Trueblood, C.E. 2009. 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. In An Invasive Species Assessment System for the North Carolina Horticultural Industry. MS Thesis. North Carolina State University, Raleigh, pp. 184-203.

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)
<u>Ecological impacts</u>					
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
<u>Invasive Potential or Current Distribution</u>					
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
<u>Management Difficulty</u>					
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
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
<u>Economic Benefits and Value</u>					
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.

LITERATURE CITED

Batcher, M.S. (2000) Element stewardship abstract for *Ligustrum spp*. Privet. The Nature Conservancy. Arlington, Virginia.

California Invasive Plant Council (Cal-IPC). (2009) Risk Mapping for Early Detection. (http://www.cal-ipc.org/ip/mapping/statewide_maps/index.php) Accessed: October 1, 2007.

Ehrenfeld, J.G. (1997) Invasion of deciduous forest preserves in the New York metropolitan region by Japanese barberry (*Berberis thunbergii* DC). Journal of the Torrey Botanical Society 124: 210-215.

Ehrenfeld, J.G., Kourtev, P., and W. Huang. (2001) Changes in soil functions following invasions of exotic understory plants in deciduous forests. Ecological Applications 11: 1287-1300.

Franklin, M.A. (2004) Natural Heritage Program List of Rare Plant Species of North Carolina. North Carolina Natural Heritage Program. Raleigh, NC.

Fox, A.M., D.R. Gordon, J.A. Dusky, L. Tyson, and R.K. Stocker. 2005. IFAS Assessment of the Status of Non-Native Plants in Florida's Natural Areas. (http://plants.ifas.ufl.edu/assessment.html) Accessed: October 1, 2007.

Gilman, E.F. (1999) Miscanthus sinensis, Fact Sheet FPS-405. Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. (http://hort.ufl.edu/shrubs/MISSINA.PDF) Accessed: April 2, 2009.

Harrington, T.B. and J.H. Miller. (2005) Effects of application rate, timing, and formulation of glyphosate and triclopyr on control of Chinese privet (*Ligustrum sinensis*). Weed Technology. 19:47-54.

Hockenberry Meyer, M. (2003) Fact Sheet and Management of Miscanthus sinensis. University of Minnesota. (http://www.horticulture.umn.edu/miscanthus/) Accessed: April 2, 2009.

Hockenberry Meyer, M. (2004) Split personality. American Nurseryman. Pgs. 30-35.

Hockenberry Meyer, M. (2008) Miscanthus in Western North Carolina. University of Minnesota (http://horticulture.cfans.umn.edu/miscanthus/NC%20escaped%20sites.htm) Accessed: April 2, 2009.

Hockenberry Meyer, M. and C.L. Tchida. (2000) Viable-seed production from Miscanthus may indicate potential invasiveness. American Nurseryman. 192: 86.

Invasive Plant Species Assessment Working Group (IPSAWG). 2005. Indiana. (http://www.in.gov/dnr_old/invasivespecies/8_03_05_assessment.pdf) Accessed October 1, 2007.

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.

Jorgensen, U. and H.J. Muhs. (2001) Miscanthus breeding and improvement. In: Miscanthus for energy and fibre, ed by M.B. Jones and M. Walsh. James and James. London

Kourtev, P.S., Ehrenfeld, J.G., and M. Haggblom. (2002) Exotic plant species alter the microbial community structure and function in the soil. Ecology 83:3152-3166.

Lubell, J.D., Brand, M.H., Lehrer, J.M., Holsinger, K.E. (2008) Detecting the influence of ornamental *Berberis thunbergii* var. *atropurpurea* in invasive populations of *Berberis thunbergii* (Berberidaceae) using AFLP. American Journal of Botany 95: 700-705.

Merriam, R.W. (2003) The abundance, distribution, and edge associations of six non-indigenous, harmful plants across North Carolina 130: 283-291.

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.

