ENGLISH NATURE

Assessment of vegetation change at Thrislington Plantation NNR, County Durham

No. 413 - English Nature Research Reports

working today
for nature tomorrow

English Nature Research Reports

Number 413

Assessment of vegetation change at Thrislington Plantation National Nature Reserve, County Durham

H J Robertson[1]
C W D Gibson[2]

ISSN 0967-876X

[1]English Nature, Northminster House, Peterborough, PE1 1UA

[2]Bioscan Environmental Consultancy, Peterley House, Peterley Road, Cowley, Oxford, OX4 2TZ

Contents

Summary

1. Thrislington Plantation is the site of a well-known case of grassland translocation, which has been the subject of monitoring for over 20 years. Other activities that affect the vegetation are grazing and scrub control and these have also been monitored. In addition, the Reserve has been chosen to be part of a network of sites across Britain to be used for monitoring climate change. This report reviews the information obtained so far on vegetation change at Thrislington and makes recommendations for future monitoring.

2. A range of data sources are available including quadrats recorded in the 1960s by Dr David Shimwell, permanent quadrats monitored by David Park, the ecologist for the quarry company (Lafarge Redland Aggregates) that owns the Reserve, and plots set up by the England Field Unit of the former Nature Conservancy Council, now English Nature.

3. The factors that could be affecting vegetation change at Thrislington Plantation include succession, transplantation, fire, grazing and mowing, atmospheric deposition and climate change. Given this diversity of influences and the possible interactions between them, interpretation of monitoring data is difficult. A preliminary attempt is made to evaluate the significance of these factors and suggest how understanding of their effects may improved by future monitoring.

4. Successional processes led to increases in scrub cover when grazing levels declined between the 1960s and 1992. It is not clear to what degree succession brought about changes within grassland vegetation. National Vegetation Classification type CG2 (*Festuca ovina- Avenula pratensis* grassland) may have developed towards CG6 (*Avenula pubescens* grassland). In the absence of scrub development, changes in ungrazed CG8 (*Sesleria albicans-Scabiosa columbaria* grassland) appear to be slow, with some declines in species such as *Scabiosa columbaria* and *Helianthemum nummularium* and appearance of other such as *Achillea millefolium, Bromopsis erecta* and *Trifolium pratense*. However, succession may not be the only reason for these changes.

5. Transplantation has disrupted the pattern of vegetation types that had developed in response to soil, topography and historical management on the donor area. Detailed information is lacking on the extent of vegetation types before transplantation but available evidence seems to suggest that there has been an unexplained reduction in extent of CG8 grassland in post-transplant vegetation compared to pre-transplant vegetation. This finding contrasts with species data for the post-transplant period which shows that *Sesleria caerulea* (*albicans*), a key CG8 species, has not declined. *Bromopsis erecta* has shown marked increases on the transplant area, especially where grazing occurs. Although no clear objective evidence of equivalent increases exists for the undisturbed part of the Reserve, casual observations suggest that *Bromopsis* has spread here. Repeating the recording of monitoring plots in this part of the Reserve is therefore a priority. Most of the other species do not show sustained increases or decreases in abundance in the transplant area, either compared to pre-transplant vegetation or in the post transplant period.

6. Fire affected most of the original site between 1982 and 1992 but there is no evidence for it being a major factor causing increases in *Bromopsis erecta.*

7. Rotational grazing of compartments on the Reserve means that each compartment has a slightly different regime. Mowing is also done in certain areas. Relatively few species seem to have either benefited or suffered from the effects of grazing and some species show apparently contradictory results, perhaps due to differences in grazing or mowing regimes between compartments.

8. The ecological impact of atmospheric deposition on the vegetation is not known. Levels of nitrogen deposition at Thrislington are estimated by the Institute of Terrestrial Ecology to be within the critical load range of 14-25 kilogrammes/hectare/year, rather than below this level or in excess of it.

9. Climate change is a potentially important factor and the spread of *Bromopsis erecta,* which is at its northern limit in County Durham, may be in part a response to warmer temperatures.

10. In the future, repeat recording of existing monitoring plots will allow assessment of the impact of grazing especially in the undisturbed part of the Reserve. It will also make possible the examination of spread of *Bromopsis erecta* in this part of the Reserve, to discover if the increase in the species is a general phenomenon or if it is particularly related to the transplant. Overall, continued monitoring at Thrislington represents an outstanding opportunity for the study of climate change, given the transitional position of the site, expressed by the co-occurrence of northern and southern elements in its vegetation.

11. Further NVC quadrat recording would enable the relationship of monitoring plots to the rest of the vegetation on the Reserve to be better understood. If the effect of grazing and mowing in different compartments is to be compared and if manipulation of these regimes is contemplated, then additional monitoring information needs to be collected. Sward height measurements, vegetation recording and population counts of nationally scarce species should be carried out. Collection of edaphic information would contribute to the assessment of the role of atmospheric deposition and would aid understanding of successional change.

1. Introduction

Thrislington Plantation National Nature Reserve is the location of a well-known case of grassland translocation, which involved moving turves of Magnesian Limestone grassland from an area to be quarried to a nearby receptor site. The translocation was carried out over the period 1982 to 1990 (Park 1989, Byrne et al 1991). Apart from transplantation, other recent activities that could be changing the vegetation of the site are grazing and scrub clearance and control. Grazing was re-introduced into the site in 1992. Scrub clearance and control were begun in the early 1980s and continued into the 1990s. The Nature Conservancy Council and its successor organisation, English Nature, were interested in studying the ecological effects of the transplantation and began recording the vegetation in monitoring plots in 1987. Plant species recorded included scrub species. In 1992 monitoring of the impact of grazing was included in the programme. Recording has continued with the latest set of data being collected in 1998. Prior to 1987, David Park, the ecologist working for the quarry company (now Lafarge Redland Aggregates), had monitored other parts of the site.

Vegetation at Thrislington has been sampled as part of wider surveys as far back as the 1960s. In 1992 Thrislington was chosen to be part of a national network of sites for the monitoring of climate change in a project funded by the Department of the Environment (now the Department of Environment, Transport and the Regions). In 1998 English Nature organised a full survey of the vegetation of the Reserve, using the National Vegetation Classification, to obtain an up to date picture for the whole site. Against this background it is timely to review what can be learnt from the existing information about vegetation change at Thrislington and consider what recommendations should be made about future monitoring.

2. Site description, history, conservation status and management

Thrislington Plantation is located 2 kilometres south of the village of West Cornforth in County Durham (Grid Reference NZ 315328). The site lies on the outcrop of Magnesian Limestone in Durham and is at altitudes between 126 and 138 metres. The climate is relatively dry, annual precipitation averaging 700 millimetres from 1916 to 1950 and 600 mm from 1966 to 1994 (Thorne 1995). Unpublished data supplied by David Park for the years 1982 to 1998, excluding 1989 for which there are no data, give an average of 625 mm. Before transplantation and quarrying the site (Map 1) was about 20.5 hectares (ha) in size (Park 1989). It now comprises an undisturbed area of 11.69 ha, including 2.75 ha of woodland, and a transplant area of 4.28 ha (Thorne 1995). The site occupies a relatively level plateau; the transplant area slopes gently at an angle of 3 degrees towards the south-west (Park 1989) while the undisturbed area is dissected by a shallow dry valley which runs from south-west to north-east. Slope angles recorded on the valley sides range from 12 to 20 degrees (Cooper et al 1992). Prior to quarrying, the dry valley extended north eastwards into the extreme eastern part of the area now quarried away, though a contour map (Buckingham 1988) indicates that most of the area sloped gently towards the south-east, the angle being 2 degrees according to Park (1989). Overall, the quarried area was flatter than the undisturbed part, except for the relatively level northern half of compartment 4 (Map 2) in the undisturbed area (Buckingham 1988). Soils in the undisturbed area are mostly thin rendzinas, generally between 10 and 30 centimetres in depth and they belong to the Elmton series of the Aberford association. There are also pockets of brown calcareous earth soils of between 55 and 85 cms in depth. These two soil types were also found in the quarried area (Park 1989). The soils of the receptor area (generally 30 to 50 cms in depth) were removed before turf transplantation took place (Park 1989).

Aerial photographs taken in 1978 at a scale of 1:4800 show faint ridge and furrow patterns on the open grassland across the original site. Shallow ridge and furrow is still visible on the ground in some places on the retained SSSI area. This evidence suggests that at least some of the site may have been ploughed in the past. Ploughing probably occurred before 1840, as Thrislington Plantation is shown as rough pasture on a tithe map of this date (Thorne 1995) and the first edition Ordnance Survey (OS) map shows that by 1857 Thrislington Plantation had been planted up by conifers. The trees were probably larch, a few mature individuals remain on the site today. It seems that the planting was largely unsuccessful, perhaps due to the thin soils. The 1898 OS map shows the area as conifers and coarse grassland, suggesting that grassland may have survived beneath a light tree canopy or in areas left unplanted. By 1919 the plantation had been substantially thinned and the 1939 map shows only sparse bushes north and south-east of the old waggonway (Map 3). However, mixed woodland remained in the area now known as compartment 7 (Map 2), (M. E. Bradshaw, unpublished notes).

The introduction of pit ponies and cattle into the plantation at some time in the past allowed the grassland to remain free of scrub. Stock grazing largely ceased by the mid 1960s although occasional *ad hoc* grazing by tethered ponies continued in places until 1985 (Thorne 1995). The maximum extent of open grassland after clearance of conifers is not known but 1958 aerial photographs show several large patches of scrub amongst open grassland and later photographs dated 1968 and 1978 show an increase in the extent of scrub. A map published in 1989 shows that the bulk of the site before quarrying was covered by dense scrub or by developing scrub (greater than 1.5 metres high) in grassland vegetation (Park 1989). There are records of sporadic, unauthorised, fires in various locations across the original site between 1982 and 1993 (D. Park unpublished notes).

The limestone grassland at Thrislington Plantation is of considerable nature conservation interest both for its flora and fauna. It includes vegetation described as *Sesleria albicans (caerulea) - Scabiosa columbaria*[3] grassland (CG8) by the National Vegetation Classification (NVC) (Rodwell 1992). CG8 is a very restricted grassland type in the UK, with a total recorded extent of less than 80 ha, all of which occurs in north-east England (Blackstock et al 1999). Notable plant species present at Thrislington include the nationally scarce *Epipactis atrorubens* and *Linum perenne* subsp. *anglicum*. Thrislington has one of the two largest populations in Britain of the latter species (Rich 1997). Notable invertebrate species include the Durham Argus butterfly (*Aricia artaxerxes* subsp. *salmacis*), which feeds on rockrose (*Helianthemum nummularium*), and the glow worm *Lampyris noctiluca*.

The site was first notified as a Site of Special Scientific Interest (SSSI) in 1962 under Section 23 of the National Parks and Access to the Countryside Act 1949. It was listed as a Grade 1 nationally important site in the Nature Conservation Review (Ratcliffe 1977). In 1979 Steetleys Quarry Products Limited applied for permission to quarry the Magnesian Limestone underlying the site and after a Public Inquiry in 1981 the application was approved for the northern 8.5 ha of the site (Map 1, the donor area) provided the turf was transplanted to an area adjacent to the remaining part of the SSSI (Map 1, the transplant area). In 1982 turf transplantation began. It proved practical to transplant about 5.5 ha (Park 1989), the remainder was covered in dense scrub (1.75 ha) or was reseeded grassland (1.25 ha). The receptor area comprised two fields under arable cultivation until soil was stripped from them prior to the commencement of transplantation from the donor area in 1982. Scrub was cut and the stumps treated with herbicide before turves were moved and scrub control was also undertaken on the remaining SSSI in compartment 4 and part of 5 (Map 2) (D. Park, unpublished notes). Translocation was carried out using specially adapted machinery to move large turves, each one up to 4.75 metres (m) by 1.75 m in area, and 0.35 m to 0.45 m in depth. The process was completed in 1990. David Park (1989) details the costs involved in the transplantation, excluding site preparation. From his figures, using a yearly average of £2.41 per square metre, this gives a total cost for moving 5.5 ha of around £132,500.

In 1991 the remaining SSSI and the transplant area were declared as a National Nature Reserve under Section 19 (1) of the National Parks and Access to the Countryside Act 1949 and Section 35 of the Wildlife and Countryside Act 1981. The Reserve operates under a Nature Reserve Agreement between English Nature and Lafarge Redland Aggregates. The site has since been recognised as a candidate Special Area of Conservation (SAC) of European importance under the Habitats and Species Directive (Council of the European Communities 1992). The site is in the habitat category "Semi-natural dry grasslands and scrub facies on calcareous substrates (*Festuco-Brometalia*)", and is the only example of CG8 grassland in the UK listed as a candidate SAC (Brown et al 1997).

---

[3]Plant species nomenclature in the report follows Stace (1997). Where published names of NVC types use other species names, both are given.

Concern over the spread of scrub in the Reserve, and the increasing rankness of the grassland and impoverishment of the flora, led to the re-introduction of grazing in 1992. Hardy breeds of sheep are grazed rotationally around the compartments of the Reserve throughout the year. Prior to the re-introduction of grazing, the transplant area was mown annually and the cuttings removed (D. Park, unpublished notes) while in the retained SSSI a flail mower was used to top *Bromopsis erecta* grassland and the cuttings left *in situ* (Cooper et al 1992). Grazing continues to be supplemented by mowing, which is used as a reclamation tool or where grazing is thought to be insufficient (Thorne 1995). Cutting and herbicide treatment of scrub has also continued while spot treatment of persistent weeds by herbicide has been done in the transplant area. *Tussilago farfara* and *Cirsium arvense*, which appeared after transplantation, have been particular targets for treatment (Park 1989).

3. Data sources and monitoring activity

3.1 Quadrats recorded by Dr David Shimwell in the mid 1960s

As part of a four year PhD study on the phytosociology of calcareous grasslands in the British Isles (Shimwell 1968), Dr Shimwell recorded plant species composition and cover in Aufnahmen, which are equivalent to large quadrats. These quadrats were recorded as representatives of homogeneous stands of vegetation. The exact location of each quadrat at Thrislington Plantation is not known but some were recorded from a narrow strip of limestone grassland along the old waggonway, outside the original site (Map 3). Evidence from aerial photographs dated 1958 and 1968 suggests that this strip was less than 10 m wide and was bounded by cultivated fields. It would have been on the northern edge of the current receptor area but has disappeared since 1968, probably because of quarry operations. Other quadrats were recorded in an area of the retained SSSI (Map 3), ie outside the donor area (D. W. Shimwell pers comm).

Dr Shimwell allocated most quadrats to an Association he called *Seslerio-Helictotrichetum*. This has since been given the synonym CG8 by Rodwell (1992) who incorporated Dr Shimwell's data into the NVC. Dr Shimwell recorded several sub-Associations at Thrislington, 11 quadrats in all:

- Sub-Association *typicum* - samples 57, 70-72 (synonym CG8a, *Hypericum pulchrum-Carlina vulgaris* sub-community)

- Sub-Association *Caricetosum pulicariae*, *Antennaria* variant - samples 59-63 (synonym CG8a)

- Sub-Association *Helictotrichetum pubescentis*, *Rosa* variant - samples 16, 19 (synonym CG8b, *Avenula* (*Helictotrichon*) *pubescens* sub-community).

A second variant of the last sub-Association, the *Bromopsis erecta* variant, was not recorded at Thrislington.

Another Association recorded by Dr Shimwell was the *Helictotricho-Caricetum flaccae*, sub-Association *typicum*, which is synonymous with CG2d, *Festuca ovina-Avenula* (*Helictotrichon*) *pratensis* grassland, *Dicranum scoparium* sub-community, in the NVC: sample 105. In addition, one quadrat of the Association *Centaureo-Arrhenatheretum* (synonym MG1, *Arrhenatherum elatius* grassland) was recorded: sample 72A. Quadrats from two scrub types, presented as constancy tables, were also recorded: *Crataegus-Rosa pimpinellifolia* scrub (synonym W21 *Crataegus monogyna-Hedera helix* scrub) and the provisional Association *Salicetum repenti-nigicantis* (no synonym in the NVC).

Details of the *Helictotricho-Caricetum flaccae* quadrat were published in Shimwell (1971), quadrats 57, 70, 72, 61, 62 and 16 were published in Graham (1998) and all appear in Shimwell (1968). Quadrats 57, 70-72 were 100 square metres in size and the remainder were 16 square metres in size. For the purposes of the analysis in section 4 below, the percent cover/abundance values in Shimwell (1968) were converted to Domin cover scores. This conversion had previously been made for the Flora of Durham quadrats (Graham 1998) so the same conversion scale was used for the remainder, as follows: + = 1, 1 = 4, 2 = 5, 3 = 6, 4 = 8. The Domin score is the second of each pair.

3.2 Quadrats recorded by Reverend G. Gordon Graham in 1980

Reverend Graham recorded plant species and Domin cover scores in 6 Aufnahmen at Thrislington in June or July 1980. Their approximate locations are shown on Map 3. Three were in the donor area, 2 in the remaining SSSI and one (227) on the boundary, either just outside or just inside the donor area. Within the circle containing quadrats 228 and 229, 228 was in the "*Linum*" area where this species has a long-established population, while 229 was in a damper area near a path. The quadrats were chosen to supplement rather than replicate samples of vegetation types recorded by Dr Shimwell (G.G. Graham pers comm). Details of the quadrats are published in Graham (1998). Using this information the present authors have allocated the quadrats to the following NVC types: Quadrats 228, 258 to CG8; 229 to CG6 (*Avenula* (*Helictotrichon*) *pubescens* grassland); 227 to CG8 with CG6 elements, CG8(CG6), 259 to CG6/W21 and 260 to CG3/W21 (CG3 - *Bromus* (*Bromopsis*) *erectus* grassland). Quadrats 259 and 260 were recorded from transitions between scrub and grassland, both had 11-25% cover of *Crataegus monogyna*. In quadrat 259 *Helictotrichon pubescens* (26-33% cover) was the most abundant species, while *Bromopsis erecta* was the most abundant species in quadrat 260 (34-50% cover) and *H. pubescens* was absent. *Sesleria caerulea* was absent from both quadrats. Quadrat 227 seems most similar to CG8, it has high number of species that occur in CG8 but lacks the constants *Festuca ovina*, *Helictotrichon pratense* and *Linum catharticum*. It contains the CG6 constant *Helictotrichon pubescens* but *Festuca tenuifolia* rather than *F. rubra* is recorded. Quadrat 229 seems closer to CG6 rather than CG8 as it lacks most CG8 constants and *Sesleria* is present only as Domin 1 (few individuals). Sizes of quadrats were as follows: 227 and 229 were 16 square metres, 228 was 25 square metres, 260 was 100 square metres and 258 was 400 square metres. The area of 259 was not recorded.

3.3 Permanent quadrats recorded by David Park between 1982-1987

David Park established 12 permanent quadrats in the donor area between 1982 and 1983, in several vegetation types. He re-recorded these quadrats twice a year until 1987, in the years prior to transplantation and after transplantation. A further 17 quadrats were established in the transplant area the year after transplantation and again recorded until 1987 (D. Park pers comm). Each quadrat was allocated to a vegetation type. All quadrats were located in the western half of compartment 2 (Map 4). Quadrats were 62 by 78 centimetres (cm) in size and plant species composition within each quadrat was recorded. In addition, percent cover was objectively estimated using a non-repetitive sampling method of three frames of 20 points taken at random positions in each quadrat. Recording was carried out at the end of June and the end of July/early August each year (Park 1989). From the data provided by David Park, the present report uses the 12 donor area quadrats pre- and post- transplant and 3 transplant area quadrats. Only data from the second recording period in a year is used and only the earliest recorded data and the 1987 data. The percent cover values were converted to Domin scores, with species which were present but had no 'hits' from the 60 points given Domin score 1.

The types of vegetation sampled were:

- *Brizo-Festuco-Helichtotrichon* 5 quadrats, nos 2, 5, 7, 10, 11
- *Sesleretum* 2 quadrats, nos 6, 29
- *Brizo-Sesleretum* 5 quadrats nos 21, 24, 25, 27, 28
- *Dactylo-Brachypodetum* 3 quadrats nos 13, 18, 19

The *Dactylo-Brachypodetum* quadrats were in areas that had been cleared of scrub prior to transplantation and had data from the post-transplant period only. Allocation of quadrats to NVC types by the present authors was done by comparing the quadrats singly and by vegetation type with NVC descriptions and tables. *Brizo-Sesleretum* and *Sesleretum* quadrats were allocated to CG8, while *Dactylo-Brachypodetum* quadrats were assigned to transitional MG1/W21. Scrub species or species associated with scrub, such as *Geum urbanum*, *Stachys sylvatica* and *Geranium robertianum* were present in the latter quadrats. The *Brizo-Festuco-Helictotrichon* type was the most difficult to assign, most quadrats having some resemblance to CG6, with *Festuca rubra* and *Helichtotrichon pubescens* usually present but also a number of CG2 constants such as *Festuca ovina*, *Sanguisorba minor* and *Linum catharticum* regularly occurring as well. The lack of strong fit of this type of vegetation at Thrislington to either CG2 or CG6 was also noted by Stuart Hedley and Argus Ecological Services in later surveys (see below). In 1987, quadrat 7 had 30% cover of *Bromopsis erecta* and would appear to have been closer to CG3 than CG6 at that date.

3.4 England Field Unit plots recorded between 1987-1998

The England Field Unit (EFU) of the Nature Conservancy Council set up three plots in 1987 to study the impact of translocation on plant species composition (Buckingham 1988). Recording was continued by English Nature Local Team staff and contractors after 1990. In 1987, two plots were marked out in the donor area and one in the part of the SSSI to be retained (Map 1). The two plots in the donor area are referred to below as Donor plot I and Donor plot II. In Byrne et al (1991) they were called the '1987 plot' and the '1989 plot' respectively, and in Buckingham (1988) they were called the 1987/1988 plot and the 1990/1991 plot. The plot in the retained SSSI is called the SSSI plot throughout all reports including the current report. Within each plot records were made of plant species present as shoots in randomly located mini-quadrats (RMQs), each 10 x 10 cm in size. Initially, 50 RMQs were recorded in each plot, but this number was increased to 100 in 1989 for Donor plot II and the SSSI plot. The SSSI plot is 0.09 ha in size (compartment 5a, Map 2), Donor plot I was 0.25 ha and Donor plot II was 0.07 ha. Donor plot I was transplanted in the winter 1987/88 and Donor plot II in the winter 1989/1990.

The SSSI plot was recorded every year up to 1998 except for 1996. The monitoring method also necessitated the recording of the translocated plots across a similar time frame, bridging the actual period of translocation. However, the project suffered the severe misfortune of misidentification of the precise locations for the translocated turves of the donor plots. In error, recording subsequently took place on parts of the transplant not corresponding exactly to the original turves of the donor plots. This mistake only became apparent when the detailed analysis for the current review began. Thus it is impossible to rigorously analyse the effect of transplantation using data from these plots, although post- transplant changes can be examined, as well as changes in the retained SSSI. After transplantation, RMQs were recorded from Receptor plot A (compartment 2a, Map 2) which is 0.08 ha in size and from

Receptor plot B (compartment 3a, Map 2) which is 0.19 ha in size. The number of RMQs recorded in Receptor plot A was increased from 50 to 100 in 1992, while 100 RMQs were recorded in all years with data in Receptor plot B. No recording was carried out in Receptor plot A in 1993 and 1996 and none in 1996 in Receptor plot B.

When grazing was re-introduced to the site in 1992, the three plots were fenced to exclude stock. The plots were left un-managed except for intermittent clearance of woody species, particularly aspen (*Populus tremula*) in Receptor plot A, where it was locally abundant. In 1992, three unfenced plots of similar size were laid out adjacent to the fenced plots to examine the effects of grazing (Map 2). The two types of plots are referred to as the exclosure plots and the grazed plots in the remainder of this report.

The method of recording the RMQs changed slightly over time, although they were always recorded in early August each year. In 1992-1995, only selected species were recorded and in 1993-1997 presence of plants rooted in the quadrat rather than those with shoots in the quadrat were recorded. In 1998 both root and shoot records were made to compare the two recording methods. From 1995 onwards 25 x 25 cm quadrats were also recorded, positioned so that the 10 x 10 quadrat was nested in the bottom left hand corner. However, the current report concentrates on the data from the 10 x 10 cm quadrats.

The locations of the RMQs were not stratified by vegetation type so frequency values for plant species in a plot represent composition and abundance across vegetation types. Examination of Buckingham's report (1988) indicates that the following grassland types were present in 1987 in the approximate proportions listed. An attempt is also made by the current authors to allocate NVC types to these different types.

Donor plot I:

i. Vegetation with abundant *Carex flacca*, patches of *Sanguisorba minor* and *Trifolium medium* (48%). CG2 moving towards CG6 where *Brachypodium sylvaticum* abundant on scrub margins.

ii. *Sesleria* area (4%). CG8.

iii. Tall, species-poor, grassland where scrub had been cut and treated, *Brachypodium sylvaticum, Cirsium arvense, Heracleum sphondylium* abundant (48%). MG1.

Donor plot II:

i. *Sesleria* area (38%). CG8.

ii. Abundant *Carex flacca* and *Festuca ovina*, with *Brachypodium sylvaticum* frequent on scrub margins (62%). CG2 moving towards CG6.

SSSI plot:

i. *Sesleria* area (60%). CG8.

ii. *Carex flacca* dominant with *Brachypodium sylvaticum* locally abundant near scrub (40%). Mostly CG2 with some development towards CG6.

In 1998 the NVC survey by Argus Ecological Services gave the following percent cover of different types for the SSSI plots and the Receptor plots.

NVC type	SSSI exclosure	SSSI grazed	Receptor A exclosure	Receptor A grazed	Receptor B exclosure	Receptor B grazed
CG2	-	-	-	-	-	3
CG3	-	17	35	30	58	70
CG6	14	65	50	70	22	22
CG8	86	9	-	trace	20	5
Wood/ scrub	-	-	9	-	-	-

In addition to the RMQs recorded in 1987, Helen Buckingham also recorded 4 quadrats from the *Sesleria* area in the SSSI plot, using the same method and quadrat size as David Park (Buckingham 1988). Domin scores were also recorded so a comparison was possible. Estimates of cover from the two methods were similar, the only percent cover values that were greater than 10% away from the equivalent Domin class were for *Carex flacca* in 3 out of 4 quadrats. In these it was quite substantially under-estimated by the Domin score (40% : Domin 4 (4-10% cover), 37% : Domin 3 (many individuals) and 32% : Domin 4). Species present with no hits were Domin score 1 or 2 with one exception (Domin 3). The subjective Domin scores were used in the following analysis, in common with what was available for most other quadrats. The 4 quadrats were allocated to CG8 by the present authors.

