Biological survey of Burnham Beeches Middle and Upper Ponds in 2016

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Summary

Surveys of the wetland plants and aquatic macroinvertebrates of Upper and Middle Ponds, Burnham Beeches, show that these are both important waterbodies that currently qualify as Priority Ponds on multiple criteria including presence of uncommon wetland plants and invertebrates, and 'Good' PSYM scores.

However, comparison of the 2016 data with surveys undertaken in the early 1990s indicates that both ponds have declined in quality over the last two decades. This includes loss of sensitive aquatic plant species and declines across all most groups of invertebrates including water beetles, bugs and dragonflies. A specific search for the uncommon Downy Emerald dragonfly failed to re-find evidence of its presence as larvae, exuviae or adults.

The reasons for these losses are speculative but are likely to include (i) loss of plant habitats including submerged aquatic plant stands in more open water, and marginal plants along shaded edges (ii) increasing depths of organic sediment (iii) anthropogenic disturbance and enrichment, and (iv) more general influences such as extinction debt.

Management recommendations are given to help (a) increase the plant and invertebrate diversity, and (b) minimise damage to the site resulting from planned maintenance of the ponds' inflow structures.

Contents

1 Aims

This report describes the results of biological surveys of Burnham Beeches Upper and Middle Ponds, undertaken in 2016 by Freshwater Habitats Trust for City of London Corporation.

The aims of the survey were to provide:

(i) Aquatic macroinvertebrate survey data for:

(a) Upper and Middle Ponds, collected with a view to informing site management, including the potential replacement of the pond outflows in the next few years.

(b) the stream section between the two ponds, specifically including taxa that might be limited to the pond outflow area which would be lost when the outflows are replaced.

(iii) An assessment of the current status of Downy Emerald dragonfly in the two ponds.

(iv) A short report of the findings including management recommendations.

In addition, the current report includes the results from a contemporaneous botanical survey of the two ponds, which was undertaken as part of a Freshwater Habitats Trust project to re-survey waterbodies that were first surveyed in the early 1990s for the National Pond Survey.

2 Background and previous surveys

Upper and Middle Ponds lie within the southern quarter of Burnham Beeches NNR (SU 9517 8481, SU 9499 8458 respectively). Both are large online ponds, over 2,000 m^2 in area, that are connected by a small seasonal stream which initially rises within a housing estate to the east of Burnham Beeches and eventually flows out through Swilly Pond at the southern tip of the reserve.

A number of ecologists have previously collected invertebrate data from the pond, with a cluster of surveys undertaken 25 to 30 years ago. A useful, but cursory, survey of plants from both ponds was undertaken by Owen Mountford from the Centre for Ecology and Hydrology as part of a hydrological assessment of the site in 1988 (Institute of Hydrology 1988). More notably, Adrian Hine undertook detailed surveys of the aquatic invertebrates in Upper and Middle Ponds in 1992 and 1993 (A Hine undated[a,b]). In the same years, Freshwater Habitats Trust happened to survey the wetland plant and aquatic invertebrates from Middle Pond using National Pond Survey (NPS) survey methods (Pond Action 1998 and unpublished).

The occurrence of a diverse dragonfly community, and particularly the presence of the uncommon Downy Emerald (*Cordulia aenea),* also led to species specific surveys by Adrian Hine in 1992-93 (A Hine undated[c]) and more recently in 2010 by Alan Nelson (Nelson 2010).

3 Methods

The methods used for the current survey were selected to:

(i) allow comparison with previous surveys

(ii) provide data detailed enough to form the basis of management advice (see below).

Two visits to the site were made, the first in late spring (06 June 2016), the second in mid-summer (01 August 2016). On both occasions the surveys were undertaken by Freshwater Habitats Trust staff Jeremy Biggs and Penny Williams.

3.1 Environmental variables measured

Environmental attributes recorded at each waterbody included conductivity and pH, measured using hand-held Hanna meters, and a range of physical attributes, particularly those needed to run PSYM to assess overall pond quality (Appendix 1).

3.2 Aquatic invertebrate survey methods

3.2.1 Pond surveys

To maximise compatibility with previous surveys, aquatic invertebrates in Upper and Middle Ponds were collected from the mesohabitats originally identified in Adrian Hine's year 2 surveys. Each mesohabitat sample was sorted and identified separately to provide information about the distribution of macroinvertebrate species around the ponds. In total each pond was sampled for 3 minutes with the sampling time divided equally between the mesohabitats. The data from all mesohabitats were collated to give a single 3-minute sample species list for each pond, compatible with previous National Pond Survey data.

For the field survey, water areas were sampled for invertebrates using a standard 1 mm mesh hand net, frame-size 0.26 x 0.30 m. The net samples were exhaustively live-sorted in the laboratory to remove all individual macroinvertebrates, with the exception of very abundant taxa (>100 individuals), which were subsampled.

For both the standard surveys and field search, macroinvertebrate taxa were identified to species level in the groups for which reliable UK distribution data and Red Data Book information are available. These were: Tricladida (flatworms), Hirudinea (leeches), Mollusca (snails and bivalves, but excluding *Pisidium* species), Malacostraca (shrimps and slaters), Ephemeroptera (mayflies), Odonata (dragonflies and damselflies), Plecoptera (stoneflies), Heteroptera (bugs), Coleoptera (water beetles), Neuroptera (alderflies and spongeflies) and Trichoptera (caddis-flies). Other taxa (mainly Diptera larvae and Oligochaeta) were noted at family or genus level, but were not included in the analysis of species richness.

3.2.2 Stream invert sampling

The 200m length of stream between the two ponds was surveyed using a standard kick-sample methodology. Additional samples were taken from the outflow area of each pond. Samples were sorted on the bankside in a large white tray, and taxa requiring microscopic identification were returned to the laboratory for checking. On the first visit in early June the sampling and bankside sorting were continued for around 2.5 hours in order to cover all areas adequately. The stream and outflows were dry at the time of the second visit in early August and so could not be sampled.

3.2.3 Dragonfly surveys

Additional surveys to assess the status of Downy Emerald dragonfly (*Cordulia aenea)* at the ponds were undertaken using three methods: (i) the British Dragonfly Society Pollard walk methodology for the dragonfly monitoring scheme (http://bit.ly/BDSMonitoring), (ii) a search for exuviae around the edges of each pond, (iii) a net search for larvae amongst coarse leaf-litter in areas of the ponds where they were previously recorded , and currently most likely to occur.

3.3 Wetland plant survey methods

Wetland plant survey methods conformed to the National Pond Survey methods that Freshwater Habitats Trust originally used to survey the pond in 1991. The aim was to make a complete list of wetland plants present within the 'outer edge' of the pond, which is defined as the upper level at which water stands in the ponds in winter. Pond plants were surveyed by walking or wading the perimeter of the dry and shallower water areas of the waterbodies. Deeper water areas were sampled from a boat using a pond net and grapnel hook.

'Wetland plants' were defined as the plant species listed in the National Pond Survey methods guide (Pond Action, 1998), which comprises a standard list of the ca. 400 submerged, floating-leaved and marginal wetland plants recorded in the UK.

4 Wetland plant results

4.1 Upper Pond

4.1.1 Plant communities

A total of 24 wetland plant species were recorded from Upper Pond. Of these, three can be classed as submerged aquatics, five were floating leaved species and 16 emergent plant species (Table 1).

The pond's deeper water areas were dominated by extensive mats of White Water-lily (*Nymphaea alba*), fringed to the south by Yellow Water-lily (*Nuphar lutea)*; and together occupying around 45% of the pond (Figure 1). Towards the margins, in shallower water, mats of Bogbean (*Menyanthes trifoliata*) covered around 8% of the pond, inter-growing with White Water-lily along the south-eastern edge. An extensive stand of Yellow Iris (*Iris pseudacorus*) occupied much of the sediment delta deposited by the inflow stream, with other clumps along the pond's north-western edge. The pond banks were relatively little vegetated; largely because of a combination of overhanging tree shade and the stepped edge which typically dropped vertically to 20-30cm water depth along the north-west and south-east margins. The main exceptions were (i) the inflow area, where Lesser Spearwort (*Ranunculus flammula*), Floating Sweet-grass (*Glyceria fluitans*), Marsh Pennywort (*Hydrocotyle vulgaris*) and Sharp-flowered Rush (*Juncus acutiflorus*) were present in the zone where the pond graded into the upstream mire, and (ii) the bank area just south of the inflow, where a more diverse floating mat grew out from the edge dominated by *Sphagnum* sp., Sharp-flowered Rush, Bog Pondweed (*Potamogeton polygonifolius*), Common Spike-rush (*Eleocharis palustris*), Marsh Pennywort, and more rarely, Star Sedge (*Carex echinata*).

4.1.2 Uncommon plants

The flora of Upper Pond included a range of plants like Bulbous Rush (*Juncus bulbosus*), Bog Pondweed (*Potamogeton polygonifolius*) and Marsh Pennywort (*Hydrocotyle vulgaris*), that are typical of more acid, low-nutrient, wetland habitats. In lowland England such habitats are increasingly uncommon, and at a national level, three of the plant species present in Upper

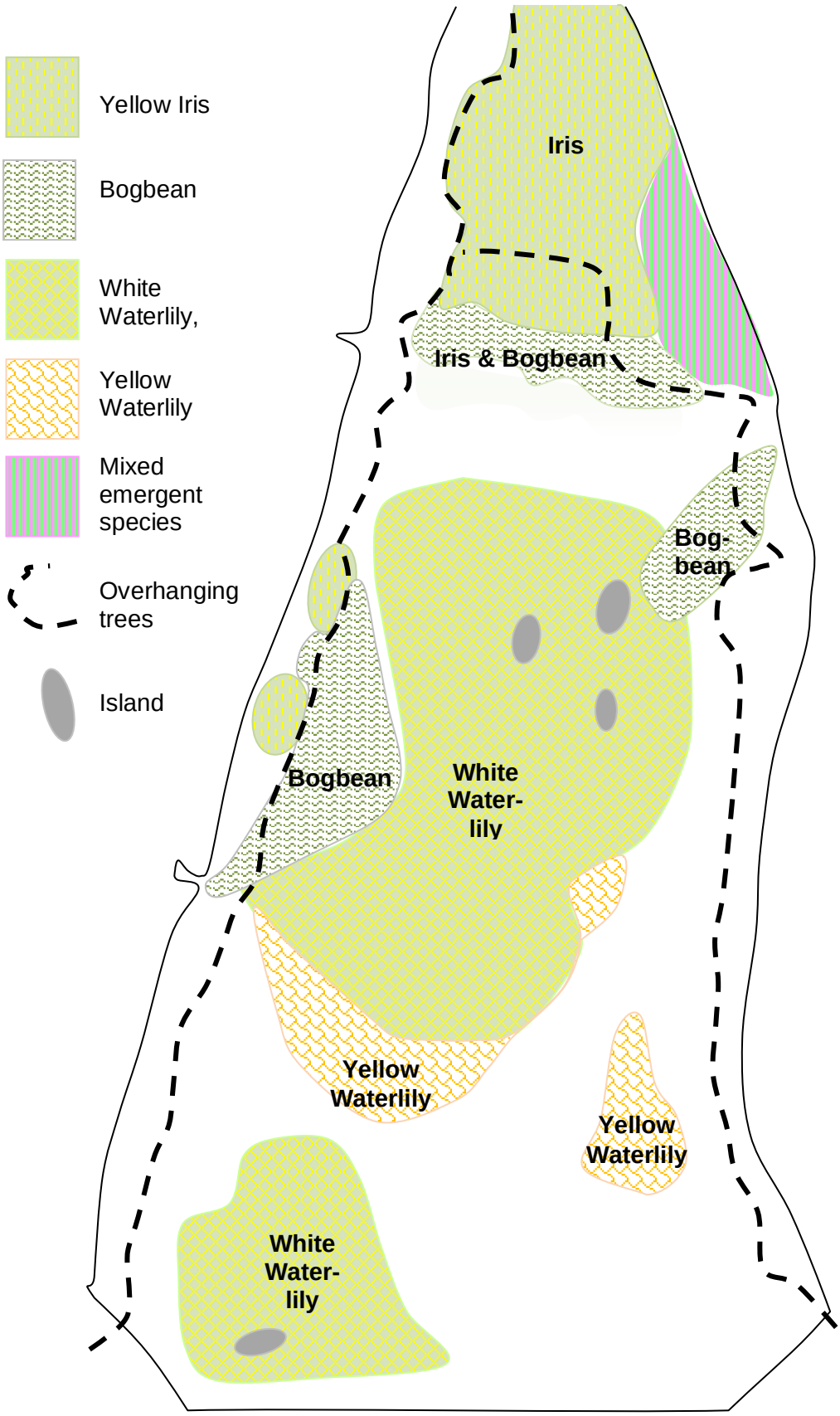
Pond have undergone such extensive declines over past decades that they are now included on the Vascular Plant Red List for England. These were: **Marsh Pennywort (Near Threatened), Star Sedge (Near Threatened)** and **Lesser Spearwort (Vulnerable)** (Stroh *et al.* 2014). Within Upper Pond all three species predominantly occurred close to the pond's inflow area and around the floating mat just to the east, where there was greatest continuity with the upstream mire and the more acid / nutrient poor water that drains from it.

Table 1. Wetland plant species recorded from Upper Pond in 2016

Scientific name	Common name	England Red List (based on IUCN categories)
Submerged aquatics:		
Callitriche stagnalis agg.[1]	Common Water-starwort	
Juncus bulbosus	Bulbous Rush	Least Concern
Sphagnum sp.	Bog Moss	
Floating-leaved plants:		
Lemna minor	Common Duckweed	Least Concern
Menyanthes trifoliata	Bogbean	Least Concern
Nuphar lutea	Yellow Water-lily	Least Concern
Nymphaea alba	White Water-lily	Least Concern
Potamogeton polygonifolius	Bog Pondweed	Least Concern
Marginal emergent plants:		
Agrostis canina	Velvet Bent	Least Concern
Agrostis stolonifera	Creeping Bent	Least Concern
Carex echinata	**Star Sedge**	**Near Threatened**
Eleocharis palustris	Common Spike-rush	Least Concern
Glyceria fluitans	Floating Sweet-grass	Least Concern
Hydrocotyle vulgaris	**Marsh Pennywort**	**Near Threatened**
Iris pseudacorus	Yellow Iris	Least Concern
Juncus acutiflorus	Sharp-flowered Rush	Least Concern
Juncus articulatus	Jointed Rush	Least Concern
Juncus effusus	Soft Rush	Least Concern
Lycopus europaeus	Gipsywort	Least Concern
Molinia caerulea	Purple Moor-grass	Least Concern
Ranunculus flammula	**Lesser Spearwort**	**Vulnerable**
Ranunculus sceleratus	Celery-leaved Buttercup	Least Concern
Sparganium erectum	Branched Bur-reed	Least Concern
Typha latifolia	Bulrush	Least Concern

[1]Small, non-fruiting plant without floating leaves

Figure 1. Upper Pond: main wetland plant stands



4.2 Middle Pond

4.3 Plant communities

Middle Pond supported 26 wetland plant species of which three can be classed as submerged aquatics, six were floating leaved species and 17 emergent plant species (Table 2).

Figure 2 shows the distribution of the main stands of macrophytes at Middle Pond. A floating mat of Yellow Water-lily dominated the southern end of the pond and graded north and westward into an extensive mixed raft of White Water-lily, Bulrush (*Typha latifolia*) and more occasional Yellow Iris which covered much of the deeper water areas of the northern pond. Clumps and larger stands of Yellow Iris also dominated much of the shallower water areas around the inflow, growing on delta sediments under the shade of overhanging trees, and giving way to a large stand of Bogbean along the north-eastern bank. Middle Pond supported more extensive stands of marginal emergent species than Upper Pond, with mixed stands of Soft Rush (*Juncus effusus*), Gipsywort (*Lycopus europaeus*), Creeping Bent (*Agrostis stolonifera*), Velvet Bent (*Agrostis canina*), Amphibious Bistort (*Persicaria amphibia*), Marsh St John's-wort (*Hypericum elodes*), Yellow Iris, Bulrush and, more occasional, Water Horsetail (*Equisetum fluviatile*) extending out on partially floating mats from the western bank. Similar stands, including rather more mesotrophic-oligotrophic species, were also present on the opposite eastern shore where stands of Soft Rush and Jointed Rush (*Juncus articulatus*), Marsh St John's-wort, Velvet Bent, occasional *Sphagnum* and, more rarely, Star Sedge occurred and sometimes inter-grew with Yellow Water-lily.

4.3.1 Uncommon plants

Middle Pond supported four plant species which are now on the England Red List: the three that were also present in Upper Pond (**Marsh Pennywort (NearThreatened), Star Sedge (Near Threatened) and Lesser Spearwort (Vulnerable)** and, additionally, good stands of **Marsh St Johns-wort (Near Threatened)**, locally growing in abundance in shallow water along parts of the western and north-eastern margins.

Middle Pond also supported a number of other plants worthy of note. The floating liverwort *Riccia fluitans* occurred sparsely in mixed stands along the western bank. It has no national rarity status but is generally a locally uncommon plant, largely restricted to higher quality and usually rather shaded sites. Trifid Bur-marigold (*Bidens tripartita*) also occurred in the mixed stands of the western margin. This bare-ground loving annual of nutrient-rich mud is again rather local and generally declining in Southern England, and often associated with areas that have long historic wetland connectivity.

