Norfolk Wildlife Services

Lound Lakes – Botanical Survey 2008.

Report prepared by Norfolk Wildlife Services Ltd
on behalf of Broads Authority, November 2008.

Summarised for website

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1. Background

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2. Introduction

2.1. Norfolk Wildlife Services were contacted by the Broads Authority in June 2007 with regard to undertaking a botanical survey of the shores of Lound Lakes on the Norfolk and Suffolk border (see Map 1, Appendix 1). The groups of water bodies, which include a number of smaller lakes along with Fritton Lake, are located approximately 2.5km south west of Gorleston, near Great Yarmouth

2.2. The lakes are owned by Essex and Suffolk Water and are managed in conjunction with the Trinity Broads partnership which includes Essex and Suffolk Water, the Broads Authority, the Environment Agency and Natural England.

2.3. The Lound Lakes form an integral part of the water management system in the local area. All the lakes are interlinked but the flow of water between them is not natural. Water is abstracted at the water treatment works at the western end of the 4 lakes and as a result of the abstraction the water appears to flow from east to west. However, to the west of the water treatment works, the water from neighbouring Fritton Lake moves east towards the abstraction point even though the natural flow of the water would carry water west towards the River Waveney.

2.4. As well as being an important source of water, the lakes also support, or have supported, a diverse flora, including some species considered as Nationally Rare or Nationally Scarce (JNCC).

2.5. The focus of the surveys comprised 5 distinct survey areas including four lakes; Hopton 1, Hopton 2, Hopton 3, and Hopton 4 and a bund between two water bodies called Mill Water and the Trout Pond. The bund is adjacent to the water treatment works and the Headquarters of Essex and Suffolk Water (see Map 2, Appendix 1).

2.6. The work was to include a re-survey of marginal aquatic plants around each of the four lakes and the bund. The most recent survey was conducted in 2002 by Essex Ecological Services in association with Suffolk Wildlife Trust. The 2008 survey repeated the methodology used in the original survey in order to identify all species, with particular attention given to the identification of certain target species and specifically *Pilularia globulifera,* Pillwort. *P. globulifera* is a Biodiversity Action Plan priority species which is a pioneer species of open sediment on the exposed shallow muddy margins of freshwater lakes and ponds. *P. globulifera* was present in very localised patches in the survey in 2002.

2.7. The survey was originally commissioned for 2007, however, the record levels of rainfall during the summer months and alterations made to the management of the lakes meant that the water levels were far too high to conduct the marginal plant survey satisfactorily; the surveys were postponed to 2008.

2.8. In the summer months of 2008, the water levels were still considered to be too high and were not expected to drop; in September 2008 the decision was made to go ahead with the marginal aquatic vegetation survey despite a draw down zone, where the majority of target species would expect to be found, being absent.

2.9. The survey was conducted by Bob Ellis with the assistance of Emma Harris and was conducted over three days; 24th, 25th and 26th September 2008.

3. Methodology

Introduction

3.1. The previous survey focused on four distinct areas that were highlighted as target species had been recorded there previously. These areas were;

- Southern bank of Hopton 2 – previous location of *P. globulifera* (2002)
- Northern bank of Hopton 3
- Northern bank of Hopton 4
- Bund between Mill Pond and Trout Water

3.2. The 2008 survey repeated the surveys in the areas above, however, extended the area of coverage to include;

- Southern shore of Hopton 1.
- Southern shore of Hopton 2.
- Northern and southern shores of Hopton 3.
- Northern and southern shores of Hopton 4.
- Bund between Mill Pond and Trout Water.

3.3. The northern shores of Hopton 1 and Hopton 2 were to be included in the survey; however both shores, at the time of survey, comprised dense stands of reed. The height and density of the reed on these banks made access extremely difficult. Instead observations were made from the opposite shores for evidence of any of the target species, or any locations such as shallow bays, where target species may be found. No suitable areas were identified and therefore the northern banks of Hopton 1 and Hopton 2 have not been included in the analysis of this report.

Field Survey

3.4. The lake edges, as in the previous survey, were divided into sections. The four lakes were divided into a total of 15 sections. The numbers of sections on each lake differed depending on the lake size and accessibility of some of the shores. In addition to the 15 sections, the bund between Mill Water and Trout Pond formed a separate survey area resulting in a total of 16 distinct sections.

