Vegetation survey

for

Catfield Fen

on behalf of **Mr & Mrs Harris**

July 2013

DRAFT

thelandscapepartnership

landscape architecture urban design environmental planning

Quality control

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for
Catfield Fen

Checked by:	Approved by:
Signature: Nick Aldus	Signature:
Name: Nick Aldus	Name: Dr Jo Parmenter
Title: Assistant Ecologist	Title: Director
Date: 18/07/13	Date: 18/07/13

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The Landscape Partnership
Registered office
Greenwood House
15a St Cuthberts Street
Bedford
MK40 3JG

Registered in England No. 2709001

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1 Introduction

1.1 Site location and context

1.1.1 Catfield and Irstead Fens, is situated in East Norfolk and is located on the floodplain of the River Ant, in the northern part of The Broads. Survey effort focussed upon 4 adjacent parcels of land, the 'Site', these being Middle Marsh (G14), South Marsh (G25), Mill Marsh East (G24) and Mill Marsh West (G23), which are separated from each other by a network of both open and partially terrestrialised dykes (see Figure 01).

1.1.2 The Site is currently managed as fen, and parts of the area surveyed are variously cut on a non-commercial basis for litter (marsh hay), on an annual rotation to maintain 'summer mowing marsh', or on a longer rotation to maintain tall herb fen, reedbed and sedge beds.

1.1.3 The approximate central grid reference for the Site is TG 373 210.

1.2 Objectives

1.2.1 The purpose of the survey was to repeat part of a vegetation survey previously carried out by Jo Parmenter in August 1991, as part of The Broadland Fen Resource Survey, a project jointly funded by Natural England and The Broads Authority[1].

1.2.2 The objectives of the study were as follows:

- To relocate 22 quadrats previously recorded in August 1991
- To record vegetation, including bryophytes, at these 22 quadrat locations
- To compare the 1991 and 2013 survey data

[1] Parmenter, Jo. 1995 *The Broadland Fen Resource Survey: volumes I-5 - report of the 1991-94 Broadland Fen Resource Survey.* Published by The Broads Authority, 1995.

2 Survey methodology

2.1 Desktop study

2.1.1 An initial desktop exercise was undertaken in June 2013 to identify, within certain limitations, the locations of vegetation quadrats previously recorded at the Site. This was done by transferring quadrat locations from the 1:2500 map on which they were originally recorded, to an aerial photograph, to assist identification in the field, and thence obtaining an 8-figure grid reference using the website 'Where's the path' http://wtp2.appspot.com/wheresthepath.htm. This grid reference was then compared with the 6 figure grid reference recorded in 1991. Approximate measurements from boundary features and other landmarks were also taken to assist relocation of quadrats in the field. Each quadrat was assigned the same unique six-digit number which included the site and parcel identifiers as used in the 1991 survey.

2.1.2 The locations of quadrats are given in Figure 02.

2.2 Vegetation survey

2.2.1 The vegetation survey was undertaken over a period of several days in late June 2013. 22 quadrats were recorded in total. The quadrat area (2x2m or 4x4m) replicated that utilised in the 1991 survey; all 22 quadrats were found to have been recorded using the 2x2m area and were re-recorded on this same basis.

2.2.2 The abundance of all vascular plants and bryophytes within each quadrat was recorded using the DOMIN scale (see below). Additional species were noted in an area of approximately 10mx10m around the quadrat. The overall percentage cover of higher plants, bryophytes and litter were noted for each quadrat. The maximum and mean heights of the various components of the vegetation were also recorded, and management was recorded visually in the field and then confirmed by the landowners. Water level data were collected during the survey and noted on the vegetation recording sheets as 'above surface', 'at surface' or 'below surface'. A ten figure grid reference was recorded at the north-eastern corner of each quadrat, using a GARMIN eTREX H hand held GPS device to allow relocation in the future.

Domin value	% cover
1	<1 (1 or 2 individuals)
2	<1 (more than 2 individuals)
3	1-4
4	4-10
5	11-25
6	26-33
7	34-50
8	51-75
9	76-90
10	91-100

2.3 Data analysis: MAVIS

2.3.1 The National Vegetation Classification (NVC) describes and classifies the types of semi-natural vegetation present in Great Britaini (Rodwell, 1991-1995[2]). The Broadland fen vegetation data obtained during the Broadland Fen Resource Survey was initially classified using the NVC system, both subjectively, and then objectively by using the VESPAN II MATCH program (Malloch, 1988[3]) to verify the subjective classification.

2.3.2 In order to allow comparisons to be drawn between the 1991 and 2013 data, the 1991 data was reclassified in July 2013 on a purely objective basis using the MAVIS Modular Analysis of Vegetation Information System[4] developed by CEH, and the 2013 data treated in the same way. Species and percentage cover values derived from the DOMIN scores were entered.

2.3.3 MAVIS enables links to be made between botanical field data and a number of widely used classifications of plant species. The result is a standard description of the entered data in terms of each classification. Because the classifications remain static and only the field data changes, different plant communities can be expressed in a standard way, allowing comparison from site to site or over time[5].

2.3.4 The classification systems available through MAVIS are as follows:

- Ellenberg scores for Light, Fertility, Wetness and pH
- Grime's (1979) triangular CSR model classifying British vegetation in terms of three established strategies; Competitors, Stress-tolerators and Ruderal species
- The National Vegetation Classification (NVC) developed at the Unit of Vegetation Science, Lancaster University

Ellenberg Scores

2.3.5 Ellenberg published lists of species in the European flora and attached to each an indicator score from 1 to 10, conveying the optimum position typically occupied by a species along a number of different gradients. The scores were based on a synthesis of experimental work, field observation and descriptive analyses. However, because Ellenberg's studies concentrated upon central European populations his scores may be less applicable to the situation in the UK. To address this problem Hill et al (in press[6]) recalculated scores for each species using weighted averaging applied to the Countryside Survey (CS) botanical dataset. This exercise has effectively re-calibrated the original scores for the British situation as represented by CS data. The list of Ellenberg scores, as 'adapted' by Hill et al. available in MAVIS are as follows:

1. Fertility (low scores = low fertility)
2. pH (low scores = low pH): 9 point score
3. Wetness (low scores = drier conditions): 12 point score

[2] Rodwell, J.S. (ed.) 1991. *British Plant Communities. Volume 1. Woodlands and scrub*. Cambridge University Press.
Rodwell, J.S. (ed.) 1991. *British Plant Communities. Volume 2. Mires and heath*. Cambridge University Press.
Rodwell, J. S. (ed.) 1992. *British Plant Communities. Volume 3. Grassland and montane communities*. Cambridge University Press.
Rodwell, J.S. (ed.) 1995. *British Plant Communities. Volume 4. Aquatic communities, swamps and tall-herb fens*. Cambridge University Press.
Rodwell, J.S. (ed.) 2000. *British plant communities. Volume 5. Maritime communities and vegetation of open habitats*. Cambridge University Press.

[3] Malloch, AJC 1988 VESPAN II. Lancaster, Lancaster University.
[4] http://www.ceh.ac.uk/products/software/cehsoftware-mavis.htm
[5] http://www.ceh.ac.uk/products/software/documents/mavisdownload.pdf

[6] Hill, M.O., Mountford, J.O., Roy, D.B., Bunce, R.G.H. 1999 Extension of Ellenberg's indicator values to Great Britain. ECOFACT 2a Technical Annex http://nora.nerc.ac.uk/6411/1/ECOFACT2a.pdf

4. Light (low scores = more shade tolerant)
5. Temperature (low scores = low temperatures)

2.3.6 Only pH and wetness scores have been considered in this study.

2.3.7 Hill et al. consider a Wetness score of above 5 as indicating a moist site, whilst scores of 9 and above indicate saturated soils and 10 and above a site where the water table is rarely below the ground surface. This is quite a crude tool to use to assess the wetness of fen vegetation, but it is based upon a large dataset and is a widely accepted means to evaluate water conditions.

