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The status and management of *Dolomedes plantarius* on Redgrave and Lopham Fen National Nature Reserve in 1995

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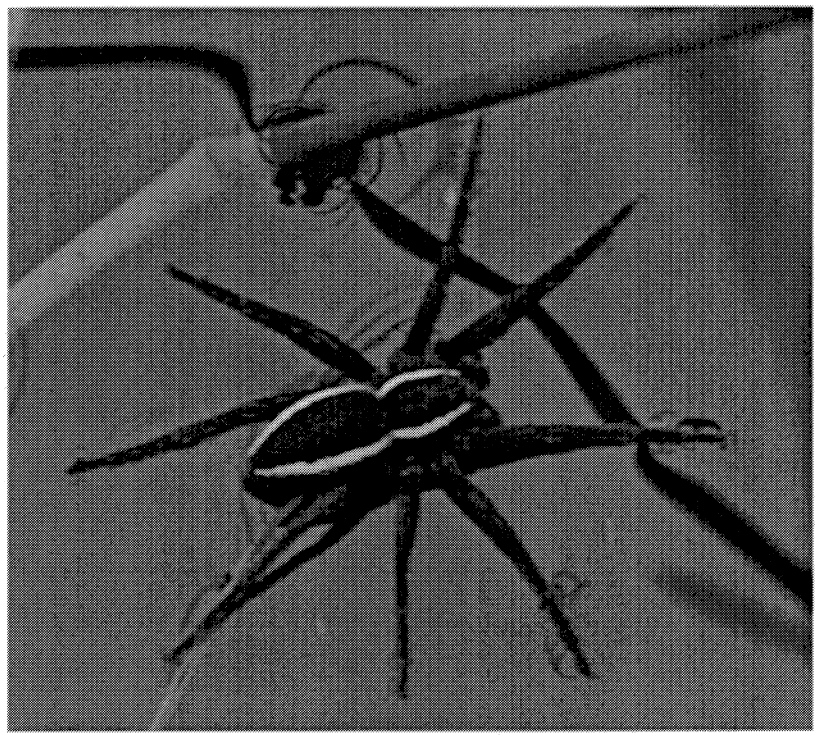

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SUMMARY

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 of the fen as a result of water abstraction. 1995 was the fifth successive year in which systematic census work to assess the status of *D. plantarius* was undertaken on the Fen. It was also the fourth year in which management operations to maintain open conditions in the pools occupied by the spiders, were conducted.

2. The 1995 census used the census area and methodology established in 1993 and 1994 although only a single, summer, census was conducted, rather than the spring, summer and autumn censuses undertaken in the previous two years. The census comprised three replicate counts at two day intervals, at randomly selected pools within the two centres of population, on Little and Middle Fens.

3. On Little Fen the spider population remained precariously small but showed a slight increase from 1994. Its range remained very similar to that in 1994. On Middle Fen the population was more than double that in 1994 although its range contracted. For the first time in five years no spiders were recorded on the unirrigated pools. Most of the increase in population size was in spiders hatched in the very successful 1994 breeding season. If this increase is to be sustained good conditions for successful breeding next year are essential. The numbers of adult female spiders recorded in 1995 were lower than in 1994. Although the single census prevented direct comparison with breeding success in previous years, there was evidence that less breeding attempts were made in 1995 than in 1994.

4. The irrigation water supply was switched on at the end of June but by mid-July water levels in both irrigated and unirrigated pools were lower than those recorded in any of the previous three years. Irrigation was less successful in maintaining water levels on Middle Fen than on Little Fen. By late August water levels were extremely low, with 80% of unirrigated and 22% of irrigated pools drying out on Little Fen. On Middle Fen, all Mean readings from piezometer tubes located throughout the Fen showed that 1995 water levels were the second lowest since recording began in 1976. On Middle Fen all but two of the 23 unirrigated pools was completely empty at this time. Although water losses from the irrigated pools on Middle Fen were substantially greater than on Little Fen, none of the irrigated pools dried out completely because of their greater depth. Loss of emergent marginal vegetation nevertheless made them unsuitable for breeding *D. plantarius*.

5. In addition to the annual census, a rigorous comparison was made of trends in the spider population over the last five years. To obtain a five year run of comparable data, a census was also conducted on the pools which comprised the 1991/'92 census area and were also monitored in 1993 and 1994 as part of an experimental assessment of the effects of pool management. This census was conducted at the same time in July as the main census using equivalent methodology.

6. Analysis of the five year data set, including data from pools in both the original and new census areas, was carried out using a poisson regression model developed for extensive

monitoring data. This showed that there has been significant variation between years in spider numbers and that the patterns of variation in the Little and Middle Fen populations have differed significantly. Annual indices of abundance are generated by the model. It is recommended that this analysis be repeated each year to generate further indices of population change.

7. The minimum requirement for monitoring the numbers of *D. plantarius* at Lopham and Redgrave Fen is an annual summer census using the established methodology. The reduction in census frequency to once-annually reduces the ability to predict and detect deleterious changes in the population.

8. All management work on the spider pools was conducted in the second half of May on pools included in the 1993/'94 management experiment. The sample of pools left unmanaged in 1993 and 1994 was managed for the first time and pools managed in those years were left unmanaged. The management work comprised cutting the bank vegetation at a 45° angle from the water and cutting just below the water, and removing, emergent vegetation.

9. It is recommended that management operations in 1996 should be carried out in May and be confined to removal of emergent vegetation from pools left unmanaged in 1995. More radical removal of emergents, rather than trimming at water level, is recommended. Management operations should continue on an experimental basis, using the two samples of pools designated in 1993. Although the practical need to alternate the sample of pools which is managed will make it increasingly difficult to identify the precise operation responsible for any significant changes in population resulting from management, it is nevertheless important to assess whether or not management is having positive effects.

1 INTRODUCTION

This report provides both a brief description of the status of *Dolomedes plantarius* on Lopham and Redgrave Fen NNR in July 1995 and an analysis of trends in its population since systematic monitoring was instigated by English Nature's Species Recovery Programme (SRP) in 1991. Management work on the spider pools, undertaken by the Suffolk Wildlife Trust (SWT) and changes in the water table during summer 1995 are also described. This report is intended to be read in conjunction with Duffey (1991) and Smith (1992, 1993, 1994, 1995), which provide detailed background.

1.1 Aims

1.1.1 1995 CENSUS WORK

The aims of the census work in 1995 were two-fold. First, the status of the spiders on Little and Middle Fens was assessed using the census scheme established in 1993 (Smith 1993). Second, a rigorous assessment was made of trends in spider numbers over the five year period since systematic census work was instigated by the SRP, as recommended in the Species Action Plan (Smith 1995). To achieve a five-year run of comparable data for this analysis, pools comprising the 1991 and 1992 census area (Duffey 1991, Smith 1992), and subsequently monitored in as part of the management experiment in 1993 and 1994 (Smith 1993, 1994), were monitored again in 1995.

Reduction in funding for the *D. plantarius* project meant that only a single census was undertaken, on a voluntary basis, in July, rather than the three censuses (in spring summer and autumn), funded by the SRP, in the previous two years.

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 in any one season, water levels in all pools were also measured in late August.

1.1.2 MANAGEMENT WORK

In 1993 and 1994 management designed to maintain the open nature of the vegetation around the core spider pools was carried out on an experimental basis, with a randomised sub-sample of pools on both Little and Middle Fens being left unmanaged. Analysis of the effects of management on spider numbers in 1994 showed that they were significantly lower on managed pools (Smith 1994). The failure of the management operation was thought to be attributable to the weakening of marginal and emergent *Cladium mariscus* by three consecutive years of cutting. It was concluded that *C. marsicus* around the pools should not be cut more frequently than every three years. Because of the practical need to 'rest' the managed pools, management work in 1995 was restricted to the sample of pools left unmanaged for the previous two years. To minimise disturbance to the spiders, cutting of marginal and emergent vegetation, previously carried out in early spring and late summer respectively, was combined in a single operation during the period between emergence from hibernation and the start of the breeding season (see Smith 1994). Details of the management

work are given in Section 2.5.

