Extension Education Methods

Diversity in Landscape Plantings: Broader Understanding and More Teaching Needed

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Additional index words. biodiversity, genetic diversity, monoculture, nurseries, overplanting, instruction, curriculum, education

Summary. **Researchers and practitioners have been aware of the importance of plant diversity for many decades. The Irish potato famine and dutch elm disease (*Ophiostoma novo-ulmi*) are examples of problems resulting from lack of diversity. Emerald ash borer (*Agrilus planipennis*) has renewed concerns over these issues, yet little has been done to increase diversity in landscape plantings. Urban trees are becoming more uniform genetically because of cloning of preferred cultivars; thus, they are losing potential resiliency to stresses at a time when these threats are increasing. A survey on plant diversity distributed to wholesale nurseries in Washington State showed that most respondents were aware of the issues, but lacked an in-depth understanding of them. This article presents additional data from the survey. Respondents reported that lack of consumer demand was an issue. Those with more education exhibited a deeper understanding of the risks from low diversity among landscape plants. Instructors in horticulture and the plant sciences should be more involved in teaching on this topic.**

There is a long history of problems associated with the overuse of specific plants in agricultural monocultures. The Irish potato famine of 1845 to 1850, which was caused partly by dependence on a single variety of potato (*Solanum tuberosum*), called "the lumper," is a well-known example of this (Fraser, 2003). The term "monoculture" is also now used for large expanses of nonagricultural crops, such as street trees (Flemer, 1981; Frank et al., 2006). The extensive loss of trees in Europe and North America to dutch elm disease, which was first described in 1921, is a well-known example of a problem resulting from this type of monoculture (Wilson, 1975). This article presents further results from a study of the wholesale nursery industry (Polakowski et al., 2011) that noted some lack of awareness of the problems that arise from monocultures and the potential role of educators in overcoming this lack of awareness.

Risks associated with overplanting come from lack of genetic variation, which increases susceptibility to pest damage and environmental stresses. Genetic variation occurs across species and within species. "Biodiversity" is the term generally used for the range of diversity across different species in an area (Lankau and Strauss, 2007). "Genetic diversity" typically refers to the range of different genetic characteristics within a single species. Both, as explained below, play a role in reducing risks associated with monocultures.

There are many examples of pest problems that have spread through landscape plantings with low biodiversity. These pests, which attack more than one species within a commonly planted genus, include dogwood anthracnose (*Discula destructiva*), hemlock woolly adelgid (*Adelges tsugae*), and ash decline disease (*Chalara fraxinea* or *Hymenoscyphus pseudoalbidus*) (Bakys et al., 2009; Daughtrey et al., 1996; Spaulding and Rieske, 2010). Another example is emerald ash borer, which attacks at least four different species of ash (*Fraxinus* sp.). In 2002, the borer was found in Michigan and Ontario (Poland and McCullough, 2006). Ash is widely used as a street tree. Only two years later, 15 million ash trees were estimated to be dead or dying from emerald ash borer injury in Michigan alone. Positive examples of efforts to reduce these potential problems can be found. For example, only three trees of the same species may be planted in a row in downtown Chicago (Heimlich et al., 2008). However, insufficient action has been taken to reduce the risks associated with low biodiversity (Muller and Bornstein, 2010).

Genetic diversity within individual species of landscape trees has unwittingly been reduced because of the use of clonal propagation for preferred clones (Iles and Vold, 2003). A recent study highlighted the issue (Morton and Gruszka, 2008). About 100 years ago, 200 seedlings of london plane tree (*Platanus ×acerifolia*) were planted in Schenley Park, Pittsburgh, PA. Since then, about half have died from sycamore anthracnose (*Apiognomonia veneta*) or canker stain (*Ceratocystis platani*). Researchers analyzed remaining park trees and trees from nurseries in Pennsylvania and Oregon. They found much greater genetic diversity in the park trees than in the nursery trees and concluded that this was because few seedling trees are sold today. Nurseries want disease-resistant london plane trees, so most clone 'Bloodgood'. Park managers, who had wanted to replant with london plane trees with expanded genetic diversity, were unable to do so. Instead, the researchers provided local nurseries with propagation material from the remaining Schenley Park trees, which presumably are resistant to both sycamore anthracnose and canker stain (Morton and Gruszka, 2008).

