Landscape and Urban Planning 122 (2014) 140–151

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Research Paper

# Sustainable plants in urban parks: A life cycle analysis of traditional and alternative lawns in Georgia, USA

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## HIGHLIGHTS

- Urban brownfields require environmental impact assessment of redevelopment techniques.
- Lawns occupy the biggest portion of green spaces created on former industrial sites.
- LCA analysis is useful for a more "sustainable lawn" selection.

## ARTICLE INFO

*Article history:*
Received 16 April 2013
Received in revised form
13 November 2013
Accepted 19 November 2013
Available online 22 December 2013

*Keywords:*
Life cycle assessment of lawns
Turf sod lawn
Hydroseeding
Xeriscaping
Native plants

## ABSTRACT

Intensive urban development is increasing the demand for green areas within cities. Urban brownfields could become a source for green redevelopment areas. Sustainable redevelopment requires precise information on the environmental impact of the installation of different vegetation types. We performed a Life Cycle Analysis (SimaPro 7 software) of six lawn installation and maintenance scenarios relevant to the conditions of Georgia, USA and confirmed that a traditional turf sod lawn has the highest environmental impact levels. Xeriscaped lawn composed of bark mulch has high impact levels owing to the substantial transportation needs at the installation stage. Hydroseeded lawns (composed of natural materials) are a sustainable alternative for traditional turf sod lawns, especially when native plants are included (11–14 times lower impact level). Professional selection and use of native plants could provide environmental, social, and ecological options for urban brownfield redevelopment into green areas.



## 1. Introduction

Ecological restoration and green space development within cities, such as green roofs and walls, wetlands, water gardens, green parking lots, permeable pavement, vegetative swales, and green ways have become very important for a variety of reasons (e.g., storm water control, air quality improvement, and human health support through the provision of recreational opportunities, heat island mitigation, biodiversity conservation, etc.). We refer to the development of this green infrastructure (vs. gray infrastructure such as storm sewers and vegetative swales) as low-impact development (Dietz, 2007; EPA, 2000; Ignatieva, Meurk, van Roon, Simcock, & Stewart, 2008; Rottle, 2011). More than half of the world's human population currently lives in urban areas (Pyle, 2003; Miller, 2005). In developed countries this number reaches 70–80% (United Nations, 2007; The World Bank, 2012). In the past, cities scraped off local ecological features and replaced them with hard scape; now, their residents desire more green space (Davies et al., 2009; Maas, Verheij, Groenewegen, de Vries, & Spreeuwenberg, 2006; Stilgoe, 2001). Moreover, an excellent way to fight health stressors experienced by urbanites is spending time in a "nature-like" environment, such as an urban park, common green space, or green backyard. These environments' importance in cities is hard to overestimate owing to their multiple functions in both social and ecosystem contexts (Bolund & Hunhammar, 1999; Carpenter & Folke, 2006; Chiesura, 2004; Gómez-Baggethun & Barton, 2013).

Historically, parks were created for esthetic pleasure (Parsons & Daniel, 2002; Smardon, 1988). US urban parks, created in the

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http://dx.doi.org/10.1016/j.landurbplan.2013.11.011

past century, were composed mostly with exotic and non-native to particular regions plants (DeCandido, 2004; Hitchmough, 2008). Similar situation is observed in modern urban parks in other countries (LaPaix & Freedman, 2010; Ye et al., 2012). At the same time, scientists and ecology professionals from all over the world have determined the positive environmental influence of native plants in parks, backyards, and urban gardens (Hanula & Horn, 2011; Ignatieva et al., 2008; Ignatieva, 2011; Ignatieva & Ahrné, 2013; Meurk & Swaffield, 2007; Mingguo & Guocang, 2007; Tallamy & Darke, 2009). The importance of increased biodiversity preservation, as stated in the Millennium Development Goals (Castelló, Gil-González, Alvarez-Dardet Diaz, & Hernández-Aguado, 2010), further stimulated use of native plants (Tallamy & Darke, 2009).

The severe impact of lawn maintenance on the environment has also led to interest in native plants. Lawn irrigation can account for 75% of total household water consumption in arid regions of USA (Milesi et al., 2005). Chemical use on urban lawns is so prevalent ($\sim$ 500 kg/ha/year of nitrogen in fertilizer, 472 kg/km$^2$/year of pesticides, up to 800 kg/ha/year of herbicides) that lawn chemicals were found in 99% of all urban stormwater samples in the USA (Alumai, Salminen, Richmond, Cardina, & Grewal, 2009; Cheng, Richmond, Salminen, & Grewal, 2008; Milesi et al., 2005; Robbins & Birkenholtz, 2003; US Geological Survey, 1999). Lawns represent one of the widely distributed vegetation types in European settlements (Müller, 1990). In the present paper, we assess lawns, which constitute the irrigated crop with the largest area (163,800 $\pm$ 35,850 km$^2$) in the United States (Milesi et al., 2005). We present a life cycle analysis (LCA) of the most common lawn types, their creation, and maintenance techniques with reference to the conditions of Southern USA and specifically Georgia State.