Whilst the 1994 results showed clearly the need to continue management work on an experimental basis, the differing past histories of the two samples of pools are likely to confound the effects of their new management regimes and present very substantial analytical problems. The effects of the 1995 management operation are not analyzed in this report but the potential for future analyses are discussed in Section 5.3.3.

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 Sections 2. The analyses of the census work 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 Lopham and Redgrave 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 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). At the same time, spider numbers were also monitored on all pools included in the 1991/1992 census area (Smith 1992) and subsequently in the 1993/94 management experiment (Smith 1993, 1994). This gave a total of 58 pools on Little Fen and 55 on Middle Fen.

2.2 Monitoring methods

A single summer census round, comprising three replicate counts (see Smith 1994) was carried out in late July. Pools comprising both the 1991/1992 and 1993/94 census area were monitored at the same time. The counts on each fen were completed in three consecutive two-day periods: those on Little Fen between 20 and 25 July and those on Middle Fen between 27 July and 1 August.

The counting method was the same as that used in previous years (Smith 1993, 1994). 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. The criteria recorded for each individual are listed by Smith (1994). Separate records were made of fresh skins and of 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.

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

2.3.1 POPULATION ESTIMATION

All data presented for 1995 are based on the highest of the three replicate counts of all spiders on each pool. There were too few data to run the analysis separately on the adult female population. Maximum counts are a conservative estimate because of the possibility that different individuals were seen on different days but Smith (1993) 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 but those for the summer 1993 census were based on two rather than three counts. However, this lower recording frequency is unlikely to account for the magnitude of the difference in numbers recorded in that and subsequent years.

Data presented for 1991 and 1992 are based on the maxima of three counts for the stated periods. However, the inter-count interval is greater for these than for subsequent years because counts were made at regular and frequent intervals, rather than as replicate blocks (Duffey 1991, Smith 1992). This may give a positive bias to the estimates of spider numbers in these years (i.e. give a relatively higher estimate than for subsequent years).

The data for 1991, the first year of systematic census work, cannot be split into size categories as in subsequent years, because of changes made during this pilot season in the way in which non-adults were recorded.

2.3.2 ANALYSIS OF FIVE YEAR TRENDS

Analysis of trends in the five year data set was carried out using log-linear poisson regression as implemented in TRIM (TRends analysis and Indices for Monitoring data), a programme being developed by STATISTICS NETHERLANDS for extensive monitoring data (van Strien *et al.*, 1995). This and related methods have been developed mainly in the context of bird population monitoring but the statistical models can be applied to data on a wide range of organisms. The underlying model is basically similar to several other indexing methods (e.g. Mountford (1982) Peach & Baillie, 1995; Underhill & Prys-Jones 1994):

$$\text{Expected count} = \text{Site effect} * \text{Year effect}$$

or the log-linear equivalent:

$$\log(\text{expected count}) = \log(\text{site effect}) + \log(\text{year effect})$$

TRIM allows the data to be split into different strata. In the context of the spider data each pool constitutes a site or plot and Little and Middle Fens form separate strata. The model allows sites to be censused in some years and not others and so both the old and new census area data could be utilised. The data modelled were single maximum (of three) counts for each pool in July each year (above).

The programme fits five standard models:

(1) Null model (no year effects)
(2) Linear Trend model (linear trends in log numbers)
(3) Annual Model (annual indices, Mountford model)
(4) Linear Trends within covariate strata
(5) Annual Model within covariate strata

TRIM includes facilities to investigate and correct for the problems of overdispersion and serial correlation in the data, which can seriously bias the precision of annual indices. The spider data were overdispersed but first order serial correlations were low.

2.4 Water levels

As in previous years, the water level in each pool was recorded at the first count at each census. However, the rate of water loss during the census period was such that repeat measurements were made on a sub-sample of pools at the third count on both Fens. In previous years a subsequent measure of water levels was provided by the late summer census. In the absence of this census (above) water levels in all pools were recorded again on 26 August on Little Fen and on 27 August on Middle Fen. 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, and are presented as the change from the April 1992 datum (see Smith 1993).

2.5 Management work

Management operation were carried out on the Little Fen on 26 May and on Middle Fen on 18 May. The pools managed are shown in Figures 3 and 4 for Little and Middle Fens respectively. Marginal emergent and bank vegetation was cut at a 45° angle from the water's edge. Emergent vegetation was cut just below water level, leaving a few old-established islands and isthmuses of *C. mariscus* where they emerged from deep water. Cut material was removed from the site.

3 RESULTS

3.1 The distribution and abundance of spiders

3.1.1 LITTLE FEN

Distribution The distribution of spiders remained very similar to that in the previous two years. As in 1994 they were absent from pools at the north western part of the compartment but were distributed throughout the remainder of the compartment (Figure 5).

Spiders were recorded on 16 pools within the census area, two more than in 1994 (Smith 1993). They were found on two pools in the south western part of the compartment, from which they had not been recorded in either 1993 or 1994.

Abundance The total maximum count of spiders on Little Fen was 37, eight of which fell within the large size category which included adults (Table 1). This estimate is conservative because it is based on the maxima of only three counts, which were likely to have included

a proportion of different individuals. Whilst still very low this estimate is slightly higher than in either of the previous two summers (Table 1). Numbers at the summer census were similar to those recorded during the equivalent period in 1993. The mean numbers of spiders per pool on both irrigated and unirrigated pools within the census area were also greater than in 1994 and 1993 (Table 3).

Maximum summer counts from the five-year run of data from the pools which comprising the 1991 and 1992 census area (see Section 2.1) also suggested a slight improvement on the situation in 1993 and 1994, particularly in the numbers of spiders recruiting to the large and medium size categories (Table 2).

3.1.2 MIDDLE FEN

Distribution For the first time since recording began in 1991, no spiders were found on any unirrigated pools on Middle Fen (Figure 6). Although it is possible that very small numbers persist, the low water levels at the time of recording made searching very easy. In the absence of a spring census round it is impossible to tell at what stage spiders were lost from this area.

As in 1994, spiders were recorded on all seven of the irrigated pools included within the main census area (Figure 6).

Abundance Despite the contraction in range on Middle Fen, numbers of spiders recorded on the irrigated pools were more than double those recorded in 1994 (Table 1). This increase was very unlikely to be attributable to a concentration effect resulting from low water levels. Although July levels were lower than in the previous two years (Section 3.4.2) they were similar to those recorded in 1992, when numbers of spiders recorded were low. Moreover, not all size categories increased in numbers, as would be expected from a concentration effect. Numbers in the medium size category were particularly high, reflecting good survival from the successful 1994 breeding season (see Smith 1994). However, numbers of spiders of adult spiders were lower than in either of the previous two years. As in the previous two years, total numbers recorded on Middle Fen were substantially higher than on Little Fen, although numbers of large spiders recorded on Middle Fen were lower than on Little Fen. The increase in mean spider numbers on the irrigated pools on Middle Fen between 1994 and 1995 was nearly four-fold (Table 3). The 1995 numbers were more than eight times greater than the equivalent figure for irrigated pools on Little Fen.

Maximum summer counts from the five-year run of data from the pools comprising the 1991 and 1992 census area (Section 2.1), most of which are irrigated and occupied by spiders, also demonstrate the substantial increase in spider numbers (Table 2). Total numbers again more than doubled. Again, the greatest increase was in the medium size category, while numbers of large individuals lower than in 1994 and also lower than those recorded from the old census area on Little Fen.

