Report to English Nature

THE STATUS AND MANAGEMENT OF *DOLOMEDES PLANTARIUS* ON LOPHAM AND REDGRAVE FEN NATIONAL NATURE RESERVE IN 1994

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SUMMARY

1. Lopham and Redgrave 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 the fen as a result of water abstraction. 1994 was the fourth year in which English Nature's Species Recovery Programme funded census work to assess its status and management operations to maintain open conditions in the pools occupied by the spiders at this site.

2. The 1994 census used the same pools as in 1993, when the area included in the census was increased. Censuses were done in spring, summer and autumn on Middle Fen but no spring census was done on Little Fen because water levels were too high to allow access. The spring and autumn censuses each comprised two replicate counts while the summer census comprised three counts.

3. Comparisons are made between the 1993 and 1994 census data. A run of comparable data for 1992 to 1994 is also presented. This is based on the pools censused in 1992 and subsequently monitored as part of an experiment on the effectiveness of management operations.

4. The status of *D. plantarius* remains precarious. On Little Fen spiders were found throughout the census area but the number of pools occupied was lower than in 1993. Numbers on this fen appear to have declined since 1992. Only four adult females were seen in 1994 and only two nursery webs found. In contrast, the population on Middle Fen increased substantially in 1994, although the area it occupied remained unchanged. Eighteen nursery webs were recorded during July and early August but second breeding attempts probably failed. Although currently more successful, the Middle Fen population may be intrinsically more vulnerable than that on Little Fen, because it is much more dependent on a small area of machine-dug, artificially irrigated pools.

5. A broad-scale survey of the fen, conducted by volunteers in July 1994, confirmed that the distribution of the spiders is extremely restricted. Search of compartments in which spiders have either been recorded in the past, or which are close to the current centres of population, revealed no new sites. The only spiders found were in the immediate hinterland of irrigated pools.

6. Water levels in spring 1994 were substantially higher than in the previous two years. They fell rapidly in June and early July. At this stage they were lower than in 1993. However, they then recovered progressively during the remainder of the summer whereas, in 1993, they remained low during August and most of September. As in the previous three years, the pools occupied by the core of both the Little and Middle Fen populations were irrigated during the summer with de-chlorinated water supplied by the Suffolk Water Company. This supply is important in maintaining water levels not only in the pools receiving a direct supply but also in a wide hinterland.

7. Management work was conducted on the same randomised sub-set of pools as in 1993. It was confined to cutting and removal of emergent vegetation from the centres of the pools

in mid-August. Spider numbers on both managed and control pools were monitored before and after the management operation, using three replicate counts on both occasions. There was good evidence that the cumulative effects of the management work done in the previous two seasons reduced spider numbers. There was no evidence that the summer management operation had deleterious effects and it was thought that sedge-cutting at the pool margins in the previous two springs was more likely to be responsible.

8. The continuing precarious state of the spider population makes it vital that the census initiated in 1993 is maintained. It is further recommended that funding urgently be sought for a study of the spiders' life-history and habitat requirements so that conservation efforts can be better targeted. This is critical both to attempts to maintain the population until the fen water table is restored and to ensuring that subsequent habitat restoration work results in recovery of the population. If such is forthcoming, census work could be restricted to a single summer census round comprising three replicate counts. Inclusion of all, rather than a sub-sample of the pools censused in 1992 is recommended. If an autecological study is not possible three census rounds are recommended, as in 1994.

9. It is recommended that the current management operations should be replaced, possibly by a single operation, conducted in May, on a three year rotation. Vegetation at the pool margins should be cut, and emergent vegetation cleaned out, from the centres of the pools. It is imperative that any future management work is conducted on a sound experimental basis.

1 INTRODUCTION

In this report I describe work funded by English Nature's Species Recovery programme in 1994 to evaluate, and attempt to improve, the status of *Dolomedes plantarius* (the Fen Raft Spider) on Lopham and Regrave Fen NNR. The report covers both monitoring work and habitat management undertaken by the Suffolk Wildlife Trust (SWT: the owners/managers of the reserve).

1.1 Background

D. plantarius occurs at only two sites in Britain. It is was first described in 1956 from Lopham and Redgrave Fen on the Norfolk/Suffolk border (Duffey 1958). The population at this site is now endangered as a result of drainage of the fen by a bore-hole built for water abstraction, adjacent to the site, in 1960. This water loss was exacerbated by severe drought between 1989 and 1992 and resulted in restriction of the spider population to two small, isolated areas of the fen. English Nature (then the Nature Conservancy Council) first funded monitoring to assess the status of the population in 1991 (Duffey 1991). The Species Recovery Programme continued to fund monitoring work in 1992, 1993 (Smith 1992, 1993) and this year. Despite summer irrigation of pools occupied by the spiders in the core of their range, from August 1991 onwards, and some recovery of the fen water table in the wetter 1992/93 winter, there was no evidence of any recovery in the size of the spider population in 1993 (Smith 1993).

Management work designed to improve the suitability of pools occupied by the spiders in the core of their range was funded by the Species Recovery Programme from 1992 onwards (Smith 1992, 1993). In both 1993 and this year, this work was carried out on an experimental basis. No significant effects of management on spiders numbers could be detected in 1993.

In 1994 work on *D. plantarius* in 1994 fell into three areas, the aims of which are described below. A planned study of the home range and breeding phenology of individually marked adult spiders on Little Fen could not be carried out because water levels were too high and adult numbers too low. Provisional plans to assess the relationship between water temperature and spider numbers, in the event of funding being available, were not realised.

1.2 Aims

1.2.1 CENSUS WORK

The status of the spiders in their two core areas was assessed using the census scheme established in 1993. The design of the census was changed in 1993 to incorporate pools outside the known range, so that any recovery in extent of the population could be detected (Smith 1993). Data collected in 1994 are therefore directly comparable with those collected in 1993. A longer run of comparable data, obtained from the census of core pools in 1992, and subsequent monitoring of the same pools as part of the management experiment (below), is also examined in this report. Data on water levels in the pools for the three year period

are examined in relation to trends in spider numbers. As in previous years, data on the breeding success of the spiders, collected during routine monitoring, were used as an additional indicator of the status of the population. Information on breeding biology was also collated to contribute to our understanding of the autecology of this little-studied species.

1.2.2 THE MANAGEMENT EXPERIMENT

The management experiment, designed to evaluate rigorously the effects of pool management work on spider numbers in 1993, was continued in 1994. Following review of the 1993 management work, it was decided that spring management of vegetation at the pool edges, carried out in 1992 and 1993, should be discontinued in 1994 because it was weakening the *Cladium mariscus*. Summer removal of vegetation from centres of the same random selection of pools was continued in 1994. Spider numbers were monitored both before and after this work was carried out to evaluate the proximate effects of the summer management as well as the medium term effects of the 1993 management work and.

1.2.3 BROAD-SCALE SURVEY

In addition to these two, ongoing areas of the project an additional, broad-scale survey was conducted. It aimed to ascertain both the current distribution of the population and the state of pools in areas of the fen from which spiders are now absent. This survey was conducted by ten experienced volunteers on one day at the peak of season.

1.3 Structure of the report

Methods and results for these three areas of work are discussed in Sections 2, 3 and 4 respectively. The implications of the results, both for the conservation of the spider populations and for future monitoring and management requirements, are considered in Section 5. All references to spiders in this report are to *D. plantarius*.

2 THE CENSUS

2.1 Methods

2.1.1 THE CENSUS AREAS

The same randomised sample of pools was censused in 1994 as in 1993. Details of the sampling strategy are given in Smith (1993). The sample was stratified to include different pool types, for example old peat diggings and newer machine-dug pools, and irrigated and unirrigated pools. The census areas on both fens included both a sample of the pools which had previously been censused in 1991 and 1992 (see Duffey 1991 and Smith 1992 respectively) and pools over a wider area which had not previously been systematically censused. A total of 31 pools was included in the Little Fen census area and 28 in the Middle Fen census area. The locations of the pools on Little and Middle Fens are shown in Figures 2.1 and 2.2 respectively.

2.1.2 MONITORING METHODS

Spiders

Three census rounds were planned for the early, mid and late parts of the season. These were completed on Middle Fen but the spring round had to be omitted on Little Fen because the very high spring water table made the pools inaccessible. The spring and autumn census rounds comprised two counts and the summer round three counts, made on separate days. The rationale for using three counts is described by Smith (1993) but this was possible only at one of the three census rounds because of financial constraints. The shortest possible interval was left between counts so that the probability of immigration and emigration occurring between counts was minimised.

The dates of the counts on Little and Middle Fens were as follows:

Census round	Little Fen	Middle Fen
Spring round:	-	31 May
	-	23 May
Summer round:	26 July	9 August
	27 July	12 August
	29 July	18 August
Autumn round:	22 September	23 September
	29 September	30 September

The counting method was the same as that used for most of the 1992 and 1993 censuses (Smith 1992, 1993). The marginal emergent vegetation and water surfaces were searched thoroughly and the rate at which each unit length of bank was searched was standardised as far as possible. As in previous years the following criteria were recorded where possible or appropriate, for each individual:

1. Sex
2. Body length in mm
3. Size/life cycle stage category. The following categories were recorded for adults and other stages where more precise body length measurement could not be made: L, large (adult or immature); M, half-grown; S, small immature).
4. Banding pattern (banded or unbanded).
5. Band and body colour.
6. Whether pregnant, carrying egg sac or attending web with young or empty web.
7. Whether the individual 'dived' (diving behaviour usually involved spiders walking a short distance under the water surface on stems or under leaves).
8. Location. A sketch map was drawn of the locations of each individual on the pool. These locations were later summarised as falling in one of four quadrants of the pools and as at

either the edge, on the open water, or on a vegetation island (e.g. emergent clumps of *C. mariscus*).

Separate records were made of all skins (including variables 1,3,4, and 8) and nursery webs. Records of fresh skins were included in spider totals for the pools only where the total number of skins exceeded that of spiders at any count. The presence of young, height in the vegetation, species composition of the vegetation and location of each web was recorded.

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'.

Water levels

The water level in each pool was recorded (see Smith 1993) at the first count at each census. Measurements were made at subsequent counts only when heavy rainfall intervened. As in 1993, water levels were measured in the pools included in both census areas and in the management experiment. The latter data provide a direct comparison with those for 1992, when the pools now included in the management experiment comprised the main census area (Smith 1992). As in previous years, the water levels were recorded to the nearest 0.5 cm, as the distance from the tops of permanent oak marker posts to the water surface, and are presented as the change from the April 1992 datum.

2.2 Results

2.2.1 THE DISTRIBUTION AND ABUNDANCE OF SPIDERS

Little Fen

Distribution Spiders were found throughout most of the new census area on Little Fen but were completely absent from pools on the extreme north western edge of the compartment. The maximum count at the summer and autumn census rounds is shown for each pool in Figure 2.3. As in 1993, spiders were found on very few pools at all census rounds, although the small number of counts makes it impossible to distinguish whether this resulted from movements between pools during the season, or simply from low detectability.

No spiders were recorded on 18 pools within the census area, six more than in 1993 (Smith 1993). They were absent from four of the sample of irrigated pools compared with one in 1993. They were only found on one pool in 1994 from which they were absent in 1993. The apparent decrease in occupied pools did not result from the lack of a spring census in 1994. In 1993 there was only one pool on which spiders were observed in the spring but not at the summer and autumn censuses.

Abundance

The total maximum count of spiders on Little Fen at the summer census was only 19, only four of which fell within the large size category which included adults (Table 2.1). This is likely to be a conservative estimate because it is based on the maxima of only three counts, which were likely to have included a proportion of different individuals. Numbers at the summer census were similar to those recorded during the equivalent period in 1993. At the autumn census a total of 33 spiders was recorded but this increase was not as great as that recorded over the equivalent period in 1993. Numbers in the different size categories were generally similar to those recorded in 1993. More small spiders were recorded at the summer census in 1994 but this may have been attributable to the rather later recording dates, which followed the peak of the breeding season.

