	No	Yes	No	No	Yes
Economic Benefits and Value					
Economic value	No	Yes	Yes	No	Yes
Sold in retail stores	No	Yes	Yes	No	No
Wholesale value	No	No	No	No	Yes
% of total sales	No	No	No	No	Yes
Ecosystem services	No	No	Yes	No	No
Wildlife habitat	No	No	Yes	No	Yes
Cultural, social benefits	No	No	Yes	No	Yes

[1]Cost is estimated indirectly.

Criteria utilized by these assessment systems were similar, which is logical considering most are modification of pre-existing protocols. Differences between models can generally be rationalized based upon the core purposes for which they were designed. For example: a model designed by and for an exotic pest plant council (EPPC) might omit consideration of potential economic value derived from the sale or use of potentially invasive species. Assessment protocols also may organize biological or ecological characters in different ways. For example, the Florida model considers reproductive potential and potential for natural dispersal within a "management difficulty" section whereas other

models place these characters within other categories. The assessment systems from North Carolina, Florida, California, Michigan, and NatureServe generated relatively similar overall conclusions regarding the potential invasiveness of three species, *Ligustrum sinense* (Chinese privet), *Berberis thunbergii* (Japanese barberry), and *Miscanthus sinensis* (Chinese silvergrass) in North Carolina (Table 5.3). Each assessment required approximately 10 to 14 hours to complete and involved the collection of supporting information, review of documentation, response to criteria, and the calculation of index category rankings and an overall recommendation.

-- *Berberis thunbergii* (Japanese barberry)

The North Carolina, Florida, California, Michigan, and NatureServe assessment protocols indicated that *Berberis thunbergii* was moderately weedy or invasive in natural areas in North Carolina. The California model categorized *B. thunbergii* with a medium level of invasiveness in North Carolina, since the model criteria identified substantial and apparent, but not severe, ecological impacts and moderate to high rates of dispersal (Appendix B1). *Berberis thunbergii* received an additional designation from the California model as an 'Alert' species to notify land managers that *B. thunbergii* may rapidly invade additional ecosystems. The Florida model concluded that *B. thunbergii* may be eligible for specified and limited use considering the moderate ecological impacts, low potential for expansion, low management difficulty, and high economic value associated with the species (Appendix B2). The Michigan model concluded that *B. thunbergii* could be moderately invasive in natural systems in North Carolina (Appendix B3). The medium overall invasiveness rank generated by the Michigan model was based on criteria that identified

moderate reproductive ability and impacts to natural systems, increasing distribution, and available control methods for *B. thunbergii*. The NatureServe assessment protocol categorized *B. thunbergii* as having a range of invasiveness, and assigned a Low/Medium Invasiveness Rank to the species (Appendix B4). The NatureServe model indicated that *B. thunbergii* represents a relatively low to moderate threat to native species and ecological communities. The North Carolina invasive assessment determined that *B. thunbergii* was moderately weedy and may be recommended for use with specific guidance, since *B. thunbergii* has less than high ecological impact, distribution and invasive potential, and management difficulty in relation to economic value (Appendix B5).

-- *Ligustrum sinense* (Chinese privet)

The available assessment models determined that *Ligustrum sinense* (Chinese privet) was moderately to highly invasive in natural systems. The California model assigned *L. sinense* an overall plant score of Medium, with an Alert Status, indicating that *L. sinense* presents substantial ecological impacts and may potentially invade additional ecosystems (Appendix B6). The Florida model concluded that *L. sinense* may be eligible for a proposal for specified and limited use considering the mid-level ecological impacts and high economic value associated with *L. sinense* (Appendix B7). The Michigan model determined that *L. sinense* has high potential invasiveness in natural systems (Appendix B8), whereas the NatureServe model scored *L. sinense* as a plant with medium invasiveness (Appendix B9). The North Carolina model criteria concluded that *L. sinense* is moderately weedy to highly invasive due to the negative environmental impacts associated with this species, great potential for long-distance dispersal, yet considerable economic value (Appendix B10). In

the North Carolina model, *L. sinense* scored one point below the most highly invasive categorization, so a range of scores from moderately weedy to highly invasive may be assigned for this species. Additional data on the species' range, expansion, or impact on native ecosystems may elevate this species to the highly invasive ranking.

-- *Miscanthus sinensis* (Chinese silvergrass)

Most assessment protocols determined that the invasiveness and environmental impacts associated with *Miscanthus sinensis* (Chinese silvergrass) in natural areas was low or insignificant in North Carolina. Only the NatureServe model (Appendix B11) indicated that *M. sinensis* could represent a moderate threat to native species and ecological communities. However, the Medium Invasiveness Rank generated by the NatureServe protocol was paired with an Insignificant Invasiveness Rank, since the assessment for this species included numerous unknown responses. The California assessment assigned an overall plant score of Low to *M. sinensis*, since this species had minor ecological impacts, low rates of invasion in non-disturbed natural areas, and limited ecological amplitude and distribution (Appendix B12). The Florida protocol determined that *M. sinensis* was not considered a problem species, since the assessment criteria indicated that *M. sinensis* had low ecological impact, potential for expansion, and management difficulty (Appendix B13). The Michigan assessment concluded that the overall invasiveness rank associated with *M. sinensis* was insignificant, since the species presented no significant impact to natural systems and showed high potential for control (Appendix B14). The North Carolina assessment determined that *M. sinensis* was noninvasive and may be recommended for horticultural use, since the

species has had limited impact in natural areas in North Carolina (Appendix B15) and high commercial value.

Table 5.3 Species evaluations and overall recommendations generated by selected assessment systems

Test species	Overall Recommendation				
	California (Warner et al. 2003)	Florida (Fox et al. 2005)	Michigan (Schutzki 2004)	NatureServe (Morse et al. 2004)	North Carolina (Trueblood 2009)
Berberis thunbergii (Japanese barberry)	Medium invasiveness, Alert status	Specified, limited use	Medium invasiveness	Low/Medium invasiveness	Moderately weedy
Ligustrum sinense (Chinese privet)	Medium invasiveness, Alert status	Specified, limited use	High invasiveness	Medium invasiveness	Moderately weedy to Highly invasive
Miscanthus sinensis (Chinese silvergrass)	Low invasiveness	Not a problem	Insignificant impact	Insignificant/ Medium invasiveness	Noninvasive

DISCUSSION

All of the assessment systems tested in this study were based upon systematic criteria designed for a specific region and require supporting documentation to complete an assessment. While it is important to address the most appropriate questions about invasiveness, including ecological impact, distribution, and management difficulty, evaluators within each state must be able to access information that addresses these criteria on a local level. In general, assessment systems that required more detailed answers resulted in more data gaps consequently resulting in lower invasive potential scores.

In testing the available assessments for use in North Carolina, it was difficult to answer criteria regarding distribution, ecological amplitude, reproductive potential, and

management difficulty when the criteria were very specific (i.e., number of seeds produced per meter annually or dollar amounts associated with management) and not supported by published information. For example, the California model, includes a section on ecological amplitude and distribution with criteria that examine the percentage of an ecological type infested by a species. Plant evaluators in California have online access to statewide surveys of wildland weed distribution, data, and maps generated by the California Invasive Plant Council, University of California Davis, and the California Department of Food and Agriculture (Cal-IPC 2009). In addition, the California model incorporates interviews with people familiar with the species' occurrence and discussion among Invasive Plant Working Group members to answer questions regarding the environmental impacts, estimated frequency, ecological amplitude, and distribution of a species.

In contrast, detailed statewide frequency information is largely unavailable for each ecological type affected within North Carolina, and the North Carolina assessment criteria were intended to be answered based on published scientific information. Distribution data within North Carolina natural areas is a large data-gap that is required to successfully complete ecological amplitude and distribution criteria of other assessment models. Without detailed distribution data, questions remain unanswered and unknown responses potentially distort overall species recommendations.

Criteria regarding reproductive biology are useful because they may be a measure of invasive potential, but questions involving precise numbers of seeds or detailed quantitative biological information are difficult to answer. Authors and literature resources often describe reproductive traits qualitatively (i.e., seeds produced in great abundance, huge seedbank), and

some criteria appear to be too detailed and precise to have documented supporting information that specifically address each reproductive attribute. With detailed criteria that cannot be answered, a species does not receive points or a score for that section, which misrepresents reproductive potential. Without supporting documentation, the evaluator is forced to mark the question 'unknown,' even when the species is generally accepted to have high reproductive potential that is not explicitly defined by the criterion. The North Carolina Invasive Species Assessment System generally has criteria to evaluate reproductive characteristics associated with invasive plant species that may be more readily documented. In the North Carolina model, points are assigned for qualitative attributes such as: reproduces readily by seed, germinates in a wide range of conditions, and reproduces readily by vegetative means.

Some criteria from other models regarding management difficulty were difficult to complete as well. For example, the Florida model includes a section that addresses factors that increase the difficulty of managing potentially invasive species. Responses are arranged in a yes/no format and affiliated with strict point values, rather than a range of points assigned to different levels of management difficulty. An evaluator must estimate the total costs of control and total area over which management would have to be conducted within the state. However, state and species-specific management information is not readily available and published in North Carolina. In contrast to the Florida model, management difficulty may be estimated within the North Carolina model by considering herbicide availability, nonchemical control methods, necessity of individual treatments, average distribution of the species, likelihood for reestablishment, and accessibility of invaded areas.

These criteria include a range of responses and may be more easily answered to estimate the difficulty of managing potentially invasive species within North Carolina.

Consideration of benefits and economic value varied among models. The Florida model assesses the state-wide distribution within the nursery trade of potentially invasive species and generates a high/low value index associated with these species. The North Carolina protocol incorporates a unique component to address the economic value of potentially invasive plant species and directly includes an economic rating that offsets risk, as a factor in the overall recommendation for a species. Economic values for potential invasive plants were determined through a survey of members of the North Carolina Nursery and Landscape Association (Trueblood 2009c). In the North Carolina model, economic value was based upon wholesale farmgate sales. In contrast, the Florida and Michigan models based the economic value upon retail sales. Both approaches may have merit depending on the specific goal and ease of data collection.

The NatureServe assessment model was used to evaluate these three species and found similar invasiveness ratings on a national level, comparable with the assessment results when it was applied strictly to North Carolina (NatureServe Explorer 2009). However, the NatureServe assessment categorized *M. sinensis* as moderately invasive, rather than noninvasive, due to higher estimated distribution and abundance across the entire United States. The Florida assessment model evaluated *L. sinense* and rated this species as Invasive in the Northern and Central regions of Florida due to higher ecological impacts and invasive potential in these areas (IFAS Assessment of Non-Native Plants in Florida's Natural Areas 2009). Applying the Florida model in North Carolina, *L. sinense* received a Moderately

Weedy to Invasive rating throughout the state. Both the Florida and North Carolina models concluded that *M. sinensis* was noninvasive in Florida and North Carolina.

The assessment systems from North Carolina, Florida, California , Michigan, and NatureServe generated relatively similar overall conclusions regarding the potential invasiveness of three species, *Ligustrum sinense* (Chinese privet), *Berberis thunbergii* (Japanese barberry), and *Miscanthus sinensis* (Chinese silvergrass) in North Carolina. These results are not surprising, since many of these models have been adapted from earlier models, most notably NatureServe. However, the North Carolina protocol generally had fewer unknown responses, provided more specific details on the range of natural communities where these plants are found in North Carolina, and included data on commercial value for North Carolina, ultimately providing perceived improvements to state-specific recommendations for North Carolina.

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DISCUSSION AND CONCLUSIONS

We developed a systematic assessment protocol to evaluate the potential invasiveness of plant species sold in the North Carolina nursery industry. The North Carolina assessment was designed to assess both the environmental risks and overall benefits associated with potentially invasive ornamental plant species through a system of weighted criteria. The assessment results are intended to allow the North Carolina Nursery and Landscape Association (NCNLA) to advise their members regarding plants that are found to be invasive. The North Carolina assessment protocol was adapted from several existing invasive assessment models that have been developed by other states and environmental groups for the evaluation and categorization of potentially invasive plant species. The criteria of these state and national assessment systems were compared and integrated to develop an assessment tool specifically tailored for the North Carolina nursery industry.

Twenty-five nonnative plant species were evaluated using the state-specific assessment. Of the 25 taxa, 18 species are potentially invasive ornamental plant species that have naturalized, at some level, in North Carolina. According to the overall score combined from the four index categories, species were classified as invasive, moderately weedy, or of minimal concern. Three species, *Celastrus orbiculatus* (Oriental bittersweet), *Lonicera japonica* (Japanese honeysuckle), and *Vitex rotundifolia* (Beach Vitex) were categorized as highly invasive. While *C. orbiculatus* and *V. rotundifolia* are sold in the North Carolina nursery industry, these species are regulated as noxious weeds within the state (NCDA&CS 2009). In addition, the environmental impacts associated with *V. rotundifolia* have been documented exclusively in coastal areas of North Carolina, rather than across the state.