3.5. Ideally, in order for direct comparisons to be made between different surveys, the locations of each section should be accurately identified. However, the grid references relating to each section from the 2002 survey were not available. A map in the report from 2002 marked the sections. Estimations of the start and finish of each section were taken from this map during the 2008 survey and grid references recorded using GPS which are displayed in Table 1.

3.6. A walkover was made of each section. Where possible, each section was walked in the water using waders and a grapple hook. A species list was recorded for each of the different sections. From the lake edge, species were recorded when rooted in the water to the distance reached by the grapple hook. Species beyond the grapple were not recorded and species growing on the banks were not recorded; the focus was on marginal plants. Species found loose in the water (not rooted) were recorded, but were not assigned an abundance value; instead the plant fragments were described as floating debris.

3.7. At the end of each section, an assessment was made of the relative abundance of each of the species identified using the ACFOR scale. Table 2 illustrates the meaning of the scale.

Table 2- Definitions of ACFOR Abundance Scale.

A	Abundant	Found all along the recording route, often as the species occupying the highest proportion of aerial cover – either because of it's size, or the high number of individuals of that species. (75% - 100% coverage)
C	Common	Found all along the recording route, sometimes as the species occupying the highest proportion of aerial cover. (50% - 74% coverage)
F	Frequent	Often found along the recording route, rarely as the species occupying the highest proportion of aerial cover. (25% - 49% coverage)
O	Occasional	Sometimes occurring along the recording route; not often recorded, and rarely as the species occupying the highest proportion of aerial cover. (5% - 24% coverage)
R	Rare	Only recorded once or twice within the stand, never as the species occupying the highest proportion of aerial cover. (0% - 4% coverage).

3.8. Where a species has been scattered along a section length, but largely in dense stands dominated by the particular species, the frequency of the species has been described as 'locally abundant'.

3.9. Where target species were present, GPS was used to provide an accurate grid reference of the location of individual specimens in order to produce maps and inform further survey.

Assessment of Ellenberg Values

3.10. As in the report from the 2002 surveys, Ellenberg Values were identified for each of the species recorded.

3.11. Ellenberg identified a number of different environmental factors that are highly influential in the growth of different species i.e. Light, Moisture, Reaction, Nitrogen and Salt. The Ellenberg Values system allows the classification of species into distinct groups depending on their differing environmental requirements. The system, which was developed for a central European flora, was updated for use in the United Kingdom by Hill et al in 1999.

3.12. The Ellenberg Values allow the detection of environmental changes through the identification of changes in floral composition.

4. Survey limitations

4.1. It should be noted that the survey was conducted at a suitable time of year for *P.globulifera* which grows around September. However, some of the other target species may not have been recorded due to the later survey timings than in previous years, although the surveyor claimed that it should have been possible to find evidence of all the "missing taxa" even at the end of September. It should be borne in mind that even if a particular species was not recorded during this survey, there is a possibility that it may still be present at Lound Lakes.

5. Results

5.1. Field Survey

5.1.1. In total, in 2008, 58 species were identified. This figure does not include those plants that were identified to genus only such as *Chara* sp or *Myosotis* sp. In comparison, in 2002, a total of 46 species were recorded, again not including plants not identified to species level.

General Results

5.1.2. 4 of the 10 target species identified in 2002 were recorded in 2008, no evidence was found of the remaining 6 target species.

5.1.3. 25 species were recorded during this survey that had not occurred on the previous survey in 2002. Additional species were;

- *Calamagrostis canescens* - Purple Small-reed
- *Carex acuta* - Slender Tufted Sedge
- *Carex pendula* - Pendulous Sedge
- *Carex riparia* - Greater Pond Sedge
- *Convolvulus arvensis* - Field Bindweed
- *Elodea Canadensis* - Canadian Waterweed
- *Eupatorium cannabinum* - Hemp Agrimony
- *Galium palustre* - Marsh Bedstraw
- *Glyceria fluitans* - Floating Sweet-grass
- *Juncus articulatus* - Jointed Rush
- *Juncus bufonius* - Toad Rush
- *Juncus subnodulosus* - Blunt-flowered Rush
- *Lemna minuta* - Least Duckweed
- *Lemna trisulca* - Ivy-leaved Duckweed
- *Lycopus europaeus* - Gypsywort
- *Lythrum salicaria* - Purple-loosestrife
- *Phalaris arundinacea* - Reed Canary-grass
- *Ranunculus flammula* - Lesser Spearwort
- *Rorippa nasturtium-aquaticum* - Water-cress
- *Rorippa palustris* - Marsh Yellow-cress
- *Rumex conglomeratus* - Clustered Dock
- *Rumex hydrolapathum* - Water Dock
- *Sparganium erectum* - Branched Bur-reed
- *Typha latifolia* - Greater Reedmace
- *Veronica beccabunga* - Brooklime

