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AN ECOLOGICAL SURVEY OF THE POND AT SAUNDERTON PUMPING STATION WITH RECOMMENDATIONS FOR FUTURE MANAGEMENT OF THE SITE TO ENHANCE ITS CONSERVATION VALUE

A Report for Thames Water

Pond Action

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1. DESCRIPTION OF BRIEF

'To carry out an ecological survey of the pond at Saunderton Pumping Station and report on the findings. The Report should include recommendations for future management of the site to enhance conservation value.'

2. BACKGROUND

The site of the now disused Saunderton Pumping Station has a small pond with an adjacent wetland area and stream. Building work is shortly to be undertaken on part of the site but the pond and wetland area will be retained.

This report describes an ecological survey of the pond with notes on the vegetation of the wetland area and the vegetation and macro-invertebrates of the stream. Features of importance for nature conservation are identified and management recommendations made.

3. SURVEY METHODS

The site was visited by Pond Action on 18th October 1988 and 21st October 1988.

3.1 PHYSICAL FEATURES AND VEGETATION MAPPING

A sketch map showing the main features of the site was drawn (see Figure 1). Vascular plants were recorded from the pond and the adjacent wetland area and stream. It is possible that further plant species would be found if the site could be surveyed earlier in the year.

A scale map of the pond was prepared (from a plane table survey) to show physical features, the extent of the main stands of vegetation and the extent of areas shaded by trees and shrubs (see Figure 2).

The depth of sediment in the pond was measured by probing with rods. Four trial holes were dug to ascertain the nature of the substrate underlying the sediment. Water samples were collected from the stream for chemical analysis. Analyses were carried-out on the day of collection using standard techniques. The following determinands were measured: pH, conductivity, total alkalinity and phosphate phosphorus.

There was no surface water in the pond at the time of either visit, preventing chemical analysis of pond water.

3.2 MACRO-INVERTEBRATE SAMPLING

Macro-invertebrates were collected from the pond and the stream using a standard time-limited sampling method. As the water level in the pond approximately coincided with the sediment surface it was first necessary to create small areas of open water, by light trampling, from which macro-invertebrates could be collected.

Four distinct zones within the pond provided habitats for macro-invertebrates:

(i) wet leaf and twig litter
(ii) reed sweet-grass (Glyceria maxima)/reed canary-grass (Phalaris arundinacea) stands
(iii) wet mud
(iv) bittersweet (Solanum dulcamara) stand

The zones broadly coincided with the vegetation zones shown in Figure 2. Each zone was vigorously swept with a standard pond net to dislodge and capture macro-invertebrates. The four zones were sampled for a total of three minutes with sampling time being allocated to each approximately in proportion to its area.

In the stream the following zones were sampled for a total of three minutes: Apium nodiflorum stand, Berula erecta stand, submerged stems of marginal emergent plants, stream bed. All samples were returned to the laboratory for sorting.

In the laboratory a 1/4 subsample was taken from each sample from which all macro-invertebrates were removed for identification and counting. The remaining three quarters of each sample was sorted to remove any additional taxa.

Macro-invertebrates were identified to species level (except Oligochaeta, Hydracarina and Diptera, which were identified to subclass, suborder and family level, respectively).

4. S I T E D E S C R I P T I O N

4.1 GENERAL FEATURES OF THE SITE

Saunderton Pond is on land owned by Thames Water at Saunderton in Buckinghamshire (Grid Reference: SP795020).

The pond is bounded to the north and east by an area of rough grassland with common nettle (Urtica dioica), hogweed (Heracleum sphondylium) and other common plants of disturbed ground (see Figure 1). South of the pond an old orchard supports a grassland flora. Neither of these areas was surveyed in detail. To the west of the pond is a small wetland area and a stream (see Figure 1). The stream is a spring-fed tributary of the Scotsgrove Brook.

4.2 SAUNDERTON POND

4.2.1 General Features of Pond

The general features of the pond are shown in Figure 2. The pond is about 20m long and up to 5m wide and is steeply banked on all sides (slope varying between 25 and 45 degrees). There is no visible evidence of an inflow to the pond from the stream although one may once have existed. Clinker found below soil level at the south end of the pond may indicate that the pond has been partly infilled or an original feeder stream blocked.

4.2.2 Sediment and Water Levels

Concrete work, suggesting a spillway or dam, was found at the north end of the pond (see Figure 2).