3.5 NVC survey by Stuart Hedley (English Nature) and Argus Ecological Services in 1997-1998

In July 1997, Stuart Hedley recorded 7 representative NVC quadrats from the transplant area, all 4 square metres in size. Five were from CG3 areas, one from CG8 and one from CG6, though Stuart Hedley noted that this vegetation was difficult to fit to the NVC and could be transitional to CG2 (unpublished notes). In late summer 1998, these quadrats were supplemented by those recorded as part of an NVC survey of the whole Reserve by Argus Ecological Services. A total of 21 representative quadrats, all 4 square metres in size, were recorded and the NVC types of the transplant and SSSI were mapped (Argus Ecological Services 1998). Locations of all these quadrats are shown on Map 5. One quadrat (number 5) was taken from the only patch of *Brachypodium pinnatum* on the Reserve. This patch was a very small, species-poor, area measuring 8 square metres. Five quadrats each were recorded from CG2, CG3, CG6 and CG8. Of these, one CG2 quadrat and 3 CG3 quadrats were taken from the transplant area, the remainder were located on the retained SSSI. The poor fit of the CG2 and CG6 quadrats to the NVC was also noted by Argus Ecological Services (1998).

3.6 Climate change project plots recorded by Elizabeth Cooper, University of Lancaster, in 1992

The national climate change project involved setting up permanent plots in calcareous grasslands across Great Britain to monitor the impact of climate change and atmospheric pollution (Cooper et al 1992). A total of 56 sites comprise the network, including Thrislington Plantation. Three plots were laid out in the retained SSSI (Map 6). Each plot measures 12 x 12 m and is permanently marked using buried copper loops. Within each plot, 36 quadrats each 50 x 50 cms in size were located by restricted randomisation. Presence of all vascular plants, bryophytes and macrolichens was recorded in each quadrat. The layout of the quadrats was within four 6 x 6 metre blocks, each divided into nine 2 x 2 metre units, each of which was sampled by one quadrat. The nine quadrats in each 6 x 6 metre block were located using a stratified unaligned arrangement. The unalignment was initially determined using randomly selected co-ordinates. The plots were recorded in late July 1992. All three were assigned to CG8 by Cooper *et al* (1992).

4. Evidence of vegetation change

4.1 Spatial extent and pattern of vegetation types

Although there is a map of vegetation types at Thrislington Plantation for 1998 there is no map available of pre-transplant vegetation of the donor area and the retained SSSI. However, David Park (1989) notes that transplantation has disrupted the community matrix of the donor area because contiguous turves were transposed when they were set down. This disruption could only have been avoided at the cost of damaging double-handling of turves. In addition, changes to the spatial dimensions of vegetation types occurred (Park 1989), not least because the donor area and transplant area have different shapes (Map 1).

The relative amounts of different vegetation types pre- and post-transplantation are not known but there is evidence that CG3 may have increased in extent on the transplant if judged by the increase in the key species *Bromopsis erecta. Bromopsis* vegetation may have increased on the retained SSSI as well, though the evidence is less clear (see 4.3.2.2 below). With regard to CG8, based on the amounts in the donor EFU plots (around 370 square metres), and a single CG8 sample of 400 square metres (sq m) recorded by Reverend Graham from the donor area, these together (770 sq m) exceed the amount on the transplant in 1998, according to the figure calculated by Argus Ecological Services (509 sq m). In addition, it seems that the donor area had other stands of CG8, for example a site visit by the Technical Advisory Committee for Thrislington in 1982 (English Nature, unpublished notes) noted *Sesleria* grassland in the northern section of the site, that was to be transplanted first, while Reverend Graham (pers comm) remembers significant areas of *Sesleria* grassland in the donor area. This apparent reduction in the area of CG8 is puzzling when compared to available data on *Sesleria* frequency in RMQs or cover in David Park's quadrats which show no obvious decline since transplantation (see 4.3.2.1 below). Perhaps parts of CG8 turves were lost in the process of translocation, although this seems unlikely as areas of grassland on shallow soils, typical locations for CG8, were relatively easy to move without loss (D. Park pers comm).

The area of scrub-dominated vegetation must have been sharply reduced in the 1980s, through scrub clearance and control and because 1.75 ha of dense scrub on the donor area was not transplanted. Only 1016 sq m (0.1 ha) were recorded in 1998 on the transplant. Although scrub control has been carried out on the retained SSSI the amount of scrub still present is substantially greater than on the transplant (1.9 ha in 1998).

4.2 Composition of vegetation types

The quadrat data from all data sets where the cover of each species in a quadrat had been estimated were analysed together using DECORANA, a multivariate ordination technique (Hill 1979). A total of 80 quadrats were analysed. The frequency data from the RMQs and Elizabeth Cooper's quadrats were excluded. Only vascular plants were included as lower plants had not been recorded in all data sets. The aim was to look at the broad picture of variation in composition of vegetation across the site in time and space. The two principal axes of variation are shown for samples and species in Figures 1 and 2 respectively. Some labels have been omitted for clarity but the full sets of values are given in Tables 1 and 2. The abbreviations identifying recorders are given at the bottom of Table 1. The ordination displayed omits one quadrat. The atypical *Brachypodium pinnatum* quadrat, which appeared as an extreme outlier in a preliminary analysis, has been excluded.

As might be expected, the dominant pattern on Figure 1 related to Axis 1 appears to be reflect the vegetation types to which quadrats had been allocated prior to analysis. Figure 3 shows the sample positions labelled with NVC types and the prefixes D, S and T which refer to Donor, SSSI and Transplant respectively. CG8 occupies the left hand part of the diagram and MG1 the right hand end. The species in Figure 2 reflect these types, with CG8 constants such as *Sesleria caerulea* and *Thymus polytrichus (praecox)*, and the notable species *Epipactis atrorubens* and *Linum perenne* towards the left, while species such as *Cirsium arvense* and *Heracleum sphondylium* are at the right hand end. In the central section of Axis 1, there is more overlap of types, with samples of CG2, CG3 and CG6 occurring close together (Figure 3). The ranges in values given in Table 1 show this overlap, though they are in the sequence CG2, CG3 ,CG6, from left to right along Axis 1. The prefixes show that particular vegetation types found on the SSSI, transplant or donor area show similar variation in composition on Axis 1 and Axis 2, with no clear separation of samples from the three areas. Interestingly, size of quadrat appears to have little relationship to sample position on these axes, as quadrats of different sizes but the same vegetation type lie close together. There seems to be no obvious pattern underlying Axis 2.

Aside from the RMQs, to date only David Park's quadrats can be used to examine change over time in the same piece of vegetation and his quadrats are the only pre- and post-transplant samples. Compared to the variation among all the quadrats shown in Figure 1 the differences between these pre- and post-transplant samples are not great. When considered alone the detail of these small differences can be seen. Figure 4 shows an ordination of the 24 pre- and post- transplant quadrats. The CG8 quadrats are grouped more tightly than the CG6 samples, suggesting less variation over time and space. The species distribution is shown in Figure 5. In terms of species gained and lost and changes in cover values, these are slightly greater on average for the CG6 type than the CG8 type, as shown in Tables 3, 4 and 6. The post-transplant changes in the scrub-cleared plots are considerably larger than the pre- to post-transplant changes in the other two types (Tables 5 and 6).

To investigate whether there is a discernable pattern underlying these changes, an analysis of the functional strategies of plants in each of David Park's quadrats was undertaken. The categories of functional strategies are those defined by Grime et al (1988), ie competitors (C), ruderals (R), stress-tolerators (S) and combinations of these strategies. The data was analysed using the FIBS package (Hodgson and Colasanti 1995) to calculate the proportions of each strategy present in a quadrat, weighted by the abundance, ie cover, of each species. Table 7 gives the results for each quadrat and the average values by vegetation type. Comparison between types shows, as might be expected, that the mesotrophic grassland, MG1, has a considerably lower proportion of stress-tolerators and a greater proportion of competitors and CSR species. Competitive ruderals (CR) are higher and stress-tolerant ruderals (SR) are lower in MG1 than values for the two calcareous grassland types. The differences between CG6 and CG8 quadrats are smaller but CG6 occupies an intermediate position between MG1 and CG8. Comparisons over time in the quadrats from each vegetation type show only slight differences. As suggested by the ordination, CG8 changes hardly at all in most proportions. All three types show very small increases in competitors and decrease in ruderals and stress-tolerant ruderals. CG6 and MG1 also show change in

SC proportions, though in opposite directions. In MG1, the CR proportion decreases and CSR proportion increases.

Examination of differences within vegetation types over time using other quadrats collected at Thrislington can only lead to tentative conclusions at best. On Figures 1 and 3, Dr Shimwell's CG8 quadrats, recorded in the 1960s, appear as two distinct groups, one comprising the bulk of the quadrats (CG8a) the other being the two *Rosa* variant quadrats (CG8b, quadrats 16 and 19). His CG8 quadrats were taken from the same area in the retained SSSI as Plot 119 recorded in 1992 by Elizabeth Cooper, and her Plots 120 and 121 lie on the edge of his sample area (Maps 3 and 6). However, it should not be forgotten that some of Dr Shimwell's quadrats were taken from the old waggonway. The CG8 quadrats taken by Argus Ecological Services in 1998 (8, 11, 13-15 on Map 5) were more dispersed over the SSSI. Table 8 gives the constancy values for the three sets of data, arranged in the order in the NVC table for CG8. Among CG8 constants, which by definition should occur in all or most quadrats, there are lower frequencies of occurrence in 1992 and 1998 compared with the 1960s for *Scabiosa columbaria*, *Helianthemum nummularium* and *Helictotrichon pratensis*, while *Koeleria macrantha* is absent. However David Park reports that *Koeleria macrantha* still occurs in part of compartment 6. Among other species there is a suggestion of lower frequencies of *Stachys officinalis*, *Carlina vulgaris*, *Pilosella officinarum* and *Gentianella amarella* and higher frequencies of *Centaurea nigra*, *Briza media* and *Succisa pratensis*. Some species only occur in the more recent quadrats: *Achillea millefolium*, *Danthonia decumbens*, *Bromopsis erecta*, *Trifolium pratense* and *Vicia cracca*.

In terms of functional strategies, an unweighted FIBS analysis of Plot 119 and Dr Shimwell's CG8 quadrats (Table 9) reveals that Plot 119 has higher proportions in C, CR and CSR categories while Dr Shimwell's quadrats have higher proportions of S and SR species. The R and SC strategies are not much different. An unweighted analysis was undertaken as the abundance measures are different in the two sets of data. Compared to other CG8 quadrats, recorded from different locations since the 1960s, in a weighted analysis (Table 10), Dr Shimwell's quadrats are again higher in proportions of S and SR species and lower in C and CSR species. SC is higher in other quadrats and R is lower, CR is not distinctly greater or smaller for later quadrats. These same relative differences are seen even when comparing Dr Shimwell's quadrats with the much smaller CG8 quadrats recorded by David Park and Helen Buckingham (Table 10).

To assess whether past changes in extent of vegetation types, such as expansion of CG3, or possible future changes might be reflected in differences in functional strategies, FIBS analysis was done for quadrats from different vegetation types collected at the same period, ie the 1997 and 1998 data. The results indicate that on average CG2 quadrats currently have the highest proportion of species with the S strategy and lowest with CSR strategy, followed by CG8 quadrats (Table 11). CG8 has the lowest C, R and CR and highest SC proportions. Stuart Hedley's CG6 quadrat stands out as somewhat different from the average of the Argus Ecological Services' CG6 quadrats, while the two sets of CG3 quadrats are very similar. Excluding Stuart Hedley's quadrat, CG6 and CG3 are quite similar. The proportions of S and CSR of CG3 and CG6 are not much different while C and CR are slightly higher in CG6 and R and SR lower compared to CG3. Information on which to compare the same vegetation type in the transplant and retained SSSI is scanty. From this limited data (Table 10, EFU and David Park's 1987 quadrats and Table 12), there is some indication that within types transplant examples have lower S and higher R and CSR proportions.

4.3 Species abundances

4.3.1 General patterns of change in frequency

To obtain a general picture of how frequency changed over time for species in different RMQ plots on the transplant and the SSSI, an ordination using data from 'pooled' RMQs was carried out. Comparable data between years for all plots was only available for selected species in 1992-1998 (Tables 13-18, frequencies standardised as percentages). In some years root rather than shoot frequency was recorded but data from 1998 for both methods shows that frequencies of most species are similar whichever method is used (Tables 13-18). RMQs were pooled to reduce the data set to a manageable size for analysis. Each RMQ from a plot in any one year was randomly assigned to one of 10 pooled quadrats (5 where only 50 RMQs had been recorded). Each species therefore had a measure of abundance in a pooled quadrat from 0 (no RMQs contained the species) to 10 (the species was present in all RMQs in the random assignment).

Overall, the plots show relatively little post-transplant change over the period 1992 to 1998 (Figure 6, only 1992 and 1998 samples shown. A = Receptor A plots, B = Receptor B plots, S = SSSI plots, U = ungrazed, G = grazed). The Receptor B grazed plot seems the most different between the two dates. Most plots are somewhat separate in character from each other at both dates, even though only selected species have been used. Receptor A and SSSI grazed plots are always more similar to each other than their respective exclosure plots. In contrast, Receptor B grazed and exclosure plots overlapped in 1992 but were relatively widely separated in 1998. Ordination of full species records (Tables 19 and 20) in individual years show the separate character of plots more clearly, including in the pre-transplant period. The Donor plots (DI, DII) and the SSSI plot were different in 1987 (Figure 7) as were the Receptor and SSSI plots in 1998 plots (Figure 8). These differences probably reflect the different composition of the plots in terms of vegetation types (see 3.4 above). The species ordinations tend to bear this out (Figures 9 and 10). For example, constants of CG8, *Sesleria caerulea, Thymus polytrichus* and *Helictotrichon pratensis* are at the right hand side of Figure 10, the same as the pooled RMQ samples from the two plots with the greatest extent of CG8, ie the SSSI and Receptor B exclosure plots (Figure 8, section 3.4 above). Species such as *Arrhentherum elatius* and *Heracleum sphondylium* occur at the left of Figure 9, the same as pooled RMQ samples for Donor plot I, which is the only plot having MG1 type vegetation (section 3.4 above).

Exclosure plots are the only ones with full species records that could be usefully analysed by FIBS to look at change over time. The earliest available year for the Receptor plots is 1990 (Table 21), and is for exclosures only, and the latest is 1998 (Table 20). The SSSI exclosure has information for 1987, 1990 and 1998 (Tables 19-21). The results for a weighted analysis of these data are given in Table 22. For the SSSI, C, CR and CSR proportions are higher in 1987 while SC is lower compared to 1990 and 1998. The proportion of stress-tolerators fluctuates and is little different in 1987 and 1998. Comparing 1990 and 1998, R and SC are lower and S higher in 1990, while other categories are very similar. In Receptor plots, proportions of C, CR, SR and CSR are higher in 1990 compared to 1998 while S and SC are lower in 1990. Overall, there seems to be some small shift away from more competitive strategies over time but this is only the case for the SSSI plot if a longer time period is considered (1987-1998). Either the proportions here change in a non-linear way or the year to year fluctuations are as large as any difference discernable over a period of years. Of course such fluctuations could also have happened in the Receptor plots.

Comparison of different plots in the same time period shows that some of the 1987 results for the Donor plots are in line with the variation in Figure 7, with Donor plot I having the lowest S and highest CR and CSR values, the SSSI plot the reverse and Donor plot II intermediate values. The donor plots have similar C, SC and SR proportions, which are higher than the SSSI for C and SC but lower for SR. Comparison of the pairs of exclosure plots with grazed plots in 1998 shows a variable picture, for example, sometimes grazed plots have lower S or CSR proportions than exclosures and sometimes the reverse (Table 22). Comparison of Receptor versus SSSI plots indicates SSSI plots have higher S and SC and lower CSR overall, other proportions are variable depending if grazed or exclosure plots are considered (Table 22).

4.3.2 Individual species

Two species of particular interest are *Bromopsis erecta* and *Sesleria caerulea.* Both are key species in characterising vegetation types, *Bromopsis* in CG3 and *Sesleria* in CG8. In addition *Bromopsis* is on the northern edge of its range in County Durham (Perring and Walters 1976).

4.3.2.1 *Sesleria caerulea*

The frequencies of *Sesleria* in different RMQ plots fluctuates year to year but no overall trend of decline is visible either on the transplant or the SSSI (Figures 11-13). In fact in the SSSI plots the trend is upward (Figure 11) and in the Receptor B exclosure plot frequencies for 1997 and 1998 were marginally higher than in previous years (Figure 13). Shoot frequencies are used for all years where they are available, ie not 1993-1997, for which root frequencies are used. Frequencies in Receptor A plots have been very low almost every year (Figure 12). The cover values in David Park's quadrats for pre- and post-years also suggest little change in cover of *Sesleria* (Table 3). The largest difference is a 10% reduction between 1982 and 1987 in quadrat 28.

4.3.2.2 *Bromopsis erecta*

Bromopsis shows more marked changes in frequencies than *Sesleria.* The trend is upward on the transplant (Figures 15 and 16) which accords with casual observations of spread of *Bromopsis* here and with the one quadrat that David Park recorded containing *Bromopsis.* In this quadrat cover increased from 5% to 30% between 1982 and 1987 (Table 4, quadrat 7). Increases are larger in grazed Receptor plots than exclosures (Figures 15 and 16). Casual observation has suggested that *Bromopsis* is increasing on the retained SSSI. The frequencies in the SSSI plots fluctuate (Figure 14) and it remains to be seen if higher frequencies in 1998 continue into the future. However, *Bromopsis* occurs in two of Elizabeth Cooper's 1992 CG8 plots (119, 8% of quadrats: 121, 17%) and in 3 out of 5 CG8 quadrats recorded in 1998 by Argus Ecological Services on the SSSI. In contrast the species does not occur in Dr Shimwell's quadrats from the mid-1960s.

4.3.2.3 Scrub species

Only selected scrub species were recorded in most years but the total frequencies of woody species as a group were calculated for 1998 to obtain an idea of the abundance of scrub that remains after several years of scrub clearance and grazing activity. The results are shown in Table 23 for 10 x 10 cm RMQs and 25 x 25 cm RMQs. Interestingly, grazed plots do not consistently have lower frequencies than exclosures, where intermittent cutting of scrub is done. Overall, the figures suggest quite a substantial reservoir of scrub within grassland both on the transplant and the retained SSSI.

4.3.2.4 Other species

Among the selected species recorded annually (Tables 13-18), a few show trends in frequency over the years but most show fluctuating frequencies with no obvious increases or decreases. In addition, the changes that are shown by particular species often are not consistent among RMQ plots of the same type ie exclosures or grazed plots. In the SSSI exclosure several broad-leaved herbs have declined; *Linum catharticum*, *Pimpinella saxifraga* and *Plantago lanceolata* (Table 13). *Pimpinella* also declines in the two Receptor exclosures but there is no obvious trend in the frequencies for the other two species (Tables 14 and 15). *Linum catharticum* increases in all grazed plots (Tables 16-18) but *Pimpinella* increases sharply in grazed Receptor plot B while decreasing in grazed Receptor plot A and fluctuating in the SSSI grazed plot.

Carex flacca has generally been the most frequent species in all the plots including the donor plots and its frequencies have almost always remained high (over 70%), although there is an apparent downward trend in the SSSI exclosure plot (Table 13). Other species which fluctuate but reach moderately high frequencies (over 50%) across all the plots are *Helianthemum nummularium*, *Lotus corniculatus*, *Festuca* species and *Brachypodium sylvaticum*. *Briza media*, *Sanguisorba minor* and *Centaurea nigra* are generally in the 20-40% range while species such as *Scabiosa columbaria* and *Knautia arvensis* often are at frequencies of less than 10% (Tables 13-18).

5. Factors affecting vegetation change

There are several possible factors that could have influenced vegetation change at Thrislington Plantation and which may affect future directions of change. These factors may interact with each other making the assessment of their relative roles difficult without a more comprehensive approach to monitoring and field experiments. However a preliminary attempt is made below to evaluate them, primarily to inform the consideration of future monitoring at Thrislington.

5.1 Succession

The impact of successional processes was clearly important when grazing levels declined in the period before 1992. Grassland was invaded by, or totally replaced by, scrub over large parts of the site. Build-up of biomass in ungrazed grassland and the development of scrub may have led to increased nutrient levels in soils, particularly under dense scrub, as was found for nitrogen and phosphate content of soils at the Devil's Ditch, Cambridgeshire (Grubb and Key 1975). The quadrats that David Park recorded from scrub-cleared areas had MG1 vegetation, which is generally found on more nutrient-rich soils than calcareous vegetation (Rodwell 1992). The vegetation that pre-dated the scrub in these quadrats is not known but it would be very interesting to find and re-record them to see if vegetation change has since been towards a more calcareous type or whether the vegetation remains mesotrophic in character.

Whether successional change has increased levels of soil nutrients and altered vegetation more generally across the site is an open question. One possible course of succession in the transition to scrub may have been from CG2 vegetation to CG6. Rodwell (1992) describes CG6 as found on more mesotrophic soils than other calcareous types and in situations of little or no grazing. David Park's *Brizo-Festuco-Helictotrichon* quadrats and CG6 quadrats recorded by Stuart Hedley and Argus Ecological Services appear to have floristic characteristics of both CG2 and CG6. In contrast, Dr Shimwell's CG2 quadrat is quite distinct (Figure 1) and may represent an earlier stage. In fact his quadrat is closer to his CG8 quadrats in Figure 1, leading to the question of what controls the development of these two types, especially in relation to *Sesleria*, the key species of CG8. Dr Shimwell investigated the soil differences associated with these two types by recording plant species and soil factors along a transect of 32 1 x 1 metre quadrats at Thrislington (Shimwell 1968). The transect ran through *Helictotricho-Caricetum flaccae* vegetaion (CG2), *Seslerio-Helictotrichetum* (CG8) and mixed scrub and grassland. Table 24 gives the averages for pH, humus percentages and calcium levels. CG2 seems to have lower calcium and pH values than CG8, although humus percents are similar. As might be expected, the humus percents of the mixed scrub and grassland were higher than either CG2 or CG8, though pH and calcium levels were similar to CG2. The primary controlling factors at Thrislington may be base status and pH, perhaps influencing phosphate levels. Phosphate becomes less available at higher pHs (Etherington 1982). Dixon (1982) reported that *Sesleria* is found on soils with very low phosphate levels and that *Sesleria* was replaced by *Festuca ovina* when available phosphate was increased an experiment in Teesdale.

The relationship between CG2 and CG8 at Thrislington may therefore be edaphic in nature, but not necessarily any kind of sequence mediated by succession. Dr Shimwell suggests that CG8 vegetation develops into *Centaureo-Arrhenatheretum* (MG1) or through the *Rosa pimpinellifolia* variant of *Seslerio-Helictotrichetum* Association, sub-Association *Helictotrichetum pubescentis* (CG8b) to scrub or directly into scrub (Shimwell 1968). The 1998 survey did not pick up any areas of MG1 on the transplant or retained SSSI, although areas of scrub which might have superseded CG8 stands were very evident. Rodwell (1992) suggests that CG8 may grade into *Helictotrichon pubescens* grassland (CG6) depending on soil development and amount of grazing but these possibilities would need further investigation of soils and vegetation change at Thrislington before they could be confirmed. Successional processes are still operating in the exclosures, except for some control of scrub species. However, FIBS analysis provides no evidence of increase in competitive strategies, which might be associated with higher nutrient levels, in the undisturbed SSSI. Indeed *Sesleria* itself (a SC strategy species) increased in the SSSI exclosure, and the extent of CG8 here also seems to have increased, indicating that change to other vegetation types, such as MG1 or CG6, is not a rapid process, at least in the absence of high scrub cover. This finding is off-set by the comparison of Dr Shimwell's quadrats with those from later recording of CG8 and Elizabeth Cooper's plots where higher proportions of competitive strategies were evident and some CG8 constants were less frequent or absent. Re-recording of Elizabeth Cooper's plots would show if the grazing imposed after they were recorded in 1992 has altered this picture. The reservoir of scrub species in open grassland shown to exist by the 1998 data for RMQ plots indicates that succession to scrub has the potential to proceed rapidly once again if management is relaxed.

5.2 Transplantation

The impact of transplantation is clear in relation to changes to the pattern of vegetation types and the alteration of the historical development of the vegetation in relation to the soils and topography that obtained in the donor area. This element of naturalness, integral to the nature conservation value of the site, has been lost, albeit from a habitat that has always been influenced to some degree by human activity. There seems to have been some reduction in the area of CG8, during or after transplantation, although species abundance data indicate that *Sesleria* has not decreased noticeably in post-transplant vegetation. It would be extremely useful to re-record David Park's quadrats, if they could be found, to see if change in *Sesleria* occurs beyond time periods longer than 5 to 10 years. No data for longer periods is available yet for the transplant. The lack of change in CG8 is somewhat surprising as the disturbance associated with transplantation might be expected to release nutrients and thus deleteriously affect species restricted to nutrient-poor soils. Monitoring of a mesotrophic grassland transplant at Brocks Farm in Devon (Jefferson et al 1999) shows that a turf transplant has developed characteristics of more nutrient-rich vegetation compared to the retained SSSI at that site. However, FIBS analysis of David Park's quadrats revealed only slight increases in competitive strategies in CG6 and CG8, which parallelled limited changes in species composition and abundances. The greatest changes in abundance and the largest turnover of species, from the post-transplant data only, was in the MG1 quadrats, perhaps because gaps left by scrub clearance were exploited by fast-growing species (eg *Arrhenatherum elatius* and *Heracleum sphondylium*), on quite a nutrient-rich soil. In addition, scrub species continued to decrease in these quadrats, presumably due to control measures. The FIBS analysis of the post-transplant RMQ exclosure plots shows no increase in competitive strategies, rather, these are less well-represented in 1998 compared to 1990.