Use of 'Indicator' species

2.3.8 It was noted on a previous site visit that calcicolous species such as *Peucedanum palustre, Carex elata, Sium latifolium*) appear to be associated with the fen close to the ditches, which are understood to typically have a higher pH than the fen peat (Peter Riches pers. comm., and appeared, in general, to be much less common towards the centre of marsh parcels away from the ditches. This suggests that there may be a decreasing pH gradient from the ditches into the interior of parcels. Conversely, the more acid loving species, notably *Sphagnum* spp in general, appeared more common towards the centre of marsh parcels, although these species appeared particularly abundant in Middle Marsh.

2.3.9 The assessment considers whether certain commonly occurring plant species at Catfield Fen might be used as indicator species of acidification (whether by natural processes or changes in the chemistry of the water irrigating the site), and whether species presence and abundance of these species might have altered over the 20 years which have elapsed since the 1991 survey was undertaken. The species set out in the table below were considered as possible indicator species, using data taken from the Ecological Flora of the British Isles[7] to establish tolerance of extremes of pH in the irrigating water. Only those species present in a number of quadrats in either 1991 or 2013, but were not so widespread and ubiquitous as to indicate a tolerance of a wide range of habitat conditions, were considered. Species for which environmental data is not readily available were not considered further. Species tolerant of a very wide pH range were discounted. Other species such as *Myrica gale* were discounted as distribution could be influenced by factors such as management frequency as much as by pH. The distribution of *Sphagnum* was also examined.

2.3.10 There is very little quantitative data on tolerances to wetting or drying, and so indicator species which might suggest relative wetness or dryness were not considered.

Species	**Water pH: extreme max.**	**Water pH: extreme min.**	**Use as indicator species?**
Calamagrostis canescens	7.32	3.72	No: tolerant of very wide pH range
Carex elata	6.91	5.31	Yes - intolerant of low pH
Cirsium dissectum	8.22	4.00	No: tolerant of very wide pH range
Cirsium palustre	8.26	4.11	No: tolerant of very wide pH range
Cladium mariscus	7.15	4.85	No: tolerant of wide pH range

[7] http://www.ecoflora.co.uk/

Eriophorum angustifolium	7.48	2.88	No: tolerant of very wide pH range
Galium palustre	7.32	4.04	No: tolerant of very wide pH range
Hydrocotyle vulgaris	7.14	3.86	No: tolerant of very wide pH range
Iris pseudacorus	8.37	4.31	No: tolerant of very wide pH range
Juncus subnodulosus	8.26	4.25	No: tolerant of very wide pH range
Lycopus europaeus	6.78	5.59	Yes - intolerant of low pH
Lysimachia vulgaris	8.02	4.28	No: tolerant of very wide pH range
Lythrum salicaria	8.02	4.31	No: tolerant of very wide pH range
Molinia caerulea	8.26	3.59	No: tolerant of very wide pH range
Myrica gale	6.87	3.46	Yes – broadly acidophile
Peucedanum palustre	7.32	4.96	Yes – broadly calciphile
Phragmites australis	8.26	3.71	No: tolerant of very wide pH range
Rumex hydrolapathum	7.32	5.58	Yes - broadly calciphile
Sium latifolium	6.69	5.72	Yes - intolerant of low pH

2.3.11 No attempt was made to compare water level data collected during 1991 and 2013, as a number of episodes of drought occurred during the early 1990s and, with the exception of the swamp communities adjacent to the broads, the then water table invariably lay below the surface of the fen.

2.4 Limitations

2.4.1 The main survey limitation was in precisely relocating the 1991 quadrats. Reliable relocation of a 2x2m quadrat using a 6 figure grid reference alone is obviously not possible, however it is considered that combining the 6 figure reference with the 1:2500 scale mapping, and the use of facilities such as 'where's the path' made it possible to relocate the quadrats to within 10m of their previous positions.

2.4.2 The aim of survey, as stated above, was to repeat quadrats previously recorded in 1991. The survey aims did not extend to full NVC survey of the Site, nor to mapping of stands of vegetation.

2.4.3 The timings of the survey visits were slightly different. The 2013 survey took place in late June 2013, whilst the 1991 survey took place in mid August 1991. By late June, however, all fen species will have above-ground growth, and it is therefore not expected that the species complement of the quadrats would differ significantly for this reason. It is, however, possible that the percentage cover values for some species might be slightly reduced in June when compared with the situation in August, although as the DOMIN scale is a fairly crude estimate of percentage cover, this may not have significantly affected the DOMIN score and is considered unlikely to have led to any quadrat being attributed to a different NVC community as a result.

2.4.4 The National Vegetation Classification System (NVC) is the standard system for phytosociological classification in the UK. It provides a framework for identifying vegetation types. NVC however, was not developed as a monitoring tool, and is widely recognised as being unsuitable for such usage. Monitoring data produced using NVC are therefore only likely to be able to demonstrate change at a fairly crude level, and so would indicate major damage or very long term trends, but would be much less helpful in identifying very minor or gradual changes, albeit potentially highly significant.

2.4.5 The use of indicator species is to some extent limited by a relatively small sample size, and the broad range of pH values over which many fen species could potentially occur. A further limitation is the response of fen species to management; changes in management, including cessation of management can be responsible for quite significant changes in vegetation composition.

2.4.6 The conclusions, assessment and advice presented in this report are based on the conditions encountered and the information available at the time of writing. The assessment and discussion is based on the ecological data presented within this report, except as indicated. This report is accordingly factually limited by these circumstances.

2.4.7 Certain statements made in this report that are not historical facts may constitute estimates, projections or other forward-looking statements and even though they are based on reasonable assumptions as of the date of the report, there is risk and uncertainty which means that outcomes may differ. We do not guarantee or warrant any estimate or projections contained in this report unless stated.

2.5 Acknowledgements

2.5.1 The permission of the Broads Authority and Natural England to use original data from the 1991 Fen Resource Survey is gratefully acknowledged. NOTE THAT WE ARE STILL AWAITING PERMISSION FROM NE

3 Results and analysis

3.1 Comparison of quadrat data using indicator species

3.1.1 An initial visual comparison between the 1991 quadrat data and the findings of the 2013 survey was undertaken to identify any significant trends in vegetation change. The vegetation descriptions recorded in 1991, and the presence or absence, and relative abundance of species which might be considered as indictors of vegetation change trends, or which are of concern to the landowner, were compared with the equivalent data from 2013. The results are tabulated below, with the relative frequency of indicator species being given using DOMIN. Species present in close proximity to the quadrat (within 10x10m area) are listed as '+'. Species richness of each parcel (including species recorded within 10x10 area) is also given. Species richness (diversity) was also considered.

