Fen Raft Spider Recovery Project:
2008 Summary Report for Redgrave & Lopham Fen

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Summary

1 This report describes the results from the eighteenth year of systematic monitoring of the nationally endangered fen raft spider (*Dolomedes plantarius*) at Redgrave & Lopham Fen National Nature Reserve, on the Norfolk/Suffolk border. This work was undertaken as part of Natural England's Species Recovery and BAP programmes in 2008. Habitat survey and management work and measurements of surface water levels are also documented and discussed in relation to spider population trends.

2 Throughout the 18-year census the population was very small and its range restricted to two small and spatially separated areas, on Little Fen and Middle Fen.

3 Desiccation of the fen by artesian abstraction, thought to be responsible for the decline in this semi-aquatic species, ended in 1999 with relocation of a borehole that had drained the fen. This, in combination with higher than average rainfall in the following two years, resulted in rapid hydrological recovery.

4 An annual index of population size that allowed statistical comparison between years showed that the census data were best described by a model in which population size varied substantially and sometimes significantly between years with no evidence of a sustained upward or downward trend.

5 Modelling of the data sets for both the Little and Middle Fen sub-populations showed that there was a significant difference between them in the pattern of annual variation. In 2008 the index for both sub-populations was slightly higher than in 2007 but well within the range of values for the previous 17 years.

6 The range occupied by *D. plantarius* on Middle Fen increased in 2008, building on an expansion begun in 2006. Spiders were found along a linear series of ponds, over 120m beyond the area in which they had been recorded since 1993. This returned them to one extremity of a series of ponds on which they were last recorded in the mid-1980s. This the first range expansion since monitoring began.

7 Numbers of breeding females on both Little and Middle Fen were not quite as high as in 2007 but there was evidence that 2008 was a second, successive good breeding season.

8 Rotational mowing of *Cladium mariscus,* which dominated the core areas for *D. plantarius*, was abandoned in favour of extensive grazing in summer 2002. Failure of the stock to graze much of the area occupied by *D. plantarius* on Little Fen necessitated supplementary mowing of stands of tall fen vegetation from 2004 onwards. In 2007 and 2008 the stands that were cut were outside the census area. On Middle Fen, rotational mowing of mature stands of *C. mariscus* within the core area for *D. plantarius* was resumed in 2006. In the area into which the population extended in 2008 *C. mariscus* is largely confined to the pool margins and the vegetation is managed effectively by grazing.

9 High rainfall, particularly in March and August, sustained high summer water levels in the core spider areas. Summer water levels in ponds on Great Fen, likely to be used as a focus for a re-introduction of *D. plantarius,* were sustained proportionally better in 2007 and 2008 than in previous years. This coincides with, and may be attributable to, the effective operation of a new sluice on the river immediately downstream from this part of the fen.

10 A survey of the main vegetation stands throughout the Fen complex, particularly in relation to the distribution and abundance of *C. mariscus* and of deep standing water, showed that there is considerable and increasing potential for re-colonisation of the Fen by *D. plantarius*.

11 Opportunities for natural recolonisation from the existing sub-populations could be substantially increased by the excavation of new turf ponds in areas of suitable vegetation. Because of the very slow rate of natural dispersal, translocation will be required to assist recolonisation of more isolated areas of the Fen. These include Great Fen and some of the scrapes created in the late 1990s and in which *C. mariscus* is starting to replace *Phragmites australis* as the dominant marginal emergent.

12 Translocation is expected to be the primary means of achieving the BAP target of an increase in the number of sustainable populations of *D. plantarius* across the UK. The monitoring data from Redgrave & Lopham Fen in 2008 suggest that translocation, together with targeted habitat management to allow further natural expansion in range, will also help to achieve the BAP target for increase in the occupied area at this site.

Contents

1 Introduction

This report summarises monitoring and management work undertaken as part of the Fen Raft Spider (*Dolomedes plantarius*) Recovery Project at Redgrave & Lopham Fen National Nature Reserve (NNR) in 2008, the eighteenth year of monitoring and targeted management for *D. plantarius* at this site. Redgrave & Lopham Fen remains one of only three UK sites for this Schedule 5 species. The recovery project was initiated in 1991 (under English Nature's Species Recovery Programme) to prevent extinction of this population, which had been reduced to very low levels by desiccation of the site by artesian abstraction since 1960, compounded by droughts in the 1980s and 1990s (Smith 2000). By the late 1980s, the remnant population had become restricted to turf ponds on two separate parts of the NNR. Throughout the 1990s, despite targeted habitat management, monitoring showed not only that there was no significant increase in the size of the population, but also that its range was continuing to contract. Between 1991 and 1999, irrigation of the ponds inhabited by the spiders appeared to be the key factor in their persistence (Smith 2000).

Rapid hydrological recovery of the fen, following the ending of artesian abstraction in 1999, was expected to result in a rapid increase in *D. plantarius*, which has very high potential fecundity. This expectation was encapsulated in the original *D. plantarius* Species Action Plan targets for this site (U.K. Biodiversity Steering Group 1999), of a sustained increase in density per pond to the maximum recorded during the 1990s, and a ten-fold increase in range.

By the time of the 2005 BAP Review, the *D. plantarius* population showed no sign of sustained or significant recovery (Smith 2006). It was clear both that any recovery would be slow and that the wetness of the fen was not the only factor required to trigger it. Revised targets (BARS 2008) included both a less ambitious increase in range on Redgrave & Lopham Fen (to 13 Ha in three years out of every five by 2010, and to 65 Ha by 2020) and reduction in the risk of stochastic extinction by the establishment of six more sustainable populations by 2010. By 2020 the total number of sites with sustainable populations should be increased to 12.

In 2007, for the first time since the current highly standardised census was established in 1993, and eight years after restoration of the fen's hydrology, the range of one of the two sub-populations remaining on the fen increased over a distance of around 75m. This change was not accompanied by any significant increase in an annual index of population size but it was the first indication that habitat conditions beyond the core range of this sub-population were becoming suitable for the spiders.

This report presents the 2008 results from the standardised annual census of *D. plantarius* at Redgrave & Lopham Fen and examines the progress of this range expansion as well as changes in population size and in breeding success. These results are discussed in the context of the previous seventeen years' monitoring data and are used to assess progress towards the BAP targets for this site. The results of a survey of the habitat suitability for *D. plantarius* throughout the Redgrave & Lopham Fen complex are used to assess the possibilities for natural recolonisation of the Fen and the potential need for translocation to ensure that the BAP targets for this site can be met. The influence of habitat management on the current distribution of *D. plantarius* is discussed together with the potential for using targeted management to encourage natural recolonisation and prepare for translocation. This report also describes the results of monthly monitoring of water levels in the census ponds and summarises ground water and rainfall data collected the Suffolk Wildlife Trust, the NNR managers.

More detailed analyses of the census data to examine the effects of water levels and of vegetation management on the long-term trends in numbers are beyond the scope of this report but will be published in the scientific literature. Further background to the project, and details of previous years' work, are given by Duffey (1991) and Smith (1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000a and b, 2005, 2006, 2007, 2008).

2 Methods

2.1 Annual census

The annual census of *D. plantarius* followed the methodology adopted in 1993 and described by Smith (1993, 2000, 2007). Three replicate counts were made at 29 turf ponds on Little Fen (Fig. 1) and 30 on Middle Fen (Fig. 2) in late July and early August. Whenever consistent and favourable weather conditions allowed, the counts for each fen were made on three consecutive days. In 2008, the census period coincided with one of the very few periods of settled and sunny weather during the summer (Table 1).

In 2000 and 2001 very high water levels made it impossible to census Little Fen during the summer. From 2002 onwards, two Little Fen ponds included in the original scheme had to be excluded from the census because they had been substantially infilled with spoil during the fen restoration operations (Harding 2000). Counts at two other Little Fen ponds were made from the bank because the depth of sediment made work in the water unsafe (L31 and L33: Fig. 1). By 2004 two of the three replicate counts at a further pond (L36) also had to be made from the bank and in subsequent years all counts at this pond were made from the bank.

Table 1 Census dates for 1994-2008

Year	July (& /Aug.) Census dates	
	Little Fen	Middle Fen
1994	26-29	9-18/08
1995	20-25	27-1/08
1996	18-21	22-26
1997	24-21	22-26
1998	18-21	21-24
1999	17-19	21-26
2000	-	17-20
2001	-	17-20
2002	14-18	19-21
2003	18-22	23-27
2004	21-27	12-24
2005	21-05/08	18-21
2006	13-17	17-20
2007	31-11/08	19-31
2008	24-28	21-23

2.2 Analyses of annual census data

The annual census data are expressed as an index derived from analyses of population trends carried out using generalised linear models, with the maximum count for each pond in July as the response variable (Smith 1995, 2000). Log-linear Poisson regression models were fitted to the systematic data collected since 1991 (excluding Little Fen in 2000 and 2001, when it was deeply inundated)**,** as implemented in program TRIM (Pannekoek and van Strien, 1998). TRIM allows the data to be split into different strata: in this context Little and Middle Fens form separate co-variate strata. The model also allows sites to be censused in some years and not others and so both the data from the set of ponds censused at the outset of the project (1991-1995), and those from the set of ponds censused from 1993 onwards, could be utilised (see Smith 1995).

The program fits five standard models: (i) no time (year) effects; (ii) linear trend (in log numbers); (iii) linear trends within covariate strata (linear trends differ between Little and Middle Fen); (iv) time effects (separate effects for each year); (v) time-effects within covariate strata (year effects differ between Little and Middle Fen.

2.3 Breeding indicators

Very limited but comparable quantitative information on breeding success each year is derived from the counts of adult females and of nursery webs during the annual census (above). Additional information is derived from casual records and from sedge-cutting management but this cannot be used for quantitative comparison between years.

2.4 Water levels

Routine water level measurements against posts in the census ponds on Little and Middle Fens, and in the ponds dug on Great Fen in 1998 (Smith 2000, 1998), were carried out at approximately monthly intervals. The levels in the Little and Middle Fen ponds are expressed relative to an arbitrary datum established in April 1992. The heights of the measuring posts in the Great Fen ponds were levelled and so the measurements are expressed relative to Ordnance Datum.

Ground water levels on the Fen have been monitored by the Suffolk Wildlife Trust (SWT) since 1976 using a network of 54 piezometer tubes (Smith 2000). Most of these monitor near-surface hydrology: eight are sunk into the underlying chalk. The data presented in this report are the highest monthly mean recorded from all of these tubes between November and April (winter maximum) and the lowest monthly mean recorded between May and September (summer minimum) each year. Although this is a coarse measure, it gives a good picture of differences between years over the 31-year recording period. Monthly rainfall data measured by the SWT at a gauge on the fen since 2001 are also presented.

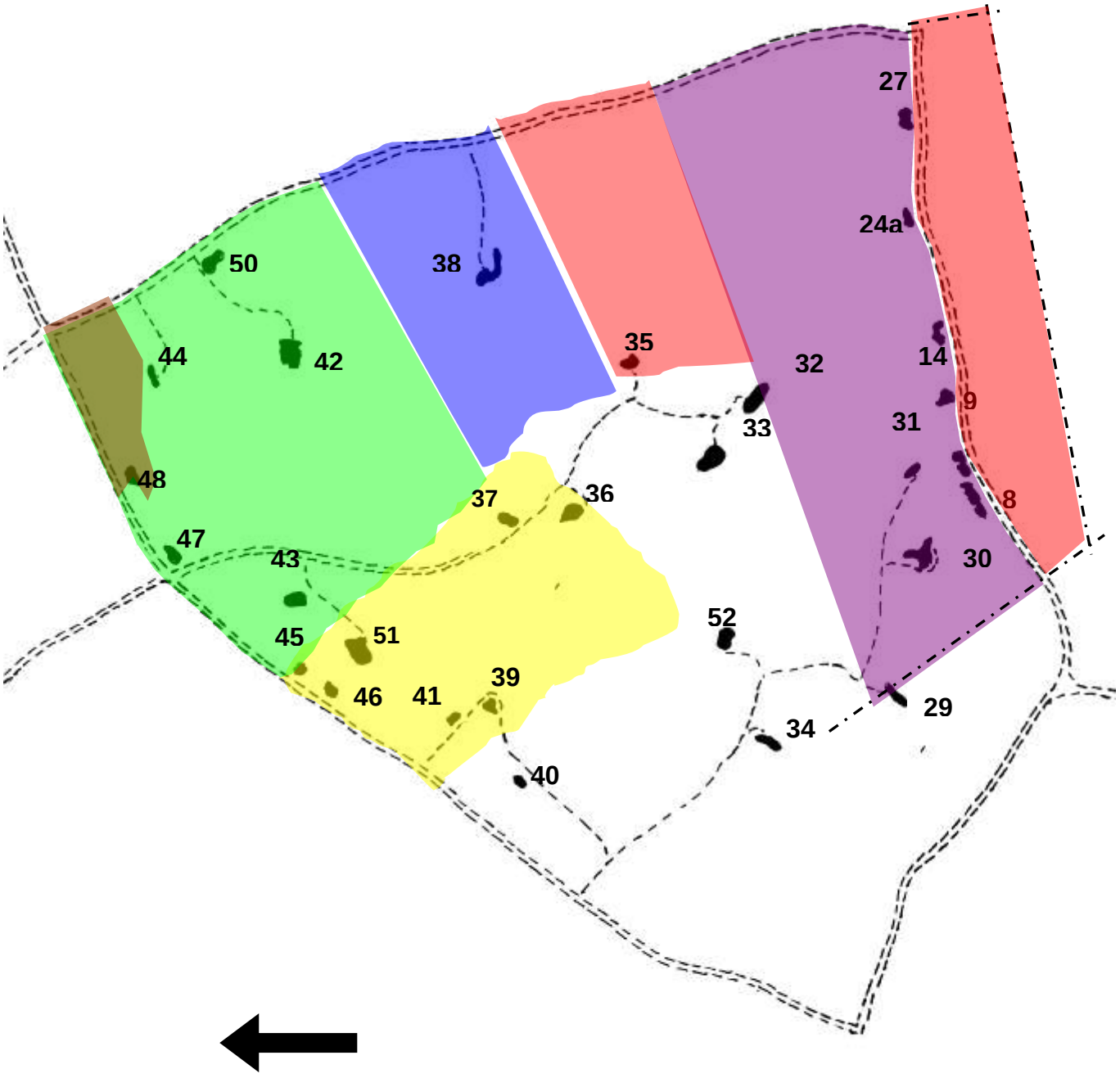
2.5 Survey of *Cladium mariscus* and suitability of fen areas for recolonisation *by D. plantarius*

A survey of the main vegetation types on the fen peat areas, focussing particularly on the distribution of *C. mariscus* in relation to the availability of standing water, either as turf ponds or recent large scrapes, was carried out in early autumn 2008. The fen surface was subdivided into easily physically defined blocks (Appendix 1: Fig. A1), within which both the main vegetation stands, and the abundance of *C. mariscus* within them, was mapped onto recent aerial photographs of the site. The major stands of vegetation were described in notes accompanying the maps. The data are qualitative but make the following distinctions for *C. mariscus*:

- *C. mariscus* beds (>80%)
- where *C. mariscus* was less dominant, its abundance/age and the character of the vegetation matrix in which it occurs was noted
- whether or not it occurred in association with ponds/scrape that were likely to retain water in most summers.

The notes were used to provide an assessment, for each of the mapped areas of the Fen, of their suitability for *D. plantarius,* the likely time-scale on which they may become suitable, and the likelihood of re-colonisation occurring naturally. These results were summarised as a map showing the potential for re-establishment of *D. plantarius* in all of the fen peat areas in which suitable conditions may be expected to within the next 10-15 years.

Fig. 1 The Little fen census area showing ponds included in the census. Shading shows areas where vegetation was cut and removed in July/August each year: 2001, 2002, 2003, 2004, 2005 and 2006. Broken black line: -------- shows boundary of area from which stock were excluded until 2004.



