

**Fen Raft Spider Recovery Project:
2011 Summary Report for Redgrave and Lopham Fen**



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Summary

- 1 This report describes the results from the twenty-first year of systematic monitoring of the nationally endangered Fen Raft Spider *Dolomedes plantarius* at Redgrave and Lopham Fen National Nature Reserve (NNR), Norfolk. It also documents a translocation programme for this species within the NNR to increase occupancy of suitable habitat on the reserve and to reduce the intrinsic vulnerability of the population. Habitat management work and measurements of surface water levels are also documented and discussed in relation to spider population trends.
- 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 21-year census period, the population on the reserve remained small and its range restricted to two 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. 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 the 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. In July 2011 the index for Little Fen was the highest since census work began in 1991 and built on a substantial increase seen in 2010. The index for Middle Fen was slightly higher than in 2010 but well within the range of variation since 1993.
- 7 On Middle Fen, a westward expansion in the spider's range that began in 2006, and was sustained until 2010, appeared to be retracting in 2011. Only one individual was found in the recently occupied area. This was an adult female and continued a pattern in which breeding adults were only found in alternate years. This suggests that the recent expansion originated as a single saltatory colonisation event rather than a spread on a broad front.
- 8 Numbers of both breeding females and nursery webs on Middle Fen in 2011 were the highest ever recorded. On Little Fen numbers were lower than in 2010, the peak year to-date, but were nevertheless higher than in many recent years.
- 9 On Little Fen a large belt of both *Cladium mariscus* and grass-dominated fen within the core area for *D. plantarius* was cut in late July. No *C. mariscus* was cut on Middle Fen for the third successive year. Grazing stock had access to both areas but, as in previous years, made more impact on Middle Fen than on Little Fen. As in 2010, a spring drought resulted in low levels and rapid water loss from the ponds but recovery began in June and resulted in adequate levels during the peak of the *D. plantarius* breeding season. Drought re-established in September and, by early winter, levels were similar to those encountered in recent drought summers.
- 10 Following a first translocation of captive reared spiderlings of local provenance on Great Fen in autumn 2010, a further ca 500 spiderlings were released at the same site in September 2011 to create a new sub-population with a natural age-structure. In addition, another ca 500 spiderlings were released at a second new site within the NNR, on a scrape created in the mid-1900s at the eastern edge of Middle Fen

1 Introduction

This report summarises monitoring and management work undertaken in 2011 as part of the Fen Raft Spider *Dolomedes plantarius* Recovery Project at Redgrave and Lopham Fen National Nature Reserve (NNR), one of only three UK sites where this Schedule 5 species occurs in the wild.

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. Throughout the 1990s, despite targeted habitat management, monitoring showed that there was no significant increase in the size of the population and 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).

Abstraction of water from the aquifer underlying the fen ended 1999 and hydrological recovery was rapid (Harding 2000). This was expected to result in a rapid increase in *D. plantarius*, which has very high potential fecundity. However, despite the wetness of the fen, the spider population showed no sign of significant or sustained recovery for a decade after abstraction ended. 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. Despite downward revision in 2005 (BARS 2011) the BAP targets for the Redgrave and Lopham Fen population in 2010, 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 involved 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 recolonisation 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 2008 survey of the extent of suitable vegetation types and of standing water in summer on the Fen (Smith 2009) showed that a lack of continuity of summer-wet habitat was also likely to be impeding dispersal and recolonisation of restored areas. These problems were addressed in two ways. First, a rolling programme was initiated of excavation of chains of new turf ponds linking existing population centres and larger scrapes created during the restoration operation of the 1990s. Over 40 new ponds were excavated both to the east and west of the core area of population on Middle Fen in 2009 and 2010 (Smith 2010, 2011b). Secondly, a translocation programme was initiated, introducing *D. plantarius* to suitable areas of restored habitat within the Redgrave and Lopham Fen complex. A national translocation programme was started at the same time to address the Biological Action Plan (BAP) target to reduce this species' vulnerability in the UK by increasing the numbers of sites with sustainable *D. plantarius* populations (Smith 2011a). In autumn 2010 captive-reared spiderlings of local provenance were released on Redgrave and Lopham Great Fen. The release site comprised turf ponds excavated in 1998 within an extensive stand of *Cladium mariscus*, the spider's preferred habitat on this site (Smith 2011a). The founding of a second new sub-population within the Redgrave and Lopham Fen complex was planned for autumn 2011. At the same time a second introduction of spiderlings would also be made to the 2010 introduction to ensure a natural age structure in the new sub-population.

This report details progress with these translocations and presents the results from the standardised annual census of *D. plantarius* at Redgrave and Lopham Fen, including the progress of the natural range expansion on Middle 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 twenty years' monitoring data. The next steps required to progress the BAP targets, 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, 2005, 2006, 2007, 2008, 2009, 2010, 2011a & b, Smith 2012).

2 Methods

2.1 Annual census

The annual census of *D. plantarius* followed the methodology adopted in 1993 and described by Smith (1993, 2000, 2010). 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 1994-2011

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

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 (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 1991 and 1992 ponds were censused in much more restricted areas of both Little and Middle Fen. 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 (see 2.2).

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). 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).