5.1.4. Comparison of the current and previous species lists indicate that 14 species recorded in 2002 were not identified in 2008. Of these 14 missing species, the most notable was *P. globulifera*; the main target species. The water levels at the time of survey were high in all lakes resulting in a lack of exposed mud and an inundation zone and therefore a lack of suitable habitat for this colonising species.

5.1.5. According to the data Hopton 2 was the most species diverse in 2008 with 40 recorded species. Hopton 2 was identified as the most diverse in 2002 but with 32 species identified.

5.1.6. Of the 40 plants identified in Hopton 2, 3 were target species; *Baldellia ranunculoides*, *Myriophyllum spicatum* and *Potamogeton crispus*. Also notable was the presence of *Chara* sp in Hopton 2, although the lack of vegetation could not enable species identification. Hopton 2 was the only lake which recorded these target species.

5.1.7. 27 species were recorded from Hopton 3 whilst 25 were recorded from Hopton 4. 17 species were identified in Hopton 1 and 12 identified from the bund between Mill Water and Trout Pond, which, most notably was the only location of *Cicuta virosa*.

Target Species

5.1.8. ***Cicuta virosa* – Cowbane**

This species is designated as Nationally Scarce. At least 10 plants of this species were recorded along either side of the bund separating Mill Water from Trout Pond. No further evidence of this species was observed along any other of the lake margins. Cowbane was recorded in the same place in both 1994 (Harding) and 2002 (Essex & Suffolk Water).

5.1.9. ***Pilularia globulifera* – Pillwort**

No evidence of this species was recorded during this survey from any of the survey sections. *P. globulifera* was recorded in all sections along the southern edge of Hopton 2, but was found to be frequent along the second section. Casual records from the Broads Authority indicate that *P. globulifera* was present in Hopton 2 in 2006. Therefore it can be estimated that *P. globulifera* has been lost from Lound Lakes in the last 2 years. *P. globulifera* is classified as Nationally Scarce and is also a priority Biodiversity Action Plan or BAP species both nationally and locally.

5.1.10. ***Baldellia ranunculoides* – Lesser Water-plantain**

This species was recorded as rare in section 1 and section 2 of Hopton 2 in the approximate location from which it was found in 2002 (Essex & Suffolk Water). However,

the sites on Hopton 3 and Hopton 4 from where it was noted in the previous survey have been lost. In 1994, Harding recorded lesser water-plantain on all shores apart from the northern shore of Hopton 2 where dense reed bed was present as it is now. This species is classified as Near Threatened.

5.1.11. ***Eleogiton fluitans*** **– Floating Club-rush**

This species has not been recorded from the lakes since 1994 where it was present on Hopton 4. The 2008 surveys found no evidence of this species in any of the survey sections.

5.1.12. ***Isolepis setacea*** **– Bristle Club-rush**

This species was present in 1991 (Casey) but was absent in 1994 (Harding), in 2002 bristle club-rush was re-recorded as rare along the northern shore of Hopton 3. In 2008, no evidence of this species was found.

5.1.13. ***Myriophyyllum spicatum*** **– Spiked Water-milfoil**

This species was recorded in 1991 by Casey and in 2002 was found in various amounts along Hopton 2, 3 and 4. During this survey the species was recorded as occasional along section 1 of Hopton 2. Floating debris was recorded along section 1 on the southern edge of Hopton 3. No further records of this species were found in 2008.

5.1.14. ***Nymphea alba*** **– White water-lily**

In 2002 this species was present along the Mill Water side of the bund, as it was in 1994. No evidence was found of this species being present as a marginal aquatic plant.

5.1.15. ***Potamogeton berchtoldii*** **– Small pondweed**

This species was recorded in 1994 and 2002. During this survey, the species was recorded as frequent along section1 of Hopton 2 and rare along the first northern section of Hopton 3. Floating debris was found along the entire southern shore of Hopton 3 and part of the northern edge.

