BIODIVERSITY AND THE BUILT ENVIRONMENT

Guy Barnett
CSIRO Sustainable Ecosystems, Canberra

This note, GEN 3, was originally published in 1995 and authored by Richard Lamb. The note was reviewed in August 2001 and the original paper needed revision and updating. Guy Barnett has re-written the note and updated the information.

SUMMARY OF

ACTIONS TOWARDS SUSTAINABLE OUTCOMES

Environmental Issues/Principal Impacts

- The term 'biodiversity' was popularised in the early 1990's, as a shortening of 'biological diversity'.
- There are three levels of biodiversity – genetic diversity, species diversity and ecosystem diversity.
- Australia has one of the highest levels of biodiversity, much of which is found nowhere else in the world.
- Loss of biodiversity is often related to the implementation of development projects and changes in land use.
- Biodiversity conservation is a key requirement for achieving ecologically sustainable development (ESD).
- There are three key reasons to conserve biodiversity – ecosystem services, biological resources and social benefits.
- Design professionals shape our built environment and are thus pivotal to the success of biodiversity strategies.

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:

- Know your biodiversity – It is impossible to conserve or manage biodiversity if you are unaware of the biodiversity that exists in an area and how that biodiversity relates to the regional context.
- Don't choose to lose biodiversity – Design professionals should make every possible effort to retain existing native vegetation, rather than choosing restoration as an acceptable substitute.
- Design for biodiversity – Reduce the:
  - building footprint
  - overshadowing
  - creation of wind tunnels
  - obstructions to wildlife movements and ecological processes
  - area of impervious surface; and
  - areas of low diversity (e.g. lawn).
- Adopt a life cycle approach – It is important to design and construct energy efficient buildings and urban infrastructure that minimise embodied energy and ongoing operating energy.
- Manage the construction process – Vegetation clearance, grading and excavation should be limited. Pollution, contamination and indiscriminate damage must be avoided. Materials must derive from a sustainable source.
- Design native landscape schemes – Plant species should be indigenous and sourced from a reputable nursery. Potential pest species should not be used. Buffers around remnants should be used to mitigate edge effects.
- Reduce pests, weeds and disease – Minimise site disturbance and the opportunity for pests, weeds and disease to establish. Manage wildlife to enhance regional biodiversity values. Avoid potential human-wildlife conflicts.
- Minimise maintenance and encourage urban renewal – Assess maintenance issues and product life cycles during the design phase. Use urban renewal to re-establish biodiversity and important ecosystem services.
- Promote adaptive management – Design professionals and their clients should, within reason, be prepared to 'experiment' using monitoring approaches to provide feedback that will continually inform the design process.

Cutting EDGe Strategies

- ESD and the 'Precautionary Principle' must be fundamental considerations of development projects.
- Apply ecological thinking and biodiversity considerations throughout all phases of urban development.

Synergies and References

- *BDP Environment Design Guide:* GEN 11, GEN 17, GEN 28, GEN 39, DES 5, DES 18, PRO 1, PRO 15.
- Beattie, AJ (ed) (1995) *Biodiversity, Australia's Living Wealth*, Reed, Sydney.

BIODIVERSITY AND THE BUILT ENVIRONMENT

Guy Barnett
CSIRO Sustainable Ecosystems, Canberra

This note, GEN 3, was originally published in 1995 and authored by Richard Lamb. The note was reviewed in August 2001 and the original paper needed revision and updating. Guy Barnett has re-written the note and updated the information.

'Biodiversity' is a shortening of the term 'biological diversity'. There are three main types of biodiversity – genetic diversity, species diversity and ecosystem diversity. Biodiversity includes all the different species and the individual plants, animals and microorganisms in a region, the functions and processes they perform, and the communities that they make up. The conservation of biodiversity is of critical importance to the notion of ecologically sustainable development (ESD). Design professionals must ensure that their actions do not result in a decrease in biodiversity and that they take all possible opportunities to restore and increase biodiversity.

