

ENVIRONMENT DESIGN GUIDE

MEASURING SITE BIODIVERSITY FOR SUSTAINABLE DEVELOPMENT

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SUMMARY OF ACTIONS TOWARDS SUSTAINABLE OUTCOMES

Environmental Issues/Principal Impacts

- Biodiversity is required for the health of the natural environment and the continuation of the human species.
- Human activities, including urban development, simplify ecosystems leading to reductions in biodiversity.

Basic Strategies

In many design situations, boundaries and constraints limit the application of cutting EDGE actions. In these circumstances, designers should at least consider the following:

- Don't put new developments on sites of high ecological value, especially where sites contain rare, threatened or vulnerable flora and fauna.
- Undertake brownfield developments involving site remediation to enhance the ecological value of the site.
- Enhance rather than diminish the ecological value of the site.
- Biodiversity targets should be based on local and regional conditions.
- Select building materials and products which in their extraction, processing and manufacturing cause the least damage to the environment.
- Maximise site developments, without reducing amenity, to reduce the need for greenfield developments.

Cutting EDGE Strategies

- Undertake baseline biodiversity assessments of the site prior to the commencement of construction.
- Undertake environmental assessments of the proposed development at the design stage.
- Undertake environmental assessments of the development after the building and landscape works are complete and compare to previously undertaken baseline assessments.

Synergies and References

BDP Environment Design Guide:

- GEN 3 *Biodiversity and the Built Environment* by Guy Barnett (February 1995, revised February 2002)
- GEN 17 *Urban Planning for Sustainability* by Matthew Ulterino (February 1998, revised February 2004)
- GEN 39 *Ecosystem Services for Regional Sustainability* by Guy Barnett (May 2001)
- DES 45 *Biodiversity in Landscape Design* by Alan Chenoweth (February 2002)
- DES 53 *Roof and Facade Gardens* by Darren Holloway, Peter Ho and Boyd Boxshall (February 2003)
- DES 54 *Water and Landscape Design in Arid Environments* by David Jones and John Zwar (May 2003)
- DES 56 *Birds and Buildings* by John Gelder (August 2003)
- DES 58 *A More Sustainable Approach to Urban Freeway Vegetation Design and Management* by Stephen Thorpe and Peter May (November 2003)
- PRO 30 *Timber and Wood Products – Applications and ESD Decision Making* by Andrew Walker-Morison (November 2003)

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Biodiversity, the variety of life on earth, is required for the health of the natural environment and the continuation of the human species. Though Australia has large endowments of biodiversity, human activities over the past 220 years have had serious environmental impacts resulting in species loss.

Measuring biodiversity of building developments should be integral to environmentally sustainable design practice and assessment but it presents unique problems, since there are few agreed methods for rating land at the scale of the individual building site. This Note outlines issues relating to biodiversity in Australia and discusses the strategies used to rate biodiversity in a number of international and Australian building environmental rating systems and those recommended in design guides.

1.0 BACKGROUND

1.1 The importance of biodiversity

"Biodiversity can be most simply defined as the variability of life, from the minute genetic level through to the large scale of an ecosystem. The existence of the human race is dependent on the interactions of all forms of life, and by extension, on diversity. Vegetation sustains the earth's atmosphere through absorbing the carbon dioxide we exhale and generating the oxygen we breathe. The food we consume, the electricity that powers our homes and offices, the fabric we are clothed in and the pharmaceuticals available to treat our illnesses are all directly related to biodiversity" (Australian Government, 2003a).

Australia is classified as a 'megadiverse' country, being rich in species and has the world's second highest number of reptile species, the fifth in flowering plants and many species of birds, mammals, reptiles and plants that are found only in Australia (Biodiversity Working Party, 1991).

It is estimated that there are between 200,000 and 250,000 species of fungi, between 27,000 and 32,000 species of plants and some 225,000 species of animals in Australia (DEST, 1994; Scott et al, 1997; Orchard, 1999). It is worthwhile noting that biodiversity refers not only to flora and fauna that are readily apparent but also to invertebrates and other micro-fauna that may form the base of food chains and which in some places (especially in soil) comprise a large number of very diverse and often poorly described taxa. However, European settlement of Australia over the past 200 years has resulted in habitat destruction and modification and species loss and this must be halted if the risk of environmental decline is to be reduced.

