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Chippenham Fen NNR

Botanical, invertebrate and hydrological monitoring 1991-1995
Appendix 2 - Vegetation monitoring

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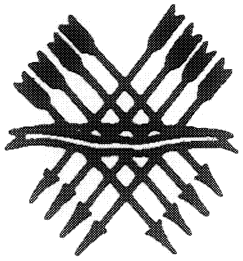

ENVIRONMENTAL CONSULTANCY
UNIVERSITY OF SHEFFIELD

Chippenham Fen NNR
Monitoring 1991–1995

Appendix 2
Vegetation Monitoring

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Report to English Nature
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Chippenham Fen NNR

Vegetation Monitoring
1991–1995

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1. Introduction

Chippenham Fen and Snailwell Poor's Fen (Cambs; NGR TL 648697) together comprise a site considered to be of national importance for the wide range of wetland habitats and associated birds and insects (NCC, 1988). The whole site (SSSI) covers an area of nearly 115 ha, of which 103 ha is currently managed by English Nature as an NNR. The site comprises a wider variety of habitats, including grassland, herbaceous fen, sedge beds, mature woodland and scrub, resulting in a very diverse flora. A number of uncommon species and communities are represented, including the EU-MOLINION Alliance, for which the site is a proposed Special Area of Conservation (SAC site), together with the nearby Wicken Fen and Woodwalton Fen.

The hydrological regime of the site is complex (see main report and Appendix 1). There are some inputs from chalk springs, and water moves around the site through a controlled dyke system (which divides the site into a series of compartments), draining into the Chippenham River. The water regime within the compartments is generally characterised by low water levels during the summer, with levels just below, or slightly inundating the peat surface in winter.

In an attempt to mitigate possible adverse effects of a reduction of water supply (as a consequence of water abstraction) upon the water balance of Chippenham Fen, a supplementary supply has been provided, as part of the 'Lodes/Granta' scheme. A nearby redundant public water supply borehole was brought back into service specifically to supply the fen with water.

Although the supplementary water source is apparently of suitable chemical composition for introduction into a fen ecosystem that is intrinsically of quite low productivity (Wheeler & Shaw, 1987), it was difficult to predict whether the quality and amount of this water, or its method of introduction would be able to sustain the present vegetation and invertebrate resource. With this in mind, a programme of vegetation and invertebrate monitoring was put in place in 1991, the former with the additional aim of attempting to provide an empirical assessment of the changing hydrochemical regime by long-term monitoring of changes in floristic composition of the vegetation, by the use of a cost-effective monitoring programme.

This section reports on the fifth year of the programme of monitoring vegetation composition at Chippenham Fen NNR, and assesses trends evident from the five years of data collection.

2. Rationale

2.1 Introduction

The rationale of the study was developed in response to the original contract specifications, largely in order to provide baseline data for an empirical assessment of the changing hydro-chemical regime following provision of a supplementary water supply. Vegetation monitoring was carried out in selected compartments of the Fen (see Section 3) using three different techniques; random quadrats, permanent quadrats and crop mass estimates.

2.2 Random quadrats

Random quadrats can be used to provide information on vegetation composition throughout a (desirably uniform) stand of vegetation. Depending on the records that are made (here, species presence was specified), they can take less time recording than the detailed records typically made in permanent plots. Here, frequency determinations were made on a compartment basis, and such data are not directly comparable with root frequency determinations made within the permanent plots.

2.3 Permanent quadrats

Permanent quadrats can be used to provide a detailed record of compositional changes at particular points within the fen. They can provide clear evidence of temporal change at these points, but do not necessarily reflect changes elsewhere in the compartments. In this study, permanent quadrats were specified to be used as a basis for examining changes in root frequency of all vascular plant and bryophyte species.

2.4 Crop mass determinations

Estimates of species frequency measure the chance of encountering a particular species. This is often a useful indication of abundance, but it does not necessarily indicate other aspects of change in performance (such as cover or crop mass). This is particularly the case in vegetation that is coarse and species-poor, as is found in some compartments at Chippenham Fen. Cover of individual species would be a better index of abundance in such situations, but is difficult to estimate reliably, particularly in tall fen vegetation. A more reliable method, though time-consuming, is to estimate changes in crop mass components.

3. Monitoring compartments

3.1 Introduction

Four compartments were chosen for monitoring, in consultation with staff of English Nature (Figure 3.1). The constraints upon selection were:

(i) to represent a range of characteristic vegetation-types;

(ii) to represent contrasting hydrological conditions;

(iii) proximity to water-level recording stations;

(iv) a sufficiently large area of visually-uniform, herbaceous vegetation to facilitate extensive sampling.

The compartments chosen were North Meadow and Compartments 6, 8 and 11. Within each compartment, an area of visually-uniform vegetation (*c.* 30 x 30 m) was selected for sampling (Figure 3.2 to Figure 3.5); in one compartment (6), two contrasting vegetation-types were present.

Summary characteristics of the vegetation in the four compartments are given below. Species data for each compartment are provided in Section 5.

Hydrological regime

An important part of the assessment of variation in vegetation composition in the different compartments is to consider the hydrological regime during the monitoring period. Water level data were collected for each monitoring area from one dipwell (see Appendix 1), which for the present purposes, has been assumed to be representative of the monitoring area, although not actually within it. Figure 3.6 is a compilation of the dipwell data taken for these compartments from the hydrological assessment; these data are summarised in Table 3.1. The 'duration lines' shown in Figure 3.6 can be used to illustrate the number of sampling occasions over a given period on which a given water level was exceeded (e.g. Grootjans & Ten Klooster 1980). For example, a convex duration line represents the water regime of a site in which the water table remains mainly in the upper half of its fluctuation range. Of the four compartments, the water regimes in Compartment 8 and North Meadow show the most similarity, with water levels generally lower, but more stable than in Compartments 6 and 11.

In the compartments where vegetation was monitored, dipwells were only installed at the start of the monitoring period (*i.e.* in 1991), and there are therefore no data for a comparable earlier period. This is particularly problematic for the comparison of crop mass data, which was only sampled at the beginning and end of the monitoring period. It may be possible to make some inferences from the longer-standing dipwell records, but time constraints mean that it has not been possible to do this yet. Comparisons of duration lines drawn for different periods could also be useful in looking at changes in the water regime through time.

Table 3.1 Variation in water level in the dipwells closest to the vegetation sampling areas

(Measurements in cm above/below ground surface)

	North Meadow	Compartment 6	Compartment 8	Compartment 11
Dipwell No.	15	14	12	10
Elevation (mAOD)	12.3	12.6	12.7	12.92
Mean	–27.8	–18.3	–23.9	–21.4
Median	–17	–4	–15	–6
St. Deviation	23.7	29.7	21.2	34.7
Minimum	–91	–119	–103	–135
Maximum	0	7	–5	12
Range	91	126	98	147
Spring	–37.1	–17.5	–29.3	–21.0
Summer	–48.7	–46.9	–42.3	–59.1
Autumn	–14.4	–6.3	–13.5	–9.0
Winter	–11.8	–1.9	–11.1	3.7

3.2 North Meadow

This supports a relatively low-growing sward of fen grassland vegetation, with *Molinia caerulea* and *Juncus subnodulosus* as some of the most important component species, but with a well-developed sward of associates giving a clear appearance of a 'diverse' stand. The vegetation supports a number of notable species including *Anagallis tenella*, *Carex hostiana*, *Gymnadenia conopsea* and *Selinum carvifolia*, together with a quite large population of marsh orchids, some of which may be referable to *Dactylorhiza incarnata* ssp. *ochroleuca* (this could not be determined, as the plants were long past flowering by the time of the monitoring). The vegetation is quite different to that of the other compartments monitored but, interestingly, did not have the largest total number of species recorded.

This area is regularly managed by a combination of mowing and grazing. It is cattle grazed every winter, between late September and April, although the animals may be taken on and off the site several times during this period, depending on weather conditions and food availability. 20–30 animals have access to an area of some 30 acres, which includes the monitored area, although they tend to be quite selective in what they eat (leaving the coarsest vegetation to the last). The mowing is carried out in late summer (early September) every 2–3 years, the frequency determined by the warden depending on the amount of the vegetation. Over the last 11 years, it has been mown four times, in 1985, 1988, 1990 and 1993. The most meaningful comparisons taking into account stage in management cycle are therefore made between data collected in 1991 & 1994, and 1992 & 1995. Unfortunately, this means that the crop mass data were not collected at the same point in relation to mowing, the 1991 sampling occurring one year, and the 1995 sampling two years after mowing.

The hydrological regime experienced in the western part of North Meadow was similar to that in Compartment 8 in terms of the range of values experienced, the relatively high variability during winter periods and to depths to which the water table declines during summer. One notable difference is that the range of summer minima over 5 years is *c.* 10 cm, compared with *c.* 20 cm for Compartment 8. The water level only reached the surface at one recording event (interestingly, in August 1991), with mean winter water levels at *c.* –12 cm, and mean summer level of –49 cm. The mean water table depth (–27.8 cm) was the lowest of the four areas.

3.3 Compartment 6

Most of the monitoring area comprised tall sedge (*Cladium mariscus*) beds, which were rather species poor, with most associates being sparsely scattered through the stand. These main areas were interspersed with lower-growing patches dominated by *Molinia caerulea* with some *Schoenus nigricans*.

The sedge is mown on a regular mowing cycle. Prior to the commencement of monitoring, it was mown in 1988; it was subsequently mown in 1992, and is due to be cut again in 1996. The most meaningful comparisons taking into account management cycle are therefore made between data collected in 1991 & 1995.

Records showed that, overall, Compartment 6 was the wettest of the four, with a mean and median water level of –24 cm and –4 cm respectively (Table 3.1). Autumn/winter water levels were fairly stable and close to the ground surface in 1991/2 and 1992/3, but with rather more variation in 1993/4. There was a long period of inundation in winter 1994/5. However, water levels were particularly low in the summers of 1991, 1994 and 1995, reaching depths of more than 100 cm below ground surface.

3.4 Compartment 8

This Compartment is largely dominated by *Molinia caerulea* and *Juncus subnodulosus*, with some *Cladium mariscus* prominent in patches. It is floristically quite similar to Compartment 11, with similar numbers of species recorded. However, more rare fen species were recorded from this compartment than from Compartment 11. More notable species included *Anagallis tenella*, *Carex hostiana*, *Carex pulicaris*, *Selinum carvifolia* and *Thalictrum flavum*, although all are present at low frequencies.

The vegetation is managed as a litter fen by 2-year rotational mowing. It was cut in 1989, 1991 and 1993 (immediately after monitoring had been carried out), *i.e.* monitoring started in the second year of the mowing cycle. The most meaningful comparisons taking into account stage in the management cycle are therefore made between data collected in 1991, 1993 & 1995, and 1992 & 1994.

Winter maximum water levels showed little variation between years, with water tables consistently between 5 and 10 cm below the ground surface (Table 3.1). Water table depths within each winter period were more variable than those exhibited in Compartment 11, and in contrast to this compartment, Compartment 8 was not inundated during the recording period. Minimum values in summer reached between *c.* 55–100 cm below ground level, with the highest summer water table found in 1993 and lowest in 1995.

3.5 Compartment 11

Structurally, this monitoring area was similar to Compartment 8 (which is not surprising as they are close together and share a comparable management regime), though with rather more *Juncus subnodulosus* and less *Cladium mariscus.* There was a similar range of 'notable' species. *Pedicularis palustris* also occurred.

This Compartment is also managed as a litter fen by 2-year rotational mowing, but mowing takes place in alternate years to Compartment 8, *i.e.* monitoring was started in the first year of the mowing cycle. The vegetation was cut in 1990, 1992 and 1994. The most meaningful comparisons taking into account stage in management cycle are therefore made between data collected in 1991, 1993 and 1995, and 1992 & 1994.

Records for Compartment 11 showed initial winter maxima of *c.* 8–10 cm below the ground surface in 1991, rising gradually to *c.* 10 cm above ground level over the next 3 winters (Figure 3.6). Water table depths in summer vary over the recording period, reaching a low of *c.* 125 cm below the ground surface in 1991, rising to *c.* 35 cm below the ground surface in 1993 and then declining over the next two summers to a low of *c.* 130 cm below the ground surface in 1995. In summer 1992 and 1994, the water levels dropped to around –85 cm. This compartment showed the widest variation in water levels, with maximum and minimum water levels of +12 and –135 cm respectively (Table 3.1).