Key words
biodiversity; ecologically sustainable development; design; planning; construction; maintenance; renewal

1.0 INTRODUCTION

Interest in biodiversity and the built environment has traditionally focused on the identification and measurement of impact. More recently, this focus has shifted towards the application of ecosystem concepts and principles to urban areas in recognition of the many biodiversity and ancillary benefits that can be gained from such approaches. For instance, Savard et al (2000) report that enhancing biodiversity in the built environment, if well done, can have a major positive influence on the quality of human life and, through greater education and awareness among urban populations, indirectly facilitate the conservation of biodiversity in those areas that are more natural.

Yencken and Wilkinson (2000) report that more than 50% of the threatened or rare plants, mammals, birds, reptiles and freshwater fish in Australia, have habitats in and around our major cities and population growth areas. In other words, the places that humans choose to settle are often also attractive for many native species.

Vegetation clearance is the single greatest threat to biodiversity. Other more insidious impacts on biodiversity are the indirect influences – the ecological footprint of human needs and desires for food, water, housing, energy, transportation, recreation, consumer goods, professional services and many other aspects of modern living, which impact upon other people's landscapes and ecosystems.

Each design choice has environmental impacts and many have the possibility of impacting on biodiversity. Each design problem therefore also creates opportunities to maintain and enhance biodiversity. The main purpose of this paper is to provide an overview of the biodiversity concept, to highlight the benefits that we derive from it, and to outline various strategies that design professionals can use to conserve, manage and enhance biodiversity, throughout all phases of the urban development process.

2.0 THE CONCEPT OF BIODIVERSITY

When people think of biodiversity they often think of the remote natural areas of regional Australia – icons such as the Daintree and Kakadu, for example. While it is true that these areas host a significant wealth of biodiversity, there is far less recognition of the considerable biodiversity that can be found in urban and peri-urban Australia. For instance, Andrew Beattie, a researcher at Macquarie University, counted at least 4,620 different species living in just one suburban backyard – almost certainly, there were many thousands more that he missed.

2.1 What is biodiversity?

The term 'biodiversity' was popularised in the early 1990's by ecologist EO Wilson. Since then numerous definitions have been proposed. The most accepted within Australia is that used in the 1996 *Australia, State of the Environment* report:

> *"The variety of all life forms – the different plants, animals and microorganisms, the genes they contain and the ecosystems of which they form a part".*

The broad nature of this and other definitions of biodiversity have led to considerable debate. This is because the term has essentially become a synonym of 'all life' and is thereby extremely difficult to apply as a practical measure (Doherty et al 2000). Most people have a simpler understanding of what biodiversity means – either species diversity, or just the conservation of rare and endangered species (James and Saunders 2001).

2.2 Units of measurement

It is widely recognised that there are three levels of biodiversity – ecosystem diversity, species diversity and genetic diversity – thereby forming the key units of biodiversity measurement (Beattie 1995). However, due to the complexity associated with assessing multiple levels of biodiversity, natural resource managers tend to

evaluate only one or two of these levels. The majority of studies focus on species diversity as the preferred unit of biodiversity assessment and management, largely because of the ease with which different species can be recognised, but also due to the roles in ecosystem functioning that many species are now known to play (Doherty et al 2000). Conserving species across their range is also likely to contribute to conserving genetic diversity within these species.

Ecosystem diversity is considered by many as too difficult to operationalise as a unit of measurement because of problems with 'on-ground' delineation of ecosystem boundaries (Austin and Cunningham 1981). Genetic diversity, while being fundamentally important as the basic unit of biodiversity, is considered too difficult and costly to evaluate.

2.3 Ecological uncertainty

Design professionals must recognise that ecology is a relatively young scientific discipline. Recognising the often overwhelming complexity of natural systems, it is therefore not surprising that there are considerable gaps in our understanding of the levels of resilience in ecosystems and other aspects of biodiversity. As such, we don't know how much and what kind of external changes an ecosystem can tolerate before it is significantly degraded ecologically. For instance, there is current academic debate about the degree of redundancy that may occur in ecosystems – if we lose a species from a functional group (species with related functions) will other species within that functional group replace it in the ecosystem? So far, empirical evidence to support such conjecture is scarce and experiments designed to test the idea have not been rigorous (Doherty et al 2000).

