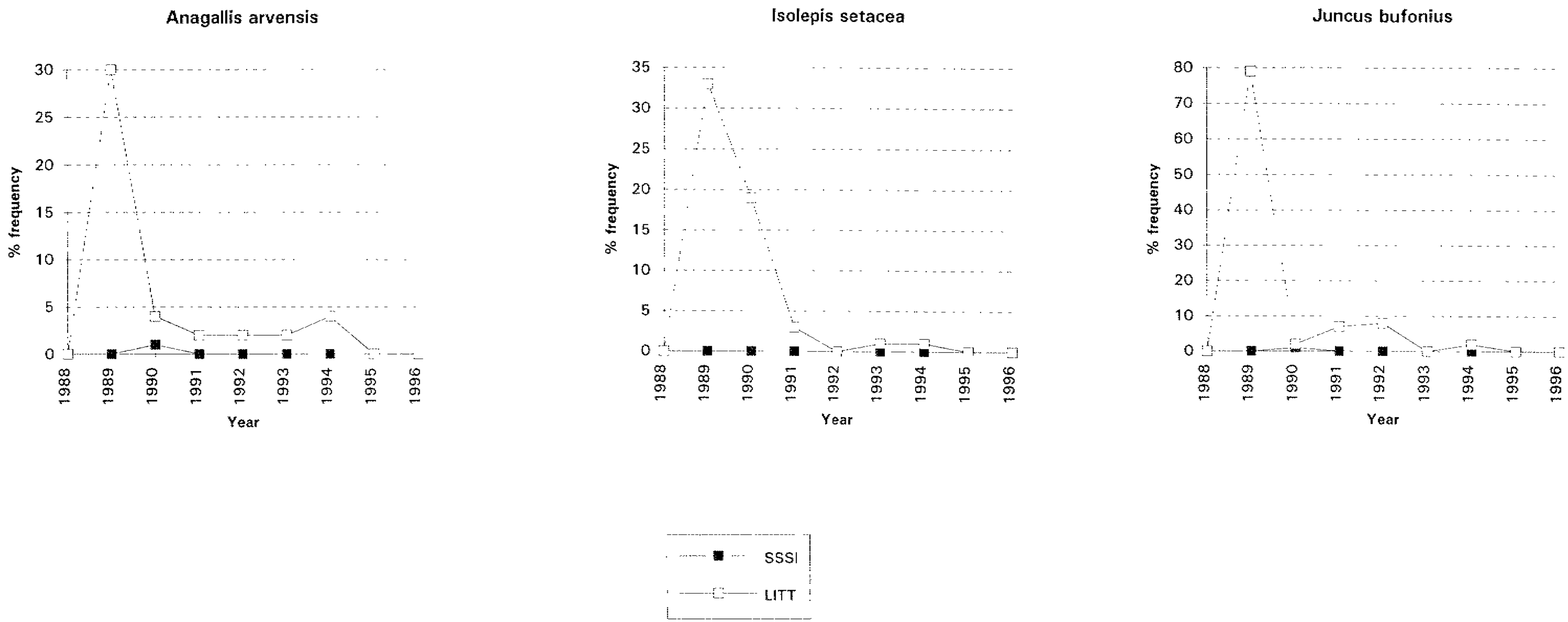

Anagallis arvensis
Isolepis setacea
Juncus bufonius
% frequency
Year
1988 1989 1990 1991 1992 1993 1994 1995 1996
SSSI
LITT

FIGURE 15

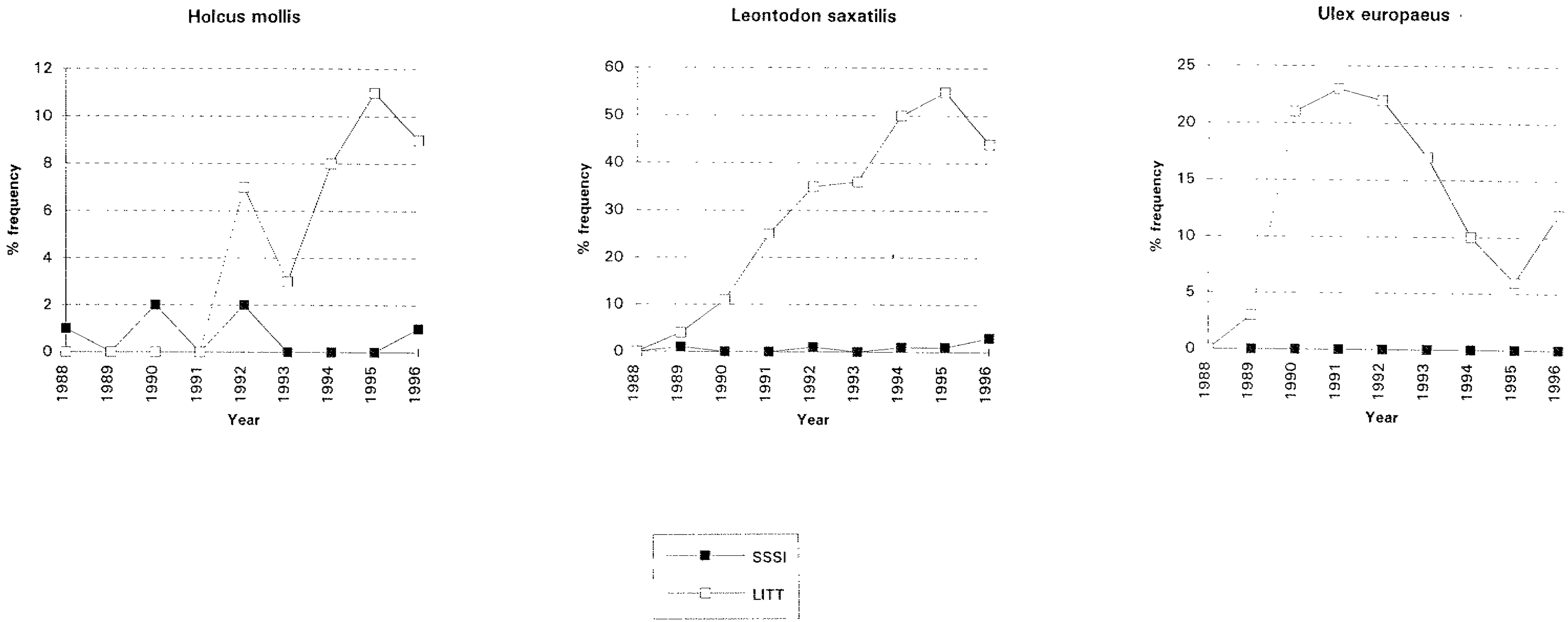

Holcus mollis
Leontodon saxatilis
Ulex europaeus
% frequency
Year
1988
1989
1990
1991
1992
1993
1994
1995
1996
SSSI
LITT

