Survey of ponds at Stow Bedon

Fuel Allotment

A report for the Freshwater Habitats Trust

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Fenland Botanical surveys

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Summary

Stow Bedon Fuel Allotment is part of Stow Bedon Common, a landscape containing numerous natural ponds formed in the late Ice Age by freezing and thawing of upwelling ground water. Such ponds are referred to as pingos or palsa-scars and are a characteristic feature of the Breckland Commons of West Norfolk. Neighbouring Thompson Common is famous for the rich biodiversity of its pingos, but the wildlife interest of the ponds on Stow Bedon Common is much less well-recorded.

In spring/summer 2016, 16 ponds on Stow Bedon Fuel Allotment were surveyed for wetland plants and aquatic macro-invertebrates using National Pond Survey methodology. One further pond was sampled briefly in early October. Nine of these ponds were also evaluated using PSYM, the recognised methodology for monitoring the ecological quality of permanent or semi-permanent ponds. Eight of these were categorised as being of high ecological quality. All pingo/palsa-scar ponds are classed as Priority Ponds and are therefore Habitats of Principal Importance as defined under Section 41 of the Natural Environment and Rural Communities Act; eleven of the sixteen ponds surveyed also qualified as Priority Ponds under other criteria such as the presence of rare species or their exceptionally diverse plant or invertebrate assemblages.

Although not as rich as neighbouring Thompson Common, the site produced an impressive list of aquatic invertebrates including several 'relict fen' rarities which are restricted to ancient wetlands. Red List (Vulnerable) species included the diving beetle *Hydroporus glabruisculus* and the scavenger water beetle *Hydrochus brevis*; Near Threatened species included Variable Damselfly *Coenagrion pulchellum*, the diving beetles *Dytiscus dimidiatus* and *Laccornis oblongus*, the scavenger water beetles *Hydrochus crenatus* and *Enochrus nigritus*, and the moss beetles *Hydraena palustris* and *Limnebius aluta*; Nationally Scarce species included the Mud Snail *Omphiscola glabra*, the caddis-fly *Trichostegia minor*, the moss bug *Hebrus pusillus*, the burrowing water beetle *Noterus crassicornis*, the diving beetles *Hydaticus seminiger*, *Hydroporus neglectus* and *Hygrotus decoratus*, and the scavenger water beetle *Helochares punctatus.* The Fuel Allotment probably supports the most important population of Mud Snail in Norfolk.

Seven wetland plant species of conservation concern were recorded (Fringed Heartwort, Tufted Sedge, Water Violet, Tubular Water-dropwort, Lesser Spearwort, Ragged Robin and Marsh Valerian). There are also plants which are scarce in Breckland such as Soft Hornwort, Greater Duckweed and Greater Bladderwort. Vertebrates were only noted casually but Great Crested Newt was recorded from one pond and Water Vole from two.

Analysis of the survey data indicates a strong negative correlation between shading and key biodiversity indicators (e.g. number of wetland plant or invertebrate species recorded, or number of species of conservation concern). This confirms findings from Thompson Common and provides support for the excellent work being done by the Trustees of the Fuel Allotment Charity to reduce shading of selected pingos. However, shaded, seasonal pools towards the northern edge of the Common are a valuable habitat for Mud Snail and should be retained in their current condition. The data suggests that larger ponds on the Allotment are richer in biodiversity, so resources should be focussed on these water bodies.

An important difference between Thompson Common and Stow Bedon Common is the lack of extensive mossy margins at Stow Bedon. These are a key habitat for rare pingo invertebrates. If the

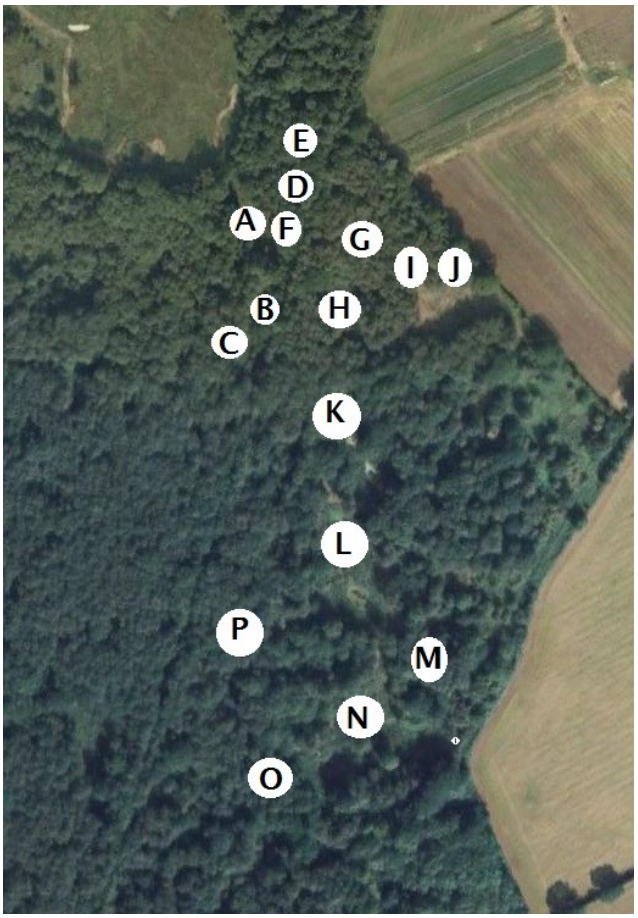
ponds east of the Pingo Trail could be grazed by cattle, this could encourage the development of mossy edge vegetation.

As Stow Bedon Fuel Allotment is not accessible to the public, it is recommended that consideration be given to opening up one or more ponds adjoining the Great Eastern Pingo Trail to increase public appreciation of these unique ponds.

1. Introduction

Stow Bedon Common is situated in the Norfolk Breckland, 15 km north-east of Thetford (national grid reference TL 939 958). A key feature of the Common is the abundance of natural ponds known as pingos or, more accurately, palsa-scars. These were formed by the freezing and thawing of upwelling ground-water under tundra-like conditions at the end of the last glaciation[1].

The palsa-scar ponds on neighbouring Thompson Common have long been known to support extraordinary assemblages of plants and invertebrates but Stow Bedon Common has been much less well-recorded. 'Pingo' systems are of exceptional importance for the conservation of wetland biodiversity because they contain high densities of ponds, often within a matrix of semi-natural grassland, fen and woodland. However, it is the longevity of these ponds which makes them unique: many of the rarer species, especially amongst the wetland beetles, are closely associated with wetlands of prehistoric origin.



This survey covered the northern portion of the Common known as Stow Bedon Fuel Allotment, an area still owned and managed by the Trustees of the Fuel Allotment Charity established at the time of Enclosure. This contains around 32 ponds with several others overlapping ownership boundaries. Sixteen ponds were selected for survey, and were chosen to encompass the range of pond types on the site, e.g. seasonal pools in deep shade, shallow ponds dominated by reed fen and larger permanent water bodies. The approximate location of the ponds surveyed is shown in Figure 1.

Figure 1: indicative location of the ponds surveyed

[1] Briffa & Atkinson (1997) state that pingos in England and Wales formed during the Younger Dryas period, 11,300 to 10,300 years ago, when mean annual temperatures were -5 to -2°C.

2. Methodology

2.1 Invertebrate, plant and environmental surveys

The survey methodology was adapted from the National Pond Survey (NPS) (Pond Action, 1998). At each pond, aquatic invertebrates were sampled for three minutes[2] using a long-handled net with a 1 mm mesh bag, with effort divided equally between each of the meso-habitats present (e.g. floating-leaved vegetation, tall reedswamp, moss fringe). A further minute was spent collecting invertebrates from the surface film or submerged debris. The standard NPS method requires that samples are sorted in the laboratory. However, because Stow Bedon Common was expected to support important populations of rare species, samples were sorted in a white polythene tray on the bankside, to avoid removing large numbers of individuals. Species were either identified in the field or preserved for identification at a later date. Macro-invertebrates were identified to species level with the exception of flatworms, pea mussels and midge larvae.

The botanical survey involved a careful examination of each pond, using a grapnel or pond net to collect submerged plants where necessary. Wetland vascular plants listed on the NPS pro-forma were recorded along with charophytes and bryophytes. Some material was collected for microscopic examination. Standard NPS environmental variables were recorded for each pond.

3.2 Additional recording

As 'pingos' support a rich invertebrate fauna associated with pond edges, some additional sampling was undertaken in this habitat, with material kept in separate tubes. This additional collecting was not time-limited. A small amount of bottle-trapping was also employed, as this is a useful technique for capturing large diving beetles which often escape detection in hand-netting surveys. Ponds B, C and K were bottle trapped in late April with two baited traps left overnight in each pond.

3.3 Survey timing

The invertebrate samples were collected and environmental data recorded by Martin Hammond on 25th to 29th April 2016. Sampling was therefore earlier than the normal period for NPS surveys (June to August) but was timed to coincide with the peak spring emergence period for adult water beetles associated with seasonal ponds: Foster (1993) noted that, "The pingo [water beetle] fauna is dominated by early spring breeding species adapted to life in pools that are dry in summer". The botanical survey was undertaken by Jonathan Graham on 10th June 2016.

Three ponds were sampled for invertebrates on 12th October 2016: C, K and an additional small pond coded 'Q' which was not investigated in the earlier survey.