A number of values are associated with biodiversity. They include, inter alia, direct utilitarian values (for example, the provision of food, construction materials and pharmaceuticals), indirect utilitarian values (maintenance of 'ecosystem services' that maintain water quality in catchments, for example), aesthetic and recreational values, scientific and educational values and earth stewardship responsibilities. The need to maintain or improve biodiversity, therefore, is high.

The CSIRO estimates that the total annual value of ecosystem services within Australia is \$1327 billion.

Human populations "divert energy and material flows through ecosystems from other species to ourselves" (Rees, 2001). In short, Rees notes, "what people consume, other species cannot." In addition, human populations also simplify ecosystems leading to a reduction in complexity that causes loss of biodiversity.

Australia's 2001 State of the Environment Report notes that: "Studies of the urban environment and biodiversity in urban settings are important if these components of biodiversity are to be sustained... Because most Australians live in urban environments, increasing awareness of biodiversity and the role of individuals is essential" (Williams et al., 2001).

However, biologists work mostly on non-urban agendas (Platt, 1994) and "...the notion that cities themselves are inherently linked to the natural systems that govern life on earth" has not been perceived until recently as part of the environmental agenda (Hough 1994). Hough notes the paradox that the landscapes we ignore "are often more interesting and complex, and have a greater sense of place, than the ones we admire as the expression of civic pride and good urban design." Hence, contrived and highly controlled urban gardens and parks may contribute less to biodiversity than neglected urban areas in which evolving plant communities flourish and support a variety of flora and fauna, although higher values still will be found in areas of remnant natural vegetation.

In Agenda 21, an outcome of the 1992 United Nations Conference on Environment and Development, only one of its forty chapters addresses urban issues (sustainable human settlements). However, the emphasis was on technical rather than natural systems. Greenbie suggests that applying an ecological definition of sustainability to urban communities might be viewed as an oxymoron (cited in Platt 1994). He notes that urbanisation tends to destroy natural phenomena and processes and has ecological impacts far beyond the urban fringe. This is embedded in the notion of the 'ecological footprint' (Wackernagel and Rees, 1996).

Therefore, though much emphasis is placed on the natural environment, biodiversity is very relevant to the built environment since the built environment mostly

displaces natural habitat, alters water flows and in its construction and operation phases pollutes water, land and air. However, there are opportunities to protect and enhance biodiversity, even in relatively dense cities. One alternative view is that increasing urban density, while reducing biodiversity within it, may protect land of medium to high ecological value from development. Thus, increasing urban density avoids expansion of the urban footprint and natural areas are left to support a wide diversity of native species.

1.2 The cause of changes in biodiversity

Biodiversity losses in Australia have been attributed to a number of causes including: urbanisation arising from changes in population numbers, density and location; introduced plants; the use of chemicals such as pesticides, herbicides and fertilisers; invasive species; clearing of terrestrial vegetation and marine habitat; pollution; and climate change. These issues are discussed below.

Urbanisation

Biodiversity in dense cities is significantly reduced, relative to pre-settlement conditions, while in less dense suburban settlements it may be higher or less affected. While biodiversity in suburban settlements may appear higher, it often comprises highly visible taxa tolerant of human contact, and locally endemic taxa and soil micro-fauna may have declined. Urbanisation may also involve land clearing or land use changes that affect biodiversity. Refer to section 1.4 for further discussion.

Introduced plants

Introduced plants may replace native plants. All crops and pastures have replaced native plants formerly occupying the land. Many introduced plants have the potential to become invasive (refer to section below). It is of some interest that Australia has a long history of 'Acclimatisation Societies' which fostered, with government and scientific support, the spread of European plants and animals, often with disastrous ecological consequences.

Chemicals

Chemicals are used on both plants and animals, and affect both soil (especially micro-fauna) and water. The use of synthetic chemicals reduces biodiversity within soils and their runoff or drift also affects biodiversity in watercourses, with flow on impacts affecting the health of terrestrial fauna. Excess nutrients in watercourses also lead to eutrophication, fish kills and algal bloom.

The chemicals include:

- Residual pesticides and herbicides
- Non-persistent pesticides and herbicides
- Synthetic fertilisers
- Organic fertilisers
- Hormones and antibiotics.

In urban areas, chemical and fertiliser use in parks, gardens and golf courses may also be a factor in biodiversity decline.

