

**The status and
management of
Dolomedes plantarius
on Redgrave and
Lopham Fen
National Nature
Reserve in 1996**



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Report to English Nature

**THE STATUS AND MANAGEMENT OF *DOLOMEDES PLANTARIUS*
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IN 1996**

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SUMMARY

1. Redgrave and Lopham Fen is one of only two locations for *Dolomedes plantarius* (the fen raft spider) in Britain. Its survival there is endangered by the drying-out of the fen as a result of water abstraction. In this report census work funded by the Species Recovery Programme (SRP) and Suffolk Wildlife Trust (SWT), habitat management work undertaken by the SWT and measurements of water levels in pools occupied by the spiders, in 1996, are described.
2. 1996 was the sixth successive year in which systematic census work to assess the status of *D. plantarius* was undertaken on the Fen. The census used the area and methodology established in 1993. As in 1995, only a single, summer census was conducted. This comprised three replicate counts at randomly selected pools within the two centres of population, on Little and Middle Fens, in mid-July.
3. The number of pools occupied by spiders on both Fens was lower than in previous years. On Little Fen spiders were virtually restricted to pools which received water either directly or indirectly from an artificial irrigation supply. On Middle Fen spiders were absent from unirrigated pools for the second successive year and the number of irrigated pools occupied was reduced by the very low water levels.
4. On both fens spider numbers were less than half those in 1995. The annual indices reflect this reduction although lower indices have been recorded on both fens in two of the last six years. Over this period the populations have shown significant variation between years with no evidence of any linear trend. The annual pattern of variation differed significantly between Little and Middle Fen.
5. On both Fens the low numbers were attributable largely to a reduction in numbers of medium-sized, and to a lesser extent, small spiders. Numbers of adult spiders on Middle Fen were very similar to those in 1995 while those on Little Fen were higher than in any of the previous three years.
6. No nursery webs were found during the census in mid-July. On Little Fen 14 webs, including seven on pools included in the census, were found in a large area cut for sedge during August. The need for cautious interpretation of these casual records is discussed. No equivalent, casual records were collected on Middle Fen but the very low water levels there make it unlikely that 1996 was a good breeding season.
7. Water levels in 1996 were atypical. The drought of 1995 extended through the winter, resulting in the lowest winter water levels for at least 20 years. The drought continued into July but water levels recovered slightly during August, when they are usually at their lowest. The irrigated pools on Little Fen remained virtually dry during until irrigation was resumed in April. This was successful in restoring and maintaining water levels in these pools and in pools in wide hinterland of the supply pipes. Most pools beyond the reach of this supply were dry by July. On Middle Fen most pools retained some water during the winter but all of the unirrigated pools were virtually empty by July. The irrigation supply was inadequate to maintain levels in the irrigated pools and

by mid-July many were almost empty, with levels 31 cm lower than those in 1995. As on Little Fen, levels rose slowly during August.

8. Four types of management work were carried out in 1996:

- (i) Excavation of 12 new pools in the hinterland of the irrigated pools on Middle Fen in March
- (ii) Bottoming out of 18 irrigated pools on Little Fen in February to deepen and remove emergent vegetation
- (iii) Cutting of marginal *Cladium mariscus*-dominated vegetation around pools within and adjoining the blocks cut as part of the rotational management of the sedge-beds.
- (iv) Introduction of *Stratoides aloides* to 15 pools on Middle Fen to provide breeding habitat in the event of very low water levels recurring within the next three years.

9. The effects of the atypical water levels on numbers and breeding success are discussed and limitations on the interpretation of the data from a single annual census are stressed.

10. Recommendations are made for monitoring and management requirements in 1997:

- (i) Provision should be made for increasing the irrigation water supply in summer 1997 and the supply should be resumed as early as possible in the spring if the winter is dry.
- (ii) New pools should be excavated in the immediate hinterland of the irrigated pools on Little Fen in early spring 1997.
- (iii) More irrigated pools should be cleared of emergent vegetation by 'bottoming-out' in spring 1997. Priority should be given to those with most emergent *Phragmites australis*. In 1998 unirrigated pools should be treated in the same way.
- (iv) Marginal vegetation should be cut around pools within or fringing the blocks of *Cladium mariscus* included in the 1997 rotational cutting, following the protocol developed in 1996. Areas of bank left uncut around the irrigated pools adjoining the sedge blocks cut in 1996 should also be cut in 1997.
- (v) The July census should be expanded to include all irrigated and new pools on Middle Fen. This will enable simultaneous assessment of the feasibility of modifying the distribution of irrigation water between the pools, of colonisation of the new pools and of the success of the *S. aloides* introduction. *S. aloides* should also be monitored for the presence of nursery webs at frequent and regular intervals throughout the breeding season.

1 INTRODUCTION

This report describes the status of *Dolomedes plantarius* on Redgrave and Lopham Fen NNR at the annual July census, in 1996. Changes in the status of the two populations on the Fen are made by comparison with July census data from the previous five years. Comparisons over the whole of this period are based on a population index which allows for changes in the sample of pools censused (Smith 1995). Brief description is also given of casual observations on *D. plantarius* during August and September. Management work on the spider pools undertaken by the Suffolk Wildlife Trust (SWT) and changes in the water table during 1996 are also described. This report is intended to be read in conjunction with Duffey (1991) and Smith (1992, 1993, 1994, 1995a 1995b), which provide detailed background.

1.1 Aims

1.1.1 1996 CENSUS WORK

The 1996 census work was designed to provide indices of the July population size on both Little and Middle Fen, comparable with those derived for the previous five years (Smith 1995a). It also provided an estimate of the approximate age-structure of the population in July. This was the second year in which assessment of the status of the population has been based on only one census period. 1996 was first year in which the data collection was restricted to the sample of pools comprising the census established in 1993 (Smith 1993). In all previous years data have also been collected from all of the pools covered by the original, 1991 census, a much higher proportion of which were in the core areas of the spider populations. As a result, the number of pools contributing records of spiders to the index calculation for 1996 was smaller than in any previous year.

As in previous years, data on water levels in the pools were collected during the census. Since variations in water levels during the season, and particularly in late summer, are thought to be one of the main determinants of breeding success, water levels were also measured in sub-samples of pools on other dates.

1.1.2 MANAGEMENT WORK

Four types of management work designed to enhance the quality of the habitat for spiders were carried out in 1996. Two of these followed recommendations made by Smith (1995a & b) but the others were planned during the summer season in response to changing circumstances on the fen:

1. New pools, designed to provide additional habitat within the irrigated areas within the next two to three years, were excavated during the winter. These were restricted to Middle Fen where fewer pools benefit from the irrigated water supply than on Little Fen.
2. Irrigated pools on Little Fen were deepened to reduce the risk of drying-out in extreme drought conditions. None of the irrigated pools on Middle Fen was deepened because they are already substantially deeper than those on Little Fen (Smith 1995a).
3. On Little Fen, marginal and some emergent *C. mariscus*-dominated vegetation was cut around all of the pools within an area cut in July\August, as part of the sedge-cutting rotation. Where this area bordered irrigated pools, short sections of their bank vegetation were also cut. Proposed

removal of emergent vegetation in May, from irrigated pools that were not deepened in winter (Smith 1995a), was not carried out because of the late season. There was little emergent vegetation growth in the pools until June, by which time the risk to breeding spiders of removing it was judged to be too great.

