

II

RESEARCH ARTICLES

APPLYING ECOLOGICAL LANDSCAPE DESIGN PRINCIPLES TO UNIVERSITY PLANNING

Dr. Wei Deng,¹ Professor Mike Browell,² and Zoe Wareham²

ABSTRACT

This article summarises how ecological design principles have become incorporated into landscape design in Great Britain. A case study of the planning and construction of a new University Campus at Riccarton, a country estate on the outskirts of Edinburgh is used to show ecological landscape design in practice since 1968.

KEY WORDS

ecological landscape design; ecological process; campus planning

1. THE HISTORY, PRINCIPLES, AND PRACTICES OF ECOLOGICAL LANDSCAPE DESIGN IN THE UK

1.1 Pre 1960

Great Britain landscape has been influenced by a host of cultures: Roman town planning and road networks, Norman defences; from monasteries and Royal hunting forests, to gardens which could accommodate the neo-classicism brought back from ‘The European Grand Tour’ and the strange and wonderful plants returned by planting and hunting trips to the New World and Far East. Capability Brown’s ‘English Landscape’ was just one more phase or influence, albeit one of the most recent, and one whose planting has matured in the last 100 years. Despite its apparent harmony with the surrounding pastoral landscape, the ‘English landscape’ was no more led by ecological principles than the building of Hadrian’s Wall or Stonehenge. As previous landscape fashions, it was a showcase of power of man over the landscape.

Until mid 20th century, landscape development was driven by the growing needs of the population, industry, or status needs of the wealthy landowners wanting to display their own prestige by keeping up with the latest landscape fashions. During Capability Brown’s time and the Industrial Revolution (mid 18th–19th century) there was no planning legislation and certainly no formal consideration of ecol-

ogy. However, in practice, those who could afford the large-scale earthworks associated with the ‘English landscape’ lakes and vistas through woodlands on their country estates were reacting to the ecological pressures we recognise today. As the Industrial Revolution gathered speed, those who could, lived away from the pollution of the increasingly industrialised cities. The polluted rivers, sooty air, and generally overcrowded conditions were not only aesthetically unpleasant and dirty, but also created an extremely unhealthy environment in which to live. These conditions led to the work of early 19th century philanthropists who recognised the need for the working population to have access to green spaces and clean air. Their commissioning of large city parks for this purpose can be seen as the first steps in Ecological Design.

The 20th century World Wars disrupted the status quo of the social class structure in UK, such that health, housing and development control became paramount in the national consciousness. New legislation was introduced to improve the health of the nation, including the creation of the first National Parks. National Parks are regional conservation areas protected by strict development control. These aim to conserve a vernacular way of life and the local countryside: a pollution-free ‘wild country’ and areas of natural beauty available for leisure pursuits by those working in the cities.

¹ Correspondence author. Randall Thorp Landscape Architects, Manchester, UK. weideng.landscape@gmail.com.

² Weddle Landscape Design, Sheffield, UK.

1.2 1960–Present Ecological Design

In 1968 Professor Arnold Weddle was appointed Granada Professor of Landscape Architecture at Sheffield University, the first chair of Landscape Architecture in the country. His task was to set up a new Department of Landscape Architecture, outside of the Department of Architecture. Weddle took Landscape Architecture away from architecture and reconstructed it from a kit of parts, including earth sciences, plant science and ecology. This was a visionary step, and a pure ecologist was appointed to teach landscape architecture. Weddle was Editor of *Techniques of Landscape Architecture*. He asked Dr Oliver Gilbert, as ecologist in his newly established Landscape Architecture Department, to review and add an ecological design thread to this textbook. Within a few years ecological landscape design was recognised as a style, and Weddle's textbook still remains a professional standard text.

