Landscape and Urban Planning 146 (2016) 20–28

Contents lists available at ScienceDirect

Landscape and Urban Planning

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

Green leaf colours in a suburban Australian hotspot: Colour differences exist between exotic trees from far afield compared with local species

Margaret J. Grose*

Melbourne School of Design, University of Melbourne, Grattan Street, Carlton 3010, VIC, Australia

HIGHLIGHTS

- Leaf colour of endemics and exotics were compared in a global hotspot.
- Australian endemics were greyer, less chromatic, and darker than exotics.
- Colour changes might occur with planting exotics from far afield.
- Due to the genetic isolation of Australian plants, colour impacts may be greater.
- Colour is a component of homogenisation with urbanisation.

ARTICLE INFO

Article history:
Received 9 April 2015
Received in revised form 14 August 2015
Accepted 7 October 2015
Available online 22 November 2015

Keywords:
Leaf colour
Suburban change
Homogenisation
Urbanisation
Visual change
Colourscape

ABSTRACT

Endemic species are often replaced by plantings from non-local areas in new suburbs in the developed world. Does this lead to colour changes? This paper compares colour in the leaves of exotic trees planted in suburbs to that of endemics in the Southwest Australian Floristic Region. Colour in plant parts was assessed by the Natural Colour System of Sweden, which enabled quantitative comparison between species. Hue, chromaticness, percentage yellow, blackness, whiteness, luminescence, and visual lightness were determined. The leaves of Australian trees were less chromatic and darker than exotic trees, suggesting that colour changes are occurring with suburbanisation in this region.

1. Introduction

The colour green dominates tree-scapes of many urban and non-urban areas. Yet what colour is that green? Do particular greens reflect particular environments? The study described here grew out of concerns about the increased number of exotic trees planted in Australia in urban areas. Australia is the only continent almost defined by one plant genus, *Eucalyptus*, which is found in almost every biome and local region. Suburban development in Australia has led to endemic tree species such as eucalypts being removed and their replacement with exotic trees, here defined as those whose natural range is outside of Australia. This study addressed the question as to whether colour changes have occurred with the introduction of large numbers of exotic trees. While a concern about colour change due to exotics has been raised verbally by botanists, there has been little comment in either science or urban design (Fig. 1), although Grose (2012) asked if colour is a neglected visual aspect of conservation.

Urban expansion in much of Australia and in the world, such as the US (Alig, Kline, & Lichtenstein, 2004) and the mega-cities of Asia (Murakami, Medrial Sain, Takeuchi, Tsunekawa, & Yokota, 2005), is typically into agricultural areas; in contrast, urbanisation in south-western Australia is commonly into bushland of the Southwest Australian Floristic Region (SWAFR), one of the world's global biodiversity hot spots (Myers, Mittermeier, Mittermeier, da Fonseca, & Kent, 2000), and one of only two hotspots in the megadiverse country of Australia (Mittermeier, Myers, & Mittermeier, 1997). Hopper and Gioia (2004) suggest that at least 8000 endemic floral species will be confirmed for the region when current long-term taxonomic surveys are completed. In other global

* Corresponding author. Tel.: +61 3 8344 4898; fax: +61 3 8344 5532.
E-mail address: mgrose@Unimelb.Edu.Au

http://dx.doi.org/10.1016/j.landurbplan.2015.10.003

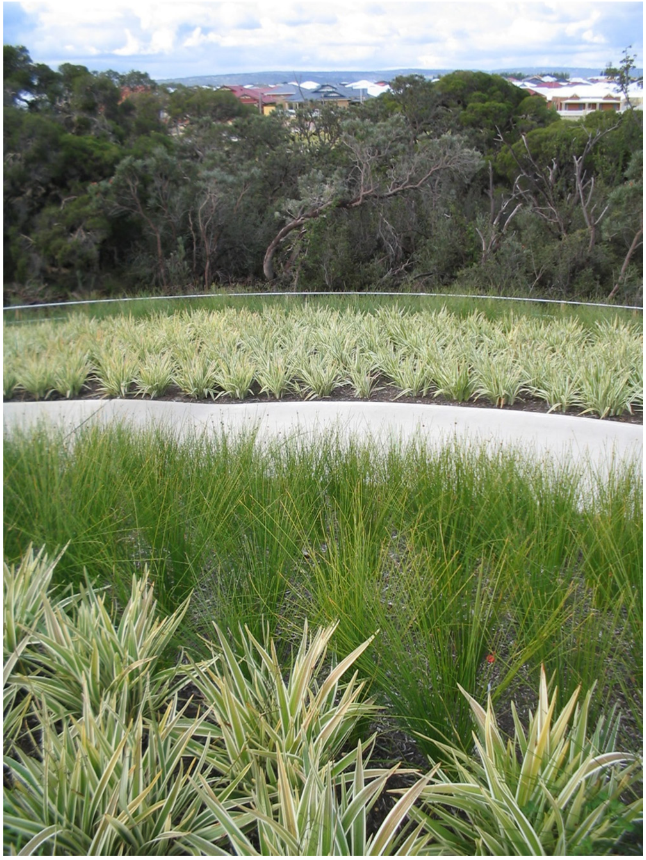

Fig. 1. A view of northern suburbs in the Southwest Australian Floristic Region (SWAFR), with new planting by landscape architects and remnant bushland behind consisting of eucalypts and banksias in the upper storey. What colours are we planting?