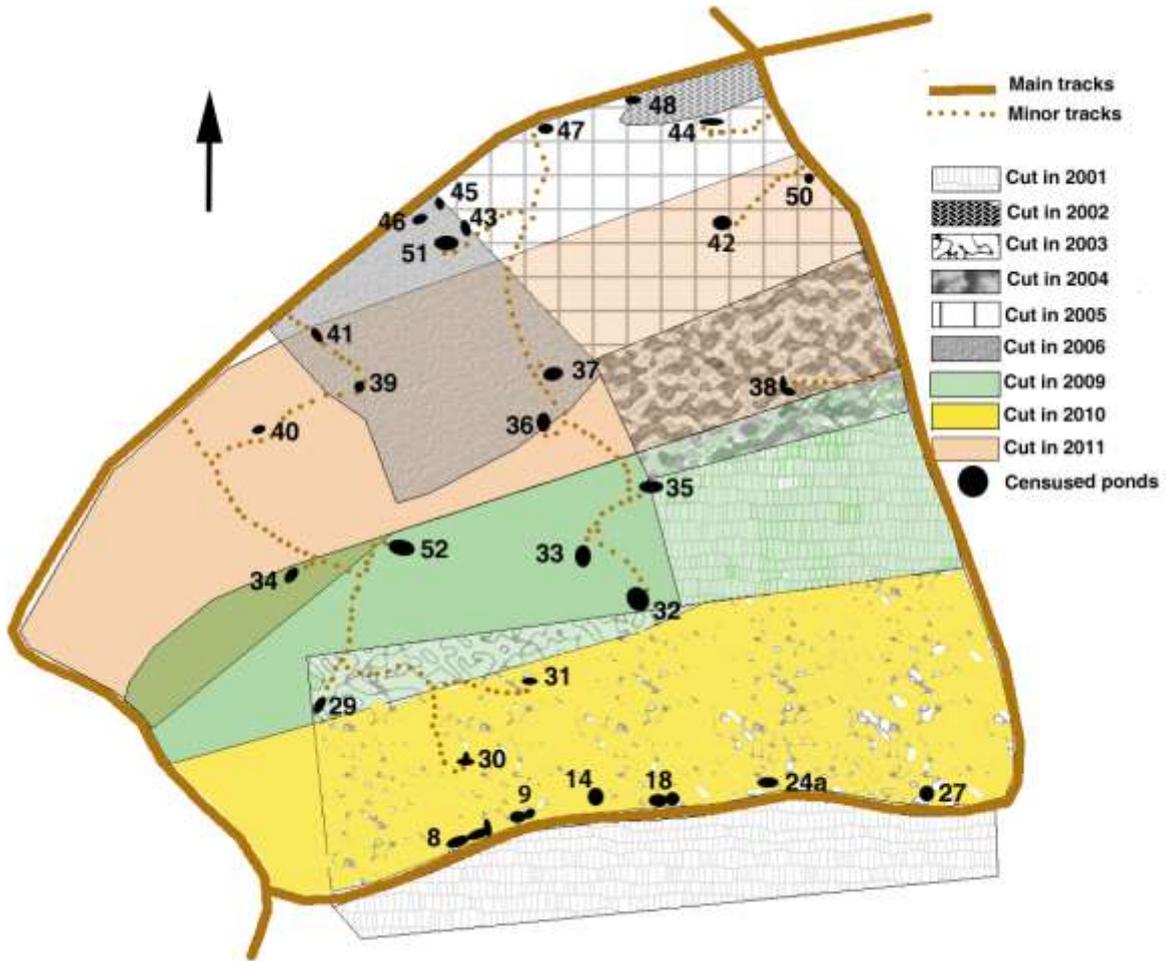


Fig. 1 The Little Fen census area showing ponds included in the census. Shading shows areas where vegetation was cut and removed in July/August each year.

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 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

In most years routine water level measurements have been 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). This regular monitoring has not been possible since March 2010; measurements have since been taken during the July census periods (Little and Middle Fens only), and in November 2011. The levels in the Little and Middle Fen ponds are expressed relative to an arbitrary datum established in April 1992. The levels in the Great Fen ponds are expressed relative to Ordnance Datum.

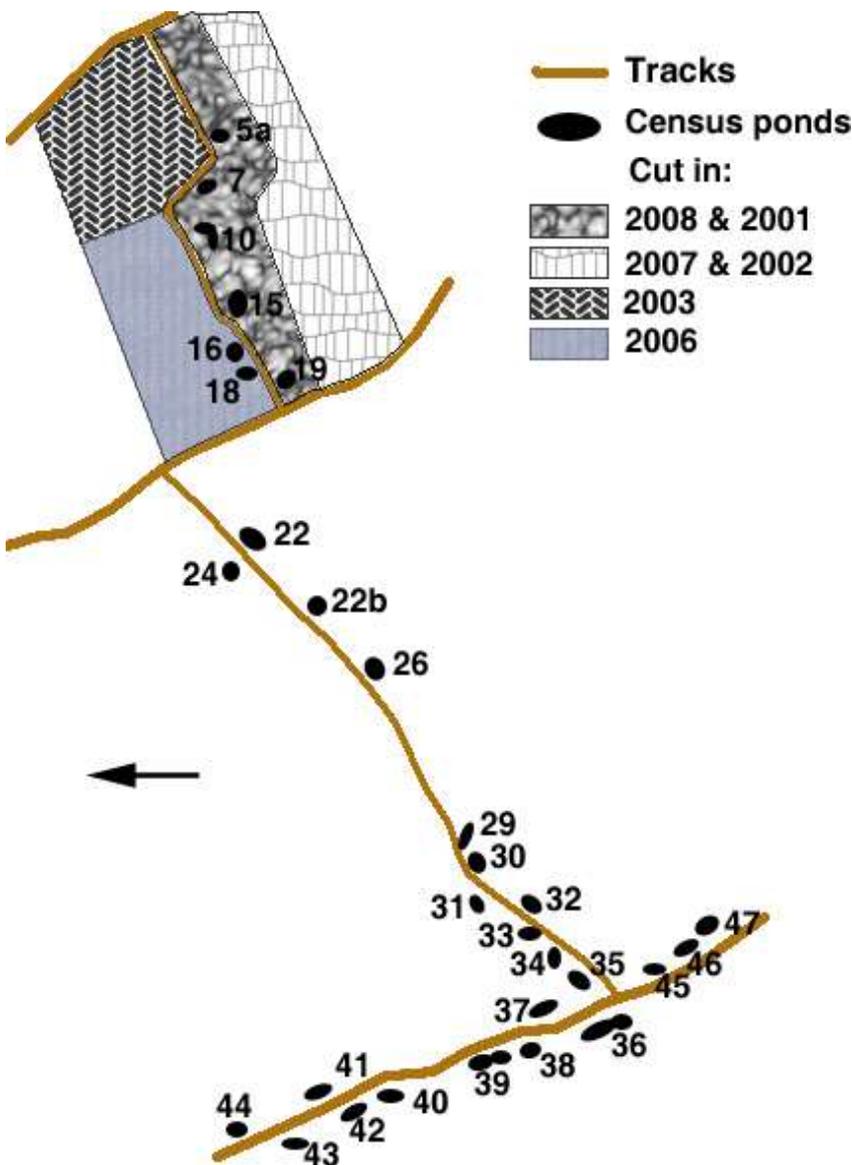


Fig. 2 The Middle Fen census area showing ponds included in the census. Shading shows areas where vegetation was cut and removed in July/August each year.

Ground water levels on the Fen have been monitored by 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 35-year recording period. Monthly rainfall data measured on the Fen since 2001 are also presented.

2.5 Translocations of *D. plantarius* within the fen complex

2.5.1 Great Fen

Following introduction of a first cohort of spiderlings to the Great Fen in October 2010 (Smith 2011a), a second introduction, of 522 spiderlings, was made to the same area on 28 September 2011. As in 2010, these spiderlings were all the progeny of females caught as adults on Redgrave and Lopham Little Fen and Middle Fen. Six females from Little Fen and four from Middle Fen were taken into captivity as adults with egg sacs or when heavily gravid. Their offspring were removed from their nurseries after about one week, when dispersal would occur in the wild. Two hundred of the spiderlings from each brood were reared in individual test tubes over the summer using established protocols (Natural England, unpublished reports). This technique results in far higher survival over the first three months of life than is thought to occur in the field (Smith 2011a, 2012). The captive reared spiderlings from these broods were used to supply translocations to new sites (Smith 2012) as well as to establish the new sub-populations at Redgrave and Lopham Fen.

The broods produced by the captive females in 2011 were so large (mean 454, maximum 714) that it was not practicable to rear all of the spiderlings in captivity. Because of this, spiderlings in excess of 200 in each brood were released at the dispersal stage. During the last two weeks of July, 828 were released at the Great Fen site.

As in 2010, the Great Fen release was made around the ponds excavated in an extensive bed of *C. mariscus* in 1998 (Smith 1998), concentrating on the most accessible and open ponds (Figs. 3 & 4). The test tubes were positioned at approximately 4cm intervals along lines of tape prior to release. This helped to reduce the risks of cannibalism and of creating concentrations of spiderlings that might attract predators. The lines of tubes were positioned in dense *C. mariscus* around the pond margins. They were angled downwards to avoid rain and the lids were removed. After two days they were collected and checked to ensure that the spiderlings had left.

2.5.2 Middle Fen

Four hundred and sixty four captive-reared spiderlings from the same broods as those used on Great Fen were introduced to a new area, at the south-eastern edge of Middle Fen, on 27 September 2011 (Fig. 3). The release site comprised a wide, marginal emergent fringe of *C. mariscus* on one of the 50cm deep scrapes excavated as part of the Redgrave and Lopham Fen restoration operation in the mid-1990s (Fig. 5). The same release protocols were followed as on Great Fen. In addition to the captive-reared spiderlings, 834 dispersal stage spiderlings from the same broods were released at the Middle Fen sites during the last two weeks of July.