Lonicera japonica is generally presumed to be invasive in North Carolina, and it is not a popular ornamental plant species.

Nine species evaluated using the North Carolina assessment were categorized as Moderately Weedy. These species have less than high ecological impact, distribution and invasive potential, and management difficulty in relation to their economic value. All of the Moderately Weedy species are sold in the North Carolina nursery industry and either identified by land managers in North Carolina as potentially invasive plants or categorized as invasive species in other state assessments. Thirteen species were classified as Noninvasive with limited ecological impact, distribution and invasive potential, and management difficulty. The majority of the Noninvasive species are nonnative plants with very high economic value in the North Carolina nursery industry that have not been shown to invade natural areas.

The North Carolina Invasive Species Assessment System incorporates a unique component to address the economic value of potentially invasive plant species and directly includes the economic rating, in the form of negative point values, as a factor in the overall recommendation for a species. Among agricultural sectors in North Carolina, the nursery and floriculture industry captured the majority (29 percent) of total crop sales in 2007 with an estimated wholesale value of $890 million (North Carolina Agricultural Statistics 2008). Considering the large economic contribution of the nursery industry, an assessment system uniquely tailored to the horticultural industry would include criteria that address the economic benefits of these potentially invasive ornamental plants. In this way, economic benefits could be weighed against the ecological risk of invasiveness.

We developed a short online grower survey for NCNLA members to provide information on plant production and general sales. The survey results were intended to fill the data-gap regarding the economic value associated with potentially invasive ornamental plant species sold in North Carolina. We found that the 18 potentially invasive ornamental plant species examined in this study have substantial value to the nursery industry in North Carolina. Total statewide wholesale value attributed to these potentially invasive plants was estimated at $206 million, or 23.1% of state-wide industry sales.

The results of our survey were used to evaluate species using the North Carolina invasive protocol. Species with high economic value in the North Carolina nursery industry were identified and received negative point values in the Benefits and Value section of the assessment protocol. These negative point values subtracted from the overall invasiveness rating and likelihood that a species may be categorized as highly invasive. In one instance, the negative point values associated with economic value prevented the species from receiving a highly invasive rating and possible do not sell recommendation. Due to the negative point values associated with economic value, *Ligustrum sinensis* (Chinese privet) was classified as moderately weedy and remained one point away from the highly invasive category.

The response rate for the NCNLA member survey was lower than expected, and our economic impact values are only a general estimate of the production and percentage of total annual sales attributed to potentially invasive ornamental species. The economic impact of potentially invasive ornamental plants in North Carolina could be better understood with greater survey response rates and additional economic data. The survey results, and in turn,

the North Carolina invasive assessment protocol, could be strengthened with increased responses from NCNLA members.

Furthermore, the process of assessing invasiveness of ornamental plants within North Carolina may be strengthened with additional research in invasive biology as it relates to the horticultural industry. In particular, more information is needed regarding environmental impacts, including the impact on abiotic ecosystem processes and plant community structure, and distribution within natural areas. Distribution data within North Carolina natural areas is a large data-gap that is required to successfully complete ecological amplitude and distribution criteria. Without ecological impact information and detailed distribution data, questions remain unanswered and unknown responses may potentially distort overall species recommendations.

The North Carolina assessment provides a tool to evaluate the invasiveness of ornamental plants and develop a categorized listing of invasive ornamental plant species. By modifying the criteria utilized in existing assessments and tailoring the model for the North Carolina horticultural trade, we have created an assessment system unique to the nursery industry that may be completed using resources available in North Carolina. The assessment results are intended to allow the NCNLA to advise their members regarding plants that are found to be invasive.

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APPENDICES

Appendix A1. Assessing the Economic Value of Potentially Invasive Plants Sold in the North Carolina Horticultural Industry.

Appendix A1. Assessing the Economic Value of Potentially Invasive Plants Sold in the North Carolina Horticultural Industry

Survey Instructions and Questions

Thank you for supporting this NCNLA-funded research project at North Carolina State University.

Please answer all questions as they relate to your nursery for 2008.

All responses will be strictly anonymous and will be used for this NCSU research project only.

You are not required to complete this survey as part of your membership in the NCNLA. Participation is optional.

If you have any questions regarding the survey, please contact Ms. Clara Englert (caengler@ncsu.edu).

1. What is the estimated percentage of your total annual sales attributed to Mimosa (*Albizia julibrissin*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Mimosa.

2. What is the estimated percentage of your total annual sales attributed to Evergreen Azaleas, including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Evergreen Azaleas.

3. What is the estimated percentage of your total annual sales attributed to the sale of Japanese Barberry (*Berberis thunbergii*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Japanese Barberry.

4. What is the estimated percentage of your total annual sales attributed to Butterfly Bush (*Buddleja davidii*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Butterfly Bush.

5. What is the estimated percentage of your total annual sales attributed to *Camellia* species and hybrids?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell *Camellia*.

6. What is the estimated percentage of your total annual sales attributed to Chinese Bittersweet (*Celastrus orbiculatus*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%

6 - 10%
1 - 5%
< 1%
0% - We do not sell Chinese Bittersweet.

7. What is the estimated percentage of your total annual sales attributed to Thorny Elaeagnus (*Elaeagnus pungens* and/or *Elaeagnus x ebbingei*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Thorny Elaeagnus.

8. What is the estimated percentage of your total annual sales attributed to Burning Bush (*Euonymus alatus*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Burning Bush.

9. What is the estimated percentage of your total annual sales attributed to English Ivy (*Hedera helix*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell English Ivy.

10. What is the estimated percentage of your total annual sales attributed to Japanese Privet (*Ligustrum japonicum*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Japanese Privet.

11. What is the estimated percentage of your total annual sales attributed to Chinese Privet (*Ligustrum sinense*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Chinese Privet.

12. What is the estimated percentage of your total annual sales attributed to Leatherleaf Mahonia (*Mahonia bealei*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Leatherleaf Mahonia.

13. What is the estimated percentage of your total annual sales attributed to the sale of Maiden Grass (*Miscanthus sinensis*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%

6 - 10%
1 - 5%
< 1%
0% - We do not sell Maiden Grass.

14. What is the estimated percentage of your total annual sales attributed to Heavenly Bamboo (*Nandina domestica*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Heavenly Bamboo.

15. What is the estimated percentage of your total annual sales attributed to *Liriope* and/or *Ophiopogon* species, including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell *Liriope* and/or *Ophiopogon* species.

16. What is the estimated percentage of your total annual sales attributed to Callery Pear (*Pyrus calleryana*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Callery Pear.

17. What is the estimated percentage of your total annual sales attributed to Japanese Spiraea (*Spiraea japonica* and/or *S. x bumalda*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Japanese Spiraea.

18. What is the estimated percentage of your total annual sales attributed to Lace-bark Elm (*Ulmus parvifolia*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Lace-bark Elm.

19. What is the estimated percentage of your total annual sales attributed to Common Periwinkle (*Vinca minor*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Common Periwinkle.

20. What is the estimated percentage of your total annual sales attributed to Beach Vitex (*Vitex rotundifolia*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%

6 - 10%
1 - 5%
< 1%
0% - We do not sell Beach Vitex.

21. What is the estimated percentage of your total annual sales attributed to Japanese and/or Chinese Wisteria (*Wisteria floribunda* and/or *W. sinensis*), including cultivars?

> 75%
51 - 75%
26 - 50%
11 - 25%
6 - 10%
1 - 5%
< 1%
0% - We do not sell Japanese and/or Chinese Wisteria.

Please provide some general information about your business.

22. Is your nursery classified as a wholesale business, retail, or both wholesale and retail?

Wholesale
Retail
Both Wholesale and Retail

23. What was the total gross value in sales for nursery crops from 2008?

$1 - $2,499
$2,500 - $9,999
$10,000 - $39,999
$40,000 - $99,999
$100,000 - $199,999
$200,000 - $499,000
$500,000 - $999,999
$1,000,000 - $2,000,000
Other

24. How many individuals are employed by your nursery?

> 50
40 – 49
30 – 39
20 – 29

10 – 19
1 – 9

Appendix B1. Testing the California assessment system with *Berberis thunbergii*

Appendix B1. Testing the California assessment system with *Berberis thunbergii*

Model: Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands

(Warner et al. 2003)

Species: *Berberis thunbergii* DC. (Japanese barberry)

Section 1. Ecological Impact
Question 1.1 Impact on abiotic ecosystem processes *Score: C*
Identify ecosystem processes impacted: Minor alteration to soil dynamics.
Rationale: Alters soil chemistry (raises soil pH and nitrification) and microbial communities of deciduous forests in New Jersey (Ehrenfeld et al. 2001). Impacts soil ecosystem, nitrogen cycling, soil biota, soil structure, and function (Kourtev 2002).
Question 1.2 Impact on plant community composition, structure, and interactions *Score: B*
Identify type of impact or alteration: Moderate alteration of plant community composition
Rationale: *Berberis thunbergii* has the ability to outcompete native species in the understory (Xu et al. 2007). Biomass of co-occurring species is suppressed by Japanese barberry (Silander and Klepeis 1999).
Question 1.3 Impact on higher trophic levels *Score: C*
Identify type of impact or alteration: Minor alteration of higher trophic level populations
Rationale: Impacts earth worm populations (Ehrenfeld at al. 2001).
Question 1.4 Impact on genetic integrity *Score: D*
Identify impacts: No known hybridization
Overall Impact Rating: B
Section 2. Invasive Potential
Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score: A*
Describe role of disturbance: Severe invasive potential
Rationale: Japanese barberry infestations may occur in undisturbed closed-canopy forests and areas distant from disturbed or open areas, sometimes up to 100 m into undisturbed forest (Ehrenfeld 1997).
Question 2.2 Local rate of spread with no management *Score: C*
Describe rate of spread: Stable
Rationale: Found in mountains, piedmont and coastal plain of NC (Weakley 2008).
Question 2.3 Recent trend in total area infested within state *Score: C*
Describe trend: Stable
Rationale: Found in mountains, piedmont and coastal plain of NC (Weakley 2008).
Question 2.4 Innate reproductive potential *Score: B*
Describe reproductive potential: Moderate
Rationale: Plants reproduce readily from seed (Silander and Klepeis 1999). Produces large number of seeds that have a high germination rate (Swearingen 2005). Branches that are in contact with the ground root freely at nodes and facilitate vegetative spread (Swearingen

2005). Root fragments regenerate to form new plants (Swearingen 2005).
Question 2.5 Potential for human-caused dispersal *Score: A*
Identify dispersal mechanisms: Commercial sales (High potential)
Question 2.6 Potential for natural long-distance dispersal *Score: A*
Identify dispersal mechanisms: Frequent long-distance dispersal
Rationale: Japanese barberry produces large numbers of bird dispersed fruits (Silander and Klepeis 1999). Seed contained within berries spread by birds and small rodents (Lubell et al. 2008).
Question 2.7 Other regions invaded *Score: B*
Identify other regions: Invades 2 ecological types that exist but are not yet invaded in North Carolina
Rationale: Forms dense stands in canopy forests, open woodlands, wetlands, pastures, and meadows in New England and northern states in the Southeast U.S. (Swearingen 2005). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests, low elevation dry and dry-mesic forest and woodlands
Overall Invasiveness Score = 15 points (B)
Section 3. Ecological Amplitude and Distribution
Question 3.1 Ecological amplitude *Score: Unknown*
Question 3.2 Distribution *Score: Unknown*
Overall Distribution Rating = Unknown
Overall Plant Score = Medium, with an Alert Status
Medium: These species have substantial and apparent - but generally not severe – ecological impacts on ecosystems, plant and animal communities, and vegetational structure. Their reproductive biology is conducive to moderate to high rates of dispersal, though establishment is generally dependent on ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.
Alert: This is an additional designation for some species in either the high or medium category, but whose current ecological amplitude and distribution are limited. The designation alerts managers to species that are capable of rapidly invading unexploited ecosystems, based on initial, localized observations, and on observed ecological behavior in similar ecosystems elsewhere.