Existing data suggest that most individual species, such as *Carex flacca*, have maintained their populations on the transplant and have not markedly increased or decreased. It is possible though that transplantation has enhanced the spread of *Bromopsis erecta* and the expansion of CG3 vegetation at the expense of another vegetation type. Increase in frequency of *Bromopsis* on the transplant has not yet been matched by increases in the EFU plot in the undisturbed SSSI, although casual observations suggest that *Bromopsis* has been increasing to some extent in the undisturbed part of the site (D. Park pers comm). The species began spreading on the transplant before grazing was introduced but it has increased more in grazed plots than exclosures. Therefore grazing may be interacting with transplantation or some other factor to promote the expansion of *Bromopsis*. Grime et al (1988) report that its functional strategy is between CSR and SC and that it is associated with vegetation of intermediate productivity. It may be responding to raised soil nutrient levels in the transplant compared to the donor area but there is no evidence of an increase in nutrients, judged by change in plant strategies discussed above. Whether *Bromopsis* increase is a precursor to a wider change among other species is unknown at this stage. FIBS analysis of 1997-98 CG3 quadrats from the transplant suggests the proportion of competitive strategies is greater than in CG3 on the undisturbed SSSI or CG2 and CG8 anywhere, but is similar to CG6. It may be that CG3 will replace, or has already replaced CG6 vegetation rather than other types. There is certainly no evidence yet that increases in *Bromopsis* are matched by decreases in *Sesleria*.

5.3 Fire

Sporadic, unauthorised fires occurred at Thrislington Planatation until 1993. David Park recorded the location of fires on the donor area and the retained SSSI over the period 1982 to 1992 (unpublished records). Concern has been expressed in the past that the spread of *Bromopsis erecta* was encouraged by these fires (J. J. Hopkins, English Nature, unpublished notes). *Bromopsis* apparently increased rapidly in the south-western part of compartment 4 in the retained SSSI, east of an area of scrub, as result of fire. It was abundant there in 1983 after a fire in 1982 and it was thought to have been sparse in that area in 1981. However, David Park's records show that most of the retained SSSI has been affected by fire in the period 1982-1992 (Map 7) and it was not totally covered by CG3 in 1998 (Argus Ecological Services 1998). In the SSSI RMQ plots, *Bromopsis* has not yet shown much sign of increase even though this area appears to have been burnt in 1982 and 1986. Elsewhere, there is no obvious relationship between fire frequency and vegetation type as recorded in 1998. CG3, CG6 and CG8 occupy areas that have been burnt between 1 and 3 times in the period 1982-1992, while CG8 occurs in an area burnt 4 times in this period. Fire may have had an immediate stimulating effect on *Bromopsis* but the species is increasing most markedly in the transplant, which has no recent fire history. Overall, fire is unlikely to be a major factor behind the spread of *Bromopsis*.

5.4 Grazing and mowing

The re-introduction of grazing appears to have had relatively little discernable effect on species frequencies in the RMQ plots. *Linum catharticum* is the most obvious species that may have benefited from grazing as it has increased in all grazed plots, while decreasing or fluctuating in exclosure plots. The greater increase in *Brompsis erecta* in the grazed compared to exclosure RMQ plots on the transplant has already been referred to above. It is not clear why grazing should be favouring *Bromopsis* now and why it did not in the past, unless some other factor is involved. Sheep are grazed on the site today rather than cattle and ponies but Rodwell (1992) notes that *Bromopsis* is eaten by sheep, cattle and rabbits.

Grime et al (1988) report that *Bromopsis* tends to be replaced by *Festuca ovina* under heavy grazing pressure. Re-recording of Elizabeth Cooper's plots would indicate if CG8 constants, that were less frequent in 1992 compared to the 1960s, have increased since grazing has been re-established.

It would be helpful to have records of sward heights at the beginning and end of grazing periods in each compartment to aid in the assessment of the effect of grazing intensity both on *Bromopsis* and on other species such as *Epipactis atrorubens* and on invertebrates of interest. For instance, the current grazing regime aims to take account of the habitat requirements of the Durham Argus butterfly (*Aricia artaxerxes* subsp. *salmacis*). The rotational pattern of grazing means that timing and duration of grazing in different compartments varies, which may have an impact on the variable response of species to grazing eg *Pimpinella saxifraga* in the grazed RMQ plots on the transplant. Table 25 gives a crude breakdown of the length of grazing period over the four seasons in a year for 1992-1998 in compartments 2, 3 and 5, which contain the RMQ plots. It shows, for instance, that over 6 years compartment 2 has had the shortest total grazing duration and compartment 3 (where *Bromopsis* has increased most markedly) the longest duration. Autumn/winter grazing is more a feature of compartment 5 than the other two compartments. Monitoring of the effects of grazing in the future would ideally be based on floristic information and sward measures for all compartments. Records of mowing by compartment and whether cut material is removed would also be useful. Leaving cuttings *in situ* may affect the species richness or nutrient status of grassland (Crofts and Jefferson 1999). Mowing has been used on the retained SSSI when grazing has been deemed insufficient (Rich 1997) and more floristic and sward measurement data by compartments or in subdivisions of compartments would help in the assessment of the effect of this management.

5.5 Atmospheric deposition

The increase in atmospheric nitrogen deposition that has occurred in the twentieth century may lead to changes in vegetation, for instance, Dutch work has produced convincing evidence of an increase in *Brachypodium pinnatum* in relation to nitrogen deposition (Bobbink et al 1998). For calcareous grasslands in the UK, critical loads for nitrogen deposition, above which changes would occur, have been estimated in the range 14 to 25 kg/nitrogen/ha/year. A model of nitrogen deposition in the UK, developed by the Institute of Terrestrial Ecology, provides a figure of 19-20 kg/nitrogen/ha/year for Thrislington Plantation (Carol Pitcairn, ITE Edinburgh, pers comm). This level is within the critical load range rather than decisively below it. To have an effect, phosphate may also need to be available, eg if *Sesleria* occupies soils with very low phosphate amounts, other species might be limited by these levels despite higher levels of nitrogen being available. Thus there may be a differential response between vegetation types to nitrogen deposition depending on soil phosphate levels. Interestingly, Grubb and Key (1975) report experiments by Michael Fenner which showed that the growth of a closed mature sward of *Bromopsis erecta* was increased by nitrogen alone but not phosphate alone, the reverse of the response by seedlings. In the future, recording of edaphic factors, particularly phosphate and nitrogen, alongside floristic recording would help to establish whether changes are occurring in the system through nitrogen deposition or some other cause. Monitoring of the size of the *Brachypodium pinnatum* patch, in case it is responding to such changes, would seem to be a wise precaution given the management problems this species can pose when it is present in abundance. Observations over time of any occurrences elsewhere on the Reserve would also be useful to see if it is regenerating by seed.

5.6 Climate change

The most insidious and wide-ranging factor that may be affecting the vegetation at Thrislington Plantation is climate change. A rise in average temperatures, perhaps associated with altered rainfall patterns could bring about changes in species composition and abundance either directly or through changes in soil nutrient cycling. It is possible that the increase in *Bromopsis erecta*, especially if confirmed for the undisturbed SSSI, may represent the first sign of the effect of climate change. *Bromopsis* is at its northern limit in Britain in County Durham and is a lowland species not found above 310 m in the UK (Grime et al 1988). Casual observations from other Durham Magnesian Limestone sites suggest that it is increasing elsewhere, not just at Thrislington (Stuart Hedley pers comm). It is also possible that climate amelioration is interacting with other factors at Thrislington. Grazing may be opening up the sward and creating gaps for seeds to regenerate which *Bromopsis* can now exploit more effectively than in the past. Transplantation may have altered the microclimate for *Bromopsis* by changing the orientation of the slope from south-east to south-west, by being at a lower altitude (126-129 m rather than 129-137 m) and by providing a more hummocky surface with locally steep and warm slopes. However, if evidence of more general spread of *Bromopsis* on the site and elsewhere becomes available this would suggest these microclimatic differences are of minor significance compared to climate change at a macro scale.

Climate change may also affect other species on the site. *Brachypodium pinnatum* is on the northern edge of it main range in County Durham though a few 10 x 10 km squares to the north have records (Perring and Walters 1976). *Epipactis atrorubens* is a northern species largely restricted in England to Cumbria, North Yorkshire and Durham apart from a few records in the Peak District (Stewart et al 1994). It might show a decline in the face of rising temperatures. Continuation of monitoring of RMQ and Elizabeth Cooper's plots offers an outstanding opportunity to investigate the impact of climate change in an transition zone between northern and southern elements of vegetation. It would be worth supplementing this monitoring with recording of populations of *Epipactis atrorubens*, which occurs rather sparsely in existing plots. If climate change instigates a shift in vegetation type, for instance from CG8, the Special Area for Conservation interest feature, to CG3, this may be an intractable problem to deal with by available methods of management. Experimental manipulation of grazing and mowing are probably the only feasible responses and there needs to be sound compartment-wide data for vegetation and scarce species, including invertebrates, on which base any modifications in management. In particular, *Epipactis atrorubens* and *Linum perenne* appear to prefer lightly grazed swards (Rich 1997) and might be deleteriously affected by more intensive grazing and mowing regimes.

6. Summary of monitoring recommendations

6.1 Questions to answer

The preceding review of monitoring activity at Thrislington sets the scene for proposing future monitoring priorities. In order of priority the main questions of interest can be defined as follows:

i. Is the nature conservation interest of the SAC habitat of the retained SSSI at Thrislington Plantation being maintained and what factors are influencing any changes in interest?

ii. Are populations of notable species on the Reserve being maintained and what factors are affecting changes in populations?

iii. What changes are taking place on the transplant and can these be related to the effect of transplantation or other factors?

6.2 Monitoring of vegetation

Elizabeth Cooper's plots should be re-recorded as soon as possible, and again at suggested intervals of 5 years. The original aim of the climate change recording was to look at change across a range of sites in Britain. To make the monitoring more specific to change within a particular site the following modification is suggested. At the same time as the 36 quadrats per plot are recorded, a minimum of 50 RMQs should be recorded in each plot, in a completely randomised layout. This would allow the translation of the data set derived from the 36 quadrats so that it is comparable to RMQ data across the site. Thereafter, RMQs should be recorded from these plots. To maintain consistency across the national network of sites, the 36 quadrats should be recorded when the network is re-recorded in the future. To improve understanding of the context of these plots and their representativeness of CG8 in the Reserve, particularly the area sampled by Dr Shimwell, where there are no quadrats from 1998, a further set of 10 NVC 2 x 2 m quadrats (Domin estimates of cover should be made for all NVC quadrats) should be recorded from this area. In addition, within each of Elizabeth Cooper's plots, 2 of the 2 x 2 m blocks should be recorded in the same way.

The RMQ plots should be recorded at the same time as Elizabeth Cooper's plots and at the same suggested interval. The method should be shoot frequency and all vascular plant species should be recorded. Each plot should be sampled by 100 10 x 10 cm RMQs. Prior to the recording, the vegetation of the RMQ plots should be mapped with 5 2 x 2 m NVC quadrats recorded in each type in each plot (fewer if very small areas of particular types occur). This recording will improve understanding of the context and representativeness of the plots. The random co-ordinates of each RMQ should be preserved and RMQs allocated to a vegetation type as they are recorded. This information will facilitate study of possible spatial change in species distributions and indicate the relationship of RMQ data to more subjectively described vegetation types. In addition, the results can be more easily related to the interest features of the site as a whole.

If re-locatable, David Park's quadrats should be re-recorded every 5 years. These quadrats represent the only source of data for the same area of vegetation pre- and post- transplant.

The priority would therefore be the 12 pre- transplant quadrats but the other 17 would provide information for assessing post-transplant change in addition to the RMQ Receptor plots. The understanding of the composition of vegetation types present on the transplant and their relationship to the vegetation of the retained SSSI needs to be improved. There are few quadrats on the transplant from 1997/98 except for CG3 and only 2 CG3 quadrats on the retained SSSI. A further 3 CG3 NVC 2 x 2 m quadrats should be recorded in the retained SSSI and further 5 NVC 2 x 2 m quadrats should be recorded in CG2, CG6 and CG8 vegetation on the transplant. This information will also help the understanding of the functional attributes of the different types of vegetation on the transplant and SSSI and help in assessments of likely changes in proportions of these vegetation types.

To investigate differential changes in vegetation and species such as *Bromopsis erecta* in different compartments in relation to grazing and mowing regimes, monitoring would have to be extended beyond the existing plots. This may become important in the future if mowing and grazing regimes are to be manipulated in an effort to alter the direction of vegetation change and maintain the interest features of the site, eg in the face of climate change. A method comparable to the RMQs or Elizabeth Cooper's plots should be chosen. RMQs would be easiest to implement and likely to be more representative of the vegetation in the compartment as a whole. Each RMQ should be allocated to a vegetation type as it is recorded. The 1998 vegetation map shows that there are 4 types in each compartment, excluding the *Brachypodium pinnatum* patch, edges, scrub and the waggonway. It is suggested that these latter areas are not sampled. If 200 RMQs per compartment were recorded, this would make an overall total of 1000 in the five compartments. This total compares with the 600 quadrats in the existing RMQ plots.

On a longer time scale, say every 15 years, it would be worth re-mapping the distribution of the vegetation types at Thrislington, particularly in relation to the transplant where change may be quite rapid.

In relation to the question of the more general spread of *Bromopsis erecta* on the Magnesian Limestone, it would be useful to repeat a transect of permanent quadrats set up in 1990 on a neighbouring SSSI, West Farm Meadows. The transect traverses mesotrophic grassland and grassland with *Bromopsis erecta*.

6.3 Plant species recording

The nationally scarce species, *Epipactis atrorubens* and *Linum perenne* subsp *anglicum*, would not be well covered by general vegetation monitoring yet could be affected by changes in climate or management. For example, David Park reports that the area containing the *Linum perenne* population in 1982 was severely burnt in the mid-1980s and the population has greatly reduced, although small colonies exist elsewhere on the site. Unless a University project could be instituted to study the population ecology of the two species more closely, it is recommended that as a minimum, yearly counts of flowering individuals be made by compartment. If numbers are above 500 in any one compartment then a minimum of 3 areas for sub-sampling should be defined.

Two other scarce species, which have no recent records and which would be worth continuing to search for, are *Primula farinosa* and *Carex ericetorum*. David Park (pers comm) has examined the historical site of *Primula farinosa* every year since the early 1980s but has not seen the plant. *Molinia caerulea* was also recorded in the past, along with *Primula farinosa*, possibly in areas that were damper. It would be useful to assess whether hydrological or other factors might be implicated in decline of these species.

The extent of the *Brachypodium pinnatum* patch should be monitored with permanent markers at least every other year and notes kept of occurrences elsewhere on the site to provide early warning of possible spread beyond the existing patch.

The extent of scrub should be monitored using information from the RMQs and some kind of photographic recording, eg fixed point photography or repeat of the aerial photographic coverage. It would be useful to review the balance of scrub versus grassland in the retained SSSI, particularly if areas of CG8 grassland could be restored, given the conservation importance of this grassland type.

6.4 Vegetation height

To complement the information on composition of vegetation in different compartments in relation to grazing and mowing and the population counts of *Epipactis atrorubens* and *Linum perenne*, sward height should be quantitatively measured at the beginning and end of each grazing period in each compartment. The suggested method is a sward stick, positioned at 30-50 random points in each compartment.

6.5 Invertebrate species recording

The habitat requirements of invertebrates are not discussed in the present report but need to be taken into account in management and monitoring programmes on the Reserve.

6.6 Edaphic information

Edaphic information would aid the understanding of possible edaphic variation that may underlay vegetation change, particularly in relation to causal factors such as atmospheric deposition. It is suggested that soil and vegetation chemical analysis be undertaken at sample points close to Elizabeth Cooper's plots, when these are re-recorded. Following on from Dr Shimwell's work, more general soil sampling in relation to vegetation types would help understanding of their distribution and any potential changes among these types.

7. Acknowledgements

Dr David Shimwell, Reverend Gordon Graham and Dr John Rodwell kindly provided information used in this review. Thanks are also due to Steetley Minerals and later Lafarge Redland Aggregates for their co-operation and assistance, in particular to David Park for his invaluable help and enthusiasm and for his generous provision of data. Many England Field Unit staff of the former Nature Conservancy and Local and National Team staff of English Nature contributed to the monitoring project at Thrislington over the years. Among these individuals especial thanks go to Stuart Hedley, Mike Leakey, Rob Lamboll, Simon Leach and Richard Jefferson.

References

ARGUS ECOLOGICAL SERVICES. 1998. *Thrislington National Nature Reserve vegetation survey*. Contract report for English Nature Northumbria Team. Newcastle.

BLACKSTOCK, T.H., RIMES, C.A., STEVENS, D.P., JEFFERSON, R.G., ROBERTSON, H.J., MACKINTOSH, J., & HOPKINS, J.J. 1999. The extent of semi-natural grassland communities in lowland England and Wales: a review of conservation surveys 1978-96. *Grass and Forage Science*, **54**: 1-18.

BOBBINK, R., HORNUNG, M. & ROELOFS, J.G.M. 1998. The effects of air-borne nitrogen pollutants on species diversity in natural and semi-natural European vegetation. *Journal of Ecology*, **86**: 717-738.

BROWN, A.J., BURN, A.J., HOPKINS, J.J. & WAY, S.F. eds. 1997. The Habitats Directive: selection of Special Areas of Conservation in the UK. *Joint Nature Conservation Committee Report 270*. Peterborough: Joint Nature Conservation Committee.

BUCKINGHAM, H. 1988. Monitoring grassland transplant sites: Thrislington Plantation, Co Durham, baseline Phase III surveys. *England Field Unit Project No 67*. Peterborough: Nature Conservancy Council.

BYRNE, S.A., BUCKINGHAM, H.G., LEACH, S.J. & KEYMER, R.J. 1991. Progress reports on monitoring of grassland transplantation sites: Thrislington Plantation, Durham. *England Field Unit Project No 105/07*. Peterborough: English Nature.

COUNCIL OF THE EUROPEAN COMMUNITIES. 1992. Council Directive 92/43 EEC of 21 May 1992 on the conservation of natural habitats and wild fauna and flora. *Official Journal of the European Communities* L.206.

COOPER, E.A., RODWELL, J.S. & MALLOCH, A.J.C. 1992. Effects of climate change and air pollution on British calcicolous ecosystems: Thrislington Plantation NNR (site number 51). *Report for the Department of the Environment, PECD Reference 7/12/22*. Lancaster: University of Vegetation Science, Lancaster University.

CROFTS, A. & JEFFERSON, R.G. eds. 1999. *The lowland grassland management handbook*. Second edition. Peterborough: English Nature/ The Wildlife Trusts.

DIXON, J. M. 1982. Biological flora of the British Isles: *Sesleria albicans*. *Journal of Ecology* **70**: 667-684

ETHERINGTON, J.R. 1982. *Environment and plant ecology*. Second edition. Chichester: John Wiley & Sons.

GRAHAM, G.G. 1998. *The flora and vegetation of County Durham*. Durham: The Durham Flora Committee and the Durham County Conservation Trust.

GRIME, J.P., HODGSON, J.G. & HUNT, R. 1988. *Comparative plant ecology: a functional approach to common British species*. London: Unwin Hyman.

GRUBB, P.J. & KEY, B.A. 1975. Clearance of scrub and re-establishment of chalk grassland on Devil's Ditch. *Nature in Cambridgeshire*, **18**: 18-22.

HILL, M.O. 1979. *DECORANA: a FORTRAN program for detrended correspondence and reciprocal averaging*. Ithaca: Section of Ecology and Systematics, Cornell University.

HODGSON, J.G., COLASANTI, R. & SUTTON, F. 1995. Monitoring grasslands. *English Nature Research Report* 156. *2 vols*. Peterborough: English Nature.

JEFFERSON, R.G., GIBSON, C.W.D., LEACH, S.J., PULTENEY, C.M., WOLTON, R. & ROBERTSON, H.J. 1999. Grassland habitat translocation: the case of Brocks Farm, Devon. *English Nature Research Report* 304. Peterborough: English Nature.

PARK, D.G. 1989. Relocating magnesian limestone grassland. *In*: G. P. BUCKLEY, ed. *Biological habitat reconstruction*. London: Belhaven Press. pp 264-280.

PERRING, F.H. & WALTERS, S.M. 1976. *Atlas of the British flora*. Wakefield: EP Publishing Ltd.

RATCLIFFE, D.A. 1977. *A Nature Conservation Review*. 2 vols. Cambridge: Cambridge University Press.

RICH, T.C.G. 1997. The management of semi-natural lowland grassland for selected rare and scarce vascular plants: a review. *English Nature Research Reports*, No. 216. Peterborough: English Nature.

RODWELL, J.S. ed. 1992. *British plant communities volume 3: grasslands and montane communities*. Cambridge: Cambridge University Press.

SHIMWELL, D.W. 1968. The phytosociology of calcareous grasslands in the British Isles. Durham: Ph. D. thesis, University of Durham.

SHIMWELL, D.W. 1971. Festuco-Brometa Br.-Bl. & R.Tx. 1943 in the British Isles: the phytogeography and phytosociology of limestone grasslands. Part II. Eu-Mesobromion in the British Isles. *Vegetatio* **23**: 29-60.

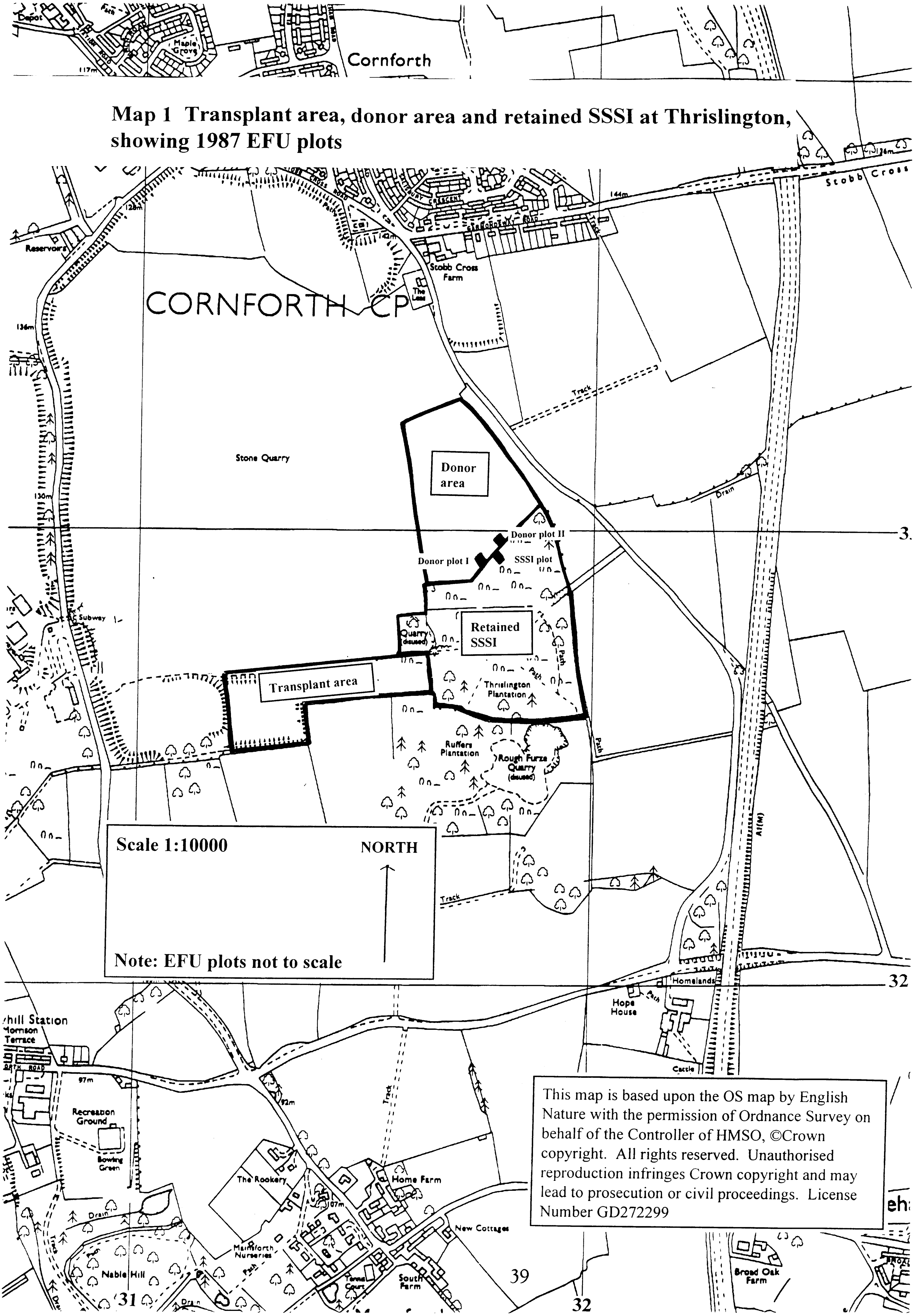
STEWART, A., PEARMAN, D.A. & PRESTON, C.D. 1994. *Scarce plants in Britain*. Peterborough: Joint Nature Conservation Committee.

STACE, C. 1997. *New flora of the British Isles*. Second edition. Cambridge: Cambridge University Press.

