UNIVERSITY of York

ECOLOGICAL MANAGEMENT PLAN

Ecological Management Plan

It is now over a decade since the development of Campus East was initiated. In 2011 following the completion of the first phase of development a baseline ecological survey was undertaken to gauge how successful habitat creation efforts had been. Since then however there have been no other extensive surveys carried out and as such there is no full picture as to how successful the ecological management of the site has been in terms of habitat improvement and increases or changes in biodiversity. Nearly a decade on it would be useful and interesting to undertake a fresh and extensive survey to determine these factors and help inform future management. The University is now a corporate member of the Yorkshire Wildlife Trust and there may well be the potential to ask the Wildlife Trust to assist the University in this regard.

Notwithstanding this, there is ample visual evidence of both flora and fauna that is either colonising or visiting the campus and it is not unreasonable to now claim the campus constitutes a significant wetland habitat within the Vale of York and has a regional conservation significance. Moreover, with the passage of time and as the landscape evolves this becomes more and more the case.

The fundamental aims of improving and broadening habitat and thus by doing so increasing biodiversity remain exactly the same, but periodically it becomes necessary to re-visit management plans in the light of results and progress to date to understand what has worked and what might additionally be done.

The University's new Heslington East development is approximately 120 Hectares in size. Almost half of this area is designated as peripheral landscape and as such offers a huge opportunity for the creation of a range of diverse habitats to encourage biodiversity.

One of the mandates on the University whilst developing Heslington East was to increase the biodiversity of the site. On the face of it, this seemed relatively easy to achieve, given that the land used to be intensively farmed arable land. Nonetheless, important well established habitats existed on the land and it was important to preserve and enhance these where possible.

The scale of Heslington East will mean that a substantial proportion of the peripheral landscape will see low intervention management. This however should dovetail well with enhancing biodiversity, as most habitats will benefit from being less well manicured.

Following the completion of phase 1 of the development , the University commissioned a baseline ecological survey both to obtain information on the existing biodiversity of the site and to gauge how successful habitat creation efforts have been to date.

Over Arching Management Principles

- Do not inadvertently destroy existing valuable habitats
- Give preference to native species of local provenance. For example, the Tansy Beetle now has a very limited range along the Ouse. Planting wild Tansy in wetland areas on Heslington East could provide an extended habitat for the beetle
- Create a mosaic of different habitats that will provide a range of habitats for more species. For example, woodland areas should contain a range of trees, have glades and contain dead wood in the form of nature sticks or log piles.
- Link Habitats to enable species movement between them
- Time management operations carefully to reduce impacts on species that may be feeding/breeding or hibernating.
- Think about pest control – can a chemical control be substituted with a cultural control. Reduce chemical usage generally
- Compost green waste
- Keep management intervention to a minimum. Do not over manage and in doing so reduce habitat potential
- Consult the UK Biodiversity Action Plan and specifically the Local Biodiversity Action Plan to inform which habitats and species should form the focus of habitat creation measures.

↓ Humming Bird Moth

↑ Hares on Campus East

Existing Habitats

HEDGEROWS

Many hedgerows were lost on Heslington East as a consequence of site development, however to compensate for this the following principles were adopted:

- Where hedgerows have been lost there will be compensation in the planting of additional locally appropriate native trees and shrubs
- Hedgerows around the perimeter of the site will be reinforced and diversified
- Where possible, existing hedgerows will be incorporated within the design of the infrastructure

Existing hedgerows were surveyed in September 2011 as part of the ecological baseline survey. The Low Lane hedge qualifies as a hedge of importance under the 1997 Hedgerow regulations and offers a good potential for habitat enhancement by

- Allowing the hedge to broaden
- Planting additional native tree and shrub species
- Adding nest boxes and Bat roosting boxes to the mature trees contained therein

When surveyed, the Low Lane hedgerow contained 23 species of tree and shrub. Species appear to have been added at different dates and this together with current management has allowed the development of a range of different height structures and enhanced species diversity. As such the hedgerow constitutes a high conservation value and important habitat resource which will be maintained by careful future management.

- Existing hedgerows will be retained where possible and restored so that they are rich in woody species but dominated by Hawthorn
- New Species rich hedgerows will be planted along suitable parts of the site boundary lacking existing hedgerows
- The dense habitat of hedgerows will provide valuable nesting habitat. Species that have already been observed within the baseline ecological survey and the Winter bird surveys carried out by the consultant Ornithologist include, Redwing, Mistle Thrush, Goldfinch, Bullfinch, Tree Sparrow, and Yellow Hammer
- Hedges will act as wildlife corridors, in particular linking patches of woodland and are likely to be used by feeding bats, feeding Barn Owls, small mammals including Hedgehogs.

Figure 1 **Male Bullfinch**

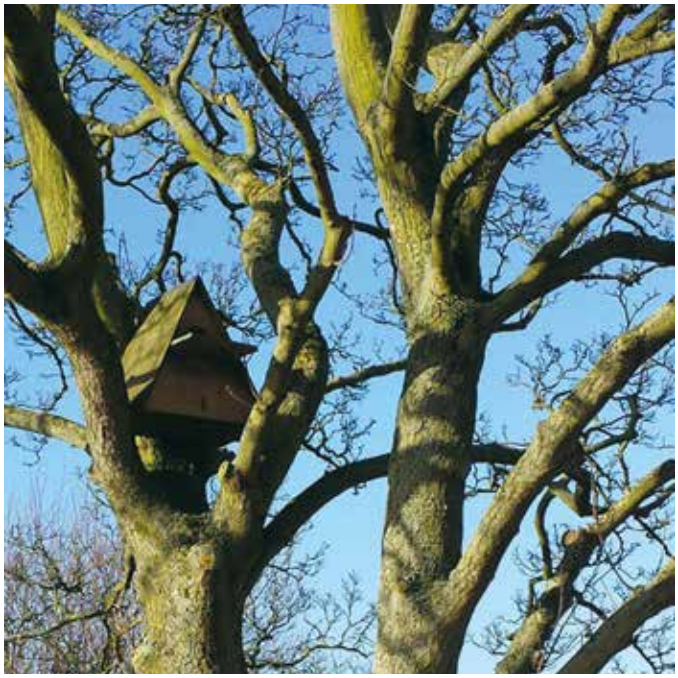


Figure 2 **Barn Owl nesting box**

DITCHES

As with hedges, several ditch courses were lost on the Heslington East site when development took place. One important section of ditch along the South Western boundary of the site has however remained and this has great value from an ecological point of view for several reasons:

- It has a hedge line running along its length, which provides associated habitat.
- It provides connectivity to watercourses in farmland to the South of the site and thus provides a corridor for Water Vole particularly to reach and colonise the wetland habitats on Heslington East
- It is already rich in moisture loving species and its proximity to the wetland area and top section of the lake should facilitate seed dispersal by these plants
- Natural colonisation of parts of wetland areas has already taken place with Bullrush and Stickleback, which are likely to have been already present within the ditches and watercourses, prior to development.

Several additional sections of ditch were added during development, associated with the lake outfall. These ditches also connect to watercourses outwith the site and may also provide migration routes for Water Vole.

Ditches have to be periodically managed so that they maintain their primary function of draining the land. It is important however that management operations are carried out to cause the least amount of impact on the habitat potential, particularly for Water Vole. As such, ditch clearance will take place at intervals according to their importance to drainage. Key drains will be cleared on an annual basis, with subsidiary ones every second or third year but will follow the National Guidance for Internal Drainage Boards, specifically related to mitigation measures for Water Voles, jointly issued by Natural England and the Association of Drainage Authorities.

↑ *Figure 3* **Water Forget me not amongst Flag Iris**

↑ **Swans on lake at Heslington East**

Newly Created Habitat

LAKE AND WETLANDS

This encompasses a broad habitat range including:

- A 10Ha lake
- Associated wetland pools
- A detention basin with fluctuating water levels
- Reed beds
- Swales

The lake is a substantial body of water making up 8% of the total area of the development site. It is an integral part of the surface water drainage system for the site, but simultaneously presented a huge opportunity in terms of habitat creation and increasing biodiversity.

Generally lakes which have a 40% cover of higher aquatic plants will have transparent water, as higher plants assist in reducing the development of algal blooms through shading, uptake of available nutrients and providing a refuge for zooplankton, which in turn graze on phytoplankton. Harvesting of decaying plants in the Autumn, will effectively remove Phosphorous from the lake system. This will be carried out on a rotational system with different sections being cut one year in four, or when judged to have become too dense. This should minimise the removal of invertebrates.

Studies and historical experience has demonstrated that certain species of bottom feeding fish (Specifically Carp & Bream) can encourage nutrient recycling through the disturbance of bottom sediments. Fish will also graze zooplankton, thus removing a natural control on algal blooms.

As anticipated fish have started to colonise the lake. The species range is expected to find its balance over a period of time, with natural controls on population density coming from any predatory fish which colonise and from fish eating birds such as Grebe, Heron, Kingfisher and Little Egret, all of which have been observed on the lake. The fish population may also be controlled by Otters, of which there was a confirmed sighting in the lake in December 2017.