In the 1960s, as groups of individuals organised demonstrations to raise awareness of the environmental damage caused by industrial processes, a new style of landscape design looked at the existing or potential Ecology of a site to influence landscape proposals. 'Ecological Design' decreed that planting should be "a functional structural element in the external environment, where possible becoming woodland in the shortest possible time; that landscape users would determine the landscape form, and that amongst other things, the results would be lower maintenance costs, high social benefits and long term ecological stability i.e. a self-sustaining landscape that can offer something for the needs of today's population, whilst not impacting on the future requirements of the environment, or the people." This principle is also used today in relation to sourcing materials and plants.

Since 1990, ecological design principles have been incorporated into the Town and Country Planning Act by requiring development projects of a certain type, scale or location to prepare an Environmental Impact Statement (EIS) to accompany the Planning Application. The EIS should describe the baseline environmental conditions, the development proposals and propose specific measures to ensure that predicted negative impacts of the development on the environment can be mitigated.

2. THEORY AND PROCESS OF ECOLOGICAL LANDSCAPE DESIGN

Some landscape ecologists, such as Arnold Weddle (1968) and Ian McHarg (1971), set up the foundation of the theory of landscape Ecology by their publications and projects. The principles of landscape ecology are clarified as follows:

1. Landscape ecology aims to achieve a balance between natural ecosystems, agricultural bio-ecosystems, rural-techno ecosystems and urban ecosystems.
2. Landscape ecology considers ecosystems as holistic entities where the total ecosystem is greater than the sum of its parts.
3. Ecosystems are made up of elements that interact with each other.
4. Ecosystems work on the principle of self stabilization and self organization.
5. Landscape ecology uses simplified, abstract models to represent complex ecological systems.

Ecological landscape design is based on an integrated understanding of landscape, which encourages a flexible and responsive approach. Ecological landscape design is guided by three fundamental objectives: the maintenance of landscape integrity; promoting landscape sustainability; and reinforcing the natural and cultural spirit of place. The analytic and descriptive nature of landscape ecology, the science, provides for a holistic understanding of existing landscapes, while the intuitive and creative problem-solving capabilities of design prescribe alternative courses for future landscape development.

Ecological Landscape design concepts, including well known 4R principles (Reduce, Reuse, Recycle, Renewable) in ecology, have several special benefits to be used in landscape design (Makhzoumi, 2000). First, unlike the abstract ecosystem concept in ecology, landscape ecology regards the 'landscape' as an integrated system concrete and tangible entity. Second, landscape ecology's holistic view reflects a basic philosophy in which landscape is perceived in its totality and cannot be studied by analysing its components as separate units. Third, landscape ecology's integrative perspective allows it to accommodate not only the bio-ecological sciences, but also to embrace the realm of human-centred fields of sociology, economics and the cultural sciences.

The process of Ecological Landscape Design in the UK includes five stages.

Stage One: Phase 1 Habitat Survey

'Phase 1 Habitat Survey' by Landscape Consultant or Ecologist to NJCC (Joint Nature Conservation Committee) Phase One Habitat Survey Guidelines is a broad brush analysis of the existing landscape in terms of habitat and species diversity, and their comparative ecological value. The Survey will identify habitats which potentially could support seasonal populations of fauna e.g. reptiles, bats or badgers which may qualify for detailed ecological surveys at the appropriate time of year.

Stage Two: Detailed Ecological Surveys

Detailed ecological survey of significant habitats identified in Phase 1 Habitat survey, e.g. natural grassland, wetland, aquatic, woodlands.

Stage Three: Ecological Impact Assessment; Mitigation Measures & Methodology

An Ecological Impact Assessment, often part of a wider 'Environmental Impact Assessment', is a desk-based analysis of the impact of the development proposals against the existing site conditions as identified in the various ecological and habitat surveys.

The Impact Assessment qualifies potential impacts in terms of significance, benefit/detriment, likelihood and permanence, on landscape features categorised by their durability or carrying capacity for disturbance.

By identifying the most significant negative impacts, the Assessment generates suggestions for possible mitigation measures which could be included as part of the development proposals to minimise the potential impacts.