FIGURE 16

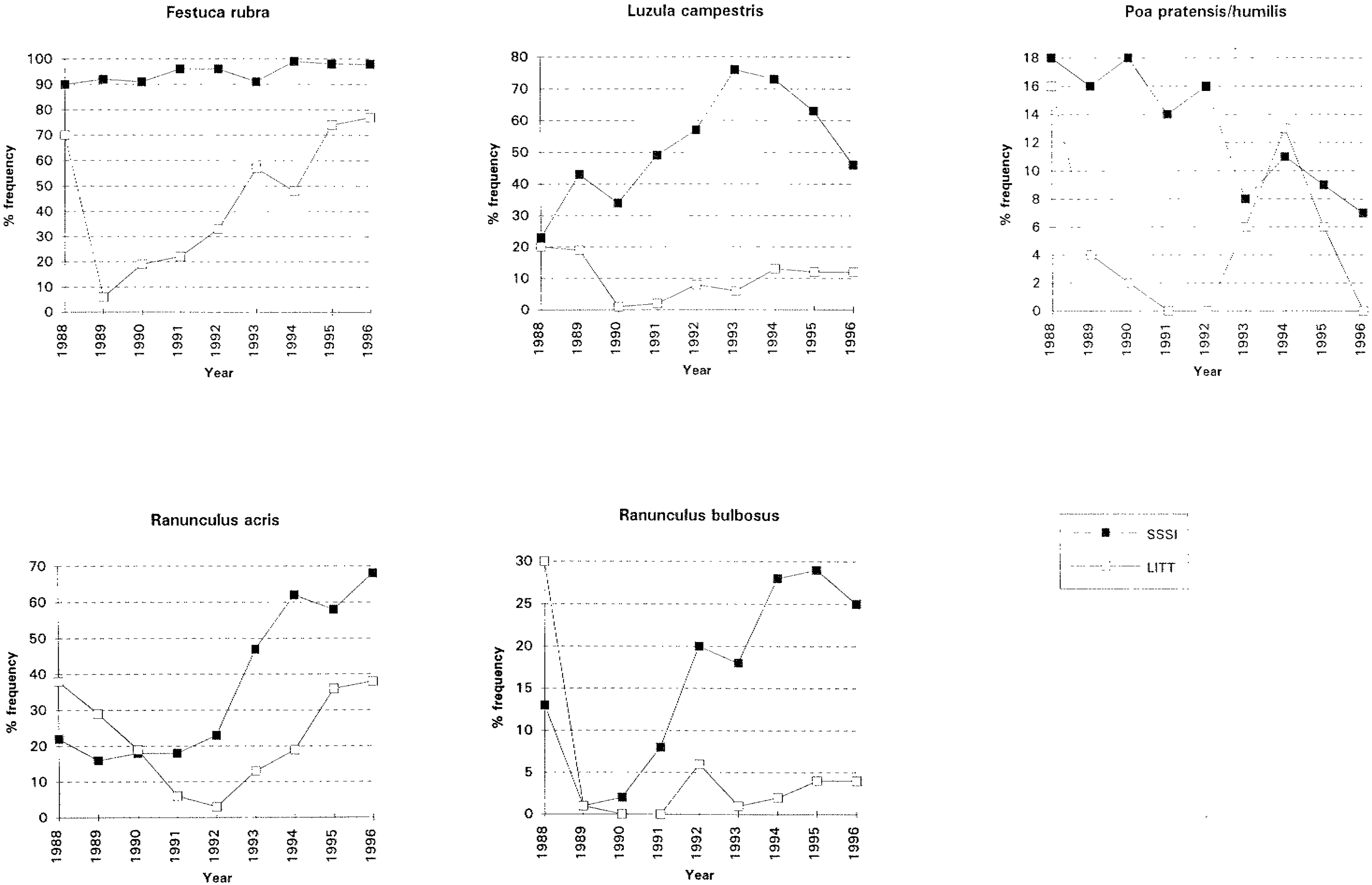

Festuca rubra
Luzula campestris
Poa pratensis/humilis
Ranunculus acris
Ranunculus bulbosus
% frequency
Year
1988
1989
1990
1991
1992
1993
1994
1995
1996
SSSI
LITT