Table 2. Wetland plant species recorded from Middle Pond in 2016

Scientific name	Common name	England Red List (based on IUCN categories)
Submerged aquatics:		
Callitriche stagnalis agg.	Common Water-starwort	
Juncus bulbosus	Bulbous Rush	Least Concern
Sphagnum sp.	Bog Moss	
Floating-leaved plants:		
Lemna minor	Common Duckweed	Least Concern
Menyanthes trifoliata	Bogbean	Least Concern
Nuphar lutea	Yellow Water-lily	Least Concern
Nymphaea alba	White Water-lily	Least Concern
Persicaria amphibia	Amphibious Bistort	Least Concern
Riccia fluitans	Floating Crystalwort	Uncategorised[1]
Marginal emergent plants:		
Agrostis canina	Velvet Bent	Least Concern
Agrostis stolonifera	Creeping Bent	Least Concern
Alisma plantago-aquatica	Water-plantain	Least Concern
Bidens tripartita	Trifid Bur-marigold	Least Concern
Carex echinata	**Star Sedge**	**Near Threatened**
Carex flava agg.[2]	Yellow Sedge species	
Equisetum fluviatile	Water Horsetail	Least Concern
Glyceria fluitans	Floating Sweet-grass	Least Concern
Hydrocotyle vulgaris	**Marsh Pennywort**	**Near Threatened**
Hypericum elodes	**Marsh St Johns-wort**	**Near Threatened**
Iris pseudacorus	Yellow Iris	Least Concern
Juncus effusus	Soft Rush	Least Concern
Lycopus europaeus	Gipsywort	Least Concern
Molinia caerulea	Purple Moor-grass	Least Concern
Ranunculus flammula	**Lesser Spearwort**	**Vulnerable**
Ranunculus sceleratus	Celery-leaved Buttercup	Least Concern
Typha latifolia	Bulrush	Least Concern

[1] England Red list currently excludes mosses and liverworts

[2] Non-flowering/ fruiting plants

Figure 2. Middle Pond: main wetland plant stands

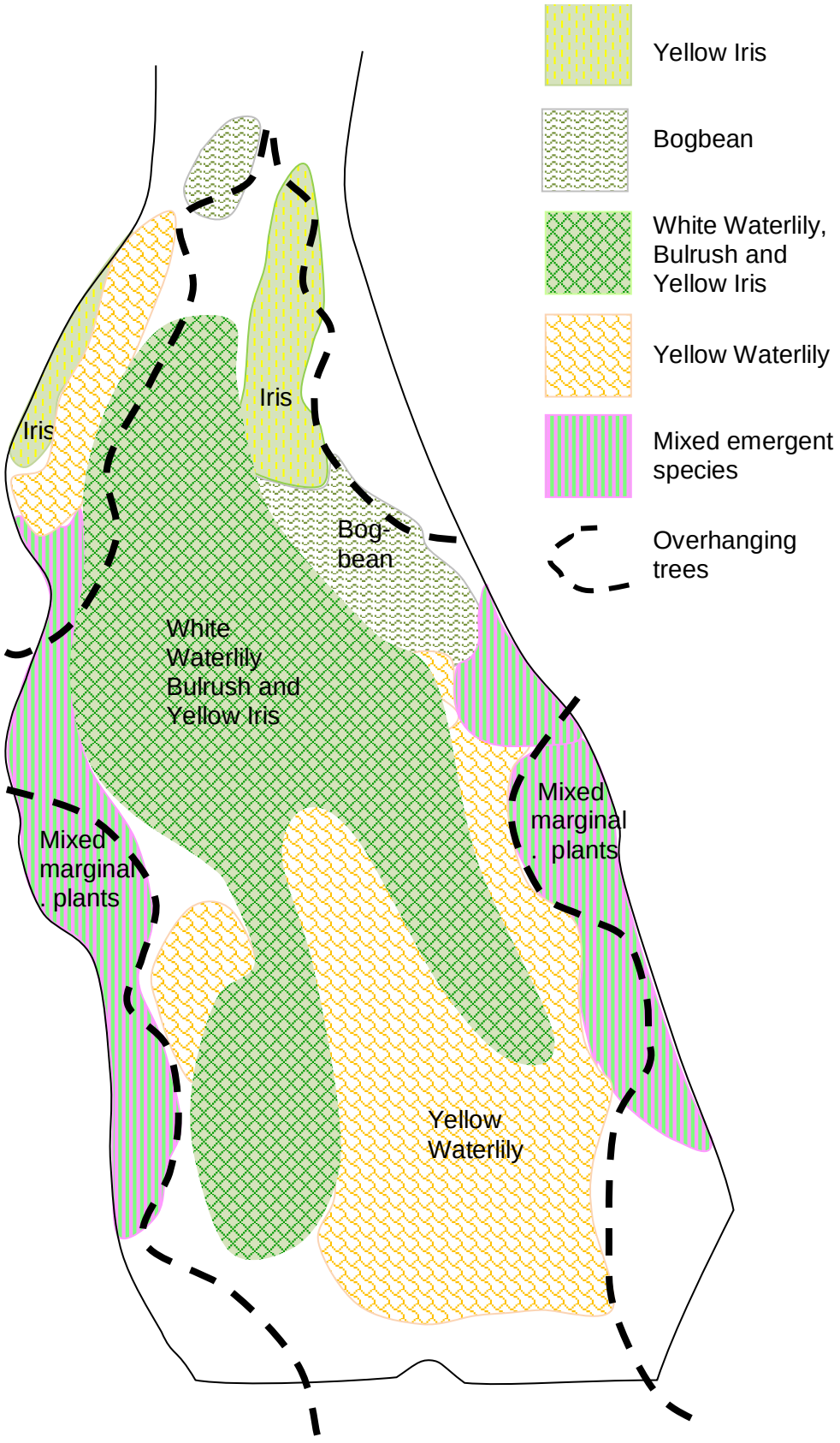


Table 3. Wetland plant species recorded by Owen Mountford from Upper and Middle Ponds in October 1988

Upper Pond	Middle Pond
Juncus bulbosus	*Agrostis stolonifera*
Juncus effusus	*Callitriche stagnalis*
Molinia caerulea	*Iris pseudacorus*
Polygonurn hydropiper	*Juncus effusus*
Sphagnum spp	*Lycopus europaeus*
Iris pseudacorus	*Myosotis scorpioides*
Nuphar lutea	*Polygonurn hydropiper*
Utricularia vulgaris s.l.[1]	*Utricularia vulgaris s.l.* [1]
Typha latifolia	*Sphagnum* spp.
	Equisetum fluviatile
	Juncus bulbosus
	Molinia caerulea
	Nuphar lutea
	Ranunculus flammula
	Typha latifolia

[1]the surveyor noted that the *Utricularia* was reported to him as being *U. neglecta [now U. australis].*
As noted in the IUCN red list '*the genus Utricularia is taxonomically complex, partly due to the desire of botanists to establish methods of identifying non-flowering populations (particularly in the field), with the consequence that the literature is complicated by vast numbers of unreliable records. U. australis [Bladderwort] has frequently been confused with U. vulgaris [Greater Bladderwort] and, in much of the literature it is not possible to know for certain which of the two species is intended or whether a mixture of both is involved*'.

4.3.2 Comparison with previous plant surveys

Baseline data

The Burnham Beeches ponds and mires have long been recognised for their distinctively 'acidic' wetland flora. For example, in *A History of the County of Buckingham* (W Page, 1925) many of the wetland plants listed as present at Burnham Beeches in the early 20th century are species typical of nutrient-poor, acid, habitats including: Many-stalked Spike-rush (*Eleocharis multicaulis)*, White Beak-sedge (*Rynchospora alba)*, Common Cotton-grass (*Eriophorum angustifolium)*, Cross-leaved Heath (*Erica tetralix)*, Bog Asphodel (*Narthecium ossifragum)*, Marsh St. John's-wort, the stonewort *Nitella translucens*, the Bladderwort *Utricularia neglecta* [now *U. australis*], the pondweeds *Potamogeton polygonifolius* and *P. pusillus*, Bogbean, Marsh Violet (*Viola palustris)*, Common Butterwort (*Pinguicula vuigaris)*, the sundews *Drosera rotundifolia* and *D. intermedia,* and rare Marsh Clubmoss *Lycopodiella inundata* as well as and a range of sedges including *Carex echinata*, *C. pulicaris*, *C. flava*, *C. panicea*, *C. paniculata*, *C. rostrata*, *C. binervis*, *C. pilulifera* and *C. leporina*.

The last decades of the 20th Century saw specific botanical surveys of the ponds. In 1988 Owen Mountford (Institute of Terrestrial Ecology, now CEH) surveyed significant habitats at Burnham Beeches, including both ponds, as part of a preliminary site investigation for proposed mineral extraction and landfill in the area. The survey was clearly brief and undertaken rather late in the season (27th October) so direct comparisons with current results are not possible. However it is evident that at this time, both ponds had stands of Bladderwort and it was specifically noted that there was a 'very large' population in the Upper Pond.

Table 4. Comparison of the wetland plants in Middle Pond in 1992 & 2016

Scientific name	Common name	1992	2016
Callitriche stagnalis (s.l.)	Common Water-starwort	+	+
Eleogiton fluitans	Floating Club-rush	+	
Juncus bulbosus	Bulbous Rush	+	+
Ranunculus sp. (undet.)	Water-crowfoot species	+	
Utricularia australis	Bladderwort	+	
Sphagnum sp.	Bog Moss	+	+
Lemna minor	Common Duckweed	+	+
Menyanthes trifoliata	Bogbean	+	+
Nuphar lutea	Yellow Water-lily	+	+
Nymphaea alba	White Water-lily		+
Persicaria amphibia	Amphibious Bistort	+	+
Riccia fluitans	Floating Crystalwort		+
Agrostis canina	Velvet Bent	+	+
Agrostis stolonifera	Creeping Bent	+	+
Alisma plantago-aquatica	Water- plantain	+	+
Bidens tripartita	Trifid Bur-marigold	+	+
Carex echinata	**Star Sedge**		**+**
Carex flava agg.	Yellow sedge species		+
Eleocharis palustris	Common Spike-rush	+	
Epilobium ciliatum	American Willowherb	+	
Equisetum fluviatile	Water Horsetail	+	+
Eupatorium cannabinum	Hemp-agrimony	+	
Glyceria fluitans	Floating Sweet-grass		+
Hydrocotyle vulgaris	**Marsh Pennywort**	**+**	**+**
Hypericum elodes	**Marsh St John's-wort**	**+**	**+**
Iris pseudacorus	Yellow Iris	+	+
Juncus effusus	Soft Rush	+	+
Lycopus europaeus	Gipsywort	+	+
Molinia caerulea	Purple Moor-grass	+	+
Myosotis scorpioides	Water Forget-me-not	+	
Persicaria hydropiper	Water-pepper	+	
Ranunculus flammula	**Lesser Spearwort**	**+**	**+**
Ranunculus sceleratus	Celery-leaved Buttercup		+
Solanum dulcamara	Bittersweet	+	
Typha latifolia	Bulrush	+	+
Number of species		**29**	**26**

Comparison with 2016 data

For Middle Pond a direct comparison is possible between the current survey and the flora recorded in August 1992 during the National Pond Survey (NPS), with both surveys undertaken using NPS methods by the same surveyor (P Williams).

The findings show that Middle Pond has dropped in richness from 29 to 26 wetland plant species over the last two decades. Eight species were recorded in the 1990s which are not currently found. The majority of these are common and widespread taxa, such as Water Forget-me-not (*Myosotis scorpioides*) and Water-pepper (*Persicaria hydropiper*). However two more notable plants appear to have been lost: Bladderwort and Floating Club-rush (*Eleogiton fluitans*). The latter is an acid water species that is increasingly uncommon species in the lowlands and borders on being Near Threatened in England (Stroh et al. 2014).

Balanced against these losses, the current survey included four species not recorded in the late 1980s and early 1990s: White Water-lily, Celery-leaved Buttercup (*Ranunculus sceleratus)* a disturbed ground annual, the liverwort *Riccia fluitans* which tends to occur in good quality, shaded, eutrophic to mesotrophic waterbodies and, encouragingly, the acid water Star Sedge (*Carex echinata*) which is now Near Threatened in England.

In terms of the broad distribution of plant stands, comparison with Adrian Hine's Upper Pond habitat map in 1992-93 (Hine, undated[a]), shows that the large stand of Water Horsetail occupying much of the central part of the pond has now gone, although this species is still present in mixed stands on the western edge. Taking its place is a more extensive stand of Yellow Waterlily in the south of the pond and mixed floating rafts of White Waterlily, Bulrush and Yellow Iris in the ponds' central and northern sections. There also appears to be a new stand of Bogbean along the north-east bank below the inflow which was not previously present.

There are fewer data with which to compare changes in the wetland flora of Upper Pond. However, the large stand of Bladderwort present in the late 1980s now appears to have been completely lost. Comparison with Adrian Hine's habitat map in 1992-93 also suggests some additional differences, particularly in the open water areas in the south and central areas of Upper Pond which once supported an extensive stand of the acid water specialist Bog Pondweed (*Potamogeton polygonifolius*). This stand has now completely gone, although a small number of Bog Pondweed plants are still present associated with the *Sphagnum* mats on the eastern bank to the south of the inflow. The large area where Bog Pondweed used to occur is now dominated by White and Yellow Waterlily, the latter not previously noted at the pond on Hine's 1990s maps.

5 Aquatic macroinvertebrates

5.1 Upper Pond

5.1.1 Invertebrate communities

A total of 46 macroinvertebrate species were recorded from Upper Pond (Appendix 2), of which half were water beetles (23 species). Nine water bug species were found including greater and lesser water boatmen, the Common Water Measurer (*Hydrometra stagnorum*), the Sphagnum Bug (*Hebrus ruficeps)*, Water Scorpion *(Nepa cinerea)* and nymphs of water cricket (*Velia* sp likely *caprai*). The larvae of three dragonfly species were recorded: the Southern Hawker (*Aeshna cyanea),* Ruddy Darter (*Sympetrum sanguineum)* and Emerald Damselfly *(Lestes sponsa)*.

A single mayfly species was found: the widespread Pond Olive *(Cloeon dipterum)* as well as Mud Alderfly (*Sialis lutaria*) and Water Spider (*Argyroneta aquatica*). The caddisfly assemblage was rather poor, with just a single species recorded; the common case-building caddis *Limnephilus lunatus*. The larger crustaceans were represented by the two widespread native water-slaters: the Common Water-slater (*Asellus aquaticus*) and the less common One-spotted Water-slater (*Proasellus meridianus*). The non-native but widespread freshwater shrimp *Crangonyx pseudogracilis* was also recorded across all areas of the pond.

As would be expected from acid waters ponds where calcium is scarce, the site supported very few molluscs with only the tolerant bladder snail *Physella* cf *acuta*, and the limpet *Ferrissia wautieri* recorded. Both are non-native species.

5.1.2 Distribution of invertebrate species around Upper Pond

The detailed distribution of invertebrate species around the pond is described in Appendix 3. Maps showing the invertebrate locations are given in Appendix Figure 3.1.

5.1.3 Uncommon Species in Upper Pond

There were three Nationally Scarce invertebrate species recorded from Upper Pond. All were water beetles, and all were recorded in relatively low abundance.

The distinctive crawling water beetle ***Peltodytes caesus*** was found in only one habitat in Upper Pond, amongst the Yellow Water-lilies in the deeper south-central region of the pond (sampling points 12 and 13, see Appendix Figure 3.1). Four individuals were found, all in the August sample. This species was not recorded from Upper Pond in Adrian Hine's 1990s samples.

The diving beetle ***Hydroporus neglectus*** was recorded from the northern quarter of the pond in sampling areas 16-21 which comprise the wooded inflow area, and floating mats of Bogbean and *Sphagnum*. *H. neglectus* is a species associated with acid waters, woodland and *Sphagnum* (see Table 5), so it perhaps unsurprising that it occurs in areas of Upper Pond closest to the more acid upstream mire. Only single beetles were found each time, and they were recorded on both sampling occasions, suggesting that this beetle has a sparse population across this part of the pond. The beetle was found in just one location (site 21 on the north eastern edge) during Adrian Hine's 1990s surveys, so it is possible that it may have spread as *Sphagnum* rafts have begun to develop in the more central northern areas of the pond.

Helochares punctatus is a rather beautiful gold-coloured water scavenger beetle. It was recorded in a range of habitat types across the pond with single individuals found in June in the shaded and undercut banks of the NW margin (sample areas 5 & 6), and August

amongst the central stands of Yellow and White Water-lily (Sample areas 14 & 15). Five individuals were also recorded from pools amongst the Bogbean and *Sphagnum* mats in the central northern area of the pond (Sample areas 16,17&18). Adrian Hine also recorded *H. punctatus* in Upper Pond in his 1990 surveys. They were found in different locations (areas 2 & 3 and 21), but the habitat types were analogous to the 2016 surveys. This may suggest that the species maintains a scattered population across Upper Pond.

5.2 Middle Pond

5.2.1 Invertebrate communities

There were similarities between the invertebrate faunas of Upper and Middle Pond. A total of 44 macroinvertebrate species were recorded, and although there were proportionally fewer beetles in Middle Pond (16 vs 23 species) the number of water bug species was similar (10 vs 9 species). As in Upper Pond the bug species included the Common Water Measurer and Water Scorpion. However the specific assemblages of water boatmen recorded often differed. In Midddle Pond, for example, the lesser water-boatman *Sigara limitata* was present, whereas in Upper Pond the only *Sigara* was *S. dorsalis*. Similarly whereas *Hesperocorixa moesta* and *Hesperocorixa linnaei* occurred in Middle Pond, only *Hesperocorixa sahlbergi occurred* in Upper Pond. Neither the Sphagnum Bug (*Hebrus ruficeps)* nor the water cricket (*Velia* sp) which were recorded in the Upper Pond, were found in Middle Pond.