3.2 Breeding success

The brief recording period during the 1995 breeding season makes rigorous comparison of breeding success with that in previous years impossible. However, on Little Fen, despite the lower sampling effort, a total of three nursery webs was recorded from pools included in both the old and new census areas, compared with two in 1994 (Smith 1994). Nine females with eggs were also recorded on Little Fen, reflecting the increase in numbers of animals in the large size category.

On Middle Fen a total of nine webs was recorded compared with 18 under the rather more intensive sampling regime in 1994.

3.3 Five year trends

The TRIM model which gave best fit to the five year summer data set for maximum counts of all individuals, was the annual model within covariate strata (see Section 2.3.2). This shows first, that over the last five 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 $\chi^2_{[4]} = 97.45$, $P < 0.001$). 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 generated by this model provide a reliable description of changes in spider numbers over the five year period using all of the available data from both the old and new census areas (Table 4). In general, the indices model reflect the pattern in the totals data over this period, with spider numbers on both fens increasing between 1991 and 1992, presumably as the population recovered from the severe drought in 1990. Middle Fen suffered a very poor year in 1993 but recovered during 1994 to reach a maximum for the five year period in 1995. On Little Fen the indices drop to a very low level in 1994 with a slight recovery in 1995.

3.4 Water levels

3.4.1 LITTLE FEN

In 1995 the irrigated water supply was turned on in early July. When the census was carried out, in late July, water levels in the unirrigated pools in the new census area were substantially lower than in either 1994 or 1993 (Figure 7). Levels in the irrigated pools (pools 2-28: Fig.3) were also slightly lower but were comparable with those recorded from the larger sample of irrigated pools in the 1992 census area.

A mean of 1.7 cm of water a day was lost from the unirrigated pools and 0.4 cm a day from the irrigated pools during the six day census period. By late August these high rates of water loss resulted in the loss of standing water in 19 of the 24 unirrigated pools. Many of these retained damp mud in their deepest areas. In the remaining five pools water levels were very low, in all cases leaving wide, unvegetated, muddy margins with no emergent vegetation.

The datum presented in Figure 7 for unirrigated pools on this date is based on the height of the posts emerging from drying mud and therefore substantially underestimates the minimum water levels.

For the first time since systematic recording of water levels in the pools began in 1992, some of the irrigated pools furthest from the pipe outlets also dried out by late August. Seven of the 32 pools lost all standing water and because the water depth measuring posts are rarely in the deepest parts of the pools, a further one was dry at the post. Again, this means that the estimates presented in Figure 7 for these pools on this date are conservative and were probably substantially lower than in the previous 'worst' year, of 1992. The rate of water loss was from the SWT piezometer tubes showed that 1995 was second driest summer on the fen since recording began in 1976. Only in 1990 were levels lower. In that year mean late August levels for the whole fen were 14 cm lower than in 1995. The 1995 piezometer tube data show that water levels on Little Fen increased slightly by late September but then dropped again by 8 cm during October. There was little improvement in levels in the unirrigated pools until late November and early winter levels remained extremely low (pers. obs.).

3.4.2 MIDDLE FEN

As in previous years water losses from the spider pools on Middle Fen were greater than on Little Fen. By late July they were already substantially lower than in any of the previous three years. All of the measurements shown in Figure 8(d) underestimate the water loss: when the first measurements were made during the census in late July six unirrigated pools were already dry at their measuring posts and one was completely dry. Water loss over the following four days averaged 1.8 cm a day, by which time six were completely dry and a further 11 were dry at their measuring posts. By late August, 21 of the 23 unirrigated pools were completely dry. The remaining two were dry at their measuring posts with only a very small water surface remaining.

The irrigation supply was inadequate to maintain the water levels in the irrigated pools (pools 1-20: Fig.4). Irrigation has always been less successful in maintaining consistent and high levels on Middle Fen than on Little Fen (Smith 1992, 1993, 1994) but in 1995 losses from the irrigated pools were very much more severe than in any previous year (Figure 8). A temporary reduction in the irrigation water supply led to dramatic water loss from all Middle Fen pools in the second week of July. Few pools had any open water remaining although some water remained in most pools beneath dense stranded masses of *Chara* spp. and other submergents. This loss was rectified on 13 July, after approximately one week. By late July water levels in the irrigated pools were already lower than in the previous two years. During a four day period water was lost at the same rate as from irrigated pools and unirrigated pools. By late August water levels in the irrigated pools were similar to those recorded in the unirrigated pools in the previous two years. Variation between pools was substantial depending on distance from the irrigation outlets. Despite the much greater losses from the irrigated pools on Middle than on Little Fen, none of the irrigated pools dried out completely and only three were dry at their measuring posts. This reflects the substantially greater depth of pools on Middle Fen than on Little Fen.

4 DISCUSSION

1995 saw a slight improvement in numbers of *Dolomedes plantarius* on Little Fen from the extremely low point of 1994 and a substantial increase in numbers on Middle Fen to the highest since systematic recording began five years ago. However, there is no evidence that either of these changes forms part of a longer-term tend. There was no substantive change in the distribution of the spiders on Little Fen. On Middle Fen the population in the unirrigated pools appears to have been lost. In the absence of an autecological study it is impossible to assess the likelihood of this area being recolonised before the fen water table is restored. This loss illustrates the ease with which small populations can suddenly disappear after persisting at low levels for a number of years. Equally, the very rapid increase in numbers on the irrigated pools on Middle Fen illustrates the potential for rapid recovery if suitable conditions can be maintained.

The extent of water losses from the spider pools in July and August 1995 suggests that in the substantially more extreme conditions in 1990, before the irrigation scheme was started, very few pools indeed could have retained any water. Successful breeding attempts may have been made in June that year but individuals hatched in the much wetter summer of 1989 and recruiting to the adult population in 1991 must also have contributed to the progressive recovery in numbers between 1991 and 1992. This recovery was undoubtedly aided substantially by the instigation of irrigation. However, the annual fluctuations in numbers over the last five years suggest that urgent attention should be given to the maintenance of more consistent summer water levels.

On the irrigated pools on Middle Fen, failure of the irrigation to maintain consistent and high water levels in many pools seems increasingly likely to be the major factor depressing population size. It creates conditions unsuitable for breeding and, in drought years, is also likely to affect survival. The variability in the Middle Fen levels within the breeding season is also likely to 'waste' breeding attempts because conditions are likely to deteriorate rapidly during the course of a breeding attempt. That variations in water level on Middle Fen are more important than other aspects of the pool environment in determining spider numbers, is suggested by the nearly four-fold increase in mean numbers of spiders supported per pool in 1995. Most of this increase constituted progeny from the very successful 1994 breeding season (Smith 1994), when water levels were maintained successfully by irrigation in July and August. This indicates that in previous years the numbers of spiders supported on the irrigated pools on Middle Fen pools have been well below carrying capacity.

The high numbers on Middle Fen in July 1995 should not be regarded as indicative of a recovery and cause for any relaxation of conservation effort. The relatively good conditions in 1994, which resulted in a very successful breeding season, were not maintained in 1995 and the effects of the extreme drought on survival are not known. However, the data from previous drought years suggest that it is likely to be very deleterious. Although it was difficult to compare the breeding success in 1995 (Section 3.2) with that in 1994 the indications are that adult female population was smaller and fewer webs were built in the early part of the season while drought made successful breeding in the second half of the season extremely unlikely. The water loss from the majority of pools created muddy shores with no emergent vegetation that is essential for successful breeding (Smith 1994). The

temporary loss of the irrigation supply to Middle Fen in July(Section 3.4.2), is also likely to have disrupted substantially breeding attempts at the peak of the season. The main scope for capitalising on the 1995 increase is therefore dependent first on favourable overwintering conditions and second on the maintenance of consistent and high summer water levels which favour successful breeding by the large cohort due to mature in 1996.