FIGURE 17

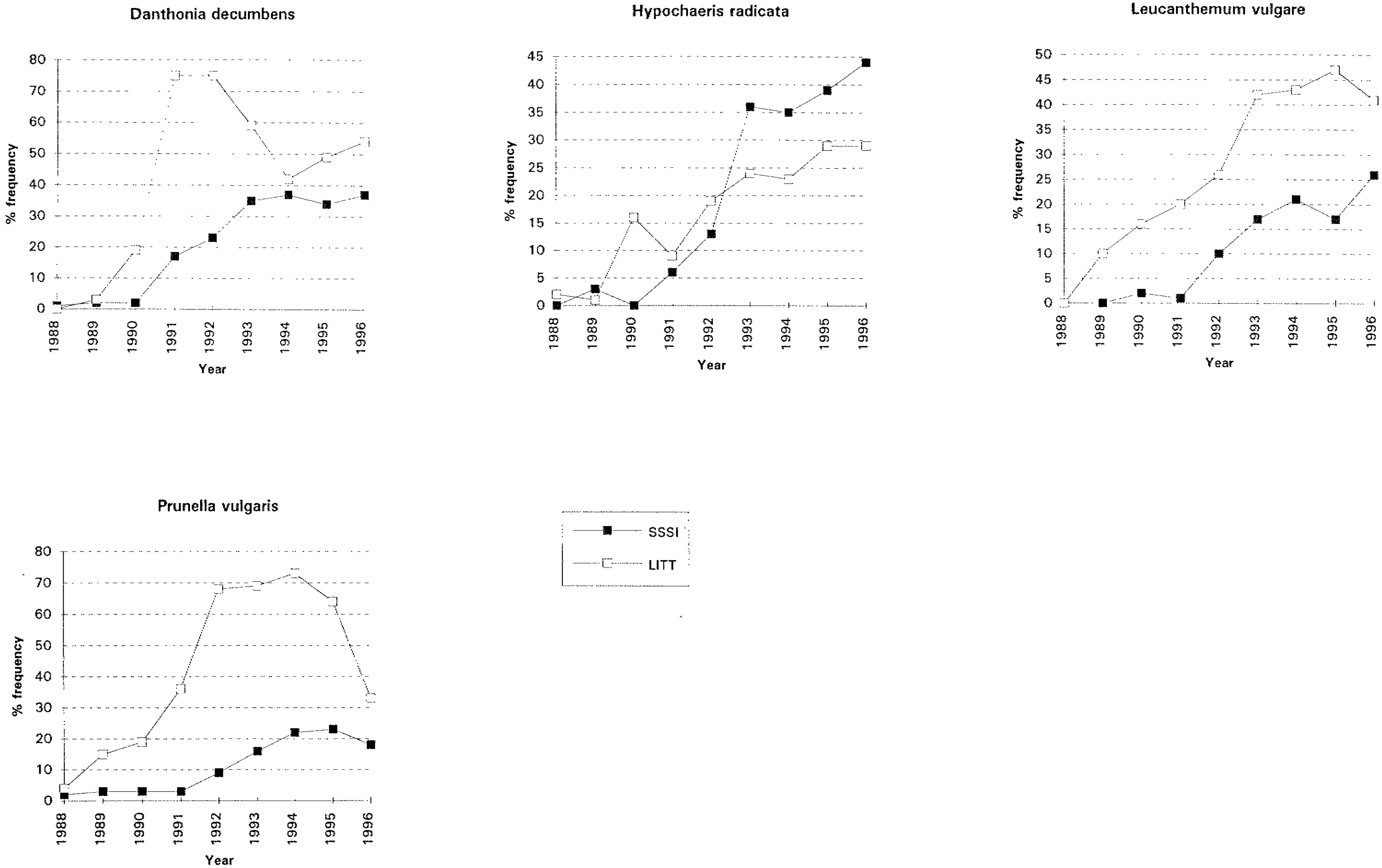

Danthonia decumbens
% frequency
0
10
20
30
40
50
60
70
80
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
Hypochaeris radicata
% frequency
0
5
10
15
20
25
30
35
40
45
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
Leucanthemum vulgare
% frequency
0
5
10
15
20
25
30
35
40
45
50
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
Prunella vulgaris
% frequency
0
10
20
30
40
50
60
70
80
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
SSSI
LITT

FIGURE 18

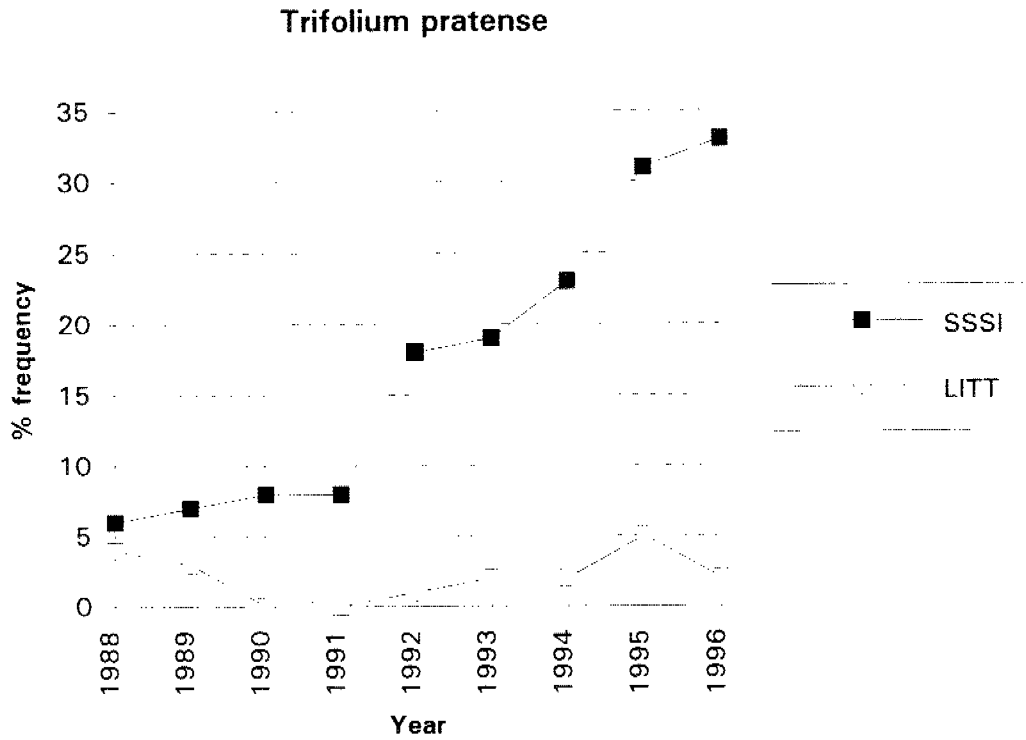

Trifolium pratense
35
30
25
20
15
10
5
0
% frequency
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
SSSI
LITT

