Native plants in urban landscapes: a biological imperative

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A biologically diverse residential landscape in central Oregon, USA. Objectives of the project included providing wildlife habitat, creating pollinator habitat, and aesthetic quality. To meet those objectives, 53 species of native plants were installed.

ABSTRACT

Urban populations rely on a suite of ecosystem services generally provided by the ecological function of natural areas. But the expansion of urban environments and growing suburban or exurban neighborhoods often necessitates destruction of those natural areas for development supporting a growing urban populace. Ecological impacts from development reduce regional biodiversity and negatively affect the ability of remaining natural areas to provide goods and services critical to people. Secondary impacts to biodiversity also occur at broad geographic scales through commodity production supporting urban centers. For example, agricultural production often involves creating agroeconomic systems based largely on farming a limited number of species, and commonly relegates biological diversity to small patches of land deemed unsuitable for crops. Such practices exacerbate the negative biological effects inherent in urban development and drastically increase the need for urban populations to address biological diversity within municipalities. Residents are becoming progressively knowledgeable about environmental issues and are expressing values and concerns to local and regional managing agencies. Governments are responding to public pressure through recommendations intended to reduce resource use, improve wildlife habitat, and provide a local aesthetic. Although the appropriateness of native plants in urban settings is often questioned, the use of regionally specific native vegetation is identified as one method to meet those recommendations. Native plants as primary landscape elements have the added benefit of increasing biodiversity and creating environments capable of providing ecosystem goods and services within urban environments.

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KEY WORDS
urban ecology, biodiversity, ecosystem services

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The rapid growth of urban populations throughout the world places an increasing demand on ecosystem services critical for the health and well being of urban residents. Current reports of global demographics indicate that approximately 55% of the world's population reside in urban environments, and that number is expected to increase to more than 68% by 2050 (United Nations 2018). In the US, the percentage of the urban population rose from 40% in 1900 to more than 75% by the end of the 20th century and increased by 12.1% from 2000 to 2010—outpacing the nation's overall growth rate of 9.7% for the same period (United States Census 2012). More recent estimates indicate urban areas contain more than 82% of the total US population (United Nations 2018). With the majority of the population in urban areas, and the associated geographic expansion of urban areas, substantial resources and services are required from natural and agricultural landscapes, even as urban populations expand into those landscapes. Additionally, as urban populations expand into prime agricultural areas, farmers are often displaced to more marginal lands that require clearing and preparation for agricultural production (Hatab and others 2019). This secondary effect of urban expansion increases the loss of natural environments. Cities cover a relatively small geographic area but have large ecological footprints (Chini and others 2017; da Silveira 2018).

The effects of an increasing urban population include an associated impact not often discussed in the literature: a general decline in native biodiversity as a result of the expansion of commodity production in support of urban residents. For example, current trends in agricultural production mean that more areas of natural vegetation (natural areas) are being converted to farmland, increasing the demand on remaining natural areas to provide ecosystem services to support urban residents.

But natural areas are increasingly modified or affected through human activity (Forester and Machlist 1996; Hulme and others 1999; Vick and Tufts 2006), limiting the ability of extant native areas to provide ecosystem services essential to the function and health of urban residents. These essential functions include regulating services, such as water and air purification, or stormwater and flood control; support services, such as oxygen generation and nutrient cycling; and even spiritual and recreational benefits. The scale of combined urban and agricultural influence is evident throughout much of the US by the percentage of agricultural land located far from urban centers (Figure 1). The broad-scale reduction of natural areas increases the need for urban residents to create an environment capable of providing many of the services that were lost as a result of urban growth. For example, pollinators co-evolved with many native plant genera or species but are currently experiencing significant population declines as a result of host plant habitat loss—largely attributable to agricultural expansion and urban development (Steffan-Dewenter and others 2005; Gallai and others 2009; Spiesman and Inouye 2013). And although reestablishing habitat corridors or islands in urban environments has proved beneficial to many pollinator species (Hall and others 2016; Senapathi and others 2017), the potential benefit of using predominantly native plant species as pollinator habitat in urban environments is rarely explicitly studied. Yet, the benefits of a biodiverse environment for ecosystem function, including pollinator populations, are well documented (Balvanera and others 2001; Balvanera and others 2006; Nicholls and Altieri 2013). But many planners, architects, and landscape professionals have a limited knowledge of local native flora and rarely consider the ecological importance of native plants in highly managed urban environments. Those who do have such knowledge often approach planning and design as ecological restoration projects.