Figure 3.1 Location of vegetation monitoring plots

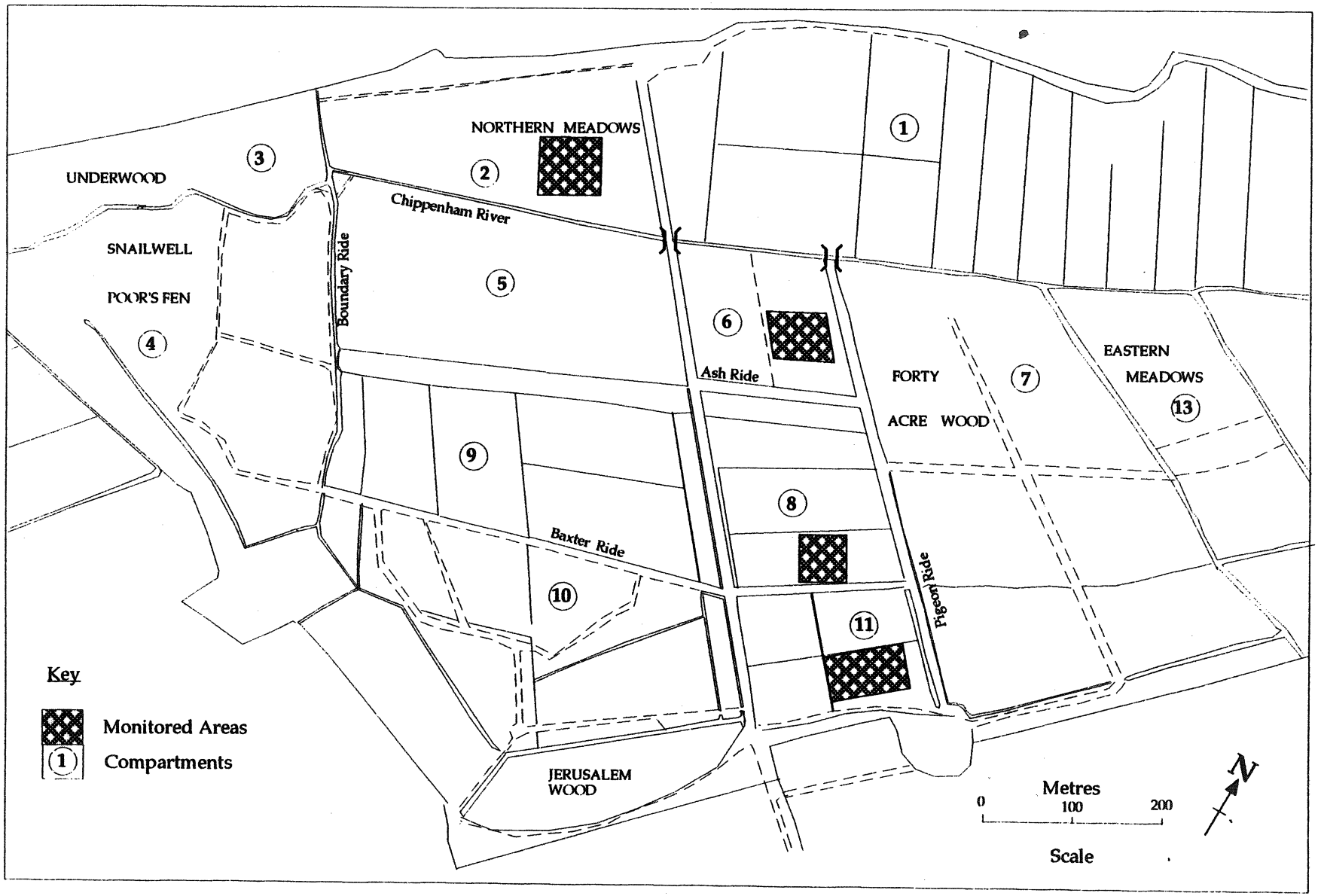


Figure 3.2

Location of North Meadow sampling area and permanent quadrat

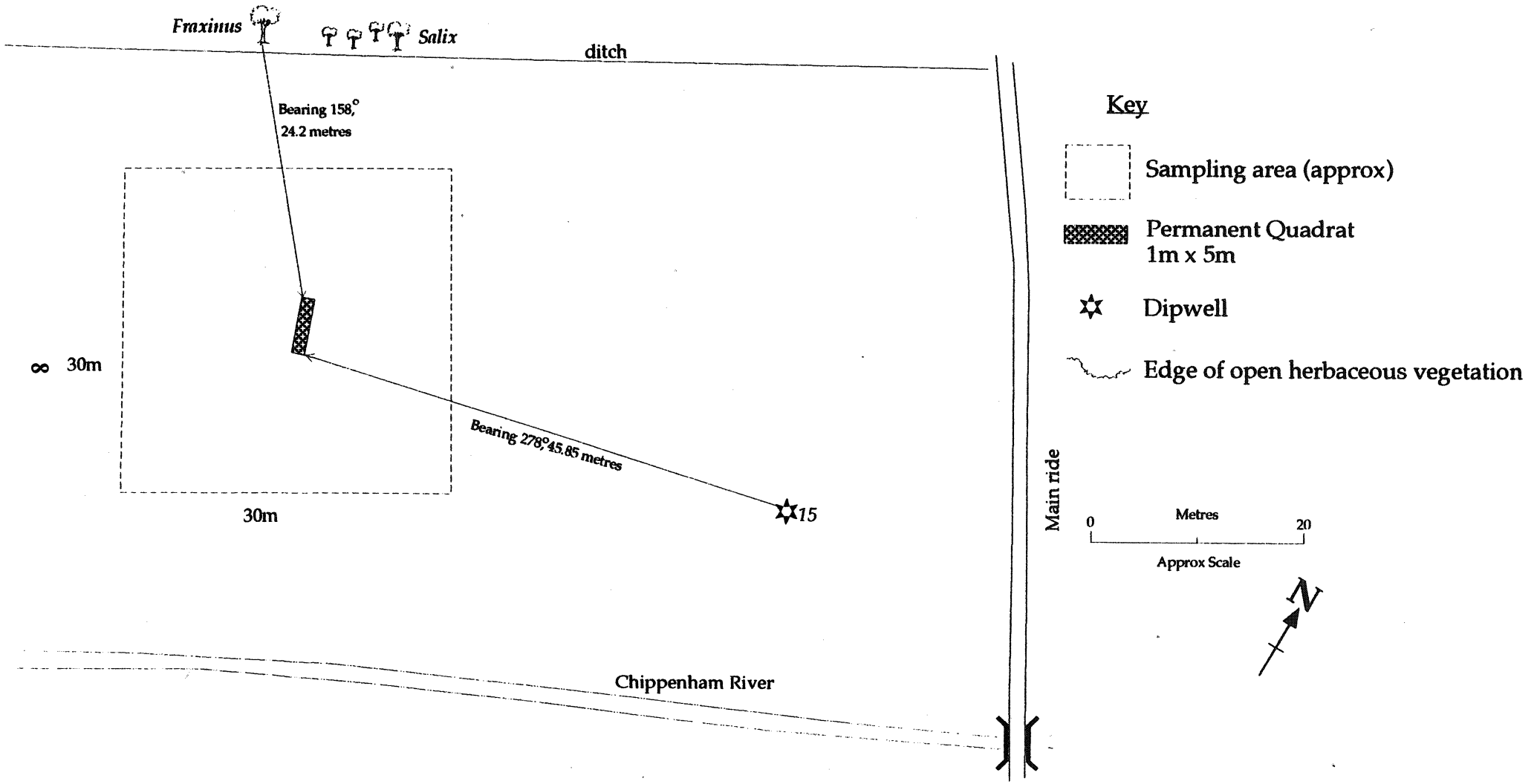


Figure 3.3

Location of Compartment 6 sampling area and permanent quadrats

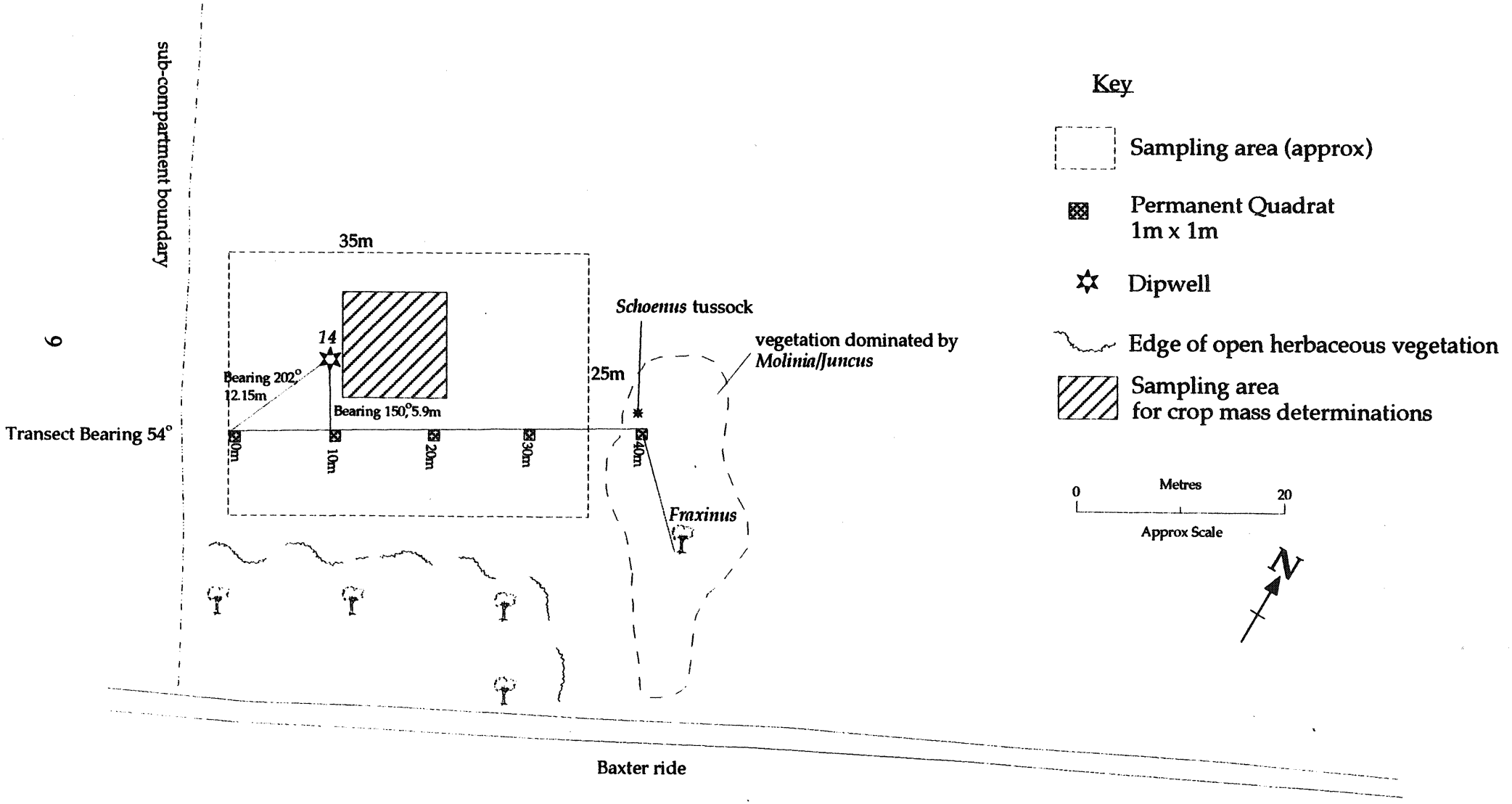


Figure 3.4

Location of Compartment 8 sampling area and permanent quadrat

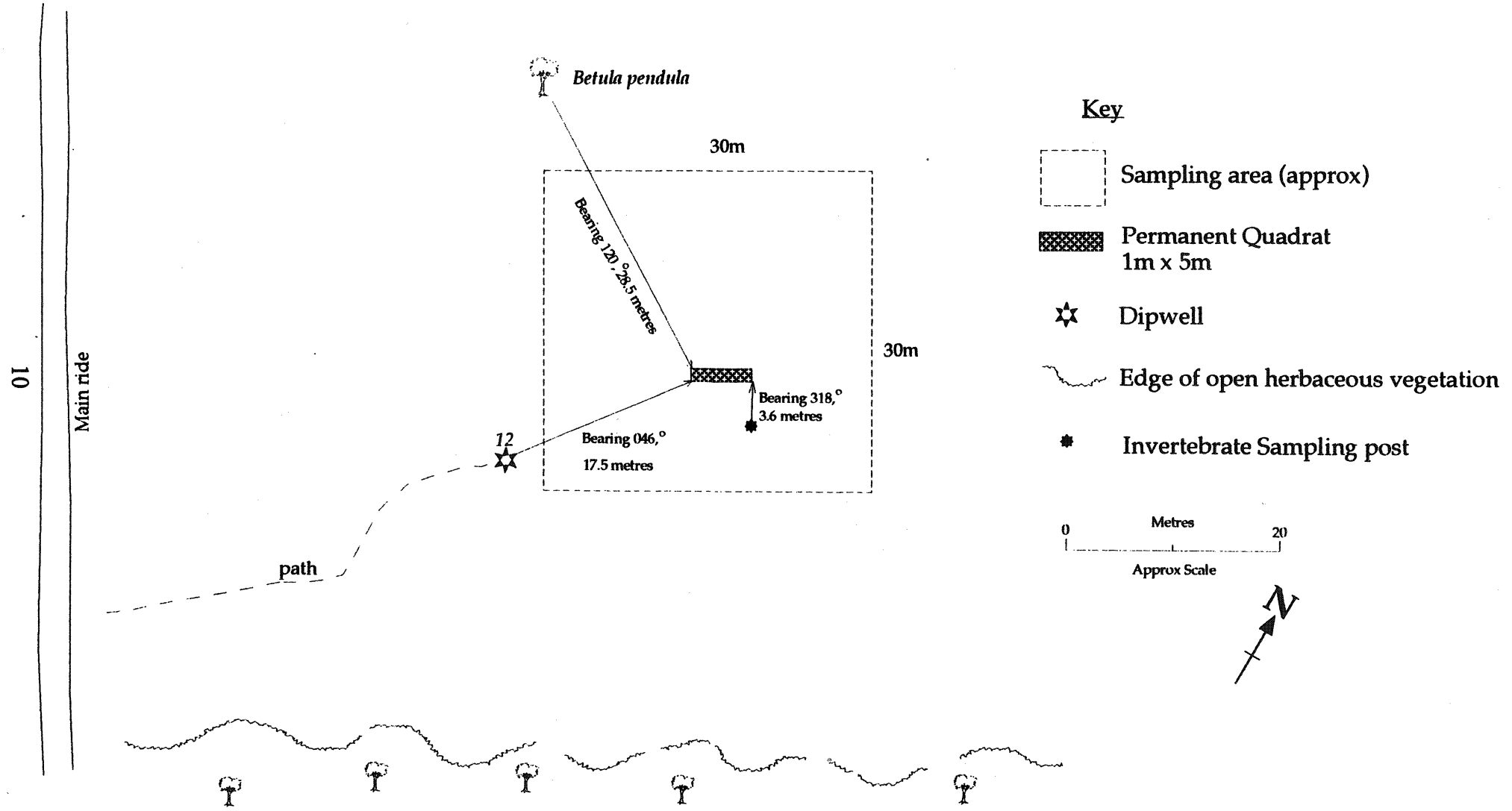


Figure 3.5

Location of Compartment 11 sampling area and permanent quadrat

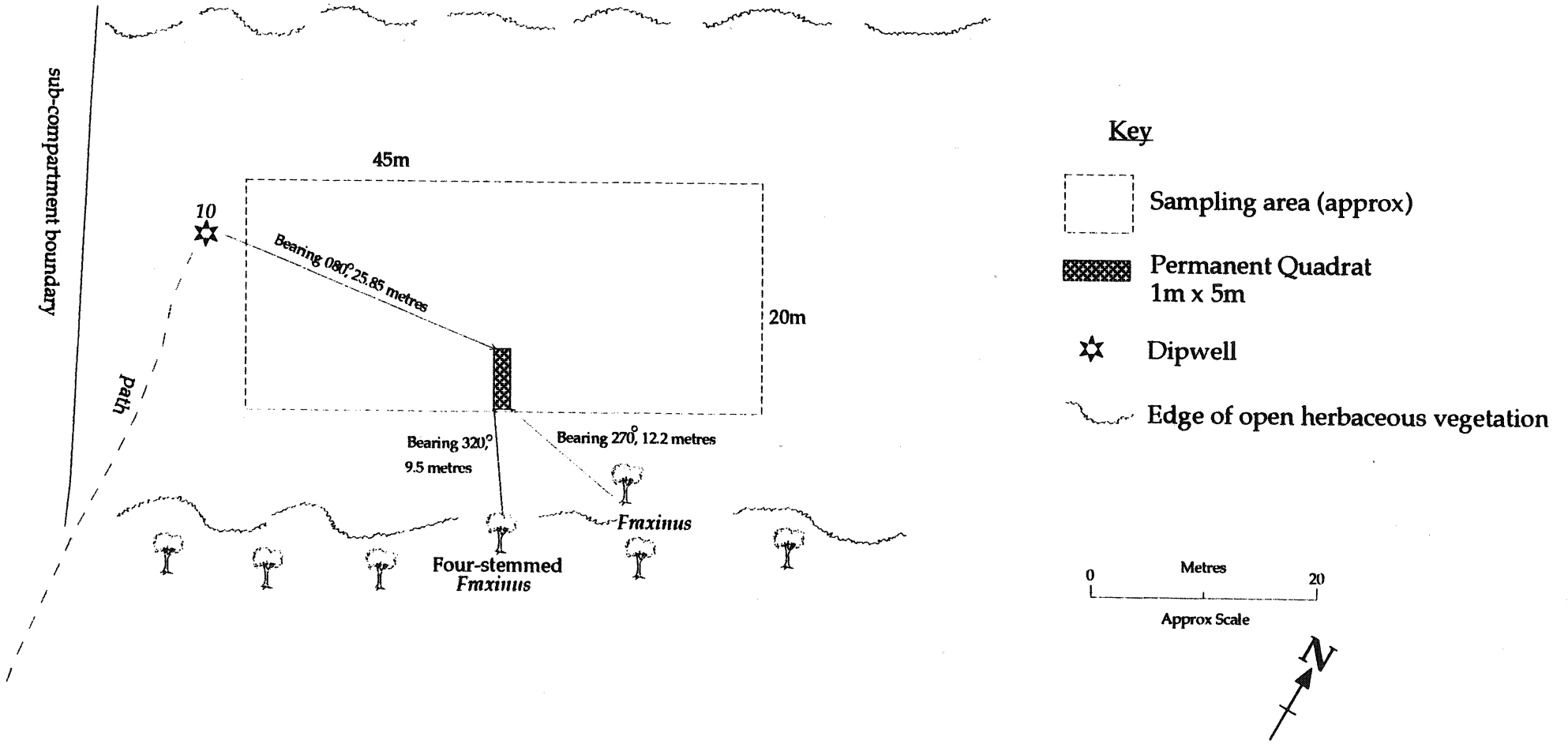
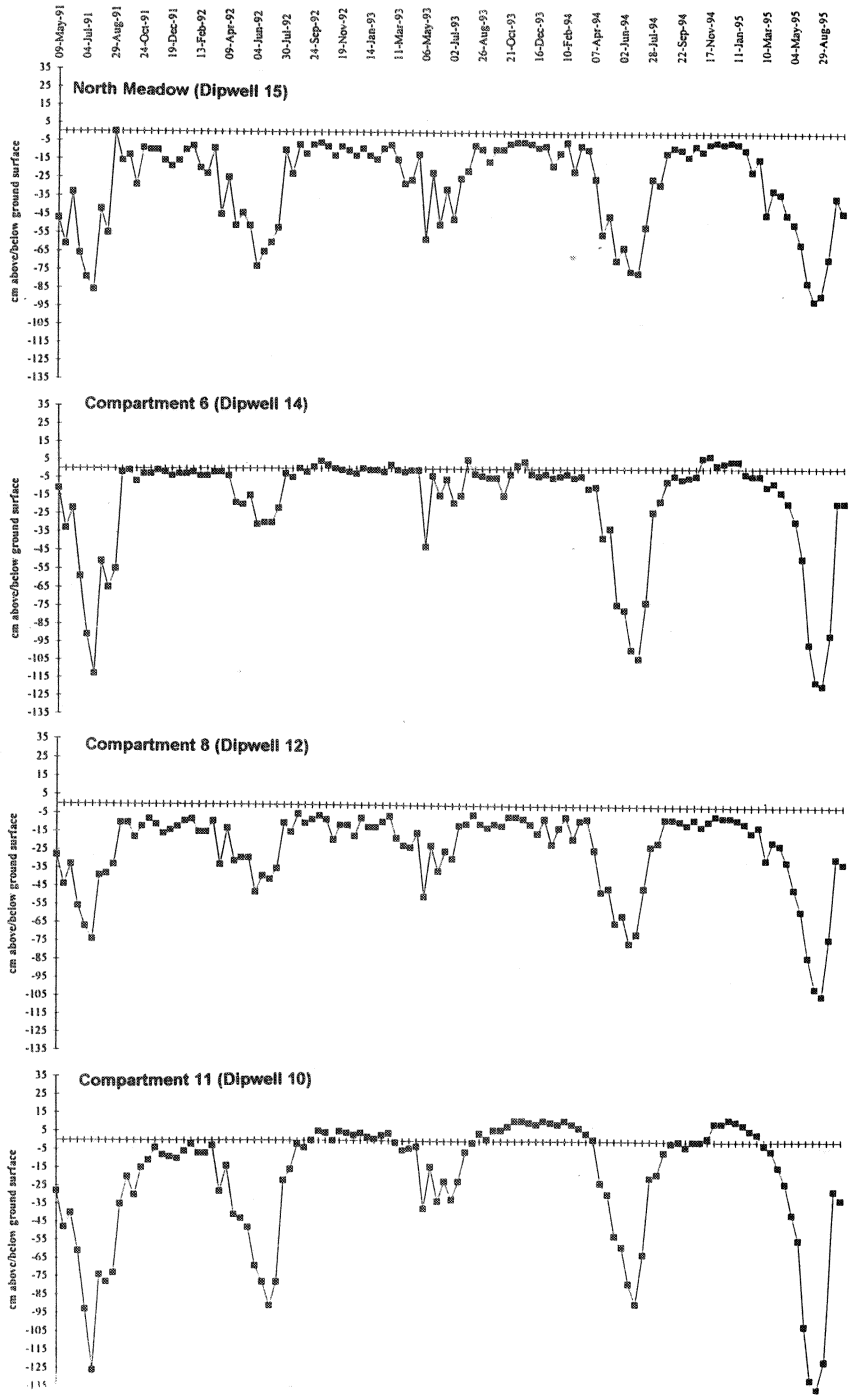
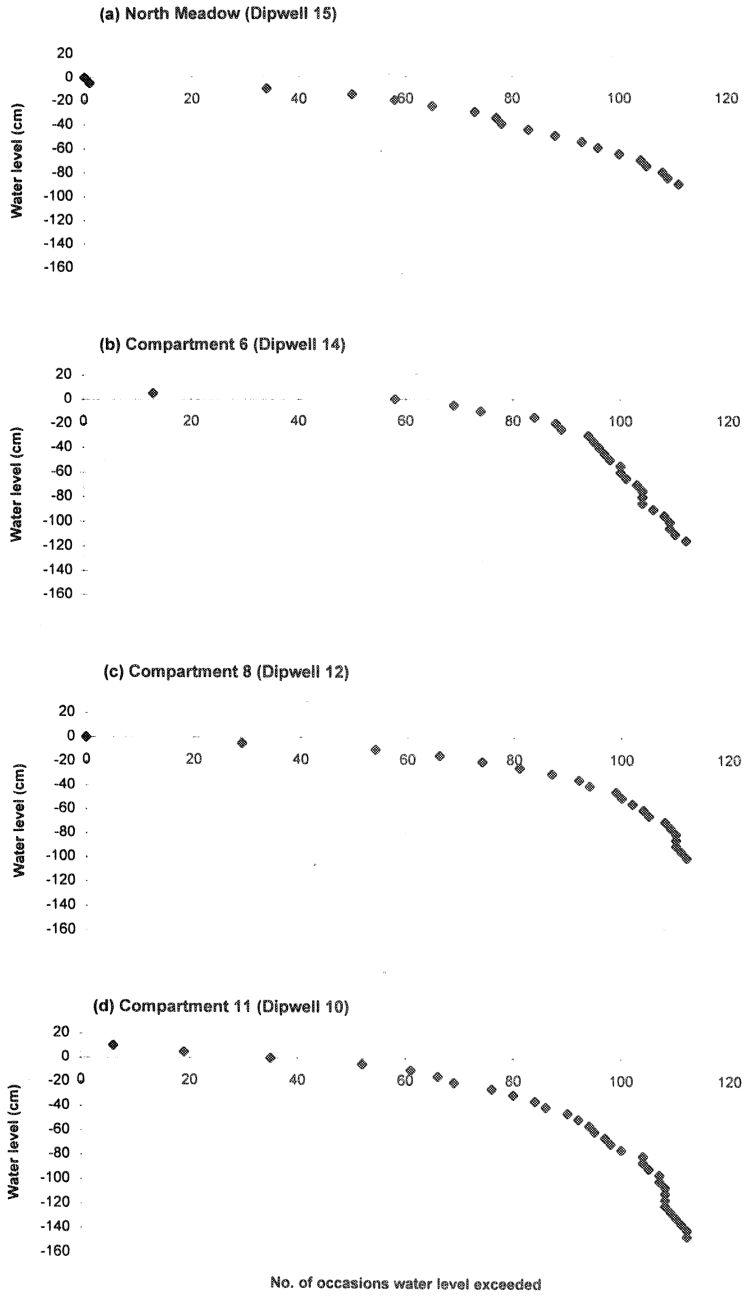


Figure 3.6 Variation in dipwell water levels in North Meadow and Compartments 6, 8 & 11 for the period 9.5.91 to 9.10.95

A. Water level in dipwell (relative to ground surface)



B. Duration lines (Showing no. of occasions on which given water level was exceeded)



4. Methods

4.1 Time of monitoring

Each year, the monitoring was carried out between the last week in July and second week in August. Samples were clipped for crop mass determinations at the beginning of August in 1991 and 1995. The dates were chosen as a compromise between the requirement (i) to attain near maximal biomass in the vegetation (for the crop mass determinations) and (ii) to not cause excessive delay to management operations.

4.2 Random quadrats

Monitoring was based upon estimates of species frequencies, derived from records of species presence in random quadrats. In the first year of the study (1991) a detailed assessment of the results from 30 random nested quadrats (each with eleven nest sizes) was carried out. This suggested that the minimum sample size needed to be 30 quadrats. Two quadrat areas were used: size 1, 50 x 50 cm ($0.25m^2$), for most compartments corresponded to the point of greatest inflection on the species/area curve; all frequency distributions were bimodal, therefore the second quadrat size ($2m^2$) was chosen to correspond to the larger nodum, while $0.25m^2$ corresponded with the smaller nodum. The quadrats were sampled at random from within an area of approximately 30 x 30 m within each compartment. Within each quadrat a record was made of the presence of all plant species, the two quadrat sizes being nested.

Records for random quadrats were made in five consecutive years (1991–1995). Note that within compartment 6, 25 quadrats were recorded from within the main area of *Cladium* with a further 5 from the central *Molinia* dominated area.

4.3 Permanent quadrats

Permanent quadrats were established in 1991 in all four compartments, with subsequent species records made in 1993, 1994 and 1995. With the exception of Compartment 6, the permanent quadrat comprised a 5 x 1 m rectangle, subdivided into 5 contiguous 1 x 1 m squares. Within these sub-quadrats, species presence was recorded in sub-divisions of 16, 25 x 25cm squares, using a strung quadrat. In Compartment 6 a short transect was set up with five, non-contiguous one metre square quadrats, and species presence was recorded from within 25, 20 x 20 cm square sub-divisions, using a strung quadrat. It should be noted that the lack of records in 1992 makes it difficult to assess trends in relation to the management cycle for compartments 8 and 11, as these are mown every two years (*i.e.* the comparisons are between data collected in 1991/1993/1995 with 1994 only).

The locations of permanent quadrats are shown in Figure 3.2 to Figure 3.5. When established in 1991 the corners and 1m intervals for each quadrat were marked with angle iron, to be re-located using a metal-detector. As this caused some problems in re-location, the corners were re-marked using transponders in 1995, which should prove to be more easily re-located.

4.4 Crop mass determinations

In each selected compartment, the vegetation was harvested by clipping ten randomly-located 50 x 50 cm quadrats close to the ground using battery-operated, electric garden shears. In Compartment 6, the vegetation was sampled from a smaller sub-plot within the main sampling area to reduce the variability. However, lack of vegetation uniformity was found to be a particular problem with this sampling procedure.

The cut material, together with moss and litter, was put into black polythene bags and returned to the laboratory, where it was stored at 5°C until it could be sorted into the following components, which were subsequently air-dried and weighed:

Phragmites australis	herbaceous species
Cladium mariscus	bryophytes
Molinia caerulea	other living material
Juncus subnodulosus	litter

5. Results

5.1 Random quadrat data

Results for random quadrat data are presented for each year in terms of:

- mean frequency of individual species in each compartment (Table 9.1 to Table 9.4);
- mean species density (SPD), mean numbers of Principal Fen Species (PFS)[1] and Rare Principal Fen Species (RPFS) (Table 9.5 and Figure 5.1);
- mean proportion of species in the monitoring area encountered in each quadrat (mean frequency SPD, PFS and RPFS) (Table 9.6 and Figure 5.2);
- total number of species, PFS, RPFS and non-fen species in each compartment (Table 9.7 and Figure 5.1, Figure 5.3 and Figure 5.4)

Frequency distribution curves have also been plotted (Figure 5.5 to Figure 5.8), which summarise the trends in changes in individual species frequencies.

5.1.1 North Meadow

Individual species frequencies

Species frequencies recorded in North Meadow using random nested quadrats are given in Table 9.1.

Dominant species
Three species were found at or near 100% frequency throughout the monitoring period: *Juncus subnodulosus, Molinia caerulea* and *Phragmites australis.*

Species which showed some fluctuation, but occurred at > 75% frequency in every year were:

quadrat size 1: *Carex panicea*

quadrat size 2: *Carex flacca, Carex panicea, Cirsium dissectum, Galium uliginosum, Potentilla erecta, Succisa pratensis, Valeriana dioica.*

Associate species
Two species have shown a general increase in frequency at both block sizes during the five years of monitoring, *Angelica sylvestris* and *Selinum carvifolia.*

Two species have shown a general decrease in frequency during the five years of monitoring:

Agrostis stolonifera - declined at both quadrat sizes, but sharpest at size 2.

Cirsium palustre - declined from 1992 level of 37% and 63%, to 10% and 23% in 1995 at quadrat size 1 and 2 respectively.

The frequency of three species showed particularly large fluctuations during the five years monitoring, but varying patterns of increase and decrease:

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[1] A list of principal fen species and rare principal fen species is given in Appendix C

Campylium stellatum - which crashed in 1992 to virtually zero, followed by a rapid increase up to 50% and 77% at quadrat sizes 1 & 2 respectively in 1995.

Centaurea nigra - showed striking fluctuations from year to year; peaking in 1992 and 1994, with lowest frequency in 1993.

Valeriana dioica - population showed a decreased frequency (from 83 to 57%) at quadrat size 1 in 1994, but was recorded in every quadrat at quadrat size 2. However, it seemed to have recovered again by 1995.

There was a massive invasion of *Salix* seedlings in 1995, which had previously been unrecorded.

Many species were very sporadic in occurrence, being recorded at very low frequency, or not at all. These include such species as *Ajuga reptans, Cirsium arvense, Filipendula ulmaria, Fissidens adianthoides, Holcus mollis, Viburnum opulus, Anagallis tenella, Frangula alnus, Dactylorhiza incarnata* and *Gymnadenia conopsea*, and seedlings of *Frangula, Fraxinus, Betula* and *Quercus*.

Summary data

Summary data for species numbers recorded from the North Meadow are provided in Table 9.5 to Table 9.7 and presented graphically in Figure 5.1 to Figure 5.4.

Species numbers

Mean species density was between *c.* 13 and 15 at quadrat size 1. At quadrat size 2, it was around 19 in all years except 1993, when it dropped to 16.3. These were the highest species densities of all the compartments.

Changes in the mean number of principal fen species recorded per quadrat were similar to those in species density, with lowest numbers recorded in 1993. At the larger quadrat size, the mean number of principal fen species recorded in North Meadow was exceeded by Compartment 8 in all years.

The mean number of rare principal fen species recorded in each quadrat remained very stable over the monitoring period, at 2.6–2.8 at quadrat size 1 and 3–3.3 at quadrat size 2, being greater than in the other three Compartments.

The total number of species recorded (57) was more than Compartment 6, but less than both Compartments 8 and 11. However, North Meadow had the highest number of rare principal fen species (8) recorded over the 5 year monitoring period; the variation in species numbers was a mainly result of contributions from non-fen species ().

Mean species frequencies

Trends in mean frequency of species were similar at both quadrat sizes, with much overlap between the values for each species category. Lower frequencies were recorded at the smaller quadrat size (as would be expected). Mean frequency of RPFS was highest in 1994. In most years, the mean frequencies in each category were higher than for the other compartments, illustrating the 'finer-grained' nature of the vegetation.

The frequency distribution curves (Figure 5.6) show that at quadrat size 1, most species were recorded at low frequency, but there was a fairly even spread of species across the higher classes. At quadrat size 2, there was a similar steep fall in numbers of species recorded in the lower frequency classes, but a general trend for a rise in species numbers after the 51–60%

class, with 7–9 species recorded at the highest frequencies in all years except 1993. This reflects well the 'fine-grained' nature of the vegetation, and provides a good contrast with the curves for Compartment 6.

5.1.2 Compartment 6

Individual species frequencies

Species frequencies recorded in Compartment 6 using random nested quadrats are shown in Table 9.2.

Dominant species

Only one species, *Cladium mariscus*, was recorded at 100% frequency throughout the monitoring period. The frequency of *Phragmites australis* fluctuated to some degree, but was recorded at >85 % frequency at both quadrat sizes in all years, with the exception of 1995, when it was recorded at a frequency of only 72% at quadrat size 1. The frequency of *Juncus subnodulosus* was fairly high, but fluctuated quite widely throughout the monitoring period (68–92% at quadrat size 2), with lowest levels in 1993 (the year following mowing).

Associate species

There were relatively few species which were present with more than just a scattered occurrence across the compartment: *Lythrum salicaria, Eupatorium cannabinum, Equisetum palustre, Fraxinus excelsior.*

Several species have shown marked changes in frequency over the 5 years:

Angelica sylvestris - showed a large increase between 1993 and 1994. In 1995, at quadrat size 1, frequency was reduced, but stayed at the same level (40%) at quadrat size 2.

Brachythecium rutabulum - increased markedly in 1994 and 1995.

Cirsium palustre - recorded at a low frequency in most years (or not at all), but with a peak in frequency in 1994.

Equisetum palustre - showed a slight reduction in frequency between 1991 and 1992, but this was followed by a substantial increase in 1994.

Eupatorium cannabinum showed the most dramatic changes, declining sharply from 77% and 100% at quadrat sizes 1 and 2 respectively in 1991, to 12% at both block sizes in 1993, and then rising sharply to 63% and 97% at quadrat sizes 1 and 2 in 1994.

Fraxinus excelsior – there was a marked increase in frequency of seedlings between 1992, 1993 and 1994, followed by a reduction in 1995.

Lythrum salicaria – there was a reduction in frequency between 1991 and 1992, followed by a rise to high frequencies in 1995 (76 % and 92% at quadrat size 1 and 2 respectively)

Molinia caerulea – recorded at a low frequency in 1991 to 1993 (or not at all), but was present at 20-24% (quadrat size 1) and 44-28% (quadrat size 2) in 1994 and 1995 respectively.

Alga were only recorded in 1993 (16% and 32% at quadrat size 1 and 2 respectively).

Many *Betula* seedlings were recorded in 1994 (20–40%) (previously unrecorded), although these had dropped to a frequency of 8% by 1995.

Reflecting the peak in species density in 1994, a large number of previously unsampled species appeared at low frequencies, and were not recorded again in 1995:

Agrostis stolonifera	*Anagallis tenella*	*Bromus commutatus*
Cirsium arvense	*Fissidens adianthoides*	*Juncus inflexus*
Lycopus europaeus	*Pellia endivifolia*	*Plantago major*
Schoenus nigricans	*Scrophularia aquatica*	

Summary data

Summary species data for Compartment 6 are provided in Table 9.5 to Table 9.7 and presented graphically in Figure 5.1 to Figure 5.4.

Species numbers

There was a small decline in species density and mean PFS from 1991 to 1993, but numbers of species increased substantially in 1994, followed by a slight decrease in 1995. This compartment had the lowest total number of species (53), and much lower mean species density than the other three Compartments.

The mean number of rare fen species has remained fairly steady at *c.* 2 species since monitoring started, being only slightly greater at the larger quadrat size than the smaller. This can be attributed to the dominance of two 'rare' species at high frequencies: *Cladium mariscus* and *Juncus subnodulosus*. This also explains why this Compartment had a higher mean number of rare fen species than Compartment 11.

Mean species frequencies

Mean frequency of species density was fairly constant, and similar at both quadrat sizes. Mean frequency of principal fen species showed a similar trend, although the mean was higher at quadrat size 2 than at quadrat size 1. This reflects the sparse distribution of associate species, which are mainly picked up at the larger quadrat size.

The mean frequency of RPFS increased sharply to 88% in 1992 from 34% in 1991, decreasing again in 1993 and 1994, with another increase in 1995. In this Compartment, the mean frequency of RPFS was much greater than that of SPD or PFS, again attributable to the dominance by *Cladium mariscus* and *Juncus subnodulosus.*

The frequency distribution curve (Figure 5.6) shows a much flatter base than those for the other compartments, and with less variation, with most species being recorded at low frequency, with only a few dominant species present at high frequency. The curve is less steep in 1994, reflecting the increase in numbers of species in this year. This is particularly noticeable at quadrat size 2.

5.1.3 Compartment 8

Individual species frequencies

Species frequencies recorded in Compartment 8 using random nested quadrats are shown in Table 9.3.

Dominant species

Three species were recorded at or near 100% frequency at both quadrat sizes throughout the monitoring period: *Phragmites australis, Juncus subnodulosus* and *Molinia caerulea. Galium*

uliginosum and *Calliergon cuspidatum* were recorded with > 80% frequency at quadrat size 2, but at lower frequencies in quadrat size 1.

Associate species

Two species have shown a trend of increasing frequency during the five years of monitoring:

Angelica sylvestris – increased from 16.7 to 70% and 60% to 86.7% at quadrat size 1 & 2 respectively.

Anagallis tenella – this was not recorded at all in 1991, but was found in subsequent years, and was recorded at 23 and 30% at quadrat size 1 & 2 respectively in 1995.

Several species showed a peak in frequency in 1994, with a subsequent decline in 1995. These included *Equisetum palustre*, *Fissidens adianthoides* (present at a generally low frequency, but recorded at 13 and 53% frequency in 1994 at quadrat sizes 1 and 2 respectively), *Fraxinus excelsior, Mentha aquatica, Vicia cracca* and *Lythrum salicaria*.

Eurhynchium praelongum and *Brachythecium rutabulum* both showed a general decrease in frequency since 1991, and were not recorded in 1995.

Cirsium dissectum was recorded at very low frequencies in 1992 and 1993, compared with 1991 and 1995.

Brachythecium rutabulum declined from 1991 to 1994, but was recorded at high frequency in 1995.

Cladium mariscus and *Carex flacca* both increased in frequency between 1992 and 1993, but decreased between 1994 and 1995.

Species with particularly scattered distributions were either not recorded, or present at low frequencies. These included many non-fen species.

Response to management

Of the more common species, most showed no apparent consistent trend in response to mowing regime: *Galium uliginosusm, Phragmites australis, Juncus subnodulosus, Molinia caerulea, Angelica sylvestris, Calliergon cuspidatum, Eupatorium cannabinum, Mentha aquatica, Potentilla erecta.*

Carex panicea and *Samolus valerandi* both showed a trend for an increase in frequency between years 1 and 2 of the mowing cycle, while species showing a trend for decrease in frequency were: *Cirsium palustre, Lythrum salicaria, Valeriana dioica, Frangula alnus, Agrostis stolonifera* and *Fraxinus excelsior. Carex lepidocarpa* showed a trend for reduction in frequency between years at quadrat size 1, but this was not apparent at quadrat size 2.

It is noticeable from Table 9.3 and Figure 5.3 that there was a slight increase in species numbers recorded between the first and second years following mowing. This is largely a result of more species being recorded at low frequency in the second year (see below).

Summary data

Summary species data for Compartment 8 are provided in Table 9.5 to Table 9.7 and presented graphically in Figure 5.1 to Figure 5.4.

Species numbers

Mean species density rose slightly in 1993 in quadrat size 1, but in quadrat size 2, not until 1994. Mean PFS was lower than SPD, but showed similar changes at quadrat size 2. At

quadrat size 1, mean PFS was more consistent, at around 9 species. Total numbers of species recorded were lower than Compartment 11, but this is largely a result of fewer non-fen species. Compartment 8 consistently had the highest mean number of principal fen species recorded per quadrat, and the highest total number of PFS of all the areas monitored.

Mean numbers of rare fen species are low (*c.* 2 species), but remained fairly consistent over the monitoring period, although the total number of rare fen species recorded (7) was only one less than in the North Meadow, and greater than in Compartment 11.

Mean species frequencies
Trends in mean frequency of SPD and PFS were similar at both quadrat sizes, being fairly consistent (with qs2 > qs1), but with a slight peak in 1992 and 1994. Mean frequency of RPFS showed a large increase at both quadrat sizes in 1992, with a subsequent decline in 1993 and 1994, but a further increase in 1995. However, these figures are undoubtedly influenced by the patchy occurrence of *Cladium*.

The distribution curve of species frequencies (Figure 5.7) shows a fairly good correspondence between the values in 1992 and 1994, *i.e.* the years following mowing, with a trend for fewer species to be recorded at low frequencies in these years. This can probably largely be attributed to the lower total numbers of species recorded in these years.

5.1.4 Compartment 11

Individual species frequencies

The frequencies of individual species recorded in Compartment 11 using random nested quadrats are shown in Table 9.4.

Dominant species
Several species were recorded at high frequency throughout the monitoring period; *Phragmites australis* and *Juncus subnodulosus* at both quadrat sizes, and species such as *Calliergon cuspidatum*, *Mentha aquatica*, *Molinia caerulea*, *Galium uliginosum* at slightly lower frequency at quadrat size 1, reflecting the slightly sparser distribution.

Associate species
Three species have shown a general increase in frequency over the five years of monitoring:

Cardamine pratensis - was not recorded in 1991, and only present at low frequency in 1992. Frequency increased sharply after mowing in 1992 at both block sizes. In 1994 frequency had further increased in quadrat size 2, however, a decrease was noticeable at quadrat size 1.

Mentha aquatica - the increase in frequency was most apparent at the smaller quadrat size.

Filipendula ulmaria showed a general trend for an increase in frequency, but only at quadrat size 2.

Species which have shown a general decrease in frequency during the five years of monitoring include *Brachythecium rutabulum* and *Eurhynchium praelongum,* which both declined between 1991 and 1993 and were not recorded in 1994 or 1995, and *Cirsium palustre,* which declined dramatically from 80% and 97% in 1991, to zero and 10% in 1994 at block size 1 and 2 respectively, but made a subsequent recovery in 1995 to 43 and 70%.

The population of *Eupatorium cannabinum* decreased sharply between 1991 and 1993/1994, followed by a rise in 1995 to levels approaching those recorded in 1991.

As noted in other compartments, a high frequency of *Salix* seedlings was recorded in 1995. *Betula* and *Frangula* seedlings had also increased in frequency, although there had been a reduction in *Fraxinus.*

Note high frequency of *Lycopus europaeus* in 1995 at quadrat size 2 (previously at low frequency), and the high frequency of *Potentilla reptans* in 1993, also otherwise at low frequency. *Anagallis tenella* was most abundant in 1992.

Species with particularly scattered distributions were either not recorded, or present at low frequencies. These include many non-fen species.

Trends in relation to management
Species showing a trend for a reduction in frequency between years 1 and 2 following mowing were: *Molinia caerulea, Equisetum palustre, Cirsium palustre, Deschampsia cespitosa, Symphytum officinalis, Agrostis stolonifera,* while *Mentha aquatica* and *Potentilla erecta* tended to increase in frequency following mowing. *Angelica sylvestris* and *Cladium mariscus* increased in frequency in the second monitored period (*i.e.* between 1993 and 1994, but not 1992 and 1993).

Thus, the only consistent species response to mowing in both Compartments 8 and 11 was shown by *Cirsium palustre.* The trend for an increase in species numbers between the first and second years following mowing noted in Compartment 8 was only apparent here in the second period monitored (*i.e.* between 1993 and 1994, but not between 1991 and 1992, when there was a decrease in species numbers recorded).

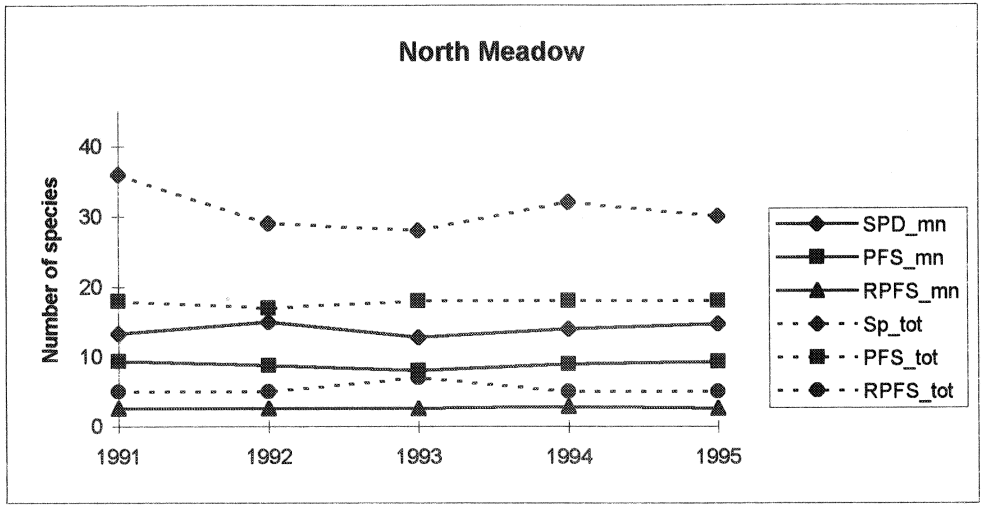
Summary data

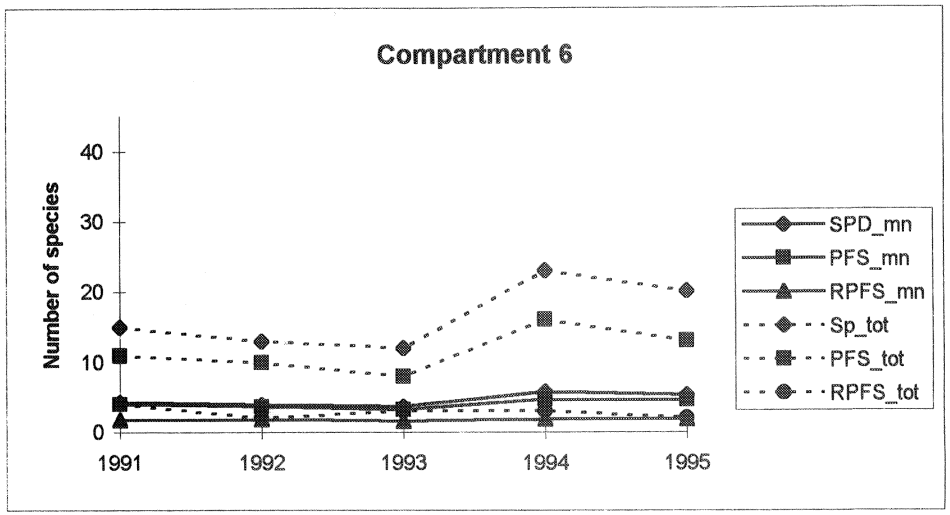
Summary species data for Compartment 11 are provided in Table 9.5 to Table 9.7 and presented graphically in Figure 5.1 to Figure 5.4

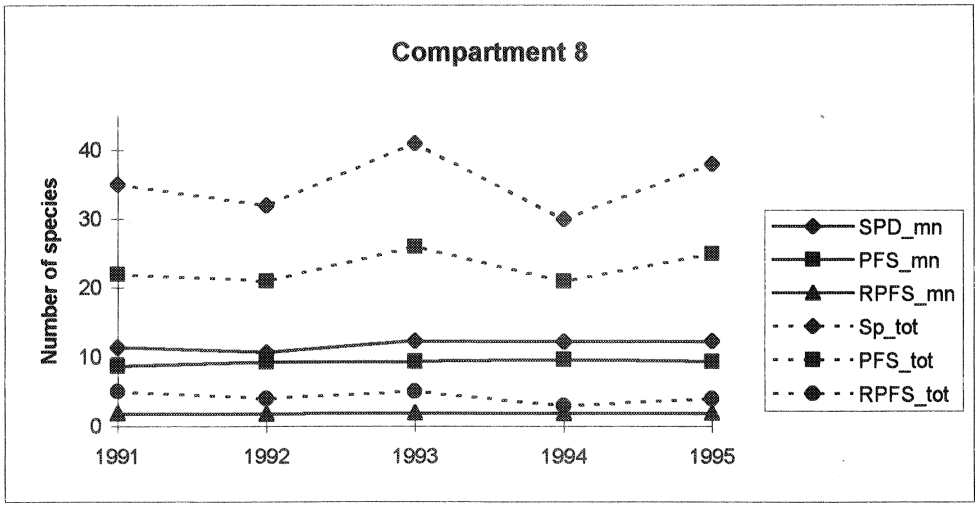
Species numbers
Mean species density and principal fen species at quadrat size 1 were lowest in 1992 and 1994 (*i.e.* in the second year after mowing). At quadrat size 2 the trend was similar, but the 'peak' in 1993 was not apparent. This is consistent with the trend noted above for an increase in total species numbers in the second year after mowing. Mean numbers of RPFS remained fairly constant at both quadrat sizes, varying between 1.2 and 1.5 species per quadrat. Compartment 11 had fewer principal and rare principal fen species recorded than Compartment 8, but a greater number of non-fen species.

Species frequencies
Mean frequency of species density remained fairly constant over the monitoring period. That of PFS showed more variation, being lowest in 1991 and 1994, while RPFS increased sharply up to 1993 at both quadrat sizes, but subsequently declined.

The distribution curves of species frequencies (Figure 5.8) were similar to those for Compartment 8, with most species being recorded at low frequencies. At quadrat size 2 there was a sharp distinction between first and second year mowing records, with greater numbers of species being recorded at 91–100% in the year following mowing. This difference was apparent at quadrat size 1 in 1995 and 1993, but not in 1991. In 1995, no species were recorded at between 71 and 90 % frequency at quadrat size 1.