Sediments have accumulated to a depth of 80-90cm throughout the pond (see Figure 3). Measurements at the margins suggest the pond is very steep sided. Approximately 100 cubic metres of sediment are contained within the existing pond area. Probing indicated that a hard substrate was present below the sediment. Weathered material from the base of the trial holes, and observation of rock exposures in the stream and adjacent building site, suggest that the pond lies directly on the Lower Chalk. Water levels in the pond are therefore likely to be predominantly controlled by the water table.

4.2.3 Vegetation in and around the pond

The pond is dominated by a large crack willow (Salix fragilis) growing a little way back from the east bank (see Figure 2). About half of the pond is shaded by this tree and little vegetation grows beneath it. The east bank also supports a mixture of elder (Sambucus nigra) and crack willow scrub. The west bank is dominated by a mixture of young elms (presumably Ulmus procera), bramble (Rubus fruticosus agg.), great horsetail (Equisetum telmateia), wild angelica (Angelica sylvestris), and lower growing herbaceous vegetation.

In lightly shaded areas bittersweet (Solanum dulcamara, hard rush (Juncus inflexus), reed sweet-grass and reed canary-grass have colonised the pond sediments and bank. Common duckweed (Lemna minor agg.) was observed stranded on the mud suggesting that more surface water had been present earlier in the year. Two young crack willows have colonised the centre of the pond and a fallen crack willow has also rooted in the sediments.

Other common plants associated with damp ground at the pond margin are square-stemmed St. Johns wort (Hypericum tetrapterum), water figwort (Scrophularia auriculata) and great hairy willowherb (Epilobium hirsutum).

A list of plant species recorded in and around the pond is given in Table 1.

4.2.4 Macro-invertebrates of the pond

Sixteen macro-invertebrate taxa were recorded in the pond of which four were members of dipteran families (see Table 2). The most abundant animals in the pond were the marsh snail (Lymnaea palustris) and the hydrophilid water beetle Anacaena limbata. Phantom cranefly larvae (Ptychopteridae) and Asellus aquaticus were also common.

4.2.5 Other observations

A Common Frog (Rana temporaria) was observed close to the pond on 21st October but it seems unlikely that the pond currently provides a breeding site for amphibians.

A Reed Bunting was noted in the vicinity of the pond as were a variety of common scrub/woodland bird species.

4.3 SAUNDERTON FEN

4.3.1 Vegetation

Between the pond and the stream a small wetland area supports 'rich-fen' vegetation, dominated by common reed (Phragmites australis), reed sweet-grass and a shrub willow species most resembling almond willow (Salix triandra) (Meikle, 1984). This area also supports wild angelica, common nettle and water mint (Mentha aquatica).

'Rich-fen' vegetation usually develops where a nearly permanently waterlogged substratum is irrigated by base-rich water in the pH range (6.0)-6.5-7.5 (Wheeler, 1988). Despite its name (which refers to nutrient status) 'rich-fen' may be poor in species.

4.4 SAUNDERTON STREAM

4.4.1 Vegetation

The stream supports dense stands of fools watercress (Apium nodiflorum) with lesser water-parsnip (Berula erecta), yellow flag (Iris pseudacorus), a sedge species (probably Carex riparia), reed sweet-grass and branched bur-reed (Sparganium erectum).

4.4.2 Macro-invertebrates

The stream supported a community of common macro-invertebrate species dominated numerically by Gammarus pulex and larval Simulium angustitarse (see Table 3). Other species observed included Ancylus fluviatilis, Asellus aquaticus, Baetis rhodani and Sericostoma personatum. Amongst marginal vegetation the beetles Agabus sturmi and Anacaena globulus were observed.

The BMWP score for the stream was 55 (number of BMWP taxa = 12; ASPT = 4.5)

No fish were recorded during the stream survey.

4.4.3 Water Chemistry

On 18th October the stream had a pH of 7.73, conductivity of 571 uS/cm and a total alkalinity of 4.32 mM/l.

On two separate occasions (18th October and 21st October) the stream was found to have extremely high concentrations of phosphate phosphorus (measured as soluble reactive phosphorus: 18th October - 10.3 mg/l PO4-P; 21st October - 9.7 mg/l PO4-P). No obvious source of enrichment was apparent in the immediate vicinity of the site.

5. EXISTING CONSERVATION VALUE OF THE SITE

5.1 SAUNDERTON POND

5.1.1 Vegetation

All wetland plants found in and around the pond are common and widespread species. For example, bittersweet and hard rush are amongst the most frequently observed marginal plants of ponds.