2.5.3 Re-enforcement of the source populations

To ensure that the source populations on Little and Middle Fen were not depleted by removal of the parents of these broods, the mothers were retained in captivity to produce second broods. They were then released at their site of capture together with their new brood. Releases were made when the spiderlings were *ca* 1 week old, at around the time when they would normally disperse from the nursery. Successful second broods are rare in the wild (Pearson (2008) estimated 11%) but the 80% of females kept in captivity in 2011 successfully hatched spiderlings from second egg sacs (Smith 2012).

2.5.4 Monitoring of the 2010 introduction to Great Fen

The Great Fen introduction site is intrinsically difficult to monitor because the, mostly small, turf ponds are amongst very dense *C. mariscus*. None can be viewed adequately from a track and views from

single points at the pond edge are very restricted. Trampling of the sedge around the pond edges to gain additional views runs the risk of damaging both the sedge and the spiders.

The survey method used on Little and Middle Fens, entailing searching from the water, is not viable for new monitoring programmes because it is too labour intensive. The Great Fen ponds will therefore be monitored, at least initially, both by counts of spiders from fixed viewing points at the pond edges and by counting nursery webs from 2012 (when the 2010 cohort should mature and breed) onwards. If the population establishes well, monitoring of nurseries is expected to be the better method on Great Fen. Trials of fixed point counts of *D. plantarius* on the larger and more open turf ponds on Middle Fen in 2000 showed that it produced far fewer records than counts made from the water (Smith 2001). In 2011, monitoring was limited to fixed-point counts made in mid-August, and mid and late September, at the five ponds on which the spiderlings were released in 2010.



Fig. 3 Locations of the 2010 and 2011 *D. plantarius* release areas on Redgrave and Lopham Fen NNR (blue) and the existing sub-populations on Little Fen and Middle Fen (red). The inset shows the ponds around which the Great Fen releases were made (shaded red).



Fig. 4 The 2010/2011 *D. plantarius* release area on Great Fen



Fig. 5 The 2011 *D. plantarius* release area on Middle Fen

3 Results

3.1 Distribution

On **Little Fen** the number of census ponds on which *D. plantarius* was recorded in 2011 was the highest since the current systematic census began in 1993 (Table 2). Since closure of the artesian borehole in 1999, *D. plantarius* has been found predominantly in the southern part of the census area (Fig. 6). 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 occupied a band of ponds stretching north from this core area but records outside this zone have been sporadic. In both 2010 and 2011, however, spiders were recorded much more consistently in a wide area behind this zone, and particularly to the north and east (Fig. 6).

On **Middle Fen** *D. plantarius* was recorded in fewer ponds than in the previous three years, during which numbers of occupied ponds had been the highest since the census began (Table 2). This decline resulted entirely from loss of spiders from ponds that had been colonised by a slow westward expansion in range since 2006 (Fig. 7). In 2011 *D. plantarius* was recorded from only one pond in this area. This record was of a single adult female.

No *D. plantarius* were seen on any of the ponds on **Great Fen** on which spiderlings were released in October 2010. However, the views of the pond margins were for the most part very restricted because of dense emergent *C. mariscus*. By September this was exacerbated by low water levels that further reduced the search area.

3.2 Abundance

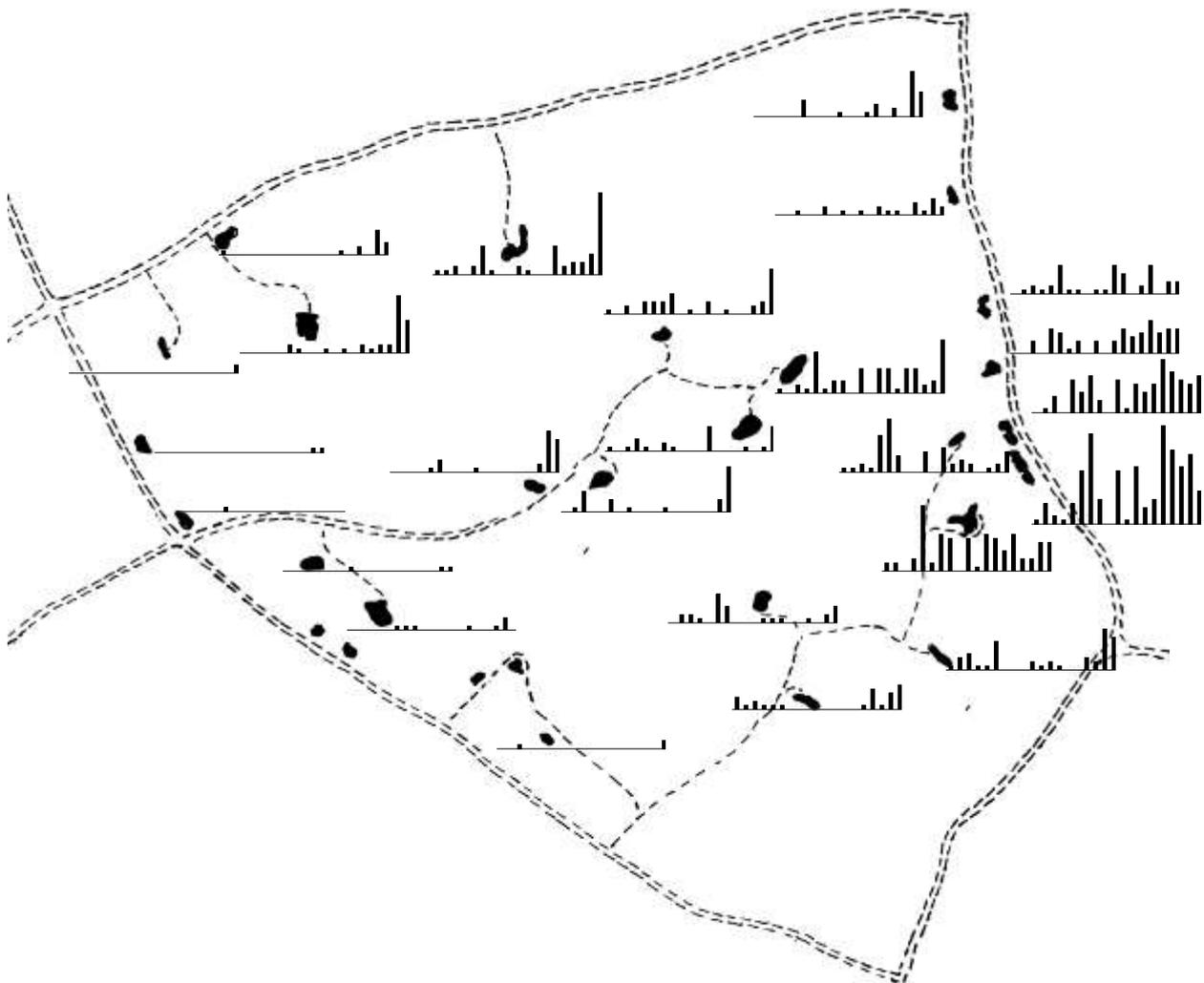
On Little Fen numbers of *D. plantarius* recorded in July 2011 were the highest since census work began in 1991. This built on the substantial increase seen in 2010 and resulted in an index that was significantly higher than any since 1998 (Table 3, Fig. 8).