↓ *Figure 4* **Broadleaved Pondweed thriving in the lake**

↑ **Mute Swan with recently hatched Cygnets**

↑ *Figure 5* **Young Pike already colonising the lake**

↑ *Figure 6* **Great Crested Grebe are established breeders on campus**

NUTRIENT MANAGEMENT APPROACH

A large proportion of the management problems associated with lowland lakes are a result of nutrient enrichment or eutrophication. Elevated levels of phosphorous typify nutrient enriched conditions. Soil analysis prior to development of the site indicated high levels of Phosphorous, which tends to persist for long periods within the soil.

Several routine management techniques may reduce Phosphorus availability within the lake:

- Plant and maintain 40% cover of aquatic macrophytes
- Do not stock with fish
- Discourage the residence and use of the lake by some species of waterfowl (Primarily populations of Canada & Greylag geese)

Several features have or are to be incorporated into the design and management of the lake and wider site to discourage geese and thus notionally reduce nutrient inputs from this source:

- Extensive planting of reed type marginal aquatics that will resist goose grazing and provide a poor food source once established
- Establishment of a broad marginal fringe of vegetation to act as a barrier to reduce access for birds between the lake and surrounding potential grazing areas
- Unlike Heslington West, there are no islands within the lake to encourage roosting/breeding

In the interests of promoting a broader species range across the site it may well be necessary to take more active measures to control over dominant species such as Greylag & Canada geese, as their effect on the environment generally might prove a limiting factor in the longer term to other species by unbalancing the lake ecology. In recent years this has taken the form of egg oiling under licence as a breeding prevention measure. In future a licence will also be sought to handle and transport birds whilst in moult to other nature reserves that are prepared to take the geese, such as the Lower Derwent Valley NR.

Active management of the geese population on the Lake and the Heslington East site generally is only one strand of nutrient management to limit the nutrient loading in the lake water:

- Soil stripping/inversion. As part of the initial earth moving and profiling works on site, nutrient rich top soil was buried and mixed with nutrient poor sub soil. As part of the lake construction low nutrient sand won from the site was used as an overburden layer for the lake liner and to form an inert planting substrate for the planting of aquatics.
- Water filtration. The circulation system within the lake sends water through a reed bed filtration system planted with Phragmites australis to act as a bio-filter after which the water percolates down through a layer of blast furnace slag which is known to be an effective absorber of Phosphorus.
- A ring drain encircles the lake system, which intercepts surface water drainage from flowing directly into the lake and is diverted into the re-circulation system to pass through a reed bed at the Eastern end of the lake.
- Herbage cropping of phosphate rich soils. Both species rich and species poor meadow land is cut on an annual basis with the arisings being taken for a hay crop and thus removing the nutrient contained therein

↓ *Figure 7* **Marginal planting around the lake edge**

In the past couple of years the University's Environment Department have been running a series of student projects based on the environmental systems on Campus East. Some of these projects have been centred on nutrient management, particularly the effectiveness of the reed bed filtration system and the impact the goose population has on the nutrient levels within the lake. The findings and recommendations arising from these projects can both help to inform future management and indicate whether management carried out to date has been effective in its purpose. As such, they are an extremely useful tool.

Appendix 2 of this plan provides summary information from a selection of the latest projects to be carried out.

↑ *Figure 8* **Phragmites establishing in reed beds shortly after planting and what it looks like now**

PONDS AND WETLANDS

In the South West corner of the site a wetland area has been created. The area was to comprise a mixture of permanently wet pools with a series of scrapes of varying depths within and around the pools. It was anticipated that several of these scrapes would dry up during the Summer and the area generally would support a diverse range of aquatic plant species, which would migrate into the wetland from nearby water courses as well as being sown and form a mosaic of vegetation. Species such as Meadowsweet, Purple Loosetrife, Common Reed, Great Willowherb and Flag Iris are likely to be prominent. And a range of aquatic invertebrates, such as Dragonflies, Damselflies and water Beetles. The habitat would in turn become suitable for bird species such as Sedge Warblers, Reed Buntings and Kingfishers, which have all now been observed and recorded on site. Additionally an abundance of invertebrates should provide good foraging for Bats, of which 4 species have been identified as using the site in the 2011 ecological baseline survey.

Several years ago, Tern rafts were introduced on the main lake in anticipation of attracting Common Terns to breed. Due to the depth of the lake and because it has a liner to which damage needs to be avoided, it has proved difficult to keep the rafts permanently anchored in a desirable location. Consequently it has been decided to introduce Tern rafts to the wetland area instead, where a shallower water depth and absence of liner will make anchoring the rafts considerably easier. It will also help to make subsequent moving and cleaning of the rafts easier too.

The objectives of creating the wetland area can be summarised as follows:

- To increase significantly the existing biodiversity of the site by providing freshwater pond habitat with submerged, floating and marginal vegetation for freshwater invertebrates, amphibian, Water Vole and bird life.
- To provide water bodies sufficiently large to incorporate shallow margins for Water Vole and Amphibian access, whilst maintaining a central deeper zone.
- To connect the Western lake to the wetland area to provide top up water during periods of drought.

However, the wetland area has not so far developed as anticipated. The pools and scrapes have over filled and joined to become one homogenous body of water (In effect a small lake). This limits the potential of the habitat as described above. Fluctuating water levels in the scrapes

Figure 9 **A pair of Terns scoping out a raft**

Figure 10 **Brooklime spreading into the wetlands from neighbouring water courses**

would provide suitable habitat for Great Crested Newt. Larvae and adults are vulnerable to predation by fish. Scrapes that dry up completely will eliminate fish and thus should allow the Newt to breed successfully.

Currently there is no way of managing the water level within the wetland. Supplementary water can be added via the connection to the Western lake, although this has never been necessary, but lowering water levels cannot just be left to seasonal variation in rainfall and temperature. An outlet valve would have to be introduced to the system to artificially reduce levels. In the long term this would be a less invasive way of removing water as opposed to periodically pumping water from the system. The alternative is to let the area develop as it is. Much of the area is quite shallow and may eventually grow over. Having one large area of water may not be as beneficial for wildlife in the short term, but longer term it may prove to be better, as deeper water will limit the growth of vegetation.

It is also hoped that in time Water Voles will colonise the site. Evidence of Water Vole has been found in the water courses of the surrounding farmland, which connect to existing ditches on site in close proximity to the wetland area.

↑ *Figure 12* **Kingfishers have also been observed on the lake**

↓ *Figure 11* **Little Egret now a frequent visitor to the campus**

Management intervention within the wetland area will be minimal and may be summarised as follows:

- The introduction of desirable marginal and emergent aquatic species, including the transfer of plants seeds that do well on Heslington West and are of local provenance such as Carex riparia, and Scrophularia auriculata.
- The introduction of subjects such as Cowslips, and Orchid species such as Northern Marsh Orchid and Common Spotted Orchid
- The introduction of rock and log piles to enhance the suitability of the habitat for Great Crested Newt
- Long term removal of dominating vegetation – removed material will be left by the waterside for several days to allow any trapped invertebrates to migrate back to the water.
- Removal of large accumulations of fallen leaves
- Removal of any unintentionally introduced alien species.

↑ *Figure 13* **Carex riparia introducing itself naturally**

↑ *Figure 14* **Hemp Agrimony Introduced to water margins**

← *Figure 15* **Northern Marsh Orchid now colonising on Campus East**

DETENTION BASIN

Originally planned as a flood plain which would be seasonally inundated with water much like an area of ings. The original concept has had to be abandoned because the basin was dug too deep and is now permanently or partially covered with water, whether from ground water or water running through the Badger Hill surface water drain. This has however presented an opportunity to develop a different type of wetland habitat to the one originally envisaged. The principles involved in the creation and management of this habitat are as follows:

- Allow the basin to flood as prevailing conditions dictate and not try to prevent frequent inundation
- Allow natural colonisation of the basin. For example. Reed mace and Phragmites have both colonised to a large degree, as have Willows around the water margins. There is now also evidence of colonisation by both Common Spotted and Northern Marsh Orchid

The on-going management of the Detention basin will follow a minimal intervention strategy, with the main management operations being:

- Long term removal of over dominant vegetation (most likely Bullrush). This could potentially provide a source of plant material for adding to the marginal vegetation around the main lake, where there is still ample space available.
- Coppicing of low growing carr woodland trees

If it is felt necessary, there is also the option to broaden the species range by introducing marginal aquatics such as Flag Iris, Purple Loosestrife and Hemp Agrimony and wet carr woodland subjects such as Guelder Rose, Dogwood and Osier however, the basin has developed so rapidly and naturally that at this juncture little if any intervention seems necessary.

Although the detention basin is not technically an element of the nutrient management system, it is nonetheless a popular study area for students carrying out environmental systems projects. Although the findings amongst different projects vary, it seems quite likely the basin does contribute to maintaining water quality within the broader hydrology system. Again summary information from latest projects can be found in the appendix to this plan.

↑ Marginal and carr vegetation colonising the detention basin margins

↑ *Figure 16* **Willow Warbler caught and ringed on campus**

REEDBEDS

Reedbeds and associated planting will be established in a diverse range in water and wetland areas on the Heslington East site, and these will be managed in line with other marginal vegetation (periodic cutting-back and removal of excess material). However, there are also designated reed bed areas used as part of the lake water recirculation system. The designated recirculation reed beds are part of the lake system because they perform a specific function in filtering recirculated water, but they are also habitats in their own right with water levels and flows controlled by switching the circulation pumps on and off.