More detailed comparisons of numbers between years should be treated with great caution because they are likely to be confounded both by the effects of differences in water levels and by the precise timing of the census rounds in relation to the phenology of the breeding season. Detailed comparisons of numbers of small spiders are particularly subject to question both for the latter reason and because juveniles in their first season spend most of their time in the vegetation at the pool margins. As a result the reliability with which they can be detected, without systematic beating of marginal vegetation, is low. However, the substantial increase in the numbers of juveniles between the summer and autumn census rounds, in both 1993 and 1994 (Table 2.1), is likely to have reflected the recruitment of that year's cohort of juveniles.

Data collected from monitoring the management experiment (Section 3) in 1993 and 1994, which utilised the pools included in the 1992 census area, allows an equivalent comparison of spider numbers, over a three year period from 1992 to 1994. The run of data from the 1992 census and subsequent monitoring of the same pools in 1993 and 1994 also suggest a decline in numbers over the three year period. The data in Table 2.2 are the mean maxima of three counts in each of two summer months each year.

These data suggest a decline in spider numbers over the three year period. Numbers of large (including adult) spiders were particularly low from July 1993 onwards. Only one adult spider was recorded in the irrigated pools on Little Fen in the peak of the breeding season in 1994. There did not appear to have been any recovery from the loss of spiders from the irrigated pools in summer 1993 (described by Smith 1993) by July 1994. By August, however, numbers of spiders on these pools had increased. Most of the increase was in spiders in the medium size category, suggesting that there were successful breeding attempts in this area of the fen in the latter part of the 1993 season.

Mean numbers of spiders per pool in the Little Fen census area in 1994 followed a similar pattern to total numbers (Table 2.3) and were extremely low. Densities on the irrigated pools included in the census area remained unchanged between the summer and autumn censuses while those on the unirrigated pools increased.

Middle Fen

Distribution As in 1993, spiders on Middle fen were restricted to the pools on which they were found in 1992, with no marked extension in range (Figure 2.4). None was found on the pools, first included in 1993, to the west of the 1992 census area. There was no change between the two years in the numbers of pools on which animals were recorded (10 pools). The monitoring undertaken for the management experiment, which included all of the pools in the 1992 census area, showed spiders on one, unirrigated pool (pool 25), at the western edge of their distribution, on which they had not previously been recorded.

Abundance The total maximum counts for the Middle Fen pools at the summer census were much higher than those for Little Fen, but were slightly lower by the autumn (Table 2.1). The mean number of spiders per irrigated pool on Middle was much greater (11 times greater in summer) than on Little Fen (Table 2.3).

Summer numbers within the main census area on Middle Fen were about twice as high as in 1993 although similar numbers were recorded in spring and autumn in the two years. These high summer numbers are much more marked in the sample based on the 1992 census area (Table 2.3), which included a very much higher proportion of pools occupied by spiders. These data show clearly a very substantial rise in the numbers of spiders in all size categories in summer 1994. While numbers recorded on Middle Fen were lower than on Little Fen in 1992 (Table 2.2 & Smith 1992) and were similar in 1993, they were substantially greater in 1994. These data do not necessarily imply that the Middle Fen population is now larger than that on Little Fen because the proportion of the two populations sampled is not known. However, they do show that the Middle Fen population is increasing while that on Little Fen is declining.

2.2.2 BREEDING SUCCESS

The relative numbers of nursery webs recorded on Little and Middle Fens during 1994 reflected the trends in numbers. A total of 18 webs was recorded on Middle Fen pools included within both the census area and management experiment, while only two webs were recorded on an equivalent sample on Little Fen. The dates on which all of these webs were found (between the third week of July and mid-August) suggested that they represented first breeding attempts. Only two webs were found on both Middle Fen and Little Fen in 1993 (Smith 1993). Precise comparisons of numbers of webs are not valid because of the differences in the timing and frequency of recording between the two years. However, their similarity, together with the relative ease with which webs can be detected, suggests that there was a substantial increase in the numbers of breeding attempts on Middle Fen in 1994. In 1992 the higher frequency of recording of pools in the irrigated series revealed 18 webs on Little Fen and six on Middle Fen. This suggests that Little fen, as well as having higher counts, was a better breeding area than Middle Fen in 1992, before declining in 1993.

There was no evidence that second broods were successful in 1994. No new nursery webs were recorded after the third week of July. Six spiders were recorded carrying egg sacs in mid-August, two of which were seen as late as 18 September. None of these built nursery webs at the sites where they were regularly seen with their eggs. At Least four of these were

confirmed second breeders. They were close to sites of previous webs, first recorded as empty on 21 July and were recorded as post-partum in late July. All were identifiable by missing legs, which is a common feature in females after their first breeding attempt (Smith 1992). The egg sacs of two of these females were about half the normal size, again a feature recorded in previous years in females breeding for a second time.

2.2.3 BREEDING BIOLOGY

The data and observations in this section are not intended to be a comprehensive account but, with those collected as part of routine monitoring in previous years, contribute to understanding of the spiders' life-history.

Not all females recorded as post partum in late July attempted a second breeding attempt. Some individually identifiable females did not become pregnant again and were seen in this condition as late as 5 September.

Although most females appeared to start their first breeding attempt by mid-summer, one adult female was seen being courted by a male as late as 22 July. A very large (18 mm) female which was in good condition, with a slightly swollen abdomen, was seen on the same pool on several occasions in August and September. Although she was not positively aged as adult, it is very unlikely that a spider of this size and abdomen shape was immature. If this was the case she must have entered the winter as adult, a feature not previously recorded in *D. plantarius*, and it seems possible that she will breed relatively early in the 1995 season.

Small juvenile spiders (5 mm or less) were frequently recorded in the vegetation around the sites of abandoned nursery webs during the 1994 season. The growth rates of spiders found in these concentrations at consecutive counts suggested that all 1994 progeny remained in the small size category when they entered the winter. The data on size distributions during the past three seasons suggest that these individuals are likely to enter the medium size category the following summer and spend the following winter as medium or large immatures before breeding in their third summer. This could explain the apparent resilience of the population to years in which breeding success is extremely poor, as in 1993. The population would be buffered even against complete failure to produce progeny in any one year but would be eradicated after two years in this condition. It is also possible, however, that age at first breeding may vary with environmental conditions and population density. Intensive study, using individually marked animals, is required to elucidate the life history of these animals.

2.2.4 WATER LEVELS

Little Fen

Water levels in spring 1994 were substantially higher than at any time in the previous two seasons (Figure 2.5). Systematic measurement of spring and early summer water levels was impossible on Little Fen because the high water table made the measuring posts inaccessible. Estimates made in late May were around 28 cm higher than on similar dates in 1993. At that stage the mud marking the winter water line on the vegetation suggested that levels had

already dropped at least 15 cm from their winter maxima. Measurement of the Little Fen water table, using permanent piezometer tubes, showed that winter/spring levels were higher than at any time since 1988 (SWT unpublished data).

Water levels fell very rapidly on Little Fen during June and the first half of July (Figure 2.5 c), by which time they were lower than at the same time in 1993. From then onwards they recovered steadily as a result both of the start of irrigation and of substantial rainfall. These factors maintained the irrigated pools at levels similar to those sustained in 1993. Rainfall alone resulted in recovery of levels in the unirrigated pools in the remainder of the compartment. Water levels in these pools were higher than in 1993 for most of August and September, increasing during a period when they decreased in 1993 (Figure 2.5 b & c). As in 1993, there was a marked gradient in water levels across Compartment 5, with the lowest levels on the north-western edges. This is illustrated by Figure 2.6, which shows the levels on 25 July, which were the lowest recorded in the unirrigated pools during the season. There is some evidence that this gradient results largely from the irrigation supply, although this requires confirmation. Inspection of the data from the first count of the summer census, which were collected on 26 July, six days after irrigation began, showed that the gradient was already established. Data collected on 2 May 1993, before irrigation began that season, show no evidence of a gradient across the compartment. The dependence of pools in at least a 50 m wide hinterland of the irrigated pools in Compartment 4 of Little Fen on irrigation water was further illustrated by the fact that almost all were empty at the end of October 1994, a month after irrigation ended, but had been flooded in the dry month of July.

Neither 1994 nor 1993 saw water losses on Little Fen as severe as those in 1992 (Figure 2.5). Although data were collected only for the irrigated series of pools in that year, it is clear both from the dramatic loss of water in May, prior to starting the irrigation supply, and the relatively low levels at which the irrigated pools in 1992 were subsequently maintained that levels in the unirrigated pools must have been extremely low. Piezometer tube readings show that minimum summer water levels were on average 22 cm lower in 1992 than in 1993 (SWT unpublished data).

Middle Fen

On Middle Fen winter water levels were also higher than in either 1993 or 1992 (Figure 2.7). Around the irrigated pools in Compartment 4 they were around four centimetres higher than at the same time in 1993, and around the unirrigated pools in Compartment 3, they were 10 cm higher. Elevation of winter water levels on Middle Fen was less extreme than on Little Fen because the rise is limited by a sluice on the river which bounds the edge of these compartments.

Water levels on Middle Fen were more similar to those recorded in 1993 (Figure 2.7). As in previous years, irrigation was less effective in sustaining water levels in the irrigated pools on Middle Fen than on Little Fen while water loss from the unirrigated pools was very much greater than on Little Fen (Figure 2.7 *cf* 2.5).

Water levels in the irrigated pools dropped sharply during June but recovered rapidly when irrigation commenced on 11 July, and increased again with rainfall in August (Figure 2.7 c).

Water levels in the unirrigated pools fell rapidly throughout June and July to levels slightly lower than those recorded at any time in 1993. However, in contrast to 1993, when levels in these pools remained very low throughout the late summer, they recovered relatively rapidly during August and September. A small but marked fall in water levels on both irrigated and unirrigated pools during the last week of September (Figure 2.7 c) resulted from lack of rainfall, exacerbated on the irrigated pools by ending of irrigation for the year.

There was a gradient in water levels across the Middle Fen census area with water levels in the unirrigated pools in Compartment 3 falling both from east to west and from north to south, towards the river (Figure 2.8 shows the lowest summer levels). Similar gradients were detected in 1993 (Smith 1993).

As on Little Fen, water levels on Middle Fen in both 1994 and 1993 were well above those recorded in 1992. Irrigation failed to prevent a progressive decline in water levels in the irrigated pools in 1992, while levels in the unirrigated pools were around 20 cm lower than at any time in the subsequent two years.

2.3 Discussion

Between 1993 and 1994 the numbers of both irrigated and unirrigated pools occupied by spiders on Little Fen decreased. Numbers of irrigated pools occupied in 1993, and numbers of adult spiders recorded, represented a substantial reduction compared with 1992. I suggested in 1993 that this may have been attributable to spiders being more widely dispersed as a result of higher water levels in both pools types, rather than to a real reduction in population size (Smith 1993). However, the comparative data now available from unirrigated pools within Compartment 5, as well as the longer run from irrigated pools, suggests that the further reduction in occupancy by summer 1994, when water levels were similar to those in 1993. It now seems most likely that there has been a real contraction of the Little Fen population, despite a substantial improvement in water levels since the drought of 1989 to 1992. Rigorous statistical comparison is required to assess the significance of the trends in numbers since 1992, but was outwith the scope of the current project.

The decline in numbers of nursery webs on Little Fen, together with my suggestion that the majority of spiders breed in their third summer (Section 2.2.3), gives further cause for concern about their status on Little Fen. The relatively large numbers of breeding attempts in 1992 should have resulted in an increase numbers of medium sized spiders in 1993, and of large and adult spiders this year, but neither was detected. This suggests that some aspect of the spiders' environment on Little Fen may have deteriorated in 1993. The lack of an equivalent decline on Middle Fen suggests that weather conditions were not directly responsible. Our extreme lack of understanding of the spiders' ecological requirements, combined with, at best, speculative understanding of their life-histories and a very low frequency of monitoring, makes it almost impossible either to confirm this conclusion or attempt to explain it.

One possibility, however, that may warrant closer examination, is that winter flooding of

Little Fen with water severely contaminated by pig slurry, from surrounding agricultural land, is deleterious to the spiders' survival. *D. plantarius* has been lost from sites in Holland following influx of polluted water from surrounding farmland (P.J. van Helsdingen, pers. comm.). Surface flooding of Little Fen was more protracted in both the 1992/93 and 1993/94 winters than at any time since 1988. Surface flooding on Middle Fen is much more limited because it is controlled by a sluice on the adjacent river (Section 2.2.4). A much higher proportion of the winter water supply to the core area of spider pools is therefore filtered through the fen peat.