It is necessary to define two terms used in the article: "native plant" and "more sustainable lawn". The Environmental Protection Agency of the USA defines native or indigenous plants as those that have evolved over thousands of years in a particular region such that they have adapted to that region's geography, hydrology, climate, and other species (EPA, 2010). Our paper accepts such a definition and does not provide support for the common in the literature but controversial statements about the "co-evolution" of invasive species in native ecosystems via relative connections (Tallamy & Darke, 2009), or their "naturalization" through interactions with pollinators (Amtmann, 2010; Pejchar & Mooney, 2009).

For the past two decades, "more sustainable" trends in agriculture have been connected with increasing biodiversity and native plant use (Hietala-Koivu, Järvenpää, & Helenius, 2004a; Hietala-Koivu, Lankoski, & Tarmi, 2004b; Soini & Aakkula, 2007; Swift, Izac, & van Noordwijk, 2004). However, native plant practices can be successful under some sets of conditions (Wania, Kühn, & Klotz, 2006) but can be resource consuming and fail in others (Brown & Bugg, 2001; DeCandido, 2004; Pickett et al., 2001) because cities represent diverse environments with artificially created conditions, some of which do not exist in the native landscapes. Therefore, such conditions are suitable for both non-native plants and those from native local landscapes (Kowarik, 2011; Kühn & Klotz, 2006). However, some authors claim the need and possibilities of using only native or historical species in urban ecosystems (Ignatieva et al., 2008; Meurk & Swaffield, 2007; Mingguo & Guocang, 2007; Tallamy & Darke, 2009).

In the present article, "a more sustainable lawn" is the one that supports diverse ecosystems with fewer input resources and less impact. Such ecosystems are important for their ability to provide "ecosystem services – benefits people obtain from ecosystems" (Millennium Ecosystem Assessment Board, 2005). Their creation expenses (resources use, environmental impact of installation, indirect pollution) should not exceed the beneficial supporting, provision, regulating or cultural services (Millennium Ecosystem Assessment Board, 2005). In this situation, most scientific literature argues that native plants have the biggest significance to sustain humanity (Tallamy & Darke, 2009). At the same time, a plant's "sustainability" can be assessed according to its ability to survive in extreme and harsh urban conditions (Hitchmough, 2008) or its distribution and "self-sustaining" rate of spread (Schulze et al., 2005; Waldner, 2008). Such abilities of invasive species are successfully used in brownfield reclamation (Dutta & Agrawal, 2003; Naveh, 1975; Wan, Qin, Liu, & Zhou, 2009) and agriculture (USDA NRCS, 2013; Waldner, 2008). Brownfield redevelopment requires an environmental impact assessment of the installation and maintenance of different vegetation types. Thus, there is a lack of such information and assessment that could be used in brownfields redevelopment into parks areas (Chrysochoou et al., 2012; Doick, Sellers, Castan-Broto, & Silverthorne, 2009).

Common benefits of native plants that are used in landscape design include: (1) they require less maintenance and therefore less money (water, fertilizers, pesticides, mowing, etc.) than lawns (non-native); (2) they help reduce air pollution (less mowing) and withstand regional climate extremes; and (3) they promote regional biodiversity and provide natural habitats for wildlife (EPA, 2010; Meadows et al., 2012). However, most of the turf plants recommended for Georgia (Landry, 2010a) are not native. According to the identification used in USDA Natural Resources Conservation Service Plants Database, 50% of the lawn grass species used in the USA are not native (USDA NRCS, 2013). Lawns in other countries are mostly composed of non-native species as well (Horne, Stewart, Meurk, Ignatieva, & Braddick, 2005; Stewart et al., 2009), however, European lawns are characterized as native (Horne et al., 2009), with some exceptions (Müller, 1990). One of the biggest concerns in the selection of native plants versus traditional turf lawns is the attractiveness of the landscape (Helfand, Park, Nassauer, & Kosek, 2006); however, Nassauer and colleagues demonstrate that homeowners find certain types of native plants attractive for their yards (Nassauer, Wang, & Dayrell, 2009).

Direct economic comparisons of different vegetation types in the USA demonstrate that native plants are preferable because they are adapted to the local climate and soil conditions and require less maintenance (EPA, 2010; Sourcebook on Natural, 2004). However, official documents do not estimate the costs of seeds and turf sod, different maintenance techniques, or required anti-invasive plant management (Adams, Bwenge, Lee, Larkin, & Alavalapati, 2011). Simmons et al. compared the ecological benefits of native and non-native lawns in the US context (Simmons, Bertelsen, Windhager, & Zafian, 2011). Their study confirmed that native polyculture lawns have higher ecological value but lower esthetic value than a traditional non-native monoculture lawn. Helfand et al. analyzed four lawn compositions: (1) 100% traditional lawn, (2) 50% lawn with 50% prairie garden, (3) 25%lawn with 75% prairie garden, and (4) 25% lawn with 75% prairie mixed with additional native shrubs (Helfand et al., 2006). They estimated that in Michigan (USA) a 100% monoculture lawn will have the lowest installation and maintenance cost over a 5-year period.

Despite the combined social and environmental benefits of using native plants, their use in parks of US is still limited. An analysis of seed harvesting, planting techniques, and further maintenance in parks, in comparison with identical maintenance of traditional plants (most of which are non-native), was not published at the time of this report. We examine herein what comprises the most sustainable "product": the type of lawn that does not require excessive resources for creation and maintenance and therefore does not pollute the environment or negatively influence human health.