This is an important practical issue for design professionals. For instance, in the case of landscape design, there is too often the tendency to substitute an existing, often native, vegetation cover with another, often exotic, vegetation treatment. It is not always clear how this new vegetation will respond and what risks it might pose, for example, the potential for weediness and invasion of urban bushland.

To deal with this ecological uncertainty, design professionals should apply the precautionary principle, which has appeared in a number of broad policy statements, in particular, the National Strategy for Ecologically Sustainable Development and the National Strategy for the Conservation of Australia's Biological Diversity. It also appears in the Intergovernmental Agreement on the Environment (IGAE) (para 3.5.1):

> *"If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation."*

3.0 THE BENEFITS WE DERIVE FROM BIODIVERSITY

The importance that people place on the conservation and management of biodiversity will vary depending on their individual values and beliefs. However, from a purely anthropocentric perspective, there are three main reasons to both conserve and manage biodiversity – provision of ecosystems services, the supply of biological resources, and the social benefits that can be derived.

3.1 Ecosystem services

The concept of ecosystem services is discussed in GEN 39 but, in simple terms, it can be thought of as all the benefits that humans derive from the natural environment – water purification, atmospheric cleansing, control of pests, flood mitigation, shade and shelter, cycling of nutrients, and the like. Biodiversity is integral to the delivery of these services, a fact that often goes unrecognised by human beings, particularly those in modern urban lifestyles.

Ironically, the importance of biodiversity in supplying these ecosystem services is often only revealed through the disturbance of ecosystems. Deforestation, the loss of the ozone layer, and the salinisation of land, are but a few examples of the problems that derive from the impairment of ecosystem services and loss of biodiversity.

Design professionals could significantly improve Australia's urban environmental performance, by adopting planning and design approaches (see GEN 39) that focus on the many benefits of ecosystem services, such as clean air and safe water, adequate food, tolerable temperature, stable climate and protection from solar ultraviolet radiation.

3.2 Biological resources

The supply of a diversity of genetic resources is perhaps one of the most important roles of biodiversity.

Industries such as agriculture, medicine and gene technology derive considerable benefit from genetic material obtained from plants, animals or microorganisms. According to Myers (1997), one in four western medicines and pharmaceuticals owe their origins to biodiversity. The more notable examples include antibiotics, analgesics, diuretics and tranquillisers.

The value of the genetic resource that biodiversity provides is virtually infinite. For this reason, it is critical that design professionals ensure that options for the future are not compromised through inadvertent loss of biodiversity. This is because useful genes can be found in any type of environment, including urban.

3.3 Social benefits

The key social benefits of biodiversity include scientific, recreational, aesthetic and other intrinsic cultural values.

One of the key impediments to the conservation and management of biodiversity is our lack of understanding. Saunders et al (1996) suggest that over one million species (including microorganisms) are thought to live in Australia, but only 15% have been formally described. Thus there is still much to learn about biodiversity.

Australia's biodiversity is highly valued for nature based recreation purposes – bushwalking, camping, bird watching, photography and so on. This is in part due to the aesthetic appeal of Australia's unique landscapes and the flora and fauna they comprise. Several studies show that beautiful scenery and wildlife are a key attraction for both domestic and international tourists.

The conservation of biodiversity is critical for maintaining the culture of Aboriginal and Torres Strait Islander peoples. It is also important for the cultural identity of many other Australians who value the 'bush'.

4.0 BIODIVERSITY STRATEGIES FOR THE BUILT ENVIRONMENT

As discussed earlier, the concept of biodiversity is expressed at a range of different scales – from the genes within biological cells to broad ecosystem types such as forests and lakes. For this reason, it is important that we apply a mutli-scale approach to the development of strategies for conserving, managing and enhancing biodiversity in the built environment. In other words, there is no single best scale that is adequate for addressing biodiversity issues in a comprehensive manner – local actions (e.g. lot scale) are equally as important as regional actions (e.g. city scale).