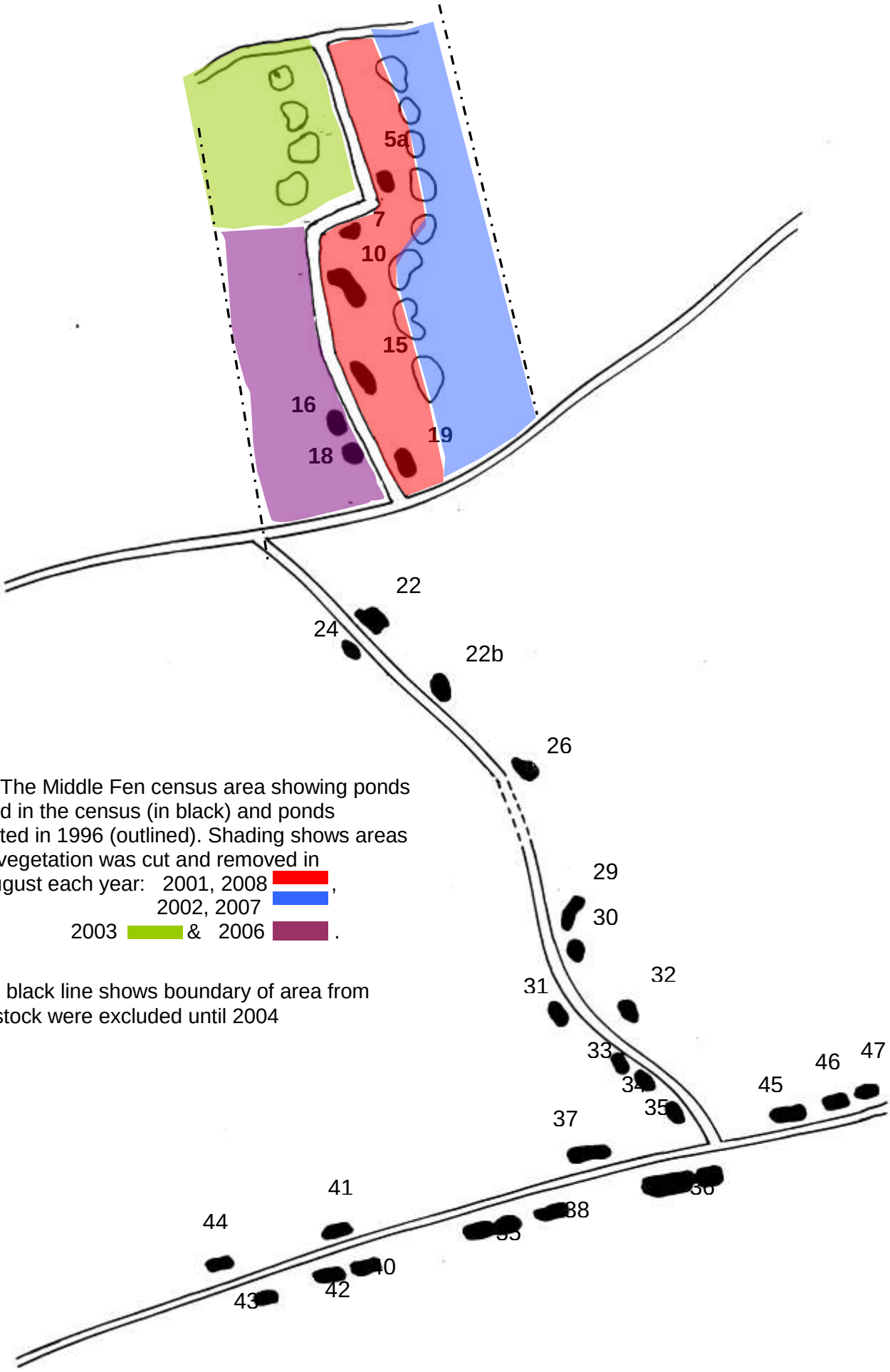


Fig. 2 The Middle Fen census area showing ponds included in the census (in black) and ponds excavated in 1996 (outlined). Shading shows areas where vegetation was cut and removed in July/August each year: 2001, 2008 , 2002, 2007 2003 & 2006 .

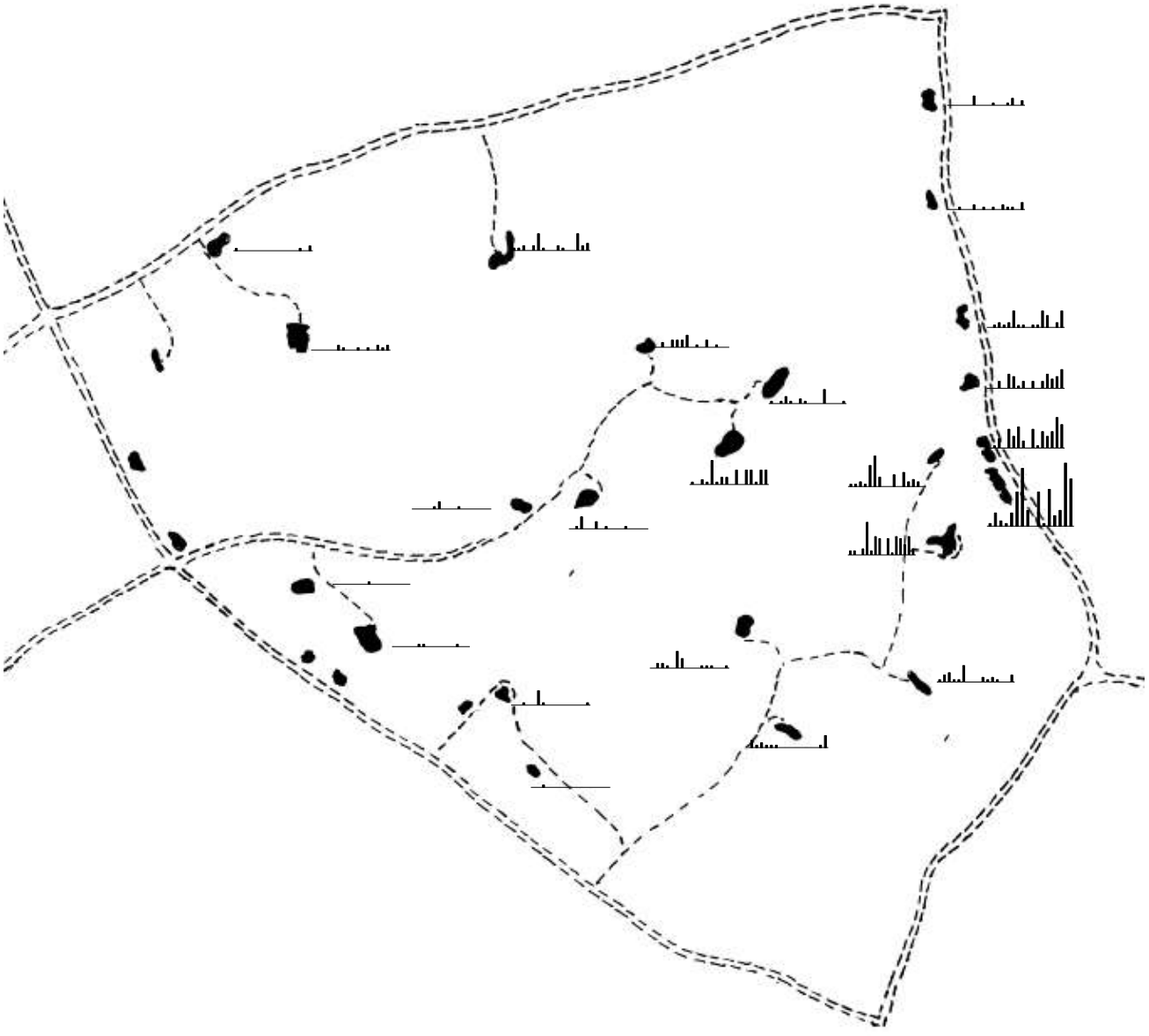
Broken black line shows boundary of area from which stock were excluded until 2004

3 Results

3.1 Distribution

On **Little Fen** the number of census ponds on which *D. plantarius* was recorded was the highest since the peak year of 1998 (Table 2) when numbers of spiders recorded were also at their highest (Fig. 5). Since closure of the artesian borehole in 1999, *D. plantarius* has been found predominantly in the southern part of the census area (Fig. 3). This area also held the core of the population during the 1990s when it was irrigated with a piped water supply to maintain summer water levels in the ponds. In most years spiders have also occurred in a band of ponds stretching north from this core area but records outside this zone are sporadic. The slight increase in number of pools occupied in 2008 did not represent any change from this pattern.

Fig. 3 Little Fen census area showing relative numbers of *D. plantarius* recorded at each pond in late July between 1993 and 2008. Bars represent maximum counts for consecutive years (highest count=24 :no July data were collected in 2000 and 2001). Where ponds have no chart, *D. plantarius* was not recorded during this period.



On **Middle Fen** *D. plantarius* was recorded in more pools than at any time since the present census was established in 1993. In contrast to Little Fen, this increase represented a change in distribution. After closure of the bore-hole, *D. plantarius* was largely restricted to the area of ponds that benefited from irrigation between 1991 and 1999 (Fig. 4, Table 2). Spiders were recorded on ponds to the west of this area only in some years. After a two-year absence, they re-appeared in this area, at the western end of their range recorded since 1993. In 2007, two nursery webs were found in this area, one of them west of their recorded range. No nurseries were found in 2008 but juvenile spiders were found in ponds extending as far as the southern extremity of a north/south chain of pools (Fig. 4), from which spiders have been absent since the mid-1980s. This represents a range extension of *ca* 120m since 2006 and of *ca* 200m from their core area.

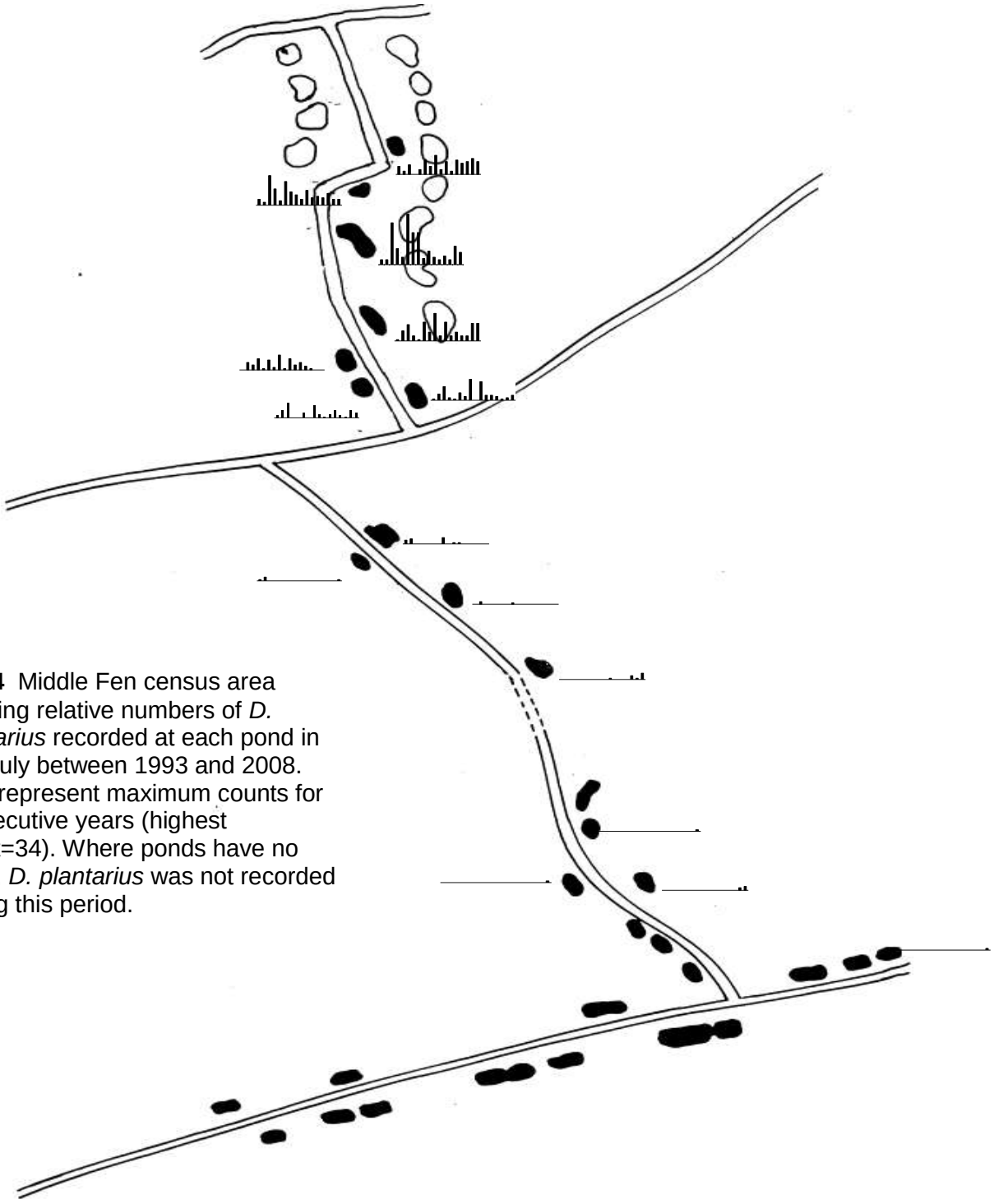


Fig. 4 Middle Fen census area showing relative numbers of *D. plantarius* recorded at each pond in late July between 1993 and 2008. Bars represent maximum counts for consecutive years (highest count=34). Where ponds have no chart, *D. plantarius* was not recorded during this period.

Table 2 Numbers of census ponds on which *D. plantarius* was recorded in July each year. Numbers are given separately for ponds that were and were not influenced by the irrigation supplied between 1993 and 1999. The 2000 data for Little Fen are based on two, rather than three replicate counts, made in September rather than July: no data were collected on Little Fen in 2001 (see Smith 2005)

Year	**'93**	**'94**	**'95**	**'96**	**'97**	**'98**	**'99**	**'00**	**'01**	**'02**	**'03**	**'04**	**'05**	**'06**	**'07**	**'08**
Little Fen																
'Irrigated' n=15[1] ponds	8	8	12	9	12	14	11	-	-	12	6	12	11	9	8	12
'Unirrigated' n=14[1] Ponds	2	2	4	0	1	6	4	-	-	2	1	2	0	4	2	4
Total	**10**	**10**	**12**	**9**	**13**	**20**	**15**	**(11)`**	**-**	**14**	**7**	**15**	**11**	**13**	**10**	**16**
Middle Fen																
'Irrigated' n=7 ponds	6	7	7	5	6	7	6	7	6	7	7	7	7	7	6	6
'Unirrigated' n=23 pond	2	3	0	0	0	0	1	2	0	2	1	0	0	1	2	6
Total	**8**	**10**	**7**	**5**	**6**	**7**	**7**	**9**	**6**	**9**	**8**	**7**	**7**	**8**	**8**	**12**

[1] Prior to 2003, n=16 irrigated and 15 unirrigated ponds respectively

Table 3 Proportions of *D. plantarius* in different size classes, and maximum counts of all individuals, adult females and nursery webs, in the standard annual census ponds on Little and Middle Fen at the July census from 1993 to 2008. * The number of adult females given is based on identification of individuals and may be a higher figure than the maximum count.

	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Little Fen																
% Large	36	21	20	65	30	5	8	-	-	9	29	4	10	14	18	11
% Medium	57	37	66	15	41	50	53	-	-	57	43	68	88	45	73	68
% Small	7	42	15	20	29	45	39	-	-	34	28	28	2	41	9	21
Max. spider count	**14**	**19**	**41**	**20**	**66**	**94**	**62**	**-**	**-**	**53**	**7**	**68**	**40**	**42**	**66**	**75**
Adult females*	0	1	6	6	16	4	4	-	-	4	2	3	4	7	10	10
Nursery web count	0	2	0	0	9	0	4	-	-	0	0	1	2	4	4	0
Middle Fen																
% Large	29	30	3	17	47	5	15	6	20	6	10	5	13	10	19	12
% Medium	33	48	62	34	53	32	46	49	30	55	48	50	45	63	50	46
% Small	38	22	35	49	0	63	39	45	50	39	42	45	42	27	31	40
Max.spider count	**21**	**44**	**102**	**41**	**15**	**99**	**52**	**112**	**20**	**72**	**29**	**42**	**31**	**30**	**54**	**56**
Adult females*	0	8	1	5	6	5	7	7	0	2	2	1	4	3	8	5
Nursery web count	1	3	1	0	0	0	7	0	0	0	0	0	3	1	2	1

3.2 Abundance

Since census work began in 1991, the size of the *D. plantarius* sub-populations on both Little and Middle Fens has varied substantially, and in some cases significantly, between the years but at no time has there been any evidence of sustained or significant recovery (Table 3, Fig. 5). In 2008 numbers were well within the range of variation since 1991 and were slightly, but not significantly, higher than those in the previous five years on both Middle and Little Fen.

Separate analysis of the 18 year data set for the Little and the Middle Fen sub-populations shows that, in both cases, the annual time effects models gave a better description of the data (lowest AIC values) than either the linear-trend or no-time-effects models. For Little Fen this model had an AIC value of –162.9 (Wald test for significance of deviation from linear trend: 98.06, $p<0.001$, df=14). Linear-trend and no-time-effects models had AIC values of 7.0 and 54.3 respectively. For Middle Fen this model had an AIC value of –85.8 (Wald test for significance of deviation from linear trend: 166.2, $p<0.001$, df=16). Linear-trend and no-time-effects models had AIC values of 227.6 and 277.5 respectively.

Inclusion of the data for both fens in the population models showed that, as in previous years when such comparison was possible, there was a highly significant difference in the annual pattern of variation between Little and Middle Fen (analysis of data for 1991-'99 and 2002-'08: Wald test for difference between fens: 85.47, $p<0.001$, df=15).

3.3 Breeding indicators

On **Little Fen** the number of adult females encountered during the July census was the same as in 2007 and second only to those recorded in the peak year of 1997 (Table 3). Although no nurseries were encountered, seven of the eight adult females were carrying eggs sacs. Four nursery webs were recorded as casual records.

On **Middle Fen** the numbers of adult females recorded during the census was slightly lower than in 2007 (Table 2). One of these was recorded with an egg sac, two were clearly post-partum and one had a nursery web. Twenty-five webs were recorded on Middle Fen as casual records during the 2008 breeding season. The effort put into casual recording was much higher on Middle than on Little Fen.