4. At a meeting between SWT and EN to consider emergency management measures to counter the effects of extremely low water levels on the spiders, it was agreed that a limited and short term (three years) introduction of *Stratiotes aloides* should be attempted. *S. aloides* is the main species in which *D. plantarius* constructs nursery webs on the Pevensy Levels and also in parts of Holland. *D. plantarius* breeds only in stiff, emergent vegetation but the *C. mariscus*-dominated vegetation used for nursery-web construction on the Fen is often left stranded as the water levels fall during dry summers. *S. aloides* has the advantage that it floats and so can move up and down with changes in the water table. Prior to introduction of the plants in September, a surface-sterilisation procedure was developed to prevent parallel introduction of other species and informed advice was obtained that complete removal of introduced stock within a two-to-three year period should be possible. The plants were introduced to Middle Fen, where the irrigation supply is inadequate to maintain water levels in most summers. Details of all management operations are given in Section 2.5.

Although it was proposed in 1995 that the routine management of the pools should continue on an experimental basis, using the two samples of pools comprising the 1993-94 management experiment (Smith 1995a), errors made in the identification of pools during the winter management operations together with the pragmatic decision to manage irrigated pools bordering the sedge-cutting block (above), made this impossible.

1.2 Structure of the report

Methods for the census work, including measurement of water levels, the analysis of five year trends and the pool management operations are described in Section 2. The analyses of the census data, casual records and water level data are presented in Section 3 and their implications are discussed in Section 4. Recommendations for improving the conservation of *D. plantarius* at Redgrave and Lopham Fen, including future monitoring and management requirements, are considered in Section 5. All references to spiders in this report are to *D. plantarius*.

2 METHODS

2.1 The census areas

Spider numbers were monitored on the same randomised sample of pools on Little and Middle Fens as in 1995, 1994 and 1993. The locations of the pools on Little and Middle Fens are shown in Figures 1 and 2 respectively. Details of the sampling strategy are given by Smith (1993).

2.2 Monitoring methods

A single summer census round, comprising three replicate counts (see Smith 1994) was carried out in late July. The three counts on Little Fen were made between 18 and 21 July and those on Middle Fen between 22 July and 26 July.

The counting methods and criteria recorded for individual species were the same as those used in previous years (Smith 1993, 1994). For the first time one pool on Little Fen was not searched from the water because the depth of mud was considered unsafe. However, the pool was searched from the bank using close-focus binoculars and sightings of spiders were checked by entering the water close to the animals. The data collected in this way were considered sufficiently representative to allow their inclusion in the data set.

Where data are presented on the age-structure of the population, small immatures of body length 8 mm or less are classified as 'small', those between 8 and 15 mm as 'medium' and those of 15 mm or greater as 'large'.

2.3 Data Analyses

All data presented for 1996 are based on the highest of the three replicate counts of all spiders on each pool. For some purposes these are subdivided into maximum counts within each of three size classes. Maximum counts are a conservative estimate because of the possibility that different individuals were seen on different days. Smith (1993) showed that three replicate counts was the minimum necessary to give a reasonably consistent estimate of numbers present. Data presented for 1994 are exactly comparable with those for 1995 and 1996 but those for 1993 were based on two rather than three counts. No direct comparison of the numbers recorded in 1991 and 1992 with those in 1996 is possible because of the change in sample of pools included in the census (Section 1.1.1, Smith 1993). Valid statistical comparison of changes in the population over the whole of this period are, however, made using log-linear poisson regression models, as implemented by TRIM software (Panneloek & van Strien 1996). As well as generating annual indices of population size, these models are used to test for linear trends in the data and for differences in patterns of interannual variation on Little and Middle Fen (see Smith 1995a for details).

2.4 Water levels

The water level in each pool was recorded on the first day of the census. As in 1995, the rate of water loss during the census period was such that measurements were repeated on a sub-sample of pools on the last day of the census. Additional records of water levels were made in response to extreme or rapidly changing water levels at other times during the year. Levels were measured in the irrigated pools on Little Fen and a sub-sample of all pools on Middle fen in mid-January, in all pools at the end of April and in irrigated pools included in the census area on 1 August, 9 August and 27 August.

Levels in the newly-excavated pools on Middle Fen (Section 2.5.1) were measured on 2 May and 26 July.

As in previous years, the water levels were recorded to the nearest 0.5 cm, as the distance from the tops of permanent oak posts to the water surface. They are presented as a deviation from the April 1992 datum (Smith 1993).

2.5 Management work

2.5.1 EXCAVATION OF NEW POOLS ON MIDDLE FEN

Twelve new pools were excavated on Middle Fen during the week beginning 11 March using the SWT digger. They were positioned immediately behind the lines of irrigated pools to maximise benefit from the irrigation supply. Eight were on the south side of the irrigated line and four on the north side (Figure 4). The digger accessed these areas from behind the line of new pools to avoid damage to the sedge beds around the existing pools. The pools varied in size and shape but were mostly as large, or larger than the existing irrigated pools. All had gently shelving banks around most of their perimeter, to maximise the area of emergent marginal vegetation, but they also had deep areas (> one meter) to aid water retention in extreme drought conditions. Clumps of *C. mariscus* were dumped into some pools to expedite colonisation.

2.5.2 DEEPENING OF POOLS ON LITTLE FEN

Eighteen of the irrigated pools on Little Fen were deepened, using a mini-digger with a long arm, between 13 and 15 February (Figure 3). It had been intended that deepening should be done on the same pools as were managed in 1995 but errors in identification of the pools in difficult working conditions led to some discrepancies. Thirty to 45 cm of sediment was removed from the bottoms of the pools, avoiding the areas around the marker posts. The sediment removed from the more westerly pools was muddy but some sand was removed from pools at the eastern end. Removal of *C. mariscus* was avoided except where shallow depressions around the pool margins were deepened to increase the potential area of flooded marginal vegetation. As well as increasing the water-holding capacity of the pools, this management operation also fulfilled my recommendation (Smith 1995a) that emergent vegetation infilling pool centres should be removed by the roots, rather than trimmed at water level each summer.