The trends in numbers on Middle and Little Fen suggest that, in contrast to the situation in 1992 (Smith 1992), the Middle Fen population is now in the more healthy state. Although 1994 saw no significant extension in the spiders' range on Middle Fen, summer numbers were over twice as high as in either 1993 or 1992 and numbers of nursery webs were much greater than in previous years. Failure to detect the increase in numbers at the spring and autumn census rounds may be attributable to the relatively high water levels at these times leading to the population being more dispersed throughout the flooded vegetation around the pools.

The possibility that the great majority of spiders breed in their third summer implies that populations are buffered against complete failure of a single breeding season. This may account for the apparent resilience of the population to very low numbers and poor breeding performance in recent years.

The 1994 results underline the importance of the irrigation water in the survival of both the Little and Middle Fen populations. Although a proportion of the population on both fens survives outside the area influenced by irrigation water, the majority of animals occur within the irrigated zones. Whilst I suggested in 1993 that the decline in spider numbers on the pools receiving a direct irrigation supply on Little Fen may have been attributable to lower water temperatures (Smith 1993), the overall effects of irrigation are likely to be beneficial and important over a wide hinterland. The data on water gradients and the rapid loss of water from pools behind the irrigated line when irrigation ceased, as late as October (Section 2.2.4) suggests that the supply may be important in maintaining suitable conditions in pools over a wide area.

Direct comparison of the data from the 1991 census with those for subsequent years awaits their computerisation. However, the results reported by Duffey for that year (Duffey 1991) tend to support several of the above conclusions. They emphasise the importance of the irrigation supply. Irrigation was started for the first time on 5 August 1991. By that stage in the summer most of the 'irrigated' pools were reduced to small areas of shallow, muddy water with exposed marginal areas. No nursery webs were found on either fen despite weekly recording. I suggested in 1992 that the smaller numbers of nursery webs recorded on Middle than on Little Fen that year may have been attributable to the greater water loss on Middle Fen, despite the irrigation, which left exposed pool margins (Smith 1992). Nursery webs are always constructed in tall, emergent vegetation at the pool margins. Its seems likely very poor breeding success in 1991, and probably also in 1990, when the fen water table was even lower (SWT piezometer tube data), must have reduced the population to precariously low numbers. Some successful breeding attempts late in the 1991 season, suggested by the presence of small immatures in spring 1992 (Smith 1992), may well have saved the

population from extinction.

3 THE MANAGEMENT EXPERIMENT

3.1 Methods

3.1.1 EXPERIMENTAL DESIGN

Management operations were carried out on the same random sample of pools managed in 1993 (Smith 1993). On Little Fen 18 of the 32 irrigated pools were managed (Figure 3.1). On Middle Fen the sample was stratified between the irrigated pools in Compartment 4 and the unirrigated pools in Compartment 3. Thirteen of the 24 pools in the irrigated series and 6 of the 12 pools in the unirrigated series were managed (Figure 3.2).

3.1.2 MANAGEMENT WORK

The only management work carried out on the pools in 1994 was summer removal of emergent vegetation (Section 1.2.2). This was done on Little Fen on 19 August and on Middle Fen on 23 August. Tall, emergent vegetation (mostly *Phragmites australis* and *C. mariscus*) was cut from the centres of the pools with a long-handled cutting blade. Cutting was done with great care to avoid disturbance to the water and particularly to the marginal vegetation. Dense floating mats of *Juncus subnodulosus* were removed from pools where they completely obscured the water surface. Some dense, old, island clumps of *C. mariscus* were left intact. Removal of cut material was all done from one point on the bank of each pool.

3.1.3 MONITORING

Spider numbers were monitored on the pools both before and after the summer management work. The post-management monitoring was delayed for at least ten days after management work was completed so that any very short term effects of the disturbance did not bias the data. Each monitoring round comprised three replicate counts, the dates of which were as follows:

Census round	Little Fen	Middle Fen
Pre-management round:	15 July	21 July
	16 July	22 July
	18 July	25 July
Post-management round:	31 August	5 September
	2 September	8 September
	3 September	11 September

Monitoring methods were the same as those used in the main census (see Section 2.1.2 above).

3.2 Results

Comparison of the mean maximum counts at each of the two monitoring rounds, on both fens, showed managed pools had, on average, fewer spiders than unmanaged pools (Table 3.1). Two-way analyses of variance (fen*management) of the mean maxima (normalised by log transformation) from managed and unmanaged pools on Little and Middle Fens showed significant effects of management both before ($F_{[2,57]}=6.25$, $P=0.015$) and after ($F_{[2,57]}=8.39$, $P=0.005$) the summer management was carried out. The effect of fen was highly significant ($P<0.001$) in both analyses. Pools on which no spiders were recorded in either 1994 or 1993 (one pool on Little Fen and seven on Middle Fen) were excluded from these analyses because they were likely to have been either unsuitable for, or inaccessible to, spiders. When these pools were included in the analyses the data could not be normalised by transformation. Inclusion of these pools in non-parametric comparisons (Mann-Whitney U-tests) of managed and unmanaged pools gave non-significant results ($P=0.174$ and 0.094 for pre- and post-summer management respectively). Analyses of variance of the mean (of six) counts for each pool over the season gave similar results to the analyses of maximum counts. Significantly more spiders were recorded on unmanaged pools ($F_{[2,57]}=6.05$, $P=0.017$).

There were no significant differences between managed and unmanaged pools in the proportional change in numbers between 1994 and 1993. Analyses of variance of the mean proportional change in the maximum numbers recorded on each pool over three counts in July each year showed that the effects of management were non-significant. Those of Fen were again highly significant ($P<0.001$).

No significant differences in spider numbers could be detected between managed and unmanaged pools before and after the summer management operation was carried out. Two-way analyses of variance of the proportional difference in mean maximum counts from the pre and post-management monitoring showed that the effect of management was non-significant ($F_{[2,44]}=0.19$, $P=0.666$). Differences between Little and Middle Fens were again highly significant ($P<0.001$).

3.3 Discussion

These results provide good evidence that management work done on the spider pools in 1992 and 1993 did not have the beneficial effects that were expected. The cumulative effects of management over this period were to make the pools less suitable for spiders. Equivalent analyses in 1993 failed to detect this effect although significant negative effects (all $P<0.05$) of management were suggested by separate analyses of additional counts conducted by a volunteer during summer (Smith 1993). The more robust negative result obtained in 1994 is likely to be attributable to two factors. First, the larger numbers of spiders on Middle Fen

in 1994 increased the probability of detecting significant effects, although a significant result was obtained even for Little Fen. Second, the effects of management may have become more pronounced in the medium than the short term.

It is impossible to separate the effects of spring and summer management work using the present experimental design. No significant effects of the summer work could be detected in 1994, although the possibility of medium term effects cannot be ruled out. The probability of detecting any effects of the summer work was reduced by the decline in spider numbers on all pools during the period between the pre- and post-management monitoring rounds.

It nevertheless seems likely that the spring work was primarily responsible for the decline. The most likely cause of the deleterious effects of spring management seems to be weakening of the *C. mariscus*, which provides both shelter and breeding habitat, at the pool edges. *C. mariscus* is known to be weakened by cutting at frequencies greater than once every three years. Observations suggested a decline in *C. mariscus* around the pools by late 1993, but the absence of any quantitative data on the effects of management on the vegetation makes it impossible to confirm this.

4 BROAD-SCALE DISTRIBUTION SURVEY

4.1 Methods

The broad-scale survey of the fen was conducted by 11 experienced volunteers on 24 July. Uniformly sunny, and extremely hot, weather gave optimal conditions for seeing basking spiders easily. We attempted to survey all compartments of the Fen for which there are either historical records of spiders, or which are close to the current centres of population and have pools which retain water for at least part of summer. Compartment 5 on Little Fen was excluded because it is comprehensively covered by the main census (Section 2 above) but the interiors of other compartments fringed by machine dug pools included in the census were included. The surveyors walked as much of their allocated compartment as possible, examining each pool encountered for spiders for at least 10 minutes, and recording the pool's approximate dimensions, water quality and vegetation. Lack of adequate aerial photograph cover and the height of the fen vegetation at the time of the survey made it impossible either to attempt to map the positions of the pools or to assess the proportion of the pools surveyed. The compartments included, and the approximate area covered, are shown in Figure 4.1.

4.2 Results

4.2.1 Spider records

Spiders were encountered in only two compartments, both of which were fringed by machine-dug pools included in the main census areas and in which spiders had been routinely recorded over the past four years.

In Compartment 4 on Middle Fen nursery webs were found on two of 13 pools encountered, two on one pool and one on the second. Adult females (two banded and one unbanded) were

present at all webs and young were present in two of them. These pools were less than 10 m south of the irrigated line and were certain to have benefitted from the irrigation supply. The vegetation was predominantly *C. mariscus*, with some *P. australis*, and was mown in summer 1993. All pools in this area were quite shallow and narrow, with estimated average dimensions of 1.5 x 4.7 m, and most had very little open water surface. In spring 1993, when the new census was set-up, they were considered either too small or too shallow for inclusion, because of the likelihood that they would dry out or infill with vegetation during the duration of the scheme. Four of the 13 pools, which bordered the track between Compartments 4 and 3, were machine dug in 1989 but the remainder all originated as peat diggings.

On Little Fen one adult male spider was found in Compartment 4, in a pool maintained by irrigation, only 5 m behind the line of irrigated pools included in the main census area (Section 2.2.4). No other spiders were found on nineteen other pools examined in the same area. *C. mariscus* had been cut from the whole of this are the previous week and no tall, standing vegetation remained. All of the pools had oily surface films. Spiders and nursery webs had previously been recorded in this area when it was last examined, very briefly, on 30 July 1992.

4.2.2 Other areas searched

No other spiders were recorded in any compartment. Figure 4.2 shows both the approximate area searched and areas identified as being intrinsically unsuitable because of progression to scrub and woodland. Information on the pools in these compartments, together with historical information on the occurrence of spiders is summarised below.

On Compartment 3 of Middle Fen the coverage included (a) machine-dug pools which interspersed those included in the main census, along either side of the board walk and the south side of the path through the compartment and, (b), two east/west transects of the compartment to the south of the path (Figure 4.2). Seventeen machine-dug pools, resembling those covered by the main census, were examined along the path. Five pools, overgrown and largely dried-out were encountered on the transect closest to the path. On the parallel transect, nearer the river, two pools constituting little more than overgrown, damp depression and a series of small pools shaded by alders, with very shallow water covering deep anoxic mud, were encountered. Pools in this area of Compartment 3 were considered for inclusion in the new census in spring 1993. Few were found, none of which fulfilled the size and depth criterion for inclusion (see Smith 1993). However, an adult female spider was found with an egg sac on one of these in late May 1993. It was not known whether she bred successfully. No nursery web was found and by July only a small area of deeply shaded, open water remained (Smith 1993). These results suggest that restoration of a slightly higher summer water table, together with deepening of existing pools or creation of new ones, could result in recolonisation of this area, as long as the presumed source population, in the machine-dug pools at the eastern end of this compartment, still exists.

On Little Fen pools were found at high density in Compartment 6. Those fringing Rolfe track (Figure 4.2) were machine-dug in 1989 but the remainder all originated as peat diggings. They varied in size between approximately five and 12 m^2 and were similar in character to those on the near-by north western edge of Compartment 5 (see Section 2.2.1). They had

relatively steep banks but retained a reasonable depth of mostly clear water, in which *Utricularia vulgaris* was often abundant. Thirteen pools were searched thoroughly for spiders but over half of the compartment remains to be searched. However, the proximity of these pools to those on the edge of Compartment 5, from which spiders have not been recorded in the main census, and the likelihood that their summer water table was lower than that of pools in Compartment 5, makes it unlikely that spiders are present. Spiders were last noted in these pools in *ca* 1980 (Thornhill 1985).