Appendix B2. Testing the Florida assessment system with *Berberis thunbergii*

Appendix B2. Testing the Florida assessment system with *Berberis thunbergii*

Model Test: IFAS Assessment of the Status of Non-Native Plants in Florida's Natural Areas (Fox et al. 2005)

Species: *Berberis thunbergii* DC. (Japanese barberry)

Section I Invasion Status
1a. Occurrence in natural areas *Yes*
2a. Occurrence in natural areas only because of previous cultivation *No*
1b. Existence outside of cultivation *Yes*
2b. Invasion only with alteration of natural disturbance regime *No*
Section II. Ecological Impacts of Invasion
II-a Known Impacts at Worst Sites
i. Long-term alterations in ecosystem processes *0 points*
ii. Negative impacts on Federal or Florida (North Carolina) listed Species of Special Concern or Threatened or Endangered plants or animals *4 points*
Impacts are considered likely
Comments: May displace native flora (Lubell et al. 2008). In eastern deciduous forests, Japanese barberry has replaced the native blueberries (*Vaccinium* spp.) normally found in the forest understory (Kourtev 2002). In North Carolina, *Vaccinium macrocarpon* (Cranberry) and *V. virgatum* (Small-flower blueberry) are significantly rare (Franklin 2004).
iii) Displaces or precludes native vegetation by achieving populations in the zone that have at least 50% coverage of this species in the affected stratum *8 points*
Comments: Japanese barberry may limit tree regeneration and herbaceous plants in the forest understory (Ward et al. 2009). *Berberis thunbergii* has the ability to outcompete native species in the understory (Xu et al. 2007).
iv) Changes community structure in ways other than vegetation displacement (adds a new stratum) 0.5 *points*
Comments: Biomass of co-occurring species is suppressed by Japanese barberry (Silander and Klepeis 1999).
v) Hybridizes with native Florida plants or economically-important species *0 points*
vi) Covers over 15% of invaded stratum *0 points*
Section II-a Score: 12.5 points
II-b Range of Communities in Which Species is Invading
II-b Is this species known to be invading at least four community groups OR does it occur in at least one community group of each of the terrestrial and palustrine/aquatic lists? *No (12.5 points)*
Comments: Rich forests, old fields in North Carolina, uncommon (Weakley 2008).
II-c Proportion of Invaded Sites with Significant Impacts
II-c Of the invaded sites, might any of the worst impacts only occur under a few, identifiable,

environmental conditions? *Unknown*
Section III. Potential for Expansion
III-a Known Rate of Invasion
III-a. Was this species reported in more than two new discrete populations (at least 1 mile apart) in any 12 month period within the last 10 years? *Unknown*
Known Rate of Invasion P = Low
Section IV. Difficulty of Management
i) Available herbicide treatments *0 points*
Comments: Herbicides, including glyphosate and triclopyr, applied mid-to-late season following an initial pre or early-season mechanical (cutting), prescribed fire, or directed flame treatment provide effective control in a single growing season (Ward et al. 2009).
ii) This species is difficult to control without significant damage to native species. *0 points*
iii) Total costs of known control method per acre in first year, including access, personnel, equipment, materials, and re-vegetation are > $1,500/acre. *0 points*
iv) Further site restoration is necessary. *0 points*
v) The total area over which management would have to be conducted is > 500 acres. *0 points*
vi) Much of the area to be surveyed and controlled cannot be reached easily. *3 points*
Comments: Japanese barberry is capable of invading closed canopy forests (Ehrenfeld 1997). Extensive patches of Japanese barberry have been documented to exist within the forest interior in protected forest areas in New York (Ehrenfeld 1997).
viii) Occurs in more than 20 discrete populations in managed areas. *0 points*
ix) The number of viable, independent propagules per mature plant is >200 per year and >10% disperse a horizontal distance from the parent plant of at least 10 yards, or 3 times the height of the parent plant. *3 points*
Comments: Produces large number of seeds that have a high germination rate (Swearingen 2005). Branches that are in contact with the ground root freely at nodes and facilitate vegetative spread. Root fragments regenerate to form new plants (Swearingen 2005).
x) Age at first reproduction (by seed or vegetative) is within first 10% of likely life-span and/or less than 3 months. *0 points*
Total points Section IV = 6
Section V. Economic Value
1. Does this species have any economic value in Florida (North Carolina) *Yes*
2. Is this species sold in national or regional retail stores? *Yes*
Economic Value = High
Conversion of Index Scores to Index Categories
Ecological Impact = Medium *Potential for Expansion = Low* *Management Difficulty = Low* *Economic Value = High*
Conclusion: *No – unless limited use approved*: This species may be eligible for a proposal for specified and limited use.

Appendix B3. Testing the Michigan assessment system with *Berberis thunbergii*

Appendix B3. Testing the Michigan assessment system with *Berberis thunbergii*

Model Test: Michigan Plant Invasiveness Assessment System (Schutzki et al. 2004)

Species: *Berberis thunbergii* DC. (Japanese barberry)

Section 1: Biological Character	
I-A Reproductive Ability	
I-A1 Reproduction by Seed	*Medium*
Comments: Plants thrive under a variety of light and soil moisture conditions and reproduce readily from seed (Silander and Klepeis 1999). Produces large number of seeds that have a high germination rate (Swearingen 2005).	
I-A2 Reproduction by Vegetative Means	*Medium*
Comments: Branches that are in contact with the ground root freely at nodes and facilitate vegetative spread (Swearingen 2005). Root fragments regenerate to form new plants (Swearingen 2005).	
I-B Dispersal	*Medium*
Vector categories: Wildlife, Human activity (horticulture) Dispersal distance: Great potential for long-distance dispersal	
Comments: Japanese barberry produces large numbers of bird dispersed fruits that allow the plant to effectively spread across the landscape (Silander and Klepeis 1999). Seed contained within berries spread by birds and small rodents (Lubell et al. 2008).	
Section II Impact	
II-A Natural Systems	
II-A1. Ability to Invade Natural Systems	*15 points*
Comments: Japanese barberry infestations may occur in areas distant from disturbed or open areas, sometimes up to 100 m into undisturbed forest (Ehrenfeld 1997).	
II-A2. Impact on Ecosystem Processes	*5 points*
Comments: Alters soil chemistry (raises soil pH and nitrification) and microbial communities of deciduous forests in New Jersey (Ehrenfeld et al. 2001). Impacts soil ecosystem, nitrogen cycling, soil biota, soil structure, and function (Kourtev 2002).	
II-A3. Impact on Natural Community Structure	*7 points*
Comments: Japanese barberry may limit tree regeneration and herbaceous plants in the forest understory (Ward et al. 2009). *Berberis thunbergii* has the ability to outcompete native species in the understory (Xu et al. 2007). Biomass of co-occurring species is suppressed by Japanese barberry (Silander and Klepeis 1999).	
II – A4. Impact on Natural Community Composition	*3 points*
Comments: May displace native flora (Lubell et al. 2008). In eastern deciduous forests,	
II-A5. Conservation Significance of the Natural Systems and Native Species Threatened	*7 points*
Comments: Rich forests, old fields in North Carolina, uncommon (Weakley 2008). Japanese barberry has replaced the native blueberries (*Vaccinium spp*.) normally found in the forest	

understory (Kourtev 2002). In North Carolina, *Vaccinium macrocarpon* (Cranberry) and *V. virgatum* (Small-flower blueberry) are significantly rare (Franklin 2004).
Natural Systems Impact Subrank: Medium
Section III. Distribution in Michigan (North Carolina) and the United States *Increasing*
Comments: Native to Japan (Weakley 2008). Found in mountains, piedmont and coastal plain of NC (Weakley 2008). In New England, there has been a slow increase in the frequency with which Japanese barberry has been observed in mature forest (Ehrenfeld 1997).
Section IV. Control Methods
IV-A. Control Methods *Available*
IV-B Control Methods Currently Available
Response: Mechanical, Chemical
Comments: Initial pre- or early-season mechanical (cutting), prescribed fire, or directed flame treatments applied prior to herbicide treatments of glyphosate or triclopyr provide effective control of dense infestations (Ward et al. 2009).
Control Method Subrank: A
Section V. Control Effort
V-A. Control Potential *10 points*
Response: The nonselective herbicides glyphosate and triclopyr must be applied carefully to individual plants to avoid impacting non-target native plants (Swearingen 2005). Seed spread by birds and small rodents (Lubell et al. 2008) and may be reintroduced to treated area. Nearly all Barberry clumps treated once with mechanical control methods or prescribed fire had new sprouts by the end of the growing season (Ward et al. 2009).
Comments: *Control Potential Subrank: High potential for control*
Section VI. Value within Michigan (North Carolina)
Horticulture *5 points*
Response: This plant has provided a crop that has been sold within the state and used by the general public within the state.
Landscape *5 points*
Response: This plant is currently sold in retail stores and used in residential, commercial, and public landscapes.
Value Subrank: High
Overall Invasiveness Rank = Medium Potential Invasiveness in Natural Systems

Appendix B4. Testing the NatureServe assessment system with *Berberis thunbergii*

Appendix B4. Testing the NatureServe assessment system with *Berberis thunbergii*

Model Test: An Invasive Species Assessment Protocol (Morse et al. 2004)

Species: *Berberis thunbergii DC. (Japanese barberry)*

Screening Questions
S-1 Establishment in Region of Interest *Yes*
Comments: Present in the Coastal Plain, Piedmont, and Mountains of North Carolina (Weakley 2008).
S-2 Occurrence in Native Species Habitat *Yes*
Comments: Japanese barberry infestations may occur in undisturbed closed-canopy forests in New England and Mid-Atlantic states (Ehrenfeld 1997).
Section I. Ecological Impact
1. Impact on Ecosystem Processes and System-Wide Parameters *C (11 points)*
Response: Low
Comments: Alters soil chemistry (raises soil pH and nitrification) and microbial communities of deciduous forests in New Jersey (Ehrenfeld et al. 2001). Impacts soil ecosystem, nitrogen cycling, soil biota, soil structure, and function (Kourtev 2002). Reduces litter layer (Kourtev 2002).
2. Impact on Ecological Community Structure *B (12 points)*
Response: Moderate
Comments: Japanese barberry may limit tree regeneration and herbaceous plants in the forest understory (Ward et al. 2009).
3. Impact on Ecological Community Composition *B (12 points)*
Response: Moderate
Comments: *Berberis thunbergii* has the ability to outcompete native species in the understory (Xu et al. 2007). Biomass of co-occurring species is suppressed by Japanese barberry (Silander and Klepeis 1999).
4. Impact on Individual Native Plant or Animal Species *C (3 points)*
Response: Low
Comments: May displace native flora (Lubell et al. 2008). In eastern deciduous forests, Japanese barberry has replaced the native blueberries (*Vaccinium* spp.) normally found in the forest understory (Kourtev 2002). In North Carolina, *Vaccinium macrocarpon* (Cranberry) and *V. virgatum* (Small-flower blueberry) are significantly rare (Franklin 2004).
5. Conservation Significance of the Communities and Native Species Threatened *C (8 points)*
Response: Low
Comments: Found in mountains, piedmont and coastal plain of NC (Weakley 2008).
Subrank I: Low (46 points)
Section II. Current Distribution and Abundance
6. Current Range Size in Region *B (10 points)*

Response: Moderate
Comments: Found in mountains, piedmont and coastal plain of NC (Weakley 2008).
7. Proportion of Current Range Where Species is Negatively Impacting Biodiversity *Unknown (0-15 points)*
8. Proportion of Region's Biogeographic Units Invaded *B (2 points)*
Response: Moderate
Comments: Found in mountains, piedmont and coastal plain of NC (Weakley 2008).
9. Diversity of Habitats or Ecological Systems Invaded in Region *C (2 points)*
Response: Low
Comments: Forms dense stands in canopy forests, open woodlands, wetlands, pastures, and meadows in New England and northern states in the Southeast U.S. (Swearingen 2005). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests, low elevation dry and dry-mesic forest and woodlands
Section II Interval: Low/High (14-29 points)
Section III. Trend in Distribution and Abundance
10. Current Trend in Total Range Within the Region *C (6 points)*
Response: Low
Comments: Found in mountains, piedmont and coastal plain of NC (Weakley 2008).
11. Proportion of Potential Range Currently Occupied *C (1 point)*
Response: Low
Comments: Found in mountains, piedmont and coastal plain of NC (Weakley 2008).
12. Long-Distance Dispersal Potential Within Region *A (9 points)*
Response: High
Comments: Japanese barberry produces large numbers of bird dispersed fruits that allow the plant to effectively spread across the landscape (Silander and Klepeis 1999). Seed contained within berries spread by birds and small rodents (Lubell et al. 2008). Japanese barberry infestations may occur in areas distant from disturbed or open areas, sometimes up to 100 m into undisturbed forest (Ehrenfeld 1997).
13. Local Range Expansion or Change in Abundance C *(6 points)*
Response: Low
Comments: In New England, there has been a slow increase in the frequency with which Japanese barberry has been observed in mature forest (Ehrenfeld 1997).
14. Inherent Ability to Invade Conservation Areas and Other Native Species Habitat *A (6 points)*
Response: High
Comments: Japanese barberry infestations may occur in undisturbed closed-canopy forests (Ehrenfeld 1997).
15. Similar Habitats Invaded Elsewhere B *(6 points)*
Response: Moderate
Comments: Forms dense stands in canopy forests, open woodlands, wetlands, pastures, and meadows in New England and northern states in the Southeast U.S. (Swearingen 2005). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic

forests, low elevation dry and dry-mesic forest and woodlands
16. Reproductive Characteristics A *(9 points)*
Response: High
Comments: Plants thrive under a variety of light and soil moisture conditions and reproduce readily from seed (Silander and Klepeis 1999). Produces large number of seeds that have a high germination rate (Swearingen 2005). Branches that are in contact with the ground root freely at nodes and facilitate vegetative spread (Swearingen 2005). Root fragments regenerate to form new plants (Swearingen 2005).
Section III Interval: Medium (43 points)
Section IV. Management Difficulty
17. General Management Difficulty *B (12 points)*
Response: Moderate
Comments: Herbicides, including glyphosate and triclopyr, applied mid-to-late season following an initial pre or early-season mechanical (cutting), prescribed fire, or directed flame treatment provide effective control in a single growing season (Ward et al. 2009). Manual control methods must be combined with herbicide applications in moderate to heavy infestations (Swearingen 2005). Root wrenching and herbicide applications to cut stems are effective, but labor intensive (Ward et al. 2009).
18. Minimum Time Commitment *B (10 points)*
Response: Moderate
Comments: Seed spread by birds and small rodents (Lubell et al. 2008) and may be reintroduced to treated area. Nearly all Barberry clumps treated once with mechanical control methods or prescribed fire had new sprouts by the end of the growing season (Ward et al. 2009).
19. Impacts of Management on Native Species *C (5 points)*
Response: Low
Comments: The nonselective herbicides glyphosate and triclopyr must be applied carefully to individual plants to avoid impacting non-target native plants (Swearingen 2005).
20. Accessibility of Invaded Areas C *(1 point)*
Response: Low
Comments: Japanese barberry is capable of invading closed canopy forests (Ehrenfeld 1997). Extensive patches of Japanese barberry have been documented to exist within the forest interior in protected forest areas in New York (Ehrenfeld 1997).
Section IV Interval: Medium (28 points)
Overall I-Rank: Low/Medium Range (42-59 points)
Low I-Rank*: Species represents a significant but relatively low threat to native species and ecological communities.* ***Medium I-Rank:*** *Species represents moderate threat to native species and ecological communities*