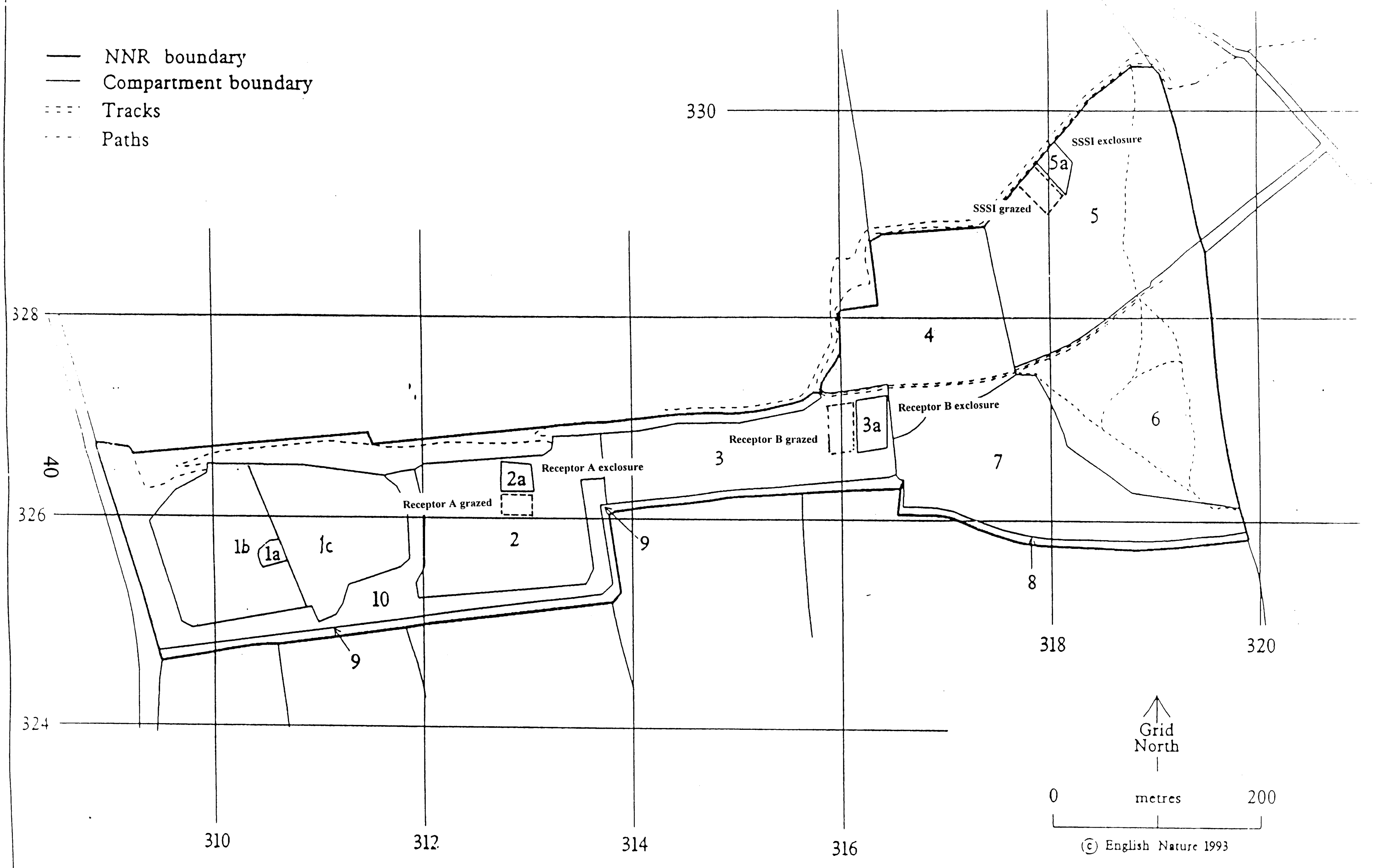
THORNE, N. 1995. *Thrislington Plantation management plan*. Peterborough: English Nature.

Maps

Map 1 Transplant area, donor area and retained SSSI at Thrislington, showing 1987 EFU plots

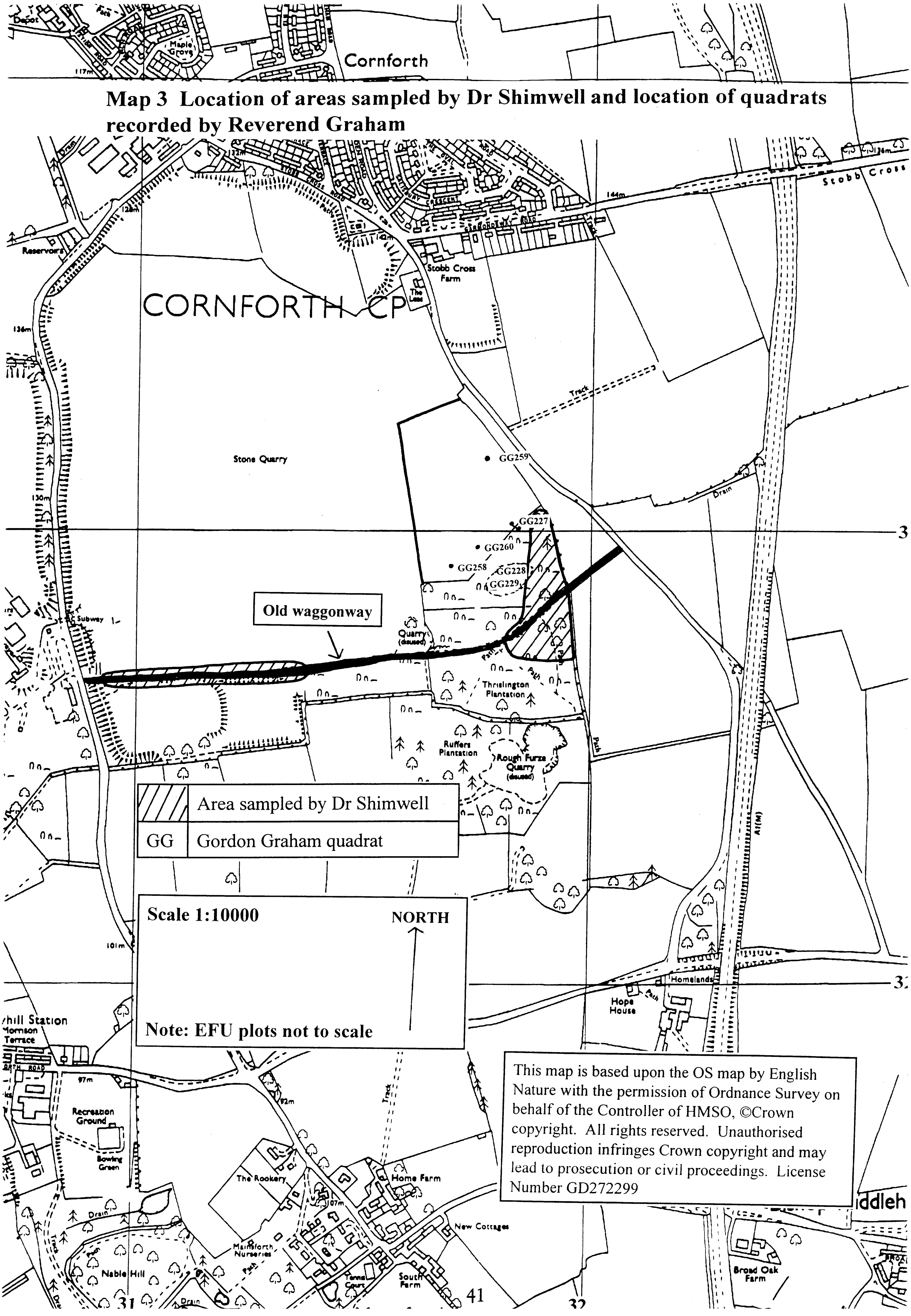


Map 2 Compartments of Thrislington NNR and location of EFU plots

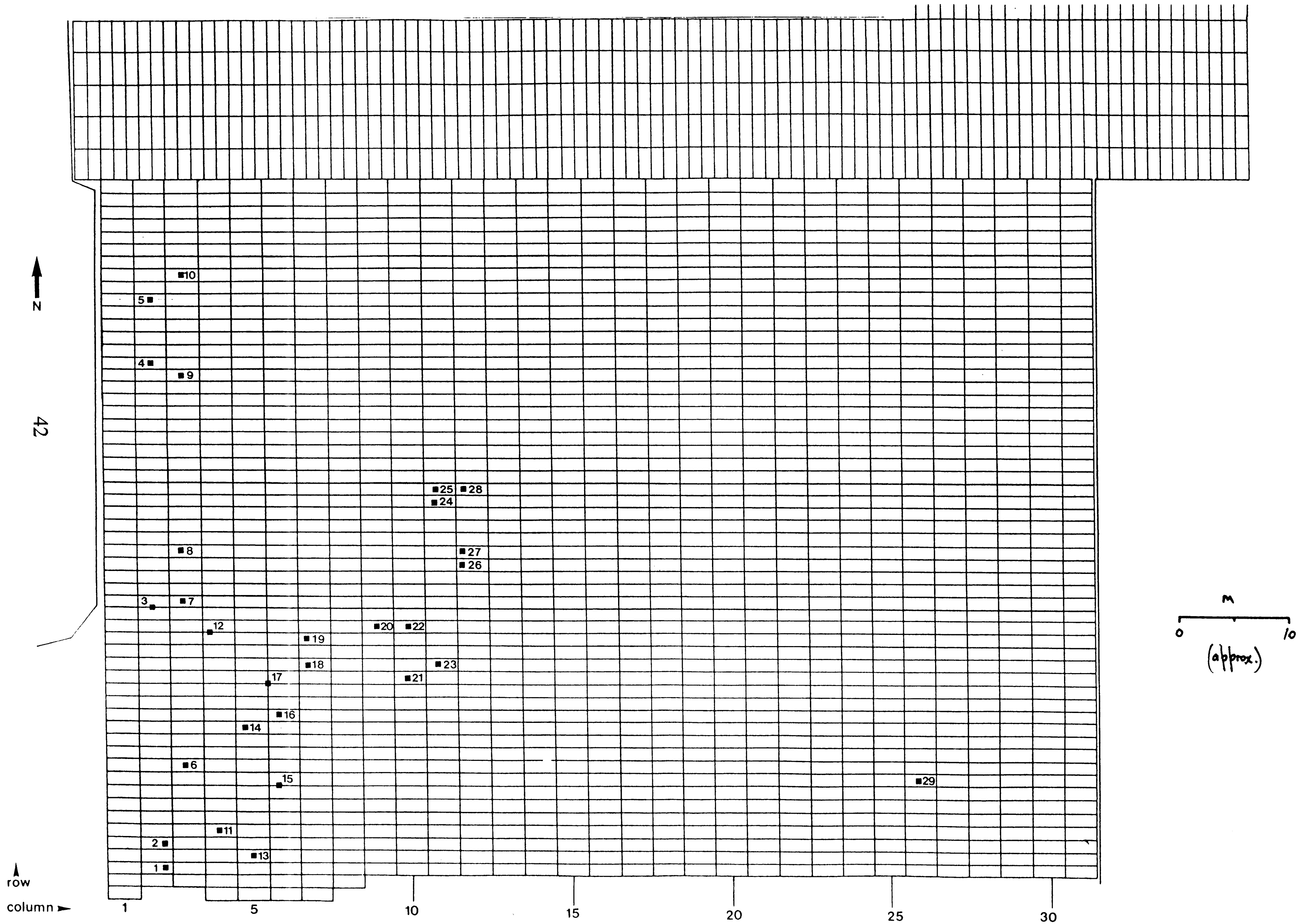


Prepared by Geographic Information Unit, English Nature, Peterborough. Grid taken from Ordnance Survey map with the permission of the controller of Her Majesty's Stationery Office. © Crown Copyright

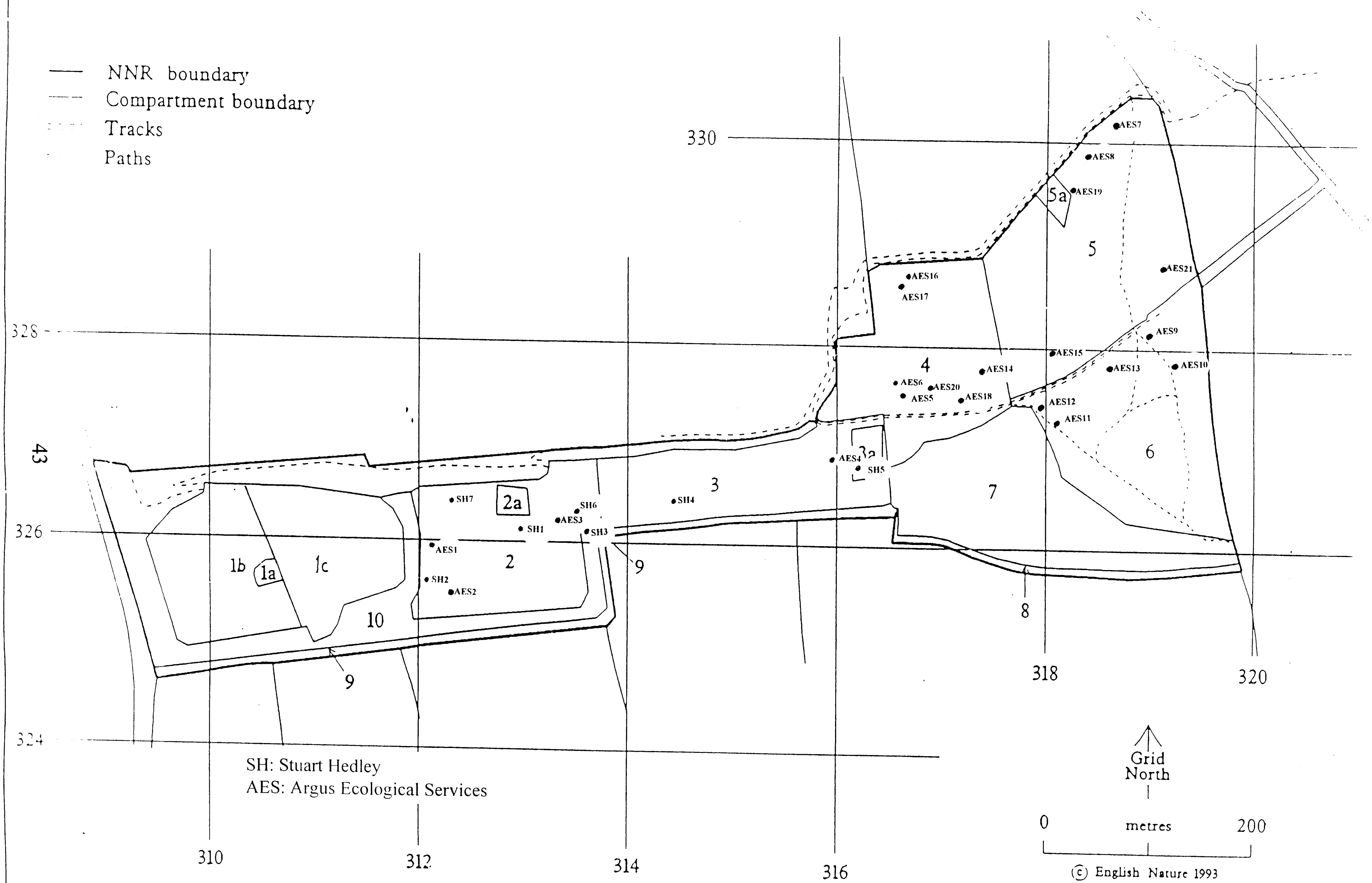
Map 3 Location of areas sampled by Dr Shimwell and location of quadrats recorded by Reverend Graham



Map 4 Location of David Park's permanent quadrats at the western end of compartment 2 of the NNR



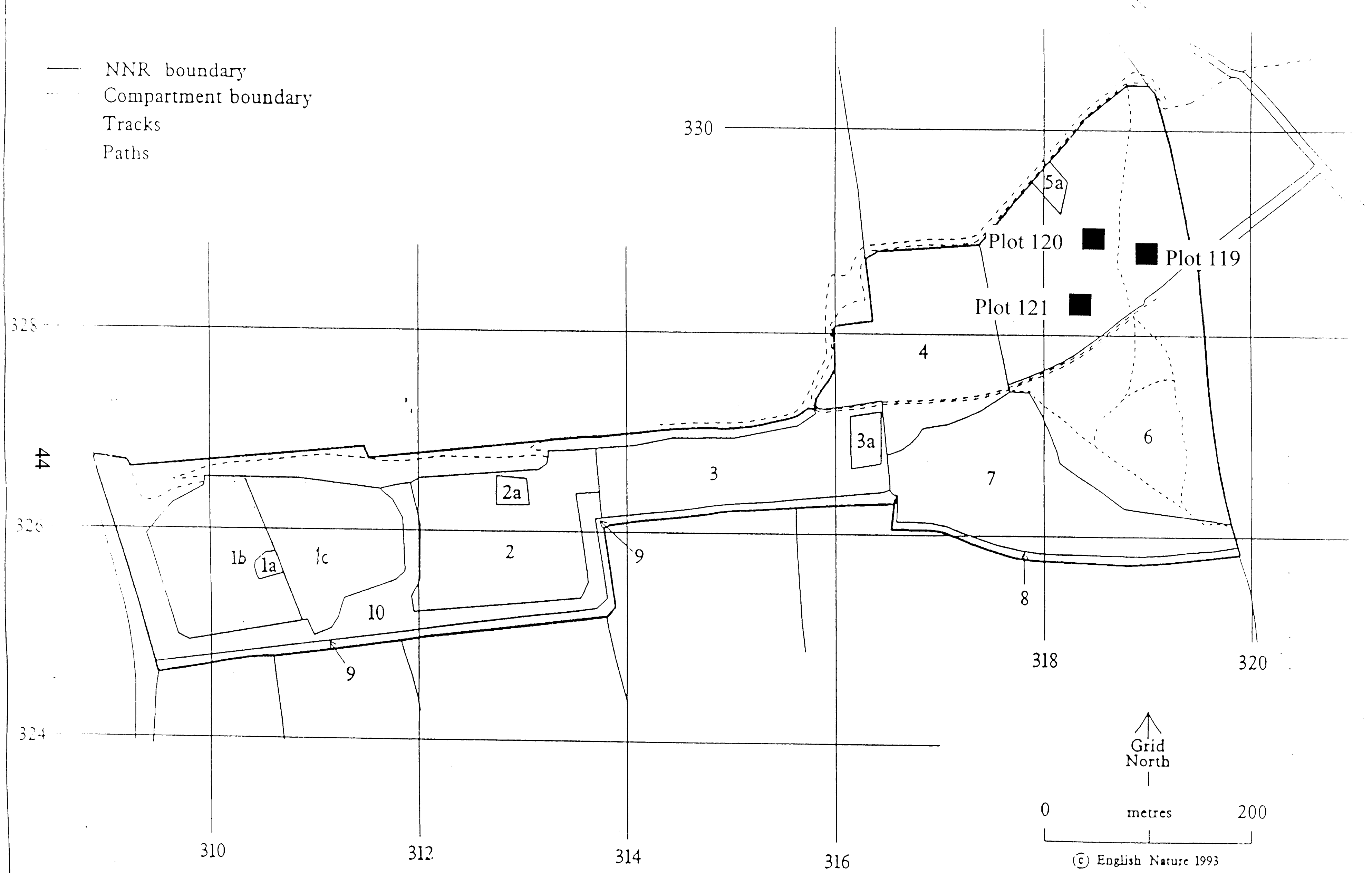
Map 5 Location of quadrats recorded in 1997-98



Ⓒ English Nature 1993

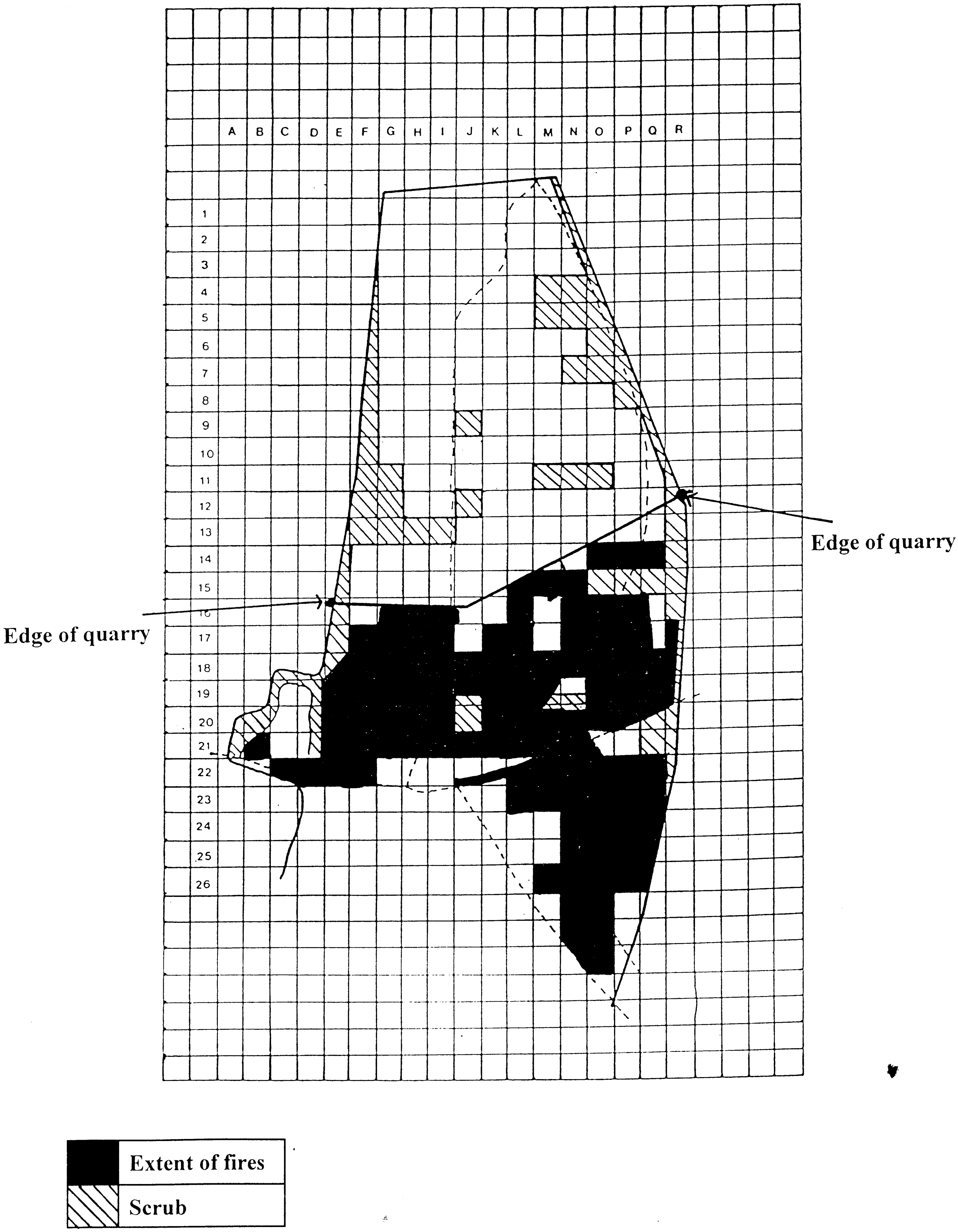
Prepared by Geographic Information Unit, English Nature, Peterborough. Grid taken from Ordnance Survey map with the permission of the controller of Her Majesty's Stationery Office. Ⓒ Crown Copyright

Map 6 Location of Elizabeth Cooper's plots recorded in 1992



Prepared by Geographic Information Unit, English Nature, Peterborough. Grid taken from Ordnance Survey map with the permission of the controller of Her Majesty's Stationery Office. © Crown Copyright

Map 7 Extent of fires between 1982 and 1992 on the retained SSSI



Figures

Fig 1: Samples on DCA ordination
(80 quadrats with cover values)

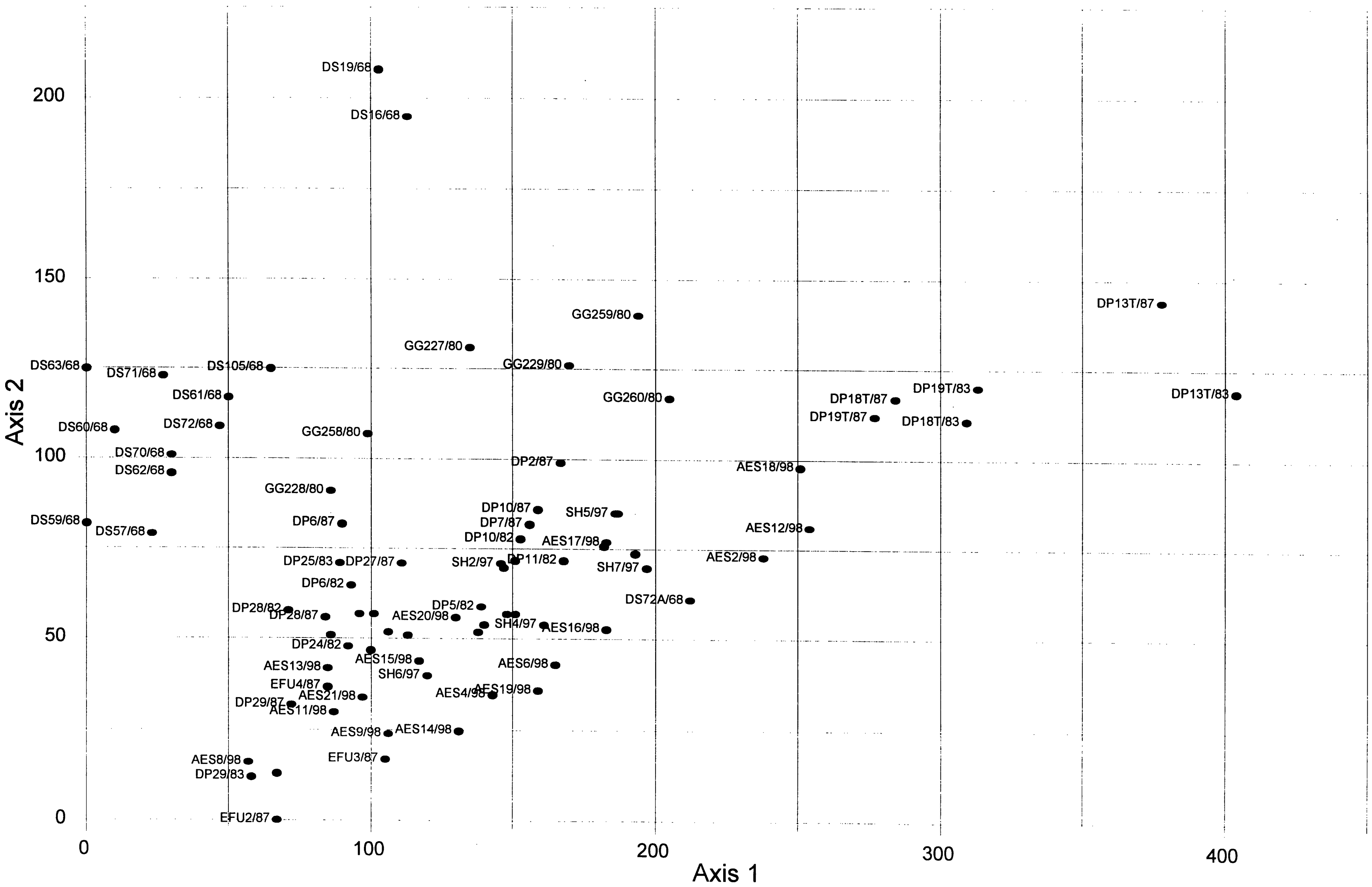


Fig 2: Species on DCA ordination
(80 quadrats with cover values)