In Compartment 7, 34 pools were examined, all of which were amongst vegetation dominated by dense, *ca* 2m tall *P. australis*. Those adjacent to the track were machine-dug in 1989 but those in the interior of the compartment were old peat diggings. Most were shaded both by marginal and emergent *P. australis*. They varied from damp hollows, particularly in the interior of the compartment, to well defined pools over 30 cm in depth. Most had an oily surface film. Thatching of litter and dust was also common. There are no historical records of spiders in this compartment but this may be attributable to inadequate recording. Its proximity to the population in Compartment 5 and the large number of pools suggest that management work to open up the pools may be worthwhile when summer water levels are restored. However, although spiders are found elsewhere on the Fen in areas where *P. australis* rather than *C. mariscus* is dominant around the pools, they have not been recorded in dense, tall *P. australis* stands. The eutrophication believed to be responsible for the development of *P. australis* dominated vegetation in Compartment 7 may have to be reversed before the vegetation and water quality are suitable for spiders.

In Compartment 8 of Little Fen 15 pools immediately adjacent to the track along its western edge were examined. All of these were machine-dug in 1989. No pools were found adjacent to Rolfe track on the northern edge of the compartment and a north easterly transect across the compartment revealed only dry pools (Figure 4.2). The pools along the track were surrounded by mixed, tall fen vegetation, including *P.australis*. Only one pool had submerged macrophytes. Most contained filamentous algae and had surface scum and oily films. In 1992 a nursery web was recorded in one of these pools on 30 July, although the pool dried out later that summer. This pool was dry at the time of this year's survey. These data, together with the immediate proximity of these pools to the Compartment 5 population, suggest that restoration of the summer water table and vegetation management around existing pools could result in re-colonisation of this area of the fen.

Two blocks of Redgrave Fen were examined. *D. plantarius* was first discovered in Compartment 13 of Redgrave Fen by Eric Duffey in 1956. It was last recorded from this Fen in the early 1980s when it occupied pools in an area of less than 1 ha (Thornhill 1985). Eric Duffey searched this area of the fen on two occasions in 1991 but reported that the pools in which he originally found spiders, which were deepened in 1968, were completely dry and overgrown with vegetation (Duffey 1991).

The volunteer who surveyed this Fen (David Orr) was familiar with the former distribution of spiders in this area. About half of this compartment is now unsuitable for spiders, comprising scrub and carr woodland. Five pools were found in the remaining area of suitable habitat. They varied in size from one to 9 m^2 and in maximum water depth from 15-22 cm. The surrounding vegetation was mixed tall fen vegetation in which *P. australis* was

dominant.

A total of 32 pools was examined along a transect walked around Compartments 7 to 10 of Redgrave Fen (Figure 4.2). The maximum depth of most was between 15 and 30 cm. Almost all were situated in reed bed and infilled with *P. australis* although those in Compartment 9 had some *C. mariscus* as well.

Redgrave Fen is relatively isolated from the two remaining spiders populations. This, together with the deterioration in the habitat to both reed bed and scrub, suggest that efforts to restore the pools there are unlikely to be profitable in the absence of restoration of the fen water table and a general expansion, or reintroduction, of the spider population.

4.3 Discussion

Although the broad-scale survey of the fen was far from comprehensive, the experience of the observers, the concentration on likely areas, and the ideal weather conditions and time of year for observing spiders, suggests that no substantive spider population exists on the fen outside the areas covered by the current census scheme. In most of the areas examined, loss of water from the pools in late summer, often combined with habitat deterioration, either to reedbed or to scrub, make it unlikely that, even in the event of restoration of the water table and increase in the core spider population, spiders would recolonise. Deepening of the pools, together with management of the surrounding vegetation, is likely to be required. In a few areas close to the current centres of population, restoration of the water table and increase in the core population size might alone result in recolonisation. The pools in Compartment 6 of Little Fen and along the board walk in Middle Fen are likely examples.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The status of *D. plantarius* on Redgrave and Lopham Fen NNR continues to be precarious. Its population remains very small and restricted to two small areas, the populations of which are almost certainly isolated from one another. In 1993 I concluded that the Little Fen population was likely to be better buffered than that on Middle Fen because spiders occurred over a wider area, on large, deep old pools as well as on the irrigated machine-dug pools and on relatively shallow pools in the irrigated hinterland (Smith 1993). I also suggested that the decline recorded on Little Fen in 1993 may have been partly attributable to the population being more dispersed because of higher water levels. This year's data, however, suggest that the decline on Little Fen since 1992 is real. Reasons for this decline are likely to be specific to Little Fen since the potentially more vulnerable population on Middle Fen has increased substantially over the same period. Whilst the increase in numbers, although not in range, on Middle Fen is encouraging, our lack of understanding of what drives the fluctuations in numbers of this species, and the lack of any fundamental change in the physical environment

in this part of the fen, cautions against over-optimistic interpretation.

It is essential that census work to assess the status of this endangered species is continued. However, this alone will not ensure the survival or recovery of the population. Maintenance of the population until water levels are restored on the fen, and subsequent recovery, further require that the lack of understanding of its basic habitat requirements and life-history are urgently rectified. The marked failure of the management work carried out over the past three years to improve conditions for the spiders underlines the importance of acquiring a more scientific basis for future efforts to conserve this species. The radical habitat restoration work planned for the fen over the next five years, much of which may have to be completed prior to restoration of the water table, makes it imperative that these problems are addressed. Improvement in conditions could result in rapid expansion of the population because of its high fecundity (Smith 1992) but even a slight deterioration in conditions could rapidly result in the final demise of a species which has been instrumental to the success of the campaign to restore the fen. Moreover, as long as the population remains small, it is intrinsically at high risk of extinction due to stochastic processes, irrespective of small improvements that might result from successful management.

5.2 Recommendations

Recommendations for the work required to address these problems and to continue to manage the pools in the short-term, are given below.

5.2.1 Scientific work

To-date almost all of the information on the autecology of *D. plantarius* on the fen has been obtained as a by-product of the census work. Particularly with the low frequency of census rounds funded in the last two years, this is a very inadequate and inefficient means of collecting data of this kind. I suggest below two alternative options for how to obtain more of the information required, the first of which is likely to require new sources of funding and would be much the most productive.

Option A

Under this option the census and autecological data gathering work are separated. The census work is confined to a single summer census, comprising three replicated counts, as in 1994. The spring and autumn censuses are discontinued for three reasons. First, working in very deep water at these times of year has implications both for safety and for the probability of locating spiders (it increases the 'blunder factor'). Second, counts made at these times are more difficult to compare and interpret than those made in summer because water tables are more variable and usually higher. Third, much of the value of the records collected at these times of year to-date, has been in the information they have provided on life-history. In this option this information is more effectively provided by an autecological study (below).

I further recommend that the numbers of pools included in the summer census is increased to include all, rather than a sub-sample, of those censused in 1992 and monitored in subsequent years as part of the management experiment. There are several reasons for this.

First, the data set for these pool already extends over four years. Whilst the new census is a preferable basis for long-term monitoring, ability to interpret interannual fluctuations in numbers would be substantially enhanced if the period of overlap between the two data sets was increased. Second, on Middle Fen the spider population is confined to these pools, only a small proportion of which are included in the new census. This means that census is relatively insensitive to changes in the core population. Third, pool management operations have so-far been restricted to these pools. If any further data on the effects of past or future management work is required, extension of the data set for these pools is essential (see below).

Acceptance of this proposal would imply an increase in the numbers of pools sampled on Little Fen by 25 and on Middle Fen by a maximum of 24. Time implications for this increase in the numbers of pools censused would be an increase from three to five or six days on each fen.

Reduction in the census frequency implies loss of information, however inadequate, on breeding success and other aspects of life history. This information, together with much needed data on habitat requirements, should be gathered as part of an intensive autecological study lasting for a full season. Most of the work would be concentrated in the summer months, using a marked population in a relatively restricted part of the spiders' range. However, attention should also be given to early and late parts of the season and to requirements for successful overwintering.

Option B

This, much less favoured, option assumes no substantial change in current levels of funding for census work. Recommendations for the summer census are as in option A, with three counts and inclusion of all, rather than a sub-sample of pools in the 1991-'92 census area. In the absence of funding for a proper autecological study, I recommend that the spring and autumn censuses be retained, each with two counts at the same pools as in 1994. Despite the draw-backs of counts made during these rounds (above), the life-history information that they yield is worthwhile and greatly preferable to none.

A rigorous statistical comparison of trends in spider numbers over the last four years should be carried out following the 1995 census. Allowance should be made in future for repeating this type of analysis, possibly at two or three yearly intervals.

5.2.2 MANAGEMENT WORK

The management strategy for the core areas of spider pools requires urgent review. The results of the 1993 and 1994 experiment show that a new strategy is required. Better design of management strategies requires the information that should be generated by an autecological study. At present we remain largely ignorant of the factors that cause spiders to favour one pool over another. Whilst it seems likely that management of the machine-dug pools could potentially be beneficial, spiders persist in parts of Compartment 5 of Little Fen that have not been managed for many years. They occur on both large and small pools, surrounded and overhung by very old, dense *C. mariscus*. In *C. mariscus*, rather than *P.*

australis, dominated areas of the fen, maintenance of deep water with emergent marginal vegetation during the breeding season may be more important than controlling the age and density of the vegetation. Because aging *C. mariscus* bends into the water, it usually leaves the centres of the pools unshaded. Invasion of the centres of the pools by tall *P. australis* causes much more shading.

Management of the marginal vegetation around the pools should not be done more frequently than once every three years because of the danger of weakening the *C. mariscus*. It is likely that different ages of re-growth are more or less favourable to spiders, and so a programme of selective management of pools within the core areas is most likely to provide optimal compromises. If the population expands following restoration of the water table, re-incorporation of the spider pools into the large blocks cut as part of the normal sedge-cutting rotation on the surrounding fen should be possible. At present this is too risky a strategy because a high proportion of pools may be simultaneously included in an unfavourable regime.

I suggest that management work on the pools be confined to a single operation, carried out in early summer (May), when the spiders are likely to be least dependent on the marginal and emergent vegetation (between emerging from hibernation and starting to breed). This operation should combine both cutting of marginal vegetation and removal of emergent vegetation. To-date the latter operation has involved cutting at or just below the water surface and its effects have therefore been very short-term. I suggest that a more radical dredging of rooted material from the pools would be a more cost-effective option in the medium term. This may also be the only feasible option in early summer since there is little emergent growth of *P. australis* at this time of year. However, old, island clumps of *C. mariscus* within the pools should not be removed since these are often important breeding sites. I suggest that this work should be done on a three year rotation, with only a proportion of the pools being managed in any one year.

In the absence of a sound scientific basis for making decisions on management, it is vital that any management work continues to be carried out on an experimental basis, and the results monitored. The importance of this approach is underlined by the results of the 1992/1993 work, the deleterious results of which would have been undetectable, and potentially devastating, had it been done on a non-experimental basis. My proposal (above) that all of the pools in the management experiment be included in the summer census provides automatic means of monitoring the results. In view of the already variable management history of the pools and the vulnerability of the spider population to sub-optimal management, extremely careful consideration must be given to the design of the management experiment. Statistical advice should be sought to ensure that any proposed design will produce robust results.

5.3 Summary of Recommendations

1. A single summer census comprising three replicate counts should be conducted in 1995. The same pools should be monitored as in 1993 but a much higher proportion of pools from

the 1991/1992 census should also be included.

2. An autecological study of the life-history and habitat requirements of *D. plantarius* on Lopham and Redgrave Fen should be conducted as a matter of urgency.

3. If recommendation 2 is not feasible, summer an autumn census rounds, comprising two replicate counts of the new census area pools only, should be done in addition to the summer census proposed in 1 above.

4. A rigorous statistical analysis of trends in spider numbers over the last four years should be undertaken in 1995.

5. Management work should be confined to a single operation in May. The marginal vegetation should be cut and emergent vegetation removed from the pools. This should be done on a three year rotation with only a proportion of the pools being managed each year.

6. The immediate surroundings of the core, irrigated pools should not be incorporated into the main sedge-cutting programme on the fen until the water table is restored <u>and</u> there is evidence of recovery in numbers.

7. Monitoring of any management work is essential but is encompassed by the summer census work, as proposed in 1 above. It therefore requires additional funding only for analysis and report production.