The establishment phase of the vegetation in the reed beds is now complete with the firm establishment of the Norfolk Reeds planted into the over lying soil layer of the reed bed, itself laid over filtering substrates. Over the first two to three years, the circulation pumps were periodically switched on and off, keeping the growing medium moist enough for the reeds to establish and become large enough for them to withstand inundation on a permanent basis. Now established, the circulation pumps run permanently so that water passes continuously through the reed bed allowing it to perform its primary function of removing nutrient from the water. As the reeds act partially as a bio-filter, taking nutrient from the water as they grow, the reeds need to be harvested every year to remove this nutrient from the lake system. At the same time, the arising could provide a useful seed source for the propagation of more reeds . Additionally, pieces of rhizome could be dug out which could be planted into the wetland environment in subsequent years.

As a secondary function the reed beds will provide ideal habitat for a range of invertebrates and birds.

In the longer term a decision will have to be made as to whether to dig out the reed beds and replace the underlying layer of blast furnace slag, which has a finite life of circa ten years in terms of absorbing and holding phosphates. It may be however that phosphate levels in the surrounding landscape may have fallen sufficiently by then to only have to rely on the bio-filter properties of the Phragmites. This will no doubt be determined by future water sampling as part of environment student projects.

SWALES

The strategy for draining the new Heslington East site has been developed to provide a sustainable system that will harvest water for discharge into the lake using a combination of swales. Swale design varies in response to anticipated water volumes carried and the character of the landscape setting it passes through. In the soft landscape areas around residences the swales are sinuous dry grassed channels with variations in width and gradient. As the swales progress through the site towards the lake, they take on a different character becoming wider and deeper conveyance swales and having a more 'ditch' like appearance.

As well as being functional, the swales serve a dual purpose of providing a more naturalistic landscaping element to that between the buildings and a link to the peripheral landscape and will provide a micro habitat in themselves for moisture loving plants such as Marsh Marigold, Purple loosestrife Meadowsweet , Cowslips, some bulb species and to invertebrates such as Dragonflies.

The functional purpose of the swales means that maintenance of them is important to ensure water flows are not impeded:

- Rubbish and litter will be removed on regularly (weekly)
- During Autumn vegetation within the swale channel will be cut down and removed for composting and any accumulations of leaf litter will be removed
- Monitoring of Species within the swale channel, with re-planting if necessary to maintain a desirable species mix.

The larger conveyance swales will also have to be managed in a similar way to perimeter and lake outfall ditches, so that they too maintain their drainage function. The same criteria will apply in terms of following national guidance for internal drainage boards, indeed it will be the local Ouse & Derwent Drainage Board that are engaged to carry out clearance work. Where this has already taken place, it has provided some very useful plant material for transplanting into the margins of the main lake and has established very successfully.

Again, although the swale network is not technically an element of the nutrient management system, it is also a popular study area for students carrying out environmental systems projects and summary information from project work can be found in the appendix to this plan. As with other areas of ecology this type of project information can be useful in terms of management going forward.

↑ *Figure 18* **Swale outside Goodricke College in phase 1 development**

↑ *Figure 18* **Common Darter Dragonfly commonly seen on water courses on Campus East**

SPECIES RICH NEUTRAL GRASSLANDS

As part of a range of habitat creation measures the Heslington East Environmental site management plan identified the creation of a range of species rich neutral grasslands. One of the main aims of the project is to create species rich hay meadows similar to those described in the National Vegetation Classification (NVC). The most suitable type of grassland for this type of habitat is the MG5 Cynosurus cirstatus – Centauria nigra grassland, which normally occur on nutrient poor clay-loam soils. Some parts of the site are quite sandy, although this isn't critical, as the whole site does not have to match a given NVC category.To achieve the necessary conditions for species rich grasslands to develop has involved a large degree of soil inversion and mixing to bring the sub soil of the site to the surface to provide the low nutrient medium for a species rich treatment to be successful and to discourage coarse grasses from out competing wild flowers.

In some areas, grass has dominated in the first few years of establishment, though excessive grass development has been controlled to some extent by the inclusion of Hay Rattle in the initial seed mix. This species is semi parasitic on grass and will give the less competitive wildflower species a chance to establish. Hay Rattle is an annual species and as such is reliant on self seeding to perpetuate itself. It has however managed to maintain itself to the extent that there are now several areas of extensive Hay Rattle cover, which has provided a valuable seed source for harvesting and redistributing across site. Over the next 5 – 10 years the cover of flower and broad leaf species should steadily increase as nutrient levels decline and a more species rich plant community should develop.

↑ *Figure 19* **Yellow Rattle established in sward**

The grasslands in the North Western buffer zone landscape have already been established now for 7 - 8 years. The baseline ecological survey carried out in 2011 highlighted some differences in establishment over the area, which most likely relate to the nutrient status of the soil and in turn how effective soil mixing and inversion has been. The species rich grassland close to the Western site entrance has established well, with high overall cover including Clover, grasses and herbaceous species.

Establishment of species rich grassland in other areas across site has varied according to soil nutrient conditions. For example, around the wetland area establishment has been much more patchy with Birds Foot Trefoil dominating. This is consistent with very low nutrient levels however over the preceding time period the nutrient fixing characteristics of Birds Foot Trefoil coupled with the nutrient inputs from waterfowl excretia may have raised nutrient levels, with a resulting diversication of species, which is anticipated to steadily albeit slowly continue. For example species such as Spiny Restharrow have now started to appear, which were not a constituent part of the original seed mix. Another approach may be to over-sow or plant key missing species, but it may be equally appropriate to just monitor and see what colonises naturally over time.

Where species rich meadowland has been sown down on Kimberlow Hill, its establishment has been sparse in many areas due to the very poor soil that was moved up there from the excavation of the lake basin. This has meant however that wildflowers have very little competition from grasses and as such are continuing to steadily increase in number and diversity.

The base line survey concluded that in general, a good proportion of the species included in the species rich seed mixes were represented across the site, with the potential for wider dispersal as conditions develop.

A proportion of the projects conducted by Environment students focus on terrestrial biovidersity. One of the latest suite of projects looked at the species richness of Campus East grassland areas and whether pH has an influence on this. The project findings where unfortunately

Figure 20 **Brown Argus Butterfly**

Figure 21 **Common Blue Butterfly**

disappointing in that it found a significant decrease in species diversity since the 2011 baseline survey. This is of concern, but perhaps not wholly unexpected, as there may well be an initial decrease in the first few years of management, until conditions stabilise and improve enough to allow more species to move in. The time of year when the project was carried out may also be a significant factor as it would be significantly more challenging to detect species in early winter, than it would in late spring/ early summer. Again, as summary of findings is included in the appendices.

The long term management of species rich hay meadows is as follows:

- Established species rich meadows will be cut annually in late August once the flower species have set seed. Cutting height will be around 10 cm and all arisings will be uplifted and removed. An agricultural contractor is engaged to carry out this operation, with as much of the arisings as possible being taken as a hay crop and given to the local farming community.
- Perennial weeds such as Ragwort will be controlled by herbicide spot treatment during late Spring and hand pulling of plants that have been missed in late June/ early July.
- Excessive grass development will be controlled with an over sowing of Hay rattle in Autumn, which will locally inhibit grass growth giving less aggressive species an opportunity to colonise. Although this should only be necessary if the Hay Rattle already sown fails to establish.
- No fertilisers or other nutrients will be added.
- Periodic monitoring of the vegetation sward should take place. Any desired species needing to be re-introduced can be done so either by plug planting, over sowing, or cutting in and laying wildflower turf.

Species rich grassland will provide a naturally colourful display throughout the Summer and will support a diverse community of invertebrates, particularly Butterflies, Moths, Grasshoppers and Crickets. Perhaps most importantly though, they will provide a good source of food for Bees. The large areas of grassland on site also provide excellent habitat for Skylarks to breed. This is one of the priority species identified in the local biodiversity action plan. Skylarks have been regularly observed on site in surveys carried out through the breeding season, with more than 10 singing males often present on site. The meadows will also provide good foraging habitat for Song Thrushes, Linnets and Yellowhammers.

Cutting for hay would normally take place in June, as this would provide better quality hay that was 'sweeter' and richer in nutrients and as such more attractive to farmers. It would also be beneficial from the point of view of depleting nutrient from the soil. The timing of the cut has however got to be balanced with other considerations, such has the habitat it provides for ground nesting birds. The food source it provides for bees and other pollinators and giving the wildflowers therein plenty of time to set seed. It is quite probable however that in future the cutting of meadowlands might be more staggered, with some areas being cut earlier, particularly where there is still a high ratio of grass to flowers in an attempt to increase species diversification.

SPECIES POOR HAY MEADOW

The sowing down of species poor hay meadow has been carried out as part of the nutrient management regime. The cropping of these areas is intended to take nutrient from the soil year on year to reduce nutrient leaching into the lake and to eventually make conditions favourable for species rich hay meadows.

In the short to medium term, species poor hay meadows will be cut annually at approximately the same time as the species rich meadows and by the same means, with the arisings being offered as a hay crop. As nutrient levels progressively fall, it is anticipated that broad leaved species from adjacent species rich meadows will migrate in and colonise over time, thus steadily increasing the proportion of species rich meadowland. One of the best ways to increase the species richness of the species poor meadows is to take some turves from species rich grassland (once established) and plant into the species poor grassland; from which the extra species can spread. Also, spraying out patches of the species-poor grassland (to cut down competition) and sowing (seed/plugs) a species-rich mix can work in the long term.