FIGURE 19

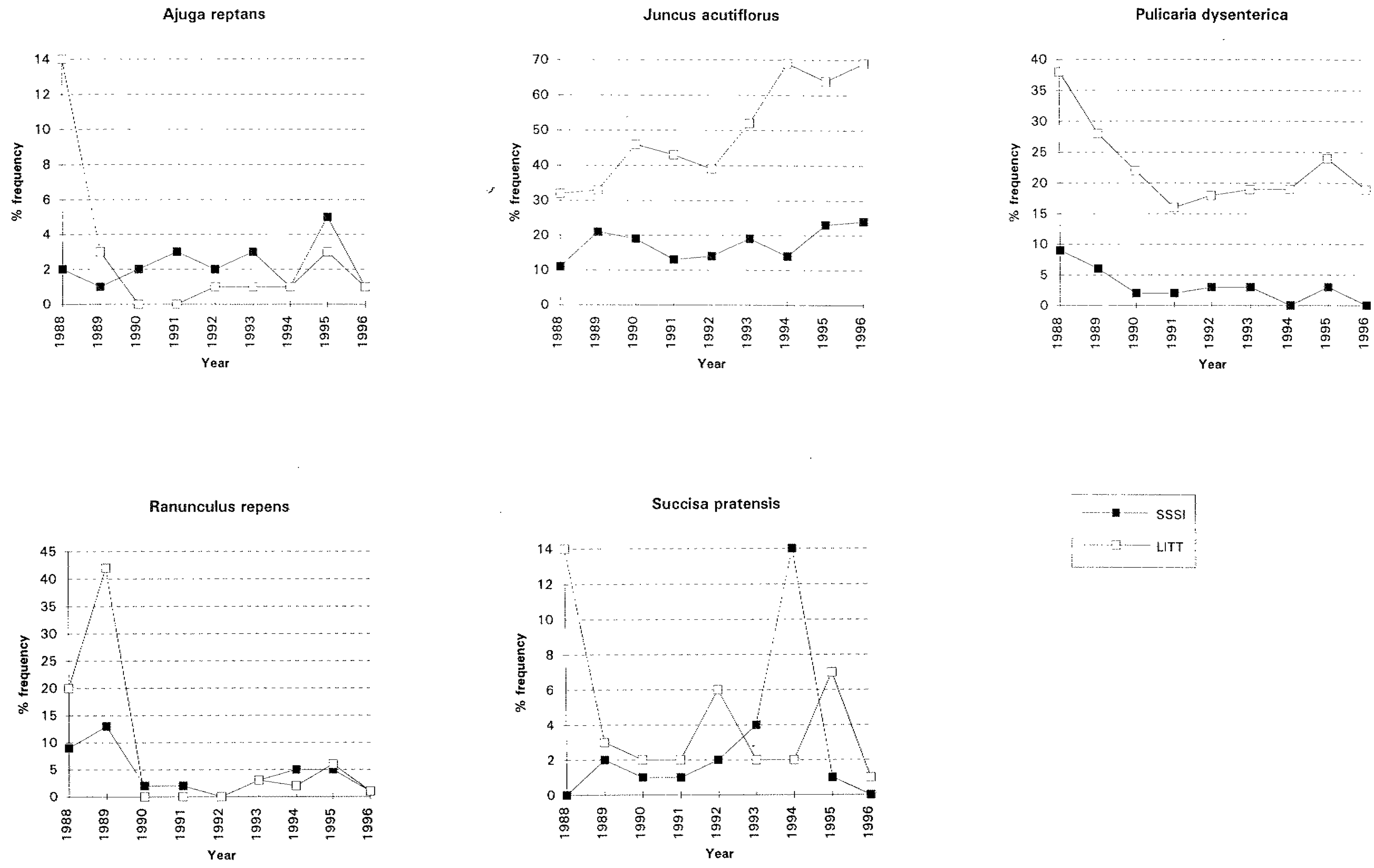
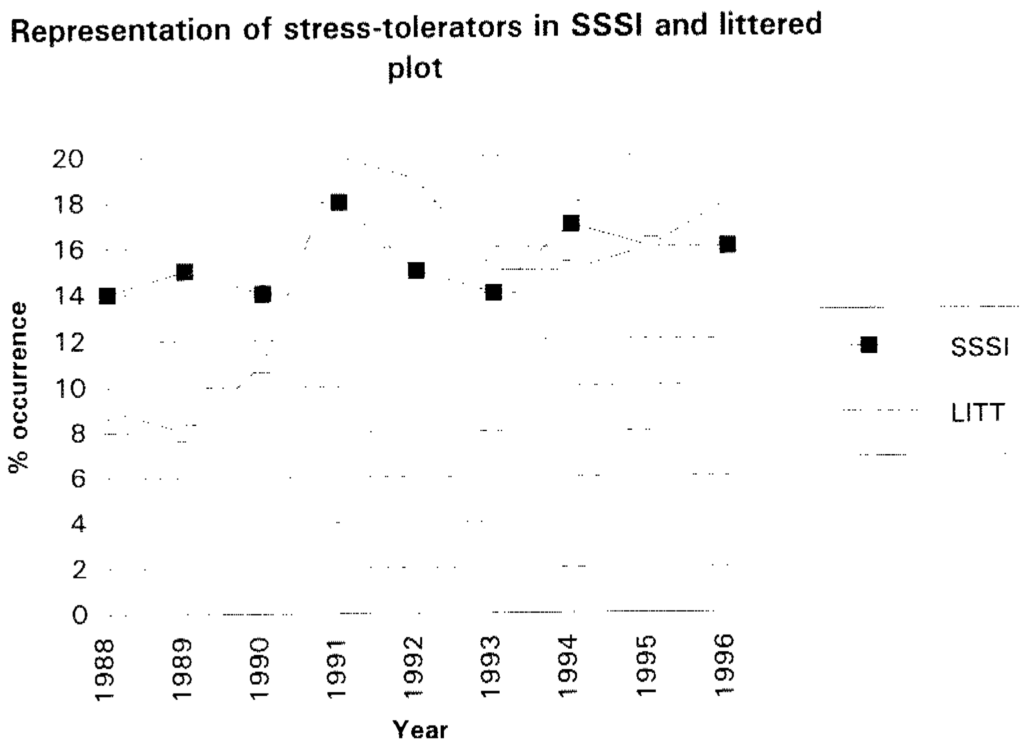
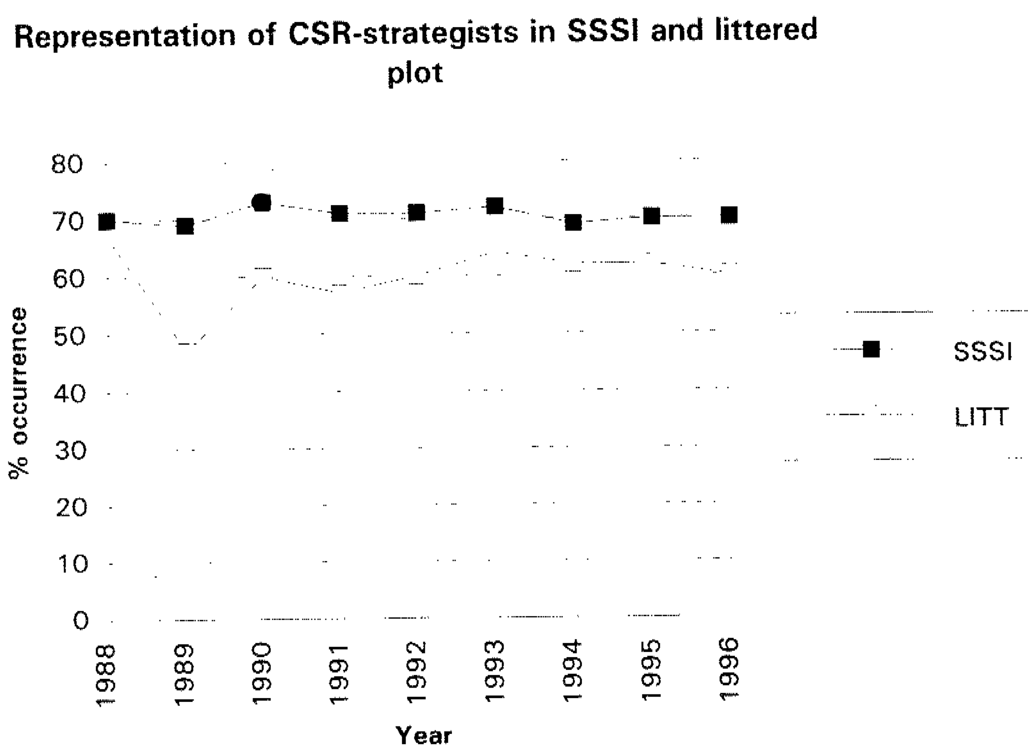

Ajuga reptans
Juncus acutiflorus
Pulicaria dysenterica
Ranunculus repens
Succisa pratensis
% frequency
Year
1988
1989
1990
1991
1992
1993
1994
1995
1996
SSSI
LITT

