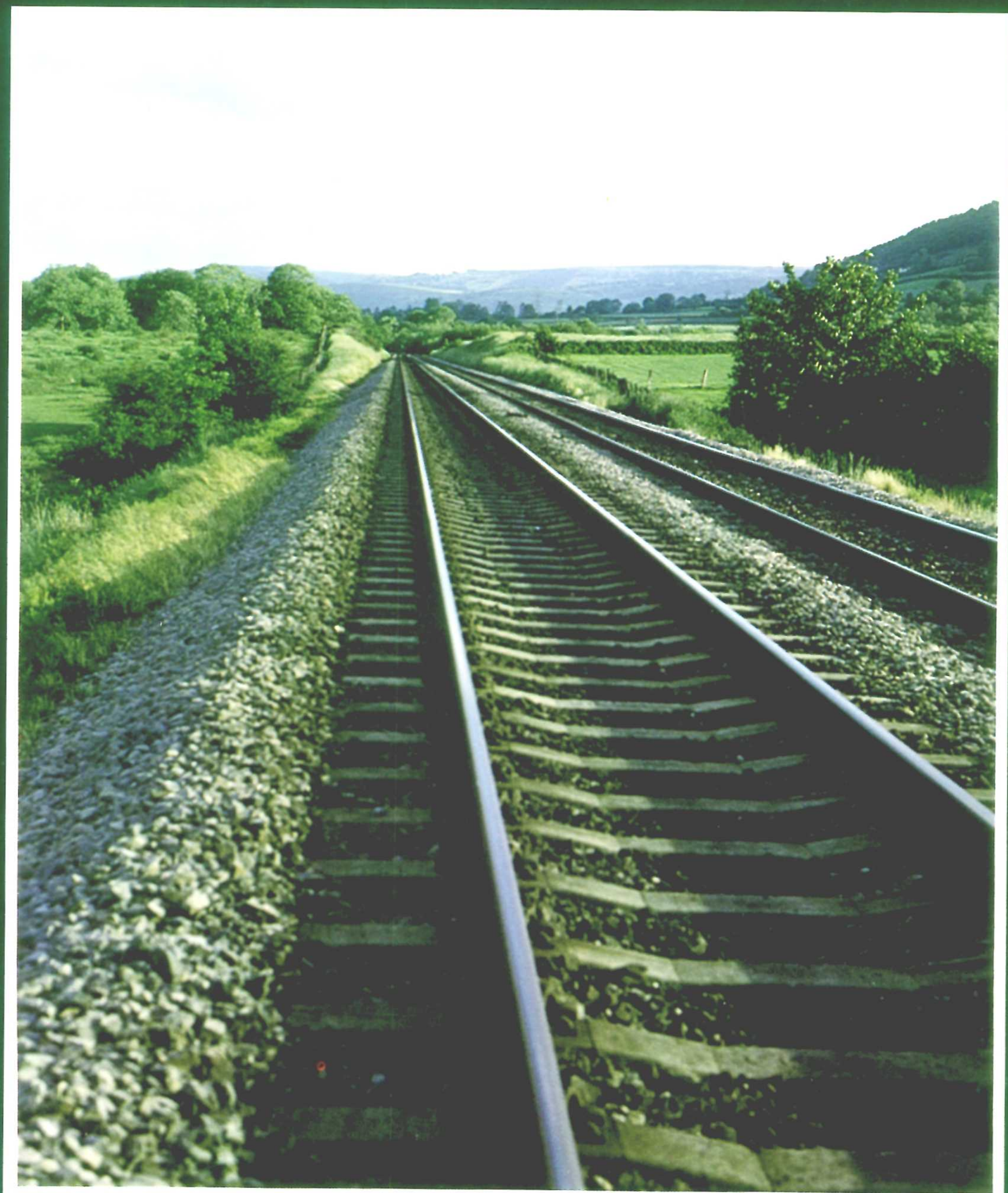
Britain's railway vegetation



Institute of Terrestrial Ecology

Natural Environment Research Council

Natural Environment Research Council

Institute of Terrestrial Ecology

Britain's railway vegetation

Caroline Sargent

Institute of Terrestrial Ecology
Monks Wood Experimental Station
Abbots Ripton
Huntingdon