3.4 Water Levels

Overall, 2008 was the wettest year on the fen since 2004, with particularly heavy rain in March and August (Fig. 6). However, both the winter maximum and summer minimum levels in the dip wells were very similar to those in 2007 (Fig. 7). In the turf ponds on Little Fen, levels were well maintained during the summer, rising in December and January 2009 to the second highest on record (Fig. 8). Summer levels were also relatively high on Middle Fen although the levels reached by December were not as exceptional as those on Little Fen and, not as high as those experienced after the heavy rain in March (Fig. 9). In the ponds dug on Great Fen in 1988 (Smith 1988), summer levels were similar to those in 2007, the highest since recording began in 2000 (Fig. 10). Water levels in the 2007/08 winter were also high, but not as high as the peak following the rainfall in March. This was the highest ever recorded in these ponds (Fig.10).

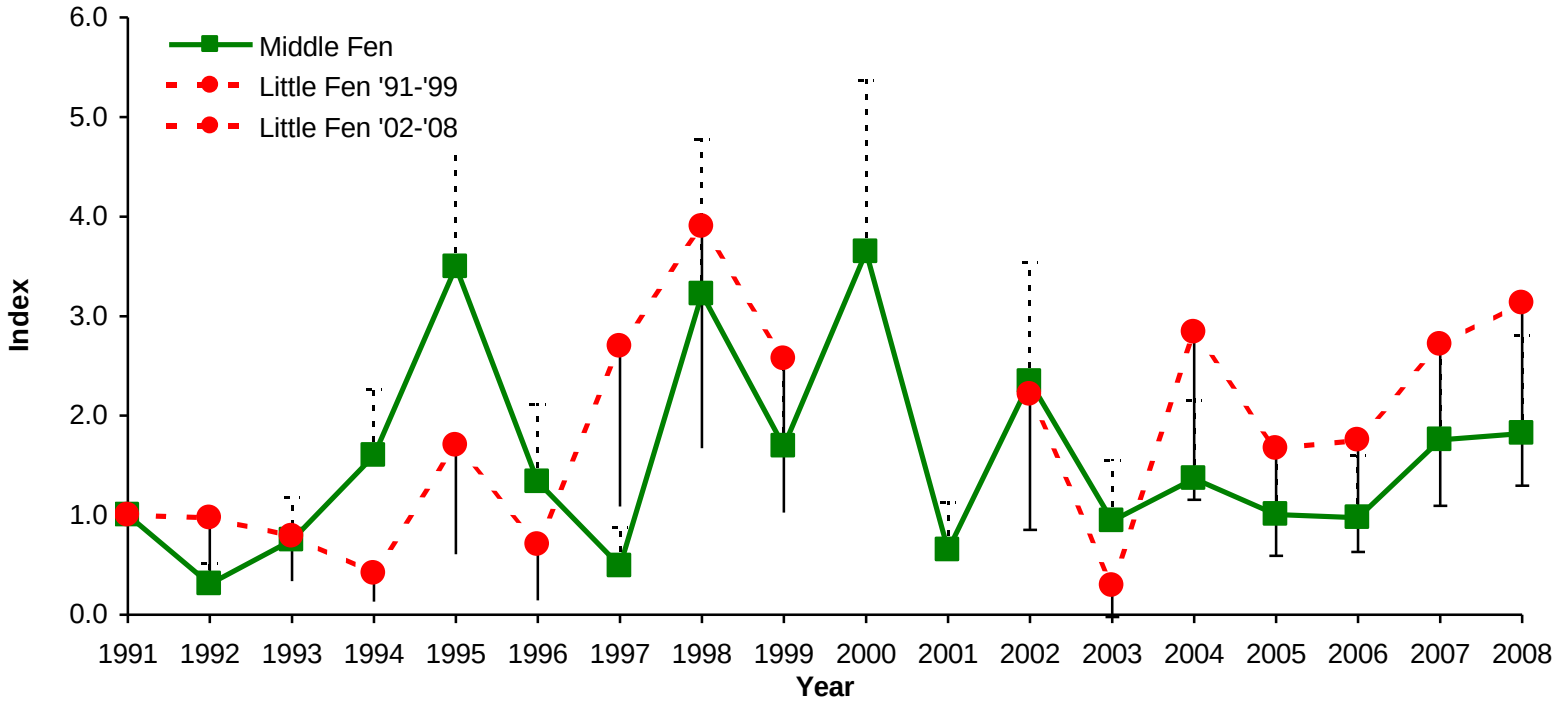


Fig. 5 Annual population indices for *D. plantarius* on Middle and Little Fens in July 1991-2008, generated by a log-linear Poisson regression model and plotted on a linear scale. See text for missing data on Little Fen. 2SEs shown by positive vertical bars for Middle Fen and negative bars for Little Fen.

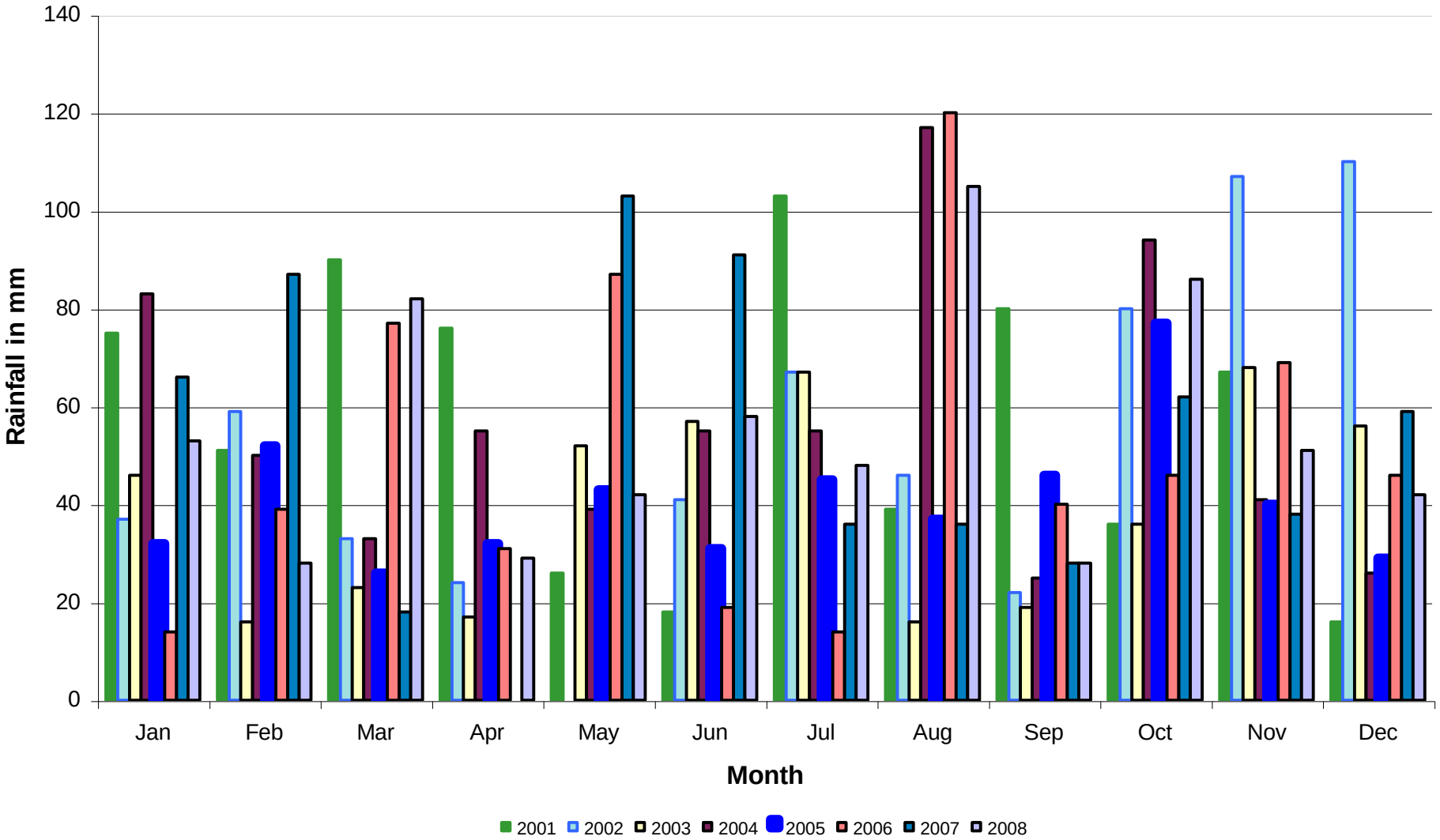


Fig. 6 Monthly rainfall totals for Redgrave & Lopham Fen NNR 2001-2008

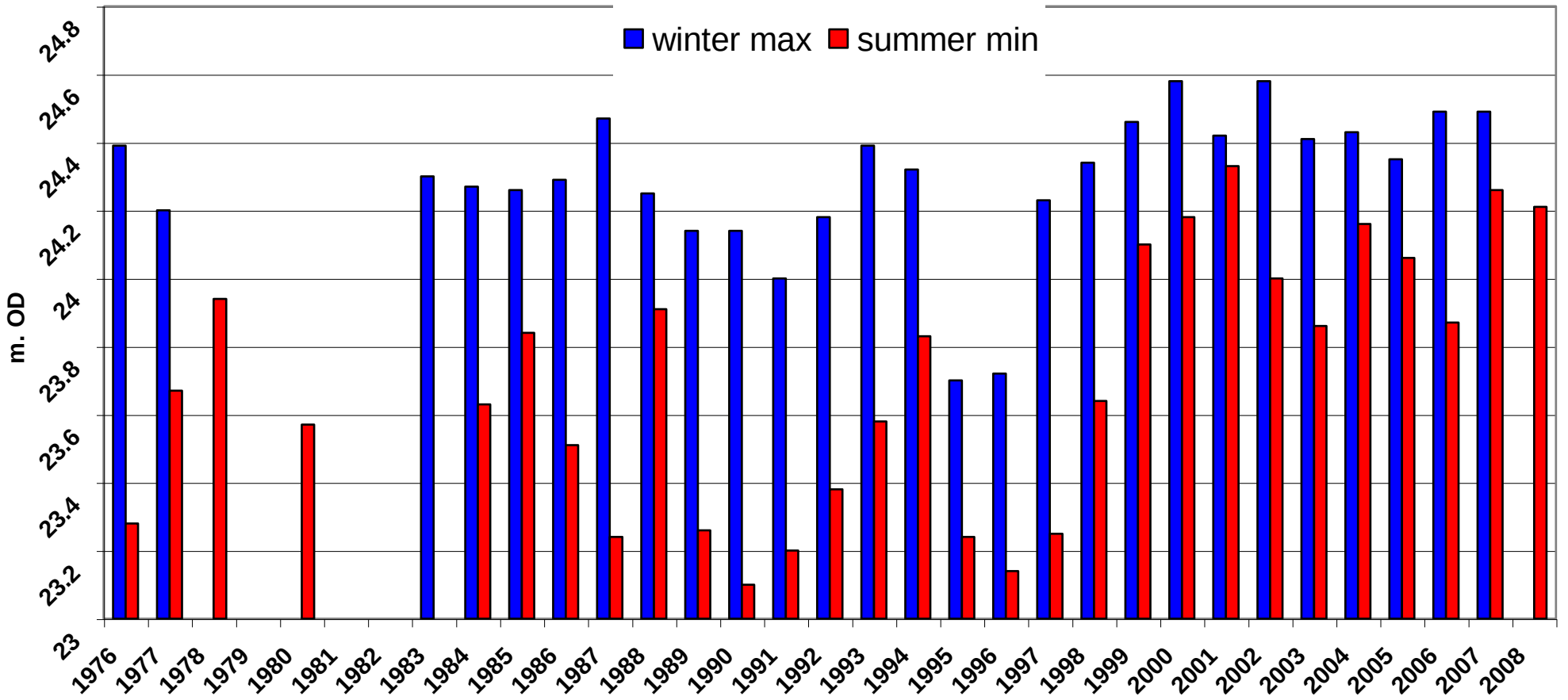


Fig. 7 Mean winter maximum and summer minimum water levels in piezometers on Redgrave & Lopham Fen NNR, 1976-2008

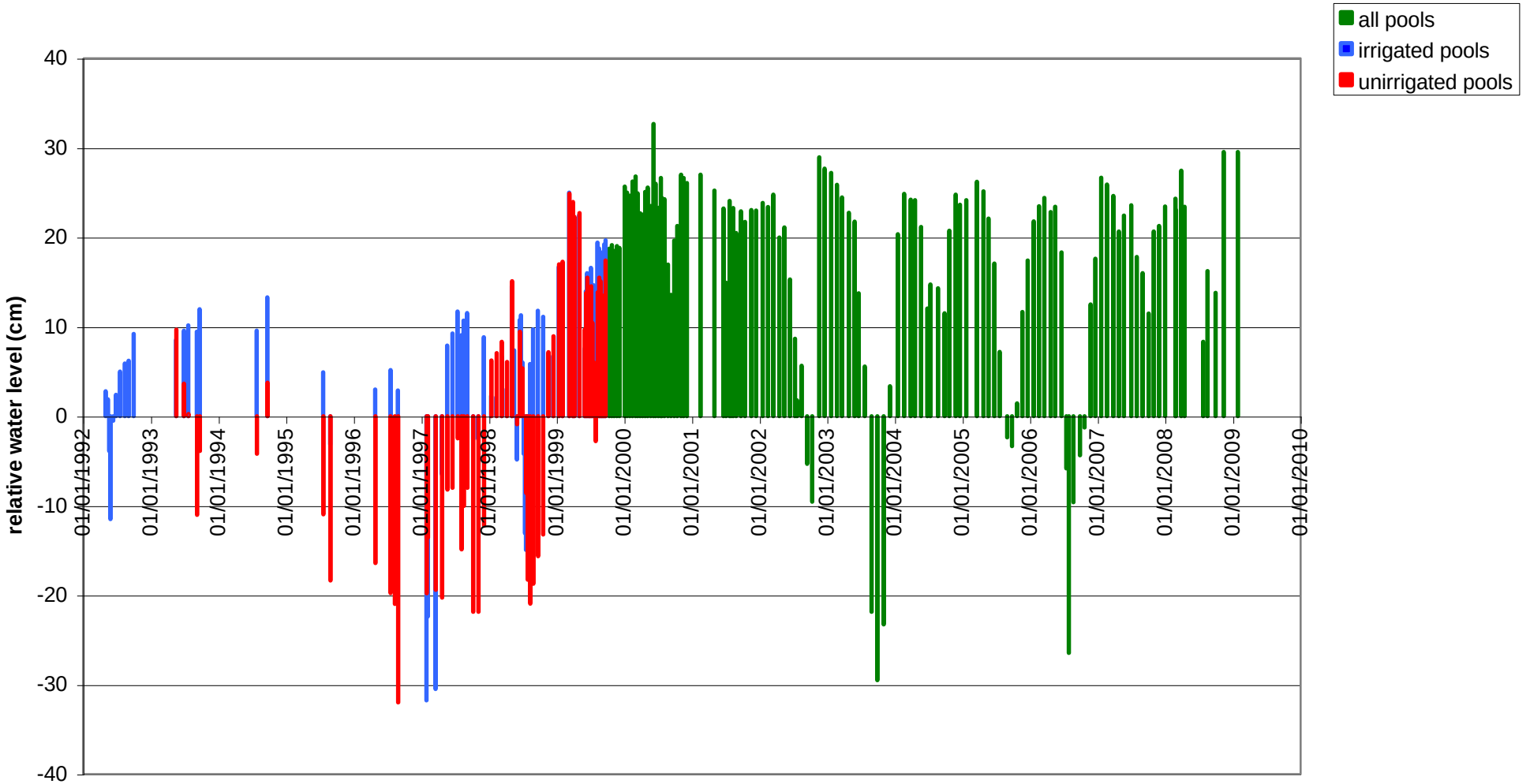


Fig. 8 Water levels in Little Fen ponds 1992-2008. Horizontal line represents the April 1992 datum. Blue and red lines represent mean levels in irrigated and unirrigated ponds respectively : summer irrigation stopped in 1999 (see text).