Typical mitigation measures are additional tree planting to create screening and/or woodland habitat; or to actively manage one part of the site for wildlife conservation ensuring that it is protected from development operations.

Stage Four: Landscape Masterplan

All the mitigation measures and methodologies identified by the Impact Assessments are incorporated into the development proposals by a long-term Landscape Masterplan strategy. Each new development project should refer to the strategy.

Stage Five: Long-term Management and Review

Long-term management plan to ensure the healthy establishment of the proposed landscape and the long-term protection of the existing landscape and ecology. Periodic monitoring of landscape and ecology every 10–20 years is an excellent method of checking the effectiveness of current management regimes.

3. CASE STUDY: HERIOT-WATT UNIVERSITY AT RICCARTON

3.1 Weddle Landscape Design leading ecological landscape design

In 1967, Professor Weddle was asked to advise Heriot-Watt University on their selected site for a new university campus, Riccarton, in the Green Belt, west of Edinburgh in Scotland. Weddle took the ecology-led design process pioneered at Skelmersdale New Town to Heriot Watt's Riccarton site. An early photograph shows the design team standing at the heart of the campus studying a layout drawing, in a meadow of tall grass surrounded by mature trees. The grass and mature trees are still present today, carefully protected at the very heart of the fully developed campus.

3.2 Ecological Landscape Design in Heriot Watt University Campus at Riccarton

Moving Heriot-Watt University to Riccarton campus was very much a unique project because the development took place within an existing landscape environment of very high quality, both visually and ecologically. Heriot Watt University was previously located at the heart of Edinburgh. The opportunity to develop a new campus in the Edinburgh Green Belt was a special opportunity and challenge. The basic information is shown in the table 1.

The site selected for Heriot Watt University was a 200 hectare Scottish Estate man-made landscape dating back hundreds of years. The Riccarton Estate is one of many similar Estate Lands that give the West Edinburgh Greenbelt its special interest and ecological diversity. These landscapes surrounding previous grand houses contain significant woodlands, water bodies and meadows. The Riccarton Estate had perimeter shelter belt woodlands over 300 years old, and an ancient formal garden dating

TABLE 1. Riccarton Campus Information

Heriot-Watt University, Riccarton Campus, Edinburgh	
Client:	Heriot-Watt University, Edinburgh
Landscape Architect:	Weddle Landscape Design, Sheffield
Ecologist:	Weddle Landscape Design
Contractor:	University Estate Office Landscape Section
Initial involvement:	1968
Work started on site:	1973
Completion:	Ongoing
Project Value:	£100 million plus over 30 years
	£30 million for hard landscape and over £5 million for soft
Capital Funding Sources:	University Grants Committee and sale of university properties
Revenue Funding Sources:	Annual budgets
Project Aims	
To create a university campus within the grounds of a central Scotland historic estate dating from the 17th Century, retaining woodlands, a loch, gardens and creating a new landscape for 5,000 students. A masterplan has been prepared by the Landscape Architect to increase the campus to 10,000 students.	
Ongoing Management of the Project	
A management plan was drawn up by the Landscape Architects in 1978. This document covers issues of general estate management such as woodland management regimes, playing field and general landscape maintenance. The landscape management plan is implemented by the Heriot-Watt Estate Office with ongoing advice from the Landscape Architect. This is subject to ongoing review through the twice yearly meetings of the Site Conservation Committee.	

back to the 15th century. Several hundred years of landscape development had created a range of habitats for birds and mammals, including deer. Grassland and woodland flora were also highly varied. The area around Riccarton is open arable landscape subject to continued simplification. (Figure 1)

Building a new campus for 5000 students, eventually rising to 10,000, would mean major installation of new infrastructure, roads, drainage and services, and many new buildings. With a new student population poised to arrive on site, habitats and features within the grounds of a historic estate needed to be made robust enough to withstand the inevitable changes. Weddle recognised that development pressure would threaten these habitats, and identified ecological design principles as the means to manage the changes in landscape.