Undesirable species

This group includes environmental weeds, invasive plants and feral animals. Environmental weeds are "plants growing out of place" (Thorpe, 2003). They "are considered one of the greatest threats to nature conservation in Australia and plant species not native to Australia now account for about 15% of our total flora. About half of them invade native vegetation and about one-quarter are regarded as serious environmental weeds or have the potential to be serious weeds" (Australian National Botanic Gardens, Environmental Weeds in Australia, 2002). Hence as well as overseas exotic species, some native but non-indigenous species may also become environmental weeds. Some exotic plants on the other hand, while not native or indigenous, may provide habitat for fauna. Invasive species, including plants and feral animals, readily spread unaided in both disturbed sites and undisturbed areas. Lantana, considered to be an invasive species, for example, does provide habitat for small birds and some native marsupials such as wallabies and bandicoots.

Environmental weeds degrade the ecology of natural and near natural ecosystems. Garden plants can also become potential environmental weeds. A study by the Nursery Industries Association in 1999 identified 860 invasive plants available through plant nurseries (Australian and New Zealand Environment and Conservation Council, 2001). Moreover, indigenous plants located outside their normal range can become environmental weeds (Thorpe, 2003). Australia's State of the Environment 2001: Biodiversity report (Australian and New Zealand Environment and Conservation Council, 2001) lists 20 weeds of national significance and these could be used as a guide in a reporting system. However, they are rarely found in urban areas.

Birds, by eating and later excreting fruit, can carry fleshy-fruited plants at least 400 metres from gardens. Consequently, it is preferable that certain exotic plants, particularly those bearing berries such as privet, cotoneaster and ivy, should not be used in landscaping. Nectar yielding exotics, on the other hand, may be as beneficial for some native birds as native plants. However, increasing native populations beyond natural levels, in turn, may negate this.

Feral animals in urban areas, such as foxes, rabbits, hares, starlings, pigeons, Indian Mynas and cane toads, together with domestic animals, have a significant affect on native fauna, by direct predation, toxicity or by displacement.

1.3 Biodiversity indicators and measurement

Few biodiversity indicators and means of measuring biodiversity at the scale of either the individual building site or the broad scale subdivision site exist in the ecology and urban ecology and biodiversity literature.

Biodiversity indicators

The 2001 State of the Environment Report identifies 65 threats to biodiversity. Of these, 14 relate to

pressures on biodiversity, 17 to the conditions of biodiversity and 34 to responses to the loss or perceived threats to biodiversity. However, these national level indicators provide limited guidance at the individual building site level.

The National Objectives and Targets for Biodiversity Conservation 2001-2005 set out a number of priority aims (Australian Government, 2001). These are inter alia, to: protect and restore native vegetation and terrestrial ecosystems; protect and restore freshwater ecosystems; protect and restore marine and estuarine ecosystems; and control invasive species. Other aims are directed towards rural problems, institutional reforms, climate change, knowledge acquisition and access and the ethnobiological knowledge of indigenous peoples.

For Australia, relevant key indicators of biodiversity addressing the national and regional scales include (Williams, 2001):

- Human population distribution and density
- Changes in human population density
- Extent and rate of clearing or major modification of natural vegetation or marine habitat
- Pest numbers
- Pollution
- Human-induced climate change.

However, these national targets and indicators are of little assistance in relation to urban developments since very often they involve clearing of natural vegetation and/or removal of habitat. Regional and local inventories of flora and fauna, and identification of specific ecosystems and taxa that are at risk, are of more direct relevance. These documents provide the best starting point for site-specific biodiversity maintenance or enhancement, especially if linked to land use planning whereby parts of any urban area having high biodiversity are identified. Developers and designers should then be dealing with developable land of lesser significance. The issue then would be how to measure biodiversity on sites that are, or appear to be, of low habitat value.

Biodiversity measurement

A 1994 publication, *The Ecological City: Preserving and Restoring Urban Biodiversity*, outlines the advantages of biodiversity and how to improve it, though it provides no methods to measure biodiversity (Platt 1994). Other references, such as *Mapping the Diversity of Nature*, (Miller 1994) use maps and other tools to chart diversity at the regional or country scale arguing that “the protection of nature in general, rather than concern for the protection of one individual element versus another, is the principle over-riding all these programs.” Maddox argues that: “Devising ways of estimating biodiversity quantitatively remains an unsolved problem” (cited in Gaston and Spicer, 1998). Furthermore, as Gaston and Spicer argue: “As a result of the variety of elements of biodiversity, and of the differences between them, there is no single all-embracing measure of biodiversity.” To complicate the

issue further, higher levels of biodiversity may not in all cases be desirable. Designed gardens are likely to have a higher biodiversity per square metre than a woodland (Fullick, 2002). Therefore, what is measured and how it is measured “reveals something about what you most value.” (Gaston and Spicer, 1998). However, a regional context would allow measurement to focus on the species characteristic of the particular ecosystem(s) that exist(s) or formerly existed on site.