On Middle Fen numbers were slightly higher than in 2010 but well within the range of variation since 1993. Over the last decade, numbers on Middle Fen have fluctuated less than in the previous decade. Although there appears to have been a gradual, though neither consistent nor significant, increase in the population index over this period, peak numbers remain well below those seen in 1995, 1998 and 2000.

Separate analysis of the 21 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 -160.75 (Wald test for significance of deviation from linear trend: 125.52, $p < 0.001$, $df = 17$). Linear-trend and no-time-effects models had AIC values of 60.37 and 248.81 respectively. For Middle Fen the annual time effects model had an AIC value of -152.93 (Wald test for significance of deviation from linear trend: 170.74, $p < 0.001$, $df = 19$). Linear-trend and no-time-effects models had AIC values of 162.16 and 173.93 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-'11: Wald test for difference between fens: 111.92, $p < 0.001$, $df = 18$).

Fig. 6 Little Fen census area showing relative numbers of *D. plantarius* recorded at each pond in late July between 1993 and 2011. 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* has never been recorded during these censuses.



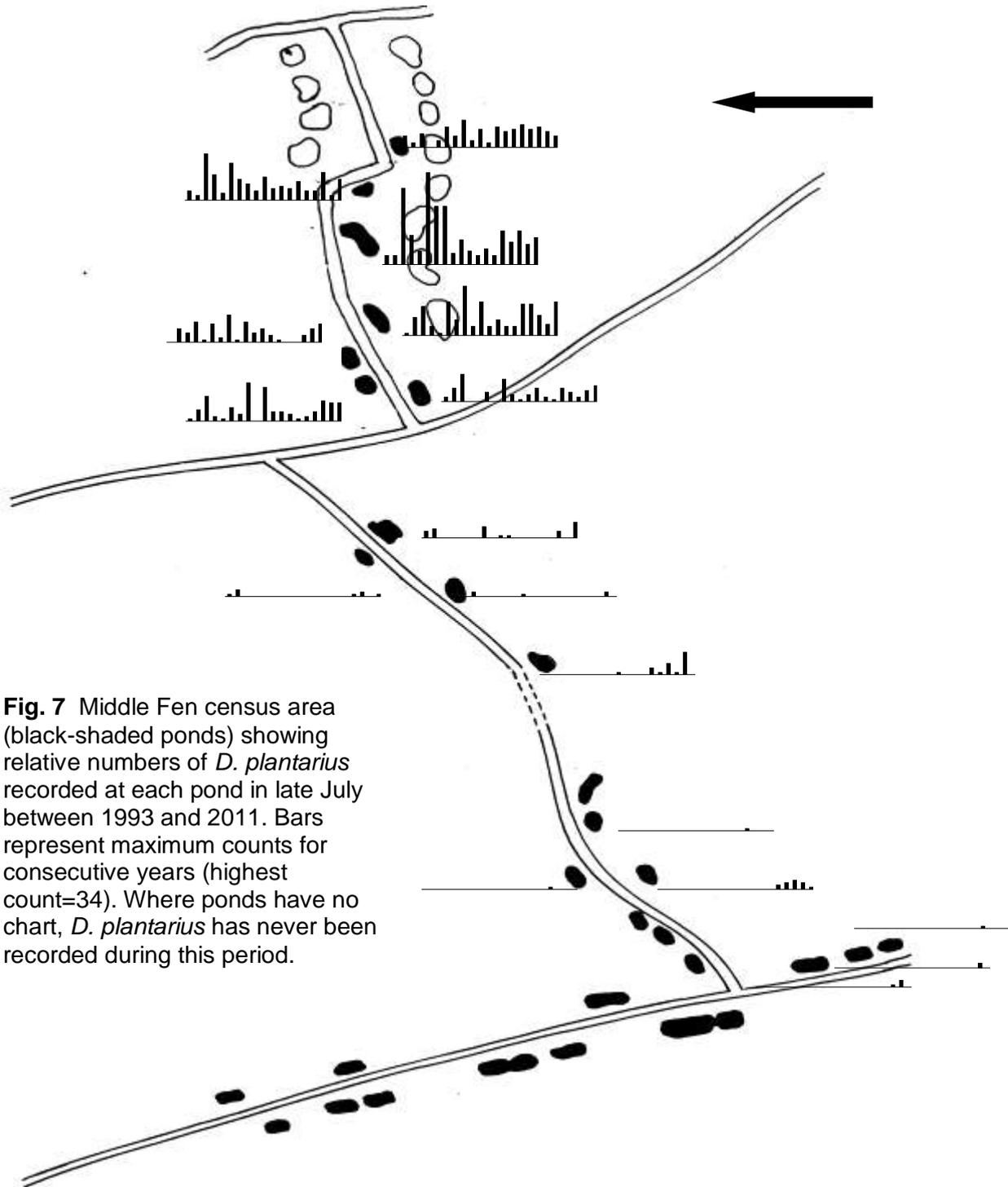


Fig. 7 Middle Fen census area (black-shaded ponds) showing relative numbers of *D. plantarius* recorded at each pond in late July between 1993 and 2011. Bars represent maximum counts for consecutive years (highest count=34). Where ponds have no chart, *D. plantarius* has never been recorded during this period.

3.3 Breeding indicators

On **Little Fen** the numbers of adult females and nurseries encountered during the July census was lower than in 2010, the peak year since 1993 (Table 3). This evidence was, to some extent supported by a lack of observations of nurseries by sedge cutters working in the core areas in late July. The same team encountered high numbers in 2010 although they were then working in a more densely populated area of Little Fen (Fig. 1).

In contrast, on **Middle Fen**, where the 2010 breeding season was poor, 2011 saw much the highest numbers of both adult females and nurseries in any year to-date (Table 3). Casual records from ponds not included in the census bore out that 2011 was an exceptional year for nurseries.

3.4 Water Levels

Recent winter water levels, summarised as the annual average monthly maximum recorded in the dipwells, saw very short-lived peaks in both December 2009 and October 2010. These two months saw the highest recorded levels since records began in 1976 (Fig. 9). This, together with moderate rainfall in June, July and August 2011 appears to have protected ground water levels against the effects of the very severe spring drought; rainfall in March, April and May was the lowest recorded in the last decade (Fig. 10). Despite this, surface water levels at the time of the late July census remained lower than in many recent years on both Little and Middle Fen (Figs. 11 & 12). More exceptional than the spring drought in 2011 was an autumn drought, with October and November rainfall again the lowest in the decade since records began (Fig. 10). Water levels in the census ponds in late November were the lowest recorded since the summer droughts of 2009, 2006 and 2003 (Figs 11 & 12).

4 Habitat management

4.1 Rotational mowing of *Cladium mariscus*

Since 2004 it has been SWT's policy to cut *C. mariscus* 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 2011, on Little Fen, a large east-west strip of *C. mariscus*, was cut during the last week of July. This incorporated, and extended west, parts of the blocks last cut in 2004-2006 (Fig.1). 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 third successive year.

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. By 2010 this had resulted in shorter, more open, mixed associations, with a poached, tussocky structure, largely replacing tall dense reed, which formerly resulted in deep shading of many of the pools. By 2011, however, the grazing pressure in this area had started to destroy the tussocky structure of the vegetation between the turf ponds and replace it by shortly-grazed 'lawns'.

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). The autumn drought, however, allowed them to make more substantial inroads into the extensive area cut in summer (Fig. 1).

Full records of stock types, rates and movements are maintained by the SWT.

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)

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

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 2011. * 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.

