Fen Raft Spider Recovery Project:
2013 Summary Report for Redgrave and Lopham Fen

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Contents

Fen Raft Spider Recovery Project: 2013 Summary Report for Redgrave and Lopham Fen

Summary

1 This report describes the results from the twenty-third year of systematic monitoring of the nationally endangered Fen Raft Spider *Dolomedes plantarius* at Redgrave and Lopham Fen National Nature Reserve (NNR), Norfolk. Habitat management work and measurements of water levels are also documented and discussed in relation to spider population trends and to re-introductions of the spiders to other parts of the fen complex.

2 The Biological Action Plan target for *D. plantarius* at this site is for 65ha of habitat occupied in 3 years out of 5 by 2020.

3 Throughout the 23-year census period, the population on the reserve has been small. Its range has been restricted to two small and spatially separated areas, constituting a maximum of *ca* 5ha, on Little Fen and Middle Fen.

4 Desiccation of the fen by artesian abstraction, and 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. Subsequent hydrological recovery was rapid.

5 An annual index of the size of the *D. plantarius* population, 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.

6 Modelling of 23 years of census data for both the Little and Middle Fen sub-populations showed that there was a significant difference between them in the pattern of annual variation. On Little Fen the 2013 index was slightly lower than in very recent years but not significantly lower than that the substantial increase seen in 2010. On Middle Fen the index was also similar to those of recent years, which show less dramatic interannual variation than in the 1990s.

7 Numbers of both breeding females and nursery webs on Middle Fen during the mid-July census were very low, possibly in part because the breeding season was delayed by 2-3 weeks after an exceptionally cold spring. On Little Fen breeding records during the late July census were the second highest recorded.

8 On Middle Fen, no evidence was found of *D. plantarius* in a westward expansion in their range that began in 2006 but they were recorded for the second successive year on turf ponds excavated in 2009 to the east of the core area.

9 On Little Fen, there was some evidence of an expansion in range, with adult spiders found in compartments adjacent to the core area, although they were not seen on the upper stretch of the river Waveney where they were encountered in 2012.

10 Habitat management by mowing was confined to sedge beds outside the census area on the southern edge of core area for *D. plantarius* on Little Fen. No *C. mariscus* was cut on Middle Fen for the fifth successive year. Grazing stock had access to both areas but, as in all previous years, made more impact on Middle Fen than on Little Fen.

11 Although the current census method has provided robust data for the *D. plantarius* on Redgrave and Lopham Fen while the population has been very small and restricted in range, a new monitoring strategy is now required. This is needed (1) to accommodate the changes in range on Little and Middle Fen, and the recent translocations to restored areas on Great Fen and Middle Fen, (2) to cater for the progressive decrease in the numbers of Little Fen ponds that can safely be surveyed using the current method, and (3) to facilitate volunteer involvement in monitoring for the longer-term.

12 Development of a statistically robust method that relies primarily on counts of nursery webs throughout the breeding season is recommended. Extension of the current census method to new areas is not an option because it is unsafe for use in many of the water bodies that should now be included.

1 Introduction

This report summarises monitoring and management work undertaken in 2013 as part of the Fen Raft Spider *Dolomedes plantarius* Recovery Programme at Redgrave and Lopham Fen National Nature Reserve (NNR) on the Norfolk/Suffolk border in East Anglia. This Schedule 5 species was first discovered in the UK at this site in 1956 (Duffey 1958) and this remains one of only three natural populations where it occurs in the wild. Since 2010 a translocation programme designed to reduce vulnerability to stochastic extinction has started to establish populations at other sites in East Anglia and southern England (Smith 2011a, 2012a and 2013b).

Systematic monitoring and targeted management for *D. plantarius* began at this site in 1991 (under English Nature's Species Recovery Programme) to prevent extinction of the population. Desiccation of the fen, resulting from artesian abstraction since 1960 and compounded by droughts in the 1980s and 1990s, reduced the spider population to very low levels (Smith 2000). By the late 1980s, the remnant population had become restricted to turf ponds on two separate parts of the NNR. Targeted habitat management in the 1990s, including the irrigation of the ponds inhabited by the spiders, probably prevented extinction of the spiders but systematic monitoring showed that there was no significant increase in the size of the population and that its range was continuing to contract (Smith 2000).

Artesian abstraction ended in 1999 and hydrological recovery was rapid (Harding 2000). But despite both the very high potential fecundity of *D. plantarius* and the wetness of the fen, the spider population showed no sign of significant or sustained recovery during the following decade. It was clear that any recovery would be slow and that the wetness of the fen was not the only required trigger. Even with a downward revision in 2005 (BARS 2011), the 2010 BAP targets for the Redgrave and Lopham Fen population were not met; the population still showed no evidence of sustained or significant recovery (Smith 2011b). The most positive development during this period was an increase in range of the Middle Fen population, which began in 2006, eight years after restoration of the fen's hydrology. Although this appeared to involve small numbers of spiders over a modest distance, it was the first indication that habitat conditions beyond the core range of this sub-population were becoming suitable.

The extremely slow recolonization of the recovering habitat at Redgrave and Lopham Fen is consistent with recent research that shows that *D. plantarius* at this site has very limited tendency to disperse (Pearson 2008). A 2009 survey of the extent of suitable vegetation types on the Fen, and of standing water in summer (Smith 2009), showed that a lack of continuity of summer-wet habitat was also likely to be impeding dispersal and recolonization of restored areas. These problems were addressed in two ways. First, a rolling programme of excavation of chains of new turf ponds started to provide links between existing population centres and larger scrapes created during the 1990s restoration work (Smith 2010, 2011b). Secondly, as part of national translocation programme to reduce this species vulnerability, *D. plantarius* of local provenance were introduced to suitable areas of restored habitat within the Redgrave and Lopham Fen complex. The first phase of the translocation programme was completed in 2012, with introductions having been made in two successive years to two areas of the Fen from which the spider was absent. The details of this work, including monitoring of the new populations, are given by Smith 2011a, 2012a, 2013b and 2014.

This report presents the results from the standardised annual census of the natural population of *D. plantarius* at Redgrave and Lopham Fen. It also summarises ground water and rainfall data collected by the Suffolk Wildlife Trust (SWT), the NNR managers. All of these results are discussed in the context of the previous 22 years of monitoring data. The next steps required to progress the BAP targets for this site, in terms of monitoring, further translocations and both habitat and hydrological management, are considered.