2.5.3 SUMMER SEDGE CUTTING

A large block of *C. mariscus* within the core spider area on Little Fen was this year subject to rotational management by cutting in summer. Much of this block was last cut in 1992 but this year's cut extended into areas which have not been cut since rotational management of the sedge beds was restored by the SWT in 1983 (Figure 1). When the area was cut in 1992, fringes of sedge were left around many of the pools because it was considered too risky to remove them during the spider breeding season. Since then, however, observations on pools which were included within the cut areas have suggested that the open conditions in the year following cutting can provide favourable breeding habitat. It was therefore decided this year to risk cutting the margins of all of the pools within the block of cut sedge. Small marginal patches of *C. mariscus* and some emergent clumps were left uncut to provide cover. By mid-August, some of the pools managed in this way in July were found with nursery webs both amongst regrowth and in the uncut clumps (Section 3.2). In view of this it was decided, in August, to risk cutting sections of the margins of the irrigated pools bordering the block of cut sedge. Between 22 August and 2 September one to two meter long 'windows' were cut from the main cut area into the sides of the irrigated pools, from pool number 8 to 18.

On Middle Fen a band of sedge was cut along the north side of the irrigated pools in late

August and early September and on the south side of the easterly unirrigated pools in October (Figure 2). As on Little Fen, 'windows', were cut from the sedge blocks into the pool margins (pool numbers 22b, 22a, 22, 20, 16, 14, 13, 11 & 9).

2.5.4 INTRODUCTION OF *STRATIOTES ALOIDES*

Approximately 170 *S. aloides* plants were obtained from the SWT reserve at Castle Marshes (TM 475915) on 8 September. This site is a grazing marsh, approximately 55 km down the river Waveney from Redgrave and Lopham Fen. The plants were transported to the Fen in sealed polythene sacs and then cleaned to remove as much surface plant and animal contamination as possible. They were first individually washed, with a high pressure water supply, and then sterilised in a solution of one part hypochlorite bleach in 25 parts water, for eight minutes. Prior trials had shown that this sterilisation procedure killed the great majority of aquatic invertebrates and filamentous algae without causing long-term damage to healthy tissues. Although it killed damaged and senescing tissues this was thought unlikely to be a problem in plants about to enter winter dormancy. Similarly, loss of the very brittle leaves, as a result of physical damage to the plants during handling, was though unlikely to be a problem. The plants were rinsed immediately on removal from the sterilising solution, again with a high pressure water jet to remove any remaining invertebrates. After a further rinse they were transported to Middle Fen and placed in the deepest parts of selected pools.

Ten plants (some with attached offsets and turions) were put into each of nine irrigated pools (Figure 5). These were mostly those that retained the greatest water depths during summer 1996. Similar proportions of the pools included in, and excluded from, the annual census received plants. Between ten and 20 plants were also put in to each of six of the newly-excavated pools (10 plants in 56 and 57, 15 in 49 and 54, 17 in 52 and 20 in 48).

2.5.5 IRRIGATION WATER SUPPLY

The irrigation water supply for 1995 was finally turned off in the third week of December and was resumed on 22 April 1996. The period without a supply was thus much shorter than in previous years. Because of the exceptionally low winter water levels (Section 3.4) it was confined to the period when there was significant risk of frost damage to the pipes.

The number of outlet pipes on Middle Fen was increased from five to eight to distribute the water more evenly between the pools. On Little Fen the number was doubled from five to ten.

Until 26 July the pools received 215 litres water per minute, 5 litres per minute less than the agreed allocation. This was then rectified and the additional 5 litres supplemented the Middle Fen supply. At that stage 130 litres were directed to Middle Fen and 90 to Little Fen (the way in which the supply was divided between the two fens prior to this date is not known).

2.5.6 PERMANENT LABELLING OF MARKER POSTS IN CENSUS POOLS

Metal labels with engraved numbers were screwed to all of the pool marker posts (including the new Middle Fen pools), on 29 April. In most cases the last two digits of the new numbers correspond with the old numbers but there are exceptions where pools formerly had 'a', 'b' *etc.* suffixes. The new numbers are listed with the old in Appendix 1.

3 RESULTS

3.1 Analysis of six year trends

As in 1995, the TRIM model which gave best fit to the six year summer data set for maximum counts of all individuals, was the annual model within covariate strata (Smith 1995a, Section 2.3). This implies, first, that over the last six years there has been significant variation in spider numbers between years on both Little and Middle Fens and, second, that the two fens have significantly different patterns of annual variation (Wald test for differences in annual indices for Little and Middle Fens, corrected for overdispersion in the data: $X^2_{[5]}=52.55$, $P<0.001$). Neither a linear trend model (consistent upward or downward change) nor a null model (no significant change over time) provided an adequate description of the data. The annual indices of population size derived from the model, are described below in Sections 3.2.1 and 3.2.2.

3.2 The distribution and abundance of spiders

3.2.1 LITTLE FEN

Distribution The distribution of spiders in Compartment 5 in July was more restricted than in previous years. Extremely low water levels resulted in restriction of spiders to pools receiving water either directly or indirectly from the irrigation supply (Figure 6). Spiders were thus absent from a much larger area of the north-west of the compartment than at any previous July census. They were recorded from a total of nine pools, compared with 16 in 1995.

Abundance Numbers of spiders in the large size category (mostly adults) were higher than in any of the previous three years. However, numbers of medium and small spiders were low (Table 1). The total recorded was half that in 1995. The mean overall maximum numbers recorded per pool, on both irrigated and unirrigated pools, were also substantially lower than in 1995 but were comparable with those recorded in earlier years (Table 2a). The annual index, which allows comparison of July totals over the past six years, also shows a substantial drop between 1995 and 1996 with 1996 numbers on Little Fen being comparable with those in the previous two 'worst' years of 1993 and 1994. However, because of the small sample size and substantial variability in numbers between pools, few of the differences between annual indices are statistically significant (Table 3).

It should be noted that discrepancies in the magnitude of the index (Table 3) and the annual totals (Table 1), result from the index being derived from a larger sample of pools than the census totals in all years except 1996 (see Section 2.3).

3.2.2 MIDDLE FEN

Distribution 1996 was the second successive year in which no spiders were recorded from unirrigated pools on Middle Fen (Figure 7).

Spiders were recorded on only five of the seven irrigated pools included within the main census area (Figure 7). In the previous two years they were recorded on all seven pools. Those from which they were absent were virtually empty at the time of the 1996 census (Section 3.4.2).

Abundance The numbers of spiders in both the small and medium size categories recorded on the irrigated pools were much lower than in 1995, although numbers of adult spider were higher (Table 1). The mean totals per pool were also substantially lower than in 1995 although they were not lower than those for 1994 and 1993 (Table 2b). The annual index reflected the substantial fall in numbers on the irrigated pools since 1995, together with the contraction in range since 1994. It was nevertheless higher than the index for 1991 and significantly higher than that for 1993 (Table 3).

3.3 Breeding success

No reliable quantitative evaluation of breeding success is possible on the basis of a single summer census. On Little Fen two pregnant females and three with egg sacs were recorded during the 1996 census period. This compares with three pregnant females and three with egg sacs on the same sample of pools in 1995. No nursery webs were found on these pools in either year. Casual records collected from the area of cut sedge in Compartment 5 in 1996 revealed a total of seven nursery webs on these pools during August. Three of these were built, *ca* 10 cm above the water level, in the cut stumps below 30 to 40 cm regrowth of *C. mariscus* cut in early July. This was the first time spiders had been recorded breeding in same-year regrowth on the Fen and the lowest recorded nursery web heights. A further seven webs were recorded on pools not included in the census. Four were found within an area of less than a meter square, in an uncut clump of emergent *C. mariscus* in a pool close to pool 30. Although these webs were still active on 28 August, they had disappeared by 31 August, following 24h of heavy rain and high winds. No active webs were recorded after that date.