CORNFIELD ANNUALS

Several high profile areas within the Heslington East site have been identified to be planted with drifts of cornfield annuals such as Poppies, Cornflowers and Corn Marigolds. The primary function of these areas is aesthetic rather than habitat creation, they will however have a secondary function of providing foraging for Bees and other insects and in this respect they are useful.

As these flowers need cultivated ground to grow successfully the initial establishment regime will have to be repeated on an annual basis to achieve the desired effect.

- Applying a non selective herbicide to the area to kill perennial weeds
- Harrow ground to create a seed bed onto which seed mix is sown
- Roll the soil to ensure good contact between seed and soil
- Cut down in September after seed has set to make sure ripe seed is dispersed widely
- The following Spring, plough or rotovate the area and sow an additional amount of seed to supplement the natural seed bank.

↑ *Figure 22* **Species rich meadowland in the peripheral landscape**

NATURALISTIC AREAS OF ROUGH GRASSLAND

The area of peripheral landscape , with runs East from the Wetland area between the Southern shore of the lake and the site boundary hedge has been treated as an area of naturalistic rough grassland and has received received minimal management interventions. It has been allowed to develop as an essentially wild area largely undisturbed by people. In several respects it should provide a similar habitat to the more managed grassland areas, but it is also hoped that it will become a good habitat for small mammals, which in turn would provide a food source for bird species such as Owls and Hawks (Owl and Kestrel nesting boxes have been introduced into the mature trees along the Low Lane boundary hedge). The connecting ditches from the lake outfall to Germany Beck & Tilmire Drain also run though this area and eventually these ditches may become populated by Water Vole.

As stated, interventions in this area have been minimal, only consisting of the following treatments:

- Marginal planting along the Southern shore of the lake
- Regular ditch maintenance to make sure drainage off site is not impeded (Reference has already been made to National Guidance for Internal Drainage Boards, specifically related to mitigation measures for Water Voles in the section on ditches)
- Control of invasive perennial weeds such as Ragwort by spot treatment with herbicide
- Selective introduction of wildflowers that would be good food sources for insects and birds, such as Foxglove and Teasel and Comfrey
- Periodic thinning of self sown trees to keep the ground relatively open and contain the amount of leaf litter entering the lake

This area of campus is characteristically wild. It is evident from the sparse vegetation in much of the area that nutrient levels in the soil must be fairly low and as a result wildflowers such as Knapweed, Oxeye Daisy and Birdsfoot Trefoil are prevalent. There is also now evidence that Orchid species are beginning to colonise. In some areas thickets of Alder saplings particularly are starting to dominate and these will have to be periodically thinned, with the expectation that over time a mix of Alder Birch and Willow will begin to establish across parts of the site.

The relative isolation of the area has also lent itself to several habitat creation measures, such as the introduction of Sand Martin boxes and Kingfisher banks along the lake edge and it is anticipated these features will be added to over the next few years.

↑ *Figure 23* **Cornfield annuals - a food source for forraging bees**

Figure 24 **Long Tailed Tit**

WOODLANDS

Deciduous woodland is a priority habitat in the UK Biodiversity Action Plan and the creation of this habitat on the Campus East contributes to the national target. In total circa 70,000 trees and shrubs have been planted across Campus East in 15 separate woodland planting blocks

- Blocks of woodland have been planted throughout the peripheral landscape. The primary species are Pedunculate Oak and Ash, but each block contains a broad mix of native species.
- Where possible the plants have been sourced locally, with most being grown within the Vale of York.
- Woodland margins have been planted with smaller decorative berry bearing shrubs such as Spindle, Guelder Rose and wayfaring Tree, which should provide a valuable food source for birds.
- Additionally, to begin with, the initial batch of trees used in the woodland plantings were planted in a temporary nursery on the development site to give them some time to acclimatise to local soil and weather conditions. From here they were lifted and re-planted to their final positions within the woodland blocks.
- The trees within the woodland blocks have initially been protected from grazing animals by tree shelters. These also provide a micro climate around the tree encouraging their establishment.
- Bio-degradable mulch mats have been placed around the base of trees to exercise some degree of weed control
- Planting comprises species of tree, shrub and field heights offering a multi –layered environment into which deadwood piles, roosting and breeding boxes can eventually be introduced.

Over the intervening period most of the woodland blocks have established well, with at least an 80% success rate in terms of tree survival. Establishment of the woodland blocks on Kimberlow Hill have been more patchy due to poor soils with low nutrient levels that were used to build up Kimberlow Hill when the lake basin was dug out. Establishment and growth has been much slower, but still reasonably successful, with particularly Alder and Birch doing well to the extent they are now self seeding quite freely.

Woodland ground flora is generally recognised as being one of the most difficult habitats to create. It is anticipated that a woodland groundflora seed mix will be sown down within the woodland blocks at some point, but most woodland herbs require shade , which is not possible to provide until the tree canopy has developed.

Since the initial production of this management plan several more woodland areas have been planted and with input from an organisation called Landlife, which promotes and facilitates the creation of new wildflower

landscapes, these woodland blocks were sown down prior to tree planting with a woodland wildflower mix. This seed mix contained species which give significant Bee interest and supported then local initiatives by Friends of the Earth to promote and enhance habitat for Bees. Unfortunately establishment has been poor.

Over time it is hoped that a diverse herb layer will develop as the tree canopy closes including target species such as Bluebell, Wood Sorrel, Ground Ivy, Foxglove, Red Campion, Wood Avens and Archangel.

Woodland blocks should also provide habitat for priority bird species such as Dunnock, Song Thrush, Spotted Flycatcher and Bullfinch. Some other species that have been observed and recorded are Whitethroat, Lesser Whitethroat, Blackcap, Chiffchaff, Garden Warbler, Wren, Robin, Blackbird, Long tailed Tit, Willow Tit, Coal Tit, Blue Tit, Great Tit, Chaffinch and Yellowhammer.

A range of bat species may also begin to use the woodlands for foraging , particularly along the margins where night flying insects may congregate.

Hedgehogs may also colonise the woodlands over time.

Over the initial years of development the woodland areas will be maintained and improved through the following measures:

- Periodic inspection, whereby shelters and guards will be adjusted/removed as necessary
- Herbicide spot treatment in the first few years to prevent the encroachment of non desirable species such as Sycamore
- As the canopy begins to close it may become necessary to carry out selective thinning and coppicing to improve the woodland structure
- At the same time and as more typical woodland conditions begin to develop, woodland ground flora seed mixes will be sown down
- Where trees become large enough, bird and bat boxes can be introduced and particularly in existing mature trees which are close to or within woodland plantings.
- Log piles will be created from wood generated through thinning operations.

Figure 25 **Great Tit**

- Ground flora will be assessed to determine the rates of colonisation. If this is poor, the introduction of native species through re-sowing or plug planting will be considered.
- Clearing of glades once the woodland matures.

Some of the woodland planting blocks close to Grimston Bar are still struggling to develop in very poor soil. The logistics will have to be carefully considered, but it may well be possible and desirable to mulch out these planting blocks with composted greenwaste to improve soil structure and also stimulate microbial activity within the soil. Providing an organic mulch in this way would probably also improve conditions for a desirable woodland herb layer to develop over time.

A further consideration in relation to the woodland plantings is the long term effect that Chalara fraxinea (Ash dieback) may have. Ash was one of the two main primary species used in the woodlands, so there is the potential to lose many trees. Should this be the case, then partial replanting may have to take place in the future using a substitute species such as Small Leaved Lime.

↑ *Figure 26* **Woodland planting block on Kimberlow Hill**

↑ *Figure 27* **Present day woodland block**

Ecological Management Plan Campus West

Biodiversity is an important aspect of the management of the external environment of the University. Biodiversity and habitat creation were not the primary concerns when the Heslington West campus was being developed through the 1960's and 70's . However over the course of the last two decades or so there have been subtle alterations to the way the landscape is managed and maintained on Heslington West to encourage wildlife. Biodiversity considerations are at the forefront of the development of the Heslington East campus and although Heslington West and Heslington East have developed at separate times and in separate ways, there are common over-arching principles that need to be adopted across both sites.

↑ *Figure 28* **Common Sotted Orchid on Campus West**

Over Arching Management Principles

- Do not inadvertently destroy existing valuable habitats
- Give preference to native species of local provenance. For example, the Tansy Beetle now has a very limited range along the Ouse. Planting wild Tansy in wetland areas could provide an extended habitat for the beetle
- Create a mosaic of different habitats that will provide a range of habitats for more species. For example, woodland areas should contain a range of trees, have glades and contain dead wood in the form of nature sticks or log piles.
- Link Habitats to enable species movement between them
- Time management operations carefully to reduce impacts on species that may be feeding/breeding or hibernating.
- Think about pest control – can a chemical control be substituted with a cultural control. Reduce chemical usage generally
- Compost green waste
- Keep management intervention to a minimum. Do not over manage and in doing so reduce habitat potential
- Consult the UK Biodiversity Action Plan and specifically the Local Biodiversity Action Plan to inform which habitats and species should form the focus habitat creation measures.

