The second axis contrasts tall vegetation (height towards the top) with shorter vegetation. This largely follows a trend through time (Figure 4) as the effects of management (too confounded with height in this analysis to show separately) took hold.

The species shown in Figure 5 identify those characteristic of littering in a definitive manner. Species on the right of axis 1 indicate the effects of littering after the effects of all other variables have been removed and/or taken into account. The strongest are clearly gorse (ULEXEUR), lesser hawkbit (LEONTAR), scarlet pimpernel (ANAGARV), toad rush (JUNCBUF) and bristle club-rush (ISOSETA). These species were virtually absent from other treatments throughout. They increased as a group in the first year in the littered treatment and then fell back to approximately half the initial abundance, where they have remained ever since (Figure 6).

Although the analysis in Figures 3 and 5 shows that turf transplantation produced a significant effect, it is relatively inefficient at defining the changes involved. There are two reasons for this. First, effects of turf transplant are in danger of being swamped by the very large effect of littering. Second, differences between treatments over time could not be examined in the most efficient manner because there were different numbers of samples in treatments in different years.

Both these problems can be resolved by carrying out a separate analysis comparing turf transplant and controls alone, after transplant, when the strip numbers are identical across treatments and years. The existence of a turf transplant effect is already proven by the first analysis: its nature is explored further in the analysis which follows.

4.3 DCCA comparing turf transplant and controls

The analysis shown in Figures 7 to 9 uses the data from turf transplant and controls from 1989 to 1996, when all plots had a hay cut each year. Grazing was not started until 1992, so has been included as an explanatory variable. Only those effects of grazing which do not simply match changes over time can be included because the effect of year is removed as a covariable.

This analysis shows that the strongest single effect is the way in which year-to-year change differs between the turf transplant and SSSI control (Yea * Turf on Figure 7). This is much larger than the effect of 'turf transplant' itself. This result could be produced either by the turf transplant starting out very different and then recovering, or starting out with little change and having differences which accelerate. Figure 1 suggested, and the further analysis below shows, that the latter is the case.

The second axis (lesser importance) mainly contrasts tall and short swards, or that part of the variability in height which was not directly connected with the trend through time. The number of quadrats taken within a strip is also associated with axis 2.

The effect of grazing (as independent from the time trend with which it is connected and which has been removed from this analysis as a covariable) is a good example of an effect which is statistically significant but minute and unimportant. This does not mean that grazing does not affect the vegetation: it means that most of the effect was expressed through a temporal trend common to all treatments.

The positions of strips on the same axes are shown in Figure 8 and of species in Figure 9. Examination of Figure 8 shows clearly that species on the right in Figure 9 would be expected to be favoured in the turf transplant; those at top left to increase over time in the SSSI but not in the turf transplant.

This allows a derivation of two indicator lists which summarise the most important distinctions between the treatments, shown in Figure 9. Species associated with high values of the 'turf x time' variable should increase most in the turf transplant treatment, and vice versa. Lesser stitchwort (STELGRA), field horsetail (EQUIARV), tufted vetch (VICICRA), yellow rattle (RHINMIN) and lesser yellow trefoil (TRIFDUB) are the strongest 'turf transplant indicator species'. Ox-eye daisy (LEUCVUL), heath grass (DANTDEC) self-heal (PRUVULG), green-winged orchid (ORCHMOR) are examples of the contrasting 'SSSI increasing species'.

As with the litter species identified by CANOCO, these species were virtually absent from the vegetation before the transplant took place. Figure 10a shows the temporal pattern of average increase of transplant indicators across all strips and Figure 10b the contrasting indicators which increased in the SSSI control and failed to thrive in the turf transplant.

4.4 Species richness

In contrast, there was relatively little difference in species richness between treatments (Figure 11). The littered area in particular has tended to match the SSSI control, although species richness in the turf transplant fell slightly and has remained consistently below the remainder. This result is not unexpected. Although unimproved grasslands of high quality rarely have low species richness, high species richness is a frequent characteristic of disturbed or recovering sites (Gibson & Brown 1991). The type of species is therefore more important in defining the 'quality' of a grassland community than the total number of species considered irrespective of their type.

5. Conclusions

5.1 Littering

Littering caused a massive initial shift in species composition. At Brocks Farm this was associated with invasion of species not normally found in MG5, predominantly open-ground species, including those associated with both wet and dry conditions.

This shift was followed by an initial quick return towards the original vegetation and then a slower process of recovery which continued up to 1996. It is not possible to say how long the effects will remain detectable for but after nine years the area is still clearly distinct and is recognised as damaged by the persistence of a set of species which are not characteristic of MG5 grassland. Further, there is no sign of these litter indicator species declining (Figure 6).

Recovery was represented instead by the increase and/or recovery of species which are characteristic of MG5 grassland. A few, such as green winged orchid, have increased considerably, others are recovering to levels more like those in the managed SSSI control

(Leach *et al* 1997). Increasing species have tended to be those which, like many orchids (Bradshaw 1983), can take advantage of open conditions.

5.2 Turf transplant

The turf transplant at Brocks Farm caused only a small initial deviation from the SSSI control. However, this was the precursor to substantial damage which took several years to become apparent and is still increasing. This may be caused by one or more of the following factors: differences in edaphic conditions including soil structure and hydrology, disruption of mycorrhizal associations and changes in the balance of competition between the component species, eg the effects of 'root-pruning'. There may also be unknown factors contributing to the effects of turf transplantation.

The strongest indicators of difference are contained in two sets of species. One group includes species which are largely MG5 preferentials and this group increased in the SSSI control following reimposition of appropriate management to all treatments, but failed to increase in the turf transplant. The second group, a mixture of species which do not occur in MG5 or are MG5 associates which normally occur at low frequency and abundance, increase in the turf transplant area and remain rare or absent in the SSSI control.

The net effect of transplantation at Brocks Farm has been to produce a community which is less like the best quality MG5 grasslands than the SSSI control and which continues to diverge from it.

5.3 Acceptability of translocation

The results of this analysis show that substantial, persistent and increasing (in the case of turf transplant) damage occurred to the special interest of the MG5 grassland community even when the best available practice was followed.

Other studies (eg in Buckley 1989) have claimed success in transplanting grasslands. None of these appear to have applied methods of community analysis such as those presented here and none have been able to use a long enough monitoring period to detect the accelerating damage to the turf transplant area seen at Brocks Farm.