Printed in Great Britain by
The Cambrian News, Aberystwyth

Published in 1984 by
Institute of Terrestrial Ecology
68 Hills Road
Cambridge
CB2 1LA

ISBN 0 904282 76 7

Cover photograph shows a stretch of the Western Region railway near Abergavenny

The *Institute of Terrestrial Ecology (ITE)* was established in 1973, from the former Nature Conservancy's research stations and staff, joined later by the Institute of Tree Biology and the Culture Centre of Algae and Protozoa. ITE contributes to, and draws upon, the collective knowledge of the 14 sister institutes which make up the *Natural Environment Research Council*, spanning all the environmental sciences.

The Institute studies the factors determining the structure, composition and processes of land and freshwater systems, and of individual plant and animal species. It is developing a sounder scientific basis for predicting and modelling environmental trends arising from natural or man-made change. The results of this research are available to those responsible for the protection, management and wise use of our natural resources.

One quarter of ITE's work is research commissioned by customers, such as the Department of Environment, the European Economic Community, the Nature Conservancy Council and the Overseas Development Administration. The remainder is fundamental research supported by NERC.

ITE's expertise is widely used by international organizations in overseas projects and programmes of research.

Dr Caroline Sargent
Institute of Terrestrial Ecology
Monks Wood Experimental Station
Abbots Ripton
HUNTINGDON
Cambs
PE17 2LS
048 73 (Abbots Ripton) 381

Contents

ACKNOWLEDGEMENTS

This project was begun in 1976 by Dr Michael Way (now at MAFF), and has been very much a question of team work, on which it is my privilege to report.

Without the close co-operation of BR, and especially of Mr Christopher Beagley (BRB HQ), who gave freely of his time and attention, this work would almost certainly have foundered.

Particular appreciation is felt for the enthusiasm and competence shown by Mr Owen Mountford during data collection and the documentation of sites of Biological Interest. Dr Dorian Moss, Dr Robert Bunce, Mr Ken Lakhani, Mr Jeff Moller (all ITE) and Dr Brian Huntley (Durham University) gave invaluable analytical and statistical advice and assistance with computing. Dr Steve Chapman (ITE) kindly oversaw the project during 1977, and Mr John Killick (NERC) has given constant encouragement and help.

During each field season a student was attached to the project and I would like to thank the following for their useful and enthusiastic contributions:
Mr Ian Bolt, Bath; Mr Alan Lawes, UWIST; Mr Alan Marsden, Brunel; Mr Brendan Carleton, Bath; Mr Jonathan Harris, UWIST; Mr Jonathan Turner, Plymouth.

I am also most grateful to Mr John Jeffers and Dr Jack Dempster for critically reading the manuscript. The graphs and the drawings were prepared by Miss Susan Nicholson and Mr Andrew Foy, both of Luton College, and the digitized maps by Mr David Catlow at the Experimental Cartography Unit (NERC). The manuscript was kindly typed by Mrs Julie Delve, Miss Jayne Abblitt and Mrs Penny Ward, to all of whom my especial thanks are due.

1. Introduction

"The railways were built with the idea that they would make the countryside more beautiful."

Sir John Betjeman, 1979
BBC Radio Broadcast

Much of the past interest in railway botany has been in the study of adventive plants. Whilst describing the flora of Thalkirchen Station (near Münich), Kreutzpointner (1876) gave the earliest account of the introduction of alien species with rail traffic. Thellung (1905) showed that a large proportion of introductions into Switzerland was associated with the railway (which, at that time, carried the greater bulk of goods), although Lehmann (1895) had earlier recognized that railways were also interesting from the point of view of the native flora. Working in Latvia, he noted certain meadow species growing along embankments, where they had been transported with sod, or soil, during construction. He was able to tell the origin of ballasting materials by the plants he found. Matthies (1925) made an important contribution to railway botany by considering the effects of construction, management, aspect and slope on the distribution of species. Much recent floristic work in Europe has followed this approach (eg Lejmbach *et al.* 1965; Lienenbecker & Raabe 1981; Niemi 1969; Westhoff 1964). The literature has been reviewed by Muehlenbach (1979), who also gives a very detailed account of the adventive flora of the St. Louis (Missouri) railway yards and tracks.