General Ecological Measures

The Heslington West campus has a built footprint of 20%. This means that 80% of the estate is comprised of green space. Of this 80% formal grounds form a large proportion, these areas being highly managed with frequently mown grass, trimmed hedges and pruned shrub borders. The recently re-written Landscape Management Plan has provided on opportunity to review accepted grounds maintenance practises and in some situations reduce management interventions to encourage biodiversity.

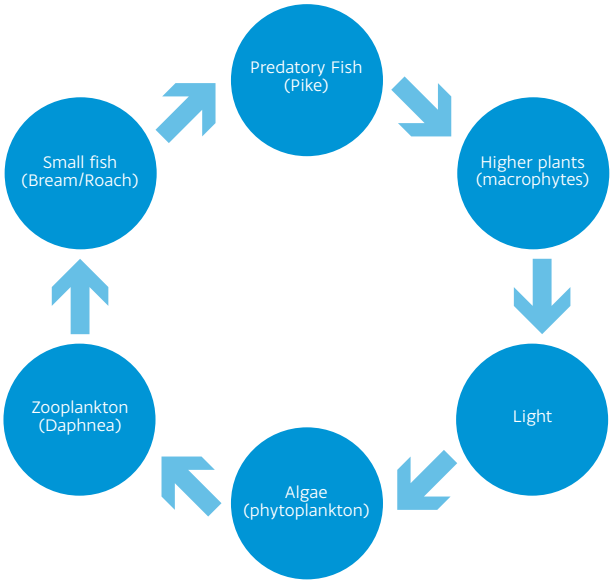
- Leave perennials standing until Spring to provide habitat and food sources
- Provide nest sites and cover for wildlife by allowing shrubbed areas to grow to maturity undisturbed
- Adopt reduced mowing regimes in selected appropriate areas
- Mulch planting beds with woodchip generated on site through necessary tree work
- Substitute organic for non-organic fertilisers
- Compost self- generated green waste to use as soil improvers and mulch
- Consider plant selection carefully – single flowers provide easily accessible pollen and nectar whereas double flowers don't
- Use a variety of species with a range of flowering times to ensure a continuity of food sources for insects
- Use trees and shrubs that keep fruit and berries into winter
- Diversify habitats by using a variety of plants/trees/shrubs to provide a range of vegetation levels
- Use artificial habitats ie invertebrate shelters/bug hotels.

Habitats

WATER

Wetlands and water are among the most productive ecosystems of all and can support a highly diverse range of species. The easiest way to improve the biodiversity of any site is to introduce water. As it happens, water dominates the Heslington West landscape in the form of a serpentine lake which lies through the centre of the campus. The management of the lake is dealt with extensively within the Landscape Management Plan. One of the key issues with the lake is its stressed or unbalanced ecosystem. Rebalancing the ecosystem of the lake is not a simple process.

The lake is impoverished in three elements of this balanced system:



PREDATORY FISH, HIGHER PLANTS AND ZOOPLANKTON

Conversely the lake has an overabundance of small fish. As the diagram above shows, each of these elements affect the other. Too few predatory fish leads to too many small fish, particularly Bream which are heavy grazers of zooplankton. This in turn means that zooplankton levels are severely depleted. Zooplankton feed on phytoplankton but, as zooplankton are largely absent, phytoplankton flourishes making the lake water turbid. This means that sunlight cannot penetrate very far down the water column, so any emergent aquatic vegetation will not have enough light to establish and photosynthesise.

Higher plants are extremely important to the ecology of a water body. They act as a buffer against phytoplankton by using up available nutrients and they also provide important habitats for zooplankton and young predatory fish, as they provide cover from other predators. It follows that the ecological management of the lake needs to concentrate on trying to re-balance these elements.

- Manipulating the fish population. This can be done either by introducing an effective predator (most probably Pike) at the top of the food chain to bring down the small fish population. Alternatively fish could be netted and removed. This however would have to be done on a regular basis, as the fish population would keep increasing to fill the void left. A third alternative is to encourage piscivorous birds to the lake. A large fish population is itself the most effective way of doing this! But creating suitable nesting/breeding conditions for species such as Greebe is also important.
- Improving conditions for marginal and emergent aquatics to grow. This can be done by protecting the plants from grazing by wildfowl. This has to be achieved by providing physical barriers around new planting. Improving light penetration down the water column is another way of helping higher plants. This however is far from straightforward, as there is now a thick silt layer on the lake bed which is perpetually stirred up by bottom feeding fish. The other cause of turbid water which is the growth of phytoplankton also has to be controlled by encouraging the zooplankton population and reducing nutrient availability within the water. Higher plants are integral to this and so in some senses it presents a catch 22 situation.
- Transplanting emergent aquatic plants from Heslington East lake, where species such as broad leaved pondweed and amphibious bistort are now beginning to flourish.

Additional to the above is the possibility of establishing additional water features on the Heslington West campus. Although small in scale out of necessity and in comparison to the existing lake a smaller pond that was not stocked with fish could broaden the water habitat range providing a home for a variety of other species such as amphibians and invertebrates.

The future re-development of the Heslington West campus may in theory create an opportunity for improvements works to be carried out to the lake generally. Demolition of some of the older CLASP buildings may give greater accessibility to the lake to enable possible dredging and re-profiling work to be undertaken, enhancing the lake both aesthetically and ecologically.

↑ Swan Mussells thriving in Campus West lake

WOODLAND AND TREES

Several areas of mature woodland already exist across the Heslington West campus. Managing the woodlands to make sure they stay in a safe condition is of primary importance but almost as important is to manage the woodlands so as to create a broad range habitat and attract a variety of wildlife. Minimal intervention is almost always best from a naturalistic point of view but the following is a list of pro-active measures being undertaken to improve woodland habitat.

- Following tree work, as much wood as possible is left within the woodland, either as standing or felled trunks, log stacks and any brash chippings used to reinforce woodland paths.
- Broadening the species range when replanting, introducing trees that flower and subsequently carry fruit/berries.
- Evergreens that provide shelter and roosting for birds.
- Planting species of varying sizes to provide a multi-layered woodland canopy.
- Introducing nesting boxes for birds
- Planting predominantly native species which are generally best in terms of habitat for invertebrates and in turn birds.
- Sowing down woodland ground flora seed mixes where it is likely to succeed to establish an effective herb layer

In woodlands climbers such as Ivy will be left to grow up tree trunks where this is possible. It has to be borne in mind however that in many cases it is necessary to remove Ivy to allow adequate inspection of tree structure, as climbing growth can often cover structural defects.

↓ Established woodland herb layer

GRASSLAND AREAS

Grass is the most common habitat found across campus and one of the easiest ways to encourage biodiversity is by reducing grass cutting and introducing less frequent mowing regimes. There are already several areas around campus where grass areas have been left to grow naturally, only being cut once or maybe twice a year. These areas tend to be on the periphery of campus or in association with trees. There is still some potential on the Heslington West campus to increase the extent of naturalistic rough grassland.

In association with less frequent mowing, it should also be possible to introduce wildflowers into the sward. This has also been done quite effectively in the past, particularly at waterside locations, where plug planting and reduced maintenance has led to a proliferation of Cowslips and even the emergence of several Orchid species in the past few years.

The grass banks along University Road represent several areas where a limited mowing regime has to be adopted for practical reasons. Unfortunately when cutting these banks it is not possible to lift and take off the arisings. Consequently nutrient is being returned to the soil, making it a less valuable habitat.

Although reduced mowing regimes are good for wildlife and biodiversity, there is also a value to areas of mown grass. Several bird species are drawn to mown grass as feeding sites, where they can easily forage on leatherjackets in the soil and other invertebrates that can be easily located in short grass. Many of these same bird species, such as Starling, thrushes and Wagtails also dislike being penned in by taller vegetation.

The University's sports fields constitute a very large area of closely mown grass and from that point of view are least attractive to wildlife. There are however some opportunities to broaden the wildlife appeal in terms of leaving uncut aprons of grass associated with hedge bottoms and introducing nesting and Owl boxes into the mature trees within the hedge rows. The added benefit of doing this around the sports fields is that they are close to the wider countryside at the campus margin and as such can provide a link between the two for wildlife to find its way onto campus.

↑ Snowgoose nesting amongst Cowslips

↑ Saw Leaved Bell Flower

SHRUB BEDS AND SEASONAL BEDDING

Shrubs can be an extremely important habitat for many bird species, as they provide opportunities for nesting and shelter. Shrubs which produce fruit and berries are also an important potential source of food.

Inevitably there are security considerations attached to tall dense shrub plantings and as such it is necessary to avoid these too close to buildings and paths. There is already quite a broad range of shrubs around campus of varying sizes, deciduous and evergreen, native and non-native, so already a broad spectrum habitat. There are also several specific actions that can be taken to increase the wild life value of shrub plantings:

- Using subjects that are known to be specifically bee and insect friendly in shrub plantings. Also having planting beds that are wholly planted with the intention of attracting bees and other insects.
- Using a broad selection of native species which are good providers of berries and which attract a broad range of invertebrates to encourage birds.
- Many seasonal bedding subjects have little if any value to foraging bees as many have double flowers and don't produce nectar. As such only seasonal bedding subjects which have some foraging value should be used in bedding displays. In some situations it might even be more appropriate to substitute bedding with annual wildflower plantings, which will give the same colour impact as bedding but with the added value of providing food for bees and other invertebrates.