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, 2000, 2001, 2006, 2007, 2008, 2009, 2010, 2011a & b, Smith 2012b, Smith 2013a).

2 Methods

2.1 Annual census

The annual census of *D. plantarius* followed the methodology adopted in 1993 and described by Smith (1993, 2000, 2013). The three replicate counts were made at 29 turf ponds on Little Fen (Fig. 1) and 30 on Middle Fen (Fig. 2) in late July. Whenever consistent and favourable weather conditions allowed, the counts for each fen were made on three consecutive days (Table 1).

Table 1 Census dates for 1994-2013

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
2009	13-20	23-28
2010	19-26	26-30
2011	25-31/07	1-3/08
2012	-	1-8/08
2013	22-27/07	15-17/07

In 2000, 2001 and 2012, very high water levels made it physically impossible to census Little Fen during the summer. Sustained, very high water levels that result in establishment of submergent aquatic plants, and development of aquatic invertebrate populations over extensive areas of the fen surface, appear to result in dispersion of *D. plantarius* away from the turf ponds and are likely to bias the data.

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 (ponds 31 and 33: Fig. 1). By 2004 two of the three replicate counts at a further pond (36) also had to be made from the bank and in subsequent years all counts at this pond were made from the bank. In 2013 counting from the water also had to be abandoned in pond 32 and only one of the three counts at pond 51 was made from the water. Only part of the circumference of pond 42 could be surveyed from the water.

In 1991 and 1992 the census covered ponds in much more restricted areas of Little and Middle Fens. The methodology was changed in 1993 to include a wider area and allow detection of changes in range (Smith 1993) although the two methods were run in parallel until 1995 (Smith 1995). There was sufficient overlap in the sets of ponds sampled to allow formal analysis of population trends for the entire period since 1991.

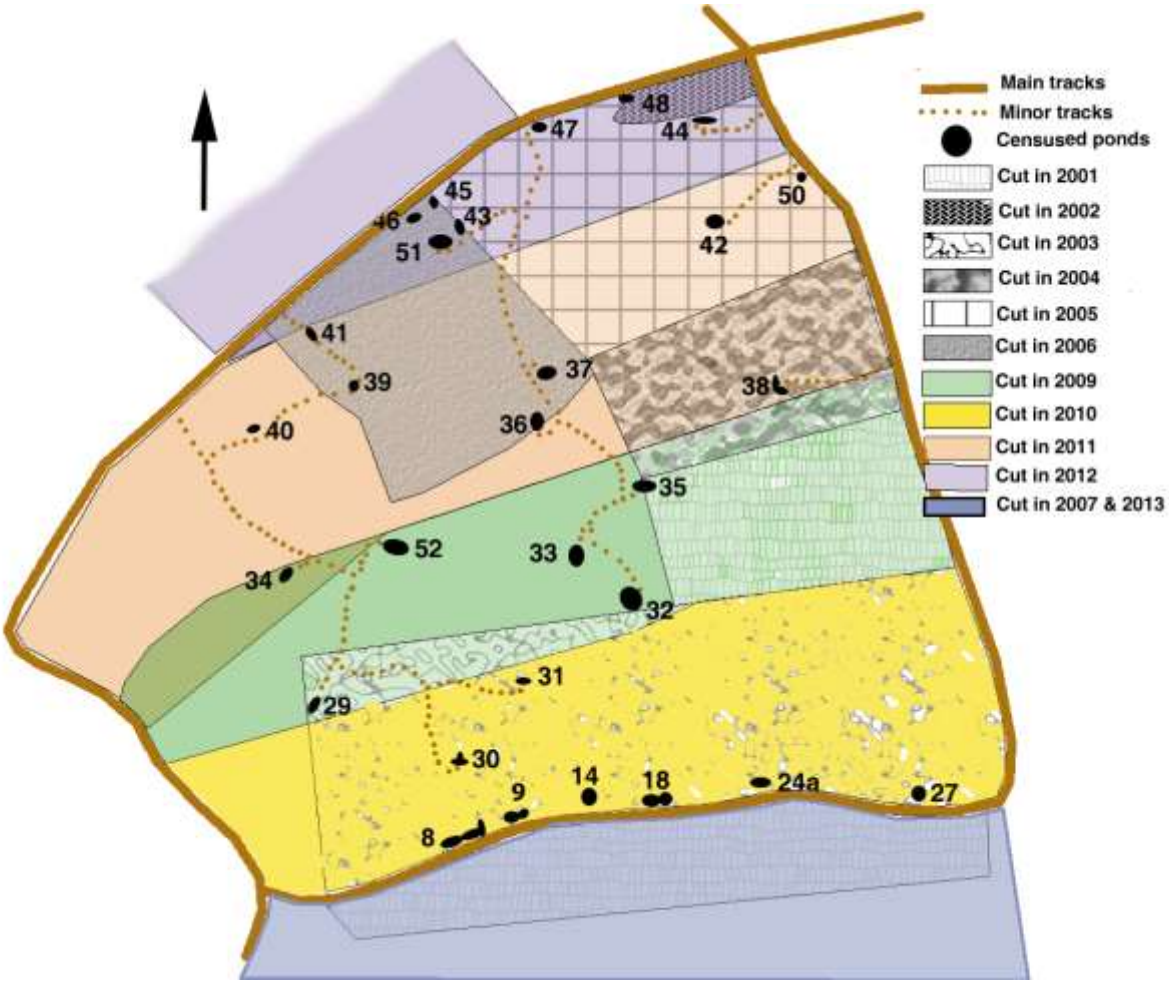


Fig. 1 The Little Fen census area showing ponds included in the census. Shading shows areas where vegetation was cut and removed in July/August each year

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 & van Strien, 1998). In years when data from both Little and Middle Fen are available, TRIM allows the data to be split into different strata: 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 the data from the set of ponds censused at the outset of the project (1991-1995), and those from ponds censused from 1993 onwards, could be utilised (Section 2.1, 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.