Figure 1. A fallow sugar beet field on the Oregon-Idaho border in the western US, approximately 60 mi from the nearest urban center. This farm is one of many that cover eastern Oregon and western Idaho and produce a variety of crops supporting urban populations around the world. Approximately 50% of the crops from this region are marketed globally. The decline of native biodiversity resulting from large-scale farming throughout the US is well documented, and it negatively impacts the ability of natural areas to provide ecosystem services that are critically important to urban populations.

ECOLOGICAL RESTORATION AND REPLACEMENT ECOSYSTEMS

The ability to actively restore any functional ecological system is commonly debated (Walker and Reddell 2007; Dodds and others 2008; Perring and others 2014) and is expressly challenged when discussing urban ecology, and rightly so. Designing native plant landscapes in urban environments requires consideration of a number of variables and constraints that frequently preclude the ability to restore pre-existing vegetative communities. Ecological restoration, however, is suggested as only one of four approaches to address a reduction of biodiversity in urban settings (Zari 2014). Other methods include

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conservation of remnant ecosystems, reducing fragmentation, and managing for biodiversity.

Urban development requires construction, and the act of constructing a building, road, complex, or other common feature in an urban environment is, in itself, a severe ecological disturbance. The Society for Ecological Restoration (SER) describes this level of disturbance as *Destruction of an Ecosystem* in which degradation or damage removes all macroscopic life and ruins the physical environment of an ecosystem (Gann and others 2019). Construction activities in urban environments typically remove all or most of the existing vegetation on a site; alter surface and subsurface hydrology; change wind patterns and exposure; and severely impact soil biota, chemistry, and structure (Figure 2). Recreating a pre-existing plant community is generally not possible following this level of disturbance. Typically, landscapes in these unique environments are designed with non-native species in patterns and densities addressing aesthetic ideals of the architect or property owner rather than ecological function. Yet, designing replacement ecosystems based on reference communities within the same Level IV ecoregion (Omernik 1995) is possible by considering the unique environmental conditions created by construction and by choosing native plant species associated with the original or historic vegetation of the site, but adapted to conditions that exist after development. Human perception and a landscape aesthetic based largely on marketing efforts since World War II are often the most challenging aspects of creating a functional replacement ecosystem in urban settings. Many people simply do not relate well to created urban landscapes that reflect a local native ecology (Thompson 2000; Nassauer and others 2009), especially when the native plant community is wilder or less orderly in appearance. Fortunately, that paradigm is beginning to shift.

Figure 2. Level of disturbance commonly associated with urban development. The Society for Ecological Restoration (SER) describes this level of disturbance as *Destruction of an Ecosystem* in which the level of degradation or damage removes all macroscopic life and ruins the physical environment of an ecosystem. Recreating a pre-existing plant association after this level of disturbance is generally not possible.

Consumer awareness of the importance of biodiversity and the benefits realized through the inclusion of a regional flora in urban landscape design is growing (Golley and Bellot 1991; Helfand and others 2006; Cadenasso and Pickett 2008; Connery 2009; Lovell and Johnston 2009; Ahern 2013). An increasingly knowledgeable public is expanding the demand for native plants and stimulating advances in the production and use of native flora as primary landscape plant material. A growing mindfulness of the resource dependency of conventional landscape practices has stimulated efforts by municipalities to reduce resource dependency—primarily water—in urban and suburban environments. Increasing appreciation of the value of native vegetation has intensified the interest in using regional native flora as a key method of achieving resource conservation targets. Although a native flora includes a range of species with widely varying water requirements, many recommended natives exhibit greater water use efficiency than do widely available landscaping plant materials.