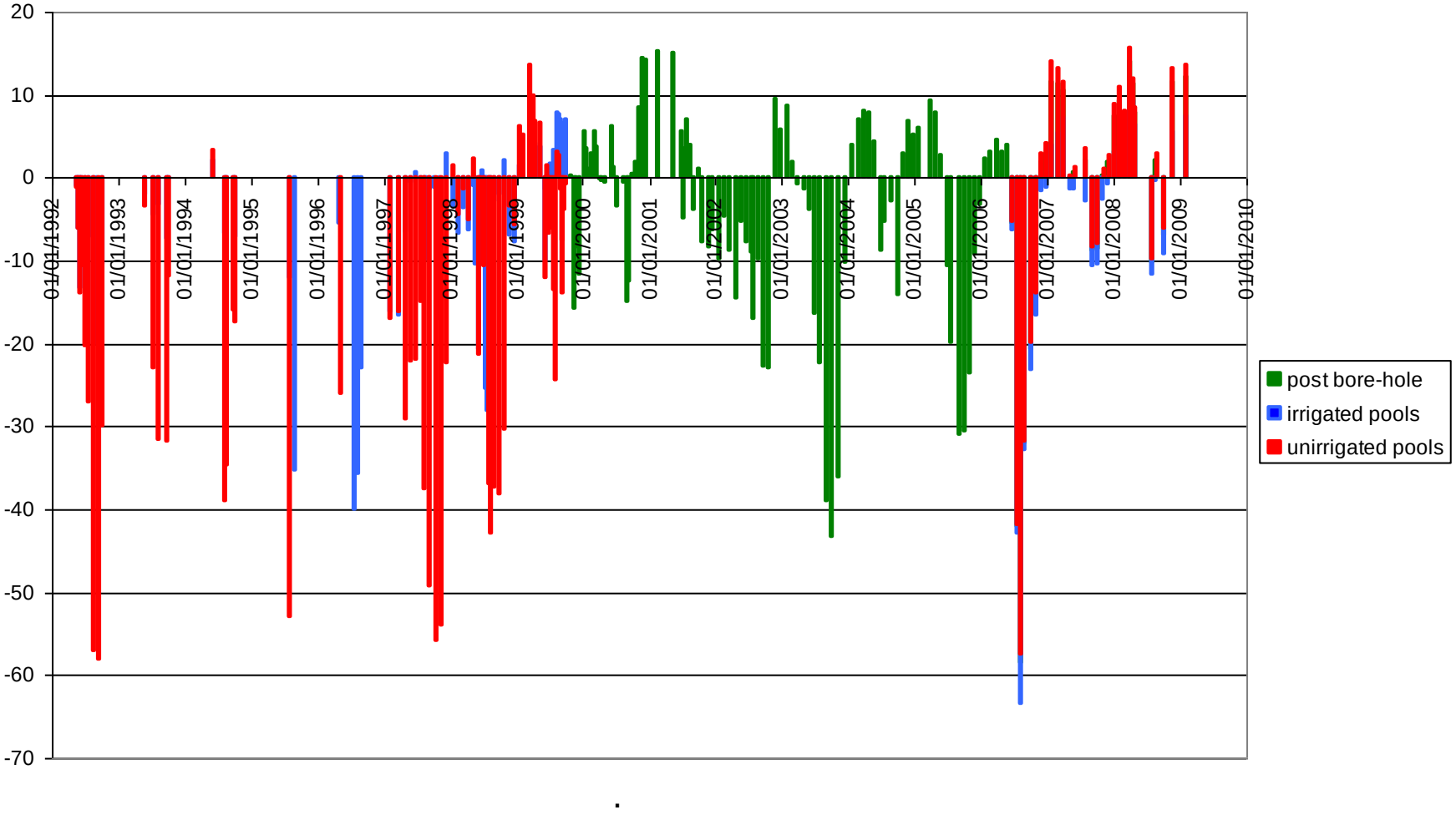


Fig. 9 Water levels in Middle Fen ponds 1992-2008. Horizontal line represents the April 1992 datum. Blue and red lines represent mean levels in irrigated and unirrigated ponds respectively : summer irrigation stopped in 1999 but differences between the two sets of pools are shown again for 2006 (see text).

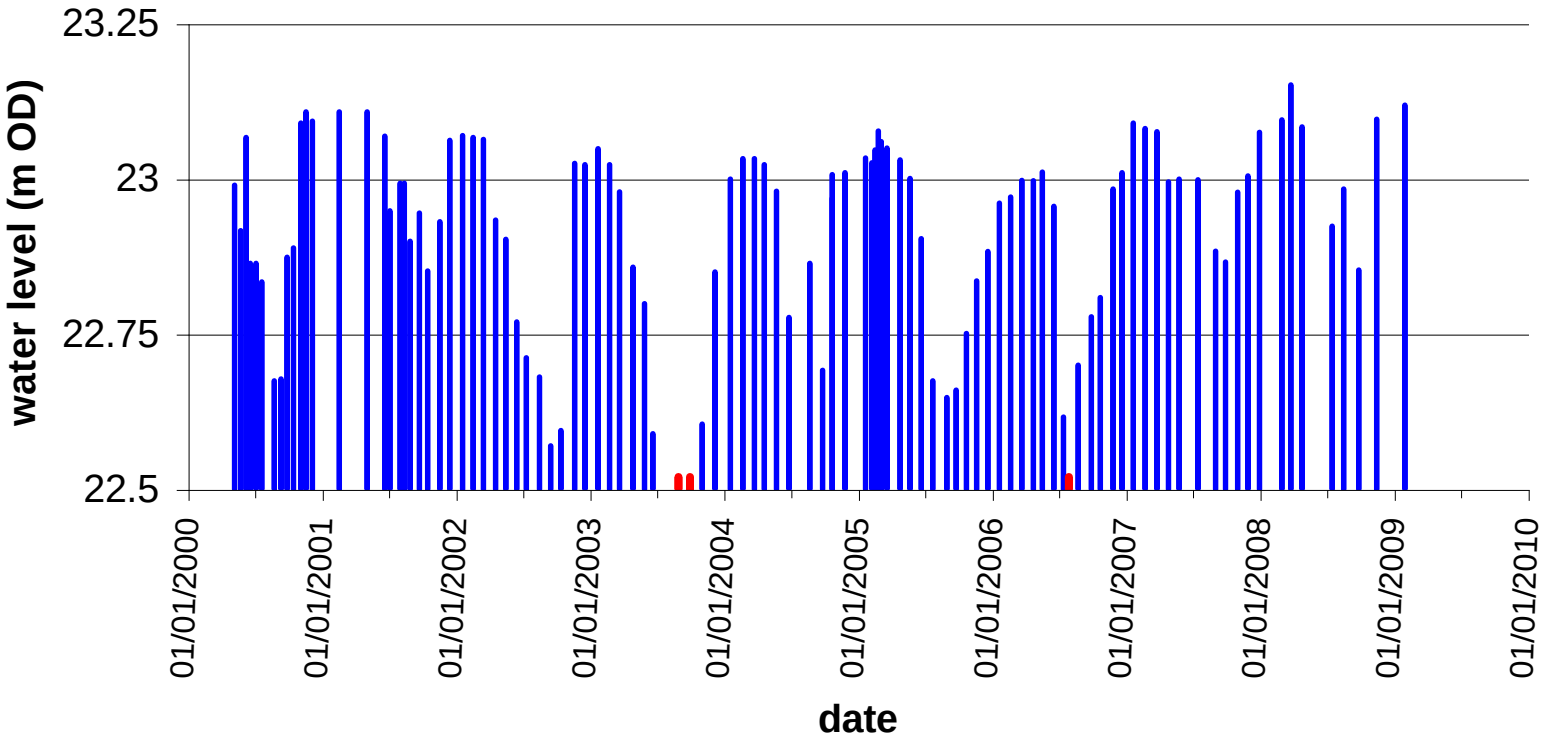


Fig. 10 Water levels in ponds excavated on Great Fen in 1998. Broken line denotes level below which most ponds are dry. Red indicates dates on which all ponds were completely dry (other 'blank' months are missing data).

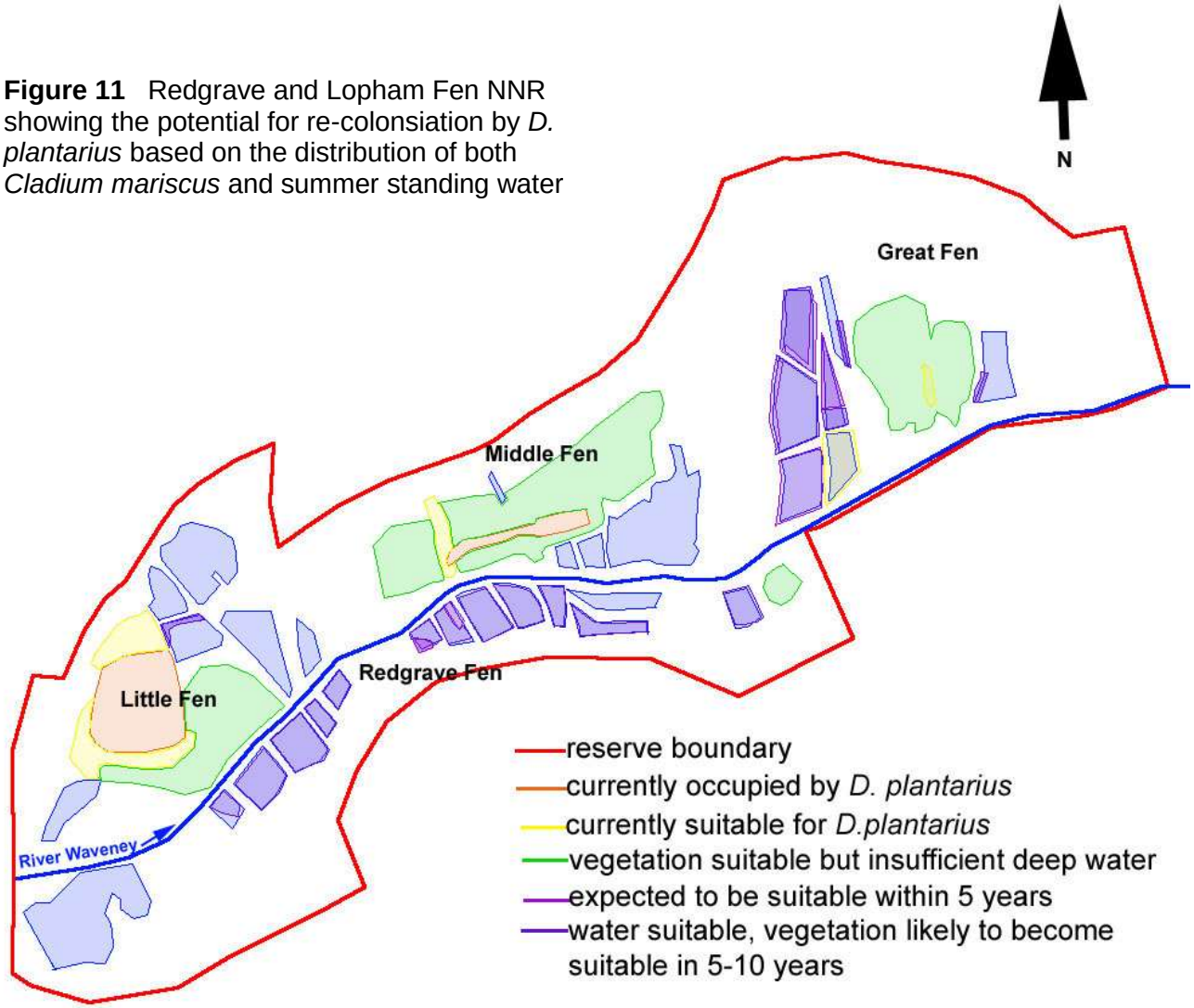


Figure 11 Redgrave and Lopham Fen NNR showing the potential for re-colonsiation by *D. plantarius* based on the distribution of both *Cladium mariscus* and summer standing water

3.5 *Cladium mariscus* survey and suitability of fen areas for recolonisation *by D. plantarius*

This survey showed that the potential exists for widespread re-colonisation of Redgrave & Lopham Fen by *D. plantarius* in the next ten to fifteen years (Fig. 11). This is in part attributable to the recent colonisation of the *ca* 18ha of scrapes created in the late 1990s, by *C. mariscus*. However, few of the potentially suitable areas of vegetation are likely to be colonised by the spiders without some form of intervention. Natural re-colonisation can only be expected on this timescale in areas close to the existing two centres of population but, on both Middle Fen and Little Fen, this will require the excavation of new series of turf ponds to provide sufficient water in dry summers.

On Great Fen, which now has the most extensive *C. mariscus* stand on the Fen complex, further excavation of turf ponds would create ideal conditions for *D. plantarius*. Here, however, natural re-colonisation is extremely unlikely because of the distance from the core populations: deliberate re-introduction will be required to establish new sub-populations. At the western end of Middle Fen, where the 1990s scrapes are increasingly suitable for *D. plantarius*, and on parts of Redgrave Fen where it seems likely that some of the scrapes will become suitable within the next 5-10 years, deliberate re-introduction will also be needed to ensure re-colonisation by *D. plantarius*.

4 Habitat management

4.1 Rotational mowing of *Cladium mariscus*

The *C. mariscus* cutting rotation initiated in 1998 (Smith 1998) in stands surrounding the ponds that supported the highest density of *D. plantarius* on both Little and Middle Fen (Figs. 1 and 2) was

abandoned after 2003. In 2004 the fences around these areas were removed to allow stock to enter (Smith 2005). However, because of failure of the stock to graze much of the wetter fen, from 2004 onwards the SWT re-initiated limited cutting of stands judged to be in most need of management, both within and beyond the core area for *D. plantarius*.

On Little Fen none of the vegetation within the census area was cut in 2008 (Fig.1). On Middle Fen, for the third successive year, an area of dense, mature *C. mariscus* was cut within the core of the *D. plantarius* census area. The rotational blocks correspond with those of the five-year rotation practiced from 1999 to 2003 (Smith 2006) although, as a result of an error in 2007, the block cut in 2008 was eight years old (Fig.2).

4.2 Grazing

On **Middle Fen**, as in previous years, the grazing management of areas occupied by *D. plantarius* was more successful than on Little Fen (full records of stock types, rates and movements are maintained by the SWT). However, stock rarely entered areas of tall, dense mature sedge unless they were recently cut (Fig.2).

In the western part of the census area, away from the dense *C. mariscus* beds that dominate the core range for *D. plantarius,* the grazing regime initiated in 2001 continued to have a substantial and positive impact on the vegetation. Tall dense reed, which formerly resulted in deep shading of many of the pools, has been largely replaced by shorter, more open, more mixed associations, with *C. mariscus* thriving, particularly around the margins of the turf ponds.

On **Little Fen,** as in previous years (e.g. Smith 2007), the stock made few incursions into the areas occupied by *D. plantarius* and had a negligible effect on the vegetation. They appeared to be deterred by the much wetter conditions than on Middle Fen.

5 Discussion

The annual population indices for both the Little and Middle Fen populations of *D. plantarius* on Redgrave & Lopham Fen NNR in 2008 were well within the range recorded over the previous seventeen years since systematic monitoring began. Although high numbers of both adult females and nurseries in 2007 (Smith 2007) provided the potential for significant population growth in 2008, no such increase was detected. Evidence of breeding in 2008 indicated another relatively good year on both Little and Middle Fens and so the potential remains for significant population increase. The maintenance of high summer water levels for a second successive year, and avoidance of the deleterious effects of drought seen in 2006 (Pearson 2008, Smith 2007), may increase the probability of population recovery. However, understanding of the complex effects of water level on population size requires further analyses of the long-term data sets.

Although the population index showed no sign of significant increase, the range of the spiders on Middle Fen expanded for a second successive year. This expansion took the population 120m west of its previous most westerly census record on Middle Fen, and returned it to one extremity of a series of ponds that was last occupied in the mid-1980s. Prior to 2006, the Middle Fen population had been recorded consistently only in ponds that were irrigated during the droughts of the 1990s (Smith 2000b). Ponds extending *ca* 80m to the west of this area were occupied only intermittently and appeared to be acting as a 'sink' for colonists from the core area. These ponds were very susceptible to drying out during the 1990s. Their emergent and surrounding vegetation remains less suitable than that associated with ponds in the core area, where *C. mariscus,* the species with which *D. plantarius* is most closely associated at Redgrave & Lopham Fen, occurs at a much higher frequency. Since 2002 the condition of these more westerly ponds has improved progressively as a result of a more effective grazing regime (Smith 2007), probably in combination with a reduction in nutrient status of the peat following the restoration operations. Removal of scrub and reduction in height and vigour of *P.australis,* has substantially reduced shading and allowed the development of a rich submergent flora and of more a more suitable vegetation structure at the pond margins. The condition of the series of ponds that the spiders reached in 2008 has undergone similar improvement and it seems likely the range expansion of *D. plantarius* will continue until these are also reoccupied.

On both Middle and Little Fens further natural expansion in range from the core populations is likely to be limited more by the lack of availability of turf ponds than of *C. mariscus.* The survey of the distribution of vegetation types, and particularly of *C. mariscus*, showed that the latter still persists at varying frequencies beyond the stands where it is dominant and in which the *D. plantarius* population is concentrated. Excavation of new series of ponds, radiating from those in the core *D. plantarius* areas, and focussing on areas where *C. mariscus* occurs at relatively high frequency, will increase substantially the probability of recolonisation. If improvements in the vegetation quality continue, it is estimated that natural recolonisation by *D. plantarius* could eventually be stimulated on approximately 20ha of the fen in this way. However, the slow rate of expansion of Middle Fen population, the lack of any evidence of expansion of the Little Fen population on the same timescale, and research confirming a low propensity and ability to disperse (Pearson 2008), all suggest that this will be slow process even if conditions remain consistently favourable.

Further afield on the Fen, more major habitat barriers, including dense reedbeds and wooded firebreaks, make natural recolonisation by *D. plantarius* highly unlikely. The 2008 survey showed that some of these areas of the fen are very currently suitable for *D. plantarius*, others could be made more suitable by the excavation of turf ponds, and others still are likely to become suitable over the next 5-15 years if current vegetations trends continue. Deliberate re-introduction of *D. plantarius* to these areas is the only means by which recolonisation is likely to be achieved in the foreseeable future.

Translocations within Redgrave & Lopham Fen have been proposed as part of the national translocation programme for *D. plantarius*, expected to start in 2010. This year's survey re-confirms the need for translocations if the BAP target, of recolonisation of 65Ha of this site by 2020 (BARS, 2009) to protect the population from chance extinction, is to be met. The urgency of the need to increase the *D. plantarius* population size at Redgrave & Lopham Fen was further underlined in 2008 by the discovery of a sharp decline in genetic diversity, sampled from *D. plantarius* exuvia collected at this site since 1992 (Holmes 2008).