[2] NB: The three minutes are the active netting time, not the total time expended on the survey.

3.4 Species identification

Most invertebrate identification was undertaken by Martin Hammond but Professor Garth Foster kindly identified a small number of specimens.

3.5 PSYM evaluation

In addition to recording their plants and aquatic invertebrates, the overall ecological quality of the Stow Bedon Fuel Allotment ponds was assessed using PSYM (**P**redictive **Sy**stem for **M**ultimetrics), (Environment Agency, 2002). PSYM uses six 'metrics' (measurements) representing important indicators of ecological quality and can be based on survey data obtained using the more detailed NPS methodology. The three botanical metrics are:

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

The three invertebrate family-level metrics are:

- Average Score Per Taxon (ASPT, an estimation of biological water quality based on the sensitivity of different invertebrate families to organic enrichment)
- diversity of dragonfly, damselfly and alderfly families[3]
- diversity of water beetle families

Environmental data obtained for each pond include: surface area, altitude, grid reference, water pH, presence/absence of inflows, substrate composition, degree of shade, accessibility to livestock and cover of emergent vegetation.

The results are analysed using software which compares the observed data with values predicted from a large reference dataset of undegraded ponds. PSYM predicts how a high quality pond with similar attributes *should* score for each metric, and compares the predictions with the survey results. The scores for each metric are combined to produce an Index of Biotic Integrity (IBI) which provides an overall indication of the ecological quality of the pond. Ponds are then categorised as Very Poor, Poor, Medium and Good.

The PSYM methodology canot be used to assess highly seasonal pingos because these ponds are not represented in the PSYM database. In the current survey, seven ponds were excluded from analysis because they fell into this category (Ponds D, E, F, I, J, N & O). In addition, the results for one metric, Trophic Ranking Score, were adjusted for some pingos. In contrast to most metrics which have a linear relationship with degradation (i.e. the higher the metric score the lower the degradation, or vice versa), Tropic Ranking Score has a U-shaped relationship: observed values that are significantly higher than expected suggest degradation from nutrient enrichment, observed values that are significantly lower usually

[3] As no alderflies were recorded in the survey, this metric is referred to simply as diversity of Odonata families.

suggest degradation through acidification, particularly in base-poor areas of the north and west of the UK. In the current analysis some pingos had TRS scores that were significantly lower than predicted but in lowland England, rather than indicating acidification, this is indicative of exceptionally high quality plant communities with species that are typically lost from more eutrophicated landscapes. In short, some pingos were less nutrient-enriched than some sites in PSYM's semi-natural baseline dataset. Where pingo TRS scores were lower than predicted, the PSYM score was therefore adjusted upwards to indicate minimal impact from nutrients.

3. The survey ponds

Although the Norfolk Wildlife Trust has mapped pingos using GIS, the data for Stow Bedon Common appears to be less reliable than for Thompson Common with several ponds not shown on either OS base maps or the NWT pingo map. In order to identify ponds so that they can be monitored in future, readings were made using a hand-held GPS and relevant landmarks noted.

Pond A (TL 93918 96056)

This is a sprawling pingo with a convoluted outline, extending from the western edge of the Great Eastern Pingo Trail into the oak-birch woodland bordering Thompson Common NWT reserve. The more open area is dominated by Tufted Sedge *Carex elata* swamp with some grass-mats and patches of Water Violet *Hottonia palustris*. More fen-meadow plants were recorded from Pond A than any other water body surveyed, e.g. Tubular Water-dropwort *Oenanthe fistulosa*, Fen Bedstraw *Galium uliginosum*, Marsh Valerian *Valeriana dioica* and Glaucous Sedge *Carex flacca*. This element of the pingo flora is much more poorly represented on Stow Bedon Common than on Thompson Common.

Twenty aquatic macro-invertebrate taxa were identified from the sample, none of these being species of conservation concern. Twenty-nine wetland plant species were recorded; species of conservation concern included Tufted Sedge, Water Violet, Tubular Water-dropwort and Marsh Valerian.

PSYM assessment gave Pond A an Index of Biotic Integrity of 83%, placing it within the top (**Good**) category of ecological quality. It scored well for all three botanical metrics. It scored highly for ASPT (biological water quality) and representation of water beetle families but

produced a null score for damselfly, dragonfly and alderfly families. The lack of Odonata in the PSYM sample reflects the very shallow and partly seasonal nature of the pond.

Pond B (TL 93851 96036)

This largely unshaded, circular pond on the western side of the Pingo Trail is fringed by tussocks of Tufted Sedge with open water in the centre. Eighteen wetland plant species were recorded, Tufted Sedge being the only one of conservation concern. The uncommon feather-moss *Brachythecium salebrosum* was found on litter between sedge tussocks.

Fifty aquatic macro-invertebrate taxa were identified from the sample with one extra obtained by bottle-trapping. Species of conservation concern included the diving beetles *Dytiscus dimidiatus*, *Hydaticus seminiger*, *Hydroporus glabriusculus, H. neglectus* and *Hygrotus decoratus*; the scavenger water beetles *Hydrochus brevis* and *H. crenatus*; and the moss beetle *Limnebius aluta*.

PSYM assessment gave Pond B an Index of Biotic Integrity of 89%, placing it within the top (**Good**) category of ecological quality. It scored well for diversity of emergent and submerged plants but only moderately for representation of uncommon wetland plants and Trophic Ranking. It scored highly for all three invertebrate metrics.

Pond C (TL 93843 96020)

This mid-sized pingo is located 110 metres from the boundary with Thompson Common NWT reserve, on the western side of the Great Eastern Pingo Trail. About a quarter of the pond is shaded by overhanging trees and shrubs. The heavily-vegetated eastern half contains several previously-coppiced sallow stumps amongst Tufted Sedge swamp with small stands of Great Fen Sedge *Cladium mariscus* and a discrete area of *Sphagnum* (mainly *S. subnitens*). In more open water to the west, there are extensive submerged stands of Delicate Stonewort *Chara virgata* with Fire-moss *Fontinalis antipyretica* occurring more locally.

This pond is rich botanically with forty wetland plant species were recorded; species of conservation concern included Tufted Sedge and Water Violet. The uncommon Orange Foxtail *Alopecurus aequalis* is also of note.

Sixty-seven aquatic macro-invertebrate taxa were identified (48 from the PSYM sample), making this the most species-rich pond in the survey for invertebrates. Species of conservation concern included the moss bug *Hebrus pusillus*; the burrowing water beetle *Noterus crassicornis*; the diving beetles *Hydaticus seminiger*, *Hydroporus neglectus, Laccornis oblongus* and *Hygrotus decoratus*; the scavenger water beetle *Hydrochus crenatus*; the moss beetles *Hydraena palustris* and *Limnebius aluta*; and the caddis-fly *Trichostegia minor*.

PSYM assessment gave Pond C an Index of Biotic Integrity of 89%, placing it within the top (**Good**) category of ecological quality. It scored highly for all metrics except representation of Odonata, which was poor.

Pond D (TL 93898 96116)

This heavily-shaded, seasonal pool is small and elongate. It is situated within acidic woodland on the western side of the Pingo Trail. Vegetation is limited to trailing mats of Rough Meadow-grass *Poa trivialis* and it has deep deposits of soft detritus. A row of fence posts runs through it. Thirteen aquatic invertebrate taxa were recorded, none of which were of conservation concern. Only three wetland plant species were present, Tufted Sedge being a species of conservation concern. Due to its seasonal character, Pond D was unsuitable for PSYM assessment.

Pond E (TL 93870 96150)

This is another elongate, deeply-shaded woodland pool, close to Pond D. It has little vegetation except a limited fringe of trailing grass but contains some fallen timber. The invertebrate fauna was dominated by mosquito larvae (Culicidae). Only nine aquatic invertebrate taxa were recorded, none of which were species of conservation concern. Seven wetland plants were present including Tufted Sedge. Due to its seasonal character, Pond E was unsuitable for PSYM assessment.

Pond F (TL 93865 96096)

This small, very shallow temporary pool adjoins the disused railway track. It contains a small area of trailing grass and sparse shoots of Common Reed *Phragmites australis*. As with other deeply-shaded pools, mosquito larvae were the most abundant invertebrates. Thirteen aquatic invertebrate taxa were recorded, the only species of conservation concern being the diving beetle *Hydaticus seminiger*. Just two wetland plant species were found.

Due to its seasonal character, Pond F was unsuitable for PSYM assessment.

Pond G (TL 93923 96081)

This is an ill-defined reed-filled hollow within the gated area on the eastern side of the Pingo Trail. Much of it is only seasonal wet, with patches of ankle-deep water amongst the reed litter at the time of the survey; there is an area of shaded open water beneath the tree canopy at its north-eastern end. A small marshy area with rushes and Water Mint *Mentha aquatica* is located on the northern margin (TL 93939 96086), 38 metres from the edge of the Common; several Mud Snails *Omphiscola glabra* were found here.

Eighteen aquatic invertebrate taxa included three species of conservation concern: Mud Snail and the diving beetles *Hydroporus neglectus* and *Laccornis oblongus*. Nineteen wetland plants included two species of conservation concern: Tufted Sedge and Ragged Robin *Silene flos-cucculi*.