The independent variation in the sizes of the populations between Little Fen and Middle Fen and the failure of the Little Fen population to show any substantial recovery despite much better maintenance of summer water levels prior to 1995, suggests that factors other than summer water levels may limit population density on the core, irrigated pools. I suggested in 1994 (Smith 1994) that the quality of the standing water on Little Fen in late winter may have direct or indirect deleterious effects (through the quality of the vegetation or prey availability) on the spiders. No data are available on changes in the emergent or marginal vegetation around the spider pools although detailed scrutiny of qualitative observations made for each pool at the time of the census rounds for the last three years may be of value by next year. The 1995 drought shows that the Little Fen population, in irrigated as well as unirrigated pools is also very vulnerable to drought. The loss of water from such a high proportion of unirrigated pools makes the remaining small population highly vulnerable.

5.3 RECOMMENDATIONS

5.3.1 WATER SUPPLY

The above discussion suggests that the population at least on Middle Fen could be increased by more positive action to maintain summer water levels. Moreover, it is increasing clear that unless the population is increased there is a real risk of stochastic extinction before the fen water table is restored as part of the LIFE project restoration work. There is no doubt that much the best way of achieving this would be to increase the irrigation supply to Middle Fen but the political will to achieve this may be lacking. Suggestions from EN that lining some of the pools with pond liner during the winter need to be discussed. This would be an expensive option for the conservation bodies involved and, in the absence of any controlled trial, is likely to entail high risks. The potentially negative effects on the spiders of resulting changes in water chemistry, prey supply and maintenance of emergent marginal vegetation essential for successful breeding, should be considered.

5.3.2 EXCAVATION OF NEW POOLS

At the review meeting in 1994 it was agreed that additional pools be excavated in the immediate hinterland of the irrigated pools on both Little and Middle Fen to create additional quality spider habitat within a three year period. This suggestion was incorporated into the agreed Species Action Plan as a high priority action (Action 11 : Smith 1995). The continuing precarious state of the population creates the urgency of this action and a precise plan and timetable for this work should be determined.

5.3.3 MANAGEMENT WORK

Because of the relatively small samples of pools involved in the management experiment, maintenance of robust experimental design is likely to have to sacrificed to the pragmatic limitation in the frequency with which *C. mariscus* can be cut. However, maintenance of the present two sets of pools for management purposes optimises that chance of detecting significant effects of management even if the contributory management operation becomes more difficult to identify.

In 1996 emergent vegetation should be removed in May from the pools left unmanaged in 1995. In 1994 I recommended that this operation should be more radical than hitherto and include some bottoming out and deepening of the pools rather than simply trimming of emergent stems. This is a more difficult operation and was not achieved in 1995. However, because the pools on Little Fen are now very shallow (Section 3.4.2), with substantial depths of anoxic sediments, and because such an operation would obviate the need to manage emergent vegetation each summer, this management possibility should again be discussed at the review meeting.

Management work in 1996 should avoid any cutting of marginal *C. mariscus* since this was done on the previously unmanaged sample of pools in 1995 and on the remainder in 1993. Where pools are surrounded by *Phragmites australis* there may be benefit in more frequent cutting. However, I do not favour this for two reasons. First, this could not be accommodated within the aim of maintaining two sets of pools with common management histories and second, where *C. mariscus* occurs with *P. australis* this may further weaken the former at the expense of the latter.

5.3.4 MONITORING

(a) **Spiders**: The minimum monitoring requirement for 1996 is to continue the July census on both Little and Middle Fens, using the scheme established in 1993 (total of six days field work). It should be borne in mind, however, that abandoning of spring and autumn census rounds introduces a substantial delay in our ability to predict and detect population change. Thus, for example, there will be no way of assessing the effects of this summer's drought on the recovery of the population Middle Fen until data collected next July are analyzed. This loss of sensitivity in the monitoring increases the risk of both failure to detect and respond to catastrophic changes in the population and also of taking inappropriate conservation action.

Monitoring of all of the pools which formed the 1991/'92 census, and were subsequently used for the management experiment, should be repeated every two or three years but may no longer be cost effective as an annual exercise. The value of continuing to monitor these pools is two-fold. First, it remains essential to check that the effects of pool management are not deleterious to the spiders. Second, particularly on Middle Fen, the majority of these pools harbour spiders while only a small proportion of the pools included in the new census area have spiders. As a result the old census gives a much more precise measure of changes in population size, while the new census area enables detection of changes in range. The separate estimates of changes in population size derived from monitoring both the old and the new census areas over the last three years shows both indicate changes of similar

magnitude (Sections 3.1.1 & 3.1.2 and cf. Tables 1 and 2). This suggests that monitoring the new census area alone may give an adequate description of changes in population size. However, if the population decreases, or if there is any further contraction in range, a larger sample of pools with spiders is likely to be needed.

The inclusion of three of the pools in the Little Fen census area should be reviewed because the accretion of deep bottom sediments is making survey work increasing unsafe. I am reluctant to drop these from the census because two are large old peat diggings which have harboured spiders for the last three years. The work on these pools could be achieved safely by two people.

(b) **Water**: Because fluctuations in water levels throughout the season are such a critical factor in determining the spiders' success, and because it is easy for potentially devastating interruptions in the irrigation supply, through deliberate flow reduction (as in 1995: above) or vandalism to go unnoticed, it is vital that water levels in the pools are both inspected and monitored at regular and frequent intervals. I recommend, first, that water levels are inspected for major changes every one or two days, as was the case prior to 1995. Second, a sub-sample of irrigated pools (e.g. ten per fen) should be monitored at least once a fortnight from June until the late September and that all pools are monitored in early June and in late August as well as at the July census.

5.3.5 MINOR MAINTENANCE WORK

(a) **Anchorage of irrigation pipes.** The irrigation hose outlets are intended to be placed on the tracks between the pools so that the irrigation water filters through the peat into a number of surrounding pools. Members of the public frequently move these pipes so that they feed directly into one pool. This results in often substantial perturbation of the water levels in several pools. Since maintenance of more consistent water levels is likely to be beneficial to breeding spiders, it is important that the pipe outlets are very securely anchored to the tracks. A method needs to be devised of achieving this with minimum inconvenience to path mowing operations. Consideration should also be given to the desirability of displaying an explanatory notice.

(b) **Increase in the number of irrigation outlets.** Much of the variation between pools in the irrigated areas reflects the proximity of the pools to the irrigation outlets. A small increase in the numbers of outlets would increase the numbers of pools able to maintain more constant levels during the summer. However, such an increase would also result in a reduction in the volume of water supplied by each outlet. On Little Fen, where the irrigation supply is usually successful in maintaining high levels, this may not be a problem. It is more likely to be a problem on Middle Fen unless an increase in the supply can be negotiated (1 above) but a quantitative assessment of the flow reduction for given increases in the number of outlets would be worthwhile.

(b) **Permanent labelling of oak marker posts.** It was decided in 1994 to replace the ink numbering system on the oak marker posts with metal labels because the former required renewing annually. Although new labels have been purchased, they have not yet been attached to the posts. This requires a maximum of one day's work and cannot be done as part of the annual census work.

(c) **Trampling damage**. Consideration should be given to ways of restricting trampling around the pools by members of the public wanting to see the spiders. This was not a problem in 1994 when water levels were high but became an increasing problem as the water levels fell in summer 1995. *D. plantarius* is particularly vulnerable to trampling at the water margin because nursery webs constructed in the marginal vegetation are easily destroyed. A partial solution to this problem may be to construct one or more viewing platforms on consistently well populated pools, as recommended in the Species Action Plan (Action 28: Smith 1995).