Fig 3: NVC type and place of samples

(Same ordination as Fig 1)

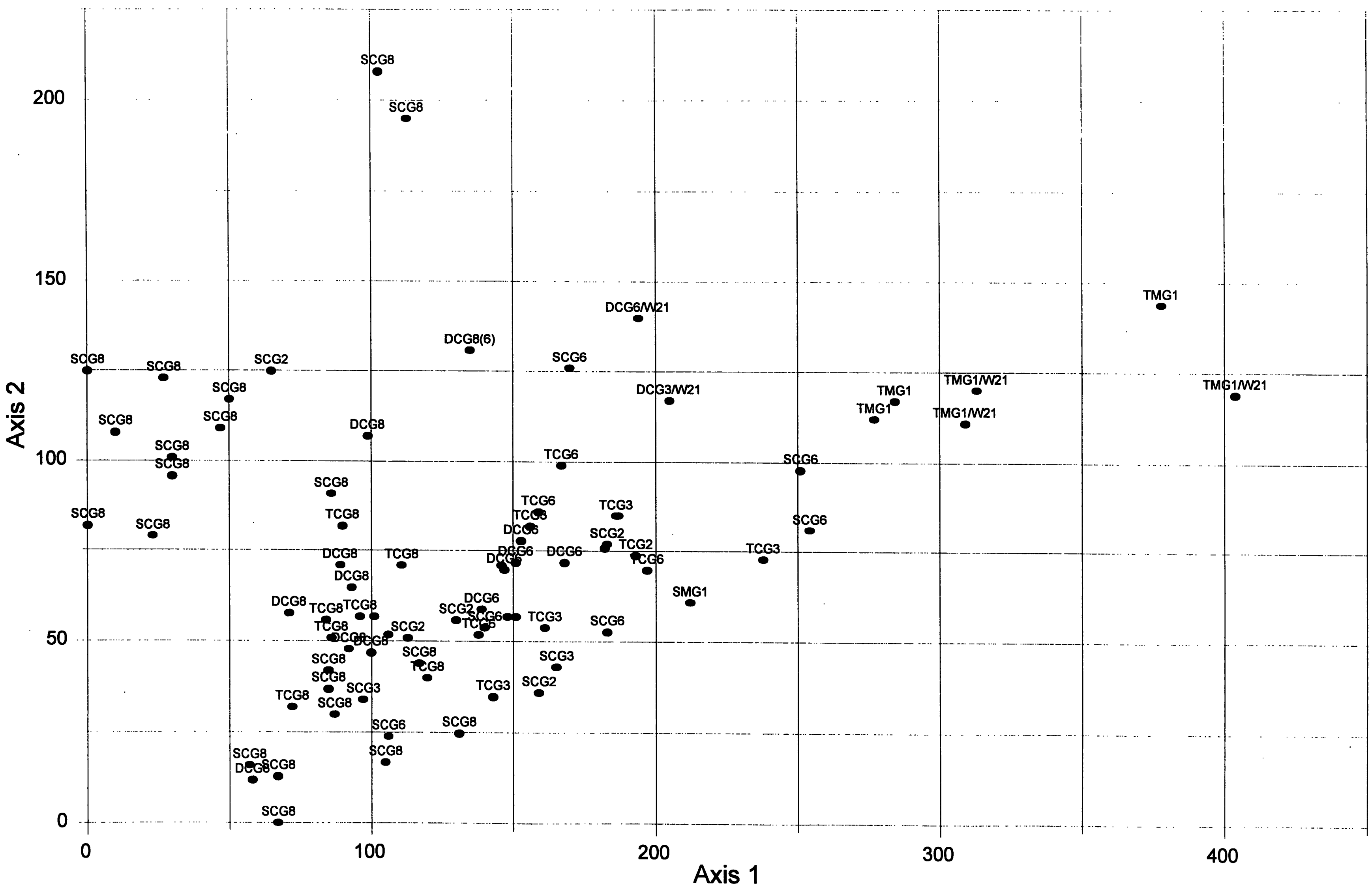


Fig 4: Samples on DCA ordination

24 pre & post transplant quadrats

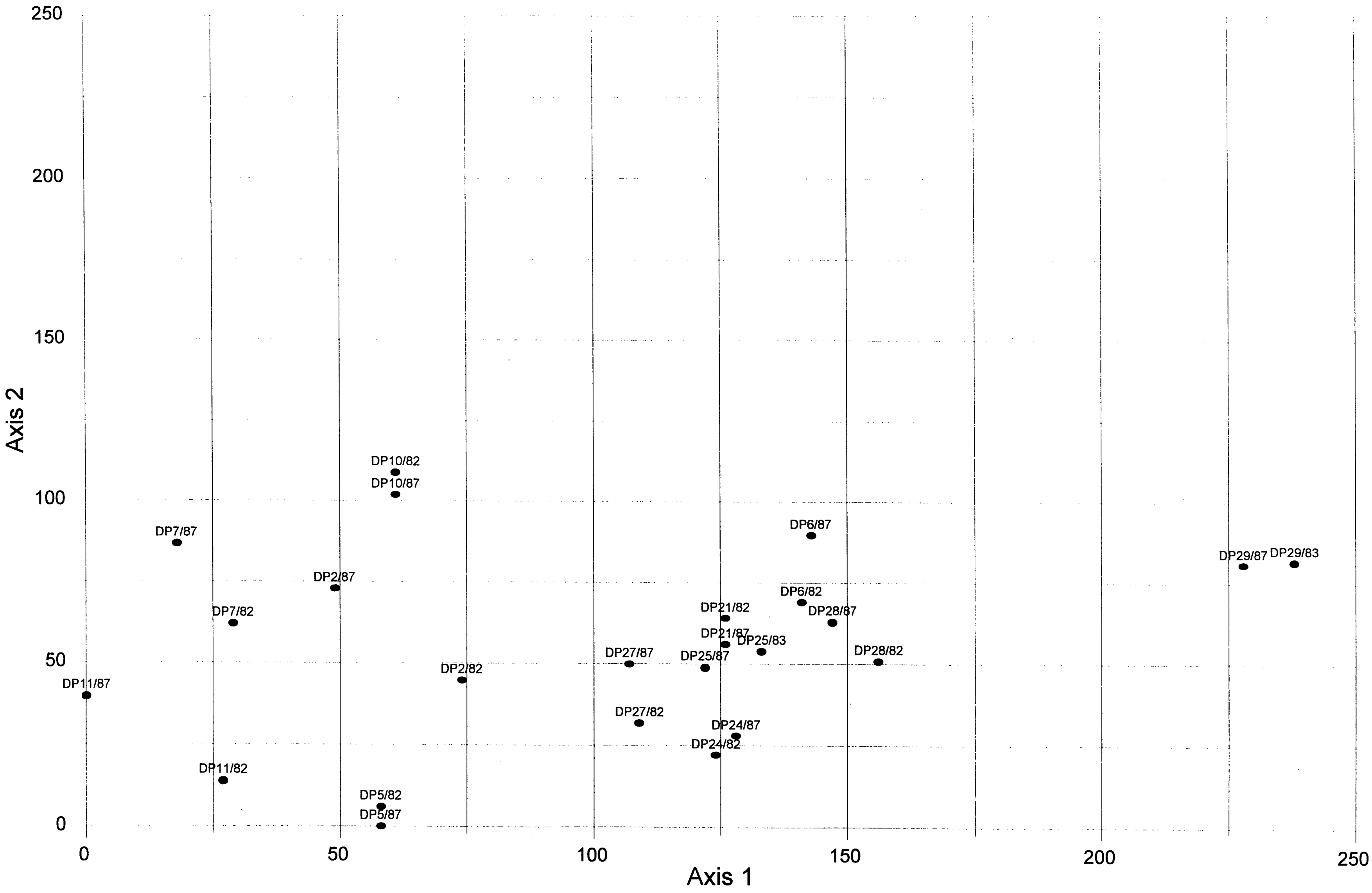


Fig 5: Species on DCA ordination
24 pre & post transpalnts quadrats

Fig 6: Samples on DCA ordination

RMQs for 1992 & 1998

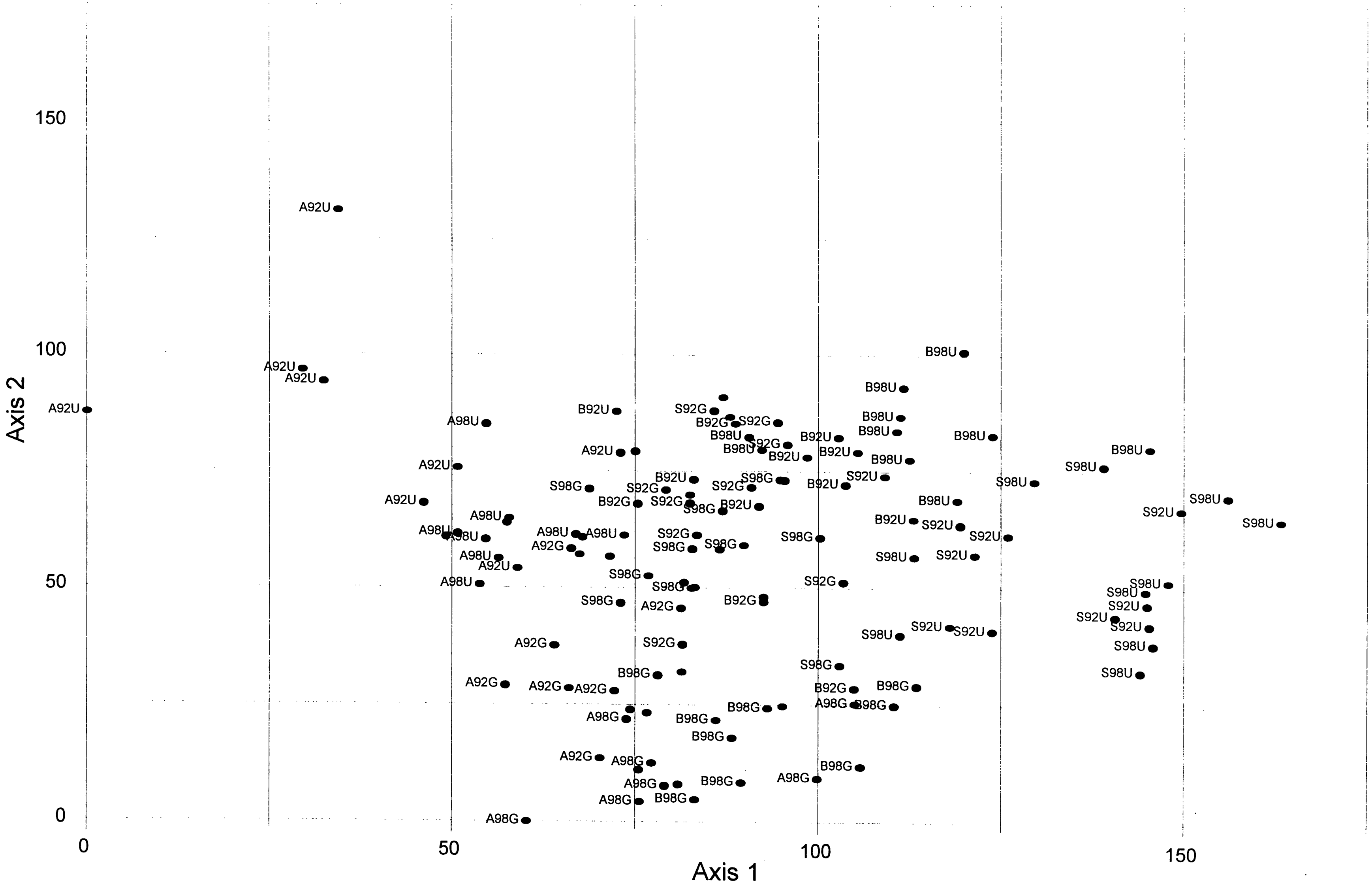


Fig 7: Samples on DCA ordination

RMQs for SSSI and Donor plots in 1987

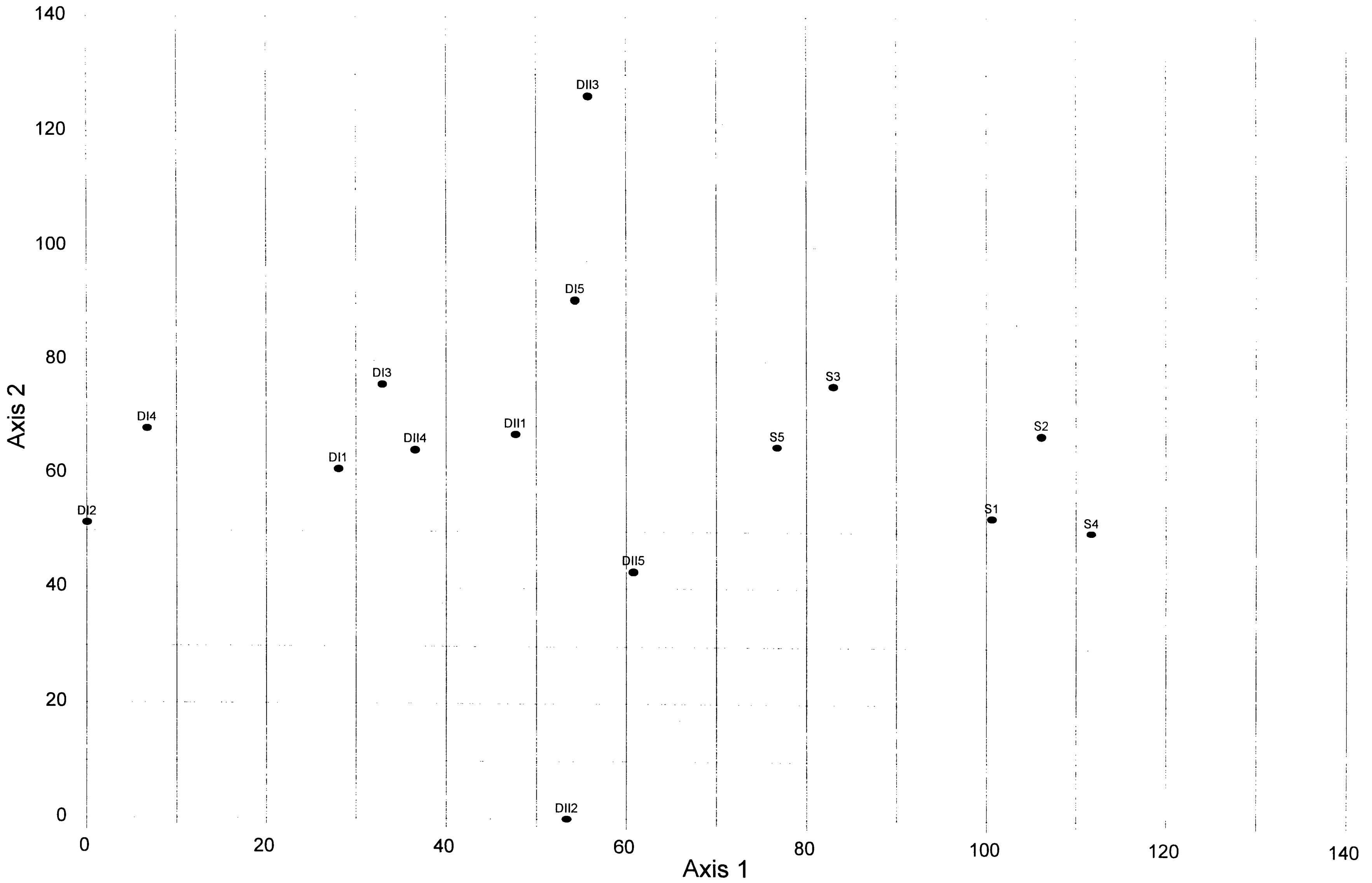


Fig 8: Samples on DCA ordination

RMQs for all plots in 1998

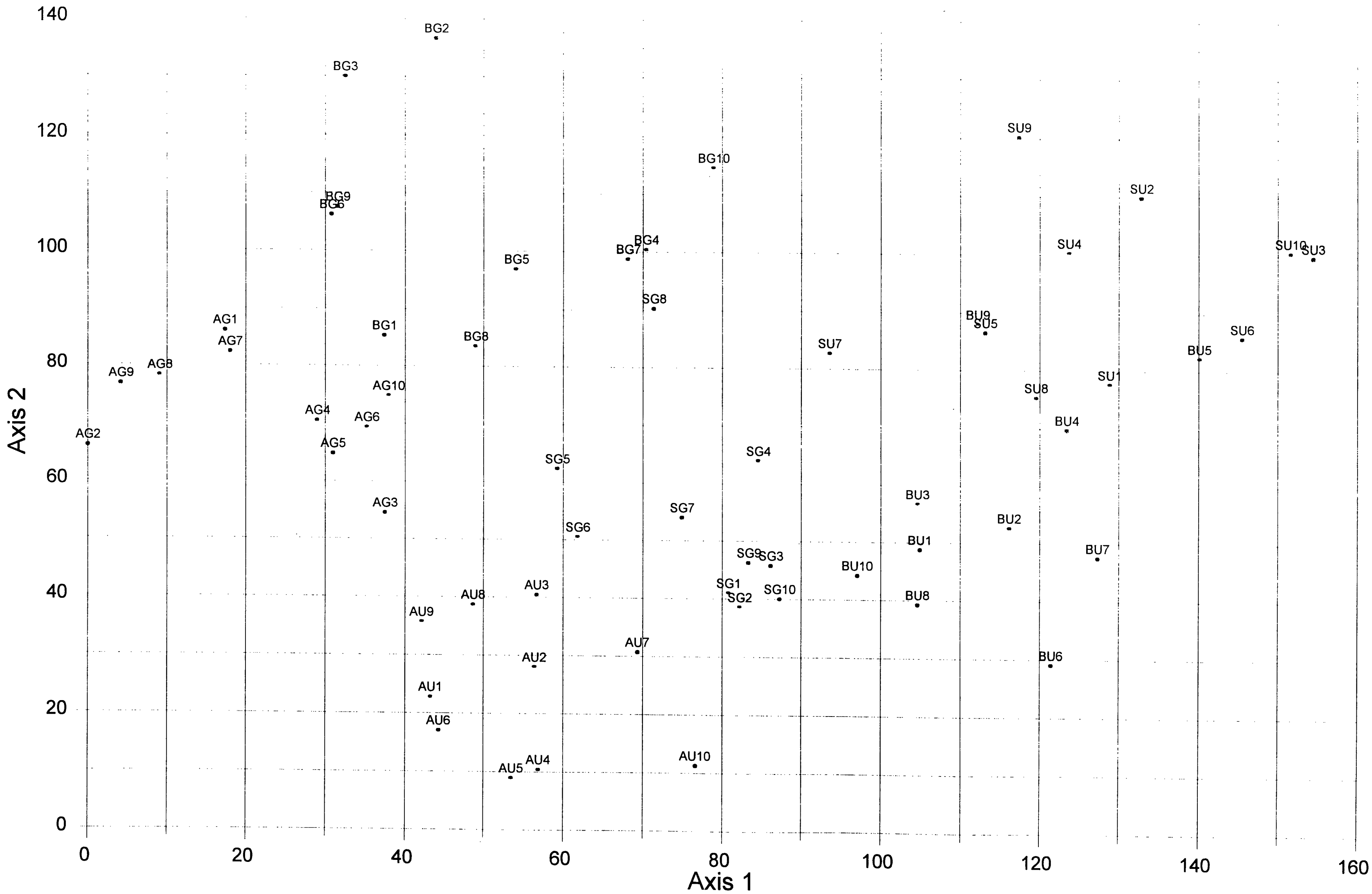
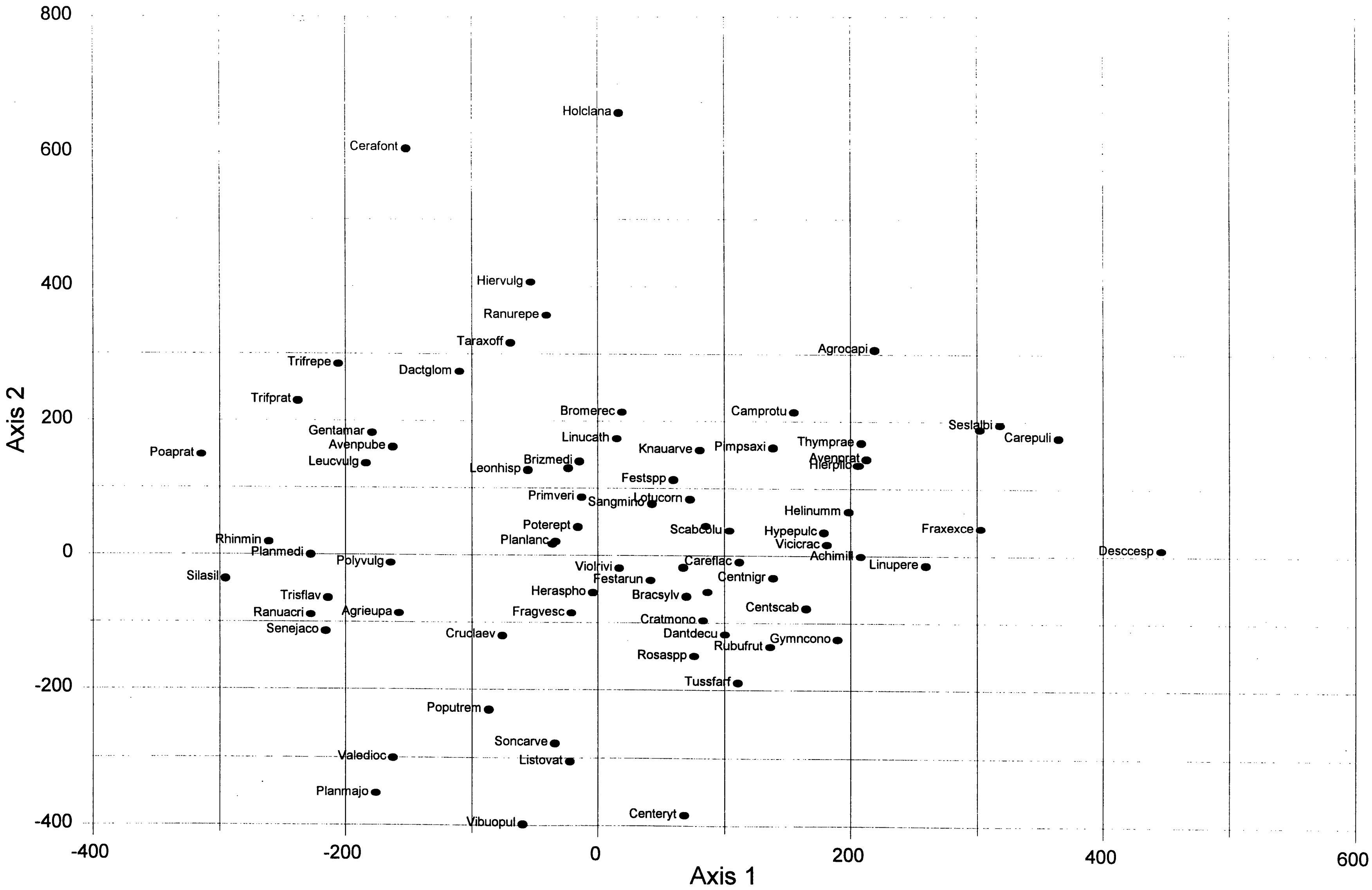


Fig 9: Species on DCA ordination

RMQs for SSSI and Donor plots in 1987

Fig 10: Species on DCA ordination

RMQs for all plots in 1998



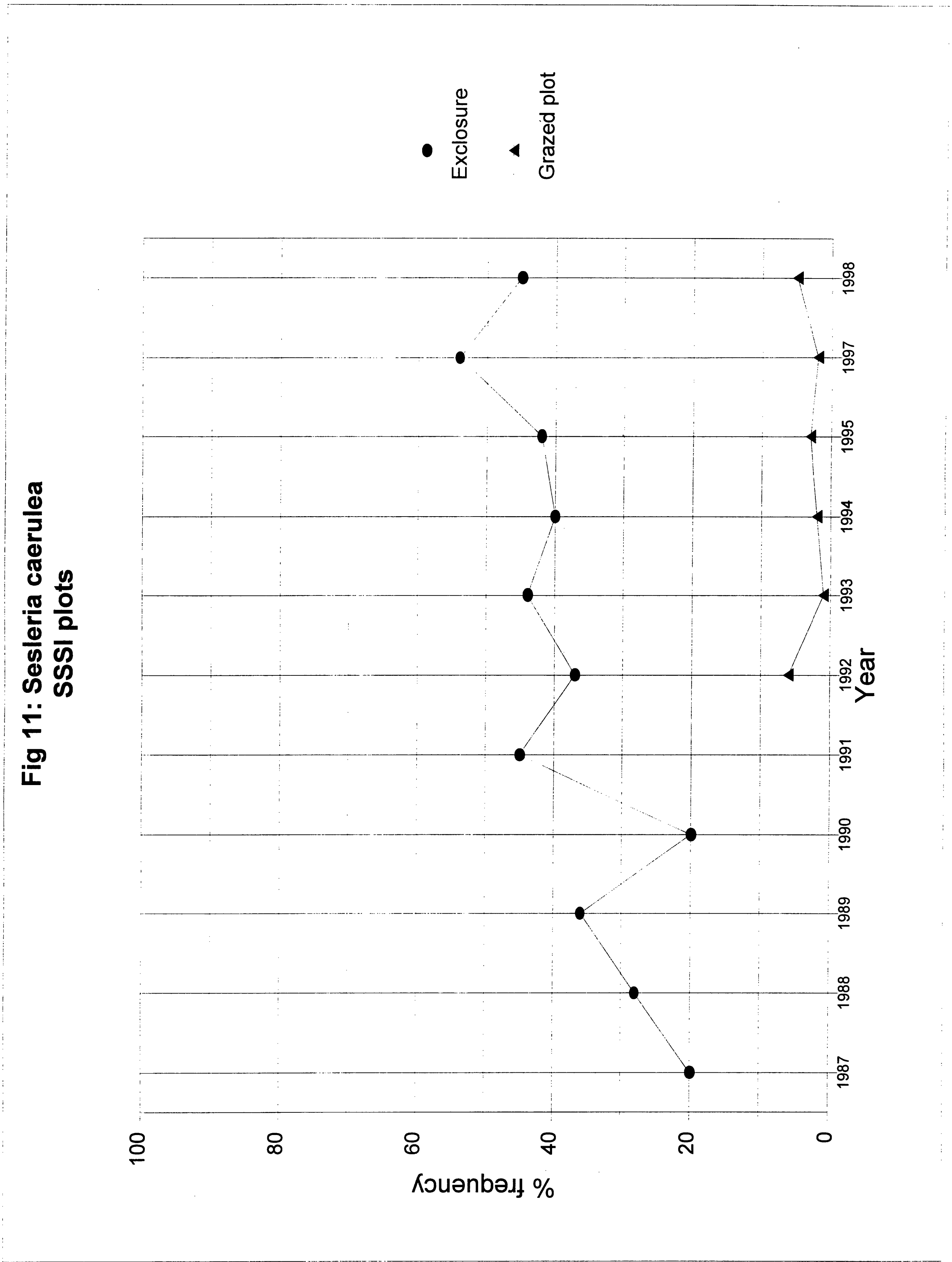


Fig 11: Sesleria caerulea
SSSI plots
% frequency
100
80
60
40
20
0
1987
1988
1989
1990
1991
1992
1993
1994
1995
1997
1998
Year
Exclosure
Grazed plot

