Considering Ecological Imperatives in Public Open Space in a Global Hotspot of Biodiversity

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Public open space within the suburbanising South-west Australian Floristic Region is reviewed in this paper in relation to key ecological imperatives. Qualitative sources, quantitative research and professional practice are examined across science, planning and landscape architecture, with a focus on turf, water, species and retained bush.

New relationships between turf and bush in public open spaces in designed suburban developments in this Mediterranean-type hotspot are outlined. Four types of public open space are distinguished, with a focus on 'turf that works' and the use of hydrozoning and ecozoning as new strategies in this hotspot. These strategies provide concurrent opportunities for water conservation and biodiversity, and are designed for resilience. This review positions these new strategies as an example of better design outcomes in public spaces as a result of improved translation of knowledge across the disciplines.

KEY WORDS
Suburban development
Public open space
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RESEARCH

INTRODUCTION

This paper reflects on major aspects of the design and planning practices of public open space (POS) in a global hotspot of biodiversity, the South-west Australian Floristic Region (SWAFR). The main concern relates to how ecological issues are dealt with in new suburban developments in a biodiverse region such as the SWAFR, which includes the city of Perth, which is central to studies of the ecologies of cities.

Planners in the practice of suburban development in the SWAFR suggest that POS is the frame around which a new suburb is built, and thus POS might be expected to expose current interdisciplinary issues about suburban development. McDonnell et al (2009) discuss that the effective creation of sustainable cities requires the development of a knowledge base of the ecology of cities and towns. From such a knowledge base comes the need for translation of information between and within disciplinary 'territories', defined as the ideas across which disciplinary communities work (Becher and Trowler, 2001, p 23). With improved connections between disciplinary territories, those involved in important changes within urban areas, such as the creation of POS and suburban design, will be better placed to make design and planning decisions with more meaningful ecological outcomes. The need to surmount difficulties in the translation of information between disciplines in the field of land planning and design has been noted by several practitioners (Sukopp, et al, 1995; Hobbs, 1997; Niemelä, 1999; Antrop, 2001; Fry, 2001; Robertson and Hull, 2001; Palmer, et al, 2004; Pickett and Cadenasso, 2008; Grimm, et al, 2008; Musacchio, 2009; Grose, 2010b).

Harris (2007, p 169) argues that while scientific knowledge is an agent of change, change will occur only if science works with and through various forms of natural, human and social capital to achieve outcomes.

Many practitioners in the SWAFR recognise that planners and landscape architects often lack access to, or ignore, good, informative science to increase the richness of solutions for applied problems in suburban development and POS (Grose, 2010a). At the same time, ecological science and studies in urban ecology continue to focus on detailed analyses of specific biological and spatial problems, and the causes and consequences of processes, and rarely provide accessible solutions to the design and planning ramifications of scientific aspirations in human landscapes. It has been suggested that the fields of design, planning and the sciences have separated into mutually unregarded discourses (see Roux, et al, 2006), and, if so, this can lead to wasted knowledge. An important consequence of such separation is that the environmental aspects of sites have been found difficult to translate into better designed outcomes, a problem made more acute by the specificity of the journal publishing industry within the territories of ecological theory and research, and design theory and practice. This review incorporates cross-disciplinary matters about the planning and design of suburban POS that might be lost to those working within one specific discipline. Ecological science has been placed here in terms of its intersections with the disciplines involved in the planning and design of suburbs rather than being purely as part of site analysis as so often occurs, both in practice and landscape architectural education. This review focuses on literature dealing specifically with the SWAFR and the suburban development within it. The review examines current practice and ideas, much of which is in the grey literature; it can be seen as an international case study on issues that need to be addressed for improved ecological outcomes, and others, in suburbanising landscapes.

As a case study, the city of Perth (32°S, 150° 50´E) on the west coast of Australia provides a rich source of issues because its metropolitan area falls entirely within the boundaries of the SWAFR, one of only 34 global hotspots of biodiversity on earth (Mittermeier, et al, 1999, 2004; Myers, et al, 2000) (Figure 1).