In Britain, 2 important studies have been made. Dony (1955, 1974) describes the flora of railway lines in Bedfordshire, paying particular attention to adventives and to plants introduced with shoddy for the Luton wool industry, whilst Messenger (1968) has made a careful study of the flora of the railway in Rutland.

Additionally, the majority of County Floras (especially in England and Wales) cite plants from railway habitats. However, when the use of chemical weed control along verges was questioned in Parliament (Parliamentary Debates 1961), it became apparent that insufficient was known about the quality, structure and distribution of vegetation on British Rail (BR) land.

In attempting to provide such baseline information, the Institute of Terrestrial Ecology (ITE), under contract with the Nature Conservancy Council (NCC), structured a survey in which the following questions were asked.

1. What kinds of habitats occur and what areas do they cover? There are distinct differences between cess (permanent way) and verge, but is the slope, aspect or kind (cutting or embankment) of engineered formation important in determining the distribution of vegetation (and hence animals)? What are the important effects of management and disturbance?

2. Does the railway provide a refuge? Which species move along, or are blocked by, this linear environment?

3. What kinds of vegetation occur? Are these associations unique to the railway, or are they essentially continuous with neighbouring forms?

4. Is the system comparatively stable, or are irreversible changes occurring? Is intervention needed to prevent such change or to protect particular areas?

The survey took place between 1977 and 1981, and its outcome is reported in the present publication.

2. The railway environment and sampling

2.1 Introduction

BR lines in use at present extend for 18 000 km (11 300 miles). For safety reasons, the survey, which was carried out with full co-operation from BR, was restricted to verges bordering the 14 000 km (8900 miles) of rural or semi-rural track. Observations along the cess were made, although systematic sampling was prohibited. In this chapter, the range of habitats, divided loosely into 'cess' and 'verges', is discussed, and the methods evolved for sampling vegetation along this diverse linear environment are described.

2.2 The railway cess

The cess (Plate 1.2) is usually defined as the freely draining area of cindery material over which ballast (the track bed) and rails are laid. The cinder is usually exposed between tracks and in station and shunting yards. Here, the sense has been extended to include all engineered railway habitats in which desiccation limits the development and diversity of the flora. These are the stressed habitats (*sensu* Grime 1979) and include, together with cinder and ballast (*in situ* and discarded along verges), masonry and rock cuttings.

Ballast is composed of rock chippings, not usually more than 10 cm (4 inches) in diameter in any one plane. Until recently, most limestones were considered suitable as ballast, but it has been found that many of these have a higher attrition rate when below concrete sleepers, and greater use is now being made of igneous material. When the ballast eventually breaks down into fine particles or becomes polluted with plant litter or oily and nitrogenous wastes from trains, drainage becomes impeded. This can lead to a reduced support of the sleepers, reduced life of timber sleepers, and a softening and eventual failure of the subsoil below. The ballast is therefore sieved or replaced as necessary and the spent material is spread on to the adjacent verge or is loaded away to tip by train.

The term 'masonry' includes tunnel mouths, bridges, platforms, buildings, and concrete posts and sleepers. Particularly in East Anglia, where natural rock outcrops are scarce, these areas provide habitats which support interesting additions to the flora (Walters 1969; Dony 1974).

Rock cuttings expose a wide variety of surfaces. Where the material is soft or unstable, as with chalk or some shales and sandstones, cuttings are engineered at considerably less than 90°. Elsewhere, the walls may approach vertical. Marked differences are observed between predominantly northern and southern aspects.