8. Maintenance of the irrigation supply to the pools is essential.

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Table 2.1 Maximum numbers of spiders counted in Little and Middle Fen census areas in 1994. Numbers in parentheses are 1993 data (from Smith 1993).

	Spring		Summer		Autumn	
Little Fen						
Large	-	(13)	4	(5)	6	(8)
Medium	-	(5)	7	(8)	12	(19)
Small	-	(1)	8	(1)	15	(19)
Total	**-**	**(19)**	**19**	**(14)**	**33**	**(46)**
Middle Fen						
Large	10	(11)	13	(6)	2	(3)
Medium	6	(5)	21	(7)	12	(14)
Small	0	(2)	10	(8)	11	(10)
Total	**16**	**(18)**	**44**	**(21)**	**25**	**(27)**

Table 2.2 Maximum numbers of spiders counted on pools comprising the 1992 census on Little and Middle Fen census areas during two months in each of 1992, 1993 and 1994. Data are the means of the maxima of three counts in each month.

	1992		1993		1994	
	June	July/ Aug.	June	July	July	Aug.
Little Fen						
Large	13	23	17	3	1	5
Medium	3	22	12	2	4	21
Small	13	24	8	11	2	7
Total	**29**	**69**	**37**	**16**	**7**	**33**
Middle Fen						
Large	9	27	15	7	29	19
Medium	2	16	10	17	56	39
Small	1	6	24	25	39	36
Total	**12**	**49**	**49**	**49**	**124**	**94**

Table 2.3 Mean numbers of spiders on irrigated and unirrigated pools within the census area in 1994 and 1993. Data are means of the maximum of the counts carried out during each census period (two in spring and autumn and three in summer) ± 2 S.Es. Equivalent mean maxima are also given for equivalent periods in 1993 (from Smith 1993). There were 25 unirrigated and 7 irrigated pools and Little Fen and 23 unirrigated and 7 irrigated pools on Middle Fen.

	Little Fen				Middle Fen			
Census period	Unirrigated		Irrigated		Unirrigated		Irrigated	
	1994	'93	1994	'93	1994	'93	1994	'93
Spring	-	0.32	-	1.57	0.04±0.09	0.09	1.71±1.21	1.78
Summer	0.33±0.23	0.48	0.86±1.11	0.29	0.35±0.41	0.13	3.71±1.21	2.00
Autumn	0.96±0.78	0.60	0.86±1.19	1.71	0.17±0.24	0.00	2.71±0.84	2.86

Table 3.1 Numbers of spiders on managed and unmanaged pools during the pre- and post-management censuses. Data are the means of the maximum numbers recorded on each pool over three counts

	Unmanaged pools			Managed pools		
Monitoring round	Mean[1]	±	2 S.E.s[2]	Mean[3]	±	2 S.E.s
(a) Little Fen						
Pre-management	0.31	±	0.27	0.11	±	0.15
Post-management	1.16	±	0.63	0.67	±	0.36
(b) Middle Fen						
Pre-management	4.38	±	1.63	2.56	±	1.30
Post-management	3.54	±	1.56	1.63	±	0.51

Figure 2.1 The location of pools included in the 1994 *D. plantarius* census on Little Fen

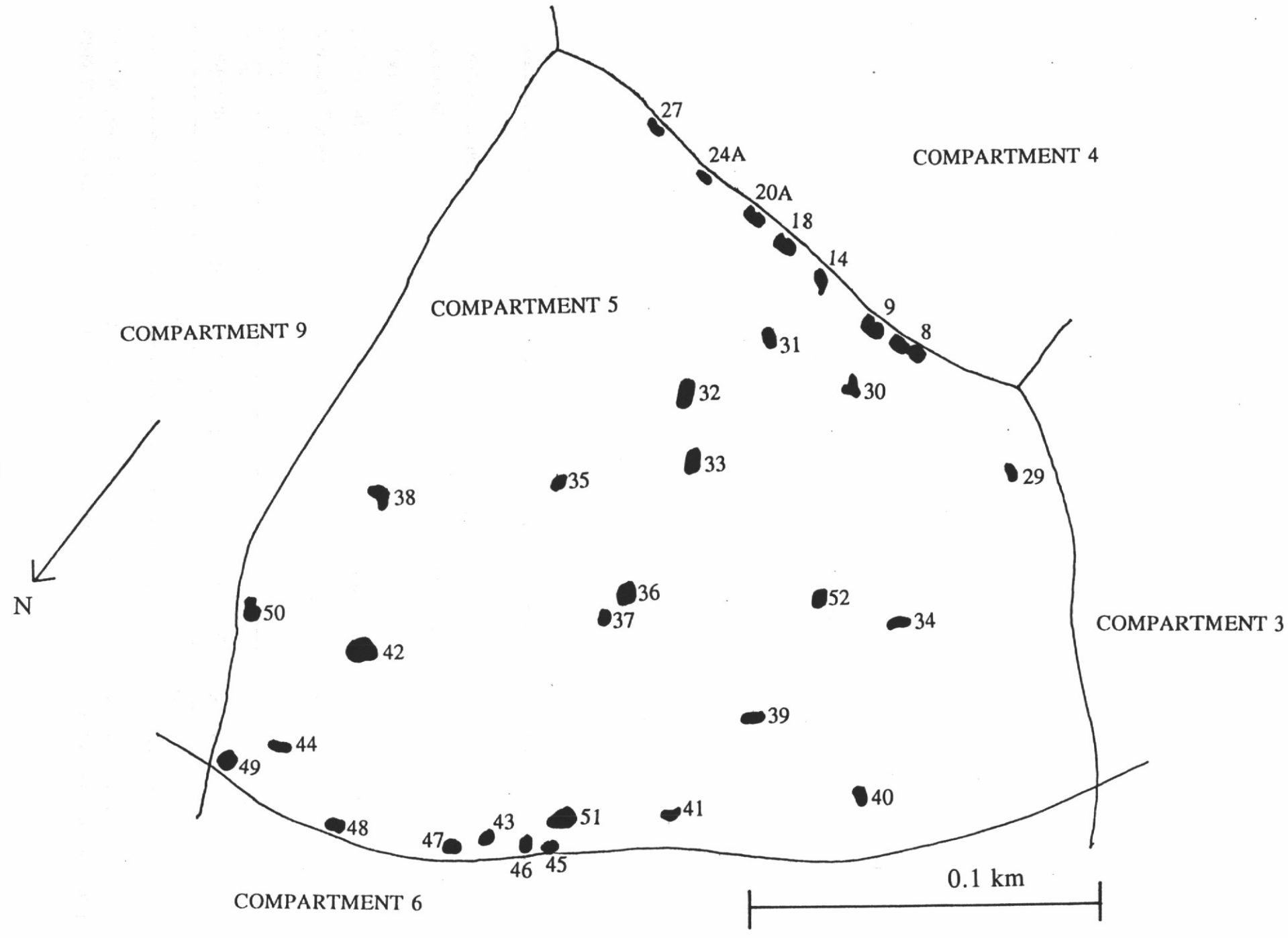


Figure 2.2 The location of pools included in the 1994 *D. plantarius* census on Middle Fen

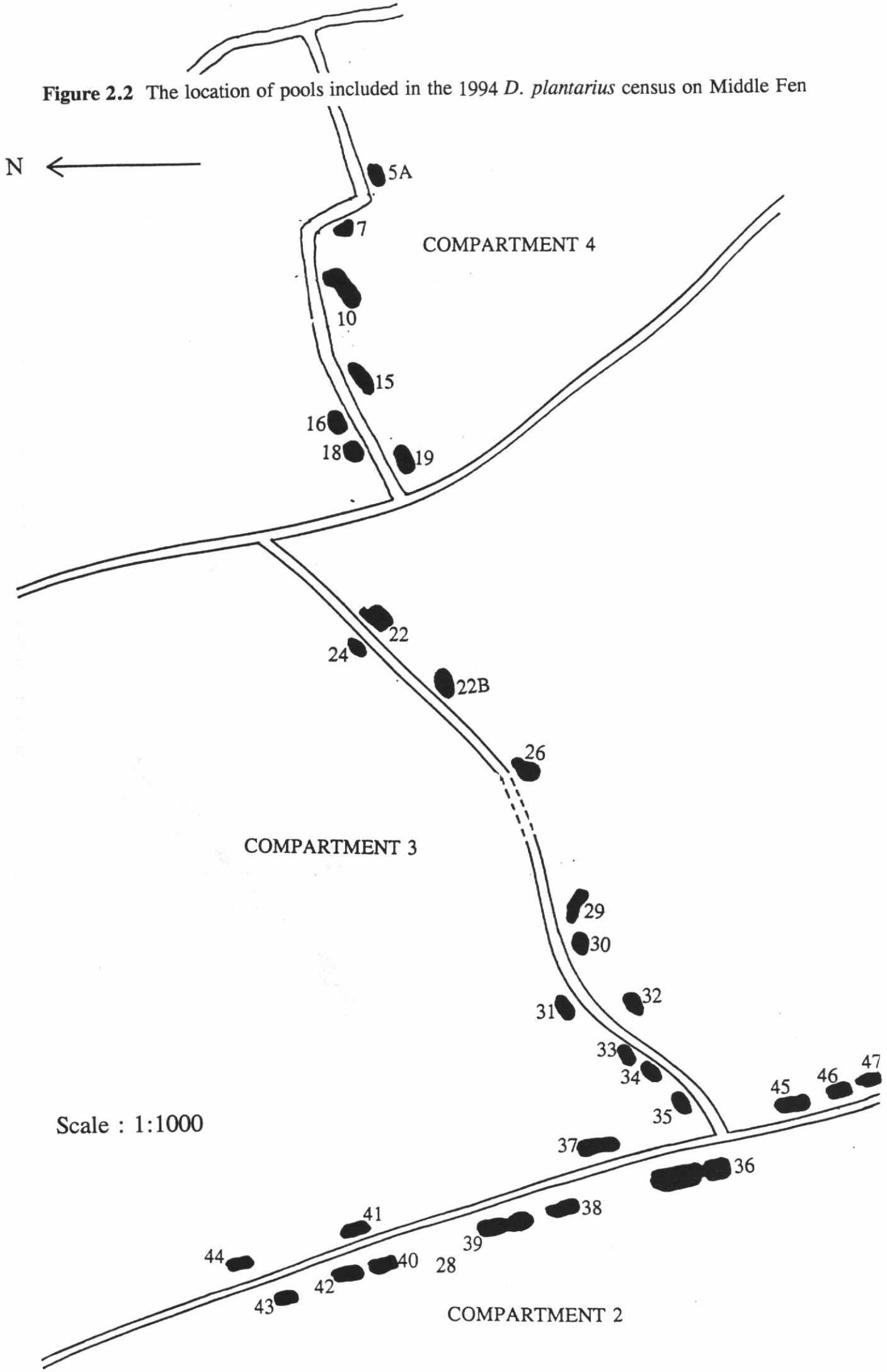


Figure 2.3 Maximum number of *D. plantarius* seen on each pool during the summer and autumn census on Little Fen (this Fen was not censused in spring)

