White Young Green

DRAFT

City Campus Ecological Enhancement Report

for
University of Bradford

thinking beyond construction

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Reference: **University of Bradford – City Campus Ecological Enhancement Report – October 2005**				
Issue		**Prepared by**	**Checked by**	**Verified by**
V1	September 2005			
V2	-			
V3	-			
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File Ref: N:/ Projects / E7000 – 7500 / E7362 / Reports / Ecological Enhancement Report				

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UNIVERSITY OF BRADFORD

CITY CAMPUS ECOLOGICAL ENHANCEMENT REPORT

SEPTEMBER 2005

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APPENDICES

1.0 INTRODUCTION

1.1 Background

White Young Green Environmental (WYGE) was commissioned by the University of Bradford in August 2005 to undertake a site survey of the city campus, addressing the objectives as discussed in Section 1.3. Arising from the site survey a range of ecological enhancement measures were formulated to develop a structured approach to increasing the campus biodiversity. Specifically this entailed a survey to establish the current biodiversity of the campus and a range of prescriptive measures pertaining to individual species and habitats. In the longer term the University is intent on improving the ecological value of the campus through enhancement of areas of existing low ecological value and through the incorporation of biodiversity enhancements into the design of future building footprints.

The guidance included within this document provides a range of options to ecologically enhance the campus. The final measures incorporated into the landscape and building designs may need to be tailored to meet the end use of the site components. As the sites will be subjected to high levels of human disturbance, it is acknowledged that the adoption of some of the enhancement measures listed below will help in ameliorating the severity of the impacts. This may be achieved through suitable integrated planting schemes; amenity and ecologically-based, designed features and ensuring connectivity both internally and externally.

Generally the vegetation of many urban open spaces (parks, gardens, car parks, etc) comprises mostly non-native species and common, ruderal or 'weed' species. Typical bird species of such sites include blue tit, great tit, pied wagtail, song thrush, blackbird and robin. Where there is greater habitat diversity and where lakes, ponds or mature trees occur, additional species such as great spotted woodpecker, long-tailed tit, moorhen and grey heron are likely to be found. The invertebrate assemblages in urban parks and green spaces tend to comprise primarily of common, ubiquitous species, which reflect the low diversity of habitats. It is also worth mentioning that the size of an area and the extent to which it is connected with adjacent suitable land is a major factor in influencing the wildlife that may use it. However all such areas regardless of their connectedness, such as the campus; if managed correctly for wildlife, can be significant in their own right.

The structure of the report incorporates a general assessment of the baseline ecological conditions within the campus. Section 3 progresses on to detail enhancement options in terms of habitat, vegetation and structural improvements. The recommendations described in Section 4 generally relate to ecological sustainable management practices and complement the proposed enhancements.

1.2 Site Description

The University of Bradford is a rapidly expanding academic institution with 6,300 full-time undergraduates and around 800 full-time postgraduates. This entails more than 170 degree courses at undergraduate level and around 80 at postgraduate level. These are spread across eight faculties including Archaeological, Geographical and Environmental Sciences, Engineering, Design and Technology, etc. The main campus is located centrally in Bradford City with satellite campuses located further away from the city centre, such as the School of Management which is located over two miles from the city campus on its own parkland site.

The city campus, which is the focus of this report, consists of the four main academic buildings (Richmond, Horton, Chesham and Phoenix) and student amenities (Sports Centre, Library, Computer Centre, Communal Building & Students Union); all linked by a pedestrian causeway. The University provides approximately 1,700 residential places within Shearbridge, Bradford, Longside, University, and Kirkstone halls of residence, all of which are also located within the city campus.

Four relatively busy roads tightly bound the perimeter of the city campus: Longside Lane and

Shearbridge Road define the western and northern boundaries respectively, with Great Horton Road and Smith Street/Carlton Street forming the southern and eastern edge of the campus.

1.3 Objectives of the Report

The main objectives of this report are to identify potential ecological enhancement measures for the campus, including:

- Identification of key areas within the centre of the campus.
- The creation of on site waterbodies.
- Linking green areas on-site to create green corridors.
- Linking to green areas off-site to create larger green corridors.
- Provision of planting lists for native trees, shrubs and flowering plants for the Peace Garden and for future site improvements.
- Recommendations for growing mediums, pesticide use and composting practices.
- Measures to encourage invertebrates.

The wider and core objectives of the University are detailed in their own document: *Ecoversity, Working Towards a Sustainable Campus*; which aims to establish a green heart to the Campus. This will entail extending and creating wooded areas, hedgerows, meadows and ponds. Generally the aim is to develop a programme of native planting to encourage wildlife into the area. Ancillary related amenities enhancements will include walking and jogging routes to encourage exercise throughout the campus. It is envisaged that this report should provide the foundation and initial guidance by which the University should initiate its wider aims of environmental sustainability.

2.0 BASELINE ECOLOGICAL ASSESSMENT

2.1 Introduction & Methodology

West Yorkshire Ecology was contacted in September 2005 to obtain any potential biological records for the immediate site and up to 2 km from the campus itself. The site was also visited in September 2005 by a WYGE ecologist Rory Canavan with full membership of the Institute of Ecology and Environmental Management (IEEM); during which an ecological walkover survey was undertaken to record features of interest, such as habitats and protected or threatened species and identify any enhancement opportunities.

2.2 Existing Baseline Data

The results of the biological record search failed to identify any records of protected species within the city campus. The nearest records for species of interest are listed in Table 1.

Table 1; Results of the biological records search

Species	Date	Distance from campus
5 records of bats, two confirmed pipsestrelle	1998-2004	1.75km re bats (Other species unknown)
2 records of grass snake	1973 - 1977	1.5-2km Bradford moor golf course and at unconfirmed location
1 record of water vole	1999	1km
1 record of common frog	1998	1.75km Boar's Well urban wildlife reserve

The data search did not identify any statutory designated sites, such as Sites of Special Scientific Interest (SSSI), within the 2 km search area. However, five non-statutory sites, classed as third tier sites and identified as Bradford Wildlife areas (BWA), were recorded within the 2km search radius. These sites are designated by the City of Bradford Metropolitan District Council as sites which, although they may not necessarily support rare species, provide general wildlife habitats and local access to the public.

The sites identified within the data search include:

- Boar's Well Urban Wildlife Reserve; approximately 1.75km from the campus.
- Copthorne Linear Park; approximately 0.75km from the campus.
- Cecil Avenue Allotments; approximately 1.2km from the campus.
- All Saints Nature Reserve; approximately 0.75km from the campus.
- Brackenhill ULA (Urban Landscape Area) approximately 1.9km from the campus.

2.3 Site survey

The site survey arbitrarily identified five principal areas in the campus (Figure 1). Within this, two core areas, (the Amphitheatre and the copse) were identified as being the most suitable for habitat creation and enhancement (Figure 1). The campus is largely devoid of semi-natural habitats, with soft landscaping consisting of predominantly ornamental vegetation. The bulk of the campus comprises hard standing abutting the various university buildings with sporadic areas of shrubberies and specimen trees. The inner areas of the campus retain greater areas of amenity grassland with ubiquitous ornamental shrubs and trees strategically planted to compartmentalise the grassed areas.

Area 1: The car park, Estates office, Kirkstone Hall and part of Longside Lane/Richmond Road.

The car park and areas around the Estates office along Richmond Road is generally neatly defined with shrubberies, borders and trees. For the most part the vegetation within the borders is comprised of ornamental species, including: Potentilla *Potentilla sp*., cherry laurel *Prunus laurocerasus*, flowering currant *Ribes sanguinea*, buddleija *Buddleija davidii*, evergreen euonymus *Euonymous sp*., senecio *Senecio greyii*, Viburnum *Viburnum tinus*, hebe *Hebe sp*., mahonia *Mahonia japonica*, shrubby honeysuckle *Lonicera nitida* and berberis *Berberis stenophyla & B. darwinii*. Native shrubs are also interspersed through the ornamental plantings, including species such as hazel *Corylus avellana*, broom *Cytisus scoparius* and osier *Salix viminalis*. Most of the trees are a mixture of native and cultivated ornamental species; including, rowan *Sorbus aucuparia*, birch *Betula pendula*, sycamore *Acer pseudoplatanus*, alder *Alnus incana* and hornbeam *Carpinus betulus*. The areas are densely planted with limited foraging opportunities for birds. Additionally, the open structure and small height of many of the borders is likely to preclude many breeding species. Of particular note is the presence of two clearly defined stands of Japanese knotweed *Fallopia japonica*, and sporadic shoots on the southern side of the estates office, the entrance to the car park off Longside Lane and single shoots at the entrance to the car park from Richmond Road. The principal grassland areas lie within the Kirkstone Hall complex and along Longside Road. A similar range of ornamental species forms the bulk of the shrubberies with the addition of Pyracantha *Pyracantha coccinea*. A larger lawned area is situated between Longside Hall and Kirkstone Hall consisting of approximately 25 semi-mature ornamental/native trees including sycamore, rowan and birch.

Area 2: Longside Halls.
Both Halls are similar in planting and layout to Kirkstone Hall with neatly compartmentalised box shaped ornamental shrubberies, intersected by footpaths, small trees and lawned areas. A row of mixed tree species runs parallel to the Phoenix Buildings consisting of larch *Larix decidua*, birch, alder, sycamore, etc; and culminates at a large mature grey willow *Salix cinerea* specimen. This quiet recess houses service buildings (generators), and is underplanted with olearia *Olearia sp*., cotoneaster *Cotoneaster sp.,* flowering currant and dogwood *Cornus sanguinea*. The large and mature willow has potential to support roosting bats and is undoubtedly used by breeding birds. The row of trees is approximately 100 m long and is likely to form an aerial or arboreal corridor into the campus.

Area 3: The Amphitheatre and beck.
The large open areas of amenity grassland are steeply banked and terraced to form an open amphitheatre, which runs roughly south to north. The area is generally open, bisected with paths and long thin ornamental shrubberies comprised of berberis and gorse amongst other species. The arboricultural interest is reflected by a line of trees on the crest of the amphitheatre consisting of spruce *Picea sp*., pine *pinus sylvestris*, leylandii *X cupressocyparus leylandii* and larch. The beck or stream is partially culverted for a section from the Phoenix to the Theatre in the Mill buildings. The water quality is poor with minimal ecological interest. To the west of the amphitheatre and forming a boundary planting; an area of predominantly coniferous trees (larch, pine and leylandii) is situated. The understorey generally consists of ivy *Hedera helix* and berberis.

Area 4: The copse and JB Priestley Buildings.
This area is largely defined by a small copse or spinny of approximately thirty semi-mature trees. Species recorded include sycamore, willow, field maple *Acer campestre*, hornbeam, variegated poplar *Populus sp*. and an edging of hawthorn *Crataegus monogyna* and guelder rose *Vibunum opulus*. The ground vegetation grades from the centre out to the edge in the following species order, ivy, nettle *Urtica dioica* and dock *Rumex sp.* grading from the centre to the edge. The copse is surrounded by managed amenity grassland, which in places is steeply sloped.

Area 5: Shearbridge Green Hall, Chesham and Horton Buildings.
Shearbridge Hall is similar in terms of layout and planting compositions to the other halls of residence, namely Longside and Kirkstone Halls. However Shearbridge Hall has many more trees, most of which are ornamental. Species recorded include acacias *Acacia sp*., ornamental cherry *Prunus sp.* and apple cultivars *Malus sp*., birch, lilac *Syringa vulgaris* and tulip trees *Liriodendron tulipera*. The shrub borders are also similar with the additions of snowberry *Symphoricarpos albus* and dogwood. The Horton complex is planted with Norway maple *Acer*

platanoides, cherry laurel, holly *Ilex acquifolium*, spotted laurel *Acuba japonica*, flowering currant and mahonia within island shrubberies facing Richmond Road. The site of the planned Peace garden is situated on a southerly aspect facing Great Horton Road. Trees growing within the area include birch, cherry and rowan.

In summation, the campus is relatively well vegetated, with many shrubberies and trees used in a traditional means to provide soft landscaping. Ecologically the site is subject to considerable human disturbance, within, from pedestrians and along the periphery from vehicular traffic. Unfortunately the campus is largely without significant external links to surrounding habitat, which may provide access/entrance routes for some species. However many species require different forms of linkages to travel through a landscape and under the right situation may well be able to access the campus. Whilst undertaking the walkover survey, bird species casually recorded include magpie *Pica pica*, blue tit *Parus caeruleus*, wood pigeon *Columba palumbus* and house sparrow *Passer domesticus*. This is not a definitive reflection of the diversity on the campus, but it is reasonable to assume that urban species, habituated to disturbance are likely to predominate. The anecdotal evidence for nesting sparrowhawks *Accipiter nisus* on the Richmond Building is interesting and worthy of more investigation, as the species is not known to use buildings. Additionally the vague evidence relating to bats flying around the JB Priestley Buildings may also be significant as it infers that bats are using the campus to forage and possibly roost, although roosts are more likely to be confined to old neighbouring mill buildings off-site.

