BBOWT Wild Oxford Project

Raleigh Park Nature Reserve

Report on the First Year

November 2016 to December 2017

January 2018

Raleigh Park, view towards Oxford - 16 December 2017

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All photographs in the following report are my own.

Full-sized versions of photos are available at ***https://photos.app.goo.gl/2ZVYg4T4OfYNmjVQ2***

AIMS OF THE WILD OXFORD PROJECT AND GENERAL INTRODUCTION

The Wild Oxford Project is a collaborative initiative of BBOWT and Oxford City Council (OCC). It has already been running for three years on three other sites owned by OCC in the Oxford area (Lye Valley Nature Reserve, Chilswell Valley and Rivermead Nature Park) under the leadership of Andy Gunn. This is the first year that the work has extended to Raleigh Park Nature Reserve. The project is grant funded by a local charitable trust.

The Project Aims are to:

- Introduce local people to the wildlife on their doorstep
- Enable local people to take an active role in enhancing and protecting the sites
- Deliver improvements to the wetlands (fen and stream) and other key habitats

Introduction and Background to Raleigh Park

Raleigh Park Nature Reserve (27 acres, 9.6 ha) between North Hinksey and Botley, was given in trust to Oxford City Council (OCC) in 1935. Once part of the estates owned by the Harcourt family, it was sold to Raymond Ffennel in 1924 and later donated to the City of Oxford as a park to be kept as open space forever. Raleigh Park is named in honour of Sir Walter Alexander Raleigh (1861-1922), an English scholar, poet and author, who was Professor of English Literature at the University of Oxford and the founder of Oxford Preservation Trust.

The land is maintained as public open space and a nature park, managed by OCC and The Friends of Raleigh Park.

The park is on sloping land facing north-east and has small areas of a variety of habitats that make it a pleasant site for a walk and wildlife observation. It is on the slope of the Boars Hill escarpment and attractive views over the Thames floodplain and the city of Oxford may be seen from the highest part of the park.

The geology is mainly Jurassic Corallian limestone and sandy clay. Habitats include relic dry limestone grassland (rather rank and species-poor due to lack of grazing) copses of trees and scrub, with the most important habitat being the wetlands - small areas of spring-fed, calcareous, alkaline, tufa-forming fen on peat and a tufa-forming stream with a constructed pond.

In 2014 the whole publically accessible part of the park was designated a Local Wildlife Site (LWS) referred to as **Site 40X03** by Thames Valley Environmental Records Centre (**TVERC**) in recognition of its county importance for wildlife. The LWS centre's Ordnance Survey grid reference is SP492052. Access is only on foot from Raleigh Park Road, Westminster Way or Harcourt Hill.

A local group, **Friends of Raleigh Park**, set up in 2011, were active prior to the start of this project, carrying out scrub control and working on the pond and stream, as well as reducing the alien invasive plant known as Himalayan Balsam. The objectives of the Friends of Raleigh Park are to protect, conserve and enhance the Park, which is a Local Wildlife Site, for the benefit of the community.

Raleigh Park was added to the suite of sites within the Wild Oxford project in 2016 and work on site started with a volunteer taster scrub work session on 12th November 2016.

The Boar's hill escarpment has a number of spring-fed wetlands deriving water from the Corallian limestone aquifer. One of the oldest references to these wetlands is '***The Bogs on the west side of Oxford***'' (Bobart, 1690; mentioned in Druce, 1897) when referring to the wetland plants to be found in these bogs. Today, Raleigh Park still contains some of these 'bogs' (bog being then a general term for any wet, sinky, ground). Historic plant records in Druce (1897) give us a taste of the rich flora these wetlands once used to have. For example, Grass of Parnassus is quoted as being 'in a bog between Ferry Hinksey and Hen Wood'. Ferry Hinksey is North Hinksey, so the only two likely wetlands between it and Hen Wood are Raleigh Park and Hinksey Heights. It is like that Grass of Parnassus was in both when they were short turf fens.

Rocks of the Jurassic Corallian limestone and sandstone underlie most of the site. Above the park lie the Kimmeridge clay and acid Greensand on the top of Boar's Hill (Arkell, 1947). The small stream running through the centre of the park rises on higher ground and runs to the main part of the park through a wetland in a shallow valley, which forms a tongue-like extension of the park boundaries to the south-west. This south-western extension is fenced off and there is no public access. Further down in the lower slopes of the park the geology is lower Corallian Calcareous Grit, which grades into the Oxford Clay.

The steep slopes of the park area would have prevented ploughing for agriculture in the past, as did the markedly uneven topography and patches of swampy, peaty, habitat. Consequently the site was only suitable for rough grazing, which has preserved habitats and biodiversity that would have been lost, if the ground had been level and turned to arable. The whole slope of the park faces to the north-east. The constructed raised bank (causeway) running from south-east to north-west across the wettest middle area of the site is presumed to have been put there to enable progress dry-footed or more likely to enable carts to cross difficult sinky wetland terrain. The date of its construction is not known, but it is clearly shown on the earliest site map possessed by the OCC, the one in use when they assumed responsibility for the site in 1935.

Public access to the park on foot is from the southwest side of the A34 from Westminster Way or from Harcourt Hill or Raleigh Park Road.

- A full table of **records of species found at Raleigh Park in my surveys from 2011 to November 2017** is presented in **Appendix 2** (separate document). I'm grateful for the addition of the bird records of Colin Hayes and Clive Smith of the Friends Group.
- For further **background information** on the site and its history, see the Friends of Raleigh Park website http://www.raleighpark.org.uk/

Historical and Current Management

Grazing of the park grassland was originally by horses from a riding school in North Hinksey. However, this ceased and after a time the horses were replaced by a small number of cows. Occasionally the cows have had to be withdrawn from the site during the grazing period due to some complaints from members of the public. Lack of annual grazing at intervals in the last 10 years had resulted in increasing rankness and scrub (mostly hawthorn) invasion.

The first species survey of the site that I carried out was in 2011. My species list and small advisory report resulted in Oxford City Council carrying out a single cut-and-collect of hay in the drier open areas in order to prevent loss of biodiversity to rankness. Subsequently grazing was started again, by cows.

An excellent map of the habitats present on site in 2013 was produced by **Colin Hayes (Figure 1).** This represents the site before the start of restoration work by the Wild Oxford project and is reproduced here by kind permission of Isobel Hayes

Figure 1: Sketch map by Colin Hayes (2013) indicating the various habitat types at Raleigh Park before the Wild Oxford Project work started in November 2016

Habitats and species at Raleigh Park today

The whole valley is used by a good variety of common birds, as shown in the records of local residents Colin Hayes and Clive Smith in the species tables in **Appendix 2**. Clive is responsible for the 15 nest boxes put up around the park. Information from Clive is that 8 of these were used in 2017, resulting in the fledging of 36 young blue tits.

Mammals seen so far using the site include badgers (evidence of a set in the middle of the site) grey squirrels, moles, roe and muntjac deer; but mammal surveying has not yet started properly. There will be a degree of cat predation on birds and small mammals because of the proximity of houses and gardens. Whilst common frog, smooth newt and toad have been recorded in the wetlands, no monitoring for reptiles by the use of refuges has yet happened. Records of other smaller animals such as invertebrates are accumulating well, but there are many more to find (see **Appendix 2**). As they are more likely to be restricted to particular habitats, mention may be made of them in the sections below.

Walking over the site, first impressions are that it is predominately grassland scattered with copses of scrub and small trees (hawthorn, ash, blackthorn, bramble) with some wetland areas. However, a more detailed study shows that much of the scrub in the centre hides old wetlands that have become almost completely hidden and deeply shaded, losing their characteristic wetland flora. Thus the total wetland area is much larger than is initially apparent.

The copses and patches of trees and scrub in rough grassland are a fairly common type of habitat but one, of course, that is valuable for animals like mammals and birds. The wetland fen areas are, however, a much rarer habitat type, valuable to small, rather obscure, wetland plants and a range of specific insects that breed only in such spring-fed wet areas.