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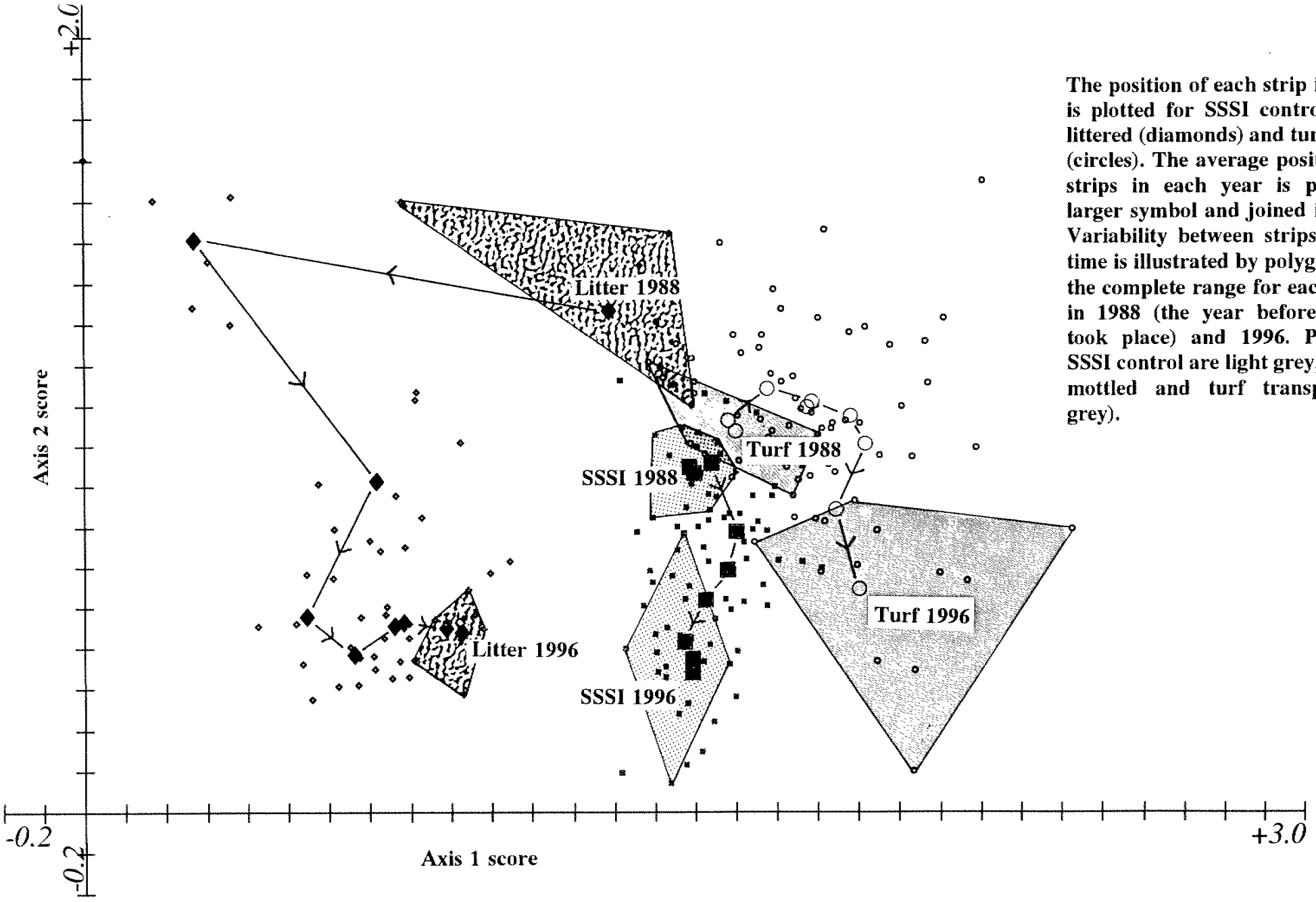
Appendix 1. Plant species from Brocks Farm showing acronyms used in the Figures

Acronym	Latin name	English name
ACHIMIL	*Achillea millefolium*	Yarrow
AGRCANI	*Agrostis canina*	Brown Bent-grass
AGRCAPI	*Agrostis capillaris*	Common Bent-grass
AGRIMEU	*Agrimonia eupatoria*	Agrimony
AGRSTOL	*Agrostis stolonifera*	Creeping Bent
AJUGREP	*Ajuga reptans*	Bugle
ALOPRAT	*Alopecurus pratensis*	Meadow Foxtail
ANAGARV	*Anagallis arvensis*	Scarlet pimpernel
ANTHODO	*Anthoxanthum odoratum*	Sweet Vernal-grass
ARRELAT	*Arrhenatherum elatius*	False Oat-grass
BELPERR	*Bellis perennis*	Common Daisy
BRIMEDI	*Briza media*	Quaking-grass
BROMOLL	*Bromus hordeaceus* Subsp. *hordeaceus*	Lop-grass
BRORACE	*Bromus racemosus*	Smooth Brome
CALVULG	*Calluna vulgaris*	Heather
CARDPRA	*Cardamine pratensis*	Cuckoo Flower
CARECAR	*Carex caryophyllea*	Spring Sedge
CAREDEM	*Carex demissa*	Common Yellow-sedge
CAREFLA	*Carex flacca*	Glaucous Sedge
CAREHIR	*Carex hirta*	Hairy Sedge
CAREOVA	*Carex ovalis*	Oval Sedge
CAREPAN	*Carex panicea*	Carnation Sedge
CAREPUL	*Carex pulicaris*	Flea Sedge
CENTERY	*Centaurium erythraea*	Common Centaury
CENTNIG	*Centaurea nigra*	Hardheads
CERFONT	*Cerastium fontanum* Subsp. *triviale*	Common mouse-ear chickweed
CIRARVE	*Cirsium arvense*	Creeping Thistle
CIRPALU	*Cirsium palustre*	Marsh Thistle
CIRVULG	*Cirsium vulgare*	Spear Thistle
CRATMON	*Crataegus monogyna (g)*	Hawthorn
CREPCAP	*Crepis capillaris*	Smooth Hawksbeard
CYNCRIS	*Cynosurus cristatus*	Crested Dogstail
DACGLOM	*Dactylis glomerata*	Cocksfoot
DACTFUC	*Dactylorhiza fuchsii*	Common Spotted Orchid

Acronym	Latin name	English name
DACTPRA	*Dactylorhiza majalis ssp. pratermissa*	Southern marsh Orchid
DANTDEC	*Danthonia decumbens*	Heath Grass
DESCAES	*Dechampsia caespitosa*	Tufted hair-grass
ELYREPE	*Elymus repens*	Couch-grass
EQUIARV	*Equisetum arvense*	Field Horsetail
FESARUN	*Festuca arundinacea*	Tall Fescue
FESPRAT	*Festuca pratensis*	Meadow Fescue
FESRUBR	*Festuca rubra*	Red Fescue
GALAPAR	*Galium aparine*	Cleavers/Goosegrass
GALMOLL	*Galium mollugo*	Hedge Bedstraw
GALPALU	*Galium palustre*	Marsh Bedstraw
GLECHED	*Glechoma hederacea*	Ground-ivy
GLYCFLU	*Glyceria fluitans*	Floating Sweet-grass
HERASPH	*Heracleum sphondylium*	Hogweed
HOLCLAN	*Holcus lanatus*	Yorkshire Fog
HOLCMOL	*Holcus mollis*	Creeping Soft-grass
HYPHUMI	*Hypericum humifusum*	Trailing St John's-wort
HYPORAD	*Hypochaeris radicata*	Cat's-ear
HYPPULC	*Hypericum pulchrum*	Slender St John's-Wort
HYPTETR	*Hypericum tetrapterum*	Square-stalked St John's-wort
ISOSETA	*Isolepis setacea*	Bristle clubrush
JUNCACU	*Juncus acutiflorus*	Sharp-flowered Rush
JUNCART	*Juncus articulatus*	Jointed Rush
JUNCBUF	*Juncus bufonius*	Toad Rush
JUNCCON	*Juncus conglomeratus*	Compact Rush
JUNCEFF	*Juncus effusus*	Soft Rush
JUNCINF	*Juncus inflexus*	Hard Rush
LATHPRA	*Lathyrus pratensis*	Meadow Vetchling
LEONAUT	*Leontodon autumnalis*	Autumnal Hawkbit
LEONTAR	*Leontodon taraxacoides*	Hairy Hawkbit
LEUCVUL	*Leucanthemum vulgare*	Ox-eye daisy
LINUCAT	*Linum catharticum*	Fairy Flax
LOLPERR	*Lolium perenne*	Perennial Rye-grass
LOTCORN	*Lotus corniculatus*	Common Birdsfoot-trefoil
LOTULIG	*Lotus uliginosus*	Large Birdsfoot-trefoil
LUZCAMP	*Luzula campestris*	Field Woodrush
MENTAQU	*Mentha aquatica*	Water Mint
MENTOTH	*Mentha sp.*	