Four dragonfly species were recorded as larvae in the Middle Pond: the Southern Hawker (*Aeshna cyanea),* Emerald Damselfly *(Lestes sponsa)*, Large Red Damselfly (*Pyrrhosoma nymphula*) and the Common Darter (*Sympetrum striolatum*), but not the Ruddy Darter (*S. sanguineum)* which was only recorded in Upper Pond.

The molluscs, leeches, flatworms and crustaceans recorded were generally similar to the assemblages that occurred in Upper Pond, with the exception that only One-spotted Water Slater (*Proasellus meridianus*) was recorded, rather than both water slaters. Again the only mayfly species recorded was the Pond Olive *(Cloen dipterum)* and the Mud Alderfly (*Sialis lutaria*) was present. The caddisfly assemblage was a little richer that in Upper Pond with three species recorded.

5.2.2 Distribution of invertebrate species around Middle Pond

The detailed distribution of invertebrate species around the pond is described in Appendix 3. A Map showing the invertebrate sampling locations is given in Appendix figure 3.2.

5.2.3 Uncommon species

One Nationally Scarce invertebrate species was recorded from Middle Pond. This was the water scavenger beetle ***Hydrochus angustatus*** *(*Table 5). It was recorded as single individuals from two locations in the pond: in mixed stands of vegetation along the western margin (Sites A & B, see Appendix Figure 3.2) and along the eastern bank amongst the tussocky mats of Iris, Bulrush, Soft Rush, Waterlily and Bog-bean downstream of inflow. In Adrian Hine's 1990s samples this species was recorded from site E further down the eastern bank.

During the current survey the water scavenger beetle *Helochares punctatus* was only recorded from the Upper Pond. In Hine's 1990 surveys, however, it was also found to be widespread in Middle Pond, then occurring in a range of marginal habitats along the eastern and western margins (sites A, B, E & G).

5.3 Comparison with previous invertebrate surveys

5.3.1 A note about comparing samples

Direct comparison of invertebrate survey data is never completely straightforward. Wetland plant surveys are census-type surveys, so two species lists from the same site should have a high degree of correspondence. Aquatic invertebrate samples from larger waterbodies are inevitably quite small sub-samples of the whole site, and so any two surveys will inevitably show some degree of disparity.

In tests carried out during the 1990s, Freshwater Habitats Trust found that any two three-minute net samples have around 75-80% of species in common suggesting that comparisons between the richness of two NPS samples is a fairly robust metric of change (Freshwater Habitats Trust, unpublished data). In the current case comparing invertebrate assemblages in the ponds is a little more complicated because a range of different methods were used in Adrian Hine's comprehensive surveys. However, having competent invertebrate species lists from past surveys of any site is an unusual luxury, and looking across all the datasets together provides exceptionally useful information about likely changes in Upper and Middle Ponds.

5.3.2 Comparison of invertebrate species richness in Upper and Middle Ponds

For Middle Pond, a useful three-way comparison of survey methods was possible. Adrian Hine's combination of timed and bankside surveys collected in 1992-93 gave a total list of 56 species for Middle Pond[1]. The National Pond Survey (NPS) data from three seasons of sampling (spring, summer, autumn) yielded 68 species. Using just two NPS season's data from spring and summer, 61 species were recorded. This can be directly compared with the two surveys carried out in the current survey when 44 species were recorded.

Together these findings suggest that:

(i) In terms of species richness, Hine's 1992-93 samples are broadly comparable with two season (spring and summer) of NPS samples (56 and 61 species respectively).

(ii) The invertebrate richness of Middle Pond appears to have declined since the early 1990s, with only 44 species recorded from two NPS surveys in 2016 compared to 61 from directly comparable surveys in 1992-93.

(iii) In Upper Pond, where only Hine's original 1992-93 survey data are available for comparison, the data show that 46 species were recorded in the current 2016 survey, compared to 72 species in 1992-93. Given that the NPS and Hine surveys of Middle Pond appear to give broadly comparable richness tallies (i above), this suggests that invertebrate richness in Upper Pond is also likely to have declined significantly since the early 1990s.

5.3.3 More detailed invertebrate species and group changes

Picking apart the observed decline in more detail it is evident that the trend of decline was widespread, and seen in all of the more sensitive invertebrate groups.

For dragonflies, the 1992-93 surveys of Middle Pond recorded similar numbers of species as larvae in both the NPS and Hine surveys (8 and 7 species respectively). This compares with 4 species in the current survey. In Upper Pond the 1990's dragonfly assemblage was exceptional with 11 species compared to just 3 species in 2016. Particularly evident were losses of the widespread Common Blue Damselfly (*Enallagma cyathigerum*) and Azure Damselfly (*Coenagrion puella*) which were widespread in both ponds in the 1990s but not

[1] These totals refer to invertebrates whose identification to species level was common to all surveys

recorded at all in 2016. Similarly, the Emperor Dragonfly (*Anax imperator*) occurred in smaller numbers in both ponds but was, again, found in neither in 2016.

Water bugs also appear to have declined in both ponds. In Middle Pond, 16 bug species were recorded in 1992-93 NPS surveys in spring and summer (14 in Hine's surveys) but only 9 species were recorded in 2016. In Upper Pond the 19 species in Hine's 1992-93 survey dropped to less than half this number (9 species) in 2016. Species which previously occurred in both ponds but were not recorded in 2016 included the backswimmer *Notonecta marmorea*, the diminutive Lesser Backswimmer (*Plea leachi*) as well as a range of lesser water boatmen (*Cymatia bonsdorffi, Cymatia coleoptrata, Callicorixa praeusta, Sigara distincta* and *Sigara falleni*).

Over the same timescale water beetles, almost always the richest invertebrate group in ponds, dropped from 23 to 15 species in the Middle Pond, and from 32 to 21 in Upper Pond. Losses of particular note were the Near Threatened species *Helochares punctatus* which was formerly common in Middle Pond, but restricted to Upper pond by 2016, and *Hydaticus seminiger* which occurred in a range of habitat types in Upper Pond in the early 1990s, but was not recorded at all in the 2016 survey. The latter is generally found in ponds and ditches with plenty of vegetation, often in wooded areas, and the reason for its loss are not clear.

Table 5. Uncommon invertebrate species recorded from the ponds

Peltodytes caesus. A crawling water beetle (Nationally Scarce).
Peltodytes caesus is a small and distinctive crawling water beetle, a group which, confusingly, are good and active swimmers. It is found in well-vegetated ponds, ditches and sometimes small lakes, usually in high quality sites. It is a clearly southern species with most modern records south of a line from the Severn to the Wash. It is Nationally Scarce and has a distribution associated with the ancient lowland fen and river valley environment (e.g. Otmoor in Oxfordshire, the Somerset Levels, the Norfolk Broads, the Thames Estuary marshes) but is able to colonise new waterbodies in those areas. There is a concentration of records to the west of London (Foster *et al*. 2014)
Hydroporus neglectus. A diving beetle (Nationally Scarce)
Hydroporus neglectus is a small diving beetle that is largely restricted to shaded lowland acid waters, small woodland pools and *Sphagnum* carpets. It has a stronghold on the acid soils west of London, the Cheshire Meres and the Vale of York, its most northerly site being Catterick in north-east Yorkshire. It can occur in small temporary pools, and is often found amongst submerged leaf litter. It is largely confined to old wetlands and heathland but can fly and has been found in recently created ponds (Foster *et al*. 2014)
Hydrochus angustatus. A relative of the water scavenger beetles (Nationally Scarce)
Hydrochus angustatus is an uncommon water beetle, resembling the water scavenger beetles in being unable to swim in open water. It is found in good quality, permanent, lowland ponds, and sometimes on the edge of rivers, usually in places with some exposed mud or peat. It is typical of heathland ponds in southern England (Foster *et al.* 2014).
Helochares punctatus. A water scavenger beetle (Nationally Scarce)
Helochares punctatus is a water scavenger beetle found mainly in acid ponds and pools on wet heaths, moorland and bogs. The reason for the association with acid water is unknown. It is a strong flyer and can colonise new ponds in suitable habitats (Denton, 2007).

Other much more common and widespread water beetles which formerly occurred in both ponds and were not re-found include *Agabus sturmii, Hyphydrus ovatus, Laccophilus minutus* and *Ilybius fuliginosus*. Set against these losses three beetle species were recorded for the first time in the current survey: the rather beautiful chestnut red, and delightfully named, *Liopterus haemorrhoidalis* was recorded in the Middle Pond, and the two common diving beetles *Hydroporus pubescens* and *Hydroporus tessellatus* in the Upper Pond.

Caddis flies, although less diverse than water beetles, also dropped in species richness from 5 to 3 species in Middle Pond and from 5 to 1 species in Upper Pond. This included the apparent loss of the only caseless caddis previously recorded: *Holocentropus dubius* – a species typically found amongst submerged water plants which was formally common and widespread in both the Middle and Upper Ponds.

Some taxa did increase slightly in richness however (Table 5). Of the molluscs, only the bladder snail *Physella* cf. *acuta* was recorded in the 1992-93 NPS survey and then only in Middle Pond. By 2016 both this and the non-native limpet *Ferrissia wautieri* were present in both ponds. Shrimps and slaters increased too with the colonisation of Upper Pond by the Common Water Slater, and both ponds by the non-native shrimp *Crangonyx pseudogracilis*. Leeches and flatworms retained a similar richness in Upper Pond, but may have increased slightly in diversity in Middle Pond.

As noted above, the hand net samples only produce a subsample of the species present at each pond, so species that were formerly widespread may still be present. However these findings do suggest that there has, at least, been a marked reduction in the abundance of many species.

In addition, taken together the pattern of changes observed in Upper and Middle Ponds over the last two decades paint a consistent picture indicative of species decline. The invertebrate groups that have been maintained or increased in richness (shrimps, slaters, leeches, flatworms) are generally widespread tolerant groups found in waterbodies of all qualities including those that are degraded. The groups that declined are typically those more sensitive to water and habitat quality.

The taxa that are generally held to be most sensitive to water quality, dragonflies and to lesser extent caddis-flies, declined the most - supporting the idea that there has been some degree of water quality deterioration in the ponds. Upper Pond generally showed a greater decline than Middle Pond. Unlike dragonflies and caddis, the majority of water beetles are surface air breathers and rather less sensitive to water quality. Many live in very shallow water amongst plants at the water's edge and our data more widely shows that their richness correlates with bank/edge habitat quality. The water beetle decline in both ponds may therefore suggest a reduction in the quality of shallow vegetated habitats at the water's edge.

6 PSYM evaluation

6.1 PSYM method

In addition to conservation value assessments of the ponds based on their species richness and rarity, the overall ecological quality (i.e. 'health') of Upper and Middle Ponds was assessed using PSYM (**P**redictive **Sy**stem for **M**ultimetrics). PSYM uses six metrics calculated from National Pond Survey data to evaluate pond quality. Each metric has been shown to have a strong relationship with anthropogenic degradation.
The three botanical metrics are:

- diversity of emergent and submerged plant species
- the number of uncommon plant species
- Trophic Ranking Score (TRS, an indication of nutrient status based on selected plant species)

The three invertebrate metrics are:

- Average Score Per Taxon (ASPT, an estimation of biological water quality, recalculated for ponds to reflect invertebrate sensitivity to a range of water chemistry stresses)
- diversity of dragonfly, damselfly and alderfly families
- diversity of water beetle families

To run PSYM, environmental data from each pond (e.g. surface area, altitude, pH) are fed into the PSYM programme which uses them to produce a list of taxa which should occur in the pond if it is in pristine condition. It then calculates the six metrics from this predicted list. The predicted results are compared with the recent site survey data to indicate how the site now compares to its pristine state, and hence how degraded it is. Ponds are then categorised as Very Poor, Poor, Moderate and Good. More information about this method is given in Appendix 1.

6.2 PSYM results

Table 6 summarises the results of the PSYM analysis from Upper Pond in 2016 and from Middle Pond where we have PSYM-quality from both the early 1990s and 2016.

They findings show that in the early 1990s Middle Pond was classified as **Good** quality: the top quality category in PSYM. Based on Adrian Hine's invertebrate data, and Owen Mountford's quick plant list for Upper Pond, it is highly likely that Upper Pond would also have fallen into the **Good** category at this time.

The PSYM results from 2016, show that both ponds still fall into the **Good** quality. By default this means that Upper and Middle Ponds both qualify as **Priority Ponds** under the provisions of the 2006 NERC Act (Appendix 1.8).

Looking at the results in more detail shows that Middle Pond has declined in quality somewhat since the 1990s with the Index of Biotic Integrity dropping from 100% to its current 94%. In addition, the drop in the number of families of dragonflies and beetles present pushed the pond close to an even lower score.

Upper Pond, whilst still retaining a **Good** score, had the lowest Index of Biotic Integrity of 83% and was close to falling into the **Moderate** group.

Table 6. PSYM input variables and results			
	Middle Pond	**Middle Pond**	**Upper Pond**
Survey year	**1992**	**2016**	**2016**
Environmental variables			
Altitude (m)	63	63	65
Easting	4949	4949	4951
Northing	1845	1845	1848
Shade (%)	25	28	30
Inflow (0/1)	1	1	1
Grazing (%)	0	0	0
pH	5.9	6.2	5.8
Emergent plant species cover (%)	31	22	12
Base clay (1-3)	1	1	1
Base sand, gravel, cobbles	3	3	3
Base peat	1	1	1
Base rock	1	1	1
Area (m^2)	2637	2637	2144
Results			
Submerged + marginal plant spp			
Predicted (SM)	24.7	24.9	24.0
Actual (SM)	25	21	19
EQI (SM)	1.01	0.84	0.79
IBI (SM)	3	3	3
Uncommon plant species*[3]			
Predicted (U)	4.2	4.2	4.1
Actual (U)	5	3	0
EQI (U)	1.19	0.71	0.00
IBI (U)	3	2	0
Trophic Ranking Score (TRS)			
Predicted (TRS)	8.30	8.44	8.35
Actual (TRS)	7.54	7.34	6.95
EQI (TRS)	0.91	0.87	0.83
IBI (TRS)	3	3	3
ASPT			
Predicted (ASPT)	5.17	5.15	5.18
Actual (ASPT)	5.00	4.90	4.90
EQI (ASPT)	0.97	0.95	0.95
IBI (ASPT)	3	3	3
Odonata + Megaloptera (OM) families			
Predicted (OM)	3.36	3.26	3.40
Actual (OM)	4	3	2
EQI (OM)	1.19	0.92	0.59
IBI (OM)	3	3	2
Coleoptera families			
Predicted (CO)	3.84	3.82	3.84
Actual (CO)	4	3	4
EQI (CO)	1.04	0.79	1.04
IBI (CO)	3	3	3
Sum of Individual Metrics	**18**	**17**	**15**
Index of Biotic Integrity (%)	**100%**	**94%**	**83%**
PSYM quality category[1]	**Good**	**Good**	**Good**
Is this a Priority Pond?[2]	**Yes**	**Yes**	**Yes**

*[1] >75%=Good, 51-75%= Moderate, 25-50%=Poor, <25%=V Poor). *[2] Ponds that fall into the 'Good' quality category qualify as Priority Ponds. *[3]Note that the metric 'uncommon plant species' refers to plants that were rated as nationally uncommon in the 1990s when the algorithm for PSYM was developed.

7 Downy Emerald

Downy Emerald (*Cordulia aenea*) is a rather uncommon dragonfly with a mainly southerly distribution. Although not threatened nationally, there is some evidence that its populations are declining in more outlying areas like East Anglia, Shropshire and Cheshire. In the past the ponds at Burnham Beeches have supported good populations of Downy Emerald. In the early 1990s detailed surveys by Adrian Hine recorded over 40 exuviae from the Upper Pond in 1992 and over 70 in 1993. Adults were always evident during visits on sunny days during the main flight season between late April and early July, with at least five adults present together on some occasions in early June. The population in Middle Pond was lower but adults were still regularly seen.

More recent surveys co-ordinated by Alan Nelson in 2010 provided five records of adults males from the Upper Pond, with one or two individuals seen on each of 3 visits between 30th May and 3rd July. There were also three records from Middle Pond, with males recorded during visits on both 30th May and a few days later on 6th June.

Because the 1990s and 2010 surveys are not fully compatible it is not possible to draw definitive conclusions about *Cordulia aenea*'s population trends in between the two dates. However comparisons of adult counts in the peak flight period suggest that the population may have declined, at least at Upper Pond which originally held the strongest population.

Since 2010 there have been no formal surveys of Downy Emerald in Upper or Middle Pond. However casual reports suggest that the species has not been recorded from either pond for some time (Helen Read *pers com*).

As part of the current survey, a search for Downy Emerald was made at Upper and Middle Pond using four techniques.

Survey Method	Life stage	Detail
National Pond Survey hand-net sample	Larvae	Standard NPS method for the whole of each pond, sub-divided into the main habitats (see Section 3.2.1)
Hand-net search of submerged leaf litter	Larvae	Methods as outlined in Hine (undated[c]), focussing on areas where larvae were previously found or which currently appeared most suitable. 0.5 hrs spent at each location.
Search of marginal plants and trees	Exuviae	Methods as outlined in Hine (undated[c]) focussing on area's where exuviae were previously found or which currently appeared most suitable. 1.5 hrs per pond.
'Pollard walk' survey	Adults	Based on BDS methods. http://bit.ly/BDSMonitoring. 2.5hrs spent at each pond.