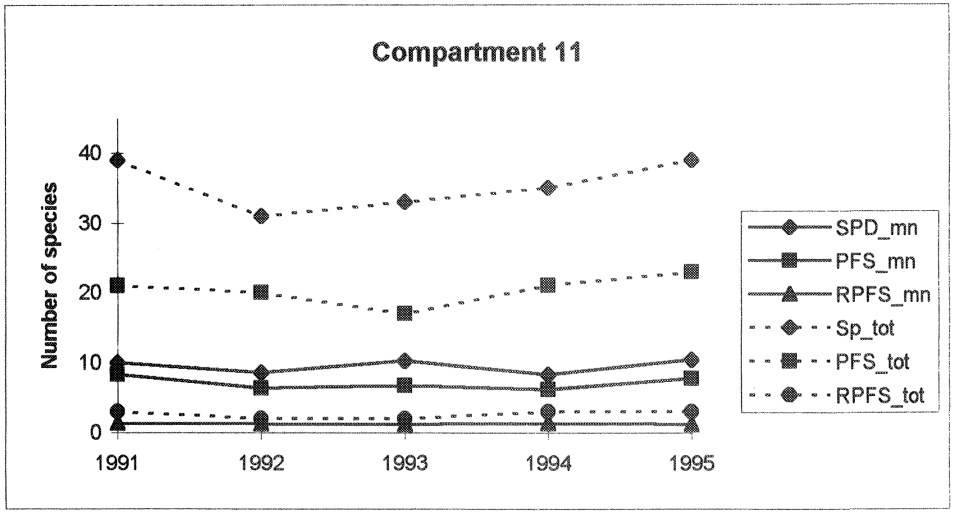
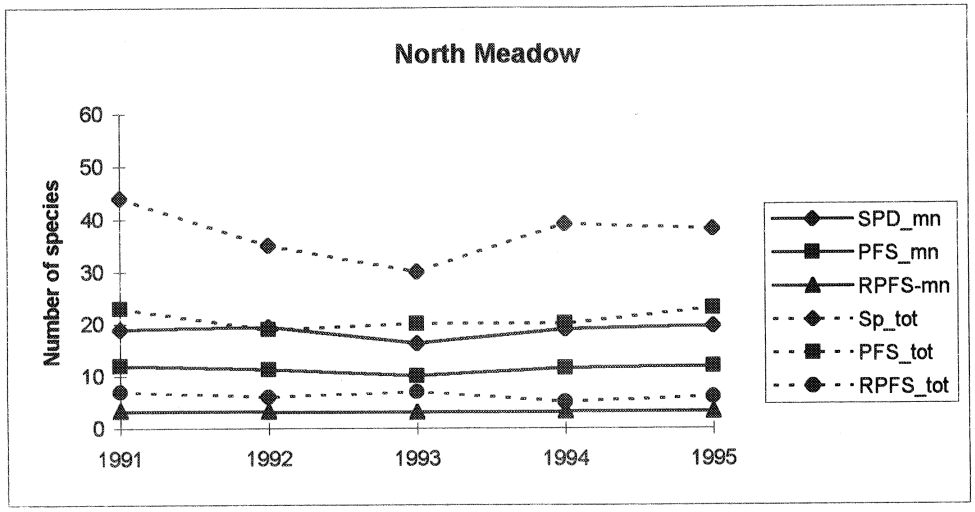
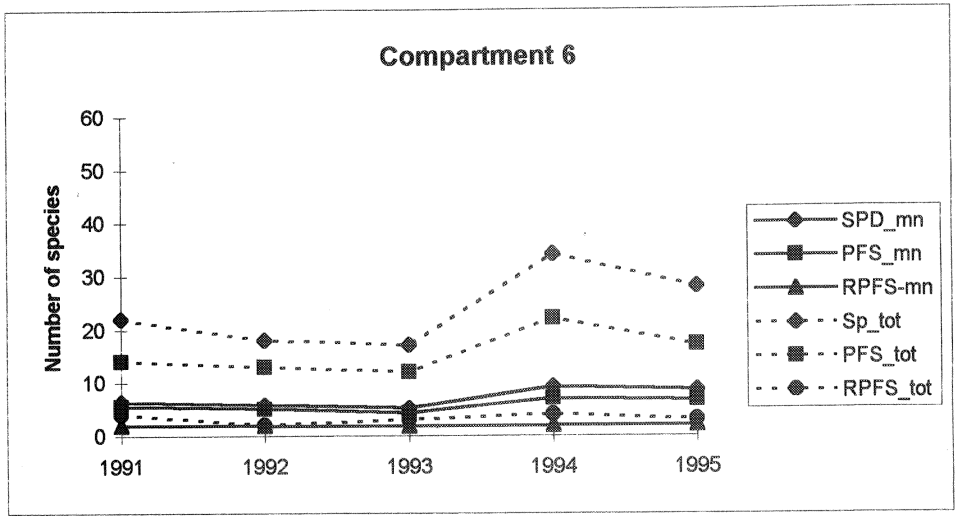
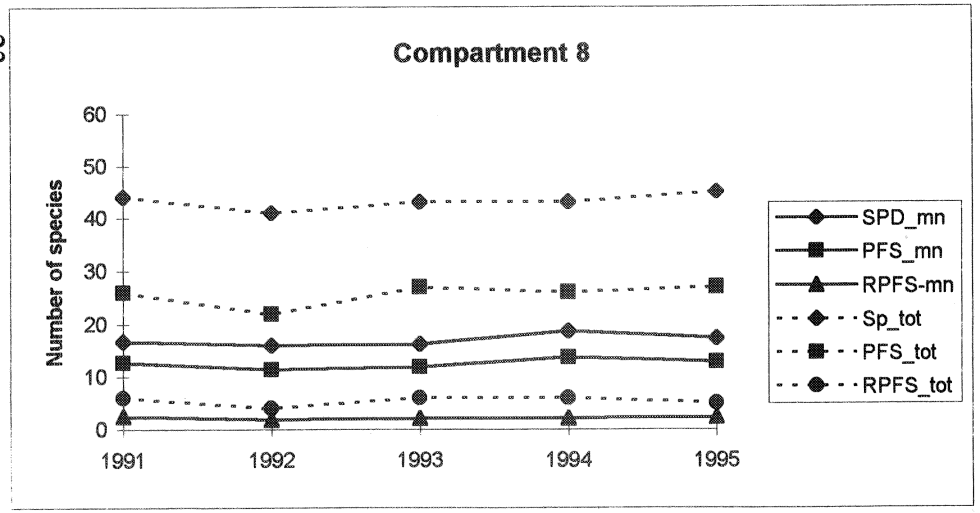


Figure 5.1a **Mean (mn) and total (tot) numbers of species, principal fen species (PFS) and rare principal fen species (RPFS) recorded in random quadrats ($0.25m^2$)**







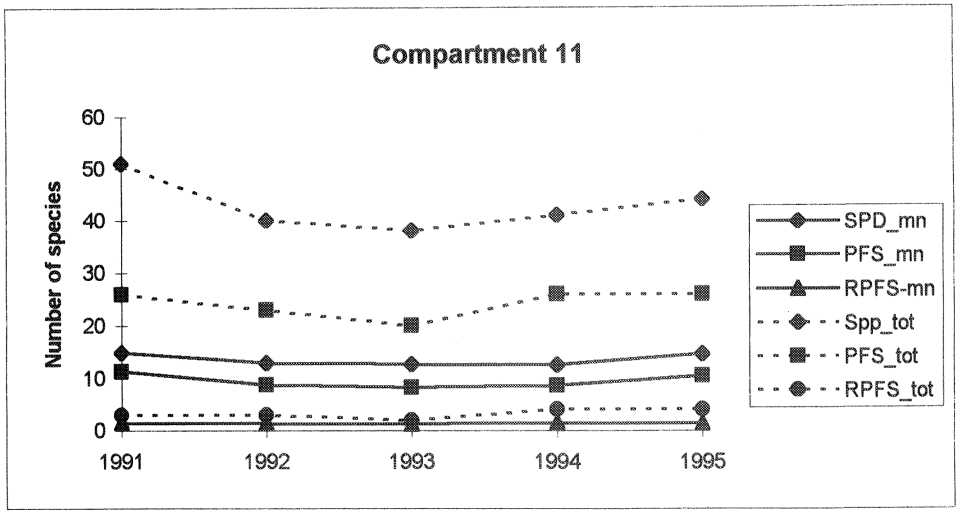
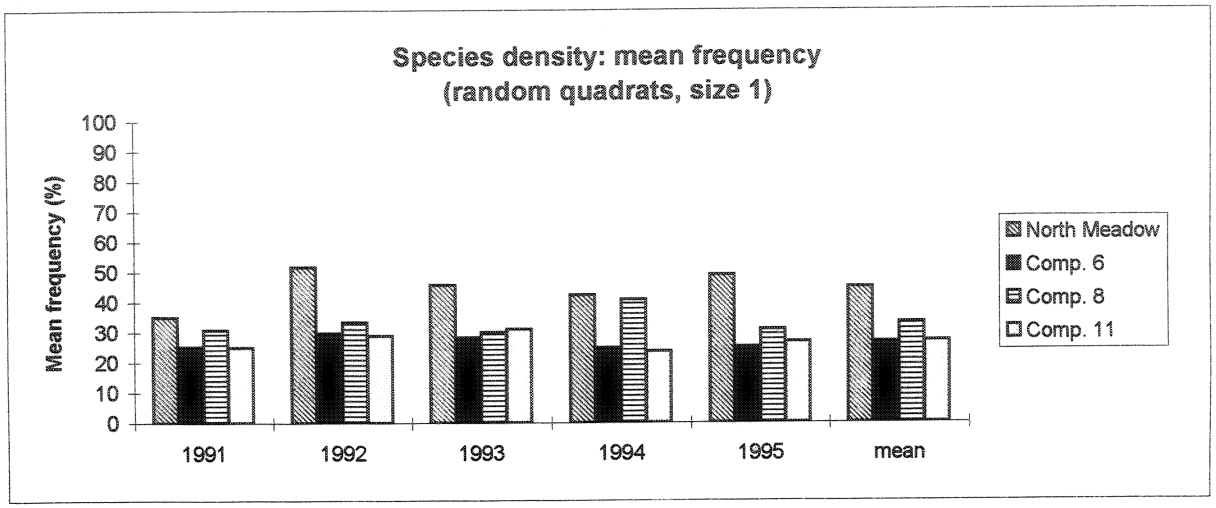
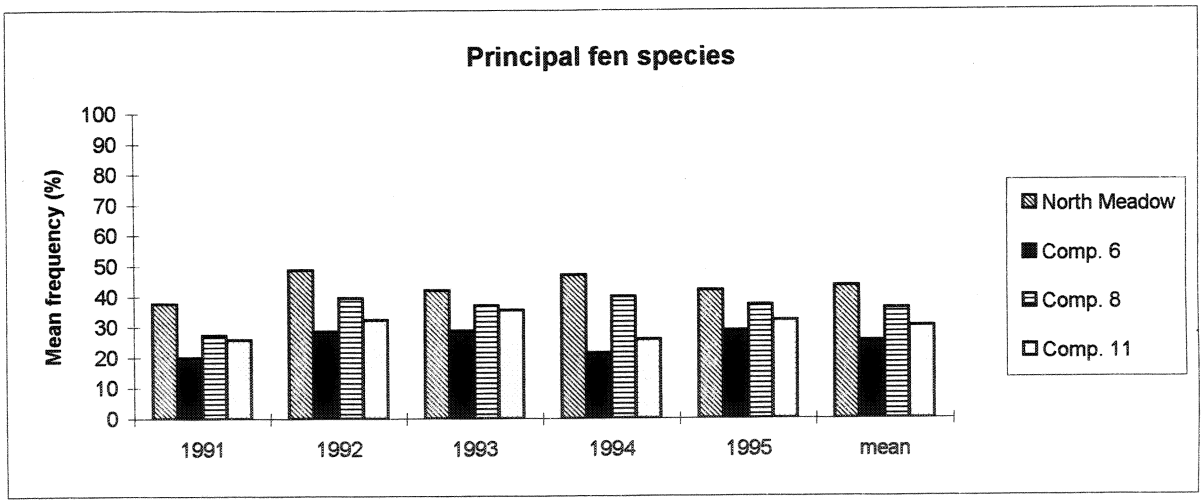


Figure 5.1b **Mean (mn) and total (tot) numbers of species, principal fen species (PFS) and rare principal fen species (RPFS) recorded in random quadrats ($2m^2$)**

Figure 5.2a Mean species frequencies recorded in random quadrats (size 1)





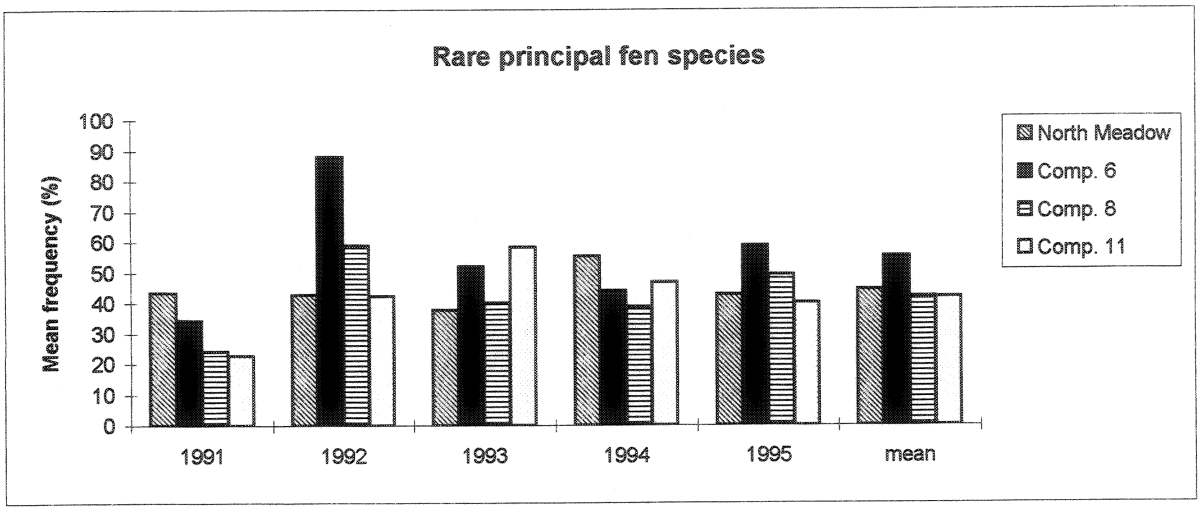
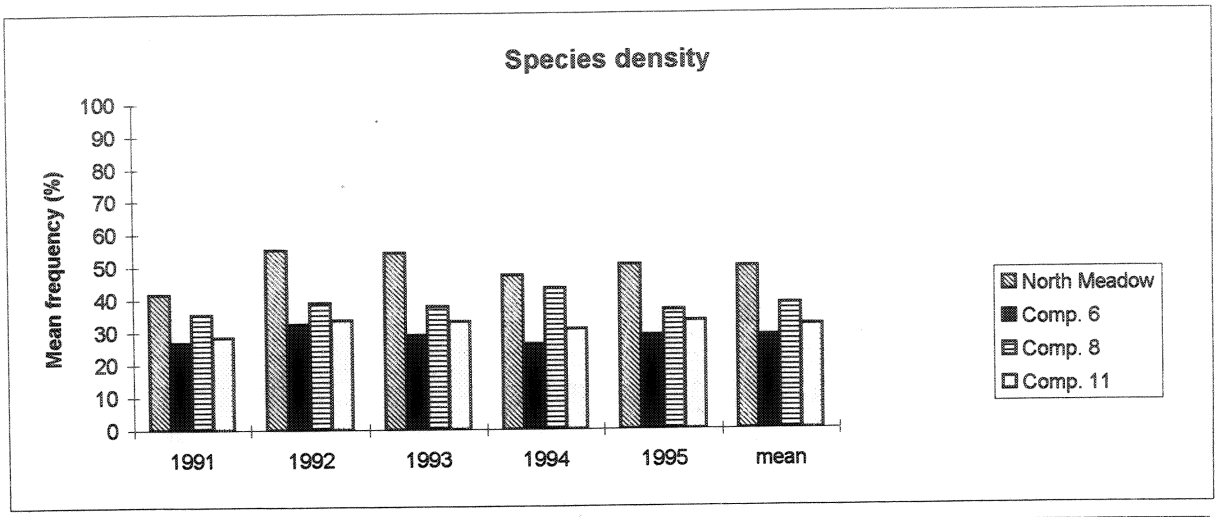
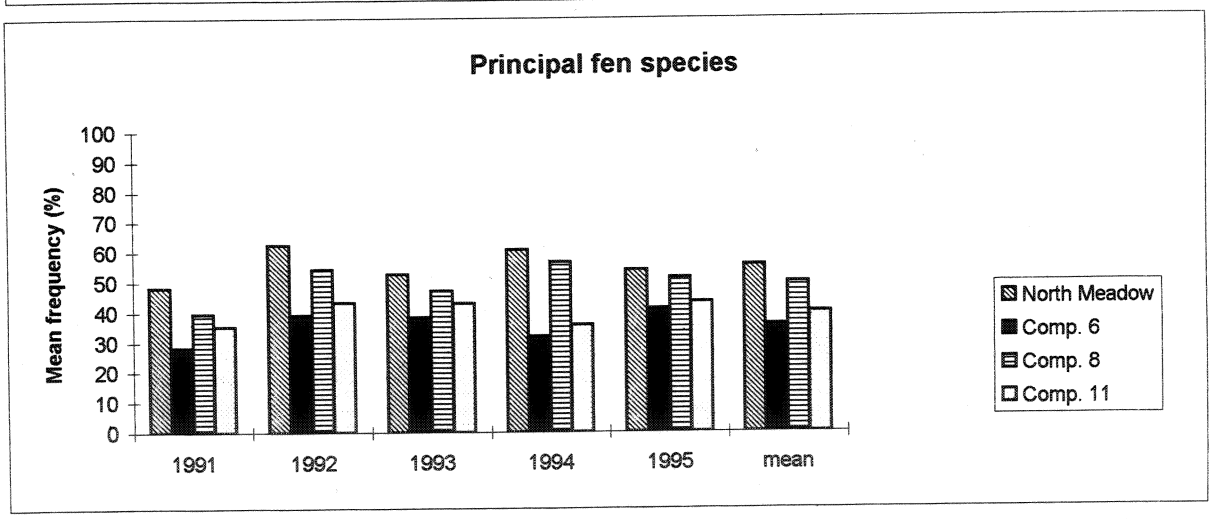


Figure 5.2b Mean species frequencies recorded in random quadrats (size 2)





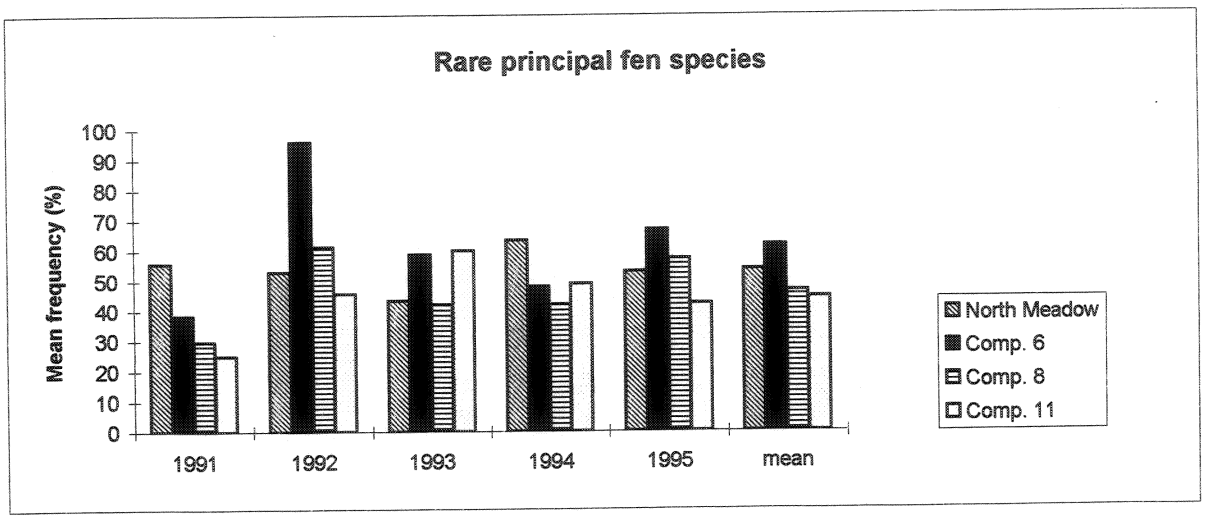
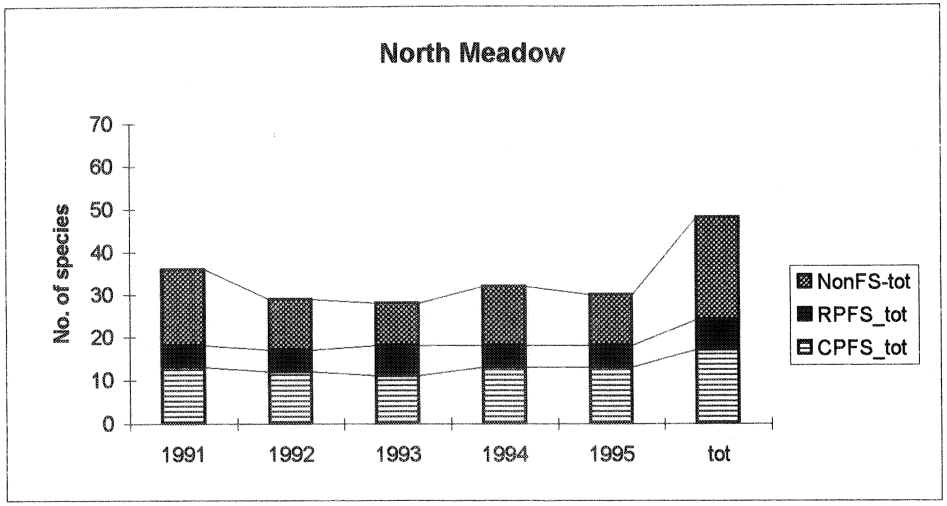
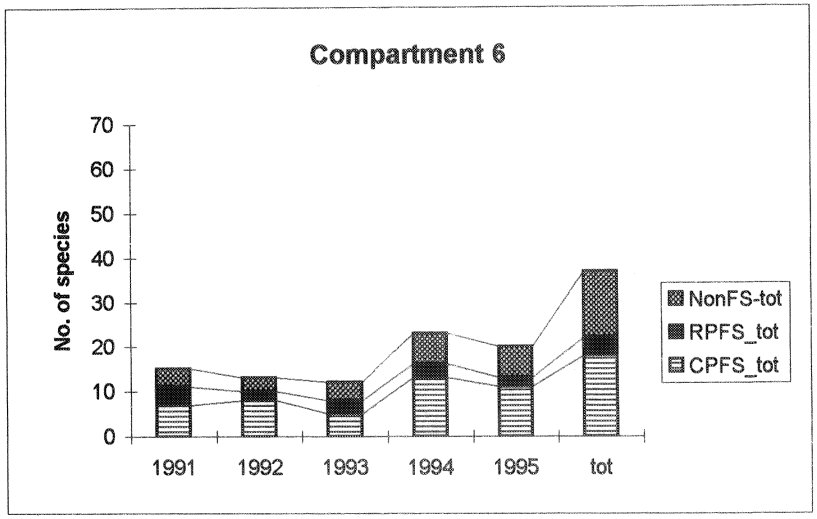
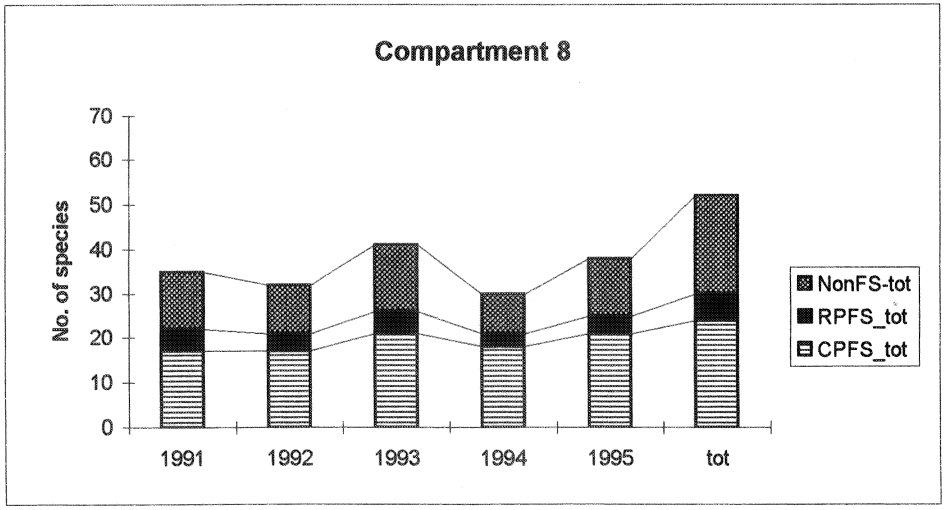


Figure 5.3a

Variation in total numbers of principal (PFS), rare (RPFS) fen and non-fen species (quadrat size 1)







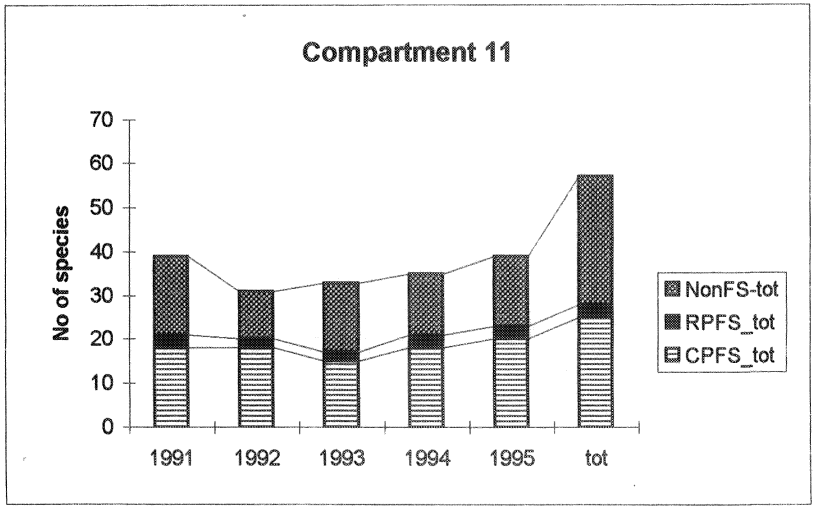
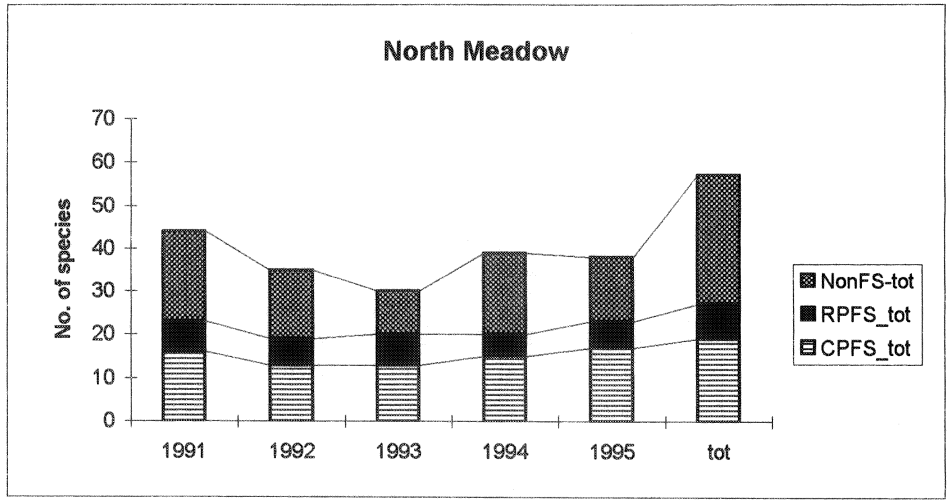
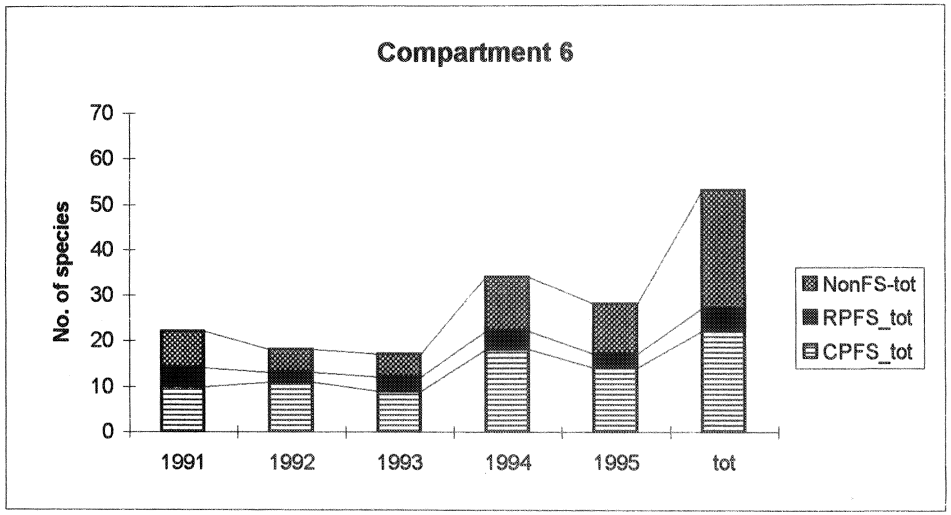
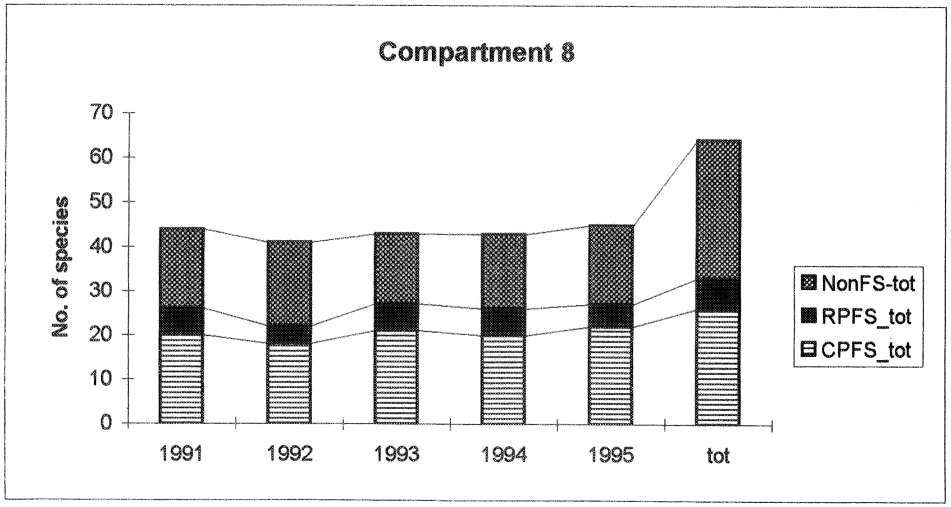


Figure 5.3b

Variation in total numbers of principal (PFS), rare (RPFS) fen and non-fen species (quadrat size 2)