As along sand/shingle foreshores, particle size, and hence water retention capacity (Fuller 1975), has a major effect on the kinds of plants that become established. Brandes (1979) has investigated the colloidal capacity of soil samples from railway stations in Eastern Saxony (DDR), and is able to show a correlation with vegetation. Hard vertical rock cuttings clearly retain very little water, whilst softer, rotting, or more sloping surfaces have a higher capacity. Newly laid ballast is engineered to be very freely draining. Niemi (1969) has shown comparatively high maximum temperatures and wide diurnal fluctuations on a macadamized track bed in Finland. It is very likely that a considerable amount of condensation occurs when ballast cools at night. Along verges, spent ballast has a mulching effect, the surface layer inhibiting evaporation from below. The material is often tipped on to existing vegetation, and a damp, nutrient-rich soil may be formed from the dead and decaying plants beneath. The flora in these areas is strongly influenced by the depth of ballast, although the proportions of smaller particled, organic and chemical materials present will also determine which kinds of plant become established.

Drainage through cinder along the track may become impeded by the accumulation of plant litter. In railway yards, cinder is sometimes admixed with brick and rubble, as well as organic materials and oily pollutants. Yards often become compacted by trampling and vehicular movement, and, despite the larger sized fraction, will retain water more efficiently than the looser packed cinder along tracks.

Detailed edaphic measurements are required to expand these observations.

The water balance of the cess is altered when plants become established. Rail traffic safety requires that the track is freely draining and that sight lines are kept open (C Beagley, BRB HQ, personal communication). The track bed and a restricted area of adjacent verge are therefore sprayed with chemical weed killer. This is done annually in early summer from especially adapted trains run by BR, or under contract with Chipmans Chemical Co Ltd or Fisons Boots Chemicals Ltd. Vegetation in railway yards is more often controlled by the manual application of herbicide—sprays or granules. A list of chemical weed killers currently approved for use on BR land is given in Table 1.

Thus, in many cases, the vegetation on the cess is subject to radical disturbance (management), as well as water stress.