Appendix B5. Testing the North Carolina assessment system with *Berberis thunbergii*

Appendix B5. Testing the North Carolina assessment system with *Berberis thunbergii*

Model Test: The North Carolina Invasive Species Assessment System (Trueblood 2009)

Species: *Berberis thunbergii* DC. (Japanese barberry)

	Answer Choices	Response
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Sale of prohibited in Massachusetts and New Hampshire (Lubell et al. 2008). Appears on several invasive species lists (not laws) in the Southeastern U.S., including Tennessee (Rank 2, Significant threat), Kentucky (Rank b, Significant threat), Virginia (Rank b, Medium invasiveness), and the National Forest Service (Category 1, species known to be invasive and persistent) (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
3. North Carolina nativity	Y/N	N
Native to Japan (Weakley 2008)		
4. Presence in natural areas	Y/N	Y
Japanese barberry infestations may occur in undisturbed closed-canopy forests (Ehrenfeld 1997).		
5. Non-invasive cultivars	Y/N	N
Some ornamental Japanese barberry genotypes have reduced fruit and seed production and limited fecundity (Lubell et al. 2008). Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	4
Alters soil chemistry (raises soil pH and nitrification) and microbial communities of deciduous forests in New Jersey (Ehrenfeld et al. 2001). Impacts soil ecosystem, nitrogen cycling, soil biota, soil structure, and function (Kourtev 2002). Reduces litter layer (Kourtev 2002).		
1b. Impact on plant community structure and composition	20	15
Japanese barberry may limit tree regeneration and herbaceous plants in the forest understory (Ward et al. 2009). *Berberis thunbergii* has the ability to outcompete native species in the understory (Xu et al. 2007). Biomass of co-occurring species is suppressed by Japanese barberry (Silander and Klepeis 1999).		
1c. Impact on species of special concern	5	2
May displace native flora (Lubell et al. 2008). In eastern deciduous forests, Japanese barberry has replaced the native blueberries (*Vaccinium* spp.) normally found in the forest understory (Kourtev 2002). In North Carolina, *Vaccinium macrocarpon* (Cranberry) and *V.*		

virgatum (Small-flower blueberry) are significantly rare (Franklin 2004).		
1d. Impact on higher trophic levels	5	3
Impacts earth worm populations (Ehrenfeld at al. 2001). Barberry-infested forests have especially high populations of blacklegged ticks (I*xodes scapularis*) that are the major vectors for several diseases, including Lyme disease (Ward et al. 2009).		
Section 1. Subrank	***40***	***24***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	1
Found in mountains, piedmont and coastal plain of NC (Weakley 2008). In New England, there has been a slow increase in the frequency with which Japanese barberry has been observed in mature forest (Ehrenfeld 1997).		
2b. Long-distance dispersal potential	13	13
Japanese barberry produces large numbers of bird dispersed fruits that allow the plant to effectively spread across the landscape (Silander and Klepeis 1999). Seed contained within berries spread by birds and small rodents (Lubell et al. 2008). Japanese barberry infestations may occur in areas distant from disturbed or open areas, sometimes up to 100 m into undisturbed forest (Ehrenfeld 1997). Songbirds, white-tail deer (*Odocoileus virginianus*), wild turkeys (*Meleagris gallopavo*) and grouse (*Bonasa ubmellus*) may utilize and distribute the berries (Ehrenfeld 1997).		
2c. Reproductive characteristics	8	6
Plants thrive under a variety of light and soil moisture conditions and reproduce readily from seed (Silander and Klepeis 1999). Produces large number of seeds that have a high germination rate (Swearingen 2005). Branches that are in contact with the ground root freely at nodes and facilitate vegetative spread (Swearingen 2005). Root fragments regenerate to form new plants (Swearingen 2005).		
2d. Range of communities	6	0 (Unknown)
Rich forests, old fields in North Carolina, uncommon (Weakley 2008).		
2e. Similar habitats invaded elsewhere	6	4
Forms dense stands in canopy forests, open woodlands, wetlands, pastures, and meadows in New England and northern states in the Southeast U.S. (Swearingen 2005). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests, low elevation dry and dry-mesic forest and woodlands		
Section 2. Subrank	***40***	***24***
Section 3. Management Difficulty		
3a. Herbicidal control	5	3
Herbicides, including glyphosate and triclopyr, applied mid-to-late season following an initial pre or early-season mechanical (cutting), prescribed fire, or directed flame treatment provide effective control in a single growing season (Ward et al. 2009). Glyphosate applied in early spring at first leaf-out is an effective chemical control option (Silander and Klepeis 1999).		

3b. Nonchemical control methods	2	2
Manual control methods must be combined with herbicide applications in moderate to heavy infestations (Swearingen 2005). Initial pre- or early-season mechanical (cutting), prescribed fire, or directed flame treatments applied prior to herbicide treatments of glyphosate or triclopyr provide effective control of dense infestations (Ward et al. 2009). In dense infestations where Japanese barberry plants are waist high or taller, medium (drum chopper) or heavy (bulldozer) equipment is necessary (Ward et al. 2009). However, medium and heavy equipment may be limited by terrain, forest density, and operator experience (Ward et al. 2009). No biological control organisms are available (Swearingen 2005).		
3c. Necessity of individual treatments	2	2
Root wrenching and herbicide applications to cut stems are effective, but labor intensive (Ward et al. 2009).		
3d. Average distribution	2	1
Dense stands may form in the forest understory (Ward et al. 2009). Distribution patters may be sparse, moderate, or dense populations (Ehrenfeld 1997).		
3e. Likelihood of reestablishment	2	2
Seed spread by birds and small rodents (Lubell et al. 2008) and may be reintroduced to treated area. Nearly all Barberry clumps treated once with mechanical control methods or prescribed fire had new sprouts by the end of the growing season (Ward et al. 2009).		
3f. Accessibility of invaded areas	2	1
Japanese barberry is capable of invading closed canopy forests (Ehrenfeld 1997). Extensive patches of Japanese barberry have been documented to exist within the forest interior in protected forest areas in New York (Ehrenfeld 1997).		
3g. Impact on native species and environment	5	2
The nonselective herbicides glyphosate and triclopyr must be applied carefully to individual plants to avoid impacting non-target native plants (Swearingen 2005).		
Section 3. Subrank	***20***	***13***
Section 4. Economic Value		
4a. Estimated wholesale value in North Carolina	-7	-4
The estimated wholesale value attributed to Japanese barberry in North Carolina is $16,123,300 (Trueblood 2009).		
4b. Percentage of total sales	-5	-3
Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be: 11-25% (Trueblood 2009).		
4c. Ecosystem services	-1	0
4d. Wildlife habitat	-1	0
4e. Cultural and social benefits	-1	0
Section 4. Subrank	***-15***	***-7***

Overall Score and Recommendation	***100***	***54***
(Medium) Moderately weedy and recommended for use with specific guidance		
Summary: *Berberis thunbergii* (Japanese barberry) is moderately weedy and recommended for horticultural use in North Carolina with specific guidance. Japanese barberry may suppress herbaceous plants in the forest understory and outcompete native species. Japanese barberry has high long-distance dispersal potential and may invade additional natural areas. The difficulty of managing Japanese barberry is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of this species. Japanese barberry is economically valuable to the nursery industry. Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications. Use of seedless cultivars would be desirable when they become available.		

Appendix B6. Testing the California assessment system with *Ligustrum sinense*

Appendix B6. Testing the California assessment system with *Ligustrum sinense*

Model: Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands

(Warner et al. 2003)

Species: *Ligustrum sinense* Lour. (Chinese privet)

Section 1. Ecological Impact
Question 1.1 Impact on abiotic ecosystem processes *Score: B*
Identify ecosystem processes impacted: Light availability
Rationale: The greatest threat posed by *L. sinense* is large-scale ecosystem modification by outcompeting (for light) and displacing native vegetation (Urbatsch).
Question 1.2 Impact on plant community composition, structure, and interactions *Score: B*
Identify type of impact or alteration: Displacement of shrub layer, additional layer of understory vegetation
Rationale: Forms dense thickets (Morris et al. 2002) that may displace shrub layer in woodlands (Batcher 2000). Provides additional layer of understory vegetation and dominates the understories of mesic forest habitat in the southeastern U.S. (Harrington and Miller, 2005).
Question 1.3 Impact on higher trophic levels *Score: D*
Identify type of impact or alteration: Not known to impact higher trophic levels
Question 1.4 Impact on genetic integrity *Score: D*
Identify impacts: Not known to impact genetic integrity.
Overall Impact Rating: B

Section 2. Invasive Potential
Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score: B*
Describe role of disturbance: Soil disturbances and natural disturbances provide colonization opportunities.
Rationale: Soil disturbances and natural disturbances provided colonization opportunities (Urbatsch). Invades both edge and interior of woodland habitats in the southeastern United States (Morris et al., 2002).
Question 2.2 Local rate of spread with no management *Score: U*
Describe rate of spread: Unknown
Question 2.3 Recent trend in total area infested within state *Score: B*
Describe trend: Moderate rate of spread across the state
Rationale: Moderate rate of spread across North Carolina - 5.4% increase in counties reporting occurrences per year (Merriam, 2003). Continues to invade bottomland and upland forests in the Southeast (Harrington and Miller, 2005). Distribution across southeastern U.S. experienced exponential growth between 1950-1980 (Harrington and Miller, 2005). Over the past 70 years, Chinese privet has rapidly engulfed southern wetlands (Weakley 2008).

Question 2.4 Innate reproductive potential *Score: U*
Rationale: Fleshy fruit, seeds germinate readily without cold stratification (Harrington and Miller, 2005). Grows from seed, root and stump sprouts (Batcher, 2000). Produces large number of viable seeds that are readily dispersed by birds and have high germination rates in a wide variety of environmental conditions (Batcher, 2000). Plants mature rapidly and produce prolific amount of seeds, spread vegetatively by root suckers (Urbatsch).
Question 2.5 Potential for human-caused dispersal *Score: A*
Identify dispersal mechanisms: Commercial sales for use in ornamental horticulture, spread along transportation corridors.
Rationale: Introduced from China in 1852 for horticultural use and still used in landscaping (Merriam, 2002). Spreads along roadsides (Batcher, 2000).
Question 2.6 Potential for natural long-distance dispersal *Score: A*
Identify dispersal mechanisms: Birds, animals, water
Rationale: Seeds spread by birds and animals (Harrington and Miller, 2005). Fleshy fruit consumed by birds and other animals (Batcher, 2000). Flooding and water transport may be major seed-carrying mechanism, since the species is often distributed along rivers and streams (Merriam, 2003).
Question 2.7 Other regions invaded *Score:* B
Identify other regions: Invades 1 ecological type (Low elevation dry and dry-mesic forest and woodlands) that exist but are not yet invaded in North Carolina
Rationale: Chinese privet grows in red cedar and hardwood forests around cedar glades in Tennessee (Morris et al., 2002) and has been reported in oak-hickory pine forest and longleaf pine forest habitats in Alabama (Batcher, 2000). *Ligustrum* spp. colonize floodplains, woodlands, bogs, wetlands, old fields, calcareous glades and barrens, and mesic hardwood forests in North America (Batcher, 2000). NC Primary Systems (Shafale and Weakley, 1990) = Low elevation dry and dry-mesic forest and woodlands
Overall Invasiveness Score = 12 points (B)
Section 3. Ecological Amplitude and Distribution
Question 3.1 Ecological amplitude *Score: U*
Describe ecological amplitude: Unknown
Rationale: Known to occur in moist forests, alluvial bottomlands, and southern wetlands in North Carolina (Weakley 2008), but the frequency within each ecological type is unknown.
Question 3.2 Distribution *Score: U*
Describe distribution: Unknown
Overall Distribution Rating = Unknown
Overall Plant Score = Medium, with an Alert Status
Medium: These species have substantial and apparent - but generally not severe – ecological impacts on ecosystems, plant and animal communities, and vegetational structure. Their reproductive biology is conducive to moderate to high rates of dispersal, though establishment is generally dependent on ecological disturbance. Ecological amplitude and

distribution may range from limited to widespread.