Parcel	Quadrat number	Grid reference	Brief vegetation description and indicators 1991	Brief vegetation description and indicators 2013
Middle Marsh	071401	TG 37351 21234	Species rich vegetation with occasional Sphagnum mounds. Carex elata + Peucedanum palustre 3 Sphagnum >7 Species Richness 17	Calamagrostis dominated vegetation with Juncus effusus and thick Sphagnum layer Peucedanum palustre 1 Sphagnum 6 Species Richness 16
Middle Marsh	071402	TG 37319 21244	Species poor Phragmites dominated vegetation Peucedanum palustre 2 Species Richness 10	Calamagrostis dominated vegetation, with Phragmites and Myrica gale Myrica gale 4 Peucedanum palustre 1 Sphagnum 2 Species Richness 13
Middle Marsh	071403	TG 37259 21248	Species poor Phragmites dominated vegetation Myrica gale 2 Peucedanum palustre 2 Species Richness 5	Phragmites bed with abundant Calamagrostis and some Myrica and Cladium Myrica gale 5 Peucedanum palustre 2 Sphagnum 3 Species Richness 14
Middle Marsh	071404	TG 37248 21162	Species rich Calamagrostis dominated vegetation Peucedanum palustre + Species Richness 16	Calamagrostis and Thelypteris prominent in mowing marsh, with dense Sphagnum carpet Sphagnum 6 Species Richness 19
Middle Marsh	071405	TG 37272 21178	Species rich Calamagrostis dominated vegetation Peucedanum palustre 1 Species Richness 14	Calamagrostis dominated litter fen Peucedanum palustre 2 Sphagnum 2 Species Richness 15
Middle Marsh	071406	TG 37287 21108	Species rich Phragmites dominated vegetation Carex elata 1 Peucedanum palustre + Sium latifolium 2 Species Richness 16	Species rich S24 reedbed Peucedanum palustre 4 Sphagnum 2 Species Richness 15

Parcel	Quadrat number	Grid reference	Brief vegetation description and indicators 1991	Brief vegetation description and indicators 2013
Middle Marsh	071407	TG 37288 21068	Species poor Phragmites/Juncus dominated vegetation Peucedanum palustre 1 Species Richness 11	Phragmites bed, with Calamagrostis Myrica gale 3 Peucedanum palustre 2 Sphagnum 2 Species Richness 13
Middle Marsh	071408	TG 37355 21186	Acidic grassland with occasional Sphagnum. Species rich Peucedanum palustre + Sphagnum + Species Richness 18	Litter fen; Molina, Juncus articulatus and Anthoxanthum Sphagnum >7 Species Richness 12
Middle Marsh	071409	TG 37357 21147	Rush dominated; species poor Lycopus europaeus + Peucedanum palustre 1 Species Richness 8	Litter fen with Juncus and Calamagrostis: some difficulty in relocating Peucedanum palustre 1 Sphagnum 6 Species Richness 16
Middle Marsh	071410	TG 37386 21239	Species poor Phragmites dominated vegetation Lycopus europaeus 1 Peucedanum palustre 2 Rumex hydrolapathum + Species Richness 10	Phragmites dominated with Calamagrostis, and a ground layer including abundant Sphagnum Peucedanum palustre 2 Sphagnum 4 Species Richness 15
Middle Marsh	071411	TG 37305 21140	Species poor Phragmites dominated vegetation Lycopus europaeus + Peucedanum palustre 2 Species Richness 7	Phragmites swamp Species Richness 6
Mill Marsh (W)	072301	TG 37319 20888	Phragmites bed with abundant Sium latifolium Lycopus europaeus 2 Rumex hydrolapathum 1 Peucedanum palustre + Sium latifolium 4 Species Richness 11	Phragmites bed with Rumex hydrolapathum and Sium Carex elata 1 Peucedanum palustre 1 Rumex hydrolapathum 3 Sium latifolium 3 Sphagnum + Species Richness 12
Mill Marsh (W)	072302	TG 37286 20966	Phragmites bed Lycopus europaeus 1 Peucedanum palustre 1 Rumex hydrolapathum 2 Sium latifolium + Species Richness 11	Reedbed Lycopus europaeus + Peucedanum palustre 2 Rumex hydrolapathum 2 Sium latifolium 1 Species Richness 11
Mill Marsh (W)	072303	TG 37265 20967	Juncus subdnodulosus bed Lycopus europaeus 2 Peucedanum palustre 3 Rumex hydrolapathum + Sium latifolium + Species Richness 11	Juncus, with Phragmites and Calamagrostis: some difficulty in relocating Peucedanum palustre 2 Species Richness 11

Parcel	Quadrat number	Grid reference	Brief vegetation description and indicators 1991	Brief vegetation description and indicators 2013
Mill Marsh (W)	072304	TG 37288 20896	Phragmites community with Cicuta virosa Lycopus europaeus 1 Peucedanum palustre 2 Rumex hydrolapathum 1 Sium latifolium 1 Species Richness 13	Phragmites, with Juncus subnodulosus and Calamagrostis Peucedanum palustre 2 Rumex hydrolapathum + Sium latifolium + Species Richness 12
Mill Marsh (E)	072401	TG 37286 21024	Phragmites bed with Juncus and Cladium. Species rich. Carex elata 1 Lycopus europaeus 1 Myrica gale 1 Peucedanum palustre 3 Species Richness 15	Mixed fen Carex elata 2 Lycopus europaeus 2 Myrica gale 2 Peucedanum palustre 2 Sium latifolium 1 Species Richness 15
Mill Marsh (E)	072402	TG 37305 20980	Patchy Sphagnum-Dryopteris carpet; previous scrub clearance Carex elata 1 Myrica gale + Peucedanum palustre + Sphagnum >5 Species Richness 18	Mixed fen over Sphagnum Peucedanum palustre 2 Sphagnum >7 Species Richness 13
Mill Marsh (E)	072403	TG 37393 20848	Phragmites bed with abundant Cicuta virosa – species rich Lycopus europaeus 1 Peucedanum palustre 2 Rumex hydrolapathum 1 Sium latifolium 1 Species Richness 11	Phragmites bed Peucedanum palustre 2 Rumex hydrolapathum 2 Sium latifolium 1 Species Richness 11
Mill Marsh (E)	072404	TG 37349 20974	Phragmites bed Lycopus europaeus + Peucedanum palustre 3 Rumex hydrolapathum 2 Sium latifolium 3 Species Richness 12	Reed, with invasive Myrica gale – becoming scrubbed over Myrica gale 6 Peucedanum palustre 2 Rumex hydrolapathum 2 Species Richness 11
South Marsh	072501	TG 37412 20961	Heavily trampled area – due to recent pond excavation Peucedanum palustre 3 Species Richness 7	Phragmites, with Calamagrostis and Juncus subnodulosus Carex elata + Lycopus europaeus 1 Myrica gale 3 Species Richness 15
South Marsh	072502	TG 37329 21038	Disturbed ground due to dyke clearance Peucedanum palustre 1 Species Richness 8	Reedbed Lycopus europaeus + Myrica gale + Peucedanum palustre 2 Species Richness 10
South Marsh	072503	TG 37429 21022	Phragmites dominated vegetation Myrica gale 3 Peucedanum palustre 3 Species Richness 9	Phragmites/Calamagrostis dominated fen Myrica gale 1 Peucedanum palustre 1 Species Richness 11

3.1.2 The statements below are based solely on the quadrat data collected in 1991 and 2013, and may not reflect changes elsewhere on the site.

3.1.3 The management of Catfield Hall Fen is reported as having been has been consistent ever since Mr and Mrs Harris acquired the property in 1994 (Peter Riches pers. comm.). The management has been one of rotational cutting to maintain the fen vegetation on annual and longer rotations, as agreed with Natural England and their predecessors. Scrub has been regularly rogued. The management of the sluices has also been consistent during the Harris's ownership.

Changes in species diversity

- South Marsh has seen a general improvement in species diversity in all the surveyed quadrats. This may be due to vegetation recovery following major works on dykes and waterbodies prior to the 1991 survey or could be the result of long term beneficial fen management.
- There has been an overall increase in species diversity at Middle Marsh, perhaps as a result of consistent annual mowing management, with the exception of Quadrat 8, which lies in an area now very much dominated by a dense layer of *Sphagnum.* A similar decline was observed at Quadrat 2 in Mill Marsh East, which again, is now heavily dominated by *Sphagnum.* It is unclear whether the losses of the calciphile species at Middle Marsh are a consequence of local acidification/terrestrialisation caused by the expansion of *Sphagnum*, physical competition with *Sphagnum*, or whether the losses reflect a change in the availability or chemistry of the water irrigating the site.
- There was minimal change in vegetation diversity at Mill Marsh East or Mill Marsh West, excepting a sharp decline in species diversity at Quadrat 2 in Mill Marsh East, as noted above.