LEGEND

TRACK CLASSIFICATION

South Eastern

Weald

Southern Chalk Uplands

Chilterns

South Western

Central Southern

South Coastal

South Midlands

Midlands and East Anglia

Eastern Lowlands

Fens

Pennine Coal Measures

Northern Sandstones

West Coastal

Lancashire Plain

Pennines

Western Coal Measures

Midland Hills

North Coast Carboniferous

Scottish Lowlands

North West Coastal

Highland Coastal

West Highlands

Central Highlands

Welsh Uplands

Igneous Coastal

SAMPLING SITES

▽ Random

○ Biological Interest

□ Cutting / Embankment

▼ Random - revisited during 1981

SITES OF PARTICULAR BIOLOGICAL INTEREST

▽ Random

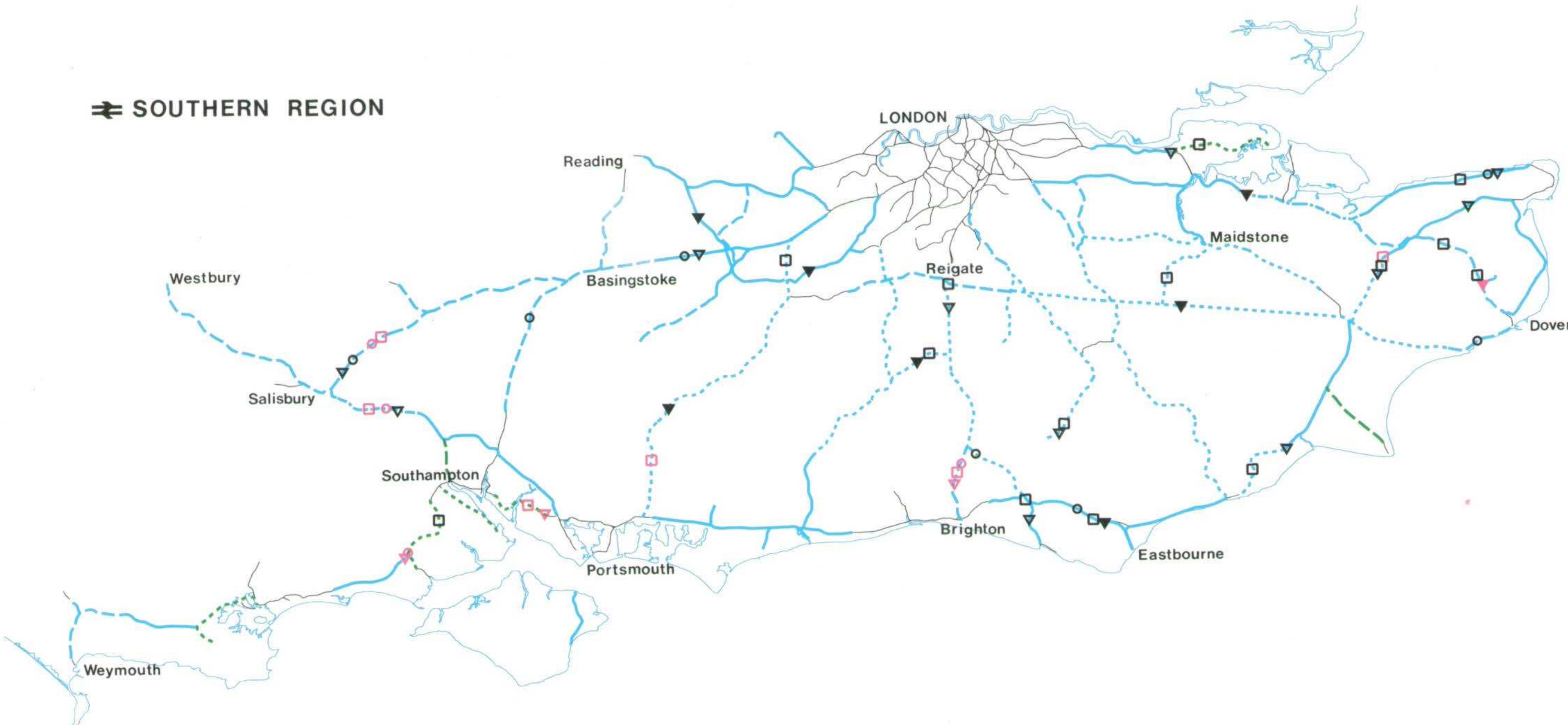
○ Biological Interest

□ Cutting / Embankment

▼ Random - revisited during 1981

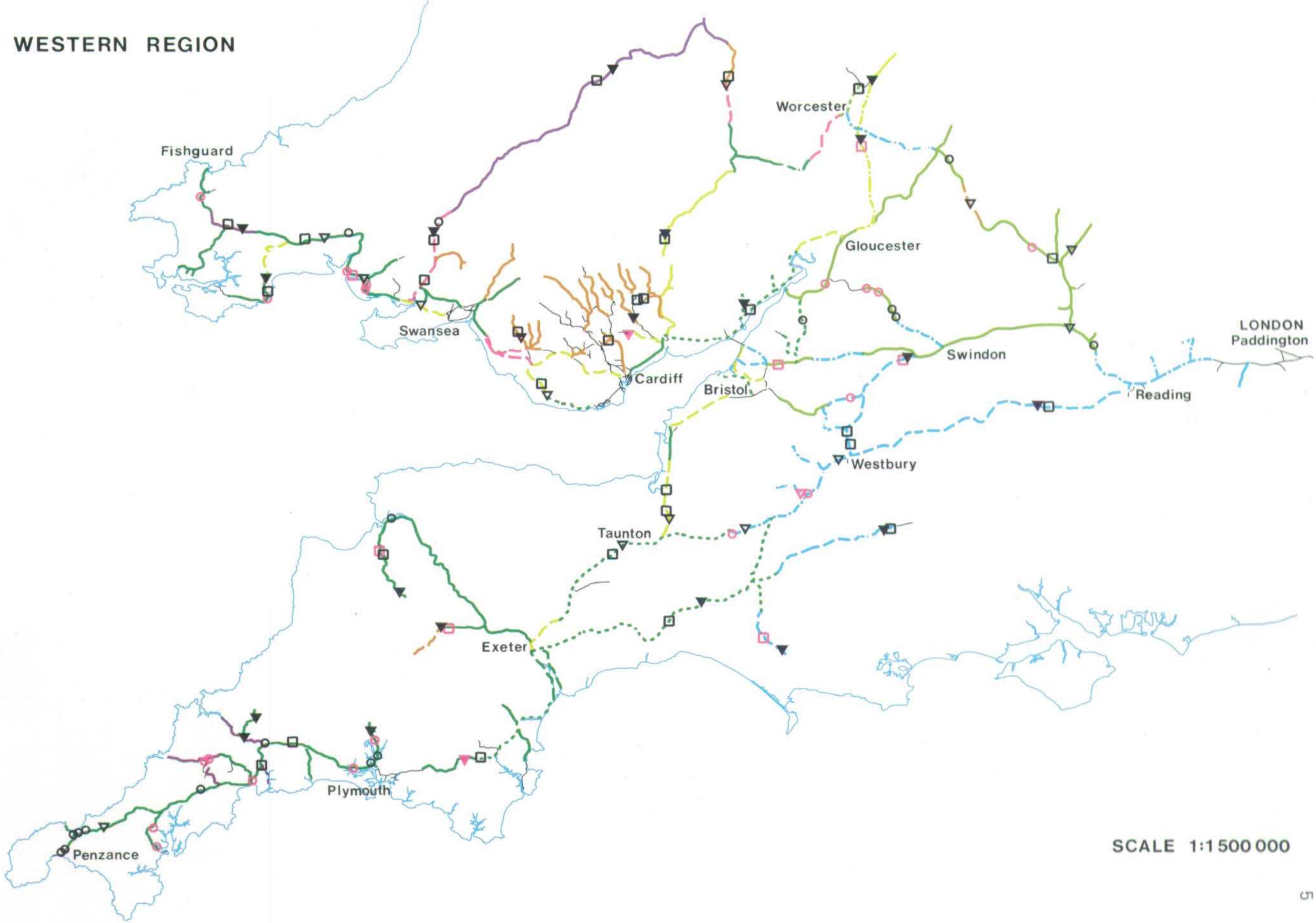
Cartography by the Experimental Cartography Unit