HOMEOWNER PREFERENCES

But are conservation efforts by municipalities the primary drivers of an increased interest in native plants, or do consumers value other characteristics of native species? To address these questions, we completed an informal, online survey designed to assess how homeowners or property managers value native plants and why they choose natives as primary landscape elements. The survey was sent through the Facebook page of WinterCreek Nursery, a native plant propagation nursery located in Bend, Oregon. The survey was "boosted" twice to reach friends of friends of friends of WinterCreek Nursery. Respondents were self-selected and were predominantly from Oregon, Washington, and California (N = 124). The survey included a series of questions focused on phenotypic characteristics and genetic variability, but one question explicitly asked why consumers choose native species (Figure 3). Results indicate that water conservation is highly valued (80.7% of respondents), but only slightly more than wildlife habitat (75.0%) or pollinator habitat (74.2%), suggesting efforts to reduce resource dependency in urban landscapes is effective but also indicating a general understanding of the habitat value of native plants (n = 122). Note that results of this informal survey reflect resource values in the western US where long-term drought has increased concerns over water availability, distribution, and use, which may not represent the values or concerns of populations in other areas.

Municipalities and governmental agencies are responding to increasing public interest by providing user-friendly information on native plants to homeowners and landscape professionals. Programs such as Audubon's Certified Backyard

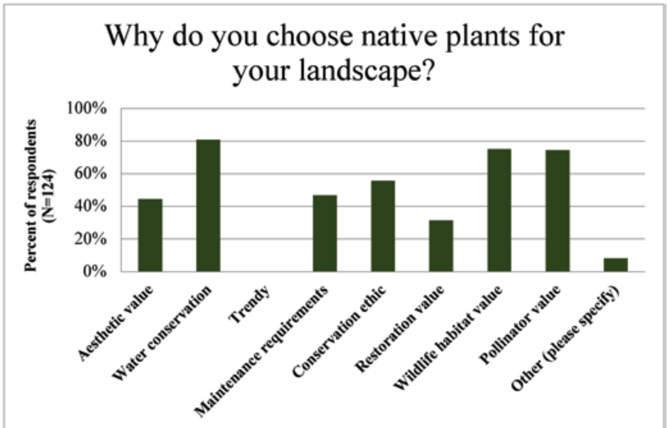

Figure 3. Responses to question 1: Why do you choose native plants? Columns indicate percentage of responses for each option (n = 122). Water conservation and habitat value are rated significantly higher than other options. The high score of Conservation Ethic suggests a broad understanding of environmental values of native plants and their potential to contribute to overall resource conservation and not only water. "Other" responses ranged from valuing genetic diversity to deer resistance. This survey was informal and is not scientifically valid. Respondents were self-selected and represent a population remotely associated with WinterCreek Nursery, a native plant propagation nursery in Bend, Oregon, USA.

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Habitat Program, or Portland, Oregon's Metro provide information on regionally specific native plants for urban gardens. Similarly, county extension offices and soil conservation districts often provide free information and low-priced native plants that allow for increased success in urban native gardening. These efforts raise the general awareness and appreciation of native plants and help support the growing number of nurseries propagating and marketing native species.

NATIVE PLANT PHYSIOLOGY IN URBAN SETTINGS

The ability of native plants to acclimate to environmental characteristics of developed urban sites is often questioned (Endter-Wada and others 2008; Hooper and others 2008; Salisbury and others 2015). Planners, designers, and landscape architects who operate in urban settings rarely have a background in native plants or ecological theory and are therefore reluctant to codify the use of native species in urban environments, or to specify appropriate native vegetation in landscape design. Some of the reluctance may stem from a general lack of data on the efficacy of native plants in highly modified environments, or may reflect a widespread limited availability of native nursery stock. Although a landscape architect may be altruistic, if a landscape professional is unable to locate native plants specified in a design, conventional plant material is typically substituted during landscape construction.

Several studies provide data on water use efficiency of native vegetation (Jones 1979; Chaves and others 2003; St Hilaire and others 2008; Evans and others 2013; Martinson 2018), or physiological responses of native plants under various irrigation regimes (Mata-González and others 2014), but few studies have looked at the ability of native plants to acclimate to the altered conditions typical in urban settings. However, one study reported similarities in physiological characteristics and function of native plants in a semi-arid urban landscape (Martinson and others 2019) and a few discussed those in more natural settings (Mata-González and others 2005; Evans and others 2013; Martinson and others 2019). The results of these studies suggest that using regionally appropriate native vegetation may help reduce dependency of created landscapes on irrigation, fertilizers, and pesticides and may meet conservation goals identified as important landscape attributes by homeowners.