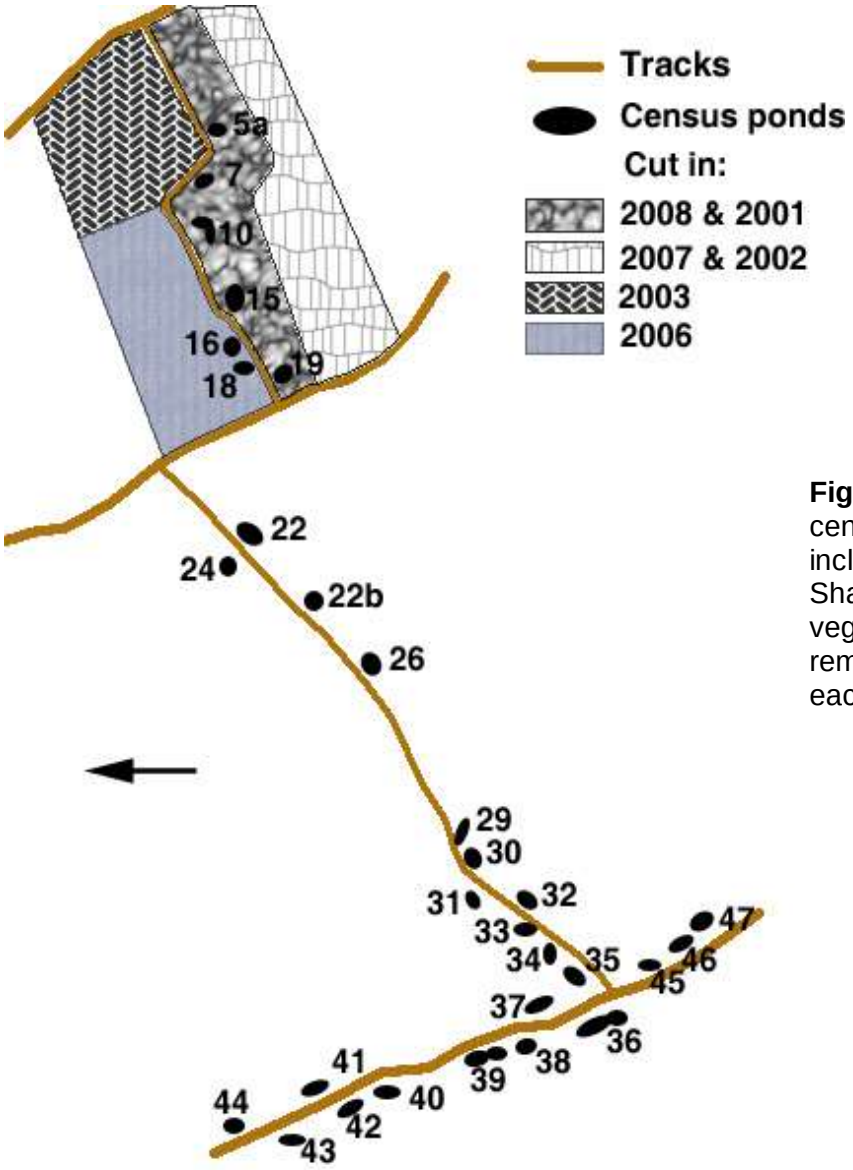


Fig. 2 The Middle Fen census area showing ponds included in the 2013 census. Shading shows areas where vegetation was cut and removed in July/August each year.

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. Additional information comes from casual records, including observations when sedge-cutting management is carried out, but this cannot be used for quantitative comparison between years.

2.4 Water levels

Until spring 2010 routine water level measurements were made at approximately monthly intervals against permanent posts in the census ponds on Little and Middle Fens and in the ponds dug on Great Fen in 1998 (Smith 2000, 1998). Since then measurements have since been taken during the July census periods (Little and Middle Fens only), and in November 2011 and March 2012. In 2012 the very high summer water levels on Little Fen in July delayed collection of water level data until early August. The levels in the Little and Middle Fen ponds are expressed relative to an arbitrary datum established in April 1992 and the levels in the Great Fen ponds relative to Ordnance Datum.

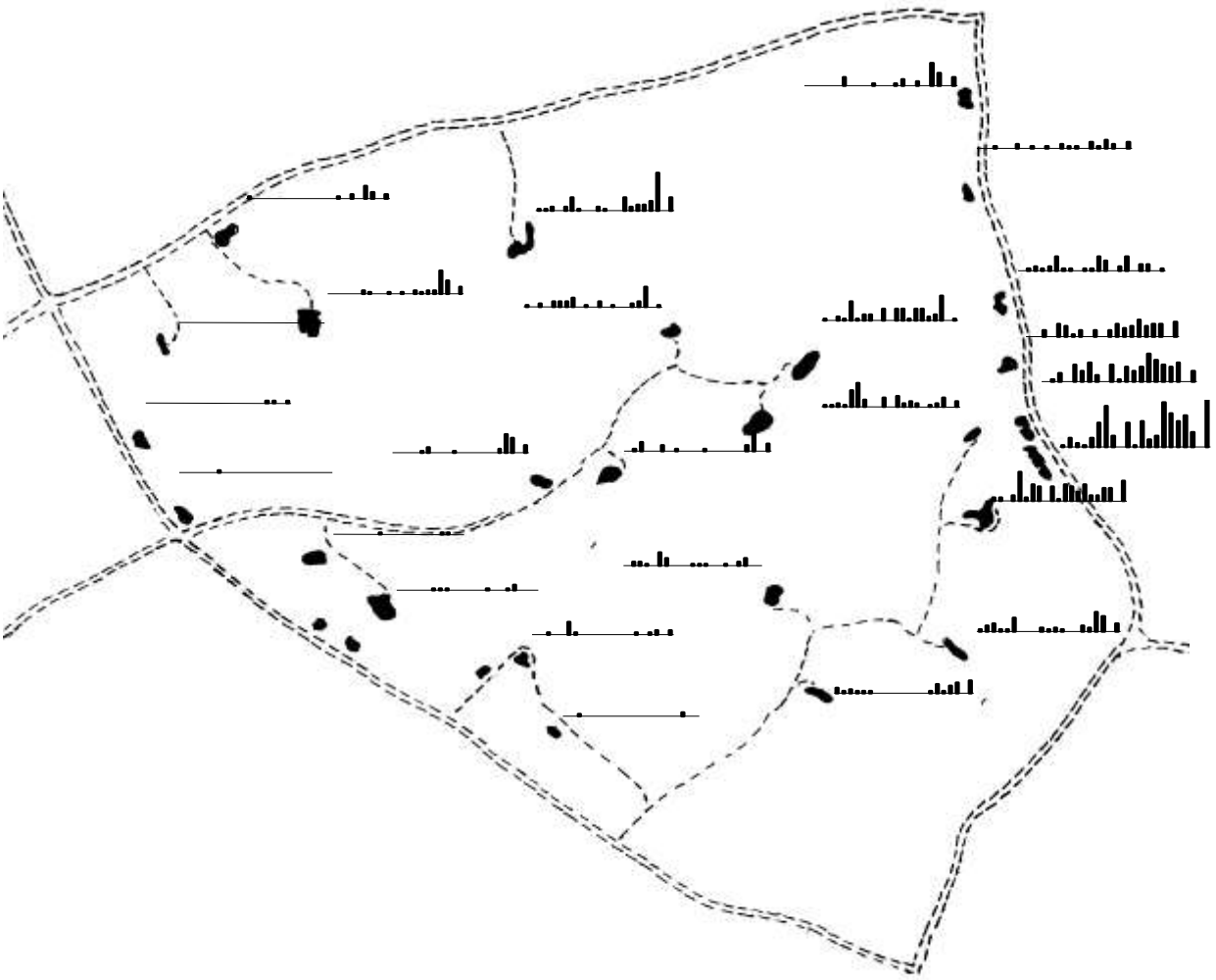
Ground water levels on the Fen have been monitored by SWT since 1976 using a network of 54 dipwells (Smith 2000). Most of these monitor near-surface hydrology: eight are sunk into the underlying chalk.