FIGURE 20

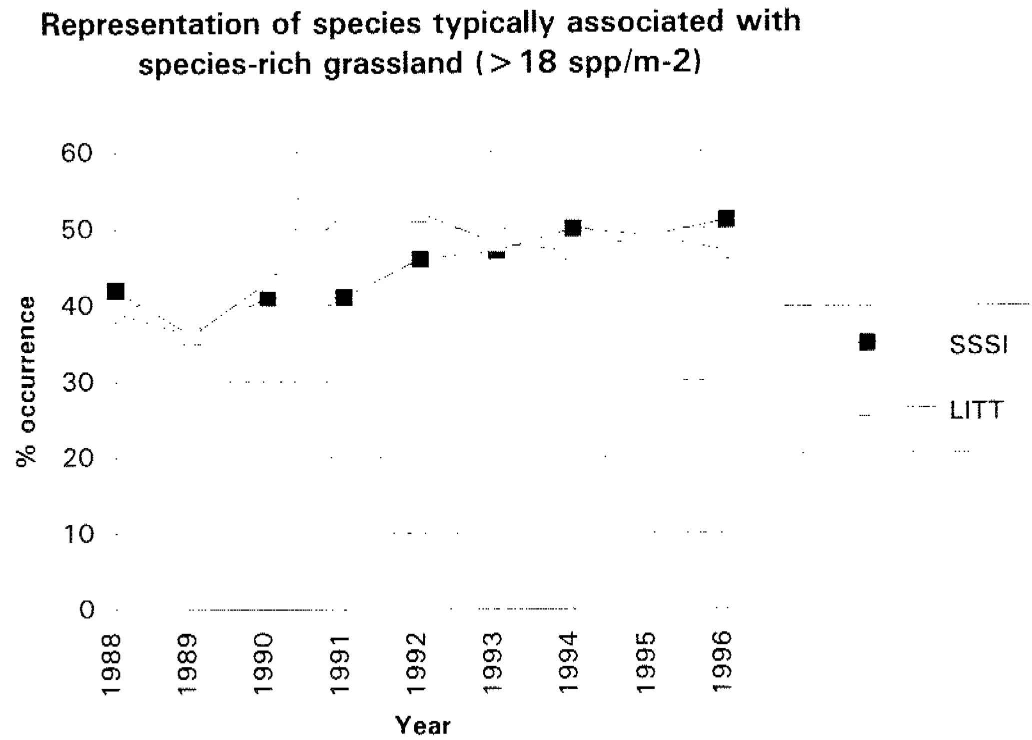


Representation of stress-tolerators in SSSI and littered plot
% occurrence
20
18
16
14
12
10
8
6
4
2
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
SSSI
LITT



Representation of CSR-strategists in SSSI and littered plot
% occurrence
80
70
60
50
40
30
20
10
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
SSSI
LITT

FIGURE 21


Representation of species typically associated with species-rich grassland (>18 spp/m-2)
% occurrence
60
50
40
30
20
10
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
SSSI
LITT

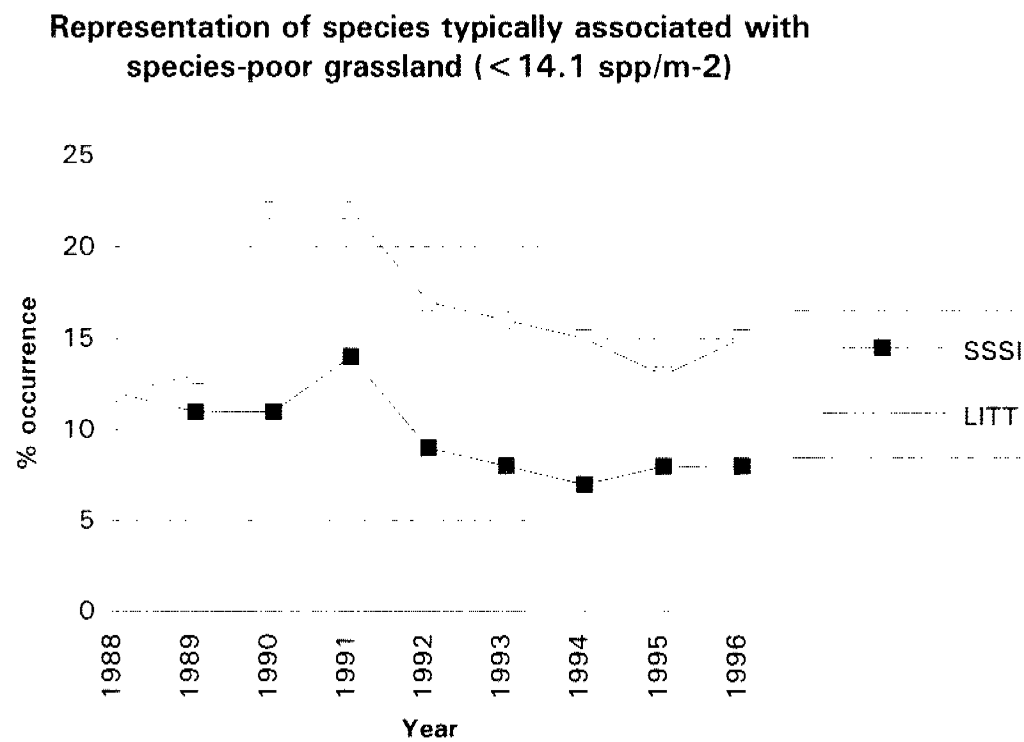
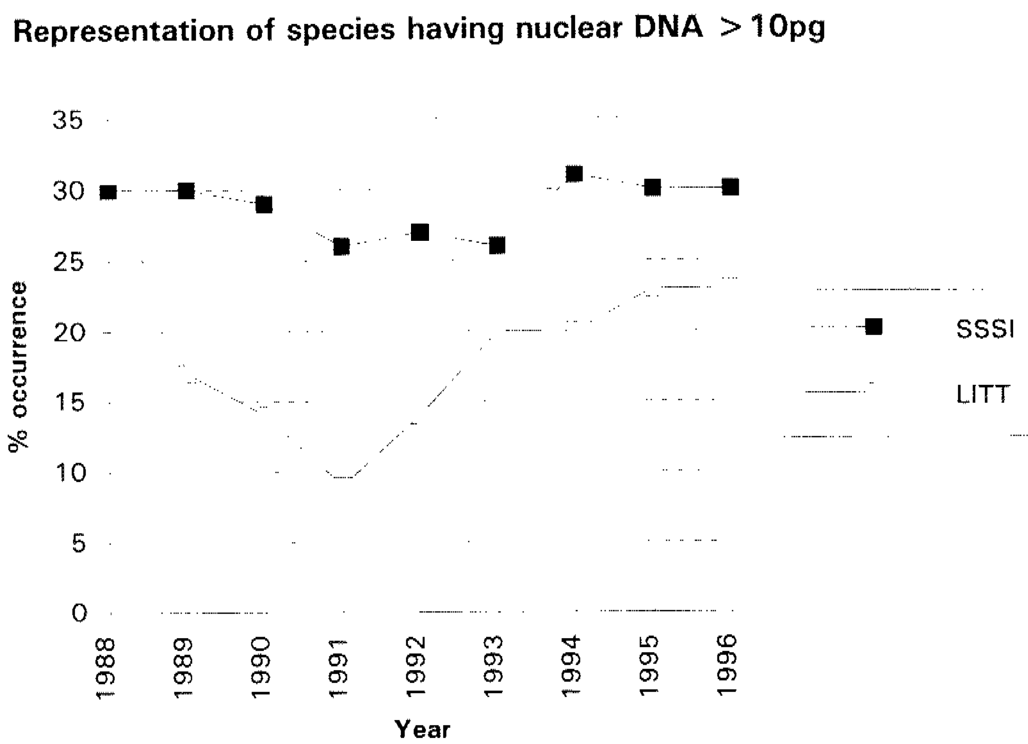
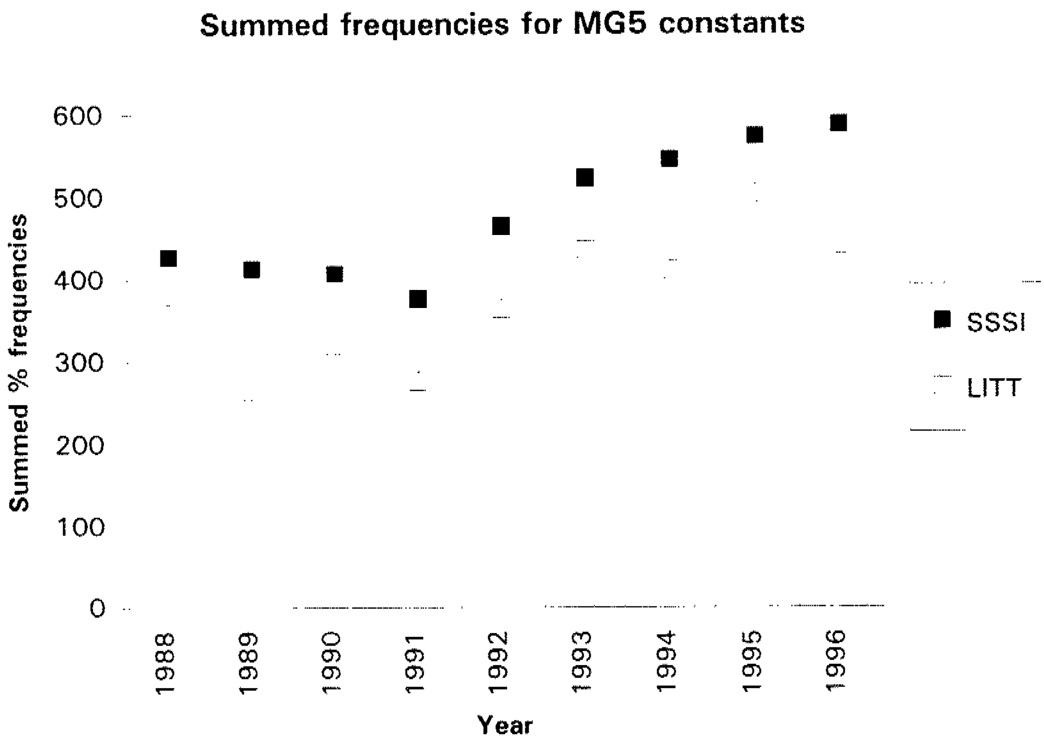