3.0 RECOMMENDED ECOLOGICAL ENHANCEMENT MEASURES

3.1 Introduction

The ecological enhancement of the campus should be viewed as a multi-tiered approach; for example linking and altering the composition of many of the shrubberies in favour of native species with the ultimate goal of ensuring a process of 'green-veining' through the site. The next stage should seek to create and develop new habitats such as ponds and grasslands; followed by maximising the opportunities onsite through nesting/roosting boxes, green roofs etc. The wider 'tiers' of enhancement may involve targeting of measures for particular species, which may be achieved through appropriate management and strategies. Consequently, on a wider landscape level, the enhancement of the campus may become significant to the localised survival of some species.

In relation to urban habitats, the general rule is that they tend to support fewer vertebrate species (mammals, birds, amphibians, etc) than equivalent areas of the same habitat in the countryside. For invertebrates (insects) and higher plants the situation is complicated by the presence of species not found in rural situations and species encouraged by increased disturbance (ruderal species), which may compensate in terms of numbers for the absence of species unable to survive the pressures of an urban environment. However, there can be considerable differences in species numbers between equal areas of different habitats.

Various studies of species have shown a strong positive correlation between species richness and area. That is to say, the larger the area the greater the number and diversity of species. However in many cases other elements of a habitat, such as vegetation density, may be more important than area, i.e. small areas of more dense vegetation may be more favourable than larger areas of less dense vegetation. For example, studies in Oxford of small mammals such as wood mouse *Apodemus sylvaticus*, bank and field vole *Clethrionomys glareolus* & *Microtus agrestis* and common shrew *Sorex araneus*, show that species presence and population size are strongly correlated with the density of vegetation above the ground. Management which affects the height and continuity of plant cover can therefore provide a better explanation of species number than purely the size of an area (Dickman 1987). Crucially the study mentioned above examined small areas of habitat ranging from 0.17 – 20 ha. Additionally similar relationships hold for birds in urban areas, subject to human disturbance. The provision of refuge areas (shrubs and boxes) is known to increase the number of breeding bird Luniak (1992). The number of layers in the vegetation, its density and the number of old trees also have a positive effect on bird numbers within a site.

Consequently, in relation to the campus enhancement measures, it is important to place emphasis on maximising and developing areas of high quality habitat. While it is acknowledged that enhancement opportunities are limited and generally confined to smaller areas away from the greatest human disturbance; it is these areas that should be viewed as the starting point for the ecological improvement of the University. Additionally once these areas are defined, the ancillary processes of green veining or establishing a network of hedges/shrubberies/plantings can then be implemented. Subsequent enhancements can address individual species issues and appropriate targets. It is also suggested that a detailed management plan is formulated and devised to ensure the enhancements are strategically and appropriately implemented.

3.2 Infrastructural Planting

3.2.1 Habitat isolation

Infrastructural planting is a term used to denote the core planting throughout the campus; in effect the collection of hedges, shrubberies and plantings. It is these plantings which will link different habitats and other ecological features allowing species to move through the site with greater ease. This is also a form of green veining and increases the campus permeability to species, creating a range of habitats in terms of movement corridors and core areas for foraging and breeding. The small size of most urban habitat areas coupled with the potential impact of fragmentation factors, such as roads, buildings, hard surfaces; serve to isolate pieces of similar

habitat. The fragmentation and isolation of habitats means that some species may have difficulty in colonising or recolonising sites. Species which have poor dispersal abilities are likely to be more affected by severance factors and isolation. However more mobile species, capable of wider dispersal, are less affected, even when sites are small. As discussed below a network of small areas (>0.25ha) may be sufficient for some species to colonise new areas. Within the University campus it is important to understand the necessity of ensuring wildlife permeability, by habitat creation, plantings, etc; to ensure ecologically enhanced areas do not remain isolated. For example, when designing new waterbodies, consideration of the proximity to other areas of habitat should always form a key design component.

3.2.2 Biodiversity targets for small areas

Within the campus, habitat enhancement opportunities will be limited to less than one hectare in size. However, the ecological benefits of small-scale enhancements can be significant with a quantifiable threshold of potential targets to aim for (Harrison *et al.* 1995).

1. Plant species richness in an urban site, at the upper end of the size range (1 ha), can be expected to support between 50-90 plant species. If it is maintained as a grassland area, species diversity will be lower, ranging from 11-24 species.

2. Animal species richness within a wooded site larger than 0.65 hectare is likely to support at least four species of small mammal. Population densities of small mammals of between 30-60 have been recorded for sites of this size (Harrison *et al.* 1995).

3. A wooded/scrub site of one hectare could be expected to contain between ten and twenty breeding bird species. In general disturbance coupled with the absence of safe refuges would limit bird numbers. Species habituated to human presence and disturbance would generally predominate, such as common garden birds.

4. Realistic numbers for butterflies in an area below one hectare range from 1-5 species, although with selective management of food sources and habitat structure to ensure successful growth of both larval and adult stages (Section 3.3.5), higher species numbers could be expected. It is possible to achieve up to 21 species of butterfly within a managed garden (Harrison *et al.* 1995).

5. A small waterbody of 0.25 hectares can easily support up to four species of amphibian.

The principal limitation of a small site of this size ranging up to 1ha, is that it is too small to be likely to develop more than a few different habitats on it.

3.2.3 Corridor design

The recommended plantings should form the basis of a network of corridors within the campus running through the site creating greater permeability. These potential corridors should form an important link within the whole site. The network of hedges, shrub borders and trees should all intersect at core areas of habitat, e.g. the wooded copse by the JB Priestley Building and within the amphitheatre (Figure 2). The core areas within the campus are designed to be larger areas of greater ecological diversity which are buffered by other habitats (e.g. areas of grassland and plantings).
It is also important to stress that these corridors should also form habitats in their own rights.

The suggested objectives governing corridor design should focus on:

- The wildlife corridor being as continuous as possible with minimal breaks; e.g. footpaths.

- Ideally, plantings/hedges bisected by paths should be situated perpendicular to the long axis of the bisected hedge.

- The corridor should be supplemented or buffered by the addition of contiguous strips of habitat, e.g. rough grassland margins running along parallel to hedging/shrub strips.

- Crucially the width of the linear corridor should be maximised to inhibit edge effects such as disturbance and increased predation etc. By increasing the width of the corridor or habitat link the opportunities for more species increases.

- The creation of scalloped edges and/or allowing a degree of sinuosity into the design will increase habitat variation. Thus maximising habitat potential in the form of aspect, microhabitat etc.

As a general rule the composition of the wildlife links should incorporate at least five shrub species and three tree species. In short species such as hawthorn, oak, ash, blackthorn, hazel, field maple, privet, alder, dogwood, holly and spindle are all suitable species to form the framework of any habitat link. The use of native species is preferred and recommended within areas subject to more sensitive habitat creation, however some non-native or ornamental species are also ecologically valuable and often more appropriate in urban situations. Consequently ornamental species may be used in situations which may require a greater emphasis on aesthetics. Further detail in relation to woodland and shrub planting is provided within Section 3.3.2.

3.3 Vegetation & Habitat Enhancements

3.3.1 Grassland components

For the most part it is anticipated that many of the grassed areas within the campus will be subject to immense pressure in the form of trampling and disturbance. Consequently in high disturbance places a hard wearing amenity mix should form the basis of the vegetative elements. It is expected that the bulk of the mix will be composed of perennial rye grass *Lolium perenne*, i.e. up to 50%; with the remainder of the mix, where appropriate, formulated from other native species. Areas of new grassland creation pertain to the creation of habitats and the future reseeding of areas as indicated on Figure 2.

For areas where disturbance is likely to be less, the mixes listed in Tables 2 & 3 should improve the diversity of the grassland areas within the campus. The mixes should not be viewed in isolation, as the subsequent management regime will greatly affect the diversity of any grassland. The species selected, represent those, which are characteristic of and frequent in communities with reasonably widespread distributions. All species should be of native origin and preferably of local provenance:

Table 2; Recommended general wildflower seed mix

Grass Species	Herb species
False oat grass *Arrhenatherum elatius* Cocksfoot *Dactylis glomerata* Red fescue *Festuca rubra* Yorkshire fog *Holcus lanatus*	Cow parsley *Anthriscus sylvestris* White Dead-nettle *Lamium album* Yarrow *Achillea millefolium* Plantain *Plantago lanceolata* Common knapweed *Centaurea nigra* Birds-foot trefoil *Lotus corniculatus* Red clover *Trifolium pratense* Meadow vetchling *Lathyrus pratensis* Common vetch *Vicia sativa nigra* Selfheal *Prunella vulgaris* Oxeye daisy *Leucanthemum vulgare*

Table 3; Alternative wildflower mix

Grass Species	Herb species
False oat grass *Arrhenatherum elatius* Yorkshire fog *Holcus lanatus* Red fescue *Festuca rubra* Rye grass *Lolium perenne* Cocksfoot *Dactylic glomerata* Crested dogs tail *Cynosurus cristatus* Rough meadow grass *Poa trivialis* Creeping bent *Agrostis stolonifera*	Field Mouse-ear *Cerastium arvense* Red campion *Silene dioica* Meadowsweet *Filipendula ulmaria* Cowslip *Primula veris* Yellow rattle *Rhinanthus minor* Bugle *Ajuga reptans* Red clover *Trifolium pratense* White clover *Trifolium repens* Meadow buttercup *Ranunculus acris* Chickweed *Cerastium fontanum* Common sorrel *Rumex acetosa* Dandelion *Taraxacum officinale agg.* Autumn hawkbit *Leontodon autumnalis* Creeping buttercup *Ranunculus repens* Black knapweed *Centaurea nigra*

There are many other possible permutations for grassland enhancement within amenity areas, some of which are suggested below. Potential grassland enhancement locations include the western slopes to the side of the JB Priestley building, the grass banks within the amphitheatre, to the west of Shearbridge Green Hall, around the central copse and on Longside Lane (Figure 2). These options specifically outline methods to enhance existing amenity grassland areas and are all, in some form, applicable to the campus. Enhancement of existing amenity grasslands can be undertaken by planting plugs or through deep scarification, with seed directly sown.

- Amenity grassland meadow. In a fertile grass area, taller and more vigorous wild flowers can be used. Possible choices are oxeye daisy, greater knapweed and black knapweed, meadow cranesbill *Geranium pratens,* musk mallow *Malva moschata* and field scabious *Knautia arvensis*. Other effective plants include tufted vetch, which can clamber over tall grass, red campion and yarrow. Grass competition and growth needs to be reasonably controlled in the establishment year, as the wildflowers tend to use the long grass to provide support for their initial leggy growth.

- Low maintenance area. When certain species are established successfully, they are much more able to sustain themselves than others. These species include many mentioned above such as field scabious, greater knapweed, common knapweed, meadow cranesbill, musk mallow, red campion, meadowsweet and others including bladder campion *Silene vulgaris* and cow parsley.

- Cowslip meadow. Alternatively to the range of species listed above, plantings of singular species often have significant ecological benefits; e.g. early sources of nectar for invertebrates etc. Cowslips can be planted into a lawn, which is kept mown at 5 cm until late February/early March. Grass cutting is stopped and the cowslips are allowed to flower for at least six to eight weeks in April and May. Cutting can be started after flowering is finished or in mid June to allow for seed dispersal. Afterwards the lawn is cut as normal.

- Flowering lawn. These are mixed swards made up of grasses and a range of wild flowers that are extremely tolerant of cutting. The grass is cut four to six times during the season. Wild flowers that can be planted include birds-foot trefoil, cats ear *Hypochoeris radicata*, selfheal, rough hawkbit, small scabious and musk mallow.

Appropriate areas of grassland can be supplemented with the inclusion of wildflower plugs containing a range of species to suit soil conditions, with the possible inclusion of some of the species listed in Table 4 below.