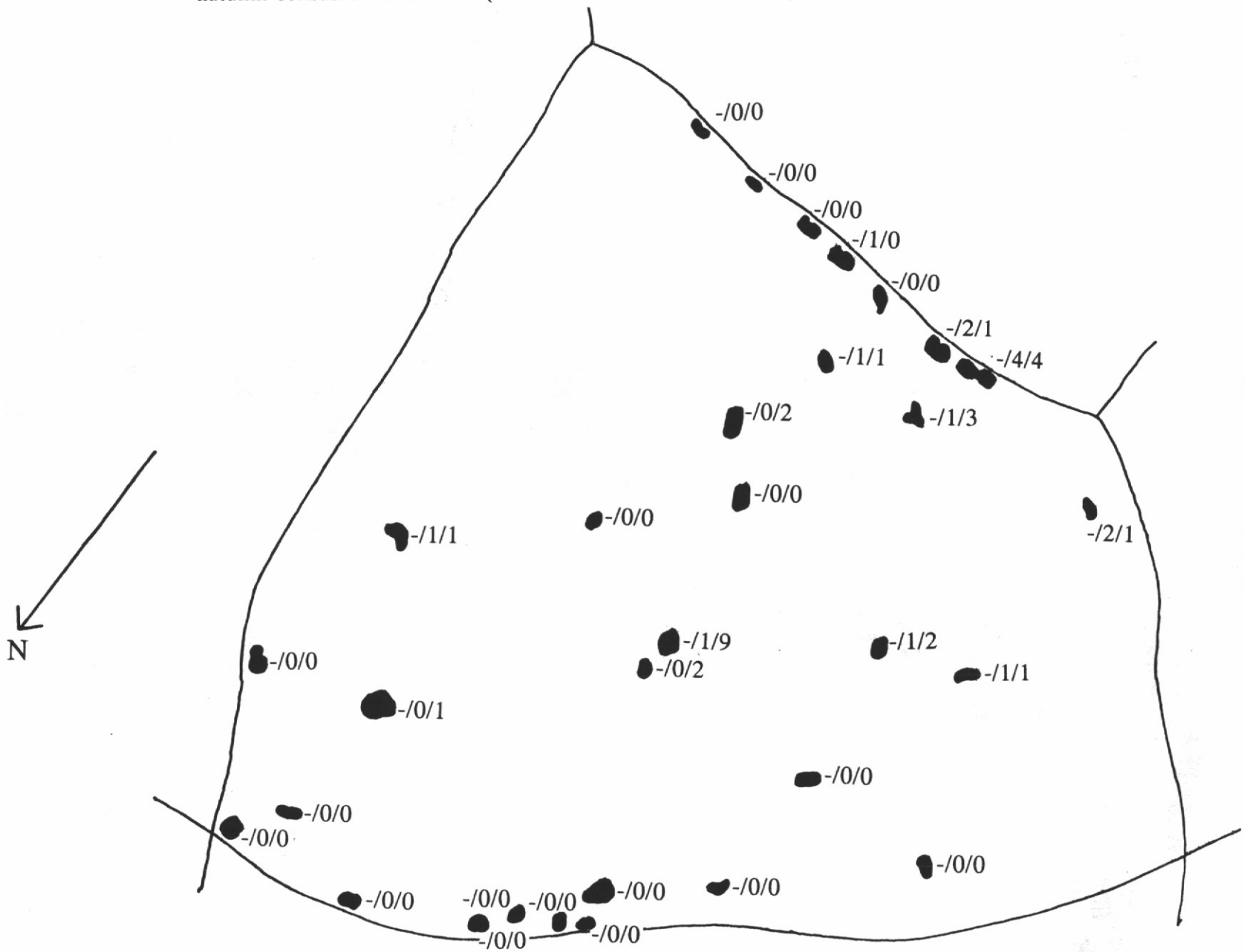


Figure 2.4 Maximum number of *D. plantarius* seen on each pool during the spring, summer and autumn census on Middle Fen

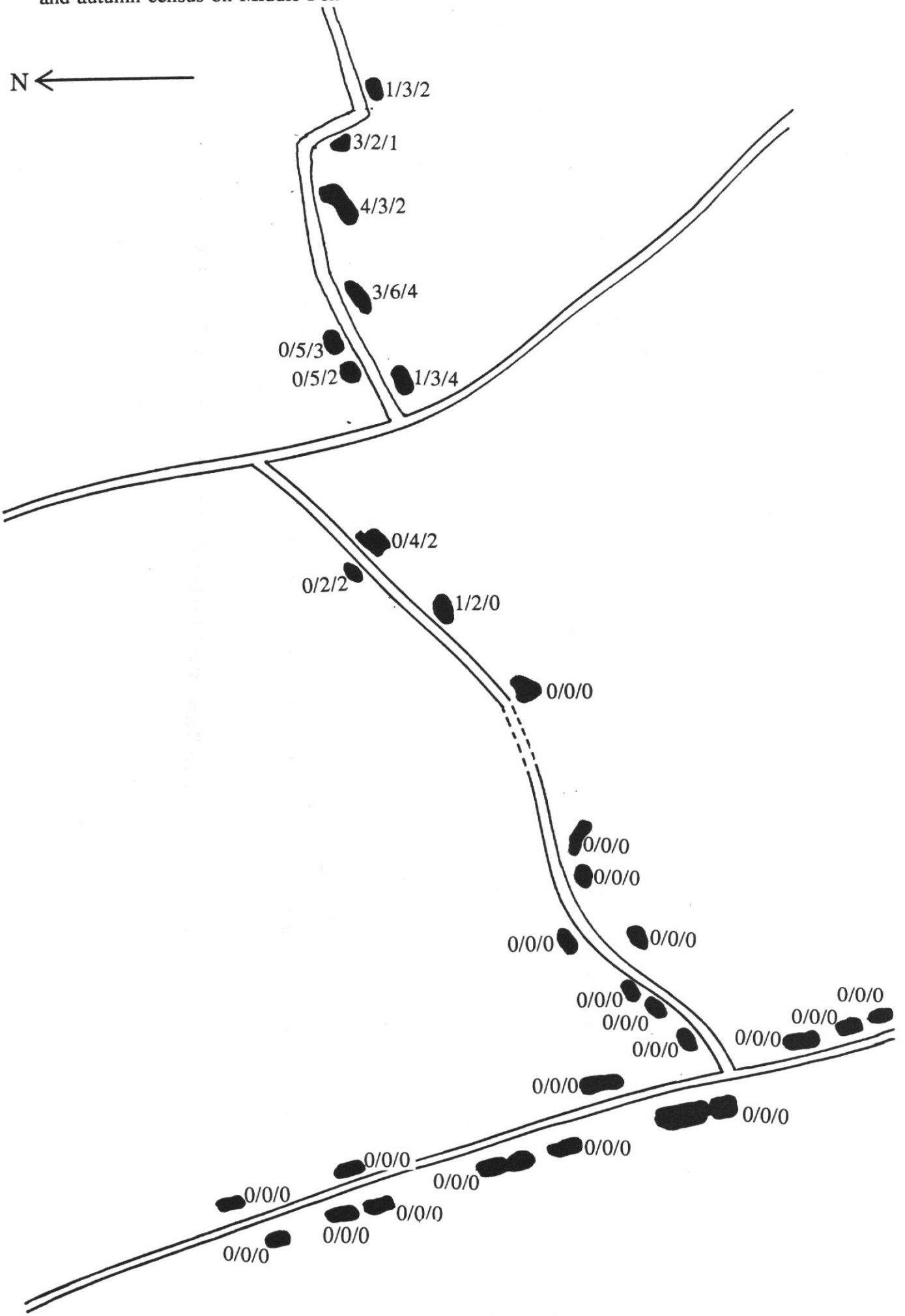
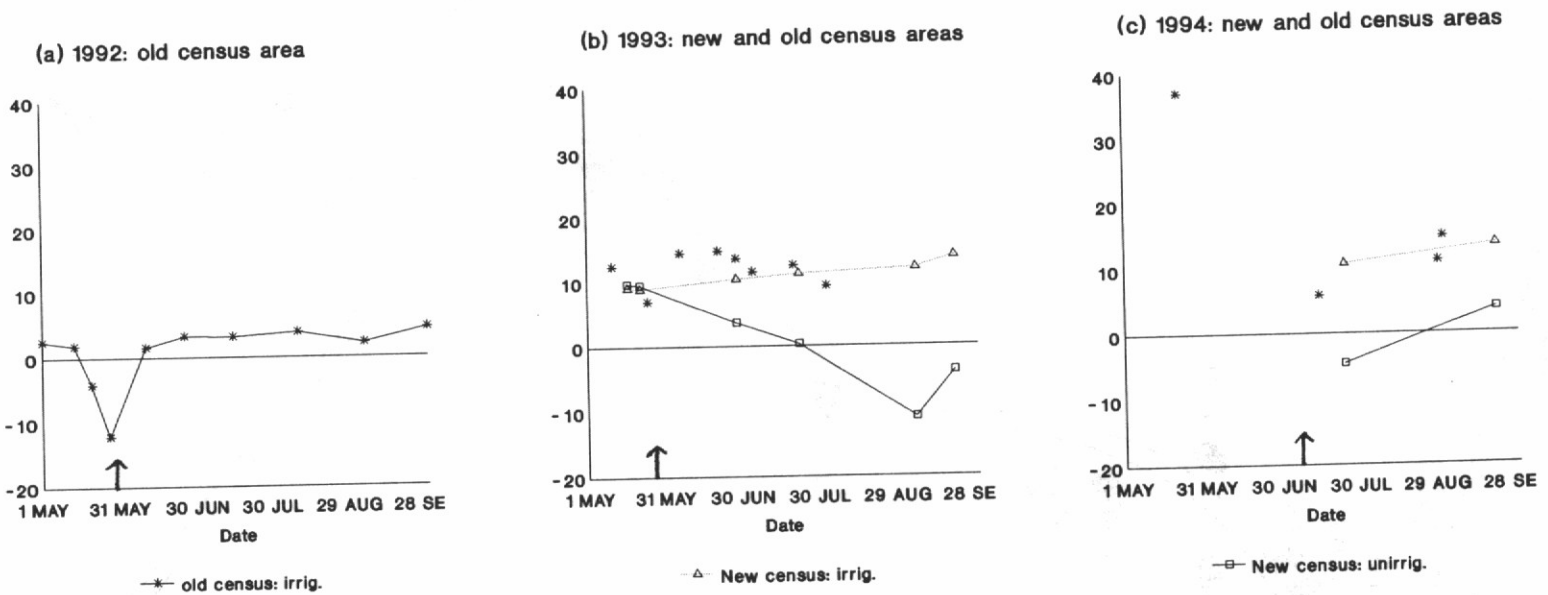