Acronym	Latin name	English name
MOLCAER	*Molinia caerulea*	Purple Moor-grass
MONTFON	*Montia fontana*	Blinks
OENPIMP	*Oenanthe pimpinelloides*	Corky-fruited water dropwort
ORCHMOR	*Orchis morio*	Green-winged Orchid
PHLEPRA	*Phleum pratense*	Cat's-tail
PLANLAN	*Plantago lanceolata*	Ribwort Plantain
PLANMAJ	*Plantago major*	Greater Plantain
POAPRAT	*Poa pratensis /subcaerulea*	Smooth Meadow-grass/Spreading Meadow-grass
POATRIV	*Poa trivialis*	Rough Meadow-grass
POLVULG	*Polygala vulgaris*	Common Milkwort
POTANSE	*Potentilla anserina*	Silverweed
POTEREC	*Potentilla erecta*	Tormentil
POTREPT	*Potentilla reptans*	Creeping Cinquefoil
PRUSPIN	*Prunus spinosa (g)*	Blackthorn
PRUVULG	*Prunella vulgaris*	Selfheal
PTERAQU	*Pteridium aquilinum*	Bracken
PULIDYS	*Pulicaria dysenterica*	Fleabane
QUERCSP	*Quercus seedling/sp*	Oak
RANACRI	*Ranunculus acris*	Meadow Buttercup
RANBULB	*Ranunculus bulbosus*	Bulbous Buttercup
RANFICA	*Ranunculus ficaria*	Lesser Celandine
RANFLAM	*Ranunculus flammula*	Lesser Spearwort
RANREPE	*Ranunculus repens*	Creeping Buttercup
RANUSPP	*Ranunculus sp.*	
RHINMIN	*Rhinanthus minor*	Yellow Rattle
ROSACAN	*Rosa canina (g)*	Wild rose
RUBFRUT	*Rubus fruticosus sens.lat.*	Bramble
RUMACEL	*Rumex acetosella*	Sheep's Sorrel
RUMACET	*Rumex acetosa*	Sorrel
SAGIPRO	*Sagina procumbens*	Procumbent Pearlwort
SALCINE	*Salix cinerea*	Grey Willow
SENERUC	*Senecio erucifolius*	Hoary Ragwort
SENJACO	*Senecio jacobaea*	Ragwort
STACARV	*Stachys arvensis*	Field woundwort
STELALS	*Stellaria alsine*	Bog Stitchwort
STELGRA	*Stellaria graminea*	Lesser Stitchwort
STELHOL	*Stellaria holostea*	Greater Stitchwort

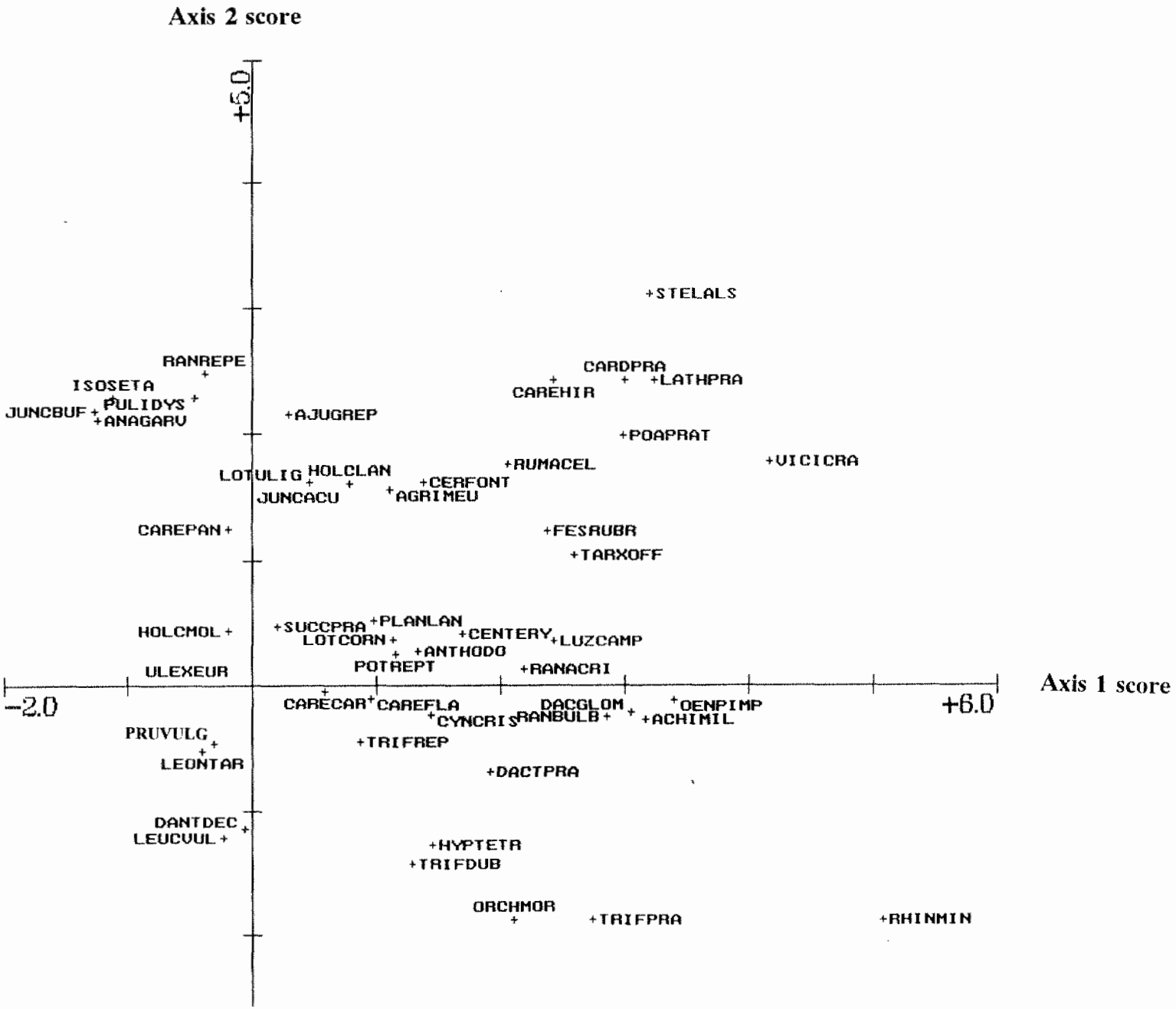
Acronym	Latin name	English name
SUCCPRA	*Succisa pratensis*	Devil's-bit Scabious
TARXOFF	*Taraxacum seedling/sp*	Dandelion
TRIFDUB	*Trifolium dubium*	Lesser Trefoil
TRIFMED	*Trifolium medium*	Zigzag Clover
TRIFPRA	*Trifolium pratense*	Red Clover
TRIFREP	*Trifolium repens*	White Clover
ULEXEUR	*Ulex europaeus*	Gorse
VERCHAM	*Veronica chamaedrys*	Germander Speedwell
VERSERP	*Veronica serpyllifolia*	Thyme-leaved Speedwell
VICICRA	*Vicia cracca*	Tufted Vetch
VICISAT	*Vicia sativa* Subsp. *nigra*	Common vetch
VIORIVI	*Viola riviniana*	Common Dog-violet



The position of each strip in each year is plotted for SSSI control (squares), littered (diamonds) and turf transplant (circles). The average position over <u>all</u> strips in each year is plotted as a larger symbol and joined in sequence. Variability between strips at a single time is illustrated by polygons showing the complete range for each treatment in 1988 (the year before treatments took place) and 1996. Polygons for SSSI control are light grey, littered are mottled and turf transplant (dark grey).