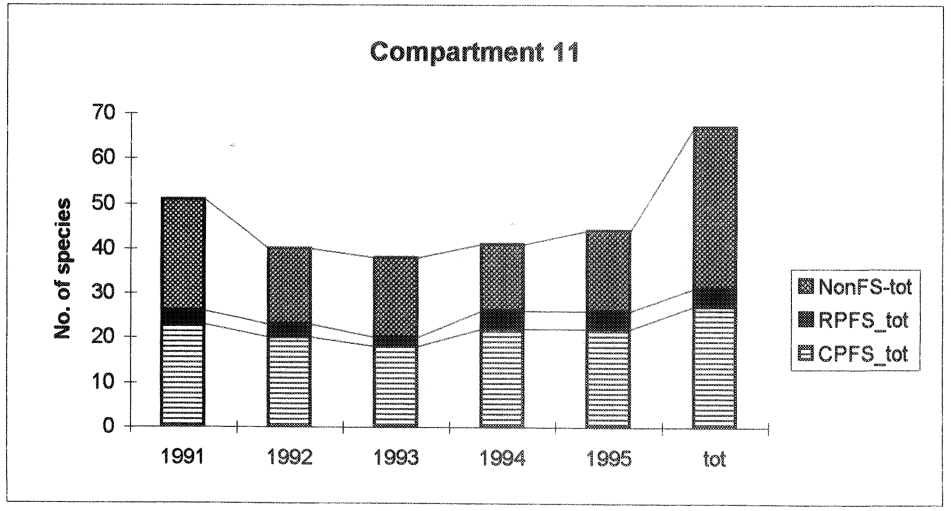
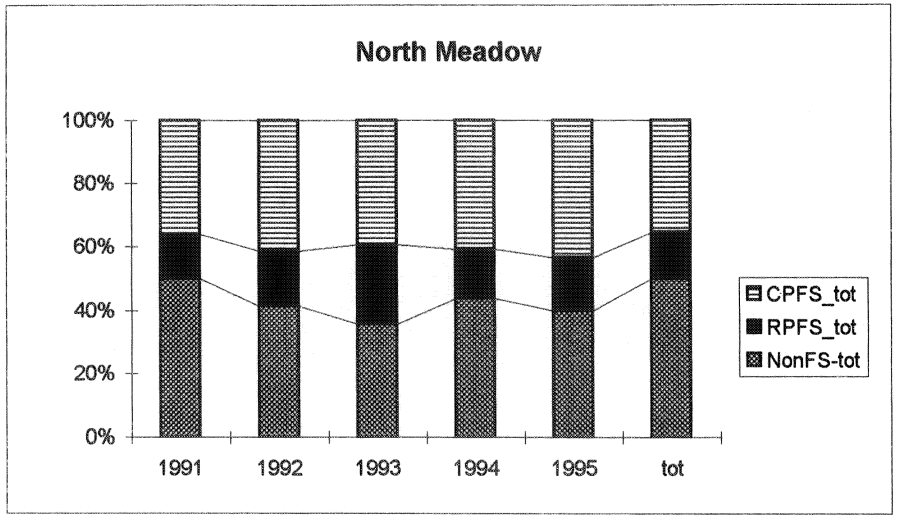
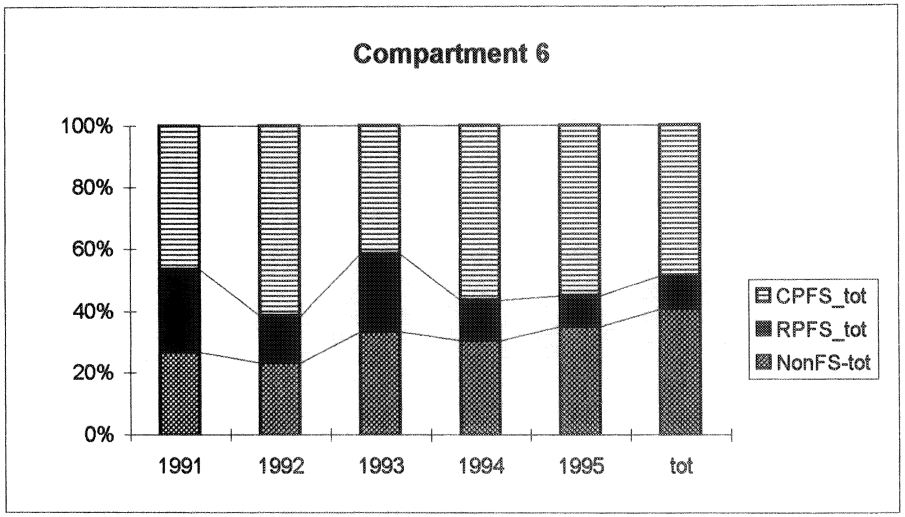
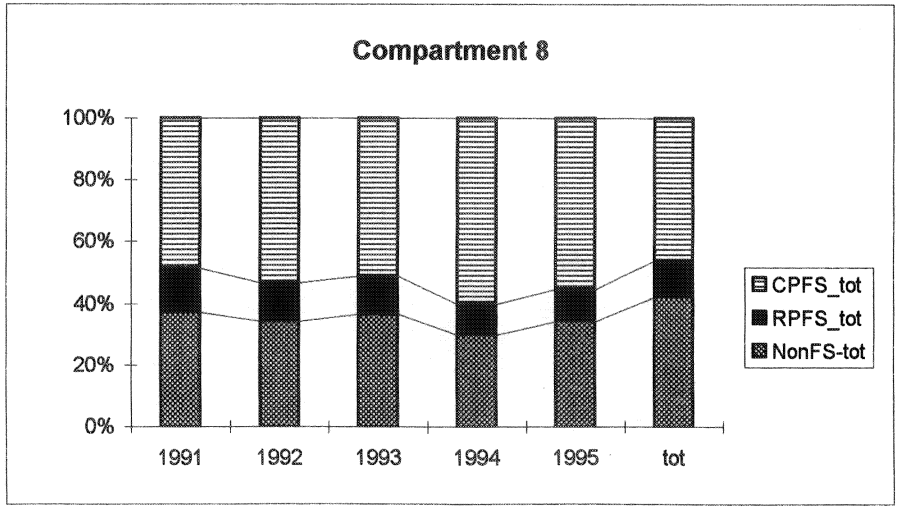


Figure 5.4a

Variation in numbers of species recorded, as a percentage of the total number of species (quadrat size 1)







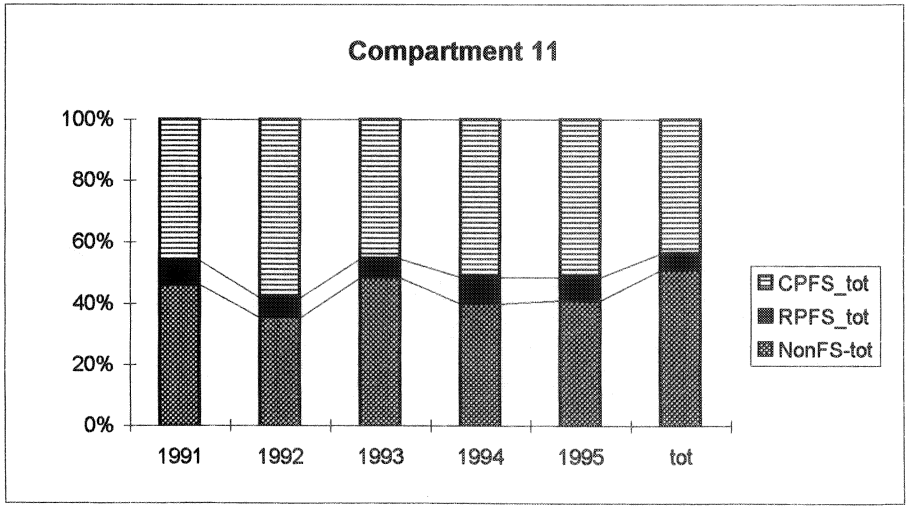
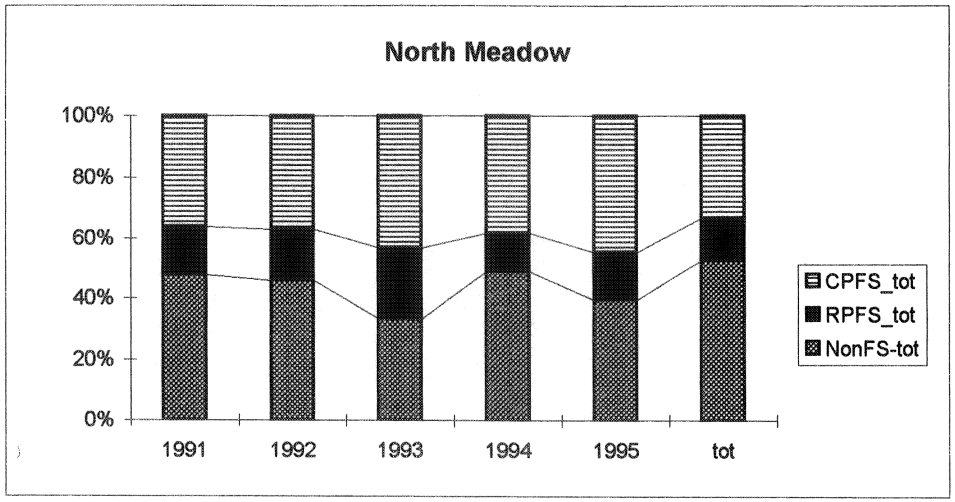
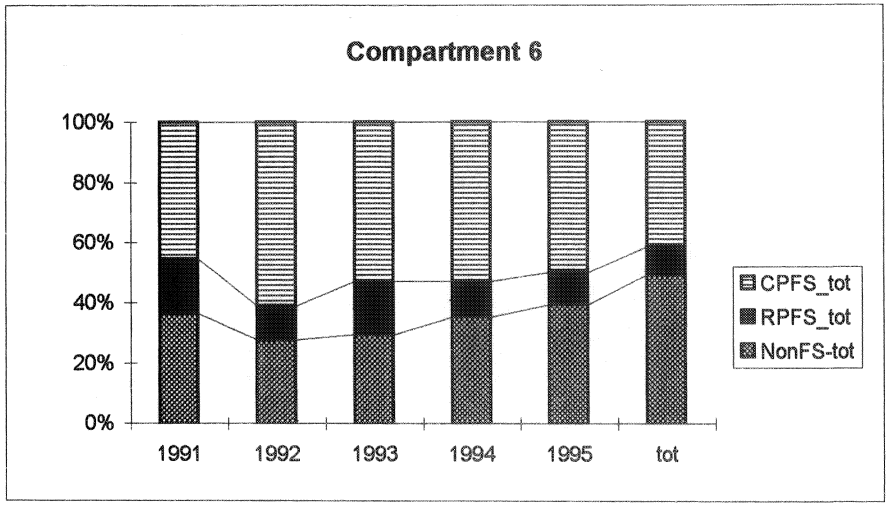
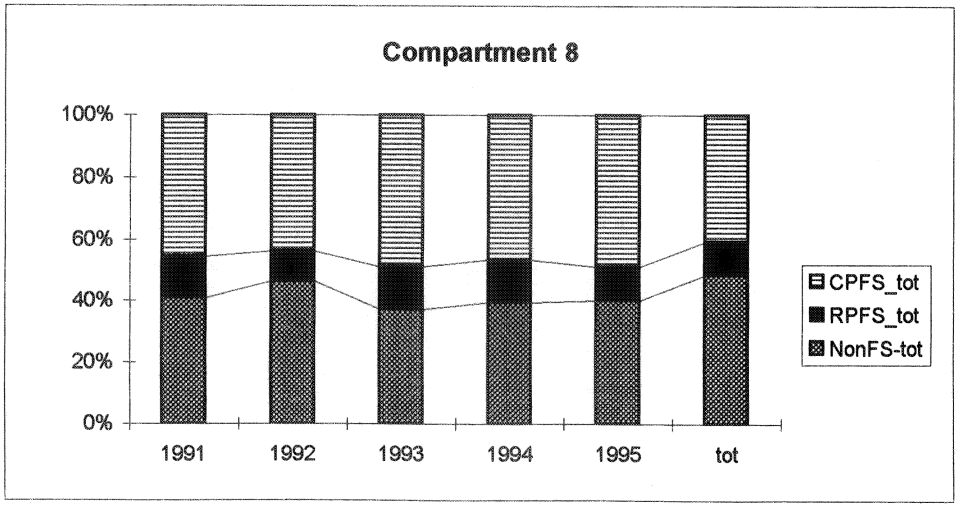


Figure 5.4b

Variation in numbers of species recorded, as a percentage of the total number of species (quadrat size 2)







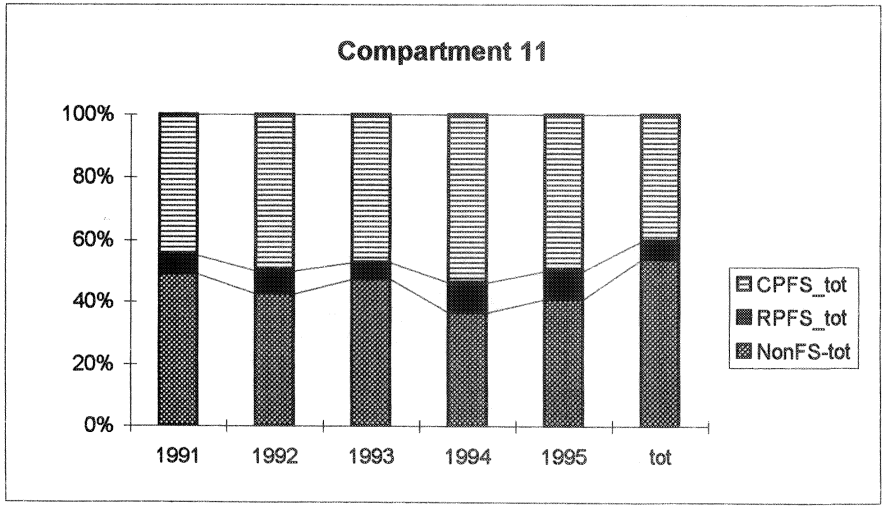
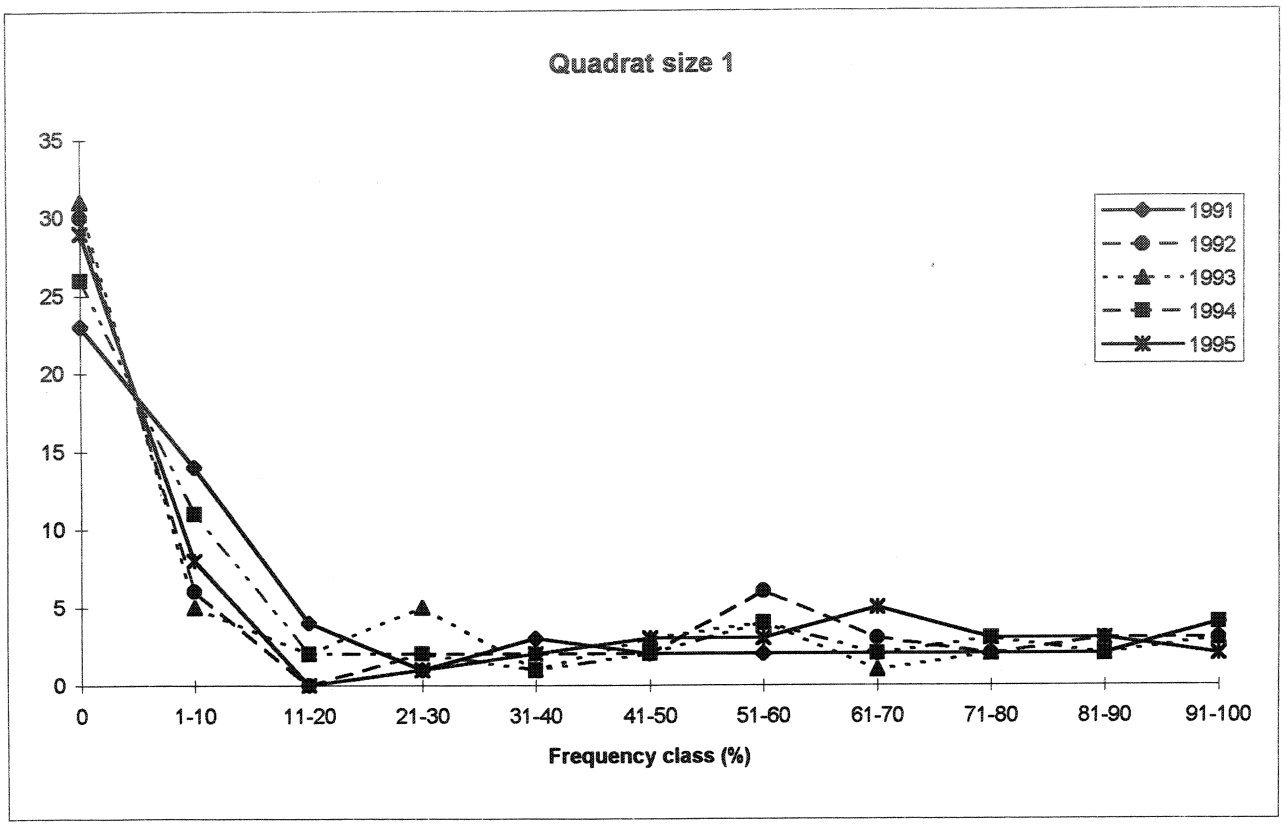


Figure 5.5
North Meadow: frequency distribution of random quadrat data



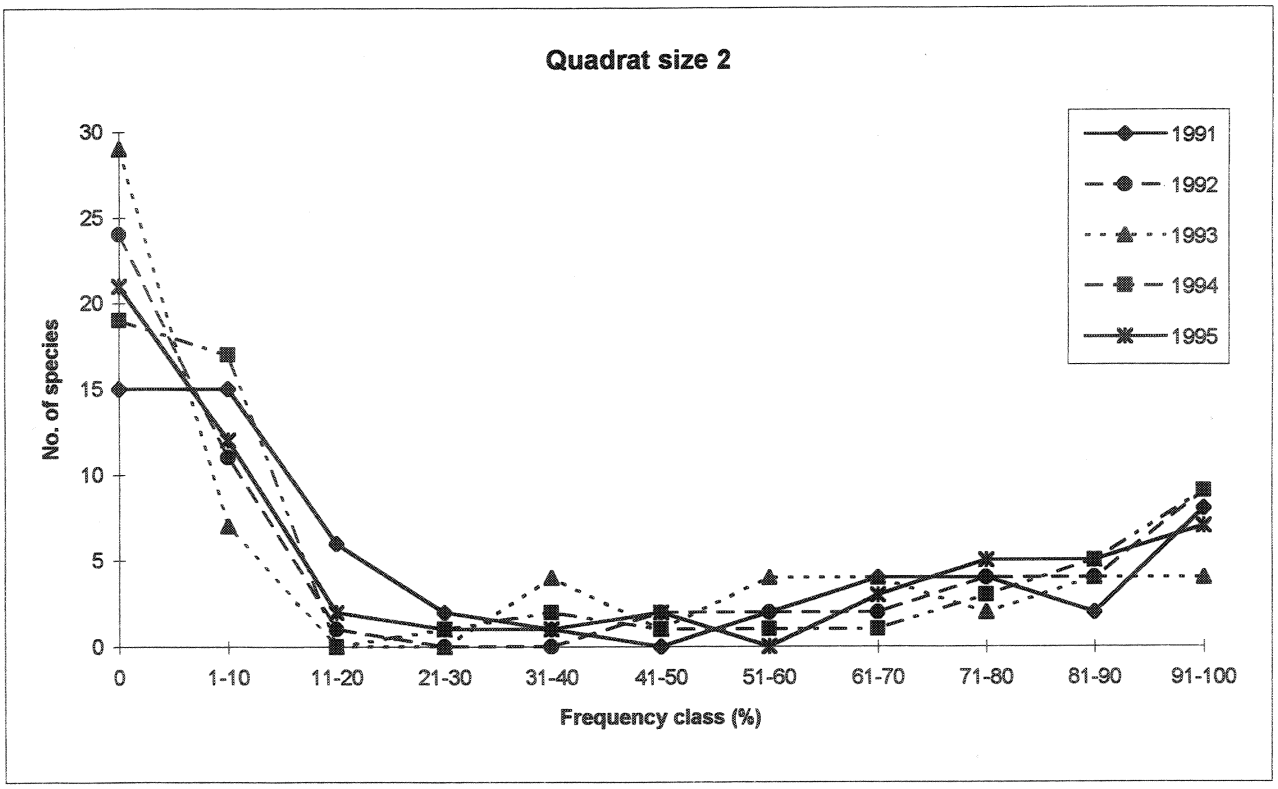
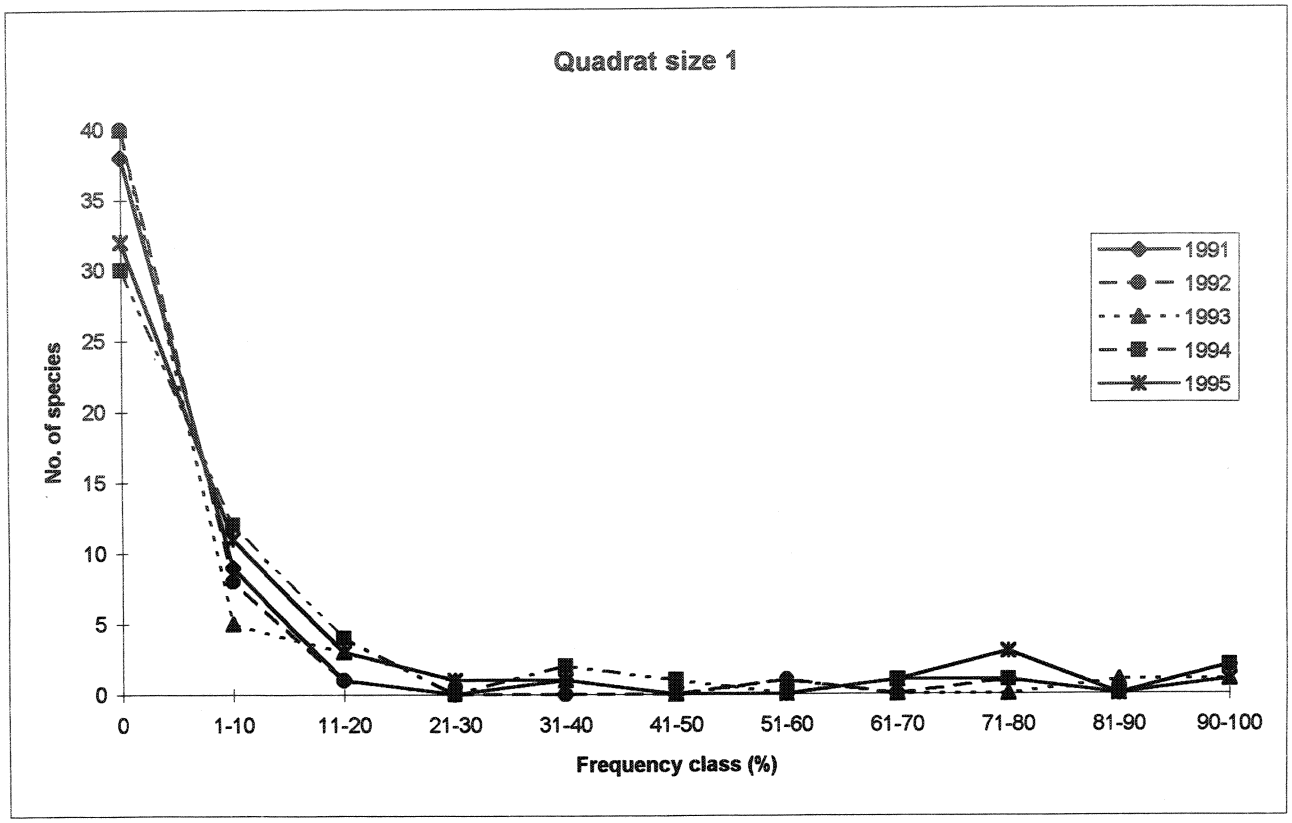


Figure 5.6
Compartment 6: frequency distribution of random quadrat data



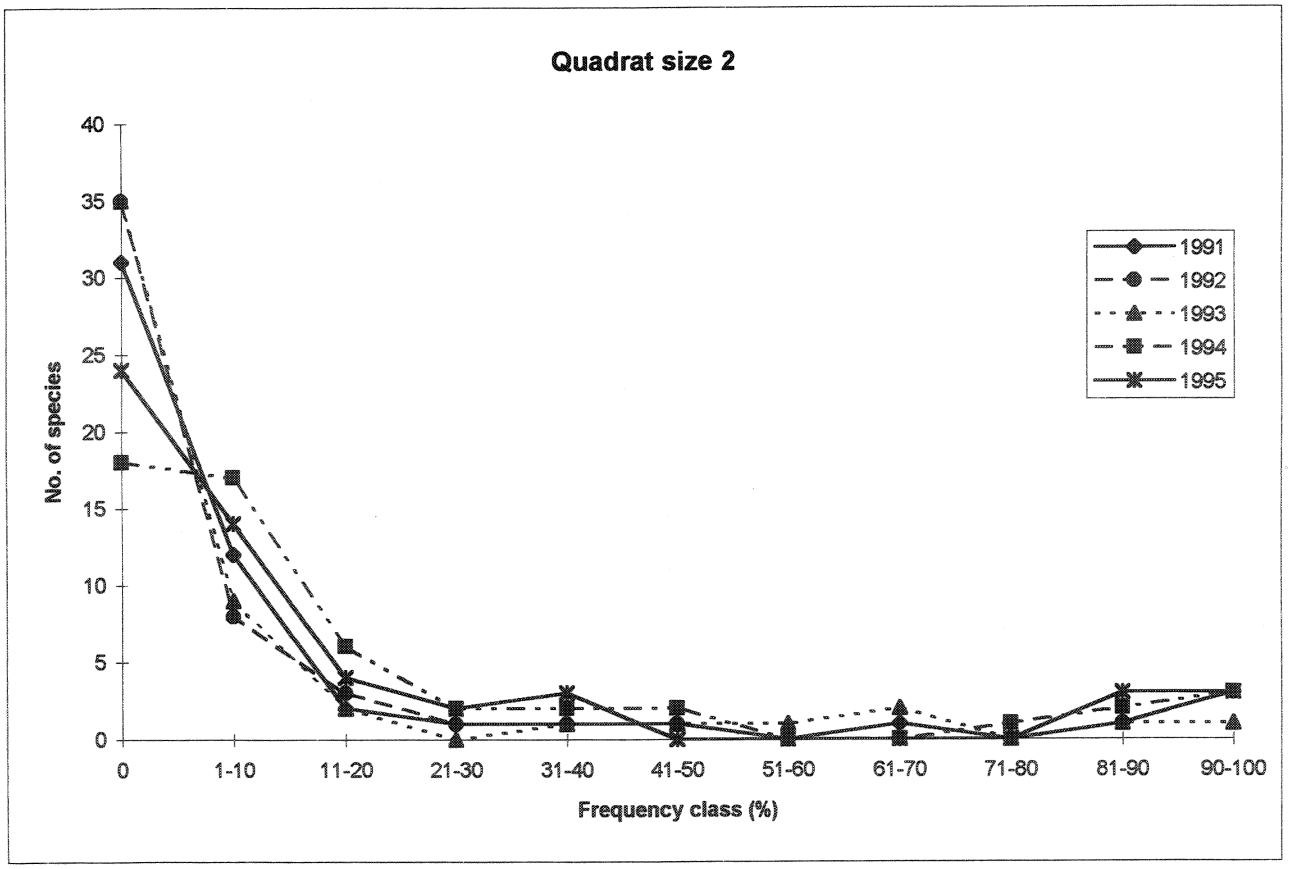
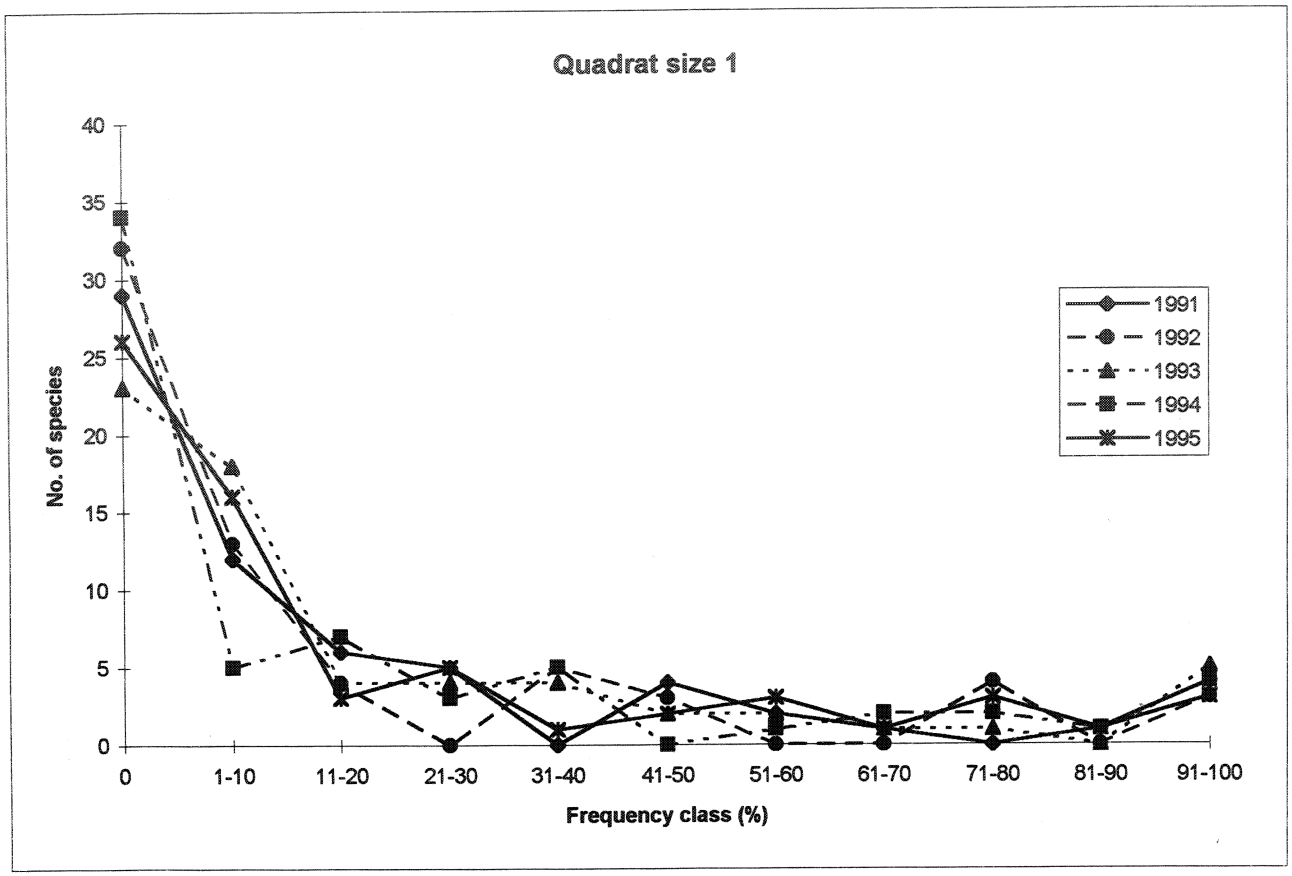