5.1.16. ***Utricularia vulgaris*** **– Greater bladderwort**

This species was recorded in 1994 and 2002. However no evidence of this species was found in the current survey.

5.1.17. ***Crassula helmsii*** **– New Zealand Pigmyweed**

In the 6 years since the previous survey, there has been a dramatic, although not surprising increase in the distribution of *C. helmsii*. In 2002 the section with the greatest abundance of this species was section 4 of Hopton 3 where it was recorded as frequent. In the same section during this survey the *C. helmsii* was recorded as abundant.

Map 5 illustrates the abundance of *C. helmsii* in the different sections in 2008. Hopton 3 has the greatest concentrations with *C. helmsii* being recorded as abundant on 4 of the 6 sections. This is not surprising given that the greatest abundance in 2002 was also in Hopton 3.

The most significant increase in the distribution of this species has occurred in Hopton 4 along the northern shore. In 2002, *C. helmsii* was recorded as being rare along this section, but in 2008 has been recorded as abundant and locally abundant.

No *C. helmsii* was recorded in Hopton 1 or along the Mill Water / Trout Pond bund. Map 5 seems to indicate that *C. helmsii* is spreading from east to west which would correspond to the flow of the water between the lakes caused by water abstraction at the water treatment works. However this contradicts the findings from 2002 which indicate that the species was rare in Hopton 4 but most abundant in Hopton 3. This could indicate that *C. helmsii* is spreading by a means other than the flow of water such as on the feet of wildfowl moving between water bodies.

5.1.18. Other Notable Species

Callitriche hamulata Intermediate Water-starwort is classified as Locally Rare in Norfolk as it occurs at only 6 sites. This species was recorded in both 2002 and 2008. Carex acuta Slender Tufted Sedge is classified as Locally Scarce in Norfolk as it only occurs within 21 tetrads, this is a new species in 2008.

5.2. Ellenberg Values

5.2.1. The Ellenberg Values for the species recorded during this survey illustrate great diversity. When considering each of the environmental factors separately, a wide range of figures are associated with the different species growing at each of the lakes. A good range of Ellenberg Values indicates the presence of a number of different habitat conditions.

L – Light

5.2.2. As was found in 2002, the majority of the species present at Lound Lakes have scores of 7 or 8. Scores of 7 represent plants that are found in generally well lit areas, although can also survive in partial shade; an example being Berula erecta Lesser Water-parsnip. Scores of 8 are assigned to light-loving plants that rarely grow where the relative illumination in the summer is less than 40% such as Eleocharis palustris Common Spike-rush.

5.2.3. The exception to the 7 or 8 scores was Carex pendula Pendulous Sedge with a score of 5. This score indicates that C. pendula is a semi-shade plant, rarely found growing in full light but with more than 10% relative illumination when trees are in leaf. The only section in which C. pendula was recorded is Hopton 4 – 2N; the shore of the lake along this section is backed by woodland which would create localised, very shady conditions.

5.2.4. In general, the range of values recorded for Light have not changed significantly since 2002.

F – Moisture

5.2.5. The values for Moisture for the species recorded in 2008 ranged from 4 to 12. These figures represent a range of plants that are indicators of dry sites which are more likely to be found on dry grounds than moist places such as Convolvulus arvensis Field Bindweed (value 4) to plants that are permanently or almost constantly submerged such as Myriophyllum spicatum Spiked Water-millfoil (value 12).

5.2.6. The majority of the plants scored between 8 and 10, indicating preferences for damp but not wet soils (8) to plants indicating shallow-water sites that potentially lack standing water for extensive periods (10).

5.2.7. In 2002 67.4% of species identified had values of 9 or more for moisture. In 2008, this figure had dropped slightly to 63.8% of species. A score of 9 represents wet site indicators, plants often found on water-saturated or badly aerated soils for example Cicuta virosa Cowbane or Galium palustre Marsh Bedstraw.

5.2.8. The range of values recorded is representative of the different moisture conditions found along lakes that reflect that differing structure of the shores i.e. steep banks form along some shores and in other areas the shores are formed by a gradual slope and inundation zones creating very different micro-habitats.