PSYM assessment gave Pond G an Index of Biotic Integrity of 72%. This is borderline between Moderate and Good ecological quality. It scored highly for diversity of wetland plants and Trophic Ranking but only moderately for representation of uncommon species. It scored moderately for biological water quality (ASPT) and well for representation of water beetle families but no Odonata or alderflies were present in the PSYM sample. As with several other pingos in this survey, this reflects the shallow and partly seasonal character of the pond.

Pond H (TL 93927 96047)

This pingo is similar to Pond G, being dominated by seasonally-wet Common Reed swamp. A small area of Purple Moor-grass *Molinia caerulea* tussocks and Spiky bog-moss *Sphagnum squarrosum* occurs on the pond margin at TL 93904 96081, suggesting more acidic conditions. A small gulley contiguous with the edge of the pond at TL 93924 96035 produced a few Mud Snails.

Twenty-eight aquatic invertebrate taxa were recorded. Species of conservation concern included Mud Snail; the diving beetles *Hydaticus seminiger* and *Laccornis oblongus*; and the moss beetle *Limnebius aluta*. Twenty-three wetland plant species were identified, the only one of conservation significance being Tufted Sedge.

PSYM assessment gave Pond H an Index of Biotic Integrity of 78%, placing it within the top (**Good**) category of ecological quality. It scored highly for all three botanical metrics and for biological water quality (ASPT). Representation of water beetle families was lower than predicted and no Odonata or Megaloptera were present in the PSYM sample. The lower invertebrate scores for this pond reflect its very shallow and partly seasonal character and the extent of reedswamp.

Pond I (TL 93955 96064)

Ponds I and J are seasonal pools shaded by overhanging sallows near the northern edge of the Common, both containing collapsed/sprawling boughs. There are modest patches of trailing grasses. Twelve wetland plants included a small amount of Tufted Sedge.

Thirteen aquatic invertebrate taxa were recorded. The only species of conservation concern was Mud Snail, which has a significant population in this pond (10+ live specimens were netted in the sample).

Ponds I and J were not suitable for PSYM assessment due to their strongly seasonal character.

Pond J (TL 93978 96064)

This pond is only 17 metres from the northern boundary of the Fuel Allotment. It has a fringe of grass-mats and a few stunted tussocks of Tufted Sedge. Only eight aquatic invertebrate taxa were recorded but the sample did include two specimens of Mud Snail. Eight wetland plant species were noted.

Pond K (TL 93891 95961)

This large, sinuous pingo contains varied habitats including an extensive area of Common Reed swamp but also open water at either end. There are also stands of Tufted Sedge swamp, some low marginal vegetation with modest amounts of moss and submerged vegetation including Fine-leaved Water-dropwort *Oenanthe aquatica*, Greater Bladderwort *Utricularia vulgaris* and Soft Hornwort *Ceratophyllum submersum*.

This is a botanically rich pond with 34 wetland plant species recorded. Plants of conservation concern included Tufted Sedge and Fringed Heartwort *Ricciocarpos natans* (a floating liverwort). Other uncommon plants included Soft Hornwort, Orange Foxtail and Greater Duckweed *Spirodela polyrhiza*.

Sixty-two aquatic macro-invertebrate taxa were recorded (50 in the PSYM sample), making this the second richest pond for invertebrates. Species of conservation concern included Variable Damselfly; the diving beetles *Dytiscus dimidiatus*, *Hydaticus seminiger* and *Hygrotus decoratus*; the scavenger water beetles *Hydrochus crenatus* and *Helochares punctatus*; and the moss beetle *Limnebius aluta*.

PSYM assessment gave Pond K an Index of Biotic Integrity of 89%, placing it within the top (**Good**) category of ecological quality. It scored highly for all metrics except for representation of Odonata and Megaloptera, which was poor.

Pond L (TL 93913 95853)

This relatively large permanent pond has a seasonal connection to Pond K at its northern end. Tufted Sedge dominates the shallow margins but there are also grass-mats and a limited amount of Bottle Sedge *Carex rostrata*.

Fifty-one aquatic invertebrate taxa were recorded (44 in the PSYM sample), making this another very species-rich pond. Species of conservation concern included the diving beetle *Hydaticus seminiger*; the scavenger water beetles *Hydrochus crenatus*, *Helochares punctatus* and *Enochrus nigritus*; and the moss beetle *Limnebius aluta*. Thirty-one wetland plant species included Tufted Sedge, Water Violet and Fringed Heartwort.

PSYM assessment gave Pond L an Index of Biotic Integrity of 94%, placing it within the top (**Good**) category of ecological quality. **This was the highest overall score out of the nine ponds suitable for evaluation using PSYM**. It scored highly for all metrics except for representation of Odonata and Megaloptera, which was moderate.

Pond M (TL 93948 95811)

A shaded, seasonal pool with seasonal connectivity to other pingos at either end. Pond M yielded only five aquatic invertebrate taxa and vegetation is limited to fringing grass-mats. Seven wetland plants included Tufted Sedge. Due to its temporary character, this pond was unsuitable for assessment using PSYM.

Pond N (TL 93927 95753)

This is a convoluted pingo largely dominated by Common Reed swamp but with two areas of permanent open water; at its western end, the open water is fringed by Tufted Sedge swamp and small areas of trailing grass-mat vegetation. Thirty-one aquatic invertebrate taxa were recorded, including a single specimen of Mud Snail. Twenty-nine wetland plant species were observed, with Tufted Sedge, Water Violet being species of conservation significance. Also of note were Orange Foxtail, Greater Bladderwort and Soft Hornwort.

PSYM assessment gave Pond N an Index of Biotic Integrity of 89%, placing it within the top (**Good**) category of ecological quality. It scored highly for all metrics, except for representation of Odonata and Megaloptera, which was poor.

Pond O (TL 93879 95729)

This is a circular, heavily shaded pool within mature birch woodland. An upended birch rootplate forms an island in the centre colonised by small amounts of Spiky Bog-moss. Ten aquatic invertebrate taxa were recorded, none of which were species of conservation concern. Only four widespread wetland plant species were noted.

Due to its seasonal nature, Pond O was unsuitable for evaluation using PSYM.

Pond P (TL 93866 95825)

Trees around this rather elongate, permanent pond had recently been felled. Tufted Sedge swamp is well-developed around the margins, with more of a litter layer than in the other ponds surveyed. There is a small stand of Greater Reedmace *Typha latifolia* in the centre. A small patch of Flat-topped Bog-moss *Sphagnum fallax* and Blunt-leaved Bog-moss *S. palustre* occurs on the western bank at TL 93861 95817.

Thirty-seven aquatic invertebrate taxa were recorded. Species of conservation concern included Mud Snail; the diving beetles *Hydaticus seminiger*, *Hydroporus neglectus* and *Hygrotus decoratus*; the scavenger water beetles *Hydrochus crenatus* and *Enochrus nigritus*; the moss beetle *Limnebius aluta*; and the caddis-fly *Trichostegia minor*. Fourteen wetland

plants were observed; Tufted Sedge and Lesser Spearwort *Ranunculus flammula* were the only species of conservation concern but Soft Hornwort and Greater Bladderwort were also of interest.

PSYM assessment gave Pond P an Index of Biotic Integrity of 89%, placing it within the top (**Good**) category of ecological quality. It scored moderately for wetland plant diversity but highly for representation of uncommon plants and Trophic Ranking Score. It scored highly for biological water quality and representation of water beetle families, and moderately for representation of Odonata.

Pond Q (TL938958)

This small pond is in a modest opening on the western side of the Pingo Trail. It was sampled briefly on 12th October 2016, too late in the season to evaluate using PSYM. It contains deep leaf litter and was almost dry at the time; several tussocks of Tufted Sedge *Carex elata* grow around the margin with a small grass mat in the centre.

Twenty two aquatic macro-invertebrate taxa were recorded, including the diving beetles *Hydroporus neglectus* and *Hygrotus decoratus*; the scavenger water beetle *Hydrochus crenatus*; and the moss beetle *Limnebius aluta*.

4. Results

A summary of the project findings is given below. Full species records for each site are available in spreadsheet format.

4.1 Environmental variables

Water pH and electrical conductivity (a measure of solute content) were measured for each pond. Samples for 11 of the 15 ponds were also tested for nitrate (NO_{-3}) and soluble reactive phosphate (PO_4-P). Results are shown in Table 1.

Site	pH	conductivity (µS/cm^{-1})	nitrate (mg/l)	SR phosphate (mg/l)	grid ref	area (m^2)
Pond A	7.6	401	<0.2	<0.02	TL9385496082	620
Pond B	7.8	364	<0.2	<0.02	TL9385196036	171
Pond C	7.7	320	<0.2	<0.02	TL9384396020	320
Pond D	7.29	610	-	-	TL9339896116	112
Pond E	6.67	440	0	0	TL9387096150	120
Pond F	7.59	490	-	-	TL9386596096	30
Pond G	6.89	210	-	-	TL9392396081	300
Pond H	6.92	370	0	0.02	TL9392496035	209
Pond I	7.1	200	0	<0.02	TL9395596064	60
Pond J	6.35	190	0	<0.02	TL9398396075	84
Pond K	7.49	590	-	-	TL9392895940	1000
Pond L	7.68	640	-	-	TL9392295880	420

Pond M	7.29	680	<0.2	<0.02	TL9396195807	168
Pond N	7.67	490	<0.2	0.02	TL9394495749	514
Pond O	7.12	690	0	<0.02	TL9387995729	176
Pond P	6.74	420	<0.2	<0.02	TL9384995794	632

Table 1: physico-chemical data for ponds A to P

Water pH varied from 6.35 to 7.8 with a mean of 7.24. This is a similar range to the data for 41 ponds on Thompson Common sampled in 2014. Electrical conductivity ranged from 190 to 690 µS/cm^{-1} with a mean of 444. This was a lower mean value than for the Thompson Common ponds (574) and suggests that conditions are somewhat poorer in dissolved minerals. The conductivity values are also commensurate with ponds which are not impacted by pollution, which is borne out by the consistently low nutrient measurements.