The main survey for adult *Cordulia* was undertaken at the optimal time in early June. Additional surveys were undertaken after that period on a voluntary basis by Jonathan Jones.

7.1 Results

Downy Emerald was not recorded in any of the 2016 surveys from either pond. That the larval surveys drew a blank was not of great concern because *Cordulia* larvae can be sparsely present and difficult to find amongst the considerable volumes of leaf litter that top the sediment of the ponds. The absence of any evidence of exuviae or adults is more worrying. The early June survey was undertaken at an optimal time of year for Downy Emerald and the weather was fine and sunny. Under these conditions, adults should have been apparent if a significant population was present at the site. Additional volunteer surveys undertaken in later months by Jonathan Jones also failed to find Downy Emerald (Helen Read *pers com*).

These findings, together with the absence of casual records for Downy Emerald in recent years, suggest that the species is now either: (i) lost from the ponds (ii) still present at low population levels (iii) still present but had a poor emergence year in 2016. Further surveys in future years are needed to confirm which of these possibilities is correct.

If Downy Emerald is still present at the site, it is clear that its population has now declined significantly, and management is likely to be needed to have a chance of retaining the species (see Section 11). If Downy Emerald has been lost from the ponds, it may recolonise naturally, although the chances of it doing so are uncertain since the species is believed to be a poor coloniser. If pond management is carried out to favour Downy Emerald, and it is still not seen for some years, a trial translocation might be considered.

8 The stream section between the two ponds

The 200 m stream section between the Upper and Middle Ponds was surveyed for macroinvertebrates using a 'bug hunt' method with the netted sample sorted on the bankside in a white tray (Section 4.4.2). This technique was also used to survey the areas around the outflow of each pond: areas that would be destroyed when the outflow structures are replaced. A total of 2.5 hours was spent undertaking this search. It was only possible to undertake this survey during the June visit because both the stream and outflow areas were dry during the second visit in early August.

8.1 Results

At the time of the June survey, water in both the stream and the outflow areas was very shallow (<2 cm). The areas were also generally heavily shaded by overhanging trees and devoid of wetland macrophytes. Given that the stream and outflows were also seasonal, it is unsurprising that their macroinvertebrate fauna was limited. The only taxa associated with the outflows were blackflies (Simuliidae). In addition to chronomids and oligochaetes, the stream had a restricted fauna with a low abundance of the freshwater shrimp *Crangonyx pseudogracilis* and Common Water-slater (*Asellus aquaticus*), and a single occurrence of the common water scavenger beetle *Anacaena globulus.* All are common species and were also found in the adjacent ponds.

Invertebrate taxa recorded from the stream between the two ponds and the pond outflow areas
Crangonyx pseudogracilis
Asellus aquaticus
Anacaena globulus
Chironomidae
Simuliidae
Oligochaeta

Overall, the results of the survey suggest that the pond outflow areas and stream probably have limited biodiversity value and there is little concern about the impact of future work to replace the outflow structures.

9 Conclusions

9.1 Overall quality of the ponds

Surveys of the wetland plants and aquatic macroinvertebrates in Upper and Middle Ponds show that they are important and valuable waterbodies.

Both ponds currently qualify as UK Priority Ponds on multiple criteria (Appendix 1.8). Specifically:

Criterion 2. Ponds with species of high conservation importance, based on the occurrence of Red List plant species in both ponds (Sections 5.1.2, 5.3.1) and the occurrence of three Nationally Scarce water beetle species in Upper Pond (Section 6.1.3). Middle Pond supported a single Nationally Scarce water beetle species, which although not fulfilling Criterion 2 requirements, is important in its own right (Section 6.2.3).

Criterion 4. Ponds of high ecological quality, based on a **Good** PSYM score for both Upper and Middle Ponds (Section 7.2).

Both waterbodies still have a flora and fauna that retains strong elements of their acid, low-nutrient heritage. This includes uncommon acid water beetles like *Hydroporus neglectus*, and a range of plant species that have undergone national declines over the past decades, such as Star Sedge and Marsh St John's-wort for which there are now very few records in the county. In the nutrient-drenched lowlands of England such waterbodies are at a premium.

9.2 Evidence and possible reasons for decline

9.2.1 Evidence of loss

Although both ponds remain important for biodiversity, there are multiple lines of evidence that suggest their ecological quality has declined over the last two decades.

Loss of sensitive plants: Comparison of the 2016 data with surveys undertaken in the early 1990s indicates that there has been a net decline in the number of plant species in both ponds. Of particular note are the loss of Bladderwort, a nutrient sensitive species of clean, clear water, which was not recorded from either pond, and Floating Club-rush, a declining species of oligotrophic waters, lost from Middle Pond. Over the same period in Upper Pond, a very extensive stand of the oligotrophic Bog Pondweed has been replaced by Yellow and White Water-lily: species that are much more tolerant of nutrient enrichment, turbidity and disturbance.

Currently, the remaining nutrient sensitive plants such as Bog Pondweed, *Sphagnum* and Star Sedge are largely (a) clustered in the northern end of Upper Pond close to the inflow, where they are flushed with acid water from the upstream mire and (b) growing in less shaded areas along the eastern banks of both ponds where there is least public disturbance and the waterbodies must receive low-nutrient near-surface run-off from the wooded slopes above.

Invertebrate declines: The invertebrate assemblages in both ponds have undoubtedly declined significantly over the last two decades. Upper Pond appears to have lost over a third of its species (c. 36 %), with over a quarter (c. 28%) lost from Middle Pond. In practice, the declines were slightly greater for the major groups of invertebrates which are most sensitive to water and habitat quality including dragonflies, beetles, caddis-flies and water

bugs. A specific search for the uncommon Downy Emerald dragonfly failed to re-find evidence of its presence as larvae, exuviae or adults.

PSYM score: Although both ponds remain Priority Ponds, the PSYM score for Middle Pond has declined since the early 1990s, and Upper Pond too is now close to 'Moderate' status and therefore close to losing its Priority status based on a PSYM assessment.

9.2.2 Possible reasons for loss

In the absence of detailed information about the changes in the physico-chemical status of the pond over the last decades, the reasons for the biodiversity losses in the pond are somewhat speculative. The most likely factors are outlined below.

(i) Natural infilling, enrichment and associated factors

Natural infilling
There is a general tendency for ponds to become more enriched as they naturally infill with sediment, both as a result of nutrients from inorganic and organic sediments brought in by streams and surface run-off, and from the decay of wetland plants growing in the pond itself. Deep organic sediments create conditions that are challenging for some aquatic plants and invertebrates and a build-up of organic matter may help to explain the decline in some invertebrates in particular.

However, ponds in acid water catchments would normally be expected to deposit peaty sediments and retain a distinctive acid water flora and fauna, ultimately developing into a *Sphagnum* dominated mire. Sphagnum communities are indeed developing in the delta area of Upper Pond, and also along the eastern margins of both ponds where they are least disturbed, and presumably, receive clean natural runoff from the hillside above.

In the remaining areas of the ponds, including along the western margins, a range of biological indicators, including loss of water-quality sensitive plants, suggest that water enrichment, disturbance or other pollution may have played an important role in the ponds' biodiversity decline.

Anthropogenic enrichment and other disturbance
The most likely factor contributing to the enrichment of the ponds is the indirect influence of people. Upper and Middle Pond are popular features at Burnham Beeches with high visitor numbers. This is likely to have increased significantly since the 1980's, when the paved path was created along the north-western edge of Upper Pond. Mud and silt running off bare ground and paved areas created by and for people, is likely to have added nutrients to the water, particularly phosphorus which is likely to be the limiting nutrient in the ponds. The silt loading to the ponds is likely to be exacerbated after heavy rain, because in many areas the woodland has limited undergrowth vegetation and sediment from the bare ground can run into the pond unimpeded because there is little vegetation at the water's edge.

Dogs can potentially have a major impact on ponds by disturbing bottom sediment which makes the water cloudy and releases nutrients from the sediment into the water column. There is also increasing concern about the effect of topical and internal medications (i.e. pesticides) given to dogs to control parasites and diseases, which can leach into the water as dogs swim, and is a potential area of risk for the ponds' invertebrate communities.

Burnham Beeches now has a Dog Control Order in place, which requires that dogs are kept on leads in areas around the ponds. Although there are occasional infringements, this must now significantly reduce problems of turbidity and enrichment from this source. In the past, however, the disturbance caused by dogs may have helped contribute to loss or decline of plant species such as Bog Pondweed, Floating Club rush and Bladderwort from the ponds.

Inflow stream
On balance, it does not seem likely that the quality of the inflow stream to Upper Pond is a significant concern. Although the stream's headwaters lie in urban areas to the east of Burnham Beeches much of any pollutant burden will have been stripped out as it runs through the mire before it reaches Upper Pond. Plant and invertebrate evidence that the highest quality, acid, water and most important habitats in Upper Pond are located immediately adjacent to the inflow, suggest that the main cause of enrichment in Upper Pond likely lies elsewhere.

*Nutrients in rain wate*r
Nitrogen deposition from the atmosphere is known to be increasing in rainwater across the developed world as a result of transportation, agriculture, and industry. Ecological effects have already been identified in some nutrient poor streams, and lakes. For the ponds at Burnham Beeches the effects of atmospheric nitrogen are likely to be minor, but may still be a contributory influence.

(ii) Shaded edges and leafy sediment
In both ponds, all but the dam margins are largely shaded by overhanging trees. Trees are a natural habitat which provide leaf-litter habitats and increased diversity to ponds, including cooler temperatures on hot days, and lower light levels which, if not too heavy, can suppress dominance by tall emergent plants, favouring a wider range of species. Set against this, uniformly heavy shade reduces habitat diversity and can completely shade-out plants, whilst the accumulation of fallen leaves rapidly increases sediment build up and creates a de-oxygenated substrate which many submerged aquatic plants and invertebrates avoid.

Currently the eastern and western margins and the inflow areas of Upper and Middle Ponds are rather uniformly shaded and overhung by trees and in many areas considerable depths of coarse organic debris have accumulated at the water's edge.

Reducing levels of shade along the margins would help a wider range of marginal plant species to develop, and reduce sedimentation levels at the edges.

(iii) Extinction debt
Extinction is known to be a natural and very common occurrence for almost all species in all habitats at a local level. In most semi-natural environments the loss is often temporary and passes unnoticed, because plants and animals quickly recolonise from the surrounding adjacent habitats. At sites like the Burnham Beeches ponds, which are now highly unusual and isolated in the landscape, if a specialist species goes extinct it is likely to be lost for good. 'Extinction debt' describes this process, and the 'debt' in particular refers to the list of species still at a site, that are no longer sustainable in the long term.

Freshwater Habitats Trust's experience of re-surveying high quality ponds, like Upper and Middle Ponds, over 25 years shows a sustained decline at around 70% of sites. Much of this is likely to be attributable to extinction debt and it is likely that some of the plant and invertebrate losses observed at the Burnham Beeches ponds are due to its effect.

10 Management Recommendations

10.1 Manage or don't manage?

There is always a 'do nothing' option with pond management and at some sites it can be the best option. However, based on findings from the current study it is likely that Upper and Middle Ponds will require active management if they are to retain and potentially improve their aquatic biodiversity value.

Both ponds have declined in quality since the 1990s and it seems likely that this decline will continue. As noted above, extinction debt is likely to be an issue for the Burnham Beeches waterbodies (and indeed almost any high quality acid water site in Southern England), because these waterbodies are isolated within wider landscapes that are largely saturated with nutrients and generally support much more generalist and more impoverished freshwater communities.

A major advantage for both Upper and Middle Ponds is that their communities are partly buffered by continuity with the upstream mire which provides a recolonisation source when more-acid loving species become naturally extinct in the ponds. However the mire will only support shallow water and wetland loving species. More specialist species characteristic of deeper water, once lost, may be permanently lost.

If Upper and Middle Ponds are left to mature naturally it is likely that they will fairly rapidly succeed to dense mats of Water-lily, Bogbean and Bulrush, followed by carr woodland. There is a risk that, in doing so the ponds will permanently lose more of their distinctive acid-associated flora and fauna.

This suggests an ecological imperative to actively manage the ponds in order to retain their value and halt the decline, although in practice, the ability to achieve this at any site remains little tested and success is by no means guaranteed.

Both ponds have previously been managed. The most recent significant management was undertaken in the in the early 1990s following Adrian Hine's survey work to establish the conservation value of the site and provide a rationale for management decisions. This included dredging the silt and leaves from approximately 15% of the perimeter of Upper Pond and 25% of the perimeter of Middle Pond. Selective tree clearance was also undertaken to reduce marginal shade whilst still retaining sufficient canopy to provide submerged leaf-litter for Downy Emerald (Hine, 1995). Comparison of the current sediment depths around the pond margins and the extent of overhanging trees, suggests that levels of both are currently greater than were present in the early 1990s, before this management was undertaken. These results emphasise that any management undertaken will need to be sustained, with moderately regular tree clearance and more occasional dredging, particularly around the pond margins.

10.2 Priorities for management

Recent literature reviews clearly show that preventing decline is a much more effective conservation tool than restoration after loss. Based on this premise we suggest the following management approach at both ponds:

- Prioritise the protection of existing high quality areas from damage, and extend out from them where possible.
- Create conditions that will potentially enhance and restore biodiversity at the ponds, focussing on (a) reducing shade and (b) increasing the amount of clean, low nutrient status water.

10.2.1 Protecting the existing high quality habitats from damage

Figures 3 and 5 highlight areas of both ponds that current surveys suggest are of greatest ecological value and should be left as undisturbed as possible in any wider management of the site.

In Upper Pond the key habitats are focussed in the northern areas close to the inflow. These are flushed by acid water from the mire, and maintain distinctive high quality assemblages. Of particular importance are:

(i) the *Sphagnum* and rush mats and pools on the north-eastern bank

(ii) the floating mats of Bogbean, *Sphagnum*, Yellow Iris and White Water-lily in deeper water and near the islands.

Maintaining these areas should protect both Upper Pond's Near Threatened plant species and two of the three Nationally Scarce invertebrates recorded from the pond: *Hydroporus neglectus*, which is restricted to this area, and *Helochares punctatus* which is also found in other areas of the pond. In the event that Downy Emerald larvae are still present in the pond at low densities, this area also includes the main area where larvae were recorded by Hine in the 1990s. The third Nationally Scarce invertebrate, the water beetle *Peltodytes caesus,* was recorded from Yellow Water-lily closer to the southern corner of the pond (Figure 3)

In Middle Pond the most ecologically sensitive area was the eastern bank which supported all of the uncommon, nutrient sensitive, species recorded at the site. However areas of the eastern bank, particularly where shade was absent or dappled, also supported rich plant communities including species rarely found elsewhere in either ponds such as Water Horsetail and Trifid Bur-marigold.

The main objective in these existing high quality areas should be protect them from damage, for example, major dredging. Some management will be needed however, particularly judicious scrub clearance along the pond margins, to maintain areas that are currently unshaded or have dappled shade.

10.2.2 Increasing / restoring other areas of the pond to benefit biodiversity more widely

Factually-based studies of the effectiveness of managing high quality ponds to increase or restore wildlife are few and far between. The empirical evidence we have suggests that different ponds can respond to the same type of management in very different ways. This means that, in principle, management activities at high quality sites should be undertaken a little at a time, observing the effect over a number of years before continuing. Logistically, of course, this is not always possible, especially with major activities such as dredging.

Suggestions for managing the ponds on this basis are given in Figures 4 and 6.

1. Marginal tree clearance
Comparison with Adrian Hine's data show that both ponds are currently more shaded by bank-side trees than in the early 1990s, and the depth of leafy sediment at the edge has increased considerably since that time. Selective thinning of marginal trees along the eastern and western edges of both ponds would help to provide more open glades and greater development of edge vegetation which will benefit aquatic invertebrates.

Hine's observation's that Downy Emerald dragonflies preferred to oviposit close to the boundary between shaded and unshaded bank, suggests that maintaining banks with alternating lengths that are shaded and open is ideal for this species. This approach, which creates dappled shade as well as more open areas, works well for a wide range of other pond species, and provides a simple template to work to (Figures 5 and 6).

2. Clearance of trees near the inflow of Upper Pond
An area that is likely to significantly benefit from tree clearance is the inflow delta of Upper Pond, where the stream and the semi-solid sediment it has deposited, have created a large shallow muddy area colonised by carr. Clearing trees from this area has a number of benefits:

(i) Reducing shade will enable the area to be colonised with emergent vegetation which will help to stabilise the sediment, preventing it from washing further into the deeper water areas to fill the pond.

(ii) It makes the most of the low nutrient water from the mire: the vegetation that develops is likely to be valuable as an acid water transition community between the bog and the pond.

(iii) Once stabilised, it may be possible to create additional pools in this area to further diversify the habitat.

(iv) Alternatively, once stabilised, a larger area of sediment could be dug out to create a sediment trap for Upper Pond, extending the period before the pond requires further dredging.

A note of caution however: carr habitats can have a value in their own right, including for diptera, which were not included in the current study. It is advisable that any clearance of this area leaves a proportion of the existing carr intact (Figure 4).