The achievement of **Local Wildlife Site** status depended to a large degree on the presence of these spring-fed alkaline wetlands as a key feature. They are a rare habitat type, which can have high invertebrate biodiversity.

As regards public appreciation and enjoyment of the site, the drier grassland slope areas are, of course, much enjoyed for informal walking, picnicking and peaceful wildlife observation.

The Wetlands - Alkaline spring fen patches

The many small areas of wet, sinky, ground experienced by walkers in the park are actually important examples of small spring-fed wetlands known as alkaline fens, with sometimes a surprising depth of peat accumulated. The spring water emerges over a ‘seepage zone’, so often no actual spring issue point is seen. Fens are wetlands fed by groundwater and these are alkaline fens (pH usually between 7 and 8) because the emerging groundwater is very high in dissolved calcium from the limestone rock.

Peat is a very dark, soft, material formed from partly decomposed plant and other organic matter. This forms when a lack of oxygen (due to waterlogging) limits microbial activity and thus prevents the vegetation from fully decomposing. The peat depth in the fen areas varies from a few centimetres to nearly a metre. Peat accumulates very slowly, so the deeper peat areas represent thousands of years of plant material accumulation.

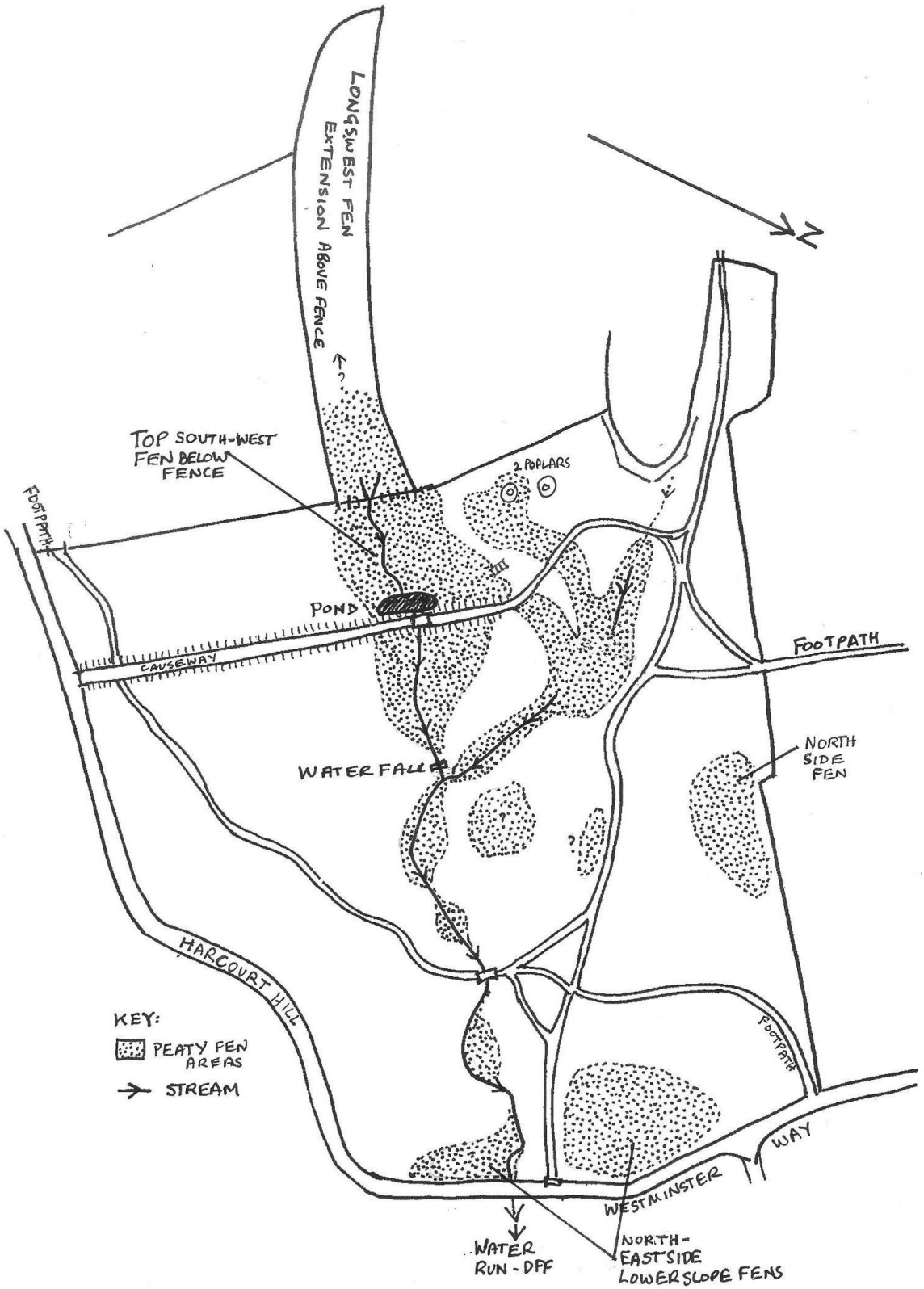
The spring/seepage flow ensures the water table remains more or less at the surface year-round, giving the continual waterlogging necessary to form peat. The peat is a huge store of carbon from the bodies of dead plants of past times.

In addition to the dark peat, two other types of deposits can be seen in the fens. When it meets the air, the calcium-rich water that emerges forms deposits of whitish lime (calcium carbonate precipitate) in a form called '**tufa**' on stones, twigs and plants. Mosses growing in this calcium-rich water become so coated in lime they are 'petrified'.

The continual spring flow ensures the water table remains more or less at the surface year-round, which allows peat accumulation by the continual waterlogging, retarding decomposition of plant remains. Water continually flows gently through and over the peat surface towards the central stream.

Tufa deposited on twigs in stream

Figure 2: Sketch map of Raleigh Park showing only stream, drainage channels and wetland areas as identified by the extent of peat deposits. Not all peaty areas are currently open fen. A good many have been colonised by scrub where access was difficult; therefore this map is tentative



Parts of the wetlands (more towards the top west end of the site) evidently have spring water issuing that is higher in dissolved iron instead of calcium. As this water hits the air, iron is precipitated as iron oxide, which forms a bright orange, cloudy, deposit under water and, at the water surface, a single layer with mirror-like reflectivity looking just like the effect of petrol or oil on the water surface. It may resemble pollution but it is not, being a completely normal, natural, phenomenon. This orange deposit may be seen in the pond margins, now they are cleared of vegetation. Iron-depositing areas may be slightly less alkaline than tufa-depositing areas. The formation of these iron oxide deposits is an interesting geological phenomenon and involves the chemical action of extremely ancient iron bacteria known as 'extremophiles'.

See **Appendix 1** for a fascinating description of the bacteria and the chemistry of iron oxide deposition by geologist Owen Green of the **Oxfordshire Geology Trust.**

Iron oxide deposition in the top south-western fen area

Iron oxide mirror on water surface

Iron oxide formation under water

Historic short-turf fen would have been dependent on grazing or cutting for survival. Stock like to graze such wetland areas due to the vegetation being more juicy and attractive in dry summer times.

A reduction in the intensity of grazing in the past probably allowed wetland vegetation to grow tall and young willows to invade most fen areas, thus shading out shorter plant species with their tall, dense, vigorous growth. Cooler conditions would have replaced the warm conditions of open short fen.

One of the most important features of the Raleigh Park wet alkaline tufa and iron fen areas is the lack of common reed, an aggressive tall grass-like plant found in nearby Chilswell Valley fen and Hinksey Heights fen, where lack of grazing has resulted in the fen areas becoming almost entirely dominated by a monoculture of head-high reed with consequent loss of plant species diversity. At Raleigh Park the dominant wetland plant, which has become tall and excluded many others, is the giant horsetail. This relative of ferns is not consumed by stock, therefore its growth has not been limited. It is particularly abundant in spring areas where clay is near the surface, as it needs silica from the clay to form the silica particles in the cells, which give the horsetails such a rough feel (they were used in the past as pot-scourers because of this silica).