Figure 5.7
Compartment 8: frequency distribution of random quadrat data



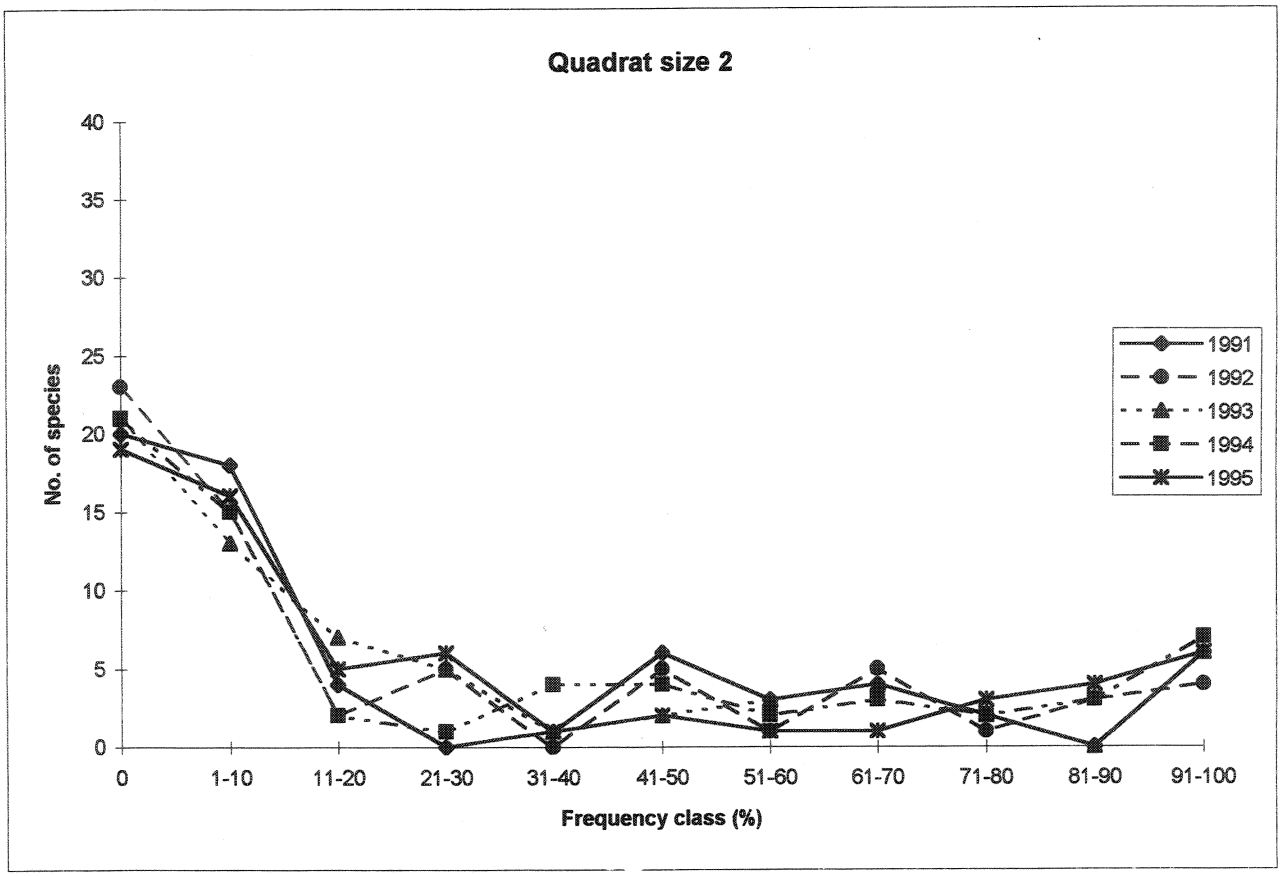
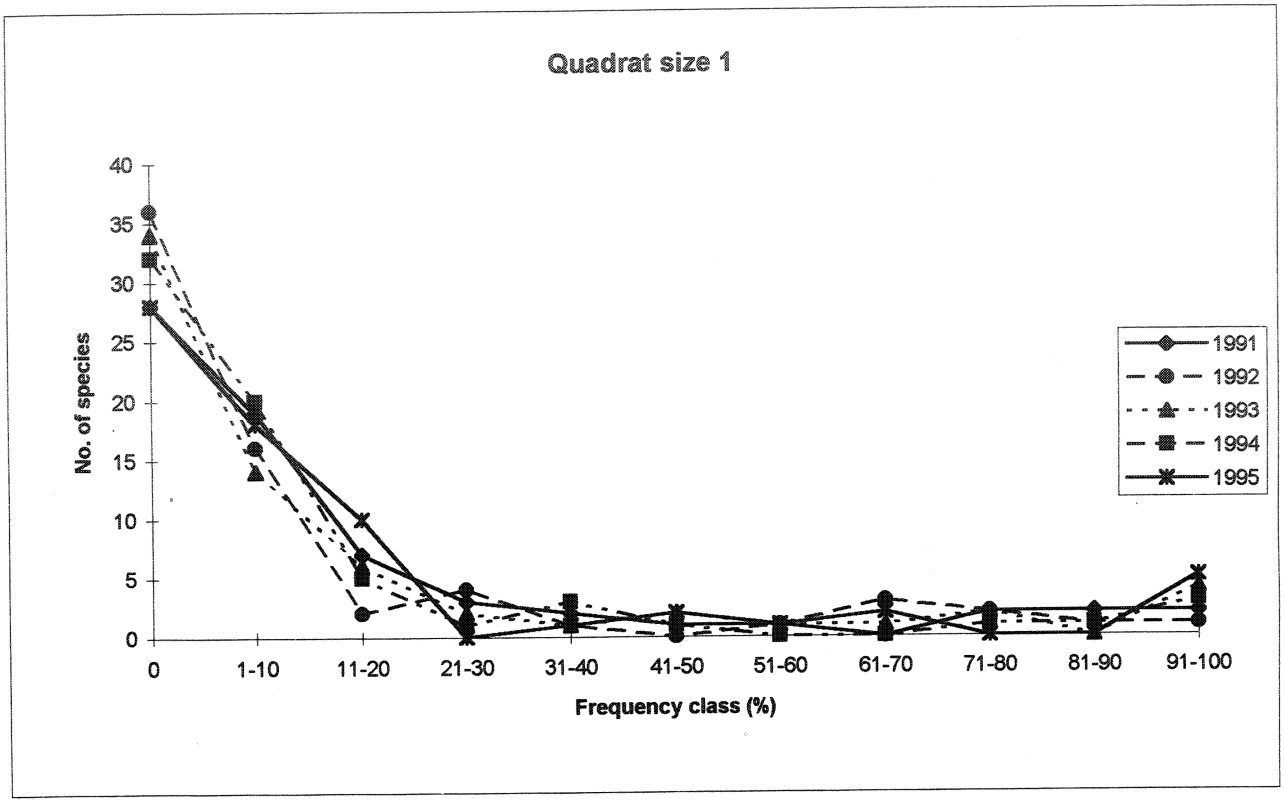
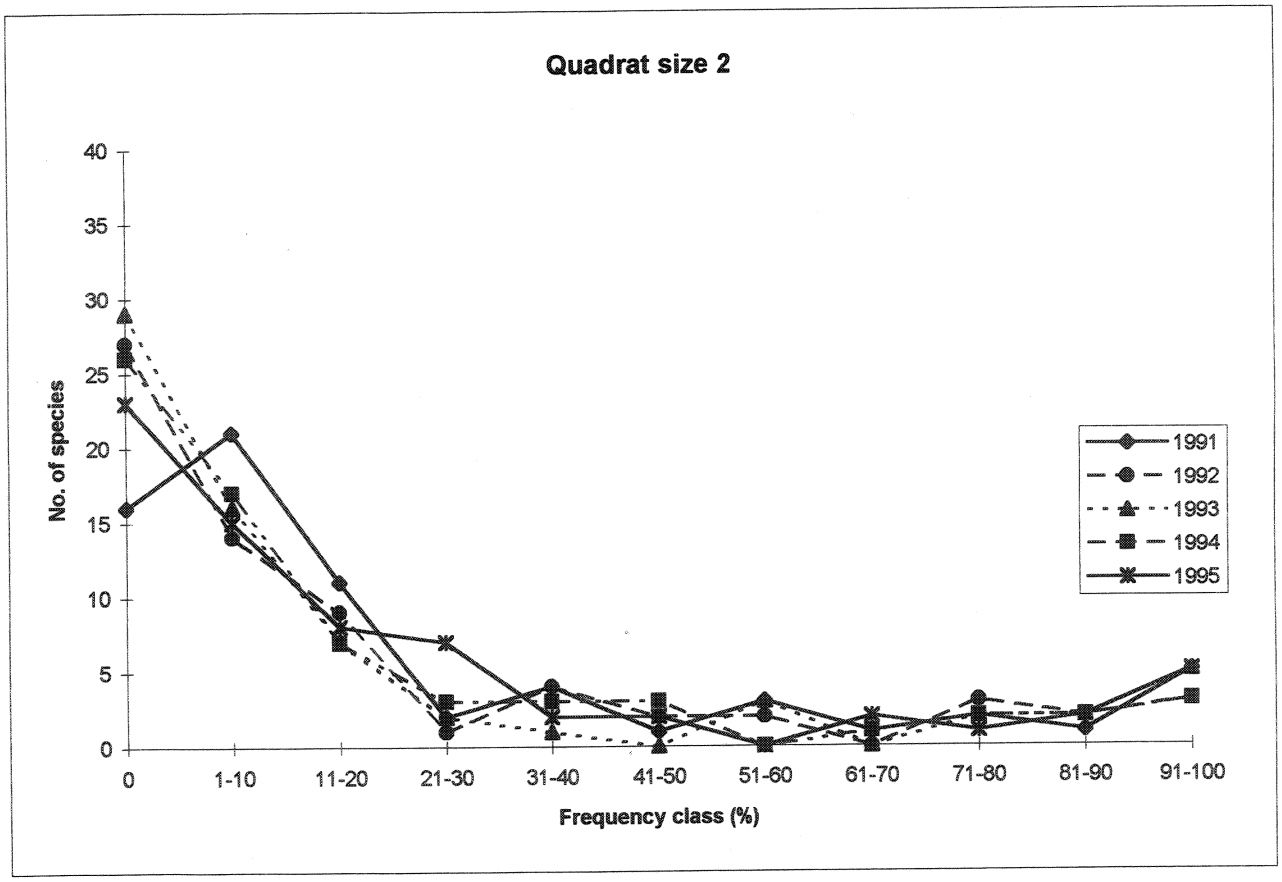


Figure 5.8
Compartment 11: frequency distribution of random quadrat data





5.2 Permanent quadrat data

Results for permanent quadrat data are presented as frequency of individual species in each 'sub-quadrat' (Table 10.1 to Table 10.4) and as total frequency for each year (Table 10.5). The data have been ordinated using DECORANA; the resultant ordination diagrams are given in Figure 5.9 and Figure 5.10. The latter is a separate diagram for Compartment 6 as this was sampled on a different basis to the others. Individual diagrams were also prepared for the other compartments, but as these essentially showed the same trend as the composite diagram, only the latter has been presented. Note that no data were collected in 1992.

5.2.1 North Meadow

Of the main species present, *Molinia caerulea* was the only species present at maximum frequency in all years. *Juncus subnodulosus* showed a trend for a decrease in frequency from 100% to 88.75%, while *Phragmites australis* varied between 72.5 and 91.25%. There was a trend for a decrease in frequency of *Calliergon cuspidatum*, from 92.5% in 1991 to 63.75% in 1995. Other notable changes in species frequency were as follows:

Angelica sylvestris increased in rooted frequency from 1.25% in 1991, to 43.75% in 1995.

The frequency of *Brachythecium rutabulum* varied considerably, with 22.5% and 33.75% in 1991 and 1995 respectively, but only 5–6% in 1993 and 1994.

Eupatorium cannabinum and *Mentha aquatica* have both shown a gradual increase in rooted frequency during the monitoring period from 5–18.57% and 6.25–53.75% respectively.

Selinum carvifolia increased slightly in 1993, and very sharply in 1994 (maximum 58.75%), with a decline in 1995.

Valeriana dioica increased in frequency between 1991 and 1993 (42.5–63.75%) but was only recorded at 25% in 1994 and 1995.

Festuca rubra showed an increase in frequency between 1991 and 1993, with a reduction in 1994, and increase again in 1995.

Carex panicea shows a steady decline from high frequency in 1991 (98.75%) to a moderately low frequency in 1994 (45%), but increased again in 1995 to 95%.

Galium uliginosum increased between 1991 and 1994, with a slight reduction in 1995.

The *Gymnadenia conopsea* and *Dactylorhiza* sp. recorded in 1991 were not re-located in subsequent years.

There was a massive input of *Salix* seedlings in 1995 from unrecorded to 78.75%.

The frequency of *Serratula tinctoria* increased over the monitoring period from 5 to 22.5%.

The DECORANA ordination (Figure 5.9) showed that for the North Meadow, the overall species composition did not differ much between years, other than 1995. The main difference in 1995 seems to be a large influx of previously unrecorded *Salix* seedlings, with contributory factors such as a general decrease in *Agrostis stolonifera* and *Calliergon cuspidatum*, and increase in *Brachythecium rutabulum, Mentha aquatica* and *Eupatorium cannabinum.*

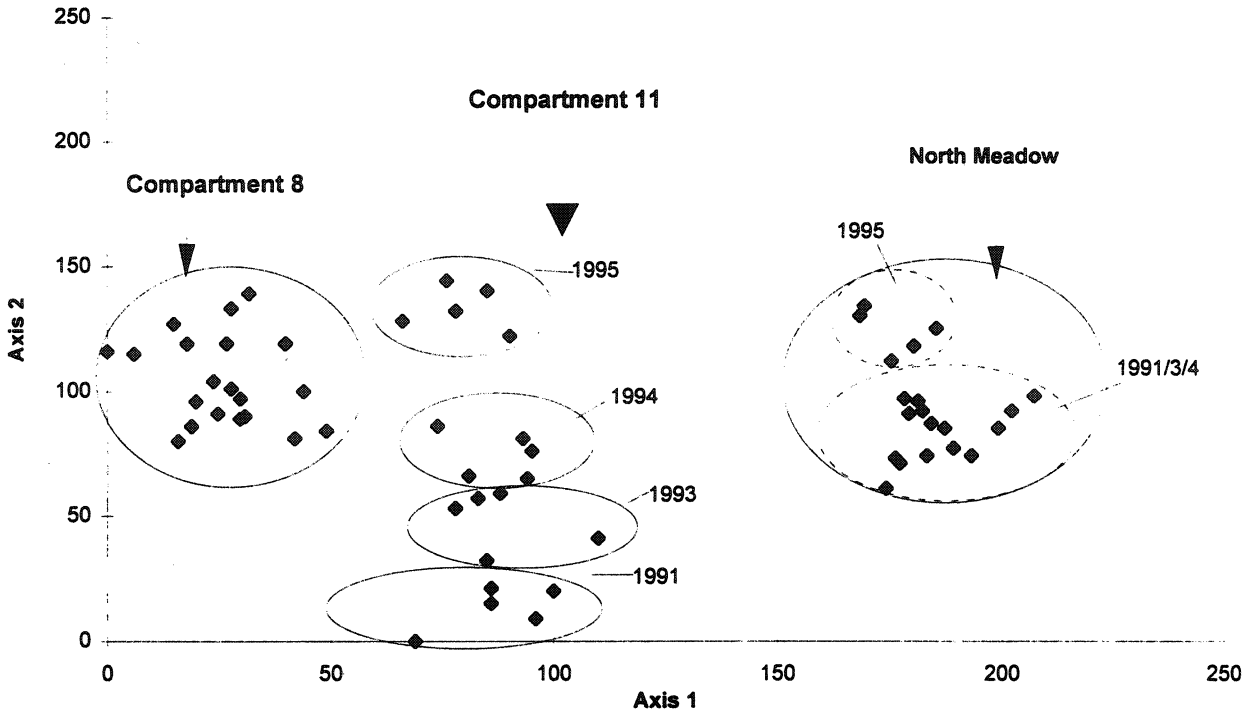


Figure 5.9 DECORANA ordination of permanent quadrat data for North Meadow, Compartments 8 and 11

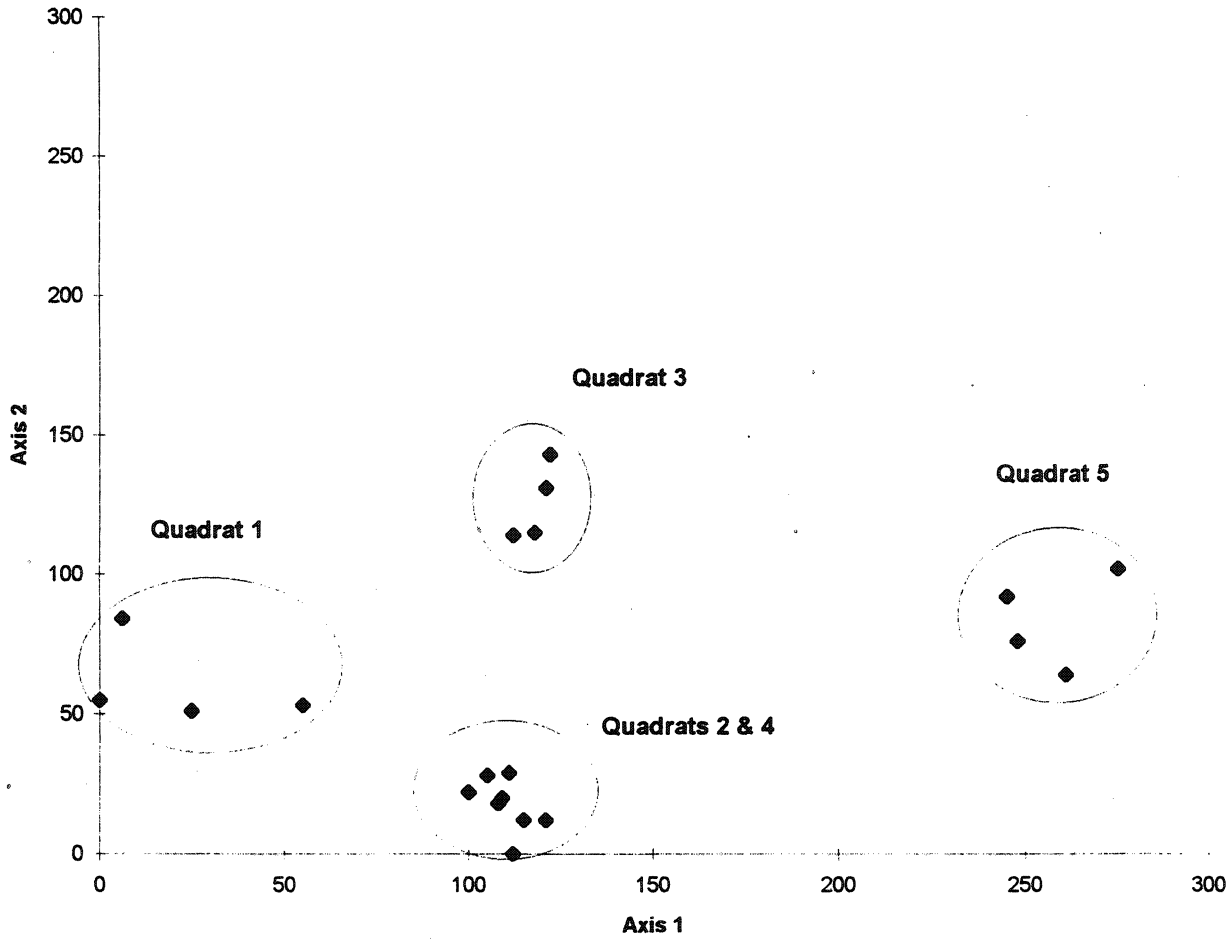


Figure 5.10 DECORANA ordination of permanent quadrat data for Compartment 6

5.2.2 Compartment 6

The variation in vegetation composition through the compartment lead to the setting up of five quadrats along a transect. Quadrats 1–4 were in the main sedge bed while quadrat 5 represented the patches of low-growing vegetation, dominated by *Molinia caerulea*. In quadrats 2 and 4, *Juncus subnodulosus* was co-dominant with the *Cladium*, while in 1 and 3 *Phragmites australis* was more prominent than the *Juncus*.

There were few discernible changes in species frequencies:

In 1991 *Alga* was found in all 25 sub-quadrats of Quadrat 1 only; but by 1994 it had vanished completely.

Brachythecium rutabulum was present in only Quadrat 3 throughout the monitoring period and showed consistent increase from 1991 to 1994.

Equisetum palustre showed a slight increase in frequency in 1993, most apparently in Quadrats 3 and 4, but declined slightly in 1994.

Juncus subnodulosus tended to increase in frequency throughout the monitoring period, particularly in quadrat 3.

Lythrum salicaria was prominent in quadrat 3 in 1993 and 1995, in contrast to the low frequencies in 1991 and 1994.

In quadrat 5, the frequency of *Phragmites australis* varied considerably, being present at only low frequencies in 1993 and 1994, in contrast with 1991 and 1995. The frequencies of *Angelica sylvestris* and *Galium uliginosum* increased through the monitoring period.

The DECORANA ordination for Compartment 6 (Figure 5.10) shows that while there were some floristic differences between the five 'sub-quadrats' recorded (with the exception of 2 and 4), the composition of these was fairly stable over the monitoring period. Most change was evident in quadrat 1, which can probably be mainly attributed to the loss of the algal mat (recorded in 1991 and 1992), and reduction in frequency of *Phragmites* and *Eupatorium cannabinum*.

5.2.3 Compartment 8

The main dominant species of the vegetation (*Juncus subnodulosus* and *Molinia caerulea*) remained at fairly constant levels throughout the monitoring period, being present at a frequency of > 93 % in each year. Most of the other main components showed some small variation, but with no consistent trends. These included *Phragmites australis*, *Calliergon cuspidatum*, *Campylium stellatum, Galium uliginosum. Mentha aquatica* and *Cladium mariscus* were both present at fairly high frequency, increasing between 1991 and 1993, but then remaining at a fairly constant level (*c.* 80% and 90% respectively). *Hydrocotyle vulgaris* showed a similar trend, but at a lower frequency (2.5% in 1991 to 12.5% in 1995). Other noticeable trends were as follows:

Brachythecium rutabulum and *Eurhynchium praelongum* have both declined since 1991.

Lythrum salicaria increased in frequency from 1991 to 1994, with a slight decrease in 1995.

Carex panicea increased consistently between 1991 and 1995. *Carex viridula* also showed a small increase.

Fissidens adianthoides decreased in frequency between 1991 and 1993, but was present at moderate levels in 1994 (20%). However, it was absent in 1995.

Equisetum palustre was virtually absent in 1991, but showed a large increase in 1993 (to 27.5%), declining slightly in 1994, with 1995 levels similar to 1991.

Eupatorium cannabinum increased considerably between 1991 and 1993 (to 60%), with a reduction in 1994, followed by a smaller increase in 1995.

Potentilla erecta increased in frequency from 1.25% in 1991, 1994 and 1995, to 16.25% in 1993.

Anagallis tenella was present in small amounts, but nearly doubled in frequency through the monitoring period, from 8.75% to 15%.

There was a large influx of *Salix* seedlings in 1995, which had previously been recorded only at a low level.

It is difficult to determine trends in species abundance which may relate to management, as this compartment is mown on a two year cycle, and data were not collected in 1992. The only species which showed a possible peak in 1994 (*i.e.* one year after mowing) was *Lythrum salicaria.*

The DECORANA ordination (Figure 5.9) showed that for Compartment 8, the overall species composition did not differ much between years, and that, as expected, the composition was closer to that of Compartment 11 than North Meadow. This suggests that there has been no major shift in species composition through the monitoring period.

5.2.4 Compartment 11

The main dominant species of the vegetation (*Molinia caerulea* and *Juncus subnodulosus*) remained at fairly constant levels throughout the monitoring period, being present at a frequency of > 93 % in each year. Most of the other main components showed some small variation, but with no consistent trends. These included *Phragmites australis* (lowest frequency in 1993), *Calliergon cuspidatum, Galium uliginosum* and *Valeriana dioica.* Other noticeable trends were as follows:

Agrostis stolonifera showed a general decreasing trend in frequency, from 46% in 1991 to 7.5% in 1995.

Anagallis tenella, present at moderate frequency (27.5%) in 1991, was not recorded in 1993, but was found at low frequencies in 1994 and 1995.

The frequency of *Angelica sylvestris* increased dramatically in 1993 (from 16.25 to 75%) and then decreased to 1995. *Equisetum palustre* showed a similar trend, varying from 11.25 to 43.75%).

Carex flacca exhibited a large increase in frequency during the monitoring period, from 5 to 37.5%. Similarly, the frequency of *Mentha aquatica* increased from 7.5% to 71.25%.

Carex lepidocarpa declined between 1991 (16.25%) and 1993, but then increased to much greater frequency by 1995 (42.75%).

The frequency of *Cirsium palustre* rose sharply from 1991 to 1993 in all quadrats. It was not recorded in 1994, but had returned to 1991 levels by 1995.

Deschampsia caespitosa declined dramatically between 1991 and 1993, with a smaller decrease between 1993 and 1994 and a slight increase in 1995.

Eupatorium cannabinum was first recorded in 1994 at a low frequency, increasing to 47.5% in 1995, while *Festuca rubra* was first recorded in 1993, and subsequently increased in frequency to 16.25%.

Serratula tinctoria was found at relatively low frequency in 1991, but was not subsequently recorded.

There was a large influx of *Salix* seedlings in 1995.

It is difficult to determine trends in species abundance which may relate to management, as this compartment is mown on a two year cycle, and data were not collected in 1992.

The DECORANA ordination (Figure 5.9) showed that the species composition had greater similarities with Compartment 8 than North Meadow. However, it also shows that the overall species composition altered markedly between 1991 and 1995. The main species changes which could account for this are as follows:

increase in frequency:	**decrease in frequency:**
Angelica sylvestris	*Agrostis stolonifera*
Equisetum palustre	*Anagallis tenella*
Carex flacca	*Carex hostiana*
Carex viridula ssp. brachyrrhyncha	*Deschampsia cespitosa*
Eupatorium cannabinum	*Glechoma hederacea*
Festuca rubra	
Fraxinus excelsior	
Mentha aquatica	
Salix seedlings	

5.3 Crop mass determinations

Figures for the different components of crop mass are provided in Table 5.1 and summarised in Figure 5.11 and Figure 5.12 to Figure 5.15.

Differences between means were tested statistically using the t-test. The main points of note can be summarised as follows:

5.3.1 North Meadow

- North Meadow had the lowest crop mass of the four areas measured.
- There was an increase in total crop mass between 1991 and 1995, although the difference was not statistically significant. The change can mainly be attributed to increases in litter and *Molinia*.
- The moss and herb crop mass remained the same, while the contribution from 'other' species (mainly sedges) decreased significantly. There was a small decrease in amount of *Juncus subnodulosus* and small increase in *Phragmites australis*, although these changes were not significant.

- The increase in *Molinia* and litter, and decrease in contribution from 'other' species is consistent with the sampling being carried out one year after and two years after mowing in 1991 and 1995 respectively. The vegetation is reported by the warden to become gradually more 'coarse' each year. However, there was no corresponding increase in *J. subnodulosus* or *Phragmites australis*.

5.3.2 Compartment 6

- Compartment 6 had the highest total crop mass of all the areas measured, with nearly double the mass of Compartments 8 and 11, and three times that recorded from North Meadow.
- Approximately 45–55 % of the crop was made up of living *Cladium*, while only a slightly smaller proportion (40–50%) was comprised of litter (mainly *Cladium*). The only significant difference in crop mass recorded between 1991 and 1995 was an increase in the amount of litter. An increase in total crop mass was suggested, but the difference was not statistically significant.
- There are only small contributions from *Juncus subnodulosus*, *Phragmites australis* and *Molinia caerulea*, which did not change between the two sampling dates.
- The biomass of *Phragmites* was similar to that recorded in North Meadow.

5.3.3 Compartment 8

- Total crop mass is significantly smaller than Compartment 6 and larger than Compartment 11, and North Meadow.
- There was a small decrease in total crop mass, largely attributable to a measured decrease in contribution from *Cladium,* although neither change was statistically significant, due to the patchy distribution of *Cladium* and hence large variability in the data.
- The litter, moss, herbs, *Molinia caerulea* and *Phragmites australis* components remained fairly constant.
- The only significant change was the decrease in contribution from *Juncus subnodulosus.* There was an increase in contribution from 'other' species, which was marginally statistically significant (p=0.06).

5.3.4 Compartment 11

- The total crop mass was significantly smaller than Compartment 6 and Compartment 8, and larger than North Meadow.
- There was no significant change in total crop mass between 1991 and 1995.
- There was a significant increase in contribution from mosses and *Phragmites australis*.
- The contribution from *Cladium* is very variable, reflecting the patchy distribution in the Compartment.

- Many of the 1995 samples included much less *Molinia caerulea* than in 1991, although the difference was on the borderline of statistical significance (p=0.053), due to the high variability, particularly in 1991.

5.3.5 General comments

Table 5.1 provides a summary of the changes in crop mass between 1991 and 1995. The highest crop mass was recorded from Compartment 6, followed by Compartment 8, Compartment 11 and North Meadow. There was some variation in contribution from component groups, but no trend for an overall increase in crop mass, which would be consistent with an increase in fertility, other than perhaps in Compartment 6 (although the apparent increase in total crop mass was not statistically significant).

The greater crop mass recorded from Compartment 8 than Compartment 11 is consistent with the stage of mowing cycle in which they were sampled, *i.e.* the biomass in the former includes an additional years growth. The difference is particularly noticeable in the litter component. The contribution from herbs and *J. subnodulosus* is lower in Compartment 8 than Compartment 11. The latter species is present at high frequency in both compartments, and, as it is deciduous, it could be speculated that less biomass is produced in the second year following mowing than in the first. This difference is also consistent with the possibility that the substratum in Compartment 11 is more fertile than that in Compartment 8.

Table 5.1 Summary of changes in crop mass between 1991 and 1995

	North Meadow	Compartment 6	Compartment 8	Compartment 11
Phragmites australis	(↑)	≈	≈	↑↑
Cladium mariscus	not present	≈	(↓)	≈
Juncus subnodulosus	≈	(↑)	↓	≈
Molinia caerulea	↑↑	≈	≈	(↓)
Herbs	≈	≈	≈	≈
Moss	≈	≈	≈	↑↑
Others	↓	≈	(↑)	≈
Litter	↑↑↑	↑↑↑	≈	≈
Total	(↑)	(↑)	≈	≈

The number of arrows indicates the degree of statistical significance of the change ($p < 0.05$, 0.01 or 0.001). Brackets indicate an apparent change, although not statistically significant.