Nevertheless, Chenoweth (2004) argues there are various ways to measure biodiversity, and although species richness is one surrogate, it is an inadequate tool that fails to take abundance into account. Formulae such as “Simpson’s Diversity Index” incorporate both richness and abundance and have been developed to assess the diversity of flora and fauna species in natural ecosystems. Simpson’s Diversity Index is also applied at ecosystem level in Queensland as one of 13 criteria to evaluate and rate the ecosystem diversity (not species diversity) of remnant bushland patches (mapped polygons) in the Biodiversity Assessment and Mapping (BAMM) procedures developed by EPA for regional biodiversity mapping.

The National Strategy for the Conservation of Australia’s Biological Diversity offers only broad guidance in relation to urban conservation. It recommends that biodiversity in urban areas be promoted by encouraging the retention of native habitat; improving strategic planning and infrastructure coordination; reducing fringe development; preserving natural ecosystems and using locally indigenous species; and integrating biodiversity considerations into relevant policies and programs (Australian Government, 1996).

Two projects are worth noting. The first is an internet-based integrated Australian flora information system. It is expected to be completed by 2005 according to The National Objectives and Targets for Biodiversity Conservation 2001-2005 report. This information may make it less expensive and easier to identify locally indigenous plants than current practices.

The second is a bioregional classification system for the whole of Australia. “The Interim Biogeographic Regionalisation for Australia (IBRA) is a framework for conservation planning and sustainable resource management within a bioregional context. IBRA regions represent a landscape-based approach to classifying the land surface from a range of continental data on environmental attributes. In 1999-2000, IBRA version 5 was developed and 85 bioregions have been delineated, each reflecting a unifying set of major environmental influences which shape the occurrence of flora and fauna and their interaction with the physical environment” (Australian Government, 2003b). However, these two projects are of little relevance to specific sites. Nevertheless it is feasible to prepare complete inventories of development sites.

Given the difficulties in measuring biodiversity and given that a complete inventory of biodiversity is not a realistic option in the near future, ecologists make use of surrogate measures or indicator species which are correlates of the actual measures desired but which

can be more readily identified. Aquatic insects, for example, are used to measure the quality of fresh water. However, there is no widespread agreement among scientists as to which species best indicate biological diversity, or which species might best indicate changes in biodiversity. A solution might be “to generalise the units of diversity into more heterogeneous classes such as ecological communities, species assemblages or environments” (Australian Government, 1991). Australia’s State of the Environment Report states: “In the absence of other means, vegetation assemblages are used as surrogates for ecological communities and ecosystem diversity” (Williams et al, 2001).

With respect to vegetation assemblages as surrogates of biodiversity, State environmental agencies (especially the Queensland EPA) have developed the concept of ‘Regional Ecosystems’ (associations between vegetation, geology and land types) to a sophisticated level as a basis for broad scale mapping and identification of conservation priorities. The BAMB methodology, although based on mapped polygons of vegetation, now goes well beyond simply using vegetation assemblages (Chenoweth 2004).

Gaston and Spicer note that while biodiversity can be measured in many ways, in practice it tends to be measured in terms of species richness because this is a good surrogate since it is measurable in practice, a substantial amount of information already exists and consequently the task is manageable. However, biodiversity is not distributed evenly and this makes the measurement task more complex. The number of species locally will be influenced by regional richness (compare a desert to a rainforest, for example) and by geographical area (larger areas will contain larger numbers of species).

In the absence of measurement strategies applicable at the level of the individual building site and taking into account critical biodiversity issues identified as relevant to Australia’s unique flora and fauna (discussed above), the following indicators have been suggested (Kirkpatrick, 2003):

- Extent of local native cover
- Degree of spatial complexity in the landscape
- Extent of use of synthetic pesticides, herbicides and fertiliser inputs
- Provision of habitat in urban areas and built structures
- Bird dispersed exotics
- Building design attributes resulting in bird deaths and injuries.

However, Chenoweth (2004) believes these indicators may be of limited applicability to urban development sites since development sites may have generally low biodiversity and generally exclude threatened ecosystems, old growth forest and wildlife corridors. He also argues that if we want to measure biodiversity on a development site, then presumably the objective of measurement is to check if biodiversity is being reduced or enhanced by development, and to identify those aspects of development causing the loss or

increase. In order to do that, we need to know in detail what is present on site pre-development. A thorough baseline survey of flora and fauna is essential, with particular emphasis (through targeted searches) on ‘at-risk’ taxa that may potentially be in the area. This baseline survey needs to be interpreted in the light of currently available scientific information regarding the ecological determinants of existing populations, so that the chances of each species remaining on-site following development can be predicted and the conditions maintained or replicated.