The fen wetlands feature plants other than giant horsetail, such as tall herbs: great willow-herb, meadowsweet, ragged robin, greater reedmace, water figwort, flag iris, marsh thistle, hemp agrimony, purple loosestrife and wild angelica. Shorter herbs include creeping jenny, brooklime, silverweed, lesser celandine, square-stalked St John's-wort, cuckoo flower, water mint, creeping buttercup, bugle, fool's water cress, floating and plicate sweet grasses and rushes such as jointed rush, soft rush and hard rush. This last rush species is a bit of a problem because it has such tough, wiry, stems and leaves that stock do not eat it, therefore it has come to dominate some of the wetland areas to the exclusion of other plant species.

Margins of the uppermost fen area have shown good numbers of common spotted orchids, but this also is the zone that had been invaded by the alien pink-flowered, tall, Himalayan balsam, successfully much reduced by the work of the Friends of Raleigh Park group pulling up the balsam plants. Wetland areas to the north and east of the site show valuable amounts of greater bird's foot trefoil, ragged robin and common fleabane.

The large, tussock-forming, pendulous sedge is present occasionally in the wetlands, but this plant is really recommended for removal by digging out at the earliest opportunity, as it can spread abundantly by seed and come to dominate wetlands to the detriment of total species diversity. Hairy sedge, brown sedge and false fox sedge are to be found mainly in wetlands towards the lower slopes but it is remarkable that large aggressive sedge species such as greater and lesser pond sedge are absent from Raleigh Park. Like the absence of common reed, the lack of these tall dominant sedge species is a real bonus point for restoration of greater biodiversity on the site, as without them progress towards short turf fen will be much easier and quicker.

Smaller plants of the wetlands include various mosses and liverworts, which thrive in semi-shade and waterlogged conditions, like the endive pellia and fern-leaved hook moss. The green strap-shaped fronds of lemon-scented liverwort and the miniature 'trees' of hart's-tongue thyme-moss are a feature of the shaded wetlands currently. The smaller fern-leaved hook-moss is a key indicator species for high calcium alkaline water in the fens.

Lemon-scented liverwort, Conocephalum conicum

The absence of dominant, aggressive, plant species and the long history until the present of grazing on the site has allowed the Raleigh Park wetlands to retain rather more plant diversity than wetlands nearby on the Boar's Hill escarpment, such as in Chilswell Valley and Hinksey Heights. Because of this lack of aggressive plant species, fen restoration at Raleigh Park will enable different short-fen wetland assemblages to spread to restored communities at those other two sites, making a valuable addition to the habitat and species diversity in the whole of the Boar's Hill escarpment.

Wetland-dependent invertebrates

The waterlogged peaty soil is an ideal breeding site for particular little craneflies and soldierflies but as yet only preliminary survey data is available on the range of species present, generated by sweep netting at each site visit. The lists in **Appendix 2** represent only the tip of a very big iceberg of total insect diversity on site that is yet to be discovered. Targeted trapping methods need to be used next year to obtain better coverage of invertebrate diversity. Placing of insect traps (e.g. pitfall traps, yellow pan traps) in an open access site with stock grazing presents some challenges. Light trapping for moths would be a possibility next year and could be a good public engagement event for a summer evening.

Pair of narrow-bordered 5-spot burnet moths mating at Raleigh Park

Just a single example of the importance of restoration of the wetland areas for insects: the spectacular and uncommon narrow-bordered 5-spot burnet moth *Zygaena lonicerae* has caterpillars that mainly feed on the greater bird's foot trefoil *Lotus pedunculatus*, which grows in the more open fen areas on the north and north-east sides.

Fen restoration cutting and raking will allow the population of greater bird's foot trefoil to increase by reducing rank rush, which tends to shade it out. An increase of greater bird's foot trefoil will, in turn, enable the burnet moths to thrive and spread to newly-cleared fen areas that have the plant (top south-west fen area).

Not only burnet moths depend on this plant. Its leaves can be used by the caterpillars of common blue butterflies and the flowers are very popular with many bee species; so an increase in this one key plant species will help populations of many invertebrate species.

Greater birds foot trefoil, Lotus pedunculatus

Even if one does not care much about the 'invisible' small flies breeding in the fen, their importance can be immediately appreciated, if one considers the vast numbers and biomass of flying insects generated by wetlands; this provides an important food source for insectivorous birds and bats using the site.

Stream

The highly calcareous nature of the water in the stream sometimes results in lime tufa deposition on stones and vegetation turning them white and 'petrifying' them. In a couple of places the lime deposition occurs as small tufa 'dams' (*photo left*) which are 'steps' across the stream made of deposited calcium carbonate. These are uncommon geological features and should be carefully preserved and protected from casual damage in conservation work along the stream. This tufa deposition can be seen on the re-built stone waterfall, where encrustations of lime now coat the stones and liverworts.

Tufa on twigs in stream

Dead wood, from logs to small twigs, falling into the tufa-rich stream or lying in areas of wet seepage from the banks will become waterlogged and ideal for use of by a variety of specific insect (flies, beetles) that have larvae which feed by burrowing into it and are dependent on this very particular habitat. Therefore, waterlogged wood and twigs should be retained in these wet stream areas and not cleared from them.

Next year, species surveying will include removing small portions of this tufa-encrusted, waterlogged, wood and retaining it to rear out any dependent insects present in the larval stages, thus giving information on biodiversity of this important habitat.

Wetland Water Quality

Wetlands live or die by their water supply. There needs to be sufficient water supply to ensure all-year-round water at the surface and for these fens the water quality needs to be good (unpolluted). It is particularly important that the levels of chemicals like dissolved nitrate and phosphate are very low. For a good spring water supply there needs to be plenty of natural green vegetated areas in the catchment upslope and the catchment must not be covered by a lot of hard surfacing, which prevents rainwater entering the ground. Green fields and gardens enable rainwater to freely penetrate the ground and enter the limestone aquifer underground, from whence it later emerges downslope in spring and seepage zones.

The cleaner the water, the higher the diversity of aquatic and wetland wildlife produced. In March 2017 simple test kits supplied by the Freshwater Habitats Trust (FHT) were used to find out the phosphate and nitrate levels in spring water at two points on the west side as it entered the park. The degree of colour change in these tests indicates quantities of chemicals. The most desirable situation is completely clean water, i.e. no colour change, meaning undetectably low levels of phosphate and nitrate. The results for Raleigh Park showed that the water entering had no detectable phosphate, but for nitrate, it was not completely clean, showing a low level of 0.2 parts per million present. This small amount of nitrate is likely to be coming from water pipe, sewer or septic tank leaks from developments upslope of the park. This low level is the cleanest water seen in any of the Wild Oxford project fen sites, so this is relatively good news, but even this low nitrate level is likely to cause stimulation of filamentous alga growth in the pond, once all the shading trees are finally removed, and will, in fact, limit the aquatic invertebrate diversity that might ultimately be achievable there.

Trees and Scrub

The most frequent trees are hawthorn and ash. Hawthorn is a pioneer species, spread by birds into grassland, and would have arrived on its own and thrived as grazing became lighter. Many trees will have been planted, including the hybrid poplars (2 on west side), alders (2 in centre), field maple, horse chestnut, Norway maple, sycamore and hazel. Wild cherry, blackthorn, elder, holly and crab apple are likely natural invaders brought by birds. Planted common and small-leaved lime are in the north-eastern corner, new young small-leaved limes are planted on the south side. Limes have particularly nectar-rich flowers in summer and thus benefit all nectar feeding insects.