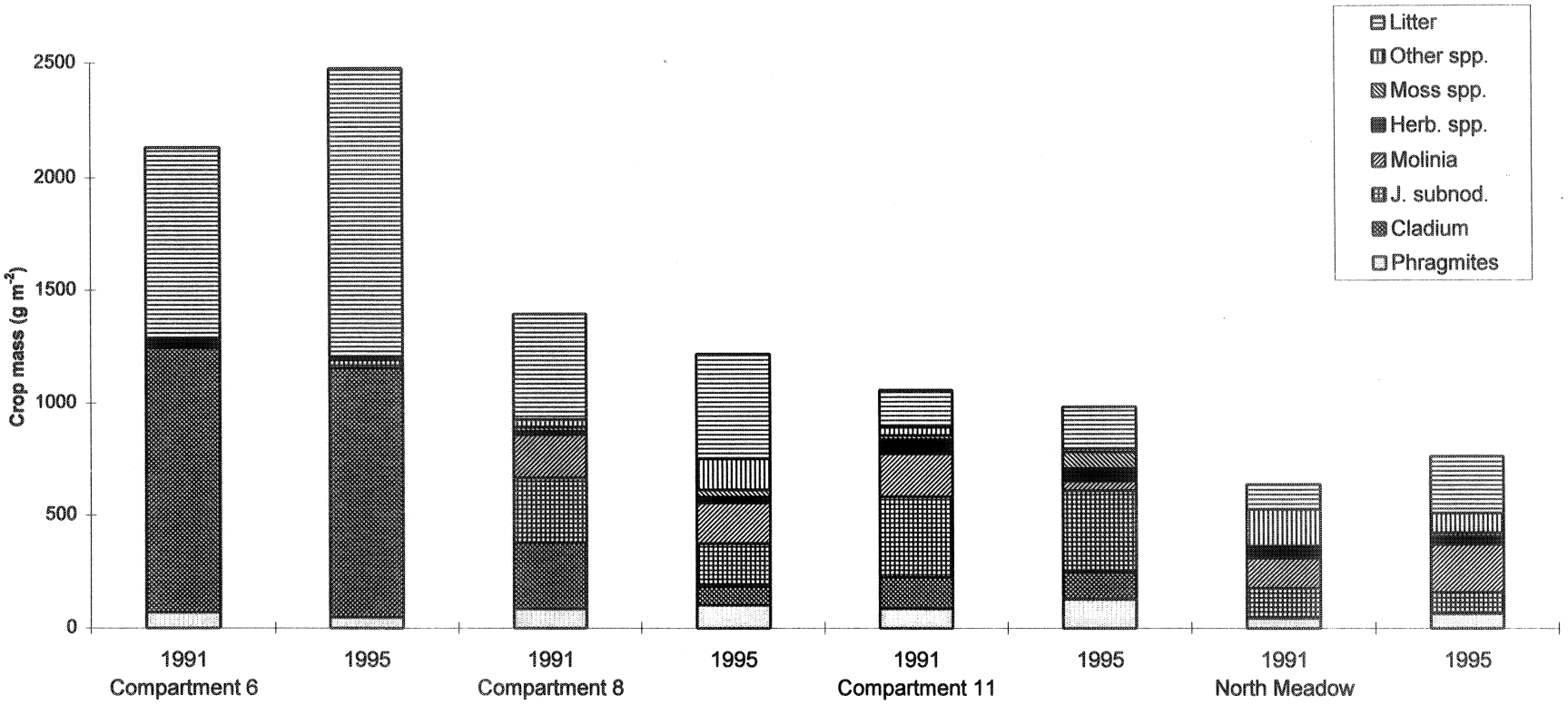


Figure 5.11 Chippenham Fen: crop mass components in 1991 and 1995

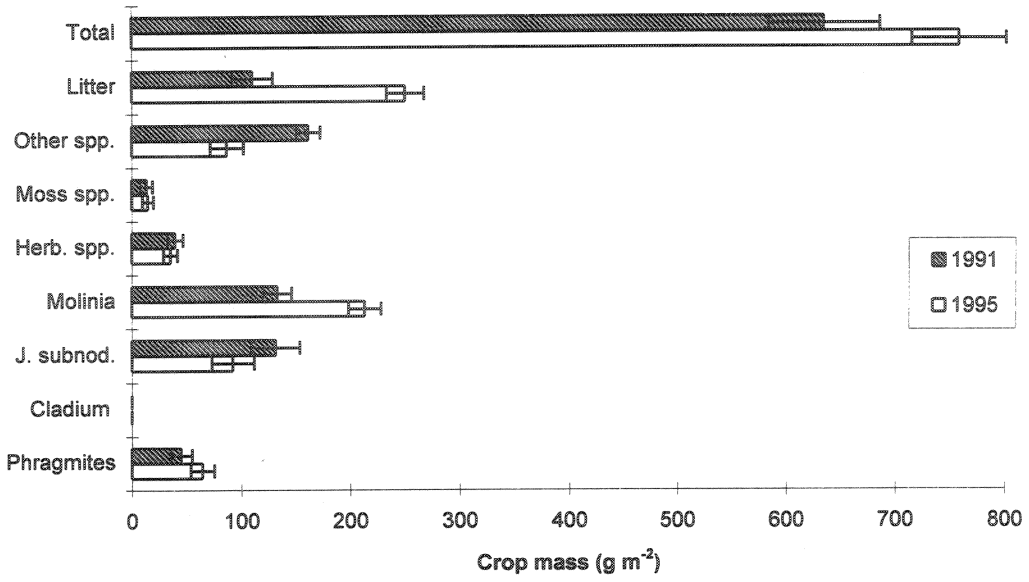


Figure 5.12 North Meadow, Crop mass components in 1991 and 1995

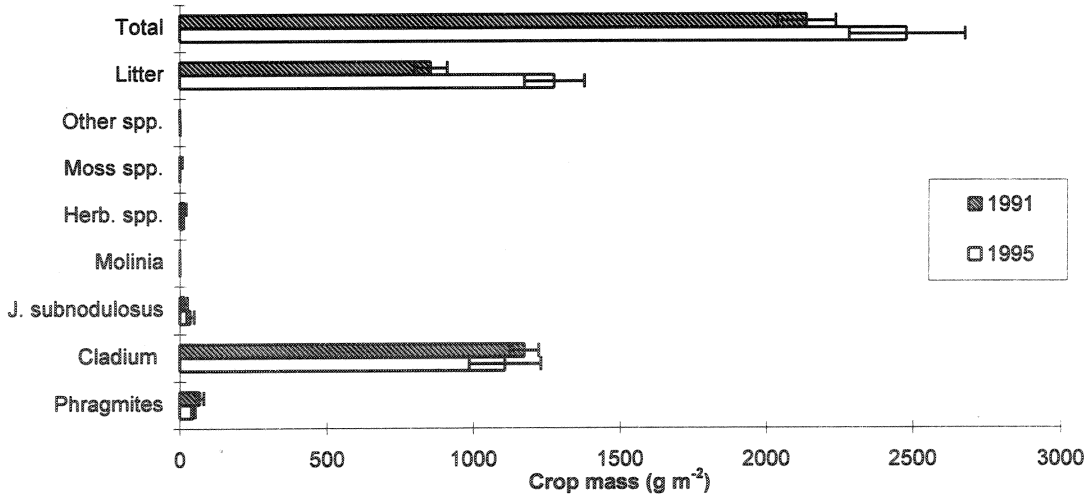


Figure 5.13 Compartment 6, Crop mass components in 1991 and 1995

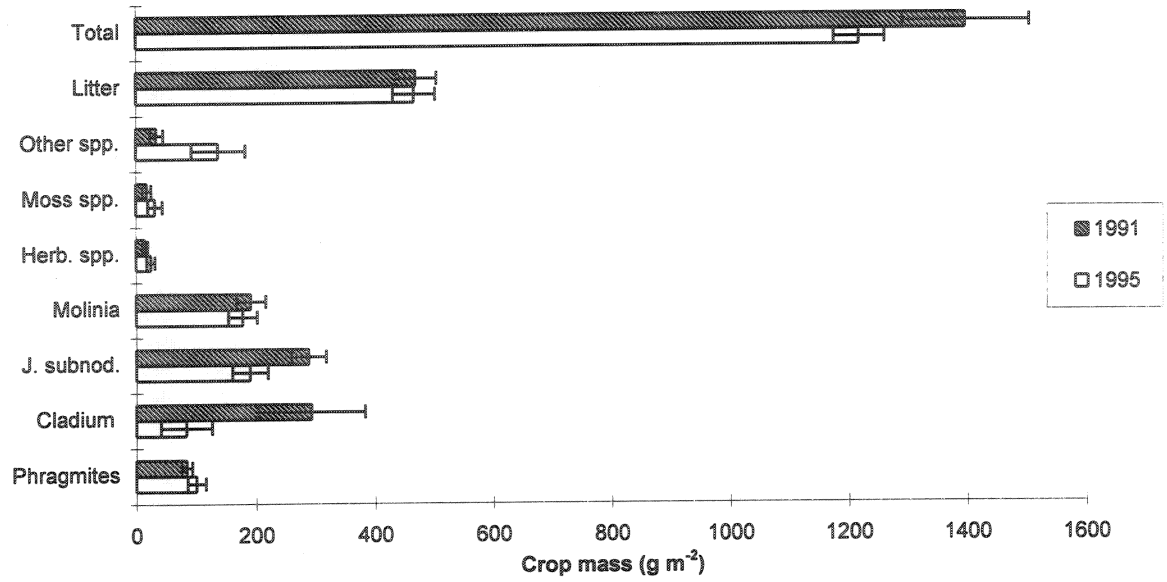


Figure 5.14 Compartment 8, Crop mass components in 1991 and 1995

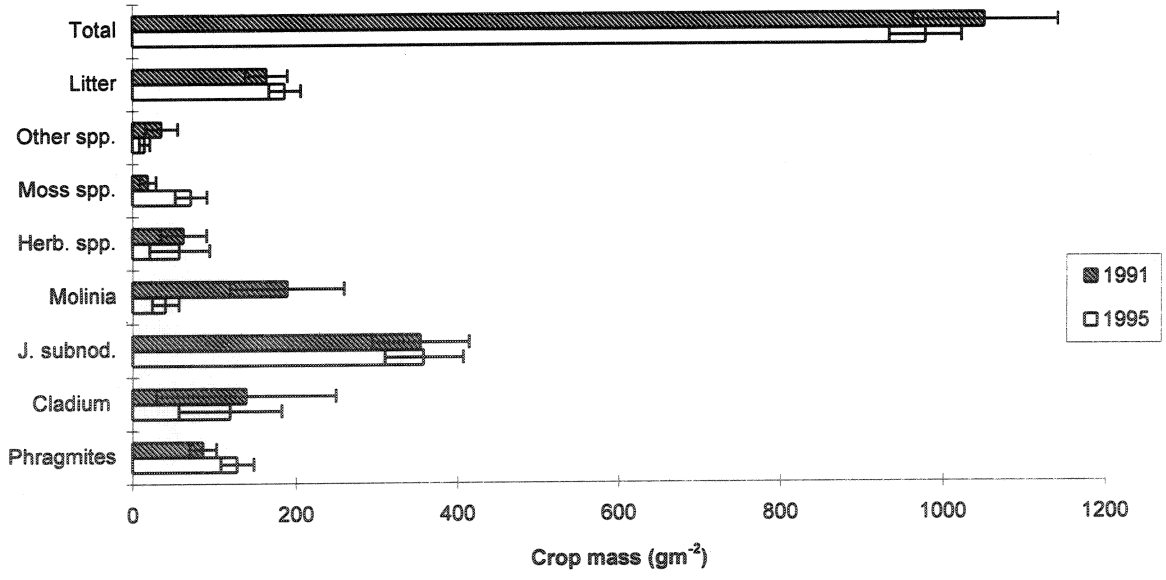


Figure 5.15 Compartment 11, Crop mass components in 1991 and 1995

6. Discussion

6.1 Monitoring methods

6.1.1 Random quadrat data

Random quadrats are used to provide information on vegetation composition throughout a stand of vegetation. Depending on the records that are made, they can take less time to record than the detailed records typically made in permanent plots. In this project, however this was not found to be the case, with the random quadrats in practice taking longer to record than the permanent quadrats. This is because the pilot study in 1991 showed that a large number of quadrats (30) was needed to provide an adequate sampling of the species present, although it was decided to use only two sizes of nested quadrats, rather than the initial eleven. Random plots lack continuity, but may provide a better representation of changes in the stand as a whole than permanent quadrats.

There would be expected to be fewer changes in species frequency at the larger quadrat size, particularly for the most abundant species. However, the less frequent species are more likely to be sampled at the larger quadrat size, and therefore changes in their abundance are more likely to be picked up (and to represent a real trend) than at the smaller size. Conversely, changes in the more abundant species will be picked up more quickly at the smaller quadrat size. In all of the compartments, there were many species which were recorded only at a low frequency or not at all. It would require the recording of many more quadrats per stand (or at least more years of recording data) to determine whether changes in the populations of these species can be considered to be significant.

The figures provided for mean frequency of species density, principal fen species and rare fen species, give an indication of the mean proportion of the species in the monitoring area encountered in each quadrat. This gives a good indication of the evenness of the vegetation composition across the area, with low figures suggesting a very patchy vegetation. Here, in most years, the compartments could be ranked in the order: North Meadow > Compartment 8 > Compartment 11 > Compartment 6. The exception is the mean frequency of rare species, which was mostly highest in Compartment 6, as this has the highest frequencies of two rare species, *Cladium mariscus* and *Juncus subnodulosus*. Clearly, these figures are influenced to a large extent by the numbers of species recorded, and thus may be biased by the sampling including, or missing, species which are only present at very low frequencies.

Variation in the frequency of individual species may be related to the mowing regime and individual species response to management, as well as to hydrological regime. However, in view of the varying conditions over the relatively short period of monitoring, it has been difficult to distinguish between responses.

6.1.2 Permanent quadrat data

Permanent quadrats were used to provide a basis for examining changes in frequency of species for a particular plot in each compartment. They can provide clear evidence of temporal change at these points, but it should be noted that they do not necessarily reflect changes elsewhere in the compartments, and are not directly comparable with frequency determinations made using the random quadrats, although of course trends can be compared.

The permanent quadrat data are useful in illustrating changes in species frequency in small sampling areas, and can help focus attention on particular species. For example, in 1991, *Anagallis tenella* was encountered in only one random quadrat (size 2) in Compartment 11, yet in the same year it was relatively abundant in the permanent quadrat. Expansion and contraction of such patches of small creeping herbs, which may be sparsely scattered throughout the monitoring area, could easily be missed by chance using random quadrat sampling. However, in the same way, general changes in species frequencies could be overlooked by only recording in permanent quadrats, particularly for species present at low frequency.

It has proved impossible to look for trends in relation to management regime using data from the permanent quadrats, as they were not recorded in 1992. This also makes it more difficult to assess whether any trends shown in the permanent quadrats correspond to those shown using random quadrats. However, there was some concordance between the random and permanent quadrat data (see Table 6.1). For example, in the North Meadow *Selinum carvifolia* showed consistent increase in both quadrat types, as did *Anagallis tenella* in Compartment 8, while in Compartment 6 *Eupatorium cannabinum* decreased sharply in 1993 and rose steeply in 1994 in both random and permanent quadrats. *Mentha aquatica* showed a trend for increasing frequency in all compartments, in both random and permanent quadrats. However, comparison of random and permanent quadrat data for most species showed little resemblance in terms of pattern of change, although this observation is influenced to some extent by the lack of permanent quadrat data for 1992.

One of the draw-backs of using permanent quadrats is that the area around the quadrat can become trampled, with some compaction of the substratum. This appears to have happened already to some extent, and it is recommended that in future years some attention is given to minimising the impact of sampling (for example by the use of ladders).

6.1.3 Crop mass determinations

Estimates of species frequency determined using quadrats can provide a useful indication of abundance, but do not necessarily indicate other aspects of change in performance, such as cover or crop mass. This is particularly the case in vegetation that is coarse and species-poor, as is found in some compartments at Chippenham Fen. Cover of individual species would be a better index of abundance in such situations, but is difficult to estimate reliably, particularly in tall fen vegetation. Therefore, the approach adopted here was to estimate changes in crop mass components.

One of the main determinants of crop mass is substratum fertility (Wheeler, Shaw & Cook, 1991). The crop mass data collected here have not suggested any consistent differences which might be indicative of substantive changes in substratum fertility, although the patchy nature of the vegetation makes the variation between samples quite high, and could mask any changes, especially as only one sampling period has been assessed.

6.2 General trends in vegetation

A table has been constructed which summarises the overall changes in selected species between 1991 and 1995 (Table 6.1). The 'moisture value' and 'nitrogen value' assigned to each species by Ellenberg (1974) have been included. These provide an indication of the water levels and nitrogen levels associated with particular plant species, based on an intuitive assessment of their preferences in western Central Europe. An indication is also given of the typical water levels and substratum fertilities with which the species were found to be associated in the synoptic survey of British fen vegetation-types reported by Shaw & Wheeler (1991). Although with clear limitations in their extrapolation, (see Wheeler & Shaw, 1995), these figures help to give some idea of the conditions with which the species are typically associated, and thus facilitate the interpretation of the data in terms of the possible ecological significance of variations in species' abundances.

Table 6.1 Summary of changes in frequency of selected species between 1991 and 1995

1 = random quadrat size 1 ($0.25m^2$); 2 = random quadrat size 2 ($2m^2$); P = permanent quadrat. The number of arrows is an indication of the degree of change; ≈ denotes little, or no change; brackets indicate species present at very low frequency, or small change in frequency. Ebg.F = Ellenberg 'moisture value'; Ebg.N = Ellenberg 'Nitrogen value'; Wtab = mean summer water table; Fert = substratum fertility (M=moderate, L = Low) (see below)

	Ebg.F	Wtab	Ebg.N	Fert	Q	North Mead.	Comp. 6	Comp. 8	Comp. 11
Agrostis stolonifera	6~	M	5	M	1	↓↓↓	–	↓↓	↓↓
					2	↓↓↓	(≈)	↓↓	↓↓
					P	↓↓	–	≈	↓↓↓
Anagallis tenella *	–	M	–	L	1	↑	–	↑↑	↑
					2	↑	(≈)	↑↑	↑
					P	–	–	↑	↓↓
Angelica sylvestris *	8	M	X	M	1	↑↑↑	↑↑	↑↑↑	↑
					2	↑↑	↑↑	↑↑	↓
					P	↑↑↑	(↑)	↑↑	↑↑
Cardamine pratensis	7	M	X	M	1	–	–	–	↑
					2	–	–	–	↑↑
					P	–	–	(≈)	(≈)
Carex flacca	6~	M	X	L	1	≈	(≈)	↓	(↓)
					2	≈	(≈)	↓	↓
					P	≈	–	↑↑	↑↑
Carex hostiana **	9	M	2	L	1	(↓)	–	(≈)	–
					2	(↓)	–	(≈)	–
					P	≈	–	–	↓
Carex panicea *	7	M	3	L	1	↓	–	↑↑	≈
					2	≈	(≈)	↑↑	≈
					P	≈	–	↑↑	(≈)
*Carex viridula ssp. brachy.**	8	M	2	L	1	–	(≈)	≈	≈
					2	–	(≈)	↓	≈
					P	≈	(≈)	↑	↑↑
Cirsium dissectum **	–	L/M	–	L	1	↓	(↓)	↑	–
					2	≈	↑	↑	–
					P	↓	(≈)	(≈)	–
Cirsium palustre *	8~	L/M	3	M	1	↓↓	(≈)	↓	↓↓
					2	↓↓	(↓)	↓	↓↓
					P	↓	(≈)	↑	≈
*Cladium mariscus**	10	L/M	3	L/M	1	–	=	(↓)	(↓)
					2	–	=	(↓)	(↓)
					P	–	=	↑	–
Deschampsia cespitosa	7~	M	3	M	1	(≈)	(≈)	(↓)	↓↓
					2	≈	(≈)	≈	↓↓
					P	–	–	≈	↓↓↓
Epilobium hirsutum *	8=	L	9	H	1	–	–	(↓)	–
					2	–	–	(↓)	–
					P	–	–	–	–
Equisetum palustre *	7	M	3	M	1	(≈)	↑↑	≈	↑
					2	(≈)	↑↑	↑	↑↑
					P	–	≈	≈	↑↑
Eupatorium cannabinum *	7	L/M	8	M	1	↑↑↑	(↓)	↑↑	(↓)
					2	↑↑↑	↓	↑↑	↓
					P	↑↑↑	≈	↑↑↑	↑↑↑
Festuca rubra	X	L/M	X	M	1	↑↑	(≈)	≈	(↑)
					2	≈	(≈)	≈	↑
					P	↑↑	(≈)	≈	↑
Filipendula ulmaria *	8	L/M	4	M	1	–	(≈)	(≈)	≈
					2	≈	↑	(≈)	↑↑
					P	–	(≈)	–	–
Fraxinus excelsior	X	–	7	–	1	(≈)	(↑)	≈	↓
					2	(≈)	(↑)	≈	↓
					P	(≈)	(≈)	(≈)	↑
*Galium uliginosum**	8	L/M	X	L/M	1	↑	(≈)	↓	(↓)
					2	↑	(↑)	≈	≈
					P	↑↑	(↑)	↑	≈
Glechoma hederacea	6	–	7	–	1	–	–	–	–
					2	(≈)	–	–	(≈)
					P	(≈)	–	–	↓↓

	Ebg.F	Wtab	Ebg.N	Fert	Q	North Mead.	Comp. 6	Comp. 8	Comp. 11
Hypericum tetrapterum *	8=	L	5	M	1	–	–	–	–
					2	–	–	(≈)	–
					P	–	–	–	–
Juncus subnodulosus **	8	M	X	M	1	(↓)	≈	(↓)	≈
					2	≈	≈	(↓)	≈
					P	↓	↑	≈	=
Lythrum salicaria *	8=	L/M	X	M	1	(≈)	↑↑	↑	(≈)
					2	(≈)	↑	≈	(≈)
					P	–	–	↑	–
Mentha aquatica *	9=	M	4	M	1	↑	(↑)	↑	↑↑
					2	↑	↑	↑	↑↑
					P	↑↑↑	–	↑↑	↑↑↑
Molinia caerulea *	7~	M	2	L	1	≈	↑	≈	≈
					2	≈	↑	≈	≈
					P	=	–	≈	≈
Phragmites australis *	10~	M	5	M	1	≈	(↓)	(↓)	≈
					2	≈	≈	≈	≈
					P	↑	≈	↓	≈
Prunella vulgaris	X	L/M	X	L	1	↓	–	(↓)	↓↓
					2	↓	–	≈	↓↓
					P	↓	–	–	–
Ranunculus flammula *	9~	M/H	2	L/M	1	–	–	–	≈
					2	–	–	–	≈
					P	–	–	–	–
Salix seedlings (cf. cinerea)	(9~)	M	(4)	M	1	↑↑↑	–	≈	↑↑↑
					2	↑↑↑	(≈)	≈	↑↑↑
					P	↑↑↑	–	↑↑	↑↑↑
Samolus valerandi **	8=	–	6	–	1	–	(↓)	≈	≈
					2	–	(↓)	↑	↑
					P	–	–	(↑)	–
Scrophularia auriculata *	–	–	–	–	1	–	(≈)	–	–
					2	–	(≈)	(≈)	–
					P	–	–	–	–
Selinum carvifolia **	7~	–	2	–	1	↑↑	–	–	–
					2	↑	–	(↑)	↑
					P	↑↑↑	–	–	–
Symphytum officinale	8	M	8	M	1	–	–	–	↑
					2	–	–	–	↑↑
					P	–	–	–	–
Valeriana dioica *	8~	M	2	L/M	1	–	–	–	↑
					2	↑	–	≈	↓
					P	↓	–	≈	≈
Vicia cracca	5	L	–	M	1	–	(↑)	↑	↑
					2	↓	↑	↑	≈
					P	↓	–	≈	≈
Brachythecium rutabulum	–	L/M	–	M	1	↑↑	↑	↓	↓
					2	↑↑	↑↑	≈	↓↓
					P	↑	↑	↓↓	≈
Calliergon cuspidatum *	–	M	–	M	1	↓↓	(↑)	↓	↑
					2	↓	(↑)	↑	↑
					P	↓↓	≈	↓	≈
Eurhynchium praelongum	–	L	–	M	1	↓	–	↓↓	↓
					2	↓	(≈)	↓↓	↓
					P	↓	(≈)	↓	(≈)
Fissidens adianthoides *	–	M	–	L	1	≈	(≈)	↑	–
					2	≈	(≈)	↑	–
					P	↑	(≈)	↓	–

* = principal fen species, ** = rare principal fen species

Ellenberg values are taken from Ellenberg (1974). 'Moisture values' range from 1 (occur in extremely dry soils), through 7 (in moist soils which do not dry out) to 12 (submerged plants, usually entirely immersed). X: with broad amplitude, or with different behaviour in contrasting habitats; ~ in fluctuating mosture conditions. = soils that are fairly regularly inundated.

'Nitrogen values' range from 1 (only in soils very poor in mineral nitrogen), through 7 (mostly in soils rich in mineral N) to 9 (only in soils very rich in mineral N).

Water table and fertility values are taken from Shaw & Wheeler (1991). Summer water table: low = -25 to -10 cm; moderate = –9 to +1 cm. Substratum fertility: low = 3–9 mg/seedling; moderate = 10–20 mg/seedling.

6.2.1 North Meadow

The vegetation of the North Meadow is quite different to that of the other compartments, comprising a relatively low-growing sward of vegetation, with *Molinia caerulea* and *Juncus subnodulosus* as some of the most important component species, but with a well-developed sward of associates, giving a diverse stand. This area was the most species rich in terms of mean species density, but supported fewer species in total, and fewer principal fen species than both Compartments 8 and 11. However, interestingly, it did support the highest number (8) of rare fen species of the four compartments (see Table 9.5 and Figure 5.1). The vegetation supports a number of notable species including *Anagallis tenella, Carex hostiana, Cirsium dissectum, Gymnadenia conopsea* and *Selinum carvifolia*, together with a quite large population of marsh orchids.

The hydrological regime experienced in the western part of North Meadow was similar to that in Compartment 8 in terms of the range of values experienced, the relatively high variability during winter periods and to depths to which the water table declines during summer. The mean water table depth (–27.8 cm) was the lowest of the four areas.

The three main species (*Juncus subnodulosus, Molinia caerulea* and *Phragmites australis*) were found at or near 100% frequency throughout the monitoring period, although there was a trend for a slight decrease in *J. subnodulosus*. The fluctuating and generally sub-surface water table is likely to favour the growth of species such as *Molinia caerulea*. This species showed an increase in biomass over the period monitored. However, this does not necessarily suggest an increase in substratum fertility, as the sampling was carried out one-year and two-years after mowing, and therefore a straight comparison cannot be made between the two samples. However, the trend for an increase in frequency of *Angelica sylvestris, Eupatorium cannabinum* and *Mentha aquatica* could also be suggestive of an increase in nutrient supply. The *Molinia* is clearly kept in check by the current management regime of grazing and mowing. The present intention to maintain higher water levels, particularly in winter (a bank at the west end of the Compartment has recently been repaired) should help to dis-favour *Molinia* and maintain species diversity, although extended inundation should be avoided. The decline in *Calliergon cuspidatum* and increase in *Brachythecium rutabulum* may reflect the relatively dry conditions, as may the sudden influx of *Salix* seedlings in 1995. It would be interesting to monitor the overall effect of the recent raising the water levels (the site was inundated in winter 1995/6).

The general increase in frequency over the monitoring period of both *Anagallis tenella* and *Selinum carvifolia* is of note, as these species are of particular interest. The latter showed a particularly strong increase in frequency at the smaller random quadrat size (from 33% to 53%), which suggests that it has become generally much more frequent within the monitored area, now occurring in over half of the quadrats sampled. For *Anagallis*, the increase was from 3.3 to 7%, which is probably of significance, although may just be an expression of the generally low frequency of this species. Further monitoring would help to determine whether this was a general trend.

Selinum carvifolia and *Angelica sylvestris* may be damaged to some extent by grazing, and it is of interest to note that in both species there was apparently an increase in frequency of these species following mowing of the sward. It is possible that for such species (which are fairly short-lived perennials), that it is the dynamics of recruitment of individuals which has been monitored, rather than response to environmental conditions.

6.2.2 Compartment 6

It is difficult to make an assessment of trends for this compartment as there is no previous management period with which to compare, having only been mown once during the present monitoring period considered. However, a few general observations can be made.

Cladium mariscus retained its dominance and crop mass throughout the monitoring period, with fairly minor changes in the infrequent associated species. The patchy nature of the vegetation is apparent from both the permanent and random quadrat data, and make it particularly difficult to discern any general trends over one monitoring period.

Compartment 6 supports only few rare fen species, but as two of these formed the major components of the vegetation, this Compartment showed the highest mean frequency of RPFS in most years. The apparently large increase in mean frequency RPFS between 1991 and 1992 can be explained by the fact that in 1992 *Cladium mariscus* and *Juncus subnodulosus* were the only two rare fen species recorded.

Compartment 6 was the wettest of the four, having the highest mean and median water levels. However, although autumn/winter water levels were fairly stable and close to the ground surface (sometimes above), summer water levels can fall to more than a metre below surface level, giving a range of 126 cm over the 5-year period. The wet conditions in 1993 were reflected in records of algae on the peat surface, which were not apparent in other years, other than in one of the permanent quadrats in the first year of monitoring (1991).

The increase in mean species density, and total number of species recorded in the random quadrats in 1994, including massive invasion of *Betula* seedlings in 1994, may have been a result of the early drop in water levels in comparison with the previous two years. However, most of the *Betula* seedlings had disappeared by 1995 (possibly drowned by the winter inundation?), and this species does not appear to offer a management threat at present.

There were no trends in vegetation composition which could be clearly related to the mowing regime, where it might be expected that the initial opening-up of the canopy would promote an influx of species, followed by a reduction as the *Cladium* becomes more dense. However, random quadrat data showed a sharp rise in frequency of a number of species in 1994 (*i.e.* in the second year following mowing), many of them having been unsampled or at very low frequencies prior to this, including *Anagallis tenella*, *Fissidens adianthoides* and *Lycopus europaeus*. The low frequencies at which they were sampled explains the slight decline of mean frequency of species density and number of principal fen species.

There was a marked decline in frequency of *Juncus subnodulosus* in 1993 (the year following mowing), which is perhaps surprising as it might be expected that this species would benefit from the opening up of the canopy. The marked increase in frequency of *Fraxinus* seedlings in the two years following mowing with subsequent decline may also be a result of the mowing regime.

In order to reduce the variability due to the patchy vegetation structure, the samples for crop mass were taken from a restricted area of dominant *Cladium*, and thus the lack of changes in contribution from associated species in comparison with trends noted in the random quadrats is not surprising. Although there was an apparent increase in total crop mass, the only significant difference in crop mass recorded between 1991 and 1995 was an increase in the amount of litter. It is possible that this is related to the generally wet conditions following the mowing in 1992, through to spring 1994, and again in autumn/winter 1994/5, which would help to retard decomposition.

6.2.3 Compartment 8

This Compartment is largely dominated by *Molinia caerulea* and *Juncus subnodulosus*, with some *Cladium mariscus* prominent in patches. It is floristically quite similar to Compartment 11, with similar numbers of species recorded, although Compartment 8 supports more rare fen species. There were no changes noted amongst the main dominant species, other than fairly minor variations in frequencies. However, Compartment 8 had the largest number of species exhibiting some change in frequency. Particularly interesting is that the frequency of eight species in this compartment showed considerable variation, seemingly in accord with the mowing cycle. Two species, *Carex panicea* and *Samolus valerandi*, increased in frequency between years 1 and 2 on both occasions, while six species, including *Lythrum salicaria, Valeriana dioica* and *Cirsium palustre* decreased in frequency between years. Total species numbers recorded in the first year following mowing were slightly lower than in the second. This was evident for principal fen species, rare fen species and non-fen species, and seems to be a result of more species being recorded at low frequency in the second year. Although of interest, it is possible that this effect is just a co-incidence of recording rather than a result of species dynamics, particularly as the same trend was not consistent in Compartment 11. Further monitoring would help to determine this. Three species, *Angelica sylvestris, Mentha aquatica* and *Anagallis tenella,* increased in frequency throughout the whole monitoring period.

There was little significant variation in crop mass between 1991 and 1995, although the decrease in *Juncus subnodulosus* and trend for an increase in contribution from 'other' species (mainly sedges and *Equisetum*) could suggest that conditions have particularly favoured the latter group. Data provided by the random quadrats were suggestive of a decrease in frequency of *J. subnodulosus* (from 100 to 93%) over the last year, and also demonstrated an increase in frequency of *Equisetum palustre* and *Carex panicea.* In the permanent quadrat, *Carex panicea, C. flacca* and *C. lepidocarpa* all increased in frequency.

The water regime in Compartment 8 showed more similarities with that in the North Meadow than in Compartment 11, with sub-surface winter water levels, although summer minima were lower, reaching between *c.* 55–100 cm below ground level. It is noticeable from the plot of dipwell water levels (Figure 3.6) that the first management period (*i.e.* between mowing in 1991 and 1993) was generally wetter than the second (*i.e.* after mowing in 1993), and this is likely to have influenced some species changes which might have been a response to mowing.

6.2.4 Compartment 11

The vegetation in this Compartment is similar to Compartment 8, though with rather more *Juncus subnodulosus* and less *Cladium mariscus.* There was a similar range of principal fen species, but only four of these were rare: *Cladium mariscus*, *Juncus subnodulosus*, *Selinum carvifolia* and *Samolus valerandi*. The vegetation is mown every two years, alternating with mowing in Compartment 8.

The water regime in Compartment 11 showed more similarities with Compartment 6, than Compartment 8. It is typically inundated in winter to a depth of a few cm, but showed the widest variation in water levels, with a range of 147 cm. Comparison with the data for Compartment 8 show that Compartment 11 was generally wetter in winter, but with lower summer water levels.

There was a slight decrease in mean species density and mean number of principal fen species from 1991 to 1993, followed by an increase to 1995. However, this was also reflected in the total numbers of species recorded. In the permanent quadrat, *Carex flacca* and *Carex lepidocarpa* both increased in frequency, although this was not apparent from the random quadrat data. In contrast with North Meadow and Compartment 8, *Calliergon cuspidatum* increased in frequency over the monitoring period – this could be a result of the generally wetter conditions in this compartment. The inundation in this compartment is of interest as it is lies higher above the river than the other 3 compartments monitored (see Table 3.1). It would be of interest to know whether this was a result of flooding from adjacent dykes, or ponding of rainwater. The trend for an increase in winter water levels should be monitored, as if it continues, may result in some undesirable floristic changes.

There was some evidence of changes in species frequencies in line with the mowing regime, for example, *Molinia caerulea, Equisetum palustre, Cirsium palustre, Deschampsia cespitosa, Symphytum officinalis, Agrostis stolonifera* all decreased in frequency, while *Mentha aquatica* and *Potentilla erecta* tended to increase in frequency following mowing. However, the only consistent species response to mowing in both Compartments 8 and 11 was shown by *Cirsium palustre.*

There was no significant change in total crop mass between 1991 and 1995, although there was a significant increase in contribution from mosses and *Phragmites australis.* The frequency of *Phragmites* did not change over this period, suggesting that there may be a response to some external factors (such as nutrient supply), although, of course, some natural variation in biomass production cannot be discounted. However, the overall species changes noted (see Section 5.2.4) would also be suggestive of an increase in nutrient supply, and are also consistent with the observation that there has been a general increase in water levels (see Appendix 1).

6.2.5 Discussion

Few species appear to have shown a consistent pattern of increase or decrease across the site during the five years of monitoring (Table 6.1). Exceptions include *Mentha aquatica,* which increased in frequency in all compartments, *Angelica sylvestris,* which increased in frequency in Compartments 6, 8 and the North Meadow and *Anagallis tenella,* which increased in North Meadow and both Compartments 8 and 11. There was a reduction in frequency of *Cirsium palustre* and *Agrostis stolonifera* in all compartments except 6 (where they were only present at low frequency). There was a major influx of *Salix* seedlings into North Meadow and Compartments 8 and 11 in 1995.

In attempting to interpret such trends, and others reported here, there are several general points which should be made:

- Conditions seem to have been drier in the period 1989-1991 than in the period through which the vegetation has been monitored (see Appendix 1). It is therefore possible that some of the changes in species abundance recorded may be a response to this.
- The field distribution and abundance of many wetland species are likely to be strongly influenced by environmental variables other than water levels, for example, substratum fertility, base status and availability of toxic metals (*e.g.*

iron). The species composition of a sward is also strongly affected by the management regime.