Pond size (surface area when full) ranged from 30 to 1,000 m². Pond substrate was consistently recorded as clay/silt, with no well-defined peat layer observed although several shaded ponds contained much organic detritus. All ponds are located at an elevation of around 42 metres AOD.

4.2 Vertebrates

Amphibians and Water Voles were recorded casually during the invertebrate survey with no special effort made to search for these. No fish were found. Amphibian records are summarised in Table 2.

Pond	Smooth Newt	Great Crested Newt	Common Toad
A	1♂ adult		
H	3♀ adults		
K	4 adults		
L	5 adults	1♀ adult	
N	1♂ adult		Small numbers of tadpoles

Table 2: amphibian records

A Water Vole latrine was found in Pond H. Water Vole latrines and burrows were also found amongst large Tufted Sedge tussocks at the edge of Pond L.

4.3 Invertebrates

The survey produced 500 records of 128 aquatic macro-invertebrate taxa. The vast majority were identified to species level with the exceptions of: fly larvae (Diptera) and flatworms (Turbellaria), which were mostly recorded to Family level; oligochaete worms which were recorded only as a Class; and pea-mussels which were recorded only as *Pisidium* sp. This follows standard NPS procedure.

Figure 2 shows the composition of the species list by Order: water beetles make up by far the largest group of taxa identified to species level (69 species or 57% of the total) with water bugs (Hemiptera),

gastropod molluscs, caddis (Trichoptera) and damselflies & dragonflies (Odonata) making much smaller but significant contributions[4].

A list of the invertebrate taxa recorded is provided in Appendix 2.

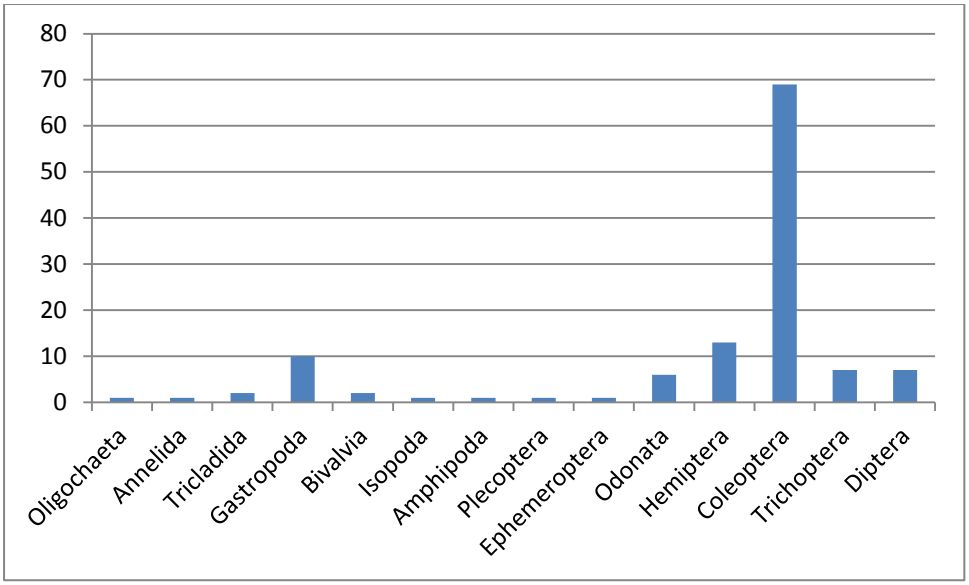


Figure 2: composition of the aquatic macro-invertebrate fauna recorded from 16 ponds on Stow Bedon Fuel Allotment in April 2016. Bars show the number of taxa recorded.

4.4 Wetland plants

A total of 74 wetland plant species were recorded during the survey (i.e. species listed on the PSYM/NPS recording form plus wetland bryophytes and one stonewort (see Appendix 3). Alongside seven species of conservation concern, there were significant populations of several uncommon plants including Great Fen Sedge (three ponds), Orange Foxtail (four ponds), Greater Bladderwort (also four ponds) and Soft Hornwort (three ponds). The moss *Brachythecium salebrosum* (Pond B) does not have a conservation designation but is considered scarce; it is not an exclusively wetland species and is likely to be under-recorded.

The only alien plant species detected was Least Duckweed *Lemna minuta*, in Pond H.

4.5 Priority Pond status

Priority Ponds are defined as the best ca. 20% of ponds in England and Wales based on a range of criteria[5]. These were originally developed for the UK Biodiversity Action Plan but Priority Ponds are recognised as a Habitat of Principal Importance for conservation under Section 41 of the Natural Environment & Rural Communities Act 2006. As natural ponds formed through geological processes, all pingo/palsa-scar ponds automatically qualify as

[4] It should be noted that aquatic Diptera (fly) larvae are likely to be very diverse in these ponds but are less amenable to sampling in pond-netting surveys as most live within the silt.
[5] See http://freshwaterhabitats.org.uk/projects/pond-hap/priority-pond-criteria/

Priority Ponds. However, 12 of the 17 ponds surveyed on Stow Bedon Fuel Allotment also qualify under at least one other criterion (Table 3). The ponds which do not qualify (D, E, F, M and O) are small, heavily shaded seasonal pools supporting poor vegetation structure.

Pond	A	B	C	G	H	I	J	K	L	N	P	Q
PSYM Good ecological quality	✓	✓	✓		✓			✓	✓	✓	✓	
UKBAP species/Species of Principal Importance: TWD = Tubular Water Dropwort, MS = Mud Snail. GCN = Great Crested Newt	TWD			MS	MS	MS	MS		GCN	MS	MS	
1 or more Nationally Scarce plants (Rn = *Ricciocarpos natans*, Fringed Heartwort)								Rn	Rn			
1 or more Red List invertebrates		2										
3 or more Nationally Scarce invertebrate species[6]		6	8	3	4			6	5		8	4
30 or more wetland plant species			40					34	31	31		
50 or more aquatic invertebrate species		50	67					62	51			

Table 3: Ponds meeting Priority Pond criteria

6. Species of conservation concern

6.1 Invertebrates

MOLLUSCA

Omphiscola glabra (Lymnaeidae), Mud Snail

GB status: Nationally Scarce; NERC Act Section 41 Species of Principal Importance

IUCN global status: Near Threatened

A distinctively elongate pond snail, closely associated with pools and pond margins in agriculturally-unimproved habitats, typically on historic Commons. This species has declined seriously, though significant populations persist in a few regions such as the New Forest and Humberhead Levels/Vale of York. There are post-1999 records from 47 hectads in Great Britain (Seddon *et al.*, 2014). Kerney (1999) mapped TL99 as the only modern (post-1964) East Anglian hectad record; this grid square includes Stow Bedon and Thompson Commons.

Its remnant distribution implies that Mud Snail is much more sedentary than most of the Lymnaeidae. It avoids water bodies supporting a rich variety of aquatic molluscs, preferring those which dry out in summer or are poor in nutrients (e.g. Kerney, 1999) though the oft-repeated claim that this is a calcifuge species is misleading.

Stow Bedon Fuel Allotment supports large and important populations of Mud Snail, in contrast to Thompson Common where it was only found in one

[6] Several invertebrates are categorised as Near Threatened, a higher conservation status than Nationally Scarce but which was not in use when the Priority Pond criteria were developed.

out of 41 ponds surveyed in 2014. It was present in small, discrete marshy areas at the edges of the reed-filled hollows in Ponds G & H; in grass mats in shaded, seasonal conditions in Ponds I & J; in marginal vegetation in Pond N; and amongst sedge litter around tussocks in Pond P. Large numbers of individuals were encountered in Ponds I and P. All populations included live snails rather than old, empty shells.

ODONATA

Coenagrion pulchellum (Coenagrionidae), Variable Damselfly

GB status: Near Threatened

This scarce 'blue' damselfly has localised populations concentrated in: East Anglia; Fenland; the grazing levels of south-east England, Somerset and Gwent; the Cheshire Plain; and south-west Scotland. Variable Damselfly appears to have declined significantly in recent decades (Dauget *et al.*, 2008). It is well-known species of Thompson Common but it is unclear if it has been recorded previously from Stow Bedon: during this survey three larvae were identified from Pond K based on the shape of the caudal lamellae compared with Azure Damselfly *C. puella* larvae in the same sample.

HEMIPTERA

Hebrus pusillus (Hebridae), a moss bug

GB status: Nationally Scarce

This tiny bug runs amongst mossy vegetation at the water's edge. It occurs very locally in Norfolk, southern England and north-west Wales, variously inhabiting heathland pools, flushes on coastal slopes, dune slack ponds and coastal grazing-marsh ditches (Huxley, 2003). It appears to have declined historically, including in Norfolk (Kirby, 1992). *Hebrus pusillus* has long been known from Thompson Common (Irwin, 1987). During this survey, specimens were collected from Pond C in October 2016.