Representation of species typically associated with species-poor grassland (<14.1 spp/m-2)
% occurrence
25
20
15
10
5
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
SSSI
LITT

FIGURE 22



Representation of species having nuclear DNA >10pg
35
30
25
20
15
10
5
0
% occurrence
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
SSSI
LITT

FIGURE 23



Summed frequencies for MG5 constants
600
500
400
300
200
100
0
Summed % frequencies
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
SSSI
LITT

FIGURE 24

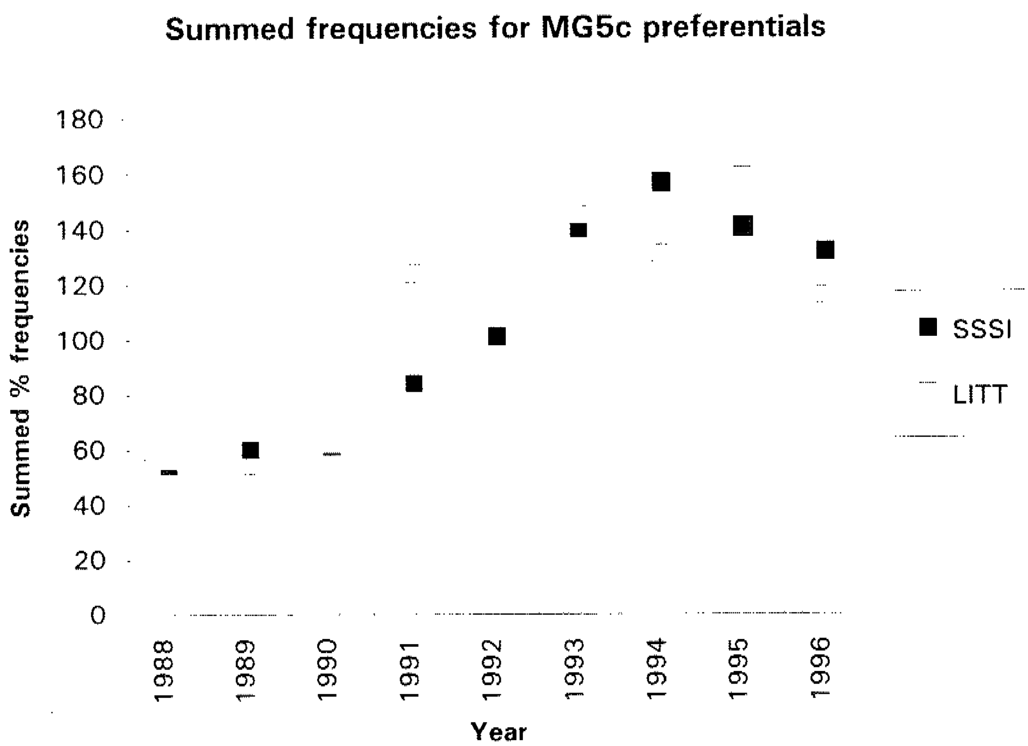

Summed frequencies for MG5c preferentials
180
160
140
120
100
80
60
40
20
0
Summed % frequencies
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
SSSI
LITT