With respect to mobile populations, or species with habitat requirements extending beyond the development site, measurement needs to also extend beyond the site to determine the viability of the local population(s) and the contribution of on-site habitat. Baseline measurements need to be undertaken in a way that can be followed later during monitoring of development impacts and the effectiveness of mitigation.

The discussion above highlights some of the problems involved in the measurement of biodiversity.

1.4 Biodiversity indicators and measurement for human settlements

Biodiversity indicators for construction projects

While indicators are discussed below in Sections 2 and 3 (in relation to environmental rating systems and design guides), it is worth noting that a UK study was recently undertaken (Woodall and Crowhurst, 2003). This report identified 17 indicators and through a process of consultation reduced them to three. These indicators are:

- Impact on biodiversity: products
- Impact on biodiversity: construction process
- Area of habitat retained/created.

The method for the first two is the use of a client survey that asks questions about the considerations given to biodiversity. An example cited in the study: “Local biodiversity expertise (e.g. local wildlife trust) was used to help identify ecologically important habitats/species on the site, to be addressed during the project.” In addition, project developers are required to comply with legislation relating to biodiversity. They are able to get advice from recognised bodies/consultancy practices and in some cases may be required to work within a Local Biodiversity Action Plan.

The method for the third indicator is direct measurements on site of the area of ecologically valuable habitat within the total area of the site at the start (Area 1) and completion (Area 2) of the project and the total area of the site. The Performance Score is calculated as (Area 2 – Area 1)/Total Area, expressed as a percentage. The score can be modified by actions taken that cannot be easily measured in terms of area, for example, putting up bat boxes or donating money to a local initiative to enhance biodiversity.

Biodiversity targets

The biodiversity of urban areas will differ to that of an undisturbed pre-settlement landscape. Urban areas are a matrix of infrastructure, backyards, gardens, parks and remnant natural vegetation all of which will have differing values for different native and exotic species. For most cities in Australia the original condition was a complex of forests, woodlands, heath and wetlands having up to three structural layers of vegetation – ground cover, shrubs and trees. For both urban and suburban sites it is not feasible or even necessarily desirable to recreate the original conditions. Australia also contains large areas of desert, rainforest, and alpine areas and so on and many people live there. Consequently, Chenoweth (2004) argues, targets for each city, suburb and development site must differ since they should take into account their regional context.

Gardens, comprising native or exotic plants, or both, are highly managed systems maintained to varying degrees in a semi-mature state by pruning, irrigating, aerating, tilling, clearing and controlling using a variety of chemicals. Moreover, urban settlements modify microclimate and water, soil and air quality. Urban landscapes, therefore, are cultural landscapes and cannot recreate pre-settlement conditions (Kelly, 2003).

Urban areas vary in the density of development – suburbs are less densely developed than central business districts. There are easier options for maintaining or increasing biodiversity in the suburbs than in inner city areas where medium to high rise buildings may occupy all or most of their sites, leaving little open space for flora and fauna. An alternative view is that dense cities preserve land by reducing their size for a given population, thus freeing up land elsewhere that can be used for agriculture, forest and grasslands, for example.

The issues discussed above make clear that setting biodiversity targets for human settlements is a complex and loaded issue. Given the number of bioregions in Australia, consideration should be given to biodiversity targets that respond to local conditions, including locations with unique or threatened species.

1.5 Impact of buildings on biodiversity

Construction projects all have the potential to damage natural habitats, thereby threatening wildlife and plant species. They do this not only through the obvious mechanism of displacement (when a building replaces an area previously vegetated) but also as a result of the processes involved in the mining and extraction, processing and distribution of products used in the construction sector. However, at a very direct level buildings and structures have an impact on local biodiversity as the two examples below demonstrate.

Provision of habitat in urban areas and structures

Clearly, many exotic and native animals can persist in urban areas. Peregrine falcons, for example, have been known to live on the 'cliffs' of high-rise buildings in Melbourne. Design features can provide resting or nesting places for birds and mammals and this can

assist in maintaining local biodiversity. Protected bird baths, ledges, verandahs, alcoves, roofs, rock piles, dense growth of shrubs, nectar producing plant species and 'safe' water (e.g. ponds, lagoons, and lakes) have the potential to provide habitat for fauna in urban areas. However, these are difficult to measure in a meaningful way and may provide habitat for invasive rather than indigenous species, and/or unnatural levels of indigenous populations.