COLEOPTERA

Noterus crassicornis (Noteridae), a burrowing water beetle

GB status: Nationally Scarce

This small, brown, bullet-shaped beetle has a very patchy, 'semi-relict' distribution associated with lowland fenland areas. Its principal centres are the coastal grazing levels of south-east England; East Anglia; the Trent Valley and Humberhead Levels; the Cheshire Plain and Anglesey. *Noterus crassicornis* is flightless, having markedly reduced wings, and is probably a good indicator of historic (though sometimes highly modified) wetland landscapes. This species occurs both in primary wetlands (such as natural meres and pingos) and in secondary habitats such as ditches, ponds and borrow-pits on drained fenland. It was recorded only from Pond C during this survey.

Dytiscus dimidiatus (Dytiscidae), a great diving beetle

GB status: Near Threatened

Britain's largest diving beetle, this species occurs in ponds and drains in lowland fenland areas. It is now largely restricted to the Cambridgeshire Fens, Norfolk, the Somerset Levels and the coastal grazing marshes of Sussex and Kent. Although *D. dimidiatus* has disappeared from the north of its former range, it has increased in some southern areas including in Kent and West Norfolk. It was first detected at Thompson Common in 2001 (Foster & Friday, 2011). During this survey, specimens were bottle trapped from Ponds C and K.

Hydaticus seminiger (Dytiscidae), a diving beetle

GB status: Nationally Scarce

This large diving beetle occurs in richly-vegetated ponds, mainly in East Anglia, the Home Counties, Dorset and the Cheshire Plain. It is widespread on Stow Bedon Fuel Allotment, with records from eight ponds (50% of those surveyed). *Hydaticus semininger* was sometimes found in well-shaded situations.

Hydroporus dorsalis and ***figuratus***, (Dytiscidae), diving beetles

The small diving beetle formerly known as *Suphrodytes dorsalis* has recently been recognised as comprising two distinct species, distinguishable by both morphological and genetic characters (Bergsten *et al.*, 2012; Foster & Friday, 2011). Phylogenetic studies have also shown that the complex belongs within the genus *Hydroporus* (Bergsten *et al.*, 2013). Both species inhabit ponds shaded by trees or tall emergent vegetation.

The distribution of the two species is as yet poorly understood but initial findings suggest that *H. figuratus* is widespread in lowland England whilst *H. dorsalis* has a more restricted, southern distribution. Both are found on Stow Bedon Common: *H. dorsalis* was collected from Ponds C & H, and *H. figuratus* from Pond K.

Hydroporus glabriusculus (Dytiscidae), a diving beetle

GB status: Vulnerable

A small, dark-coloured beetle found in pools surrounded by tussocks or mats of mossy vegetation in relict fens (Foster & Friday, 2011). Its population centres are in the Scottish Border Mires and the palsa-scar fens of the Brecks with a small handful of sites in East Norfolk. Although it is unclear whether *H. glabriusculus* is capable of flight (Bilton, 1994a), genetic studies suggest that it persists for very long periods in self-contained colonies which have little interchange with neighbouring populations (Bilton, 1994b). The Norfolk populations of this beetle show a closer genetic relationship to Swedish populations than to

Scottish ones (Bilton, 1994b), suggesting a possible post-glacial colonisation route similar to that of Norfolk Pool Frogs (Snell *et al.*, 2005). During this survey, a specimen was collected from Pond B.

Hygrotus decoratus (Dytiscidae), a diving beetle

GB status: Nationally Scarce

This small but attractively-marked diving beetle occurs very locally in fen pools and pond margins from North Yorkshire southwards. During this survey, *H. decoratus* was collected from five ponds (B, C, K, P & Q), a lower rate of occupancy than found on Thompson Common in 2014 (29% compared to 63%). This reflects the lower availability of richly vegetated, mossy water margins on Stow Bedon Common.

Laccornis oblongus (Dytiscidae), a diving beetle

GB status: Near Threatened

An important indicator of relict fens albeit capable of persisting in small, isolated sites (Foster, 1983 & 2010). *Laccornis oblongus* has a, very fragmented distribution in Britain as a whole, with strongholds in the Scottish Border Mires and the East Anglian fens. During this survey, *L. oblongus* was collected from three ponds (C, G & H), a lower rate of occupancy than found on Thompson Common in 2014 (19% compared to 39%). This probably reflects the scarcity of mossy margins on Stow Bedon Common.

Hydrochus brevis (Hydrochidae), a scavenger water beetle

GB status: Near Threatened

This species has a wide but extremely fragmented distribution in old fens, with strong populations largely confined to Broadland and Breckland (Foster, 2010). A single specimen of *Hydrochus brevis* was collected from Pond B. It is more frequent on Thompson Common.

Hydrochus crenatus (Hydrochidae), a scavenger water beetle

GB status: Near Threatened

A small, slender hydrophilid, virtually confined to fenland habitats in East Anglia and the counties around the Wash. Despite its very restricted distribution, *Hydrochus crenatus* can occur in secondary habitats including clay pits and the reedy margins of arable ditches. During this survey, *H. crenatus* was collected from six ponds (B, C, K, G, P & Q), a lower rate of occupancy than found on Thompson Common in 2014 (35% compared to 51%).

Helochares punctatus (Hydrophilidae), a scavenger water beetle

GB status: Nationally Scarce

Although listed as Nationally Scarce by Foster (2010), *H. punctatus* is a localised rather than rare beetle, mostly associated with acidic bog-pools at low to moderate elevations but sometimes occurring in base-rich ponds. It was recorded from Ponds K & L.

Enochrus nigritus (Hydrophilidae), a scavenger water beetle

GB status: Near Threatened

Occurring in "mesotrophic and base-rich fen, most often in relict sites", *E. nigritus* is known in England from scattered sites between Hampshire and Cheshire, and also on Anglesey (Foster *et al.*, 2014). During this survey, it was identified from Ponds L & P, a lower rate of occupancy than found on Thompson Common in 2014 (12.5% of ponds compared to 41%).

Hydraena palustris (Hydraenidae), a moss beetle

GB status: Near Threatened

A very small beetle restricted to ancient fens in Cambidgeshire and East Anglia with an outlying site in East Yorkshire, though subfossil records indicate that *H. palustris* was once much more widespread. Two specimens were collected from Pond C.

Limnebius aluta (Hydraenidae), a moss beetle

GB status: Near Threatened

Britain's smallest Hydraenid, *L. aluta* occurs in silty water margins in old fen habitats. During this survey, it was collected from seven ponds (B, C, H, K, L, P & Q), a higher rate of occupancy than found on Thompson Common in 2014 (41% compared to 27%). At some locations it was observed in large numbers (e.g. 100+ at Pond K) and Stow Bedon Fuel Allotment is clearly an important location for this species.

DIPTERA

Odontomyia tigrina (Stratiomyidae), Black Colonel soldierfly

GB status: Nationally Scarce

A species of richly-vegetated pond and ditch margins, predominantly in southern Britain. A larva was collected from Pond C; another species of *Odontomyia* larva was collected from Pond L but could not be keyed out. The status of *O. tigrina* is due to be downgraded in a forthcoming review.

TRICHOPTERA

Trichostegia minor (Phryganeidae), a cased cadds-fly

GB status: Nationally Scarce

A local caddis of pools rich in leaf litter which dry out in summer. It has been recorded from 98 ten km squares in Britain since 1980 (Wallace, in prep), so only narrowly qualifies for Nationally Scarce status. Larvae were collected from Ponds C and P.

6.2 Plants

Plants of conservation concern considered here include vascular plants meriting Red List[7] or Near Threatened status in England (Stroh *et al.*, 2014[8]) and Nationally Scarce bryophytes (as per Preston, 2006). No vascular plants or charophytes listed as Nationally Rare or Nationally Scarce in Great Britain were recorded.

A number of other species are scarce in a regional context. For example, Trist (1979) recorded Soft Hornwort from only two sites in Breckland, neither in TL99, and he had no records of Greater Duckweed, though he referred to one published in 1968 for grid square TL78.

Carex elata, Tufted Sedge

English status: Near Threatened

This tussock-forming sedge is associated with fluctuating water margins in base-rich fens. Its British distribution is centred on the belt of former fenland extending from East Anglia to the Vale of York with outlying centres in the Lake District, the Cheshire Plain and Anglesey. Its range (Extent of Occurrence) in England contracted by 29% during the second half of the 20th century.

Tufted Sedge is one of the most characteristic plants of the Breckland palsa-scar ponds, in both shaded and open habitats, and forms an important structural component of their vegetation. It was recorded from all ponds except F & O (88% of the ponds surveyed, similar to 90% of 41 ponds surveyed on Thompson Common in 2014).

Hottonia palustris, Water Violet

English status: Vulnerable

A widespread but local and declining plant in eastern England, Water Violet tolerates considerable shade and persisted in many pingos when their surrounds became wooded during the 20th century. It is less frequent on Stow Bedon Fuel Allotment than on neighbouring Thompson Common but was nonetheless recorded from four ponds during this survey.