Alert: This is an additional designation for some species in either the high or medium category, but whose current ecological amplitude and distribution are limited. The designation alerts managers to species that are capable of rapidly invading unexploited ecosystems, based on initial, localized observations, and on observed ecological behavior in similar ecosystems elsewhere.

Appendix B7. Testing the Florida assessment system with *Ligustrum sinense*

Appendix B7. Testing the Florida assessment system with *Ligustrum sinense*

Model Test: IFAS Assessment of the Status of Non-Native Plants in Florida's Natural Areas (Fox et al. 2005)

Species: *Ligustrum sinense* Lour. (Chinese privet)

Section I Invasion Status
1a. Occurrence in natural areas *Yes*
2a. Occurrence in natural areas only because of previous cultivation *No*
1b. Existence outside of cultivation *Yes*
2b. Invasion only with alteration of natural disturbance regime *No*
Section II. Ecological Impacts of Invasion
II-a Known Impacts at Worst Sites
i. Long-term alterations in ecosystem processes *0 points*
ii. Negative impacts on Federal or Florida (North Carolina) listed Species of Special Concern or Threatened or Endangered plants or animals *4 points*
Impacts are considered likely because Federal or Florida (North Carolina) listed Species of Special Concern, Threatened, or Endangered species and the invading species closely co-habit
Comments: Chinese privet is one exotic species that has threatened the Schweintz's sunflower (*Helianthus schweinitzii*) in the piedmont, an endangered species in North Carolina (Urbatsch). Chinese privet is an aggressive weed species that when unmanaged, out shades Schweintz's sunflower (Weakley and Houk, 1994).
iii) Displaces or precludes native vegetation by achieving populations in the zone that have at least 50% coverage of this species in the affected stratum *0 points*
iv) Changes community structure in ways other than vegetation displacement (adds a new stratum) *4 points*
Comments: Provides additional layer of understory vegetation and dominates the understories of mesic forest habitat in southeastern U.S. (Harrington and Miller, 2005).
v) Hybridizes with native Florida plants or economically-important species *0 points*
vi) Covers over 15% of invaded stratum *1 point*
Comments: Dense monocultural thickets may dominate the understories of mesic forest habitat in southeastern U.S. (Harrington and Miller, 2005)
Section II-a Score: 9 points
II-b Range of Communities in Which Species is Invading
II-b Is this species known to be invading at least four community groups OR does it occur in at least one community group of each of the terrestrial and palustrine/aquatic lists? *13.5 points*
Comments: In North Carolina, *L. sinense* may affect moist forests, alluvial bottomlands, and southern wetlands (Weakley, 2008). NC Primary Systems (Shafale and Weakley, 1990) = Low elevation mesic forests, river floodplains, nonalluvial wetlands of the mountains and

Piedmont
II-c Proportion of Invaded Sites with Significant Impacts
II-c Of the invaded sites, might any of the worst impacts only occur under a few, identifiable, environmental conditions? *Unknown*
Section III. Potential for Expansion
III-a Known Rate of Invasion
III-a. Was this species reported in more than two new discrete populations (at least 1 mile apart) in any 12 month period within the last 10 years? *Unknown*
Known Rate of Invasion P = Low
Section IV. Difficulty of Management
i) Available herbicide treatments *0 points*
Comments: Low rates of glyphosate effective when applied in spring or fall, lower control with summer application (Harrington and Miller, 2005).
ii) This species is difficult to control without significant damage to native species. *0 points*
iii) Total costs of known control method per acre in first year, including access, personnel, equipment, materials, and re-vegetation are > $1,500/acre. *0 points*
iv) Further site restoration is necessary. *0 points*
v) The total area over which management would have to be conducted is > 500 acres. *0 points*
vi) Much of the area to be surveyed and controlled cannot be reached easily. *3 points*
Comments: Birds may spread seeds to forest openings (Batcher, 2000). Seeds spread by birds, shade tolerant and able to spread under dense forest canopies (Harrington and Miller, 2005).
viii) Occurs in more than 20 discrete populations in managed areas. *3 points*
ix) The number of viable, independent propagules per mature plant is >200 per year and >10% disperse a horizontal distance from the parent plant of at least 10 yards, or 3 times the height of the parent plant. *3 points*
Comments: Produces large number of viable seeds that are readily dispersed by birds and have high germination rates in a wide variety of environmental conditions (Batcher, 2000).
x) Age at first reproduction (by seed or vegetative) is within first 10% of likely life-span and/or less than 3 months. *2 points*
Comments: Plants mature rapidly and produce prolific amount of seeds, spread vegetatively by root suckers (Urbatsch).
Total points Section IV = 11
Section V. Economic Value
1. Does this species have any economic value in Florida (North Carolina) *Yes*
2. Is this species sold in national or regional retail stores? *Yes*
Economic Value = High
Conversion of Index Scores to Index Categories
Ecological Impact = Medium *Potential for Expansion = Low* *Management Difficulty = Low*

Economic Value = High
Conclusion: *No – unless limited use approved*: This species may be eligible for a proposal for specified and limited use.

Appendix B8. Testing the Michigan assessment system with *Ligustrum sinense*

Appendix B8. Testing the Michigan assessment system with *Ligustrum sinens*e

Model Test: Michigan Plant Invasiveness Assessment System (Schutzki et al. 2004)

Species: *Ligustrum sinense* Lour. (Chinese privet)

Section 1: Biological Character	
I-A Reproductive Ability	
I-A1 Reproduction by Seed	*Low*
Response: Reproduces readily by seed, can germinate in a wide range of conditions	
Comments: Seeds germinate readily (Harrington and Miller, 2005). Produces large number of viable seeds that have high germination rates in a wide variety of environmental conditions (Batcher, 2000). Plants mature rapidly and produce prolific amount of seeds (Urbatsch).	
I-A2 Reproduction by Vegetative Means	*Medium*
Response: Reproduces readily by vegetative means, resprouts when cut, grazed or burned, other (Spreads vegetatively by root suckers)	
Comments: Grows from root and stump sprouts (Batcher, 2000). Spreads vegetatively by root suckers (Urbatsch).	
I-B Dispersal	*High*
Response: Vector categories: Water, Mammals, Birds Dispersal distance: Great potential for long-distance dispersal	
Comments: Seeds spread by birds and animals (Harrington and Miller 2005, Batcher 2000). Flooding and water transport may be major seed-carrying mechanism, since the species is often distributed along rivers and streams (Merriam, 2003).	
Section II Impact	
II-A Natural Systems	
II-A1. Ability to Invade Natural Systems	*7 points*
Response: Often establishes in mid-late-successional natural areas where minor disturbances may occur, but no major disturbance within the last 20-75 years	
Comments: Invades both edge and interior of woodland habitats in the southeastern United States (Morris et al., 2002). Colonizes moist forests, especially alluvial bottomlands, in North Carolina (Weakley 2008). Over the past 70 years, Chinese privet has rapidly engulfed southern wetlands (Weakley 2008).	
II-A2. Impact on Ecosystem Processes	*10 points*
Response: Significant alteration in ecosystem processes	
Comments: The greatest threat posed by *L. sinense* is large-scale ecosystem modification by outcompeting (for light) and displacing native vegetation (Urbatsch). May limit hardwood regeneration, wildlife habitat, and biodiversity (Harrington and Miller, 2005).	
II-A3. Impact on Natural Community Structure	*7 points*
Response: Significant impact on at least one layer	

Comments: Provides additional layer of understory vegetation and dominates the understories of some mesic forest habitats in the southeastern U.S. (Harrington and Miller, 2005). May displace shrub layer in woodlands (Batcher, 2000).
II – A4. Impact on Natural Community Composition *7 points*
Response: Significantly alters community composition
Comments: Chinese privet is one exotic species that has threatened the Schweintz's sunflower (*Helianthus schweinitzii*) in the piedmont, an endangered species in North Carolina (Urbatsch). Chinese privet is one aggressive weed species that when unmanaged, out shades Schweintz's sunflower (Weakley and Houk, 1994).Outcompetes many kinds of native vegetation (no specific species identified) (Batcher, 2000).
II-A5. Conservation Significance of the Natural Systems and Native Species Threatened *7 points*
Response: Known to occasionally threaten vulnerable or high quality species or communities
Comments: Affects moist forests, alluvial bottomlands, southern wetlands in North Carolina (Weakley, 2008). NC Primary Systems (Shafale and Weakley, 1990) = Low elevation mesic forests, river floodplains, nonalluvial wetlands of the mountains and Piedmont
Natural Systems Impact Subrank: Medium
Section III. Distribution in Michigan (North Carolina) and the United States
Response: Current trend increasing
Comments: Colonizes moist forests, especially alluvial bottomlands, in the Coastal Plain, Piedmont, and Mountains of North Carolina (Weakley 2008). Over the past 70 years, Chinese privet has rapidly engulfed southern wetlands (Weakley 2008). Moderate rate of spread across North Carolina - 5.4% increase in counties reporting occurrences per year (Merriam, 2003). Continues to invade bottomland and upland forests in the Southeast (Harrington and Miller, 2005). Distribution across southeastern U.S. experienced exponential growth between 1950-1980 (Harrington and Miller, 2005).Appears on several invasive species lists in the Southeastern U.S., including Mississippi, Georgia, South Carolina, Florida, Tennessee, Kentucky, Virginia, and the National Forest Service (Invasive.org 2009).
Section IV. Control Methods
IV-A. Control Methods
IV-B Control Methods Currently Available *(A) Available*
Response: Pulling using tools, cutting, contact herbicides
Comments: Low rates of glyphosate are effective when applied in spring or fall, lower control with summer application (Harrington and Miller, 2005). Manual uprooting of plants provides less control than glyphosate application (Harrington and Miller, 2005). Mowing or cutting will control the spread of *L. sinense* but may not eradicate it (Batcher, 2000). No known biological controls (Urbatsh).
Control Method Subrank: (A) Chemicals Available
Section V. Control Effort
V-A. Control Potential *10 points*
Response: Following the first year of control of this species, it would be expected that individual sites would require re-survey or re-treatment, due to recruitment from persistent seed or vegetative structures, or by dispersal from outside the site: at least once a year for the

next 5 years.
Comments: Abundant regeneration possible from root sprouts (Harrington and Miller, 2005). High likelihood of continued dispersal of seeds into treated area (Batcher, 2000). Eradication is difficult due to high reproductive capacity, by seed and vegetative propagation (Urbatsch). *Control Potential Subrank: High Potential for Control*
Section VI. Value within Michigan (North Carolina)
Horticulture *8 points*
Response: This plant has provided a crop that has been sold within the state and used by the general public within the state.
Landscape *15 points*
Response: This plant is currently sold in retail stores and used in residential, commercial, and public landscapes.
Value Subrank: High
Overall Invasiveness Rank = *High Potential Invasiveness in Natural Systems*

Appendix B9. Testing the NatureServe assessment system with *Ligustrum sinense*

Appendix B9. Testing the NatureServe assessment system with *Ligustrum sinense*

Model Test: An Invasive Species Assessment Protocol (Morse et al. 2004)

Species: *Ligustrum sinense* Lour. (Chinese privet)

Screening Questions	
S-1 Establishment in Region of Interest	*Yes*
Comments: Present in the Coastal Plain, Piedmont, and Mountains of North Carolina (Weakley 2008).	
S-2 Occurrence in Native Species Habitat	*Yes*
Comments: Colonizes moist forests, especially alluvial bottomlands, in North Carolina (Weakley 2008).	
Section I. Ecological Impact	
1. Impact on Ecosystem Processes and System-Wide Parameters	*C (11 points)*
Response: Low significance	
Comments: The greatest threat posed by *L. sinense* is large-scale ecosystem modification by outcompeting (for light) and displacing native vegetation (Urbatsch 2000).	
2. Impact on Ecological Community Structure	*B (12 points)*
Response: Moderate significance	
Comments: Forms dense thickets (Morris et al. 2002). Provides additional layer of understory vegetation and may dominates the understory of mesic forest habitat in the southeastern U.S. (Harrington and Miller 2005). Forms dense, monocultural thickets (Urbatsch 2000).	
3. Impact on Ecological Community Composition	*A (18 points)*
Response: High significance	
Comments: Suppresses native vegetation in North Carolina (Weakley 2008). May displace shrub layer in woodlands (Batcher 2000).	
4. Impact on Individual Native Plant or Animal Species	*A (9 points)*
Response: High significance	
Comments: Chinese privet is one exotic species that has threatened the Schweintz's sunflower (*Helianthus schweinitzii*) in the piedmont, an endangered species in North Carolina (Urbatsch 2000). Chinese privet is one aggressive weed species that when unmanaged, out shades Schweintz's sunflower (Weakley and Houk, 1994). Outcompetes many kinds of native vegetation (Batcher, 2000).	
5. Conservation Significance of the Communities and Native Species Threatened	*B (16 points)*
Response: Moderate significance	
Comments: One rare species in North Carolina - Schweintz's sunflower (*Helianthus schweinitzii*) (Urbatsch 2000). Colonizes moist forests, especially alluvial bottomlands, in North Carolina (Weakley 2008). Over the past 70 years, Chinese privet has rapidly engulfed southern wetlands (Weakley 2008).	
	Subrank I: Medium (66 points)