3.2.1. Stage One in Practice: Phase 1 Habitat Survey. In carrying out an appraisal of the Riccarton site, Weddle's professional practice office, to-

gether with Dr Oliver Gilbert, made a baseline survey of the existing vegetation and ecology (similar to the current NJCC Phase One Habitat Survey).

3.2.2. Stage Two in Practice: Detailed Ecological Surveys. Weddle presented his assessment in Site Conservation Report No. 7 in 1969. He then asked his team together with Dr Oliver Gilbert to carry out further Ecological Studies to measure the value of habitats and their tolerance to change. Three priority areas were identified; the Lawn, Woodlands and Loch. The findings were described in Landscape Consultant's Report No. 11 Ecological Studies 1970–1972.

3.2.3. Stage Three in Practice: Ecological Impact Assessment; Mitigation Measures & Methodology. Report No. 11 described the ecological impacts to the Lawn, the Woodlands and the Loch in the preceding 5 years of development in terms outlined in the table 2 on the next page.

FIGURE 1. Riccarton Campus Aerial view (1. The Lawn; 2. Central Woodland; 3. The Loch)

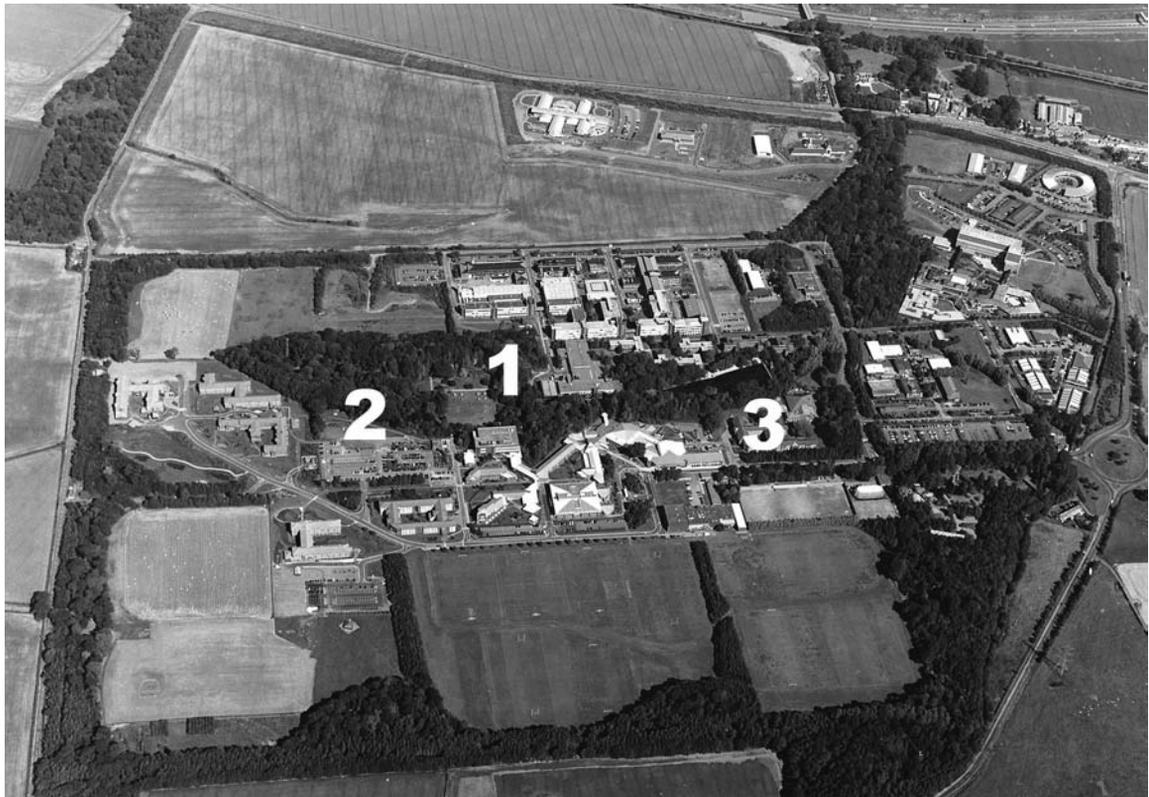


TABLE 2. Ecological Impacts

Categories of Landscape	Carrying Capacity/ Resistance to Disturbance	Example on Heriot-Watt Campus
Existing landscape features: watercourses, woodlands, fully protected from development	Nil	Central Woodland; requires minimal management intervention
Existing landscape features capable of serving development	Moderate	Perimeter Woodlands, Farmland, Garden managed in accordance with normal standards
Landscape features modified to cope with moderate intensity of use	Moderate	Loch and watercourses
Existing landscape features substantially modified to cope with moderate intensity of use	Considerable	Playing fields, courtyards, areas close to buildings
Heavily modified landscape for high intensity use	Considerable	Car park, pedestrian areas.

The report made recommendations for future mitigation and methodology/management measures during and after further development phases as follows:

The Lawn (Figure 2)

The old gardens of Riccarton House are at the heart of Heriot-Watt's campus and have been safeguarded during site development. The Lawn is now used for graduation ceremonies. The gardens date back some 250 years to before 1750. The present Lawn is quite similar to the original except that flower beds surrounded the golden yew domes. In ecological terms the Lawn is remarkable for the diverse number of species present, having developed without organic fertilisers for over 250 years. Weddles gave general advice on management for ecological diversity, balanced with the need for a durable grass sward for occasional heavy use. On the north side of the Library is the Riccarton Sweet Chestnut, which is several centuries old and possibly the oldest tree on the campus. The original tree had collapsed at the centre, leaving a number of survive regenerating root suckers. Whilst well over-mature, Weddles recommended keeping this veteran as a historic and ecological habitat.