3. Removing vegetation rafts
The central deeper water areas of both ponds are currently covered by extensive solid and semi-solid mats of vegetation. In Upper Pond, these are mainly formed by the floating rhizomes of Yellow and White Water-lily, with mats of Bogbean and Yellow Iris along the north-eastern and north-western banks and towards to the inflow. In Middle Pond, in addition to extensive mats of Yellow and White Water-lily, mixed floating stands of water-lily, Bulrush and Yellow Iris dominate the central and northern parts of the pond.

Where it was possible to access these mats it was clear that (a) most were floating over deep water (b) many formed solid rafts that were already beginning to terrestrialise with other species.

If these floating rafts persist, they will begin to form a solid base over both ponds, which will colonise with alder and willow. This will allow the pond to fill in 'top down' long before it would ever fill in with sediment from the bottom-up.

In terms of their biodiversity value, most areas of these mats seemed to be of rather limited value. Occasional dragonfly larvae and newt efts were recorded in some net samples,

however, with the exception of *Peltodytes caesus,* in the Upper Pond (Figure 4), the species recorded were also found in other habitats within the ponds.

Overall, removal of a considerable proportion of the floating mats from the pond would undoubtedly please visitors to the site who currently perceive the ponds as 'overgrown' and, as noted above, some removal needs to be undertaken if the area is to be retained as a pond, rather than developing into a mire.

Unless the floating mats are removed when the pond is drained down and dredged (see below), the process of removing thick rhizome mats from deep water will require specialist equipment - most likely a floating dredger with a solid bucket. Such operations are likely to be expensive, and may not be completely successful, since a proportion of the waterlily rhizomes are likely to rapidly regenerate.

4. Dogs and other disturbance

A Dog Control Order should, in theory, prevent dogs from entering either pond. However, there are occasional infringements, and as a principle it is best to minimise opportunities for dogs to swim in the ponds. If the ponds are dredged (see below), it is likely that the presence of bare gravel edges will provide an attractive ways for dogs to enter the pond. For this reason it is advisable not to clear sediment from obvious entrance points to the ponds such as the shallow east corners adjacent to the dam. In a similar vein, retaining existing trees and scrub in the south eastern corner of the ponds will continue to reduce public access to the higher quality eastern margins of the ponds, leaving them relatively undisturbed.

5. Dredging

Considerable volumes of silt have accumulated in some areas of the ponds, and it is likely that this contributes directly or indirectly to nutrient enrichment of the waterbodies. Deep organic silt also de-oxygenates the water column and creates a poor substrate for many submerged plants and aquatic invertebrates.

Dredging the delta areas

The greatest depths of sediment are present at the inflow areas of both ponds. It would be possible to dredge these areas, and relatively easy to so do from the bank with a long reach excavator. However, there are a number of reasons for being cautious:

(i) these deltas and the plants that grow on them, currently provide a useful function, acting as a sediment trap preventing fines from being deposited in deeper water.

(ii) Upper Pond in particular area supports uncommon invertebrates in the sediment delta area

(iii) There are opportunities to use these areas to enhance biodiversity, particularly in Upper Pond (see10.2.2 above).

Our recommendation would therefore be to avoid dredging out the majority of the delta areas in the short term. There is always potential for further dredging from the bank at a later date if this is desirable.

Dredging the margins

Most of the pond margins had accumulated considerable depth of organic silt at the margins: ranging from 15-50 cm, and typically increasing in depth towards the inflow and under heavy shade from tree canopy.

In Upper Pond the sediments adjacent to north-west bank were generally species poor, and removing them is likely to cause little damage. Although Downy Emerald Dragonfly larvae were formerly recorded from this area, the larvae were not found in our specific search in

2016, and the deep organic silt that has accumulated in these areas is unlikely to be suitable. This said, taking a generally cautious approach to pond management is wise and, if this bank is dredged it would be appropriate to leave some sections untouched to retain a portion of the existing habitat for the species currently present there.

The north eastern edge of Upper Pond includes an area of rush and *Sphagnum* pools which should be left un-dredged (see section 10.2.1) the remaining length of bank would benefit from partial dredging, particularly to remove deep organic silt beneath overhanging trees However, areas where the edge has developed marginal wetland vegetation should d be retained.

In Middle Pond the western bank has developed good stands of mixed of emergent vegetation growing on silt at the margins. These should be retained, although silt and more uniform stands of vegetation further out (c 5+m from the shore), could be removed. In other less vegetated bank areas the majority of silt deposited in shallow water can be removed, leaving some refuge areas.

The Eastern Bank of Middle supports some important edge communities that need to be protected from dredging or vehicle disturbance during dredging. However, other areas of bank could be partly dredged (See Figure 6).

Much of the dam edge in both ponds currently has relatively little silt.

Deeper dredging
In itself, there is likely to be little biodiversity interest lost if the deeper water areas of the pond were to be dredged. There are also potential benefits in (i) removing nutrient rich sediment (ii) enhancing the flow of (what is likely to be relatively clean) groundwater through the ponds by exposing the bare gravels, (iii) creating an inorganic substrate which might just encourage submerged plants such as *Nitella* and Bladderwort to regenerate from the seed bank.

The main issue with removing deep sediment is the difficulty and disturbance of doing so. Effective dredging is likely to entail draining-down the ponds for some months which will undoubtedly cause disturbance to the ponds and their wildlife (see below).

Disposing of the sediment
If, as seems likely, sediment dredged from the ponds will need to be disposed of on site, it is important to ensure that it is not dumped uphill of the ponds in areas where surface or groundwater will run back into the ponds, flushing them with nutrients.

10.3 Actions to repair the pond outflow structures

A major repair of the ponds' outflows will destroy the existing structures and could, depending on how the work is undertaken, require that the ponds are drawn down. In doing so the repairs have the potential to impact both the ponds and the stream that links them.

Invertebrate surveys of the existing outflow and the stream between the ponds indicate that both have low biodiversity value and the works are unlikely to cause ecological damage.

The impact of draining the ponds is much less certain – both because the ponds have more to lose, and because there have been exceptionally few studies of the impact of pond drainage for dredging purposes.

The most relevant information we have to draw on is from the drainage of a small number of waterbodies outside the UK, and from our own work looking at ponds before and after extreme drought. Both studies suggest that biodiversity damage from temporary drainage is most likely to be limited and temporary, however, this is by no means a guarantee, and one of the most useful outcomes of any drawdown of the Beeches ponds, would be to investigate the impact after the event!

There is no single safe time either for draining or managing ponds. Different animals and plants have different rhythms of breeding, growing and dispersing, so the least damaging time for one species can be the most damaging for another.

However, in practice, pond drainage is likely to be easiest to carry out in summer when pond water levels are naturally low, the inflow to top pond is at its lowest, and the linking stream is dry.

In principle, summer may also be one the least damaging time for many pond invertebrates and plants, in that the loss of water mimics natural summer drawdown to which many species are well adapted. This includes the many adult bugs and beetles which can fly in warm weather and, therefore have an opportunity to escape the draining pond. Less mobile species such as a wide range of dragonfly larvae have been shown to be able to survive loss of water in summer by burying themselves in wet mud or under damp leaves. In contrast, lower temperatures generally make animals less active and less likely to move into safe areas if disturbed. Certainly, for amphibians, there have been cases where Great Crested Newt ponds have been managed in winter, devastating the population of newts which were hibernating underwater and in the banks.

Recommendations

If draining the pond is necessary to replace the inflow, the current, very limited, evidence suggests that this is unlikely to have a majorly damaging effect on the ponds' biodiversity value. Doing so would also provide an opportunity to remove the floating mats and dredge out the accumulated sediment in the central areas and some marginal areas of the ponds. Expert advice would need to be taken on the best approach to use for this work, but because of the extensive floating mats, it would be likely to involve both an excavators and sludge pumps.

Ideally, it would be preferable to stage the outflow repairs, drawdown and dredging so that the ponds are not both managed in the same year, giving at least some of the inhabitants of each pond in turn, a refuge against the disturbance caused.