Fig 12: Sesleria caerulea
Receptor A plots

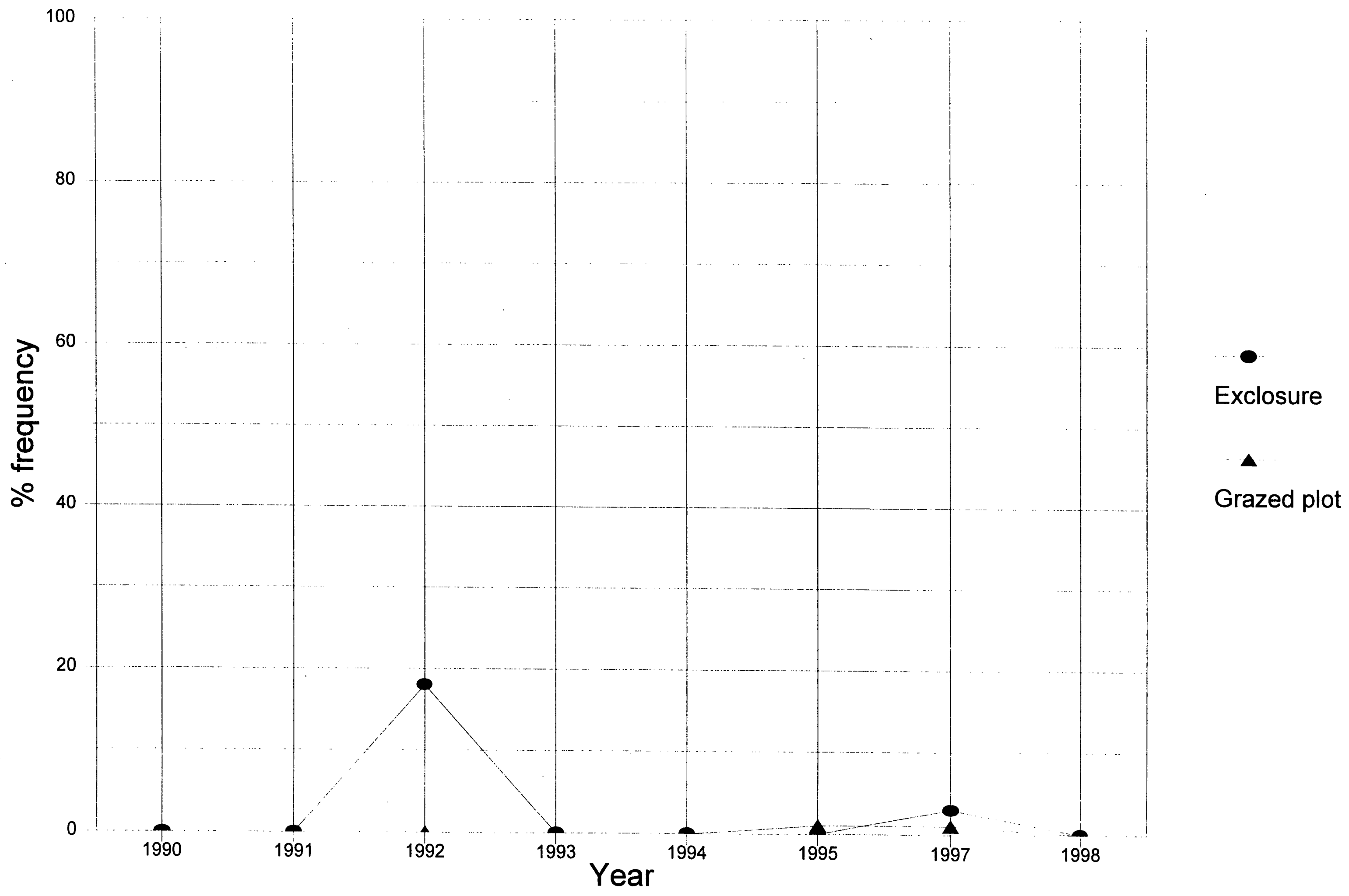


Fig 13: Sesleria caerulea
Receptor B plots

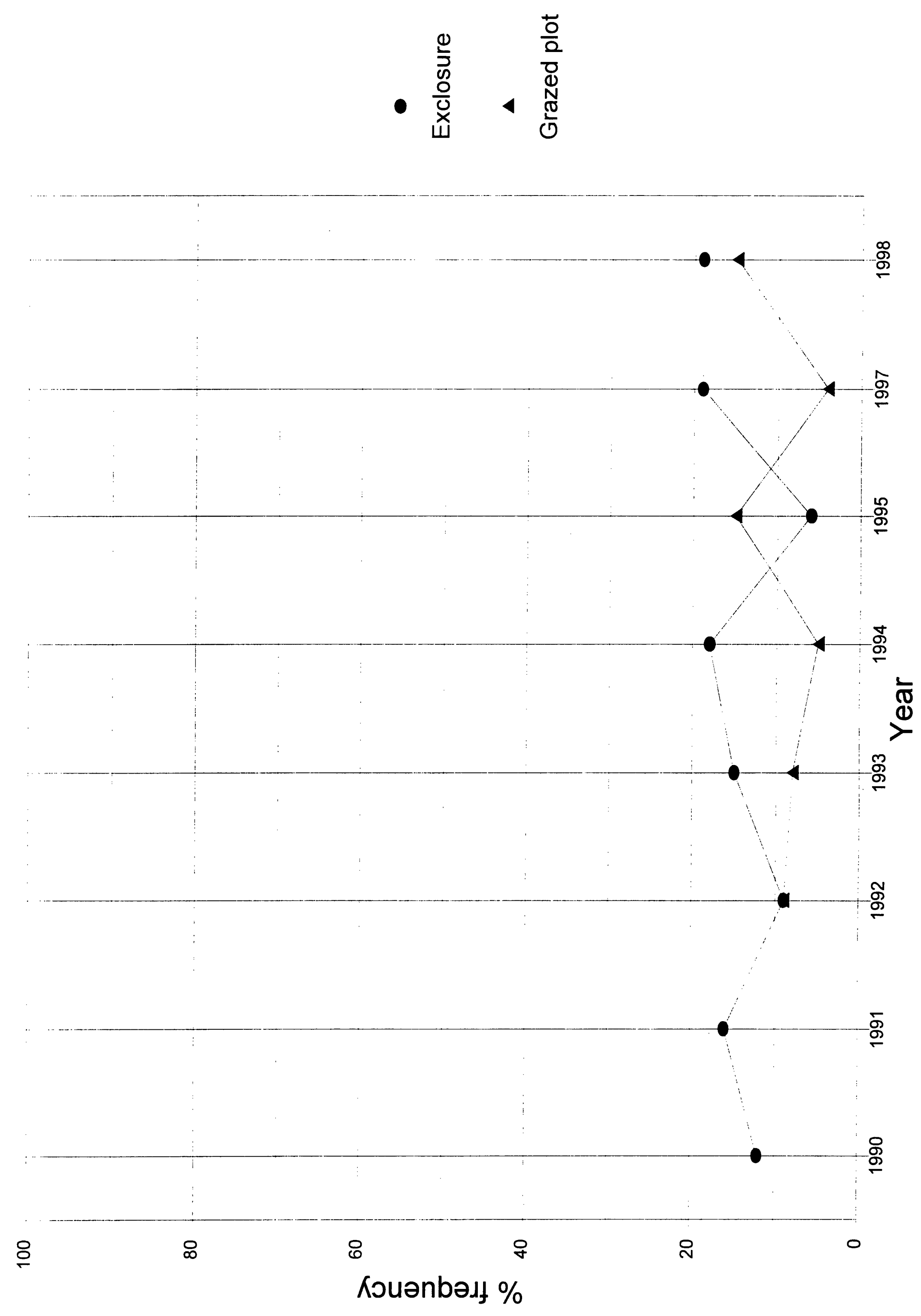


Fig 14: Bromopsis erecta SSSI plots

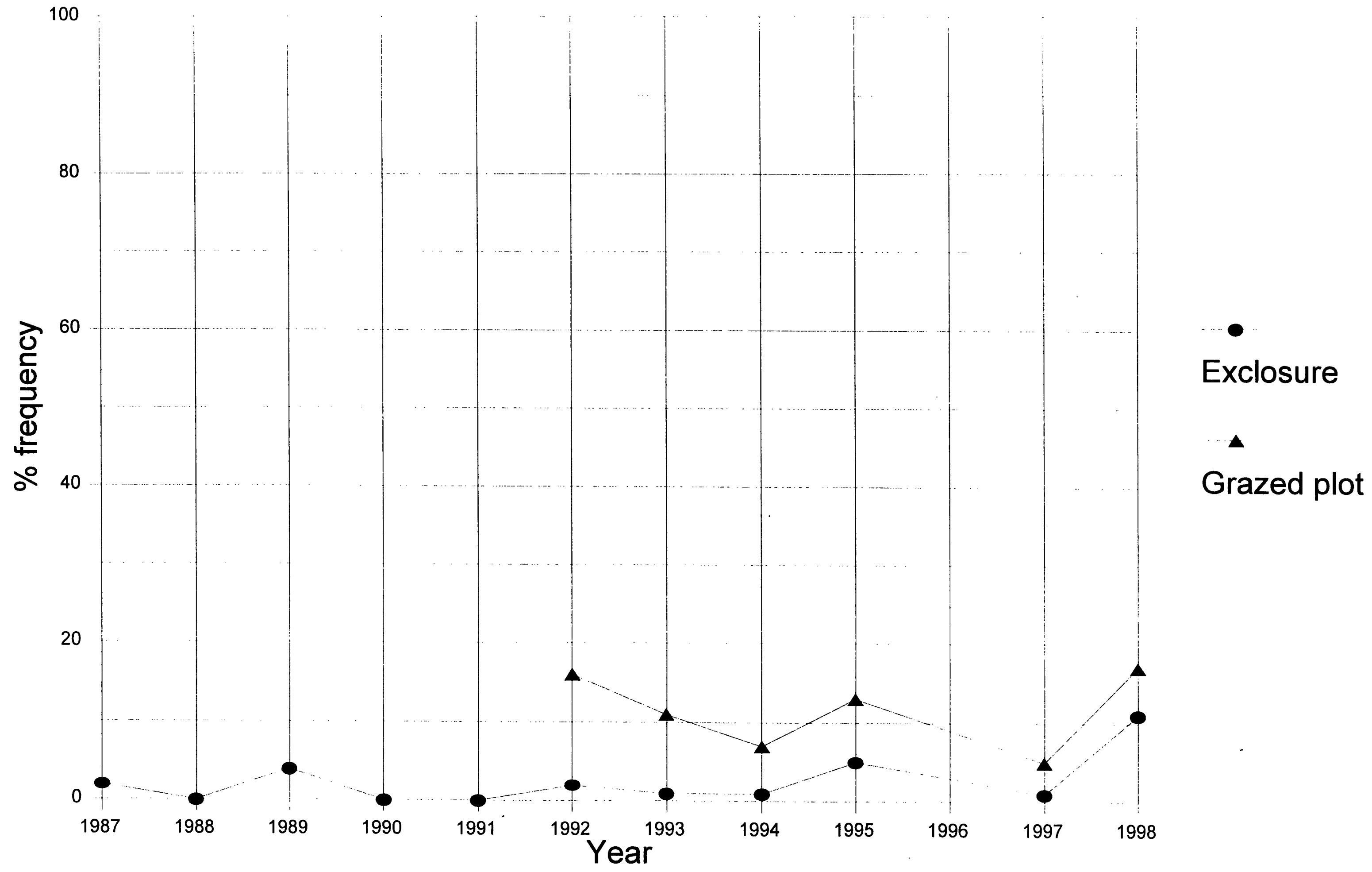


Fig 15: Bromopsis erecta
Receptor A plots

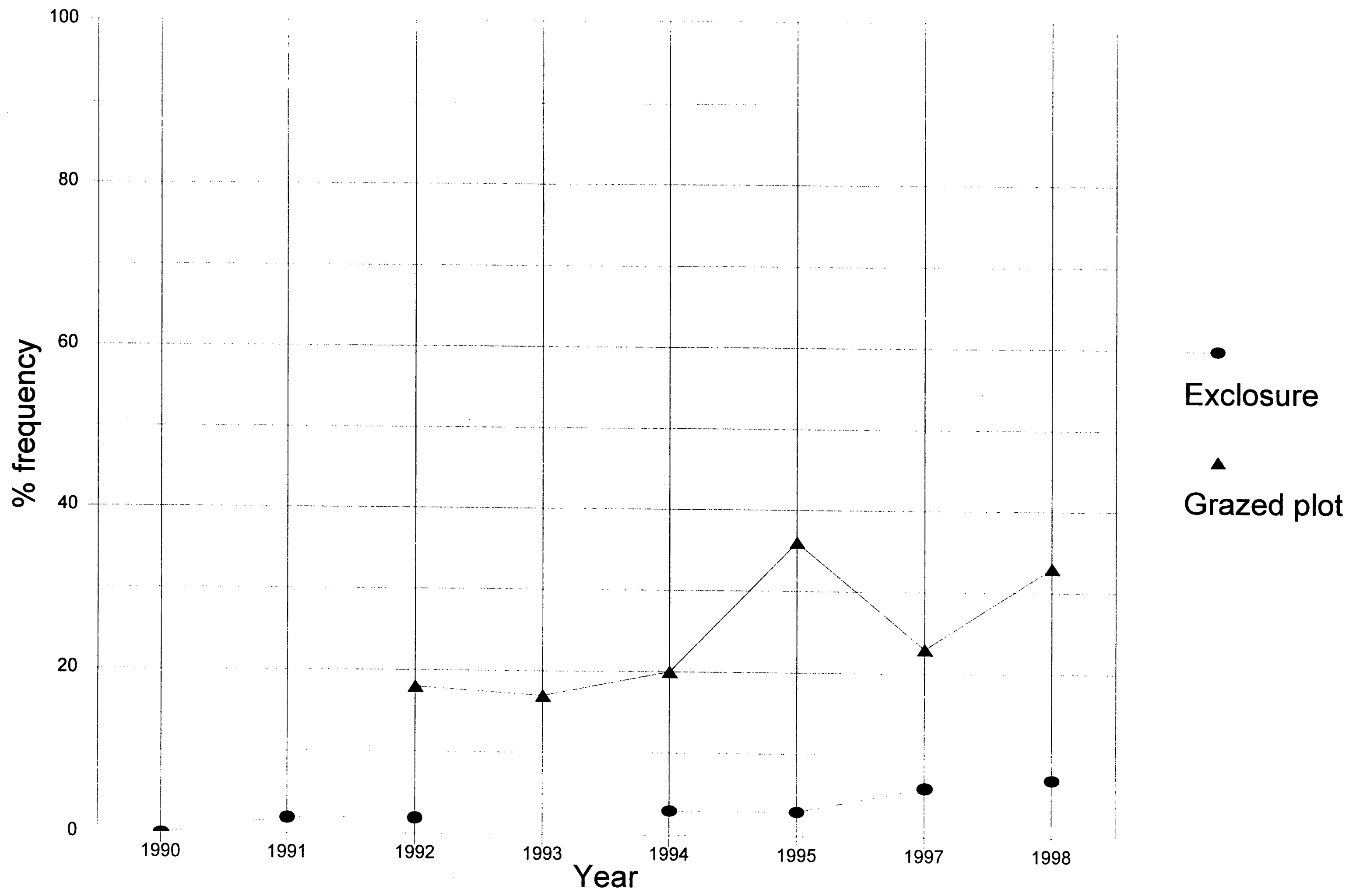
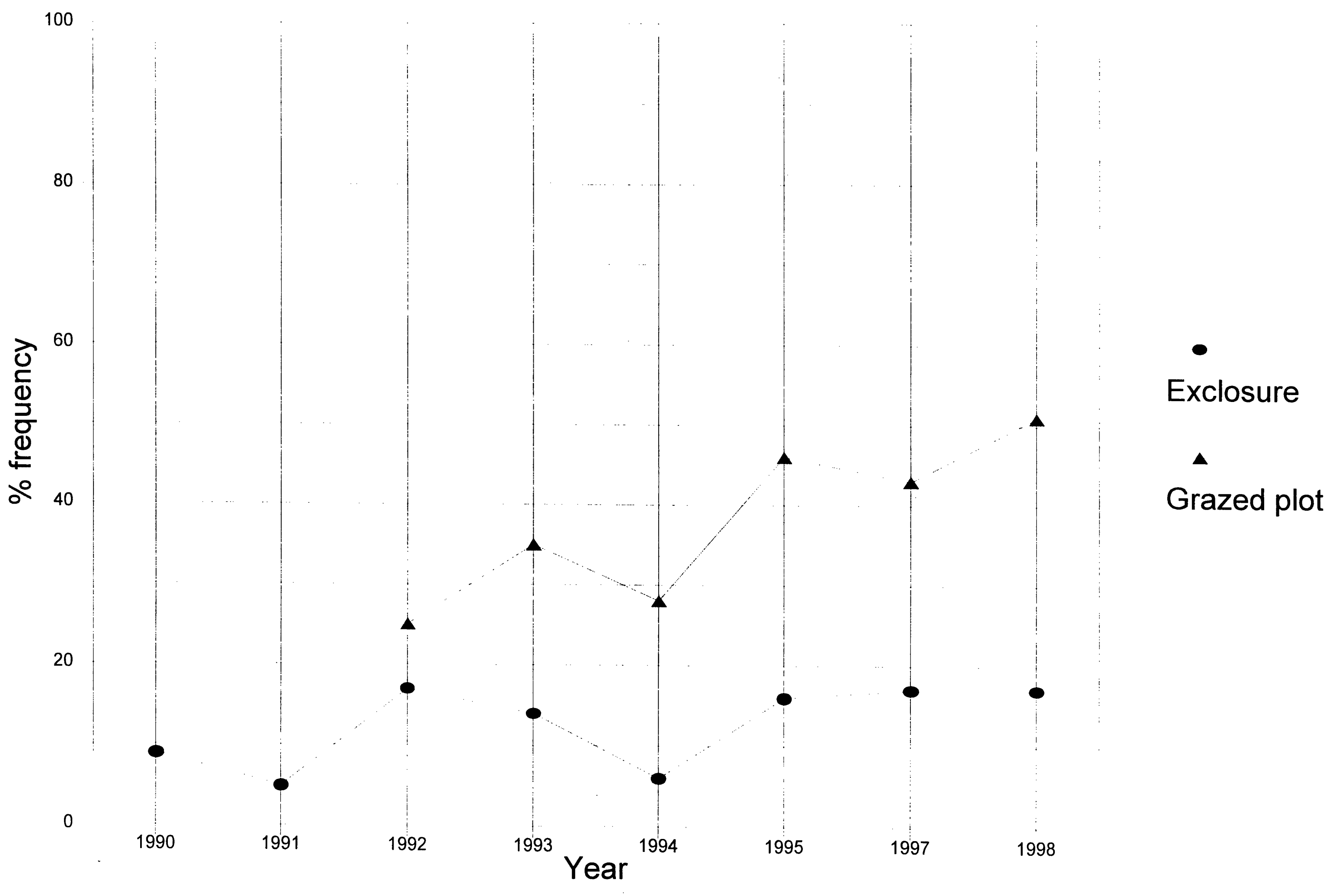


Fig 16: Bromopsis erecta
Receptor B plots



Tables

Table 1. Position of samples on DCA ordination, ranked by Axis 1 value

Sample ID	Location	NVC type	Axis 1	Axis 2
DS63/68	S	CG8	0	125
DS59/68	S	CG8	0	82
DS60/68	S	CG8	10	108
DS57/68	S	CG8	23	79
DS71/68	S	CG8	27	123
DS70/68	S	CG8	30	101
DS62/68	S	CG8	30	96
DS72/68	S	CG8	47	109
DS61/68	S	CG8	50	117
AES8/98	S	CG8	57	16
DP29/83	D	CG8	58	12
DS105/68	S	CG2	65	125
EFU2/87	S	CG8	67	0
EFU1/87	S	CG8	67	13
DP28/82	D	CG8	71	58
DP29/87	T	CG8	72	32
DP28/87	T	CG8	84	56
EFU4/87	S	CG8	85	37
AES13/98	S	CG8	85	42
DP24/87	T	CG8	86	51
GG228/80	S	CG8	86	91
AES11/98	S	CG8	87	30
DP25/83	D	CG8	89	71
DP6/87	T	CG8	90	82
DP24/82	D	CG8	92	48
DP6/82	D	CG8	93	65
DP25/87	T	CG8	96	57
AES21/98	S	CG3	97	34
GG258/80	D	CG8	99	107
DP21/82	D	CG8	100	47
DP21/87	T	CG8	101	57
DS19/68	S	CG8	103	208
EFU3/87	S	CG8	105	17
AES9/98	S	CG6	106	24
DP27/82	D	CG8	106	52
DP27/87	T	CG8	111	71
AES10/98	S	CG2	113	51
DS16/68	S	CG8	113	195
AES15/98	S	CG8	117	44
SH6/97	T	CG8	120	40

Sample ID	Location	NVC type	Axis 1	Axis 2
AES20/98	S	CG2	130	56
AES14/98	S	CG8	131	25
GG227/80	D	CG8(CG6)	135	131
DP5/87	T	CG6	138	52
DP5/82	D	CG6	139	59
AES7/98	S	CG6	140	54
AES4/98	T	CG3	143	35
SH2/97	T	CG3	146	71
DP2/82	D	CG6	147	70
SH3/97	T	CG3	148	57
DP7/82	D	CG6	151	72
SH1/97	T	CG3	151	57
DP10/82	D	CG6	153	78
DP7/87	T	CG3	156	82
AES19/98	S	CG2	159	36
DP10/87	T	CG6	159	86
SH4/97	T	CG3	161	54
AES6/98	S	CG3	165	43
DP2/87	T	CG6	167	99
DP11/82	D	CG6	168	72
GG229/80	S	CG6	170	126
AES3/98	T	CG3	182	76
AES16/98	S	CG6	183	53
AES17/98	S	CG2	183	77
SH5/97	T	CG3	186	85
DP11/87	T	CG6	187	85
AES1/98	T	CG2	193	74
GG259/80	D	CG6/W21	194	140
SH7/97	T	CG6	197	70
GG260/80	D	CG3/W21	205	117
DS72A/68	S	MG1	212	61
AES2/98	T	CG3	238	73
AES18/98	S	CG6	251	98
AES12/98	S	CG6	254	81
DP19T/87	T	MG1	277	112
DP18T/87	T	MG1	284	117
DP18T/83	T	MG1/W21	309	111
DP19T/83	T	MG1/W21	313	120
DP13T/87	T	MG1	378	144
DP13T/83	T	MG1/W21	404	119

Sample ID:
Surveyor/sample no/date
AES = Argus Ecological Services
DP = David Park
DS = David Shimwell
EFU = England Field Unit
GG = Gordon Graham
SH = Stuart Hedley

Location
D = donor area
S = retained SSSI
T = transplant

Table 2. Position of species on same DCA ordination as samples in Table 1

Species label	Species name	Axis 1	Axis 2
Achimill	*Achillea millefolium*	213	24
Agrieupa	*Agrimonia eupatoria*	237	136
Agrocapi	*Agrostis capillaris*	-86	278
Agrostol	*Agrostis stolonifera*	379	-24
Alchfili	*Alchemilla filicaulis*	354	72
Antedioi	*Antennaria dioica*	-156	99
Anthsylv	*Anthriscus sylvestris*	529	82
Anthvuln	*Anthyllis vulneraria*	-35	107
Aquivulg	*Aquilegia vulgaris*	127	404
Arenserp	*Arenaria serpyllifolia*	-54	268
Arrhelat	*Arrhenatherum elatius*	411	193
Avenprat	*Avenula (Helictotrichon) pratensis*	-31	239
Avenpube	*Avenula (Helicotrichon) pubescens*	194	232
Blacperf	*Blackstonia perfoliata*	-54	268
Bracsylv	*Brachypodium sylvaticum*	328	158
Brizmedi	*Briza media*	117	18
Bromerec	*Bromopsis erecta*	163	-5
Camprotu	*Campanula rotundifolia*	44	-66
Carecary	*Carex caryophyllea*	-87	239
Careflac	*Carex flacca*	125	78
Carenigr	*Carex nigra*	-14	213
Carepilu	*Carex pilulifera*	13	-105
Carepuli	*Carex pulicaris*	-100	143
Carlvulg	*Carlina vulgaris*	-116	190
Centnigr	*Centaurea nigra*	173	105
Centscab	*Centaurea scabiosa*	98	253
Cerafont	*Cerastium fontanum*	110	247
Cerasp	*Cerastium sp*	512	126
Cirsarve	*Cirsium arvense*	495	162
Coelviri	*Coeloglossum viride*	-132	-77
Cratmono	*Crataegus monogyna*	278	248
Crepcapi	*Crepis capillaris*	-54	268
Cruclaev	*Cruciata laevipes*	517	112
Cynocris	*Cynosurus cristatus*	168	257
Dactfuch	*Dactylorhiza fuchsii*	80	165
Dactglom	*Dactylis glomerata*	354	189
Dactmaja	*Dactylorhiza majalis*	19	209
Dantdecu	*Danthonia decumbens*	24	-102
Dauccaro	*Daucus carota*	82	394