Oenanthe fistulosa, Tubular Water-dropwort

English status: Vulnerable; NERC Act Section 41 Species of Principal Importance

[7] **Red List** species are those categorised as Regionally Extinct, Critically Endangered, Endangered or Vulnerable in relevant inventories. **Near Threatened** plants are mainly those undergoing significant declines in distribution which are not yet at risk but liable to become so if present trends continue.

[8] The recently-published vascular plant Red List for England provides a more relevant basis for conservation assessment than previous inventories covering the whole of Great Britain as many species which have stable populations in Scotland are threatened in lowland England.

A widespread but seriously declining umbellifer of pond and ditch margins, fens and wet grassland, Tubular Water-dropwort was found only in Pond A.

***Ranunculus flammula*, Lesser Spearwort**

English status: Vulnerable

Although still widespread and locally common, Lesser Spearwort underwent a 32% decline in distribution in England during the latter half of the last century (Stroh *et al.*, 2014). It was found only in Pond P during this survey, compared to 18 locations (45% of ponds surveyed) on Thompson Common in 2014, which reflects the lack of grazed fen-meadow around the Fuel Allotment pingos.

***Ricciocarpus natans*, Fringed Heartwort**

GB status: Nationally Scarce

This distinctive floating liverwort has a restricted distribution in base-rich, lowland waters, mainly in eastern England. Thalli were recorded from Ponds K & L. The weevil *Tanysphyrus ater* feeds on this liverwort and was recorded as new to Britain from Thompson Common in 2011 (Duff, 2014); although not found during this survey, it would be worth searching for on Stow Bedon Fuel Allotment.

***Silene flos-cucculi*, Ragged Robin**

English status: Near Threatened

A familiar plant of wet meadows and water margins, recorded from Pond G. Ragged Robin underwent a 25% decline in distribution in England during the late 20th century (Stroh *et al.*, 2014).

***Valeriana dioica*, Marsh Valerian**

English status: Near Threatened

This small herb of base-rich flushes and fen-meadows declined by 25% in the second half of the last century. At Thompson Common, it is a locally-frequent species in fen-meadow vegetation in the flushed margins of pond basins, but on Stow Bedon Fuel Allotment it was found only in Pond A.

7. Implications for conservation management

Stow Bedon Common was predominantly open grazing in the mid 19th century with only scattered trees and bushes, as shown on the first edition OS 6" map (extract below). At this time permanent open water seems to have been no more extensive than now, with most pingos mapped as marshy hollows. RAF aerial photography from 1946 also shows an open landscape dotted with pingos (Figure 3), confirming that most tree cover on the Fuel Allotment has developed since World War 2 (Childs, 2010).

Extract from the first edition Ordnance Survey 6" map, ca. 1850

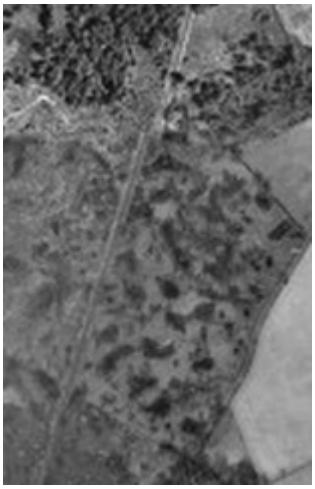


Figure 3: Aerial photograph of Stow Bedon Fuel Allotment from 1946

As on Thompson Common, this survey has shown that while some species tolerate shaded conditions, the ponds support no distinct fen-carr flora or fauna. The lack of any distinct fen-carr water beetle assemblage is particularly noteworthy. For example, the absence of the relict fen-carr specialist *Agabus striolatus* from Breckland pingo sites was alluded to by Foster (1993): this Vulnerable species has its British 'headquarters' in the East Norfolk Broadland and its absence from Breckland almost certainly reflects the fact that wet woodland has, historically, been scarce and discontinuous in this region.

The survey data[9] show that shading has a negative effect on the botanical and invertebrate richness of ponds on the Fuel Allotment. There is a very strong negative correlation between shade (percentage of the pond directly overhung by trees/shrubs) and the number of invertebrate taxa recorded in the PSYM sample (Pearson's coefficient r = -0.86); the same applies to the correlation between shade and the number of invertebrate species of conservation concern (r = -0.77). There was also a marked negative correlation between shade and number of wetland plant species (r = -0.69), although the shade tolerance of Tufted Sedge meant the correlation between shade and number of plant species of conservation concern was less pronounced (r = -0.48).

This supports the Fuel Allotment trustees' programme of tree clearance and corroborates the conclusion by Dolman *et al.* (2010) that,

> "Open standing water, littoral margins and open fen habitats are vitally important to Breckland biodiversity and support many more priority species than shaded wetland habitats (e.g. damp/wet woodland)".

The same authors recommend that "Scrub and woodland should be largely removed from fen and wetland sites" on the Breckland commons: the results of the present survey support this approach.

However, it should be noted that significant populations of Mud Snail occur in shaded pools near the northern edge of the site (e.g. Ponds I & J). Since Stow Bedon Common may well be the regional stronghold for this seriously declining species, it would be advisable to retain these ponds in their current state. Few other molluscs tolerate such conditions, so these ponds could potentially be valuable as a refuge from competition.

Simple correlation coefficients indicate a moderately strong positive relationship between pond area and biodiversity indicators (Table 4). This may not be straightforward since larger ponds may possess other attributes favouring plant and invertebrate diversity (e.g. greater diversity of meso-habitats), but it does suggest that conservation effort would probably be most efficiently targeted on larger water bodies.

Variables	**coefficient for Pearson's *r***
Pond area: number of invertebrate taxa in PSYM sample	0.61
Pond area: number of invertebrate species of conservation concern	0.46
Pond area: number of wetland plant species	0.57
Pond area: number of wetland plant species of conservation concern	0.53

Table 4: correlation coefficients for pond area and key biodiversity variables

[9] analysis based on Ponds A to P

Mossy pingo edges have long been recognised as one of the most important habitat features for rare invertebrates on the Breckland commons (e.g. Irwin, 1987). A striking contrast between Thompson Common and Stow Bedon Fuel Allotment is the lack of extensive mossy margins to the Stow Bedon pingos. This may relate to environmental conditions but lack of grazing on Stow Bedon Common is likely to be a major factor. Consideration should be given to extending the eastern grazing unit on Thompson Common NWT reserve to incorporate Ponds A, B and C on the west side of the Pingo Trail in order to encourage the development of short, mossy vegetation.

As Stow Bedon Fuel Allotment is not accessible to the public, it is recommended that consideration be given to opening up one or more ponds adjoining the Great Eastern Pingo Trail to increase public appreciation of these unique ponds.

8. References

Bilton, D.T. (1994a). The flight apparatus and flying ability of *Hydroporus glabriusculus* (Coleoptera, Dytiscidae), with a brief review of structural modifications in flightless beetles. *Entomologisk Tidsskrift,* **115** (1-2): 23-32.

Bilton, D.T. (1994b). Phylogeography and recent historical biogeography of *Hydroporus glabriusculus* Aubé (Coleoptera: Dytiscidae) in the British Isles and Scandinavia. *Biological Journal of the Linnean Society*, **51:** 293–307.

Briffa, K. & Atkinson, T. (1997). Reconstructing late-glacial and Holocene climates. Pp 84-111 *in* Hulme, M. & Barrow, E. (eds). *Climate of the British Isles: past and future*. Routledge: London.

Childs, P. (2010). *Stow Bedon Fuel Allotment Charity: a short history*. Accessed on Stow Bedon & Breckles Parish Council website[10].

Cook, A.A. (2015). *A review of the Hemiptera of Great Britain: the aquatic and semi-aquatic bugs*. Species Status No. 24. Natural England.

Daguet, C.A., French, G.C. & Taylor, P. (2008). *The Odonata Red Data List for Great Britain*. *Species Status* **11**: 1-34. Joint Nature Conservation Committee: Peterborough.

Dolman, P.M., Panter, C.J. & Mossman, H.L. (2010) *Securing Biodiversity in Breckland: Guidance for Conservation and Research. First Report of the Breckland Biodiversity Audit.* University of East Anglia: Norwich.

[10] http://www.parish-council.com/StowBedon/documents/

Duff, A.G. (2014). *Tanysphyrus ater* Blatchley, 1928 (Erirhinidae) new to the British Isles. *The Coleopterist*, **23** (2): 49-50.

Environment Agency (2002). *A guide to monitoring the ecological quality of ponds and canals using PSYM.* Version 2. Environment Agency Midlands Region: Solihull.

Falk, S. (1991). *A review of the scarce and threatened flies of Great Britain. Part 1*. Research & Survey in Nature Conservation no. 39. Joint Nature Conservation Committee: Peterborough.

Foster, G. N. (1983). Atlas of British water beetles: preliminary edition, Part 2. *Balfour-Browne Club Newsletter* **27**: 1-20.

Foster, G.N. (1987). Wetland Coleoptera. Page 377 *in* Irwin (1987).

Foster, G. N. (1993). Pingo fens, water beetles and site evaluation. *Antenna*, **174**: 184-195.

Foster, G.N. (2010). *A review of the scarce and threatened Coleoptera of Great Britain, Part 3: water beetles of Great Britain*. Joint Nature Conservation Committee: Peterborough.

Foster, G.N., Bilton, D.T. & Friday, L.E. (2014). *Keys to adults of the water beetles of Britain and Ireland (Part 2)*. Handbooks for the Identification of British Insects, **4** (5b). Royal Entomological Society: London.