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
<u>Little Fen</u>																				
% Large	36	21	20	65	30	5	8	-	-	9	29	4	10	14	18	11	45	27	13	
% Medium	57	37	66	15	41	50	53	-	-	57	43	68	88	45	73	68	34	67	70	
% Small	7	42	15	20	29	45	39	-	-	34	28	28	2	41	9	21	21	6	17	
Max. spider count	14	19	41	20	66	94	62	-	-	53	7	68	40	42	66	75	47	124	150	
Adult females*	0	1	6	6	16	4	4	-	-	4	2	3	4	7	10	10	15	20	12	
Nursery web count	0	2	0	0	9	0	4	-	-	0	0	1	2	4	4	0	3	14	4	
<u>Middle Fen</u>																				
% Large	29	30	3	17	47	5	15	6	20	6	10	5	13	10	19	12	16	30	25	
% Medium	33	48	62	34	53	32	46	49	30	55	48	50	45	63	50	46	58	54	62	
% Small	38	22	35	49	0	63	39	45	50	39	42	45	42	27	31	40	26	16	13	
Max. spider count	21	44	102	41	15	99	52	112	20	72	29	42	31	30	54	56	70	63	73	
Adult females*	0	8	1	5	6	5	7	7	0	2	2	1	4	3	8	5	9	1	19	
Nursery web count	1	3	1	0	0	0	7	0	0	0	0	0	3	1	2	1	2	0	11	

Fig. 8 Annual population indices for *D. plantarius* on Middle and Little Fens in July 1991-2011, generated by a log-linear Poisson regression model and plotted on a linear scale. No data were collected on Little Fen in 2000-2001 (see text). 2SEs shown by positive vertical bars for Middle Fen and negative bars for Little Fen.

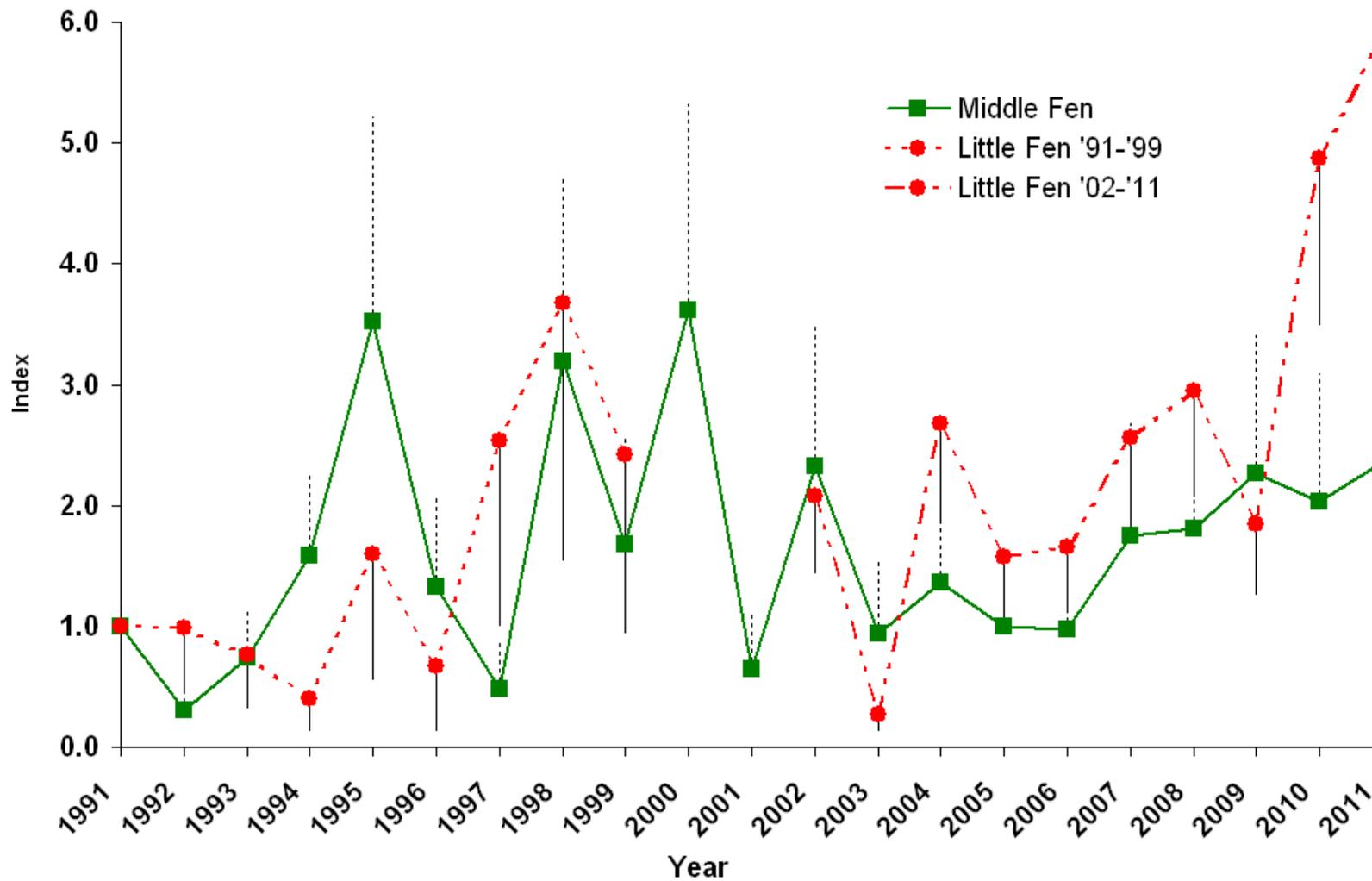


Fig. 9 Mean winter maximum and summer minimum water levels in piezometers on Redgrave and Lopham Fen NNR, 1976-2011 (Suffolk Wildlife Trust data)