Building design professionals also operate at a variety of different scales. For instance, urban planners, landscape architects and city engineers tend to focus on the design of cities and precincts, and their associated infrastructure and development requirements, rather than the finer scale design of individual buildings, which is the responsibility of architects and engineers. However, as noted in DES 18, environmentally sensitive design, regardless of the scale at which it is developed and applied, cannot deliver ecological sustainability on its own. Management of the building and landscape construction process is vital, as is the ongoing management and renewal of the built environment.

To be effective, strategies and actions for conserving, managing and enhancing biodiversity must address all phases of urban development – design, planning, construction, maintenance and renewal. The result of these strategies will be a shift from the notion of a stable 'built environment' to one of 'built ecosystems', which are alive and adaptive.

4.1 Urban design and planning approaches

Urban design and planning, particularly at the regional scale, can make a significant contribution to biodiversity. This is because many of the major threats to Australia's biodiversity are related to the impacts of land use, development and management. In the context of the built environment, the most dominant threats are:

- construction works
- erosion and sedimentation
- clearance of native vegetation
- pollution and land contamination
- waste disposal and rubbish dumping
- weeds, feral animals, domestic pets.

Many of these threats require local action (Fallding et al 2001), but it is critical that these actions are implemented in a strategic and coordinated fashion. This is where design professionals must ensure that urban design and planning activities are integrated with regional biodiversity management policies and programs. The development of these regional biodiversity strategies has been the traditional responsibility of natural resource management agencies in each State, such as the NSW National Parks and Wildlife Service in New South Wales, for example. However, with an ever-increasing focus on Ecologically Sustainable Development (ESD) at the local government level, particularly through global initiatives such as Local Agenda 21, more and more responsibility for biodiversity is being shared with design professionals, in particular urban planners and landscape architects. This cooperation will allow traditional natural resource management agencies to more effectively influence the way development occurs, and generate opportunities where local actions can contribute to larger collective goals, such as the creation of a biological corridor to facilitate regional wildlife movements.

Specific actions that design professionals should consider during the urban design and planning phase include the following.

Know your biodiversity

It is impossible to conserve or manage biodiversity if we are unaware of the biodiversity that exists in an area and how that biodiversity relates to the regional context. Education and training of the importance of biodiversity must be paramount. At the site level, there is a significant role for design professionals in ensuring that an adequate assessment of the significance or value of biodiversity on a particular area or site has been undertaken prior to commencing development. This assessment would usually involve an inventory of plant communities and species, as well as all major fauna groups, such as birds, mammals, amphibians, reptiles, fish and invertebrates. Ecological consultants should be used to undertake much of this activity, but design professionals should also endeavour to acquire skills in ecological planning and site evaluation.

Understand the impact of urbanisation

Many people would consider the impact of urbanisation on biodiversity to be insignificant, when compared with the more expansive land uses such as agriculture and pastoralism. This would be true when considering the area of land affected by each of these land uses, but the key difference is the intensity of the land disturbance. Urban development generally results in a very rapid and devastating impact on biodiversity through the removal of native vegetation, alteration of soil profiles, topography and hydrological regimes.

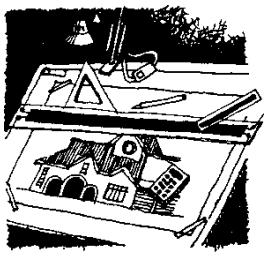
Influence your local government

Local government has a very significant role to play in the conservation of biodiversity, because it is this level of government that dictates where and how development will occur (Fallding et al 2001). Many urban planners, city engineers and landscape architects, are employed by local government and thus have a significant opportunity to influence the conservation, management and enhancement of biodiversity through land use policies, statutory controls, and decision on matters such as urban density (GEN 17). Those who have this opportunity should ensure they have a solid understanding of the biodiversity values in their region and make certain that planning and development controls reflect regional biodiversity values and priorities.

Don't choose to lose biodiversity

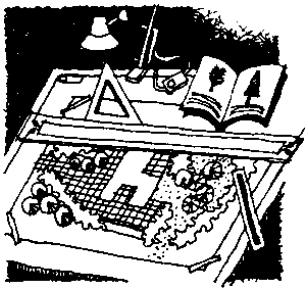
Land clearance is the most serious threat to biodiversity. Once land has been cleared it is almost impossible to restore pre-disturbance levels of biodiversity. As such, it is critical that decision-making processes are not based on the ill-founded philosophy of 'no net loss'. Instead, design professionals should make every possible effort to retain existing native vegetation, rather than choosing restoration as an acceptable substitute. There are few, if any, examples of restoration attempts that have successfully restored the full suite of pre-existing biodiversity values.