Figure 3. Upper Pond: areas of particular biodiversity interest

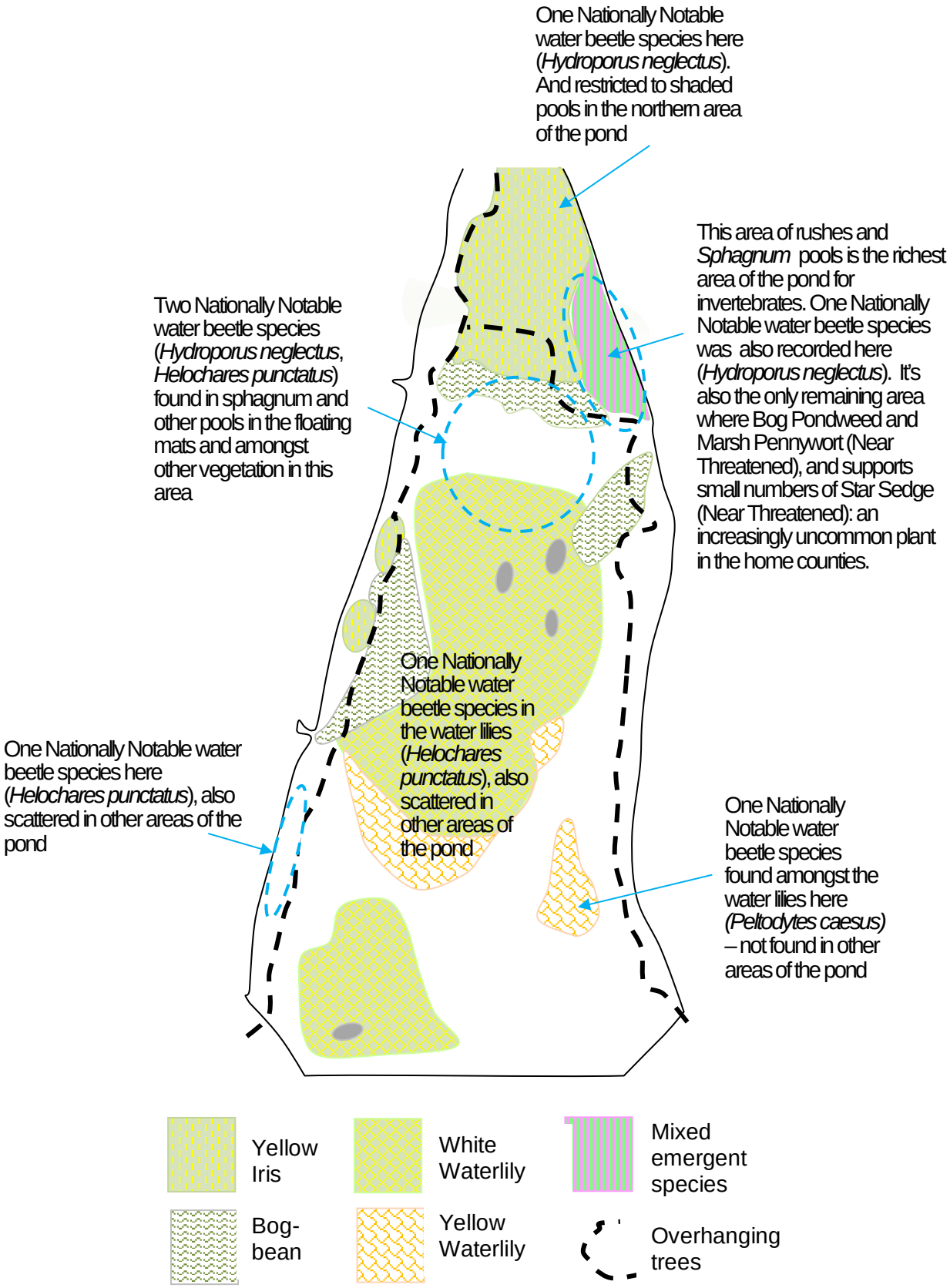


Figure 4. Upper Pond: management recommendations

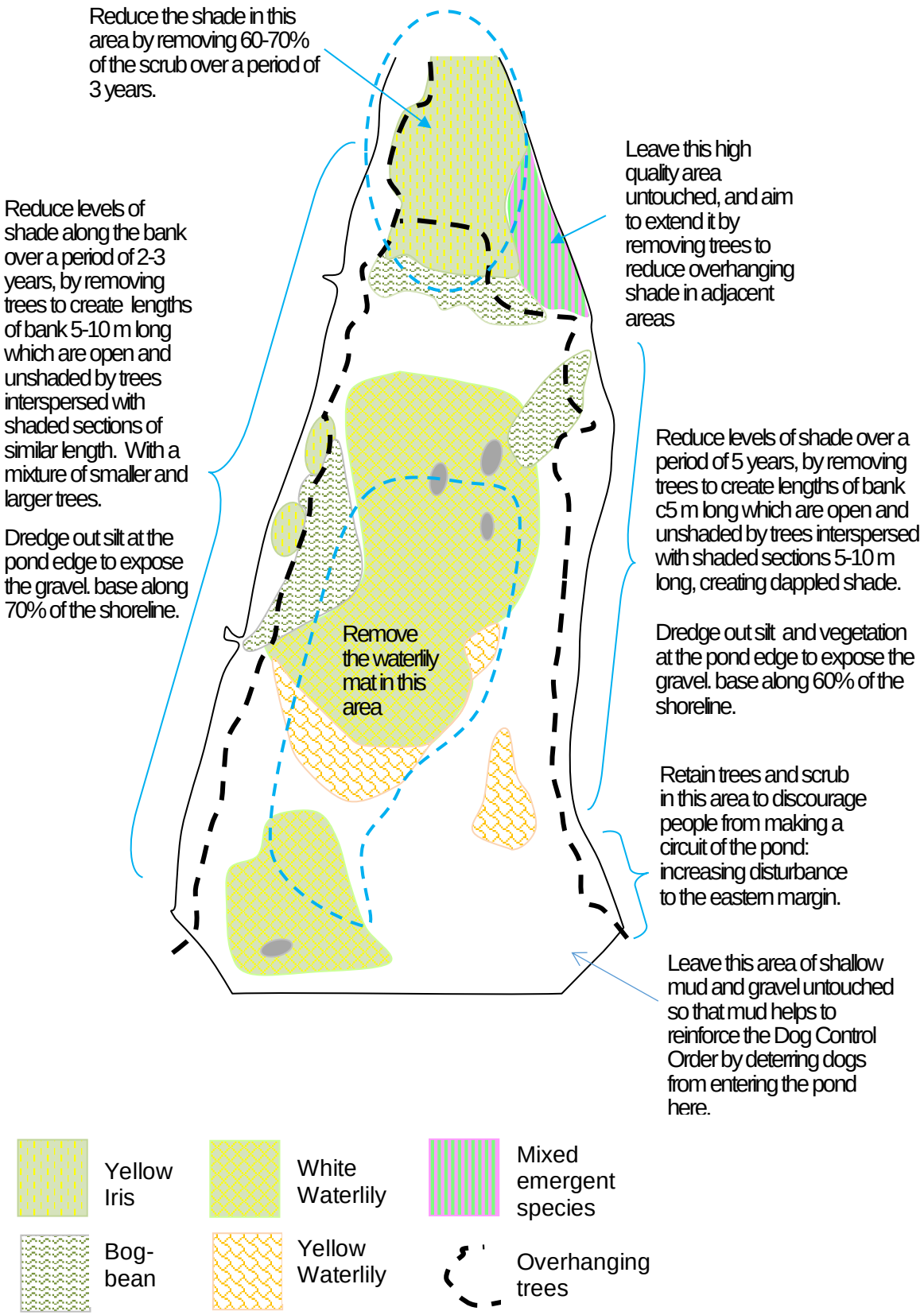


Figure 5. Middle Pond: areas of particular biodiversity interest

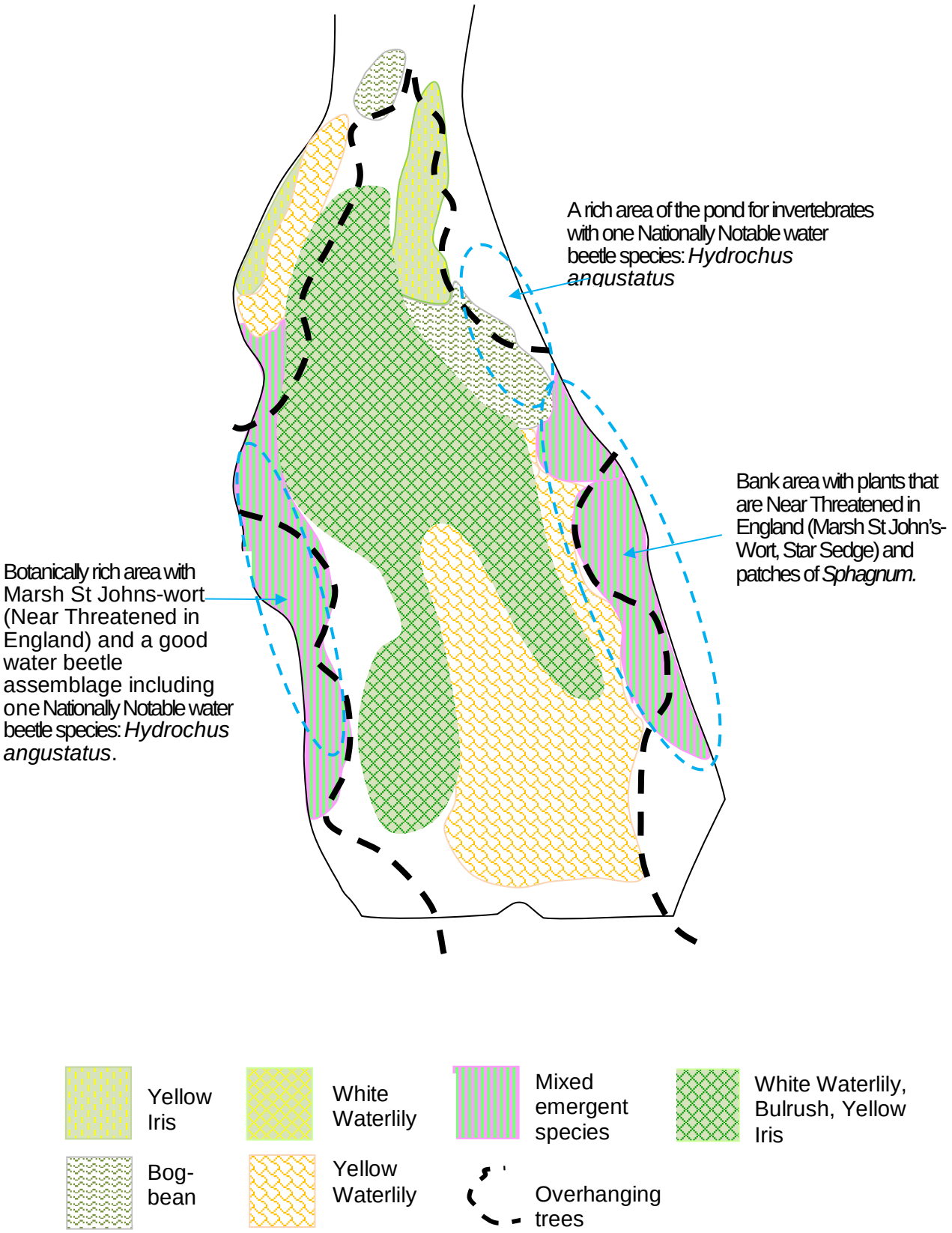
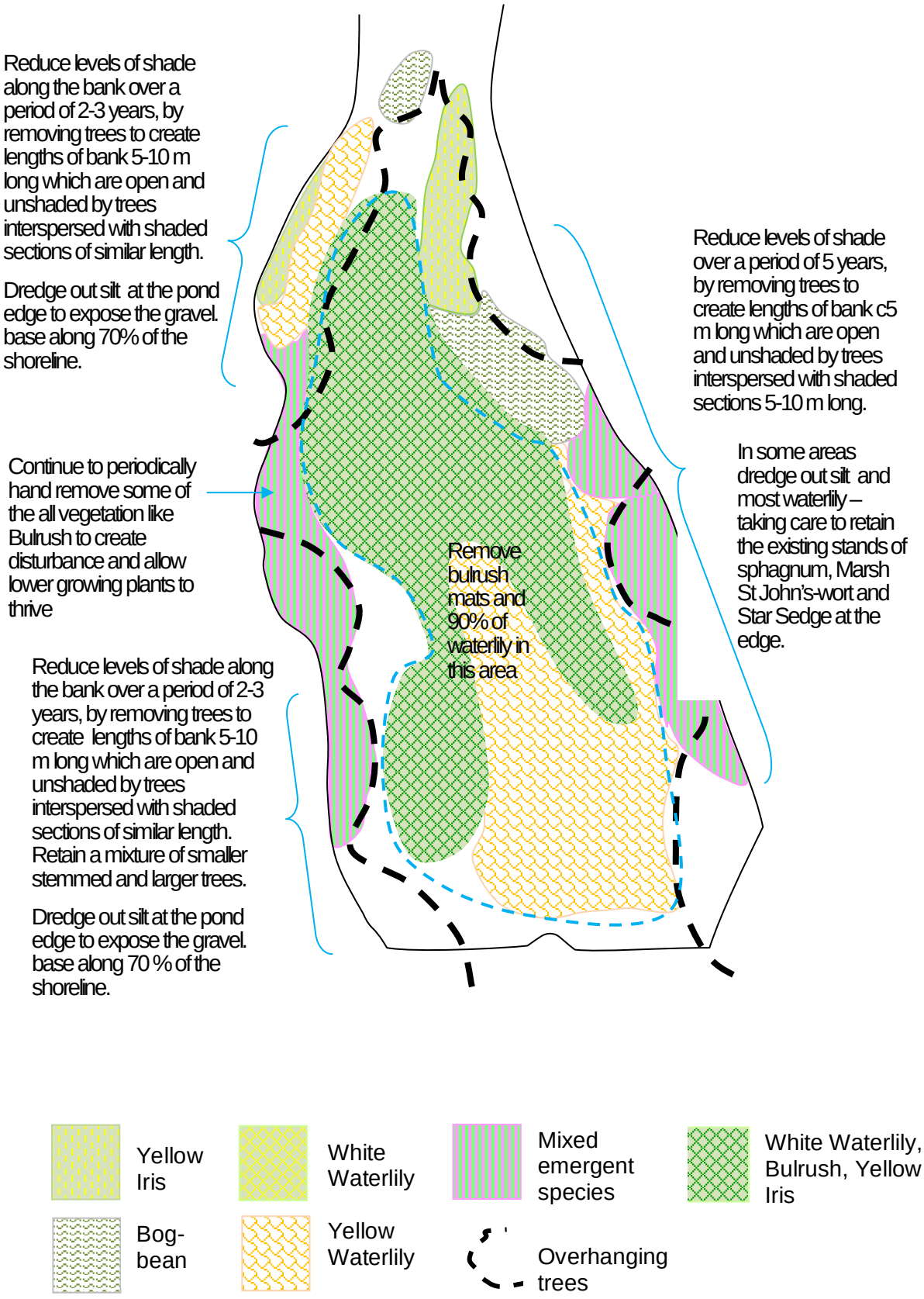


Figure 6. Middle Pond: management recommendations



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Appendix 1 PSYM and Priority Ponds

A1.1 What is PSYM?

PSYM is an acronym for the Predictive SYstem for Multimetric, and is pronounced 'sim'. It is a standard method for assessing pond quality, in which environmental, plant and invertebrate information is used to identify how degraded a pond is on a scale from badly degraded to pristine.

PSYM works by comparing the plants and animals currently at a pond, with what would be expected at that pond if it was in pristine condition.

A1.2 How is PSYM calculated?

PSYM uses six biological measures or 'metrics' (such as the number of plant species) to measure pond quality. Each metric is known to be linked to one or more types of degradation. The values from all six metrics are added together to give a single measure which represents the overall quality of the waterbody.

PSYM's metrics are calculated using a wetland plant species list and an invertebrate family list, that are first collected from the survey pond using standardised survey methods.

Environmental data (such as pond area and pH) are also collected from the pond. These physical and chemical factors are entered into the PSYM computer programme, which then uses them to predicts, for that specific pond, which plant and invertebrates should be present if the pond is in pristine condition. The computer program then uses the plant and invertebrate lists collected from the pond to calculate the six biological metric for this pristine pond.

Comparing the computer's predicted 'pristine pond' metrics, with the plant and animal metrics actually found at the pond, tells you the pond's quality - i.e. how close the pond currently is to its pristine state.

PSYM assessments should ideally be made using both plant and aquatic invertebrate survey data, because, together, plants and animals span a complimentary range of sensitivities to degradation. Plants, for example, are particularly sensitive to waterbody nutrient levels, whereas animals typically exhibit greater sensitivity to organic pollution and some pesticides.

A1.3 What PSYM is used for?

1. PSYM assesses the overall ecological quality of a pond. It is particularly suitable for *monitoring surveys*, because it is a standardised method which can be used to assess change in pond quality over time. For example PSYM is currently used in the government's Countryside Survey to assess the state of Britain's ponds, and see if their quality is changing.
2. PSYM assessments are one of the ways for assessing whether a pond qualifies as a Priority Pond (see below).
3. PSYM can add value to existing surveys: for example if a conservation assessment for a site has already been made, the plant and invert species lists can be re-used in a PSYM assessment to provide additional information about pond quality.
4. The six biological metrics can also be looked at individually to indicate possible causes of degradation. For example plant Trophic Ranking Score can suggest if ponds are polluted by nutrients, and the number of water beetle families indicates whether the pond's physical habitats are good for wildlife.

A.1.4 PSYM Metrics

There are three plant and three invertebrate metrics in PSYM. These are:

Plants:

- Number of Submerged and Marginal Plant species (SM). Floating-leaved species are not included.
- Trophic Ranking Score (TRS): which assigns scores to still-water plant species based on their tolerance to nutrients.
- Number of Uncommon Plant species (U): the number of locally uncommon, scarce or Red Data Book plant species recorded at each pond. "Locally uncommon" is defined here as species recorded from less than 25% of 10 x 10 km squares in GB.

Invetebrates:

- Average score per taxon (ASPT). ASPT is calculated (as in RIVPACS), by summing the BMWP[2] scores for all taxa recorded at the site and dividing by the total number of BMWP taxa recorded.
- Number of dragonfly (Odonata) and alderfly (Megaloptera) families recorded (OM)
- Number of beetle (Coleoptera) families recorded (COL).

A1.5 How PSYM works

Different pond types naturally support different plant and animal communities depending on where the pond is located, how big it is, whether the pond is shaded by trees or grazed etc. The PSYM software programme takes geographic and environmental information gathered from surveys of your pond and uses this to predict the plant and animal metric values that would be expected for that type of pond, if the pond was in pristine condition.

The true biological condition of a pond can be judged by comparing the value of each metric actually observed at the pond with the value expected if that pond was pristine. So, for example, if the pond is a small, shady, ungrazed pond in south west England, its metrics will be compared with those of computer-predicted *pristine* small shady ungrazed ponds from the south west. The PSYM programme gets its "pristine pond" information from the un-degraded ponds Freshwater Habitats Trust has surveyed across England and Wales as part of the National Pond Survey.

The difference between the metric values from your real (observed) pond, and PSYM-predicted pristine pond shows how degraded your pond is by non-natural (anthropogenic) factors. The observed metric results can be expressed either as an index (observed/expected), or as a percentage of the expected value. In high quality ponds the metric value similarity with a pristine site is high (75%-100% similarity). As degradation increases, the percentage similarity between the observed and expected values falls.

A1.6 Interpreting PSYM results

For reporting purposes the similarity between your total observed score and the computer predicted score is divided into four grades of ecological condition.

[2] BMWP (Biological Monitoring Working Party) scores assigned to taxa defined by Maitland (1977), so each is allocated a value from 1 to 10 depending on its known tolerance to organic pollution, a higher score indicates lower tolerance.

Percentage similarity	Grades of ecological condition
0%- 25%	Very Poor
26% - 50%	Poor
51% - 75%	Moderate
76% or above	Good. These ponds are close to pristine, and automatically qualify as “Priority Ponds”

A1.7 Is the pond a Priority Pond?

Ponds that are particularly high quality qualify as ‘Priority Habitats’, which means that they fall under the provisions of Section 41 (S41) of the 2006 Natural Environment and Rural Communities (NERC) Act (see below).

A1.8 Identifying Priority Ponds

In 2007, ponds were added to the list of priority habitats recognised in the UK Biodiversity Action Plan (BAP). Ponds are widespread throughout the UK, but high-quality examples are now highly localised, especially in the lowlands. Estimates, based on the relatively small pond data sets currently available suggest that around 20% of the c.500,000 ponds found outside curtilage (e.g. gardens) in the UK, might meet the criteria for recognition as a Priority Pond under the UK Pond HAP. The highest density of these ponds will occur in Scotland and Wales, far fewer in England where pollution and other damage are so pervasive.

UK BAP Priority Ponds are defined as permanent and seasonal standing water bodies up to 2 hectares in extent which meet one or more of the following 5 criteria:

1. Habitats of high conservation importance
Ponds that meet criteria under Annex 1 of the Habitats Directive.

2. Ponds with species of high conservation importance

These are Red Data Book species, BAP species, species fully protected under the Wildlife and Countryside Act Schedule 5 and 8, Habitats Directive Annex II species, a Nationally Scarce wetland plant species, or three Nationally Scarce aquatic invertebrate species.

3. Ponds with exceptional populations or numbers of key species
This is based on: criteria specified in guidelines for the selection of biological Sites of Special Scientific Interest (currently amphibians and dragonflies only), exceptionally rich sites for plants or invertebrates (supporting 30 or more wetland plant species or 50 or more aquatic invertebrate species).

4. Ponds of high ecological quality
These are ponds **c**lassified in the top category for ecological quality, as assessed by the standardised method for assessing the biological quality of still waters in England and Wales - the Predictive System for Multimetrics (PSYM).

5. Other important ponds
These are individual ponds or groups of ponds with a limited geographic distribution recognised as important because of their age, rarity of type or landscape context e.g. pingos, duneslack ponds, machair ponds.

Appendix 2 Invertebrate species recorded

Appendix Table 2.1 Upper Pond invertebrate species recorded from each sampling area

	1 & 2	3 & 4	5 & 6	7	8 & 9	10 & 11	12 & 13	14 & 15	16 - 18	19 & 20	21
Flatworms and Leeches											
Polycelis sp.	4	1	10	3	3	6			4	4	5
Dendrocoelum lacteum											
Helobdella stagnalis	2	9	50	47	44	7	9	2	3	4	3
Erpobdella testacea	1		4	1		2		3	4	1	
Snails											
Physella cf acuta								2			
Ferrissia wautieri	1					1	1	3	1	2	
Shrimps and Slaters											
Crangonyx pseudogracilis	121	53	86	91	39	135	20	9	178	89	155
Asellus aquaticus		1		1	2				1		
Proasellus meridianus				1	1	1			1	1	2
Beetles											
Anacaena bipustulata				1							
Anacaena globulus										1	
Anacaena lutescens			1			2		1			4
Cercyon tristis				1							
Coelostoma orbiculare											1
Colymbetinae						1					
Cyphon sp.	1									2	2
Enochrus coarctatus						2					5
Helochares lividus								1	1		
Helochares punctatus			1					1	5		
Helochares sp.	1		1					1	1		1
Helophorus aequalis				3					1		4
Helophorus brevipalpis				4		1	2	3	1	1	13
Helophorus minutus								1			
Helophorus sp.								3			
Hydrobius fuscipes		2		1		1					1
Hydroporus angustatus						1					
Hydroporus incognitus										1	
Hydroporus neglectus									1	1	1
Hydroporus planus											1
Hydroporus pubescens						1				1	
Hydroporus sp.											2

	1 & 2	3 & 4	5 & 6	7	8 & 9	10 & 11	12 & 13	14 & 15	16 - 18	19 & 20	21
Hydroporus tessellatus										1	
Hygrobia hermanii					1						
Ilybius ater						1					
Peltodytes caesus							4				
Bugs											
Corixa punctata				1	1						
Corixa sp.			3	1	94	2				1	
Gerris lacustris											
Hebrus ruficeps									20		4
Hesperocorixa sahlbergi	2				2						
Hydrometra stagnorum		1									
Nepa cinerea										2	
Notonecta glauca	2			2		6	3	2			
Notonecta nymphs	1	2			2	3		1	2		1
Sigara dorsalis					14						
Sigara nigrolineata					1						
Sigara sp.				1							
Velia sp.			2	1	2						
Cloeon dipterum			15	6	19	1	2				
Dragonflies											
Aeshna cyanea			1	1		3	3	3			
Aeshna sp.											1
Aeshnidae	2	1	1	12		8					1
Libellulidae			1								1
Lestes sponsa							2				
Sympetrum sanguineum							1				
Sympetrum sp.									1		1
Caddis-flies											
Limnephilus lunatus			1								
Spider											
Argyroneta aquatica											1

Appendix Table 2.1 Middle Pond invertebrate species recorded from each sampling area

	A & B	C & D	E & F	G	H & I	J & K
Flatworms and Leeches						
Polycelis nigra gp.	0	1	1	0	0	0
Polycelis sp.	3	1	36	2	0	1
Dendrocoelum lacteum	0	3	1	0	4	0
Helobdella stagnalis	6	26	4	6	14	8
Erpobdella testacea	2	10	7	1	5	2
Theromyzon tessulatum	0	0	0	1	0	0
Snails						
Physella cf acuta	13	6	54	7	23	9
Ferrissia wautieri	1	18	0	15	66	16
Shrimps and Slaters						
Crangonyx pseudogracilis	8	101	142	72	66	154
Proasellus meridianus	0	0	2	1	0	0
Beetles						
Anacaena globulus	0	0	0	2	0	0
Anacaena lutescens	2	1	4	1	0	1
Colymbetinae	0	0	1	0	0	0
Cyphon sp.	0	0	0	0	0	0
Enochrus coarctatus	1	2	3	0	0	0
Enochrus sp.	1	1	0	0	0	0
Enochrus testaceus	0	0	0	0	1	0
Haliplus flavicollis	1	0	0	0	0	0
Haliplus ruficollis	1	2	0	0	1	0
Haliplus ruficollis gp.	5	2	0	0	2	0
Haliplus sp.	2	0	0	0	0	0
Helophorus aequalis	0	0	1	1	0	0
Helophorus brevipalpis	1	0	2	1	1	2
Helophorus sp.	0	0	1	0	0	0
Hydrobius fuscipes	1	0	0	0	0	0
Hydrochus angustatus	1	0	0	1	0	0
Hydroporus gyllenhalii	0	0	2	2	0	0
Hydroporus palustris	0	2	3	1	0	0
Hydroporus sp.	0	0	0	1	0	0
Liopterus haemorrhoidalis	1	0	1	2	0	0
Noterus clavicornis	1	0	0	0	0	0
Bugs						