hotspots of Mediterranean-climate type, such as the Californian Floristic Province and the Mediterranean Basin, urban expansion and tourism have long been considered threats to biodiversity (Konstant & Mittmeier, 1999; Myers & Cowling, 1999). Likewise, the biodiversity of the coastal strip of the SWAFR is threatened by suburban development equal to the highest rate in Australia.Lozano et al. (2013) noted that in the Mediterranean hotspots of the SWAFR, California, and Spain, threats to biodiversity originating from human activities represented more than 80% of all threat types. The question about colour changes with suburbanisation has arisen because in the last thirty years suburban development in Western Australia has featured the processes of clear-felling, elimination of topography, removal of topsoil, and terracing of land prior to the establishment of new house blocks (Grose, 2010; Kullmann, 2014). This process of suburbanisation has led to a great loss of endemic trees and considerable ecological change in the region (Grose, 2011), although new design practices are challenging this process (Grose, 2009, 2010). Suburban expansion in the SWAFR has thus produced a highly constructed landscape.

Canfield and Runkle (1999), working in the USA, considered that there is now an eclectic mix of endemic and introduced tree species in urban landscapes but did not suggest a percentage breakdown. Also in the USA, McKinney (2005) and La Sorte, McKinney, and Pyšek (2007) noted the increasing number of non-native species among urban floras and across continents, with non-native species originating from outside the USA or Europe playing a secondary role as a 'homogenizing source' on urban floras, with the primary role of homogenisation coming from American species. In the SWAFR the situation appears to be quite different. While non-local species are now dominant in most urban areas (Powell & Keighery, 2003), a study of newer suburbs in the region confirmed that exotic species (those from outside of Australia) comprised more than 83% of new plantings (Farrelly, pers. comm., 2003). Concerns have been raised about the loss of endemic species *per se* and about biotic homogenisation with genetic changes (McKinney & Lockwood, 1999; McKinney, 2005; La Sorte et al., 2007) but subtle issues of visual change, such as colour, texture, form, density, and height of the top-storey remain unexamined (Grose, 2012). The lack of research into colour changes in suburbs is paralleled by the general lack of research in the whole arena of non-reproductive colour in plants (Lev-Yadun, Inbar, Izhaki, Nèman, & Dafni, 2002) beyond experimental and microscopic work on chlorophyll and the nature of autumnal colour changes. Recent work on plant structure has been slowly changing this situation, and thus it is timely to ask: what green is that?

In McKinney's (2005) study, he distinguished species as those outside of the US and those from internal, less distant sources, and suggested that introductions from nearby sources were more frequent than species from more distant sources. However, in Australia this pattern is generally the reverse, with introduced trees being overwhelmingly from distant sources—from Europe, North America, and north-eastern Asia; many of these are deciduous and placed into the overwhelmingly evergreen continent of Australia. In addressing the question as to whether such a suburban shift from endemic Australian trees to exotics from distant sources brings a visual colour change in green leaf colour (beyond the obvious one of 'autumn' foliage) the study reported here compared the green leaf colours of major endemic trees and those exotic trees which are commonly planted as street-trees and in public parks in the SWAFR.

Gage (1993) makes the point that the study of colour *par se* is a vastly daunting subject, and Lancaster (1996) considers colour one of the most problematic of interpretations relating to the visual world. Colour observation has difficulties noted for centuries. Monge (1789, cited in) commented: "So the judgements that we hold about the colours of objects seem not to depend uniquely on the absolute nature of the rays of light that paint the picture of objects on the retina; our judgements can be changed by the surroundings." Measuring colour by eye is subjective, ephemeral, prone to changes with weather, time of day and age of the plant, thickness of vegetation, light and sun-angles, "gleam and glitter" (Fridell Anter, 1996), haze, adjacent colours, and the distance of the viewer from the subject. Colour is further influenced by art history and theory, general history, lexicography, the science of optics, and 'the eye of the beholder'.

Importantly for the current study which compares floras, the colour differences which we see can occur due to structural differences in the plant itself (Glover, 2009; Whitney, Glover, Walker, & Ellis, 2011), with very small differences in structure producing changes in the wavelength of light reflected. Structural colour is also independent of pigment colour, and can overlay it (Glover, 2009). Since plant anatomy is very much influenced by the light conditions in which the plant has evolved (Vignolini, Moyroud, Glover, & Steiner, 2015), it must be noted that suburbanisation in the SWAFR is likely placing plants from very different light environments into more intense light environments in the SWAFR, where plants have evolved for greater intensity. Thus the colour which we see is a product of three things: of external conditions, our eyesight, and the coloured object itself, which in this study is a leaf. These three components determine what we can see when leaves appear a different colour green to the human eye.

Plant leaf colour is very little recorded, perhaps due to a prevailing belief that leaves have little colour variation in comparison to flower colour, as considered by Glover (2009). However, scale or degree of difference is the key to this issue, and there are