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 36-year recording period. Monthly rainfall data measured on the Fen since 2001 are also presented.

3 Results

3.1 Distribution

Fig. 3 Little Fen census area showing relative numbers of *D. plantarius* recorded at each pond in late July between 1993 and 2013. Bars represent maximum counts for consecutive years (highest count=24: no July data were collected in 2000, 2001 and 2012). Where ponds have no chart, *D. plantarius* has never been recorded during these censuses.



Within the **Little Fen** census area *D. plantariu*s were found on slightly fewer ponds than in 2010 and 2011 (Table 2) but they nevertheless remained distributed throughout the area (Fig. 3). They were also found by casual recording on ponds close to the census area in adjacent fen compartments, although they were not found the upper Waveney where a gravid female and courting male were seen in 2012. They have been present throughout in the northern part of Compartment 4, cut for sedge in 2013 and in occasional, wet years in Compartment 9, opposite the south east corner of the census area (Fig 3). Their return there is probably attributable to the restoration of open and sunny conditions through the excavation of an extensive new turf pond in 2011. In 2013 they were also found in Compartment 6 on the north west fringe of the census area. A viewing platform for the spiders was built on one of the turf ponds in this area in the 1970s. It is not known when the spiders were lost from the compartment but, despite frequent searches, the 2013 records were first time since the systematic census began.

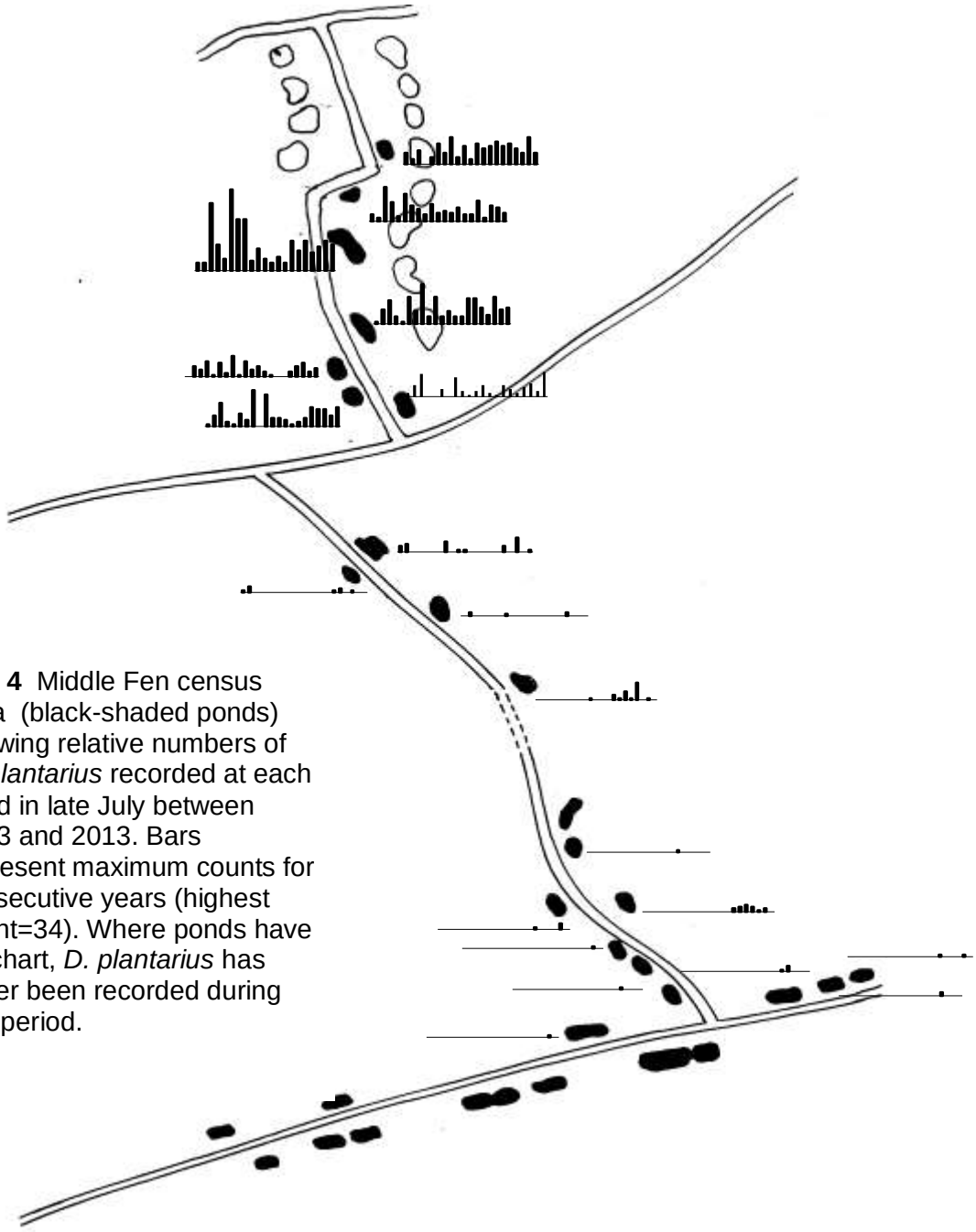
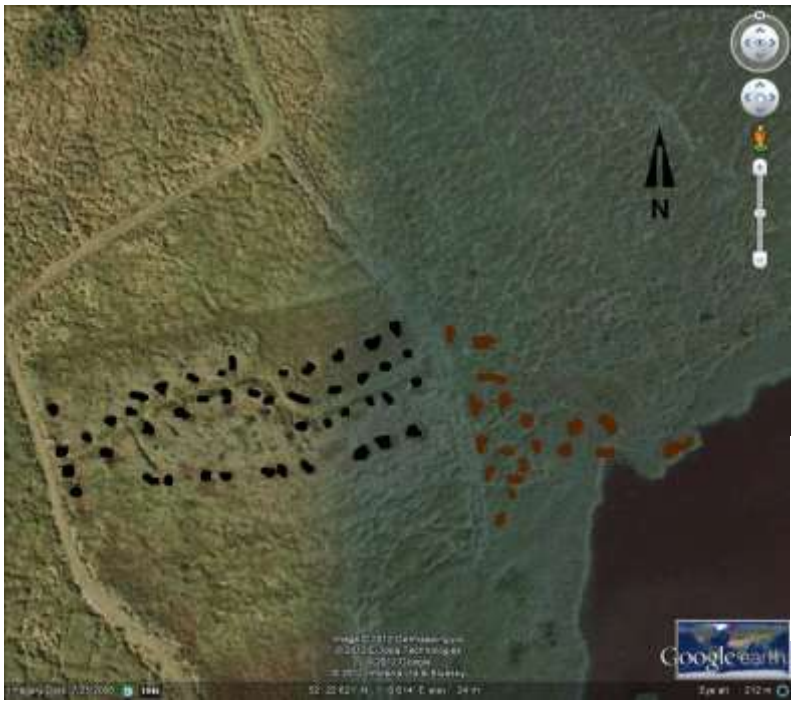