Table 4; Suggested wildflower plugs for a range of grassland areas

Species	**Species/habitat requirements**				
	Clay	**Chalk**	**Neutral**	**Sandy**	**Acidic**
Broad-leaved helleborine *Epipactis helleborine*	**XX**				
Foxglove *Digitalis purpurea*				**X**	**XX**
Yarrow *Achillea millefolium*	**XX**	**XX**	**XX**	**XX**	**XX**
Birds-foot trefoil *Lotus conriculatus*	**X**	**XX**	**XX**	**XX**	**XX**
Field Mouse-ear *Cerastium arvense*	**XX**	**XX**	**XX**	**XX**	
Common knapweed *Centaurea nigra*	**XX**	**XX**	**XX**	**X**	**XX**
Selfheal *Prunella vulgaris*	**XX**	**XX**	**XX**	**XX**	**XX**
Silverweed *Potentilla anserina*	**X**	**X**	**X**		

Meadow vetchling *Lathyrus pratensis*	**XX**		**X**		
Oxeye Daisy *Leucanthemum vulgare*	**XX**	**XX**	**XX**	**XX**	**XX**
Common sedge *Carex nigra*	**XX**				
Red campion *Silene dioica*	**X**			**XX**	
Mullen *Verbascum nigrum*		**X**		**XX**	
Dog violet *Viola canina*				**XX**	
Meadowsweet *Filipendula ulmaria*	**XX**		**X**		
Ragged robin *Lychnis flos-cuculi*	**XX**			**XX**	
Musk-mallow *Malva moschata*	**X**	**XX**	**XX**	**X**	**XX**
Primrose *Primula vulgaris*	**XX**	**XX**	**XX**	**XX**	
Cowslip *Primula veris*	**XX**	**XX**	**XX**	**XX**	
Yellow rattle *Rhinanthus minor*	**XX**	**XX**	**XX**	**XX**	**XX**
Bugle *Ajuga reptans*	**XX**	**XX**	**XX**	**X**	**X**
Enchanter's-nightshade *Circaea lutetiana*	**XX**	**X**	**X**		

In relation to the site flora, the long-term management program will heavily influence the species composition of the grassland areas and also the soil fertility. Mowing and removing the new grass growth at least once each year is the minimum requirement for survival of a wide range of species. The timing of mowing may vary between sites, but it should be consistent from year to year. Management options are discussed below and should be adopted within appropriately localised areas. Vegetation cutting options include:

- Mowing in September/October ensures the maximum time for plants to flower and set seed but large volumes of standing or flattened vegetation (possible fire risks) may then need to be removed.

- A July cut enables many spring and early summer species to seed; the vegetation remains quite short and tidy during the later summer months (useful for informal recreation) and some species will flower a second time in the autumn.

- A June/July (traditional hay-making time) cut will selectively weaken the most vigorous grasses, leaving a tidy appearance in summer and giving the maximum period for late flowering species to set seed.

- Where tidiness is particularly important, mowing in July and again in October may be desirable. On fertile soils, more frequent mowing may be necessary at least in the first few years. This may be more appropriate around more formal areas directly adjacent to buildings.

- Some rougher areas can be cut every other year to leave standing cover for over-wintering insects.

- Finally, as the sward develops and thickens some thought should be given to gap creation, deliberate damage to the surface, to allow new plants to establish by seed and provide opportunities for invertebrates. This can be replicated with the careful use of a chain harrow.

It is envisaged that the subsequent management details for the adopted enhancements should be incorporated into the grounds maintenance. The specific enhancements adopted should then be specified within a wider campus management plan.

3.3.2 Tree and shrub components

As described in Section 3.2.1 the need for greater permeability is essential in ensuring the movement of species through the campus. The formation of corridors and stepping stones may be achieved by altering the vegetation composition of the existing shrubberies (i.e. increasing the native shrub content) and the creation of new woodland/shrub stands. It is envisaged that these elements will be realised by their incorporation into the design process for the campus. As mentioned it is also recommended that a management plan is formulated to strategically address the ecological enhancement process.

The species lists below (Tables 5-9) can be adapted to form part of any future wider landscape plantings; however the scrub and edge mixes should be incorporated in some manner into more immediate plantings. The lists do not include bramble as it is expected to naturally colonise suitable areas. Single species can also be used in larger blocks of planting. Specifically, areas which can immediately be targeted for tree and shrub planting include the central copse to the east of the JB Priestley building, Longside Halls and Lane, the car parking areas and by Horton buildings and Richmond buildings (Figure 2).

Table 5; Woodland mix

Species %	**Species**	**No. Invertebrates associated**
25	Hazel *Corylus avellana*	107
25	Oak *Quercus robur*	423
20	Alder *Alnus glutinosa*	141
12.5	Ash *Fraxinus excelsior*	68
5	Holly *Ilex acquifolium*	13
5	Bird cherry *Prunus avium*	157
2.5	Scots pine *Pinus sylvestris*	172
2.5	Elder *Sambucus nigra*	19
2.5	Elm *Ulmus glabra*	124
To be planted at 1m centres and group planted with trees at 10-50 per group and shrubs at 5-10 per group; *Alnus* and *Corylus* can be planted randomly.		

Table 6; Scrub mix

Species %	**Species**	**No. Invertebrates associated**
75-100	Hawthorn *Crataegus monogyna*	230
	Blackthorn *Prunus spinosa*	157
	Dog rose *Rosa canina*	107
	Gorse *Ulex europaeus*	52
0-15	Hazel *Corylus avellana*	107
	Holly *Ilex aquifolium*	13
	Elder *Sambucus nigra*	19
	Guelder rose *Viburnum opulus*	17
0-10	Tree species	
Planted at 0.75m or 0.5m centres; main species group planted at 5-30 per group; additional shrubs and trees randomly planted when included; forms blocks detached from other planting mixes.		

Table 7; Tall hedgerow mix

Species %	**Species**	**No. Invertebrates associated**
42.5	Hawthorn *Crataegus monogyna*	230
17.5	Hazel *Corylus avellana*	107
15.0	Blackthorn *Prunus spinosa*	157
10	Alder *Alnus glutinosa*	141

5	Field maple *Acer campestre*	41
5	Elder *Sambucus nigra*	19
5	Honeysuckle *Lonicera periclymenum*	48
2.5	Goat willow *Salix caprea*	450
Planted at 1m or 0.75 centres, group planted at 5-50 per group; *Lonicera* planted randomly; frequently forms edge to planting; percentage of *Crataegus* increased when used as hedge.		

Table 8; Low edge mix

Species %	**Species**	**No. Invertebrates associated**
50	Dog rose *Rosa canina*	107
	Field rose *Rosa arvensis*	107
30	Blackthorn *Prunus spinosa*	157
	Hazel *Corylus avellana*	52
	Hawthorn *Crataegus monogyna*	107
20	Holly *Ilex aquifolium*	13
	Guelder Rose *Viburnum opulus*	17
	Gorse *Ulex europaeus*	52
	Dogwood *Cornus sanguinea*	18
	Burnet rose *Rosa pipinellifolia*	107
Planted at 0.75 or 0.5 m centres, all species group planted at 5-30 per group; percentages and combinations may vary widely depending upon effect required, small scale variation is important.		

Table 9; Light demanding mix

Species %	**Species**	**No. Invertebrates associated**
22.5	Hazel *Corylus avellana*	107
17.5	Alder *Alnus glutinosa*	141
17.5	Birch *Betula pendula*	334
12.5	Mountain ash *Sorbus acuparia*	58
10	Field maple *Acer campestre*	41
5	Elder *Sambucus nigra*	19
5	Holly *Ilex aquifolium*	13
5	Aspen *Populus tremula*	153
2.5	Scots pine *Pinus sylvestris*	172
Planted at 1 metre centres; all species groups planted at 5-100 per group. Can be used to form an edge to woodland mix. Can also be mostly group coppiced on rotation.		

(Invertebrate associations adapted from Kennedy& Southwood (1984) and Duffey (1974)) (Species mixes adapted from Greenwood & Moffat 1982)

3.3.3 Additional habitat enhancements

Complementing the planting regimes including grasslands, shrubberies and trees; habitat enhancement should also occur where possible, in the form of:

- The creation of scalloped edges along the grassland and shrub margins, which will also facilitate a greater structural diversity for both flora and fauna. This can be achieved by drift planting of wild flower plugs along the shrub interface and sporadically extending taller herbaceous plants into the grassland.

- The construction of hibernacula (including deadwood piles) for invertebrates and amphibians and potentially for reptile species. Each hibernaculum should be recessed

into the ground and composed of deadwood and clean rubble, capped with soil and seeded with an appropriate grass mix. Deadwood piles function as refugia for many species and are also essential components within many invertebrate life cycles. The erection and installation of specific invertebrate boxes is considered in Section 3.4.3.

- The formation of wet/damp scrapes/hollows within appropriate areas to provide opportunities for ephemeral wetland/marginal flora and associated invertebrates.

- The erection of education panels may also help to inform and educate in relation to the habitats within the campus.

It is important to stress that in recognition of human pressure and disturbance, any health and safety issues should be fully addressed for each enhancement. For example deadwood piles (500mm high approximately), should be situated within shrubs and composed of rotten wood and chippings to prevent any fire risks.

3.3.4 Ornamental species

It is envisaged that ecologically beneficial species should be used in a contemporary and designed manner in areas with greater amenity orientation such as formal garden areas. However the recommended ecological enhancements do not necessarily preclude the use of exotic or non-native plant species within the campus. It is recognised that there are already considerable plantings of ornamental species and that their use may be deemed more appropriate in certain situations. Some ornamental or non-native species also have ecological benefits such as offering significant nectaring resources for invertebrates, which also indirectly benefit larger predators. For example, like native ivy, some cultivated varieties are a seasonally important source of nectar and berries, and provide nesting and roosting habitats for birds. Pyracantha, cotoneaster and female holly trees provide autumn berries and nesting sites for thrushes and blackbirds, if allowed to grow to a sufficient height. However some ornamental plants have comparatively little value for wildlife, such as double-flowered varieties, which produce no nectar or pollen. A range of ornamental species beneficial to wildlife is listed in Section 4.3.

An inherent potential conflict exists between management of urban sites with amenity plantings and the needs of wildlife. A balanced approach is often needed, which provides more natural areas away from the most important locations for formal design. Even within formal areas, e.g. courtyards (Section 3.5.2) appropriate structure planting can provide good habitat for birds and potentially invertebrates.

However student/public perception of wildlife areas may be associated with feelings of insecurity, especially for women and people on their own. Long grass may appear to be uncared for and may accumulate litter. Introducing new ideas incrementally, with good consultation and interpretation at each stage may help to elicit student and staff support and interest.

The future modernisation of sports facilities and construction of sports fields will have implications for the ecology on the campus. Playing fields in particular are often regarded as inimical to wildlife, because of the need for very regular mowing of the playing areas. However, even these featureless ‘green deserts’ may provide foraging habitat for a variety of common bird species such as gulls, starling, blackbird, thrushes and pied wagtail. Creating rougher more diverse grassland on the periphery of any sports field can reduce adverse ecological effects. Floodlighting may also affect wildlife; whilst some birds make use lit up areas to extend their feeding day, other species may be adversely affected, including certain bats. The issue is complex and not fully understood but is discussed in relation to bats in Section 3.4.1.

3.3.5 Enhancements for invertebrates

Although the availability of specific plant species and the resources they provide are a key factor for many invertebrate species and in turn their larger predators such as birds; the structural characteristics of habitats are also very important. In essence, a varied sward and mosaic of vegetation heights, continuity throughout the season of leaf, stem, bud, seed, nectar and pollen resources are essential. Additionally the availability of over-wintering dead stems and seed heads are all crucial for many species.

The invertebrate importance of a site is largely dependent on the unmanaged nature of the vegetation enabling the survival of species which live and over winter inside leaves, stems, flower heads, bases of dead herbaceous stems and in ground litter. Management that removes dead wood or herbaceous stems on a regular basis can therefore be very harmful for many species. Equally plants that provide nectar and pollen resources are also important, and in many cases specific plant species support specific invertebrate species. Unmanaged or sporadically managed vegetation provides a continuity and large resource of dead herbaceous stems, seeds and fruit.

Additional habitat enhancements could include the creation of varied surface contours where possible. Specifically this could entail micro topographical modelling, i.e. the formation of bumps and hollows to maximise micro habitat/climate opportunities for invertebrates and floral species. This should be varied, with small-scale hollows, mounds and banks to increase the physical diversity and associated biodiversity.

In addition to the landscaping, open areas, devoid of vegetation, can be important to a number of species and often are undervalued resources. These areas can have a number of benefits; in particular they warm up rapidly in sunshine, they may be used by burrowing/ground nesting species, function as an egg laying resource and provide hunting opportunities for predators such as Carabid (ground beetles) and Cicendela (tiger beetles) species. The substrate should be as nutrient poor as possible, and the friability and particle composition should be varied over different parts of the site. The end objective is to create areas, which provide friable substrates with topographical variety, which should emulate the micro scale requirements of many invertebrates. However it should be stressed that open areas may be incorporated naturally within the landscape design in the form of paved and gravel areas contiguously situated to plantings.