Foster, G.N. & Friday, L.E. (2011). *Keys to adults of the water beetles of Britain and Ireland (Part 1)*. Handbooks for the Identification of British Insects, **4** (5). Royal Entomological Society: London.

Huxley, T. (2003). *Provisional atlas of the British aquatic bugs (Hemiptera, Heteroptera)*. Biological Record Centre: Huntingdon.

Irwin, A.G. (1987). The fauna of Thompson Common. *Transactions of the Norfolk & Norwich Naturalists' Society*, **27** (5): 375-380.

Kirby, P. (1992). *A review of the scarce and threatened Hemiptera of Great Britain*. UK Nature Conservation No. 2. Joint Nature Conservation Committee: Peterborough.

Pond Action (1998). A Guide to the Methods of the National Pond Survey. Pond Action: Oxford.

Preston, C.D. (2006). A revised list of nationally scarce bryophytes. *Field Bryology* **90**, 22–30.

Preston, C.D., Pearman, D.A. & Dines, T.D. (eds) (2002). *New atlas of the British and Irish Flora*. Oxford University Press: Oxford.

Seddon, M.B., Killeen, I.J. & Fowles, A.P. (2014). *A review of the non-marine Mollusca of Great Britain*. Species Status No. 17. NRW Evidence Report 14. Natural Resources Wales: Bangor.

Snell, C., Tetteh, J. & Evans, I.H. (2005). Phylogeography of the pool frog (*Rana lessonae* Camerano) in Europe: evidence for native status in Great Britain and for an unusual postglacial colonization route. *Biological Journal of the Linnean Society*, **85**: 41–51.

Stroh, P.A., Leach, S.J., August, T.A., Walker, K.J., Pearman, D.A., Rumsey, F.J., Harrower, C.A., Fay, M.F., Martin, J.P., Pankhurst, T., Preston, C.D. & Taylor, I. (2014). *A vascular plant Red List for England*. Botanical Society of Britain and Ireland: Bristol.

Trist, P.J.O. (ed) (1979). *An ecological flora of Breckland*. EP Publishing Ltd: Wakefield.

Wallace, I.D. (in prep.) *A review of the status of the caddis flies (Trichoptera) of Great Britain*. Species Status Review for Natural England (draft version, September 2015).

APPENDIX 1: PSYM DATA

Site name	Pond A	Pond B	Pond C	Pond G	Pond H	Pond K	Pond L	Pond N	Pond P
Survey date	10-Jun-16	10-Jun-16	10-Jun-16	10-Jun-16	10-Jun-16	10-Jun-16	10-Jun-16	10-Jun-16	10-Jun-16
Grid reference	TL 938 960	TL 938 960	TL 938 960	TL 939 960	TL 939 960	TL 939 959	TL 939 958	TL 939 957	TL 938 957
Plant metrics									
No. of submerged + marginal plant species (not including floating leaved)	27	14	31	15	15	25	26	25	11
Number of uncommon plant species	8	2	11	2	3	13	11	12	4
Trophic Ranking Score (TRS)	8.26	9.26	8.16	8.76	7.64	8.47	8.51	8.40	7.86
Invertebrates metrics									
ASPT	5.38	4.95	4.78	4.30	5.11	4.70	4.80	4.81	5.07
Odonata + Megaloptera families	0	3	1	0	0	1	2	1	2
Coleoptera families	3	5	3	3	2	4	4	3	4
Environmental variables									
Altitude (m)	42	42	42	42	42	42	42	42	42
Shade (%)	30	3	25	15	25	3	2	10	5
Inflow (0/1)	0	0	0	0	0	0	0	0	0
Grazing (%)	0	0	0	0	0	0	0	0	0
pH	7.6	7.8	7.7	6.89	6.92	7.49	7.68	7.67	6.74
Emergent plant cover (%)	40	30	50	80	90	60	40	70	35
Base clay (1-3)	3	3	3	3	3	3	3	3	3
Base sand, gravel (1-3)	1	1	1	1	1	1	1	1	1
Base peat (1-3)	1	1	1	1	1	1	1	1	1
Base rock (1-3)	1	1	1	1	1	1	1	1	1
Area (m^2)	620	364	320	300	209	1000	420	514	632
Results									
Submerged + marginal plant species									
Predicted (SM)	19.6	17.4	17.3	17.0	15.9	21.0	17.8	18.6	19.4
Actual (SM)	27	14	31	15	15	25	26	25	11
EQI (SM)	1.38	0.81	1.80	0.88	0.94	1.19	1.46	1.34	0.57
IBI (SM)	3	3	3	3	3	3	3	3	2
Uncommon plant species									
Predicted (U)	3.4	2.9	3.0	2.9	2.8	3.5	3.0	3.1	3.3
Actual (U)	8	2	11	2	3	13	11	12	4
EQI (U)	2.34	0.69	3.70	0.68	1.08	3.71	3.72	3.82	1.20
IBI (U)	3	2	3	2	3	3	3	3	3

Trophic Ranking Score (TRS)									
Predicted (TRS)	8.74	8.74	8.73	8.70	8.72	8.74	8.74	8.74	8.65
Actual (TRS)	8.26	9.26	8.16	8.76	7.64	8.47	8.51	8.40	7.86
EQI (TRS)	0.95	1.06	0.93	1.01	0.88	0.97	0.97	0.96	0.91
IBI (TRS)	3	2	3	3	3	3	3	3	3
ASPT									
Predicted (ASPT)	5.11	5.08	5.11	5.11	5.10	5.10	5.08	5.10	5.09
Actual (ASPT)	5.38	4.95	4.78	4.30	5.11	4.70	4.80	4.81	5.07
EQI (ASPT)	1.05	0.97	0.94	0.84	1.00	0.92	0.94	0.94	1.00
IBI (ASPT)	3	3	3	2	3	3	3	3	3
Odonata + Megaloptera (OM) families									
Predicted (OM)	3.34	3.14	3.38	3.41	3.47	3.17	3.15	3.29	3.16
Actual (OM)	0	3	1	0	0	1	2	1	2
EQI (OM)	0.00	0.96	0.30	0.00	0.00	0.32	0.63	0.30	0.63
IBI (OM)	0	3	1	0	0	1	2	1	2
Coleoptera families									
Predicted (CO)	3.75	3.74	3.75	3.75	3.75	3.75	3.74	3.75	3.74
Actual (CO)	3	5	3	3	2	4	4	3	4
EQI (CO)	0.80	1.34	0.80	0.80	0.53	1.07	1.07	0.80	1.07
IBI (CO)	3	3	3	3	2	3	3	3	3
Sum of Individual Metrics	15	16	16	13	14	16	17	16	16
Index of Biotic Integrity (%)	**83%**	**89%**	**89%**	**72%**	**78%**	**89%**	**94%**	**89%**	**89%**
PSYM quality category (IBI >75%=Good, 51-75%= Moderate, 25-50%=Poor, <25%=V Poor)	**Good**	**Good**	**Good**	**Moderate**	**Moderate**	**Good**	**Good**	**Good**	**Good**
Is this a Priority Pond? (Good quality category)	**Yes**	**Yes**	**Yes**	**No**	**No**	**Yes**	**Yes**	**Yes**	**Yes**

APPENDIX 2: AQUATIC MACRO-INVERTEBRATES RECORDED FROM STOW BEDON COMMON, APRIL & OCTOBER 2016

TAXON	ENGISH NAME	FAMILY	ORDER	GB STATUS
Oligochaeta	worms	Oligochaeta	Oligochaeta	
Erpobdella testacea	a leech	Erpobdellidae	Annelida	
Polycelis sp.	a flatworm	Planariidae	Tricladida	
Dendrocoelum lacteum	a flatworm	Dendrocoelidae	Tricladida	
Bithynia tentaculata	Common Bithynia	Bithyniidae	Gastropoda	
Radix balthica	Wandering Snail	Lymnaeidae	Gastropoda	
Stagnicola palustris agg.	Marsh Pond Snail	Lymnaeidae	Gastropoda	
Lymnaea stagnalis	Greater Pond Snail	Lymnaeidae	Gastropoda	
Galba truncatula	Dwarf Pond Snail	Lymnaeidae	Gastropoda	
Omphiscola glabra	Mud Snail	Lymnaeidae	Gastropoda	NS, SPI
Bathyomphalus contortus	Twisted Ramshorn	Planorbidae	Gastropoda	
Gyraulus crista	Nautilus Ramshorn	Planorbidae	Gastropoda	
Planorbis planorbis	a ramshorn snail	Planorbidae	Gastropoda	
Anisus leucostoma	ramshorn snail	Planorbidae	Gastropoda	
Acroloxus lacustris	Lake Limpet	Acroloxidae	Gastropoda	
Musculium lacustre	Lake Orb Mussel	Sphaeriidae	Bivalvia	
Pisidium sp.	a pea-mussel	Sphaeriidae	Bivalvia	
Asellus aquaticus	Water Hoglouse	Asellidae	Isopoda	
Crangonyx pseudogracilis	an amphipod shrimp	Crangonyctidae	Amphipoda	
Nemoura cinerea	a stonefly larva	Nemouridae	Plecoptera	
Cloeon dipterum	Pond Olive larvae	Baetidae	Ephemeroptera	
Coenagrion puella	Azure Damselfly	Coenagrionidae	Odonata	
Coenagrion pulchellum	Variable Damselfly	Coenagrionidae	Odonata	NT
Ischnura elegans	Blue-tailed Damselfly	Coenagrionidae	Odonata	
Pyrrhosoma nymphula	Large Red Damselfly	Coenagrionidae	Odonata	
Orthetrum cancellatum	Broad-bodied Chaser	Libellulidae	Odonata	
Brachytron pratense	Hairy Dragonfly	Aeshnidae	Odonata	
Aeshna cyanea	Southern Hawker	Aeshnidae	Odonata	
Aeshna grandis	Brown Hawker	Aeshnidae	Odonata	
Anax imperator	Emperor Dragonfly	Aeshnidae	Odonata	
Nepa cinerea	Water Scorpion	Nepidae	Hemiptera	
Corixa punctata	a lesser water-boatman	Corixidae	Hemiptera	
Hesperocorixa linnaei	a lesser water-boatman	Corixidae	Hemiptera	
Hesperocorixa moesta	a lesser water-boatman	Corixidae	Hemiptera	
Hesperocorixa sahlbergi	a lesser water-boatman	Corixidae	Hemiptera	
Notonecta glauca	Common Backswimmer	Notonectidae	Hemiptera	
Plea minutissima	Pygmy Backswimmer	Pleidae	Hemiptera	