Little has been published about what the green industry knows

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regarding this problem or how they are responding or could respond to the risks associated with low biodiversity and genetic diversity in landscapes. A survey of people making plant inventory decisions in wholesale nurseries in Washington State was conducted to determine current awareness of diversity issues, focusing primarily on biodiversity (Polakowski et al., 2011). Respondents indicated some awareness of the issues: 85% agreed that "increasing the number of different plant species used in an area is important for biodiversity." Many appeared to lack an in-depth understanding of the issue; only 45% agreed that "planting more than 10% of the same plant species in a region greatly increases the risk of insect or disease outbreaks." Most apparently did not feel that the nursery industry played a role in the problem, because 78% agreed that "most wholesale nurseries currently offer an adequate range of genetically different plants for their customers to choose from." A majority of the respondents (60%) were educated about plants at higher educational institutions. The survey also found that education was an important factor in respondents' knowledge of the issue: those who had learned about plant diversity issues in "school or college classes" scored significantly higher on a composite score of diversity knowledge than those who did not. To further investigate who the nursery industry thinks may be responsible for this issue and what role education could play in contributing to action on this issue, additional analyses were performed with the data from the study.

Materials and methods

A survey with sections addressing landscape plant biodiversity and genetic diversity, production at wholesale nurseries, and demographics was distributed to the person responsible for plant inventory decisions at each of the 130 active wholesale nurseries in Washington State (for a detailed description of survey methodology and results, see Polakowski et al., 2011). Forty-two surveys were completed, for a response rate of 32%, which falls within the expected range for businesses (Dillman, 2000). Most of the respondents (69%) had worked in the industry for more than 15 years. The nurseries ranged in size from 0.5 to 500 acres [mean of 28 acres, median of 3 acres (1 acre = 0.4047 ha)] and produced a wide range of crops.

Permitted responses to plant diversity statements were "strongly disagree," "disagree," "slightly disagree," "slightly agree," "agree," and "strongly agree." They were scored from 1 to 6, respectively, and used to calculate a mean attitude agreement for each statement. Responses of "slightly agree," "agree," or "strongly agree" were combined to calculate the percent of respondents who expressed agreement with the statement.

Responses to statements about where respondents had learned about landscape plant diversity were compared using a Jonckeere–Terpstra test to responses on general level of education and on this question as an indicator: "planting more than 10% of the same plant species in a region greatly increases the risk of insect or disease outbreaks" (agreement was 45%; mean was 3.26). This statement was selected to represent information about biodiversity that is often mentioned in horticultural journals (Frank et al., 2006; Galvin, 1999; Santamour, 1990; Subburayalu and Sydnor, 2012). The statement was based on the "10-20-30 rule," which simply recommends that no more than 10% of a single species, 20% of a single genus, or 30% of a single family be planted in a particular area. It has been recommended as a way to reduce the risks of losing large quantities of urban plants at a time.

Results and discussion

Most survey respondents (83%) were in agreement that "planting a wide range of genetically different plant species in a landscape increases the chances the landscape will remain healthy" (Table 1). A mean of 4.59, on a scale of 1 to 6, indicated that most respondents had a good awareness and agreement with this statement. The high level suggests that many within the industry will be highly receptive to efforts to reduce the level of risk associated with a lack of biodiversity and genetic diversity in landscapes.