Changes in occurrence of acidophiles

- Dramatic and demonstrable expansion of *Sphagnum* spp in Middle Marsh (present in/close proximity to 2 quadrats in 1991 and 10 quadrats in 2013)
- No substantial evidence for expansion of *Sphagnum* spp at Mill Marsh or South Marsh
- Apparent increase in distribution of *Myrica gale* (present in/near 4 quadrats in 1991 and 8 in 2013). This change was particularly evident at Middle Marsh and South Marsh (i.e. over solid peat). In most quadrats where it had occurred previously, the frequency of *Myrica gale* was also elevated. Interpretation of this information should be made with caution, as changes in distribution of *Myrica gale* could be due to a reduction in management intensity; however given that the fen has been in regular management at least since 1994, a 50% increase does tend to suggest acidification of the fens on solid peat. *Myrica gale* occurs over a water pH range of 6.87 to 3.46, and the data could be cautiously interpreted as a reduction in pH levels allowing growth at more locations than previously.

Changes in occurrence of calciphiles

- No evidence for reduction in frequency/occurrence in *Peucedanum palustre* in any of the quadrats surveyed. This species occupies a pH range from 7.32 to 4.96, and so would only be impacted by quite large changes in the pH of the irrigating water
- Apparent reduction in frequency of *Lycopus europaeus* (present in/close to 10 quadrats in 1991 and 4 in 2013; loss has occurred at both Middle Marsh (3 quadrats down to 0, and Mill Marsh). Possible increase in the occurrence of this species at South Marsh is not considered significant as the quadrats in which it occurs had been recently disturbed in at the time of the 1991 survey. *Lycopus* occurs over a narrower pH range than *Peucedanum palustre* (6.78 to 5.59) and is much less tolerant of lower pH.

- There is no evidence for a reduction in frequency/occurrence of *Carex elata* in the quadrats surveyed across the site as a whole (presence in/near 4 quadrats reduced to 3 quadrats); however *Carex elata* is no longer present in the Middle Marsh quadrats (previously present in 2). This could suggest a reduction in pH (*Carex elata* occurs across a pH range of 6.91 to 5.31), although the change may not be significant, given the small number of quadrats in which the species occurs.
- *Sium latifolium* is now present in/near 5 quadrats, compared with 8 in 1991 and is now no longer present at Middle Marsh. The reduction in frequency/occurrence occurs at all sites at which the species was formerly recorded. *Sium latifolium* would respond negatively to drying of the fen.
- Similarly, there is a slight reduction in frequency/occurrence of *Rumex hydrolapathum;* from 7 quadrats down to 5 quadrats and the species is now no longer present at Middle Marsh. Again, this species would also respond negatively to drying of the fen.

3.1.4 The observations set out above could potentially be attributable to either drying of the site or to a reduction in the pH of the irrigating water. As noted above, changes in management intensity could also influence the distribution and frequency of many fen species, including *Myrica gale,* however the management of the fen habitats has reportedly been regular and consistent since 1994. Given the small sample size, some of the changes may not be statistically significant, however, with the exception of *Peucedanum palustre*, all of the species considered appear to show some trend from higher to lower pH and/or relative drying of the fen surface; notably, there is no evidence for an increase in any of the calcium-loving species. The 4 species which have undergone a reduction in frequency and occurrence; *Carex elata, Sium latifolium, Lycopus europaeus* and *Rumex hydrolapathum*, all occupy quite a narrow pH range.

3.1.5 What is unclear, is whether the losses of the calciphile species at Middle Marsh are a consequence of local acidification/terrestrialisation caused by the expansion of *Sphagnum*, physical competition with Sphagnum, or whether the losses reflect a change in the availability or chemistry of the water irrigating the site.

3.2 Comparison of quadrat data using MAVIS

3.2.1 The NVC communities, Ellenberg Wetness Score and Ellenberg pH score are given below for each quadrat recorded. In each case, only the first coefficient listed by MAVIS is given; to ensure objectivity, no attempt has been made to 'manually' ascribe NVC communities to the data gathered. The quadrat data has not been replicated in this report in its entirety for reasons of space. A colour code has been applied to the figures presented in the table below to highlight any key trends.

3.2.2 An initial data comparison appears to show a slight drying and reduction of pH, and so statistical analysis of both the Ellenberg wetness scores and pH scores was undertaken using a one-tailed T-Test (paired data), to test the hypothesis that there has been a reduction in wetness and pH over time. The results of this analysis are set out below:

3.2.3 Analysis was undertaken for the entire dataset, for Middle Marsh alone, for quadrats on solid peat, and for quadrats over turbaries.

Entire dataset

		NVC Community		Ellenberg Wetness Score			Ellenberg pH Score		
Parcel	**Quadrat**	**1991**	**2013**	**1991**	**2013**	**difference**	**1991**	**2013**	**difference**
Middle Marsh	71401	**S27b**	**W2b**	7.3	7.7	0.4	5.9	6.2	0.3
Middle Marsh	71402	**S24g**	**S24g**	9.5	8.9	-0.6	7.2	6.7	-0.5
Middle Marsh	71403	**S24g**	**S24g**	8.7	9	0.3	5.2	5.7	0.5
Middle Marsh	71404	**S24g**	**S24d**	7.9	7.8	-0.1	6.1	6.2	0.1
Middle Marsh	71405	**S24d**	**S27b**	8.3	7.5	-0.8	6.1	5.6	-0.5
Middle Marsh	71406	**S27b**	**S24d**	9.1	9.2	0.1	6.4	6.7	0.3
Middle Marsh	71407	**S24g**	**S24g**	9.3	9.3	0	7.0	6.6	-0.4
Middle Marsh	71408	**M24**	**M6c**	7.5	7.1	-0.4	4.5	4.7	0.2
Middle Marsh	71409	**M23b**	**S24d**	7.6	7.7	0.1	6.2	5.6	-0.6
Middle Marsh	71410	**S24d**	**S24d**	9.5	8.4	-1.1	6.9	6.4	-0.5
Middle Marsh	71411	**S26d**	**S26d**	9.7	9.9	0.2	7.1	7.0	-0.1
Mill Marsh (W)	72301	**S4b**	**S24e**	9.4	9.5	0.1	6.9	6.8	-0.1
Mill Marsh (W)	72302	**S24d**	**S24d**	8.9	9.7	0.8	6.9	6.7	-0.2
Mill Marsh (W)	72303	**S24f**	**S24g**	9.2	8.8	-0.4	7.6	7.4	-0.2
Mill Marsh (W)	72304	**S24e**	**S24g**	9.5	8.7	-0.8	6.8	6.9	0.1
Mill Marsh (E)	72401	**S24g**	**S24e**	9.3	9.3	0	7.2	7.0	-0.2
Mill Marsh (E)	72402	**W2b**	**S24g**	6.0	7.8	1.8	6.1	6.7	0.6
Mill Marsh (E)	72403	**S24e**	**S24a**	9.6	9.2	-0.4	6.7	6.6	-0.1
Mill Marsh (E)	72404	**S24e**	**S24g**	9.6	9.4	-0.2	7	5.9	-1.1
South Marsh	72501	**S24g**	**S24g**	9.2	9.4	0.2	7.4	6.9	-0.5
South Marsh	72502	**S24g**	**S24a**	8.7	9.5	0.8	6.6	6.9	0.3
South Marsh	72503	**S24g**	**S24g**	9.6	9.4	-0.2	6.6	7.1	0.5
MEDIAN				**9.20**	**9.10**		**6.75**	**6.70**	
MEAN				**8.79**	**8.78**	**-0.01**	**6.56**	**6.47**	**-0.10**
ST.DEV				**0.97**	**0.82**		**0.72**	**0.63**	
T-TEST (p0.05)					**0.473280403**			**0.154401813**	