The concept of hotspots recognises areas of biological diversity under great biological pressure. Although Beard et al (2000) reported that the fungal disease organism *Phytophthora cinnamomi* in woodland was the main threat to the SWAFR, another major threat is suburban development. Perth's suburban development is rapidly expanding into woodlands that are rich biologically (Gibson, et al, 1994; Hopper and Gioia, 2004). Cape Town and San Diego are similarly placed Mediterranean-type cities in relation to hotspots of biodiversity (Mittermeier, et al, 1999), and around 150 cities worldwide are sited near such hotspots (Cincotta and Engleman, 2000). Decisions made in these cities are of especial importance in relation to world biodiversity. Within the general spread of such 'hotspot cities', POS needs to be framed in the context of 'life in a hotspot', where ecological issues are distinct or more pressing than those in non-hotspot regions. For example, in heavily urbanised Sheffield, United Kingdom – not a hotspot city – the relationships between green space and urban form are focused more on quality of life and housing

Figure 1: The south-west Australian hotspot (above) in relation to the city of Perth. Images courtesy of Conservation International and NASA.

prices than biota, although general ecosystem services are recognised (Davies, et al, 2008). In Perth, ecological issues will become even more acute with the predicted drying of southern Australia as a result of climate change (Palutikof, 2010).

THE SITE: NOT SINGLE, BUT A SUITE OF COMPLEX ENVIRONMENTS

The city of Perth is the capital of Western Australia and the largest centre of population in the area, with around 1.4 million people. Its suburbs sprawl along the Indian Ocean coast. Perth was a site of the Nyoongar people's almost permanent encampment on the Swan River before British settlement in 1829, when a town was declared by cutting down a tree (Appleyard and Manford, 1979). In 1901, the population was 44,000 and it is expected to reach 2.4 million by 2030 (WAG, 2008a).

There are five major landscape complexes in which new residential areas are being constructed in this hotspot: (i) coastal dunes, (ii) mixed *Banksia–Eucalyptus* woodlands, (iii) *Banksia*-dominated woodlands, and (iv) paperbark (*Melaleuca*) wetland flats, with (i)–(iv) all found on poor, highly leached, sandy soils; and (v) wooded granite hills dominated by *Eucalyptus*. The characteristics of these landscape complexes have been described generally by Seddon (1972). Thus, suburban development in the SWAFR is not one site or one set of defined biophysical parameters but a suite of heterogeneous complex environments. Within these complex environments are two essential ecological imperatives: water, which is popularly discussed, and biodiversity, which appears less widely understood by either design practitioners or members of the public.

Apart from some sectors in the south-east of the city, Perth is not moving into agricultural land or ex-urban territory, as is commonly found in other countries, but is primarily moving into bushland within the SWAFR. Indeed, Perth has been described as a 'city in the bush' (Seddon, 1972) (Figure 2). Bushland is being clear-felled for new suburbs.

Within the city's wider metropolitan area are various types of green space: large regional parks for passive recreation and biological or water conservation, sites for conservation known as 'Bush Forever', POS, and setbacks for rivers and ocean-fronts. Bush Forever and regional parks add to the percentage of total land given to bushland that might be considered to contribute to ecological function within the hotspot.

The issue of water is never far from Australian imperatives because the country is the driest inhabited continent. Most major cities in Australia are experiencing long-term water shortages. Perth has experienced a 40 percent reduction in its catchment and groundwater aquifers in the last 30 years (WAPC, 2006), with concern about early climatic drying (Nicholls, et al, 1999; Smith, et al, 2000). With inflows to Perth's dams between 2001 and 2007 a quarter of their pre-1974 levels (FarmOnline, 2008), Perth has long-term water restrictions in place. The urbanised part of the hotspot remains on water restrictions for outdoor watering, with programmes to encourage reduced internal household use. POS in the region is generally irrigated from groundwater sources and thus is susceptible to an uncertain water future in Australia's drying climate, particularly in winter rain-fed systems such as the SWAFR.

PLANNING AND DESIGNING WITHIN THE HETEROGENEOUS LANDSCAPE

Historically, Perth and all other towns in Western Australia have relied on neither ecological nor aesthetic imperatives on which to base both the process of and the form that urban development takes. Policy-based frameworks – such as for the allocation of POS – and strong economic imperatives have been the drivers of urban development. Perth has not been alone in struggling with the problems of suburban growth and preservation of landscape characters, ecology and aesthetics. Some cities, for example Phoenix, Arizona (Ewan, et al, 2004) and Seattle (Dooling, et al, 2006) are questioning the policy bases on which their growth has occurred and are seeking to build ecology more firmly and less vaguely into the planning continuum, with landscape ecological principles that can be readily understood by other disciplines. Herlin (2004), for example, reported on explicit objectives to work in interdisciplinary ways to bring more of the applications of science into planning and policy for new developments in Sweden.

