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Review

Native plant enthusiasm reaches new heights: Perceptions, evidence, and the future of green roofs

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ABSTRACT

The use of native plants on green roofs has attracted considerable attention in recent years. With this comes the implicit assumptions that native plants are better adapted, provide greater environmental benefit, and are more aesthetically pleasing than non-native plants. We examined papers published in scholarly journals and papers presented at the annual North American green roof conference to identify who is promoting the use of native plants on green roofs, their rationale for doing so, and the scientific evidence to support the assertion that natives are better adapted. Architects, landscape architects, and biologists were the most likely to promote native plants and engineers were the least likely. Many of the reasons for using native plants on green roofs originate from ground-level landscaping and have simply been transplanted to the roof, without regard for the fact that the rooftop is a fundamentally different environment than the ground. Nearly half of all pro-native papers used the term "native" without definition. This review highlights the need for greater rigor and transparency when promoting the use of native plants and further demonstrates how misconceptions can result in sub-optimal green roof design and performance.

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Introduction

Modern green roofs originated in Europe, where their primary function is to reduce stormwater runoff. Traditionally, these roofs were planted with low-growing, drought-tolerant succulent plant species, especially *Sedum*. Today, there is a great deal of interest in increasing the diversity of plant species used on green roofs with a particular focus on the use of native plants (e.g. Kephart, 2005; MacDonagh et al., 2006; Schroll et al., 2009). In Peck's (2008) book, *Award Winning Green Roof Designs*, 45% of the award winning green roofs involve native plants. Native plant green roofs comprise over half (59%) of the green roof case studies presented in Steven Cantor's 2008 book *Green Roofs in Sustainable Landscape Design*. On the Greenroofs.com database, there are over 100 green roofs listed that self-report the use of native plants. Most were constructed after 2005 and the majority of them are located in the United States. Numerous organizations are actively promoting the use of native plants on green roofs, including non-profits like the Ladybird Johnson Wildflower Center and the Peggy Notabaert Nature Museum, governmental organizations such as New York City's Greenbelt Native Plant Center and the City of Toronto's Green Roof Pilot Program, and commercial organizations, such as Rana Creek and Conservation Design Forum.

In 2008, the California Academy of Sciences building opened to the public. The focal point of this building and a symbol of its commitment to sustainability is its undulating green roof planted with California native plants. In addition to earning a LEED Platinum rating, the green roof has won awards from the American Society of Landscape Architects and Green Roofs for Healthy Cities. The architect, Renzo Piano, described the inspiration for the green roof "like lifting up a piece of the park and putting a building under it" (California Academy of Sciences, About the Building). Burke (2003) expressed a similar sentiment regarding the concept behind the green roof at the Gap headquarters in San Bruno, California. "Imagine a building design in which the native landscape on the site is merely lifted up into the sky, and the building program is placed underneath." Both Piano's and Burke's statements show the current philosophy of green roofs as an extension or continuation of ground-level landscaping. In contrast to ground-level landscaping, however, the climate on a roof is generally colder in winter, hotter in summer, and prone to rapid soil drying (Snodgrass and Snodgrass, 2006; Luckett, 2009). Because the rooftop is a fundamentally different environment than the ground, using native plants on green roofs is not straightforward and if done improperly can result in extensive plant mortality. Here we explore the reasons why native plants are being promoted for use on green roofs, how they have been selected, and the evidence for their success.

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Before we explore how and why native plants are being promoted for use on green roofs, we must first explore the definitions of "native." Definitions of "native" vary substantially in their specificity. The Sustainable Sites Initiative (2009) defines a native plant as one which is "native to the EPA Level III Ecoregion of the site or known to naturally occur within 200 miles of the site" (p. 17). The United States Environmental Protection Agency's Green Landscaping program provides a broader definition, defining a native plant as one that has "evolved over thousands of years in a particular region" (EPA Green Landscaping, Native Plants Brochure). In practice, working definitions of what constitutes a native plant differ wildly. These conceptions are complicated not only by distance (is 200 miles an appropriate radius?) but also by time (how long must a plant be established in a given region before it becomes a native?). Definitions are important because within a given geographical region, there are typically multiple ecosystems. For example, within the geographically small state of Massachusetts, there are salt marshes, wetlands, old-growth forests, coastal heathlands, rocky coastlines, and many more. Thus, a plant native to Massachusetts will likely not be able to grow equally well in all parts of the state.