Woodlands (Figure 3)

Woodlands around the Lawn were in decline with many over-mature and dangerous trees and a long-established honey infestation. Tolerance to change was seen to be very low. Weddles' advice was to retain significant safe old trees and replant new heritage species in 1970, allowing the woodland to recover over a long period, before opening up new paths in 2005. Within the East Strip and Hermiston Walk are remnants of ancient time avenues. The perimeter woodlands are typical shelterbelts originally beech trees but more recently partially replanted with conifers. Weddles advised that the conifers were to be gradually harvested and the woodlands progressively restocked with native hardwoods including beech, oak, lime and sweet chestnut, with Scot Pine. The Riccarton Estate was previously home to the Gibson-Craig family who had a deep interest in trees and plant collecting. The tree collection on the estate dates back to 1750, and was sub-

FIGURE 2. The Lawn and Central Woodlands.



FIGURE 3. The Central Woodlands.



stantially added to from 1823. The East Avenue was replanted in 1882/83 and the lime trees may have extended out to the west. A Tree Trail has been established allowing visitors access to a number of the most important trees.

Loch (Figure 4)

The man-made lake at the heart of the campus was found to be heavily silted and eutrophic caused by upstream agricultural field run-off rich in fertilisers. To create a suitable for a habitat for wildfowl as a good quality landscape feature in the heart of the campus, Weddles advised de-silting and restocking with fish and aquatic plants.

FIGURE 4. The Loch.



3.2.4. Stage Four in Practice: Landscape Masterplan. The initial Landscape Masterplan appeared as a component of the Development Plan. It established a sustainable land use framework, for a university campus retaining woodlands and farmland, a loch, gardens and by creating a new landscape for 5,000 students. This has undergone several revisions over the years, and has recently been replaced by The University's Masterplan 2010. This shows an environmentally sound strategy to increase the campus to 10,000 students. It is worth noting that the University's latest masterplan is landscape-led, and produced by Weddles.

A) Landscape Masterplan Concept

Weddles original landscape proposals for the Heriot-Watt campus followed the landscape divisions already evident on the Riccarton Estate. The ecologically valuable habitat of the central valley was spanned at a single point with Core facilities in the Hugh Nisbet building connecting academic and residences both north and south. From the beginning the intention has been to create a masterplan which allowed the University to develop in a selective way within the existing heritage landscape.