In the SWAFR, there has been vocal and sustained public concern at the loss to housing of natural pieces of land, however degraded these are to scientific assessment. Such assessment is usually based on biodiversity as species number or assessing their conservation value as if for wilderness areas, resulting in disappointing social and conservation outcomes (McDonnell, 2007). One driver

Figure 2: Perth as a city in the bush. The view east from a coastal dune ridge 7 kilometres west of the city. The low Darling Scarp is in the far distance. At right edge of image is Banksia menziesii, *a common small tree of the coastal plain that is under threat from suburban development.*

of public concern is loss of contact with nature; the human need for an aesthetic natural experience, no matter how small, has been widely acknowledged and is of worldwide concern (Kaplan and Kaplan, 1989; Louv, 2005; Kahn, 2002). In the last few years there has been a plethora of sustainability initiatives for south-western Australia at both state and local government levels. This has increased the familiarisation of sustainability initiatives in the minds of members of the public, such that POS is now often regarded in professional design and planning practice as requiring some component of sustainability, though vaguely defined. Recent built projects in the SWAFR suggest that ecological function is now being required of POS (Grose, 2009). Thus the uses to which POS can be put, and the allocation of the physical parts to achieve these aims, are still under debate, scrutiny and testing by design.

A key problem is that research bases on which design and planning decisions are made are generally poor. Each site is worked upon without regard to the region or neighbouring suburbs (Grose, 2010a), and is worked with data sets of species rather than functional ecology (Pickett, et al, 2001). Complex biological aspects of 'green' areas, whether in relation to pre- or post-development as POS, continue to receive scant detailed and long-term study. This means the landscape being consumed by the development of suburbs is incompletely known to either those who develop it or the decision makers in government. When basic ecology is understood more widely by stakeholders in suburban development, and ecological literacy (Stone, et al, 2005) is reflected with more depth in the land planning structure and regional planning, improved long-term ecological and social outcomes can arise and exist side by side in local sites. Many people involved in suburban development in the SWAFR are working towards an improved understanding of the complexities of specific landscape sites and desire to 'do it better', with both the environment and aesthetic appeal of woodlands and heath of this global hotspot foremost in their minds (Grose, 2010a). Meyer (2008) points out the importance of aesthetics as an effective agent for change in debates about what sustainable landscapes might be.

PLANNING AND RESEARCH BACKGROUNDS

Currently, 10 percent of land developable as residential is required to be allocated to POS in Western Australia. This has been based on a plan of 1955 (Stephenson and Hepburn, 1955) where the original purpose of POS was that of active recreation. Recently, it has been suggested that the 10 percent be retained with 2 percent assigned to bushland or other conservation values, with developers being able to barter for a good piece of land to be kept untouched in exchange for a reduction in the POS or for money, thereby reducing POS to perhaps 8 percent of total developable land. While this allows a degree of site sensitivity, the central issue is whether 8 percent of land set aside for POS can achieve all the requirements now placed upon it, given its original purpose as land set aside solely for active recreation (Grose, 2007). There are three important points in this ongoing debate. First, a set figure may give planners and developers statutory leverage to deny an opportunity to increase bushland in line with local community initiatives and wishes. Second, none of these figures relates to site-sensitivity of landscape type. Third, there is no research basis on which the allocation of 10 percent land to POS in the SWAFR has been based (Grose, 2007).

Linkages and connectivity are long extant ecological principles of wide use today (see Forman, 1995), and government policy in Western Australia states that an aim for managing urban growth in Perth is 'protecting biodiversity and areas of environmental significance, and promoting the concept of an interlinked system of regional and local open space' (WAPC, 2006, p 1069). However, the concept of linkages has now been heavily subsumed into the sociological sphere, such that some planners consider that 'linkage' refers only to social connections and has nothing to do with ecology at all (Grose, 2010a). 'Social' connections, however, often appear to link people to bushland or other green space because these are walkable 'lines of desire'. Indeed Miller (2005) argues that more attention must be paid to restoring human connections with nature in proximity to the places where people live and work, with the same emphasis placed on spatial and temporal scale in conservation circles extended to the scale of human experience. Much POS today links into the suburban centre, not other green spaces, and this again shows a social sub-summation of the ecological concept of 'connectivity'. The danger of such 'social connectivity' is that while the language is that of ecology, the actions and outcomes are not.