Figure 1: Sample positions on DCA ordination of all Brocks Farm data

Figure 2: Species scores on the same ordination as Figure 1



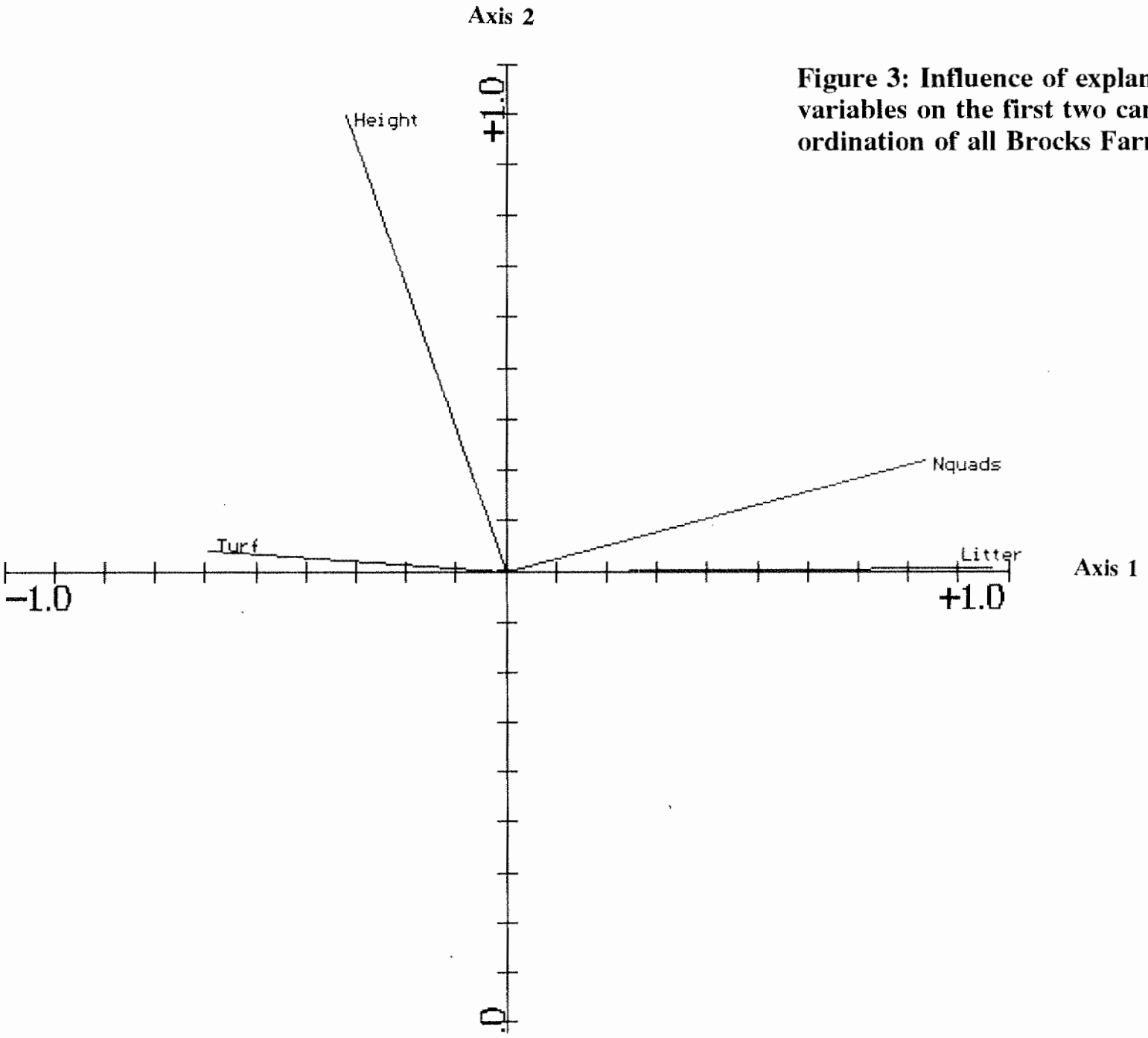
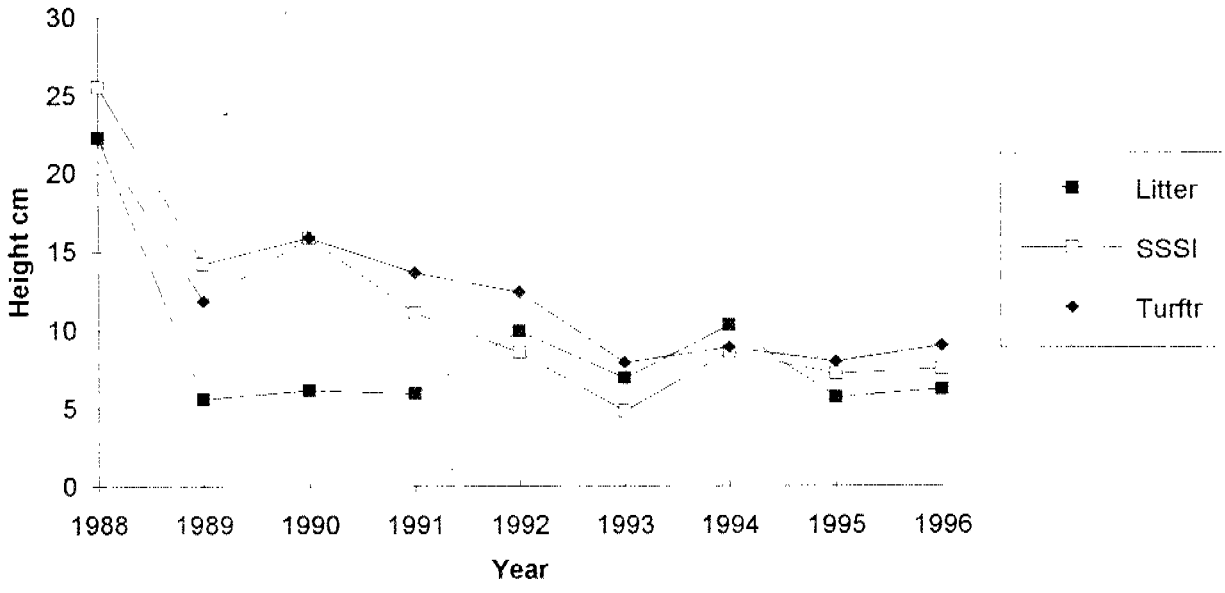


Figure 3: Influence of explanatory (environmental) variables on the first two canonical axes of a DCCA ordination of all Brocks Farm data