According to information in the document by Gerald Dawe the site used to have a lot of English Elm in the centre. Of course, this has been massively reduced by Dutch elm disease, leaving only swarms of elm suckers. These succumb to the disease when they reach a certain height and trunk diameter, leaving a lot of standing and falling dead wood, particularly noticeable at the north-western side. Disease-resistant elms are available for replacement, if it is desired to keep the historic elm presence in the park. White-letter hairstreak butterflies depend on elm and are in steep decline. This would be a suitable site to try and re-establish a colony (surveys next year could include a search to see if this butterfly might still be surviving on the remaining elms).

No ash trees on site exhibited the Ash Dieback disease (Chalara dieback) in 2017, but it is known to be present in Oxford, so it is only a matter of time before it arrives and it may be expected to ultimately remove nearly all the ashes. It is recommended that any replacement trees should be native species appropriate to the limestone soil and be planted only in marginal drier areas away from the wetlands and not in areas that are good flowery grassland.

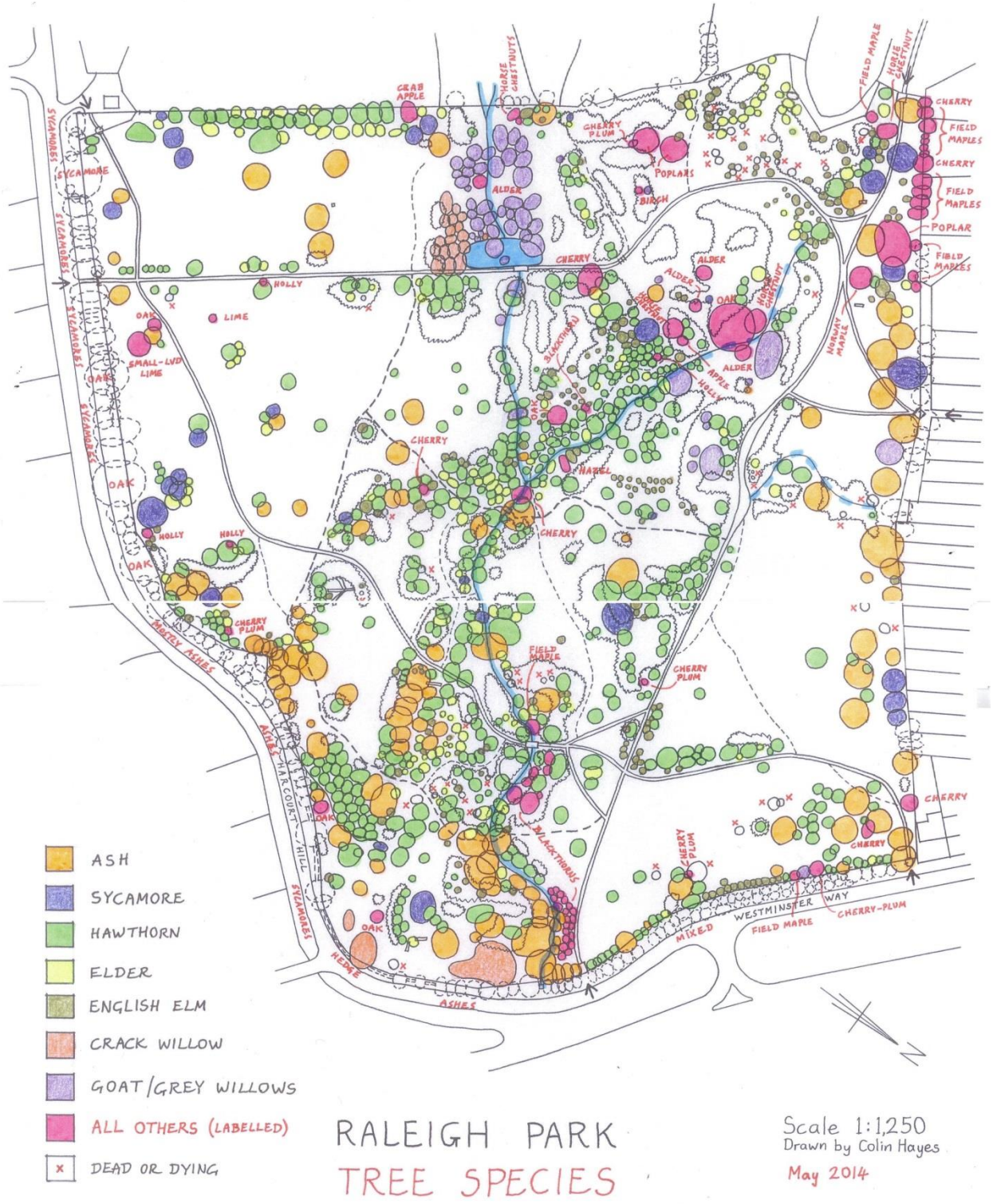
When replacing ashes, some increased diversity of scrub species would benefit wildlife. Wayfaring tree, spindle and purging buckthorn are not present but are appropriate to the soil and would increase diversity of food source for animals, without spreading clonally and eliminating grassland (introducing dogwood is not recommended for this reason).

Bramble scrub is, of course, beneficial to wildlife on site, in that it provides a nesting opportunity for birds and its flowers are an important nectar source in summer for flying insects like bees and butterflies. Currently there is too much bramble; there needs to be a decision as to how much bramble remains and which locations are best (away from restored wetland areas).

Wetlands have been colonised by grey willow and to the south of the pond a number of tall, young, crack willows are present at the time of writing, but are scheduled for removal. The single, large, pedunculate oak, which was a prominent feature of the centre of the site, fell in 2016, leaving only one live oak.

For further information on trees see the detailed tree map produced by Colin Hayes in 2014, reproduced below by kind permission of Isobel Hayes. Of course there have been some tree losses (large oak) and removals (willows) since then.

Figure 3: *Raleigh Park tree species map* produced by Colin Hayes, May 2014



Pond

The pond is obviously a feature that has been made by digging out peat in an elongated area to the west and upslope of the causeway in what was once fen wetland. A possible origin of a pond in this position could be as follows: when the causeway and bridge were constructed across the fen here, they impeded drainage, causing water moving through the fen to accumulate on the west side and form a shallow pool, which has since been artificially deepened. Information from the Friends of Raleigh Park group indicates the pond has been in place nearly 30 years.

The range of plants present in my first surveys in 2011 show that it contained mostly introduced plant species, such as parrot's feather, greater spearwort, water starwort and branched bur reed. Other plant species present, like floating sweet grass, fool's water cress, greater reedmace and flag iris, are already present in the nearby fen and would have just moved into the pond.

Parrot's feather *Myriophyllum aquaticum* is a non-British invasive alien species and is not now recommended in natural ponds. Since then it has all successfully been removed by the Friends group.

The pond has become a breeding site for amphibians, such as common frog and smooth newt. A very young juvenile toad was recorded in the fen nearby in 2017 but, as yet, toad spawn has not been observed in the pond, so there is no confirmation that toads breed here. They may, of course, be breeding in nearby garden ponds.

Pond in shaded state before restoration work, 20 October 2011

Grassland

The grassland areas are currently rank and largely dominated by grasses, such as false oat-grass with creeping bent, meadow foxtail, cock's foot, Yorkshire fog, tall fescue, meadow fescue, red fescue and rough meadow grass. Broad-leaved herbs include yarrow, meadow buttercup and creeping buttercup, with much rarer bird's foot trefoil, sorrel, clovers, common and tufted vetches, agrimony, red bartsia and cowslip. Small amounts of hoary ragwort probably do not present a problem to any stock. Grassland near copses of trees has patches of cow parsley in spring.

Raleigh Park – grassland view

Extensive patches of creeping thistle are found in some rank grass areas along with quite a lot of docks. Creeping thistle is a notifiable weed species that can be problematic, if not controlled.