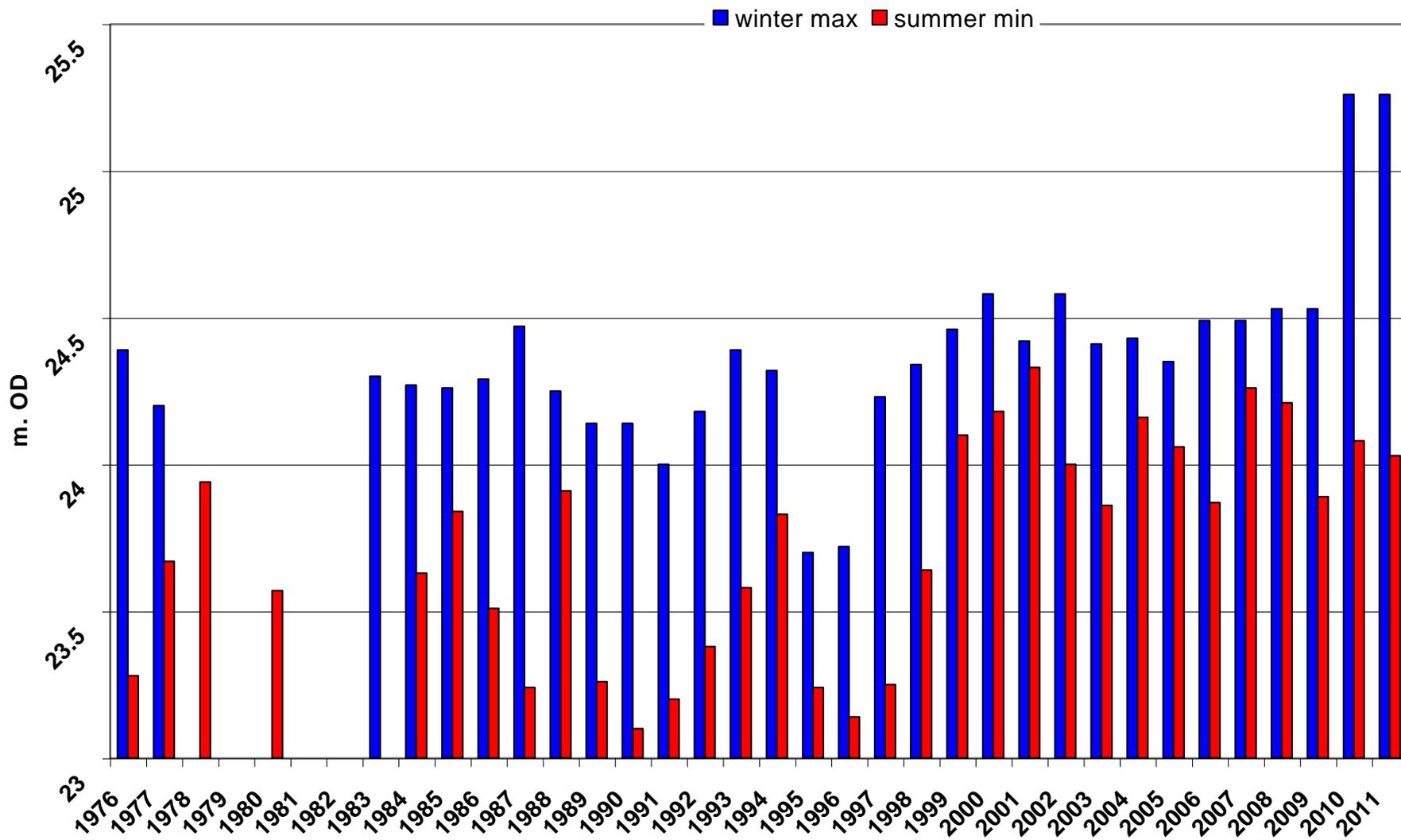


Fig. 10 Monthly rainfall totals for Redgrave and Lopham Fen NNR 2001- 2011 (Suffolk Wildlife Trust data)

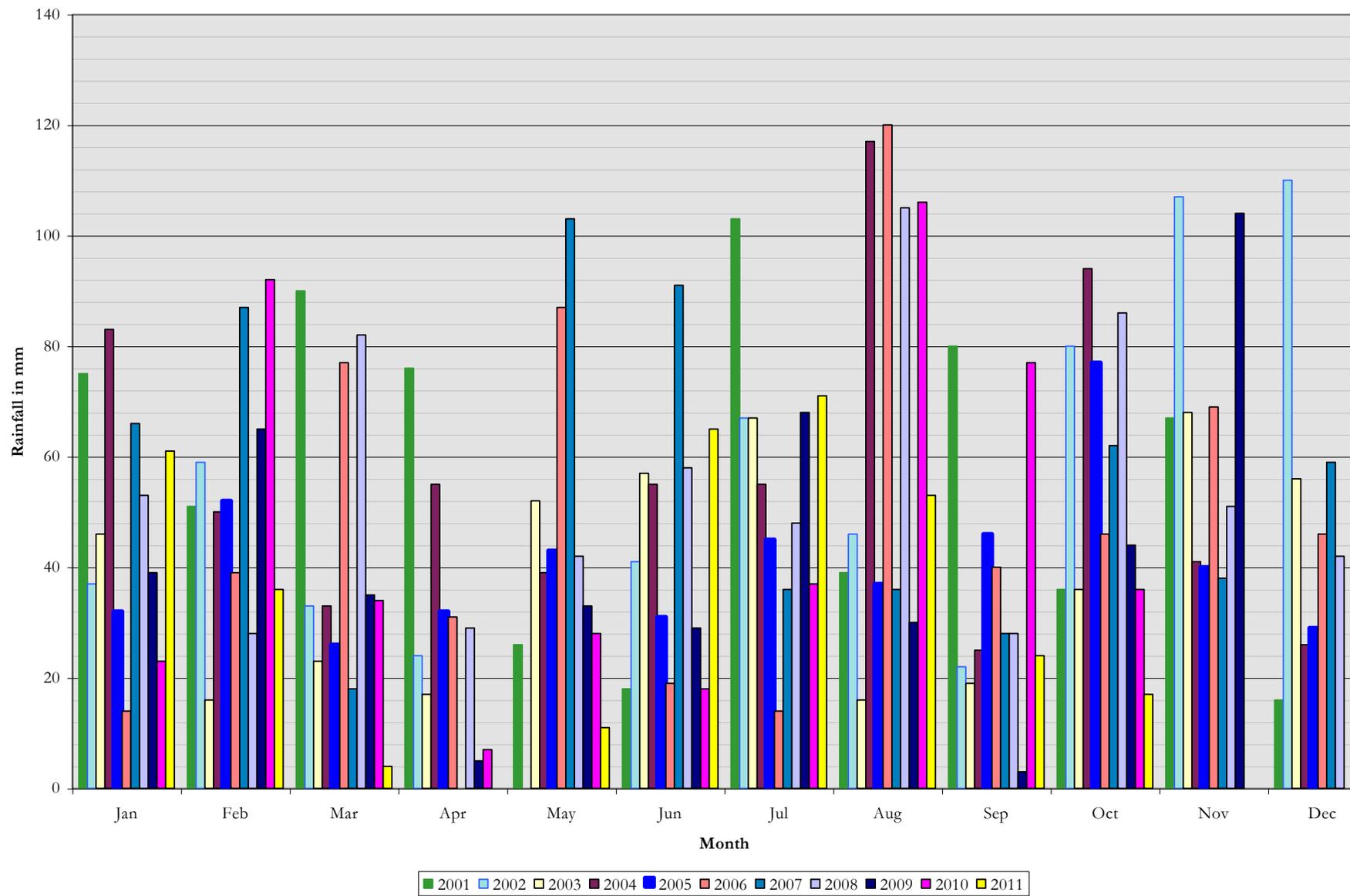


Fig. 11 Water levels in Little Fen ponds 1992-2011. Horizontal line represents the April 1992 datum. Blue and red lines represent mean levels in irrigated and unirrigated ponds respectively : summer irrigation stopped in 1999 (see text).