Middle Marsh only

		NVC Community		Ellenberg Wetness Score			Ellenberg pH Score		
Parcel	**Quadrat**	**1991**	**2013**	**1991**	**2013**	**difference**	**1991**	**2013**	**difference**
Middle Marsh	71401	**S27b**	**W2b**	7.3	7.7	0.4	5.9	6.2	0.3
Middle Marsh	71402	**S24g**	**S24g**	9.5	8.9	-0.6	7.2	6.7	-0.5
Middle Marsh	71403	**S24g**	**S24g**	8.7	9.0	0.3	5.2	5.7	0.5
Middle Marsh	71404	**S24g**	**S24d**	7.9	7.8	-0.1	6.1	6.2	0.1
Middle Marsh	71405	**S24d**	**S27b**	8.3	7.5	-0.8	6.1	5.6	-0.5
Middle Marsh	71406	**S27b**	**S24d**	9.1	9.2	0.1	6.4	6.7	0.3
Middle Marsh	71407	**S24g**	**S24g**	9.3	9.3	0	7.0	6.6	-0.4
Middle Marsh	71408	**M24**	**M6c**	7.5	7.1	-0.4	4.5	4.7	0.2
Middle Marsh	71409	**M23b**	**S24d**	7.6	7.7	0.1	6.2	5.6	-0.6
Middle Marsh	71410	**S24d**	**S24d**	9.5	8.4	-1.1	6.9	6.4	-0.5
Middle Marsh	71411	**S26d**	**S26d**	9.7	9.9	0.2	7.1	7.0	-0.1
MEDIAN				**8.70**	**8.40**		**6.20**	**6.20**	
MEAN				**8.58**	**8.41**	**-0.17**	**6.24**	**6.13**	**-0.11**
ST.DEV				**0.90**	**0.90**		**0.83**	**0.67**	
T-TEST (p0.05)				**0.132885694**			**0.195548385**		

Quadrats over turbary

		NVC Community		Ellenberg Wetness Score			Ellenberg pH Score		
Parcel	**Quadrat**	**1991**	**2013**	**1991**	**2013**	**difference**	**1991**	**2013**	**difference**
Mill Marsh (W)	72301	**S4b**	**S24e**	9.4	9.5	0.1	6.9	6.8	-0.1
Mill Marsh (W)	72302	**S24d**	**S24d**	8.9	9.7	0.8	6.9	6.7	-0.2
Mill Marsh (W)	72303	**S24f**	**S24g**	9.2	8.8	-0.4	7.6	7.4	-0.2
Mill Marsh (W)	72304	**S24e**	**S24g**	9.5	8.7	-0.8	6.8	6.9	0.1
Mill Marsh (E)	72401	**S24g**	**S24e**	9.3	9.3	0	7.2	7.0	-0.2
Mill Marsh (E)	72402	**W2b**	**S24g**	6.0	7.8	1.8	6.1	6.7	0.6
Mill Marsh (E)	72403	**S24e**	**S24a**	9.6	9.2	-0.4	6.7	6.6	-0.1
Mill Marsh (E)	72404	**S24e**	**S24g**	9.6	9.4	-0.2	7.0	5.9	-1.1
MEDIAN				**9.35**	**9.25**		**6.90**	**6.75**	
MEAN				**8.94**	**9.05**	**0.11**	**6.90**	**6.75**	**-0.15**
ST.DEV				**1.21**	**0.61**		**0.43**	**0.42**	
T-TEST (p0.05)				**0.35593613**			**0.197887633**		

Quadrats over solid peat

		NVC Community		Ellenberg Wetness Score			Ellenberg pH Score		
Parcel	**Quadrat**	**1991**	**2013**	**1991**	**2013**	**difference**	**1991**	**2013**	**difference**
Middle Marsh	71401	**S27b**	**W2b**	7.3	7.7	0.4	5.9	6.2	0.3
Middle Marsh	71402	**S24g**	**S24g**	9.5	8.9	-0.6	7.2	6.7	-0.5
Middle Marsh	71403	**S24g**	**S24g**	8.7	9	0.3	5.2	5.7	0.5
Middle Marsh	71404	**S24g**	**S24d**	7.9	7.8	-0.1	6.1	6.2	0.1
Middle Marsh	71405	**S24d**	**S27b**	8.3	7.5	-0.8	6.1	5.6	-0.5
Middle Marsh	71406	**S27b**	**S24d**	9.1	9.2	0.1	6.4	6.7	0.3
Middle Marsh	71407	**S24g**	**S24g**	9.3	9.3	0	7.0	6.6	-0.4
Middle Marsh	71408	**M24**	**M6c**	7.5	7.1	-0.4	4.5	4.7	0.2
Middle Marsh	71409	**M23b**	**S24d**	7.6	7.7	0.1	6.2	5.6	-0.6
Middle Marsh	71410	**S24d**	**S24d**	9.5	8.4	-1.1	6.9	6.4	-0.5
Middle Marsh	71411	**S26d**	**S26d**	9.7	9.9	0.2	7.1	7.0	-0.1
South Marsh	72501	**S24g**	**S24g**	9.2	9.4	0.2	7.4	6.9	-0.5
South Marsh	72502	**S24g**	**S24a**	8.7	9.5	0.8	6.6	6.9	0.3
South Marsh	72503	**S24g**	**S24g**	9.6	9.4	-0.2	6.6	7.1	0.5
MEDIAN				**8.90**	**8.95**		**6.50**	**6.50**	
MEAN				**8.71**	**8.63**	**-0.08**	**6.37**	**6.31**	**-0.06**
ST.DEV				**0.84**	**0.90**		**0.80**	**0.69**	
T-TEST (p0.05)					**0.285447397**			**0.288265408**	

3.2.4 Key conclusions arising from this exercise are as follows

- Preliminary analysis revealed that the NVC community attributed to each set of data using MAVIS did not vary significantly between 1991 and 2013, and there are no clear or obvious trends, although the frequency of occurrence of the S24e communities has reduced. There appears to be a shift towards Sphagnum mire vegetation at Middle Marsh quadrat 8. A shift towards S24a in 2 quadrat locations may represent a more pronounced tussock structure.
- There is no clear relationship between the NVC community as identified using MAVIS, and the Ellenberg pH value, however certain of the NVC communities as identified using MAVIS show a significant correlation with wetter conditions as indicated by the Ellenberg wetness score, most notably S24d, S24e and S24f vegetation communities. Conversely, W2b is associated with very much drier conditions as indicated by the Ellenberg wetness score. In itself, this is not a significant finding, as of course the Ellenberg wetness score and the NVC community have been determined using the same dataset.
- There is arguably a reduced Ellenberg pH score at the higher end of the range, i.e. a general shift towards plant assemblages which indicate slightly more acidic conditions although, conversely some quadrats saw a slight increase. Notably,

there was a significant drop of (0.4 points or more on the Ellenberg scale) in the Eastern part of Middle Marsh.

- The Ellenberg Wetness score indicates a trend towards increased dryness in some parts of the site, but conversely in others there has been a slight increase. It is understood that following vandalism in the mid 1990s the sluice in the south of this fen system was repaired, and although the height of the sluice board was not raised, the greater water retentiveness of the new structure may have resulted in the fen parcels closest to the sluice becoming slightly wetter.
- The quadrat locations showing particularly pronounced drying are in the E part of Middle Marsh. In the other fen parcels surveyed, there is no clear pattern.
- Statistical analysis shows that there is a small overall reduction in both the Ellenberg wetness and pH scores, with mean reductions of -0.01 and -0.10 respectively for the full dataset. Analysis of the quadrats over solid peat gave reductions of -0.6 and -0.8, but this trend is most pronounced when Middle Marsh is considered in isolation, with reductions of-0.17 and -0.11 respectively. Use of the paired T-Test indicated, however, that the observed trend is not statistically significant ($p = 0.05$; values in excess of 0.05 are not statistically significant), but a trend undoubtedly exists.
- It is questioned whether Ellenberg is a sufficiently precise tool to look at minor variations in ‘wetness’ or pH and it may be the case that analysis of the data using different software could better illustrate a decrease in wetness over solid peat, and an overall decline in pH.