Section II. Current Distribution and Abundance
6. Current Range Size in Region *A (15 points)*
Response: High significance (Widespread)
Comments: Distribution across southeastern U.S. experienced exponential growth between 1950-1980 (Harrington and Miller 2005). Over the past 70 years, Chinese privet has rapidly engulfed southern wetlands (Weakley 2008).
7. Proportion of Current Range Where Species is Negatively Impacting Biodiversity *U (0-15 points)*
Response: Unknown
8. Proportion of Region's Biogeographic Units Invaded *B (2 points)*
Response: Moderate significance
Comments: Moist forests, alluvial bottomlands, southern wetlands in North Carolina (Weakley 2008). Three NC Primary Systems (Shafale and Weakley 1990) = Low elevation mesic forests, river floodplains, nonalluvial wetlands of the mountains and Piedmont
9. Diversity of Habitats or Ecological Systems Invaded in Region *C (1 point)*
Response: Low significance
Comments: Moist forests, alluvial bottomlands, southern wetlands in North Carolina (Weakley 2008). Three NC Primary Systems (Shafale and Weakley 1990) = Low elevation mesic forests, river floodplains, nonalluvial wetlands of the mountains and Piedmont
Section II Interval: Low/High (18-33 points)
Section III. Trend in Distribution and Abundance
10. Current Trend in Total Range Within the Region *B (12 points)*
Response: Moderate significance
Comments: Moderate rate of spread across North Carolina - 5.4% increase in counties reporting occurrences per year (Merriam 2003). Continues to invade bottomland and upland forests in the Southeast (Harrington and Miller 2005)
11. Proportion of Potential Range Currently Occupied *C (1 point)*
Response: Low significance
Comments: Distribution across southeastern U.S. experienced exponential growth between 1950-1980 (Harrington and Miller 2005). Over the past 70 years, Chinese privet has rapidly engulfed southern wetlands (Weakley 2008).
12. Long-Distance Dispersal Potential Within Region *A (9 points)*
Response: High significance
Comments: Seeds spread by birds and animals (Harrington and Miller 2005). Fleshy fruit consumed by birds and other animals (Batcher 2000). Flooding and water transport may be major seed-carrying mechanism, since the species is often distributed along rivers and streams (Merriam 2003).
13. Local Range Expansion or Change in Abundance *B (12 points)*
Response: Moderate significance
Comments: Moderate rate of spread across North Carolina - 5.4% increase in counties reporting occurrences per year (Merriam 2003). Continues to invade bottomland and upland forests in the Southeast (Harrington and Miller 2005)

14. Inherent Ability to Invade Conservation Areas and Other Native Species Habitat *B (4 points)*
Response: Moderate significance
Comments: Invades both edge and interior of woodland habitats in the southeastern United States (Morris et al. 2002).
15. Similar Habitats Invaded Elsewhere *B (6 points)*
Response: Moderate significance
Comments: Chinese privet grows in red cedar and hardwood forests around cedar glades in Tennessee (Morris et al. 2002) and has been reported in oak-hickory pine forest and longleaf pine forest habitats in Alabama (Batcher 2000). *Ligustrum spp.* colonize floodplains, woodlands, bogs, wetlands, old fields, calcareous glades and barrens, and mesic hardwood forests in North America (Batcher 2000). One NC Primary systems (Shafale and Weakley 1990) = Low elevation dry and dry-mesic forest and woodlands
16. Reproductive Characteristics *B (6 points)*
Response: Moderate significance
Comments: Fleshy fruit, seeds germinate readily without cold stratification (Harrington and Miller 2005). Grows from seed, root and stump sprouts (Batcher 2000). Produces large number of viable seeds that are readily dispersed by birds and have high germination rates in a wide variety of environmental conditions (Batcher 2000). Plants mature rapidly and produce prolific amount of seeds, spread vegetatively by root suckers (Urbatsch 2000).
Section III Interval: Medium (50 points)
Section IV. Management Difficulty
17. General Management Difficulty *B (12 points)*
Response: Moderate significance
Comments: Low rates of glyphosate effective when applied in spring or fall, lower control with summer application (Harrington and Miller 2005). Eradication is difficult due to high reproductive capacity, by seed and vegetative propagation (Urbatsch 2000).
18. Minimum Time Commitment *B (10 points)*
Response: Moderate significance
Comments: Abundant regeneration possible from root sprouts (Harrington and Miller 2005). High likelihood of continued dispersal of seeds into treated area (Batcher 2000). Eradication is difficult due to high reproductive capacity, by seed and vegetative propagation (Urbatsch 2000).
19. Impacts of Management on Native Species *C (5 points)*
Response: Low significance
Comments: Glyphosate and triclopyr have no soil activity at registered rates and if applied as a directed foliar application, present little risk to associated vegetation (Harrington and Miller 2005). Herbicide applications may impact non-target species (Batcher 2000).
20. Accessibility of Invaded Areas *B (2 points)*
Response: Moderate significance
Comments: Birds may spread seeds to forest openings (Batcher 2000). Seeds spread by birds, shade tolerant and able to spread under dense forest canopies (Harrington and Miller 2005).

Section IV Interval: Medium (29 points)
Overall I-Rank: Medium (58-75 points)
Medium I-Rank: *Species represents moderate threat to native species and ecological communities*

Appendix B10. Testing the North Carolina assessment system with *Ligustrum sinense*

Appendix B10. Testing the North Carolina assessment system with *Ligustrum sinense*

Model Test: The North Carolina Invasive Species Assessment System (Trueblood 2009)

Species: *Ligustrum sinense* Lour. (Chinese privet)

	Answer Choices	Response
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Appears on several invasive species lists (not laws) in the Southeastern U.S., including Mississippi (General list), Georgia (Top ten listed), South Carolina (Rank a, Severe threat), Florida (Category 1, altering plant community), Tennessee (Rank a, Severe threat), Kentucky (Significant threat), Virginia (Rank c, Low invasiveness), and the National Forest Service (Category 1, species known to be invasive and persistent) (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Introduced from China in 1852 for horticultural use and still used in landscaping (Merriam 2002).		
3. North Carolina nativity	Y/N	N
Native of China (Weakley 2008)		
4. Presence in natural areas	Y/N	Y
Invades both edge and interior of woodland habitats in the southeastern United States (Morris et al. 2002). Colonizes moist forests, especially alluvial bottomlands, in North Carolina (Weakley 2008). Over the past 70 years, Chinese privet has rapidly engulfed southern wetlands (Weakley 2008).		
5. Non-invasive cultivars	Y/N	N
Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications.		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	7
The greatest threat posed by *L. sinense* is large-scale ecosystem modification by outcompeting (for light) and displacing native vegetation (Urbatsch 2000). May limit hardwood regeneration, wildlife habitat, and biodiversity (Harrington and Miller 2005).		
1b. Impact on plant community structure and composition	20	20
Suppresses native vegetation as one of the most noxious weeds in North Carolina (Weakley 2008). Forms dense thickets (Morris et al. 2002, Urbatsch 2000). Provides additional layer of understory vegetation and dominates the understories of mesic forest habitat in southeastern U.S. (Harrington and Miller 2005). May displace shrub layer in woodlands (Batcher 2000).		
1c. Impact on species of special concern	5	5

Chinese privet is one exotic species that has threatened the Schweintz's sunflower (*Helianthus schweinitzii*) in the piedmont, an endangered species in North Carolina (Urbatsch 2000). Chinese privet is one aggressive weed species that when unmanaged, out shades Schweintz's sunflower (Weakley and Houk 1994). Outcompetes many kinds of native vegetation (Batcher, 2000).		
1d. Impact on higher trophic levels	5	0
Not known to impact higher trophic levels.		
Section 1. Subrank	***40***	***32***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	4
Moderate rate of spread across North Carolina - 5.4% increase in counties reporting occurrences per year (Merriam 2003). Continues to invade bottomland and upland forests in the Southeast (Harrington and Miller 2005). Distribution across southeastern U.S. experienced exponential growth between 1950-1980 (Harrington and Miller 2005). Over the past 70 years, Chinese privet has rapidly engulfed southern wetlands (Weakley 2008).		
2b. Long-distance dispersal potential	13	13
Seeds spread by birds and animals (Harrington and Miller 2005, Batcher 2000). Flooding and water transport may be major seed-carrying mechanism, since the species is often distributed along rivers and streams (Merriam 2003).		
2c. Reproductive characteristics	8	6
Seeds germinate readily without cold stratification (Harrington and Miller 2005). Grows from seed, root and stump sprouts (Batcher 2000). Produces large number of viable seeds that are readily dispersed by birds and have high germination rates in a wide variety of environmental conditions (Batcher 2000). Plants mature rapidly and produce prolific amount of seeds, spreads vegetatively by root suckers (Urbatsch 2000).		
2d. Range of communities	6	6
Moist forests, alluvial bottomlands, southern wetlands in North Carolina (Weakley 2008). NC Primary Systems (Shafale and Weakley 1990) = Low elevation mesic forests, river floodplains, nonalluvial wetlands of the mountains and Piedmont		
2e. Similar habitats invaded elsewhere	6	2
Chinese privet grows in red cedar and hardwood forests around cedar glades in Tennessee (Morris et al. 2002) and has been reported in oak-hickory pine forest and longleaf pine forest habitats in Alabama (Batcher 2000). *Ligustrum spp.* colonize floodplains, woodlands, bogs, wetlands, old fields, calcareous glades and barrens, and mesic hardwood forests in North America (Batcher 2000). NC Primary Systems (Shafale and Weakley 1990) = Low elevation dry and dry-mesic forest and woodlands		
Section 2. Subrank	***40***	***31***
Section 3. Management Difficulty		
3a. Herbicidal control	5	0
Low rates of glyphosate effective when applied in spring or fall, lower control with		

summer application (Harrington and Miller 2005).		
3b. Nonchemical control methods	2	1
Manual uprooting of plants provides less control than glyphosate application (Harrington and Miller 2005). Mowing or cutting will control the spread of *L. sinense* but may not eradicate it (Batcher 2000). No known biological controls (Urbatsh).		
3c. Necessity of individual treatments	2	2
Shrub or small trees, grows to about 9 m tall, multiple stems, abundant production of root sprouts (Harrington and Miller 2005). Plants may be cut back for cut-stem application, or herbicides may be applied using a backpack sprayer (Harrington and Miller 2005). Herbicides may be applied using a foliar spray method where risk to desirable species is limited, or using cut stump control methods when individual shrubs must be treated to limit nontarget impacts (Batcher 2000).		
3d. Average distribution	2	1
Variability of stands, either isolated or stand-grown (Harrington and Miller, 2005).		
3e. Likelihood of reestablishment	2	2
Abundant regeneration possible from root sprouts (Harrington and Miller 2005). High likelihood of continued dispersal of seeds into treated area (Batcher 2000). Eradication is difficult due to high reproductive capacity by seed and vegetative propagation (Urbatsch 2000).		
3f. Accessibility of invaded areas	2	2
Seeds spread by birds, shade tolerant and able to spread under dense forest canopies (Harrington and Miller 2005, Batcher 2000).		
3g. Impact on native species and environment	5	2
Herbicide applications may impact non-target species (Batcher 2000). Glyphosate and triclopyr have no soil activity at registered rates and if applied as a directed foliar application, present little risk to associated vegetation (Harrington and Miller 2005).		
Section 3. Subrank	***20***	***10***
Section 4. Benefits and Value		
4a. Estimated Wholesale Value in North Carolina	-7	-3
The estimated annual wholesale value attributed to Chinese privet is $8,740,700 in North Carolina (Trueblood 2009).		
4b. Percentage of total sales	-5	-3
Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be: 11-25% (Trueblood 2009).		
4c. Ecosystem services	-1	0
4d. Wildlife habitat	-1	-1
Important component of winter deer forage (Stromayer et al., 1998)		
4e. Cultural and social benefits	-1	0
Section 4. Subrank	***-15***	***-7***

Overall Score and Recommendation	**100**	**66**
(Medium) Moderately weedy and recommended for use with specific guidance/ (High) Highly invasive and not recommended for horticultural use		
Summary: *Ligustrum sinense* (Chinese privet) ranks highly in the assessment system, and may be categorized as moderately weedy to highly invasive in North Carolina. Chinese privet has high ecological impact and distribution and invasive potential, along with high economic value in the horticultural industry. Chinese privet impacts ecosystems by displacing and outcompeting native vegetation. There is great potential for the additional invasion of Chinese privet within natural areas. The difficulty of managing Chinese privet is moderate considering the availability of control methods, but management may be costly considering the time and labor required to effectively treat stands of Chinese privet. Chinese privet is economically valuable to the nursery industry and benefits wildlife habitat. Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications. Use of seedless cultivars would be desirable when they become available.		