Morris, L.L., Walck, J.L., and S.N. Hidayati. (2002) Growth and reproduction of the invasive *Ligustrum sinensis* and native *Forestiera Ligustrina* (Oleaceae): Implications for the invasion and persistence of a nonnative shrub. International Journal of Plant Science. 163: 1001-1010.

Morse, L.E., J.M. Randall, N. Benton, R. Hiebert, and S. Lu. 2004. *An Invasive Species Assessment Protocol: Evaluating Non-Native Plants for Their Impact on Biodiversity. Version 1.* NatureServe, Arlington, Virginia.

Northam, F.E., Backer D.M., and J.A. Hall. 2005. Development of a categorized list of invasive non-native plants that threaten wildlands in Arizona. Arizona Wildlands Invasive Plant Working Group. (http://sbsc.wr.usgs.gov/research/projects/swepic/SWVMA/DevelopmentOfACategorizedList.pdf) Accessed October 1, 2007.

Ogura, A. and Y. Hiroshi. (2008) Effects of sandblasting and salt spray on inland plants transplanted to coastal sand dunes. Ecol Res. 23: 107-112.

Remaley, T. (2003) Southeast Exotic Pest Plant Council Invasive Plant Manual. Southeast Exotic Pest Plant Council. (http://www.se-eppc.org/manual/index.html) Accessed: March 3, 2009.

Schutzki, R.E., Pearsall, D., Cleveland, A., Schultz, J., Herman, K., MacKenzie, D., MacDonald, S., Wood, T., and T. Myers. 2004. Michigan Invasive Plant Assessment System. Michigan Invasive Plant Council, Newago, MI.

Shafale, M.P. and A.S. Weakley. (1990) Classification of the Natural Communities of North Carolina. 3rd Approximation. North Carolina Natural Heritage Program. Raleigh, NC.

Silander, Jr. J.A. and D. M. Klepeis. (1999) The invasion ecology of Japanese barberry (*Berberis thunbergii*) in the New England landscape. Biological Invasions 1: 189-201.

Swearingen, J.M. (2005) Fact Sheet: Japanese Barberry. Plant Conservation Alliance's Alien Plant Working Group. (http://www.nps.gov/plants/alien) Accessed: May 28, 2009.

Trueblood, C.E. (2009a) 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.

Trueblood, C.E. (2009b) Chapter 1. The development of an assessment protocol for potentially invasive plant species sold in the North Carolina horticultural trade. 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.

Trueblood, C.E. (2009c) 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.

Urbatsch, L. Plant Guide: Chinese Privet. United States Department of Agriculture Natural Resources Conservation Service. (http://plants.usda.gov/plantguide/pdf/pg_lisi.pdf) Accessed: March 3, 2009.

Ward, J.S., Worthley, T.E., and S.C. Williams. (2009) Controlling Japanese barberry (*Berberis thunbergii* DC) in southern New England, USA. Forest Ecology and Management 257: 561-566.

Warner, P. J., Bossard, C.C., Brooks, M.L., DiTomaso, J.M., Hall, J.A., Howald, A.M., Johnson, D.W., Randall, J.M., Roye, C.L., Ryan, M.M., and A. E. Stanton. 2003. *Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands.* California Exotic Pest Plant Council and Southwest Vegetation Management Association. (www.caleppc.org) Accessed: October 1, 2007.

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

Weakley, A.S. and R.D. Houk. (1994) Recovery Plan for Schweintz's sunflower (*Helianthus schweintizii*). U.S. Fish and Wildlife Service, Southeast Region,

Atlanta, Georgia. (http://ecos.fws.gov/docs/recovery_plan/940422.pdf) Accessed: March 3, 2009.

Wilson, S.B. and G.W. Knox. (2006) Landscape performance, flowering, and seed viability of 15 Japanese silver grass cultivars grown in Northern and Southern Florida. HortTechnology 16:686-693.

Xu, C., Schuster, W.S., and K.L. Griffin. (2007) Seasonal variation of temperature response of respiration in invasive *Berberis thunbergii* (Japanese barberry) and two co-occurring native understory shrubs in a northeastern US deciduous forest. Oecologia 153: 809-813.

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.		