The causeway or embankment across the site has a more diverse grassland flora, as here are found common knapweed, lady's bedstraw, cowslips, common bird's foot trefoil and, especially important, a small number of plants of spiny restharrow, which is a rare species in the county. Why should these species exist only here? Possibly the causeway has drier soil and so less of the rank growth that has suppressed these species in other grassland areas. The fact that more grassland plant diversity exists here may also point to the causeway being quite an old feature.

Spiny restharrow, Ononis spinosa

Common (or black) knapweed, Centaurea nigra

Some grassland and peaty wetland margins appear to have been lost under spreading nettle patches. Whilst some nettles are useful to feed insects, such as caterpillars of peacock, small tortoiseshell and red admiral butterflies, uncontrolled nettle dominance results in loss of more valuable flowery grassland habitat. Nettle areas are on the margins of the patches of peaty fen.

Nettles are indicator species of nutrient enrichment, having a particularly high phosphate requirement. One explanation is that the nettle patches are old stock dunging areas.

Alternatively, enrichment happens when old peat, which formed on the now-dry fen margins before they dried out, becomes oxidised by microbial activity, liberating plant nutrients required in high amounts by nettles, such as phosphate and nitrate.
Why are the fen marginal peaty areas now drier than in the past? Possibly due to historic drainage (deepening of drainage channels in the wetlands) or climate change to drier conditions.

The Friends of Raleigh Park website includes a document by Gerald Dawe, which describes how the vegetation of the site has changed. It includes a photograph of the site in the 1970s, when it was well grazed, and a carpet of yellow buttercups is prominent. This account regrets the loss (due to spread of rank grass consequent on lack of grazing) of the following grassland species that used to be present: quaking grass, hoary plantain, yellow rattle, greater knapweed and especially burnet saxifrage, which apparently at one time (in the late 1970s) used to be more or less ubiquitous throughout the Raleigh park grasslands. The last plant of this was seen flowering in 2013.

A plant thought lost from the old lists is strawberry clover *Trifolium fragiferum*, which likes damp short turf. However, my surveys show this still survives on the regularly mown and trampled paths throughout the site that run close to the wetland areas, especially near the end of the causeway to the north.

Strawberry clover, Trifolium fragiferum

Grassland Invertebrates

The current dominance of rank grass species over much of the site restricts the diversity and abundance of nectar-rich flowers. This limits the diversity of invertebrate species like bees, flies and common butterflies, which depend on nectar as an energy source. Sparse individuals of common butterflies, such as meadow brown, ringlet, speckled wood, common blue, brimstone, large and small skippers and whites, are already recorded but numbers and diversity of all invertebrate species will be much favoured by reduction of the rank grassland by either cutting and raking annually in late summer or by increased grazing pressure in autumn winter and early spring. (Grazing should be relaxed or absent in summer to allow flowering and completion of insect life cycles.)

Alien plants and garden escapes

Either the dumping of garden rubbish or spread by bird-dropped seed from gardens has given the site a small number of garden plants and aliens. A large clonal patch of spearmint *Mentha* sp. is found on the northern side. In summer the mint flowers are a good nectar source. The Himalayan balsam may have spread from a garden upslope to the west. Dumped garden weedings are usually responsible for the occurrence of plants like stinking iris or gladdon in any area near housing. The latter is easily removed by digging out.

Dead wood wood and ageing, decaying, trees

The site as a whole has a good proportion of ageing and decaying trees from elms to old hawthorns and also fallen deadwood has been usefully retained on site. Decaying trees are not a problem (needing felling only if there are health and safety issues) and should not be removed, since they add considerably to the total biodiversity on site, as they are colonised by fungi and specific deadwood (saproxylic) insects. Two of the most uncommon flies so far recorded on site were found breeding in specific fungi on dead wood. Dead wood generates insects needed by insectivorous birds, and even badgers and foxes are known to rip apart decaying logs to find juicy grubs in times of drought.

Fungi on dead wood

Velvet shank, Flammulina velutipes (L)

Bay polypore, Polyporus badius (R)

FOCUS OF WORK IN THE FIRST YEAR OF BBOWT WILD OXFORD PROJECT AT RALEIGH PARK

In the first year of project work the focus has been the top west fen area and the margins of the pond within the fen area.

Alkaline fen restoration:

At the start of the project, relic patches of a rare, valuable, calcareous, alkaline fen habitat were identified in Raleigh Park. These have been over-shadowed by uncontrolled growth of giant horsetail and scrub due to insufficient grazing and no specific cutting management.

Initial surveys showed that there was still a lot of plant diversity in the shaded large fen patch at the top south-west end of the site. In particular, a good population of common spotted orchid was surviving on the scrub edge, with many non-flowering plants found in the shade of grey willow scrub. Removal of this scrub was therefore seen as a priority to prevent further species loss, encourage return of species from the seed bank and to encourage the common spotted orchid population.

The project could provide assistance with scrub removal and regular reed cutting and raking to return it to the vegetation type typical of when the land underwent rough, extensive, grazing. In the absence of grazing the fen will need at least an annual cut and rake.

Species proven to have increased with such cutting and removal of dominant tall vegetation at other sites include attractive wetland species useful to a variety of insects, such as water mint *Mentha aquatica*, meadowsweet *Filipendula ulmaria*, marsh thistle *Cirsium palustre*, water figwort *Scrophularia auriculata*, greater bird's foot trefoil *Lotus pedunculatus,* great willow-herb *Epilobium hirsutum*, hemp agrimony *Eupatorium cannabinum*, wild angelica *Angelica sylvestris*, brooklime *Veronica beccabunga*, water forget-me-not *Myosotis scorpioides* and bugle *Ajuga reptans*.

Pond Restoration

The deeply-shaded state of the pond (by tall crack and grey willows) at the start of this project made it unsuitable for the breeding of invertebrates like dragonflies and damselflies, which prefer open, sunny, warmer ponds. It was identified that the Wild Oxford Project could make a big difference to this pond by tree and scrub removal, which would also improve the breeding success of amphibians. Initial simple dip netting in 2016 indicated very limited invertebrate fauna present, although common frog and smooth newt were in residence.

Locals who appreciate the site would much like to see the pond returned to the more open conditions they remember from years ago.

RESULTS OF FIRST YEAR OF BBOWT WILD OXFORD PROJECT WORK AT RALEIGH PARK, NOVEMBER 2016 TO DECEMBER 2017

Volunteers under the leadership of Andy Gunn contributed to remedial work on several of the patches of fen at the western higher slope areas during **7 full work days throughout the year**.

Additionally Oxford City Council contributed staff time in order to bring down some of the larger willows, which volunteers could then clear away.

Each Wild Oxford work session lasts approximately 5 hours, so the total number of session hours over the last year is 35. Numbers of volunteers per session have been variable but, in general, numbers of attendees have increased throughout the year, with the maximum total of 29 volunteers on the last session on 16th December 2017.

The entire focus of the first year has been on the wetlands and pond at the top south-west side of the site.

Ecological monitoring of species occurrence and mapping of habitat change happened either during the work sessions or by separate visits. Monitoring vegetation change with on-going wetland restoration is an important part of any recording in order to judge the effectiveness of the volunteer work. Whilst qualitative observations are useful, a more quantitative recording method was used as well, specifically for the biggest fen area being restored at the top south-west side of the site.

Alkaline Fen Restoration

The main work here involved the removal of dense willow scrub and trees, combined with scything and raking off vegetation as the site became more open and sunny.

Access for wildlife recording to the biggest top south-west fen before the start of the project was difficult because of the dense scrub and so in early 2017 recording it was limited to rather difficult walk-overs with simple listing of plant species.

Early stage of fen restoration – willows to be felled

Removing willow from top of south-west fen, November 2016

Scything and raking the fen area in Raleigh Park

As soon as there was better access to the fen following tree removal, it was thought useful to set up a more detailed monitoring system for herbaceous vegetation within the best fen areas to enable repeat recording to chart restoration progress over future years. This 2017 study will provide a baseline of the vegetation composition immediately after scrub removal to compare with future similar assessments.