5.3.6 CONTINUING ASSESSMENT OF POPULATION TRENDS

Now that the methodology has been established for rigorous analysis of trends and the generation of annual indices, each annual data set should be added to the historical set and a re-analysis run. When monitoring is be restricted to the new census area this method of indexing will be essential for comparison of the new data sets with those from 1991 and 1992 data (old census area only). By 1996 there will be sufficient data from the new census area to make it worth testing for differences between irrigated and unirrigated pools (the old census area on Little Fen did not sample unirrigated pools).

5.3.7 AUTECOLOGICAL STUDY

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

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

	1993	1994	1995
Little Fen			
Large	5	4	8
Medium	8	7	27
Small	1	8	6
Total	**14**	**19**	**37**
Middle Fen			
Large	6	13	3
Medium	7	21	63
Small	8	10	36
Total	**21**	**44**	**102**

Table 2 Maximum numbers of spiders counted on pools comprising the old (1991/'92) census areas on Little and Middle Fen. Data are the means of the maxima of three counts in July of 1991 and 1995, and during two months in each of 1992, 1993 and 1994.

	1991	1992		1993		1994		1995
	July/ Aug.	June	July/ Aug.	June	July	July	Aug.	July
Little Fen								
Large	8	13	23	17	3	1	5	17
Medium		3	22	12	2	4	21	26
Small		13	24	8	11	2	7	8
Total	**38**	**29**	**69**	**37**	**16**	**7**	**33**	**51**
Middle Fen								
Large	2	9	27	15	7	29	19	13
Medium		2	16	10	17	56	39	164
Small		1	6	24	25	39	36	83
Total	**68**	**12**	**49**	**49**	**49**	**124**	**94**	**260**

Table 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) $\pm$ 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		
	1995	1994	1993	1995	1994	1993	1995	1994	1993	1995	1994	1993
Spring	-	-	0.32	-	-	1.57	-	0.04	0.09	-	1.71	1.78
Summer	1.00	0.33	0.48	1.71	0.86	0.29	0.00	0.35	0.13	14.3	3.71	2.00
Autumn	-	0.96	0.60	-	0.86	1.71	-	0.17	0.00		2.71	2.86

Table 4 Multiplicative annual indices for *Dolomedes plantarius* on Little and Middle Fens in July 1991-1995, 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	1.992	0.586	1.467	0.296
1993	1.023	0.408	0.530	0.137
1994	0.225	0.089	1.638	0.315
1995	0.386	0.116	3.202	0.553

Figure 1 The location of pools included in the 1995 *D. plantarius* census on Little Fen

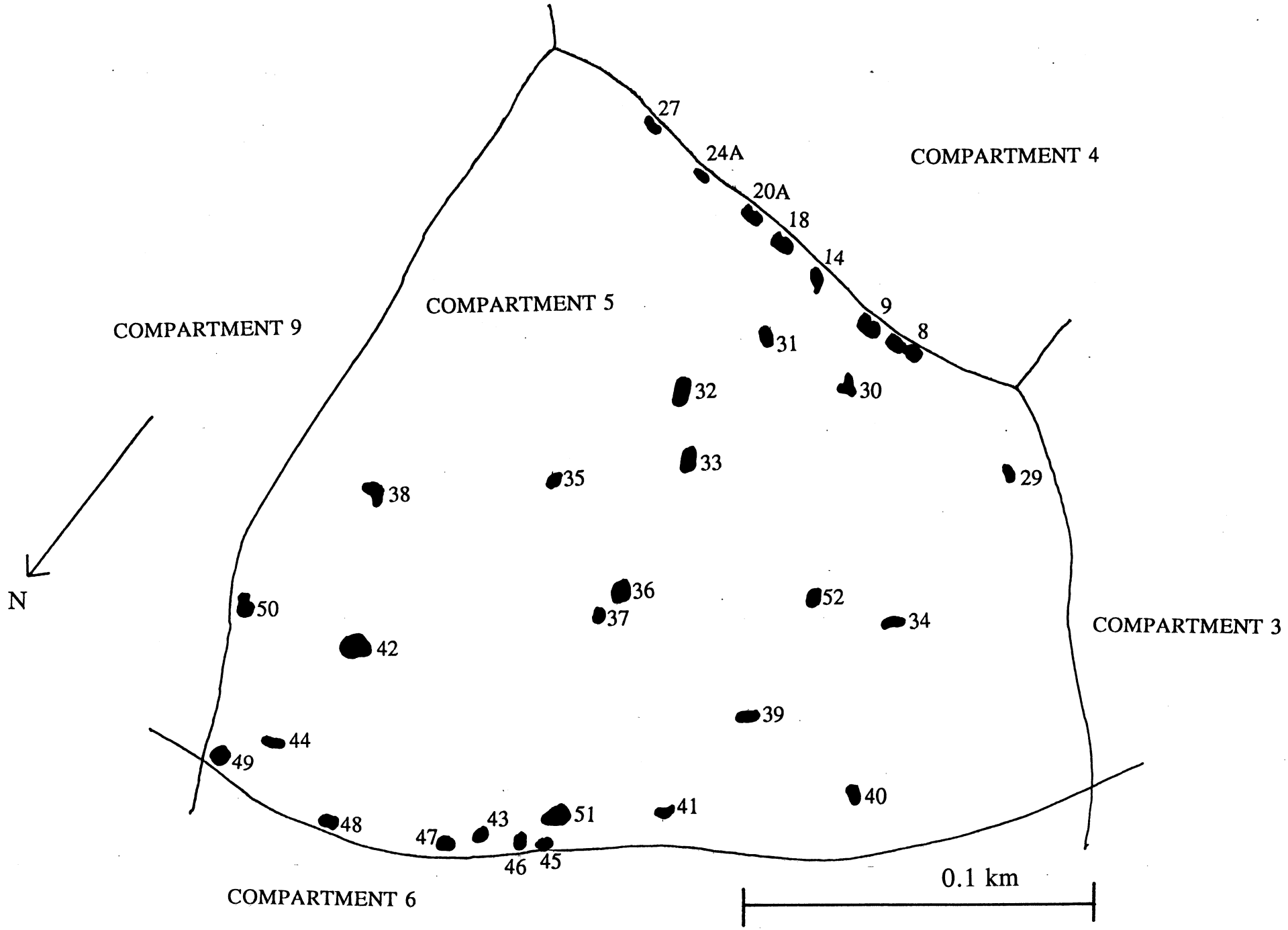
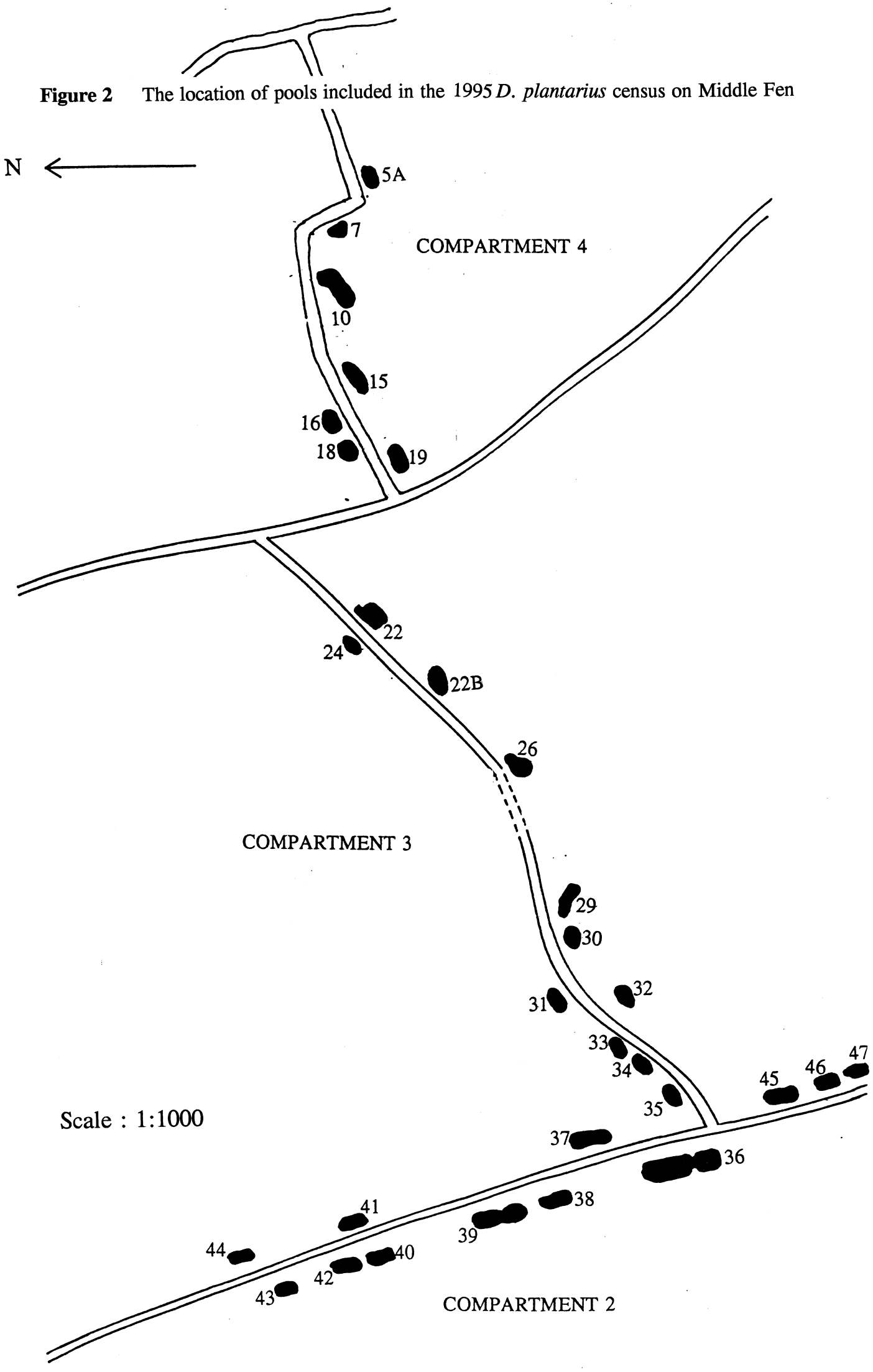