The overall concept is of a central car-free core with segregation of pedestrian and vehicular service routes. Running through the heart of this core is a zone of conserved landscape which is 'bridged' by footpaths. The experience of passing through this

zone, which includes the loch, historic gardens and central woodlands, is one of the special experiences which visitors to the campus appreciate.

Linking through the campus are desire line footpaths and cycle ways, and for those who wish to explore, a sculpture trail, tree trail and perimeter jogging track. Within the central core area it is possible to move from building to building along internal corridors and bridges, allowing students to stay out of the worst of the winter weather, whilst allowing views out into the landscape. The campus is buffered from surrounding roads by perimeter woodlands totalling 30 hectares. To the south are extensive playing fields, and to the north and east is the Research Park, the first such development in the UK.

B) Landscape Masterplan Implementation

Each development, for example, halls of residence, car parks or new academic buildings, is controlled by a Site Planning constraints diagram which defines the extent and format of the project, and ensures protection of existing landscape by appropriate measures e.g. fencing which is erected before operations commence on site. The University's Landscape Masterplan defines the University development on a grid base, with aligned buildings, generous verges, and car and pedestrian segregation. Therefore the Site Planning Constraints diagram defines the maximum building lines, emergency access, service reserves, and pedestrian links. One of the main constraints has been the desire to minimize the impact of construction works, both on the landscape itself and also on the life of the students.

The Lawn

Some historic parts of the site have been restored. The Central Lawn edges have been redefined and rhododendrons cut back. The Velvet Walk has been restored and land encroaching on the burial ground cleared of self-sown vegetation. There are plans to restore the north wall to the garden and trees have been cleared from the Ice House roof.

Woodlands

The perimeter conifer shelterbelts are now in the process of being re-established as mixed woodland. Under the University's control, the woodland belts

FIGURE 5. Old sycamore by Leonard Horner Hall.



are managed to create a mixed age woodland habitat with an increasing proportion of deciduous trees. Closer to the centre of the campus new plantings of exotic species found in the Central Woodland ensures a continuation of the plant collection started on the Riccarton Estate in the 18th Century. The oldest trees are 250 years (Figure 5), and many are more than 150 years old. Many trees that had been recorded in a special visit of a local Forestry Society in 1884 were removed by gales of 1968 and 1972. In 1969 Heriot-Watt University took over the site and have continued the tradition of tree planting on the campus. The Pinetum was a major casualty of the gales, and this has now been restored by replanting with a wide range of exotic conifers.

Loch and Watercourses

The loch was successfully de-silted and together with the mature trees of the central woodlands proves to be an attractive landscape and wildlife feature at the heart of the campus. (Figure 6)

There are a number of aquatic habitats; some are new created opening up by culverted watercourses. The major constraint has been run-off from surrounding farmland. The landscape design of the West Student Village has allowed development of wild flora meadows with ponds to take surface water from surrounding buildings.

Many of the culverted water courses have been opened up, returning aquatic ecology to their stream beds. From the outset, some buildings and

car parks drained roof and surface water directly to the watercourses and holding ponds. It is also used to maintain levels in the loch. More recently, car park drainage runs to infiltration trenches and soak ways to recharge the ground water and introduce a more sustainable indirect route for drainage as recommended by Scottish Environmental Protection Agency (SEPA) as Sustainable Urban Drainage Systems (SUDS). (Figure 7)

Research Park

The Research Park has gradually developed, taking land as required in phases. In the Research park north west fields a central stream corridor takes surface water from future building plots. In due course, when run-off allows, a small loch will be created to act as a balancing pond.