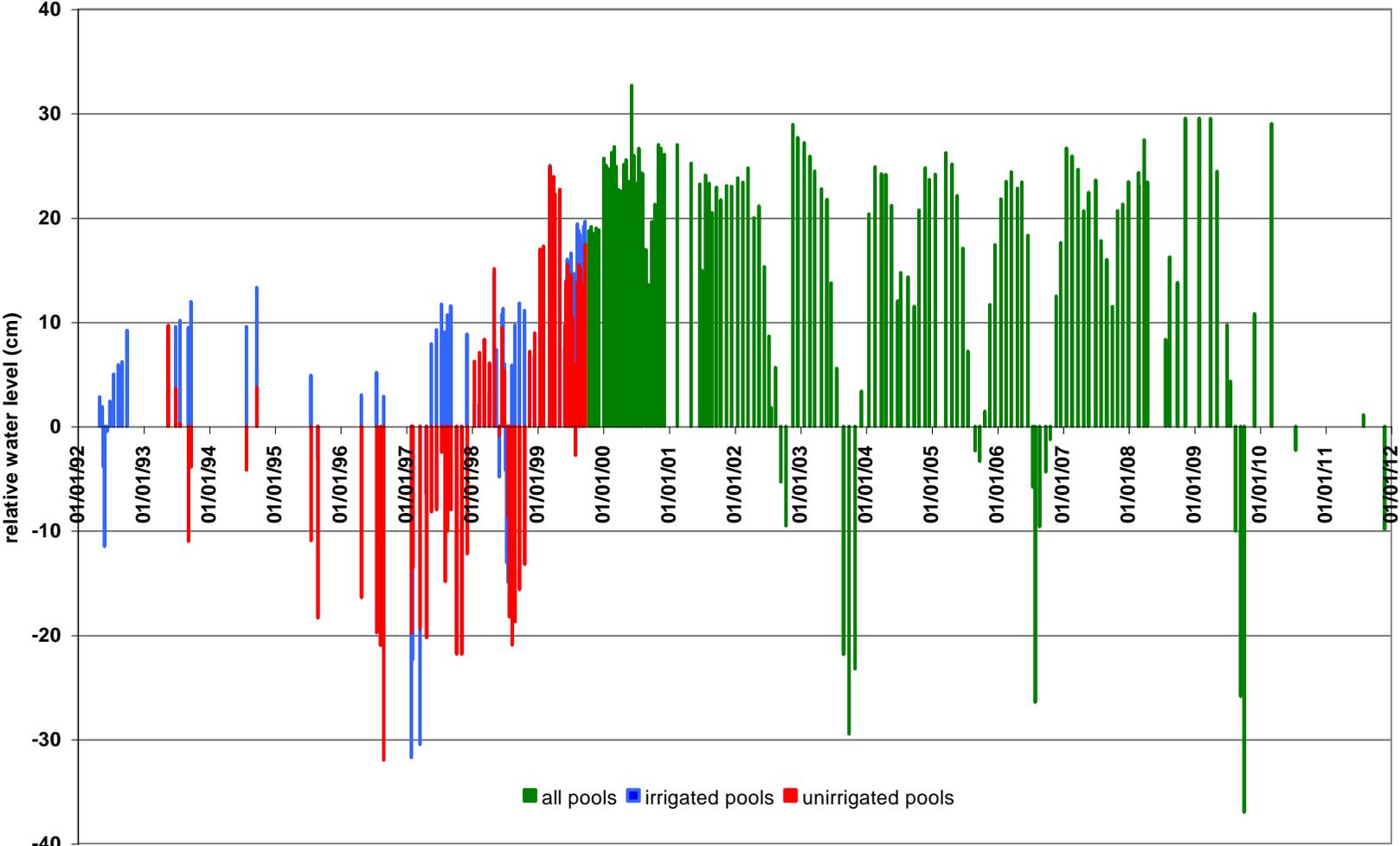
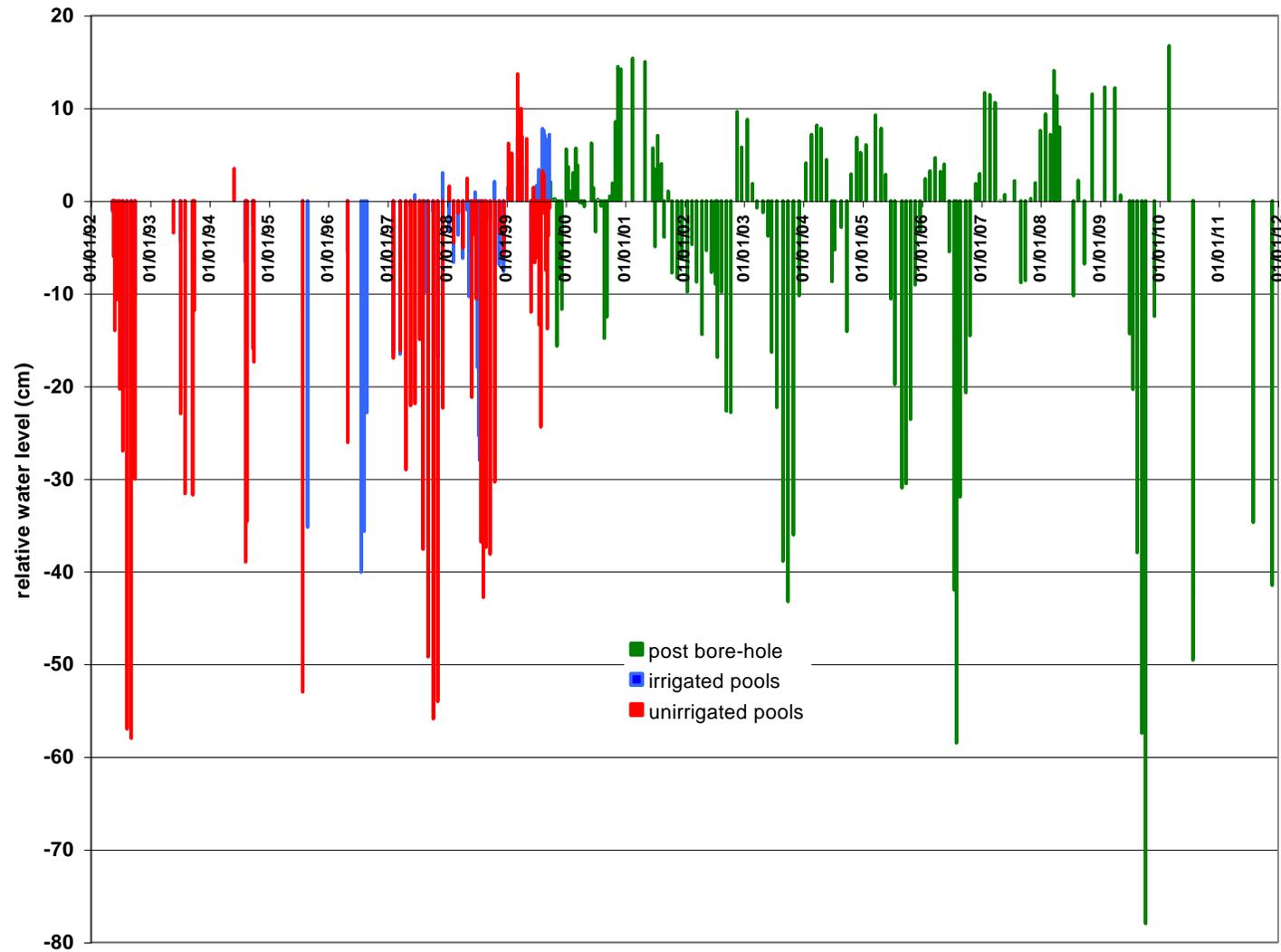


Fig. 12 Water levels in Middle Fen ponds 1992-2011. Horizontal line represents the April 1992 datum. Blue and red lines represent mean levels in irrigated and unirrigated ponds respectively: summer irrigation stopped in 1999 (see text). Arrows show the water levels at the time of July census in 2009 and 2010.