Figure 2 The location of pools included in the 1995 *D. plantarius* census on Middle Fen



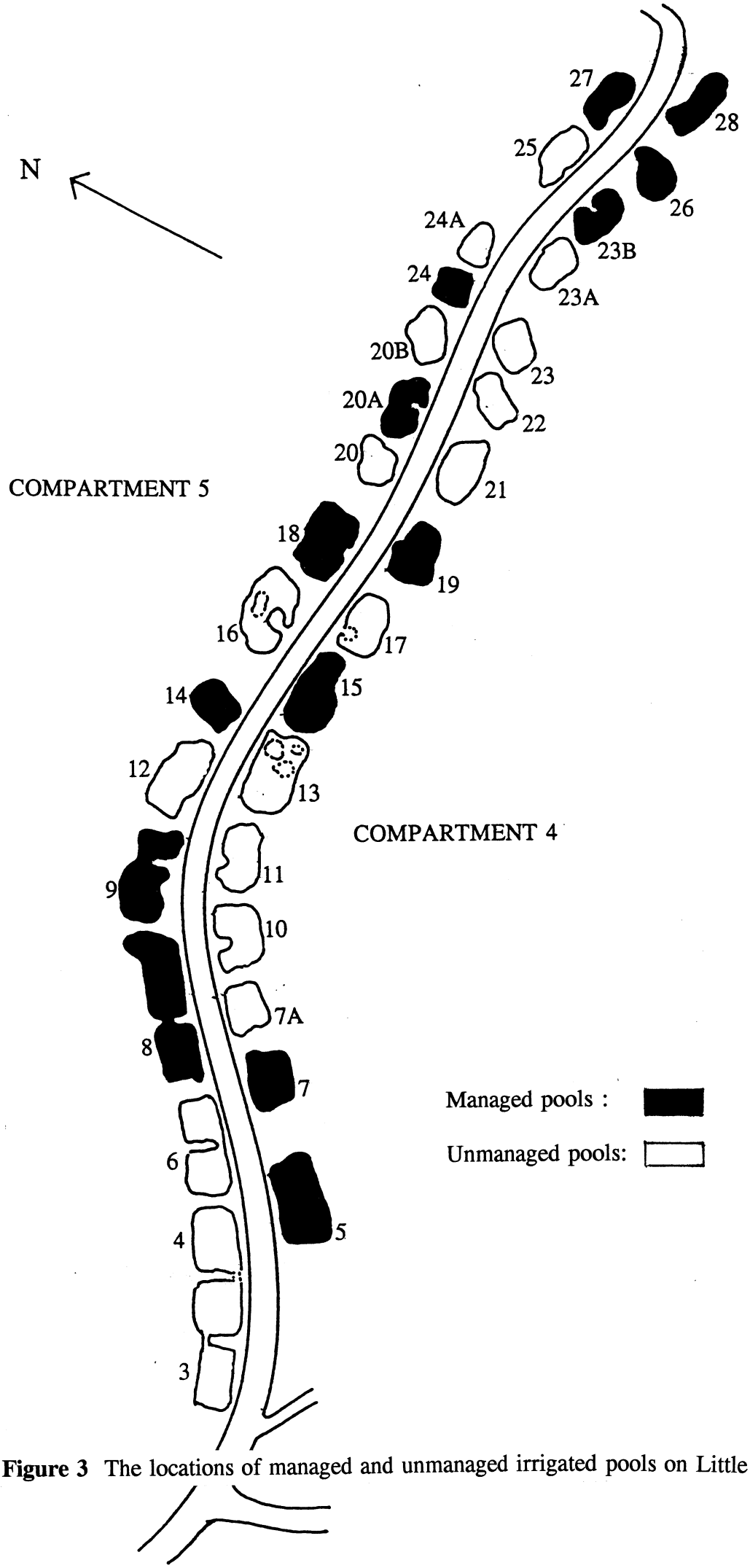


Figure 3 The locations of managed and unmanaged irrigated pools on Little Fen in 1995