Figure 4: Changes in the turf height over time at Brocks Farm



Axis 2

Figure 5: Position of species on the same DCCA ordination as Figure 3

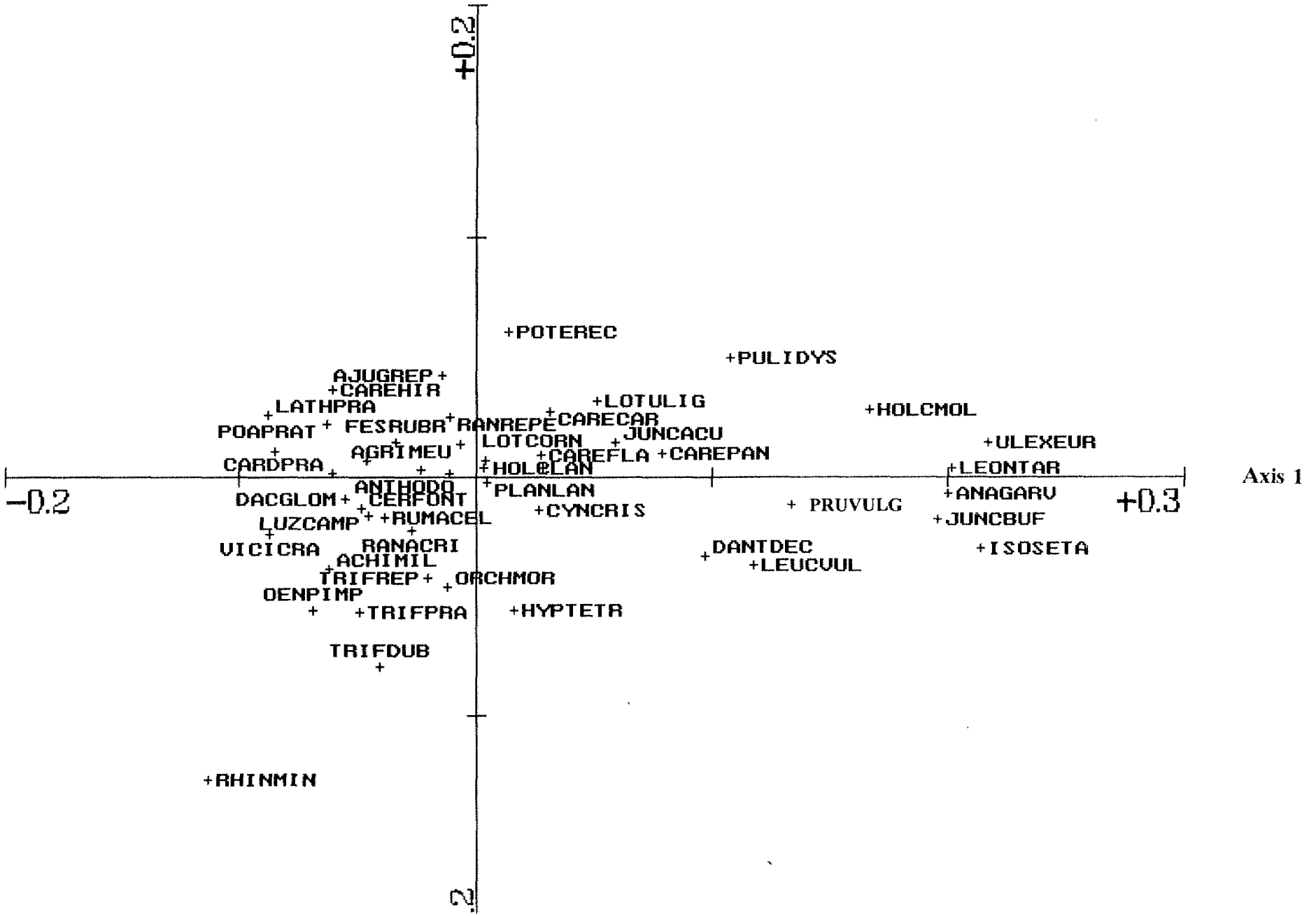
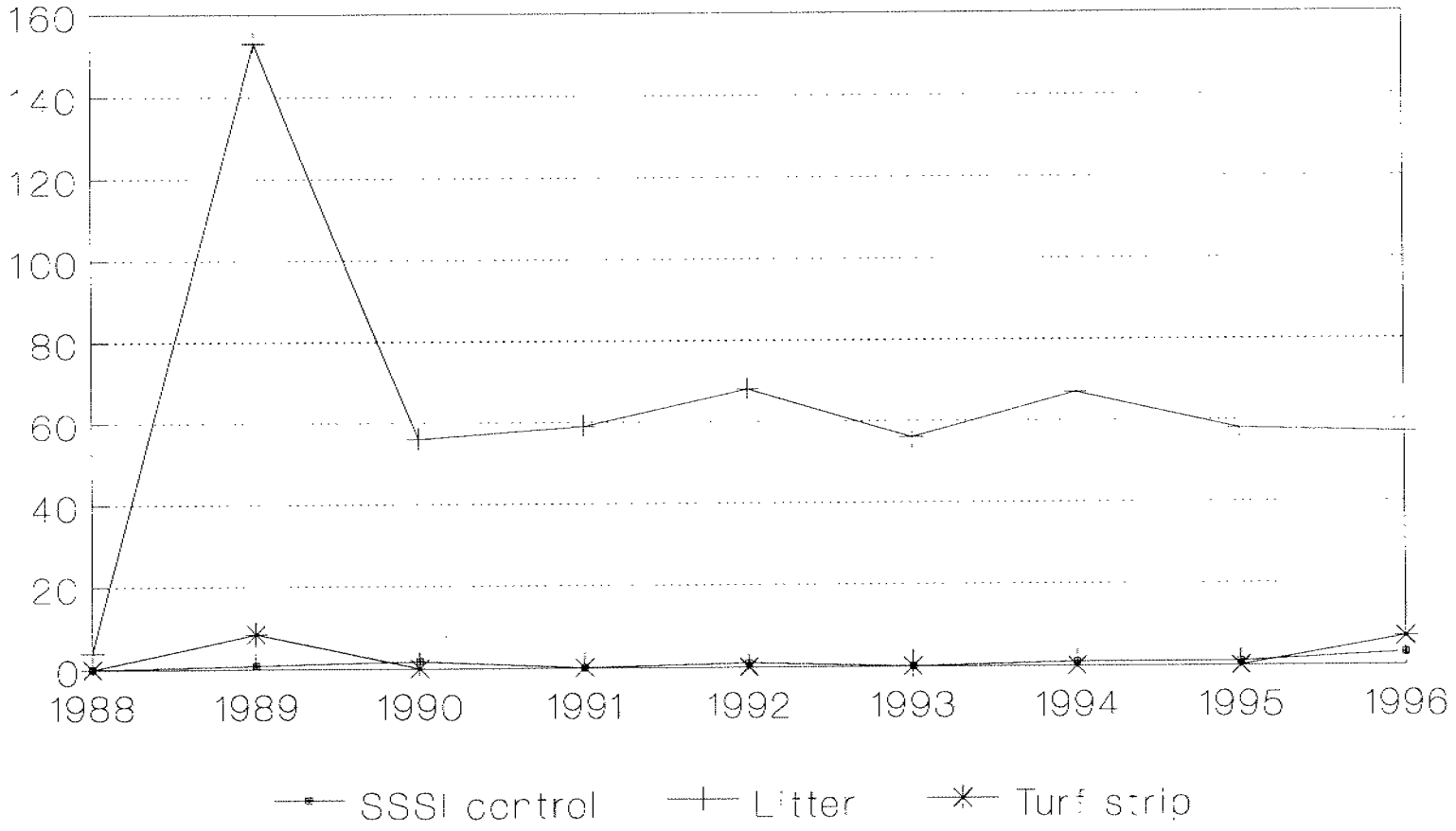