Figure 2.5 Mean water levels on Little Fen 1992-'94



Horizontal line represents the April 1992 datum

Vertical arrows show start of irrigation each year

Figure 2.6 Water levels in pools in the Little Fen census area on 25 July 1994

Water levels are expressed in cm relative to the April 1992 datum

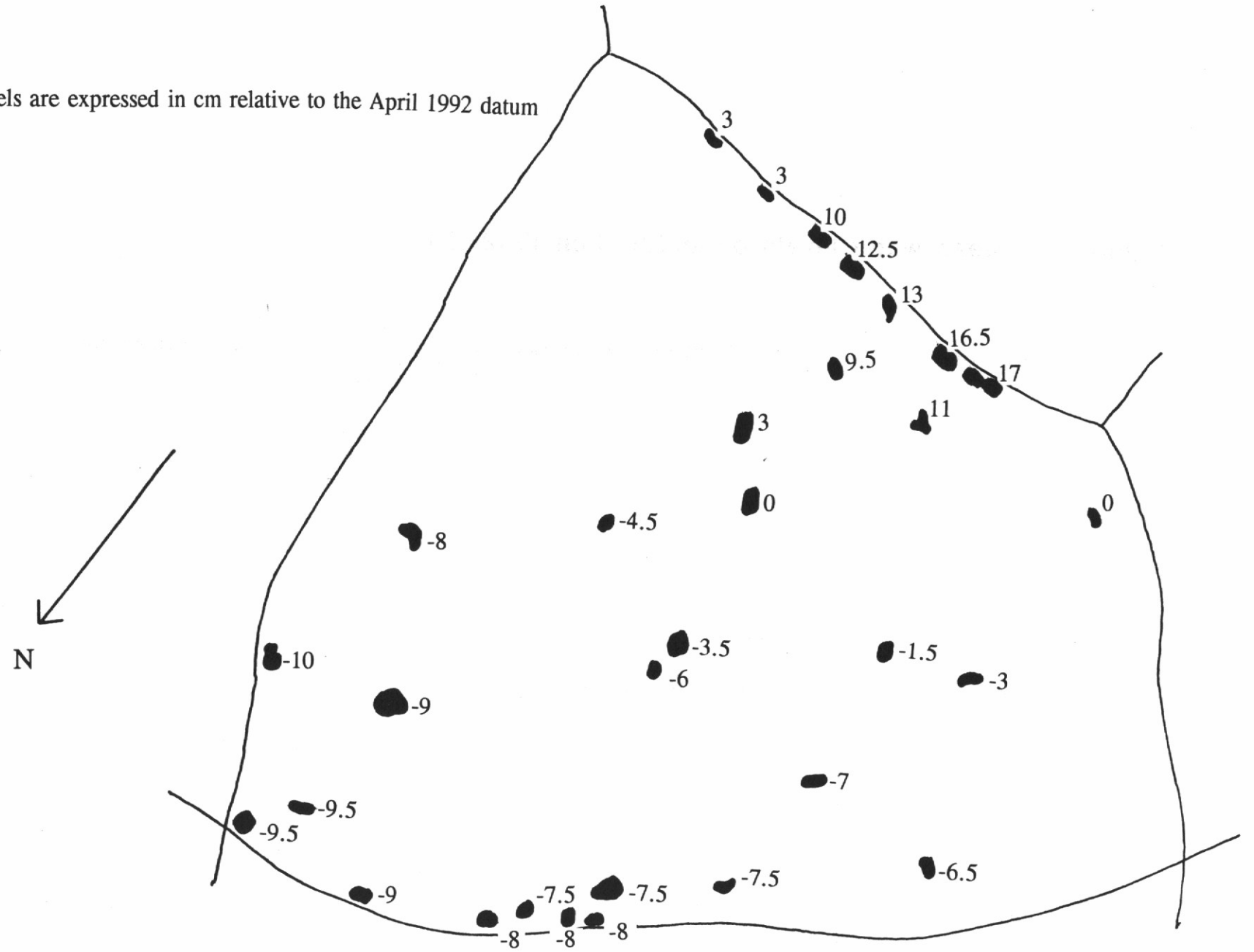
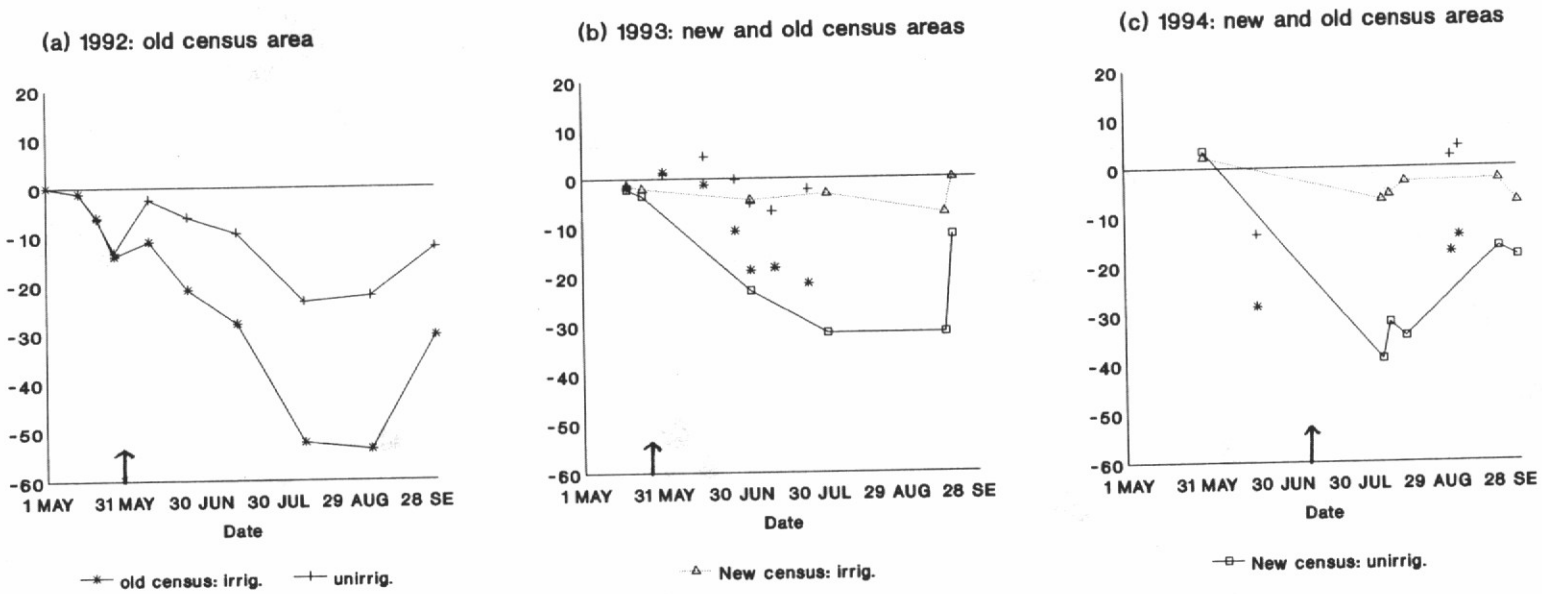


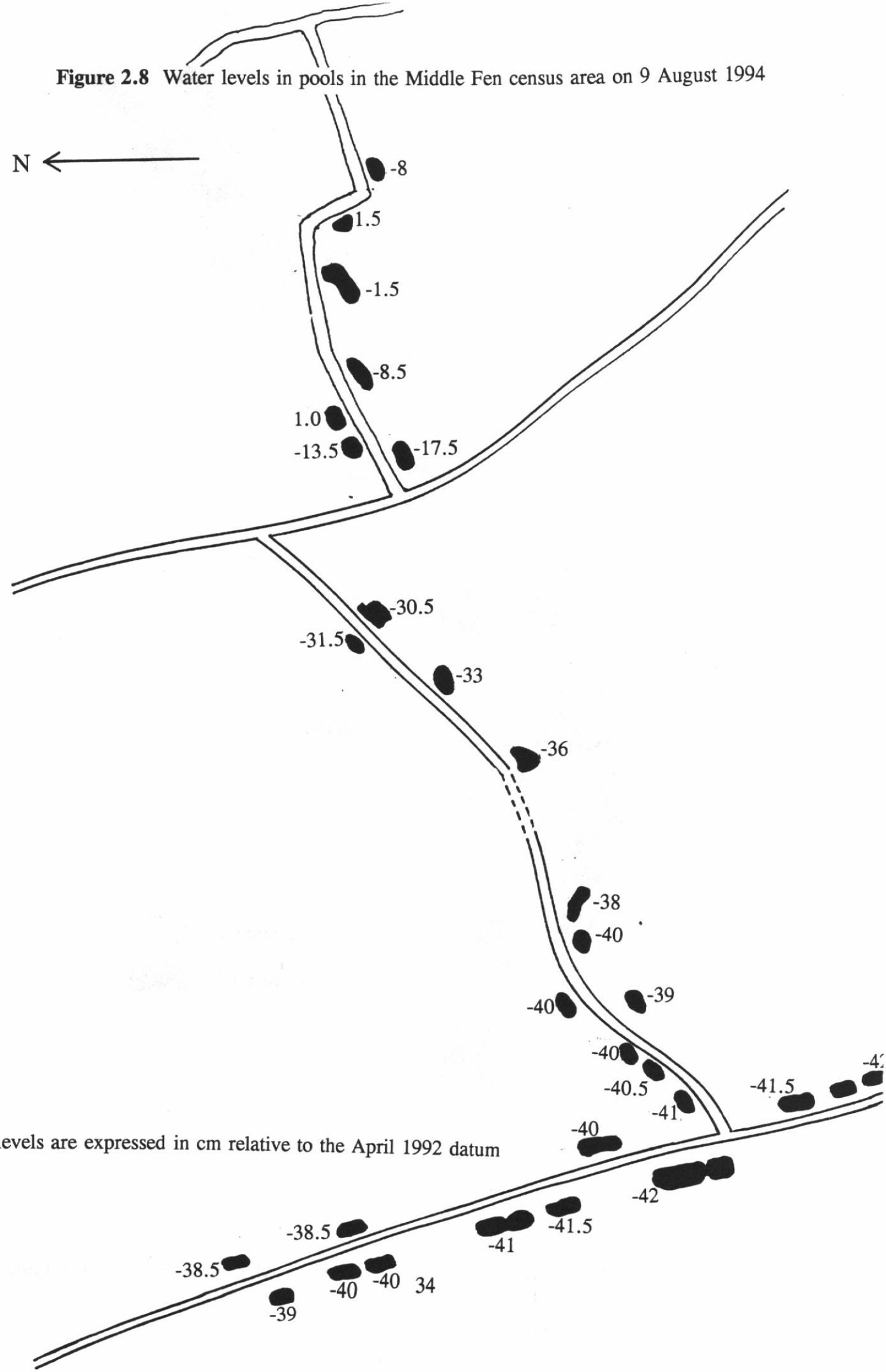
Figure 2.7 Mean water levels on Middle Fen 1992-'94



Horizontal line represents the April 1992 datum

Vertical arrows show the start of irrigation each year

Figure 2.8 Water levels in pools in the Middle Fen census area on 9 August 1994



Water levels are expressed in cm relative to the April 1992 datum

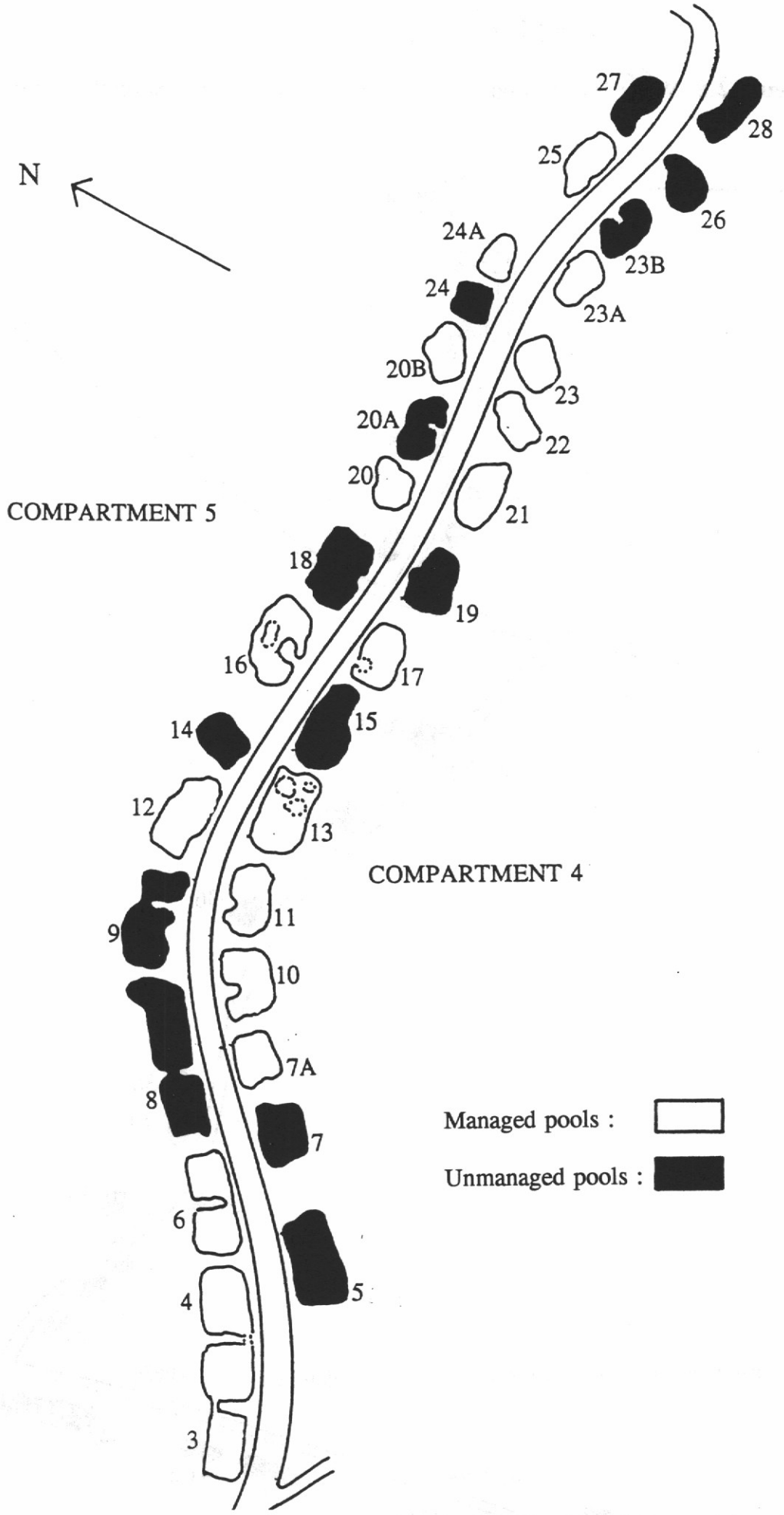


Figure 3.1 The location of managed and unmanaged pools comprising the Little Fen management experiment