FIGURE 25

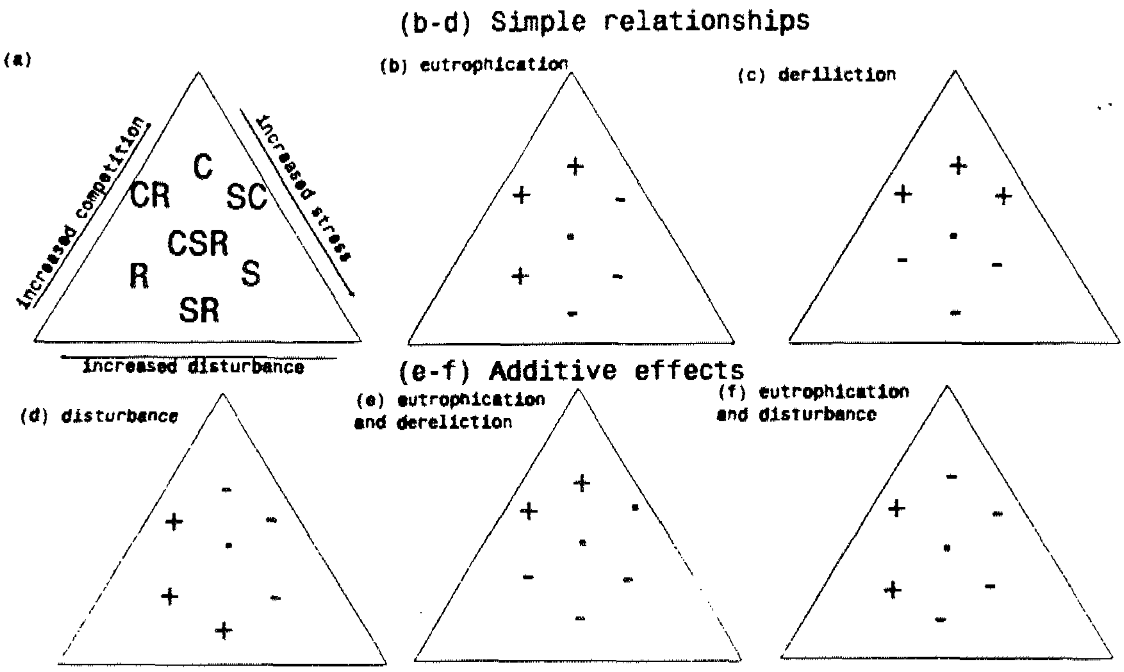


Fig 1. The Plant Strategies of Grime (1974) and their theoretically expected changes in response to changing land use.

Strategies are abbreviated as follows:-
C, competitive; S, stress tolerant; R, ruderal; CR, competitive ruderal; SC, stress tolerant competitive; SR, stress tolerant ruderal; CSR, CSR strategist.

In b-h favoured strategists are indicated by a '+' and unfavoured strategies by a '-'. Strategies that are less affected or where the outcome is uncertain are indicated by a dot.

The scenario illustrated relates to vegetation where a majority of species are CSR strategists. However, the principles are the same whichever strategy predominates. For example, had most species been stress tolerators, favoured strategies would have included in triangle b also CSR strategists.

FIGURE 26 (from Hodgson *et al.* (1995))

ANNEX 1

MANAGEMENT RECORD FOR BROCKS FARM - SSSI, TURF TRANSPLANT AND LITTERED TRANSPLANT

The following records of management history were supplied by ECCI (in letter dated 29 January 1997). Additional notes [in square brackets] are from NCC/English Nature records.

1. **Prior to November 1983 (the date that ECC purchased the site)**. There is no formal record of management, although it is understood that for around seven years before ECC purchase the fields were lightly grazed [stock type unknown].

2. **1983-1986**. No grazing was carried out, but management measures such as hedge cutting, shrub and bracken clearance and ditch clearance were undertaken. [NCC records suggest that SSSI field may have been cut in 1986.]

3. **1987**. SSSI, donor field O.S. 1285 (and O.S. 0494) were said to have been cut in August in good weather conditions and the cuttings left on the ground. [However NCC staff (S.J.Leach) visited the site in early September 1987, at which time none of the fields had been cut.]

4. **1988**. SSSI, donor field O.S. 1285 (and O.S. 0494) were cut during August and September. Cuttings from the SSSI were baled and removed. Cuttings on O.S. 1285 were left to allow seed to drop, but were removed during the transplantation exercise [at request of NCC]. The transplantation operation took place between 30 August and 11 October. O.S. 1285 was transplanted by a combination of turfing and littering. O.S. 0494 apparently provided both subsoil and litter for the litter receptor areas [although throughout the study it has been understood that litter used in the area encompassed by the littered *plot* was derived solely from O.S. 1285].

5. **1989-1991**. SSSI and turf transplant were cut in August, the cuttings carted away. Littered areas were cut but there were not enough cuttings for hay so they were left on the ground. [NCC records, based on conversations at the time with ECC staff, suggest that the littered area was left uncut in 1989 and 1990 due to sparseness of the vegetation, with cutting being resumed in 1991 (Leach *et al.*, 1992).]

6. **1992-1996**. SSSI, turf transplant and littered areas all cut for hay in August each year, the hay baled up and carted away. All areas aftermath-grazed: in 1992 18 sheep were grazed, in 1993-96 around 12 sheep were grazed, the animals being 'rotated' around the grasslands such that each area was grazed for at least two two-week periods between August and the end of April in the following year. The exact grazing period each year was dependent on weather conditions. [Very occasionally, stray cattle have been observed grazing in the SSSI.]

ANNEX 2

1. INTRODUCTION

1.1 Background to the NCC/EN monitoring study of grassland transplantation sites

In recent years it has been increasingly suggested by developers that habitats of value to nature conservation (especially grasslands) should be moved if they are in the way of proposed developments. Various transplantation techniques have been attempted, with grasslands usually being moved either as turves or as mixtures of stripped topsoil and turf fragments (Byrne, 1990).

The claim being made is that a grassland can be successfully 'dismantled', the pieces (soils, plant and animal populations) moved to a new location and 'reassembled'. Such proposals are certainly technologically appealing, although they appear to ignore the fact that the way in which a grassland is constituted is very largely determined by the environmental context within which it has developed.

There have been many attempts at grassland transplantation (Prigmore, 1987; Buckley, 1989; Byrne, 1990), yet the monitoring data available are rarely sufficient to indicate whether or not they have been 'successful' according to nature conservation criteria. In order to address this problem, in 1987 NCC's England Field Unit (EFU) commenced long-term monitoring of eight grassland sites in England where transplantation was imminent (Leach et al, 1990). The sites chosen were generally of high (SSSI standard) nature conservation interest, and covered a range of plant-communities, soil types and management regimes. They also varied in the transplantation techniques to be employed: transplantation by turf cutting was to be used on all but one of the eight sites, while at three of these some of the grassland was also to be moved by topsoil stripping ('littering' or 'blading'), thereby allowing us to investigate the relative merits of the two techniques. In addition, on three sites some grassland was to be left in situ, giving us 'controls' against which to assess the transplanted swards.

Since April 1990 monitoring work at the transplantation sites has been carried out largely by EN Regional staff, and the Brocks Farm work has been undertaken by the Survey and Monitoring Unit in South West Region HQ.

1.2 Background to the Brocks Farm transplantation (based on Byrne, 1990)

In April 1985, English China Clays Limited (ECC) submitted a planning application to extend the area of winning and working of ball clay, and the tipping of waste, at its Newbridge Ball Clay Works. NCC and the Devon Wildlife Trust (then the Devon Trust for Nature Conservation) were consulted, and noted that the application included a proposal to tip waste over two adjoining fields (Fig. 1) known from a 1978 NCC-commissioned survey of meadows to be herb-rich. They were amongst the best remaining examples of Centaurea nigra[1] - Cynosurus cristatus mesotrophic grassland (NVC community MG5) in Devon. Several uncommon plant species were present, including Orchis morio and the nationally scarce Oenanthe pimpinelloides. These two fields, each approximately 1.6 ha in size, were at that time part of Brocks Farm.