HEDGES

Hedges form an important integral part of the campus landscape as a whole. Hedges define boundaries, form barriers and channel movement around campus and in these respects form a practical component of the landscape. However species rich hedges are very important from a biodiversity point of view and also provide very good 'corridors' for wildlife to travel between habitats which they may link to. The maintenance of hedges around campus is driven to a large degree around Health & Safety considerations, making sure they don't provide potential hiding places for undesirables and maintaining sight lines around roads and car parks. However, where possible hedges will be managed to encourage wildlife:

- As far as possible, hedges will only be cut outside of the bird nesting season
- Where possible the intensity of management will be relaxed, which should allow the hedge to afford more shelter and provide a greater food source
- New hedges will be planted with a variety of native shrubs to make the hedge as attractive as possible with flower, winter berries and autumn colour but also to provide as rich and diverse a habitat as possible
- Existing hedges will be gapped up and strengthened with additional species to the ones already growing in the hedge to diversify it.
- Where possible an unmanaged apron of grass will be left along the hedge line to encourage the development of flowering plants and provide habitat for invertebrates
- Spraying out along hedge bottoms will be reduced to encourage the development of a herb layer

BUILDINGS AND STRUCTURES

Buildings occupy a significant area of the campus and they too can provide an opportunity for habitat creation. Buildings already provide roosting and nesting provision for some bird species, most notably pigeons! Much time and money is expended in proofing buildings to prevent access by pigeons, but there are some species that we might wish to encourage by providing them with bespoke nesting boxes that can be attached to buildings. A good example of this are Swift boxes. A further example is the Peregrine Falcon nesting box which was fitted onto the boiler house chimney in 2014. Buildings may well be suitable for other types of nesting boxes and possibly even roosting boxes for bats.

Green roofs also present another potential habitat for wildlife. As well as the potential to support wild flora, they could also be used for invertebrate shelters, or even for siting bee hives. They can also serve as potential feeding and nesting sites for birds.

Buildings also provide support for climbing plants, which are also a source of food, shelter and potential nesting sites for several species of birds. Much of the Heslington West campus is made up of 1960's CLASP buildings and many climbing plants had to be taken off the sides of the buildings, as they caused problems by growing through the joints between the panels. However they can still be used to support wall shrubs and many of the newer buildings on campus are now brick clad, which allows climbers to be grown on them.

Although it is the case that buildings and hard standings are at the threshold of the maximum allowed footprint of 20%, new buildings are still being built from time to time on the Heslington West campus. Every new building offers an opportunity for habitat creation measures to be incorporated into the design. This approach should dovetail well with the University's sustainability aspirations, whilst also increasing the BREAM ratings of new buildings. For example, there is currently only one building on the Heslington West campus that has a green roof, but the technology has been available for some time to cost effectively cover flat or gently sloping roofs with either turf or plants. The recently finished Environment Department Building is an excellent example of the potential to utilise buildings to increase biodiversity with its 'living wall' and offers an exciting blueprint for the future.

↑ *Figure 29* **The Living Wall on the new Environment Building**

Prior to new build or re-development projects, more time ought to be spent on impact assessment in terms of the soft landscape, particularly with respect to trees. The soft option is often to take out existing trees at the expense of new build. This represents habitat destruction, which is diametrically opposed to the sustainability objective of the University.

This report is largely concerned with habitat creation measures. As part of those measures it is easy to try to introduce the target flora through sowing and planting. This is not possible with animal species (apart from fish), which must colonise these habitats naturally if the habitat is suitable for them.

Baseline ecological surveys have already been carried out, which have included riparian mammals . together with extensive breeding bird surveys. These surveys have already indicated the presence or several target species, along with other desirable species that were probably not initially expected (particularly in relation to avian species).

It is important to bear in mind that over time the habitats initially created will mature and change and as they do so, some of the species initially attracted to the site will change with some moving out and others colonising.

In the end, the primary objective must be to optimise the potential of the habitats created on the site to attract the broadest range of biodiversity possible.

Appendix 1

Bees Needs Award – What the University is Doing to Help Bees and Other Pollinators

Since the development of Heslington East one of the primary strands of ecological management has been to help bees and other pollinators. One of the major habitats created has been species rich meadowland and one of the primary benefits of this habitat is to provide foraging for bees.

Since October 2012 the proportion of wildflower areas on campus has been significantly increased. Through an association with the Land Life organisation a further 13 hectares of land has been deep ploughed and sown down with wild flowers as a food source for bees. This compliments the existing 9.5 hectares of species rich meadowland, which means that more than 10% of the entire University estate is currently given over to wildflowers.

Sowings of annual wildflowers are also carried out in several locations every year in higher profile areas to increase interest and make for a broader species range.

In addition to this, measures on the older Heslington West campus have been put in place to significantly improve bee friendliness.

- For example two dedicated bee friendly plantings have been created (as referenced in our landscape management plan).
- Also areas of seasonal bedding are being substituted for sowings of wildflowers which will both provide the colour impact traditionally associated with bedding displays, whilst at the same time proving a food source for bees.
- Grass cutting frequencies have also been reduced in some locations on campus, for example around the margins of the sports fields. The general aim to provide food and habitat for birds and invertebrates alike, but as part of this the number of wild flowers is increased to the benefit of foraging bees.
- A dedicated wildflower meadow has also now been sown down in a central area of campus where a group of old staff housing buildings were recently demolished.

In terms of achievement, the number and range of wild flowers on campus has been increased significantly, not just in association with wild flower areas and species rich meadowland but in other areas also, for example around wetland margins and through the network of swales on campus. Establishing large areas of wild flowers has not proved straightforward, one of the biggest challenges being to control broad leaved weeds within the wildflower areas. One measure of success is the fact that we have attracted several bee keepers to campus who want to take advantage of the foraging that our wildflower areas now provide.

↑ *Figure 30* **Vipers Bugloss a favourite of bees**

In October 2014 we also held a River of Flowers event on campus which gave our students an opportunity to plant hundreds of wildflower bulbs and sow wildflower seed bombs. River of flowers is an eco-social enterprise that donates wildflowers to community groups , the ethos of which is to feed bees which in turn feed us! One of River of Flowers sponsors is Grow wild, a project supported by Kew gardens which has been set up to encourage communities to grow more wild flowers. A representative from Grow Wild came along to support the event as well as the invertebrate charity Buglife to give a talk on pollinators and how to encourage them. The event was a good opportunity for students to get involved in practical conservation work and at the same time increasing the food available for bees, hoverflies and other pollinators.

Future plans for continuing to help bees include:

- Carrying out mass bulb planting using specially chosen biodiversity mixes developed by the Dutch company Jac. Uittenbogard & Zonnen and utilising their specially developed mechanical planting technique. Bulbs are often the first flowers to appear in spring and thus very important for bees. The bulb mixtures contain a variety of species which in turn produce a successive flowering period between February and June.
- Managing additional peripheral areas of campus to eventually make species rich hay meadow by reducing soil fertility, introduction of wild flowers through seeding/plug planting and using Yellow Rattle to weaken coarse grass growth
- Generally broadening the range of wild flowers on campus to include more species known to be attractive to bees and to other wildlife.
- Working with student volunteering groups to build and increase the number of 'bug hotels' on campus.

Figure 31 **Bee hotel jointly designed by the University and Urban Buzz**

Figure 32 **Bee checking in!**

Appendix 2

Environmental systems Project – Environmental Assessment of the University of York Campus Grounds

WATER QUALITY PROJECTS: EFFECTIVENESS OF REED BED FILTRATION SYSTEM

2.1.1. An investigation into the effectiveness of the reed bed filtration system in reducing nitrate and ammonium concentrations in the Heslington East main lake to acceptable standard levels

Name: Daniel Coathup

- **Research question/issue addressed by project**: Does the reed bed filtration system, complete with circulatory pump, effectively reduce the concentrations of nitrate and ammonium in the Heslington East main lake to acceptable levels. If the reed bed filtration system is ineffective, or if the concentrations of nitrate and ammonium exceed benchmark acceptable levels, then to provide mitigation techniques to improve the concentrations.
- **Summary of the methods and approaches used**: Five sets of samples, each containing three true replicates, were taken every 15 minutes from either side of the reed bed filtration system. This would allow a determination of the filtration system's effectiveness. Conductivity readings were taken upon collection to determine if they were also above acceptable levels and if so, to see if the cause was high nutrient concentrations. In the lab, samples were filtered through a 47mm GF/F Whitman filter and analysed using a AA3 Seal Analytical nutrient autoanalyser, via a colorimetric method. N-NO3- and N-NH4+ concentrations were then statistically analysed for significant differences before and after the filtration system, and compared to acceptable levels.
- **Key findings**: Results showed higher N-NO3- concentrations of 0.216 (± 0.063) mg L-1 after the filtration system and lower concentrations of 0.089 (± 0.043) mg L-1 before, backed up by Mann Whitney values of U = 10.00, Z = -4.253, p < .001. This showed a significant difference between the two locations. Furthermore, results showed higher N-NH4+ concentrations of 0.249 (± 0.034) mg L-1 after and 0.071(± 0.01) mg L-1 before, also backed up by a Mann Whitney test statistic of U = 0.00, Z = -4.668, p < .001. This also showed a significant increase in N-NH4+ concentrations after the filtration system. Although the results are surprising as the filtration system is there to lower nutrient values, the concentrations witnessed are still well below nutrient levels thought to be harmful in freshwater systems. Furthermore, the conductivity values of 623.133 (±14.024) µS cm-1 after the filtration system and 611.333 (±15.887) µS cm-1 before, are also well within acceptable levels for freshwater lakes.
- **Recommendations**: With N-NO3- and N-NH4+ concentrations well within acceptable levels, it is clear the current nutrient mitigation techniques are successful in lowering the concentrations of these two nutrients. Therefore, it would be unnecessary to implement further nutrient mitigation techniques for these nutrients at the present time. However should N-NO3- and N-NH4+ concentrations increase in the future, the current provisions will have to be extended. This could include harvesting the reeds in the reed bed filtration system more regularly, increase marginal planting to prevent wildfowl access or increase aquatic planting of macrophytes to uptake NO3-

WATER QUALITY PROJECTS: THE IMPACT OF WATERFOWL ON NUTRIENT LEVELS

2.1.3. Waterfowl's impact on nutrient levels within Heslington East Lake, in reference to eutrophication and future management strategies

Name: Charlotte Howis

- **Research question addressed by project**: How does the presence of waterfowl on Heslington East Lake affect the nutrient content of the water, (focusing

mainly on phosphorus levels)? Consequently does this negatively affect the water quality of the lake? If so, what management strategies need to put in place in the future to prevent eutrophication and loss of biodiversity due to a large number of aquatic birds?