R - Reaction

5.2.9. The values of this environmental condition represent the pH of soil or water. The values recorded from the plants at Lound Lakes were between 4 and 8 with the majority of plants having a score of 7; the same range of scores was recorded in 2002. The values indicate that the lakes support species that are indicators of acid to moderately acid soils through to those species that are indicative of weakly acid to weakly basic conditions or soils of high pH but that would never be found on very acid soils. Juncus

acutiflorus Sharp-flowered Rush is an example of the acidity indicators at the lower end of the scale. *Juncus subnodulosus* Blunt-flowered Rush is an indicator of more basic conditions.

5.2.10. 55.2% of plants had scores of 7 for Reaction Values in 2008 compared to 43.5% of plants in 2002. This score represents plants that are indicators of weakly acid to weakly basic conditions such as *Mentha aquatica* water mint. The scores indicate that extremes of pH are not found at Lound but that there are slight variations present across the water bodies.

N – Nitrogen

5.2.11. The scores recorded Nitrogen Values ranged from 2 – 7 illustrating a wide range of nitrogen conditions across the Lakes.

5.2.12. A plant with a score of 2 for nitrogen lies between plants that indicate extremely infertile sites and plants that indicate more or less infertile sites in the Ellenberg Value scale. Species recorded in 2008 with a score of 2 included *Baldellia ranunculoides* Lesser Waterplantain and *Juncus bulbosus* Bulbous Rush.

5.2.13. A score of 7 is assigned to a plant which is often found in richly fertile places. *Rorippa nasturtium-aquaticum* Watercress and *Typha latifolia* Greater Reedmace are plants with a score of 7 for Nitrogen.

5.2.14. In 2002, the Nitrogen values ranged from 2 – 8, however it should be noted that the score of 8 was assigned to *Typha latifolia*; this score has since been revised and is now recorded as 7.

5.2.15. Although the score of 8 is not present in 2008, the numbers of plants with a Nitrogen score of 6 or above comprised 53.4% of species recorded. In comparison, in 2002, 45.6% of species recorded had a Nitrogen score of 6 or above.

5.2.16. These figures could imply that there has been a slight increase in nitrogen levels in certain areas of the lakes. The Nitrogen score of 6 lies between 5 which indicates intermediate fertility and 7 found in richly fertile places.

S – Salt

5.2.17. As was found in 2002, the values for Salt ranged between 0 and 2. Plants with a score of 0 are absent from saline sites such as *Alisma plantago-aquatica* Water Plantain. Scores of 1 represent plants that are slightly salt tolerant and capable of surviving the presence of salt but without abundant growth such as *Eleocharis palustris* Common Spikerush. Plants with a score of 2 occur in both saline and non-saline situations for example *Phragmites australis* Common Reed. The range of scores recorded in 2002 and 2008 are not surprising considering the freshwater nature of the lakes.

5.2.18. In both 2002 and 2008 the numbers of species recorded with Salt scores of 1 or above have remained at roughly 22%.

6. Conclusions

Target Species

6.1. The results of this survey indicate that the diversity of the species present at Lound Lakes has increased since the previous survey in 2002 with an additional 25 species being recorded. However none of the newly recorded 25 species are local or national BAP species and are all classified as being species of Least Concern on the JNCC website.

6.2. Despite the overall increase in diversity, there has been a dramatic decline in the occurrence of the target species, including some rare and scarce species and overall 14 species were not recorded this year that were present in 2002.

6.3. Only 4 of the10 target species identified in 2002 were present during this survey. 6 of the target species were missing during the current survey and of the missing species, *P. globulifera* is considered to be the most significant.

6.4. Two of the target species *Eleogiton fluitans*, *Isolepis setacea* and non-target species *Ranunculus sceleratus* are notoriously ephemeral and also typically benefit from fluctuating water levels which were not apparent during this survey. The lack of water fluctuation could potentially or partly explain why these species were not recorded this year.

6.5. Missing non-target species such as *Equisetum arvense* field horsetail or *Potentilla reptans* creeping cinquefoil are generally considered as terrestrial species rather than true aquatics and therefore they may not have been recorded in 2008 due to a difference between the definition of where the water margin ends compared to the 2002 survey (during this survey, plants that had roots in the water were recorded). Similarly, these species can rapidly colonise bare mud when water levels drop; the lack of exposed bare mud in 2008 could also explain why these species were not recorded.