Designing buildings for biodiversity



Reduce the building footprint to avoid excessive site coverage and to maximise the opportunity for wildlife movements. Integrating the indoor-outdoor space can be a good way of doing this (reduces internal circulation space and increases external circulation space). Going upwards can also be another good way of reducing the building footprint, but design professionals must then consider the impacts of overshadowing. When orienting and designing the building, care should be taken to ensure that external areas receive adequate sun and not just the building. Design to avoid excessive wind speeds and turbulence in natural areas. Position glass so as to avoid the migration routes and flight paths of birds, which could be evaluated as part of the site appraisal process. Other potential obstructions to the natural movement of animals and plants should also be averted during the design process. Ecological processes, such as infiltration, can be encouraged by reducing hard (impervious) surfaces to a practical minimum. Instead, porous surface materials should be used wherever possible, and rainwater retained on-site to re-create habitats.

Designing landscapes for biodiversity

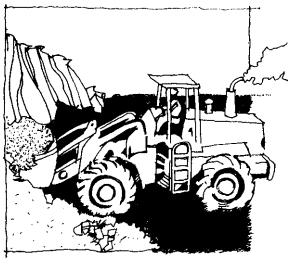


Landscape architects should use soft materials and design for habitat, rather than the tendency for hard formal schemes. Excessive lawn and paving should be avoided, as should the tendency for monocultures. A fundamental design principle should be to increase diversity. This not only refers to the adoption of schemes with higher species diversity, but also structural diversity in terms of the range of plant forms, and ecosystem diversity in terms of creating terrestrial and aquatic systems with habitat value. Linkages between these various habitats should be maximised. Where possible, textured and natural materials should be used in landscape designs to provide habitat for insects and food for birds and lizards. However, care must be taken to ensure that these materials have come from a sustainable source – for example, the harvesting of bush rock can have a significant impact on existing biodiversity.

4.2 Building and landscape construction approaches

Much of the focus on ESD in the built environment has been on design. Unfortunately, as noted in DES 18, there has typically been a lack of follow-through of these principles into the building and landscape construction phase. Existing native vegetation and other aspects of biodiversity are often damaged, impaired or destroyed during the construction process. The solution to this problem appears to lie in better training and education of construction workers, machinery operators, and site managers about the importance of on-site biodiversity and to highlight the various actions that they can use to minimise their impact. Some of these actions follow.

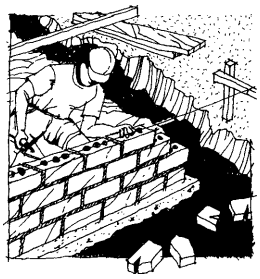
Managing site works



Development sites are often totally cleared of existing vegetation to remove obstacles to surveying and the general construction process. Vegetation clearance is the biggest threat to biodiversity. Design professionals

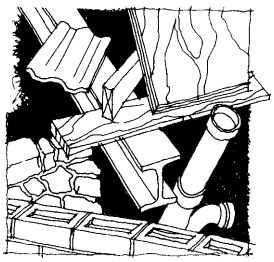
should ensure that clearing is restricted to those areas where there is no viable alternative. Uncleared areas of native vegetation should be seen as a resource and protected at all costs. Grading and excavation should be limited, and only undertaken if there are no feasible design solutions to overcome site constraints, such as slope. Impervious surfaces, such as roads and paving, should be kept to a minimum with drainage systems designed to retain rainfall as water for use on site, which will also help to prevent soil erosion and siltation of waterways.

Managing the building process



A focus on minimising waste, pollution and contamination during the building process should be paramount. Waste management activities should be restricted to specific locations. Concrete mixing and washing sites should be confined to minimise pollution (e.g. lime, cement) and the area affected should be appropriately rehabilitated once construction is completed. This similarly applies to other pollutants and potential contaminants that may be brought on site – paint, chemicals, etc. Soil compaction should be minimised by reducing vehicular and other heavy traffic. For this reason, site workers should be required to park off site. Other indiscriminate damage should be carefully monitored and those areas that are particularly sensitive fenced as off limit areas.