Of all the invertebrate species, it is undoubtedly butterflies, which people find the most attractive and endearing. Additionally, most British butterfly species are presently declining due to many reasons including habitat loss, pesticide use and climate change. Consequently it is suggested that opportunities to enhance habitats for butterflies are developed as a priority within the campus. Butterflies are useful indicators of the health of many habitats and are equally a tangible, if informal, wildlife aspiration and benchmark for the University campus. Table 10 lists butterfly species, which under suitable habitat management and creation situations could potentially maintain populations on the campus. Opportunities include appropriate grassland creation and the planting of attractive plants either informally or formally in butterfly gardens within the campus.

Table 10; Larval and nectaring plants for butterflies

Butterfly Species	**Larval Host Plants**	**Preferred Nectar Sources**
Large skipper *Ochlodes venata*	Cocks Foot *Dactylis glomerata* Brome *Brachypodium sp.* & other grasses	Thistle *Cirsium sp.* Thistle *Carduus sp.* Bramble *Rubus fruticosus agg.*
Green-veined white *Pieris napi*	Cuckoo Flower *Cardamine pratensis* Garlic Mustard *Allaria petiolata* Water Cress *Nasturtium officinale* Hedge Mustard *Sisymbrium officinale*	Cuckoo flower *Cardamine pratensis* Knapweed *Centaurea sp.* Bramble *Rubus fruticosus agg*.

Orange tip *Anthocharis cardamines*	Cuckoo Flower *Cardamine pratensis* Garlic Mustard *Allaria pertiolata* Hedge Mustard *Sisymbrium officinale*	Cuckoo Flower *Cardamine pratensis* Bugle *Ajuga reptans*
Small copper *Lycaena phlaeas*	Common Sorrel *Rumex acetosa* Sheep's Sorrel *Rumex acetosella* Knotgrass *Polygonum sp.*	Thyme *Thymus sp.* Wild Marjoram *Origanum vulgare* Common Ragwort *Senecio jacobaea* Common Fleabane *Pulicaria dysenterica*
Red admiral *Vanessa atalanta*	Common nettle *Urtica dioica*	Wild Plum *Dipsacus sylvestris* Small Scabious *Scabiosa columbaria* Field Scabious *Knautia arvensis* Thistle *Carduus sp*. Ivy *Hedera helix*
Painted lady *Vanessa carudi*	Thistle *Cirsium sp* Thistle *Carduus sp.*	Thistle *Cirsium sp.* Thistle *Carduus sp.* Small Scabious *Scabiosa columbaria* Field Scabious *Knautia arvensis* Red Clover *Trifollum pratense*
Small tortoiseshell *Aglais urticae*	Common nettle *Urtica dioica*	Goat Willow *Salix caprea* Dandelion *Teraxacum officinale* Thistle *Cirsium sp.* Thistle *Carduus sp.* Field Scabious *Knautia vensis* Knapweed *Centaurea sp*.
Peacock *Inachis io*	Common nettle *Urtica dioica* sometimes on Hop *Humulus lupulus*	Goat Willow *Salix caprea* Dandelion *Taraxacum officinale* Thistle *Centaurea sp.* Thistle *Cirsium sp.* Hemp agrimony *Eupatorium cannabinum*
Comma *Polygonia c-album*	Common nettle *Urtica dioica* Hop *Humulus lupulus* Elm *Ulmus sp*.	Goat willow *Salix caprea* Bramble *Rubus fruticosus* agg. Knapweed *Centaurea* spp. Hemp Agrimony *Eupatorium cannabinum* Thistle *Cirsium sp.*
Speckeld wood *Pararge aegeria*	Cocks Foot *Dactylis glomerata* Brome *Brachypodium sp.* Couch *Agropyron repens*	Honey-dew – aphid secretions. Common Ragwort *Senecio jacobaea* Bramble *Rubus fruticosus agg.*
Wall brown *Lasiommata mergera*	Cocks Foot *Dactylis glomerata* Tor grass *Brachypodium pinnatum* Yorkshire fog *Holcus lanatus* Meadow Grass *Poa sp.*	Hawkbit *Leontodon sp.* Cats ear *Hypochoeris radicata* Thyme *Thymus sp.* Wild Marjoram *Origanum vulgare*
Grayling *Hipparchia semele*	Bristle Bent *Agrostis curtisil* Sheeps Fescue *Festuca ovina* hair grasses e.g. *Aira* sp.	Bramble *Rubus fruticosus agg.* Bell Heather *Erica cinerea* Thyme *Thymus sp.*
Meadow brown *Maniola jurtina*	Smooth Meadow Grass *Poa pratensis* other grasses	Bramble *Rubus fruticosus agg.* Wild Privet *Ligustrum vulgare* Thistle *Cirsium sp*. Knapweed *Centaurea sp*. Wild Marjoram *Origanum vulgare*
Small heath *Coenonympha pamphilus*	Bent *Agrostis sp.* Fescue *Festuca sp.* Annual Meadow Grass *Poa annua* other grasses	not specific
Large white *Pieris brassicae*	Black mustard *Brassica sp.* Watercress *Nasturtium officinale*	not specific

Small white *Pieris rapae*	Black mustard *Brassica sp.* Mignonette *Reseda sp.* Watercress *Nasturtium officinale*	not specific

(Adapted from: Fry & Lonsdale (1991) and Rothschild & Farrell (1983)).

3.3.6 Wetland creation

Waterbodies (ponds, pools, lakes, etc) of whatever size may all be an important resource to local biodiversity. Most wildlife ponds are typically small waterbodies of shallow, still water and provide a habitat for important freshwater flora and fauna. Faunal species may live on or in the substrate, in the water column, on the surface of the water or on the surfaces of submerged plants. Invertebrates, which colonise ponds typically include species of water beetles, larvae and adults (Coleoptera), waterbugs nymphs and adults (Hemiptera), dragonfly and damselfly nymphs (Odonata), midge larvae (Diptera), and caddis larvae (Tricoptera).

Ponds also provide habitat for pond-skaters, pond-snails, bivalves, leaches, freshwater shrimp and louse as well as many microscopic organisms such as water fleas and protozoa. Additionally, vertebrates found in suitable ponds (Table 11) include a range of amphibians such as frogs, toads and newts. Ponds are also consistently used by garden birds to drink from and bathe in.

It is suggested that waterbodies could be created (Figure 2):

- Adjacent to the culverted beck beside the Theatre in the Mill, ideally connected indirectly to the beck. This waterbody could be constructed as a raised semi-formal pond.
- Within the Peace Garden.
- A larger informal core waterbody, between the JB Priestly building and Kirkstone Hall: Ideally an additional 2-3 smaller ponds could also be created within the campus.

Table 11; Pond area and likely associated species

Surface area (m^2)	**Fauna**
1	Frogs, smooth and palmate newts
4	Small dragonflies e.g. Darters, Damselflies, toads and newts
15	Other newt species
50	Large dragonflies e.g. hawkers

There are a number of core principles of wetland design and the construction of waterbodies for wildlife, which should be followed. Generally from an ecological point of view waterbodies need to be designed in the wider context of the landscape. Additionally, large numbers of wetland fauna require non-wetland habitat for part of their life cycles, e.g. dragonflies require scrub, herbaceous vegetation and sheltered clearings open to direct sunlight to forage. Water bodies are best placed close to others to facilitate colonization by new species. In general the larger the design the better, but clusters of ponds of varying design, are better than one large one for species diversity.

The second general principal is to create as diverse a structure as possible. This includes small-scale variations in horizontal and vertical profile, variation in slopes, deep and shallow water etc. Water depth and profiles are important aspects of the design. A good pond should usually be less than 1.5m deep. This protects hibernating or vulnerable species. Aquatic plants will rarely grow in depths greater than 2m and conversely many marginal plants tolerate only shallow water depths down to 30cm. Also if deeper water is created an understanding of temperature inversion and the associated changes will be required. An extended shallow edge coupled with a draw-down zone to a pond will also cater for the many emergent plant species as well as providing warm shallows for amphibians and invertebrates. Good draw-down zones can also mitigate against the effects of eutrophic conditions.

The appropriate vegetation to introduce will depend on the desired outcome for each pond, i.e. ecological or amenity; the Peace garden is likely to be more amenity orientated. In relation to wildlife ponds attention should be paid to whether the desired plants are likely to colonise the site naturally or whether a planting programme will be needed. Due to the lack of existing ponds in the vicinity of the campus, the latter option will probably be necessary. However a source of propagules (in water these will almost always be plant rather than seed) may be obtained from nearby donor sites. Additional advantages of this are the sediments, invertebrates and micro-organisms that are introduced at the same time. However there is also a distinct danger of introducing species that may take over and have to be controlled. Consequently additional ecological advice should be sought prior to undertaking such measures.

Generally pond fauna will utilize the full range of vegetation structure within a waterbody. Consequently all ponds should ensure that the waterbody contains the four plant groups as listed below. Their specific functions and roles ensure a pond ecosystem is self-sustaining with maximised biological diversity

1. Oxygenating plants: These plants produce all or most of their foliage below the water surface. They are crucial to achieving a balanced pond as they increase oxygen levels and reduce algae through competition for nutrients. They also provide cover and foraging opportunities for amphibians and other pond life.

2. Floating plants: Most floating plants are rooted on the bottom of the pond, but their leaves float on the surface. They provide shade for pond life and will help inhibit algae and duckweed through competition for nutrients and light.

3. Marginal plants: These are plants with their roots and lower stems in the water, but which carry most of their leaves and flowers, above the water. They can grow in a range of water depths and are valuable for their attractive flowers, many of which are good nectar sources. They also provide an exit route for emerging fauna, and shelter for amphibians in and out of the water.

4. Bog plants: This group contains some of the more attractive wildflowers, and is suited to areas, which are always very damp, but are not permanently waterlogged.

It is essential that native plant species and preferably plants of local provenance are used. The planting plans should seek to ensure that there is a good mixture of submerged, floating and emergent vegetation as detailed in Table 12.

It is also essential to stress that certain rampant non-native species such as floating pennywort *Hydrocotyle ranunculoides*, parrot's feather *Myriophyllum aquaticum* and New Zealand pygmyweed *Crassula helmsii,* sometimes sold as *Tillaea recurva*; rapidly-spreading floating plants such as duckweeds and water ferns *Azolla sp*. should never be introduced.

One final point to consider is the subsequent management of the vegetation within any waterbody. For aquatic weed control, digging, pulling, cutting and hoeing can be effective in removing vegetation; but these procedures are very labour intensive, so are generally unsuitable for larger water bodies. Hand pulling is often the best option for small infestations. Herbicides should not be used within wildlife ponds. In relation to health and safety with regard to any planned waterbodies within the campus any design must take current Construction Design and Management Regulations (CDM) into account.

Table 12; Recommended native pond plants.

Oxygenating plants	Floating plants	Marginal plants	Bog plants	Species to never plant
		Shallow water marginals up to 15cm		Non-native species (below) should never be introduced into semi-natural environments.
Curled pondweed *Potamogeton crispus*	Amphibious bistort *Polygonum amphibium*	Bog bean *Menyanthes trifoliata*	Bugle *Ajuga reptans*	**Parrot's feather *Myriophyllum aquaticum***
Hornwort *Ceratophyllum demersum*	Broad-leaved pondweed *Potamogeton natans*	Brooklime *Veronica beccabunga*	Globe flower *Trollius europaeus*	
Water crowfoot *Ranunculus aquatilis*	Frogbit *Hydrocharis morsus*	Lesser spearwort *Ranunculus flammula*	Lady's smock *Cardamine pratensis*	**Nuttall's waterweed *Elodea nuttallii***
Water milfoil *Myriophyllum spicatum*	Water hawthorn *Aponogeton distachyos*	Marsh marigold *Caltha palustris*	Meadowsweet *Filipendula ulmaria*	
Water starwort *Callictriche stagnalis*	Water soldier *Stratiotes aloides*	Yellow flag iris *Iris pseudacorus*	Purple loosetrife *Lythrum salicaria*	**Australian swamp stonecrop/New Zealand pigmyweed *Crassula helmsii***
Water violet *Hottonia palustris*	Fringed water lily *Nymphoides peltata*	Water plantain *Alisma plantago-aquatica*	Ragged robin *Lychnis flos-cuculi*	
Frogbit *Hydrocharis morsus-ranae*	Yellow water lily *Nuphar lutea*	Monkey flower *Mimulus guttatus*	Water avens *Geum rivale*	**Western ferns *Azolla fillculoides & A. caroliniana***
	White water lily *Nymphaea alba*	Water forget-me-not *Myosotis scorpiodes*	Water mint *Mentha aquatica*	**Floating pennywort *Hydrocotyle ranunculoides***
	Water crowfoot *Ranunculus aquatilis*	**Deep water marginals up to 30cm**		
		Common *reed Phragmites austalis*		
		Arrowhead *Sagittaria sagittifolia*		
		Burr reed *Sparganium erectum*		
		Cyperus sedge *Carex pseudocyperus*		
		Bulrush *Typha latifolia*		
		Lesser reed mace *Typha angustifolia*		
		Greater spearwort *Ranunculus lingua*		
		Flowering rush *Butomus umbellatus*		

3.4 Structural Enhancements

Structural enhancements refer to enhancements that are ultimately artificial such as bat and bird boxes. They are designed to supplement the tradition enhancements such as tree and shrub plantings by providing opportunities that may otherwise be not available to many species.