6.6. Many of the 25 new species that were recorded this year such as *Eupatorium cannabinum, Lythrum salicaria* and *Galium palustre* are more emergent species rather than marginal aquatic species and are typically associated with fen type communities. The increase in such emergent species could be reflection of the stability in the water levels. When water levels were less stable, with distinct periods of drying, such species would not have established. However it should be noted that the majority of the new species were recorded as rare and may have only occurred in 1 or 2 sections so firm conclusions cannot be drawn from the presence of these plants.

Pilularia globulifera

6.7. Lound Lakes was known to be 1 of 2 locations for this species in Norfolk and its loss from these lakes is very significant.

6.8. It is likely that a number of factors are to blame for the loss of *P. globulifera* including;

1. The increases in water levels resulting in the loss of drawdown zones.
2. The dramatic increase in the distribution of *C. helmsii* out competing *P. globulifera* on the small patches of exposed muds.
3. The lack of grazing livestock in adjacent fields which trample marginal vegetation creating areas of bare mud which can be colonised by *P. globulifera*.

6.9. The Lound Lakes are an important source of water for the surrounding area. In recent years the management of the water has changed so that the water levels remain much higher throughout the year than in previous years.

6.10. The maintenance of high water levels means that there is no drawdown zone which is formed when water levels typically drop during the summer months. The drop in water levels exposes muds and sediments which are important habitats for a number of rare species including *P. globulifera*.

6.11. Very little is known about the ecology of *P. globulifera*. However according to Plantlife, there is some evidence that spores can remain viable in sediment and other members of the family Marsiliaceae are renowned for the longevity of their sporocarps, although in the case of *P. globulifera* it is unclear for how long. This situation could provide a good opportunity to conduct a valuable research project; to re-create suitable habitat conditions in the previous locations of this species to see if it could return.

Management

6.12. If the spores of *P. globulifera* are able to survive in the sediment, management could be used to re-create suitable habitat conditions to stimulate growth and bring back the species.

6.13. If *P.globulifera* did return to the lakes, it may be beneficial to try and cultivate the species elsewhere as a reserve stock.

6.14. To re-create a draw down zone (if un-able to lower the water levels), shallow sloping scrapes could be cut into the lake margins to create open muddy areas devoid of other vegetation. In theory, if spores are viable, it would make most sense to cut the scrapes in the locations of the most recent *P. globulifera* records.

6.15. Grazing is also a contributory factor in the locations of traditional *P. globulifera* sites and is also considered as a significant factor in the restoration of *P. globulifera* sites. Grazing by livestock helps to keep marginal vegetation under control, preventing shading and preventing succession by scrub and other species. Livestock also trample the margins of lakes or water bodies creating areas of bare earth ideal for colonisation by *P. globulifera*.

6.16. As noted in 2002, the potential for contaminating the Lound Lake water source with *Cryptosporidium* carried by livestock or the chemicals used for treating livestock with *Cryptosporidium* mean that actively grazing the lake margins is not an option.

6.17. Cutting and mowing are currently employed as management techniques for controlling marginal vegetation in an attempt to recreate the effects of grazing. However, cutting cannot replicate the trampling behaviour of livestock.

6.18. Ensuring that boots are not contaminated with *C. helmsii*, volunteers could be used to trample the areas of bare earth created by the shallow scrapes. This may enhance the provision of habitat conditions for *P. globulifera* in the absence of livestock, although there is no firm evidence to support this theory.

Crassula helmsii

6.19. The spread of this invasive species has been dramatic but not un-expected. The dominance of *C. helmsii* is likely to have been a contributing factor in the loss of some of the other target species but particularly *P. globulifera*.

6.20. This species poses a very significant threat to the biodiversity of the lakes. The spread of *C. helmsii* through the lakes must be controlled and reduced if the target species such as *P. globulifera* are to be returned. However, there is no simple solution to this problem.

6.21. Significantly there was no evidence of *C. helmsii* in Hopton 1 or along the bund between Mill Water and Trout Pond. Efforts should be made to prevent the spread of this plant to these water bodies and further down stream, although this is likely to be very difficult. If the water in Hopton 2 is freely connected to Hopton 1 it would seem surprising that *C. helmsii* had not established. It may be worth investigating how the conditions in the two adjoining lakes differ to try and work out why the *C. helmsii* is finding it more difficult to colonise Hopton 1 than the other lakes, although it is likely that *C. helmsii* will spread into Hopton 1 in time.