WHAT IS BUSH?

'Bush' and 'POS' need to be defined in the Australian context. Bush is wild or uncleared land, large and small, and in whatever condition, as a 'remnant' of pre-existing landscape, while POS in the SWAFR was originally conceived for active recreation (Grose, 2007). Few areas of POS retain bush. Internationally, public open spaces are increasingly being considered as ecological links with all other types of green habitats (Forsyth and Musacchio, 2005; Tzoulas, et al, 2007) such as reserves for rail, freeway and streams, brownfields and cemeteries, which fall into the category of '*naturmark*' (Florgård, 2007). These 'bits and pieces' are not included as POS in Australia but can be used as complements and links to POS to support ecological diversity and function.

Bush Forever is a concept designed to increase the retention of native bushland in all urban regions in Western Australia (Del Marco, et al, 2005). It is a response to great concerns about the conservation of biodiversity of both plants and animals in the suburbanising SWAFR. With Bush Forever, the aim is to 'keep the common, common' and is in line with Kareiva and Marvier's (2003) concern for recognition of the importance of the conservation of biodiversity 'coldspots', and foreshadows the ecological importance of commonness (Gaston and Fuller, 2007).

In the SWAFR, an environmental report prepared for a developer for a proposed new suburban development focuses on rare and endangered species as required by legislation. However, in other government documents from the same region, it is common species, not the rare and unusual, that are recognised as 'the backbone of all natural areas' (Boeken and Shachak, 2006; WALGA, 2004). Thus, conundrums exist in planning and governance, with the specific policy framework of Bush Forever contrasting with the defined search for rare and endangered species by environmental assessors before suburban development. This conundrum fuels the public disappointment of outcomes as noted by McDonnell (2007).

Bush Forever sites cannot be included as POS because they are intended to be fenced and not generally available to members of the public. In this way, the sites are 'locked away' for purely biological functions and serve no role in giving personal contact with bushland for local people. In response, an initiative in the Perth Biodiversity Project means additional areas, aside from Bush Forever sites, will be untouchable by the development process (Del Marco, et al, 2005). Thus, there have been measures to recognise and preserve biodiverse areas as a response to the losses created by suburban development. It is not known whether these measures will be enough.

The SWAFR is one of only two global hotspots in the 'mega-diverse' country of Australia, with the world's mega-diverse countries being those that have 70 percent of the world's biodiversity while only 10 percent of the landmass (Mittermeier, et al, 1997). Despite this, no research is available to planners and those in governance to suggest how much bushland is required for ecological function to remain across suburban areas in any landscape complex within the hotspot. This clearly is a major research gap, notably so because Australia is one of only two of the mega-diverse countries classified as 'high income' (SOE, 2001). Figures supported by the Australian Government give an ambition of 30 percent bush retention for the survival of ecosystem function in every ecosystem (DEH, 2001). How then does a figure of 30 percent relate to suburban development and the survival of ecosystem function in the rich suburbanising section of the hotspot? Can POS assist in increasing ecosystem function? How can designers assist in the promulgation of a sense of place (Seddon, 1972) and an aesthetic response to the unique flora of this hotspot?

There have been increasing calls in the planning industry and local government in this hotspot to see the 'park at the end of the street' as a site of initiatives towards water conservation, biodiversity and resilience. In contrast, policies connecting *naturmark* and public spaces have been in place in Sweden since 1907 (Florgård, 2007). *Naturmark* requires all types of natural and semi-natural vegetation to be preserved, and meadows and pasture-land to be developed under long-term cultivation using traditional methods. *Naturmark* in the Australian context might fall into several categories within suburbs:

(i) managed natural remnant bush, such as the Perth Biodiversity Project, and retained bushland in POS;

(ii) designed but managed bush, which is possible in POS;

(iii) designed more formal POS with locally endemic species that reflect local bushland; and

(iv) street tree plantings of endemic species.

These categories separate into 'undesigned bush' and 'designed bush', which are part of the dynamic changes and discussions under way in the SWAFR hotspot.

