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Research Paper

Living roof preference is influenced by plant characteristics and diversity

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HIGHLIGHTS

- Living roofs with tall, green, grassy vegetation were highly preferred.
- Flowers increased living roof preference.
- Plant diversity increased preference overall, but decreased preference for most preferred vegetation.
- Psychological restoration was associated with the most preferred living roof.

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ABSTRACT

Living, or green roofs, are increasingly built in cities for their environmental benefits, however there is little evidence about how to maximise their aesthetic appeal. Because preferences for landscapes can be determined by vegetation characteristics we surveyed the preferences of 274 Australian office workers using 40 living roof images which systematically manipulated plant life-form, foliage colour, flowering, diversity and height. These preferences were compared to those for a bare concrete roof. The potential restorativeness of the most preferred living roof and the concrete roof were also assessed. Results showed that all living roofs were preferred over the concrete roof; however preferences differed according to vegetation characteristics. The most preferred and restorative living roof had taller, green, grassy and flowering vegetation, while lower-growing red succulent vegetation was least preferred. Participants preferred a productive landscape, with green foliage and flowering consistently preferred. Participants with a stronger connection to nature consistently assigned higher preferences to taller, compared to lower-growing, vegetation. Increasing diversity was associated with higher preferences overall, but decreasing preferences for highly preferred vegetation. This research makes an important contribution to understanding employee preferences in the unique context of urban living roof landscapes.

1. Introduction

As a growing number of people live and work in cities, urban green space is likely to play an increasingly important role in promoting well-being (van den Berg, Maas, Verheij, & Groenewegen, 2010). However, increasing building density means that space for ground-level urban vegetation is becoming rarer (Wong, Tan, Tan, Sia, & Wong, 2010). In response, cities are incorporating innovative forms of green space (Thwaites, 2007), such as green or living roofs, that can be integrated into existing infrastructure. Although generally constructed for environmental benefits such as stormwater mitigation (Berndtsson, 2010) and increased building energy efficiency (Sailor, 2008), living roofs may also provide social benefits such as the psychological restoration associated with vegetation in other urban landscapes like parks (Nordh, Hartig, Hagerhall, & Fry, 2009).

Psychological restoration is important as it is associated with improved mood, cognitive functioning, stress levels, and health and well-being (cf. Kaplan & Kaplan, 1989; Tennessen & Cimprich, 1995; Ulrich et al., 1991). Psychological restoration can occur when viewing preferred vegetation for short periods of time and in very limited amounts (Kaplan, 1993, 2001; Nordh et al., 2009). As such, preference may be used as an implicit measure of a landscapes' restorative potential (Hartig & Staats, 2006; van den Berg, Koole, &

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van der Wulp, 2003). In cities, where contact with plants is often limited to nearby nature (Kaplan, 1993; Nordh et al., 2009) small pockets of urban green space in parks, on roofs or in streets are likely to become increasingly important for everyday restoration (Thwaites, Helleur, & Simkins, 2005).

Previous research has highlighted links between landscape preference and vegetation characteristics (Kaplan & Herbert, 1987; Misgav, 2000; Yuen & Hien, 2005). Preferences for landscapes are partly due to the physical characteristics of the vegetation such as foliage colour, vegetation height and density (e.g. Kendal, Williams, & Armstrong, 2008; Misgav, 2000; White & Gatersleben, 2011). Consequently, determining preference for vegetation characteristics will identify the features of highly preferred living roofs capable of providing restoration. Research identifying preferred vegetation on living roofs will support the design of living roofs that are more acceptable to the public, and provide greater psychological benefits.

Existing knowledge of preferred vegetation characteristics may not be applicable to predicting preferences for vegetation on living roofs because of horticultural constraints of living roofs. For example, evolutionary accounts of preference suggest our responses to landscapes reflect the extent to which their features would be able to support survival (Orians & Heerwagen, 1992; Ulrich, 1993). Green vegetation indicates sustenance, flowers indicate future resource potential, trees provide shelter and protection from predators and a short smooth grassy understory is easier to traverse and enables a view of potential threats (Kaplan & Kaplan, 1989; Orians & Heerwagen, 1992). Many preferred landscape characteristics such as moderate to high levels of visual openness, large trees and short, smooth ground cover are commonly used in ground level park design (Kaplan & Kaplan, 1989; Ulrich, 1986). However, tall trees and the high levels of irrigation required to maintain plant palettes traditionally used in ground-level landscapes are not feasible on many living roofs (Nagase & Dunnett, 2010). To date only a single study has been published on visual preferences for living roofs (White & Gatersleben, 2011). It showed that meadow roofs were more preferred than flowering red succulent roofs, green turf roofs and ecological brown roofs. A small set of follow-up interviews suggested that peoples' preferences were affected by features like perceptions of care and vegetation characteristics; however these were not systematically examined so it remains uncertain how these vegetation characteristics influence preference.

