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SCOPE AND JUSTIFICATION

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

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

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

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

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

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

combat the spread of invasive species and found great potential for effective voluntary group initiatives (Burt et al. 2007). The NCNLA has also clarified key terms important in this project by adopting the following definitions:

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

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

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

According to the USDA Economic Research Service (2007), floriculture and nursery crops have been among the fastest growing components of the US agricultural economy, and North Carolina consistently ranks among the top 4 producers by state. The North Carolina Green Industry Council (2005) conducted an economic impact study of the green industry, which is composed of growers, producers, contractors, and retail centers in North Carolina, and determined that the green industry contributes \$8.6 billion and 151,982 jobs to the state economy. Among agricultural sectors in North Carolina, the nursery and floriculture industry captured the majority (29 percent) of total crop sales in 2007 with an estimated wholesale value of \$890 million (North Carolina Agricultural Statistics 2008). As the horticultural industry continues to grow, it becomes increasingly important to accurately assess the potential invasiveness of ornamental plants and avoid additional introductions or harmful establishments of escaped ornamentals. Lists of landscape plants to avoid have been developed by a variety of

organizations, including exotic pest plant counsels, botanical gardens, and conservation groups but these collections, while well intended, are often based on anecdotal experience or observations, rather than scientific evidence. In addition, the criteria for categorizing species on these weed lists are often not well defined.

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

Recommendations for the limited sale and distribution of an invasive species may be more understandable when evaluating plants using a system developed specifically for North Carolina.

Several national and regional invasive assessment protocols have recently been developed to examine the potential invasiveness of plant species and the associated environmental impact of identified invasive species establishing or spreading in a natural area. NatureServe (Morse et al. 2004) has developed a general assessment model that may be regionally adapted to evaluate the impact of invasive plants on native ecosystems. Several states, including Florida (Fox et al. 2005), California (Warner et al. 2003), Arizona (Northam et al. 2005) and Michigan (Schutzki et al. 2004) have developed their own risk assessment models for invasive plants. These efforts have been coordinated by state governments, universities, and exotic pest-plant councils.

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

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

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

identified, reducing the risk to North Carolina natural areas and allowing the nursery industry to effectively evaluate measures of voluntary regulation to prevent the spread of invasive plants.

OBJECTIVES

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

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