The Bus Shelter

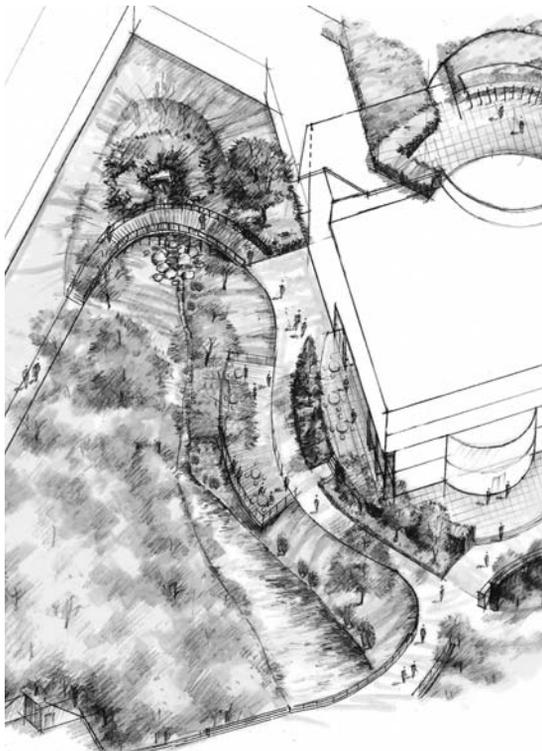
The proposal of the new bus shelter on the avenue shows respect to the old trees on the site. The 15cm space is needed around the tree trunk where the trees go through the shelter. (Figure 8)

3.2.5. Stage Five in Practice: Long-term Management and Review. From the outset of development of the Edinburgh Campus at Riccarton, Weddle saw ecological landscape design as being a long process, requiring monitoring and expert guidance over a long period. Understanding his client, he recommended that the University established a Site Con-

FIGURE 6. The Loch and Boardwalk.



FIGURE 7. The pond beside the library.



servation Sub-Committee to monitor development, conservation and management of site landscape. This was set up in 1969 and continues to meet twice annually. This was an innovative step. By providing the wider University community with an input on environmental management and conservation, this ensured that the special asset of Riccarton campus was collectively valued, and not the sole preserve of the development project team.

A Management Plan was drawn up by the Landscape Architects in 1978. This document covers issues of general estate management such as woodland management regimes, playing field and general landscape maintenance. The landscape management plan is implemented by the Heriot-Watt Estate Office with ongoing advice from the Landscape Architect. This is subject to ongoing review through the twice yearly meetings of the Site Conservation Committee. Woodlands continue to be managed on a 5 year Plan.

FIGURE 8. Bus shelter with old trees.



Weddles identified critical areas where it would be necessary to monitor change. These included the Lawn, Loch and Woodlands. Records were kept by University scientists, amateur naturalists and specialist ecologists from Weddles office. In 1973 Professor Weddles' Report No 11 on Ecological Studies recorded changes during the first intense phase of site development. This provided a baseline survey against which change and the effects of change would be monitored. It identified conservation priorities so that a durable landscape would result once the impact of development had been stabilised. Certain parts of the estate would be protected and managed as natural systems. Currently this is recognised as the concept of 'sustainability'.

The Landscape Architect has continued to advise this committee throughout the development process. As a campus university, there has been systematic community involvement through the Site Conservation Committee. The committee has met regularly in order to discuss all aspects of wildlife, campus protection and landscape development. Consultation with the wider community has been undertaken through a process of getting the University Masterplan 2010 approved and incorporated into the Rural West Edinburgh Local Plan.

After 25 years, a follow up Wildlife and Ecology Study (Environmental Audit) was carried out to measure success of the Site Conservation and Landscape Development processes. The conclusion has been an overall improvement in landscape quality and diversity. Woodlands are a most important

part of the campus and overall there has been an increase in tree cover to 30 hectares. Management of woodlands has been specifically to encourage a rich diversity in vegetation and wildlife and this has been fairly successful. Over a 25 year period, bird species recorded on campus have risen from 66 to 85, partly due to improved habitat quality. Badgers remain resident on site though Roe deer are more scarce. The central Lawn has become more resistant to wear but less diverse ecologically.