Figure 6

Brocks Farm translocation

Canoco's litter species



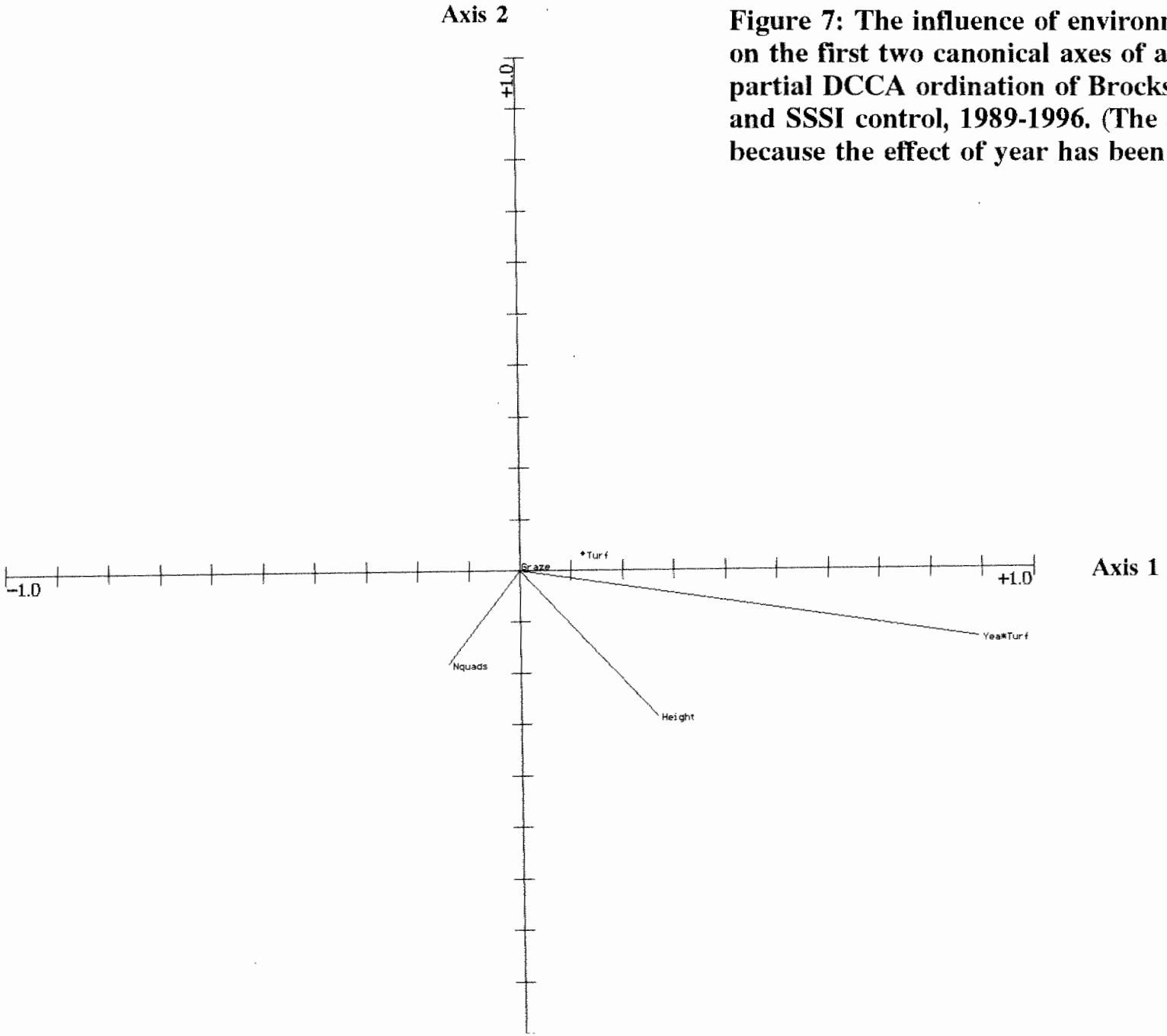
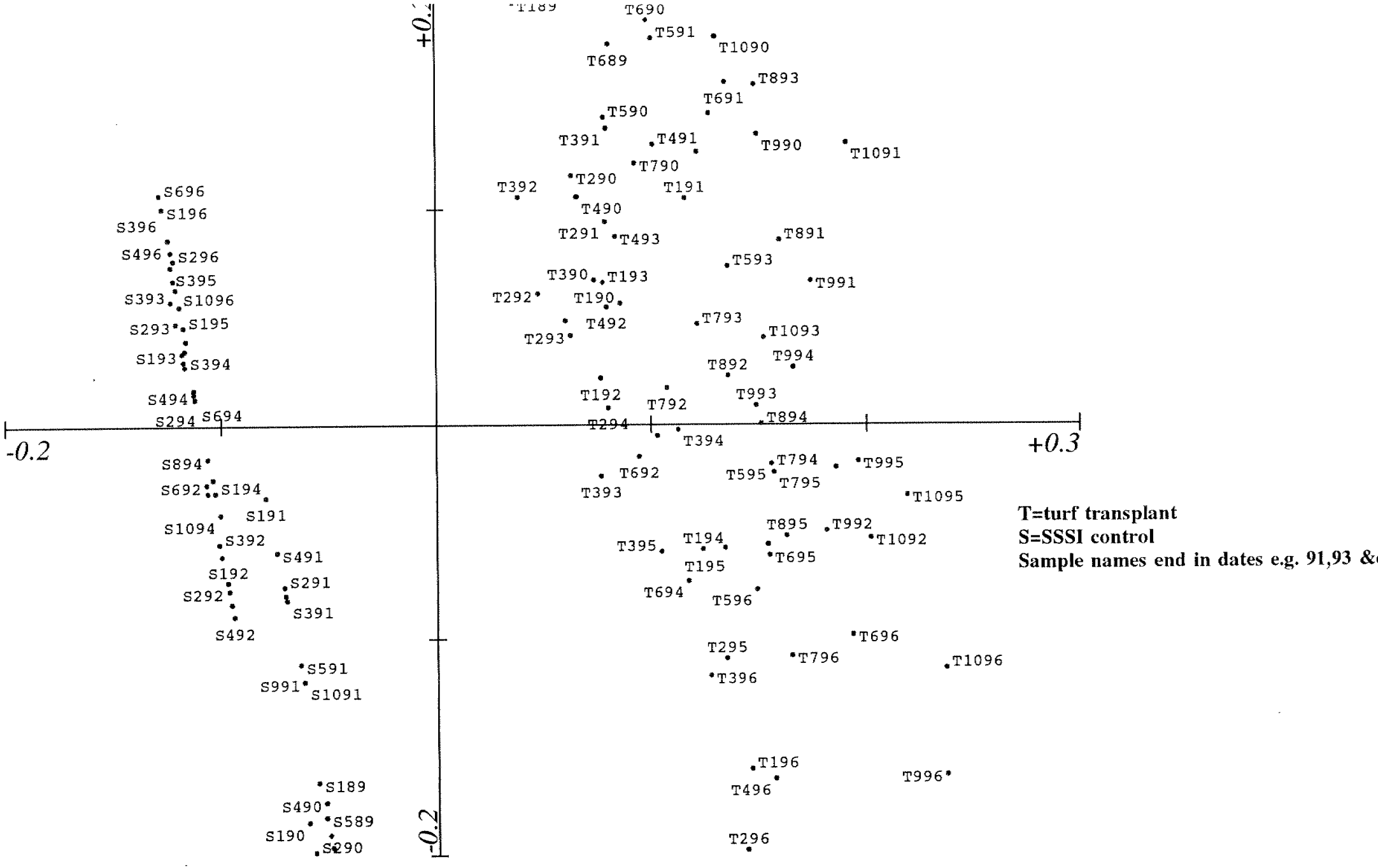