3.4.1 Bat boxes

Most modern designed bat boxes are now produced from woocdcrete, which is a formulation of wood sawdust, concrete and clay. This material allows natural respiration, a stable temperature, and is extremely long lasting being both rot and predator proof. Woodcrete also has the highest rates of occupation of all box types. There is a wide range of box designs available for trees and buildings (Tables 13 & 14); all of which have specific installation requirements. This expressly entails:

- Boxes must be sited at least 3.5 metres above ground. A box placed 4.5 – 6 metres high will potentially attract more species.
- Boxes should not be placed in an overly exposed position on trees. Crucially the entrance should face south west to south east.
- If wooden boxes are used, paint or preservatives must not be used which may discourage or kill bats if inappropriate substances are used (English Nature 2004).
- Boxes are more likely to be used if sited near to a food source (insects) such as gardens, fields, water or woodlands.
- To determine if a box is being used; checks for droppings or observations at dusk during the summer for emerging bats will indicate use.
- If the box is not used after two years, the box may be relocated to an alternative situation.
- Once discovered, a bat roost is protected by law and must not be disturbed.
- It is envisaged that bat box monitoring should be undertaken by the site management team who will require a licensed bat worker to inspect the boxes to conform with current guidance and legislation.

It is also important to stress that the high levels of lighting around the campus may have negative implications for bats. High densities of bats are often detected near white street lamps (mercury lamps) and as a consequence such street lighting may offer enhanced feeding opportunities for various species. This has proved beneficial for many species including pipistrelle bats (*Pipistrellus sp*.) that forage on invertebrates drawn to the lights. However other species, particularly long eared bats, shun bright lights. Consequently the effects of lighting on bat populations may be beneficial for some species but detrimental to others with the result culminating in an alteration in the balance of species. Additionally species that feed at lights and low flying species are more vulnerable to collisions with traffic. Generally juveniles and pregnant females form most of the casualties. Continuous streetlights may also function as a barrier inhibiting species movement and increasing habitat fragmentation. Therefore it is suggested that directional lighting is carefully designed to limit unnecessary excess illumination this applies to both existing and future lighting designs. With regard to potential health risks associated with bats, they are considered to be minimal. However as with many wild animals, if a grounded bat is discovered it is recommended that the bat is not handled and English Nature are contacted. If there is a necessity for the bat to be handled, thick gloves should always be worn.

It is envisaged that as redevelopment of the campus occurs over the longer term boxes will be considered as part of the design. In relation to the existing buildings enhancements for bats should be based on an informed opinion derived from a bat survey.

Table 13; Recommended bat boxes for trees

Model	Schwegler 2FN Bat Box	Traditional wooden box	1FW Bat Hibernation Box	Schwegler 2F Bat Box
Type	Box	Box	Box	Brick/Box
Fitting	External	External	External	External
Material	Woodcrete	Wood	Woodcrete	Woodcrete
Dimensions	Diameter: 16cm Height: 36cm Weight: 4.3kg	Width: 14cm Height: 33cm Depth: 18cm Weight: 1.8kg	Diameter: 38cm Height: 50cm Weight: 30kg	Diameter: 16cm Height: 33cm Weight: 4kg
Notes	Extremely long lasting and rot- and predator-proof box. Can be hung from a tree branch near the trunk, or fixed to a trunk. The 2FN is a large box with both a wide access slit at the base and an access hole on the underside. Particularly successful in attracting Noctule and Bechsteins bats.	A traditional softwood bat box with access slit at the base and access ladder. Wooden boxes are subject to fluctuating temperatures, so site three boxes around a tree facing different directions, in a fairly sheltered position, to provide the best choice of environments for the bats. Wooden boxes should not be painted or treated with any type of preservative, as these can harm the bats. The box can be expected to last 5-10 years.	This large box is designed to provide a protected environment, particularly through the cold winter months when bats hibernate. It has three internal wooden panels imitating crevices. This is the heaviest box so it must be fitted securely above the ground, and well away from public areas.	Can be hung from a tree branch near the trunk, or fixed to a trunk. The 2F is the most popular general purpose box, particularly attractive to the smaller British bats. A simple design with a narrow entrance slit on the front.
				

Source: http://www.alanaecology.com/

Table 14; Recommended bat boxes for buildings

Model	Schwegler 1FQ	Schwegler 1FF Bat	Schwegler N27	Schwegler No 750/6 Bat Tube	Norfolk Bat Brick
Type	Box	Box	Brick/Box	Brick/Box	Brick
Fitting	External	External	Internal	Internal	Internal
Material	Woodcrete	Woodcrete	Woodcrete	Woodcrete	Absorbent clay
Dimensions	Height: 56cm Width: 35cm Depth: 8cm Weight: 15kg	Width: 27cm Height: 43cm Weight: 8.3kg	Width: 18cm Height:29cm Depth: 23.5cm Weight: 4kg	Width: 20cm Height: 47.5cm Depth: 12.5cm Weight: 13kg	Length: 20cm Width: 10cm Depth: 7cm
Notes	A box designed specifically to be fitted on the external wall of a building. Suitable for bats as a roost or a nursery, it features a special porous coating to help maintain the ideal temperature inside, as well as a roughened front panel to enable the bats to land securely. Access into the box is via a step-like recess. The box requires no maintenance or cleaning.	The rectangular shape makes the 1FF suitable for attaching to the sides of buildings or in sites such as bridges, though it may also be used on trees. It has a narrow crevice-like internal space to attract pipistrelle and noctule bats.	Brick box designed for buildings, or underneath bridges, arches or tunnels, where conditions are relatively humid. They are particularly useful for new buildings to attract bats. This box should be cemented into a wall. It contains a single internal wooden panel which simulates a crevice. The removable front panel allows for easy cleaning.	This long box can be installed within brick masonry, beneath plasterwork or wood panelling, or incorporated into concrete structures such as factory buildings. Inside it contains a woodcrete surface, a roughened wood board, and a metal mesh, providing a choice of roosting areas. This box is maintenance free as the entrance slit is at the bottom.	Frost-proof traditional brick with a series of slits suitable for daubenton, natterer's, brown long-eared, Brandts, whiskered and barbastelle bats.
					

Source: http://www.alanaecology.com/ & http://www.norfolk-bat-group.org.uk/

3.4.2 Bird boxes

Similar to bats, bird habitats including nesting and roosting sites, are diminishing or have disappeared altogether due to changes in the landscape, environment and building techniques. Consequently the provision of boxes for birds will provide supplemental nesting sites which are relatively safe from predators, close to feeding areas, and give essential winter protection for roosting birds. A range of designs are available to suit most species including garden species, birds of prey and colonial nesting species, for trees and buildings (Tables 15 & 16). Colonial nesting species such as house sparrows, which are currently facing a dramatic decline, suffer from a lack of suitable buildings in which to nest. Moulded woodcrete boxes can be used to form a network of contiguous boxes favoured by the species. Additionally, nesting baskets can be used to encourage birds of prey to areas where they have not previously nested. Health risks from breeding birds generally relate to feral pigeons/starlings and require direct contact with nesting material, dried faeces, etc within confined spaces. Consequently the public health risk relating to encouraging nesting birds on campus is considered to be negligible.

Evidence of using nesting boxes in raising populations of some woodland birds in urban parks, suggests that it is possible to improve the species diversity of impoverished and isolated city habitats. For example, a twelve year study reported by Luniak (1992) showed that the use of nest boxes in new parks with young trees proved to be responsible for introducing 2-5 new bird species and increased the general breeding population by up to 100%. In urban parks, nest boxes increased population density rather than species number with increases of up to 60 pairs per 10 hectares being recorded (Luniak 1992). Consequently there are demonstrable benefits of using bird-boxes to increase bird species diversity in urban parks.
Bird boxes can be erected on suitable trees throughout the campus, particularly at the copse by J.B. Priestly buildings and on buildings known to attract birds. It is recommended that a bird survey is undertaken to ascertain the optimum location to erect boxes and feeding stations.

This process can be taken a step further by supplying additional food sources, using feeders and bird tables attached to the outside of buildings or creating specific feeding stations for birds. Feeding stations should be located along plantings are within the core areas of the campus.

The scope of the measures should also include the enhancement and creation of habitats. It is acknowledged that the structural development of the new plantings will in time function as a nesting resource for birds on site. Growing plants on buildings may also provide nest sites for birds. Climbing plants may be used by a variety of species to nest in, roost and foraging. Recommended plant species including both native and ornamentals are detailed in Section 3.3.1.

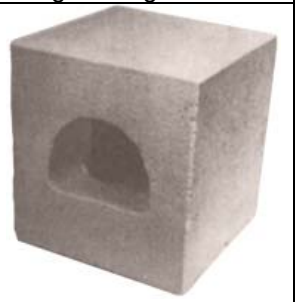
Primary considerations for breeding birds are food requirements and territory size. For example, swifts are aerial feeders and travel considerable distances to forage, so any urban site is potentially suitable for swift boxes and also house martins. Most small birds, however, do not travel far to find food, particularly in the breeding season, and therefore need a suitable food source nearby. In practice, this will usually mean trees or bushes, which attract good numbers of insects. Feeding opportunities provided by small areas of grass bring in starlings, and only a small amount of cover is required to attract songbirds such as goldfinch, blackbird and thrush. Using appropriate plants on or near buildings will encourage many more birds to inhabit even densely urbanized areas. In short, the campus subject to suitable structural and habitat enhancements may support a significant range of species.

Table 15; Recommended bird boxes for trees

Model	Schwegler 2H Open Fronted Nest Box	Nesting basket	Schwegler 1B Bird Box,	Standard nest box	Open fronted nest box	Large open fronted nest box
Notes	This box is attractive to robins, pied wagtails, spotted flycatcher, wrens, etc. Can be sited on trees or the walls of buildings with the entrance to one side.	A willow basket modelled on natural nests. It can be tied into the forks of tree branches to offer a nesting incentive in new areas. Suitable for the smaller owls and birds of prey. Site in woodland at least 5-7m high.	Suitable for a wide range of species. The box can be nailed to the trunk of a tree, or hung from a branch.	The 3.2cm entrance hole is suitable for sparrow, great tit, crested tit, nuthatch and pied flycatcher; also available with: 2.5cm hole designed to attract: blue tit, coal tit, marsh tit, treecreeper, and very small birds. 2.8cm hole designed to attract: sparrows, great tits, and crested tit.	The open fronted wooden nesting box is made to a simple fixed panel design, with access possible through the open front. Designed to attract: wagtails, robins, flycatchers, blackbirds, etc.	Designed to attract: Woodpeckers, owls, starlings, doves, pigeons, jackdaws and kestrels, together with many of the large British birds.
Material	Woodcrete	Willow basket	Woodcrete	Wood	Wood	Wood
Dimensions	n/a	Woven willow basket 40-70cm diameter	23cm high x 16cm diameter.	Size:29.5cm Height x 12.7cm Width x 14.5cm Depth	29.5cm Height x 12.7cm Width x 14.5 Depth ; Open front	52cm Height x 20.5cm Width x 19cm Depth
						

Source: http://www.alanaecology.com/

Table 16; Recommended bird boxes for buildings

Model	Schwegler N24 Nest Brick	Schwegler N25 Nest Brick	Schwegler No 18 Swift Box	Sparrow Terrace	Schwegler 9A House Martin Double Nest	Schwegler N26 Nest Brick
Notes	Designed for installation into the fabric of a building, this box is suitable for smaller birds such as tits.	Designed for installation into the fabric of a building, this box is suitable for swifts.	This nest box is suitable for fixing high under the eaves or under the guttering of a building.	House sparrows are colonial nesters and prefer to nest close to each other; this box provides room for three families under one roof. Designed for fixing to walls and buildings.	These boxes are durable and ready for immediate use when birds return each summer. Easily fixed under the eaves on the outside walls of buildings, at least 2 m from the ground. The backing board may be painted to match the building.	Designed for installation into the fabric of a building, this box is suitable for species such as pied wagtail, spotted flycatcher, etc.
Material	Woodcrete	Woodcrete	Woodcrete on board backing.	Woodcrete	Woodcrete	Woodcrete
Dimensions	Entrance hole 32mm 180mm wide x 180mm deep x 240mm high Weight 7.3kg	Entrance hole 55 x 33mm 260mm wide x 220mm deep x 180mm high Weight 8.8kg	Exterior dimensions 19 x 50 x 22cm Interior dimensions 14 x 34 x 15cm.	Dimensions 245 x 430 x 200mm. Weight 13kg.	n/a	Entrance hole 110 x 80mm Dimensions 180mm wide x 180mm deep x 200mm high Weight 5.4kg
						

Source: http://www.alanaecology.com/

3.4.3 Invertebrate boxes

The importance of invertebrates in forming the basis of most ecosystems cannot be emphasised enough. Invertebrate boxes provide over wintering sites for many species such as lacewings, ladybirds, solitary wasps, bumblebees and red mason bees, which are essential in their pollination and pest control roles within many ecosystems. The boxes detailed in Table 17; replicate many of the over wintering situations used by these species. These boxes should be used in conjunction with some of the enhancement measures specified in Section 3.3.5. For example boxes should be hung on trees or placed near supplementary enhancements as detailed in Section 3.5.