In order to obtain a frequency value for each species, two 20m x 20m square sections of the cleared top west fen were marked out and vegetation within each square was assessed by recording the presence or absence of species in 40 random 28cm quadrats (actually circular 'roundrats'). This recording method has recently proved useful in Cothill Fen SAC. These two 20 x20m squares can be re-located fairly accurately in the future for re-recording. The two squares are contiguous. The upper square is immediately below the fence line, the lower square immediately above the pond (see sketch map, **Figure 4**).

Figure 4: *Sketch map of location of plant-monitoring squares in the top west fen*

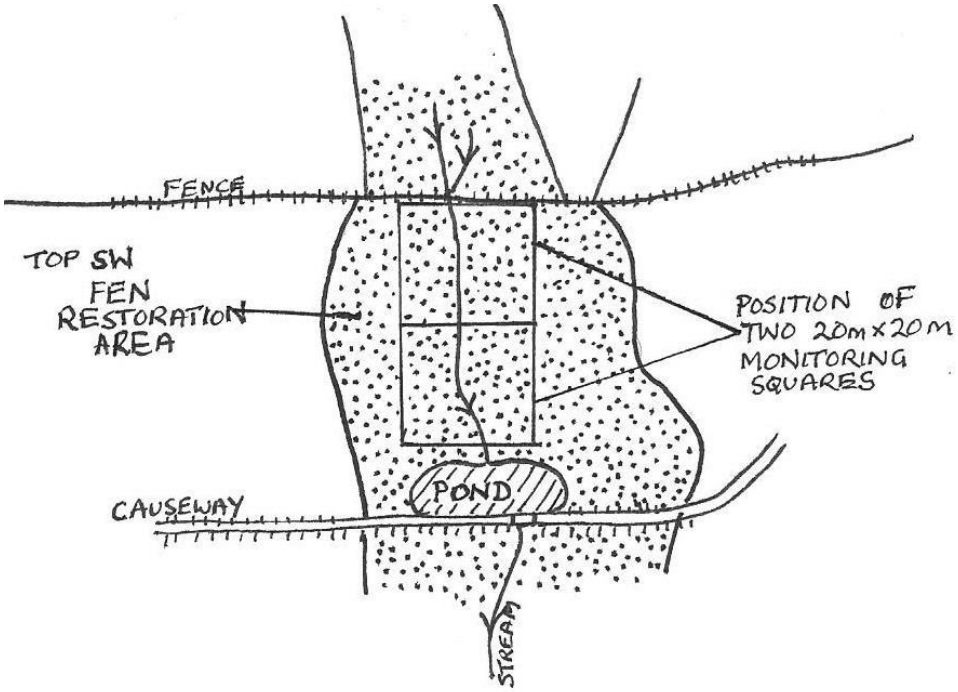


Table 1 (p.24) shows the frequency of plant species present in each of these monitored squares.

The total plant species diversity within these two fen squares (i.e. in 800m2) is 53 species, which is a high number considering the previous willow scrub dominance and the shading created, which might have been expected to eliminate more species. Not all plants could be confidently identified to species in the absence of flowering material (grazing, cutting and raking removes flowers); these are shown as genus only e.g. *Glyceria* sp. sweet grasses.

It is expected that the plant frequencies will change now that the light is high in the area and the fen is receiving cutting and raking-up, as well as light cattle-grazing.

Looking at the results in the table it should be apparent that in 2017, after clearance work, the most frequent herbaceous plants are: giant horsetail, creeping bent grass, sweet grasses, hoary willow herb, fern-leaved hook moss and common spear-moss, with the low-growing creeping jenny frequent towards the highest part of the fen.

There is quite a lot of rush (*Juncus* sp.) germination but the plants are as yet too young to flower and be easily identifiable. More species should be identifiable by summer 2018. A developing issue is the colonisation of opened-up fen areas by seedlings of greater reedmace (spread from nearby uncleared areas of the south-western long extension). These seedlings should be removed by pulling whilst at a small size, as allowing growth and dominance by tall reedmace will not achieve a return to short-turf fen.

A notable observation this summer immediately after willow clearance was the abundant flowering of creeping jenny, which had previously been present but unable to flower at all due to the deep shade of the willows – thus an immediate benefit to flower-feeding insects..

Creeping jenny, Lysimachia nummularia

The data in **Table 1**, page 24, includes relic species of the previously-wooded conditions, i.e. small amounts of willow, bramble, ivy, alder and dogwood. As restoration cutting, raking and grazing continues, these species are likely to completely disappear and other suppressed herbaceous species will thrive.

Giant horsetail will also decline because cutting and raking reduces its vigour. As it has deep underground rhizomes, it will persist forever, but cutting and raking management will weaken it, reducing its shading ability and thus allowing other species the chance to thrive. Lemon-scented liverwort and hart's tongue thyme moss will also decline now the fen is open, as they prefer shade and shrivel in full sun.

Giant horsetail, Equisetum telmateia

Giant horsetail, Equisetum telmateia

Species currently apparently absent as visible plants may return from the seed bank, e.g. ragged robin (well known for such an apparent 'return from the dead'). Dormant seed brought to the peat surface with all the trampling and tree removal will be stimulated to germinate by the higher light.

Already one of the new species found this year in the fen is the tiny bristle club rush *Isolepis setacea*, which is a well-known seed bank species. It is an uncommon species that is always a 'first responder' following fen restoration, as it has extremely long-lived seed and likes open, short, vegetation. Its recurrence is a clear indication that at one time in the past the Raleigh Park fen wetlands were short turf, maintained by a much larger number of grazing animals.

Bristle club rush, Isolepis setacea

Another 'first responder' due to its long-lived seed is the wavy bittercress *Cardamine flexuosa*.

A less desirable species that shows abundant return from a long-lived dormant seed bank is hard rush *Juncus inflexus*. This tussock-forming plant has very wiry, tough, cylindrical leaves that are not eaten by stock, so once it returns from the seed bank, it tends to be avoided by stock and thus increases, suppressing other plant species by the spreading of its dense tussocks. It can be prevented from totally dominating a wetland, if it is cut regularly to reduce vigour, or it can be removed by digging out the tussocks.

Hard rush, Juncus inflexus

In December 2017 a grey wagtail was noticed enjoying the more open fen conditions near the pond.

Figure 5: *Sketch map showing progress on fen restoration at Raleigh Park in December 2017 after the first year of Wild Oxford Project work*