The surroundings of the pond support stands of great horsetail which is only locally distributed in England and is usually found in damp, shady areas (Clapham, Tutin and Moore, 1987).

5.1.2 Macro-invertebrates

The pond supports a low diversity macro-invertebrate community composed predominantly of common taxa. The dytiscid water beetle Hydroporus memnonius is not regarded as common (Foster, 1984) although this may be the result of difficulties associated with sampling its preferred habitat, shallow water over leaf litter.

5.2 SAUNDERTON FEN

The vegetation of this area is close to the Angelico-Phragmitetum association of Wheeler (1988). This is the most widespread rich-fen community of lowland England and Wales and is typically poor in plant species.

No rare or local fen plants were found during the survey. Stands of common reed are generally considered to be of value for their associated insect and bird fauna, although the importance of small stands of reeds is difficult to determine.

5.3 SAUNDERTON STREAM

The flora of Saunderton Stream resembles that described by Holmes (1983) as typical of calcareous ditches or small, silted, enriched chalk rivers. Both typically support a small variety of species. None of the plant species were amongst those listed by Palmer and Newbold (1983) as requiring special conservation measures.

The macro-invertebrate species present in the stream were all common. Despite the high concentration of phosphorus in the water one pollution intolerant taxon (Sericostoma personatum) was found.

6. FACTORS REDUCING THE EXISTING AND POTENTIAL CONSERVATION VALUE OF THE SITE

6.1 SAUNDERTON POND

6.1.1 Accumulated sediment

The accumulation of sediment in the pond reduces the diversity of habitats available for macro-invertebrates. This excludes all species which require open water or stands of submerged/floating leaved water plants. Currently the pond has habitats suitable only for detritivores (eg A. aquaticus, Ptychopterid larvae) and other species associated with shallow water, leaf litter and fine sediments (eg Anacaena limbata, Agabus bipustulatus, Hydroporus memnonius).

6.1.2 Shade

Shade cast by marginal shrubs and trees restricts the growth of wetland plants in the pond area. Currently only sparse stands of emergent/marginal plants are present along with shade tolerant species such as bittersweet and common duckweed.

6.1.3 Bank steepness

At present the pond is long and narrow with a potential water depth of about 1m (see Figure 3 for silt depths). If the pond sediments are removed without some modification of the banks the new pond will be very steep sided, significantly reducing its potential conservation value (see Section 7.1).

6.1.4 Water table

If, as suspected, ground water provides the main source of water for the pond, any change in the height of the water table could have a significant effect on water depth in the pond. The construction of houses in the near vicinity of the site could lead to a lowering of the local water table. It is therefore recomended that the drainage programme for the building site is checked with the relevent contractors before dredging of the pond begins.

6.2 SAUNDERTON FEN AND STREAM

6.2.1 Saunderton fen

The main factors reducing the present and potential conservation value of the fen are its small area, encroachment by trees and shrubs, nutrient enrichment and the absence of gentle disturbance caused by grazing or cutting.

Encroachment by trees and shrubs is likely to lead to a reduction in the diversity of plant species in the fen area.

Nutrient enrichment within the fen may promote the growth of reed sweet-grass, a vigorous plant with high nutrient requirements and with the potential to exclude common reed when growing vigorously (Wheeler, 1980a). Nutrient enrichment also increases plant productivity generally, leading to a high standing crop (Wheeler, 1983). The accumulation of litter and competition for light that this causes leads to reductions in plant species diversity in fens (Wheeler, 1988).

Grazing, cutting and other forms of management are an integral part of the maintenance of plant species diversity in fens. They may either prevent domination by single species stands or lead to regular exporting of nutrients.

The site is generally vulnerable to lowering of the water table.

6.2.2 Saunderton stream

The conservation value of the stream may be reduced by the high phosphorus concentrations recorded and by shading from trees and shrubs.

7. MANAGEMENT RECOMMENDATIONS

Refer to Figure 4 throughout this Section.

The aim of pond management will be to increase the diversity of plants and animals found in and around the pond.

7.1 PHYSICAL FEATURES OF POND & SUPPLY OF WATER

7.1.1 Sediment removal

It is recommended that all sediment be removed from the pond except for a small area at the northern end (see Figure 4). This should be retained to provide a refuge for invertebrates associated with existing conditions and to leave an undisturbed area adjacent to the existing stand of great horsetail. These sediments may also provide a source of plant propagules for the pond. Care should be taken to avoid dumping spoil on, or moving heavy machinery over, the stand of great horsetail.