Species label	Species name	Axis 1	Axis 2
Desccesp	*Deschampsia cespitosa*	23	206
Elymrepe	*Elymus (Elytrigia) repens*	354	72
Epipatro	*Epipactis atrorubens*	-83	195
Euphoffi	*Euphrasia officinalis* agg	-18	173
Festarun	*Festuca arundinacea*	295	-32
Festovin	*Festuca ovina*	43	-80
Festprat	*Festuca pratensis*	495	162
Festrubr	*Festuca rubra*	277	15
Festtenu	*Festuca tenuifolia*	199	276
Filivulg	*Filipendula vulgaris*	-54	268
Fragvesc	*Fragaria vesca*	402	112
Fraxexce	*Fraxinus excelsior*	237	-66
Galimoll	*Galium mollugo*	-54	268
Galiulig	*Galium uliginosum*	529	82
Galiveru	*Galium verum*	108	-34
Gentamar	*Gentianella amarella*	-25	224
Gerarobe	*Geranium robertianum*	529	82
Geumurba	*Geum urbanum*	529	82
Gymncono	*Gymnodenia conopsea*	8	101
Helinumm	*Helianthemum nummularium*	55	125
Heraspho	*Heracleum sphondylium*	423	224
Hier'ind	*Hieracium* sp ('indeterminate')	-132	-77
Hierpilo	*Hieracium pilosella (Pilosella officinarum)*	-75	260
Holclana	*Holcus lanatus*	424	187
Hypeperf	*Hypericum perforatum*	314	-109
Hypepulc	*Hypericum pulchrum*	27	211
Hyporadi	*Hypochaeris radicata*	103	281
Knauarve	*Knautia arvensis*	187	-22
Koelmacr	*Koeleria macrantha*	-110	253
Lathprat	*Lathyrus pratensis*	302	100
Leonhisp	*Leontodon hispidus*	112	-4
Leucvulg	*Leucanthemum vulgare*	256	-88
Linucath	*Linum catharticum*	71	-73
Linupere	*Linum perenne*	16	179
Listovat	*Listera ovata*	73	171
Lotucorn	*Lotus corniculatus*	71	20
Luzucamp	*Luzula campestris*	281	-68
Medilupu	*Medicago lupulina*	-144	203
Ononrepe	*Ononis repens*	23	206

Species label	Species name	Axis 1	Axis 2
Ononspin	*Ononis spinosa*	23	206
Orchmasc	*Orchis mascula*	314	-109
Phleprat	*Phleum pratense*	354	72
Pimpsaxi	*Pimpinella saxifraga*	147	-41
Planlanc	*Plantago lanceolata*	168	67
Planmedi	*Plantago media*	122	84
Poaprat	*Poa pratensis*	363	149
Poasubc	*Poa subcaerulea (humilis)*	281	-68
Poatriv	*Poa trivialis*	314	-109
Polyvulg	*Polygala vulgaris*	13	-62
Poterept	*Potentilla reptans*	294	71
Primfari	*Primula farinosa*	-178	-207
Primveri	*Primula veris*	147	103
Prunvulg	*Prunella vulgaris*	314	15
Ranuacri	*Ranunculus acris*	211	131
Ranubulb	*Ranunculus bulbosus*	-79	255
Ranurepe	*Ranunculus repens*	237	-118
Rhinmino	*Rhinanthus minor*	160	94
Rosaafze	*Rosa afzeliana (Rosa caesia subsp glauca)*	242	250
Rosapimp	*Rosa pimpinellifolia*	93	377
Rosaseed	*Rosa* sp (seedling)	379	67
Rubufrut	*Rubus fruticosus* agg	302	140
Rumeacet	*Rumex acetosa*	314	-109
Salicapr	*Salix caprea*	272	237
Sangmino	*Sanguisorba minor*	129	188

Species label	Species name	Axis 1	Axis 2
Sanieuro	*Sanicula europea*	497	247
Scabcolu	*Scabiosa columbaria*	-9	227
Seduacre	*Sedum acre*	-54	268
Senejaco	*Senecio jacobaea*	239	-74
Seslalbi	*Sesleria albicans (caerulea)*	-15	-50
Silasila	*Silaum silaus*	259	36
Silevulg	*Silene vulgaris*	517	112
Stacoffi	*Stachys officinalis*	-106	129
Stacsylv	*Stachys sylvatica*	478	131
Succprat	*Succisa pratensis*	191	-70
Taraseed	*Taraxacum* sp (seedling)	273	13
Thymprae	*Thymus praecox (polytrichus)*	-79	267
Tragprat	*Tragopogon pratensis*	235	193
Trifmedi	*Trifolium medium*	164	182
Trifprat	*Trifolium pratense*	123	-79
Trifrepe	*Trifolium repens*	-7	226
Trisflav	*Trisetum flavescens*	286	151
Tussfarf	*Tussilago farfara*	148	-2
Ulexeuro	*Ulex europaeus*	38	384
Veroarve	*Veronica arvensis*	529	82
Verocham	*Veronica chamaedrys*	431	37
Vicicrac	*Vicia cracca*	192	101
Violhirt	*Viola hirta*	184	247
Violrivi	*Viola riviniana*	178	39

Species names in brackets are from Stace (1997), if different to label

Table 3. Percent cover of species in David Park's CG8 quadrats

Species/Quadrat	6/1982	6/1987	21/1982	21/1987	24/1982	24/1987	25/1983	25/1987	27/1982	27/1987	28/1982	28/1987	29/1983	29/1987
Anthyllis vulneraria	0	0	0	0	3	12	12	P	10	2	15	3	0	0
Brachypodium sylvaticum	0	0	P	P	0	0	0	0	0	0	0	0	0	0
Briza media	0	0	28	18	7	12	28	22	13	7	3	8	0	0
Carex flacca	2	P	2	7	10	13	13	10	8	10	15	20	P	P
Carex pulicaris	0	0	0	0	0	0	P	2	0	0	0	0	0	0
Centaurea nigra	5	3	2	5	2	2	P	P	P	5	3	10	0	0
Crataegus monogyna	0	0	0	0	0	0	0	0	0	0	0	P	0	0
Dactylis glomerata	P	P	0	0	0	0	P	P	2	P	0	0	0	0
Dactylorhiza fuchsii	0	0	0	0	0	0	P	P	0	0	0	0	0	2
Dactylorhiza purpurella	0	0	0	0	P	P	0	0	0	0	0	0	0	0
Festuca ovina	0	0	3	P	0	0	P	2	0	0	2	8	5	2
Festuca rubra	0	0	P	0	5	2	2	3	5	2	0	0	0	0
Gentianella amarella	0	0	0	0	P	0	0	0	0	0	0	0	0	0
Gymnadenia conopsea	0	0	0	0	0	P	0	P	0	P	0	0	0	0
Helianthemum nummularium	10	12	12	20	7	2	10	12	15	18	15	8	10	8
Helictotrichon pubescens	P	2	2	2	0	0	3	2	0	7	2	P	0	0
Leontodon hispidus	2	P	2	2	2	3	2	8	5	5	P	P	0	0
Linum catharticum	0	0	P	P	P	P	P	P	0	0	P	0	P	0
Listera ovata	0	0	0	0	0	P	P	P	0	P	0	P	0	0
Lotus corniculatus	3	P	5	5	5	3	P	2	5	2	5	10	7	5
Pimpinella saxifraga	0	0	0	0	P	P	P	2	0	0	0	0	0	2
Plantago lanceolata	2	P	P	P	2	P	P	3	P	3	P	2	0	0
Plantago media	0	0	2	2	P	P	P	2	5	P	P	P	0	0
Polygala vulgaris	0	0	P	P	P	P	P	P	0	0	P	P	0	0
Primula veris	0	0	P	P	P	P	P	P	P	P	P	P	0	0
Ranunculus acris	0	0	P	P	0	0	0	0	P	P	P	P	0	0
Rhinanthus minor	0	0	2	P	0	P	P	P	0	0	0	0	0	0

Species/Quadrat	6/1982	6/1987	21/1982	21/1987	24/1982	24/1987	25/1983	25/1987	27/1982	27/1987	28/1982	28/1987	29/1983	29/1987
Rubus fruticosus	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Sanguisorba minor	5	12	P	P	8	3	3	2	P	2	P	P	0	0
Sesleria caerulea	72	70	42	40	48	45	27	28	32	40	40	30	77	80
Trifolium pratense	0	0	0	0	2	P	0	0	P	P	0	0	0	0
Trifolium repens	0	0	0	0	0	0	P	P	0	0	P	P	0	0
Vicia cracca	0	0	0	0	0	2	0	0	0	P	0	0	0	P
Viola hirta	0	0	P	P	0	0	0	0	0	0	0	0	P	P

P = present but no cover value

Table 4. Percent cover of species in David Park's CG6 quadrats

Species/Quadrat	2/1982	2/1987	5/1982	5/1987	7/1982	7/1987	10/1982	10/1987	11/1982	11/1987
Agrimonia eupatoria	0	P	0	0	2	P	0	0	P	P
Brachypodium sylvaticum	3	8	2	2	0	P	3	7	P	3
Briza media	12	7	17	13	10	2	10	15	17	12
Bromopsis erecta	0	0	0	0	5	30	0	0	0	0
Carex flacca	8	5	10	13	5	2	15	23	5	2
Centaurea nigra	7	5	5	3	8	2	2	2	7	10
Centaurea scabiosa	0	0	0	0	P	0	0	0	0	0
Crataegus monogyna	0	0	0	0	0	0	P	P	0	P
Dactylis glomerata	2	3	0	0	P	P	P	P	3	6
Festuca ovina	P	P	P	P	P	P	2	P	P	P
Festuca rubra	7	5	12	12	13	5	2	5	17	10
Fragaria vesca	0	P	0	0	0	0	0	0	0	0
Galium verum	0	0	3	2	0	0	0	0	2	2
Gymnadenia conopsea	0	0	P	P	0	0	0	0	0	0
Helianthemum nummularium	45	38	27	23	25	15	32	32	0	0
Helictotrichon pubescens	0	12	3	3	3	7	7	3	17	18
Knautia arvensis	0	0	0	0	0	0	3	2	0	0
Lathyrus pratensis	0	0	0	0	0	0	0	0	0	2
Leontodon hispidus	2	5	5	8	P	P	3	2	5	3
Linum catharticum	P	0	P	P	P	0	P	0	P	0
Listera ovata	0	0	0	0	0	0	0	P	0	0
Lotus corniculatus	5	2	8	8	12	8	7	3	12	3
Pimpinella saxifraga	P	2	2	P	2	P	2	P	P	P
Plantago lanceolata	5	P	2	3	2	2	3	P	7	7
Plantago media	P	P	2	3	5	15	0	0	5	10
Polygala vulgaris	P	0	P	2	0	0	0	0	0	0
Primula veris	P	P	0	0	P	2	2	2	P	P

Species/Quadrat	2/1982	2/1987	5/1982	5/1987	7/1982	7/1987	10/1982	10/1987	11/1982	11/1987
Prunella vulgaris	0	0	P	P	0	0	0	0	0	0
Ranunculus acris	0	P	0	0	P	P	0	0	0	0
Rhinanathus minor	P	0	P	P	0	0	5	P	P	3
Sanguisorba minor	3	8	3	P	7	8	2	2	P	P
Silaum silaus	0	0	0	0	P	0	0	0	0	0
Trifolium pratense	2	P	P	2	2	P	0	0	2	2
Trisetum flavescens	0	P	0	0	P	P	0	0	3	2
Vicia cracca	0	P	0	0	P	3	0	0	0	2
Viola hirta	P	0	0	0	0	0	2	0	P	0

P = present but no cover value

Table 5. Percent cover of species in David Park's MG1 quadrats

Species/Quadrat	13T/1983	13T/1987	18T/1983	18T/1987	19T/1983	19T/1987
Agrostis stolonifera	13	2	3	0	3	0
Anthriscus sylvestris	P	0	0	0	0	0
Arrhenatherum elatius	0	18	7	42	0	8
Brachypodium sylvaticum	10	8	15	7	30	8
Carex flacca	0	0	0	P	P	13
Centaurea nigra	0	0	2	15	P	8
Cerastium sp	P	P	0	0	0	0
Cirsium arvense	0	P	0	0	0	0
Crataegus monogyna	0	0	P	P	17	2
Cruciata laevipes	2	P	0	0	0	0
Dactylis glomerata	23	22	7	12	3	10
Festuca arundinacea	0	0	2	P	0	0
Festuca pratensis	0	7	0	0	0	0
Festuca rubra	2	8	8	12	13	32
Fragaria vesca	12	0	42	5	3	12
Galium uliginosum	P	0	0	0	0	0
Geranium robertianum	2	0	0	0	0	0
Geum urbanum	P	0	0	0	0	0
Helicotrichon pubescens	0	P	0	P	0	P
Heracleum sphondylium	3	22	0	P	0	0
Holcus lanatus	2	2	10	0	7	P
Lathyrus pratensis	0	P	0	0	0	0
Leontodon hispidus	0	0	2	3	0	3
Linum catharticum	0	0	0	0	P	0
Lotus corniculatus	0	0	0	P	0	0
Pimpinella saxifraga	0	0	P	P	0	P
Plantago lanceolata	0	P	P	2	0	0
Plantago media	0	0	P	2	0	0
Poa pratensis	0	P	0	P	0	P
Potentilla reptans	0	0	0	0	0	2
Primula veris	0	0	2	P	0	P
Prunella vulgaris	5	0	0	P	8	0
Ranunculus acris	0	0	0	0	0	P
Rosa sp	0	P	0	P	2	2
Rubus fruticosus agg	0	P	P	0	12	0
Sanguisorba minor	2	P	2	P	P	0
Sanicula europea	12	3	0	0	0	0
Silene vulgaris	2	P	0	0	0	0
Stachys sylvatica	10	8	P	2	P	0
Succisa pratensis	0	P	0	0	0	0
Taraxacum officinale	P	P	P	0	0	0
Trisetum flavescens	0	P	0	P	0	0
Veronica arvensis	P	0	0	0	0	0
Veronica chamaedrys	2	P	0	0	0	0
Vicia cracca	0	P	0	0	0	0
Viola hirta	P	P	P	P	2	P

P = present but no cover value

Table 6. Summary of changes in species composition and cover over time in David Park's quadrats

Quadrat number	NVC type	Species present in 1987 vs 1982/3 (gained)	Species not present in 1987 vs 1982/3 (lost)	Total percent change in cover, all species 1982/3-1987
6	CG8	0	0	24
21	CG8	0	1	33
24	CG8	4	1	42
25	CG8	1	0	46
27	CG8	4	0	57
28	CG8	2	1	61
29	CG8	3	1	14
	Average	*2.0*	*0.6*	*39.6*
2	CG6	6	4	57
5	CG6	0	0	28
7	CG6	1	3	90
10	CG6	1	1	44
11	CG6	3	2	49
	Average	*2.2*	*2.0*	*53.6*
13T	MG1/W21	12	7	102
18T	MG1/W21	8	4	128
19T	MG1/W21	8	6	138
	Average	*9.3*	*5.7*	*122.7*

Table 7. Percent proportions of functional strategies in David Park's quadrats

Sample ID	NVC type	C	S	R	SC	CR	SR	CSR
DP21/82	CG8	0.0	54.3	2.2	16.3	0.0	4.3	22.8
DP21/87	CG8	0.0	53.3	1.1	16.7	0.0	3.3	25.6
DP24/82	CG8	0.0	48.0	0.0	14.3	0.0	8.2	29.6
DP24/87	CG8	2.0	49.0	1.0	14.0	0.0	10.0	24.0
DP25/83	CG8	1.0	56.9	1.0	11.8	1.0	8.8	19.6
DP25/87	CG8	0.9	53.6	0.9	10.9	0.9	6.4	26.4
DP27/82	CG8	2.1	49.0	0.0	12.5	0.0	4.2	32.3
DP27/87	CG8	2.0	45.1	0.0	13.7	0.0	2.9	36.3
DP28/82	CG8	0.0	53.3	0.0	15.6	1.1	7.8	22.2
DP28/87	CG8	0.0	54.3	0.0	15.2	1.1	3.3	26.1
DP29/83	CG8	0.0	46.2	0.0	42.3	0.0	3.8	7.7
DP29/87	CG8	1.8	42.9	0.0	39.3	0.0	3.6	12.5
DP6/82	CG8	1.6	41.9	0.0	25.8	0.0	0.0	30.6
DP6/87	CG8	1.8	46.4	0.0	28.6	0.0	0.0	23.2
DP10/82	CG6	1.8	50.9	3.6	4.5	0.0	7.3	31.8
DP10/87	CG6	1.1	57.4	1.1	6.4	0.0	2.1	31.9
DP11/82	CG6	2.5	38.1	0.8	2.5	0.0	3.4	52.5
DP11/87	CG6	5.0	31.7	2.5	5.8	0.0	3.3	51.7
DP2/82	CG6	1.9	53.8	1.0	2.9	0.0	3.8	36.5
DP2/87	CG6	3.1	57.0	0.0	3.1	0.0	1.6	35.2
DP5/82	CG6	0.0	51.8	0.9	4.5	0.0	5.4	37.5
DP5/87	CG6	0.0	50.9	0.9	3.6	0.0	4.5	40.0
DP7/82	CG6	1.7	45.0	0.0	3.3	0.0	3.3	46.7
DP7/87	CG3	3.7	42.6	0.0	6.5	0.0	0.9	46.3
DP13T/83	MG1/W21	8.2	20.0	2.7	3.6	20.0	1.8	43.6
DP13T/87	MG1	15.7	15.7	0.9	7.4	16.7	0.0	43.5
DP18T/83	MG1/W21	9.2	17.3	1.0	9.2	7.1	1.0	55.1
DP18T/87	MG1	13.2	17.9	0.0	7.5	3.8	0.9	56.6
DP19T/83	MG1/W21	4.3	14.9	0.0	31.9	7.4	2.1	39.4
DP19T/87	MG1	8.3	22.9	0.0	12.5	2.1	1.0	53.1
Averages								
Year	NVC type	C	S	R	SC	CR	SR	CSR
1982/3	CG8	0.7	49.9	0.5	19.8	0.3	5.3	23.6
1987	CG8	1.2	49.2	0.4	19.8	0.3	4.2	24.9
1982	CG6	1.6	47.9	1.3	3.6	0.0	4.6	41.0
1987	CG6 (3)	2.6	47.9	0.9	5.1	0.0	2.5	41.0
1983	MG1/W21	7.2	17.4	1.2	14.9	11.5	1.7	46.0
1987	MG1	12.4	18.9	0.3	9.2	7.5	0.7	51.1

Table 8. Constancy data for CG8 quadrats in the undisturbed SSSI arranged in NVC table order

Constant species

Species/Data set	DS 1960s, n = 11	EC 1992, plot 119, n = 36	EC 1992, plot 120, n = 36	EC 1992, plot 121, n = 36	AES 1998, n = 5
Sesleria caerulea	V	V	V	V	V
Carex flacca	V	IV	V	V	V
Linum catharticum	IV	IV	II	III	V
Sanguisorba minor	V	V	V	V	III
Scabiosa columbaria	V	II	III	I	I
Thymus polytrichus	V	V	V	II	I
Helianthemum nummularium	V	III	II	-	III
Plantago lanceolata	IV	II	I	III	IV
Helictotrichon pratense	V	II	III	II	II
Lotus corniculatus	V	V	V	V	V
Galium verum	III	-	-	I	III
Koeleria macrantha	III	-	-	-	-
Festuca ovina	IV	V	V	III	IV

Preferentials for sub-communities CG8a and b

Centaurea nigra	II	III	III	II	V
Briza media	III	IV	II	IV	V
Pimpinella saxifraga	IV	I	I	II	IV
Stachys officinalis	IV	II	-	-	I
Taraxacum officinale agg	III	I	I	III	I
Agrostis capillaris	II	-	-	-	-
Cynosurus cristatus	I	-	-	-	-
Linum perenne anglicum	I	-	-	-	-
Viola riviniana	II	-	-	-	I

Preferentials for sub-community CG8a

Hypericum pulchrum	III	II	II	IV	IV
Carlina vulgaris	III	I	I	-	-
Polygala vulgaris	II	I	-	I	I
Epipactis atrorubens	II	I	-	-	-
Succisa pratensis	II	IV	IV	I	I
Trisetum flavescens	-	-	-	-	-
Achillea millefolium	-	-	-	I	II
Carex pulicaris	III	II	V	II	-
Danthonia decumbens	-	III	II	II	III
Bellis perennis	-	-	-	-	-
Trifolium medium	-	-	-	-	II
Vicia cracca	-	I	I	II	I
Knautia arvensis	-	-	-	-	I

Preferentials for sub-community CG8b

Helictotrichon pubescens	I	-	-	-	-
Daucus carota	I	-	-	-	-
Dactylis glomerata	I	I	-	-	-
Trifolium repens	II	-	-	-	-
Senecio jacobaea	-	-	-	-	-
Ulex europaeus	I	-	-	-	-
Bromopsis erecta	-	I	-	I	III
Arrhenatherum elatius	I	-	-	-	-
Rhinanthus minor	II	-	-	-	-
Lathyrus pratensis	-	-	-	-	-
Cirsium vulgare	-	-	-	-	-

Preferentials for sub-community CG8c

Pilosella officinarum	III	I	I	I	-
Hypochaeris radicata	-	-	-	-	-
Hypericum montanum	-	-	-	-	-
Prunella vulgaris	II	I	I	I	III
Medicago lupulina	I	-	-	-	-
Plantago maritima	-	-	-	-	-
Listera ovata	I	-	I	I	-
Hieracium sect. vulgata	-	I	I	I	-
Coeloglossum viride	I	-	-	-	-
Leontodon autumnalis	-	-	-	-	-

Associate species

Campanula rotundifolia	IV	IV	III	IV	IV
Primula veris	III	I	I	II	-
Leontodon hispidus	IV	III	V	V	III
Carex caryophyllea	III	I	-	-	-
Viola hirta	IV	II	I	I	III
Anthyllis vulneraria	IV	V	III	I	II
Centaurea scabiosa	III	III	-	I	I
Plantago media	II	I	II	II	-
Gentianella amarella	IV	-	-	I	-
Gymnadenia conopsea	II	-	I	-	-
Euphrasia officinalis agg.	II	II	-	-	-
Brachypodium sylvaticum	II	I	I	III	III
Trifolium pratense	-	I	-	III	II
Cerastium fontanum	-	-	-	-	-
Festuca rubra	I	I	I	II	III

Table 9. Percent proportions of functional strategies in the 1960s and 1992

Date/Strategy	C	S	R	SC	CR	SR	CSR
David Shimwell, 1960s, n = 11	0.6	55.7	1.7	8.0	1.1	14.9	18.2
Elizabeth Cooper, Plot 119, 1992, n = 1	2.1	50.0	1.1	7.5	4.3	9.6	25.5

Note: Unweighted analysis

Table 10. Average percent proportions of functional strategies for CG8 quadrats

Data set	Date	Number of quadrats	C	S	R	SC	CR	SR	CSR
David Shimwell	1960s	11	0.3	62.4	0.9	12.0	0.6	9.1	14.8
Gordon Graham	1980	2	1.7	53.0	0	18.2	1.7	3.4	22.0
David Park	1982/3	7	0.7	49.9	0.5	19.8	0.3	5.3	23.6
David Park	1987	7	1.2	49.2	0.4	19.8	0.3	4.2	24.9
EFU	1987	4	1.0	54.3	0	19.2	2.1	6.1	17.3
Stuart Hedley	1997	1	0.6	48.3	0	16.3	2.3	7.0	25.6
Argus Ecological Services	1998	5	0.6	48.5	0.2	21.5	0.4	6.7	22.0

Table 11. Average percent proportions of functional strategies for 1997-98 quadrats

NVC type	Date	Number of quadrats	C	S	R	SC	CR	SR	CSR
CG2	1998	5	1.9	58.5	1.2	4.9	6.0	6.2	21.3
CG3	1997	5	1.0	40.9	2.2	9.4	3.1	5.4	37.9
CG3	1998	5	1.3	40.0	2.4	9.3	3.9	4.9	38.2
CG6	1997	1	1.2	27.0	3.5	6.9	6.3	10.3	44.8
CG6	1998	5	2.5	41.8	0.5	10.4	5.8	2.3	36.7
CG8	1997	1	0.6	48.3	0	16.3	2.3	7.0	25.6
CG8	1998	5	0.6	48.5	0.2	21.5	0.4	6.7	22.0

Table 12. Average percent proportions of functional strategies in the transplant and the retained SSSI in 1997-98

NVC type	Transplant/SSSI	Number of quadrats	C	S	R	SC	CR	SR	CSR
CG2	SSSI	4	2.0	61.1	0.8	5.3	6.4	7.3	17.2
CG2	Transplant	1	1.8	48.3	2.6	3.5	4.4	1.8	37.7
CG3	SSSI	2	1.0	48.9	0.7	10.7	1.4	6.8	32.7
CG3	Transplant	8	1.2	38.9	2.7	9.0	4.1	4.8	39.4
CG6	SSSI	5	2.5	41.8	0.5	10.4	5.8	2.3	36.7
CG6	Transplant	1	1.2	27.0	3.5	6.9	6.3	10.3	44.8
CG8	SSSI	5	0.6	48.5	0.2	21.5	0.4	6.7	22.0
CG8	Transplant	1	0.6	48.3	0	16.3	2.3	7.0	25.6