DESIGNED BUSH, TURF AND PUBLIC OPEN SPACE IN THE SOUTH-WEST AUSTRALIAN HOTSPOT

Naturmark (Florgård, 2007) is a helpful concept when considering designing and planning for biodiversity. *Naturmark* links bushland with 'remnant bush', POS and street planting to give a holistic view, and thus to design at all scales from the landscape to streetscape. However, is it possible to 'design' bushland and design for biodiversity – both its continuation and possible increase? This question is difficult to answer when there is only a small research base on which to build. Such a design ambition is very pertinent in the SWAFR, where turf is used extensively in POS and its use is increasingly controversial (Grose, 2010c).

The extent to which turf is required or present in POS is central to design possibilities in the SWAFR, and this fact positions the imperatives of water and biodiversity acutely. Turf remains the most common feature of POS in the region and is typified as large expanses of lawn, usually reticulated or watered by bores extracting groundwater, and large remnant trees. Palmer et al (2004) consider that designed ecosystems might blend technology and novel mixtures of native species, and create new systems that are not substitutes for natural systems but are important moves towards developing sustainable cities. An example of ecosystem design with technology and native species can be seen in the current reassessment of the amount of turf in POS in the water-scarce SWAFR.

In Perth, turf has been synonymous with POS because of its original purpose for active structured recreation, dominated by Australian Rules football (which requires a much bigger oval than soccer) and cricket. Much of the turf in POS is not used specifically; it is not part of the ball-game space – styled here 'turf that works' (Grose, 2010c) – but is general walking space, where turf is not specifically required as a walking surface. It would seem imperative in a dry climate with water restrictions that turf in POS is kept only to areas essential for ball games. Approximately 70 percent of Perth's total water usage is supplied by groundwater, with the remainder from catchments (WAPC, 2001). Gardens consume almost 56 percent of all domestic water used, with the majority going on lawns (Loh and Coghlan, 2003), and POS consumes 40 percent of all water used. The Western Australian Government has recently moved to the expense of desalination. Of vital concern in this hotspot is that groundwater is in danger of being so depleted by private bores it becomes physically alienated from the roots of native vegetation (Groom, et al, 2000, 2001; Zencich, et al, 2002). If this were to occur regionally, losses of vegetation would amount to an ecological disaster. This concern underscores the reason why the SWAFR is classed as a hotspot.

Deeley et al (2006), inspired by the Nyoongar concept of *jippy joppie boodja* (rhythm of the land), examined the use of groundwater (non-potable) and catchment-derived water (potable) for turf in POS in the SWAFR. The authors showed that by reducing turf to only those areas that are required for sports fields, substantial reductions in water use could be made without compromising sporting facilities. This led to 'Water Smart Parks' being formally introduced by the state government in November 2008 (WAG, 2008b). A feature of this new approach to POS and turf has been the practical methods of hydrozoning and ecozoning within each area of POS (WAG, 2008b). Hydrozoning is a process of applying different water rates for individual parts of POS according to use, and ecozoning replaces turf areas that are not specifically used for recreation with other species, notably 'water-wise' plants, or replanting these areas with bushland plantings. These strategies are helpful and timely changes to views of POS and can be seen as part of a wider climate adaptation strategy for resilience in the drying SWAFR climate. The strategies have been supported by performance testing and cost data, with detailed water regimes (Deeley, et al, 2006); the lack of these regimes has been found a hindrance to the uptake of water efficiency strategies by landscape architectural practitioners (Calkins, 2005). Deeley et al's (2006) study is an example of a good ecological strategy, embedded in models of water use, that has been usefully linked with other biophysical conditions and economic assessment, and thus become understandable and accessible to local government. Grimm et al (2008) note the coming importance in urban ecology in the linking of biophysical, economic and political settings.

The ideas driving Water Smart Parks are now being embedded throughout local governments, schools and the community. Importantly, water issues and biodiversity can be addressed simultaneously rather than treated as distinct entities under the control of different governance bodies. Colding (2007) made theoretical spatial proposals considering 'ecological land-use complementation' in regard to biodiversity and building resilience, and MacFarlane (2007) discussed multi-functional landscapes.

In the SWAFR, there are four likely scenarios for POS (see Table 1):

(i) turf-based POS where turf is the main surface, with scattered mature remnant trees, rarely with a middle storey and lacking in spatial complexity;

(ii) turf-based with designed but managed exotic plantings;

(iii) 'turf that works' for ball games, with designed locally endemic species that reflect local bushland complexity;

(iv) 'turf that works' with retained (existing) bushland as a component of POS.