Building design attributes resulting in bird deaths and injuries

Buildings can also cause bird deaths. A three-storey seven metre long glazed link connecting two buildings at the University of Tasmania campus in Hobart results in the death of approximately 11 birds per year. Some, such as the Swift Flying Parrot, are becoming rare, so the deaths of these birds contribute to a critical reduction in biodiversity. However, it would be very difficult to assess buildings or building designs for their potential to cause death or injury to birds.

2.0 HOW IS BIODIVERSITY ADDRESSED IN BUILDING ENVIRONMENTAL RATING SYSTEMS?

2.1 Design-based systems

Design-based systems are used at the design stage, as a guideline, with in some cases a third-party certification tool (for example, LEED). Two major systems that have influenced a number of recent systems including Green Star in Australia are the US LEED and the UK BREEAM.

LEED Green Building Rating System Version 2.1

The US system LEED (Leadership in Energy and Environmental Design) addresses biodiversity indirectly by rewarding erosion and sedimentation control, site selection and alternative transportation.

LEED addresses biodiversity directly by rewarding (US Green Building Council 2002):

- Urban redevelopment in areas with existing infrastructures and preferably to sites with high development densities:
 - Provide documentation declaring that the site has achieved the required development densities
- Brownfield redevelopment involving site remediation:
 - Provide documentation proving that the site is classified as a brownfield site
- Conservation of natural areas and restoration of damaged areas:
 - On greenfield sites, site disturbance is limited by specifying maximum distances of earthworks and clearing of vegetation from buildings, curbs, walkways and main utility trenches; or on previously developed sites,

- a minimum percentage of site area is to be restored by replacing impervious surfaces with native or adaptive vegetation (protect or restore open space)
- Ensure the development footprint exceeds the local zoning open space requirements for the site by a specified percentage; or for sites with no zoning requirements, conserve open space that is equal to the development footprint, for the life of the building (development footprint)
- Reduction of heat islands:
 - Minimum percentages are specified of high albedo or shaded surface areas or pervious pavements, or of underground car parking or of pervious parking areas (non-roof)
 - Minimum percentages of highly reflective/high emissivity roofing or vegetated roof (roof).

BREEAM

The UK system, BREEAM (Building Research Establishment Environmental Assessment Method), has been developed for a number of building types including offices, homes, industrial units and retail units. For homes, for example, Land Use and Ecology are given credit points by addressing three issues (BREEAM 2004):

- The ecological value of the land
- The change of ecological value of the site
- The effective use of the building footprint.

For the first issue, credit points are awarded for building on a site that is of low ecological value by enhancing the ecological value of the site through consultation with an accredited expert or by ensuring the protection of any existing ecological features on the site. For the second, credit points are awarded according to the magnitude of the change of ecological site value (minor and negative to significant and positive). Credit points are awarded for the final issue according to the percentage of the footprint.

LEED and BREEAM take a similar approach to the rating of design strategies aimed at maintaining or improving biodiversity. They do not provide a measure of biodiversity but instead reward practices that increase the likelihood of maintaining or improving biodiversity locally or remotely.

Green Star

Green Star was developed in Australia and released in 2003. It is now in the pilot stage of development. Although there are plans to develop rating tools for different phases of the building life cycle and for different building classes, at this stage Green Star is a rating tool for the design phase for commercial office buildings (base building construction or refurbishment). Chenoweth (2004) believes Green Star comes closest to adequately incorporating ecological values in a way that might have predictive value for biodiversity, in a regional context.

Biodiversity is addressed as Ecology and Land Use and the assessment is based on the change of ecological value. Credits “are awarded where the ecological value of a development site is either not diminished or is enhanced beyond its previously existing state. No credits are available for sites which contain rare, threatened or vulnerable flora and fauna” (Green Building Council Australia, 2004). Credits are calculated by comparing the relative ecological value of the land use before and after development. Information required includes the bioregion in which the site is located and the area of each ecological land type on the site before and after development. In addition, it must be confirmed that the site does not contain rare, threatened or vulnerable flora or fauna.