	A & B	C & D	E & F	G	H & I	J & K
Corixa sp.	1	83	2	8	1	0
Gerris lacustris	0	0	0	1	0	0
Gerris sp	0	1	0	0	0	0
Hesperocorixa linnaei	0	0	0	0	0	1
Hesperocorixa moesta	0	1	0	0	0	0
Hydrometra stagnorum	0	0	0	0	0	1
Nepa cinerea	0	2	0	1	0	0
Notonecta glauca	1	3	1	0	2	6
Notonecta obliqua	0	0	1	0	0	0
Notonecta nymphs	12	0	0	13	2	1
Sigara limitata	0	1	0	0	0	0
Sigara lutaria	0	0	0	4	0	0
Sigara nigrolineata	0	0	0	2	0	0
Mayflies						
Cloeon dipterum	0	1	1	0	17	1
Dragonflies	0	0	0	0	0	0
Aeshna cyanea	12	1	0	9	2	2
Aeshna sp.	0	0	0	0	0	1
Libellulidae	0	0	6	3	0	0
Lestes sponsa	0	1	2	0	13	0
Pyrrhosoma nymphula	1	0	0	0	1	0
Sympetrum flaveolum	0	0	0	1	0	0
Sympetrum striolatum	1	0	0	0	0	0
Caddis-flies						
Anabolia nervosa	0	1	0	0	0	0
Glyphotaelius pellucidus	0	1	1	0	0	0
Limnephilus lunatus	0	1	0	1	0	0
Alderfly						
Sialis lutaria	0	0	0	3	0	0

Appendix 3 Distribution of Invertebrate species in Upper and Middle Ponds

A3.1 Distribution of invertebrate species in Upper Pond

Sites 1 & 2 Upper Pond	Number
Polycelis sp.	4
Helobdella stagnalis	2
Erpobdella testacea	1
Ferrissia wautieri	1
Crangonyx pseudogracilis	121
Cyphon sp.	1
Helochares sp.	1
Hesperocorixa sahlbergi	2
Notonecta glauca	2
Aeshnid sp.	2
Total invertebrate species	**11**
Other groups recorded:	
Pisidium sp.	12
Chaoboridae	2
Ceratopogonidae	32
Chironomidae	95
Syrphidae	1
Oligochaeta	83

Sites 1 and 2

This area of the northern bank was heavily shaded by overhanging trees and had a steep, overhanging bank that dropped rapidly to 10 cm water depth. The pond base was overlain by a considerable accumulation of inflow sediment and coarse leaf litter which averaged around 60 cm depth. Marginal plants were typically sparse along the bank but Bogbean, Yellow Iris and occasional Branched Bur-reed formed mats in deeper water. The aquatic invertebrate assemblage was relatively poor: dominated by oligochaetes, chironomids, ceratopogonids and the freshwater shrimp *Crangonyx pseudogracilis*. Species which occurred more infrequently included the leeches *Helobdella stagnalis* and *Erpobdella testacea*, small *Polycelis* flatworms, the shade tolerant bug *Hesperocorixa sahlbergi* and the common backswimmer *Notonecta glauca.* The larvae of *Helochares* and *Cyphon* beetles were recorded but no water beetles were seen as adults. Aeshnid dragonfly larvae were recorded in May but were too young to identify to species level.

Sites 3 & 4 Upper Pond	Number
Polycelis sp.	1
Helobdella stagnalis	9
Crangonyx pseudogracilis	53
Asellus aquaticus	1
Hydrobius fuscipes	2
Hydrometra stagnorum	1
Notonecta nymphs	2
Aeshnid sp.	1
Total Invertebrate species	**8**
Other groups recorded:	
Chaoboridae	3
Ceratopogonidae	19
Chironomidae	46
Culicidae	1
Oligochaeta	45

Sites 3 and 4

The middle Section of the north-western margin had shaded, steeply overhanging banks. Water depth averaged 10 cm with a thick layer of leafy sediment beneath averaging 50 cm depth. Stands of Yellow Iris occurred close to the pond edge, growing together with semi-floating mats of Bogbean that overlay deep sediment trapped by their roots. The fauna of this area was rather impoverished with only eight species recorded across the two seasons. The assemblage was dominated by oligochaetes, chironomids, ceratopogonids and the freshwater shrimp *Crangonyx pseudogracilis*. Species which occurred more rarely included the leech *Helobdella stagnalis*, the Common Water Slater *Asellus aquaticus,* the water scavenger beetle *Hydrobius fuscipes* and the Common Water Measurer *Hydrometra stagnorum*. Backswimmer nymphs and an aeshnid dragonfly larva were also recorded but were too young to identify to species level. In Adrian Hine's previous surveys, small numbers of the Nationally Scarce water beetles *Hydaticus seminiger* and *Helochares punctatus* were recorded from this habitat, but neither were found here in the current survey.

Sites 5 & 6 Upper Pond	Number
Polycelis sp.	1
Helobdella stagnalis	50
Erpobdella testacea	4
Crangonyx pseudogracilis	86
Anacaena lutescens	1
Helochares punctatus	**1**
Helochares sp.	
Corixa sp.	3
Velia sp.	2
Cloeon dipterum	15
Aeshna cyanea	1
Libellulidae	1
Limnephilus lunatus	1
Total Invertebrate species	**13**
Other groups recorded:	
Chaoboridae	118
Ceratopogonidae	4
Chironomidae	155
Culicidae	2
Oligochaeta	64

Sites 5 and 6

Sites 5 and 6 had a steep undercut bank, reinforced by the roots of overhanging marginal trees. Water depth averaged 40 cm, overlying c.20 cm of leafy silt. There were occasional tufts of Soft Rush and Purple Moor-grass at the water's edge, with White and Yellow Water-lily in deeper water. The fauna was dominated by chironomids, chaoborids, oligochaetes, and the freshwater shrimp *Crangonyx pseudogracilis*. There was a large population of the leech *Helobdella stagnalis* and moderate numbers of the Pond Olive mayfly (*Cloeon dipterum*) the latter most numerous in late summer. Species that occurred less frequently included the leech *Theromyzon tessulatum*, the water scavenger beetles *Anacaena lutescens* and ***Nationally Scarce Helochares punctatus***, the widespread caddisfly *Limnephilus lunatus* and Southern Hawker dragonfly (*Aeshna cyanea*). A small libellulid dragonfly and nymphs of lesser water boatmen and water cricket *Velia* sp. were also recorded.

Site 7 Upper Pond	Number
Polycelis sp.	3
Helobdella stagnalis	47
Theromyzon tessulatum	1
Crangonyx pseudogracilis	91
Asellus aquaticus	1
Proasellus meridianus	1
Anacaena bipustulata	1
Cercyon tristis	1
Helophorus aequalis	3
Helophorus brevipalpis	4
Hydrobius fuscipes	1
Corixa punctata	1
Notonecta glauca	2
Sigara sp.	1
Velia sp.	1
Cloeon dipterum	6
Aeshna cyanea	1
Total Invertebrate species	**17**
Other groups recorded:	
Chaoboridae	25
Ceratopogonidae	36
Chironomidae	61
Culicidae	4
Oligochaeta	32

Site 7

Site 7 in the south-west corner of the pond was moderately shaded by marginal trees overhanging a more shallowly sloping bank. Water depth averaged 10 cm overlying 30 cm of leafy silt. Away from the bank, in deeper water, tubers of water-lily created small islands colonised by Soft Rush, Yellow Iris and young saplings of Alder and Sallow. This area was moderately rich in invertebrate species. The fauna was dominated by chironomids, ceratopogonids, chaoborids, oligochaetes, the freshwater shrimp *Crangonyx pseudogracilis* and leech *Helobdella stagnalis.* Other species occurred in very small numbers, including the Pond Olive Mayfly (*Cloeon dipterum*), the leech *Erpobdella testacea,* both water-slater species *Asellus aquaticus* and *Proasellus meridianus,* five common water beetle species including two water scavenger beetles which were only recorded at this one location: the widespread *Anacaena bipustulata* and more local *Cercyon tristis*; a species that was formerly Nationally Notable B. The common water bugs *Corixa punctate* and *Notonecta glauca* were also found together with nymphs of lesser water boatmen and water cricket *Velia* sp. The only dragonfly recorded was a single individual Southern Hawker dragonfly (*Aeshna cyanea*).

Sites 8 & 9 Upper Pond	Number
Polycelis sp.	3
Helobdella stagnalis	44
Crangonyx pseudogracilis	39
Asellus aquaticus	2
Proasellus meridianus	1
Hygrobia hermanii	1
Corixa punctata	1
Hesperocorixa sahlbergi	2
Notonecta nymphs	2
Sigara dorsalis	14
Sigara nigrolineata	1
Velia sp.	2
Cloeon dipterum	19
Total Invertebrate species	**13**
Other groups recorded:	
Chaoboridae	1882
Chironomidae	271
Culicidae	8
Oligochaeta	132

Sites 8 and 9

Sites 8 and 9 include the area along the pond's outflow dam and its south-eastern corner. Water depths adjacent to the concrete dam wall averaged around 50 cm, overlying shallow silt c.2 cm deep that covered a gravel base. In the south-east corner gravel was locally exposed, although further northwards the base was covered in deeper leafy silt where the bank was more heavily overhung by trees. This area of the pond was devoid of macrophytes, and in the deeper open water areas that dominated this habitat chaoborids occurred in very large numbers. Chironomids, oligochaetes, the freshwater shrimp *Crangonyx pseudogracilis* and leech *Helobdella stagnalis* were also common. Other more open water species occurred at lower abundance including the Pond Olive Mayfly (*Cloeon dipterum*) and a range of common water bugs (*Hesperocorixa sahlbergi, Sigara dorsalis, Sigara nigrolineata, Corixa punctata).* Backswimmers were only recorded as nymphs (*Notonecta* sp.). The only beetle found was the Screech Beetle (*Hygrobia hermani*), which, during the current survey, was not recorded elsewhere in the pond.

Sites 10 & 11 Upper Pond	Number
Polycelis sp.	6
Helobdella stagnalis	7
Erpobdella testacea	2
Ferrissia wautieri	1
Crangonyx pseudogracilis	135
Proasellus meridianus	1
Anacaena lutescens	2
Colymbetinae sp.	1
Enochrus coarctatus	2
Helophorus brevipalpis	1
Hydrobius fuscipes	1
Hydroporus angustatus	1
Hydroporus pubescens	1
Ilybius ater	1
Corixa sp.	2
Notonecta glauca	6
Cloen dipterum	1
Aeshna cyanea	3
Total Invertebrate species	**19**
Other groups recorded:	
Pisidium sp.	4
Chaoboridae	9
Ceratopogonidae	20
Chironomidae	85
Culicidae	20
Hydracarina	3
Oligochaeta	23

Sites 10 and 11

Along this length, mid-way along the south-eastern bank, both water and silt depth varied from around 5 to 35 cm with stands and mats of Yellow Iris, Bogbean and Sphagnum. This was a relatively rich area of the pond in terms of its fauna with 19 species recorded across the two seasons of sampling. The freshwater shrimp *Crangonyx pseudogracilis* was the most abundant species present, but ceratopogonids, chironomids, culicids and oligochaetes were common. Eight beetle species were recorded at low levels of abundance. They included the diving beetles *Ilybius ater* and *Hydroporus angustatus* which were only recorded in this section of the pond. The only dragonfly recorded was the Southern Hawker (*Aeshna cyanea*).

Sites 12 &13 Upper Pond	Number
Helobdella stagnalis	9
Ferrissia wautieri	1
Crangonyx pseudogracilis	20
Helophorus brevipalpis	2
Peltodytes caesus	**4**
Notonecta glauca	3
Cloen dipterum	2
Aeshna cyanea	3
Lestes sponsa	2
Sympetrum sanguineum	1
Total Invertebrate species	**10**
Other groups recorded:	
Chaoboridae	60
Chironomidae	38
Oligochaeta	2

Sites 12 and 13

These sites were located in the deeper open water in the southern part of Upper Pond. Water depths averaged 1.2 m with 10-15 cm silt. The habitat was unshaded with locally extensive floating rafts of Yellow and White Water-lily. The fauna in this area was rather limited with only 10 species recorded: mainly chaoborids, chironomids and the freshwater shrimp *Crangonyx pseudogracilis.* Most species were associated with the stands of waterlily, including the non-native limpet *Ferrissia wautieri* which grazes algae on the underside of the leaves. Two water beetle species were recorded: the very common *Helophorus brevipalpis* and distinctively marked, and much less common, crawling water beetle ***Peltodytes caesus (Nationally Scarce).*** Four individuals of the latter were recorded in late summer and this was the only area of the pond where this species was found. The site also supported three dragonfly species at low abundance: the Southern Hawker (*Aeshna cyanea*), Ruddy Darter (*Sympetrum sanguineum*) and Emerald Damselfly (*Lestes sponsa*).

Sites 14 & 15 Upper Pond	Number
Helobdella stagnalis	2
Erpobdella testacea	3
Physella cf *acuta*	2
Ferrissia wautieri	3
Crangonyx pseudogracilis	9
Anacaena lutescens	1
Helochares lividus	1
Helochares punctatus	**1**
Helophorus brevipalpis	3
Helophorus minutus	1
Notonecta glauca	2
Notonecta nymphs	1
Aeshna cyanea	3
Total Invertebrate species	**13**
Other groups recorded:	
Ceratopogonidae	4
Chironomidae	6
Syrphidae	1
Oligochaeta	3

Sites 14 and 15

An unshaded deeper water habitat, located close to the centre of Upper Pond. The flora was dominated by rafts of White Water-lily with stands of Bogbean to the west. The invertebrate fauna was moderately poor and abundance levels were very low for all the groups recorded. In addition to the Diptera and other taxa, like freshwater shrimps that were ubiquitous in all habitats across the pond, this site supported five water beetle species of which the water scavenger beetles ***Helochares punctatus* is Nationally Scarce** and *Helophorus minutus* was only recorded at this location within the pond. Two mollusc species occurred: the limpet *Ferrissia wautieri* and the bladder snail *Physella* cf. *acuta*, together with the Southern Hawker (*Aeshna cyanea*).

Sites16,17 & 18 Upper Pond	Number
Polycelis sp.	4
Helobdella stagnalis	3
Erpobdella testacea	4
Ferrissia wautieri	1
Crangonyx pseudogracilis	178
Asellus aquaticus	1
Proasellus meridianus	1
Helochares lividus	1
Helochares punctatus	**5**
Helophorus aequalis	1
Helophorus brevipalpis	1
Hydroporus neglectus	**1**
Hebrus ruficeps	20
Notonecta nymphs	2
Sympetrum sp.	1
Total Invertebrate species	**15**
Other groups recorded:	
Pisidium sp.	530
Ceratopogonidae	31
Chironomidae	1
Culicidae sp.	1
Syrphidae	2
Hydracarina	5
Oligochaeta	35

Sites 16, 17 and 18

This habitat, located in the central northern area of the pond, was dominated by Alder scrub to the north colonising the inflow's prograding sediment delta. As the shade decreased and water depths increased southwards, the scrub gave way to floating mats with muddy pools and runnels on its surface, dominated by Iris, Bogbean and *Sphagnum* and also colonised by Common Spike-rush, Bulbous Rush and Gipsywort, Water depths in this area averaged c1.1 m, and only loose sediment was present over the gravel base. The fauna recorded in this habitat was moderately diverse with pea mussels *Pisidium* sp. the most abundant invertebrate group recorded. The freshwater shrimp *Crangonyx pseudogracilis*, ceratopogonids and oligochaetes were also moderately common. Both water slater species occurred here, together with a good population of the Sphagnum Bug (*Hebrus ruficeps*). Five water beetle species were recorded, two of which are **Nationally Scarce**: the water scavenger beetle ***Helochares punctatus*** and small diving beetle ***Hydroporus neglectus.*** In his original survey, Adrian Hine recorded the Nationally Scarce water beetle *Hydaticus seminiger* from this area of the pond.

Sites 19 & 20 Upper Pond	Number
Polycelis sp.	4
Helobdella stagnalis	4
Erpobdella testacea	1
Ferrissia wautieri	2
Crangonyx pseudogracilis	89
Proasellus meridianus	1
Anacaena globulus	1
Cyphon sp.	2
Helophorus brevipalpis	1
Hydroporus incognitus	1
Hydroporus neglectus	1
Hydroporus pubescens	1
Hydroporus tessellatus	1
Corixa sp.	1
Nepa cinerea	2
Total Invertebrate species	**15**
Other groups recorded:	
Pisidium sp.	133
Ceratopogonidae	24
Chironomidae	59
Culicidae	1
Ptychopteridae	1
Hydracarina	9
Oligochaeta	41

Sites 19 and 20

Sites 19 and 20 covered the pond's inflow area. This was heavily shaded by Alder and Sallow growing on the deposited sediment. Shallow water areas between the trees averaged less than 2 cm, over leafy organic silt 30 to 60 cm deep. The vegetation was limited to stands of Yellow Iris. The most abundant faunal groups in this area were pea mussels *Pisidium* sp., chironomids, ceratopogonids, oligochaetes and the freshwater shrimp *Crangonyx pseudogracilis*. However a moderately wide range of beetles also occurred including two very widespread scavenger beetles (*Helophorus brevipalpis, Anacaena globulus*), one of the marsh beetles *Cyphon* sp. and four species of small diving beetle (*Hydroporus* sp.) of which two *Hydroporus incognitus* and *Hydroporus tessellatus* were only recorded in this area. Two Water Scorpions (*Nepa cinerea*) were also netted. In the 1990s, Adrian Hine recorded the Nationally Scarce water beetle *Hydaticus seminiger* from this area of the pond.