6.22. As a general observation; 12 Egyptian and Canada geese were present in the field along the northern edge of Hopton 3. Roughly half way along this shore was a clear slide which the geese had been using to enter the lake. The presence of *C. helmsii* in the area of the goose entrance was significantly reduced in comparison to the shore roughly 3m either side of the slide. It is possible that the grazing of the geese in this area or the disturbance of the sediment could be impacting on the growth of *C. helmsii* although the geese are also likely to impact on other species. Observations were made at a reserve called the Moor Green Lakes Nature Reserve of Egyptian Geese eating *C. helmsii* (MGLG, 2007).

6.23. Although there is a possibility that the geese could be grazing *C. helmsii*, it is also a possibility, put forward by EECOS in 2002 that the geese could be partly responsible for the spread of the invasive species by transporting fragments on their feet to other areas.

Management

6.24. It is extremely unlikely that the *C. helmsii* could be removed entirely from the lake system without a program of herbicide use. Due to the water treatment process and the domestic supply of lake water, the use of herbicides is not an option.

6.25. Other non-chemical methods have been used to remove or control the growth of *C. helmsii.* The plant can be dug up using large machinery or on a smaller scale using spades. This process is more time consuming than the use of chemicals and will need to be regularly repeated due to the rapid re-growth of the species, even from tiny fragments. Any removed material must be buried, or sprayed with herbicides.

6.26. From personal communication with the site warden, there are a number of volunteer groups available that could be utilised to undertake regular *C. helmsii* removal. Due to the unlikely eradication of this species, it would be best to concentrate removal efforts in the areas where the target species had been recorded previously, for example, in the previous *P. globulifera* locations on the southern banks of Hopton 2.

6.27. In addition to mechanical removal, the use of carpet or black polythene to prevent *C. helmsii* receiving light has had some success. Again the application of such methods is limited; it would be difficult for the use of polythene to combat the growth of *C. helmsii* in deeper water where it can survive in up to 3m. Careful consideration of the timing of this method can reduce the impacts on other species.

6.28. Covering *C. helmsii* in the more shallow areas and along banks, in combination with regular physical raking or mechanical removal of deeper plants, may create open bare mud areas that remain open long enough for species such as *P. globulifera* to establish if any spores present are still viable.

6.29. According to some observations at Brown Moss Nature Reserve in Shropshire, *C. helmsii* seems to favour semi-shaded, silty shores of pools much more than fully exposed ones. This observation was also noted at Derwent Water in Cumbria where *C. helmsii* was hardly able to establish as it appeared not to be able to withstand wave action and did not favour sandy substrate (Shropshire BSBI 2004).

6.30. A 50% kill rate of *C. helmsii* (comparable to the use of Glyphos biactive) was also achieved with the use of “Waipuna” hot foam at the Old Moor RSPB Dearne Valley Reserve Bridge (2005). The hot foam is a biodegradable organic compound comprising coconut and corn sugars. The heat breaks down the cellular structure of the plant with rapid results. This product could be of use if it did not affect the nutrient or pH conditions of the lakes and did not pose a threat in the water treatment process.

Phragmites australis

6.31. *P. australis* has also increased in abundance since 2002 and in the locations where it is present, it has been recorded as locally abundant or abundant. The northern margin of Hopton 2 was not surveyed, as in 2002, due to the blanket cover of reed.

6.32. The increasing cover of reed could also be a contributing factor in the decline of other species around the lakes, particularly some of the target species. Dense reedbed as is present along the north of Hopton 2 does not allow light to penetrate to the water’s surface and as a result tends to be species poor, although reed does provide habitat for a number of species and is not without ecological value.

6.33. Reed growth can be vigorous and can quickly dominate margins if not managed. Reed at Lound lakes should be managed to prevent domination on those margins that are currently the most bio-diverse, particularly the southern margin of Hopton 2.

Ellenberg Values

6.34. The assessment of Ellenberg Values has indicated that there may have been a slight change in the nutrient conditions at Lound Lakes. The water quality of the lakes is likely to have been regularly tested, so if this is the case, it is likely that the relevant

bodies are already aware. The other factors included in the Ellenberg assessment have not altered significantly since 2002.