Fig. 4 Middle Fen census area (black-shaded ponds) showing relative numbers of *D. plantarius* recorded at each pond in late July between 1993 and 2013. Bars represent maximum counts for consecutive years (highest count=34). Where ponds have no chart, *D. plantarius* has never been recorded during this period.

On **Middle Fen** *D. plantarius* was recorded in only eight of the census ponds – the lowest number since 2007 (Table 2). This resulted from the failure to find any spiders in the ponds at the western side of the census area that were recolonised from 2006 onwards (Fig. 4). Failure to find spider in this area does not necessarily indicate that this new spur of the population has died out but it does suggest that numbers are very low. In previous years, the spiders found there have been either all immature or all adult in alternate years. The likelihood of encounter is lower in years when only adults are present and this may account for failure to find them this year.



Casual recording on Middle Fen showed that *D. plantarius* was present on the turf ponds excavated immediately east of the core area of population in 2009 (Fig. 5, Smith 2010) for a second consecutive year.

Fig. 5 New ponds excavated on Middle Fen in September 2009 (brown). Ponds marked in black are those at the eastern end of the standard census area

3.2 Abundance

Numbers of *D. plantarius* on Little Fen were relative high, sustaining but not building on the substantial increase seen in 2010 (Table 3, Fig. 6). The annual population index for Little Fen shows that, as in previous years, 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. The annual time effects model had an AIC value of –169.67 (Wald test for significance of deviation from linear trend: 127.81, $p<0.001$, df=18). Linear-trend and no-time-effects models had AIC values of 50.76 and 264.54 respectively.

On Middle Fen *D. plantarius* numbers were slightly lower than in 2011 but well within the range of variation since 1993 (Table 3, Fig. 6). The indices over the last seven years have been very similar, and unlike the dramatic interannual fluctuations seen during the 1900s – the peak years are neither as high nor the troughs as low. The annual population index for Middle Fen shows that, as in previous years, 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. The annual time effects model had an AIC value of –239.14 (Wald test for significance of deviation from linear trend: 173.71, $p<0.001$, df=21). Linear-trend and no-time-effects models had AIC values of 70.98 and 102.08 respectively.

Table 2 Number 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) or 2012 (see text).

Year	**'93**	**'94**	**'95**	**'96**	**'97**	**'98**	**'99**	**'00**	**'01**	**'02**	**'03**	**'04**	**'05**	**'06**	**'07**	**'08**	**'09**	**'10**	**'11**	**'12**	**'13**
Little Fen																					
'Irrigated' n=15[1]	8	8	12	9	12	14	11	-	-	12	6	12	11	9	8	12	11	15	15	-	15
'Unirrigated' n=14[1]	2	2	4	0	1	6	4	-	-	2	1	2	0	4	2	4	3	8	9	-	5
Total	**10**	**10**	**12**	**9**	**13**	**20**	**15**	**(11)**	**-**	**14**	**7**	**15**	**11**	**13**	**10**	**16**	**14**	**23**	**24**	**-**	**20**
Middle Fen																					
'Irrigated' n=7	6	7	7	5	6	7	6	7	6	7	7	7	7	7	6	6	7	7	7	7	7
'Unirrigated' n=23	2	3	0	0	0	0	1	2	0	2	1	0	0	1	2	6	5	6	3	6	1
Total	**8**	**10**	**7**	**5**	**6**	**7**	**7**	**9**	**6**	**9**	**8**	**7**	**7**	**8**	**8**	**12**	**12**	**13**	**10**	**13**	**8**

[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 2012. * The number of adult females given is based on identification of individuals and may be a higher figure than the maximum count of spiders in the large size category.