On Middle Fen one pregnant female and four females with egg sacs were seen during the census. No nursery webs were seen. This compares with one female with eggs and one nursery web on the same pools in 1995 (although nine webs were recorded from all irrigated in 1995, Smith 1995a). There were no casual records of nursery webs from Middle Fen. Sedge bordering the Middle Fen pools was not cut until September. This, combined with poor weather, made the probability of finding nursery webs during sedge-cutting operation much lower than on Little Fen.

3.4 Water levels

Water levels on the Fen during 1996 were atypical. The winter of 1995/1996 was the driest on the Fen since piezometer recording began in 1976. However, rainfall at approximately fortnightly intervals from late July onwards resulted in a higher water table on the Fen in August than in July for the first time since the very wet summer of 1987. This anomalous pattern dominated the changes in water levels in both the unirrigated and irrigated pools.

3.4.1 LITTLE FEN

Despite continuing the irrigation supply until mid-December 1995, water levels in many of the Little Fen pools remained extremely low throughout the autumn. By mid-January 1996 half of the 32 irrigated pools had no water and all but three of the remainder had only small puddles of water remaining. These pools remained virtually dry until the irrigation supply was resumed on 22 April. The pools that were deepened in February (Section 2.5.2) held some water in their

deepened sections during this period (in early April these were densely filled with frog spawn). By contrast, most of the unirrigated pools held water during the late winter although the levels were low.

The irrigation supply was successful in restoring levels in the irrigated pools. All of these pools refilled within four days to a mean level 2.4 (± 1.89) cm (7.14 ± 2.45 cm in the census sub-sample) above the datum established in early April 1992 (in the absence of irrigation: Smith 1992). As in most previous years, the irrigation supply was successful in maintaining water levels in the Little Fen pools. By mid-July the level in the irrigated pools included in the census was 8.6 (± 3.47) cm above the datum, very similar to the 7.6 (± 2.5 cm) recorded at the same time in 1995. Despite heavy rain on 23 July, hot, dry weather during early August resulted in the level falling to +6.0 cm on the 1st to +0.3 cm on the 9th. Torrential rain on the 11th and some subsequent showers led to a recovery to +6.4 cm by the 27th. This was 4.4 cm higher than on the same date in 1995, when nearly a quarter of the irrigated pools dried-up during late August. Approximately 8 cm of rain fell on 29 August, resulting in full recovery in the irrigated pools.

In contrast to the irrigated pools, the mean level in the unirrigated pools in late April was 16 (± 3.3) cm lower than the datum (there are no previous records from these pools at this time of year). By mid-July they had fallen a further 10.7 cm to -27.1 (± 6.5) cm. This compares with a mean level of with -10 cm at the same time in 1995. During the three day census period they fell by an average of 1.1 cm a day. Eleven of the 24 unirrigated pools were empty at this time and a further four had only small pools of water in the bottom, a situation similar to that in late August 1995. These very low levels made it more obvious than in previous years that the irrigation supply influenced water levels in a wide hinterland and were critical in supplying many of the unirrigated pools in which spiders bred successfully (Figure 8). No further systematic records were made of water levels in these pools although, by late August, levels in a very small sample of pools were *ca* 7 cm higher than in July.

3.4.2 MIDDLE FEN

Winter water levels on Middle Fen, although low, were higher than those on Little Fen and water was retained in all pools throughout the winter. On 14 January the mean level was 22.8 cm below the April 1993 datum. By late April the mean level in the unirrigated pools was -25.4 (± 0.8) cm. By mid-July levels were lower than in any of the previous three years (measurements of these pools began in 1993). Eighteen of the 23 irrigated pools included in the census were empty and a further two were almost empty. The water level in the only three pools with water around the measuring post was -79 cm. The heavy rain on 23 July, just after the first of the three Middle Fen census counts, resulted in an immediate *ca* 8 cm rise in levels but, by the third count, three days later this has fallen to 2.8 cm. Most of the unirrigated pools dried out again in early August but heavy rain resulted in reflooding of all pools by the end of the month (no more systematic measurements were made). This contrasts with the situation in 1995, when only one pool was dry at the July census but all but two were dry by the end of August.

As in all previous years the irrigation supply was less successful in maintaining levels on Middle than on Little Fen, despite the greater rate of supply (Section 2.5.5). The resumption of irrigation in April led to a recovery to -6 (± 0.8) cm (-5.4 ± 2.0 cm in the census sample). By late May levels in the irrigated pools were very low and by mid-July many pools were virtually empty. The mean level in the census sample was -43.8 (± 13.0) cm, 31 cm lower than in 1995. The much higher variation about the mean than on Little Fen reflects the very strong effect of the proximity of the pipe outlets on the Middle Fen pools. Variation in outlet positions of only a few

centimetres could result in pools filling or emptying. The rain on 23 July, in combination with an increase in the supply rate on 26 July (Section 2.5.5), increased the mean level to -37.6 cm by 1 August. By 26 August it had risen to -33.6 cm, two centimetres higher than at the same time in 1995.

The new pools on Middle Fen, immediately behind the irrigated pools, benefitted from the irrigation supply but suffered proportionally greater losses. Those on the south side of the irrigated pools had a mean level of -7.3 cm, very similar to that in the irrigated pools, just after irrigation was resumed in late April. By late July they had fallen to -68cm, 24cm lower than the irrigated pools, and one was completely empty.

4 DISCUSSION

At the time of the annual census, in July 1996, the prognosis for persistence of both the Little and Middle Fen *D. plantarius* populations appeared to be very poor. Following the driest winter for at least 30 years, the distribution on Little Fen contracted and on Middle Fen no spiders were recorded from unirrigated pools for the second successive year. The population indices for both Fens were substantially lower than in the 1995. Although they were not the lowest recorded since systematic censusing began six years ago, both the age structure of the population, particularly on Little Fen, and the extremely low water levels (particularly on Middle Fen) increased substantially the probability of extinction. The very small numbers of immature spiders on Little Fen suggested that the future breeding population would be extremely small unless the adults present bred successfully during the remainder of the summer. On Middle Fen the 1995 peak in numbers, particularly in the size class expected to breed in 1996, was effectively 'wasted' by the very low water levels making conditions unsuitable for breeding in most pools throughout the summer.