4 Conclusions and discussion

4.1 Conclusions

4.1.1 The conclusions set out below are based solely on the 1991 and 2013 quadrat data.

- There has been demonstrable, dramatic expansion of *Sphagnum* spp in Middle Marsh (present in/close proximity to 2 quadrats in 1991 and 10 quadrats in 2013), but no substantial evidence for an increase in the frequency of *Sphagnum* spp at Mill Marsh or South Marsh.
- Species diversity for almost all quadrats increased slightly over the period from 1991 to 2013, perhaps as a result of regular management. The most notable increases were seen at Middle Marsh and South Marsh. Mill Marshes had not changed significantly in terms of species diversity.
- The main exceptions to this were Middle Marsh Quadrat 8, which lies in an area now very much dominated by a dense layer of *Sphagnum.* A similar decline was observed at Quadrat 2 in Mill Marsh East, which again, is now heavily dominated by *Sphagnum*. It is unclear whether the losses of the calciphile species at Middle Marsh are a consequence of local acidification/terrestrialisation caused by the expansion of *Sphagnum*, physical competition with Sphagnum, or whether the losses reflect a change in the availability or chemistry of the water irrigating the site.
- There has been an apparent increase in distribution of *Myrica gale* (present in/near 4 quadrats in 1991 and 8 in 2013). This change was particularly evident at Middle Marsh and South Marsh (i.e. over solid peat). In most quadrats where it had occurred previously, the frequency of *Myrica gale* was also elevated. Interpretation of this information should be done with caution, as changes in distribution of *Myrica gale* could be due to a reduction in management intensity; however there is evidence to suggest that rotational management has been undertaken regularly since 1994, and a 50% increase does therefore tend to suggest acidification and drying of the fens on solid peat. *Myrica gale* occurs over a water pH range of 6.87 to 3.46, and the data could be cautiously interpreted as a reduction in pH levels allowing growth at more locations than previously.
- There has been an apparent reduction in frequency of the calciphiles *Lycopus europaeus, Carex elata, Sium latifolium* and *Rumex hydrolapathum*. *Sium latifolium* and *Rumex hydrolapathum* would also respond negatively to drying of the fen.
- Preliminary analysis revealed that the NVC community attributed to each set of data using MAVIS did not vary significantly between 1991 and 2013, and there are no clear or obvious trends, although the frequency of occurrence of the S24e communities has reduced. There appears to be a shift towards Sphagnum mire vegetation at Middle Marsh quadrat 8.
- There is arguably a reduced Ellenberg pH score at the higher end of the range, i.e. a general shift towards plant assemblages which indicate slightly more acidic conditions although, conversely some quadrats saw a slight increase. Notably, there was a significant drop of 0.4 points or more on the Ellenberg scale in the Eastern part of Middle Marsh.
- The Ellenberg Wetness score indicates a trend towards increased dryness in some parts of the site, but conversely in others there has been a slight increase. It is understood that following vandalism in the mid 1990s the sluice in the south of this fen system was repaired, and although the height of the sluice board was not raised, the greater water retentiveness of the new structure may have resulted in the fen parcels closest to the sluice (e.g. Mill Marsh East and West) becoming very slightly wetter.
- The quadrat locations showing particularly pronounced drying are in the Eastern part of Middle Marsh. In the other fen parcels surveyed, there is no clear pattern.

- Statistical analysis shows that there is a small overall reduction in both the Ellenberg wetness and pH scores between 1991 and 2013, with mean reductions of --0.01 and -0.10 respectively for the full dataset. Analysis of the quadrats over solid peat gave reductions of -0.6 and -0.8, but this trend is most pronounced when Middle Marsh is considered in isolation, with reductions of-0.17 and -0.11 respectively. Use of the paired T-Test indicated, however, that the observed trend is not statistically significant (p = 0.05; values in excess of 0.05 are not statistically significant), but a trend undoubtedly exists.
- It is questioned whether Ellenberg is a sufficiently precise tool to look at minor variations in 'wetness' or pH and it may be the case that analysis of the data using different software could better illustrate a decrease in wetness over solid peat, and an overall decline in pH.

4.2 Discussion

4.2.1 The National Vegetation Classification System (NVC) is the standard system for phytosociological classification in the UK. It provides a framework for identifying vegetation types. NVC however, was not developed as a monitoring tool, and is widely recognised as being unsuitable for such usage. Monitoring data produced using NVC are therefore only likely to be able to demonstrate change at a fairly crude level, and so would indicate major damage or very long term trends, but would be much less helpful in identifying minor or gradual changes, albeit potentially highly significant.

4.2.2 The observations set out above could potentially be attributable to either drying of the site or to a reduction in the pH of the irrigating water. As noted above, changes in management intensity could also influence the distribution of certain species. Given the small sample size, some of the changes may not be statistically significant, however, all of the species considered appear to show some trend from higher to lower pH and/or relative drying of the fen surface; notably, there is no evidence for an increase in frequency of any of the calcium-loving species. The 4 species which have undergone a reduction in frequency and occurrence; *Carex elata, Sium latifolium, Lycopus europaeus* and *Rumex hydrolapathum*, all occupy quite a narrow pH range.

4.2.3 It is unclear whether the losses of the calciphile species at Middle Marsh are a consequence of local acidification/terrestrialisation caused by the expansion of *Sphagnum*, physical competition with Sphagnum, or whether the losses reflect a change in the availability or chemistry of the water irrigating the site.