	'93	**'94**	**'95**	**'96**	**'97**	**'98**	**'99**	**'00**	**'01**	**'02**	**'03**	**'04**	**'05**	**'06**	**'07**	**'08**	**'09**	**'10**	**'11**	**'12**	**'13**
Little Fen																					
% Large	36	21	20	65	30	5	8	-	-	9	29	4	10	14	18	11	45	27	13	-	19
% Medium	57	37	66	15	41	50	53	-	-	57	43	68	88	45	73	68	34	67	70	-	77
% Small	7	42	15	20	29	45	39	-	-	34	28	28	2	41	9	21	21	6	17	-	4
Max. spider count	**14**	**19**	**41**	**20**	**66**	**94**	**62**	**-**	**-**	**53**	**7**	**68**	**40**	**42**	**66**	**75**	**47**	**124**	**150**	**-**	**100**
Adult females*	0	1	6	6	16	4	4	-	-	4	2	3	4	7	10	10	15	20	12	-	22
Nursery web count	0	2	0	0	9	0	4	-	-	0	0	1	2	4	4	0	3	14	4	-	12
Middle Fen																					
% Large	29	30	3	17	47	5	15	6	20	6	10	5	13	10	19	12	16	30	25	11.1	12
% Medium	33	48	62	34	53	32	46	49	30	55	48	50	45	63	50	46	58	54	62	57.1	60
% Small	38	22	35	49	0	63	39	45	50	39	42	45	42	27	31	40	26	16	13	31.8	28
Max.spider count	**21**	**44**	**102**	**41**	**15**	**99**	**52**	**112**	**20**	**72**	**29**	**42**	**31**	**30**	**54**	**56**	**70**	**63**	**73**	**63**	**60**
Adult females*	0	8	1	5	6	5	7	7	0	2	2	1	4	3	8	5	9	1	19	2	2
Nursery web count	1	3	1	0	0	0	7	0	0	0	0	0	3	1	2	1	2	0	11	3	0

3.3 Breeding indicators

On **Little Fen**, 2013 was one of the best years on record for sightings of adult females and of nurseries during the census (Table 3). Casual records from ponds not in the census sample, and made later in the summer supported this conclusion.

By contrast there was little evidence of successful breeding on **Middle Fen** during the census period (Table 3). This may be partly due to the earlier census dates on Middle Fen in what was an atypically late season following an exceptionally cold spring, a possibility supported by finds of nurseries during subsequent casual recording on Middle Fen.

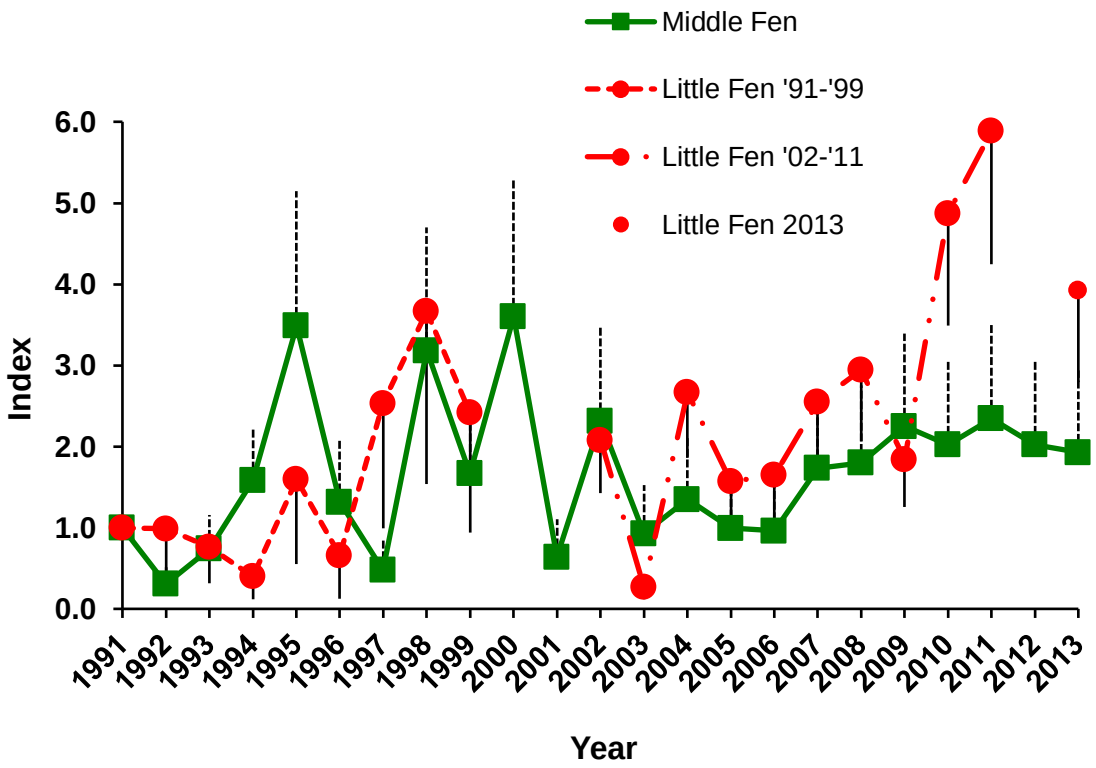


Fig. 6 Annual population indices for *D. plantarius* on Middle and Little Fens in July 1991-2012, generated by a log-linear Poisson regression model and plotted on a linear scale. No data were collected on Little Fen in 2000, 2001 and 2012 (see text). 2SEs shown by positive vertical bars for Middle Fen and negative bars for Little Fen.

3.4 Water Levels

The spring of 2013 was the coldest in the UK since 1962 (marginally colder than spring 1979), and the fifth coldest in a series since 1910. March was the coldest month of the winter. The winter was wet and most of the surface of Little Fen was flooded throughout, and the water often frozen for prolonged periods. In contrast, the summer was the warmest since 2006, with a heat wave from 3 to 22 July, and the driest in Eastern England since 2003. However, summer rainfall amounts on the Fen (Fig. 7), in combination with high surface water levels remaining from the wet summer of 2012 (when it was not possible to work on

Little Fen because of the water depth; Smith 2012) and winter were sufficient high to maintain water in all of the turf ponds during most of the of the *D. plantarius* breeding season (Fig. 8).