Table 17; Generic invertebrate boxes

Model	Wooden Insect House	Woodcrete Insect Nest
Notes	A good general insect habitat for beneficial insects in summer and, later, e.g. over wintering ladybirds and lacewings. Should be sited in a sheltered place near nectar/pollen plants or by a pond.	An insect nest made from, woodcrete, with holes of different sizes providing homes for a variety of beneficial insects such as bees and solitary wasps.
Dimensions	22 x 13.5 x 13.5cm	Dimensions 14 x 8 x 26cm Weight 3.65kg
Material	Wood	Woodcrete
		

Source: http://www.alanaecology.com/

3.5 Supplementary Enhancements

3.5.1 Green roofs

The term green roof can refer to either *Extensive* or *Intensive* green roofs (www.greenroofs.com). An intensive green roof is one planted ornamentally, similar to a garden and for primarily aesthetic reasons; an extensive green roof generally applies to a planted roof (usually consisting of low growing succulent e.g. *Sedum sp*.) or a roof composed of low growing drought tolerant succulent species. A deviation on the two forms of green roof listed above is a *brown roof* or *eco roof*. This particular model was developed as mitigation for the loss of brownfield sites in London. The process uses a substrate material (gravel), laid down on a flat roof and allowed to colonise naturally. These brown roofs systems can be modified to increase their positive impact on biodiversity, specifically for many of the issues associated with brownfield land. Consequently for the purpose of this document the term eco roof is used to describe an integrated green-brown roof concept. A comparison between green roofs and eco roofs is detailed in Table 18.

Table 18; A comparison between roof systems

INTENSIVE GREEN ROOF	**ECO ROOF**
Traditional and amenity role	Ecological role
Deep soil, irrigation system, more favourable conditions for plants.	Thin soil, little or no irrigation and stressful conditions for plants.
Advantages: • Allows greater diversity of plants/habitats • Good insulation properties • Can simulate a wildlife garden 'on the ground' • Can be very attractive visually • More diverse utilisation of roof, e.g. for growing food, as open space, etc.	**Advantages:** • Lightweight – roof generally does not require strengthening • Suitable for large areas • Suitable for roofs from 0º - 30º slope • Low maintenance • Often no need for irrigation / drainage system • Relatively little technical expertise needed • Often suitable for refurbishment projects • Can leave vegetation to develop spontaneously • Relatively inexpensive
Disadvantages: • Greater weight loading on roof • Need for irrigation and drainage systems (greater need for energy, water, materials, etc.) • Higher cost • More complex systems and expertise required	
	Disadvantages: • More limited choice of plants • Usually no access for recreation etc. • Unattractive and unkempt appearance, especially in winter

It is important to stress that eco roofs cannot be straight substitutes for wildlife habitats at ground level, as many animals cannot get to the rooftop and growing conditions are not suitable for all plants. However many insects and birds species will find suitable food, shelter and breeding opportunities. Eco roofs can go some way towards replacing lost open space beneath buildings roads and car parks. Invertebrates such as bees and butterflies will be attracted to nectar sources on a roof garden. The soil will provide a habitat for spiders, earthworms, beetles and

ants. Roof vegetation is usually subjected to fewer disturbances than an equivalent space on the ground, which may be an important factor to breeding birds susceptible to human disturbance.

Within the wider development of the University campus the opportunities to incorporate eco roofs should be given due consideration. Additionally the possibility of retro-fitting existing buildings may also ameliorate adverse impacts on biodiversity within the campus. From a technical and functional aspect, the following points need to be factored into any potential eco roof design:

- layers for waterproofing and to facilitate drainage;
- load-bearing implications;
- irrigation and
- maintenance costs.

Any eco roof should incorporate areas of gravel, which will in part, function in a similar manner to a brown roof concept. In general irrigation may only be required initially for an eco roof, to ensure the successful establishment of the vegetation. Generally maintenance requirements for eco roofs are low, consisting of occasional inspections. Specifically this may involve the annual inspection of the roof to ensure problematic species such as trees or shrubs, which may impact on the underlying membranes, are eradicated.

Any future eco roof on the campus may have a multi-functional role by integrating the designed amenity aspects and ecological elements within the roof space. A sympathetic approach to planting can also be undertaken incorporating native plants and/or wildlife friendly exotic species. When choosing appropriate plants for an eco roof, the growth habit and cultivation requirements should be considered.

Growth habit considerations include:

- low growing – generally less than 60cm;
- establish a dense root layer and stabilise substrate;
- capable of regenerating after periods of stress;
- able to form resilient, permanent cover;
- strongly rooted – particularly for steeply angled roofs;
- drought resistant characteristics such as thick protection layers, a strong system of veins, and good water storage capacity;

Cultivation considerations include:

- tolerant of thin soils and drought;
- compete well on nutrient-poor soils;
- prefer free-draining soils;
- survive periods of waterlogging.

Other considerations include:

- attempt to replicate natural habitats such as waste ground, gravel/sand pits, walls and other hard surfaces, dry grassland, heathland and rocky outcrops;
- position and height of the roof;
- species should also be tolerant of prevailing climatic conditions;
- visually attractive with many blooms, good colour and scent to attract invertebrates;
- mixture of structural diversity, i.e. blend of low and taller plants, deciduous and evergreen;
- predominance of native species.

On a separate tangent the long term monitoring or contrasting of green roofs and eco roofs across the campus in terms of their biodiversity interest, may provide both under graduate and post graduate students with research opportunities.

3.5.2 Smaller Scale Plantings

Smaller scale plantings, such as within courtyards, should endeavour to resemble niche habitats. For example native ferns and other plants which thrive in low light (e.g. ivy, holly, and a variety of grasses and mosses) can be used. Species should be chosen according to moisture and sunlight availability but also with regard to their wildlife value. Many grasses will offer cover and breeding places for invertebrates as well as food for some birds. More open but sheltered courtyards are particularly suitable for colourful plants that thrive in full sun. These can function as bee and butterfly gardens, supplying a rich source of nectar from spring to autumn. Shrubs such as buddleia, broom *Cytisus scoparius*, lavender *Lavendula sp*. and gorse *Ulex europaeus*, and herbs such as willowherb *Epiloobium sp.,* michaelmas daisy *Aster sp.*, soapwort, mullein *Verbascum sp*. and thyme Thymus vulgaris all enjoy a sunny position and provide significant nectaring resources for invertebrates.

3.5.3 Green Walls

The use of climbing plants to enhance design and aesthetic elements is generally an accepted practise. The process of allowing and encouraging plants to grow on and up walls allows the natural environment to be extended into urban areas. Indeed the natural faces of cliff and rock slopes are often simulated by brick and concrete ledges and cavities. From an ecological perspective green walls can provide resting and feeding places for birds, invertebrates and even small mammals. Climbers provide nesting habitat for birds such as wrens, blackbirds, song thrushes and house sparrows. Species such as cotoneaster, ivy, climbing roses and honeysuckles are all important fruit resources for birds. Equally climbing plants like Virginia creeper and ivy form important habitats for invertebrates. Although native species are more likely to attract wildlife, some exotic species are also effective in this respect. Within the campus it may be more productive to use a combination of native and exotic species to maximise the range of annual and perennial, deciduous and evergreen, foliage and flowering, climbing and creeping species. Table 19 provides a selection plants suitable for green walls.

The aspect of a climbing plant on a wall can have significant ancillary effects such as insulation and moisture retention. For example north facing walls are more suitable for supporting native herbs and a wider range of plants. This is due to the higher moisture regime. Further structural benefits of the space between the wall and the climbing plants include pockets to collect leaf litter and provide nesting sites, and baffles to trap rising warm air.

Table 19; Climbing plants suitable for green walls

Species	Growth habit* D deciduous E evergreen A annual	Aspect (Bold =preferred)	Max height (M)	Wildlife value
Native species				
Ivy *Hedera helix*	Self clinging climber (E)	**N** E S W	30	Good nesting site for small birds, and hibernating invertebrates e.g. butterflies. Nectar and pollen for bees and hoverflies.
Honeysuckle *Lonicera periclymenum*	Twining climber (D)	**E** S **W**	5	Excellent for insects, especially moths, due to night-scented flowers. Bark from older stems used by nesting birds. Berries eaten by birds.
Old Man's Beard *Clematis vitalba*	Twining climber (D)	E S W	10	Seeds for birds & nesting sites. Nectar for insects.
Common Hop *Humulus Iupulus*	Twining climber (D)	**E** S **W**	6	Good for bees
Bramble *Rubus fruiticosus*	Rambling shrub (D)	N E S W		Provides pollen for bees and nectar for bees and butterflies. Berries for birds and small mammals, night-scented and attracts moths
Dogrose *Rosa canina*	Rambling shrub (D)	E **S** W	3	Night-scented for moths. Nectar for insects, rosehips for birds and small mammals. Good nesting cover for birds.
Exotic species				
Virginia Creeper *Parthenocissus quinquefolia*	Self clinging climber (D)	N **E** S W	15	Useful for nesting birds if grown on a trellis. Provides nectar and pollen for bees.
Boston Ivy *Parthenocissus tricuspidata*	Self clinging climber (D)	N **E** S W	15	As above
Climbing Hydrangea *Hydrangea petiolaris*	Self clinging climber (D)	**N E W**	15	Good for nesting birds and produces nectar for bees and other insects.
Jasmine *Jasminum officinale*	Twining climber (D)	**E W**	9	Night-scented, attracting moths and other night-flying insects
Vine *Vitis sp.*	Twining climber (D)	E **S** W	20	Provides fruit for birds and nectar and pollen for bees.
Wisteria *Wisteria sp.*	Twining climber (D)	E **S W**	18	Excellent nectar and pollen for bees. Can be used by nesting birds.
Passion Flower *Passiflora caerulea*	Twining climber (D)	E **S W**	8	Nectar and pollen for bees.
Nasturtium *Tropaeolum spp.*	Twining climber (A)	E **S** W	2	Nectar/pollen for bees and beetles. Seeds eaten by birds and small mammals. Food plant of small and large white butterflies
Climbing rose Rosa sp.	Rambling shrub (D)	E **S** W	5	Excellent nectar for bees. Nesting sites for birds.
Forsythia *Forsythia suspensa*	Rambling shrub (D)	N E **S** W	4	Nesting sites for birds, as above.
Cotoneaster sp	Rambling shrub (E)	**N E**	3-6	Thick growth may be used by nesting blackbirds and thrushes. Berries for birds, especially blackbirds and small mammals. Nectar and pollen for bees.
Firethorn *Pyracantha atalantiodes*	Rambling shrub (E)	**E** S W	5	Good for nesting birds e.g. thrushes, and provides nectar and pollen for bees and berries for birds, particularly blackbirds.

*(Habits: Self clinging refers to self supporting species; Twining refers to where support is required e.g. wires, trellis etc; Rambling shrubs refers to non climbing plants which can be trained along wires etc.)

3.5.4 Japanese knotweed

The confirmed presence of Japanese knotweed around the University Estates office is significant and requires immediate action to prevent further contamination (Figure 2). Japanese knotweed was introduced to UK gardens in the nineteenth century, where it later escaped and rapidly established itself within the wider environment. Its capacity to colonise new areas relates to its ability to self-propagate from tiny pieces of stem/rhizome weighing as little as 0.7g. Consequently the regenerative qualities and its dense clump forming growth habit ensure the plants justified reputation as a highly invasive species. Economically the rhizomes can penetrate beneath hardstanding undermining structures and damaging drains.