Existing knowledge of landscape preferences also has limited applicability to predicting preferences for living roofs because of the unique perspectives from which people view living roofs. Landscape preference is context dependent (Gobster, Nassauer, Daniel, & Fry, 2007; Purcell, Lamb, Mainardi Peron, & Falchero, 1994) and we cannot assume that patterns of preference for ground-level landscapes such as parks will apply equally to living roofs. Unlike ground-level landscapes, living roofs are integrated into the building fabric, are not necessarily accessible to people and may be viewed from different angles and distances (Dagenais, Gagnon, & Pelletier, 2009; Sang, Miller, & Ode, 2008). As a result, preferences based on traditional views of nature (Loder, 2007), may not apply.

Further research is required to identify preferences for vegetation characteristics which are common to plants able to be used on living roofs, and which may enhance the restorative potential of urban environments. Therefore, we conducted a preference study focusing on images that manipulated important plant characteristics such as life-form, foliage colour, flowering, vegetation height and diversity in an urban living roof context.

1.1. Preferences for visual characteristics of vegetation

Preferences for plant life-forms, or growth-forms, in living roof contexts have received little empirical attention. While trees, grasses and shrubs all influence preference in ground-level landscapes (Nordh et al., 2009), translating these preferences to living roofs is problematic as limited water availability due to shallow substrates and weight constraints restrict planting to lower-growing drought-tolerant succulents, woody herbs and grasses (Bousselot, Klett, & Koski, 2011; Nagase & Dunnett, 2010; Oberndorfer et al., 2007). A study on English residential living roofs revealed that grassy living roofs were more preferred than succulent living roofs (White & Gatersleben, 2011). However, these living roofs also differed non-systematically in foliage colour (green grass vs. red succulents) and vegetation height (taller grass vs. lower growing succulents), so it is difficult to ascertain the extent to which plant life-form influenced preference. Therefore, while we predict that grassy life-forms should be preferred over shrubby succulent life-forms overall, there is limited evidence to suggest how plant life-form will interact with other plant characteristics to influence preference.

Foliage colour also plays an important part in determining landscape preference (e.g. Kendal et al., 2008; Orians & Heerwagen, 1992; White & Gatersleben, 2011). However particular colour preferences vary based on the setting and vegetation type (cf. Hands & Brown, 2002; Kaufman & Lohr, 2004; Kendal et al., 2008). Research suggests that green vegetation is highly preferred, and perceived as beautiful (van den Berg et al., 2003), particularly in savannah and forest-like landscapes (Balling & Falk, 1982; Heerwagen & Orians, 1993). Green foliage is associated with preferred landscapes in different countries, landscapes and contexts (Balling & Falk, 1982) as it indicates landscape health (Orians & Heerwagen, 1992). We would expect that green-coloured foliage should also be highly preferred in a living roof context.

Flowering is also perceived as an indication of healthy, productive landscapes (Heerwagen & Orians, 1993). In addition to influencing preference (e.g. Jorgensen, Hitchmough, & Calvert, 2002; Kaplan, 2007; Kendal et al., 2008), cognition and well-being (Haviland-Jones, Rosario, Wilson, & McGuire, 2005; Todorova, Asakawa, & Aikoh, 2004), flowers may be perceived as cues of human care (Nassauer, 1995). Research indicates that flowers improve preferences across a variety of contexts (e.g. Akbar, Hale, & Headley, 2003; Kaplan, 2007; Lindemann-Matthies & Bose, 2007; Todorova et al., 2004) and so preferences for living roof plantings should be higher whenever flowers are present.

Like flowers and green foliage, height may act as an indicator of care and maintenance with shorter, smoother groundcovers looking neater than taller plantings (Kaplan & Kaplan, 1989; Nassauer, 1995; Todorova et al., 2004; White & Gatersleben, 2011). While very tall vegetation such as trees elicit consistently high preferences (Ulrich, 1986), they are not able to survive on extensive living roofs. This means that preferences for much shorter understory vegetation such as grasses and shrubs need to be considered. While neat vegetation like turf may be preferred by some, it has little ecological value (Gobster et al., 2007; Steinberg, 2005) and may even be perceived as a sign of a degraded landscape (Gobster, 1994; Nassauer, 1995). Conversely, messier plantings are generally perceived as more sustainable, and higher in ecological function (Gobster, 1994). This highlights a possible role for individual differences in determining preferences for lower-growing or taller vegetation based on the extent to which a connection to the landscape and its ecological function are valued.

In addition to vegetation characteristics, the structural composition of the landscape – including landscape diversity – is important in determining preference. Research indicates that moderately diverse landscapes are most preferred (Orians & Heerwagen, 1992; Ulrich, 1986); low diversity may be perceived as boring, whereas very high diversity may be confusing (Kaplan & Kaplan, 1989; van den Berg & van Winsum-Westra, 2010). Diversity can be assessed using vegetation characteristics as proxy indicators of diversity (Jorgensen & Gobster, 2010). For example, structural heterogeneity