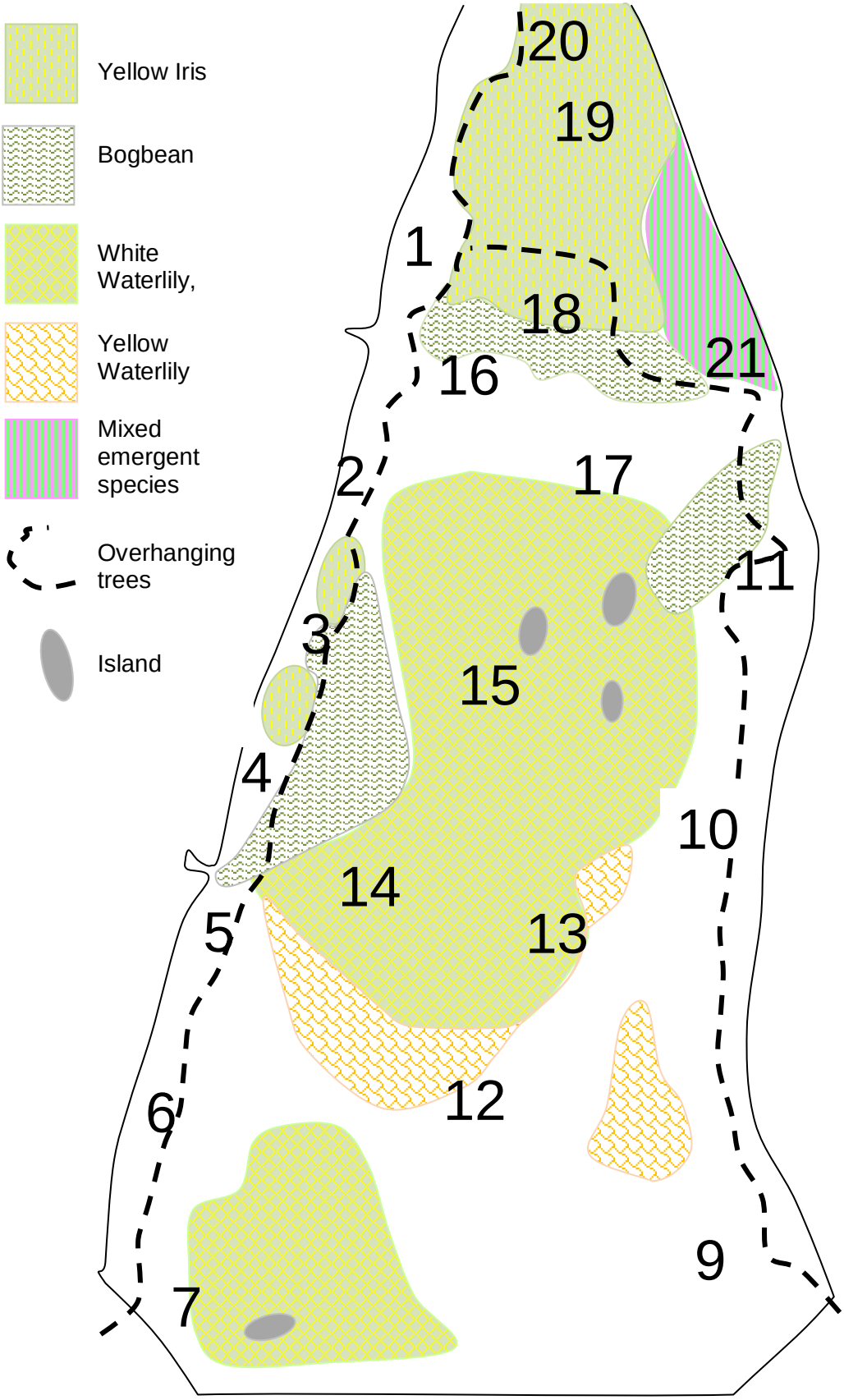
Site 21 Upper Pond	Number
Polycelis sp.	4
Helobdella stagnalis	3
Crangonyx pseudogracilis	155
Proasellus meridianus	2
Anacaena lutescens	4
Coelostoma orbiculare	1
Cyphon sp.	2
Enochrus coarctatus	5
Helochares sp.	1
Helophorus aequalis	4
Helophorus brevipalpis	13
Hydrobius fuscipes	1
Hydroporus neglectus	**1**
Hydroporus planus	1
Hebrus ruficeps	4
Notonecta nymphs	1
Aeshna sp.	1
Sympetrum sp.	1
Argyroneta aquatica	1
Total Invertebrate species	**20**
Other groups recorded:	
Pisidium sp.	48
Ceratopogonidae	12
Chironomidae	48
Culicidae	4
Hydracarina	5
Oligochaeta	54

Site 21

The location of Site 21 in Adrian Hine's survey was further to the north of the site surveyed here. The original site was now dominated by Alder and Sallow growing on the inflow delta sediments. The current location of Site 21 on the north eastern edge represents a rather more similar habitat type to that originally surveyed. The area was partly shaded and dominated by a *Sphagnum* mat colonised by Jointed Rush. Small pools a few cm deep with Bog Pondweed were associated with the mat, growing over silt up to 50 cm deep. This was the richest of the eleven habitats in Upper Pond for invertebrates. The most numerous animals were Pea mussels *Pisidium* sp., chironomids, ceratopogonids, oligochaetes and the freshwater shrimp *Crangonyx pseudogracilis*. Both water-slater species occurred, together with 10 water beetle species which included the **Nationally Scarce *Hydroporus neglectus*.** The now rather uncommon Water Spider *Argyroneta aquatica* was also recorded together with the Sphagnum Bug *Hebrus ruficeps*. Other bugs and dragonflies were present but were too young to identify to species level.

In his original survey, Adrian Hine also recorded recorded *Hydroporus neglectus t*ogether with two other Nationally Scarce water beetles: *Hydaticus seminiger* and *Helochares punctatus*. In the current survey *Helochares* larvae were recorded and could have been H *punctatus.* Although both this species, and the more common *H. lividus* were recorded elsewhere in the pond.

Apx. Figure 3.1 location of invertebrate sampling areas in Upper Pond



A3.2 Distribution of invertebrate species in Middle Pond

Site A & B Middle Pond	Number
Polycelis sp.	3
Helobdella stagnalis	6
Erpobdella testacea	2
Physella cf *acuta*	13
Ferrissia wautieri	1
Crangonyx pseudogracilis	8
Anacaena lutescens	2
Enochrus coarctatus	1
Haliplus flavicollis	1
Haliplus ruficollis	1
Helophorus brevipalpis	1
Hydrobius fuscipes	1
Hydrochus angustatus	**1**
Liopterus haemorrhoidalis	1
Noterus clavicornis	1
Corixa sp.	1
Notonecta glauca	1
Notonecta nymphs	12
Aeshna cyanea	12
Pyrrhosoma nymphula	1
Sympetrum striolatum	1
Total Invertebrate species	**21**
Other groups recorded:	
Pisidium sp.	35
Ceratopogonidae	13
Chironomidae	3
Oligochaeta	21

Sites A and B
The western bank of the pond was moderately shaded by a fringe of young birch and oak with larger Beech. Water and silt depth both varied up to 40-50 cm, with deep mud locally exposed at the surface under larger trees. The levels of shade varied too, from open and sunny in the unshaded area mid-way along the margin, to heavy shade under larger trees. Some areas had recently been managed, and dredged Bulrush piled on the bank. The habitats in this area were botanically rich comprising mixed stands of Soft Rush, Bulrush and Yellow Iris, together with grasses (e.g. Velvet Bent), occasional Water Horsetail, and lower growing broadleaved species like Amphibious Bistort and Marsh St John's-wort. This area was also relatively rich in invertebrates. The most numerous animals were pea mussels *Pisidium* sp., ceratopogonids and oligochaetes. Two mollusc species occurred: the limpet *Ferrissia wautieri* and the bladder snail *Physella* cf. *acuta*, as well as the widespread leeches *Helobdella stagnalis* and *Erpobdella testacea.* The site supported a good water beetle assemblage with nine species recorded including the crawling water beetle *Haliplus ruficollis* which was only found in this area within the pond, and the **Nationally Scarce *Hydrochus angustatus*.** Three dragonfly species were present: good numbers of Southern Hawker (*Aeshna cyanea*), and a single Large Red Damselfly (*Pyrrhosoma nymphula*) *and* Common Darter (*Sympetrum striolatum*). In Adrian Hine's survey in the early 1990s the Nationally Scarce *Helochares punctatus* was recorded in this area, though *Hydrochus angustatus* which is currently present, was not found.

Site C & D Middle Pond	Number
Polycelis nigra	1
Dendrocoelum lacteum	3
Helobdella stagnalis	26
Erpobdella testacea	10
Physella cf *acuta*	6
Ferrissia wautieri	18
Crangonyx pseudogracilis	101
Anacaena lutescens	1
Enochrus coarctatus	2
Haliplus ruficollis	2
Hydroporus palustris	2
Corixa sp.	83
Gerris sp.	1
Hesperocorixa moesta	1
Nepa cinerea	2
Notonecta glauca	3
Sigara limitata	1
Cloen dipterum	1
Aeshna cyanea	1
Lestes sponsa	1
Anabolia nervosa	1
Glyphotaelius pellucidus	1
Limnephilus lunatus	1
Total Invertebrate species	**24**
Other groups recorded:	
Pisidium sp.	5
Chaoboridae	79
Ceratopogonidae	9
Chironomidae	74
Culicidae	2
Hydracarina	8
Oligochaeta	61

Sites C and D

This area includes the pond's outflow dam and the south-eastern corner. Water depths adjacent to the concrete dam wall averaged 45 cm, overlying shallow silt (c 1-2 cm) covering the hard gravel base. The dam area was unshaded, but the south-east corner was more heavily overhung by trees. The margins of the pond were devoid of emergent water plants, although stands of Yellow Water-lily occurred further out in deeper water. Despite the lack of vegetation this was a rather rich area for invertebrates. The fauna was dominated by chironomids, chaoborids, oligochaetes, and the freshwater shrimp *Crangonyx pseudogracilis*. Greater water boatmen nymphs were also common. Two flatworm species were recorded (*Polycelis nigra* and *Dendrocoelum lacteum*) as well as the leeches and snails common in other habitats. A moderate number of common water beetles and bugs were found, including Water Scorpion (*Nepa cinerea*). The caddis fly fauna was more diverse than in other habitats and included the Brown Sedge (*Anabolia nervosa*), which was not recorded elsewhere in the two ponds.

Site E & F Middle Pond	Number
Polycelis nigra	1
Polycelis sp.	9
Dendrocoelum lacteum	1
Helobdella stagnalis	4
Erpobdella testacea	7
Physella cf *acuta*	54
Crangonyx pseudogracilis	142
Proasellus meridianus	2
Anacaena lutescens	4
Colymbetinae	1
Enochrus coarctatus	3
Helophorus aequalis	1
Helophorus brevipalpis	2
Hydroporus gyllenhalii	2
Hydroporus palustris	3
Liopterus haemorrhoidalis	1
Corixa sp.	2
Notonecta glauca	1
Notonecta obliqua	1
Cloen dipterum	1
Lestes sponsa	2
Glyphotaelius pellucidus	1
Total Invertebrate species	**22**
Other groups recorded:	
Pisidium sp.	10
Chaoboridae	5
Ceratopogonidae	21
Chironomidae	39
Oligochaeta	11

Sites E and F

Located mid-way down the eastern bank, this area was moderately shaded with water depths around 5-10 cm close to the edge, overlying 30 cm of loose leafy sediment over gravel. The marginal flora was dominated by Soft Rush, with stands of Jointed Rush, Yellow Iris, Marsh St John's-wort, Velvet Bent and *Sphagnum*, growing into Yellow Water-lily in deeper water. The freshwater shrimp *Crangonyx pseudogracilis* was the most abundant species in this habitat, although ceratopogonids, chironomids, culicids, oligochaetes, pea mussels *Pisidium* sp and the bladder snail *Physella* cf. *acuta* were common. The water beetle assemblage was moderately diverse with eight species. The Common Backswimmer (*Notonecta glauca*) together with its relative the Pied Backswimmer (*Notonecta obliqua*) which is often associated with more acid, low nutrient water bodies. The Emerald Damselfly *(Lestes sponsa)*,and the cased caddis *Glyphotaelius pellucidus* were also present. In Adrian Hine's survey in the early1990s the Nationally Scarce water beetles *Helochares punctatus* and *Hydrochus angustatus* were also recorded in this area.

Site G Middle Pond	Number
Polycelis sp.	2
Helobdella stagnalis	6
Erpobdella testacea	1
Theromyzon tessulatum	1
Physella cf *acuta*	7
Ferrissia wautieri	15
Crangonyx pseudogracilis	72
Proasellus meridianus	1
Anacaena globulus	2
Anacaena lutescens	1
Helophorus aequalis	1
Helophorus brevipalpis	1
Hydrochus angustatus	**1**
Hydroporus gyllenhalii	2
Hydroporus palustris	1
Liopterus haemorrhoidalis	2
Corixa sp.	8
Gerris lacustris	1
Nepa cinerea	1
Notonecta nymphs	13
Sigara nigrolineata	2
Aeshna cyanea	9
Sympetrum flaveolum	1
Limnephilus lunatus	1
Sialis lutaria	3
Total Invertebrate species	**26**
Other groups recorded:	
Pisidium sp.	82
Chaoboridae	68
Ceratopogonidae	5
Chironomidae	80
Dixid sp.	1
Hydracarina	3
Oligochaeta	19

Site G

Site G is located on the eastern bank close to the inflow. Water depths were shallow, averaging 5 cm over deep silt c.45 cm. Much of the area close to the bank was shaded, with tussocky mats of Yellow Iris, Bulrush, Soft Rush, Yellow Water-lily and Bogbean in deeper water beyond the overhanging trees. This was the richest part of the pond for invertebrates. The fauna was dominated by chironomids, chaoborids, pea mussels *Pisidium* sp. and the freshwater shrimp *Crangonyx pseudogracilis*. Three leech species were recorded including the Duck Leech (*Theromyzon tessulatum*), together with the non-native limpet *Ferrissia wautieri* and the bladder snail *Physella* cf. *acuta*. Eight water beetle species were found including the **Nationally Scarce *Hydrochus angustatus***, but not the Nationally Scarce water beetle *Helochares punctatus* that Adrian Hine recorded here in his original survey. A moderate number of bugs were present including Water Scorpion (*Nepa cinerea*).

Site H & I Middle Pond	Number
Dendrocoelum lacteum	4
Helobdella stagnalis	14
Erpobdella testacea	5
Physella cf *acuta*	23
Ferrissia wautieri	66
Crangonyx pseudogracilis	66
Enochrus testaceus	1
Haliplus ruficollis	1
Helophorus brevipalpis	1
Corixa sp.	1
Notonecta glauca	2
Cloen dipterum	17
Aeshna cyanea	2
Lestes sponsa	13
Pyrrhosoma nymphula	1
Total Invertebrate species	**16**
Other groups recorded:	
Ceratopogonidae	41
Chironomidae	8
Hydracarina	2
Oligochaeta	8

Sites H and I

These sites were located in the deeper water central area of the southern part of Middle Pond. The habitat was unshaded with extensive floating rafts of Yellow Water-lily. The fauna in this area was rather limited compared to other parts of the pond. The most numerous taxa were ceratopogonids, the freshwater shrimp *Crangonyx pseudogracilis* and the two mollusc species. Only two water beetle species were recorded, although one, the scavenger beetle *Enochrus testaceus* was not recorded elsewhere in the pond. Three dragonfly species were recorded however: the Emerald Damselfly (*Lestes sponsa*), Large Red Damselfly (*Pyrrhosoma nymphula*) and Southern Hawker (*Aeshna cyanea*).

Site J &K Middle Pond	Number
Polycelis sp.	1
Helobdella stagnalis	8
Erpobdella testacea	2
Physella cf *acuta*	9
Ferrissia wautieri	16
Crangonyx pseudogracilis	154
Anacaena lutescens	1
Helophorus brevipalpis	2
Hesperocorixa linnaei	1
Hydrometra stagnorum	1
Notonecta glauca	6
Cloen dipterum	1
Aeshna cyanea	2
Total Invertebrate species	**14**
Other groups recorded:	
Pisidium sp.	2
Chaoboridae	79
Ceratopogonidae	2
Chironomidae	100
Culicidae	2
Oligochaeta	141

Sites J and K

This unshaded deeper water habitat was located close to the centre of the pond. The flora was dominated by floating rafts of either Yellow Water-lily or inter-growing stands of Bulrush, White Water-lily and occasional Yellow Iris. The invertebrate fauna was moderately poor and dominated by the freshwater shrimp *Crangonyx pseudogracilis,* chironomids and chaoborids. Only two widespread water beetle species were found, together with common and widespread water bugs that included the lesser water boatman *Hesperocorixa linnaei*, Common Backswimmer (*Notonecta glauca*) and Common Water Measurer (*Hydrometra stagnorum*). The single dragonfly species recorded was the Southern Hawker (*Aeshna cyanea*).

Apx. Figure 3.2 location of invertebrate sampling areas in Middle Pond