SOUTHERN REGION



SCALE 1:1000000

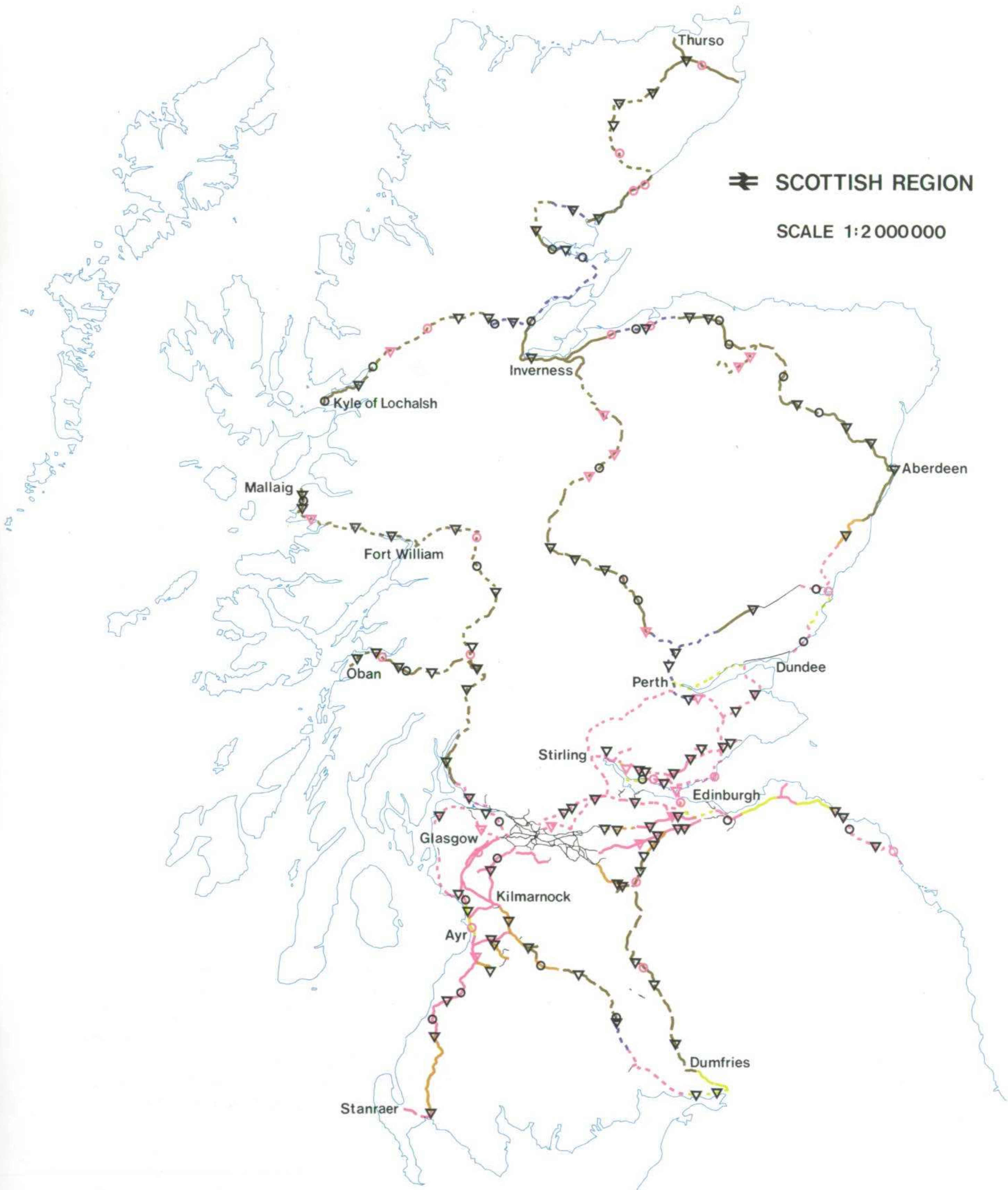
WESTERN REGION



EASTERN REGION

SCALE 1:1 750 000

LONDON MIDLAND REGION
SCALE 1:1600000
Carlisle
Barrow
Skipton
Preston
Manchester
Liverpool
Holyhead
Crewe
Derby
Nottingham
Stafford
Shrewsbury
Birmingham
Nuneaton
Coventry
Aberystwyth
Bedford
LONDON


SCOTTISH REGION
SCALE 1:2 000 000
Thurso
Inverness
Kyle of Lochalsh
Aberdeen
Mallaig
Fort William
Oban
Perth
Dundee
Stirling
Edinburgh
Glasgow
Kilmarnock
Ayr
Dumfries
Stanraer

2.3 Verges

Verges comprise cuttings (positive slopes from the railway line), embankments (negative slopes), and flats. Drainage ditches have been dug at the base of most embankments, whilst cuttings drain more frequently into concrete channels or conduits adjacent to the cess. In some areas, borrow pits, now flooded, were dug to provide additional material for embankment building. The construction of slopes is described in the interim report 'The history of the railway formations' (Sheail 1979).

The essential distinction between sloping formations is in the excavation of cuttings and the engineering of embankments. The latter were built with introduced materials, and the difference is reflected in the soil composition and structure: cuttings usually have a mineral soil, characteristic of local drift, or solid geological conditions, whilst embankments were often top-soiled and now receive organic (nitrogenous and oily) train wastes. In neither case has the time that has elapsed since building (very approximately 100 years) been sufficient for soil profiles to develop fully. The microclimate of embankments in Finland has been investigated by Suominen (1969), who showed that seasonal and diurnal temperature fluctuations were greatest at the top of slopes, where the soil was also most freely draining. The microclimate is modified downslope, where the vegetation becomes increasingly closed. Comparable studies have not been made along flat verges or cuttings, although Dony (1974) has shown that a more diverse flora develops on south-facing slopes.