- The natural population dynamics of many species is poorly known, and some of the variation recorded is undoubtedly due to natural population fluxes, although these will be influenced by prevailing environmental conditions. For example, the large invasion of *Salix* seedlings in 1995 was presumably the result of good conditions for seed production in 1994, coupled with subsequent optimum conditions for germination and establishment. Similarly, species are affected differently by management (including disturbance by trampling), and response may depend on their vegetative regenerative abilities, as well as life-history characteristics. For example, *Mentha aquatica* is known to regenerate well from fragments, and it is possible that the general increase in frequency of this species is a result of the management regime, rather than a response to changing environmental conditions.
- The response of plant species to hydrological conditions, or to changes in them, is very poorly known (see Wheeler & Shaw, 1992; 1995). In particular, little is known about the speed of response of species to changing water level conditions, but it is likely that established perennial plants will show substantial inertia against water level change (and that such plants can survive periodic, short-term droughts). The general trend for an increase in frequency of *Anagallis tenella* is of interest, as this is a species which might be expected to be badly affected by low summer water levels. However, recent evidence indicates that in laboratory conditions, *Anagallis tenella* grows better when in soil with a water table maintained at –20 cm than when kept at –10 cm or 0 cm. (P. Eades, *pers. comm.*)

It is thus difficult from the present data to separate natural population fluxes from the response to management and environmental conditions, but there is no consistent evidence that suggests that there have been any substantial general changes in vegetation composition or crop mass throughout the monitoring period which would be suggestive of deterioration in the floristic quality of the site. However, the floristic changes in North Meadow reflected the generally 'dry' conditions, perhaps coupled with a small amount of enrichment, while in Compartment 11 the changes in vegetation were consistent with the increasingly wet, although widely fluctuating, water levels, together with an increase in nutrient supply. Further monitoring would identify whether these are general trends which would be of concern in the future. The present data set provides a good baseline against which future changes in the vegetation can be assessed, and it is recommended that vegetation monitoring is continued, but perhaps on a less frequent basis.

The crop mass sampling has provided some useful information, but it is suggested that continued monitoring of crop mass cannot be justified. Some changes in species composition have been noted, particularly in North Meadow and Compartment 11, and these compartments should be monitored as a minimum. It is recommended that detailed sampling is continued on a two-yearly basis (to fit in with the management regime), if possible. If funding is limited, it may be possible to devise a less intensive monitoring strategy which would help to determine whether adverse changes are taking place. As the permanent quadrats are now marked with transponders, these should be easy to resample as required.

7. Summary and Conclusions

1. Vegetation has been monitored over a period of five years in four Compartments at Chippenham Fen: North Meadow, and Compartments 6, 8 and 11.
2. Three techniques have been employed: recording species frequencies in random and permanent quadrats and estimating the contribution of different components to the crop mass.
3. Compartment 8 and Compartment 11 are both managed on a two-year mowing cycle, thus two full management cycles have been monitored. North Meadow is grazed annually, but mown every 2–3 years and Compartment 6 is mown every four years. For these areas, only one management cycle has been monitored, making it more difficult to assess consistent trends.
4. Some changes in species abundances have been noted. However, with a relatively short period of monitoring, it is difficult to separate the effects of:

   a) natural population dynamics;

   b) management cycle;

   c) variation in hydrological conditions (water levels and climate).
5. There is no consistent evidence that suggests that there have been any substantial changes in vegetation composition or crop mass throughout the monitoring period in Compartment 6 or Compartment 8.
6. In Compartment 11, changes in species frequencies suggested that conditions are becoming wetter and perhaps more nutrient-rich. This is consistent with the trend shown by the dipwell data over the five-year period, for rising winter water levels, but with a substantial fall in water levels during the summer (*i.e.* wide fluctuations).
7. In North Meadow, the monitoring data suggest that there may have been a some increase in nutrient supply, which, coupled with dry conditions may help to explain changes in species abundance.
8. An increase in substratum fertility in wetlands, can sometimes be attributed to reduction in water levels (often coupled with wide fluctuations) leading to a release of nutrients. However, at Chippenham, the oxidised nature of the peat and its shallow depth suggest that conditions on the site have been broadly similar for a number of years, and that alternative sources should be sought to explain any increases in nutrient status. Remedial action should be taken if possible.
9. It is suggested that the current policy of maintaining high water levels (surface flooding) in the winter should be re-appraised, as this may in fact be detrimental to the current floristic interest of the EU-MOLINION. The water regime experienced in the North Meadow in recent years is probably adequate for the maintenance of examples of this Alliance, and may provide a model for manipulations of the water table in Compartment 11.
10. The present data set provides a good baseline against which future changes in the vegetation can be assessed. It is recommended that vegetation monitoring is continued, but perhaps on a less frequent basis.

8. References

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9.

Annex A: Random quadrat data

Table 9.1 North Meadow, mean species frequencies in random nested quadrats

Species		Quadrat size 1 ($0.25m^2$) 1991	1992	1993	1994	1995	Quadrat size 2 ($2m^2$) 1991	1992	1993	1994	1995
Principal fen species											
Anagtene	*	–	–	–	–	3.3	3.3	–	–	–	6.7
Angesylv	*	16.7	60	46.7	66.7	60	66.7	80	70	93.3	86.7
Callcusp	*	90	80	53.3	93.3	63.3	93.3	90	63.3	93.3	86.7
Campstel	*	20	–	26.7	43.3	50	33.3	3.3	36.7	76.7	76.7
Carepani	*	100	86.7	80	76.7	90	100	100	83.3	93.3	100
Cirspalu	*	36.7	50	20	6.7	10	63.3	73.3	40	23.3	23.3
Dactinca	*	–	–	–	3.3	–	6.7	–	6.7	6.7	3.3
Equipalu	*	3.3	–	–	–	–	3.3	–	–	–	3.3
Eupacann	*	20	33.3	26.7	30	63.3	30	63.3	53.3	53.3	86.7
Fissadia	*	–	–	–	3.3	–	–	–	–	6.7	–
Franalnus	*	–	–	–	–	–	–	–	–	–	3.3
Galiulig	*	70	60	56.7	83.3	83.3	86.7	96.7	90	90	100
Juncarti	*	–	10	–	–	–	3.3	10	–	–	–
Lythsali	*	3.3	3.3	–	–	3.3	13.3	16.7	3.3	3.3	16.7
Mentaqua	*	46.7	53.3	50	53.3	66.7	70	73.3	60	86.7	80
Molicaer	*	100	100	100	93.3	100	100	100	100	96.7	100
Pedpal	*	–	–	–	–	–	–	–	–	–	3.3
Phraaust	*	96.7	100	93.3	100	96.7	96.7	100	96.7	100	96.7
Valedioi	*	73.3	83.3	83.3	56.7	80	90	96.7	90	100	96.7
	Rare principal fen species										
Caredistans	**	–	–	–	–	–	3.3	–	–	–	–
Carehost	**	46.7	63.3	30	30	36.7	73.3	73.3	50	33.3	50
Carepuli	**	3.3	3.3	6.7	6.7	6.7	13.3	3.3	6.7	10	10
Cirsdiss	**	86.7	76.7	73.3	90	76.7	96.7	83.3	80	93.3	96.7
Gymncono	**	–	–	3.3	–	–	6.7	3.3	3.3	–	3.3
Juncsubn	**	93.3	83.3	93.3	93.3	83.3	93.3	93.3	96.7	96.7	86.7
Selicarv	**	33.3	30	53.3	56.7	53.3	60	60	63.3	83.3	70
Thalflav	**	–	–	3.3	–	–	–	–	3.3	–	–
Non-fen species											
Agrostol		53.3	60	40	33.3	3.3	93.3	86.7	63.3	66.7	36.7
Ajugrept		–	–	–	–	3.3	–	–	–	3.3	6.7
Betuseed		–	–	–	3.3	–	–	–	–	3.3	–
Bracruta		10	36.7	23.3	16.7	60	30	46.7	36.7	40	73.3
Brizmedi		3.3	3.3	–	–	–	6.7	3.3	–	–	–
Bryurube		3.3	–	–	–	–	3.3	–	–	–	–
Careflac		63.3	100	86.7	66.7	63.3	80	100	96.7	90	83.3
Centnigr		36.7	56.7	30	73.3	63.3	76.7	86.7	60	90	80

Species	Quadrat size 1 ($0.25m^2$)					Quadrat size 2 ($2m^2$)				
	1991	1992	1993	1994	1995	1991	1992	1993	1994	1995
Cirsarve	–	–	–	–	–	–	–	–	3.3	–
Desccesp	–	6.7	10	–	–	16.7	10	10	6.7	13.3
Eurhprae	10	43.3	–	3.3	–	13.3	56.7	–	3.3	–
Festarun	3.3	–	–	–	–	3.3	–	–	–	–
Festrubr	26.7	56.7	43.3	53.3	43.3	66.7	66.7	60	76.7	70
Filiulma	–	–	–	–		–	–	–	10	
Fraxexce	3.3	–	–	3.3	–	10	3.3	–	3.3	3.3
Glechled					–					3.3
Holclana	3.3	–	–	–		13.3	3.3	–	3.3	
Holcmoll	–	–	–	3.3		–	–	–	3.3	
Linucath	3.3	–	–	3.3	3.3	10	–	–	6.7	3.3
Phleprat	3.3	–	–	–		3.3	–	–	–	
Planlanc	–	–	3.3	–		–	3.3	3.3	–	
Poa triv	–	–	–	–		3.3	–	–	–	
Poteerec	76.7	63.3	66.7	76.7	80	96.7	96.7	90	96.7	100
Prunvulg	3.3	3.3	–	–		10	6.7	–	–	
Pseupuru	10	–	–	10	6.7	20	–	–	10	10
Querseed	–	–	–	–		–	3.3	–	–	
Salixseedl.					46.7					63.3
Serrtinc	20	26.7	20	20	26.7	53.3	46.7	33.3	50	43.3
Succprat	56.7	70	60	43.3	40	80	93.3	80	76.7	80
Vibuopul	–	–	–	–		–	–	–	3.3	
Vicicrac	–	–	–	–		3.3	–	–	–	

Table 9.2 Compartment 6, mean species frequencies in random nested quadrats (main area)

Species		Quadrat size 1 ($0.25m^2$)					Quadrat size 2 ($2m^2$)				
		1991	1992	1993	1994	1995	1991	1992	1993	1994	1995
Principal fen species											
Anagtene	*	.	.	.	.		.	.	.	4	
Angesylv	*	8	4	4	20	12	16	16	12	40	40
Calicusp	*	.	.	.	.	4	.	4	.	.	4
Campstel	*	.	.	.	.		.	.	8	4	
Carelepi	*	.	.	.	4		4	.	.	12	
Carepani	*	.	.	.	.		.	.	4	8	
Cirspalu	*	.	4	.	8	4	8	4	.	24	4
Epilparv	*	.	.	.	4		.	4	.	8	
Equipalu	*	12	8	20	32	36	48	36	52	84	84
Eupacann	*	76	60	12	64	68	100	84	12	96	84
Filiulma	*	.	4	.	.		.	8	4	4	12
Fissadia	*	.	.	.	4		.	.	.	4	
Franalnu	*	4	.	.	.		4	.	.	.	
Galiulig	*	.	4	.	8	4	.	8	.	16	16
Juncarti	*	.	.	.	4	4	.	.	.	16	8
Lycoeuro	*	.	.	.	.		.	.	.	4	
Lythsali	*	32	20	36	44	76	64	48	64	76	92
Mentaqua	*	.	.	.	.	4	4	8	.	4	8
Molicaer	*	4	.	.	20	24	24	.	8	44	28
Phraaust	*	92	92	88	100	72	100	96	88	100	96
Scroauri	*	.	.	.	4		.	.	.	4	4
Vicicrac	*	.	.	4	.	4	.	.	4	.	8
	Rare fen species										
Cirsdiss	**	4	.	4	.	.	4	.	8	.	12
Cladmari	**	100	100	100	100	100	100	100	100	100	100
Pellendi	**	.	.	.	.		.	.	.	4	
Samovale	**	4	.	.	.		4	.	.	.	
Schonigr	**	.	.	.	4		.	.	.	4	
Non-fen species											
Agrostol		.	.	.	.	.	.	.	.	4	4
Algamat		.	.	16	.		.	.	32	.	
Ambiserp		.	.	.	.		.	.	.	4	
Artevulg						8					8
Betusd		.	.	.	20	.	.	.	.	40	8
Bracruta		8	.	.	12	16	8	20	.	24	36

Species	Quadrat size 1 ($0.25m^2$)					Quadrat size 2 ($2m^2$)				
	1991	1992	1993	1994	1995	1991	1992	1993	1994	1995
Bromcomm	.	.	.	4		.	.	.	4	
Bryurube	4	.	.	8		4	.	.	12	
Caredist					.					4
Careflac	4	.	.	4		4	.	.	4	
Cirsarve	.	.	.	.		.	.	.	12	
Desccesp	.	.	4	.		4	.	4	.	
Eurhprae	.	.	.	.		.	8	.	.	
Festrub					4					8
Fraxexce	8	8	24	32	12	32	28	44	48	36
Juncinfl	.	.		.		.	.	.	4	
Juncsubn	64	76	52	72	76	84	92	68	84	88
Myosseed		4					4			
Planmajo	.	.	.	.		.	.	.	4	
Potasp	.	.	.	.		4	.	.	.	
Poteerec			.	.	4			4	.	8
Salix seed					.					8
Seneeruc					.					4
Soladulc	.	4	4	4	8	12	16	4	12	24
Soncoler	.	.	.	.		4	.	.	.	
Vibuopul					8					20

Table 9.3 Compartment 8, mean species frequencies in random quadrats

Species		Quadrat size 1 ($0.25m^2$) 1991	1992	1993	1994	1995	Quadrat size 2 ($2m^2$) 1991	1992	1993	1994	1995
Principal Fen Species											
Anagtene	*	–	10	6.7	13.3	23.3	–	23.3	10	30	30
Angesylv	*	16.7	36.7	33.3	63.3	70	60	63.3	63.3	83.3	86.7
Bryupseu	*	–	–	6.7	–		–	–	16.7	3.3	
Callcusp	*	66.7	76.7	93.3	93.3	60	80	83.3	96.7	93.3	86.7
Campstel	*	–	–	23.3	6.7	3.3	–	–	50	36.7	13.3
Carelepi	*	53.3	50	63.3	53.3	56.7	93.3	63.3	80	93.3	83.3
Carepani	*	50	10	43.3	40	86.7	70	30	56.7	60	93.3
Cirspalu	*	53.3	80	60	76.7	46.7	80	90	76.7	93.3	73.3
Epilhirs	*	3.3	–	–	–		3.3	–	–	–	
Equipalu	*	10	20	33.3	26.7	13.3	16.7	46.7	53.3	66.7	30
Eupacann	*	23.3	50	40	40	46.7	46.7	90	70	76.7	80
Filiulma	*	–	–	3.3	–	3.3	–	–	3.3	–	3.3
Fissadia	*	3.3	–	–	13.3	10	3.3	3.3	–	53.3	16.7
Franalnu	*	16.7	13.3	6.7	13.3	6.7	66.7	43.3	26.7	43.3	26.7
Galiulig	*	90	76.7	80	90	73	100	96.7	93.3	96.7	100
Hydrvulg	*	–	3.3	3.3	–	6.7	–	3.3	3.3	–	10
Hypetetr	*	–	–	–	–	–	3.3	–	–	–	3.3
Juncarti	*	–	–	3.3	–		–	–	3.3	–	
Lythsali	*	20	33.3	40	40	33.3	60	63.3	53.3	80	63.3
Mentaqua	*	43.3	50	56.7	66.7	60	63.3	66.7	66.7	83.3	73.3
Molicaer	*	96.7	96.7	93.3	100	93.3	100	100	96.7	100	93.3
Phraaust	*	100	100	100	93.3	93.3	100	100	100	93.3	100
Salicine	*	6.7	6.7	13.3	10	10	20	10	20	33.3	30
Scroauri	*	–	–	–	–		3.3	–	–	–	
Sympoffi	*	–	–	–	–	3.3	3.3	–	–	3.3	6.7
Valedioi	*	16.7	33.3	23.3	33.3	26.7	43.3	70	26.7	50	46.7
	Rare Principal Fen Species										
Carehost	**	–	–	3.3	–		3.3	–	3.3	3.3	
Carepuli	**	6.7	–	–	–		10	–	–	–	
Cirsdiss	**	46.7	3.3	3.3	13.3	73.3	70	6.7	6.7	20	93.3
Cladmari	**	43.3	73.3	93.3	80	30	50	76.7	96.7	83.3	36.7
Juncsubn	**	100	100	100	100	93.3	100	100	100	100	93.3
Samovale	**	3.3	3.3	6.7	–	6.7	10	10	16.7	10	23.3
Selicarv	**	–	–	–	–	–	–	–	3.3	3.3	6.7

Species	Quadrat size 1 (0.25m^2) 1991	1992	1993	1994	1995	Quadrat size 2 (2m^2) 1991	1992	1993	1994	1995
Non-fen species										
Agrostol	30	33	20	20	–	46.7	56.7	30	50	13.3
Ajugrept	–	–	–	–	–	–	–	–	10	3.3
Betuseed	–	–	3.3	–		–	3.3	6.7	–	
Bracruta	93.3	33.3	10	–	80	93.3	50	10	–	90
Calaepig	–	–	–	–	3.3	3.3	3.3	–	–	6.7
Cardprat	–	–	–	–		3.3	3.3	–	–	
Careflac	30	3.3	23.3	40	20	50	13.3	36.7	63.3	20
Centnigr	3.3	–	–	–		3.3	–	–	–	
Ctenmoll	–	–	–	–		–	–	–	3.3	
Desccesp	30	3.3	23.3	23	23.3	53.3	43.3	50	50	46.7
Eurhprae	26.7	13.3	10	–		33.3	23.3	13.3	6.7	
Festrubr	13.3	10	16.7	6.7	6.7	16.7	20	26.7	16.7	20
Fraxexce	3.3	6.7	6.7	13.3	3.3	3.3	10	10	36.7	10
Holclana	–	–	3.3	3.3	3.3	–	3.3	3.3	3.3	3.3
Lophbide	–	–	–	–		–	3.3	–	–	
Pinusylv	–	–	–	–		–	–	–	3.3	
Plagundu	3.3	–	–	–		3.3	–	–	–	
Poteerec	16.7	16.7	50	26.7	26.7	46.7	50	66.7	66.7	53.3
Poterept	3.3	–	–	–		3.3	–	–	–	
Prunvulg	3.3	6.7	6.7	–	–	3.3	26.7	16.7	3.3	3.3
Pseupuru	–	–	–	3.3	3.3	–	–	–	10	3.3
Querseed	–	3.3	–	–	3.3	–	10	3.3	–	3.3
Ranurepe	–	–	–	–		3.3	–	–	–	
Rhamcath	–	–	3.3	–		–	–	13.3	3.3	
Rhizpunc	–	–	–	–		–	–	–	3.3	
Rubufrut	–	–	3.3	–	3.3	3.3	3.3	3.3	6.7	3.3
Salixseedl.					–					3.3
Taraxseedl.					3.3					3.3
Valeoffi	–	–	–	–		–	3.3	–	–	
Vibuopul	–	–	6.7	–	–	3.3	10	13.3	–	3.3
Vicicrac	3.3	10	13.3	20	13.3	16.7	23.3	23.3	33.3	26.7

Table 9.4 **Compartment 11, mean species frequencies in random nested quadrats**

Species		Quadrat size 1 (0.25m²)					Quadrat size 2 (2m²)				
		1991	1992	1993	1994	1995	1991	1992	1993	1994	1995
Principal fen species											
Anagtene	*	–	6.7	–	–	3.3	3.3	13.3	–	6.7	6.7
Angesylv	*	10	10	6.7	20	13.3	50	40	13.3	33.3	23.3
Bryupseu	*	–	3.3	–	–		–	3.3	–	–	–
Callcusp	*	83.3	60	96.7	96.7	96.7	90	76.7	96.7	100	100
Campstel	*	16.7	–	3.3	–	–	26.7	–	3.3	–	–
Careechi	*	–	–	–	–	–	–	–	3.3	–	–
Carelepi	*	20	3.3	13.3	13.3	16.7	33.3	13.3	20	36.7	33.3
Carepani	*	10	3.3	10	13.3	6.7	16.7	6.7	13.3	23.3	20
Cirspalu	*	80	66.7	36.7	–	43.3	96.7	86.7	60	10	70
Epilparv	*	13.3	–	–	3.3	3.3	20	3.3	–	6.7	10
Equipalu	*	40	6.7	63.3	33.3	56.7	56.7	13.3	83.3	73.3	86.7
Eupacann	*	60	63.3	10	6.7	50	80	86.7	13.3	20	63.3
Filiulma	*	6.7	3.3	–	6.7	10	10	10	3.3	20	26.7
Franalnu	*	–	–	–	–	6.7	16.7	3.3	–	–	20
Galiulig	*	76.7	90	76.7	43.3	66.7	93.3	100	96.7	80	90
Hydrvulg	*	–	–	–	–		–	–	–	3.3	
Juncarti	*	–	–	–	6.7	–	3.3	–	–	10	3.3
Lycoeuro	*	–	10	–	3.3	13.3	6.7	16.7	6.7	10	46.7
Lythsali	*	–	–	–	3.3	10	3.3	–	–	3.3	10
Mentaqua	*	46.7	70	73.3	80	96.7	76.7	93.3	83.3	83.3	100
Molicaer	*	86.7	73.3	100	86.7	93.3	96.7	80	100	86.7	100
Pedipalu	*	–	–	3.3	–	–	–	–	6.7	–	–
Phraaust	*	100	76.7	100	100	100	100	80	100	100	100
Ranuflam	*	3.3	–	–	6.7	3.3	10	–	–	6.7	6.7
Salicine	*	6.7	3.3	–	–	–	13.3	13.3	–	20	3.3
Sympoffi	*	6.7	3.3	16.7	3.3	16.7	10	10	20	10	30
Valedioi	*	23.3	30	46.7	36.7	33.3	63.3	60	73.3	66.7	50
Rare principal fen species											
Cladmari	**	33.3	30	16.7	40	20	36.7	36.7	20	43.3	23.3
Juncsubn	**	100	96.7	100	100	100	100	96.7	100	100	100
Samovale	**	3.3	–	–	3.3	3.3	6.7	3.3	–	6.7	13.3
Selicarv	**	–	–	–	–	–	–	–	–	3.3	3.3

Species	Quadrat size 1 ($0.25m^2$)					Quadrat size 2 ($2m^2$)				
	1991	1992	1993	1994	1995	1991	1992	1993	1994	1995
Non-fen species										
Agrostol	23.3	3.3	20	10	6.7	40	20	26.7	26.7	23.3
Ajugrept	–	–	3.3	–	–	–	–	6.7	–	–
Algamat	–	–	–	–	3.3	–	–	–	–	3.3
Betuseed	–	–	6.7	–	16.7	–	6.7	10	–	26.7
Bracruta	16.7	13.3	3.3	–	–	53.3	33.3	3.3	–	–
Bryurube	6.7	–	–	6.7	–	10	–	–	13.3	–
Calaepig	–	–	–	–	–	3.3	–	–	–	–
Cardprat	–	–	26.7	13.3	13.3	–	10	36.7	50	33.3
Careflac	10	–	16.7	16.7	3.3	23.3	6.7	23.3	20	10
Cirsarve	3.3	30	3.3	–	–	10	46.7	3.3	–	–
Desccesp	30	23.3	30	26.7	16.7	60	36.7	56.7	50	26.7
Epilangu	–	–	3.3	–	3.3	–	–	3.3	–	3.3
Eurhprae	10	3.3	–	–	–	13.3	6.7	–	–	–
Festrubr	6.7	–	–	6.7	13.3	6.7	–	6.7	16.7	20
Fraxexce	13.3	16.7	46.7	3.3	3.3	33.33	43.3	56.7	33.3	20
Glechede	–	–	–	–	–	3.3	–	–	–	3.3
Holclana	3.3	–	–	–	–	3.3	–	–	–	–
Lathprat	3.3	–	–	–	–	3.3	–	–	–	–
Pleusubu	3.3	–	–	–	–	3.3	–	–	–	–
Poatriv	–	–	–	–	3.3	–	–	–	–	3.3
Poteerec	3.3	33.3	3.3	6.7	6.7	3.3	53.3	6.7	13.3	16.7
Poterept	13.3	3.3	56.7	3.3	3.3	13.3	6.7	76.7	10	13.3
Prunvulg	13.3	10	6.7	–	–	16.7	23.3	6.7	–	–
Pseupuru	–	–	–	3.3	–	–	–	–	3.3	–
Ranurepe	–	–	–	6.7	–	3.3	–	–	10	–
Rhamcath	–	–	–	–	–	–	–	3.3	–	–
Rubufrut	3.3	–	6.7	3.3	–	13.3	16.7	6.7	10	–
Rubuidae	–	–	–	–	3.3	3.3	–	–	–	10
Salixseedl.	–	–	–	–	63.3	–	–	–	–	80
Senevulg	–	–	–	–	–	–	3.3	–	–	–
Serrtinc	6.7	–	–	–	–	13.3	–	–	–	–
Soladulc	6.7	3.3	3.3	3.3	6.7	13.3	13.3	3.3	3.3	10
Soncaspe	–	–	–	–	–	–	3.3	–	–	–
Soncoler	–	–	–	–	–	3.3	–	–	–	–
Vibuopul	–	–	–	–	–	3.3	–	–	10	3.3
Vicicrac	–	6.7	13.3	10	13.3	13.3	13.3	13.3	23.3	13.3

Table 9.5
Mean species density (SPD) and numbers of principal (PFS) and rare (RPFS) principal fen species per quadrat

Quadrat size 1 ($0.25m^2$)

		1991	1992	1993	1994	1995	mean
North Meadow	SPD	13.3	15	12.8	14	14.7	13.96
	PFS	9.4	8.8	8	8.9	9.3	8.88
	RPFS	2.6	2.6	2.6	2.8	2.6	2.64
Compartment 6	SPD	4.3	3.9	3.7	5.8	5.3	4.6
	PFS	4	3.7	3.2	4.7	4.6	4.04
	RPFS	1.7	1.8	1.6	1.8	1.8	1.74
Compartment 8	SPD	11.4	10.6	12.3	12.2	12.3	11.76
	PFS	8.7	9.2	9.3	9.6	9.3	9.22
	RPFS	1.9	1.8	2	1.9	2	1.92
Compartment 11	SPD	10	8.6	10.2	8.3	10.4	9.5
	PFS	8.3	6.4	6.7	6.2	7.7	7.06
	RPFS	1.4	1.3	1.2	1.4	1.2	1.3

Quadrat size 2 ($2m^2$)

		1991	1992	1993	1994	1995	mean
North Meadow	SPD	19	19.4	16.3	18.9	19.6	18.64
	PFS	12	11.2	10	11.5	11.9	11.32
	RPFS	3.3	3.2	3	3.2	3.2	3.18
Compartment 6	SPD	6.4	5.8	5.2	9.2	8.6	7.04
	PFS	5.6	5.1	4.2	7	6.6	5.7
	RPFS	1.9	1.9	1.8	1.9	2	1.9
Compartment 8	SPD	16.7	16	16.2	18.6	17.3	16.96
	PFS	12.7	11.4	11.8	13.6	12.8	12.46
	RPFS	2.4	1.8	2.1	2.1	2.3	2.14
Compartment 11	SPD	14.9	12.9	12.7	12.6	14.6	13.54
	PFS	11.3	8.7	8.2	8.6	10.4	9.44
	RPFS	1.5	1.3	1.2	1.5	1.3	1.36

Table 9.6
Mean frequencies of all species, principal (PFS) and rare (RPFS) principal fen species.

Quadrat size 1 ($0.25m^2$)

		1991	1992	1993	1994	1995	mean
North Meadow	SPD	35.2	51.8	45.8	42.4	48.9	44.8
	PFS	37.6	48.7	42.1	47.0	42.1	43.5
	RPFS	43.3	42.8	37.6	55.3	42.8	44.4
Compartment 6	SPD	25.4	29.8	28.3	25.0	25.1	26.7
	PFS	20.0	28.6	28.7	21.5	28.8	25.5
	RPFS	34.4	88.0	52.0	44.0	58.7	55.4
Compartment 8	SPD	30.9	33.3	30.1	40.8	30.8	33.2
	PFS	27.3	39.5	37.0	39.9	37.1	36.2
	RPFS	24.2	58.9	40.0	38.7	49.2	42.2
Compartment 11	SPD	25.2	28.9	31.0	23.6	26.8	27.1
	PFS	25.8	32.4	35.4	25.8	32.1	30.3
	RPFS	22.8	42.2	58.3	46.7	40.0	42.0

Quadrat size 2 ($2m^2$)

		1991	1992	1993	1994	1995	mean
North Meadow	SPD	41.6	55.3	54.3	47.3	50.3	49.8
	PFS	48.0	62.4	52.5	60.7	53.9	55.5
	RPFS	55.6	52.8	43.3	63.3	52.8	53.6
Compartment 6	SPD	26.8	32.4	28.9	26.2	28.7	28.6
	PFS	28.2	39.1	38.2	31.8	41.0	35.7
	RPFS	38.4	96.0	58.7	48.0	66.7	61.6
Compartment 8	SPD	35.5	39.0	37.7	43.3	36.7	38.4
	PFS	39.6	54.3	47.1	56.7	51.2	49.8
	RPFS	29.6	61.1	42.0	42.0	57.2	46.4
Compartment 11	SPD	28.4	33.6	33.3	30.7	33.2	31.8
	PFS	35.2	43.1	43.0	35.7	43.2	40.0
	RPFS	25.0	45.6	60.0	48.9	42.2	44.3

Table 9.7
Total numbers of species, common principal (CPFS), rare (RPFS) principal fen species and non-fen species (NonFS)

Quadrat size 1 ($0.25m^2$)

		1991	1992	1993	1994	1995	total
North Meadow	All species	36	29	28	32	30	48
	CPFS	13	12	11	13	13	17
	RPFS	5	5	7	5	5	7
	NonFS	18	12	10	14	12	24
Compartment 6	All species	15	13	12	23	20	37
	CPFS	7	8	5	13	11	18
	RPFS	4	2	3	3	2	4
	NonFS	4	3	4	7	7	15
Compartment 8	All species	35	32	41	30	38	52
	CPFS	17	17	21	18	21	24
	RPFS	5	4	5	3	4	6
	NonFS	13	11	15	9	13	22
Compartment 11	All species	39	31	33	35	39	57
	CPFS	18	18	15	18	20	25
	RPFS	3	2	2	3	3	3
	NonFS	18	11	16	14	16	29

Quadrat size 2 ($2m^2$)

		1991	1992	1993	1994	1995	total
North Meadow	All species	44	35	30	39	38	57
	CPFS	16	13	13	15	17	19
	RPFS	7	6	7	5	6	8
	NonFS	21	16	10	19	15	30
Compartment 6	All species	22	18	17	34	28	53
	CPFS	10	11	9	18	14	22
	RPFS	4	2	3	4	3	5
	NonFS	8	5	5	12	11	26
Compartment 8	All species	44	41	43	43	45	64
	CPFS	20	18	21	20	22	26
	RPFS	6	4	6	6	5	7
	NonFS	18	19	16	17	18	31
Compartment 11	All species	51	40	38	41	44	67
	CPFS	23	20	18	22	22	27
	RPFS	3	3	2	4	4	4
	NonFS	25	17	18	15	18	36

10.