One challenge in dealing with this issue relates to the uncertainty of who should take responsibility for reducing the risks associated with planting too many closely related plants in an area (Iles and Vold, 2003; Sydnor et al., 2010). When asked about who was responsible for the level of diversity in nursery inventories, most survey respondents reported that both customers and landscape designers played an important role (Table 1). Mean levels of agreement suggest that respondents agreed more strongly about the role of customers than of landscape designers in determining what plants nurseries sell. Most of the survey respondents apparently think they are already contributing to the solution and are not responsible for the problem (Polakowski et al., 2011), yet information on nursery stock availability and the lack of biodiversity from cloning suggests otherwise (Iles and Vold,

Table 1. Washington State wholesale nursery industry representatives' responses (n = 42) on survey attitude statements related to landscape diversity issues (percent agreeing and mean level of agreement).

Survey attitude statement	Agree (%)[z]	Agreement (1–6 scale)[y]
Planting a wide range of genetically different plant species in a landscape increases the chances the landscape will remain healthy	83	4.59
Marketing large quantities of the same popular and well-known plants will continue until customers ask for a more diverse selection of plants	71	4.24
Landscape designers contribute to the lack of diversity in landscape plants because they look at plants primarily as design elements	71	4.07
Landscapes planted with similar plants are easier to maintain than landscapes with many different species	67	3.68
Landscapes planted with many different species often look disorganized or cluttered	27	2.54

[z]Percent of respondents who selected "strongly agree," "agree," or "slightly agree."
[y]Mean based on a scale from 1 ("strongly disagree") to 6 ("strongly agree").

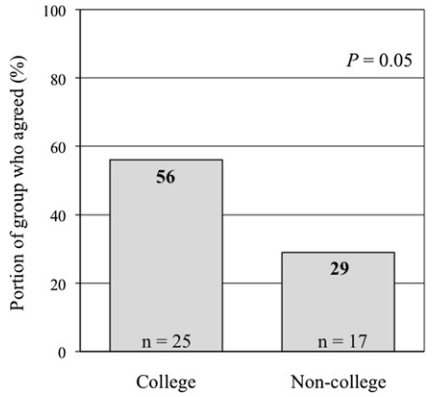

Fig. 1. Washington State wholesale nursery industry representatives' agreement that "planting more than 10% of the same plant species in a region greatly increases the risk of insect or disease outbreaks" based on whether they had learned about plants in college or not (n = 42). The probability that the columns are significantly different is based on a Jonckeere–Terpstra test.

Table 2. Washington State wholesale nursery industry representatives' agreement that "planting more than 10% of the same plant species in a region greatly increases the risk of insect or disease outbreaks," based on the information source where they learned "… about the issues with having many similar plant species in a landscape" (n = 42).

	Used source		Did not use source		
Source of biodiversity information	*N*	Agree (%)[z]	*N*	Agree (%)[y]	*P*[x]
School or college classes	12	67	30	37	0.04
News media	6	67	36	42	0.13
Trade journals and articles	28	57	14	21	0.02
University outreach (researchers, field days, or extension)	13	54	29	41	0.23
Professional organizations	17	53	25	40	0.21
Government programs (USDA, WSDA)[w]	15	40	27	48	0.31

[z]Percent of respondents using the source who selected "strongly agree," "agree," or "slightly agree."
[y]Percent of respondents not using the source who selected "strongly agree," "agree," or "slightly agree."
[x]Probability that percent agreement between those who used source and those who did not is significantly different, based on a Jonckeere–Terpstra test.
[w]USDA = U.S. Department of Agriculture; WSDA = Washington State Department of Agriculture.

2003; Morton and Gruszka, 2008; Sydnor et al., 2010). Fully addressing the problem will require working with more than just the nursery industry.

Design issues, such as the aesthetics from uniform avenues of trees, are sometimes raised as arguments against biodiversity (Flemer, 1981). Although a statement on uniform avenues of street trees was not used in this survey, other related statements were. When asked if "landscapes planted with similar plants are easier to maintain than landscapes with many different species," 67% agreed (Table 1). Interest in low maintenance landscapes (Thomas and Shrock, 2004) could be a driving force against increased diversity. However, the mean level of agreement with the statement, which was close to average, could indicate that this driving force may not be strong. When asked if "landscapes planted with many different species often look disorganized or cluttered," only 27% agreed. It is important to note that this appears not to be an issue for people working in nurseries.