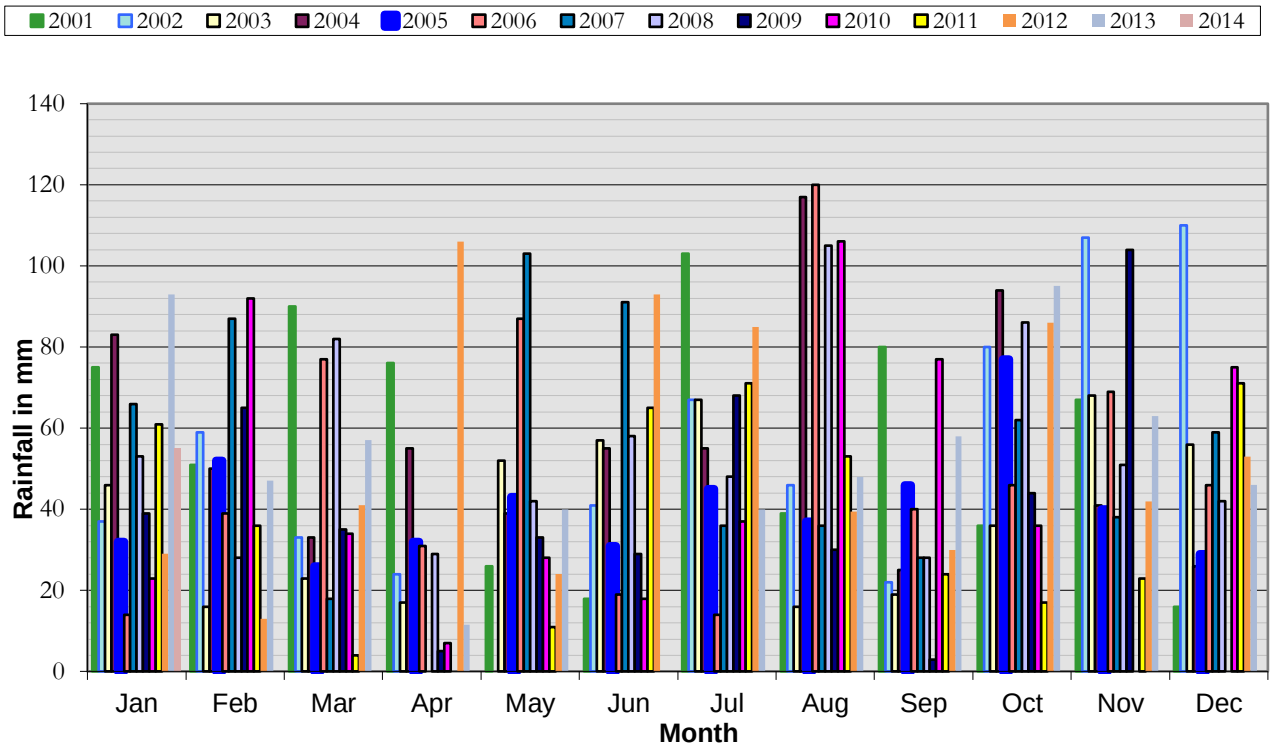


Fig. 7 Monthly rainfall at Redgrave and Lopham Fen NNR, 2001-2014 (Suffolk Wildlife Trust data)

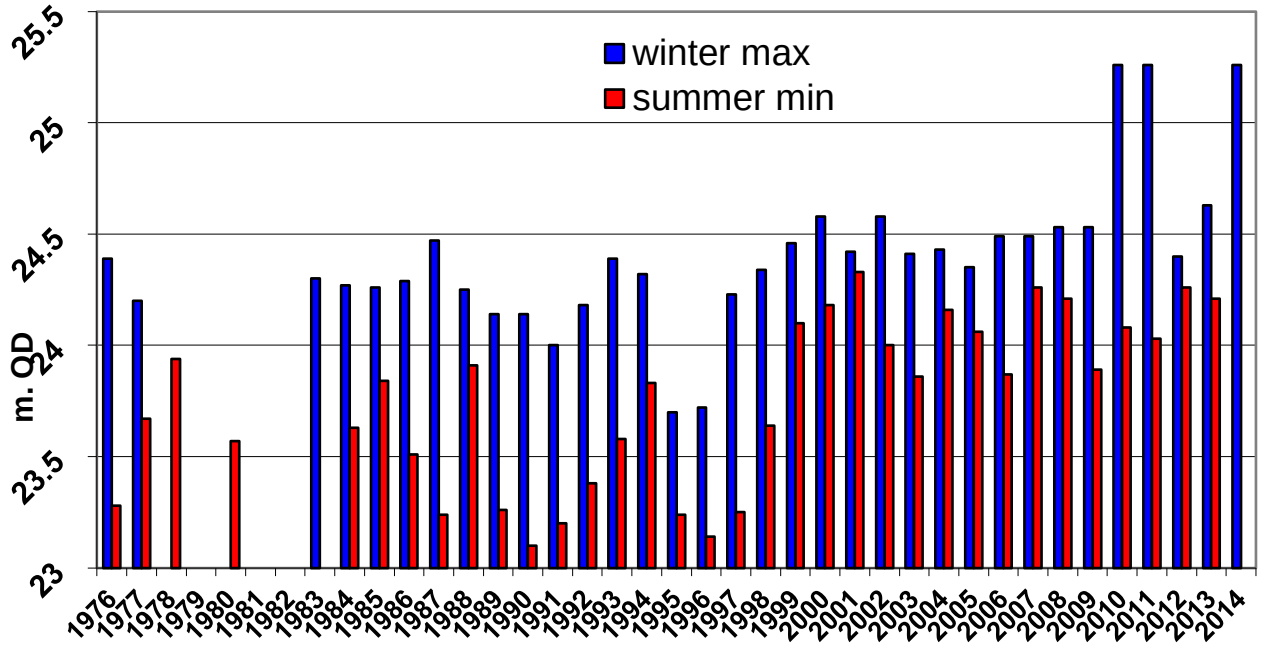


Fig. 8 Mean winter maximum and summer minimum water levels in piezometers on Redgrave and Lopham Fen NNR, 1976-2014 (Suffolk Wildlife Trust data). 2014 winter datum to February only, and likely to rise.