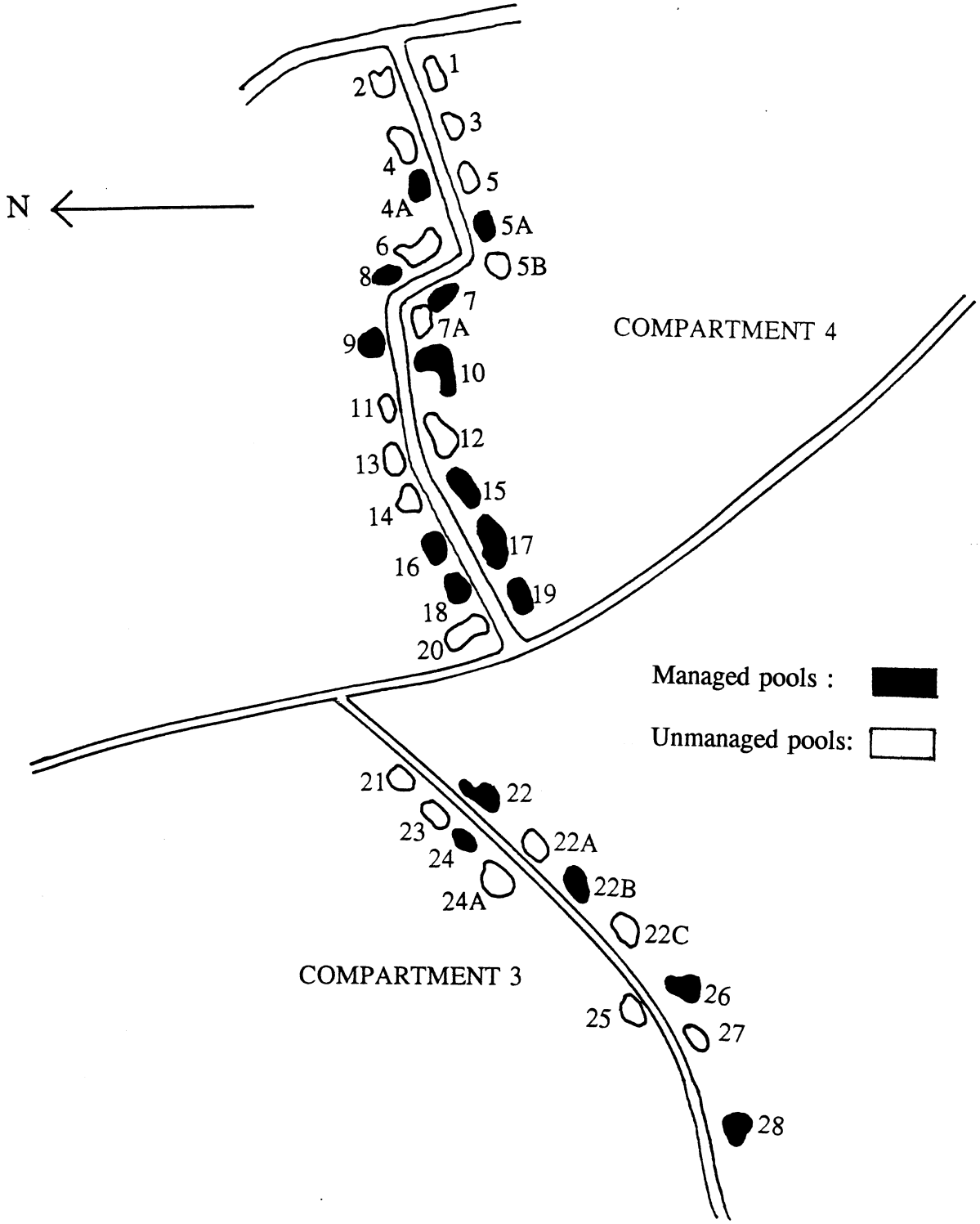


Figure 4 The locations of managed and unmanaged pools on Middle Fen in 1995

Figure 5 Maximum numbers of *D. plantarius* seen on each pool during the July census on Little Fen

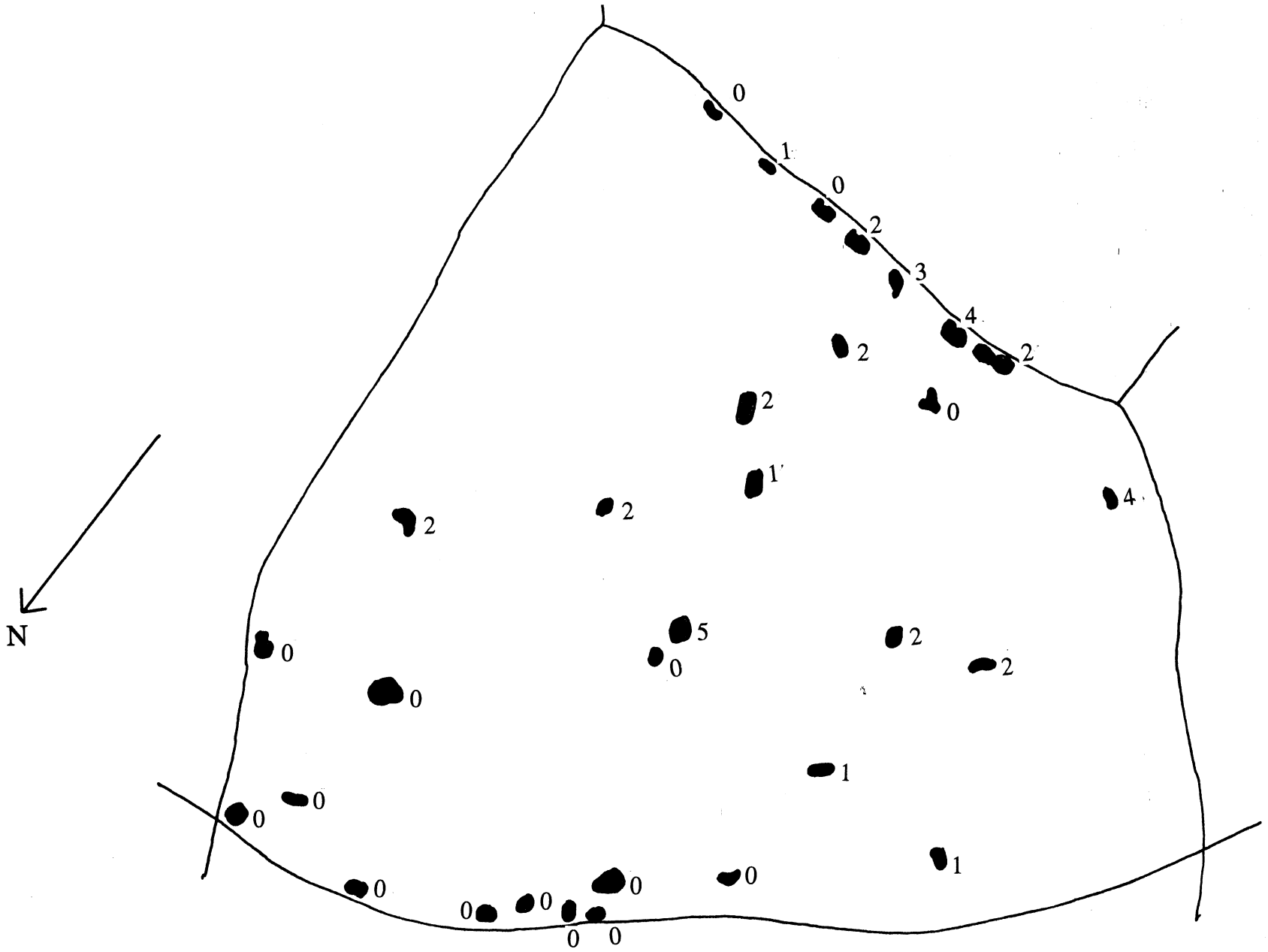


Figure 6 Maximum numbers of *D. plantarius* seen on each pool during the July census on Middle Fen