Ilyocoris cimicoides	Saucer Bug	Naucoridae	Hemiptera	
Gerris argentatus	Little Pond-skater	Gerridae	Hemiptera	
Gerris lacustris	Common Pond-skater	Gerridae	Hemiptera	
Gerris lateralis	a pond-skater	Gerridae	Hemiptera	
Gerris odontogaster	Toothed Pondskater	Gerridae	Hemiptera	
Microvelia reticulata	a pygmy water-cricket	Veliidae	Hemiptera	
Hebrus pusillus	a Sphagnum bug	Hebridae	Hemiptera	NS
Hydrometra stagnorum	Water-measurer	Hydrometridae	Hemiptera	
Gyrinus substriatus	Common Whirligig	Gyrinidae	Coleoptera	
Haliplus ruficollis	an algivorous water beetle	Haliplidae	Coleoptera	
Haliplus obliquus	an algivorous water beetle	Haliplidae	Coleoptera	
Noterus clavicornis	a burrowing water beetle	Noteridae	Coleoptera	
Noterus crassicornis	a burrowing water beetle	Noteridae	Coleoptera	NS
Agabus bipustulatus	a diving beetle	Dytiscidae	Coleoptera	
Agabus sturmii	a diving beetle	Dytiscidae	Coleoptera	
Agabus unguicularis	a diving beetle	Dytiscidae	Coleoptera	
Ilybius ater	a diving beetle	Dytiscidae	Coleoptera	
Ilybius guttiger	a diving beetle	Dytiscidae	Coleoptera	
Ilybius montanus	a diving beetle	Dytiscidae	Coleoptera	
Ilybius quadriguttatus	a diving beetle	Dytiscidae	Coleoptera	
Rhantus exsoletus	a diving beetle	Dytiscidae	Coleoptera	
Rhantus grapii	a diving beetle	Dytiscidae	Coleoptera	
Liopterus haemorrhoidalis	a diving beetle	Dytiscidae	Coleoptera	
Colymbetes fuscus	a diving beetle	Dytiscidae	Coleoptera	
Hydaticus seminiger	a diving beetle	Dytiscidae	Coleoptera	NS
Acilius sucatus	a diving beetle	Dytiscidae	Coleoptera	
Dytiscus dimidiatus	a great diving beetle	Dytiscidae	Coleoptera	NT
Dytiscus marginalis	a diving beetle	Dytiscidae	Coleoptera	
Dytiscus semisulcatus	a great diving beetle	Dytiscidae	Coleoptera	
Hydroporus angustatus	a diving beetle	Dytiscidae	Coleoptera	
Hydroporus dorsalis	a diving beetle	Dytiscidae	Coleoptera	
Hydroporus erythrocephalus	a diving beetle	Dytiscidae	Coleoptera	
Hydroporus figuratus	a diving beetle	Dytiscidae	Coleoptera	
Hydroporus glabriusculus	a diving beetle	Dytiscidae	Coleoptera	VU
Hydroporus gyllenhalii	a diving beetle	Dytiscidae	Coleoptera	
Hydroporus incognitus	a diving beetle	Dytiscidae	Coleoptera	
Hydroporus memnonius	a diving beetle	Dytiscidae	Coleoptera	
Hydroporus neglectus	a diving beetle	Dytiscidae	Coleoptera	NS
Hydroporus palustris	a diving beetle	Dytiscidae	Coleoptera	
Hydroporus striola	a diving beetle	Dytiscidae	Coleoptera	
Hydroporus tristis	a diving beetle	Dytiscidae	Coleoptera	

Hydroporus umbrosus	a diving beetle	Dytiscidae	Coleoptera	
Laccornis oblongus	a diving beetle	Dytiscidae	Coleoptera	NT
Porhydrus lineatus	a diving beetle	Dytiscidae	Coleoptera	
Hygrotus decoratus	a diving beetle	Dytiscidae	Coleoptera	NS
Hygrotus inaequalis	a diving beetle	Dytiscidae	Coleoptera	
Hyphydrus ovatus	a diving beetle	Dytiscidae	Coleoptera	
Graptodytes granularis	a diving beetle	Dytiscidae	Coleoptera	
Laccophilus minutus	a diving beetle	Dytiscidae	Coleoptera	
Hydrochus brevis	a scavenger water beetle	Hydrochidae	Coleoptera	VU
Hydrochus crenatus	a scavenger water beetle	Hydrochidae	Coleoptera	NT
Anacaena globulus	a scavenger water beetle	Hydrophilidae	Coleoptera	
Anacaena limbata	a scavenger water beetle	Hydrophilidae	Coleoptera	
Anacaena lutescens	a scavenger water beetle	Hydrophilidae	Coleoptera	
Cymbiodyta marginellus	a scavenger water beetle	Hydrophilidae	Coleoptera	
Coelostoma orbiculare	a scavenger water beetle	Hydrophilidae	Coleoptera	
Hydrobius fuscipes	a scavenger water beetle	Hydrophilidae	Coleoptera	
Hydrobius subrotundus	a scavenger water beetle	Hydrophilidae	Coleoptera	
Laccobius bipunctatus	a scavenger water beetle	Hydrophilidae	Coleoptera	
Helochares lividus	a scavenger water beetle	Hydrophilidae	Coleoptera	
Helochares punctatus	a scavenger water beetle	Hydrophilidae	Coleoptera	NS
Enochrus coarctatus	a scavenger water beetle	Hydrophilidae	Coleoptera	
Enochrus nigritus	a scavenger water beetle	Hydrophilidae	Coleoptera	NT
Enochrus ochropterus	a scavenger water beetle	Hydrophilidae	Coleoptera	
Enochrus testaceus	a scavenger water beetle	Hydrophilidae	Coleoptera	
Cercyon convexiusculus	a scavenger water beetle	Hydrophilidae	Coleoptera	
Cercyon tristis	a scavenger water beetle	Hydrophilidae	Coleoptera	
Hydraena palustris	a moss beetle	Hydraenidae	Coleoptera	NT
Hydraena riparia	a moss beetle	Hydraenidae	Coleoptera	
Hydraena testacea	a moss beetle	Hydraenidae	Coleoptera	
Limnebius aluta	a moss beetle	Hydraenidae	Coleoptera	NT
Ochthebius minimus	a moss beetle	Hydraenidae	Coleoptera	

Dryops luridus	a long-toed water beetle	Dryopidae	Coleoptera	
Contacyphon spp. larvae	marsh beetle larvae	Scirtidae	Coleoptera	
Contacyphon padi	a marsh beetle	Scirtidae	Coleoptera	
Microcara testacea larva	a marsh beetle	Scirtidae	Coleoptera	
Tanysphyrus lemnae	Duckweed Weevil	Erirhinidae	Coleoptera	
Poophagus sisymbrii	Water-cress Weevil	Curculionidae	Coleoptera	
Glyphotaelius pellucidus	a caddis-fly larva	Limnephilidae	Trichoptera	
Limnephilus flavicornis	a caddis-fly larva	Limnephilidae	Trichoptera	
Limnephilus rhombicus	cased caddis larvae	Limnephilidae	Trichoptera	
Limnephilus stigma	cased caddis larvae	Limnephilidae	Trichoptera	
Limnephilus vittatus	a caddis-fly larva	Limnephilidae	Trichoptera	
Limnephilus (other)	a caddis-fly larva	Limnephilidae	Trichoptera	
Trichostegia minor	a caddis-fly larva	Phryganaeidae	Trichoptera	NS
Culicidae	mosquito larvae	Culicidae	Diptera	
Dixidae	meniscus midge larvae	Dixidae	Diptera	
Chaoboridae	phantom midge larvae	Chaoboridae	Diptera	
Chironomidae	non-biting midge larvae	Chironomidae	Diptera	
Eristalini	a hoverfly larva	Syrphidae	Diptera	
Odontomyia sp.	a soldier-fly larva	Stratiomyidae	Diptera	
Odontomyia tigrina	a soldier-fly larva	Stratiomyidae	Diptera	NS