Each ecological land type has been assigned a Relative Ecological Weighting and this is multiplied by the area of each land type to give an Ecological Score. A building, for example, has a Relative Ecological Weighting of 0, bare ground has a REW of 5, native grazing 20, a plantation forest 10 and a wetland and an indigenous native habitat greater than 20 years old both have a REW of 100 (the maximum). The Bioregion Reservation Importance Factor was developed and used as a multiplier for native land types, wetlands and waterways. This increases the Ecological Score where the vegetation is less abundant and ecosystems are threatened.

A Total Ecological Score for before and after development is determined by adding the Ecological Scores for each land type. Each is divided by the site area to yield the Ecological Diversity Index. The Change in Ecological Value is then calculated by subtracting the EDI (Before) from the EDI (After). Credits are then awarded based on the Change in Ecological Value achieved.

Given the interest recently in roof gardens as a ‘green’ solution, it should be noted that Green Star acknowledges the use of roof gardens but awards them fewer credits than for a ground level garden, even if both use native species, arguing that they will not have the same level of biodiversity.

BASIX

The Building Sustainability Index (BASIX) has been developed by the NSW Department of Infrastructure, Planning and Natural Resources as a web-based planning tool for all residential developments (Department of Infrastructure, Planning and Natural Resources, 2003). It will address water, stormwater, energy, indoor amenity, landscape, waste, materials, transport and social sustainability indices. However, in the first stage of implementation in the period 2004/2005 it will address only water, stormwater, energy and indoor amenity. Details about the manner in which landscape will be assessed are not available yet on the State Government of NSW website.

NABERS

Two measures of landscape diversity (used as a surrogate indicator of biodiversity) were identified: the extent of local native cover and the spatial complexity of flora on the site (Department of the Environment and Heritage 2004).

This provides an assessment of the local indigenous cover as a percentage of total site area. Indigenous native planting on the ground level, mid-levels, vertical surfaces and rooftop gardens are included. Indigenous native cover is calculated for ground cover, shrubs and trees as a percentage of site area.

Spatial complexity is the second surrogate measure for landscape diversity. Plant cover on rooftop gardens is included. Vegetation is assessed in three layers:

- Layer 1 Lawn, ground cover or small shrubs <0.5m in height
- Layer 2 Shrubs 0.5–5m
- Layer 3 Trees >5m

- Only one of the layer types is present covering one third or more of the area
- Each of the layer types present covers less than a third of the area but the total plan area covered by all the layer types is greater than a third of the area.

- Two of the layer types are present covering one third or more of the area
- One of the layer types covers a third or more of the area and the total plan area of the other layer types is also greater than a third of the area.

- All three of the layer types are present, with covering of one third or more of this area.

A formula embedded in a spreadsheet simplifies the calculation for the assessor. All vegetation, native, indigenous and exotic, is to be measured. The areas of vegetation and the layer combinations are the attributes measured on site and form the data input for the calculation. A simplified measurement protocol not requiring detailed site measurement has been developed.

The rating system recognises that higher urban density avoids vegetation loss through urban sprawl. Thus, a building is compensated on the basis that floor area greater than site area has avoided the destruction of external environment that is taken to be a nominal cover of 0.5 and complexity of 1. The modification is not used where floor area is equal to or less than the site area.

An integrated landscape diversity index combines the native cover and spatial complexity indices and normalises them to account for beneficial effects of urban density to produce a single index of landscape diversity. The result is a score between 0 and 5 where 0 represents unacceptable practice (little or no biodiversity associated with the development) and 5 best practice.

Landcom

Landcom is a NSW state government land corporation providing urban developments in NSW. In its 2002 report, Landcom identified what it referred to as Triple Bottom Line indicators in relation to its business. For conservation and enhancement of natural features and biodiversity, 11 indicators were identified:

- Area of estate devoted to wildlife corridors
- Percentage indigenous planting
- Introduced flora and fauna species
- Threatening processes
- Flora and fauna conservation
- Area cleared and habitat lost
- Area enhanced/regenerated and habitat gained
- Types of species cleared
- Percentage beyond compliance of conservation conditions specific to project
- Money spent in regeneration of vegetation
- Linear metres of creek rehabilitated or enhanced.

Implementation of sustainable development (Landcom undated) would include, for example, identifying and protecting endangered species and their habitats; increasing the quality and quantity of habitat through rehabilitation; protecting remnant habitat; locating compatible land uses such as conservation areas near areas of remnant vegetation; creating buffer zones between areas of development and remnant habitat; positioning roads away from important natural ecosystems; and minimising the creation of artificial barriers such as roads.