Selecting appropriate building materials



Design professionals should not source their building materials from industries that reduce biodiversity or source raw materials from locations where biodiversity is threatened. Likewise, it is also important that materials with toxic outputs or leachate are not used when there are other non-polluting choices available on the market. For those materials that are space-intensive, prefabrication off site should be considered to minimise disturbance on site. New approaches for design professionals to incorporate eco-effectiveness and ecological design into the built environment can be found at http://www.mbdc.com.

Adopt a life cycle approach

It is important to design and construct energy efficient buildings and infrastructure that minimise embodied energy and ongoing operating energy by adopting a life cycle approach. This could include the use of re-used or reprocessed materials where feasible. However, it needs to be remembered that while life cycle analysis of building materials and products would be ideal, most builders and developers will remain focussed on the up front capital cost. For this reason, design professionals have a very important role during concept design to demonstrate that a life cycle viewpoint does not necessarily involve a detailed study, as rules of thumb and a comparison with existing case studies can be a sufficient alternative.

Undertaking rehabilitation

Existing remnants can be best conserved through the planting of buffer strips to mitigate edge effects. Landscape spatial structure, corridor dimensions, habitat suitability, and the population dynamics of the species, largely determine the effectiveness of wildlife corridors in either conserving or enhancing animal diversity. It is probable that wide-ranging habitat generalists, particularly certain species of bird, will be advantaged by the construction of new habitat. However, more habitat specialised fauna, including mammals and reptiles are likely to be faced with a hazardous journey to reach new and isolated urban wildlife habitat.

Selecting plants

It is important not to use rare and threatened species in landscaping, unless they have been acquired from a sustainable source, such as nurseries. In fact, no plant species should be obtained directly from the wild, as this can deplete local biodiversity. Plant species should be selected on the basis of the habitat value they provide for indigenous wildlife. However, care needs to be taken to ensure that the species being considered are not potential pests – some non-indigenous native species contribute to genetic pollution of surrounding areas by pollen.

4.3 Urban management and renewal approaches

As with construction, the management and maintenance of buildings and urban areas is another neglected aspect of ESD that can have a significant influence on biodiversity. It is important that design professionals view the built environment as a system, and consider the entire life cycle of buildings, infrastructure, and landscapes. This means greater focus on the operation phase of all aspects of the built environment. Where performance is deemed unsatisfactory, urban renewal activities should be actively pursued to improve the built environment and its amenity by providing people with a more ecologically sustainable lifestyle (GEN 11). Actions that should be considered during this urban management and renewal phase include the following.

Building and landscape maintenance

The cost of maintaining buildings and landscapes can be drastically reduced through the appropriate consideration of post-construction management issues at the design phase. For instance, in the case of the building, it is important to choose low embodied energy materials. However, these materials must also be considered in terms of the maintenance required during the products' life cycle (cradle-to-grave approach) and the environmental impacts of these materials during the life cycle (e.g. off-gassing, dust formation). Each of these maintenance issues has implications for biodiversity. Opportunities for recycling building and landscape materials (cradle-to-cradle approaches) also need consideration. With regard to landscapes, design professionals should strive for low maintenance designs (e.g. minimal mowing, reduced need for herbicide, pesticides and fertiliser). Where landscape maintenance is required, natural products should be used wherever possible – for example, composting of organic materials can avoid the need to bring fertilisers in from off site.

Managing pests, weeds and disease

Design professionals should be aware that the fragmentation caused by linear features such as the construction of roads and utility corridors, is often the first significant disturbance in generally undisturbed habitats, and provides an opportunity for pests, weeds and disease to infiltrate these areas and become established. Wildlife management should focus on managing feral cats and house cats with a behaviour problem rather than blanket restrictions on all cats. Similarly, active fox control through baiting and/or fencing wildlife feeding, nesting or breeding areas would also enhance biodiversity. Design professionals must be careful that by designing and managing for biodiversity they don't inadvertently create human-wildlife conflicts. Natural and constructed wetland habitats within mosquito flight range of residential areas pose a serious pest and disease threat for nearby human communities. However, this threat can be greatly reduced if constructed wetland habitats are designed to minimise mosquito breeding and if appropriate management techniques are used (Russell and Kuginis 1998).