Survey respondents who reported that they had learned about plants in "technical or community college (two-year school)" or "four-year college" were significantly more likely to agree that "planting more than 10% of the same plant species in a region greatly increases the risk of insect or disease outbreaks" than people who did not report learning about plants at the college level (Fig. 1). People in the wholesale nursery industry in Washington State who are involved in making inventory decisions appeared to be nearly twice as likely to understand the 10–20–30 rule of thumb regarding plant species, genus, and family diversity if they had college training about plants than if they did not. If we believe that understanding issues related to the risks of monocultures in landscapes is important for people involved in the green industries, then those of us who teach in horticultural and plant science programs should be involved in promoting that understanding.

When specifically asked about where they had learned about issues related to plant diversity, those who reported learning about them in school or college classes had a high level of agreement with the statement about using more than 10% of a species (67%), and they were significantly more likely to agree than those who did not learn about the issues in classes (Table 2). Those who reported learning about the issues from trade journals and articles were also significantly more likely to agree than those who did not report learning from trade journals or articles. There was no significant increase in agreement from learning via news media, university outreach, professional organizations, or government programs.

Twenty-five respondents reported learning about plants in college (Fig. 1), but only 12 respondents said that they had learned "… about the issues with having many similar plant species in a landscape" in school or college classes (Table 2). This could mean that the topic is not part of the standard curriculum regarding plants or that students do not retain such information if it is commonly part of such programs. Of those who reported learning about plants in college, 56% agreed with the statement, while 67% who reported learning about landscape diversity issues in classes agreed. This indicates that the topic should be a specific part of the curriculum, yet it appears to be largely absent. It is not being taught in nursery management and production courses in the United States, based on the results of a survey listing topics taught in such courses, unless it is included in units on "pest management" or "other" (Wright et al., 2010). Landscape diversity issues also did not appear in a list of competencies for undergraduate students majoring in horticulture in the United States, unless it was part of topics such as "understand plant populations in ecology as well as agriculture," "recognize the potential impact plant breeding has on agriculture," or "understand the impact of human activities on the environment" (Basinger et al., 2009). The ASHS Certified Horticulturist Program Certification Examination Study Outline (American Society for Horticultural Science, 2010), which is designed partly for professionals who do not have higher educational training in horticulture (Peet, 2007), at least mentions the topic. The following item is listed as one of 104 items

within the landscape design issues competency area, which accounts for 2.5% of the exam: "explain why monoculture (or culture of just a few varieties) promotes buildup of insects and disease." There are four items in other competency areas about the general loss of biodiversity, but nothing related to major risks that can occur as a result of narrow biodiversity or genetic diversity in landscape plantings is obvious.

Conclusions

Ecosystem services provided by plants are especially important in our increasingly urbanized world (Tzoulas et al., 2007). We are putting many of the potential benefits from these services at risk because of lack of both biodiversity and genetic diversity in landscape plantings, especially in urban areas, where the homogenization of plants worldwide has been noted (Wittig and Becker, 2010). The mass devastation to ash trees in North America because of emerald ash borer (Poland and McCullough, 2006) and in Europe because of ash decline disease (Bakys et al., 2009) has demonstrated the potential vulnerabilities of monocultures today. Risks associated with monocultures have been increasing and are predicted to become dramatically worse, because of climate change and loss of biodiversity (Lilja et al., 2011; Morton and Gruszka, 2008). More education is needed for people in the green industries on why biodiversity and genetic diversity among landscape plants are vital. College classes and articles can be effective ways to educate landscape professionals on these issues. Some group needs to tackle this problem more directly, and educators are an appropriate group.

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