It is assumed that spoil will need to be dumped on site. Dumping at the north and south ends (see Figure 4) should cause minimal damage. At the north end it may be possible to use some of the spoil to create a low bank to further isolate the pond from the road. Spoil should not be tipped in the fen area.

Care should be taken to ensure that excavated sediment cannot wash back into the pond.

There is evidence that the water is maintained in the pond by the water table. However, CARE SHOULD BE TAKEN TO CONFIRM THAT THE POND DOES NOT HAVE A LINING BEFORE OR DURING SEDIMENT REMOVAL.

7.1.2 Enlargment of pond and reducing steepness of banks

Enlargement of the pond is recommended in order to create a large shallow area at the southern end of the pond (see Figure 4). The bank separating the fen and the pond should be reduced to approximately 30cm in height and the extra space obtained used to reduce the slope of the south and west banks.

Excavators should avoid the north east bank and fen area to prevent damage to these areas.

It is recommended that run-off from any building development on the adjacent land is routed away from the pond.

7.2 VEGETATION

7.2.1 Shade control

Trees and shrubs around the pond should be removed, coppiced or pollarded as appropriate (see Figure 4). The large overhanging crack willow should be pollarded to allow light to reach the northern half of the pond and to reduce the quantity of leaf and twig litter entering the pond. There is some danger that this tree may be moribund and that it will not respond to pollarding. It is therefor recommended that specialist advice is sought to determine the risk of the tree being killed by pollarding.

The two small crack willows growing in the pond sediments, and the fallen willow, should be removed. Elder and crack willow scrub on the east bank of the pond should be cut back or cleared to allow light to reach this margin.

It is recommended that some of the elder and willow scrub at the north end of the pond is left intact to maintain shady conditions for great horsetail.

7.2.2 Aquatic vegetation

Following the excavation of sediment and reshaping of the pond it is recommended that some replanting is undertaken in order to establish a diverse plant community in and around the pond.

Only common and widespread water plants, which may be planted without significantly modifying natural distribution patterns, should be introduced to the pond. Table 4 gives a list of suitable species.

Reed sweet-grass and common reed should not be introduced unless it is clear that regular managment work can be undertaken to control these two potentially invasive species. During sediment removal the small clump of hard rush should be moved and later replanted.

Subsequent management of the pond should try to prevent the development of monospecific stands of plants, particularly within the shallow marginal zone (see Section 7.4 (i)).

7.2.3 Replanting shrub vegetation

If the elder and willow scrub on the east of the pond is completely cleared, a wide mixed hedgerow of local native species (such as ash, field maple, hazel, elm, dogwood, hawthorn, blackthorn and wild privet) should be established at the top of the pond bank to replace it.

7.3 ANIMALS

7.3.1 Macro-invertebrates

Renovation and subsequent management of the pond should aim to create a diversity of micro-habitats for macro-invertebrates. The following areas should be created if possible:

(i) Marginal zone (water depth 0-20cm).

In this area isolated clumps of larger emergent species (eg branched bur-reed, common reedmace) should be maintained in a mosaic of lower growing emergent species (eg common water plantain, water mint) and floating leaved/submerged species (eg flote grass, water crowfoots, ivy-leaved duckweed.

This zone presents a wide variety of habitats for macro-invertebrates. It is especially important for water beetles but also supports a variety of other species. The zone may occupy as much as half the total surface area of the pond. Selective removal of larger emergent plants may be required to prevent complete encroachment.

(ii) Submerged/floating leaved plant zone (20-100cm)

This is a deeper water zone with stands of floating leaved and submerged water plants (eg spiked water-milfoil, stoneworts, broad-leaved pondweed).

This zone is important for larval damselflies, larval caddis flies and other species. The areas of open water between clumps of plants are required by Notonecta spp. and corixids. Some water beetles (eg Haliplidae, Hyphydrus ovatus) also require submerged plant stands.

(iii) Decaying wood

Logs cut from ash (NOT WILLOW, which may take root) should be anchored in shallow water to provide oviposition sites for dragonflies like Aeshna grandis. Submerged wood also provides shelter and hard surfaces for leeches, flatworms and molluscs.

(vi) Leaf litter

An area of leaf litter/sediment flooded by shallow water is to be retained. Areas of sediment will provide a food source for detritivores such as A. aquaticus and some chironomid larvae.

7.3.2 Amphibians

The development of a range of habitats for macro-invertebrates can be assumed to create conditions suitable for amphibians.