New centres of population should initially be founded around the ponds excavated in 1998 in the extensive stand of *C. mariscus* on Great Fen. Prior clearing of these ponds of dense infilling vegetation and excavation of additional chains of ponds around the sedge bed would increase the probability of successful establishment of a large and sustainable population. One of the large scrapes made in 1990s, at the western end of Middle Fen, should also be targeted for an early introduction of *D. plantarius*. *C. mariscus* has started to re-colonise most of these scrapes in the last few years and the best of these already has ideal conditions for *D. plantarius*, with deep water and dense emergent and marginal *C. mariscus* that is increasing in extent. It is expected that other large scrapes, including some on Redgrave Fen, where *D. plantarius* was first discovered in 1956 (Duffey 1958), will become suitable for re-introductions within the next 5-10 years.

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Appendix 1 Redgrave & Lopham Fen: *Cladium mariscus* survey and wetland areas accounts 2008

The areas into which the Redgrave & Lopham Fen NNR complex was divided for the purposes of this survey are shown in Figure 1. For each of these areas, maps and broad vegetation descriptions, concentrating particularly on the abundance of *C. mariscus* in each area are given in the following sections. A brief assessment is also given of the suitability of each area for *D. plantarius* in terms of both vegetation and availability of water. The likelihood of natural re-colonisation by *D. plantarius* is considered, as is both the time-scale and the management that would be required to bring areas into more suitable condition.

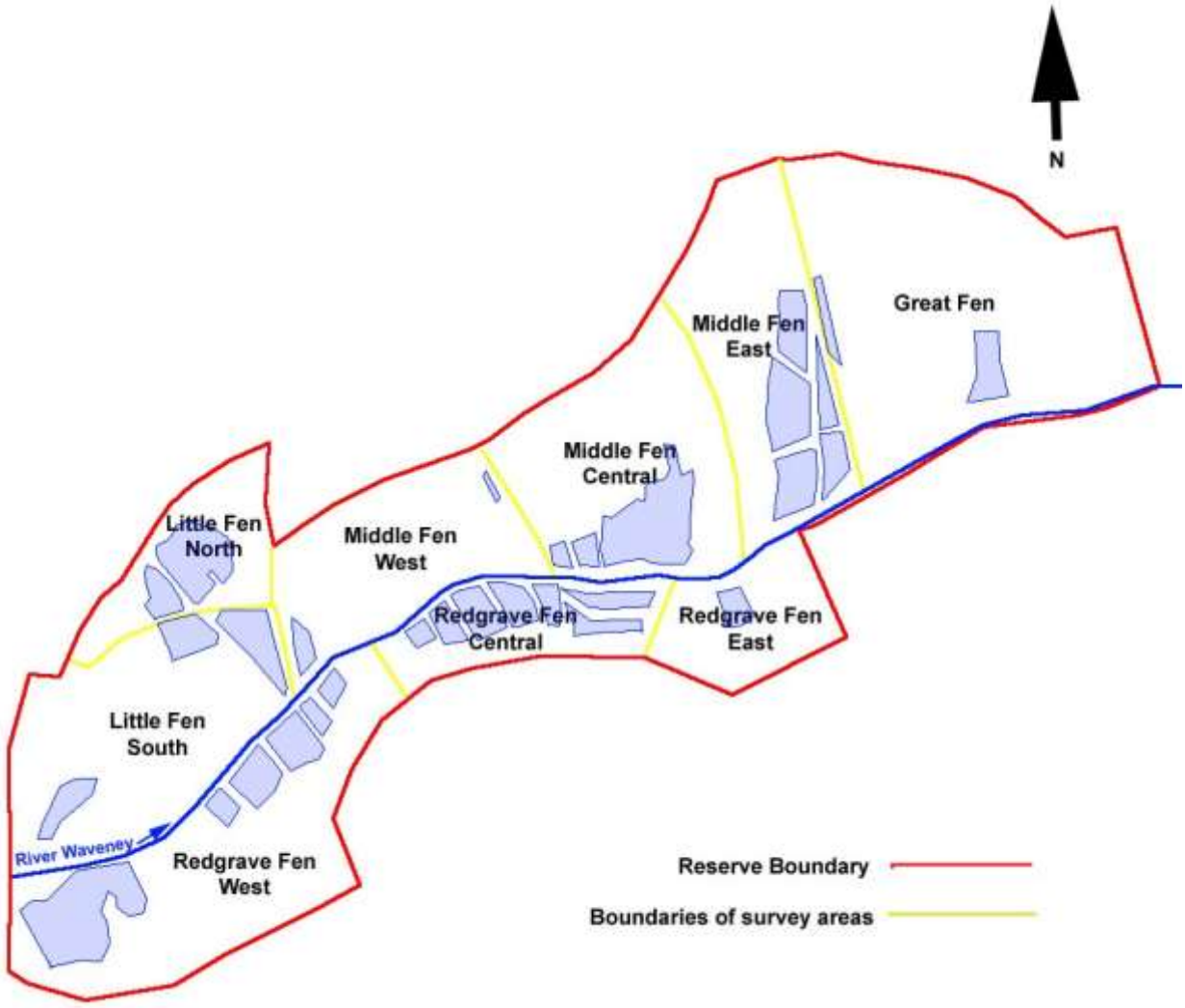

Figure A1 Areas into which Redgrave and Lopham Fen was divided for the survey of *Cladium mariscus* in 2008

A.1 Redgrave Fen

A.1.1 Redgrave Fen - East (Surveyed 23-09-08)

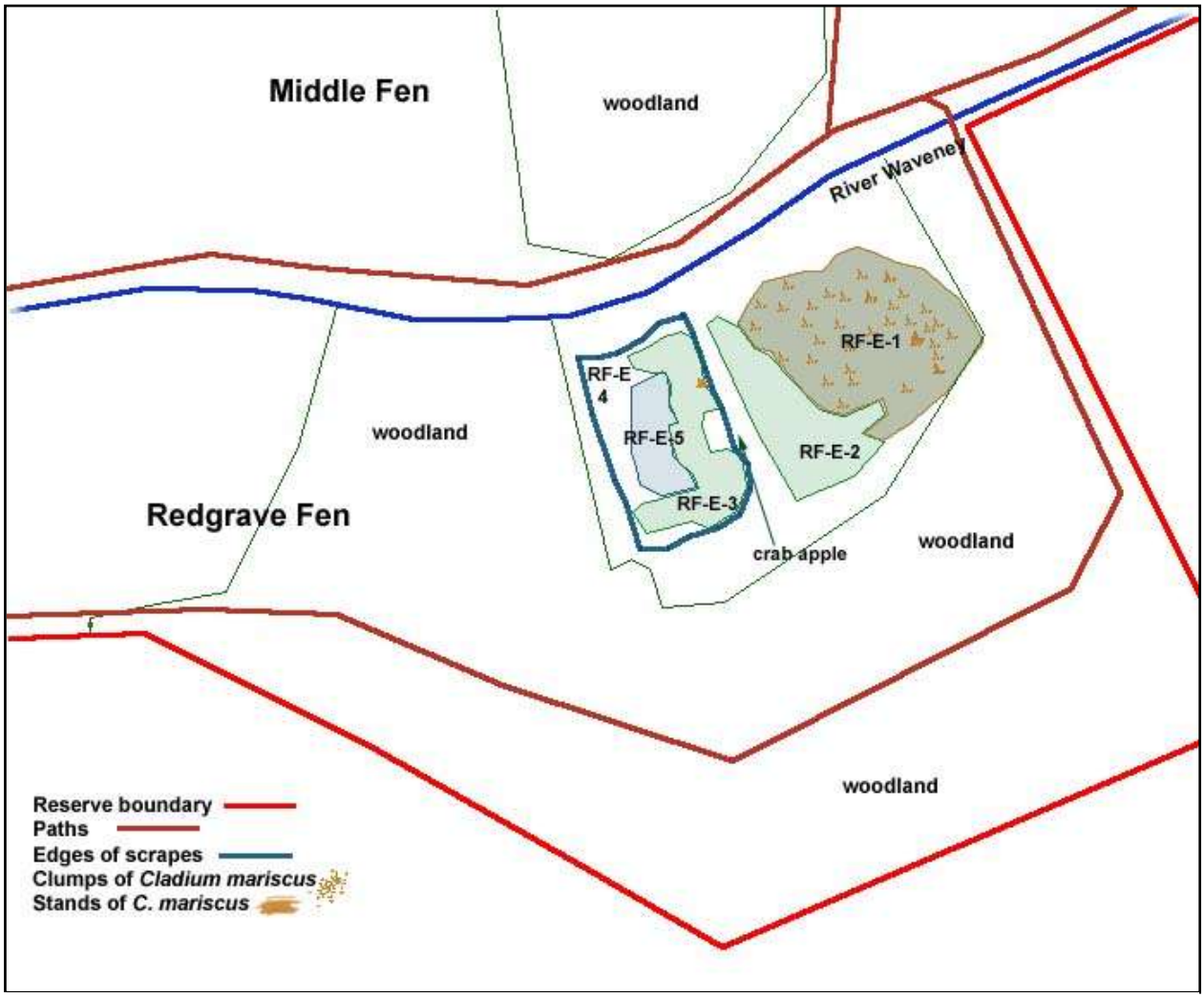

Fig. A2 The distribution of *Cladium mariscus* and the dominant vegetation types on the eastern area of Redgrave Fen

This area of Fen, the western *ca* half of which is a flooded scraped excavated in the late 1990s, is enclosed by scrub and woodland and relatively isolated from other areas of open fen. Much of the unscraped area was surface-wet in mid-September 2008. A few shallow peat diggings remain that are likely to retain water only in wet summers.

- RF-E-1: Mixed tall herb fen, dry at surface but with wet hollows marking the remains of old peat diggings. Vegetation very heterogeneous but *C. epigejos* and *Juncus subnodulosus* dominant. *Cladium mariscus* scattered throughout with a cover generally of 5-10% but with a few localised patches where it is *ca* 50%, including the margins of the wet hollows. The area is not currently grazed and so the extensive *J. subnodulosus* areas are heavily lodged.
- RF-E-2: Dominated by *Phragmites australis*, although much of it is not dense reed bed. Water was at the surface over much of the area.
- RF-E-3: the eastern side of the scrape is infilled and moderately shaded by *P. australis* although with *Potomogeton coloratus* beneath. One clump of *C. mariscus* on the eastern margin.

- RF-E-4: Relatively sparse cover of infilling emergents: *Typha latifolia*, *J. subnodulosus and P. australis,* leaving many small patches of lightly shaded water surface but no extensive areas of open water.
- RF-E-5: the central area of the scrape is more open although without any extensive open water surface. It has an open carpet of *J. subnodulosus* above dense *P. coloratus. P. australis* is present at the margins of this area but is short and sparse.

A1.1.1 Potential suitability for *D. plantarius*

The isolation of this area amongst woodland/scrub, and its distance from the present centres of population, makes it extremely unlikely that it would be colonised naturally by *D. plantarius*. Introduction of spiders here could only be justified if better continuity could be created with more extensive areas of suitable habitat.

The vegetation of much of the unscraped area has potential to become appropriate for *D. plantarius*. An increase in the level of grazing/mowing to reduce sward height and the dominance of *J. subnodulosus* and *P. australis* would benefit the expansion of *C. mariscus*. The *P. australis*-dominated area (RF-E-2) has the potential to be converted to habitat more similar to (RF-E-1) by cutting to encourage grazing.

The deepening of existing turf ponds and creation of new ones would also be required to allow this area to support *D. plantarius* because the emergent vegetation in the scrape is currently unsuitable: too much of it tall and shading, and too little stiff-leaved and tussocky. A single tussock of *C. mariscus* suggests that this species may eventually re-colonise, but this is unlikely to be achieved within the next five years.

A1.2 Redgrave Fen - Central (Surveyed 22-09-08)

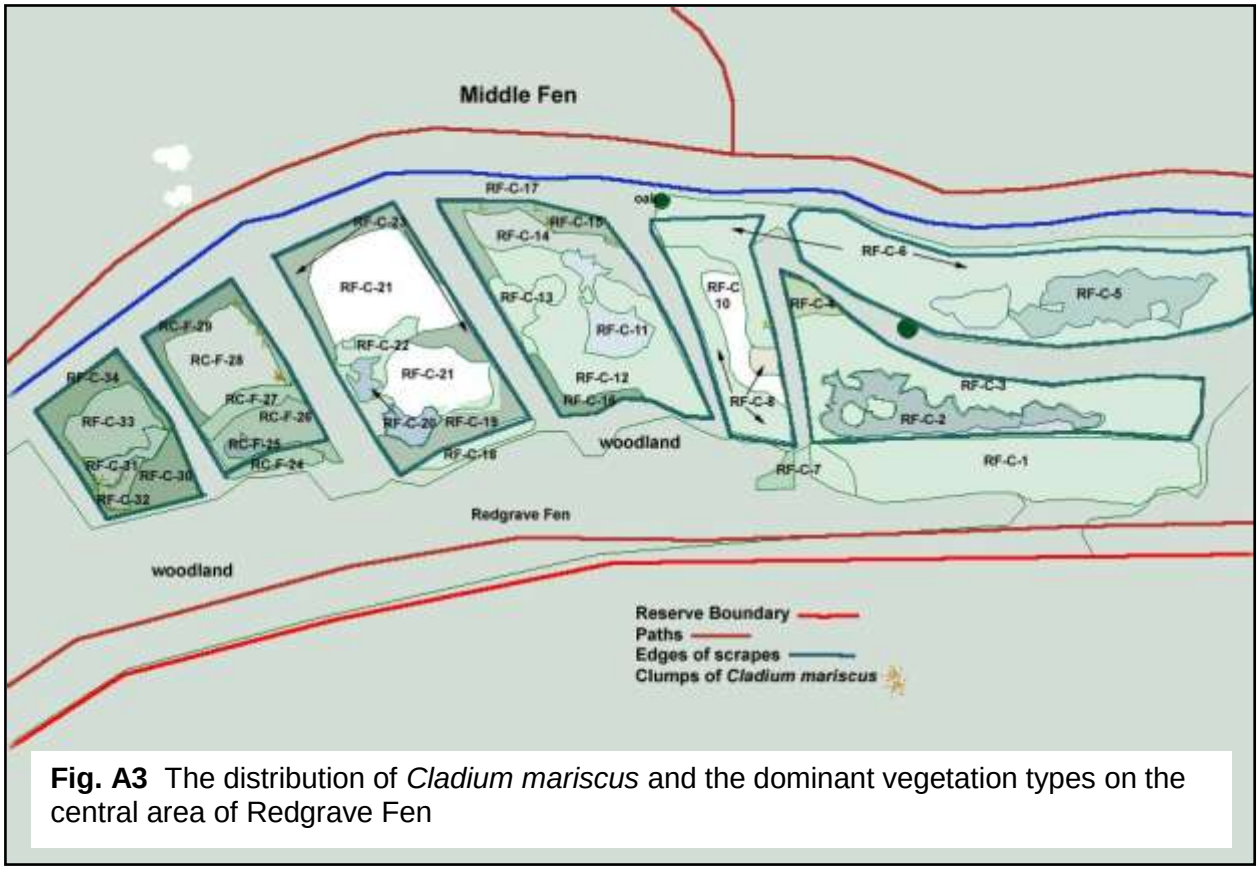

Fig. A3 The distribution of *Cladium mariscus* and the dominant vegetation types on the central area of Redgrave Fen

This is an extensive area of scrapes created in the late 1990s, separated by often high, peat bunds, most of which are aligned north-south. The vegetation varies considerably both between

and within the different scraped areas. All of the scrapes are of similar depth and hold water throughout most summers. No unscraped, open wetland areas remain in this part of the fen.

- RF-C-1: dry or surface wet area dominated in some places by *C. epigejos* with some *P. australis,* and in others by .*J subnodulosus*, with scattered clumps of *Carex elata* and remnants of *Molinia caerulea* tussocks.
- RF-C-2 and 3: deep open water (2) fringed by, and with islands of, tall *P. australis* and *T. latifolia*, the latter especially at the western end. The south bank drops vertically and has *C.epigejos* with some *C.elata* tussocks at the water's edge.
- RF-C-4: in this spur of the scrape the *T. latifolia* gives way to dense emergent *J. subnodulosus*.
- RF-C-5: deep open water surrounded by tall, dense *P. australis* and with a dense cover of water *Nymphaea alba*). This scrape is separated from the one to the south by a high peat bund. Neither scraped area has any sign of *C. mariscus*.
- RF-C-6: dominated by *P. australis*.
- RF-C-7: standing water infilled by clumps of *C. elata* in an area close to the trees on the fen edge and from which trees cover has been relatively recently removed.
- RF-C-8: the south and west sides of this scrape are infilled primarily by *T. latifolia,* although the cover is open with *J. subnodulosus* and clumps of *C. elata* beneath.