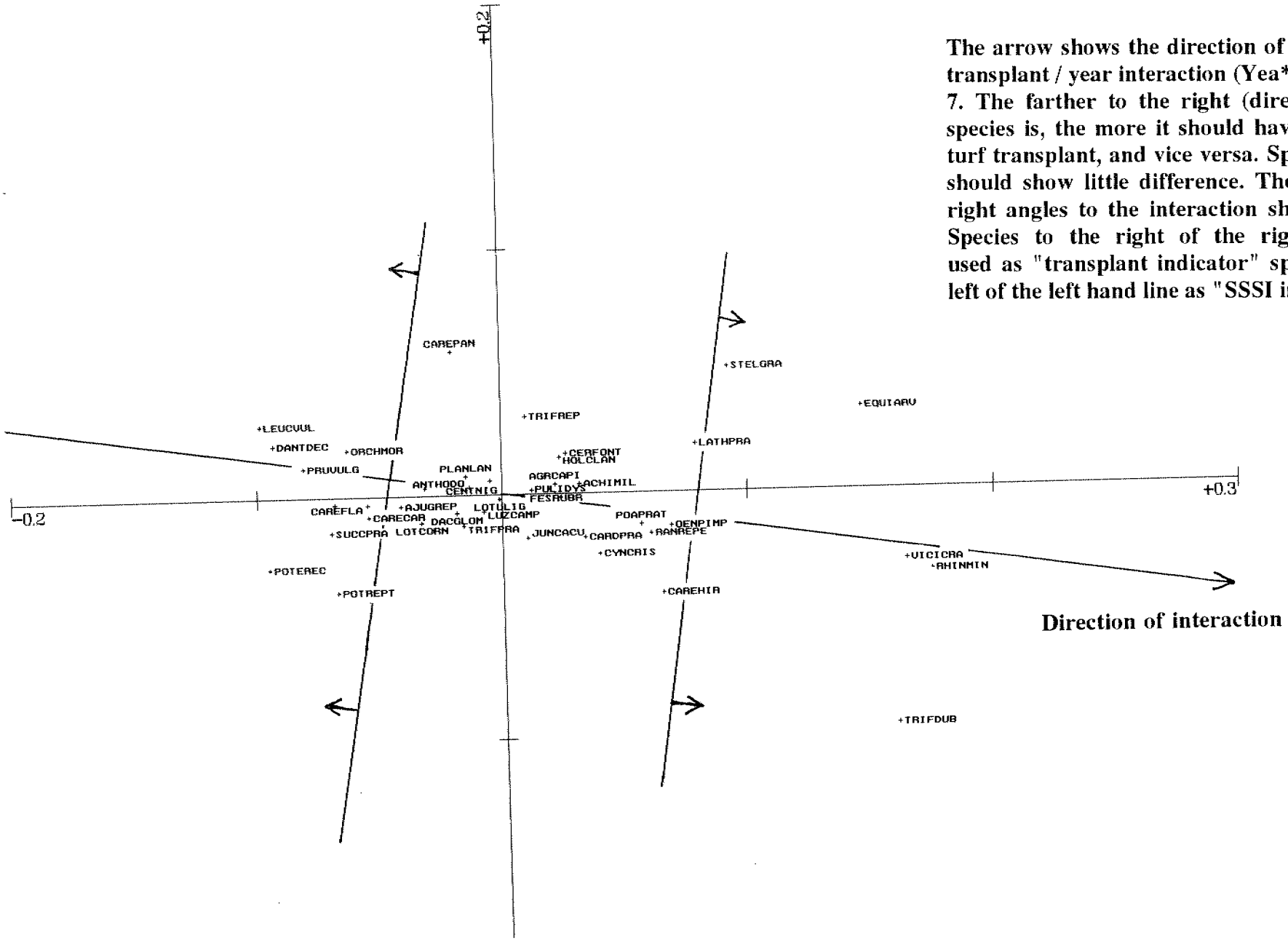
Figure 7: The influence of environmental variables on the first two canonical axes of a partial DCCA ordination of Brocks Farm turf transplant and SSSI control, 1989-1996. (The analysis is 'partial' because the effect of year has been removed as a covariable).



T=turf transplant
S=SSSI control
Sample names end in dates e.g. 91,93 &c

Figure 8: The positions of sample strips on the same ordination as Figure 7

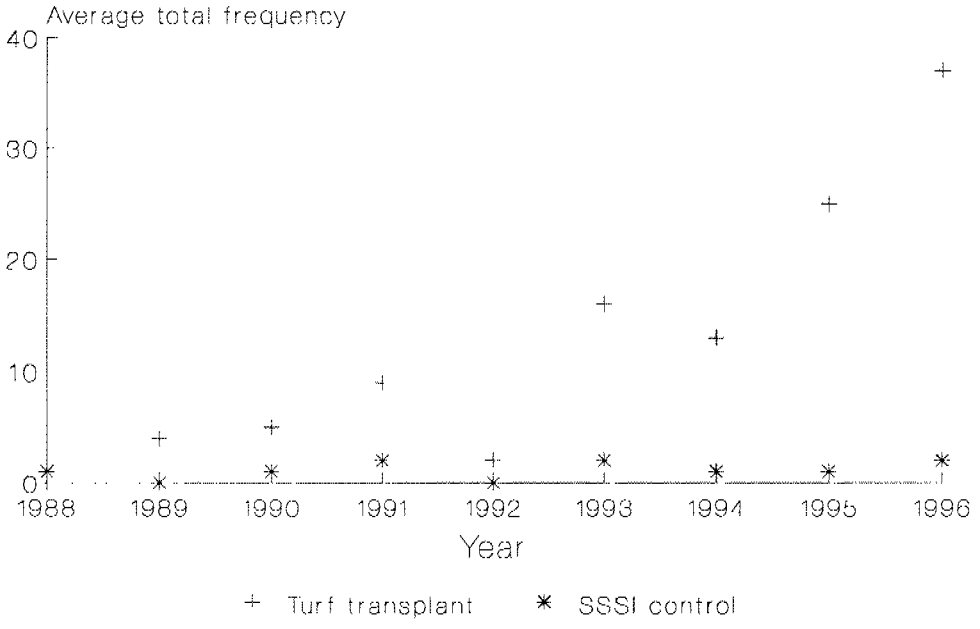
Figure 9: The position of species on the same ordination as Figure 7