Managing biodiversity with fire

Care must be taken when using flame or fuel in close proximity to areas of native bush or grassland (DES 18). Frequent burning, or conversely, the total exclusion of fire can lead to reductions in biodiversity. Advice from local fire authorities and natural resource management agencies should be sought before using fire to manage biodiversity, as it is important to understand the fire history of the region, the likely impact on local fauna, and the most appropriate fire intensity for the location. Where appropriate permission from authorities has been obtained, it may be possible to substitute hand removal of fuel loads with infrequent fires. However, there is still much to learn about the role of fire in biodiversity conservation and management, therefore such activities should be regarded as 'management experiments' with appropriate monitoring to inform future management action.

Biodiversity and urban renewal

The commonwealth government has a range of initiatives, such as the Natural Heritage Trust, for supporting rehabilitation and 'greening' activities in the built environment. There is considerable opportunity for design professionals to provide strategic direction, particularly at the regional scale, about how best these 'on-ground' community-based activities can contribute to regional biodiversity values. Design professionals should encourage urban renewal activities, especially when there is an opportunity to replace built infrastructure, with an equivalent 'ecosystem service'. For example, the replacement of conventional storm water infrastructure with grassed swale and drain landform designs, temporary detention ponds, and constructed wetlands (DES 39).

Adaptive management

An adaptive management approach is particularly useful where there is significant uncertainty about the best choice of management action, because it allows decisions to be made where delays would be inappropriate. However, because these decisions are often made in the absence of full knowledge, strong reliance should be placed on carefully designed monitoring programs to generate reliable feedback that can be used to inform and/or adjust future management. As such, adaptive management can be seen as a learning cycle that will provide better understanding of how to conserve, manage and enhance biodiversity in the built environment. It is also an important component of the precautionary principle approach and provides a mechanism for ensuring there is continual improvement in the design process.

5.0 DISCUSSION AND IMPLICATIONS

Much of the information that design professionals require for developing strategies to conserve, manage and enhance biodiversity in the built environment is already available in one form or another. In fact, many design professionals are already accessing and applying this information. The major problem, however, is that this knowledge and understanding about biodiversity is often not applied during subsequent phases of the urban development process – construction, maintenance, and renewal.

Regardless of the effort that is invested into the development of environmentally responsive designs, unless there is a commitment during the construction process to strategies for conserving, managing and

enhancing biodiversity, inadvertent loss of existing on site biodiversity values will continue to plague the building and construction industry.

Developers, local government and design professionals all have a clear responsibility to provide leadership in the identification and application of strategies for reducing the biodiversity impact of urban development (DES 18). Better training and education about biodiversity is obviously one aspect of the building and construction industry which must be improved, yet this activity alone is unlikely to result in significant change unless it is matched by a combination of personal commitment, appropriate government controls, and attractive incentive schemes for rewarding environmentally responsive behaviour. Unfortunately, few in the industry currently seem to recognise that doing good for the environment can also be good for business (GEN 39) and few obvious leaders have emerged.

As public demand for a more liveable and sustainable urban future increases, design professionals must take extra care that the building and construction industry is not tarnished by the apparent discontinuity between the design and construction phases of urban development in terms of their respective approaches to the principles of ESD. For instance, with regard to the town centre of Gungahlin in the ACT, some consider that what the developers are actually putting on the ground is a long way behind the visionary rhetoric of its planners (Collins 1993). Thus it is essential that design professionals set achievable goals and ensure appropriate management and supervision during the on-ground implementation of strategies. Once construction is completed, adequate information must be passed on to building residents and landscape managers to ensure that the operation and maintenance of the end-product is in accordance with the intentions of its environmentally responsive design.