Annex B: Permanent quadrat data

Table 10.1

Chippenham Fen, North Meadow, permanent quadrat data (scores) for 1991, 1993, 1994 and 1995

	1991					1993					1994					1995					
Sub-quadrat number	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Carex hostiana	16	16	12	5	8	14	15	15	11	12	12	14	15	16	15	13	12	14	5	9	V
Carex panicea	16	16	16	16	15	16	16	8	14	11	13	4	6	2	11	16	16	15	14	15	V
Molinia caerulea	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	V
Phragmites australis	13	13	15	13	13	8	13	9	13	15	15	11	14	13	15	13	13	16	15	16	V
Potentilla erecta	12	15	7	12	6	14	14	8	10	10	14	16	9	10	15	14	15	6	10	8	V
Succisa pratensis	8	11	11	8	6	8	11	9	13	6	7	13	7	11	3	11	12	10	12	9	V
Calliergon cuspidatum	16	15	16	14	13	15	13	11	14	12	15	10	11	15	12	12	4	7	14	14	V
Campylium stellatum	4	4	5	9	8	7	2	3	4	6	6	2	2	4	11	7	5	6	3	13	V
Cirsium dissectum	15	14	14	14	14	8	10	12	13	11	12	10	12	12	13	9	9	12	11	15	V
Juncus subnodulosus	16	16	16	16	16	14	16	16	16	11	16	16	12	15	7	16	16	16	15	8	V
Centaurea nigra	6	5	3	2	5	7	4	3	1	4	5	12	4	---	13	8	11	3	3	7	V
Festuca rubra	8	6	2	1	2	7	11	---	9	7	2	5	3	2	2	7	7	9	6	6	V
Galium uliginosum	2	1	6	3	1	2	---	5	5	3	4	3	5	8	14	4	4	7	4	8	V
Valeriana dioica	10	8	6	4	6	13	8	7	10	13	5	---	3	5	7	5	3	3	4	5	V
Carex flacca	7	7	5	7	14	9	5	16	15	16	2	---	2	---	7	7	2	9	16	14	V
Selinum carvifolia	2	3	---	---	2	2	3	---	1	6	10	14	6	5	12	6	7	6	2	12	V
Agrostis stolonifera	2	1	3	11	6	1	---	2	3	1	---	3	2	1	4	---	2	2	1	---	IV
Brachythecium rutabulum	4	3	3	4	4	1	2	---	1	---	---	1	1	---	3	6	6	5	6	4	IV
Angelica sylvestris	1	---	---	---	---	1	---	3	9	11	5	2	3	4	12	10	6	2	6	11	IV
Mentha aquatica	3	1	---	---	1	5	---	---	---	2	7	5	---	3	7	10	8	5	12	8	IV
Serratula tinctoria	1	---	1	2	---	1	---	2	3	1	1	---	1	2	---	1	---	1	3	1	IV
Cirsium palustre	1	4	---	2	2	2	1	1	1	3	---	---	---	---	3	1	2	---	---	---	III
Eupatorium cannabinum	4	---	---	---	---	2	---	---	---	1	3	1	---	1	---	4	4	1	2	4	III
Pseudoscleropodium purum	---	---	1	1	2	---	---	---	---	---	---	---	2	---	---	---	1	---	---	---	II
Salix seedling/sp	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	7	12	13	15	16	II
Eurhynchium praelongum	1	1	---	2	5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	I
Fissidens adianthoides	---	---	---	---	---	---	---	---	---	---	---	2	3	1	---	---	1	---	---	---	I
Carex pulicaris	1	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	I
Glechoma hederacea	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	4	---	1	---	---	I
Bryum pseudotriquetrum	---	---	---	---	---	---	---	---	2	---	---	---	---	---	---	---	---	1	---	---	I
Betula seedling/sp	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	---	---	---	---	---	I
Ajuga reptans	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	I
Carex viridula ssp brachyrrhyn	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	I
Gymnadenia conopsea	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	I
Holcus lanatus	---	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	I
Linum catharticum	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	---	---	I
Phleum bertolonii	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	I
Polygala vulgaris	---	---	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	I
Prunella vulgaris	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	I
Fraxinus excelsior (g)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	I
Dactylorhiza sp.	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	I
Number of species per sample	23	19	22	23	23	17	18	22	22	20	20	22	21	23	24	25	25	25	23		

Table 10.2

Chippenham Fen, Compartment 6, species frequencies in permanent quadrats.

	1991	1993	1994	1995	1991	1993	1994	1995	1991	1993	1994	1995	1991	1993	1994	1995	1991	1993	1994	1995
Quadrat number	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5
Cladium mariscus	92	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–
Phragmites australis	80	44	12	28	52	44	64	60	36	88	64	60	76	100	100	68	72	32	8	80
Juncus subnodulosus	8	–	–	16	80	100	100	96	52	64	84	88	88	100	100	100	76	100	88	100
Eupatorium cannabinum	48	–	8	20	12	–	28	8	64	32	52	68	4	–	4	4	4	4	8	12
Equisetum palustre	–	–	–	–	8	4	4	4	4	28	24	24	8	28	12	–	–	–	4	12
Lythrum salicaria	–	–	4	8	16	4	20	12	4	60	24	56	4	4	–	4	–	–	–	–
Angelica sylvestris	–	–	–	–	–	–	–	–	4	–	8	12	–	–	12	4	12	4	44	52
Galium uliginosum	–	–	–	–	–	–	–	–	80	72	92	92	–	–	–	–	32	20	44	60
Filipendula ulmaria	–	–	–	–	–	–	–	–	8	4	4	12	4	8	–	–	–	–	–	–
Molinia caerulea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	100	100	100	100
Brachythecium rutabulum	–	–	–	–	–	–	–	–	20	44	72	68	–	–	–	–	–	–	–	–
Fraxinus excelsior (g)	–	–	–	–	4	4	4	–	–	–	–	–	–	–	4	–	–	–	–	–
Cirsium palustre	–	–	4	–	–	–	–	–	–	4	4	–	–	–	–	–	–	–	–	–
Potentilla erecta	–	–	–	–	–	–	–	–	–	–	4	4	–	–	–	–	–	–	4	–
Calliergon cuspidatum	–	–	–	–	–	–	–	–	–	4	12	4	–	–	–	–	–	–	–	–
Betula seedling/sp	–	–	–	–	–	–	–	–	–	4	8	–	–	4	–	–	–	–	–	–
Algal mat	100	48	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–
Carex viridula ssp brachyrrhyn	–	–	–	–	–	–	–	–	–	–	4	4	–	–	–	–	–	–	–	–
Schoenus nigricans	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8	4	4	12
Cirsium dissectum	–	–	–	4	–	–	–	–	–	–	–	16	–	–	–	–	–	–	–	–
Cirsium arvense	–	–	–	–	–	–	–	–	–	–	12	–	–	–	–	–	–	–	–	–
Epilobium parviflorum	–	–	–	–	–	–	–	–	–	–	32	–	–	–	–	–	–	–	–	–
Festuca rubra	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–
Juncus articulatus	–	–	–	–	–	–	–	–	20	–	–	–	–	–	–	–	–	–	–	–
Solanum dulcamara (g)	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–
Vicia cracca	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
Amblystegium serpens	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–
Bryum pseudotriquetrum	–	–	–	–	–	–	–	–	–	–	12	–	–	–	–	–	–	–	–	–
Eurhynchium praelongum	–	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	–	–	–	–
Fissidens adianthoides	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–
Total number of species	5	3	5	6	7	6	7	6	11	13	20	16	7	8	7	6	7	6	8	9

Table 10.3

Chippenham Fen, Compartment 8, permanent quadrat data (scores) for 1991, 1993, 1994, 1995

	1991					1993					1994					1995					
Sub-quadrat number	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Carex viridula ssp brachyrrhyn	10	11	16	16	13	13	16	16	16	14	13	15	16	15	11	15	15	16	15	16	V
Cladium mariscus	14	15	11	13	6	16	16	13	16	16	16	14	11	15	16	16	15	12	13	14	V
Galium uliginosum	5	1	3	7	5	12	3	1	4	6	11	4	1	7	6	11	2	1	8	5	V
Mentha aquatica	9	8	7	10	10	9	13	15	14	13	10	14	14	14	13	9	14	14	16	14	V
Molinia caerulea	16	15	16	16	16	16	16	16	16	15	16	12	16	16	15	16	16	16	16	16	V
Phragmites australis	15	14	14	15	11	13	11	13	14	9	13	8	16	12	10	14	16	13	11	6	V
Calliergon cuspidatum	16	12	14	14	16	16	15	14	16	14	16	16	12	16	16	16	8	10	15	12	V
Campylium stellatum	8	14	14	13	13	14	15	15	13	16	14	16	16	14	13	11	16	16	13	10	V
Juncus subnodulosus	16	16	16	16	16	16	16	16	16	16	16	15	16	16	16	16	16	16	16	16	V
Cirsium palustre	4	3	2	1	3	3	2	---	1	3	10	4	3	---	5	6	2	3	1	5	V
Eupatorium cannabinum	3	---	3	---	2	7	13	7	12	9	8	5	3	3	4	10	8	8	5	5	V
Frangula alnus	3	1	4	4	3	3	2	2	7	3	5	---	2	4	2	3	1	---	1	2	V
Angelica sylvestris	---	---	2	3	2	1	---	1	9	7	3	2	3	1	7	5	5	3	2	3	V
Carex panicea	---	2	1	8	12	---	---	7	8	6	3	6	14	12	15	3	14	14	16	15	V
Deschampsia cespitosa cespitos	6	---	2	1	4	3	2	---	1	---	7	1	---	3	2	8	3	1	4	3	IV
Lythrum salicaria	1	3	9	4	3	---	8	14	---	1	1	8	14	10	4	---	8	13	8	---	IV
Equisetum palustre	---	---	1	---	1	3	4	4	5	6	2	6	2	4	2	1	1	---	---	1	IV
Carex flacca	---	---	1	2	4	---	---	1	5	12	---	---	2	7	2	1	---	6	12	10	IV
Festuca rubra	5	2	1	1	1	---	---	---	5	2	---	2	---	---	1	1	1	1	---	6	IV
Agrostis stolonifera	1	---	3	1	1	1	1	1	1	---	2	1	---	---	---	---	3	1	---	---	III
Hydrocotyle vulgaris	---	---	1	1	---	---	3	3	5	---	---	4	1	4	1	---	4	---	5	1	III
Samolus valerandi	---	1	1	1	1	---	1	1	---	---	1	2	4	---	---	1	1	3	---	---	III
Brachythecium rutabulum	9	4	5	5	10	---	---	---	1	---	---	---	---	---	---	1	---	1	4	4	III
Fissidens adianthoides	1	3	2	3	---	---	---	---	---	1	3	5	6	2	---	---	---	---	---	---	III
Anagallis tenella	---	---	---	3	4	---	---	---	2	7	---	---	---	4	8	---	---	---	4	8	II
Potentilla erecta	1	---	---	---	---	4	3	5	---	1	---	---	---	1	---	1	---	---	---	---	II
Valeriana dioica	---	---	---	---	---	1	---	---	---	2	1	---	---	1	2	2	---	---	---	1	II
Eurhynchium praelongum	2	3	2	2	3	---	2	---	---	---	---	---	1	---	---	---	---	---	---	---	II
Bryum pseudotriquetrum	---	---	---	---	---	2	4	1	2	---	---	---	1	---	---	---	---	---	---	---	II
Salix seedling/sp	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	4	7	6	5	2	II
Salix cinerea (g)	---	---	---	---	2	---	---	---	---	5	---	---	---	---	3	---	---	---	---	4	I
Fraxinus excelsior (g)	---	2	---	---	---	---	---	---	---	---	---	2	---	---	---	---	1	---	---	---	I
Cardamine pratensis	---	---	---	---	---	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	I
Prunella vulgaris	---	---	---	---	---	---	---	---	---	1	---	---	---	---	2	---	---	---	---	---	I
Cirsium dissectum	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	---	---	---	---	I
Betula seedling/sp	---	---	---	---	---	---	---	---	---	---	---	1	---	2	---	---	---	---	---	---	I
Bryum sp	---	6	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	I
Pinus seedling/sp	---	---	---	---	---	---	---	---	---	---	1	---	---	---	---	1	---	---	---	---	I
Rhamnus cathartica	---	---	---	---	---	---	---	---	---	1	---	---	---	---	---	---	---	---	---	---	I
Viburnum opulus (g)	---	---	---	---	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	I
Number of species per sample	20	20	25	25	25	20	23	21	23	25	22	23	22	24	24	25	23	21	21	24	0

Table 10.4

Chippenham Fen, Compartment 11, permanent quadrat data (scores) for 1991, 1993, 1994, 1995

	1991					1993					1994					1995				
Sub-quadrat number	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Equisetum palustre	2	1	1	4	1	5	5	9	12	4	5	4	7	13	6	6	2	5	9	4
Galium uliginosum	3	3	12	15	13	10	11	11	16	12	5	6	10	11	9	7	4	7	10	9
Molinia caerulea	16	16	13	15	16	13	16	14	15	16	16	16	16	15	16	15	16	16	16	16
Phragmites australis	16	15	14	16	14	12	15	13	12	7	14	12	14	15	9	15	15	15	14	15
Valeriana dioica	11	3	9	16	15	9	8	14	16	15	9	4	3	15	13	9	8	9	16	12
Calliergon cuspidatum	16	16	16	16	16	15	15	14	16	14	16	16	15	16	16	16	16	16	16	16
Juncus subnodulosus	16	16	16	16	16	14	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Angelica sylvestris	---	2	2	6	3	11	12	14	12	11	10	8	9	13	15	6	5	10	9	16
Deschampsia cespitosa cespitos	11	8	16	11	16	5	3	3	4	8	5	3	1	2	4	---	1	4	4	10
Juncus articulatus	3	8	4	2	---	3	6	3	2	---	3	8	1	3	1	7	8	2	4	---
Agrostis stolonifera	14	15	2	2	4	12	5	1	---	1	13	7	1	1	---	---	---	3	1	2
Cirsium palustre	3	1	4	6	3	7	5	11	14	11	---	---	---	---	---	2	1	4	6	4
Carex flacca	3	1	---	---	---	2	1	---	1	2	7	---	---	4	4	8	---	2	8	12
Carex viridula ssp brachyrrhyn	9	4	---	---	---	3	---	1	---	---	14	1	6	---	---	13	3	15	4	---
Mentha aquatica	---	---	3	3	---	---	---	1	---	---	3	2	6	---	---	11	9	10	13	14
Fraxinus excelsior (g)	---	2	---	1	---	---	4	---	---	1	---	1	---	---	2	2	2	2	5	1
Festuca rubra	---	---	---	---	---	---	4	1	1	---	---	---	6	4	---	4	2	2	3	2
Anagallis tenella	3	4	11	4	---	---	---	---	---	---	---	1	2	---	---	---	---	2	---	---
Eupatorium cannabinum	---	---	---	---	---	---	---	---	---	---	---	1	---	---	2	8	4	10	7	9
Glechoma hederacea	2	3	2	3	1	---	---	---	---	1	---	---	---	---	---	1	---	---	---	---
Ajuga reptans	---	---	---	---	---	---	---	2	---	1	---	---	4	1	---	---	---	2	1	---
Carex hostiana	10	2	---	---	---	13	---	1	---	---	8	---	---	---	---	---	---	---	---	---
Serratula tinctoria	1	1	3	7	5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Salix seedling/sp	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	16	16	16	16	15
Potentilla reptans	---	---	---	2	---	---	---	---	5	---	---	---	---	3	---	---	---	---	8	---
Salix cinerea (s)	---	---	---	---	---	---	---	---	---	---	---	2	3	3	1	---	---	---	---	---
Brachythecium rutabulum	1	---	1	---	2	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---
Eurhynchium praelongum	---	---	---	---	---	---	7	3	1	3	---	---	---	---	---	---	---	---	---	---
Ranunculus repens	1	1	---	---	---	---	---	---	---	1	---	---	---	---	---	---	---	---	---	---
Campylium stellatum	---	1	---	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Quercus seedling/sp	---	---	---	---	---	---	1	---	---	---	---	1	---	---	---	---	1	---	---	---
Rubus fruticosus agg (g)	---	---	---	1	---	---	---	---	1	---	---	---	---	---	---	---	---	---	---	---
Cardamine pratensis	---	---	---	---	---	---	---	---	---	---	2	---	---	---	---	---	---	---	---	---
Carex panicea	---	---	---	---	---	---	---	---	---	---	1	---	---	---	---	---	---	---	---	---
Pedicularis palustris	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1
Rubus fruticosus agg.	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	---	---	---
Vicia cracca	---	---	---	---	---	---	---	---	---	---	1	---	---	---	---	---	---	---	---	---
Bryum pseudotriquetrum	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	---	---	---
Rubus idaeus (g)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---
Number of species per sample	19	21	17	20	15	15	17	18	16	17	18	18	17	18	14	18	18	21	23	18

Table 10.5 Species frequencies recorded in permanent quadrats in North Meadow, Compartments 8 and 11 in 1991, 1993, 1994 and 1995

		North Meadow				Compartment 8				Compartment 11			
		1991	1993	1994	1995	1991	1993	1994	1995	1991	1993	1994	1995
Agrostis stolonifera		28.75	8.75	12.5	6.25	7.5	5	3.75	5	46.25	23.75	27.5	7.5
Ajuga reptans		1.25	-	-	-	-	-	-	-	-	3.75	6.25	3.75
Anagallis tenella	*	-	-	-	-	8.75	11.25	15	15	27.5	-	3.75	2.5
Angelica sylvestris	*	1.25	30	32.5	43.75	8.75	22.5	20	22.5	16.25	75	68.75	57.5
Betula seedling/sp		-	-	2.5	-	-	-	3.75	-	-	-	-	-
Brachythecium rutabulum		22.5	5	6.25	33.75	41.25	1.25	-	12.5	5	-	-	1.25
Bryum pseudotriquetrum	*	-	2.5	-	1.25	-	11.25	1.25	-	-	-	1.25	-
Bryum sp		-	-	-	-	8.75	-	-	-	-	-	-	-
Calliergon cuspidatum	*	92.5	81.25	78.75	63.75	90	93.75	95	76.25	100	92.5	98.75	100
Campylium stellatum	*	37.5	27.5	31.25	42.5	77.5	91.25	91.25	82.5	3.75	-	-	-
Cardamine pratensis		-	-	-	-	-	2.5	-	-	-	-	2.5	-
Carex flacca		50	76.25	13.75	60	8.75	22.5	13.75	36.25	5	7.5	18.75	37.5
Carex hostiana	**	71.25	83.75	90	66.25	-	-	-	-	15	17.5	10	-
Carex panicea	*	98.75	81.25	45	95	28.75	26.25	62.5	77.5	-	-	1.25	-
Carex pulicaris	**	6.25	-	-	1.25	-	-	-	-	-	-	-	-
Carex viridula ssp brachyrrhyn	*	-	-	-	2.5	82.5	93.75	87.5	96.25	16.25	5	26.25	43.75
Centaurea nigra		26.25	23.75	42.5	40	-	-	-	-	-	-	-	-
Cirsium dissectum	**	88.75	67.5	73.75	70	-	-	1.25	1.25	-	-	-	-
Cirsium palustre	*	11.25	10	3.75	3.75	16.25	11.25	27.5	21.25	21.25	60	-	21.25
Cladium mariscus	**	-	-	-	-	73.75	96.25	90	87.5	-	-	-	-
Dactylorhiza sp.		1.25	-	-	-	-	-	-	-	-	-	-	-
Deschampsia cespitosa cespitos		-	-	-	-	16.25	7.5	16.25	23.75	77.5	28.75	18.75	23.75
Equisetum palustre	*	-	-	-	-	2.5	27.5	20	3.75	11.25	43.75	43.75	32.5
Eupatorium cannabinum	*	5	3.75	6.25	18.75	10	60	28.75	45	-	-	3.75	47.5
Eurhynchium praelongum		11.25	-	-	-	15	-	1.25	-	-	17.5	-	-
Festuca rubra		23.75	42.5	17.5	43.75	12.5	8.75	3.75	11.25	-	7.5	12.5	16.25
Fissidens adianthoides	*	-	-	7.5	1.25	11.25	3.75	20	-	-	-	-	-
Frangula alnus	*	-	-	-	-	18.75	21.25	16.25	8.75	-	-	-	-
Fraxinus excelsior (g)		-	-	-	1.25	2.5	-	2.5	1.25	3.75	6.25	3.75	15
Galium uliginosum	*	16.25	18.75	42.5	33.75	26.25	32.5	36.25	33.75	57.5	75	51.25	46.25
Glechoma hederacea		-	-	-	6.25	-	-	-	-	13.75	1.25	-	1.25
Gymnadenia conopsea	**	2.5	-	-	-	-	-	-	-	-	-	-	-
Holcus lanatus		1.25	-	-	-	-	-	-	-	-	-	-	-
Hydrocotyle vulgaris	*	-	-	-	-	2.5	13.75	12.5	12.5	-	-	-	-
Juncus articulatus	*	-	-	-	-	-	-	-	-	21.25	17.5	20	26.25
Juncus subnodulosus	**	100	91.25	82.5	88.75	100	100	98.75	100	100	97.5	100	100
Linum catharticum		-	-	1.25	-	-	-	-	-	-	-	-	-

		North Meadow				Compartment 8				Compartment 11			
		1991	1993	1994	1995	1991	1993	1994	1995	1991	1993	1994	1995
Lythrum salicaria	*	-	-	-	-	25	28.75	46.25	36.25	-	-	-	-
Mentha aquatica	*	6.25	8.75	27.5	53.75	55	80	81.25	83.75	7.5	1.25	13.75	71.25
Molinia caerulea	*	100	100	100	100	98.75	98.75	93.75	100	95	92.5	98.75	98.75
Pedicularis palustris	*	-	-	-	-	-	-	-	-	-	-	-	1.25
Phleum bertolonii		1.25	-	-	-	-	-	-	-	-	-	-	-
Phragmites australis	*	83.75	72.5	85	91.25	86.25	75	73.75	75	93.75	73.75	80	92.5
Pinus seedling/sp		-	-	-	-	-	-	1.25	1.25	-	-	-	-
Polygala vulgaris		1.25	-	-	-	-	-	-	-	-	-	-	-
Potentilla erecta		65	70	80	66.25	1.25	16.25	1.25	1.25	-	-	-	-
Potentilla reptans		-	-	-	-	-	-	-	-	2.5	6.25	3.75	10
Prunella vulgaris		1.25	-	-	-	-	1.25	2.5	-	-	-	-	-
Pseudoscleropodium purum		5	-	2.5	1.25	-	-	-	-	-	-	-	-
Quercus seedling/sp		-	-	-	-	-	-	-	-	-	1.25	1.25	1.25
Ranunculus repens		-	-	-	-	-	-	-	-	2.5	1.25	-	-
Rhamnus cathartica		-	-	-	-	-	1.25	-	-	-	-	-	-
Rubus fruticosus agg.		-	-	-	-	-	-	-	-	1.25	1.25	1.25	-
Rubus idaeus (g)		-	-	-	-	-	-	-	-	-	-	-	1.25
Salix cinerea (g)		-	-	-	-	2.5	6.25	3.75	5	-	-	11.25	-
Salix seedling/sp		-	-	-	78.75	-	-	-	30	-	-	-	98.75
Samolus valerandi	**	-	-	-	-	5	2.5	8.75	6.25	-	-	-	-
Selinum carvifolia	**	8.75	15	58.75	41.25	-	-	-	-	-	-	-	-
Serratula tinctoria		5	8.75	5	22.5	-	-	-	-	21.25	-	-	-
Succisa pratensis		55	58.75	51.25	56.25	-	-	-	-	-	-	-	-
Valeriana dioica	*	42.5	63.75	25	25	-	3.75	5	3.75	67.5	77.5	55	67.5
Viburnum opulus (g)		-	-	-	-	-	1.25	-	-	-	-	-	-
Vicia cracca		-	-	-	-	-	-	-	-	-	-	1.25	-
Number of species per sample		33	24	27	31	30	33	34	31	25	25	28	27

* = principal fen species; ** = rare principal fen species

Table 10.6
Chippenham Fen, Compartment 6, species frequencies (%) in permanent quadrats

	1991	1993	1994	1995	1991	1993	1994	1995	1991	1993	1994	1995	1991	1993	1994	1995	1991	1993	1994	1995
Quadrat number	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5
Cladium mariscus	92	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–	–	–
Phragmites australis	80	44	12	28	52	44	64	60	36	88	64	60	76	100	100	68	72	32	8	80
Juncus subnodulosus	8	–	–	16	80	100	100	96	52	64	84	88	88	100	100	100	76	100	88	100
Eupatorium cannabinum	48	–	8	20	12	–	28	8	64	32	52	68	4	–	4	4	4	4	8	12
Equisetum palustre	–	–	–	–	8	4	4	4	4	28	24	24	8	28	12	–	–	–	4	12
Lythrum salicaria	–	–	4	8	16	4	20	12	4	60	24	56	4	4	–	4	–	–	–	–
Angelica sylvestris	–	–	–	–	–	–	–	–	4	–	8	12	–	–	12	4	12	4	44	52
Galium uliginosum	–	–	–	–	–	–	–	–	80	72	92	92	–	–	–	–	32	20	44	60
Filipendula ulmaria	–	–	–	–	–	–	–	–	8	4	4	12	4	8	–	–	–	–	–	–
Molinia caerulea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	100	100	100	100
Brachythecium rutabulum	–	–	–	–	–	–	–	–	20	44	72	68	–	–	–	–	–	–	–	–
Fraxinus excelsior (g)	–	–	–	–	4	4	4	–	–	–	–	–	–	–	4	–	–	–	–	–
Cirsium palustre	–	–	4	–	–	–	–	–	–	4	4	–	–	–	–	–	–	–	–	–
Potentilla erecta	–	–	–	–	–	–	–	–	–	–	4	4	–	–	–	–	–	–	4	–
Calliergon cuspidatum	–	–	–	–	–	–	–	–	–	4	12	4	–	–	–	–	–	–	–	–
Betula seedling/sp	–	–	–	–	–	–	–	–	–	4	8	–	–	4	–	–	–	–	–	–
Algal mat	100	48	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–
Carex viridula ssp brachyrrhyn	–	–	–	–	–	–	–	–	–	–	4	4	–	–	–	–	–	–	–	–
Schoenus nigricans	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8	4	4	12
Cirsium dissectum	–	–	–	4	–	–	–	–	–	–	–	16	–	–	–	–	–	–	–	–
Cirsium arvense	–	–	–	–	–	–	–	–	–	–	12	–	–	–	–	–	–	–	–	–
Epilobium parviflorum	–	–	–	–	–	–	–	–	–	–	32	–	–	–	–	–	–	–	–	–
Festuca rubra	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–
Juncus articulatus	–	–	–	–	–	–	–	–	20	–	–	–	–	–	–	–	–	–	–	–
Solanum dulcamara (g)	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–
Vicia cracca	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
Amblystegium serpens	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–
Bryum pseudotriquetrum	–	–	–	–	–	–	–	–	–	–	12	–	–	–	–	–	–	–	–	–
Eurhynchium praelongum	–	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	–	–	–	–
Fissidens adianthoides	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–
Total number of species	5	3	5	6	7	6	7	6	11	13	20	16	7	8	7	6	7	6	8	9

11.

Annex C: List of Principal Fen Species

Table 11.1 List of Principal Fen Species

(those marked * are considered to be rare)

Alnus glutinosa
Anagallis tenella
Aneura pinguis
Angelica sylvestris
Aquilegia vulgaris
Aulacomium palustris
*Bartsia alpina**
*Blysmus compressus**
Bryum pseudotriquetrum
Calamagrostis canescens
*Calamagrostis scottica**
*Calamagrostis stricta**
Calliergon cordifolium
Calliergon cuspidatum
*Calliergon giganteum**
*Calliergon sarmentosum**
*Calliergon stramineum**
Caltha palustris
*Campylium elodes**
*Campylium polyganum**
Campylium stellatum
*Carex acuta**
Carex acutiformis
*Carex appropinquata**
*Carex aquatilis**
*Carex chordorhiza**
Carex curta
Carex demissa
*Carex diandra**
*Carex dioica**
*Carex distans**
Carex disticha
Carex echinata
*Carex elata**
*Carex elongata**
*Carex hostiana**
*Carex lasiocarpa**
Carex lepidocarpa
*Carex limosa**
*Carex magellanica**
Carex nigra
Carex otrubae
Carex panicea
Carex paniculata
*Carex pauciflora**
Carex pseudocyperus
*Carex pulicaris**
Carex riparia
Carex rostrata
*Carex serotina**
Carex vesicaria
*Carex virosa**
Chara vulgaris
Chiloscyphus pallescens
Chiloscyphus polyanthos
Chrysosplenium oppositifolium
*Cinclidium stygium**
*Cirsium dissectum**
Cirsium palustre
Cladiopodiella fluitans
*Cladium mariscus**
*Cratoneuron commutatum**
*Cyperus longus**
Dactylorhiza fuchsii
Dactylorhiza incarnata
Dactylorhiza maculata
Dactylorhiza majalis praetermissa
*Dacylorhiza majalis purpurella**
*Dactylorhiza traunsteineri**
Drepanocladus exannulatus
Drepanocladus fluitans
*Drepanocladus lycopodioides**
Drepanocladus revolvens
*Drepanocladus sendtneri**
*Drepanocladus vernicosus**
*Drosera anglica**
*Drosera intermedia**
Drosera rotundifolia
Dryopteris carthusiana
*Dyopteris cristata**
Eleocharis multicaulis
Eleocharis palustris
*Eleocharis quinqueflora**
Eleocharis uniglumis
Epilobium hirsutum
Epilobium obscurum
Epilobium palustre
Epilobium parviflorum
*Epipactis palustris**
Equisetum fluviatile
Equisetum palustre
Equisetum telmateia
Equisetum variegatum
*Erica ciliaris**
Eriophorum angustifolium
*Eriophorum gracile**
*Eriophorum latifolium**
Eupatorium cannabinum
*Euphrasia pseudokerneri**
Filipendula ulmaria
Fissidens adianthoides
Frangula alnus
Galium palustre
Galium uliginosum
Glyceria maxima
Glyceria plicata
*Gymnadenia borealis**
*Gymnadenia conopsea**
*Hammarbya palustris**
*Hierochloe odorata**
*Homalothecium nitens**
Hydrocotyle vulgaris
Hypericum elodes
Hypericum tetrapterum
*Hypericum undulatum**
Iris pseudacorus
Juncus acutiflorus
*Juncus alpino-articulatus**
Juncus articulatus
Juncus bulbosus
Juncus effusus
*Juncus subnodulosus**
*Kobresia simpliciuscula**
Kurzia pauciflora
*Lathyrus palustris**
*Liparis loeselii**
Listera ovata
Lotus ulginosus

Lychnis flos-cuculi
Lycopus europaeus
Lysimachia vulgaris
*Lysmachia thyrsiflora**
Lythrum salicaria
Mentha aquatica
Menyanthes trifoliata
*Moerkia flotoviana**
Molinia caerulea
Mylia anomala
Mylia taylori
Myosotis laxa
Myosotis scorpioides
*Myosotis secunda**
Myrica gale
Narthecium ossifragum
Odontoschisma sphagni
*Oenanthe lachenalii**
Oenathe crocata
Oenathe fistulosa
*Osmunda regalis**
*Parentucellia viscosa**
*Parnassia palustris**
Pedicularis palustris
Phalaris arundinacea
Pedicularis palustris
*Pellia endiviifolia**
*Peucedanum palustre**
Philonotis fontanum
*Philonotis caespitosa**
*Philonotis calcarea**
*Philonotis fontanum**
Phragmites australis
*Pinguicula lusitanica**
*Pinguicula vulgaris**
*Plagiomnium elatum**
*Plagiomnium elipticum**
Plagiomnium rostrata
*Pleurozia purpurea**
Polytrichum alpestre
*Potamogeton coloratus**
Potamogeton polygonifolius
Potentilla palustris
*Preissia quadrata**
*Primula farinosa**
*Pseudobryum cinclidioides**
Pulicaria dysenterica
*Pyrola rotundifolia**
Ranunculus flammula
*Ranunculus lingua**
*Rhizomnium pseudopunctatum**
Rhynchospora alba
*Riccardia chamedryfolia**
*Riccardia multifida**
Rumex hydrolapathum
*Sagina nodosa**
Salix aurita
Salix cinerea
Salix pentandra
*Salix pentandra**
Salix phylicifolia
Salix repens
Salix triandra
Salix viminalis
*Samolus valerandi**
*Saxifraga aizodes**
*Scheuchzeria palustris**
*Schoenus ferrugineus**
*Schoenus nigricans**
*Scirpus fluitans**
*Scirpus setaceus (Isolepis)**
*Scorpidium scorpioides**
Scrophularia auriculata
Scutellaria galericulata
*Scutellaria minor**
*Selaginella selaginoides**
*Selinum carvifolia**
*Sium latifolium**
*Sonchus palustris**
Sparganium erectum
*Sparganium minimum**
Sphagnum auriculatum
Sphagnum capillifolium
*Sphagnum contortum**
Sphagnum fimbriatum
Sphagnum palustre
Sphagnum papillosum
*Sphagnum pulchrum**
Sphagnum recurvum
Sphagnum squarrosum
Sphagnum subnitens
Sphagnum subsecundum
*Sphagnum teres**
*Sphagnum warnstorfii**
*Spirathes romanzoffiana**
Stellaria alsine
*Stellaria palustris**
Symphytum officinale
*Thalictrum flavum**
*Thelypteris palustris**
*Tofieldia pusilla**
Triglochin palustris
Typha angustifolia
Typha latifolia
*Utricularia intermedia**
*Utricularia minor**
Vaccinium oxycoccos
Valeriana dioica
*Veronica scutellata**
Viola palustris
*Viola persicifolia**