The amelioration in conditions from late July onwards, almost certainly resulted in the successful breeding attempts recorded on Little Fen (Section 3.2). Whilst this evidence of breeding was encouraging, there are several reasons why it should not be interpreted as an increase over either the earlier part of summer or previous years. First, failure to find nursery webs during the July census may have resulted from both the relatively small numbers of pools censused and from the breeding season being delayed by the late spring (the breeding season for resident passerine birds on the fen was delayed by between two and four weeks). Second, this area is normally relatively inaccessible and includes many pools not normally covered by the census. Third, the time period during which the webs were found had not been covered by census work since 1992. Fourth, because the area was being cut for sedge the number of potential observers was high. The combination of these factors, and the fact that the area of cut sedge comprised a high proportion of the core range for spiders on Little Fen, meant that the probability of detecting nursery webs was very much higher than at any time in the past.

It would also be unsafe to conclude that newly-cut areas of sedge are particularly favoured by the spiders. The concentration of webs in clumps of *C. mariscus* left standing in pools within the cut block may have resulted from spiders being forced out of the greater part of the cut area. However, this finding, together with the discovery of spiders breeding amongst regrowth from a July cut, shows that spiders can breed successfully despite sedge-cutting operations, either when these are carried out in mid-summer, or when some tall sedge is left standing in the pools. More systematic and detailed research is required to ascertain whether the

different ages of sedge are more or less favourable to spiders, particularly because the ease of detecting both spiders and nursery webs might be expected to decline with increasing height and density of sedge.

The virtual restriction of observations on Middle Fen to the July census gives only a very small 'window' on the status of the population in 1996. This should not be assumed to be representative of the season as a whole. The census showed that numbers on the irrigated pools, although much lower than in 1995, were still substantially higher than in either 1993 or 1994. However, the population index for Middle Fen was lower than in 1994 because of the absence of spiders from unirrigated pools for the second successive year (Smith 1995a). It now seems likely that this represents a real and substantial contraction in the area occupied by spiders on this Fen. Whilst it is unlikely that 1996 was a successful breeding season on Middle Fen, because water levels were extremely low for most of the summer, no quantitative assessment will be possible until the 1997 census.

5 RECOMMENDATIONS

5.1 WATER SUPPLY

The irrigation water supply should be maintained for as long as possible during the early winter and restored as early as possible in spring 1997, unless winter water levels are very high. Particularly if the winter and spring are dry, a request should be made to the Water Company that they apply for a drought permit (to increase the volume they can pump, and hence supply to the fen) at an early stage in the summer. The water supply to the pools could then be increased during late July and August, when it most needed (it can take 35-58 days for the permit to be granted).

If drought conditions prevail again in 1997, consideration should be given to re-arranging the supply on Middle Fen such that high levels are retained in a few pools at the expense of the majority of pools. This would represent a reversal of the measures taken in 1996. Any decisions to adopt this strategy must be based on a census of spiders number in **all** irrigated pools (see Section 5.4) and should also take into account possible beneficial effects of the introduced water soldiers in pools with fairly low water levels (see Section 5.4). These problems should be reviewed immediately after the 1997 summer census.

5.2 EXCAVATION OF NEW POOLS

The excavation of additional pools on Little Fen, similar to those excavated on Middle Fen in 1996, should be undertaken in March/April 1997, if the water table permits. There may be less benefit in restricting these to the immediate hinterland of the irrigated pools, as on Middle Fen, since it is unlikely that they would be colonised before irrigation of pools is likely to cease, within one or two years of closure of the borehole. Priority should be given to construction of pools in Compartment 4, south the irrigated pools, because the old peat pools in this area are not deep enough to retain water in dry summers. Careful consideration should be given to the advantages of excavation of new pools in Compartment 5, to the north of the irrigated pools at this stage. This area supports the bulk of the Little Fen spider population and so the likelihood of damage to hibernating or newly emergent spiders, as well as to the high-quality sedge bed in this

area, should be considered carefully. Feasibility of access, the type of machinery available and the timing of operations are all likely to be important.

5.3 MANAGEMENT WORK

Infilling vegetation: Removal of emergent vegetation, particularly *Phragmites australis*, from pools on Little Fen in 1996, as part of the operation to deepen the pools, was much more successful than summer cutting with a crone carried out in previous years. More pools should be managed in this way in 1997 and a rolling programme of this type of pool maintenance should be initiated for the future. In 1997 the irrigated pools left unmanaged on Little Fen in 1996 and those with most emergent *P. australis* on Middle Fen, should be bottomed-out. In the future the machine-dug, unirrigated pools on both Fens and some of the older peat diggings on Little Fen should be included in the programme. The time-scale on which repetition of this work will be needed will depend substantially on the rate at which *P. australis* re-invades in the post-borehole period.

Marginal vegetation: Following the apparent success of inclusion of spider pools within the blocks cut for sedge in 1996 (Section 2.5.3), a similar policy should be continued in 1997. Up to half of the circumference of irrigated pools can be cut (more for unirrigated pools) but great care should be continue to be taken to ensure that nursery webs are not damaged. Where 'windows' have been cut in marginal vegetation of pools, the remainder of the margins should be cut at later date. This requires careful recording of the dates and locations of cut areas. This approach is nevertheless more convenient, and less labour intensive, than the previous, completely separate, management strategy for the pool margins. It can be abandoned progressively when more satisfactory summer water levels are established after closure of the bore-hole.

Trampling damage: No action was taken in 1996 to restrict trampling around the pools by members of the public wanting to see the spiders. However, the path between the two rows of irrigated pools on Middle Fen was left uncut for most of the season and this helped to deter many visitors. The problem is likely to increase in 1997 with increasing visitor numbers to the fen. The construction of one or more viewing platforms on consistently well populated pools, as recommended in the Species Action Plan (Smith 1995b: see also Smith 1995a) should receive more urgent consideration before the 1997 season. The 1996 Open Day at the Fen demonstrated that the spiders have a large and enthusiastic potential audience.

5.4 MONITORING

Spiders: The minimum requirement for monitoring in 1997 is to maintain the standardised July census to generate the annual population index and assess any trends. However, there are three urgent additional requirements for monitoring work in 1997. These are: (1) to assess the success of the water soldier introduction (2) to evaluate the need for changes in the disposition of irrigation water on Middle Fen in late July and August (Section 5.1) and (3) to check the pools excavated on Middle Fen in 1996 for evidence of colonisation. These requirements can be met most efficiently by including all of the Middle Fen irrigated pools in the 1997 summer census. This would require increasing the number of days of the fieldwork six to nine (three on Little Fen, six on Middle Fen). The new pools on Middle Fen may have to be assessed primarily from

their banks using close-focus binoculars because they are too deep to survey safely from the water. Assessment of the water soldier introduction should involve not only counting the numbers of plants and any nursery webs present at the time of the census but also checking for nursery webs on other dates (at least weekly during the breeding season). The latter can probably be done with binoculars and may be a suitable task for a volunteer.

Water: In addition to recording levels in pools during the summer census, systematic recording is needed on other dates as a basis for making critical management decisions. A minimum requirement would be measurements of all pools in the census sample in early April, early June and early August. In addition, frequent and regular visual checks should be made of levels in irrigated pools to ensure that any failure in the water supply is detected at the earliest possible stage.