If turf within this region were to be restricted for specific ball games, several positive ecological possibilities would arise in addition to a reduction in water consumption through hydrozoning and ecozoning as outlined above. These possibilities are outlined in Table 1, and can be considered to promote resilience, the ability of a system to absorb disturbance and still retain its basic functions and structures (Walker and Salt, 2006). Resilience has generally not been considered by planners and designers within the SWAFR. Table 1 suggests relative opportunities for increased resilience that might include soil seedbank development (Leck, et al, 1989), seedling recruitment and increased emergent local species, age structure in vegetation, species richness and complexity over time, ecological linkages with local populations (Schmiegelow, 2007), ecological function including complexity with time (White, 2007), spatial heterogeneity (Kolasa and Rollo, 1991; Pickett and Cadenasso, 1995; Pickett, et al, 2009), water consumption (Deeley, et al, 2006), ecological education (Stone, et al, 2005), 'sense of place' (see Figure 3) (Seddon, 1972), unstructured natural play opportunities for children (Louv, 2005) and maintenance by local councils (Grose, 2010a). While Table 1 shows simple assessments based on observation and discussion with practitioners, it reveals that when the amount of turf in POS is controlled for water reduction other benefits or opportunities arise beyond immediate ecological benefits.

Table 1: Four likely scenarios for public open space

Observed and predicted opportunities for increased resilience, ecological function and human experience in four scenarios for turf and POS in the SWAFR global hotspot, namely: turf-dominated (as current), turf and exotic planting (also currently common), 'turf that works' with indigenous plantings, and 'turf that works' with managed bushland.

The left-hand table column gives opportunities in the three groups of 'Particular' (physical attributes), 'General' (larger scale attributes), and 'Human–cultural' attributes. Human–cultural attributes considered include revelation of natural processes; in this, consistently maintained and watered turf in POS will not, for example, reveal the realities of drought, while 'turf that works' POS will go brown on its edges (Deeley, et al, 2006).

Table 1 cont: Four likely scenarios for public open space

	Turf-predominant	Turf and exotic planting	'Turf that works' and indigenous planting	'Turf that works' and managed bush
Particular				
Seedbank	None	None	Possible	High if weeds controlled
Recruitment of seedlings	None	Weeds and other exotics	Possible	High if weeds controlled
Emergent local species	None	Unlikely as soil cultural conditions maintained unsuitable	High if weeds controlled	High if weeds controlled
Age structure in vegetation	Poor or none	Possible	Possible	High if weeds controlled
Opportunities for species richness/genetic biodiversity	Poor	Possible	Moderate	Good
General				
Ecological function	Poor	Low	Good	Good
Ecological linkages	Poor; dependent on mature remnant trees	Poor	High potential	High potential
Complexity with time	Poor/static	Poor/static	Moderate potential	High potential
Spatially heterogeneous/complex	Poor/static	Poor/static	Moderate	Good
Water consumption	High	Likely to be high	Moderate	Low
Human–cultural				
Revelation of natural processes to people (eg, drought)	Poor	Poor	High potential	High potential
Resilience to climate change	Poor to adapt	Poor to adapt	Possible	High potential
Ecological education; engagement	Poor	Poor	Good	Excellent
'Sense of place'	Poor	Debatable	Good	Excellent
Unstructured 'natural' and messy play for children	Absent	Debatable	Possible with good design	Excellent
Maintenance*	High	High	Moderate to high	Low or not known

* *Based on a survey of local government councils in the hotspot, where turf was found to be the most expensive item.*

As an example of a general opportunity, POS treated as a Water Smart Park with designed 'turf that works' could then reflect the scientific knowledge that common species contribute a disproportionately large number of individuals and biomass to assemblages (Gaston and Fuller, 2007). For example, even though small woodland trees such as *Banksia menziesii* are perceived as common in Perth's coastal plain, it is clear that, without care, common species such as these could suffer a 'silent decline' (*sensu* Riley, 2005). This has already occurred in Australia, with the placement of Australia's wild dog, the previously common dingo (*Canis lupis dingo*), on the Endangered Species List in October 2008 due to indirect anthropogenic effects. POS in urban and suburban areas could provide a role towards non-depletion of common species, both by formal and informal designs with 'turf that works' and indigenous plantings, and by street planting of common species. Added benefits are anticipated to be water-saving, biodiversity-saving and enrichment, both psychological and aesthetic.