NCC and the Devon Wildlife Trust objected to the two fields being tipped upon, and after much discussion a compromise was reached. The permission received by the Company, in July 1986, allowed for tipping to occur on just one of the herb-rich fields, the other to be left untouched. As a condition of the planning permission it was proposed that prior to tipping, 0.4 ha of turf from the field to be tipped on should be relocated to a site nearby, with the vegetation and topsoil from the remaining 1.2 ha being moved by 'littering' onto an equivalent-sized area of land adjacent to the turf receptor site. Also, it was agreed that the field left in situ would be managed by ECC to conserve its flora, with advice from NCC and the Devon Wildlife Trust. This field was later notified as an SSSI, in recognition of its outstanding nature conservation interest. A detailed survey in 1987 confirmed that the donor field and the SSSI field were floristically very similar. This survey is summarised in Leach (1988a), which also reviews the pre-1987 information that was held by NCC.

Neither field had been managed since ECC acquired the site and both were becoming rank. ECC cut both fields in 1987 and again prior to the transplant in 1988.

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1 Nomenclature in this report follows Kent (1992) for vascular plants, Smith (1978) for mosses, and Smith (1990) for liverworts. Bryophytes have been excluded from the analysis and the text, due to inconsistencies in their recording from year to year.

2. TRANSPLANTATION TECHNIQUES AND POST-TRANSPLANT MANAGEMENT

2.1 Techniques used for transplantation (based on Byrne, 1990)

ECC made detailed plans for the transplant operation, and visited another grassland transplantation site at Thrislington, Durham, to see the techniques used there.

Four soil pits were dug in the donor field, to establish depths of topsoil and subsoil to be reconstructed at the receptor site. An area of approximately 0.5 ha was selected and marked out for transplantation as turves, following surveys by EFU in September 1987 (Leach, 1988a) and May 1988 (Fig. 2). Topsoil and vegetation from the remainder of the donor field was spread on an area adjacent to the turf receptor area ('littering' operation). A small area, invaded by scrub, was not transplanted.

The plot to be moved as turves was cut with a flail mower during the second week of August 1988. The cut herbage was left on the ground in the belief that this would allow seeds to settle. This led to yellowing of the vegetation underneath and NCC asked that the litter be removed. This was done after the turf had been transplanted to the receptor area.

The receptor site was an area owned by ECC, about 1Km from the donor site (Fig. 3). Both donor and receptor sites were more or less flat. The donor site included a wetter area, and there was also a small wet area on the receptor site.

The turf transplant was carried out between 30 August and 14 October 1988. The topsoil and subsoil were stripped from the receptor area and from parts (but not all) of the donor site not being transplanted as turves. The subsoil from the donor site was then spread onto the turf receptor site and an adjacent area which was the receptor for the littered material. The receptor site was harrowed with a tractor and chain harrow. Once all the turves were in place, the site was rolled and watered as necessary.

Vegetation and soil from parts of the donor field not used in the turf transplant were used to create two littered areas. Subsoil from the donor field was transferred to the receptor site (littered receptor) with the subsoil for the turf receptor. The littering involved close cutting or flailing of the vegetation, followed by rotovation of the top 50cm of topsoil. The cuttings and topsoil were then picked up with an excavator and loaded into dump trucks for transport to the receptor area. The vehicles did not travel over the rotovated material. At the receptor site, the littered material was spread with a wide tracked "bog dozer". A similar littering operation was carried out in summer 1989, with vegetation and topsoil from the remaining portion of the donor field.

Further details of the transplant operations are recorded in Byrne (1990).

2.2 Post-transplant management

The turfed area was transplanted well enough to permit normal grassland management in 1989, although there was initially some doubt as to whether cutting machinery would cope with the slightly uneven surface. However, the area was successfully cut, but not baled, in 1989. From 1990 to 1992 the vegetation on the turf transplant was cut in summer, and the cut material removed.

1989 was a dry summer, and irrigation of the littered area was considered, although eventually rejected. It was considered almost impossible to arrange for irrigation sufficient to allow both germination and continued growth of seedlings in a soil which had probably already built up a considerable soil moisture deficit. Observations in 1990 suggested that this was probably a sensible decision. The littered area was not cut in 1989 or 1990 due to the sparseness of the vegetation, but was cut in 1991 and 1992.

The vegetation in the SSSI 'control' field was cut in summer every year from 1988 to 1992, and the cut material removed.

In 1992 a few sheep were apparently grazed for c.1 month in spring as a trial on all three plots.

3. METHODS

3.1 Field methods

NCC and EN monitoring concentrated on detailed repeat surveys of the vegetation in order to detect any changes in species composition and the relative abundance of species. It should be noted that the monitoring done at this site has not included other elements of the grassland ecosystem, such as macro-invertebrates and the microflora and fauna of the underlying soils. Furthermore, no attention has been paid to the aesthetic consequences of transplantation. These other aspects, however significant they may be, fell beyond the scope of the present study.

Methods used for the collection of floristic data are summarised in Table 1. In each year they have included: (1) The compilation of species lists with DAFOR estimates of species abundance (Appendix 1); (2) The assessment of species frequencies using large numbers of randomly located 10 x 10cm quadrats (see Leach & Doarks (1991) and Byrne (1991) for discussion of this method); and (3) The establishment (or re-recording) of permanent quadrats (until and including 1990).

Counts of Orchis morio were made in the years 1989 to 1992 on all three plots.

Throughout the study we have kept a photographic record using fixed-point photography.

3.2 Analytical methods

3.2.1 Species lists with DAFORs

Recent work by NCC (Leach, 1988b; Leach and Doarks, 1991) has questioned the usefulness of species lists with DAFOR abundance ratings as a monitoring technique, unless used for a small number of highly visible species. There is also the obvious problem that the data gathered are not readily amenable to statistical analysis. Nevertheless, such lists are of some value in determining the likely extinction or arrival of species, and in providing confirmatory evidence of changes in the abundance/frequency of species as revealed by quadrat sampling.

The DAFOR tables for the SSSI 'control' and turf transplant specifically omit those species which were only found close to the edge of the plots (within c.2m of the edge).

3.2.2 Frequency of species in randomly located 10 x 10cm quadrats

Analysis of variance (ANOVA) was used to identify statistically significant changes in the frequency of occurrence of species between 1989 and 1990, 1990 and 1991, 1991 and 1992, and 1989 and 1992 in the SSSI 'control' field, turf transplant and littered plot, and in addition between 1988 and 1989 in the SSSI field. Analysis of variance was not possible between the 1988 and 1989 data from the turf transplant and littered plot, as different sampling patterns and densities were used in the two years.

The data were also examined to pick out those species showing a 'considerable change' in percentage frequency values, but where the change fell short of being statistically significant using ANOVA. For the purposes of this report we defined a 'considerable change' as being one where the frequency had changed by a value of 10% or more, and/or where it had more than doubled or more than halved between the two years being compared. To qualify for consideration a species had to have a percentage frequency value of 4% or more in either of the years being compared (thereby excluding species with very low frequency values, where the change in percentage frequency was likely to have been spurious).