Both aesthetic and scientific arguments are used to promote the use of native plants in ground-level landscaping. The aesthetic arguments are either culturally based – i.e. native plants are part of our cultural heritage (e.g. MacDonagh et al., 2006) or design driven – i.e. native plants blend into the surrounding landscape (e.g. Kiers, 2004). Scientific arguments are based on maintenance requirements, habitat creation, and the potential for plants to become invasive. The following quote from the EPA Green Landscaping website (EPA Green Landscaping, Benefits) illustrates many of the common reasons given for preferring native plants in ground-level landscaping:

> "Landscaping with native plants improves the environment. Native plants are hardy because they have adapted to the local conditions. Once established, native plants do not need pesticides, fertilizers, or watering . . . Landscaping with native wildflowers and grasses helps return the area to a healthy ecosystem. Diverse varieties of birds, butterflies and animals, are attracted to the native plants, thus enhancing the biodiversity of the area. The beauty of native wildflowers and grasses creates a sense of place, both at home and work. The native plants increase our connection to nature, help educate our neighbors, and provide a beautiful, peaceful place to relax."

In order to understand the rationale behind these aesthetic and scientific reasons, it is helpful to explore the origins of the native plant movement. These origins can be divided into three main categories: (1) cultural and aesthetic arguments put forth primarily by early landscape architects, (2) an alternative to turf grass promoted by environmentally conscious landscapers, and (3) environmental reasons explored by conservation biologists.

The first origin comes from landscape architecture. Common today in native plant literature is the legacy of Jens Jensen and other early landscape architects. Jensen's view of nature is an idyllic one, rife with images of harmony and interdependence. "A grove of these maples has within it the power of solemnity and beauty, and the oak and the maple are friends. They grow together, and they are tolerant of the smaller friends and associates that cling to their feet" (Jensen, 1939). Similar imagery and personification can be found today: "they are good plants, they do provide habitat, but they behave themselves, and they get along together like kindergartners" (Kephart, quoted in Cantor, 2008, p. 238).

The second origin comes from ecological landscaping. In reaction against front yard monocultures of turf grass in the suburban United States, several groups, such as the National Wildlife Federation, began to encourage the use of native plants in landscaping. Their argument was that turfgrass requires a great deal of water, fertilizer, pesticide, and mowing. These groups advocated using native plants that are adapted to local conditions and would consequently require fewer resources and less maintenance. In 1973, the National Wildlife Federation started the Certified Wildlife Habitat program, encouraging people to replace their existing lawn with a diverse native plant community (National Wildlife Federation, History of the Backyard Wildlife Program). In 1995, the National Environmental Policy Act made it a requirement for all federal projects to incorporate native plants (Federal Register, 1995). Moreover, native plants are considered to be important components of the natural food web and thus worth promoting (Tallamy, 2007). The Sustainable Sites Initiative, currently being developed by the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center and the United States Botanic Garden, is working toward establishing a set of standards for environmentally friendly landscaping [similar to the LEED (Leadership in Energy and Environmental Design) certification program created by the United States Green Building Council]. In the current version, projects earn points by using native plants (Credit 4.7, p. 109).

The third origin has its roots in restoration ecology and conservation biology. Horticulturists have been responsible for the release of many invasive plant species, including purple loosestrife (Blossey et al., 2001) and English ivy (Reichard and White, 2001). In light of this, many conservation biologists encourage the use of native plants in landscaping (Tallamy, 2007) and eradication of non-native plants in the wild (Patten and Erickson, 2001). Although the majority of non-native species do not become invasive, the few that are invasive have caused widespread damage (e.g. kudzu). Williamson (1993, cited by Williamson and Fitter, 1996) describes this using a rule of 10, with 10% of non-natives surviving in their introduced range, 10% of those becoming established, and 10% of those becoming invasive. The difficulty of predicting which plants will become invasive (Bergelson, 1994), and in which habitats (Alpert et al., 2000), is part of why invasiveness presents such a troubling conundrum.

It is clear that there is a strong preference for using native plants in ground-level landscaping. Green roofs, however, present a new ecosystem that is different enough from ground-level that the lessons of traditional landscape design must be carefully evaluated before they are applied. This paper seeks to evaluate the contemporary preference for native plants as it applies to green roofs. We quantify the extent of interest in using native plants on green roofs, and identify who is promoting their use. We also examine how they define the term "native," and their rationale for promoting native plants on green roofs. Next, we evaluate the scientific evidence regarding the assumed superior performance of native plants on green roofs. Our goal is to provide green roof designers with a better idea of the complexities of defining "native" and of the rationales behind the scientific reasons for using native plants on green roofs.

Methods

Determining the prevalence of the pro-native sentiment and the influence of career

In this review, we included papers from peer-reviewed scholarly journals and peer-reviewed papers presented at the annual North American green roof conference (2003–2009 *Greening Rooftops for Sustainable Communities*, 2010 conference was re-named *Cities Alive*). We included conference papers because green roof research is just beginning to appear in scholarly journals; the conference papers are currently the most prevalent sources of peer-reviewed writing in English on the topic of green roofs. Furthermore, green roofs exist primarily outside of academia; they are designed, built,

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