Appendix B11. Testing the California assessment system with *Miscanthus sinensis*

Appendix B11. Testing the California assessment system with *Miscanthus sinensis*

Model: Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands

(Warner et al. 2003)

Species: *Miscanthus sinensis* Anderson. (Chinese silvergrass)

Section 1. Ecological Impact
Question 1.1 Impact on abiotic ecosystem processes *Score: C*
Identify ecosystem processes impacted: Fire occurrence, frequency, and intensity
Rationale: Monocultural stands can alter native ecosystems and delay reforestation (Hockenberry Meyer 2008). Highly flammable and a wildland fire hazard (Miller 2003). May alter fire regime (Remaley 2003). However, it is unclear whether *M. sinensis* is found in natural areas of North Carolina.
Question 1.2 Impact on plant community composition, structure, and interactions *Score: C*
Identify type of impact or alteration: Minor
Rationale: Aggressive, spreading plant with invasive potential (Gilman 1999). Forms extensive infestations (Miller 2003).
Question 1.3 Impact on higher trophic levels *Score: E*
Identify type of impact or alteration: Unknown
Question 1.4 Impact on genetic integrity *Score: D*
Identify impacts: No known hybridization
Overall Impact Rating: C

Section 2. Invasive Potential
Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score: C*
Describe role of disturbance: Low invasive potential
Rationale: Common along roadsides (Weakley 2008). *Miscanthus sinensis* is a pioneer, early successional species that is very shade intolerant and quickly shaded out as natural succession progresses. Mostly found along roadsides and in abandoned pastures.
Question 2.2 Local rate of spread with no management *Score: C*
Describe rate of spread: Stable
Question 2.3 Recent trend in total area infested within state *Score: B*
Describe trend: Increasing, but less rapidly
Rationale: Becoming aggressively weedy in North Carolina (Weakley 2008).
Question 2.4 Innate reproductive potential *Score: U*
Rationale: Wind-pollinated and capable of self-seeding (Wilson and Knox 2006). While seed viability varies by cultivar and location, Wilson and Knox (2006) found that the total averaged germination among cultivars was between 42-66% in Florida. Viable seedlings are readily produced in mild climates, including Zone 6 of western North Carolina (Hockenberry Meyer 2004). The wild type *Miscanthus sinensis* sets a significant amount of airborne seed

(Hockenberry Meyer 2003).
Question 2.5 Potential for human-caused dispersal *Score: A*
Identify dispersal mechanisms: Commercial sales, spread along roadways
Rationale: Generally spread along roadsides and woodland borders (Wilson and Knox 2006). Interstate highways in western North Carolina provide a corridor for the spread of airborne seeds of Miscanthus (Hockenberry 2008).
Question 2.6 Potential for natural long-distance dispersal *Score: B*
Identify dispersal mechanisms: Occasional long-distance dispersal
Rationale: Wind pollinated and viable pollen may be carried long distances (Wilson and Knox 2006). The wild type *Miscanthus sinensis* sets a significant amount of airborne seed (Hockenberry Meyer 2003).
Question 2.7 Other regions invaded *Score: C*
Rationale: In addition to Western North Carolina, *Miscanthus sinensis* has naturalized in southeastern Pennsylvania, the Washington, D.C. area, and Iowa (Hockenberry Meyer 2003). Ogura and Yura (2008) found that sandblasting and salt spray inhibit the survival and growth of *Miscanthus sinensis* on coastal sand dunes.
Overall Invasiveness Score = C (10 points)
Section 3. Ecological Amplitude and Distribution
Question 3.1 Ecological amplitude *Score: U*
Describe ecological amplitude: Unknown
Rationale: Unable to estimate percentage of occurrences invaded
Question 3.2 Distribution *Score: C*
Describe distribution: Colonizes a variety of sites but grows best in moist well-drained areas. Invades shores of reservoirs, roadsides, and old fields in the Southeastern United States (Remaley 2003). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests.
Overall Distribution Rating = C
Overall Plant Score = Low   *Low: The ecological impacts of these species are minor. Their reproductive biology and other invasiveness attributes result in low to moderate rates of invasion. Ecological amplitude and distribution are generally limited (these species may be locally persistent and problematic).*

Appendix B12. Testing the Florida assessment system with *Miscanthus sinensis*

Appendix B12. Testing the Florida assessment system with *Miscanthus sinensis*

Model Test: IFAS Assessment of the Status of Non-Native Plants in Florida's Natural Areas (Fox et al. 2005)

Species: *Miscanthus sinensis* Anderson (Chinese silvergrass)

Section I Invasion Status
1a. Occurrence in natural areas *Unknown*
Naturalized in 3 counties (Buncombe, Madison, and Henderson) in western North Carolina (Zone 6) (Hockenberry Meyer 2008) along roadsides and in pastures.
2a. Occurrence in natural areas only because of previous cultivation *No*
1b. Existence outside of cultivation *Yes*
2b. Invasion only with alteration of natural disturbance regime *No*
Section II. Ecological Impacts of Invasion
II-a Known Impacts at Worst Sites
i. Long-term alterations in ecosystem processes *0 points*
Unclear whether M. sinensis affects ecosystem processes in natural areas.
ii. Negative impacts on Federal or Florida (North Carolina) listed Species of Special Concern or Threatened or Endangered plants or animals *0 points*
Impacts are considered unknown.
iii) Displaces or precludes native vegetation by achieving populations in the zone that have at least 50% coverage of this species in the affected stratum *0 points*
iv) Changes community structure in ways other than vegetation displacement (adds a new stratum) *4 points*
Comments: Monocultural stands can alter native ecosystems and delay reforestation (Hockenberry Meyer 2008). Aggressive, spreading plant with invasive potential (Gilman 1999). Forms extensive infestations (Miller 2003).
v) Hybridizes with native Florida plants or economically-important species *0 points*
vi) Covers over 15% of invaded stratum *0 point*
Comments:
Section II-a Score: 4 points
II-b Range of Communities in Which Species is Invading
II-b Is this species known to be invading at least four community groups OR does it occur in at least one community group of each of the terrestrial and palustrine/aquatic lists? *4 points*
Comments: Colonizes a variety of sites but grows best in moist well-drained areas. Invades shores of reservoirs, roadsides, and old fields in the Southeastern United States (Remaley 2003). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests.
II-c Proportion of Invaded Sites with Significant Impacts

II-c Of the invaded sites, might any of the worst impacts only occur under a few, identifiable, environmental conditions? *Unknown*
Section III. Potential for Expansion
III-a Known Rate of Invasion
III-a. Was this species reported in more than two new discrete populations (at least 1 mile apart) in any 12 month period within the last 10 years? *Unknown*
Known Rate of Invasion P = Low
Section IV. Difficulty of Management
i) Available herbicide treatments *0 points*
Comments: After the new growth is approximately 12" tall in mid spring or early summer, plants may be treated with glyphosate (Hockenberry Meyer 2003).
ii) This species is difficult to control without significant damage to native species. *0 points*
iii) Total costs of known control method per acre in first year, including access, personnel, equipment, materials, and re-vegetation are > $1,500/acre. *0 points*
iv) Further site restoration is necessary. *0 points*
v) The total area over which management would have to be conducted is > 500 acres. *0 points*
vi) Requires re-survey or re-treatment *2 points*
Comments: Mowing must be repeated, sometimes for several years, if a seed bank has been established (Hockenberry Meyer 2003).
vii) Much of the area to be surveyed and controlled cannot be reached easily. *0 points*
viii) Occurs in more than 20 discrete populations in managed areas. *0 points*
ix) The number of viable, independent propagules per mature plant is >200 per year and >10% disperse a horizontal distance from the parent plant of at least 10 yards, or 3 times the height of the parent plant. *0 points*
x) Age at first reproduction (by seed or vegetative) is within first 10% of likely life-span and/or less than 3 months. *0 points*
Total points Section IV =2
Section V. Economic Value
1. Does this species have any economic value in Florida (North Carolina) *Yes*
2. Is this species sold in national or regional retail stores? *Yes*
Economic Value = High
Conversion of Index Scores to Index Categories
Ecological Impact =Low *Potential for Expansion =Low* *Management Difficulty = Low* *Economic Value = High*
Conclusion: OK – Not considered a problem species at this time (may be recommended for reassessment in 10 years)

Appendix B13. Testing the Michigan assessment system with *Miscanthus sinensis*

Appendix B13. Testing the Michigan assessment system with *Miscanthus sinensis*

Model Test: Michigan Plant Invasiveness Assessment System (Schutzki et al. 2004)

Species: *Miscanthus sinensis* Anderson (Chinese silvergrass)

Section 1: Biological Character	
I-A Reproductive Ability	
I-A1 Reproduction by Seed	*Low*
Comments: Wind-pollinated and capable of self-seeding (Wilson and Knox 2006). While seed viability varies by cultivar and location, Wilson and Knox (2006) found that the total averaged germination among cultivars was between 42-66% in Florida. Spread by seeds (Ogura and Yura 2008). Viable seedlings are readily produced in mild climates, including Zone 6 of western North Carolina (Hockenberry Meyer 2004). The wild type *Miscanthus sinensis* sets a significant amount of airborne seed (Hockenberry Meyer 2003).	
I-A2 Reproduction by Vegetative Means	*Insignificant*
Comments: Does not spread by rhizomes.	
I-B Dispersal	*Medium*
Vector categories: Wind, Commercial sales Dispersal distance: Great potential	
Section II Impact	
II-A Natural Systems	
II-A1. Ability to Invade Natural Systems	*0 points*
Comments: Common along roadsides and in pastures (Weakley 2008), but *M. sinensis* is not known to spread into natural systems in the absence of disturbance.	
II-A2. Impact on Ecosystem Processes	*5 points*
Comments: Monocultural stands can alter native ecosystems and delay reforestation (Hockenberry Meyer 2008). Highly flammable and a wildland fire hazard (Miller 2003). May alter fire regime (Remaley 2003).	
II-A3. Impact on Natural Community Structure	*3 points*
Comments: Aggressive, spreading plant with invasive potential (Gilman 1999). Forms extensive infestations (Miller 2003).	
II – A4. Impact on Natural Community Composition	*0 points*
Comments: Unknown impacts	
II-A5. Conservation Significance of the Natural Systems and Native Species Threatened	*3 points*
Comments: Colonizes a variety of sites but grows best in moist well-drained areas. Invades shores of reservoirs, roadsides, and old fields in the Southeastern United States (Remaley 2003). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests.	
Natural Systems Impact Subrank: Insignificant (11 points)	

Section III. Distribution in Michigan (North Carolina) and the United States
Response: Increasing
Comments: Becoming aggressively weedy in North Carolina (Weakley 2008).
Section IV. Control Methods
IV-A. Control Methods *Available*
IV-B Control Methods Currently Available
Response: Mowing/cutting, herbicides
Comments: Regular mowing can reduce the growth of Miscanthus and eventually kill it (Hockenberry Meyer 2008). To treat with herbicides, the previous year's growth should be removed by cutting the plant back to the ground. After the new growth is approximately 12" tall in mid spring or early summer, plants may be treated with glyphosate (Hockenberry Meyer 2003).
Control Method Subrank: A
Section V. Control Effort
V-A. Control Potential *6 points*
Response: Following the first year of control of this species, it would be expected that individual sites would require re-survey or re-treatment, due to recruitment form persistent seeds, spores, or vegetative structures, or by dispersal form outside the site: one to four times over the next 5 years
Control Potential Subrank: High potential for control
Section VI. Value within Michigan (North Carolina)
Horticulture *5 points*
Response: This plant has provided a crop that has been sold within the state and used by the general public within the state.
Landscape 5 *points*
Response: This plant is currently sold in retail stores and used in residential, commercial, and public landscapes.
Value Subrank: High
Overall Invasiveness Rank = Insignificant Impact

Appendix B14. Testing the NatureServe assessment system with *Miscanthus sinensis*

Appendix B14. Testing the NatureServe assessment system with *Miscanthus sinensis*

Model Test: An Invasive Species Assessment Protocol (Morse et al. 2004)

Species: *Miscanthus sinensis* Anderson (Chinese silvergrass)