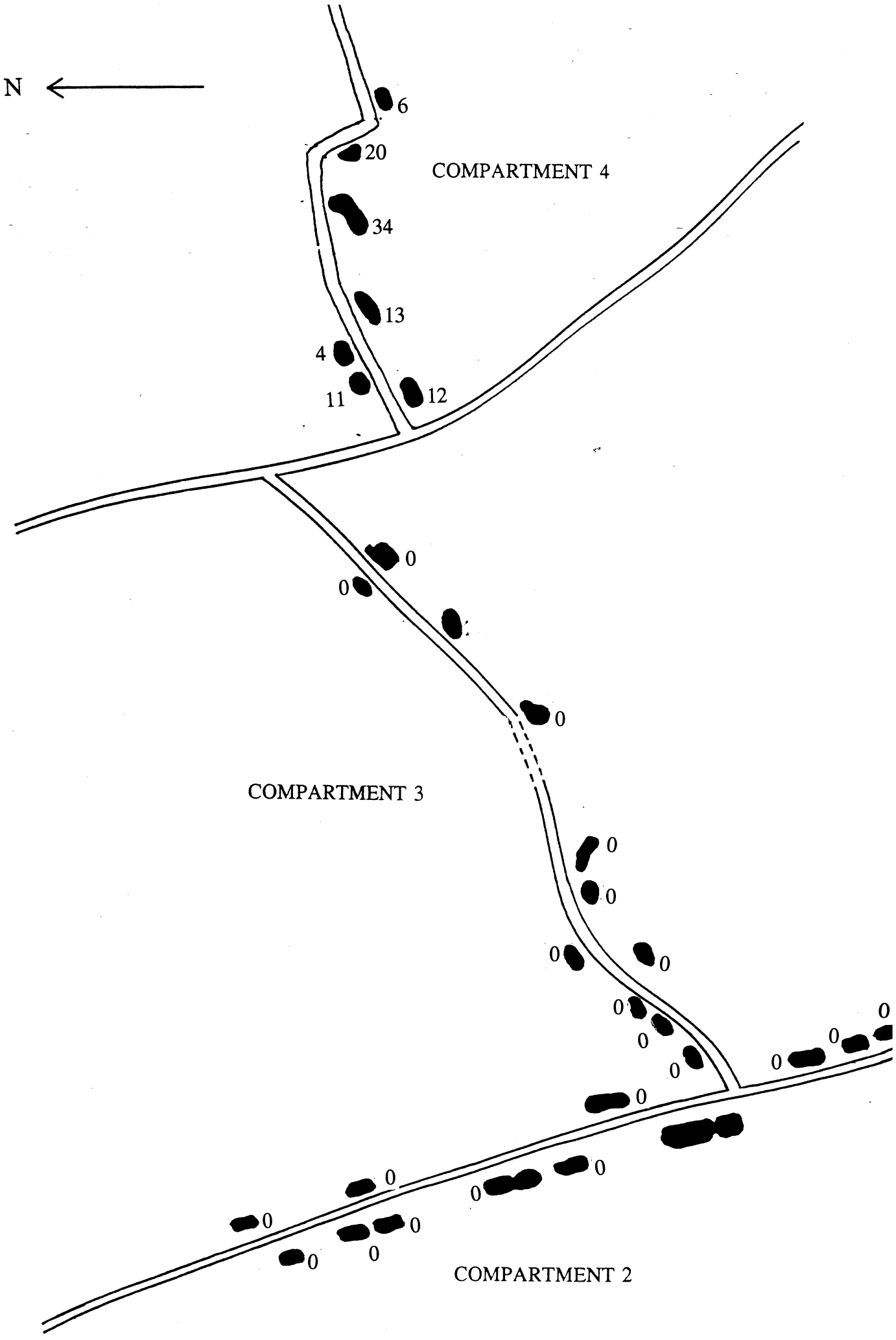
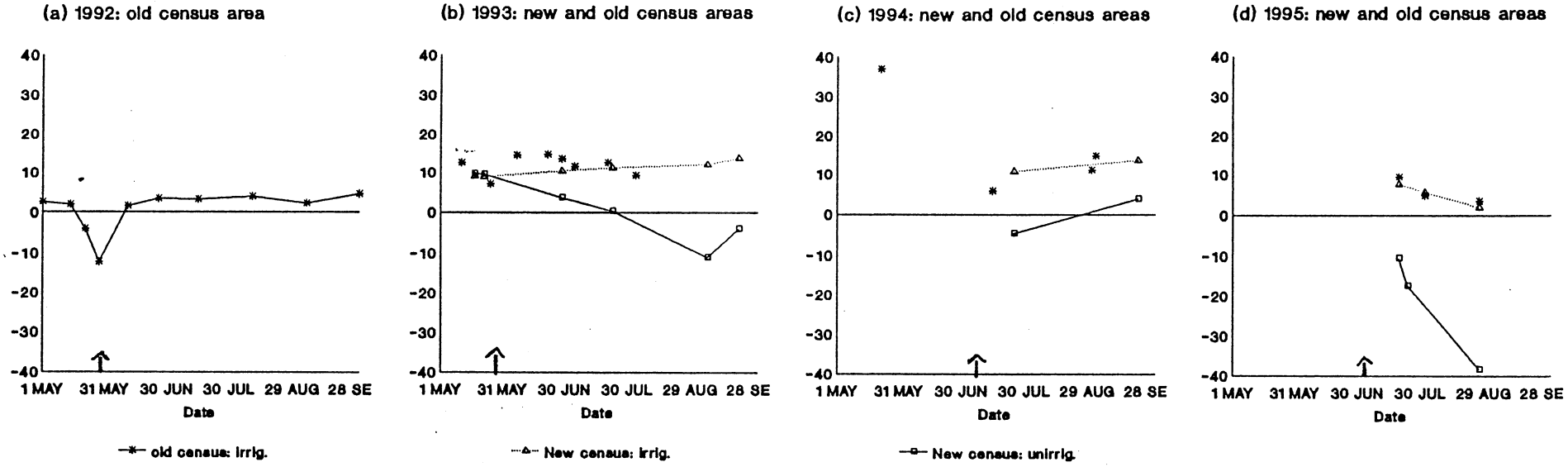


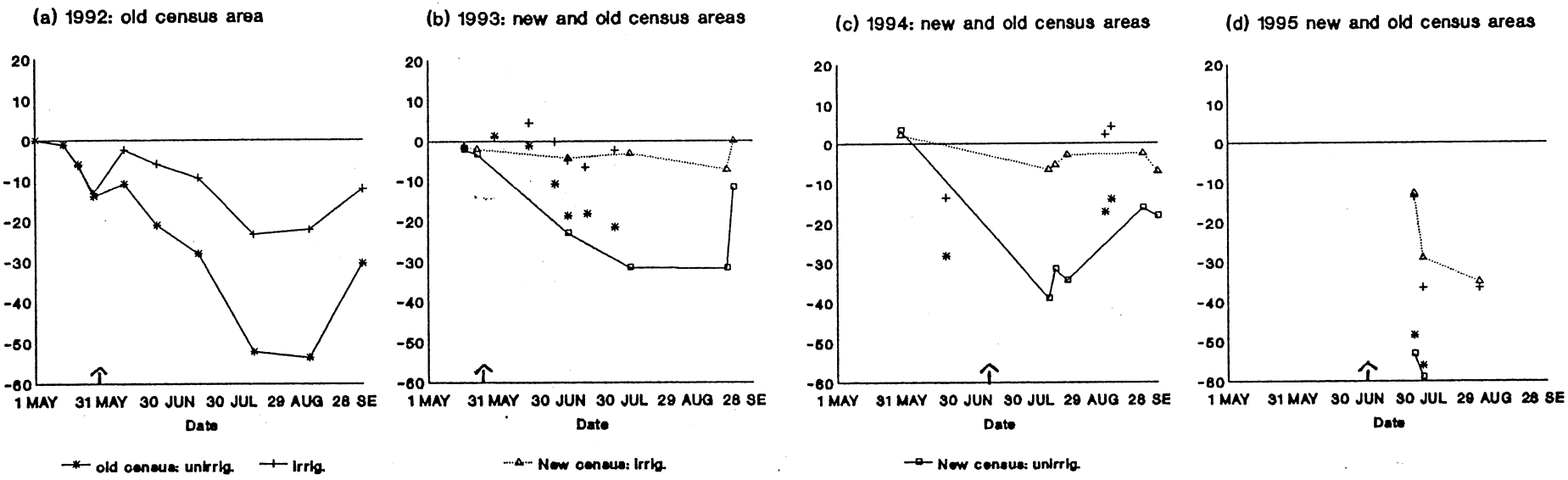
Figure 7 Mean water levels on Little Fen 1992-'95



Horizontal line represents the April 1992 datum

Vertical arrows show start of irrigation each year

Figure 8 Mean water levels on Middle Fen 1992-'95



Horizontal line represents the April 1992 datum

Vertical arrows show the start of irrigation each year