LOSS OF SPATIAL CONNECTIVITY BY DESIGN DECISIONS

In contrast to the complexity of landscape type and biology, new suburbs within the region are characterised by a resounding similarity of spatial form. The spatial form

Figure 3: (left) Remnants of the original bushland as part of POS in a new suburban area of south-east Perth. The trees are Melaleuca preissiana, *the largest melaleuca of the SWAFR, and* Melaleuca rhaphiophylla; *seedling recruitment was occurring at this site amongst the mulch.*

Figure 4: (right) A piece of bushland and wetland isolated from a part of the same wetland by a design that ignored ecological linkages as part of this suburban POS. Here, a metaphor-driven spiral with exotic plants looks down upon both parts of the wetland. This was a lost opportunity to have a coherent linear wetland system within the new suburb. Note in this image the standing water (centre of image) is not due to unpercolated rainwater but the high water table in the wetland area.

of POS, which has been discussed by Swanwick et al (2003), is outside the scope of this paper, although spatial form is entwined in ecological, aesthetic and design concerns of POS. Of particular note is the common lack of connections between adjoining new developments (Stenhouse, 2004). This is a result of both statutory planning and design failing to make basic ecological principles of connectivity and linkages into real outcomes at every scale of development. For example, in Figure 4, remnant bush was broken to provide some turf that is not specific to a particular sport and thus not 'turf that works'. In doing so, an existing wetland system was fragmented; the design ignored linkages and the impact of distance thresholds (Dramstad, et al, 1996) between patches of bush, particularly for reptiles in this reptilian hotspot. This is a poor reading of country. The importance of better knowledge of basic ecological principles, such as patches and connectivity, and systems thinking by landscape architects and planners needs to be considered for POS to be truly meaningful for the resilience of urban areas in changing climates (Felson and Pickett, 2005).

CONCLUSIONS

At the heart of this review of a region of complex hydrology supporting a globally important floral and reptilian biota is the difficulty of incorporating ecological issues meaningfully into resolved designs and the planning policies that underpin them. The imperatives of decisions in a hotspot need to be in contrast to places where POS is being framed mainly on economic criteria (for example, Choumert and Salanié, 2008). The special nature of the SWAFR highlights the point that imperatives will be dictated by the unique climatic and physical aspects of these landscapes, and social responses to and hopes for those landscapes. Some social requirements might seem trite, such as with this hotspot and its POS, where the large field required for Australian Rules football and cricket needs to be taken into account for at least some POS. Such requirements can challenge policy makers and designers.

Metabolic studies are needed to understand flows and relationships between biota, soils, topography, water, history, human socio-economic needs and emotional responses, and planning legislation, among others. We need such studies to draw the associations between what remain largely as parallel discourses of design, planning and science. If we are to look sideways as we make decisions in designing places, we will need these studies to accommodate the differences in problems and phenomena at different scales (Wilson, 2006) to create the best opportunities for life in a hotspot. Rethinking policy and design towards better water use and biodiversity within new suburban areas, from the regional to small site scale, will no doubt arise as a result of unravelling metabolic processes of both ecological and social responses.

Echoing the beliefs of Alessa and Chapin (2008), it is timely to redefine the ways in which ecology, planning and design are communicated and practised. Suburban development continues to rely on environmental mapping of species (Pickett, et al, 2001), planning standards, assumptions of land percentages based on social premises (Grose, 2007), general ideas of 'sustainability' or 'ecology' as promulgated in the grey literature (rather than specific local knowledge) and case histories (Flores, et al, 1997). Ecological insights have become codified by planning and are not site specific or 'grounded' (Meyer, 1997), a common problem pointed out by Pickett, et al (2001). Designers have to deal within this codified framework with little ecological understanding and will continue to do so without better bridges between the disciplines, from both sides.