Table 13. Frequency of selected species in the SSSI exclosure plot

Species/Year	1987S	1988S	1989S	1990S	1991S	1992S	1993R	1994R	1995R	1997R	1998R	1998S
Brachypodium sylvaticum	20	14	8	8	10	21	22	13	14	11	11	12
Briza media	40	48	53	24	54	43	35	42	29	24	23	26
Bromopsis erecta	2	0	4	0	0	2	1	1	5	1	10	11
Campanula rotundifolia	30	30	16	8	32	20	16	9	17	14	14	14
Carex flacca	92	94	89	40	72	87	76	73	80	68	58	59
Carex pulicaris	0	18	9	0	6	22	15	19	31	9	18	19
Centaurea nigra	32	42	32	16	29	30	18	17	11	15	17	23
Centaurea scabiosa	10	12	7	0	6	14	3	5	4	7	2	7
Crataegus monogyna	8	4	3	2	4	3	4	1	7	4	2	5
Dactylis glomerata	8	2	3	3	1	1	2	3	1	0	0	1
Festuca ovina	58	34	83	43	68	42	24	0	53	0	0	0
Festuca ovina/rubra	0	0	0	0	0	51	53	54	0	37	44	44
Festuca rubra	28	42	5	7	10	1	1	0	6	0	0	0
Fragaria vesca	12	0	0	2	1	2	2	3	4	1	3	3
Helianthemum nummularium	54	70	65	37	79	82	34	45	61	65	39	62
Knautia arvensis	0	6	7	2	2	6	3	3	1	2	3	3
Leontodon hispidus	12	14	9	7	12	22	11	17	11	11	11	13
Linum catharticum	24	30	9	10	11	13	13	14	5	1	12	13
Lotus corniculatus	48	58	56	31	62	50	37	39	36	27	24	29
Pimpinella saxifraga	66	76	62	37	61	40	58	29	42	37	35	38
Plantago lanceolata	30	24	7	11	11	16	10	9	8	6	9	10
Plantago media	0	0	2	3	4	3	2	2	3	1	0	0
Primula veris	0	0	0	1	2	1	1	1	2	0	2	3
Prunella vulgaris	14	4	1	1	5	4	9	1	4	0	3	3
Rosa sp.	2	0	0	0	2	1	0	0	0	0	0	1
Rubus fruticosus agg	2	8	6	2	1	4	3	5	3	4	2	4
Sanguisorba minor	14	18	22	9	35	28	14	23	17	15	19	23
Scabiosa columbaria	20	18	20	10	21	20	9	14	19	7	9	11
Sesleria caerulea	20	28	36	20	45	37	44	40	42	54	43	45
Silaum silaus	0	0	0	0	0	0	0	0	0	0	0	0
Sonchus arvensis	0	0	0	0	0	0	0	0	0	0	0	0
Trifolium medium	10	14	24	11	19	15	11	11	4	4	7	7
Tussilago farfara	0	0	0	0	0	0	0	0	0	0	0	0
Viburnum opulus	0	0	0	0	0	0	0	0	0	0	0	0
Vicia cracca	10	2	8	1	11	11	8	4	4	1	3	3
Viola riviniana	8	4	1	3	6	3	4	8	3	4	6	6

R = rooted frequency
S = shoot frequency

Note: *Carex pulicaris* only selected for recording in SSSI plots

Table 14. Frequency of selected species inReceptor A exclosure plot

Species/Year	1990S	1991S	1992S	1994R	1995R	1997R	1998R	1998S
Brachypodium sylvaticum	30	34	55	51	63	49	41	52
Briza media	30	6	17	35	32	33	24	27
Bromopsis erecta	0	2	2	3	3	6	4	7
Campanula rotundifolia	4	0	4	4	6	1	3	3
Carex flacca	92	86	93	94	93	89	79	82
Centaurea nigra	34	32	39	25	27	33	32	48
Centaurea scabiosa	22	6	12	5	5	5	6	13
Crataegus monogyna	14	12	11	14	14	16	1	13
Festuca ovina	18	0	8	5	19	7	0	0
Festuca ovina/rubra	0	48	36	72	0	11	38	38
Festuca rubra	58	0	32	0	36	36	0	0
Fragaria vesca	26	32	33	26	25	27	19	27
Helianthemum nummularium	28	26	19	34	34	36	28	36
Knautia arvensis	2	0	2	2	5	2	2	4
Leontodon hispidus	18	14	17	14	28	18	19	23
Linum catharticum	18	4	7	16	7	2	11	12
Lotus corniculatus	38	26	33	23	28	23	22	29
Pimpinella saxifraga	68	44	47	48	46	29	26	35
Plantago lanceolata	52	36	34	38	32	27	26	41
Plantago media	4	2	2	1	1	2	4	8
Primula veris	6	4	2	2	8	1	3	5
Prunella vulgaris	40	10	19	40	21	16	27	27
Rosa sp.	4	4	8	6	11	2	0	5
Rubus fruticosus agg	14	6	10	7	11	8	6	13
Sanguisorba minor	20	30	19	27	26	22	26	28
Scabiosa columbaria	2	2	2	2	1	2	7	8
Sesleria caerulea	0	0	0	0	0	3	0	0
Silaum silaus	0	0	13	0	0	0	0	0
Sonchus arvensis	16	18	18	7	12	5	4	6
Trifolium medium	4	6	9	3	4	3	4	6
Tussilago farfara	8	4	8	4	4	4	2	2
Viburnum opulus	0	4	1	0	1	3	0	2
Vicia cracca	16	8	15	15	6	4	3	4
Viola riviniana	22	48	17	29	28	33	13	14

R = rooted frequency
S = shoot frequency

Table 15. Frequency of selected species in Receptor B exclosure plot

Species/Year	1990S	1991S	1992S	1993R	1994R	1995R	1997R	1998R	1998S
Brachypodium sylvaticum	21	41	31	29	23	37	26	21	27
Briza media	15	13	3	19	15	23	14	7	7
Bromopsis erecta	9	5	17	14	6	16	17	16	17
Campanula rotundifolia	6	6	7	7	4	12	9	5	5
Carex flacca	70	82	82	60	57	84	63	80	83
Centaurea nigra	35	48	40	19	23	25	35	30	40
Centaurea scabiosa	14	11	17	9	7	8	1	4	8
Crataegus monogyna	6	7	0	5	5	9	4	3	4
Dactylis glomerata	9	23	19	4	5	14	1	1	1
Festuca ovina	33	19	0	0	0	37	0	0	0
Festuca ovina/rubra	0	25	68	49	42	0	37	44	44
Festuca rubra	18	14	0	0	0	36	0	0	0
Fragaria vesca	2	6	8	8	12	3	12	3	7
Helianthemum nummularium	52	64	60	51	59	66	71	80	83
Knautia arvensis	5	8	NR	NR	6	6	2	1	4
Leontodon hispidus	12	10	17	20	10	4	9	7	8
Linum catharticum	5	8	5	6	4	4	4	3	3
Lotus corniculatus	26	40	36	32	27	19	17	20	23
Pimpinella saxifraga	41	50	21	33	21	37	29	17	18
Plantago lanceolata	24	24	23	15	15	21	11	13	18
Plantago media	7	4	2	1	0	0	1	1	1
Primula veris	1	2	1	1	3	6	7	1	1
Prunella vulgaris	5	11	10	21	18	16	15	10	10
Rosa sp.	1	2	3	1	1	6	0	1	2
Rubus fruticosus agg	7	4	4	3	3	2	3	3	5
Sanguisorba minor	17	27	33	14	10	9	17	12	15
Scabiosa columbaria	5	3	4	8	5	4	9	3	3
Sesleria caerulea	12	16	9	15	18	6	19	16	19
Silaum silaus	7	10	4	1	1	1	3	0	0
Sonchus arvensis	0	4	1	3	1	0	0	0	0
Trifolium medium	14	15	18	14	11	8	15	13	18
Tussilago farfara	0	0	0	1	0	0	0	0	1
Viburnum opulus	0	1	0	0	0	1	0	0	0
Vicia cracca	12	12	8	2	3	7	2	6	7
Viola riviniana	7	33	12	8	7	13	15	4	4

R = rooted frequency
S = shoot frequency

NR = not recorded

Table 16. Frequency of selected species in the SSSI grazed plot

Species/Year	1992S	1993R	1994R	1995R	1997R	1998R	1998S
Brachypodium sylvaticum	51	39	44	39	51	59	61
Briza media	39	16	30	31	46	27	29
Bromopsis erecta	16	11	7	13	5	16	17
Campanula rotundifolia	4	7	3	12	5	6	6
Carex flacca	83	92	76	94	90	87	87
Carex pulicaris	11	3	8	8	7	3	3
Centaurea nigra	37	27	13	28	33	26	29
Centaurea scabiosa	18	8	4	8	3	5	6
Crataegus monogyna	15	5	5	11	6	1	2
Dactylis glomerata	11	3	8	10	8	1	1
Festuca ovina	3	9	0	43	10	0	0
Festuca ovina/rubra	75	28	37	0	38	60	60
Festuca rubra	2	3	0	8	22	0	0
Fragaria vesca	9	7	5	7	8	3	3
Helianthemum nummularium	58	35	52	58	54	39	49
Knautia arvensis	3	4	3	6	3	2	2
Leontodon hispidus	15	10	13	18	17	16	19
Linum catharticum	7	4	6	8	10	20	20
Lotus corniculatus	43	32	31	38	41	28	29
Pimpinella saxifraga	27	43	33	47	41	20	20
Plantago lanceolata	20	13	12	17	21	11	17
Plantago media	NR	NR	1	3	2	0	0
Primula veris	NR	NR	1	7	4	4	5
Prunella vulgaris	10	11	10	11	11	15	16
Rosa sp.	6	3	3	4	3	0	0
Rubus fruticosus agg	15	6	7	10	5	8	9
Sanguisorba minor	29	17	22	33	26	19	22
Scabiosa columbaria	10	7	6	8	7	6	6
Sesleria caerulea	6	1	2	3	2	5	5
Silaum silaus	0	0	2	0	0	0	0
Sonchus arvensis	0	0	1	1	1	0	0
Trifolium medium	12	7	3	13	8	9	9
Tussilago farfara	0	0	0	0	1	1	2
Viburnum opulus	1	0	0	0	0	0	0
Vicia cracca	12	11	5	3	4	4	4
Viola riviniana	17	17	15	25	15	14	14

R = rooted frequency
S = shoot frequency
NR = not recorded

Note: Carex pulicaris only selected for recording in SSSI plots

Table 17. Frequency of selected species in Receptor A grazed plot

Species/Year	1992S	1993R	1994R	1995R	1997R	1998R	1998S
Brachypodium sylvaticum	55	24	33	29	34	22	27
Briza media	63	46	51	61	54	56	57
Bromopsis erecta	18	17	20	36	23	33	33
Campanula rotundifolia	3	6	4	5	3	9	9
Carex flacca	92	74	77	92	81	85	89
Centaurea nigra	50	35	34	25	32	23	27
Centaurea scabiosa	2	1	1	5	2	1	2
Crataegus monogyna	11	NR	11	13	3	1	5
Dactylis glomerata	4	4	6	11	6	4	5
Festuca ovina	3	0	2	21	0	0	0
Festuca ovina/rubra	85	54	48	0	53	80	80
Festuca rubra	4	0	3	50	18	0	0
Fragaria vesca	19	9	16	12	17	6	7
Helianthemum nummularium	26	17	28	23	31	20	21
Knautia arvensis	1	NR	1	1	3	1	5
Leontodon hispidus	43	33	28	39	58	33	47
Linum catharticum	3	6	13	9	15	15	16
Lotus corniculatus	53	47	55	56	63	43	47
Pimpinella saxifraga	64	51	46	35	32	11	15
Plantago lanceolata	48	29	37	32	41	33	40
Plantago media	11	NR	1	3	8	13	15
Primula veris	8	NR	9	9	6	4	4
Prunella vulgaris	13	16	25	11	22	20	20
Rosa sp.	2	3	5	5	1	0	0
Rubus fruticosus agg	13	4	8	4	3	2	2
Sanguisorba minor	38	26	26	34	43	36	42
Scabiosa columbaria	5	4	2	4	5	10	12
Sesleria caerulea	0	0	0	1	1	0	0
Silaum silaus	0	0	2	0	1	2	2
Sonchus arvensis	2	2	3	2	2	0	0
Trifolium medium	0	0	1	0	0	0	0
Tussilago farfara	6	2	1	2	2	0	0
Viburnum opulus	0	0	0	0	0	0	0
Vicia cracca	6	5	8	1	12	0	0
Viola riviniana	10	9	12	13	12	9	9

R = rooted frequency
S = shoot frequency
NR = not recorded

Table 18. Frequency of selected species in Receptor B grazed plot

Species/Year	1992S	1993R	1994R	1995R	1997R	1998R	1998S
Brachypodium sylvaticum	43	19	22	42	22	12	12
Briza media	25	17	15	31	26	43	43
Bromopsis erecta	25	35	28	46	43	49	51
Campanula rotundifolia	9	11	10	17	10	15	15
Carex flacca	77	59	65	74	84	65	66
Centaurea nigra	38	28	26	33	21	19	25
Centaurea scabiosa	14	4	7	9	4	1	2
Crataegus monogyna	4	3	4	2	2	1	1
Dactylis glomerata	14	6	8	12	8	12	13
Festuca ovina	5	0	0	37	9	0	0
Festuca ovina/rubra	59	47	48	0	0	73	73
Festuca rubra	19	0	0	57	79	0	0
Fragaria vesca	4	7	5	5	2	7	7
Helianthemum nummularium	55	38	42	60	45	44	47
Knautia arvensis	NR	NR	0	4	0	1	4
Leontodon hispidus	14	16	14	17	29	40	43
Linum catharticum	11	7	6	26	22	24	24
Lotus corniculatus	34	29	9	30	39	44	46
Pimpinella saxifraga	19	37	23	41	36	58	63
Plantago lanceolata	39	25	28	44	44	37	43
Plantago media	7	2	0	1	4	7	8
Primula veris	6	3	0	11	5	7	7
Prunella vulgaris	18	23	24	21	33	31	32
Rosa sp.	2	1	0	2	1	1	1
Rubus fruticosus agg	3	0	0	2	2	0	0
Sanguisorba minor	37	33	35	41	37	37	37
Scabiosa columbaria	7	10	4	6	16	7	7
Sesleria caerulea	6	8	5	15	4	14	15
Silaum silaus	5	0	1	2	1	0	0
Sonchus arvensis	0	0	0	0	0	0	0
Trifolium medium	20	19	9	12	13	13	13
Tussilago farfara	0	0	1	0	0	0	0
Viburnum opulus	0	0	0	0	0	0	0
Vicia cracca	9	7	4	7	8	6	6
Viola riviniana	13	10	12	25	13	11	11

R = rooted frequency
S = shoot frequency
NR = not recorded

Table 19. Frequency of species in Donor and SSSI plots in 1987

Species/Plot	SSSI	Donor I	Donor II
Achillea millefoilum	16	2	0
Agrimonia eupatoria	6	2	2
Agrostis stolonifera	24	26	18
Anthyllis vulneraria	0	0	2
Arrhenatherum elatius	0	4	0
Brachypodium sylvaticum	20	58	38
Briza media	40	38	38
Bromopsis erecta	2	0	4
Campanula rotundifolia	30	4	18
Carex caryophyllea	0	0	8
Carex flacca	92	90	72
Carex pilulifera	6	0	0
Centaurea nigra	32	36	44
Centaurea scabiosa	10	18	18
Cirsium arvense	0	2	0
Crataegus monogyna	8	12	8
Dactylis glomerata	8	8	18
Danthonia decumbens	30	10	12
Elytrigia repens	0	0	6
Euphrasia nemorosa	0	2	4
Festuca arundinacea	6	6	4
Festuca ovina	58	34	52
Festuca rubra	28	52	26
Fragaria vesca	12	14	4
Gentianella amarella	4	0	0
Gymnadenia conopsea	0	2	6
Helianthemum nummularium	54	44	66
Helictotrichon pubescens	4	6	8
Heracleum sphondylium	0	2	0
Holcus lanatus	0	4	0
Hypericum maculatum	4	0	0
Knautia arvensis	0	6	8
Leontodon hispidus	12	22	34
Linum catharticum	24	4	2
Linum perenne subsp. anglicum	0	0	2
Listera ovata	4	2	4
Lotus corniculatus	48	50	54
Pilosella officinarum	2	0	0
Pimpinella saxifraga	66	60	58
Plantago lanceolata	30	28	32
Plantago media	0	8	2
Polygala vulgaris	10	4	8

Species/Plot	SSSI	Donor I	Donor II
Potentilla reptans	0	6	4
Primula veris	0	2	6
Prunella vulgaris	14	14	18
Ranunculus acris	0	4	14
Rhinanthus minor	0	2	0
Rosa sp.	2	4	0
Rubus fruticosus agg	2	22	6
Sanguisorba minor	14	18	16
Scabiosa columbaria	20	0	8
Sesleria caerulea	20	6	36
Silaum silaus	0	2	2
Sonchus arvensis	0	2	0
Sorbus sp.	0	2	0
Taraxacum sp.	0	2	0
Thymus polytrichus	2	0	8
Trifolium medium	10	14	26
Trifolium pratense	6	2	6
Triticum aestivum	0	0	2
Veronica chamaedrys	0	2	0
Vicia cracca	10	20	18
Viola hirta	10	10	14
Viola riviniana	8	20	6

Note: shoot frequency recorded for all plots

Table 20. Frequency of species in all plots in 1998

Species/Plot	SSSI Ex	SSSI Gr	Receptor A Ex	Receptor A Gr	Receptor B Ex	Receptor B Gr
Achillea millefoilum	8	6	8	1	8	6
Agrimonia eupatoria	0	0	3	2	1	1
Agrostis capillaris	4	1	1	0	0	2
Agrostis stolonifera	1	8	1	6	1	4
Brachypodium sylvaticum	12	61	52	27	27	12
Briza media	26	29	27	57	7	43
Bromopsis erecta	11	17	7	33	17	51
Campanula rotundifolia	14	6	3	9	5	15
Carex flacca	59	87	82	89	83	66
Carex pulicaris	19	3	0	0	0	0
Centaurea nigra	23	29	48	27	40	25
Centaurea scabiosa	7	6	13	2	8	2
Centaurium erythraea	0	0	1	0	0	0
Cerastium fontanum	0	0	0	0	0	3
Crataegus monogyna	5	2	13	5	4	1
Cruciata laevipes	0	0	1	0	0	1
Dactylis glomerata	1	1	2	5	1	13
Danthonia decumbens	1	4	3	1	0	0
Deschampsia cespitosa	0	0	0	0	1	0
Elytrigia repens	0	0	0	0	0	1
Euphrasia nemorosa	0	0	0	1	0	0
Festuca arundinacea	1	15	10	5	5	11
Festuca ovina/rubra	44	60	38	80	44	73
Fragaria vesca	3	3	27	7	7	7
Fraxinus excelsior	0	1	0	0	2	0
Galium verum	2	1	0	0	3	1
Gentianella amarella	0	0	0	2	0	1
Gymnadenia conopsea	0	1	1	0	1	0
Helianthemum nummularium	62	49	36	21	83	47
Helictotrichon pratense	5	3	3	0	0	4
Helictotrichon pubescens	0	1	3	12	1	16
Heracleum sphondylium	0	0	2	0	2	2
Hieracium sp	0	1	0	0	0	0
Holcus lanatus	0	0	0	0	0	3
Hypericum pulchrum	2	4	1	0	1	1
Knautia arvensis	3	2	4	5	4	4
Lathyrus pratensis	0	2	2	1	1	2
Leontodon hispidus	13	19	23	47	8	43
Leucanthemum vulgare	0	0	0	1	0	0
Linum catharticum	13	20	12	16	3	24
Linum perenne subsp. anglicum	0	0	0	0	2	0
Listera ovata	0	0	7	0	1	0

Species/Plot	SSSI Ex	SSSI Gr	Receptor A Ex	Receptor A Gr	Receptor B Ex	Receptor B Gr
Lotus corniculatus	29	29	29	47	23	46
Pilosella officinarum	2	0	0	1	0	0
Pimpinella saxifraga	38	20	35	15	18	63
Plantago lanceolata	10	17	41	40	18	43
Plantago media	0	0	8	15	1	8
Poa pratensis	0	0	0	1	0	0
Polygala vulgaris	1	5	0	10	0	1
Populus tremula	0	0	11	0	0	0
Potentilla reptans	0	2	5	3	3	8
Primula veris	3	5	5	4	1	7
Prunella vulgaris	3	16	27	20	10	32
Ranunculus acris	0	0	0	1	0	0
Ranunculus repens	0	0	1	0	0	3
Rhinanthus minor	0	2	0	19	0	0
Rosa sp.	1	0	5	0	2	1
Rubus fruticosus agg	4	9	13	2	5	0
Sanguisorba minor	23	22	28	42	15	37
Scabiosa columbaria	11	6	8	12	3	7
Senecio jacobaea	0	0	0	1	0	1
Sesleria caerulea	45	5	0	0	19	15
Silaum silaus	0	0	0	2	0	0
Sonchus arvensis	0	0	6	0	0	0
Taraxacum sp.	0	5	4	3	1	28
Thymus polytrichus	0	0	0	0	5	3
Tragopogon pratensis	1	3	1	3	0	2
Trifolium medium	7	9	6	0	18	13
Trifolium pratense	0	0	0	5	0	6
Trifolium repens	0	0	0	0	0	1
Trisetum flavescens	0	0	0	1	0	0
Tussilago farfara	0	2	2	0	1	0
Valeriana dioica	0	0	1	0	0	0
Viburnum opulus	0	0	2	0	0	0
Vicia cracca	3	4	4	0	7	6
Viola hirta	5	0	10	3	4	8
Viola riviniana	6	14	14	9	4	11

Ex = exclosure plot
Gr = grazed plot
Note: shoot frequency recorded for all plots

Table 21. Frequency of species in exclosure plots in 1990

Species/Year	SSSI	Receptor A	Receptor B
Achillea millefoilum	6	12	3
Agrimonia eupatoria	1	2	1
Agrostis capillaris	2	8	7
Agrostis stolonifera	1	12	5
Anthriscus sylvestris	0	0	2
Arctium minus	0	0	2
Arrhenatherum elatius	0	0	5
Atriplex prostrata	0	0	1
Brachypodium sylvaticum	8	30	21
Briza media	24	30	15
Bromopsis erecta	0	0	9
Campanula rotundifolia	8	4	6
Carex flacca	40	92	70
Carex pilulifera	0	2	0
Centaurea nigra	16	34	35
Centaurea scabiosa	0	22	14
Cirsium vulgare	0	2	1
Crataegus monogyna	2	14	6
Dactylis glomerata	3	10	9
Danthonia decumbens	12	0	0
Elytrigia repens	0	2	10
Euphrasia nemorosa	0	0	1
Festuca arundinacea	0	4	6
Festuca ovina	43	18	33
Festuca rubra	7	58	18
Fragaria vesca	2	26	2
Galium aparine	0	0	1
Galium verum	0	0	3
Helianthemum nummularium	37	28	52
Helictotrichon pratense	1	0	2
Helictotrichon pubescens	0	6	4
Heracleum sphondylium	0	2	2
Holcus lanatus	0	2	0
Knautia arvensis	2	2	5
Lapsana communis	0	0	1
Lathyrus pratensis	0	6	1
Leontodon hispidus	7	18	12
Linum catharticum	10	18	5
Lotus corniculatus	31	38	26
Pimpinella saxifraga	37	68	41
Plantago lanceolata	11	52	24
Plantago major	0	0	1
Plantago media	3	4	7

Species/Year	SSSI	Receptor A	Receptor B
Polygala vulgaris	1	2	2
Polygonum aviculare	0	0	2
Populus tremula	0	2	0
Potentilla reptans	0	8	3
Primula veris	1	6	1
Prunella vulgaris	1	40	5
Ranunculus bulbosus	0	2	1
Ranunculus repens	0	0	4
Rosa sp.	0	4	1
Rubus fruticosus agg	2	14	7
Rumex acetosa	0	0	1
Rumex obtusifolius	0	0	1
Sanguisorba minor	9	20	17
Scabiosa columbaria	10	2	5
Senecio erucifolius	0	4	0
Senecio jacobaea	0	0	1
Sesleria caerulea	20	0	12
Silaum silaus	0	0	7
Sonchus arvensis	0	16	0
Sonchus asper	0	0	2
Taraxacum sp.	0	2	0
Thymus polytrichus	1	0	3
Tragopogon pratensis	0	2	0
Trifolium medium	11	4	14
Trifolium pratense	0	2	2
Trisetum flavescens	0	0	1
Tussilago farfara	0	8	0
Valeriana dioica	0	0	1
Veronica persica	0	0	1
Vicia cracca	1	16	12
Viola hirta	0	2	6
Viola riviniana	3	22	7

Note: shoot frequency recorded for all plots

Table 22. Percent proportions of functional strategies for all EFU plots

Plot & date/Strategy	C	S	R	SC	CR	SR	CSR
Donor I							
1987	2.2	47.7	0.2	9.9	4.2	4.7	31.2
Donor II							
1987	2.4	50.6	0.0	9.7	2.7	5.0	29.7
SSSI exclosure							
1987	1.1	55.3	0.0	5.9	4.2	8.8	24.6
1990	0.5	60.7	0.0	9.1	1.1	9.0	19.7
1998	0.4	56.1	0.5	15.1	1.1	8.2	18.6
Receptor A exclosure							
1990	1.7	39.4	0.1	6.6	6.5	6.8	38.8
1998	0.5	45.0	0.3	11.8	2.9	5.3	34.3
Receptor B exclosure							
1990	3.1	47.9	1.1	8.6	4.8	5.1	29.5
1998	1.2	52.4	0.1	13.0	2.0	2.9	28.4
SSSI grazed							
1998	0.6	53.7	0.6	11.0	2.8	6.2	25.0
Receptor A grazed							
1998	0.4	52.0	1.8	5.8	1.6	6.6	31.9
Receptor B grazed							
1998	1.3	44.1	2.1	7.5	2.4	7.9	34.6

Table 23. Frequency of scrub in EFU plots in 1998

Plot/Quadrat type	10 x 10 cm root frequency	25 x 25 cm root frequency	10 x 10 cm shoot frequency	25 x 25 cm shoot frequency
SSSI exclosure	4	11	10	20
SSSI grazed	10	33	12	35
Receptor A exclosure	11	38	35	65
Receptor A grazed	3	27	7	32
Receptor B exclosure	9	34	12	41
Receptor B grazed	2	15	2	16

Table 24. Averages of soil measurements made by Dr Shimwell

Vegetation type	Mean pH	S. E.	Mean calcium gms/100 g dry soil	S. E.	Mean percent humus (organic matter)	S. E.
CG2 n = 6	7.07	0.08	0.42	0.01	16.25	1.91
CG8 n = 22	7.27	0.04	2.04	0.18	16.32	0.92
Mixed scrub and grassland n = 4	7.05	0.15	0.6	0.04	26.75	2.92

Table 25. Total grazing period by season between 1992-98 for compartments 2, 3 and 5

Season/Compartment	2	3	5
March-May	1.5	3	0
June-August	1.5	3.75	3
September-November	3	2.75	4.75
December-February	1.5	1.5	1.75
Total months for period	7.5	11	9.5