This Melbourne Docklands ESD Guide (2002) was prepared by the Docklands Authority with principles, design elements and performance indicators intended to guide development towards ecological sustainability.

The performance indicators for biodiversity “include restoration of plants and trees to both public and private domains, with a proportion of native planting for each development.”

The indicators are based on LEED and BREEAM (discussed above).

Biodiversity is indicated by the percentage of native planting according to the ESD Guidance Notes (ESD Guidance Notes, Melbourne Docklands ESD Guide).

Two points are awarded if 50 per cent of introduced plants are native to the State of Victoria or the landscape elements are to “embrace and demonstrate response to the spirit and intent of this clause.”

Four points are awarded if a previously used and contaminated brownfield site is restored.

Your Home

‘Your Home’ was developed for the Australian Greenhouse Office (Reardon, 2001) with the intention of providing accessible information about environmentally friendly housing for building designers, and prospective homeowners and builders. Biodiversity is addressed in two notes: ‘Biodiversity off-site’ and ‘Biodiversity on-site’. In both, land clearance is identified as the most serious threat. Other threats identified include: fragmentation into smaller patches; removal of biomass such as trees and fodder plants; spread of pest plants and animals; changes to water flow and quality; toxic effects of salinity, pesticides and pollutants; disruption to ecosystem functions; changed fire regimes; and climate change.

To improve on-site biodiversity it is recommended that through design, the use of water, land, non-recycled materials, toxic chemicals and energy are reduced. Also recommended are the use of land already cleared or degraded and the identification of flora and fauna.

Environment Design Guide (Building Design Professions, Australia)

BDP *Environment Design Guide* Note GEN 3 (Lamb, 2001) highlights the importance of retaining native habitat and recommends that this must be the highest priority for design professionals and therefore indigenous species should be used in landscaping.

In relation to natural and urban environments, Lamb sets out a six level hierarchy of ecosystems ranging from the mature natural ecosystems of forests (A) to zero culture artificial ecosystems of urban centres (F).

From A to F there is decreasing biodiversity and degree of natural control of processes and increasing demand for energy and maintenance and fragility. Lamb recommends that through design, urban centres (often F in the hierarchy) could be improved to D, for example.

BDP *Environment Design Guide* Note DES 45 addresses Biodiversity in Landscape. Chenoweth (2002) sets out three design principles: cause no loss of biodiversity, maintain existing biodiversity and enhance biodiversity. For principle one, strategies include knowing the existing biodiversity, responding to site variations

and minimising the net removal of existing habitat from the site and connecting everything to something else. Measures for principle two include knowing the local, district and regional context and maintaining biodiversity on adjacent land and water. In relation to the third principle, measures suggested include the provision of structural diversity (multiple layers) and species diversity, the encouragement of rare and threatened species, the provision of food, water and other resources and habitat niches and the restoration of degraded areas.

4.0 CONCLUSION

Biodiversity conservation is an issue of considerable importance to Australia, and indeed the planet as a whole. Making and operating human settlements has a large impact on biodiversity as a result, for example, of changes in land-use, land clearing, the use of chemicals, the spread of invasive and introduced species, and more generally, as a consequence of pollution and climate change. While building design can minimise biodiversity impacts off-site, buildings are never positive forces for biodiversity – the best that can be achieved is a minimisation of biodiversity reduction. However, as part of the development, areas around the footprint of the building can act to enhance the biodiversity of the site.

Much of the work on biodiversity indicators and measurement has been at the regional level making site-specific measurement and rating problematic. Nevertheless, design and building operation environmental rating systems have been developed for buildings together with advice to designers in guides such as the *BDP Environment Design Guide*. Their methods may vary in detail but they are in broad agreement about key issues. Any system of biodiversity measurement or prediction must take into account the role played by each site in regional and local biodiversity. Land use changes resulting in reduced biodiversity (from land clearing or conversion of forested area to housing, for example) are regarded as retrograde steps. The type of flora introduced onto a site is important, even if it results in increased biodiversity relative to the predevelopment condition, and indigenous species should be used in preference to introduced species – including the use of non-indigenous Australian plants that may become weeds when located inappropriately. Endangered communities should be protected from inappropriate development and landscapes should be managed and maintained with a minimum use of chemicals and water. At a more general level, buildings and urban agglomerations should reduce their climate changing activities since this influences biodiversity regionally, if not globally. With this in mind, Australian developed systems such as Green Star are worthwhile exemplars though without doubt over time this and other systems will develop in sophistication as our understanding of biodiversity measurement and prediction improves.

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