- **Summary of the methods and approaches used**: Our methods involved a 4-day study on Heslington East campus, at 10 am and 3 pm each day, along the North side of the Lake, which was split into five equal study sites. The number of waterfowl present was recorded at each site and the abundance of geese droppings were counted using three strip transect samples to cover the area at varying distances from the lake. Once this data was collected we analysed the significance of our findings and used literature to calculate the average leaching rates of the geese droppings into the lake.
- **Key findings**: We found that numbers of geese and droppings abundance varied across our five different study sites due to different nesting patterns and roaming. Areas of shorter grass in less isolated areas were more popular among geese species. Therefore, these areas may need more monitoring in terms of phosphate levels. The leaching rates were also calculated, using literature to work out the percentage of phosphorus in various geese faeces, which worked out to be a total of 1,464.68 g over the four days.
- **Recommendations**: From the results of our study, we can come up with future recommendations on how to manage and monitor the numbers of waterfowl in and around Heslington East Lake, and come up with a maximum number at which they will become detrimental to the water quality. To try and divert birds from the area, for example, we observed in our investigation there were lower numbers of geese in areas of longer, coarse grass Creating more of these areas may reduce nesting and keep numbers level.

2.1.6. An investigation into how goose faeces affect nitrate concentrations in Heslington East Lake

Name: Sivan Kamiel-Skeete

- **Research question/issue addressed by project**: Do goose faeces have a large contribution to the nitrate concentration in the water of Heslington East lake? This is an important issue because goose populations are growing in the UK and goose faeces have been found to cause nutrient enrichment in lakes which could lead to eutrophication.
- **Recommendations**: We recommend that nitrate concentrations are measured throughout the year to see if there is any seasonal variation. Also, a count of the goose population is recommended along with the amount of faeces they produce so that the potential amount that could be inputted into the lake and the effects can be calculated. Also, the nitrate concentration of the lake sediment could be measured as a large amount of the faeces would settle on the bottom and only enter the water column during a mixing event.
- **Key findings**: We found that the current nitrate concentration of the lake is at an acceptable level of approximately 0.278 mg/L. The concentration of nitrate that leached from the goose faeces ranged from 0.072 to 1.822 mg/L with a mean of 1.13 ± 0.587 (standard deviation) so there is potential for goose faeces to increase the nitrate concentration of the lake to above recommended levels. There was a large range of nitrate concentrations in the incubated samples with faeces which could be attributed to the different diets of the different goose species.
- **Summary of the methods and approaches used**: Water from the main lake on Heslington East Campus was sampled and analysed on the 2nd of November 2017 to find the concentration of nitrate in the lake. Water samples with and without pieces of goose faeces in them were incubated in the lake for 24 hours to find the potential amount of nitrate that could be leached from goose faeces. The samples were analysed using an autoanalyzer and colourimetric method to find the concentration of nitrate present in the water of the different samples.

2.1.12. An investigation into how geese faeces affect nitrate concentrations in Heslington East lake

Name: Lily Summerton

- **Research question/issue addressed by project**: Does goose faeces have a large contribution to the nitrate (NO3-) concentration is the waters of Heslington East lake? Nutrient loading can cause eutrophication in freshwater lakes. This is important as geese are a major problem on Heslington East.

- **Summary of the methods and approaches used**: Samples of goose faeces collected from around Heslington East lake are incubated in the lake water over night for 24 hours. (0.5 g in 40 ml). The nitrate concentration leached out of the faeces is measured by filtering and using an autoanalyser. These are compared against the nitrate concentration of control samples of lake water containing no faeces. Nitrate concentrations are also measured in the lake water before incubation to determine how much nitrate from the goose faeces can potentially impact the lake overall.
- **Key findings**: The concentration of NO3- in the lake is 0.278 mg L-1. The NO3- concentration in the water leached from faeces over 24 hours (1.13 ± 0.012 mg L-1) is higher than the concentration in the sample without goose faeces (0.06 mg ± 0.19 mg L-1). The statistical tests (Mann Whitney-U) found that there is a significant difference between the samples containing goose faeces and without goose faeces despite a large range of results from the faeces sample, due to natural variability. From these results, it is unlikely that the lake is eutrophic (DEFRA guidelines of 30 mg L-1) but management is still needed as a precaution.
- **Recommendations**: Dredging of the lake is important as sediments retain NO3-, released back into the water during mixing but it is labour intensive and involves draining the lake. Planting more reeds with protective fencing around the outside and harvesting during Autumn is not always successful due to geese grazing. However, as geese are a major problem on Heslington East, it is important that the university continues to apply for a license to dip eggs in paraffin to control populations as a preventative measure.

WATER QUALITY PROJECTS: THE DETENTION BASINS EFFECT ON WATER QUALITY

2.1.4. An assessment of the Heslington East retention basin on its abilities to increase water quality from input to the output

Name: Heather Jaques

- **Research question/issue addressed by project**: Surface run off is a major source of water for most water bodies, and through this many pollutants are transported to lakes. These pollutants greatly reduce the quality of the water and therefore management techniques need to be put in place to reduce the negative effects. One management technique used to tackle this on Heslington East is using a retention basin. This project aims to assess the effectiveness of this basin regarding its ability to increase water quality, looking at both chemical (pH, and oxygen concentrations) and biological indicators (organism abundance).
- **Summary of the methods and approaches used**: The project was conducted on the south of the basin, starting at the output. Measurements were taken systematically at 30m intervals, creating a total of 7 sites. pH and oxygen concentrations were measured in the field using probes and beakers, and OPAL scores were calculated by identifying species and totalling their OPAL scores at each site. pH and oxygen tests were repeated 3 times for accuracy. Oxygen saturation was calculated using the method provided by WVDEP (2017). Data analysis was conducted in SPSS where regression and Pearson's correlation coefficient were found.
- **Key findings**: OPAL scores vary greatly. The greatest scores were found at site one with a score of 11, and sites six and seven with scores of 10. However, there were no significant changes along the basin and therefore the basin did not improve organism abundance. pH values were deemed acceptable, with values ranging from pH 7.76 to 7.6, which is within the benchmark for good water (pH of 6.5 to 8.5). However, there was no significant changes throughout the basin suggesting it did not improve the pH. Oxygen concentration is slightly high, ranging from 9.2 to 8.01 mg/L, seeing a slight drop towards the output, this change however is not significant. Oxygen percent saturation follows a similar pattern but is also not significant, implying the basin is not effective in improving oxygen content, however the oxygen level is not a major problem. OPAL scores do not appear to have a correlation with pH or oxygen, identifying that these variables are not the cause of poor organism abundance. It is likely other variables within the lake are causing poor organism abundance, and thus poor water quality, such as the presence of too many nutrients like Nitrates and Phosphorus which are not removed.

- **Recommendations**: To ensure the basin is removing pollutants and thus increasing invertebrate abundance, more vegetation could be added to the central area to increase water residence time to allow greater sedimentation, which will remove pollutants in the water. This would also increase the oxygen percent saturation and help improve the ability for organisms to survive. Also, a wetland area could be made before the input to remove dissolved contaminants which are said to not be fully removed by retention basins. This will ensure pollutants are being removed before entering the main lake, and will help increase organism abundance.