In relation to biodiversity, it is acknowledged that the term itself often causes confusion so it is important that any goals or strategies developed specify the group of organisms as well as the scale of action (Savard et al 2000). In other words, statements like 'our goal is to increase urban biodiversity' are not workable. Instead, statements such as 'our goal is to increase plant diversity in urban parks' are much better.

6.0 CONCLUSIONS

Design professionals influence the built environment at the level of buildings, streets and landscape. This multi-scale focus is commensurate with the type of approach that is required to adequately address biodiversity issues. Each design choice has environmental impacts and many have the possibility of impacting on biodiversity. Actions that increase or sustain biodiversity should be chosen over those that reduce it. There are many opportunities for design professionals to contribute to the conservation and enhancement of biodiversity throughout the entire life cycle of the building and urban development process.

REFERENCES

Austin MP and Cunningham RB, 1981, *Observational analysis of environmental gradients*, proceeding of the Ecological Society of Australia 11: 109-19.

Beattie, AJ, ed, 1995, *Biodiversity, Australia's Living Wealth,* Reed, Sydney.

Collins, T, 1993, *Living for the City – Urban Australia: Crisis or Challenge,* ABC Books, Sydney.

Doherty, MD, Kearns AJ, Barnett G, Sarre A, Hochuli DF, Gibb H, and Dickman CR, 2000, *The Interaction Between Habitat Conditions, Ecosystem Processes and Biodiversity – A Review.* Australia: State of the Environment Second Technical Paper Series (Biodiversity), Environment Australia, Canberra.

Fallding, M, Kelly, AHH, Bateson, P and Donovan, I, 2001, *Biodiversity Planning Guide for NSW Local Government – Edition 1*, NSW National Parks and Wildlife Service, Hurstville.

James, CD and Saunders, DA, 2001, *A Framework for Terrestrial Biodiversity Targets in the Murray-Darling Basin*. CSIRO Sustainable Ecosystems and Murray-Darling Basin Commission, Canberra, 104 pp.

Myers, N, 1997, 'Biodiversity's Genetic Library', in *Nature's Services – Societal Dependence on Natural Ecosystems*, ed, Daily, GE, Island Press, Washington.

Russell, R and Kuginis, LS, 1998, 'Mosquito Risk Assessment and Management', in *The Constructed Wetlands Manual – Volume 1, eds,* Rachael Young, Greg White, Malcolm Brown, John Burton, Brendan Atkins, and Danielle Duyckers, Department of Land and Water Conservation New South Wales, Parramatta.

Saunders, D, Beattie, A, Eliott, S, Fox, M, Hill, B, Pressey, B, Veal, D, Venning, J, Maliel, M and Zammit, C, 1996, 'Biodiversity', In: *Australia: State of the Environment 1996*, Department of the Environment, Canberra.

Savard, JL, Clergeau, P and Mennechez, G, 2000. 'Biodiversity concepts and urban ecosystems'. *Landscape and Urban Planning*, vol 48, pp 131-142.

Yencken, D, and Wilkinson, D, 2000, *Resetting the compass: Australia's journey towards sustainability*, CSIRO Publishing, Collingwood.

FURTHER READING

Hitchmough, JD, 1994, *Urban Landscape Management*, Inkata Press, Sydney.

Lyle, JT, 1999, *Design for human ecosystems*, Island Press, Washington.

Peck, S, 1998, *Planning for Biodiversity: Issues and Examples*, Island Press, Washington.

Wilson, A, Uncapher, JL, McManigal, L, Lovins, LH, Cureton, M, and Browning, WD, 1998, *Green Development: Integrating Ecology and Real Estate*. John Wiley & Sons, Inc, Toronto.

Your Home – Design Guide available on the Internet (http://www.greenhouse.gov.au/).

BIOGRAPHY

Guy Barnett is a Landscape Ecologist at CSIRO Sustainable Ecosystems in Canberra. His current research interests are the study of urban areas as ecosystems and the way in which ecological knowledge can be integrated with urban design and planning techniques to foster regional sustainability.

ACKNOWLEDGMENTS

I would like to thank the author of the original note, Dr Richard Lamb, for his permission and assistance in producing this updated version of GEN 3. I would also like to thank Natasha Palich for her help and constructive comments.