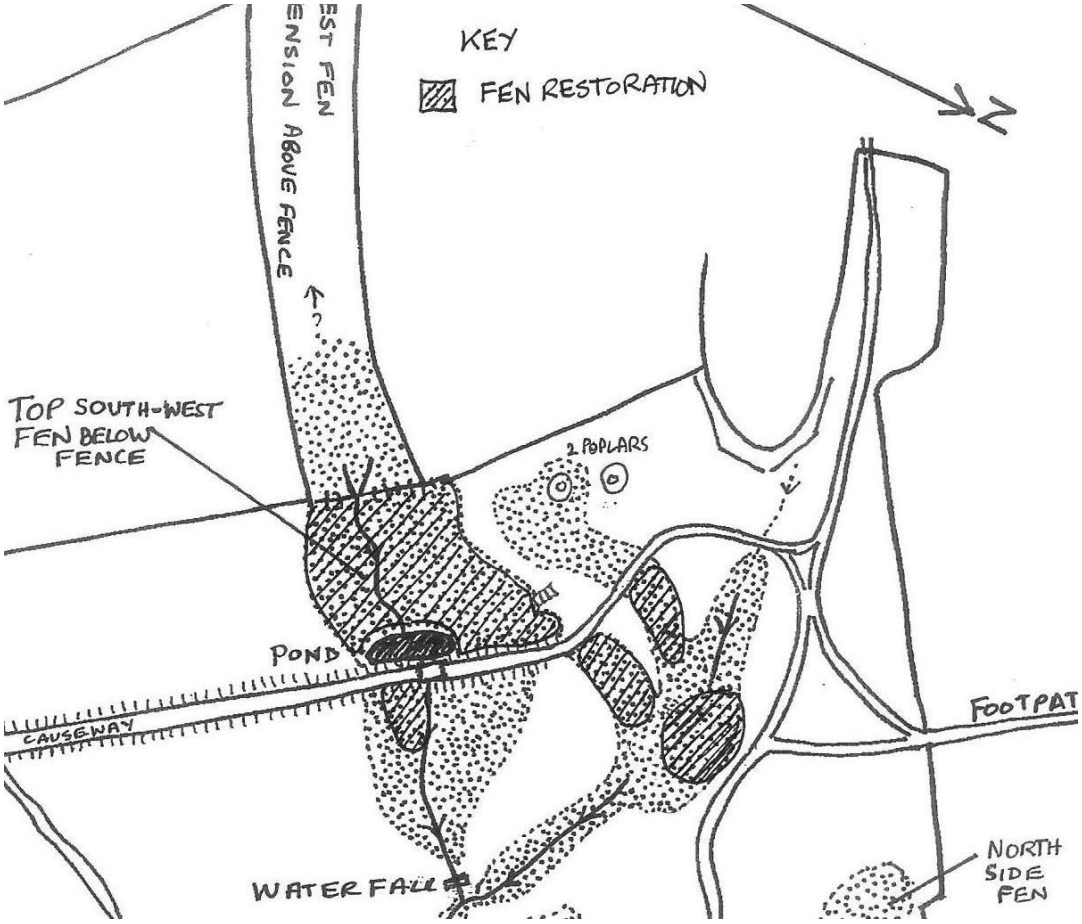


Table 1: *Percentage frequency of plant species in 40 random samples of two contiguous 20 x20m squares of the restored top west fen in 2017 after willow tree removal*

Frequency in 40 quadrats in a 20 x 20m square in west top fen		Top square below fence	Square above pond
Scientific name	**Common name**	**% freq.**	**% freq.**
Agrostis stolonifera	Creeping bent	52.5	25.0
Alnus glutinosa (seedling)	Alder		5.0
Apium nodiflorum	Fool's watercress	10	15.0
Arum maculatum	Cuckoo pint	2.5	
Brachypodium sylvaticum	Wood false brome	2.5	
Brachythecium rutabulum	Rough-stalked feather-moss		7.5
Calliergonella cuspidata	Common spear moss	40	22.5
Cardamine flexuosa	Wavy bittercress		2.5
Cardamine pratensis	Cuckoo flower	12.5	5.0
Carex hirta	Hairy sedge	10	
Cirsium palustre	Marsh thistle	12.5	2.5
Conocephalum conicum	Lemon-scented liverwort	12.5	2.5
Cornus sanguinea	Dogwood		2.5
Cratoneuron filicinum	Fern-leaved hook moss	42.5	25.0
Dactylorhiza fuchsii	Common spotted orchid	5	
Epilobium hirsutum	Great willow herb	7.5	**5.0**
Epilobium parviflorum	Hoary willow herb	42.5	5.0
Epilobium sp.	Willow herbs		10.0
Equisetum arvense	Field horsetail	10	2.5
Equisetum palustre	Marsh horsetail	5	
Equisetum telmateia	Giant horsetail	57.5	17.5
Eupatorium cannabinum	Hemp agrimony	12.5	7.5
Festuca gigantea	Giant fescue	10	
Fraxinus excelsior (seedling)	Ash	17.5	5.0
Geranium robertianum	Herb robert		2.5
Geum urbanum	Wood avens	2.5	
Glyceria sp.	Sweet grasses	42.5	40.0
Hedera helix	Ivy	2.5	2.5
Holcus lanatus	Yorkshire fog	15	
Hypericum tetrapterum	Square-stalked St John's wort	10	10.0
Iris pseudacorus	Yellow flag iris	5	12.5
Isolepis setacea	Bristle club rush	5	
Juncus articulatus	Jointed rush	22.5	2.5
Juncus bufonius	Toad rush	15	5.0
Juncus inflexus	Hard rush	7.5	10.0
Lysimachia nummularia	Creeping jenny	30	
Mentha aquatica	Water mint	5	17.5
Myosotis scorpioides	Water forget-me-not	12.5	2.5
Myosoton aquaticum	Water chickweed	2.5	
Pellia endiviifolia	Endive pellia liverwort	5	7.5
Plagiomnium undulatum	Hart's tongue thyme moss	27.5	7.5
Poa trivialis	Rough meadow grass	5	12.5
Ranunculus repens	Creeping buttercup	15	12.5
Ranunuculus acris	Meadow buttercup	5	
Rubus fruticosus	Bramble	5	10.0
Rumex sp	Docks	2.5	12.5
Salix cinerea	Grey willow	20	27.5
Scrophularia auriculata	Water figwort	2.5	20.0
Solanum dulcamara	Bittersweet		2.5
Taraxacum sp	Dandelions	2.5	
Trifolium repens	White clover	10	
Typha latifolia	Greater reed-mace	12.5	17.5
Veronica beccabunga	Brooklime	25	35.0

Pond Restoration

The creation of open sunny conditions in and around the pond is still in its early stages; it will take some months of 2018 to see the shading willows all gone. Aquatic invertebrate surveys by dip netting will start next year, once the pond has been open and sunny for some time. Water beetles and water boatmen arrive quickly but even one year may not be enough for populations of some species to build up, as it can take several years for dragonfly nymphs to complete full development to adult emergence.

See also comments under **'Water quality'**.

Pond partly cleared, 5 February 2017 (view from North)

Start of scything and raking bramble around the pond, December 2017

Result of scrub clearance around the pond, 11 January 2018

SUMMARY AND CONCLUSIONS

The BBOWT Wild Oxford Project has made a big difference to the habitats in Raleigh Park in just the first full year, with the target fen and pond areas showing positive change. However, the full response of the vegetation will not begin to be apparent until the end of 2018 and further measures of ecological success will have to wait for surveys then.

ACHIEVEMENTS

Seven full work days totalling 35 hours between the first work party in November 2016 to the last of the year in November 2017 were well attended by volunteers and much enjoyed by participants. The last work session of 2017 drew the highest single total of 29 volunteers, a record for any of the Wild Oxford sites and an indication of high interest in this site – from locals and from volunteers from all over the city.

- 0.19 hectares of top south-west fen priority area completely cleared of bramble and young willow scrub plus vegetation re-growth scythed and raked off. Some large crack willow tree felling by OCC; a few remain to be felled this winter and some grey willows also need to be winched out of the pond.
- Two small spring-fen patches to the north-central area near the path scythed and raked off - total 0.6ha.
- Oxford City Council assisted by carrying out a cut-and-collect and removal of bramble scrub patches on drier ground and marginal areas of over 1.6 hectares on the north side that were not too wet for machinery, as well as a partial cut-and-collect of some areas of rank grassland on the south side, which were not measured.
- An increasing number of people have been introduced to the site via volunteering in the Wild Oxford work sessions, and the conservation work of the Friends group has been given a boost and a clearer focus.
- The attraction of the site to the general walker has been much increased by restoring some of the open landscape views that used to be a site feature.
- Step construction to aid access. The footpath on the northern side runs over a peaty spring area, which was difficult for walkers because of a steepish slope with slippery, sinky, terrain. Clearance of bramble enabled a slight diversion of the path and construction of steps down the bank to join the causeway enabled easier progress on foot.

RECOMMENDATIONS FOR FUTURE CONSERVATION AND MANAGEMENT WORK AT RALEIGH PARK

1. **Wildlife survey of the western upslope long extension,** which is fenced off. This has not yet been studied in detail and contains more fen areas that should be assessed for biodiversity.