Fig. A4 Mature and seedling plants of *Cladium mariscus* in the south-west corner of the most westerly scrape on the central section of Redgrave Fen

- RF-C-10: the central area is much less shaded and is infilled with *J.subnodulosus* and *C. elata: T. latifolia* is present but very sparse. *P. australis* is largely restricted to the northern edge (RF-C-6). One clump of *C. mariscus* was found on the eastern side of this scrape. NB that this clump was the only *C. mariscus* recorded in or around any of these three scrapes.
- RF-C-11: A substantial area of deep open water with one patch of *N. alba*. Could not see submergent vegetation.
- RF-C-12: shallowly-flooded (23-30cm water) area dominated by *Juncus* spp. with scattered *T. latifolia* and *C. elata*. *P. coloratus* and Utricularia vulgaris amongst the rushes, indicating inundation for much of the year. On the east side of the open water, the *Juncus* spp. are taller, denser and lodged, becoming more open again at the north-east corner before grading into reedbed (RF-C-15).
- RF-C-13: this area is allied to the above but drier and more species-rich, again with a conspicuous element of *Juncus* spp. and also *C. epigejos.*
- RF-C-14: a gradation for RC-F-12, with an increasing proportion of P. australis amongst the *Juncus* spp.
- RF-C-15: P. australis-dominated and flooded beneath, but still sufficiently open and short to have *P.coloratus* and, in relatively sparse areas, *Juncus* spp. and occasional young plants of *C. mariscus*. The *P.australis* fringe on the north-west side is taller and more dense, in deeper water.
- RF-C-16: Allied to RF-C-12, the fringe of this scrape is *Juncus*-dominated, but with a conspicuous element of short *P.australis*.
- RF-C-17: a drier, species-poor area between the scrape margin and the river, dominated by *P.australis* and *C. epigejos*.
  The next scrape to the west is more reed dominated than the previous one although the reed is mostly sparse, declining in height towards the centre of the scrape:
- RF-C-18: wide, dry grassy fringe with dense J*. effusus* south of scrape.
- RF-C-19: Flooded (*ca* 30cm deep) southern fringe of scrape, dominated by *T. latifolia* but open with *J. subnodulosus* and clumps of *C. elata* and *P. coloratus* in clear, water.
- RF-C-20: small areas of deep open water
- F-C-21: although this scrape is more conspicuously reed-dominated than the previous one, the reed is mostly sparse, declining in height towards the centre of the scrape. This area is shallowly flooded with some *J. subnodulosous* beneath. CHECK these 2 areas
- RF-C-22: *J.subnodulosus* dominated area around small patches of deep open water with *Chara* sp.
- RF-C-23: *P. australis*-dominated, flooded beneath, but still sufficiently open and short to have *P.coloratus*. Occasional clumps of *C. mariscus* flowering along north-east margin of the scrape.
- RF-C-24: the southern margin of this scrape, between the excavation and the woodland is a wide, *J.effusus*-dominated meadow but is currently undergrazed
- RF-C-25: A small area of open water with *U. vulgaris* and fringing emergent *C. elata* clumps, *J. subnodulosus* and sparse *P.australis*.
- RF-C-26: emergent *P.australis* with *T.latifolia*, the latter particularly to the east in deep water.
- RF-C-27: a raised area with species-rich fen meadow, *J.subnodulosus* and mosses, grading down, as the water deepens, into emergent *P.australis/T.latifolia* to the south, and into short *P.australis* with *J.subnodulosus* with *U. vulgaris* beneath, to the north.
- RF-C-28: *P.australis*-dominated, but short and open with some tussocks of *C.elata*, and *J. subnodulosus* in the more sparse areas, and submergent *U. vulgaris*. Occasional, emergent flowering tussocks *of C.mariscus* and some non-flowering plants along the eastern margin.

- RF-C-29: Taller, denser fringe of *P.australis*.
- RF-C-30: A dry *C. epigejos*-dominated area with clumps of *J.effusus*, currently undergrazed.
- RF-C-31: the open water in the most westerly of this block of scrapes has *P. coloratus* and *U. vulgaris*. Fringed by *P.australis* on all but the southern edge. Some emergent patches of seedling and flowering clumps of *C.mariscus* at the western end.
- RF-C-32: *T. latifolia*-dominated but mostly open with clumps of *C.elata* and dense *J. subnodulosus* beneath.
- RF-C-33: scrape infilled with *P.australis*, becoming taller and denser towards the margins.

A1.2.1 Potential suitability for *D. plantarius*

The initial discovery of *D. plantarius* in 1956 was from this area of Redgrave Fen (Duffey 1958). The spiders were lost from this area at a relatively early stage in the Fen's decline, as scrub started to invade and the turf ponds dried up (Smith 2000). The clearance of scrub, excavation of new water bodies and management by extensive grazing since the late 1990s, is now resulting in the development of a diverse range of semi-aquatic and aquatic vegetation types. *C. mariscus* is starting to re-appear as a component of the vegetation in some of the scrapes and the presence of areas of seedlings suggests that the extent of re-colonisation is increasing. Although some of the scrapes which still have tall, dense, fringing *P. australis* are unlikely to become suitable for *D. plantarius*, at least within the next ten years, others are likely to develop suitable vegetation within the next five to ten years. A few small areas may already be suitable but because they are very limited in extent, a re-introduction to this area would not be appropriate at this stage. In addition to the development of *C. mariscus* swamp, some other vegetation structures that have developed in this area may well be able to support *D. plantarius*: for example, some of the inundated but lightly grazed areas of *J. subnodulosus* and *Carex elata*.

Fig. A5 Innundated *J. subnodulosus*-dominated sward (RF-C-12) on the central section of Redgrave Fen

A1.3 Redgrave Fen - West (surveyed 29/9/08)

- RF-W-1: at the south-eastern end of the large shallow scrape at the head of Redgrave Fen the vegetation is heavily grazed and trampled by stock and wildfowl. Around most of its perimeter, the scrape either has a muddy shore or is fringed by emergent *P. australis*. There is no *C. mariscus*.
- RF-W-2: east of the scrape, is dominated by tall, dense *P. australis* over mostly surface-wet, ochreous mud. In drier areas the reed is mixed with *Eupatorium cannabinum*, *Angelica sylvestris* and *C. epigejos*. *C. mariscus* is absent.
- RF-W-3: The southern fringe is relatively dry with increasing frequency of *C.epigejos* beneath the reed as it declines in height to a grazed fringe. This strip widens to the east, in places as a dry rush pasture.
- RF-W-4: infilled by *P. australis* with some *T. latifolia* but still has a substantial area of open water with *Chara* species.
  RF-W-5: This scrape is mostly infilled by *P.australis*, in places with *T. latifolia*. Small, inaccessible areas of open water remain in the north-west of the scrape. *C. mariscus* is present as a large, flowering clump on the northern side, occasional clumps more centrally and others along the west and east margins. On the southern margin a line of tall *C. mariscus* plants occurs at the point where the reed start to increases in height, *ca* 5m into the scrape. Overall, however, *C.mariscus* frequencies are very low.

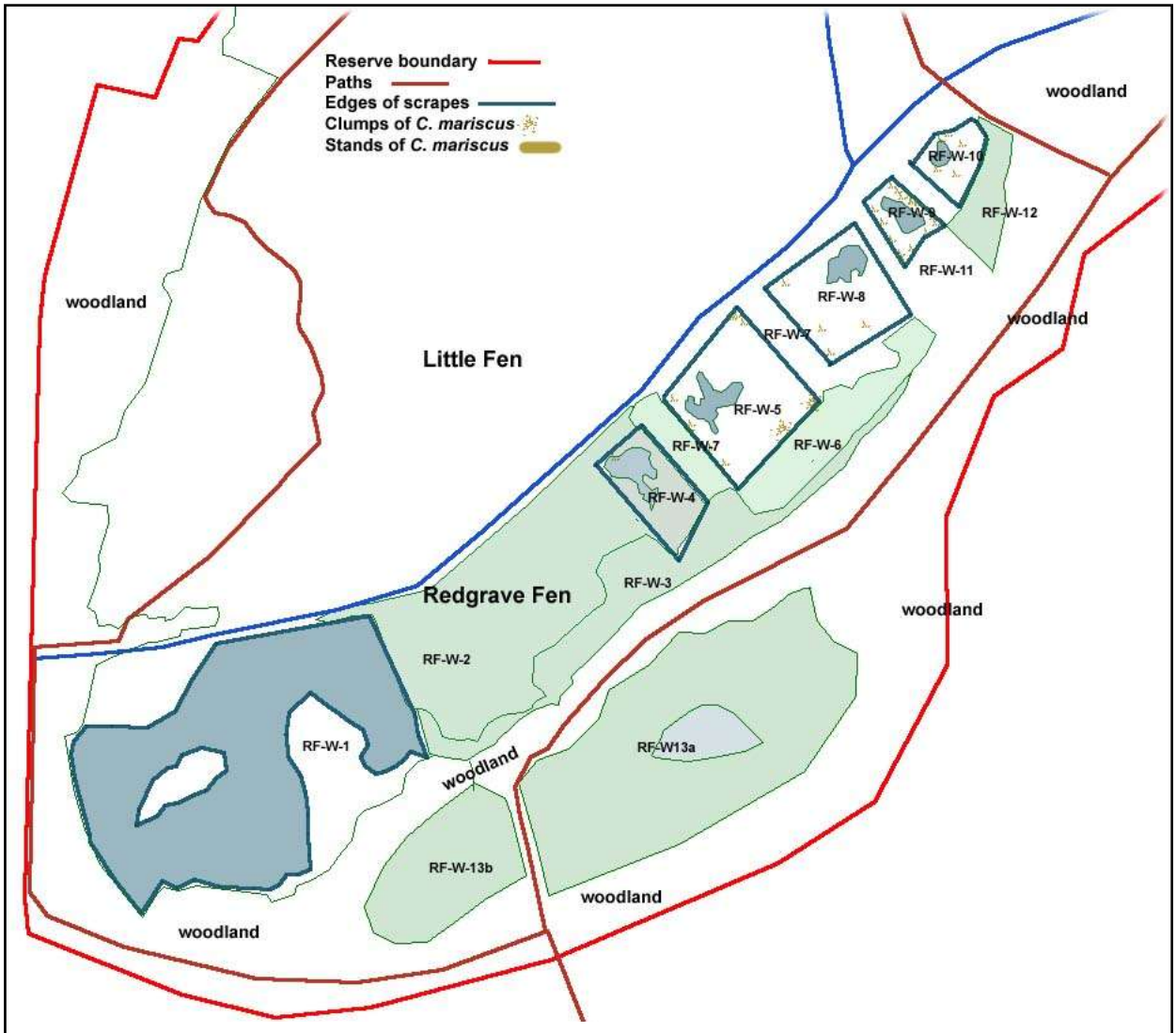

Fig. A6 The distribution of *Cladium mariscus* and the dominant vegetation types on the west end of Redgrave Fen

- RF-W-6: this southern margin is increasingly wet from this point eastwards, with fairly shortly-grazed rush pasture in which heavily grazed *P. australis* is a conspicuous element. Poached hollows were flooded at time of survey, some with *P. coloratus*, but *C. mariscus* and *Carex* spp. were absent. This pasture grades into increasingly tall reed at southern edge of the scrape, initially with *J. subnodulosus* and *P.coloratus* beneath but then by bare, ochreous mud.
- RF-W-7: these high, north-south bunds are heavily grazed.
- RF-W-8: this scrape is, again, largely infilled with *P. australis*, which varies considerable in height and density. It is most dense, and mixed with *T. latifolia,* on the south side: some small patches of open water remain to the northeast where the reed is relatively sparse and short. These areas have *Chara* species beneath the reed. A shallower area on the west side has *J. subnodulosus* with sparse, short *P. australis*. There are occasional clumps of *C. mariscus* in the central area and a clump at the northwest corner.
- RF-W-9: this scrape has tall *P. australis* particularly along the west and south edges. Much of the scrape has relatively sparse, short reed with *Chara* species beneath and some open water remaining towards the centre. *C. mariscus* occurs all along the east edge, with occasional tussocks along the west and south edges.
- RF-W-10: the south edge of this scrape is hard-grazed, allowing *J. subnodulosus*, occasional clumps of *C. elata* and *P. coloratus* to thrive before the reed gains in height and density in the deeper water. The reed is quite sparse, with some areas of open water, especially in the east of the scrape. *C. mariscus* occurs centrally as occasional clumps but there is a bigger patch on the northern edge.
- RF-W-11: a heavily grazed area dominated by *C. epigejos* but with short *P. australis* at a frequency of *ca* 25%. *J. subnodulosus* also present but at much lower frequencies than further west.
- RF-W-12: south of RF-W-10, the southern margin of the open fen grades into short-grazed 'lawns' with clumps of *Juncus spp.*, mostly *J. conglomeratus*. These run right up to the edge of the scrape (RF-W-10).
- RF-W-13: almost all of Redgrave Fen 'sink' is coarse rush pasture dominated by *J. effusus* – there is no *C. mariscus*. The RF-W-13b is similar to 13a but in parts of it the vegetation is taller and coarser. The water table was mostly below surface, and a shallow central scrape was dry, at the time of survey.

A1.3.1 Potential suitability for *D. plantarius*

It seems unlikely that much of the western end of Redgrave Fen will develop vegetation suitable for supporting, *D. plantarius* at least within the next ten years. The shallow scrape at the head of the fen has shores that are either heavily grazed and enriched by water birds, as well as by stock, or are dominated by *P. australis*. *P. australis* is also dominant to the east of the scrape and historical evidence suggests that the dominance of reed here pre-dates the dessication of the fen. However, in the series of five deeper scrapes further east, *C. mariscus* is starting to establish amongst the, still very dominant, *P. australis*. If this trend continues, these scrape may become suitable for supporting *D. plantarius* within the next five to ten years.

A2 Little Fen

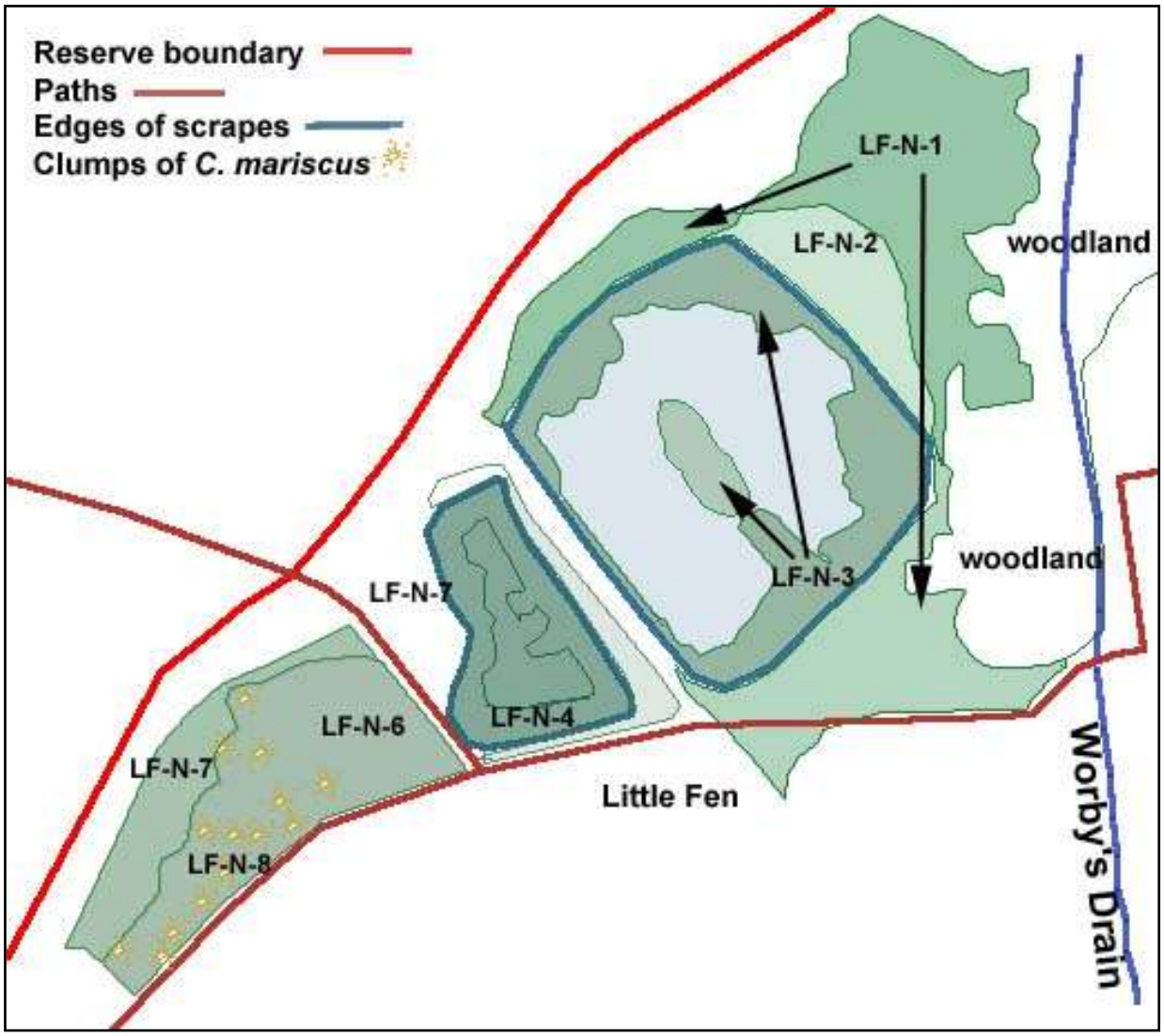

Fig. A7 The distribution of *Cladium mariscus* and the dominant vegetation types on the northern part of Little Fen

A2.1 Little Fen – North

- LF-N-1: Heavily grazed fen pasture mostly with strong representation of *C. epigejos* but varying in species richness, proportions of *Juncus* spp./*P. australis,* and in wetness.
- LF-N-2: An area of grazed *P. australis*/*C.epigejos*. Taller than the above and on wetter ground although drying out in summer.
- LF-N-3: Tall, dense *P. australis* in standing water within the scrape, with a prominent stand of *T. angustifolia* on the east side.
- LF-N-4: *P.australis* in standing water within the scrape but much of it relatively short and sparse cf the above.
- LF-N-5: Heavily grazed, relatively species-poor rush pasture
- LF-N-6: Grades from *C. epigejos*/*P. australis* pasture on relatively dry northern edge to wetter, *P.australis* dominated stand with occasional *T. latifolia* in the wetter southern part, with deep turf ponds.