5.5 AUTECOLOGICAL STUDY

The need for an autecological study of aspects of the life-history and habitat requirements of *D. plantarius* on Redgrave and Lopham Fen continues to be an urgent requirement for effective management (Smith 1993, 1994, 1995a & b).

Four areas of study would greatly improve our current ability to assess the status of the population and ensure successful recovery. These are:

- (1) **Dependency of non-breeding spiders on the pools.** The effectiveness of our current survey methodology and the confidence that can be placed on the population index is limited by our ignorance of the dependency of non-breeding spiders on water surfaces for hunting. This could be rectified by an intensive, small-scale mark-release-recapture study, preferably in combination with some form of pitfall-trapping. This information would also help predict the likely impact of trampling damage and the use of heavy machinery in the vicinity of the pools in summer.
- (2) **Hibernation requirements.** We are still completely ignorant about the location and requirements of the spiders for almost half of the year. Regulation of winter water levels to optimise conditions for successful overwintering of spiders after bore-hole closure will not be possible without this information.
- (3) **Effects of rotational sedge-cutting.** Rotational sedge-cutting has been restored throughout the areas populated by spiders. The response of the animals to this radical perturbation of their habitat requires evaluation. It has implications for the optimal areas of cut blocks and the ways in which pools within the blocks should be managed. If it is a major source of variation in spider numbers this has implications both for predicting changes in numbers and manipulating population size.
- (4) **DNA Finger printing.** Identification of the genetic distances between the two British and the near-continental spider populations is an important pre-requisite for assessing the appropriateness of potential translocations. These include both re-introduction to the fen should the existing population be lost, and introductions to new sites to reduce the vulnerability of the British population.

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Table 1 Maximum numbers of spiders counted in Little and Middle Fen census areas in July 1993, 1994, 1995 and 1996

| | 1993 | 1994 | 1995 | 1996 |
|-------------------|-----------|-----------|------------|-----------|
| <u>Little Fen</u> | | | | |
| Large | 5 | 4 | 8 | 13 |
| Medium | 8 | 7 | 27 | 3 |
| Small | 1 | 8 | 6 | 4 |
| Total | 14 | 19 | 41 | 20 |
| <u>Middle Fen</u> | | | | |
| Large | 6 | 13 | 3 | 7 |
| Medium | 7 | 21 | 63 | 14 |
| Small | 8 | 10 | 36 | 20 |
| Total | 21 | 44 | 102 | 41 |

Table 2 Mean numbers of spiders on irrigated and unirrigated pools within the census area in 1993, 1994, 1995 and 1996. Data are means of the maxima of the counts carried out during each census period (no spring or autumn census after 1994). Two S.Es. of the mean are given in parentheses for the July counts. There were 25 unirrigated and 7 irrigated pools and Little Fen and 23 unirrigated and 7 irrigated pools on Middle Fen.

| (a) Little Fen | | | | | | | | |
|----------------|-------------|--------|--------|--------|-----------|--------|--------|--------|
| Census period | Unirrigated | | | | Irrigated | | | |
| | 1996 | 1995 | 1994 | 1993 | 1996 | 1995 | 1994 | 1993 |
| Spring | - | - | - | 0.32 | - | - | - | 1.57 |
| Summer | 0.46 | 1.00 | 0.33 | 0.48 | 0.29 | 1.71 | 0.86 | 0.29 |
| | (0.36) | (0.57) | (0.23) | (0.31) | (0.37) | (1.13) | (1.11) | (0.37) |
| Autumn | - | - | 0.96 | 0.60 | - | - | 0.86 | 1.71 |

| (b) Middle Fen | | | | | | | | |
|----------------|-------------|--------|--------|--------|-----------|--------|--------|--------|
| Census period | Unirrigated | | | | Irrigated | | | |
| | 1996 | 1995 | 1994 | 1993 | 1996 | 1995 | 1994 | 1993 |
| Spring | - | - | 0.04 | 0.09 | - | - | 1.71 | 1.78 |
| Summer | 0.00 | 0.00 | 0.35 | 0.13 | 5.57 | 14.3 | 3.71 | 2.00 |
| | (0.00) | (0.00) | (0.41) | (0.19) | (4.07) | (7.64) | (1.21) | (1.07) |
| Autumn | - | - | 0.17 | 0.00 | - | - | 2.71 | 2.86 |

Table 3 Multiplicative annual indices for *Dolomedes plantarius* on Little and Middle Fens in July 1991-1996, generated by a poisson regression model (TRIM)

| Year | Little Fen | | Middle Fen | |
|------|--------------|----------|--------------|----------|
| | Annual index | Std.err. | Annual index | Std.err. |
| 1991 | 1.000 | 0.000 | 1.000 | 0.000 |
| 1992 | 2.867 | 0.529 | 1.470 | 0.230 |
| 1993 | 0.554 | 0.133 | 0.534 | 0.105 |
| 1994 | 0.378 | 0.101 | 1.651 | 0.248 |
| 1995 | 1.265 | 0.258 | 3.228 | 0.444 |
| 1996 | 0.603 | 0.187 | 1.249 | 0.465 |