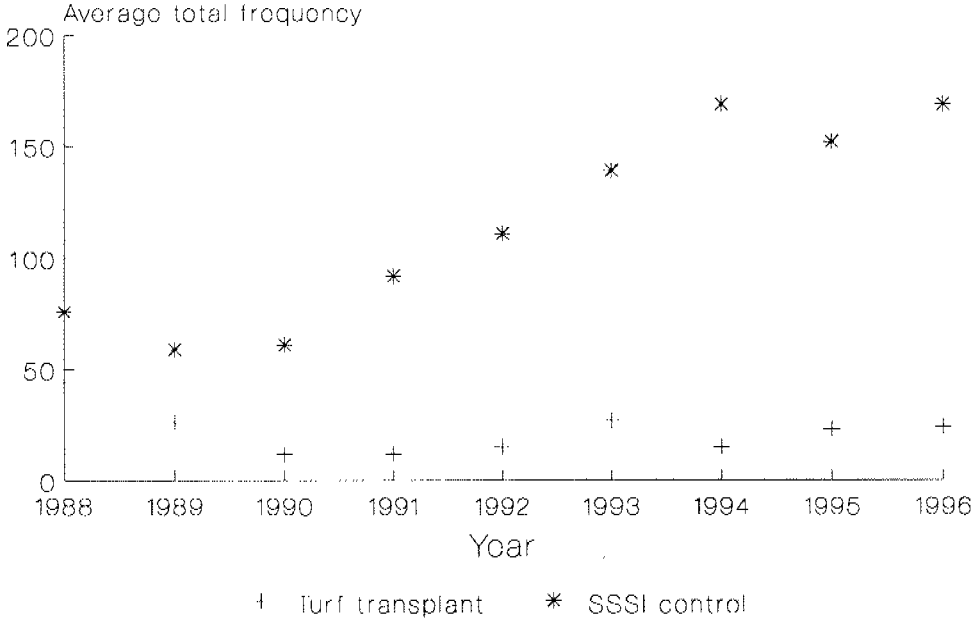
The arrow shows the direction of action of the Turf transplant / year interaction (Yea*Turf) from Figure 7. The farther to the right (direction of arrow) a species is, the more it should have increased in the turf transplant, and vice versa. Species in the centre should show little difference. The arrowed lines at right angles to the interaction show cut off points. Species to the right of the right hand line are used as "transplant indicator" species, those to the left of the left hand line as "SSSI increasing" species.

Direction of interaction

Figure 10

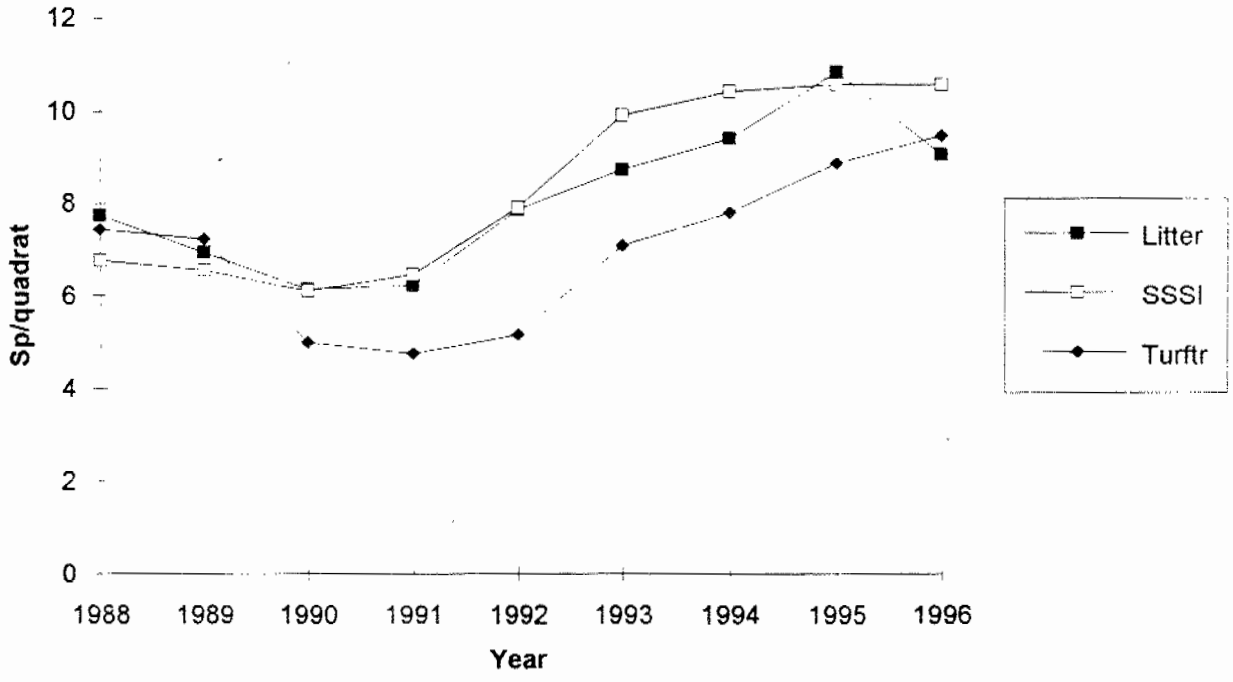


a) Turf transplant indicator species



b) SSSI increasing species

Figure 11: Brocks Farm translocations: species per 10cm square quadrat



Appendix 6 (EN 13)

Brocks Farm SSSI: NVC Quadrats May 1997

	Quadrats						
Species name	**1**	**2**	**3**	**4**	**5**	**6**	**Constancy**
Agrostis capillaris	1	4	3	3	2	5	5
Anthoxanthum odoratum	8	6	5	5	4	5	5
Danthonia decumbens	5	3	4	4	1	3	5
Festuca rubra	8	5	6	-	7	8	5
Holcus lanatus	2	3	3	3	3	4	5
Carex caryophyllea	4	1	3	4	-	2	5
Carex flacca	1	3	2	-	1	3	5
Carex panicea	3	-	4	-	-	1	3
Carex pulicaris	1	-	-	-	-	-	1
Centaurea nigra	3	3	3	3	3	3	5
Hypochaeris radicata	3	3	4	4	4	4	5
Leontodon saxatilis	1	-	3	1	-	1	4
Leucanthemum vulgare	3	3	-	3	2	3	5
Lotus corniculatus	4	3	4	3	3	4	5
Luzula campestris	1	4	3	2	3	3	5
Orchis morio	2	2	1	2	3	3	5
Plantago lanceolata	3	4	5	3	5	5	5
Potentilla reptans	2	3	3	1	2	1	5
Prunella vulgaris	1	1	3	1	3	-	5
Ranunculus acris	3	4	3	2	2	1	5
Ranunculus bulbosus	4	4	-	2	4	4	5
Senecio jacobaea	1	-	-	-	1	-	2
Succisa pratensis	3	-	-	-	-	2	2
Taraxacum sp.	1	3	1	1	2	2	5
Trifolium pratense	3	4	3	2	-	-	4
Brachythecium rutabulum	1	1	3	2	2	2	5
Briza media	-	1	-	-	-	-	1
Dactylis glomerata	-	3	-	2	4	2	4
Poa humilis	-	2	2	-	-	1	3
Juncus acutiflorus	-	4	2	3	-	-	3
Lathyrus pratensis	-	3	-	-	-	-	1
Oenanthe pimpinelloides	-	2	2	3	2	1	5
Pulicaria dysenterica	-	3	-	-	-	-	1
Rumex acetosa	-	3	1	-	2	1	4
Cirsium palustre	-	-	1	-	-	-	1
Dactylorhiza fuchsii	-	-	1	-	-	-	1
Dactylorhiza praetermissa	-	1	3	1	2	-	4
Juncus effusus	-	-	2	-	-	-	1
Lotus pedunculatus	-	-	2	-	-	-	1
Senecio erucifolius	-	-	2	-	-	-	1
Achillea millefolium	-	-	-	3	-	-	1
Linum catharticum	-	-	-	1	-	-	1
Pseudoscleropodium purum	-	-	-	3	-	-	1
Rhytidiadelphus squarrosus	-	-	-	2	-	-	1
Cynosurus cristatus	-	-	-	-	1	-	1
Crataegus monogyna	-	-	-	-	1	-	1
Lophocola sp	-	-	-	-	1	-	1
Eurynchium praelongum	-	-	-	-	-	2	1
Number of speices per sample	**26**	**30**	**31**	**28**	**27**	**28**	