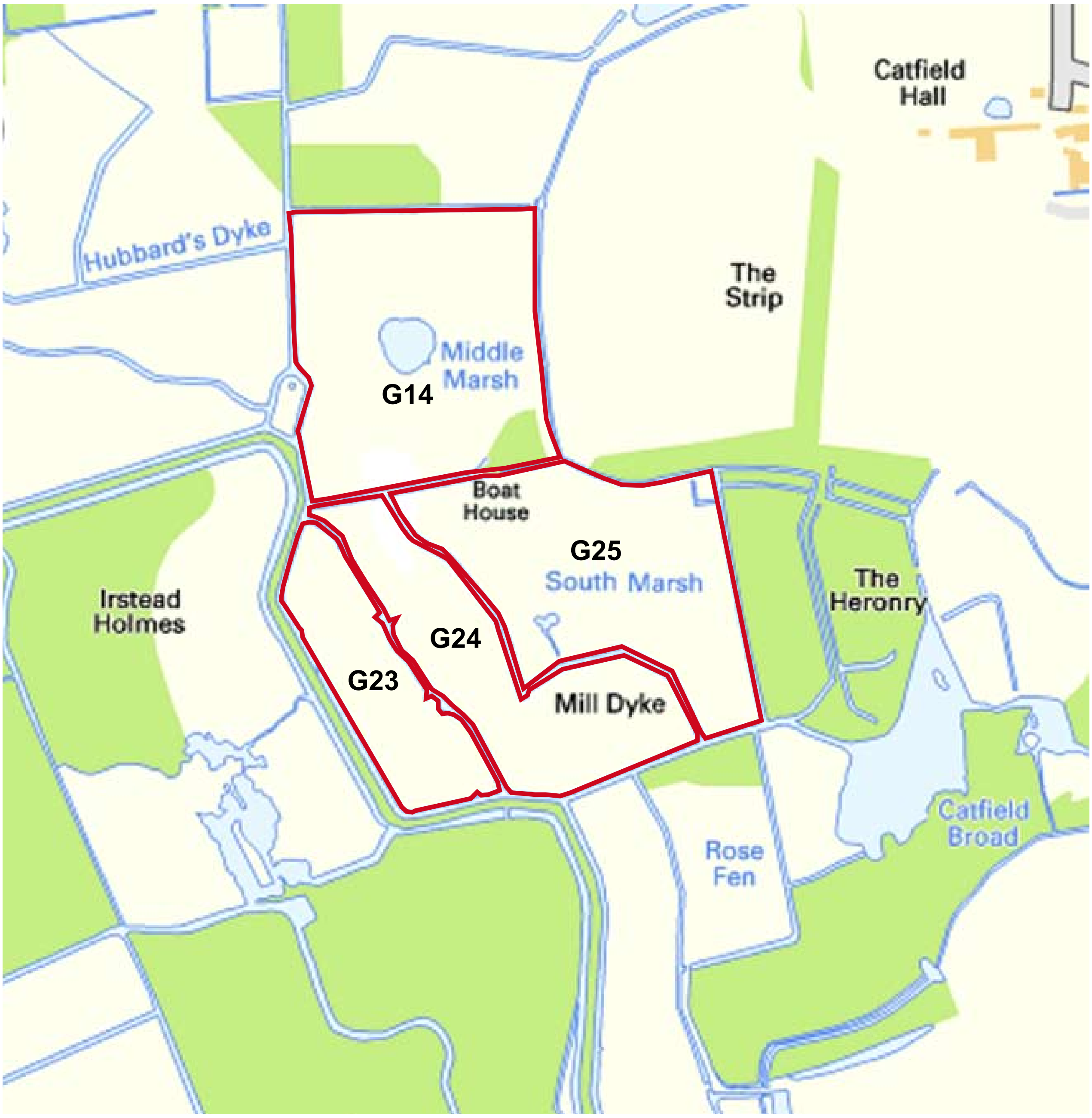
4.2.4 It is considered that the above changes suggest that there have been some adverse changes to the fen habitat at Catfield Fen. Whilst changes are relatively slight, and not all of the observed trends are statistically significant, it appears likely that the observed changes signal an ongoing trend towards drier calcifugous communities on the solid peat.

4.2.5 Whilst the development of *Sphagnum* polsters is of undoubted interest, and limited expansion of *Sphagnum* dominated vegetation could be regarded as increasing the diversity of the fen communities at the site, it is clear that the areas most heavily dominated by *Sphagnum* have seen a reduction in species diversity of up to a third, and it is considered probable that if this trend continues, the species rich fen communities at this site could be significantly impacted.

4.2.6 It is speculated, although more work would be required to verify this, that the development of *Sphagnum* polsters is being accelerated by decreased pH at marsh surface, possibly due to an increased reliance on rainfall as opposed to groundwater, which would be slightly alkaline. The progression to ombrotrophic mire and hence woodland is a successional change, which would usually be a very slow process, however it is possible that the increased rate of this progression as seen in recent years, is to some extent being influenced by the chemistry of the water irrigating the fen.

4.2.7 It would also be helpful to consider the precautionary principal: there is no data to show that water abstraction from a point close to the fen is **not** having an adverse impact upon the wetland vegetation communities of this part of Catfield Fen.