Appendix 1 Key to pool numbers on metal tags installed in 1996

Middle Fen

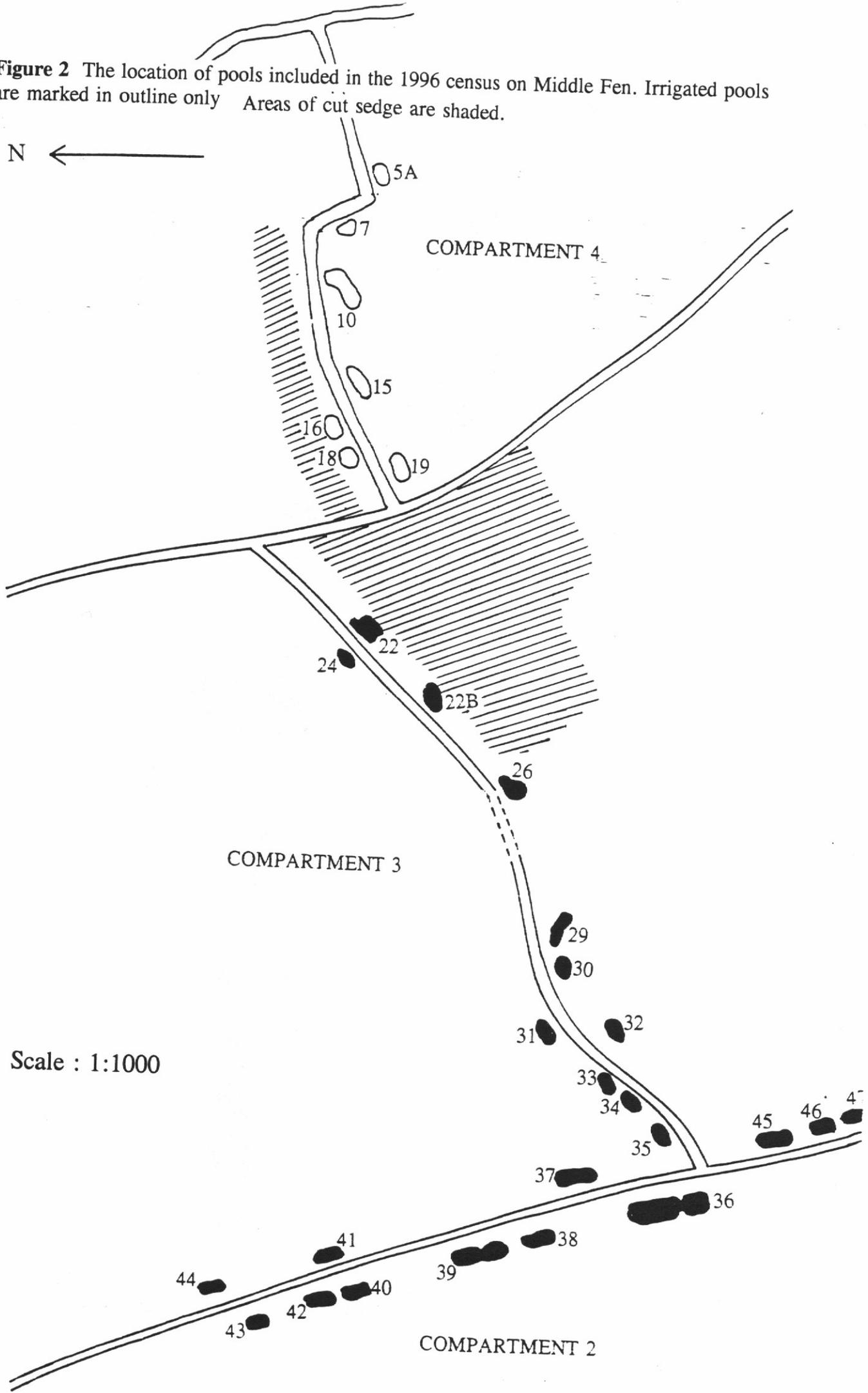
| | | | | | |
|-----|------|----|------|-----|------|
| 1 | 2001 | 42 | 2042 | 24 | 2524 |
| 2 | 2002 | 43 | 2043 | 24A | 2685 |
| 3 | 2003 | 44 | 2044 | 25 | 2525 |
| 4 | 2004 | 45 | 2045 | 26 | 2526 |
| 4A | 2190 | 46 | 2046 | 27 | 2527 |
| 5 | 2005 | 47 | 2047 | 28 | 2528 |
| 5A | 2191 | 48 | 2048 | 29 | 2529 |
| 5B | 2192 | 49 | 2049 | 30 | 2530 |
| 6 | 2006 | 50 | 2050 | 31 | 2531 |
| 7 | 2007 | 51 | 2051 | 32 | 2532 |
| 7A | 2193 | 52 | 2052 | 33 | 2533 |
| 8 | 2008 | 53 | 2053 | 34 | 2534 |
| 9 | 2009 | 54 | 2054 | 35 | 2535 |
| 10 | 2010 | 55 | 2055 | 36 | 2536 |
| 11 | 2011 | 56 | 2056 | 37 | 2537 |
| 12 | 2012 | 57 | 2057 | 38 | 2538 |
| 13 | 2013 | | | 39 | 2539 |
| 14 | 2014 | | | 40 | 2540 |
| 15 | 2015 | | | 41 | 2541 |
| 16 | 2016 | | | 42 | 2542 |
| 17 | 2017 | | | 43 | 2543 |
| 18 | 2018 | | | 44 | 2544 |
| 19 | 2019 | | | 45 | 2545 |
| 20 | 2020 | | | 46 | 2546 |
| 21 | 2021 | | | 47 | 2547 |
| 22 | 2022 | | | 48 | 2548 |
| 22A | 2194 | | | 49 | 2549 |
| 22B | 2195 | | | 50 | 2550 |
| 22C | 2196 | | | 51 | 2551 |
| 23 | 2023 | | | 52 | 2552 |
| 24 | 2024 | | | | |
| 24A | 2197 | | | | |
| 25 | 2025 | | | | |
| 26 | 2026 | | | | |
| 27 | 2027 | | | | |
| 28 | 2028 | | | | |
| 29 | 2029 | | | | |
| 30 | 2030 | | | | |
| 31 | 2031 | | | | |
| 32 | 2032 | | | | |
| 33 | 2033 | | | | |
| 34 | 2034 | | | | |
| 35 | 2035 | | | | |
| 36 | 2036 | | | | |
| 37 | 2037 | | | | |
| 38 | 2038 | | | | |
| 39 | 2039 | | | | |
| 40 | 2040 | | | | |
| 41 | 2041 | | | | |

Little Fen

| | | | | | |
|--|--|-----|------|--|--|
| | | 1 | 2501 | | |
| | | 2 | 2502 | | |
| | | 3 | 2503 | | |
| | | 4 | 2504 | | |
| | | 5 | 2505 | | |
| | | 6 | 2506 | | |
| | | 7 | 2507 | | |
| | | 7A | 2680 | | |
| | | 8 | 2508 | | |
| | | 9 | 2509 | | |
| | | 10 | 2510 | | |
| | | 11 | 2511 | | |
| | | 12 | 2512 | | |
| | | 13 | 2513 | | |
| | | 14 | 2514 | | |
| | | 15 | 2515 | | |
| | | 16 | 2516 | | |
| | | 17 | 2517 | | |
| | | 18 | 2518 | | |
| | | 19 | 2519 | | |
| | | 20 | 2520 | | |
| | | 20A | 2681 | | |
| | | 20B | 2682 | | |
| | | 21 | 2521 | | |
| | | 22 | 2522 | | |
| | | 23 | 2523 | | |
| | | 23A | 2683 | | |
| | | 23B | 2684 | | |

Figure 2 The location of pools included in the 1996 census on Middle Fen. Irrigated pools are marked in outline only. Areas of cut sedge are shaded.