6.35. Any change in nitrogen levels is likely to affect the biodiversity of the lakes and could negatively impact on the presence of rarer species that are more easily out-competed by fast growing species which thrive in high nutrient conditions. Any increase in nitrogen is likely to have been caused by a number of factors. Nitrogen could be leaching into the system from the surrounding areas which predominantly comprise arable fields. The application of fertilisers is often involved in the nutrient loading of water bodies.

6.36. A specific issue in relation to Lound Lakes is the presence of geese. In 2002, a population of barnacle geese was described as notable. In 2008 approximately 12 geese were recorded at Hopton 3. The geese population could be responsible for increased nutrient levels, although this could be localised enrichment. As noted in 2002 the geese could also increase the acid conditions of the lakes.

Scrub

6.37. As a general observation, in places scrub is encroaching on the margins of the lakes, although there are no margins which are dominated entirely by scrub growth. *Rubus fruticosa ag*g and species of *Salix* are growing along the banks and into the water along with occasional other species. Scrub will provide important cover for breeding birds and the mosaics of habitat are beneficial, however, in certain areas the shade created by the scrub could be negatively impacting on the growth of some of the rarer target species such as *Baldellia ranunculoidies* which tend to grow in open well lit areas. The banks of the only sections where this species was recorded were typically completely free of scrub, supporting open short grassland margins. Shaded areas are also believed to be more favourable to *C. helmsii*.

7. Summary

7.1. A botanical survey of the marginal aquatic vegetation of the Lound Lakes was conducted by Norfolk Wildlife Services on behalf of the Broads Authority in September 2008. The same survey, using the same methodology was conducted in 2002 by Essex Ecology Services Ltd in association with Suffolk Wildlife Trust.

7.2. The margins of 4 lakes; Hopton 1, Hopton 2, Hopton 3 and Hopton 4 were divided into sections. A species list was complied for each section and each species was assigned a score of abundance using the ACFOR system. The Ellenberg Values system, which assigns scores for every species according to 5 environmental variables, can be used to monitor changes in environmental conditions.

7.3. A list of target species was compiled in 2002; the list comprised a number of rare and scarce species, as well as BAP species and of particular significance was *Pillularia globulifera*. Lound Lakes was believed to be 1 or 2 locations in Norfolk for this nationally scarce species. The search for *P. globulifera* was a major objective of the survey.

7.4. 58 species were identified in this survey. Only 4 of the 10 target species identified in 2002 were identified in 2008; these were *Baldellia ranunculoides*, *Cicuta virosa*, *Myriophyllum spicatum* and *Potamogeton crispus*. No evidence of *P. globulifera* was found in any of the lakes.

7.5. 25 additional species were recorded that were not present in 2002 and 14 species, including 10 target species, were not recorded in 2008 that were present in 2002. The loss of target species is considered significant and the changes in water levels are likely to be a major contributing factor in the loss of these species.

7.6. The assessment of Ellenberg Values may indicate that there has been an underlying change in nitrogen conditions; however no significant changes in the environmental conditions are apparent as a result of the analysis.

7.7. There are 2 main issues that are likely to have altered the species composition of the lakes;

- ***Crassula helmsii*** – An invasive non-native called New Zealand pygmyweed that is notoriously difficult to remove; the situation at Lound is made worse by the restrictions on the use of herbicides and livestock grazing. The abundance of this species has increased dramatically in Hopton 2, Hopton 3 and Hopton 4 since 2002 forming dense blankets on exposed margins and deeper in to the water. This species is believed to out-compete other slower growing native species such as *P. globulifera*, generally resulting in a loss of diversity. *C. helmsii* will continue to spread unless concerted efforts are made to control it.
- **Water levels –** The water levels have increased across the lakes since the previous survey due to the need for maintaining water supplies. The increase in levels has resulted in the loss of the drawdown zone (fringes of mud that are exposed when water levels typically drop in the summer months). The temporarily exposed fringes are an important habitat for a number of the target species, particularly *P. globulifera*.

7.8. Suggestions have been made regarding the restoration of suitable habitat conditions for *P. globulifera* with the additional aim of encouraging the growth of other target species. These include the cutting of shallow scrapes to expose muds, the concentrated removal of *C. helmsii* using a combination of methods and the control of scrub to reduce vegetation height around margins.

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