Frogs favour areas of open, shallow water for spawning. Dense growths of submerged plants seem to be favoured by smooth newts (Triturus

vulgaris) whilst great crested newts (Triturus cristatus) require areas of open water between submerged plant stands. The vegetation management proposed would create suitable conditions for smooth newts and, if present in the area, great crested newts. Marginal areas of the pond uncolonised by vegetation are likely to be suitable for spawning frogs.

Toads are commonly found in larger water bodies (often those with fish which feed on the larvae of other species) and may be less likely to colonise a small pond such as Saunderton.

7.3.3 Fish

Fish should not be introduced to Saunderton Pond. Larval newts and frogs will be reduced in abundance by the presence of fish in a small pond.

7.4 SAUNDERTON FEN AND STREAM

The aim of fen and stream management will be to maintain or increase the existing diversity of plant and animal species.

Shading trees and shrubs should be removed as shown in Figure 4. To prevent encroachment of scrub into the fen some of the almond willow scrub should be removed.

Some nutrients may be removed from the site during clearing of woody plants but this process is likely to be very slow. It is recommended that small areas of reed sweet-grass should be cut annually in an attempt to increase plant species richness and promote colonisation of low growing fen vegetation.

There does not appear to be any immediate need to remove vegetation colonising the stream bed (unless this is required for flood control purposes). Floods may lead to this vegetation being scoured naturally.

In the light of the high phosphorus concentrations recorded during this survey it is recommended that Thames Water make further observations on stream water quality.

7.5 FOLLOW-UP

It is recommemded that a brief survey of the pond is made twelve months after renovation to monitor progress. The survey should investigate recolonisation by water plants, establishment of introduced species, establishment of macro-invertebrate communities and use of the site by amphibians.

7.6 MANAGEMENT AFTER RENOVATION

It is recommeded that, following renovation, some regular maintenance is done on the pond and fen. The main requirements will be the control of emergent vegetation and coppicing or removal of shrubs and trees. It is anticipated that this would involve approximatly 1 'man' day per year.

This work might be done by arrangement with local residents through the Parish Council or by arrangement with BBONT, the BTCV or Pond Action. If a management plan is required for the Site it is recommended that this is provided by Pond Action.

TABLE 1. PLANTS RECORDED IN SAUNDERTON POND AND SURROUNDINGS

Principal 'rich fen' species (Wheeler, 1988) highlighted.

Pond

Equisetum telmatiea	Great horsetail
Hypericum tetrapterum	**Square-stemmed St. Johns wort**
Epilobium hirsutum	**Great hairy willow-herb**
Angelica sylvestris	**Wild Angelica**
Scrophularia auriculata	**Water Figwort**
Lemna minor	Common Duckweed
Hard Rush	Juncus inflexus
Glyceria maxima	**Reed Sweet-grass**
Phalaris arundinacea	Reed canary grass
Hedera helix	Ivy
Acer campestre	Field Maple
Ulmus procera	Elm
Salix fragilis	Crack Willow
Crataegus monogyna	Common Hawthorn
Rosa canina agg.	Dog Rose
Rubus fruiticosus agg.	Bramble
Geum urbanum	Wood Avens
Urtica dioica	Stinging Nettle
Heracleum sphondylium	Hogweed
Solanum dulcamara	Bittersweet
Stachys sylvatica	Hedge Woundwort
Glechoma hederacea	Ground Ivy
Galium aparine	Cleavers
Cirsium arvense	Creeping Thistle
Carduus acanthoides	Welted Thistle
Sambucus nigra	Elder
Bromus sterilis	Barren brome

Stream and Fen

Equisetum telmatia	Great horsetail
Epilobium hirsutum	**Great Hairy Willowherb**
Fraxinus excelsior	Ash
Salix diandra	Almond Willow
Salix fragilis	Crack Willow
Angelica sylvestris	**Wild Angelica**
Apium nodiflorum	Fools Watercress
Berula erecta	**Lesser Water Parsnip**
Mentha aquatica	**Water Mint**
Myosotis sp.	
Iris pseudacorus	**Yellow Flag**
Carex sp.	(probably Greater Pond Sedge)
Phragmites australis	**Common Reed**
Glyceria maxima	**Reed Sweet-grass**