Figures



0.5km

Key

Parcels of marsh surveyed

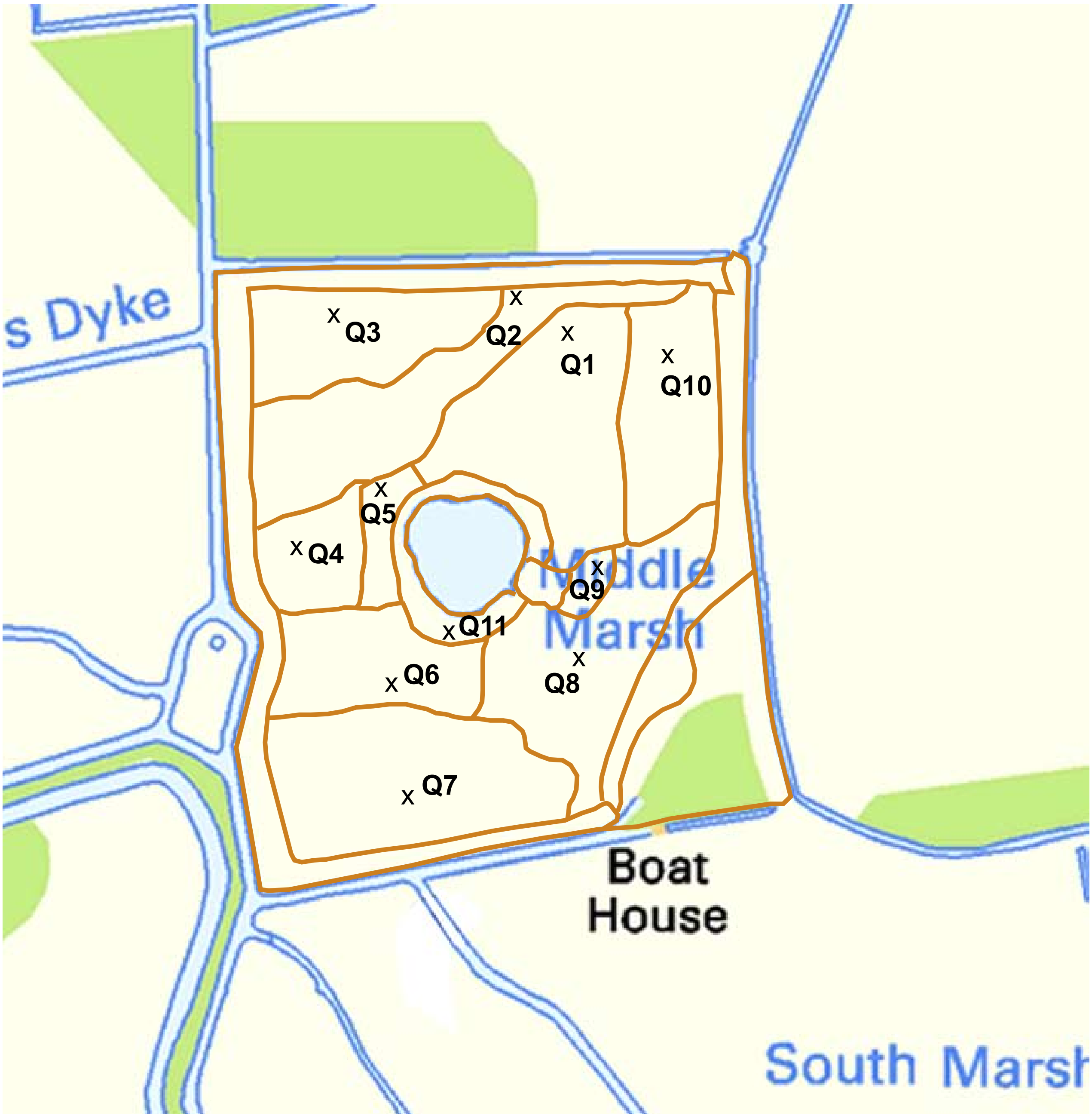
E13838 Catfield Fen

Location Plan

Figure 01

July 2013

thelandscapepartnership



Key

X Q1 Quadrat locations

E13838 Catfield Fen

Quadrat locations G14

Figure 02a

July 2013

thelandscapepartnership

Key

x Q1	Quadrat locations

E13838 Catfield Fen

Quadrat locations G23

Figure 02b

July 2013

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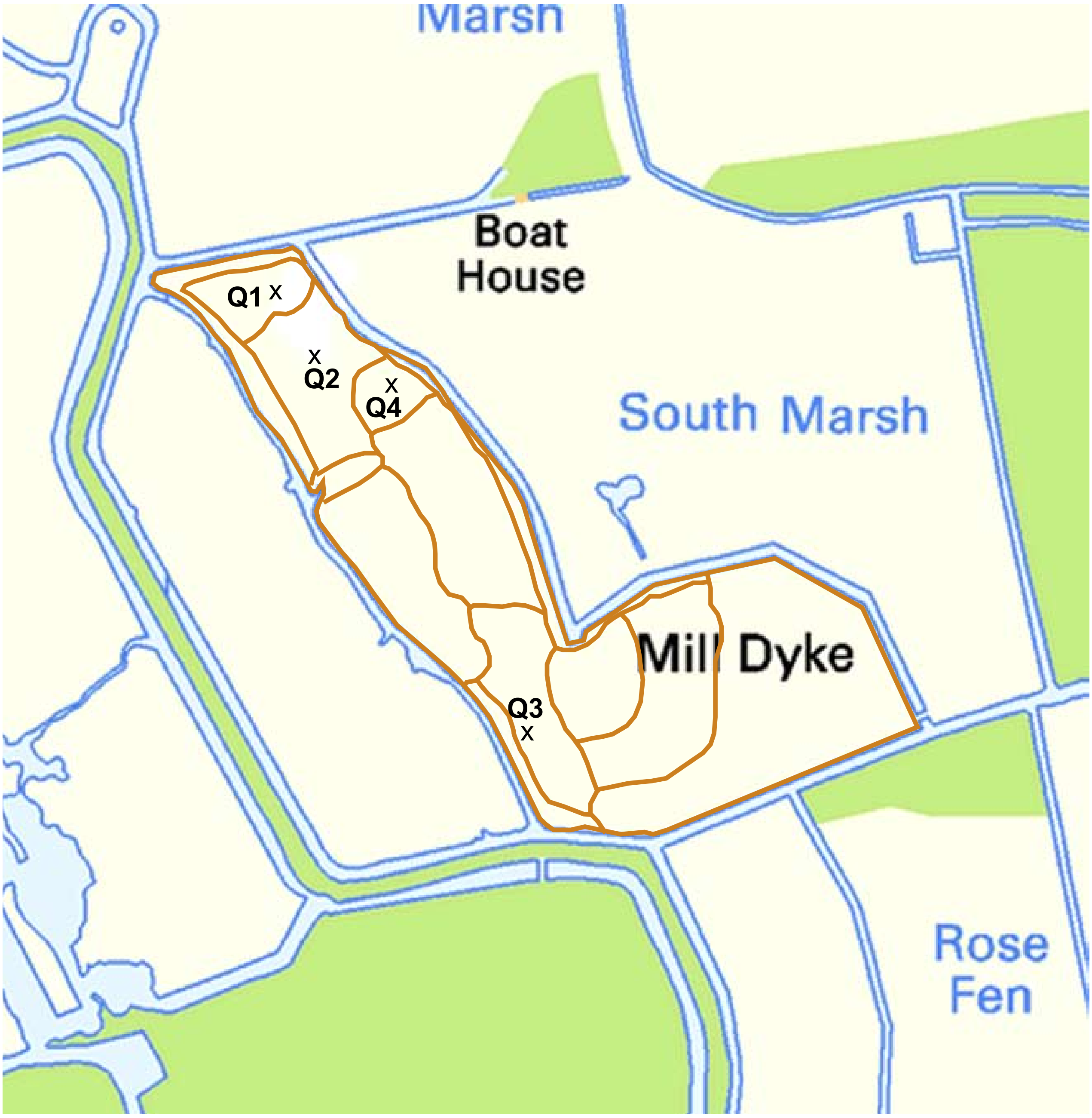

Key

X **Q1** Quadrat locations

E13838 Catfield Fen

Quadrat locations G24

Figure 02c

July 2013

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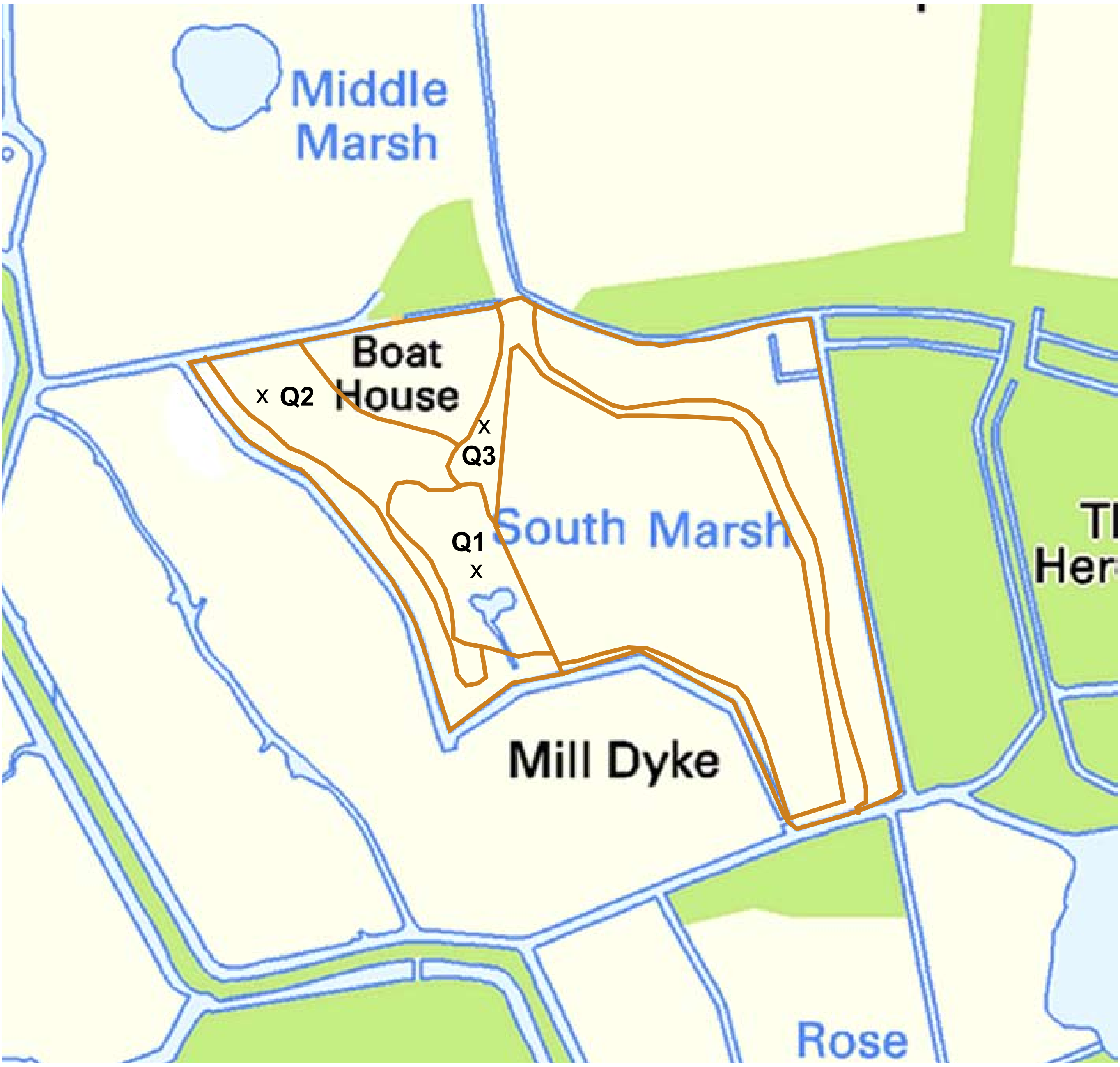

Key

x **Q1** Quadrat locations

E13838 Catfield Fen

Quadrat locations G25

Figure 02d

July 2013

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