The legislation governing the control of Japanese Knotweed is particularly onerous. Under Schedule 9, Part II of the Wildlife and Countryside Act 1981 (as amended), it is an offence to "*plant or otherwise cause to grow in the wild any plant which is included in Part II of Schedule 9".* Additionally, the Environment Protection Act (EPA) 1990, & Duty of Care Regulations 1991, state that cut knotweed material and soil containing rhizomes must be disposed of as a controlled waste if it is to be removed from the site of origin. It is normally necessary to discuss and agree treatment proposals with the Environment Agency. The legislation relates to causing it to spread, however if the stands are left intact and not interfered with there is no legal obligation to control Japanese knotweed. However from an ecological and structural point of view, the weed will continue to increase and will eventually present a larger problem to deal with.
In relation to Japanese knotweed the Environment Agency recommends that soil 7m from a stand/individual plant and to a depth of 3m should be considered as contaminated and consequently treated. Therefore the actual area of contamination and subsequent treatment is significantly larger than the actual plant area. These specifications are indicative and are derived from guidance produced by the Environment agency.

In general there are three accepted methods for the treatment and eradication of Japanese knotweed on site. Two methods are based on treating on site, whilst the third method involves off site disposal. It is also possible to combine some of the treatments as part of an eradication strategy. It is important to emphasise that the three options listed below only summarise each of the principal treatments. They are not exhaustive in terms of the procedures or methodologies.

- Off site disposal - disposal at an approved landfill site. The procedure would require the excavation, transportation and disposal at an approved landfill site and finally the backfilling of the excavations with clean imported material. This is by far the most expensive option entailing transportation and landfill costs.

- On site disposal – disposal within the site by burying. This loosely involves removing all contaminated material and burying underground. Ideally, at least one application of non-persistent herbicide will have been applied to reduce the vigour of the in-situ plants. As stated, soil to a depth of at least 3m and within a perimeter of at least 7m of the plant growth area should be excavated for burial. On site burial must be performed to a depth of at least 5m. The potentially viable knotweed material should then be covered with a geotextile layer prior to back filling.

- Herbicide treatment - Chemical control can potentially take from twelve months to three years to totally eradicate; however this is dependent on the extent of infestation, rhizome viability, environmental parameters and herbicide selection. The most effective time to apply herbicide is from July to September when foliage biomass is at the greatest. Equally spring treatment is acceptable, but less effective. Restriction on herbicide use can apply in certain circumstances, e.g. proximity to watercourses.

On balance it is recommended that the Japanese knotweed in the campus is controlled by systematic and targeted herbicide application. The affected areas should be fenced off to ensure clear demarcation of the contaminated areas. This will undoubtedly mean that in some areas planted vegetation will be lost but the ecological benefits will be considerable in terms of

enhancing biodiversity. Additional advice should be sought with regard to the eradication of Japanese knotweed in relation to specific treatments and methods of control.

4.0 ADDITIONAL ENHANCEMENT MEASURES

This section deals with management practices which will collectively enhance the quality of existing and future habitats on site. Control of undesirable species through not chemical methods and the efficient recycling or green waste; in their own way reduce potential negative impacts on biodiversity. Additionally recommendations are specifically detailed for the Peace Garden and the formulation of a Campus wide Biodiversity action Plan.

4.1 Sustainable Composts

Traditionally peat has been used for soil improvement and ground mulching but other materials are better suited to these tasks than peat. The continued practice of using peat for the horticultural industry is depleting a finite reserve of peat and more crucially destroying many habitats which cannot be replicated. Soil can be improved by incorporating composted plant remains which can also be used for mulching, along with wood chips, wood shavings, bark and other materials.

It is worth pointing out that by supporting the development of local environmentally friendly peat alternatives, as an alternative to foreign or UK peat extraction, a number of UK industries (e.g. forestry, water, composting etc) are also benefiting as are peat bog habitats across Europe. The wider environmental impacts of transport are also reduced which indirectly contributes to the overall sustainability of the University campus.

The maintenance of appropriate levels of nutrients in soil is essential for plant growth. In turn this provides opportunities for invertebrates and their predators. Bulky organic compost is a major source of humus, which is vital in the development of soil structure and in moisture and nutrient retention. It also ensures a great many soil-inhabiting organisms which are prominent in many food chains.

There are generally two accepted methods for the production of compost:

1. Aerobic method; the aerobic process encourages the natural development of decay organisms by a free flow of air and water within the heap, which is facilitated by regular turning of the compost material. During the process, heat is generated which may be sufficient to kill some weed seeds and disease organisms. Compost made by this method is an odourless, dark brown, crumbly material, and it can be available within three to six months, according to the time of year.

2. Anaerobic method; the anaerobic method is achieved without free flow of air and water. This may simply be by means of an unturned, uncovered heap, or by using proprietary sealed compost making bins or plastic sacks to contain the waste. The production of good-quality compost by this method is a much slower process than by the aerobic method. The product is less easily managed and weed seeds are also likely to survive.

Most plant remains can be composted, with the exception of any parts of injurious weeds such as Japanese knotweed. Vegetation treated with selective herbicides should also not be composted. Grass mowings provide a useful activator but must be added in loose layers and not compacted. Woody prunings can be composted after chipping or shredding. Fallen leaves can be composted satisfactorily when added to other materials, or they can be made into leafmould in separate containers. Avoid all materials which will not decompose, such as glass, metal, stones, plastic, glossy paper, thick card and man-made fabrics. Animal faeces, e.g. cat/dog excrement should never be added, nor should any food items, as there is a potential health risk. These materials are only suitable for commercial large scale digester plants.

It is also recommended that green materials with high carbon to nitrogen ratios are composted or used for mulching purposes. For example wood chippings have a high carbon to nitrogen ratio and consequently they are more suitable for use in ecologically sensitive areas, where species

are sensitive to nutrient levels. As a rule, for certain established habitats the addition of any compost or mulch should be considered very carefully.

An alternative option to the traditional composting bin, is a wormery. Brandling worms, *Eisenia sp*. will accumulate naturally in a compost heap that is in contact with the soil. Brandling worms both aid the composting process and increase the quality of the compost. Wormeries are smaller, purpose-built, enclosed containers into which kitchen and plant waste can be placed to be digested by the worms, which are introduced in small numbers initially. The unit is a self-contained system, which will quickly build up a larger worm population, able to convert food waste into high quality soil conditioner, usually with the added bonus of a liquid run-off which is ideal as a concentrated liquid feed for ornamental garden plants or pot plants.

4.2 Pesticides & Herbicides

Excessive use of pesticides (including herbicides) has been cited as one of the potential causes of the decline of certain faunal species, especially birds and hedgehogs. Concern for the use of pesticides generally is based around three issues:

- They directly reduce food availability such as insects, which are eaten by birds and many other animals.
- They are often indiscriminate in their affects, killing beneficial insects such as ladybirds along with the pest.
- Pesticides can sometimes enter the food chain, with disastrous results. For example, ants treated with ant-killer have been known to poison nestling green woodpeckers.

It is the often the indirect effects on non-target species which are cumulatively detrimental to ecosystems. In relation to species groups these effects can manifest themselves in many ways:

- Invertebrates can be affected by the removal of food plants or destruction of vegetative cover, particularly important for over-winter survival.
- Birds and mammals can be affected by reduced availability of food plants (foliage, seeds, fruit) and animal prey, and loss of nesting habitat.

Additionally, there are many knock on effects of pesticides such as the selective removal of certain plant species, which may also result in changes to the floral composition of a habitat. Eliminating, inhibiting or reducing the population of one (or a group of) species will indirectly result in enhanced competitive ability in other species. The species that subsequently thrive as a result of removal of competitors or an altered microclimate will not always be desirable species. Consequently the likely result of significant pesticide use within sensitive habitats is degradation of the ecological value of a site.

However, it is important to acknowledge that herbicides may offer a necessary alternative at times and may frequently form a component of any management programme. There are situations in which the use of herbicides may be considered essential, such as in the control of injurious weeds. In such cases, an integrated approach, involving both chemical and non-chemical methods is preferential. Any herbicide use should comply with the Control of Pesticide Regulations 1986 (COPR) and appropriate risk assessments including the Control of Substances Hazardous to Health Regulations (COSHH) 1994.

Alternative methods for the University grounds maintenance staff to instead use of chemical pesticides include:

- Environmental control: Environmental and cultural control measures tend to be used as part of an integrated control programme, rather than in isolation. Cultural methods might include use of mulches or competitive plant species, such as ground cover plantings. Mulches such as wood and bark chippings are ideal in suppressing undesirable species. In relation to aquatic habitats, water depth and velocity can be altered to reduce nutrient levels, which can control vegetation growth. Raising water levels after cutting invasive

species or dredging for example, can increase water depth and prevent immediate re-growth, which can also be an effective method of control.

- Mechanical control: Methods that remove roots, or starve roots of nutrients, are to be preferred to those that encourage coppice type re-growth. Methods can include removal by hand (e.g. pulling, levering, digging, cutting and raking) or by machine (e.g. pulling, bruising, crushing, strimming or mowing). The obvious advantages of hand weeding control, is that it allows selective removal of vegetation. However it may be resource intensive in terms of labour and expense. Frequent mowing and cutting of plants can lead to reduced growth, but non-flowering vegetative plants can take several years to kill, due to their sizeable root reserves.

- Heat control: Flame guns are effectively a portable butane gas burner, which is particularly effective in controlling annual weeds. Consequently perennial weeds may require repeated applications. Infra-red control is now an option which has been widely used in countries such as Holland. It uses less energy than a flame gun and exposes plants to a stream of radiated heat. It is suitable for use in sensitive sites, as there is no disturbance to soil and control is not weather-dependent. As with flame guns there is limited penetration below ground, so re-growth may occur from deep-rooted species, requiring re-treatment. Hot foam weed control technique using a biodegradable organic foam applied from a specially developed machine is currently being trialled for weed control on a range of habitats including within aquatic environments.

4.3 Peace Garden

The proposed Peace Garden will be developed on the south facing aspect of A Wing of the Horton Building (Figure 2). As the area is situated contiguously to Great Horton Road, which is a busy road in terms of vehicular and pedestrian traffic, it is recommended that screening is erected between the garden and the road. The future plans of the University include an eventual downgrading of the road and reduction of traffic, but the current level of disturbance is likely to continue for the short to medium term. It is generally acknowledged that attracting invertebrates into areas with high vehicular traffic is not acceptable, due to the increased mortality associated with collisions. Hence the rationale for screening; with the aim of compartmentalising the Peace Garden where invertebrates may continue to forage and are subsequently dispersed through considered routes e.g. along Richmond Road. Additionally hedging or screening should generally encourage flying invertebrates to cross roads at a greater height, i.e. above the level of the traffic. Shrubby species such as Pyracantha, Berberis and Cotoneaster are all suitable as hedge plants. Us of the ornamental shrubs in Table 20 should eventually provide cover and enhance the microclimate within the Peace Garden by screening and filtering external disturbances.

It is envisaged that in this instance shrubby and herbaceous ornamental species should form the bulk of the plantings. The choice of plants in Tables 20 & 21 reflect the southerly aspect of the site, general higher tolerance of urban environmental conditions and enhanced nectaring opportunities for invertebrates. Enhancement should focus on the provision of resources for invertebrates particularly through using fleabane *Erigeron sp.*, cosmos *Cosmos bipinnatus*, honesty *Lunaria rediviva*, sweet William *Dianthus barbatus*, tobacco plant *Nicotiana affinis*, cornflower , *Centaurea montana* bistort *Persicaria amplexicaulis* , bergamot *Monarda didyma* and bellflower *Campanula sp.*, which are significant both for butterflies and bees. The creation of a water body should also enhance the immediate area providing opportunities for aquatic invertebrates (refer to Section 3.3.6 for enhancement measures). It is important to emphasise that vegetation should need to be planted densely to provide sufficient covering.