Two philosophical questions appear to be at play within the disciplines. First, environmental scientists need to ask what is the intellectual ambition for their knowledge (Armstrong, 2008) – that is: What could this do in the world? Here the ordinary, suburbanising world where 60 percent of the world's population are soon to live, and thus: Why is it good to know this? Second, landscape architects and others have scarcely begun to understand scientists' ecological knowledge because no one has been able to answer clearly for them the questions: Why is it good to know this? and What could this do in the world? in terms of design and designing places of human engagement. If we ask these questions, there is a clear commonality. This is a far simpler view than the common assertion that, to facilitate better ecological design, the disciplines of planning, landscape architecture and environmental science need to move together towards a more holistic understanding of ecology in terms of socio-ecological systems (Berkes, et al, 2003; van Kamp, et al, 2003; Ellis and Ramankutty, 2008; Alessa and Chapin, 2008). Hydrozoning and ecozoning within 'turf that works' can be seen as examples of a strategic practice and policy difference that has arisen due to the scientists involved seeing clearly what their knowledge could do in the world, and transmitting that view so new practical designs and policies for POS might occur in the SWAFR hotspot.

Calls for increased information about socio-ecological systems are perhaps suggesting that more knowledge will improve ecological outcomes in designed landscapes. This might or might not be true, and the extra work required by an individual might be overwhelming, or distracting, or lead to superficial responses to sustainability, which can be seen in design work today. Lister (2007, pp 47–48) discusses the deterministic and static approach to design that was fuelled by McHarg's (1969) 'design with nature' and suggests any imperatives today for experimental designs need to consider ecosystem complexity, uncertainty and adaptation. 'Design as research' has been under discussion in landscape architecture for some time, although how, and in what time-scale the design experiment is to be 'assessed', has not received the same attention. Lister (2007, p 46) notes that such experiments need to be resilient enough to be 'safe to fail'; they thus need to be firmly designed with consideration of complexity, flux, scales and diversity in changing climates. Within this, we might consider that we need to be mindful of confusing different systems – ecological systems that are not human constructs, and social-political systems that are human constructs. A danger here, as noted by Guattari (2000, p 20), is that we might begin to put on the same 'plane of equivalence' material assets, cultural assets and natural systems, when our control of these is quite different.

If we ask what the combined intellectual ambitions for our knowledge might be, then they are surely primarily about ambitions for places, such as the south-west Australian hotspot. First and foremost is that we wish to design places where we want to be, and where we give something to the human experience in an increasingly crowded urban world. Meyer (2008, p 18) propounds the need for the experience of beauty, 'a process between the senses and reason' as part of sustainable design. Aesthetics and beauty are essential parts of the question: What could this do in the world?, as beauty is transformative of opinion, belief and actions. In a general sense, design can reveal that the climate-altered future can be beautiful, and this is an important part of environmental education. While aesthetic imperatives are outside the scope of this paper, the fact that designs embedded with biodiversity and water conservation can be beautiful is particularly important in the SWAFR. Beauty can assist in helping to sway public opinion to make needed changes – such as water conservation and reduced turf – to the design of places like POS and home gardens. Missed opportunities today in hotspots will have greater ecological implications both now and in the future than those in non-hotspot regions. Beauty of spatial form and spiritual meaning or sense of place are also the very things that scientists cannot provide, and they look to designers to create these within a growing base of ecological knowledge of urban areas.

When considering ecological imperatives, such as water and biodiversity in the SWAFR hotspot, and improved design outcomes, the global commonalities across the disciplines that need further exploration between science and design might be considered to be:

(i) celebrating differences in places at all scales, with 'grounded landscapes' (Meyer, 1997), which underpins the detailed assessments of sites, systems and organisms in science as noted by McDonnell, et al (2009);

(ii) the importance of local knowledge to understanding place (Orr, 2004, p 10; McDaniel and Alley, 2005) as local imperatives, with indigenous knowledge and the spiritual association of reading landscapes or reading country exemplified in the expression *jippy joppie boodja* ('rhythm of the land') of the SWAFR's Nyoongar people (Nannup and Deeley, 2006);

(iii) the preservation of sense of place (Seddon, 1972);

(iv) the avoidance of 'knowing in fragments' (Rowe, 1990, p 129) and thus building in fragments in an uncomplimentary way (*sensu* Colding, 2007), which needs to include the avoidance of design without a strong aesthetic sense as a form of knowing (*sensu* Meyer, 2008), and *jippy joppie boodja*, which is surely central to landscape architecture and design; and

(v) addressing our combined intellectual ambitions for knowledge 'to become real in the world' (Armstrong, 2007).

All of these commonalities can be seen as assisting with understanding and designing for the increasing complexities of the ecologies of suburbanising areas with climatic and societal change towards what Hargreaves (2007, p 171) has described as the complex matrices that 'capture the hearts and minds of humanity and propel a public park forward for centuries'.

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