5 Discussion

Although the two remaining, isolated sub-populations of *D. plantarius* at Redgrave and Lopham Fen NNR remained small in 2011, both showed some tentative evidence of positive change. On Little Fen, both numbers of spiders and numbers of occupied ponds were the highest recorded since census work began 21 years ago. Following a sharp but non-significant rise in the population index in 2010, a further smaller rise in 2011 resulted in an index that was significantly higher than any since a short-lived peak in 1998. It is too early to judge whether this increase will become part of a sustained trend. Most of the increase in area of occupancy occurred in 2010 and may have resulted from increased mobility when water levels were high in late summer 2009 and early spring 2010. Recolonisation of more ponds throughout the Little Fen census area might be expected to encourage further spread of the population if improvements in habitat quality can be sustained and summer water levels maintained. In many previous years, droughts during the breeding season are thought to have reduced breeding success (eg Pearson 2008, Smith 2010). Despite the severe spring and autumn droughts in 2011, higher rainfall maintained adequate water levels during the peak months of the spider's breeding season. Breeding success on Little Fen appeared to be lower than in 2010, when numbers of adult females and of nurseries were at a record high, although the unusually early spring in 2011 may have resulted in some early nurseries being missed during the late July census.

On Middle Fen the numbers of ponds occupied during the July census fell from a peak in 2010. This resulted from the loss of spiders from all but one of the ponds censused in the westward spur of the population that started to develop in 2006 (Smith 2007, 2008, 2009, 2010, 2011b). The single adult female encountered in this area bred successfully and so the potential remains for occupation of these ponds in future years. However, there is circumstantial evidence to suggest that this population is likely to be genetically monotonous. An annual alternation between adult and juvenile cohorts, encountered since juveniles were first found in this area in 2006, was perpetuated for a fifth year. Since it is thought that almost all *D. plantarius* at Redgrave and Lopham Fen breed when they are two years old, and then die, this pattern suggests that the initial colonisation may have been a single event. Although *D. plantarius* appears to have a low propensity to balloon (Pearson 2008), this could potentially have comprised a single ballooning from a nursery web in the core area to the east, rather than a progressive westward spread. If this was the case, the substantial reduction in population in this area in 2011 will have resulted in further genetic depletion.

Despite this loss on Middle Fen the very high breeding numbers encountered within the core area of ponds in 2011 gives new potential for an increase in the population. The reasons for this success are unclear. At the 2010 census, numbers of spiders in the cohort that would recruit as adults in 2011 were not unusually high. It seems more likely that survival during the intervening period must have been atypically high. The extreme and protracted cold weather during the 2010/11 winter clearly had no significant adverse effects on the population. In contrast to the sharp inter-annual fluctuations seen in the 1990s, there appears to have been a gradual, though non-significant increase in population size on Middle Fen over the last six years; the slight decrease in 2010 may have been due to very poor recovery of cut *C. mariscus* the core area, leaving *D. plantarius* very exposed to predation (Smith 2011b). The reasons for this apparent change in pattern on Middle Fen remain unclear. It is also difficult to account for the conspicuous and differing patterns of population change on Middle Fen and Little Fen. These differences are significant and suggest that different factors control population size in the two areas.

Research on genetic diversity of the Redgrave and Lopham Fen *D. plantarius* population in 2008 showed that it had declined significantly since 1991 (Holmes 2008). Despite the potentially promising increase in the Little Fen population and the record breeding season on Middle Fen,

the results of the 2011 census add further weight to the conclusion (Smith 2010, 2011b) that natural recolonisation of the many areas of restored vegetation on Redgrave and Lopham Fen is highly unlikely to occur on a time-scale that will effectively conserve the remaining genetic resource. Although excavation of new turf ponds to create summer-wet links between the existing centres of population and recently created larger water bodies is an essential part of this process (Smith 2011b), it is not a complete solution. This is illustrated by the extremely slow progress of the natural recolonisation of a chain of turf ponds on Middle Fen and the set back this suffered in 2011. These findings further emphasised the need for the programme of deliberate translocation of *D. plantarius*, initiated in 2010 (Smith 2011a) to populate the newly restored areas of the fen.

It is not yet possible to assess whether the 2010 translocation to Great Fen was successful because of the lack of sightings of *D. plantarius* in this area in 2011. However, both the considerable difficulty of monitoring this area for immature spiders, and the success of a parallel introduction to grazing marsh reserve on the lower Waveney (Smith 2012), where monitoring conditions were much easier, suggest that the lack of sightings is unlikely to indicate failure; the presence of nursery webs in 2012 will be a much more reliable indication. If successful, releases of spiderlings in two successive years should result in a population with a natural age structure. Monitoring of nursery web numbers and of genetic diversity in the Great Fen introduction area in 2012 and 2013 will be used to assess whether further releases are both justified and necessary. On the eastern fringe of Middle Fen the introduction started in 2011 will be augmented by a second introduction of spiderlings in 2012. Monitoring of nursery webs in 2013 and 2014 will again be used to assess the success of the introduction and potential need for augmentation.

Progress with these two translocations will be kept under review by the project steering group and the plans modified in the light of monitoring results. This will include the possibility of further increasing the number of new populations within the fen complex. The steering group will also keep under review the initial, conservative, decision to introduce only spiders of Redgrave and Lopham Fen provenance. The introductions to grazing marsh ditches on lower Waveney in 2010 and 2011 (Smith 2011a, 2012) used spiderlings of mixed provenance. These comprised pure stock from the Pevensey Levels, Sussex, and the Redgrave and Lopham Fen populations, and stock produced by crosses between them. The decision to use mixed provenance was based three factors: (1) the very close similarity of the lower Waveney grazing marsh habitats to those of the Pevensey Levels, (2) the proximity to Redgrave and Lopham Fen at the source of the Waveney, and (3) the results of an experiment that showed that spiderlings resulting from crosses between these populations grew and survived as well as those of single site provenance (Smith 2011a). The results of this experiment were assessed using only the first generation crosses over the first four months of life; in 2012 it is hoped to produce a second (F2) generation from a sub-set of these hybrids that have been maintained in captivity to test for the unlikely but theoretical possibility of breakdown of hybrid gene complexes. This further experiment will help to inform decisions about future introduction of Pevensey Levels genotypes to Redgrave and Lopham Fen.

There is also a continuing need to maintain a regular monitoring and review of vegetation change and management in relation to the *D. plantarius* population at Redgrave and Lopham Fen. The apparent continuing increase in *C. mariscus* at the expense of *P. australis* in the 1990s scrapes remains a very positive feature. However, the possibility that the creation of pony-grazed 'lawns' between the turf ponds on Middle Fen was a factor in loss of spiders from the newly-colonised area is of concern in the context of colonisation of the newly-created turf pond chains. Most of these are in areas with scattered clumps of *C. mariscus* within a grassy matrix that is very susceptible to grazing of this kind.

While both the re-introductions and the excavation of new turf pond chains at Redgrave and Lopham Fen should reduce the intrinsic vulnerability of the *D. plantarius* population and result in

progress towards the BAP target, droughts remain a threat to progress. The severe drought that started in autumn 2011, whilst less immediately devastating than drought in the peak breeding season, resulted in extremely low winter ground water levels. Unless there is atypically high spring re-charge, this will impact severely on water levels on the Fen in 2012. The probability of severe droughts of this kind continues to increase as the climate becomes warmer. Particularly when droughts occur in two or more successive years, they can devastate the *D. plantarius* population by preventing breeding and recruitment. There is an urgent need to plan for a sustained programme maintaining sufficient depth in existing turf ponds, and the creation both of new, deep ponds and of areas of deeper water near the *C. mariscus*-fringed margins of the larger scrapes (Smith 2010). It is also vital to continue to maintain and, where possible, improve control of the fen's water supply through the sluice system. Establishment of a sustainable, functional metapopulation of *D. plantarius* on the Fen will only be possible when reliable, summer-wet links between the subpopulations have been re-established. The hydrological measures needed to ensure the maintenance of suitable conditions for *D. plantarius* are also likely to be those needed by a high proportion of the site's many aquatic species.

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