TABLE 2. Macro-invertebrates recorded in Saunderton Pond

TAXON	ABUNDANCE CATEGORY
SNAILS (MOLLUSCA)	
Lymnaea palustris	4
Potamopyrgus jenkinsi	1
OLIGOCHAETA	3
WATER SHRIMPS & SLATERS (CRUSTACEA:MALACOSTRACA)	
Asellus aquaticus	3
Crangonyx pseudogracilis	1
WATER BEETLES (COLEOPTERA)	
Agabus bipustulatus	2
Anacaena limbata	4
Hydrobius fuscipes	1
Hydroporus palustris	1
Hydroporus memnonius	1
Laccobius minutus	1
CADDIS FLIES (TRICHOPTERA)	
Limnephilus lunatus	1
TRUE FLIES (DIPTERA)	
Ptychopteridae	3
Chironomidae	1
Psychodidae	2
Tipulidae	2

Abundance Categories: 1 = 1-9; 2 = 10-25; 3 = 26-99; 4 = 100-600; 5 = >600

TABLE 3. Macro-invertebrates recorded in stream at Saunderton Pumping Station.

TAXON	ABUNDANCE CATEGORY
FLATWORMS (TRICLADIDA)	
Dendrocoelum lacteum	1
Polycelis felina	1
HYDRACARINA	1
SNAILS (MOLLUSCA)	
Ancylus fluviatilis	1
Lymnaea peregra	1
Lymnaea palustris	1
OLIGOCHAETA	1
WATER SHRIMPS & SLATERS (CRUSTACEA:MALACOSTRACA)	
Gammarus pulex	5
Asellus aquaticus	1
MAYFLIES (EPHEMEROPTERA)	
Baetis rhodani	1
WATER BEETLES (COLEOPTERA)	
Agabus sturmi	1
Helodidae (larvae)	1
CADDIS FLIES (TRICHOPTERA)	
Sericostoma personatum	1
TRUE FLIES (DIPTERA)	
Ptychopteridae	1
Simulium angustitarse	3
Dixidae	1
Chironomidae	1

Abundance Categories: 1 = 1-9; 2 = 10-25; 3 = 26-99; 4 = 100-600; 5 = >600

TABLE 4. WETLAND PLANTS SUITABLE FOR PLANTING IN SAUNDERTON POND

Species present on or near the site are highlighted.

MARGINALS/EMERGENTS

Marsh horsetail (Equisetum palustre)
Water horsetail (E. fluviatilis)
Lesser spearwort (Ranunculus flammula)
Watercress (Nasturtium officianale)
Gipsywort (Lycopus europaeus)
Fool's watercress
Lesser water-parsnip
Water mint
Water forget-me-not (Myosotis scorpioides)
Common water plantain (Alisma plantago-aquatica)
Yellow flag
Branched bur-reed
Hard rush
Soft rush (Juncus effusus)
Common spike-rush (Eleocharis palustris)
Common reedmace (Typha latifolia) (present in moat upstream)
Sedges: Carex riparia; C. acutiformis;
Reed canary grass

SUBMERGED/FLOATING-LEAVED

Ivy-leaved duckweed (Lemna trisulca)
Common starwort (Callitriche stagnalis)
Amphibious bistort (Polygonum amphibium)
Broad-leaved pondweed (Potamogeton natans)
Water crowfoots: R. aquatilis, R. trichophyllus, R. peltatus
Spiked water-milfoil (Myriophyllum spicatum)
Flote-grass (Glyceria fluitans, G. plicata).

REFERENCES

Clapham, A. R., Tutin, T. G. and Moore, D. M. (1987). Flora of the British Isles. Cambridge University Press, Cambridge.

Holmes, N. T. H. (1983). Typing British rivers according to their flora. Nature Conservancy Council.

Foster, G. (1984). Atlas of British water beetles - preliminary edition. The Balfour-Browne Club Newsletter 31.

Meikle, R. D. (1984). Willows and poplars of Great Britain and Ireland. Botanical Society of the British Isles, London.

Palmer, M. and Newbold, C. (1983). Wetland and Riparian Plants of Great Britain. Nature Conservancy Council.

Wheeler, B. D. (1980a). Plant communities of rich-fen systems in England and Wales. 1. Introduction, tall sedge and reed communities. Journal of Ecology, 68, 365-395.

Wheeler, B. D. (1983). Vegetation, nutrients and agricultural land use in a north Buckinghamshire valley fen. Journal of Ecology, 71, 529-544.

Wheeler, B. D. (1988). Species richness, species rarity and conservation evaluation of rich-fen vegetation in lowland England and Wales. Journal of Applied Ecology, 25, 331-353.