- LF-N-7: Well grazed pasture area, dominated by *C. epigejos*, grading into:
- LF-N-8: stand of *P.australis*, with *C. epigejos* beneath, on the higher areas, and some patches of *T.latifolia*, especially in the southern half. *C. mariscus* present as a minority component in the sward but increasing in frequency (<5%-25%) towards the southern half of the area and concentrated around the turf ponds.

A2.1.1 Potential suitability for *D. plantarius*

Most of this northern part of Little Fen has little current potential for supporting *D. plantarius.* There is no evidence of *C. mariscus* becoming established in the large scrapes, which still support tall and dense *P. australis*. The marginal grassland is heavily grazed and lacking ponds around which more suitable vegetation structures might develop. The exception to this is the south-west of this area, which has a high density of deep turf ponds around which *C. mariscus* persists. This area is very close to the present centre of population and *D. plantarius* was recorded there until at least, 1980s, when there was a viewing platform on one of these ponds. Natural recolonisation of this area is a strong possibility within the next five yeas if the Little Fen population starts to expand its range.

A2.2 Little Fen - South (surveyed 8/10/08)

- LF-S-1: Wet heath area with varied vegetation types, all heavily grazed. The marked scrape is the only water body that reliably holds water in most summers but there is little emergent marginal vegetation. There are a few strong clumps of tall *C. mariscus* amongst the tall reed at the north end of the scrape but none in open sunny positions at the water's edge.
- LF-S-2: This area was cut in 2008. Although some parts are flooded, there are no deep turf ponds. The sward is dominated by a mixture of *C.epigejos*, and *P. australis*, the latter particularly towards the north and east margins. There are a few, isolated patches of *C. mariscus*, probably around shallow depressions that mark the remains of turf ponds.
- LF-S-3: this large *P.australis*-dominated area is difficult to access. It is often flooded but has very few ponds that hold water through dry summers. Although reed is dominant throughout, and particularly in the southwest sector, both *T. latifolia* and *C. mariscus* occur patchily, with frequencies of the latter varying locally from <5% to *ca* 25-50%. In the northern part of the area, towards LF-S-8, *C. epigejos* increases in frequency amongst the reed.
- LF-S-4: *P. australis* dominated area, often with standing water, although with few ponds deep enough to hold water in high summer. *C. mariscus* occurs patchily throughout, with frequencies generally <5%.
- LF-S-5: this area has a higher frequency of *C. mariscus* amongst the *P.australis* than LF-S-4, with frequencies to >50 locally. Although deep water is restricted to a small number of artificial turf ponds, much of the area remains flooded in wetter summers.
- LF-S-6: a *P. australis/Juncus spp./C.epigejos* fringe, parts of which remain shallowly flooded throughout wet summers, although lacking any deep ponds.
- LF-S-7: *P. australis*-dominated but with a conspicuous element of *C. mariscus* (*ca* 50%), particularly in the lower-lying areas and around the deep, old turf ponds.
- LF-S-8: *C. mariscus*-dominated with almost pure stands in places. *P. australis* increases to *ca* 50% towards northern margins and south-east corner.
- LF-S-9: Heterogeneous area, dominated by mostly sparse *P. australis* and *C.epigejos* but with scattered *C. mariscus*, particularly fringing the many old turf ponds.
- LF-S-10: shortly grazed *P. australis* and *T. latifolia*.
- LF-S-11: Tall fringe of pure. *P.australis.*
- LF-S-12: Tall *P.australis* fringing deep scrape with occasional clumps of *C. mariscus* along N margin.

- LF-S-13: *P.australis* almost completely infilling the scrape. No *C. mariscus* found in this area.

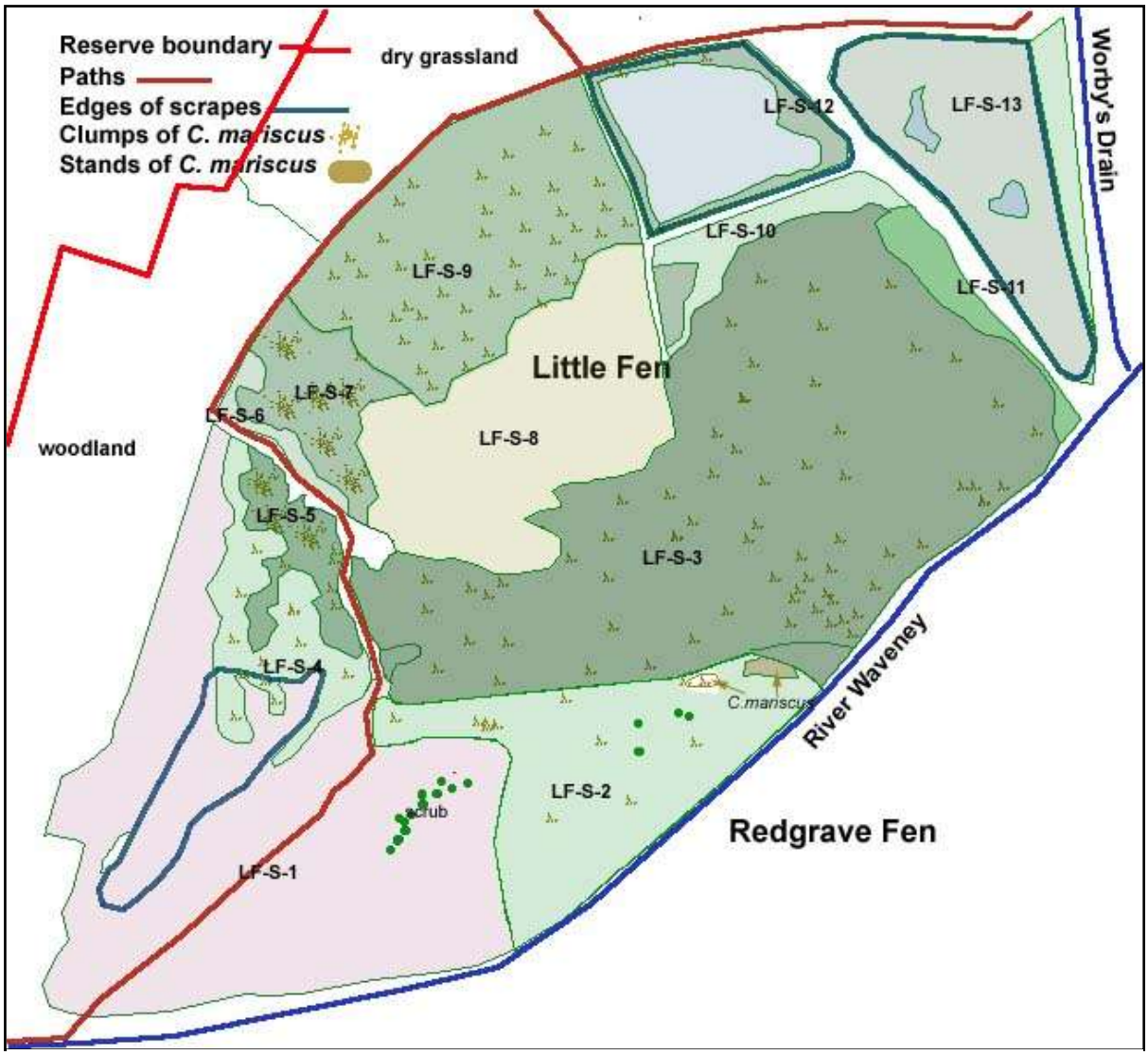

Fig. A8 The distribution of *Cladium mariscus* and the dominant vegetation types on the southern part of Little Fen

A2.2.1 Potential suitability for *D. plantarius*

Apart from the wet heath that covers the south west of this area, and the very deep scrape at its north-east corner, most of this area has the potential to become suitable for *D. plantarius* and for natural recolonsiation to occur from the core population. Most of this area was formerly *C. mariscus* swamp and, although much of it is now dominated by *P. australis, C. mariscus* still occurs at varying frequencies throughout. Extensive grazing, selective mowing of areas with tall *P. australis*, and excavation of a few shallow scrapes and ponds in recent years, are all likely to contribute to an increase in frequency of *C. mariscus* at the expense of *P. australis*. However, much of the area lacks deep turf ponds: excavation of series of ponds, radiating from the core area for *D. plantarius* is likely to encourage sustainable recolonsiation.

A3 Middle Fen

A3.1 Middle Fen - West (surveyed 15/10/08)

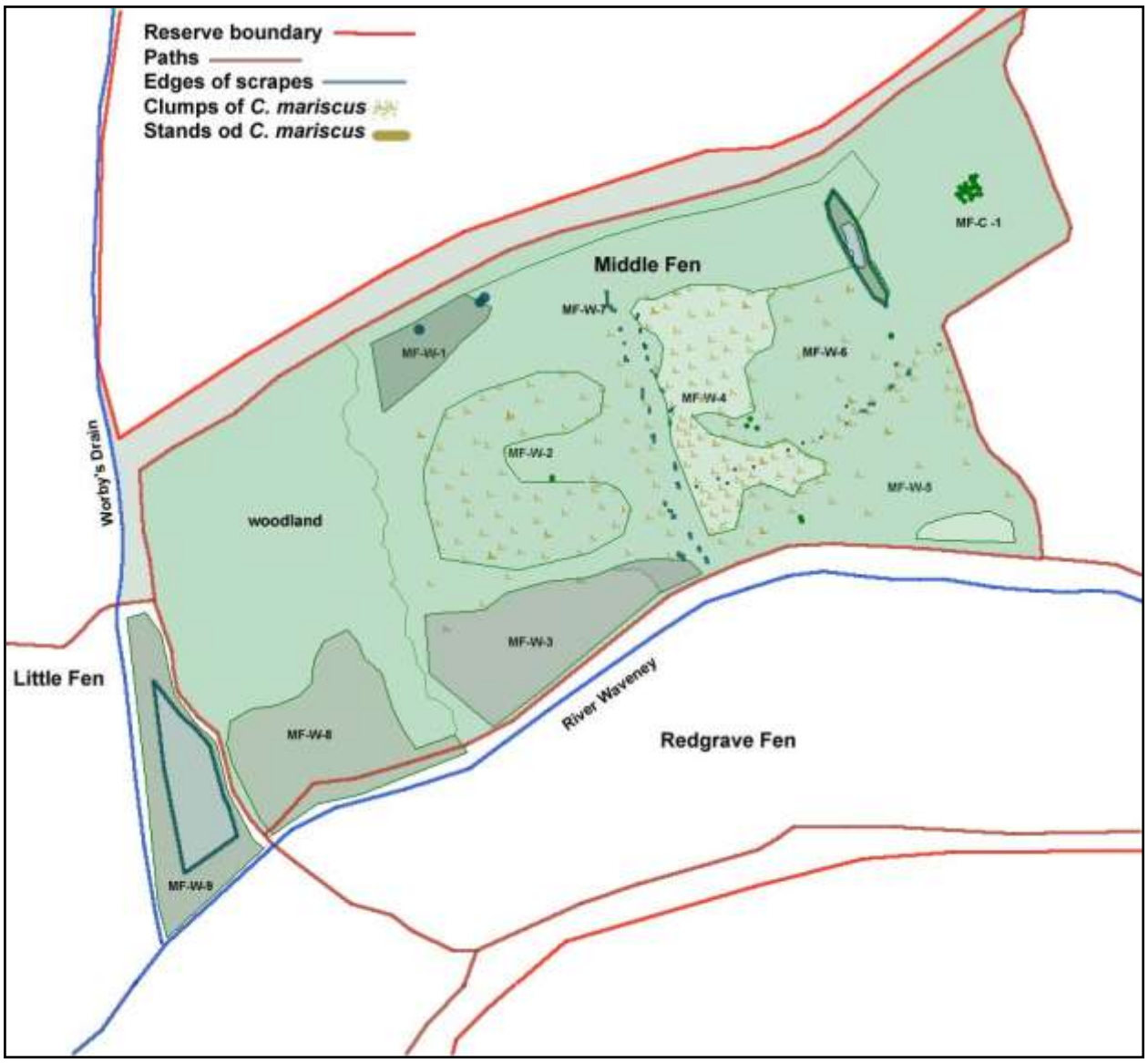

Fig. A9 The distribution of *Cladium mariscus* and the dominant vegetation types on the western area of Middle Fen

- MF-W-1: an enriched fringe dominated by dense *J. effusus* with a line of *Ulex europaeus* on the southern margin. The shallow ponds marked here were excavated in 2007/08 and were unvegetated.
- MF-W-2: a large area of moderately grazed, tussocky wet fen with *C. epigejos* and *J. subnodulosus* abundant and heavily grazed. *P. australis* throughout although so depauperate that it is inconspicuous. Particularly in the southern two thirds of the area, *C. mariscus* occurs sporadically, varying from 5%, to 50% in association with the shallow remains of old turf ponds and deeper turf ponds, dug in the 1970s/80s. This area was flooded at the time of survey but is usually only either surface-wet or dry in summer, with standing water only in the deepest ponds. A higher central area is more closely grazed, supporting more species-rich rush pasture.

- MF-W-3: *P. australis* increases in frequency and height towards the river. Scattered clumps of *C. mariscus* persist until close to the river, where *C. epigejos* remains in association with the *P.australis*.
- MF-W-4: Tall clumps of both *P.australis* with *C.epigejos* beneath, and *C.mariscus* (to *ca* 25%), broken up by cattle tracks and areas of short-grazed grasses. The only pools that hold water in most summers are those dug in the 1980s along the old former north-south track and the intersecting east-west track: the density of *C. mariscus* increases around these pools.

Fig. A10 Mosaic of grazed areas with taller *P.australis* and occasional *C. mariscus* on the western area of Middle Fen

- MF-W-5: in the south and east part of this compartment *P. australis* is the dominant component of the tall stands, which are, again, broken up by grassy tracks and grazed clearings. *C. mariscus* is rare, except in the vicinity of the deep ponds along the east-west track. In the southeast of this area, *P. australis* gives way to *C. epigejos* as the dominant, and the proportion of more tightly grazed, mixed grassy sward increases. *P. australis* increases in frequency and height again along, and immediately to the west of, the main north-south path. Further north, in a fringe on the west side of this track, the proportion of *C. mariscus* increases again to *ca* 25%. All of this area was surface wet at the time of the survey.
- MF-W-6: Tussocky, surface wet, moderately grazed *J.subnodulosus/C. epigejos* grassland with depauperate *P. australis* occurring at low frequency throughout. *C. mariscus* present at very low frequency (*ca* 5%) except around deep ponds on the east-west track. The elongated scrape is largely infilled with *P.australis* with some *T. latifolia* but no *C. mariscus*. Some open water remains in the central section.
- MF-W-7: is less tussocky *J.subnodulosus* pasture with *C. mariscus* almost absent
- MF-W-9: isolated from the remainder of this area by the woodland fire-break, has a tall *P.australis* fringe along the eastern side of Worby's drain but immediately east of

this is a dry area where the reed is more sparse and patchily trampled by stock. Towards the north of this area, it becomes increasingly grassy with the reed confined to isolated clumps. The scrape itself is mostly infilled by tall *P. australis* - there appears to be an area where the reed is relatively sparse but there is really open water. There is no *C. mariscus* in this area.

The southern end of Worby's drain is often choked with *R. nasturtium-aquaticum* and *Mentha aquatica* and fringed by grazed *P. australis* with emergent *Sparganium erectum* and *Rumex hydrolapathum* on the west side. Any open water areas have dense *Callitriche* spp. Further north, the drain becomes more uniformly reed-fringed: *R. nasturtium aquaticum* becomes less, and *Callitriche* spp. more abundant.

A3.1.1 Potential suitability for *D. plantarius*

The vegetation of much of this area is potentially suitability for *D. plantarius* and is likely to be improving in this respect as a result of grazing, probably in combination with falling nutrient status. The main factor likely to prevent recolonsiation from the core Middle Fen *D. plantarius* population is the shortage of deep turf ponds. Excavation of chains of ponds radiating from the current centre of population, and linking the areas of highest density *C. mariscus,* could allow recolonisation if the Middle Fen spider population continues to expand over the next five years. The areas of dense, lodged *C.epigejos* and *J. subnodulosus* may present an obstacle to movement of the spiders but this could be overcome control by careful control of grazing and strategic placing of new turf ponds.