3.3 Conclusion

In summary, the ecological landscape design policy used in the Heriot-Watt campus at the Riccarton is listed as follows:

- Energy efficiency is exemplified by tree belts which are sited to buffer development and provide wind protection which conserves heat loss.
- Car park hedges filter dust and pollution and reduce wind speed for human comfort. Peripheral car parks ensure the heart of the academic campus and student villages are car-free.

- Separation of pedestrians and vehicles provides a safe and healthy environment for staff, students and visitors.
- Increasing numbers of students are accommodated on campus reducing the energy costs of commuting from off-site.
- Surface water from roads and buildings is cleaned and returned to water courses and holding ponds rather than being sent down the sewers.
- New planting provides green links throughout the campus, encouraging birds and wildlife to co-exist within the built-up environment.

Heriot-Watt campus at the Riccarton Estate has been a long term development, based on the initial masterplan and subsequent revisions (Figure 9). The overall landscape concept has developed gradually over 30 years, during which experience of protecting wildlife and landscape, and of implementing landscape schemes on an active university campus has been gained (Table 3). The University Landscape Section has learnt how to provide durable and instantly available landscape for the enjoyment of stu-

FIGURE 9. The Masterplan.



TABLE 3. Ecological Landscape Design Schedule.

Library And Core Buildings Lawn, Central Woodlands & Loch		
Technique	When applied	Date
Vegetation Survey	Pre development	1968
Identify valuable habitats Ecological Impact Study	Pre development	1968
Habitat management Remove diseased trees Manage abandoned lawns Clear silt from ponds	Pre development	1969–1973
Ecological Studies Report Assess capacity to accept change	Pre development	1973
Protect during development	During construction project	1970–1977
Stabilize habitat	Post development	1977–1980
Habitat enhancement	Post development	1980–1982
Manage habitat		1980–present
Create new habitat		1980
Establish green linkages		1973–present
Monitor change after 25 years	Wildlife Audit	1998

dents, staff and visitors. The University has carefully developed its campus so as to maintain and enhance the quality of the natural environment of the Riccarton estate. The woodlands, historic landscape and gardens are highly valued, both for wildlife, and the ambience they provide for the academic campus. The high quality setting of the Edinburgh Green Belt is an important attraction to prospective students, conference delegates and research park tenants. The Landscape Masterplan illustrates the long term strategy of developing on the existing Playing Fields and creating new playing fields the south fields (currently arable farmland).

Each year the campus hosts a series of conferences and delegates have the opportunity to enjoy a number of trails within the campus landscape. In 2005 the campus hosted the International Federation of Landscape Architects Annual Conference, entitled 'Landscape Leading the Way'. Heriot Watt's campus serves as an excellent example of 'landscape-led' ecological design.

REFERENCES

- Weddle Landscape Design and Spawforth Associates; 'Heriot-Watt University Masterplan 2010' August 2000.
- Weddle Landscape Design; 'Heriot-Watt University Riccarton Campus Wildlifes Tudy—25 years of Site Development' March 1998.
- Weddle Landscape Design; *Landscape Consultant's Report No.11 'Heriot-Watt University Ecological Studies and Site Conservation Progress 1970-71-72'* January 1973.
- Makhzoumi J M., 2000. Landscape ecology as a foundation for landscape architecture: application in Malta. *Landscape and Urban Planning* 50 167–177.
- Forman, Richard T. T. and Michel Godron, 1986. *Landscape Ecology*. John Wiley and Sons, New York.
- Lyle, John, 1994. *Regenerative Design for Sustainable Communities*. John Wiley and Sons Inc., New York.
- McHarg, Ian, 1971. *Design with Nature*. Doubleday, New York.
- Naveh, Zev and Arthur Liebermann, 1984. *Landscape Ecology: Theory and Application*. Springer Verlag, New York.
- Zube, Ervin, March/April, 1986. "The Advance of Ecology" in *Landscape Architecture*. March/April, 1986.