N ←



Scale : 1:1000

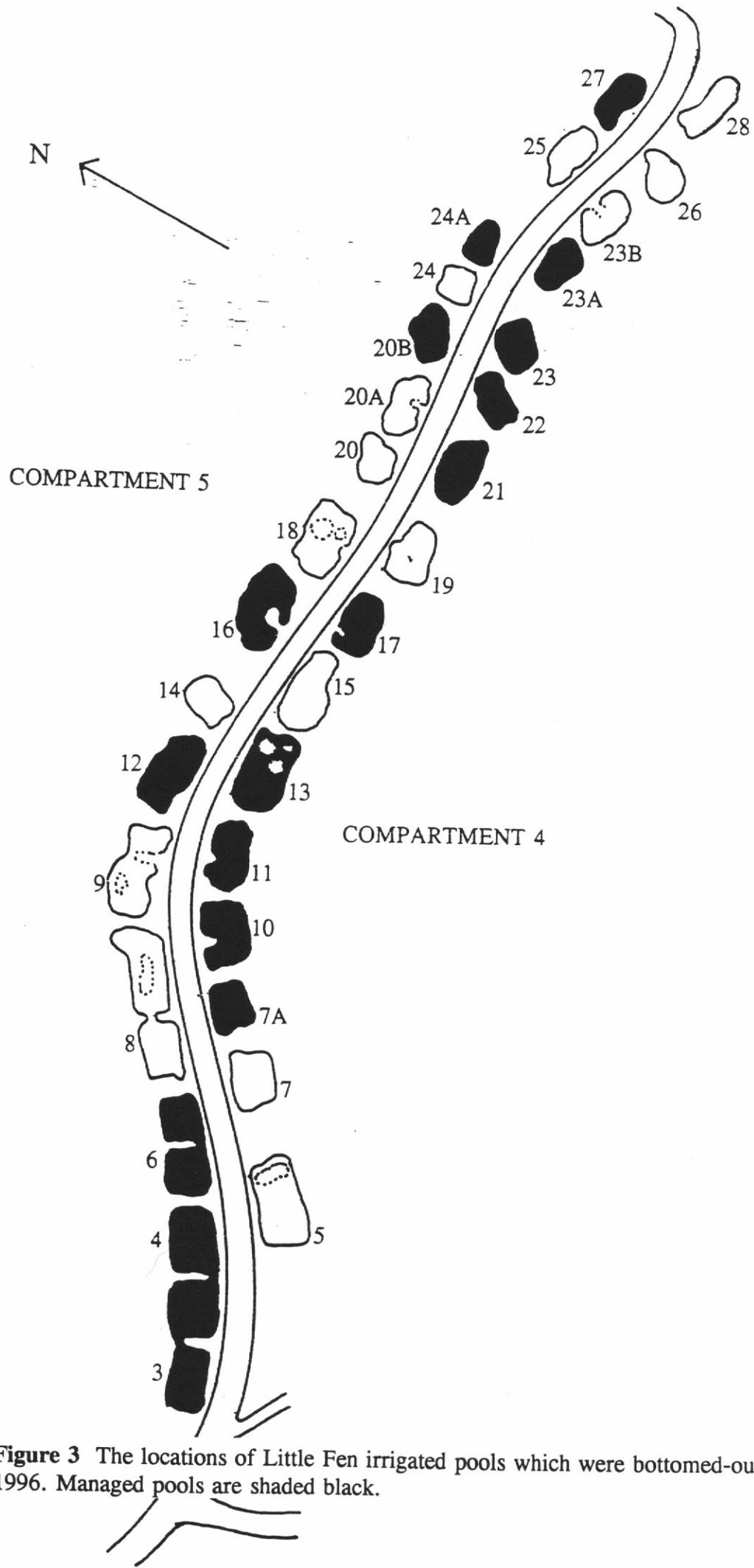


Figure 3 The locations of Little Fen irrigated pools which were bottomed-out in February 1996. Managed pools are shaded black.

Figure 4 The locations of pools excavated on Middle Fen in March 1996. Existing irrigated pools are marked in outline only, new pools in black.

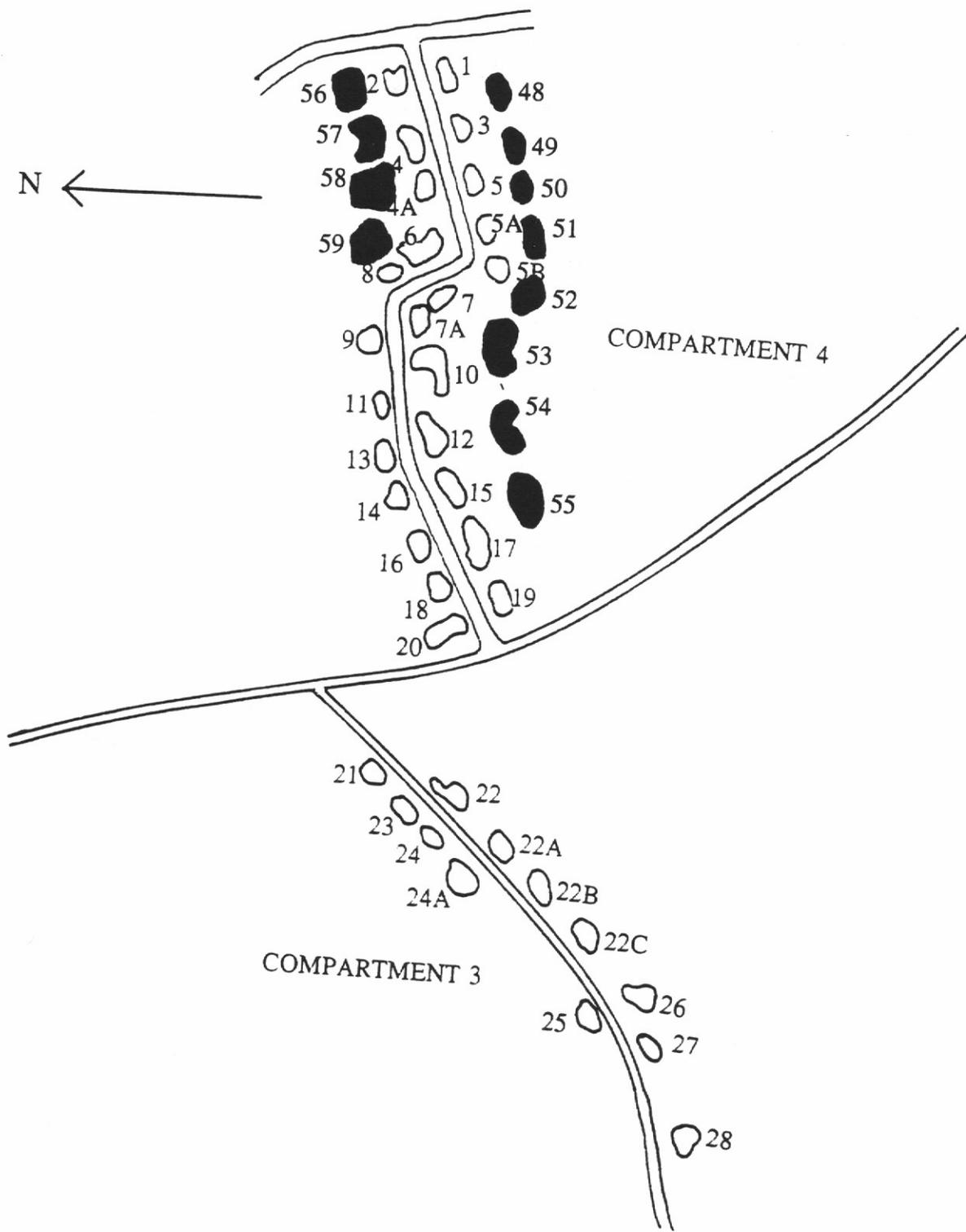


Figure 5 The locations of Middle Fen pools into which *Stratiotes aloides* was introduced in September 1996