Screening Questions	
S-1 Establishment in Region of Interest	*Yes*
Comments: Present in the Coastal Plain, Piedmont, and Mountains of North Carolina (Weakley 2008).	
S-2 Occurrence in Native Species Habitat	*Maybe*
Comments: Common along roadsides (Weakley 2008) in western North Carolina, but it is unclear if *M. sinensis* is found in any true natural areas.	
Section I. Ecological Impact	
1. Impact on Ecosystem Processes and System-Wide Parameters	*B/C (11-22 points)*
Response: Moderate/Low	
Comments: Highly flammable and a wildland fire hazard (Miller 2003). May alter fire regime (Remaley 2003).	
2. Impact on Ecological Community Structure	*C (6 points)*
Response: Low	
Comments: Aggressive, spreading plant with invasive potential (Gilman 1999). Forms extensive infestations (Miller 2003).	
3. Impact on Ecological Community Composition	*C (6 points)*
Response: Low	
Comments: Monocultural stands can alter native ecosystems and delay reforestation (Hockenberry Meyer 2008).	
4. Impact on Individual Native Plant or Animal Species	*U (0-9 points)*
Response: Unknown	
5. Conservation Significance of the Communities and Native Species Threatened	*U (0-24 points)*
Response: Unknown	
	Subrank I: Insignificant/Medium (23-67 points)
Section II. Current Distribution and Abundance	
6. Current Range Size in Region	C *(5 points)*
Response: Low	
Comments: Naturalized in 3 counties (Buncombe, Madison, and Henderson) in western North Carolina (Zone 6) (Hockenberry Meyer 2008) along roadsides and in pastures.	
7. Proportion of Current Range Where Species is Negatively Impacting Biodiversity	*U (0-15 points)*
Response: Unknown	
8. Proportion of Region's Biogeographic Units Invaded	C *(1 points)*
Response: Low	

Comments: Naturalized in 3 counties (Buncombe, Madison, and Henderson) in western North Carolina (Zone 6) (Hockenberry Meyer 2008) along roadsides and in pastures.
9. Diversity of Habitats or Ecological Systems Invaded in Region D *(0 point)*
Response: Insignificant. Only one habitat or ecological system invaded.
Comments: Colonizes a variety of sites but grows best in moist well-drained areas. Invades shores of reservoirs, roadsides, and old fields in the Southeastern United States (Remaley 2003). Natural communities of North Carolina (Shafale and Weakley 1990) = Low elevation mesic forests.
Section II Interval: Insignificant/Medium (6-21 points)
Section III. Trend in Distribution and Abundance
10. Current Trend in Total Range Within the Region *B (12 points)*
Response: Moderate
Comments: Becoming aggressively weedy in North Carolina (Weakley 2008).
11. Proportion of Potential Range Currently Occupied *B (2 points)*
Response: Moderate
12. Long-Distance Dispersal Potential Within Region *B (6 points)*
Response: Moderate
Comments: The wild type *Miscanthus sinensis* sets a significant amount of airborne seed (Hockenberry Meyer 2003). Interstate highways in western North Carolina provide a corridor for the spread of airborne seeds of Miscanthus (Hockenberry 2008).
13. Local Range Expansion or Change in Abundance *U (0-18 points)*
Response: Unknown
14. Inherent Ability to Invade Conservation Areas and Other Native Species Habitat *D (0 points)*
Response: Insignificant
Comments: Generally spread along roadsides and woodland borders (Wilson and Knox 2006)., but it is unclear if *M. sinensis* invades natural areas.
15. Similar Habitats Invaded Elsewhere *U (0-9 points)*
Response: Unknown
Comments: In addition to Western North Carolina, *Miscanthus sinensis* has naturalized in southeastern Pennsylvania, the Washington, D.C. area, and Iowa (Hockenberry Meyer 2003). Ogura and Yura (2008) found that sandblasting and salt spray inhibit the survival and growth of Miscanthus sinensis on coastal sand dunes.
16. Reproductive Characteristics *B (6 points)*
Response: Moderate
Comments: Adaptable to a wide range of environmental conditions (Wilson and Knox 2006). Wind-pollinated and capable of self-seeding (Wilson and Knox 2006). While seed viability varies by cultivar and location, Wilson and Knox (2006) found that the total averaged germination among cultivars was between 42-66% in Florida. Spread by seeds (Ogura and Yura 2008). Viable seedlings are readily produced in mild climates, including Zone 6 of western North Carolina (Hockenberry Meyer 2004). Heavy seed set (Hockenberry Meyer 2004). The wild type *Miscanthus sinensis* sets a significant amount of airborne seed

(Hockenberry Meyer 2003).
Section III Interval: Low/Medium (26-53 points)
Section IV. Management Difficulty
17. General Management Difficulty *B (12 points)*
Response: Moderate
Comments: After the new growth is approximately 12" tall in mid spring or early summer, plants may be treated with glyphosate (Hockenberry Meyer 2003). Hand pulling is ineffective due to the large root system and ability to resprout from root fragments (Remaley 2003). Regular mowing can reduce the growth of *M. sinensis* and eventually kill it (Hockenberry Meyer 2008). However, mowing or burning *M. sinensis* when plants are dormant in winter or early spring may increase plant growth (Hockenberry Meyer 2008).
18. Minimum Time Commitment *C (5 points)*
Response: Low
Comments: Individual treatments are necessary, and plants should be cut back and allowed to grow approximately 12" before treating with glyphosate (Hockenberry Meyer 2003). Mowing must be repeated, sometimes for several years, if a seed bank has been established (Hockenberry Meyer 2003).
19. Impacts of Management on Native Species *C (5 points)*
Response: Low
Comments: Nontarget plants may be killed or injured by root uptake (Miller 2003).
20. Accessibility of Invaded Areas D *(0 points)*
Response: Insignificant
Comments: Readily naturalizes in areas (roadsides, pastures) long distances from its planting (Wilson and Knox 2006).
Section IV Interval: Low (22 points)
Overall I-Rank: Insignificant/Medium (8-63 points)
Insignificant: Species represents an insignificant threat to native species and ecological communities. **Medium**: Species represents moderate threat to native species and ecological communities.

Appendix B15. Testing the North Carolina assessment system with *Miscanthus sinensis*

Appendix B15. Testing the North Carolina assessment system with *Miscanthus sinensis*

Model Test: The North Carolina Invasive Species Assessment System (Trueblood 2009)

Species: *Miscanthus sinensis* Anderson (Chinese silvergrass)

	Answer Choices	Response
Introductory Questions		
1. Current federal and state regulations	Y/N	N
Appears on several invasive species lists (not laws) in the Southeastern U.S., including Georgia (Important), South Carolina (Significant threat), Tennessee (Rank 2, Significant threat), Kentucky (Severe threat), Virginia (Low invasiveness), and the U.S. Forest Service Policy (Category 2, Species suspected to be invasive (Invasive.org 2009).		
2. Occurrence in the horticultural trade	Y/N	Y
Popular ornamental grass (Hockenberry Meyer 2004).		
3. North Carolina nativity	Y/N	N
Native to Eastern Asia (Weakley 2008).		
4. Presence in natural areas	Y/N	Unknown
Naturalized in 3 counties (Buncombe, Madison, and Henderson) in western North Carolina (Zone 6) (Hockenberry Meyer 2008) along roadsides and in pastures. Common along roadsides (Weakley 2008), but is unclear if *M. sinensis* is found in natural areas in North Carolina. *Miscanthus sinensis* is a pioneer, early successional species that is very shade intolerant and quickly shaded out as natural succession progresses.		
5. Non-invasive cultivars	Y/N	Y
Researchers at North Carolina State University are working on developing new, seedless, noninvasive cultivars for landscape applications. *Miscanthus* x *giganteus* is a sterile triploid hybrid (Jorgensen and Muhs 2001)		
	Maximum Point Value	Number of Points Assigned
Section 1. Ecological Impact		
1a. Impact on abiotic ecosystem processes	10	4
Monocultural stands can alter native ecosystems and delay reforestation (Hockenberry Meyer 2008). Highly flammable and a wildland fire hazard (Miller 2003). May alter fire regime (Remaley 2003), but it is unclear if M. sinensis is present in natural areas of North Carolina.		
1b. Impact on plant community structure and composition	20	0
Aggressive, spreading plant with invasive potential (Gilman 1999). Forms extensive infestations (Miller 2003).		
1c. Impact on species of special concern	5	0
Unknown impacts on species of special concern.		
1d. Impact on higher trophic levels	5	0

Unknown impacts on higher trophic levels.		
Section 1. Subrank	***40***	***4***
Section 2. Current Distribution and Potential for Expansion		
2a. Local range expansion	7	4
Becoming aggressively weedy in North Carolina (Weakley 2008).		
2b. Long-distance dispersal potential	13	3
Miscanthus sinensis sets a significant amount of airborne seed (Hockenberry Meyer 2003). Generally spread along roadsides and woodland borders (Wilson and Knox 2006). Interstate highways in western North Carolina provide a corridor for the spread of airborne seeds of Miscanthus (Hockenberry 2008).		
2c. Reproductive characteristics	8	6
Adaptable to a wide range of environmental conditions (Wilson and Knox 2006). Wind-pollinated and capable of self-seeding (Wilson and Knox 2006). While seed viability varies by cultivar and location, Wilson and Knox (2006) found that the total averaged germination among cultivars was between 42-66% in Florida. Viable seedlings are readily produced in mild climates, including Zone 6 of western North Carolina (Hockenberry Meyer 2004). Heavy seed set (Hockenberry Meyer 2004, Ogura and Yura 2008). *Miscanthus sinensis* sets a significant amount of airborne seed (Hockenberry Meyer 2003).		
2d. Range of communities	6	0
Colonizes a variety of sites but grows best in moist well-drained areas. Invades shores of reservoirs, roadsides, and old fields in the Southeastern United States (Remaley 2003). However, *M. sinensis* appears to occur only along the transportation corridors in any of the natural communities of North Carolina, so it is not considered to have yet invaded these systems. *Miscanthus sinensis* may be found adjacent to the ecological type, Low elevation mesic forests (Shafale and Weakley 1990).		
2e. Similar habitats invaded elsewhere	6	0
In addition to Western North Carolina, Miscanthus sinensis has naturalized in southeastern Pennsylvania, the Washington, D.C. area, and Iowa (Hockenberry Meyer 2003), but the affected ecological types are unknown.		
Section 2. Subrank	***40***	***13***
Section 3. Management Difficulty		
3a. Herbicidal control	5	3
To treat with herbicides, the previous year's growth should be removed by cutting the plant back to the ground. After the new growth is approximately 12" tall in mid spring or early summer, plants may be treated with glyphosate (Hockenberry Meyer 2003). An adequate amount of actively growing foliage should be present for effective herbicide treatments (Hockenberry Meyer 2003).		
3b. Nonchemical control methods	2	1
Hand pulling is ineffective due to the large root system and ability to resprout from root fragments (Remaley 2003). Regular mowing can reduce the growth of *M. sinensis* and		

eventually kill it (Hockenberry Meyer 2008). However, mowing or burning *M. sinensis* when plants are dormant in winter or early spring may increase plant growth (Hockenberry Meyer 2008).		
3c. Necessity of individual treatments	2	2
Plants should be cut back and allowed to grow approximately 12" before treating with glyphosate (Hockenberry Meyer 2003).		
3d. Average distribution	2	1
Dense infestations may form monocultural stands (Hockenberry Meyer 2008).		
3e. Likelihood of reestablishment	2	1
Mowing must be repeated, sometimes for several years, if a seed bank has been established (Hockenberry Meyer 2003).		
3f. Accessibility of invaded areas	2	1
Readily naturalizes in areas long distances from its planting (Wilson and Knox 2006).		
3g. Impact on native species and environment	5	2
Nontarget plants may be killed or injured by root uptake (Miller 2003).		
Section 3. Subrank	***20***	***11***
Section 4. Benefits and Value		
4a. Estimated Wholesale Value in North Carolina	-7	-6
The estimated wholesale value attributed to M. sinensis is $39,284,700 in North Carolina (Trueblood 2009).		
4b. Percentage of total sales	-5	-4
Among the producers that sell this species, the highest percentage of total sales attributed to this species from any one grower is estimated to be: 26-50%. (Trueblood 2009).		
4c. Ecosystem services	-1	0
4d. Wildlife habitat	-1	0
4e. Cultural and social benefits	-1	0
Section 4. Subrank	***-15***	***-10***
Overall Score and Recommendation	***100***	***18***
(Low) Noninvasive and recommended for use		
Summary: While *M. sinensis* has naturalized in 3 counties (Buncombe, Madison, and Henderson) in western North Carolina (Hockenberry Meyer 2008), the infestations are found along roadsides and in pastures, rather than natural areas. The ecological impacts of *M. sinensis* in natural areas of North Carolina are largely unknown, so the overall invasiveness of the species is unclear. However, Weakley (2008) indicated that *M. sinensis* is becoming aggressively weedy in North Carolina, and other states in the southeastern U.S. have included Chinese silvergrass on state listings of invasive species (Invasive.org 2009), so additional research regarding the distribution, spread, and environmental impacts in North Carolina would be useful. The species appears to have very high economic value in the North Carolina nursery industry.		