A3.2 Middle Fen - Central (surveyed 13/11/08)

- MF-C-1: an area of relatively tall vegetation, dominated by *C. epigejos*, *P. australis* and *Juncus* spp, with their tops lightly grazed. *C. mariscus* is largely confined to the eastern side where it is tall and dense in places, particularly around the shallow remains of old turf ponds. There is very little *C. mariscus* west of the large gorse patch and none to its north.
- MF-C-2: North of a former fence line, this area is lightly grazed and dominated by *C. epigejos, P. australis* and *Juncus* spp.. *C. mariscus* increases from >5% on the western side to 25-50% on the eastern margin, where there are some tall dense patches.
- MF-C-3: a relatively dry and well-grazed area with no deep pools, and dominated by *J. subnodulosus*, *C. epigejos* with sparse, grazed *P. australis*. *C. mariscus* present throughout but at frequencies of only *ca* 10-20% in the sward.
- MF-C-4: a *C. mariscus* bed with *C. epigejos* present only on higher ground. Deep pools often with with surface flooding between.
- MF-C-5: *C. mariscus* still dominant but with more *C. epigejos* and *P. australis* increasing towards the south. Shallowly flooded at the time of survey, but without deep ponds.
- MF-C-6: a drier area, without pools, dominated by *C. epigejos* and grazed *P. australis* still with C. mariscus throughout at *ca* 10-20%.
- MF-C-7: *P. australis* stand.
- MF-C-8: north of an east-west line defined by the gorse clump. This area has grazed, mixed, tussocky vegetation dominated by *C. epigejos* with frequent *Juncus* spp and depauperate *P. australis*.
- MF-C-9: Dry to surface- wet, mixed fen dominated by a mixture of *C. epigejos, J. subnodulosus* and short-grazed *P. australis,* often within a more mixed grass matrix. Overall, *C. mariscus* is a minority component of the sward but clumps are scattered throughout and particularly around the shallow remains of turf ponds. Densities vary up to *ca* 50% of the sward, with *P. australis* as an increasingly frequent and vigorous

component towards the reed bed to the south. There are no deep ponds and none that hold water during most summers.

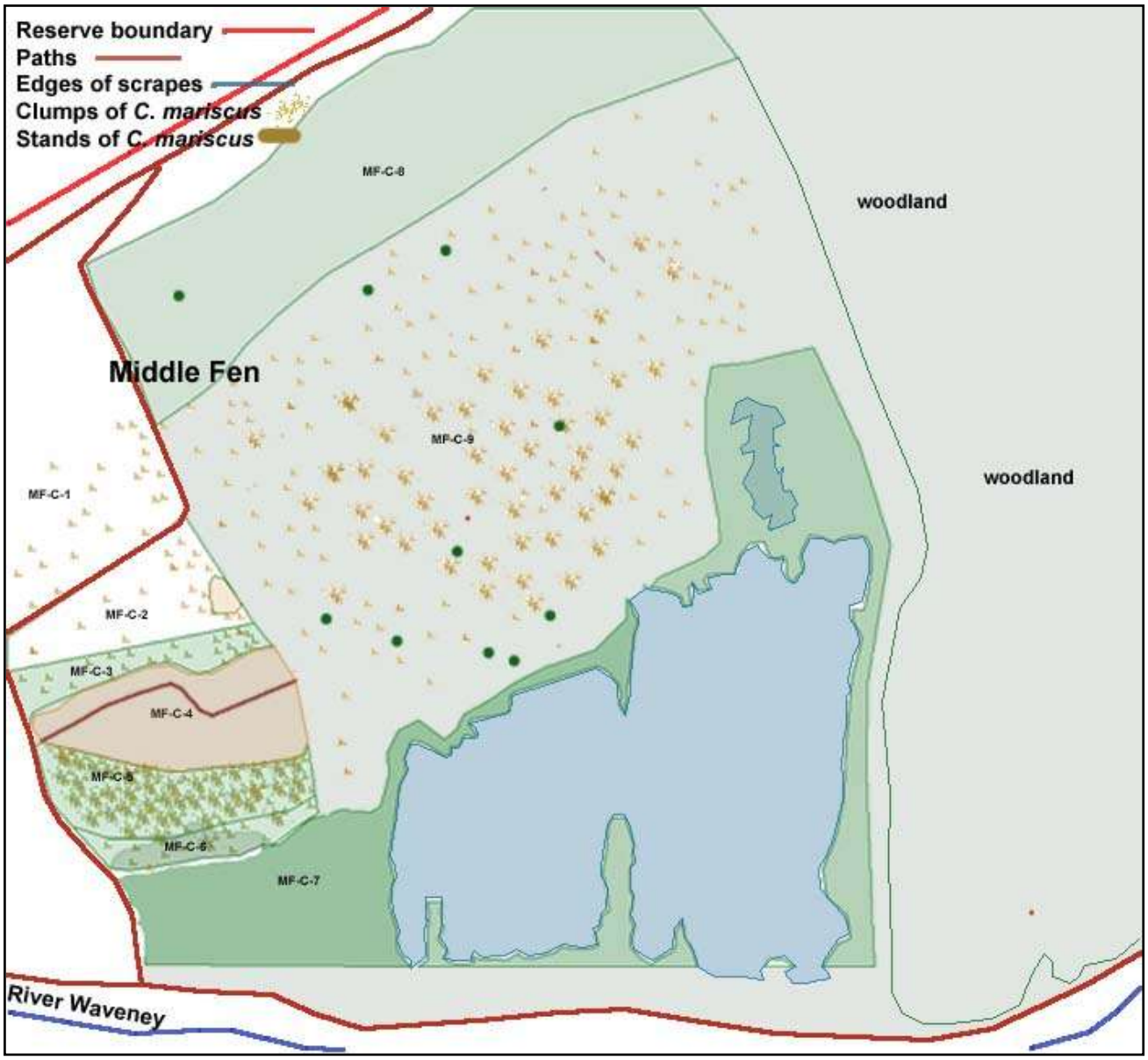

Fig. A11 The distribution of *Cladium mariscus* and the dominant vegetation types on the central area of Middle Fen

A3.2.1 Potential suitability for *D. plantarius*

The central zone of this area has *C. mariscus* scattered throughout and so has considerable potential for natural recolonisation by *D. plantarius* from its core area immediately to the west. However, excavation of lines of turf ponds in a continuous sequence in the core area is an essential pre-requisite for this. More intensive grazing, to continue to reduce the height and vigour of *P. australis* and *C. epigejos,* would also favour expansion of the spider population into this area.

The large scrapes in the south of this area are fringed by tall and dense *P. australis* and there is no evidence of colonisation by *C. mariscus*. It seems unlikely that these scrapes will become suitable for the spiders within the next ten years. The north of the area is too dry and grassy to be suitable for the spiders.

A3.3 Middle Fen - East

Fig. A12 The distribution of *Cladium mariscus* and the dominant vegetation types on the eastern area of Middle Fen

- MF-E-1: a heterogeneous area, mostly dominated by *C. epigejos/J.subnodulosus* but with *P. australis* increasing towards the south, grading into MF-E-3.
- MF-E-2: surface-dry, tussocky grassland dominated by *C. epigejos*
- MF-E-3: *P. australis* bed
- MF-E-4: A deep scrape with clear water, full of *Chara* spp. and fringed predominantly by relatively sparse *P. australis*. On the east margin, a band of *C.mariscus*, broken in the northern half but becoming continuous further south, extends right along the waters' edge. In places, sparse emergent *C. mariscus* also extends out into the water. Occasional clumps of *C. elata* occur at the water margin. The *C. mariscus* fringe extends along the south bank of the scrape, again, extending out into the water in places. *C. mariscus* occurs only as occasional clumps on the west bank, although there are young, non-flowering plants in the north-east corner. Between this scrape and MF-E-5: to the south is a band of *P. australis* with *C. epigejos.*
- MF-E-5: has a taller, denser and wider band of emergent *P. australis* than MF-E-4. A wide band of *P. australis*, with *C. epigejos* beneath, also separates this scrape from MF-E-6 to the south. A band of *C. mariscus* runs along the water's edge with

emergent *P. australis* and some J. subnodulosus beyond it. No *C. mariscus* was seen along the south bank or most of the east bank but a band runs along the west side with *P. australis* in the water beyond, often mixed with *J. subnodulosus*.

- MF-E-6: is again fringed with emergent *P. australis*. Behind this, on the east margin, a narrow band of *C. mariscus* runs along the water's edge. A narrow band also occurs on the southern shore and the southern half of the west shore, where the *P. australis* fringe is narrow and poor. *C. mariscus* extends further out into the water in places here.
- MF-E-7: the apex of this triangular scrape is infilled with *P. australis*. On the east shore, immediately below the tightly grazed bund, a band of *C. mariscus* runs along the water's edge, extending out into the water in places but ending *ca* three quarters of the way along the shore. Beyond it, sparse, short emergent *P. australis* infills most of the water body. The western shore has little *C. mariscus* but it is open and sunny. with fringing *J.subnodulosus*
- MF-E-8: a band of *P. australis* separates this scrape from MF-E-7 to the north with *C. mariscus* along the northern shore where a more substantial stand has developed along the water's edge in a shallow bay, with *J. subnodulosus/C. epigejos* and sparse *C. mariscus* and P. australis behind.
- *C. mariscus* extends right down the east side and along the south shore where emergent and island stands are forming and little emergent *P. australis* is present. There is very little *C. mariscus* on the west side.
- MF-E-9: south of MF-E-8 is a relatively dry area of tall *P.australis* with *C.epigejos/J. subnodulosus* beneath. *C. mariscus* is co-dominant with the *P. australis* in a *ca* 10m band behind the water margin. Clumps of *C. mariscus* occur patchily throughout this area although there are no significant pools.

Fig. A13 A recent scrape on the eastern part of Middle Fen, with the brown seed heads of *Cladium mariscus* throughout the fringing vegetation

A3.3.1 Potential suitability for *D. plantarius*

The recent colonisation of the scrapes in this area of Middle Fen by *C. mariscus* is making it increasingly suitable for *D. plantarius*. Some of these scrapes are already suitable and others appear likely to become so within the next five years. Because the area is isolated from the remainder of Middle Fen by a substantial woodland firebreak, natural recolonisation from the Middle Fen *D. plantarius* population is very unlikely in the foreseeable future. Deliberate re-introduction will be required to re-establish the spiders in this area.

A4 Great Fen (surveyed 08/11)

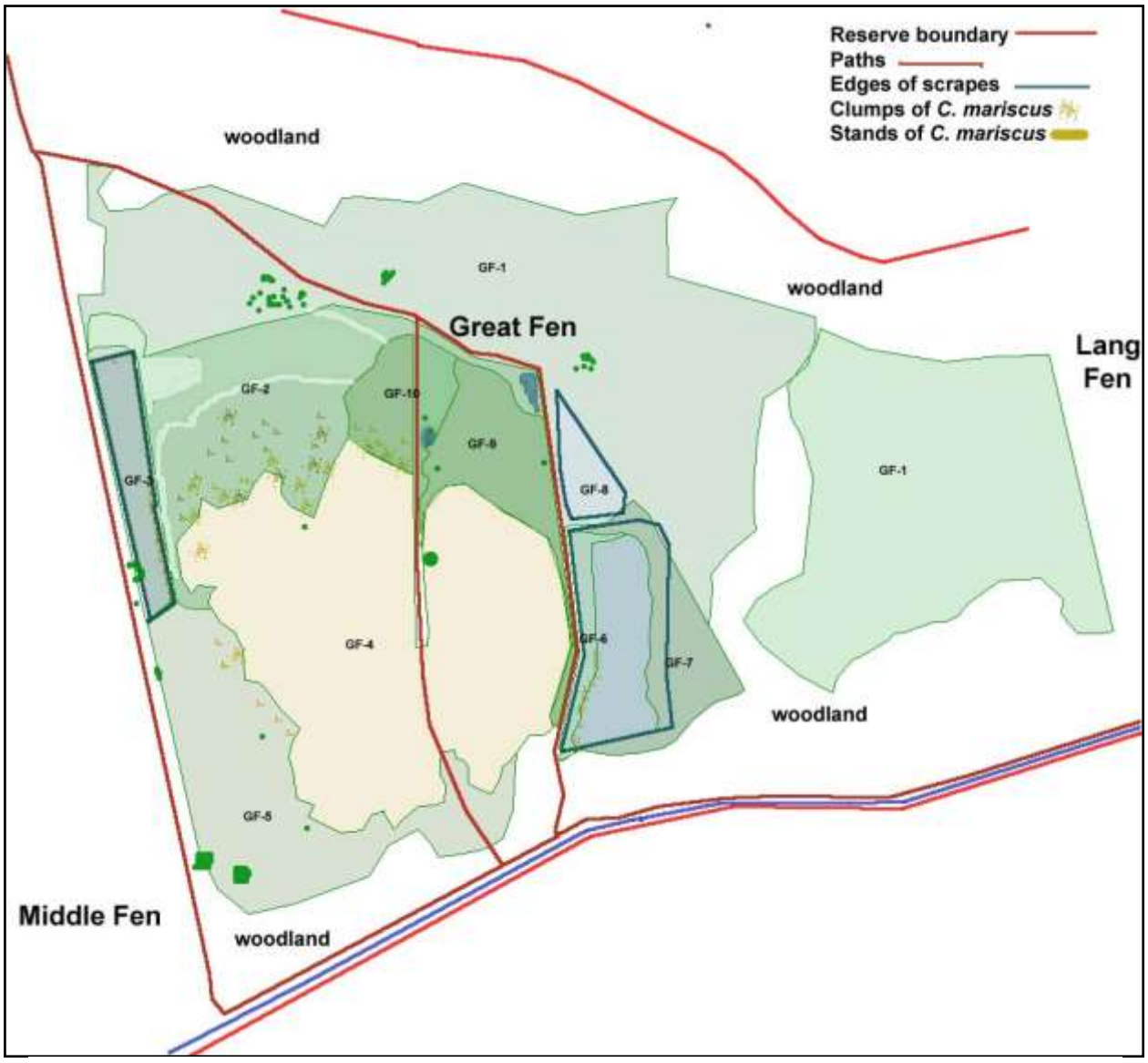

Fig. A14 The distribution of *Cladium mariscus* and the dominant vegetation types on the eastern area of Middle Fen

- GF-1: Mostly surface-dry, rush pasture (predominantly *J.effusus* and *J. inflexus*)
- GF-2: wetter than above and dominated by *C. epigejos* and *J. subnodulosus*. To the south of this area *C. mariscus* appears at increasing frequency in the sward.

- GF-3: a 1990s scrape, fringed and infilled by vigorous *P. australis* with *T. latifolia* at low frequency. Where the reed is relatively sparse, the *Chara* species and *P.coloratus* are submergent. The southern *ca* two thirds of the east bank has a narrow ribbon of *C. mariscus*.
- GF-4: an extensive and vigorous stand of *C. mariscus*, surface wet, with hollows but without deep pools except those dug on the west side of the central track in 1998. Some enclaves in the dense *C. mariscus*, particularly along paths, bunds and stock tracks, have *C. epigejos/J.subnodulosus* swards. The *C. mariscus* stops quite abruptly at the northern edge of the stand, giving way to *P. australis*. Towards the eastern side, the stand is relatively open, with a narrow *P. australis* fringe running down the bund itself.
- GF-5: a very heterogeneous area, heavily grazed to the north but taller and more rank to towards the river. A mixture of rush pasture with wetter hollows where *J. subnodulosus* and *C. elata* tussocks are dominant. Towards the eastern edge, *C. mariscus* increases in the short, grazed sward but the main *C. mariscus* stand (GF-4) rises like a wall beyond this area. Towards the river, surface wetness increases and *P. australis* enters the mostly *C. epigejos*-dominated sward. It occurs in increasingly in tall patches, with *C. epigejos* and *C. mariscus* beneath.
- GF-6: the western margin of the scrape is *J. effusus* pasture with an element of short *P. australis* which increases in frequency towards the water's edge. A ribbon of *C. mariscus* is present in the southern *ca* half of the emergent vegetation fringe.
- GF-7: *P. australis* bed, grazed on eastern side.
- GF-8: this a shallow scrape, excavated in winter 2007/08. Towards it southern end it has some emergent *P. australis*.
- GF-9: dominated by *P. australis* but increasingly grazed towards its northern edge, where *C.epigejos* and *J. subnodulosus* replace it as the dominants.
- GF-10: Dominated by *P. australis*, which is particularly tall towards southern edge, where it has *C. mariscus* beneath.

Fig. A15 The extensive stand of *Cladium mariscus* on Great Fen (GF-4)

A4.1 Potential suitability for *D. plantarius*

The *C. mariscus* stand on Great Fen is the most extensive within the Redgrave & Lopham Fen complex. It is too isolated from the Middle Fen *D. plantarius* population for natural recolonisation to be a realistic prospect but is an obvious area for deliberate re-introduction. With this possibility in mind in a series of ponds was excavated in 1988, west of central track through the stand. Since the full commissioning of the sluice on the river immediately downstream of Great Fen, in 2007, summer water levels in these ponds have been well maintained. They have been extensively invadedby *C. mariscus* and require some re-excavation to maintain water depth and an element of open sunny water surface. However, to ensure that a newly founded spider population is able to occupy the entire sedge bed and survive drought summers, further excavation of turf ponds is required, ideally in the western and northern parts of the stand.

C. mariscus is just starting to colonise the margin of the scrape just beyond the eastern edge of the stand: this area may be well be suitable for supporting *D. plantarius* by the time a population, initially established more centrally, starts to expand. Changing grazing and nutrient levels may also increase the prospect colonisation to the north of the dense *C. mariscus* stand where *C. mariscus* currently occurs as a sub-dominant amongst either *J. subnodulosus* and *C.epigeos* or *P. australis*.