Table 20; Ornamental shrubs for nectar, pollen and fruit

Serviceberry *Amelanchier canadensis*
Butterfly bush *Buddleja davidii*
Japanese quince *Chaenomeles japonica*
Creeping cotoneaster *Cotoneaster frigidus*
Variegated cotoneaster *Cotoneaster horizontalis*
Mahonia *Mahonia sp.*
Mock orange *Philadelphus sp.*
Firethorn *Pyracantha coccinea*
Lilac *Syringa vulgaris*
Bodant viburnum *Viburnum bodnantense*
Laurustinus *Viburnum tinus*

Table 21; Cultivated herbaceous plants for borders

Grecian windflower *Anemone blada*	Oxeye daisy *Leucanthemum vulgare*
Angelica *Angelica archangelica*	Primrose *Primula vulgaris*
Aubretia *Aubretia deltoidea*	Red campion *Silene dioica*
California poppy *Eschscholtzia californica*	Red deadnettle *Lamium purpureum*
Candytuft *Iberis sempervirens*	Snowdrop *Galanthus nivalis*
Christmas rose *Helleborus niger*	Spiked speedwell *Veronica spicata*
Cosmos *Cosmos bipinnatus*	Tansy *Tanacetum vulgare*
Evening primrose *Oenothera biennis*	Teasel *Dipsacus fullonum*
Fleabane *Erigeron sp.*	Toadflax *Linaria vulgaris*
Forget-me-not *Myosotis sp.*	White campion *Silene alba*
French marigold *Tagetes sp.*	White dead-nettle *Lamium album*
Globe thistle *Echinops ritro*	Wild thyme *Thymus drucei*
Grape hyacinth *Muscari botryodes*	Yellow loosestrife *Lysimachia vulgaris*
Hollyhock *Althaea rosea*	Sweet alyssum *Lobularia maritima*
Honesty *Lunaria rediviva*	Sweet bergamot *Monarda didyma*
Ice plant *Sedum spectabile*	Sweet William *Dianthus barbatus*
Lenten rose *Helleborus orientalis*	Tobacco plant *Nicotiana affinis*
Tree mallow *Lavatera sp*.	Wallflower *Cheiranthus cheiri*
Michaelmas daisy *Aster sp.*	White arabis (single) *Arabis alpina*
Mint *Mentha rotundilfolia*	Winter aconite *Eranthis hyemalis*
Perennial cornflower *Centaurea montana*	Yellow alyssum *Alyssum saxatile*
Perennial sunflower *Helianthus decapetalus*	Herb-robert *Geranium robertianum*
Phlox *Phlox paniculata*	Lady's bedstraw *Galium verum*
Poached-egg plant *Limnanthes douglasii*	Red valerian *Centranthus ruber*
Snapdragon *Antirrhinum majus*	Meadow cranesbill *Geranium pratense*
Common mallow *Malva sylvestris*	Marjoram *Origanum vulgare*
Spring crocus *Crocus chrysanthus* and hybrids	Bistort Persicaria amplexicaulis
Bergamot *Monarda didyma*	Bellflower *Campanula sp.*

Additional considerations include planting groups or drifts of each plant so that the colour or scent is easy to detect. Individual specimens may be difficult for invertebrates to find. The final choice of plants should endeavour to maintain a flowering period for as long as possible through the season. In spring nectar rich plants are important for early emerging bumblebees whilst in autumn a nectar rich source is important for over wintering species.

Generally single flowers, (as opposed to double flowers which tend to be sterile and have no nectar or pollen), are preferential as the pollen also tends to be more accessible to short tongue species. High nectar flowers also attract nocturnal feeding species such as moths, which in turn,

can provide food for bats.

4.4 Campus Biodiversity Action Plan

The previous section of the document relate to various forms of enhancements in terms of habitats, structural and management. It is important that a management plan is formulated to action and ensure implementation of the enhancements. However the creation of a Biodiversity Action Plan (BAP) will allow specific species to be targeted to increase their sustainability within the campus. Crucially it also provides a process of measuring the success of any enhancement in achieving a positive biodiversity gain.

All BAPs are designed to help translate national and regional targets for biodiversity and sustainability into local action. In general a BAP should contain an overview of biodiversity nationally and locally and a specific action plan for targeted species and habitats at the scale at which the plan is produced.

It should include an explanation of what biodiversity is, why it is important, and what is currently being done to conserve it. By following the five principles detailed below, the development of the BAP can be achieved comprehensively:

1. The initial phase of producing a BAP should entail data gathering through specific species and habitat surveys such as bat, birds, invertebrates etc. Once such an inventory has been established the next step is to prioritise and identify which habitats and species need management. Consequently it is recommended that species specific surveys are undertaken to determine the baseline situation; recommended surveys include bats, birds and invertebrates.
2. Within the BAP specific aims and objectives for the biodiversity on the campus can be identified in relation to such criteria as legal obligations, the Local BAP (Bradford) etc. Targets and deadlines including actions and timings should be clearly set out within the plan. Crucially indicators relating to the BAP process and related to the biodiversity objectives should be set out.
3. Implementation of the BAP could be executed within the University's over all Ecoverity Plan or within a specific ecological management plan.
4. Monitoring against the indicators above should be undertaken to record actions and targets achieved. This should also entail recording new and additional data such as habitats and species, which should be eventually incorporated into the BAP.
5. Finally a reviewing and reporting stage should inform all interested parties, including , if any external stakeholders/sponsors such as local industry.

The site based BAP such as for the campus should be designed to be a starting point for an ongoing and essentially practical process of contributing to biodiversity. The process should entail regular monitoring and reports on findings and achievements. Once established, the campus BAP is open to the possibility of introducing further species and habitat action plans on an ongoing basis. In particular, the listing of species below (Table 22), should not be regarded as either exhaustive or including all species with priority needs either now or in the future. The species suggested are examples of target species which the University BAP could target.

Table 22; Suggested and indicative species for the University campus BAP

Plants - Grasslands
Oxeye daisy *Leucanthemum vulgare* Attractive brightly coloured daisy and useful foraging for insects. Buttercups *Ranunculus sp.* Bulbous buttercup An early flowering buttercup, grows in less intensively managed lawns. Meadow buttercup grows in areas of longer grass. Lady's bedstraw *Galium verum* Generally occurs in established grasslands.
Species - Invertebrates
Dragonflies and damselflies *Odonata sp.* Very popular flag ship species requiring medium to large sunny open ponds, without fish, which shelve gently and have appropriate marginal planting. Meadow brown butterfly *Maniola jurtina* Typical of areas of long grassland, provided mowing regime takes account of overwintering stages. Small Tortoiseshell Butterfly *Aglais urticae* Relies on large sunny nettle patches for caterpillars to forage on. The adult butterfly feeds on many amenity species including ice plant, lavender, hebe, field scabious and aubretia. Six spot burnet moth *Zygaena filipendula* Colourful day-flying moth found in longer grassland. Ladybirds *Coccinellidae* Obvious threats include excessive pesticide use and destruction of hibernation sites. Bumble bees *Bombus sp.* Found foraging for nectar in flowerbeds. Interest and popularity has increased dramatically with this species group and are worthy of consideration within any University BAP.
Species - Birds
Song thrush *Turdus philomenos* National BAP species, in serious decline both nationally and regionally and consequently could comfortably nestle within the University BAP. House sparrow *Passer domesticus* The sparrow was once a familiar sight in urban parks, but now is in decline. Wren *Troglodytes Troglodytes* Found in shrubby corners of even the most central urban areas. Blackbird *Turdus merula* Thrives in low dense shrubs and lawns. Great tit *Parus major* Found in urban parks and gardens with a diversity of small and large trees.
Species - Vertebrates

Common frog *Rana emporaria*
Their main requirements are sunny ponds for breeding, damp cover for foraging and undisturbed hibernacula.

Hedgehog *Erinaceus europaeus*
Relict populations remain in urban parks, but generally thought to be declining. Threats include road traffic, steep-sided ponds, and the consumption of slugs poisoned with slug pellets.

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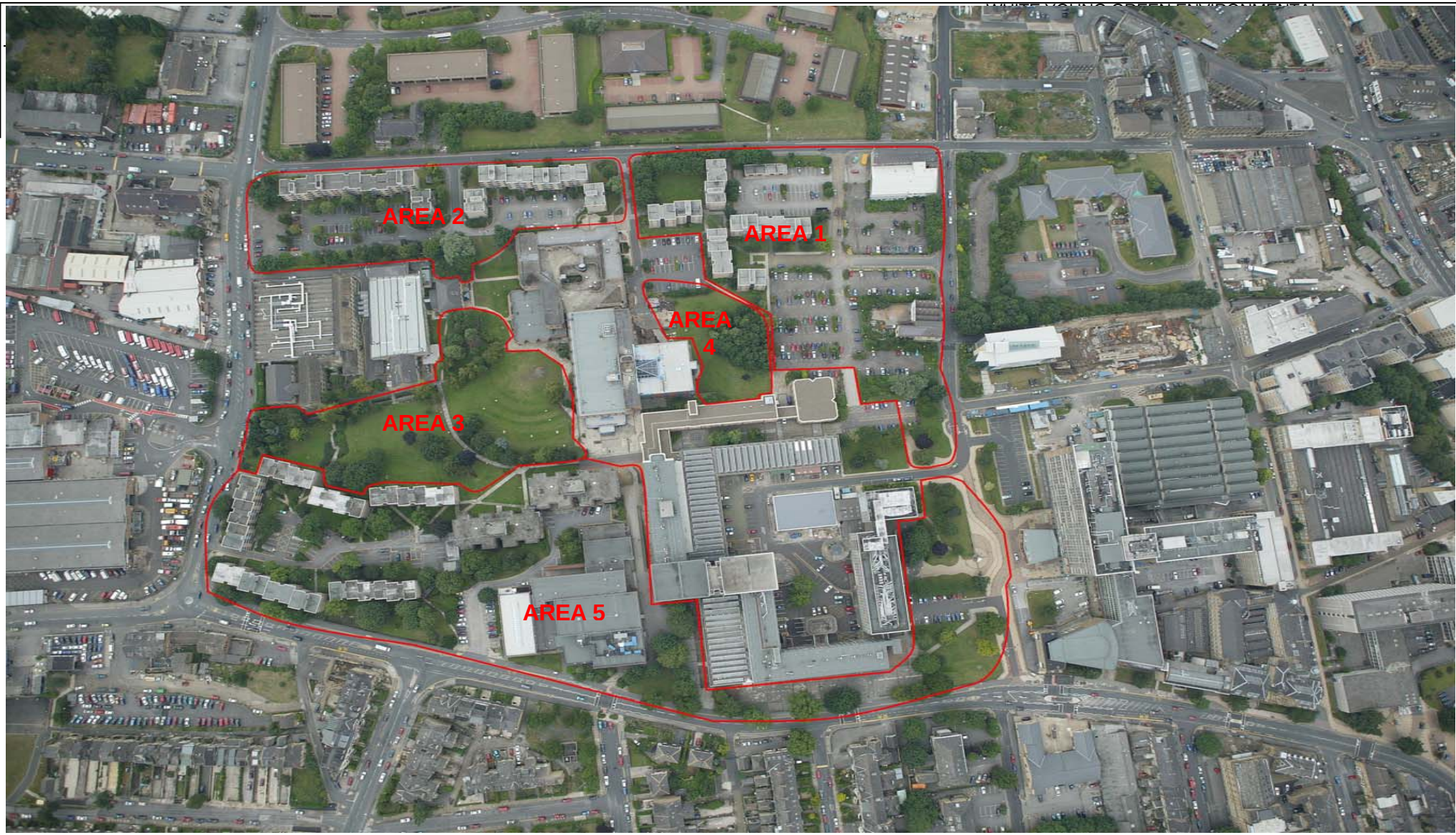
www.wildlifetrust.org.uk
County Wildlife Trusts

APPENDIX A

DRAWINGS



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White Young Green

Ecolo

1

Project
City Campus Ecological Enhancement Report

Client
University of Bradford

Site Address
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NGR: SE153327

Drawing Title **Figure No. 1**
Indicative Locations of Survey Areas

Project No. E 7362 | Scale at n/a (Image Source: University of Bradford)

Checked By RC Approved By DW

Office 4106 Type Env Approval ☐ Information ☑

APPENDIX B

REPORT CONDITIONS

WHITE YOUNG GREEN ENVIRONMENTAL

REPORT CONDITIONS

CITY CAMPUS ECOLOGICAL ENHANCEMENTS REPORT

UNIVERSITY OF BRADFORD

This report is produced solely for the benefit of The University of Bradford and no liability is accepted for any reliance placed on it by any other party unless specifically agreed in writing otherwise.

This report refers, within the limitations stated, to the condition of the site at the time of the inspections. No warranty is given as to the possibility of future changes in the condition of the site.

This report is based on a visual site inspection, reference to accessible referenced historical records, information supplied by those parties referenced in the text and discussions with local, Statutory and Non-Statutory Authorities. Some of the opinions are based on unconfirmed data and information and are presented as the best that can be obtained without further extensive research.

Whilst confident in the findings detailed within this report because there are no exact UK definitions of these matters, being subject to risk analysis, we are unable to give categoric assurances that they will be accepted by Authorities or Funds etc. without question as such bodies often have unpublished, more stringent objectives. This report is prepared for the proposed uses stated in the report and should not be used in a different context without reference to WYGE. In time improved practices or amended legislation may necessitate a re-assessment.