2. **Calculation of the rainwater catchment upslope to the west of the fen areas in the park**. Once the catchment limits are known, the green areas outside the park in the catchment can be protected from damaging hard surfacing (i.e. development) which would reduce spring water flow in the park.

3. **Removal of scrub and trees from all the fen peaty wetland areas identified in Figure 2**. Any re-growth of herbaceous vegetation should undergo scything and raking-up of arisings at least once annually to reduce the suppressing influence of inedible dominant plants like giant horsetail and hard rush. This will benefit species and habitat diversity overall on site, with the added benefit of making landscape views across the park much more attractive.

4. **Specifically target particular dominant plants, such as hard rush and pendulous sedge, in fen areas** by scything and raking off several times a year. This will control but not eliminate them, so, when weakened, the perennial tussocks of these plants may need digging out to ensure smaller plants can thrive.

5. **Grazing intensity needs to increase to promote the return of species diversity in the grassland**. Suitable stock could be either cows or horses. Without this, flowery species will continue to be lost from the drier grasslands with reduction of insects, such as butterflies.

6. **In connection with previous grazing issues, continue the further removal of a proportion of the dense bramble scrub patches** on drier ground to open up/widen rides for stock access. This will make the interaction between stock and the public easier.

7. **Blackthorn scrub needs to be surveyed annually in winter or spring for the presence of brown and black hairstreak butterflies** by an expert in egg identification. As an egg of a brown hairstreak has recently been found on blackthorn, continue the annual rejuvenation of a proportion of the old blackthorn patches already started in January 2018.

8. **Consider purchasing some Dutch Elm Disease-resistant elm saplings in order to replace the grove of dying English elms in the north-west site corner**. It may be possible to attract white letter hairstreak butterflies to breed on this elm.

9. **Creeping thistle needs control in some grassland areas** by topping combined with removal of arisings before it flowers in summer.

10. **Further surveys to get a better view of site biodiversity** would be useful and could include small mammal trapping, bat survey, moth trapping, glow worm walk, constructing reptile hibernacula and refuges. What about involving local primary children in these activities?

11. **Ponds should be managed with a light touch when shading willows are all removed.**
    Some control of the emergent and floating mat vegetation in the pond would help diversity, if it looked as though open water was disappearing. In this situation a small proportion of the vegetation mat would need to be removed carefully with a crome* annually. This should maintain open water but leave a good thick marginal vegetation fringe for amphibian breeding. **The pond should not be further deepened**, shallow margins with lots of vegetation are best for aquatic species diversity.

    **A pond-raking tool resembling a long-handled fork, with 4 tines bent at 90° (Wikipedia).*

12. **Once they are clear of scrub, consider re-wetting some of the peaty fen areas in the centre of the site** by using small woody-debris dams at regular intervals across the stream. These will slow water flow off the whole site and spread some sideways. This water retention will help to reduce the likelihood of flooding downslope. To help this process, historic deepening of the stream corridor should be reversed by shallowing the stream bed between woody dams. This will enable even greater retention of spring water on site.

13. **Consider removing one of the large hybrid poplar trees on the south-west high ground.** It has its roots in a fen marginal area (*see* **Figure 2** – *above the pond, on the right*) and, without the removal of water via transpiration, more will remain in the fen, enabling it to remain wetter and better survive climate change to drier conditions in future.

Full-sized versions of photos are available at ***https://photos.app.goo.gl/2ZVYg4T4OfYNmjVQ2***

ACKNOWLEDGEMENTS

I am grateful to Carl Whitehead of Oxford City Council for discussions and for access to documents regarding the site held in the City Council's archives and to Andy Gunn of BBOWT for discussions, as the work progressed. My thanks also go to TVERC for supplying historic species lists, Clive Smith and Colin Hayes for bird records and Marilyn Cox, who gave invaluable editorial help with this report.

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APPENDICES

Appendix 1: Information on the special chemistry of iron rich wetland areas – 'Iron-oxidizing Bacteria', Owen Green, Oxfordshire Geology Trust, 2017 *(attached)*

Appendix 2: Species found at Raleigh Park to date from 2016-2017 and including the bird records of Colin Hayes and Clive Smith (*please see separate document*)

Iron-oxidizing Bacteria

by Owen Green, Oxfordshire Geology Trust

In a wetland, a bright orange 'sludge' and a reflective mirror-like sheen on water surfaces are the result of the natural activity of an extremely ancient type of bacteria and not (as is often thought) because of water pollution. These bacteria are chemotrophic (chemical-feeding), which means they obtain the energy they need to live and multiply by oxidizing dissolved ferrous iron. They are known to grow and proliferate in waters and soil containing iron concentrations as low as 0.1mg/L. However, at least 0.3 ppm of dissolved oxygen is needed to carry out oxidation.

The bacteria combine iron and manganese with oxygen to form deposits of "rust" and a sticky, slimy, yellow / orange /red-coloured build up. They may also occur as a rainbow-coloured or "oil-like" sheen on the surface of the water. The bacteria cause stains, horrible tastes and odours (often confused with hydrogen sulphide gas and possibly redolent of a swamp, sewage, fuel oil or cucumber) and can create undesirable conditions for the growth of other organisms.

The most common known species of bacteria with microbial metabolisms based on iron oxidation include *Thiobacillus ferrooxidans* and *Leptospirillum ferrooxidans*. These are known as 'extremophiles'. The study of extremophile organisms, their environments of formation and occurrence in the geological record has received considerable funding in recent years, as astro-biologists and geo-microbiologists recognise their potential in devising analogues for the study of extra-terrestrial life.

Habitat

Iron-oxidizing bacteria colonize the transition zone where de-oxygenated water from an anaerobic environment flows into an aerobic environment. Groundwater containing dissolved organic material may be de-oxygenated by microorganisms feeding on that dissolved organic material. Where concentrations of organic material exceed the concentration of dissolved oxygen required for complete oxidation, microbial populations that contain iron-reducing bacteria can reduce insoluble ferric oxide in aquifer soils to soluble ferrous hydroxide and use the oxygen released by that reaction to oxidize some of the remaining organic material:

$$4H_2O + 2Fe_2O_3 \rightarrow 4Fe(OH)_2 + O_2$$

(water) + (Iron[III] oxide) → (Iron[II] hydroxide) + (oxygen)

When the de-oxygenated water reaches a source of oxygen, iron-oxidizing bacteria use that oxygen to convert the soluble ferrous iron back into an insoluble reddish precipitate of ferric iron:

$$4Fe(OH)_2 + O_2 \rightarrow 4H_2O + 2Fe_2O_3$$

(Iron[II] hydroxide) + (oxygen) → (water) + (Iron[III] oxide)

Since the latter reaction is the normal equilibrium in our oxygen atmosphere, while the first requires biological coupling with a simultaneous oxidation of carbon, organic material dissolved in water is often the underlying cause of iron-metabolizing bacteria populations. Groundwater may be naturally de-oxygenated by decaying vegetation in swamps, and useful mineral deposits of bog iron ore have formed where that groundwater has historically emerged to be exposed to atmospheric oxygen. Anthropogenic sources, like landfill leachate, septic drains, or leakage of light petroleum fuels, are other possible sources of organic materials allowing soil microbes to de-oxygenate groundwater.

A similar reversible reaction may form black deposits of manganese dioxide from dissolved manganese, but this is less common because of the relative abundance of iron (5.4 percent) in comparison to manganese (0.1 percent) in average soils. Other conditions associated with iron-oxidizing bacteria result from the anaerobic aqueous environment, rather than the bacteria visibly colonizing that habitat. Corrosion of pipes is another source of soluble iron for the first reaction above and the sulphurous smell of rot or decay results from enzymatic conversion of soil sulphates to volatile hydrogen sulphide as an alternative source of oxygen in anaerobic environments.