2.1.8. Investigating concentrations of nitrate (NO3-) and phosphate (PO43-) in the North Retention Basin, the weir and the Main Lake on the Heslington East Campus

Name: Gabrielle Norman

- **Research question/issue addressed by project**: To examine concentrations of 3– and 43– in the North Retention Basin, the Weir and the Main Lake on the Heslington East Campus and suggest management techniques in order to improve water quality.
- **Summary of the methods and approaches used**: Research was conducted on The University of York's relatively new Heslington East Campus in North Yorkshire, England. The random sampling procedure took place across three lakes on campus, the North Retention Basin, the Weir and the Main Lake. The Weir is situated at the north west of the campus, below Field Lane. 3 water samples, pH tests and conductivity tests were taken at each sampling site around the lake. This procedure was conducted three times per lake across three lakes, overall providing 27 water samples. An ANOVA test was used to analyse the results, to determine whether the results were significantly different.
- **Key findings**: During sample analysis for inorganic nutrient concentration, it was made apparent that PO43– levels were too low to be detected. The North Retention Basin had the highest conductivity levels and concentration of 3–, which had a mean concentration of 0.394 mg/L, which suggests that it is being impacted by urban runoff from the surrounding housing estate and main road. The standard deviation of nutrient concentration in samples from the Main Lake was 0.011 and the Weir was 0.031, which are similarly low values. The ANOVA test conducted for pH were the only data sets which were significantly different due to the large variability of the Weir values. An ANOVA tests for conductivity and inorganic nutrient concentration resulted in having no significant difference across the three water bodies. The North Retention Basin, located near Badger Hill housing estate had the highest levels of conductivity reaching 911 S cm-. When comparing the results to benchmark standards, the overall outcome was that the lakes would not be regarded as 'unsafe', therefore management of the lakes on campus is successful.
- **Recommendations**: The most successful management technique for the Heslington East lakes would be to introduce a sediment basin. This will capture runoff water before entering the North Retention Basin, thus allowing a regular chemical analysis for nutrient levels, before draining out into the lakes. However if the water is not harmful, there is no requirement for change.

2.1.10. Effectiveness of the retention basin as part of the Water Quality Control System on Heslington East Campus at preventing contamination of nitrate into the main lake

Name: Charlotte Reardon

- **Research question/issue addressed by project**: This project aims to assess how effective the retention basin is at reducing nitrate concentrations from entering the main lake on Heslington East Campus. Although nutrients can enter water bodies from a variety of sources, it is likely that the nutrients entering the retention basin arise from urban runoff from the Badger Hill housing estate. Urban runoff washes contaminants into water bodies, and of particular concern in our project is nitrate. Although this is needed in certain concentrations to maintain healthy ecosystems, high concentrations can have toxicological effects on aquatic organisms and contribute to the formation of algal blooms.
- **Summary of the methods and approaches used**: To assess the spatial variability of nitrate in the retention basin, water samples were taken from both the inlet and outlet. A total of 30 samples were collected and their pH and conductivity measurements taken to support our analysis of the nitrate concentrations. All

of the samples were filtered before being analysed for their nutrient concentrations from which we identified the nitrate values to perform further analysis. Statistical tests were performed on the nitrate concentrations in IBM SPSS Statistics 24 and coupled with the data from our ancillary variables (pH and conductivity) to allow us to form a conclusion.

- **Key findings**: It was found that the retention basin is an effective part of the water quality control system on Heslington East Campus at reducing the contamination of nitrate into the main lake. This can be said because all the variables measured decreased significantly between the inlet and outlet, and we assume the outlet measurements of the basin are equal to those entering the main lake.

  The pH was neutral at both sample sites with very little variation between the two, however the inlet pH was slightly higher with a mean of 7.74 ± 0.25 compared to 7.42 ± 0.13 at the outlet. Conductivity showed greater variation than pH, but was still significantly higher at the inlet with a mean of 738.40 ± 19.79 µS cm-1 in contrast to 634.47 ± 12.55 µS cm-1 at the outlet.

  Mean nitrate concentration dropped significantly from 4.06 ± 0.34 mg L-1 at the inlet to 0.48 ± 0.07 mg L-1 at the outlet. The inlet concentrations were all greater than our maximum benchmark criteria, however all of the outlet concentrations fell to within or below the 0.5 – 1.0 mg L-1 N-NO3- range proposed by Camargo and Alonso (2006) used for assessing stable ecological water quality.

- **Recommendations**: Since the retention basin has been found to be effective at reducing nitrate concentrations entering the main lake, no intensive intervention strategies need to be performed. To help maintain the levels of nitrate, the amount of Phragmite australis (common reed) in the basin could be increased to a 60% coverage in order to maximise nutrient removal. Altering the reed coverage would also benefit the retention basin as they are able to slow incoming water, which would reduce erosion, as well as providing a habit and food source for aquatic wildlife.

WATER QUALITY PROJECTS: THE EFFECT OF SWALES ON WATER QUALITY

2.1.9. An investigation into the effect of swales on water quality on Heslington East Lake

Name: Beth Quinn

- **Research question/issue addressed by project**: This investigation addresses the effectiveness of certain sustainable urban drainage systems (SuDS) on Heslington East Campus. These drainage systems intercept urban runoff, filtering out pollutants including excess macronutrients before they enter the wider hydrological system. Swales are a prime example of the storage/conveyance aspect of SuDS via vegetated channels. This study investigates Swale effectiveness to filter out the dissolved N-NO3- (nitrogen as nitrate), N-NH4+ (nitrate as ammonium) and P-PO43- (phosphorous as phosphate) This study aims to establish an evidence base of swales effectiveness in improving quality of runoff entering Heslington East lake. To aid future management and construction of swales.

- **Recommendations**: Recommendations were made to tackle the increase in nutrient concentrations. Check dams were advised to moderate flow and allow the vegetation within the swale more time for nutrient uptake. Further, it was recommended that further long-term studies are carried out on the swale over different months to assess consistency and the results of this investigation. As nutrient concentrations may exceed hazard benchmarks at differing times of the year. This study also raised further avenues for research such as the investigation of other pollutants such as total suspended solids and metals. This would further add to the evidence collected in this study.

- **Summary of the methods and approaches used**: The performance of the swales was evaluated using an experimental design that allowed the concentrations of nutrients to be extracted and measured at 10 equal intervals along 135 meters of the chosen swale. Removal rates of these nutrients were calculated relevant to the lake. Percentage density of plants was estimated along with the recording of Fescue (Festuca) presence at each site. Data quality measures were ensured during collection of data. Samples were then transported and

frozen within two hours of being taken. Data analysis for dissolved nitrate, phosphate and ammonium was then carried out, followed by statistical testing.

- **Key findings**: Following analysis, a significant relationship between nitrate concentration and distance along the swale from the lake was identified. The opposite to what was theorised prior to the measurements. Nitrate increased by a factor of 186 from 2.7µgl-1 (SD=±4.6) at 135 metres to 501µgl-1 (SD=±87.1) at the base of the lake, signifying a potential issue with the swales effectiveness. However, the increase in ammonium concentrations towards the lake was not significant. There was no significant relationship between the presence of Fescue species and removal rates or for plant density. Phosphate levels fell below the detection limit of the analyser used to measure concentrations so statistical analysis of phosphate did not take place. All nutrient readings fell below the hazard benchmarks. There was no significant relationship observed in this study between removal rate and percentage cover in the swale Further, no relationship was identified between Fescue species and removal rates. . However, these findings do not necessarily mean that the vegetation within the swales are ineffective, as there are many other factors influencing removal rates of macronutrients.

TERRESTRIAL BIODIVERSITY PROJECTS: MEASURE OF SPECIES RICHNESS IN MEADOWLANDS

2.2.1. To characterise whether species richness of Heslington East Grassland Areas have increased since 2011 in line with the Environmental Site Management Plan (ESMP) objectives and to assess whether the pH influences species richness.

Name: Siti Mohammad Shukri

- **Research question/issue addressed by project**: Have the grassland areas, in Heslington East, University of York, increased their plant species richness since 2011 in line with the Environmental Site Management Plan (ESMP) objectives, and do soil pH has any influence on it?
- **Summary of the methods and approaches used**: We used Penny Anderson Associates Ltd 2011 Botany Report as our benchmark and used the same quadrats as theirs, totalling of 21 quadrats in 6 different areas. Number of species present and estimated percentage cover in 1 m2 quadrat were recorded. 0-10 cm depth of soil samples were taken and brought to the lab to make soil solutions. The pH of the soils was analysed the next day. Mavis Software was used to classify the NVC of the grassland areas. Quality assurance and quality control were applied throughout the experiments.
- **Key findings**: The overall species richness of the grassland areas in 2017 showed a significant decrease since 2011 (Paired t-test, t=2.737, df=20, p=0.013), from 9.90±3.11 to 7.67±2.73.

  Only the NCA mix II area has increased slightly in species richness in 2017 by averaged 0.8 species, whereas the NCA mix III area stayed consistent and had the highest number of species in 2017 of 11.0±2.9.The grassland swale area showed the most significant decrease in number of species since 2011, from 12.3±2.4 to 5.8±1.0.

  There was no significant relationship between number of species present and the pH of the soil (Spearman's rank correlation, rs= -0.163, N=21, p=0.480), as the highest pH of 6.89 had 8.5 species, whereas the lowest pH of 5.52 had 6 species, but pH 6.67 had the most species present. Most of the areas had the grassland classification different than MG5 grassland. Western mound area was the closest to MG5 type by 34.71, but closer to MG9c.

  Overall, NCA mix III area was the most successful, with the highest averaged species richness with 15/m2 in one of the quadrats and has NVC type closer to its desired MG4 type by 36.06.
- **Recommendations**: Monitoring should be done annually and other variables should be considered too. A study by bCritchley et al. (2002) stated that even though the relationship between pH and species richness showed clear evident between broad vegetation types, but it may not apply within more specific grassland types. He also found that the relationship between species richness and extractable P concentration should be considered as it showed a clear evident in the mesotrophic communities including MG5. The lower the extractable P concentration, the higher the species richness.

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