Current studies on the efficacy of native vegetation in urban landscapes and the social acceptance of native plant landscapes are attempting to quantify the aesthetic value of individual species (Reid and Oki 2008). Some studies involve selection of desirable phenotypic characteristics for propagation with the intent to increase public acceptance of native plants as candidates for urban landscapes (Criley 2017; Baisden and others 2018). These efforts, however, may contribute to long-term decline in genetic diversity of native plants in urban landscapes, reduce resilience of native plant landscapes, and negatively affect the ability of native plant landscapes to provide ecosystem services lost through the growth of urban areas and the associated impacts. Continued research on the long-term effects of genetic selection in native plant nursery stock is needed to assess the viability of this approach on biodiversity resilience and the ability of native plant landscapes to provide ecosystem services for a growing urban population.

An unirrigated, native plant residential landscape in Bend, Oregon, USA. The landscape was designed to meet the stringent water use standards of the Living Building Challenge, a green building certification program of the Living Futures Institute. Objectives for this design included aesthetic quality, water conservation, and biological diversity.

SUMMARY

Biodiversity in urban areas becomes critically important as urban growth continues at a global scale. As the need to support human populations grows, broad impacts on natural systems increase, which reduces the ability of remaining native areas to provide goods and services that support people. We are already seeing the effects of human action in weather patterns and species impacts associated with a changing climate. Urban development that considers ecological structure and function can help mitigate the negative effects of urban growth through the design of replacement ecosystems using genetically and structurally diverse native plant species as the primary plant type. Although more work is needed to assess the appropriateness and adaptive qualities of native plants in urban environments, these practices have great potential to regenerate many of the ecological functions lost in the development of urban areas, and the indirect effect of practices that support urban populations.

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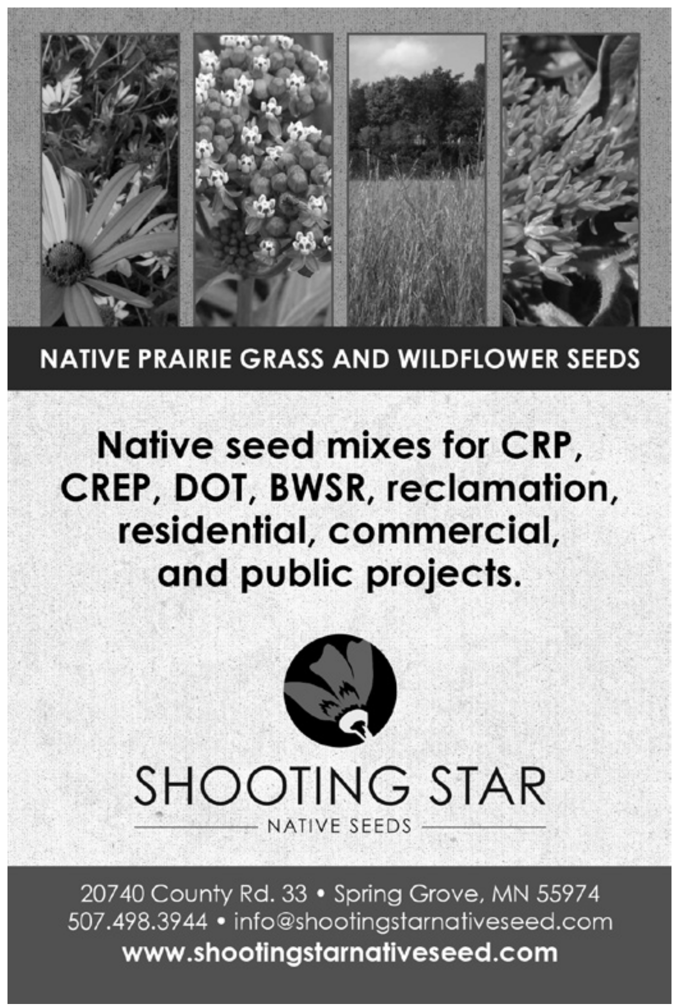

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