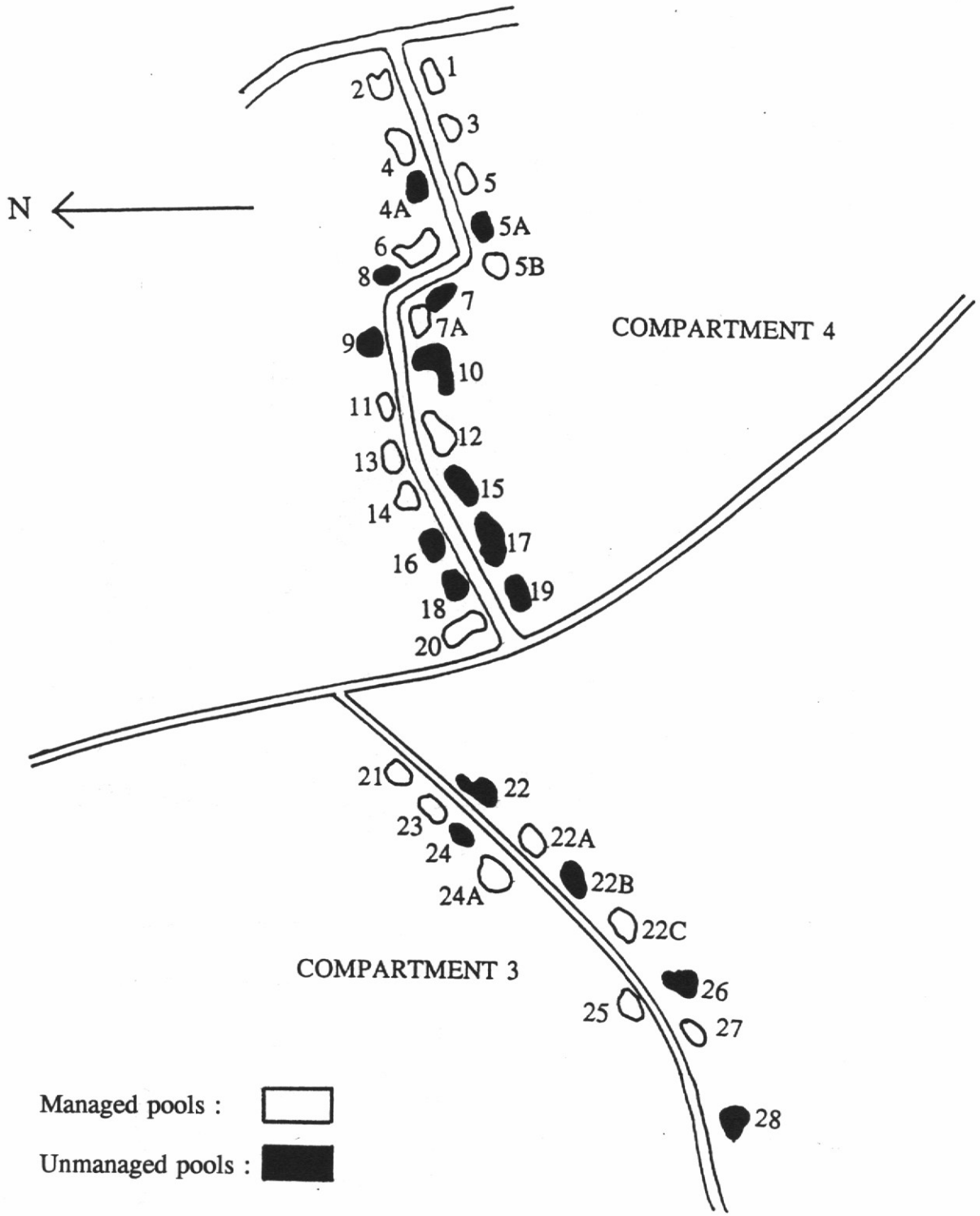


Figure 3.2 The location of managed and unmanaged pools comprising the Middle Fen management experiment

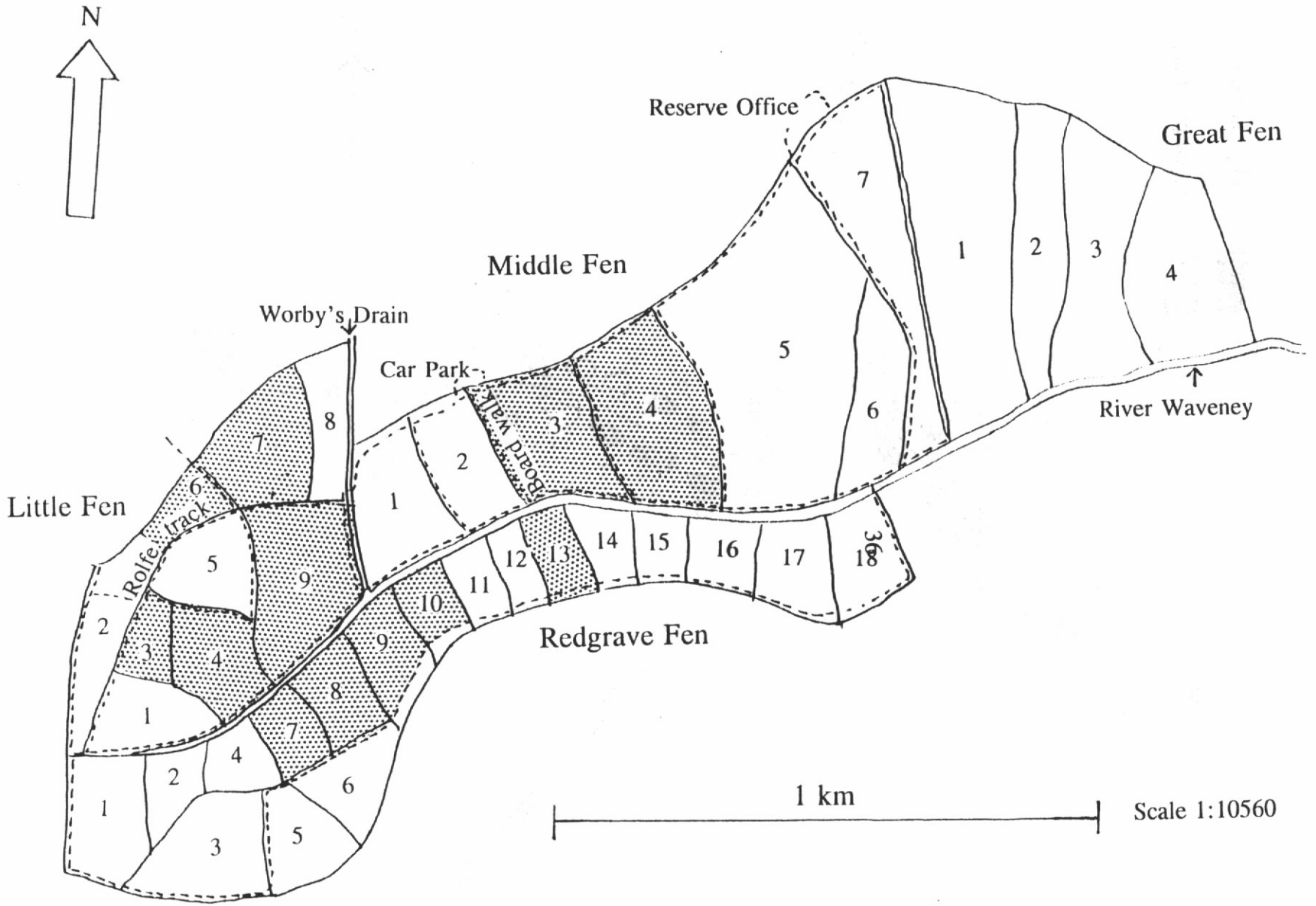


Figure 4.1 Lopham and Regrave Fen NNR showing compartments and planned coverage of the 1994 broad-scale survey (shaded areas)

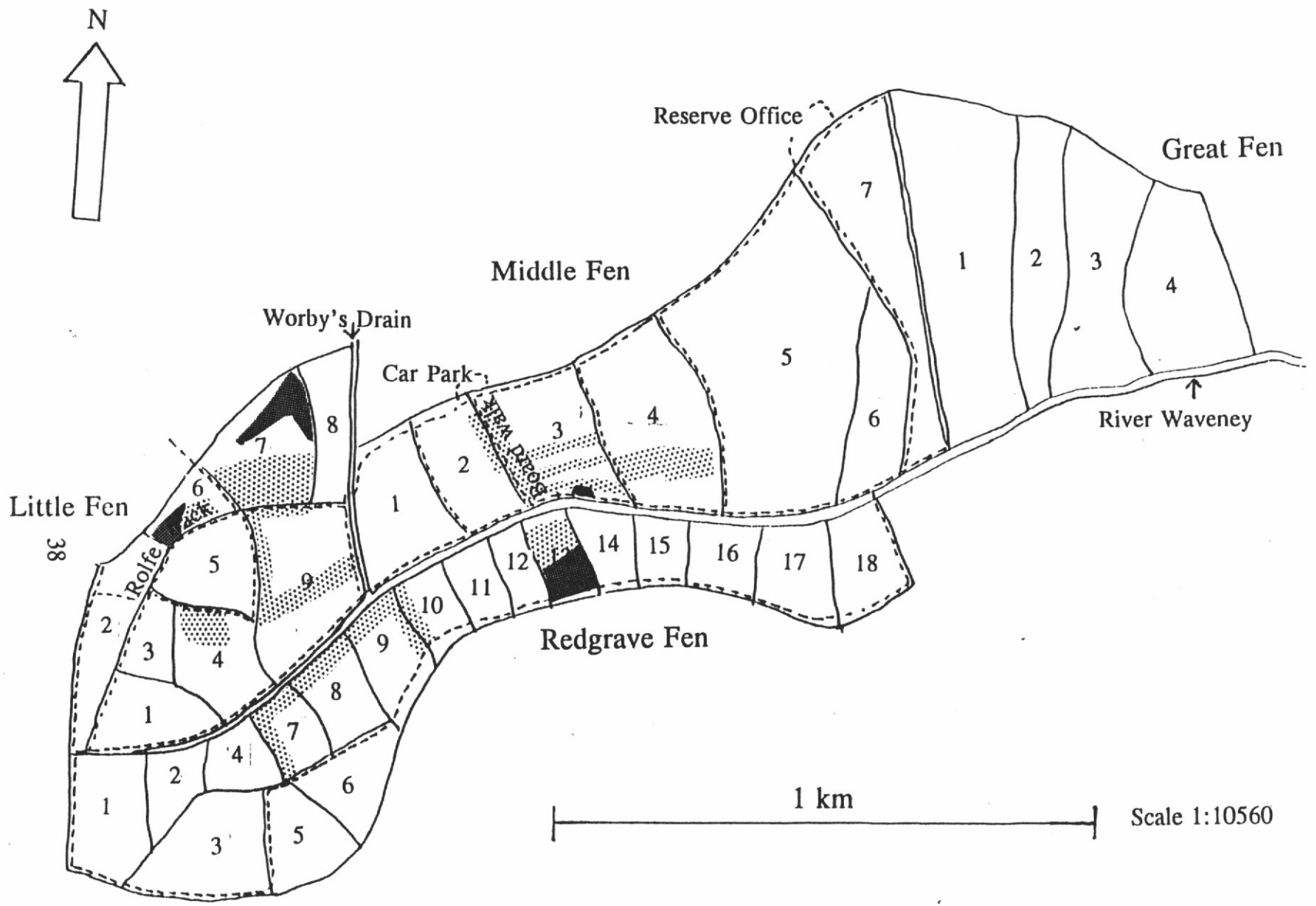


Figure 4.2 Lopham and Redgrave Fen NNR showing approximate areas searched in the 1994 broad-scale survey. Densely shaded areas represent scrub and woodland and dotted shading the area of open fenland searched.