4 Habitat management

4.1 Rotational mowing of *Cladium mariscus*

In 2004 SWT changed from a programme of rotational cutting of *C. mariscus* stands to one of cutting those stands judged to be most in need of management, both within and beyond the core area for *D. plantarius* (see Smith 2004). This need varies according to the wetness of the season and the effectiveness of stock grazing. In practice, on Little Fen, this has resulted in a return to an informal rotation within the core area for *D. plantarius* (Fig.1).

In 2013, on Little Fen, the area cut was to the south of the census area though within the core area from *D. plantarius* (Fig.1). Around the turf ponds close to the track separating this area from the census area, *Cladium mariscus* is dominant but the proportion of *Phragmites australis* increases to the south and east of the cut area. As in previous years, occasional clumps of emergent and marginal *C.mariscus* were left uncut around the turf ponds to provide shelter for the spiders and support for nursery webs.

On Middle Fen no *C. mariscus* was cut for the fifth successive year (Fig. 2).

4.2 Grazing

In the western part of the **Middle Fen** 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 impact on the vegetation. Between the turf ponds, annual variation in grazing pressure and wetness now govern the balance between the development of shortly-grazed 'lawns' and tussocky structure favourable for invertebrates and small mammals. In 2013 this balance favoured the development of lawns, leaving the turf ponds with surrounding taller, marginal emergent vegetation, effectively isolated from one another.

On **Little Fen**, as in previous years, the stock made relatively few incursions into the areas occupied by *D. plantarius* and had relatively little effect on the vegetation (e.g. Smith 2007). Full records of stock types, rates and movements are maintained by the SWT.

4.3 Turf Ponds

On Little Fen, planned removal of infilling sediment from turf ponds that were not cleaned in 2009 and 2010 (Smith 2010, 2011b), remains to be done. This work was also postponed in 2012 because of the access difficulties created by high water levels.

On Great Fen, a new series of turf ponds was excavated in November 2012, at the west side of the sedge bed to which *D. plantarius* was introduced in 2010/11 (Figs. 9 and 10). They were surveyed for invertebrates by Adrian Chalkley in May and August 2013 (Chalkley 2013) but are unlikely to be become suitable for *D. plantarius* for several more years. They will be included in larger-scale future survey of the Fen for the spiders.

Fig. 9 Turf pond creation on Redgrave and Lopham Fen in relation to the *D. plantarius* populations

Fig. 10 Locations of the ponds excavated on Great Fen in 2012: (from Chalkley 2013).

5 Discussion

2013 saw some continued progress towards the BAP targets for *D. plantarius* at Redgrave and Lopham Fen, **particularly in terms of expansion in range**. Most of the expansion was to areas immediately adjacent to the two centres of population - both recently excavated areas of turf ponds and flooded areas of recovering vegetation dominated by *C. mariscus*. The spiders were not recorded in two areas where they had been found in 2012 but, when densities are low, under-recording is a possibility.

The spiders translocated to Great Fen in 2010/11 (Smith 2011a, 2012a, 2013b) were shown to be breeding successfully in 2013 (Smith 2014), further contributing to the increase in range. Success of the translocation to Middle Fen in 2011/12 has yet to be confirmed. The progress of both populations will be reviewed and the need for augmentation evaluated (Smith 2014). Genetic monitoring of the new populations and the existing populations, which have been shown to loosing genetic variability (Holmes 2009), should be used to evaluate the need to augment the genetic stock, as opposed to the numbers of spiders. To date, translocations within the Fen complex have taken the conservative approach of using spiders only of local provenance while the new populations established on the lower Waveney have used stock from both Redgrave and Lopham Fen and the Pevensey Levels to maximise genetic variability (Smith 2011a & b). Boosting genetic variability of the Fen population could be achieved by introducing adult males from the Pevensey Levels with negligible effect on the parent population.

The rapid colonisation of the new turf ponds closest to the core population on Middle Fen requires further monitoring but suggests that **new chains of ponds are likely to be a successful mechanism for expanding the range of the population**, and eventually for linking isolated sub-populations, particularly in the drier areas of the Fen. A rolling programme of turf pond creation is vital in defending the spiders against the predicted increase in summer droughts, and in facilitating reestablishment of a sustainable, functional metapopulation. This pond creation programme must be accompanied by continued work to maintain adequate depth in the older turf ponds, deeper water near the *C. mariscus*-fringed margins of the larger scrapes (Smith 2010), and the best possible hydrological outcomes via the sluice system.

Within the core areas of population on Middle and Little Fens, numbers are generally higher and less volatile than during the 1990s but **there is still no evidence of a sustained increase in either density or number of ponds occupied**. Modelling the data for these two sub-populations shows that the pattern of inter-annual variation remains significantly different, and suggests that different factors control their population sizes.

The current systematic census method, whilst still delivering robust population estimates for the core areas of population, **is no longer the most appropriate method for evaluating expansion in range of *D. plantarius* on the Fen**. There are several reasons for this:

1. Evidence that the spiders are increasing their range beyond the census area, colonising flooded and regenerating areas *Cladium mariscus* resulting from both the Fen restoration programme of the 1990s and the creation of new turf ponds.
2. The need to include the areas of Great Fen and Middle Fen to which spiders were translocated in 2010-2012 (Smith 2011, 2012, 2013) within a standardised census.
3. The increasing difficulty of census work using the current method on Little Fen. High water levels have prevented work in the ponds on Little Fen in three years since the Fen re-wetted in 2000, and the number of ponds there can no longer be surveyed by this method increases each year because the changing nature of the sediment has made working conditions unsafe (Section 2.1).
4. The populations now appear sufficiently robust that potential exists for using nursery webs rather than the spiders themselves as the main census metric. Nursery webs are static and much easier to count than the spiders. They are used successfully as the

main monitoring metric in the grazing marsh populations (Pevensey Levels, East Sussex, and newly translocated populations on the lower Waveney, Suffolk). Better comparability with these populations will be an additional benefit of this change.

5 The increasing need for a method that can potentially be carried out by volunteers.

A new monitoring scheme is now urgently required and should be in place for the 2014 field season. Although running the old and new schemes in parallel would be desirable (Smith 2013), the substantial number of years that would be needed for robust cross-calibration, together with the need to abandon the old scheme for health and safety reasons, makes this impractical.

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