Table 1. BR approved weed killing chemicals.

Chemicals approved for use on BR land, 1983

Verges, selective	Track, cess, yards, total
Picloram	Atrazine
Trichlopyr	Simazine
2,4-D	Aminotriazol
Fosamine ammonium	Bromacil
	Diuron
	Picloram
	2,4-D
	MCPA
	2-3-6-TBA
	Glyphosate

Chemicals discontinued

2-4-5T	Sodium chlorate
	Dalapon
	Borax
	Paraquat

In Britain, spent ballast is tipped on to embankments (and sometimes on flats or cuttings, if the slope is not too great). In addition to obvious mechanical disturbance and the removal of sites available for establishment, accumulation of ballast influences the temperature and drainage of the soil, and hence the composition and structure of the vegetation.

The discontinuance of traditional hand maintenance methods–scything, cutting and controlled burning–was a prime motive for this research, the implication being that the fine, species-rich grassland, likely to have developed after 100 years of such management, was at risk. Since the early 1960s, BR policy has been to cut and clear verges only where a hazard exists, although, recently, labour released by cut-backs in expansion and electrification has been deployed to verge maintenance (C Beagley, pers comm). In particular, scrub and woodland have been cleared from main line cuttings, where the accumulation of leaf litter on rails has interfered with traction and braking (Plate 2).

A narrow strip (generally less than 3 m) adjacent to the track bed is, however, usually sprayed annually by train with selective herbicides (Table 1). The growth retardant Fosamine ammonium (Krenite) was introduced for this purpose during 1980, but has met with little favour, as the cost of running additional spray trains in late summer, when the chemical is most effective, is inhibitive. Until recently, 2-4-5T was used to help control brushwood (usually thorn, ash and bramble), but this is now banned and Picloram and Trichlopyr are applied instead.

Ditches are usually more carefully maintained, because the stability, and hence safety, of the line depends on adequate drainage. Boundary hedges are also looked after to prevent casual straying by animals or trespassing. Following complaints from local farmers, rabbit-proof fencing has been installed in some areas.

In general, the maintenance of main and overhead electrified lines is of a higher standard than that of branch lines. Cuttings are more frequently cleared than embankments, because of the dangers of falling trees/branches and of leaf litter accumulating on the lines. Trees are encouraged along embankments, where they help stabilize the slope, and have sometimes been planted for this purpose after construction.

2.4 Geographic stratification and sampling

Objective sampling of the vegetation was based on a stratification of all rural BR land (Sargent 1983). The rural railway network was divided into 893 measured 10-mile units. Selected geographic attributes were scored from maps for each of these units, where they abutted on to, or were crossed by, the railway line. The information was classified using Indicator Species Analysis (Hill *et al.* 1975), a polythetic divisive method based on correspondence analysis. After inspection and some modification, the classification yielded 26 track classes (ie groups of 10-mile units). The distribution of classes within each Region is shown on the maps following page 00. Constant attributes, which are present in more than 80% of members of each track class, are given in Table 2. The table is ordered using an index derived from the relative representativeness of each attribute within each track class, and is designed to show the relationship between classes. There is an evident gradient between lowland south-eastern and upland north-western classes.

The number of units in each track class is given in Table 3, together with the verge area (excluding track, yards, etc). Verge width was measured at each site visited, enabling the area of each track class to be calculated. The total area of rural BR verge is 30 678 ± 4524 ha.

A total of 480 sites was distributed proportionately according to the number of members within each track class. Members to be sampled were randomly selected, and measured 100 m sampling sites (Plate 1.1) were located at randomly chosen BR mile posts within the selected members. For practical purposes, sites were restricted to areas of convenient access. Four transects were measured at each site at right angles to the track (Plate 1.3), the direction which, within a short stretch of track, usually includes most variation. A number of 4 m^2 (nested 4 and 25 m^2 in woodland) quadrats,

Table 2. Constant attributes of the 26 railway track classes distinguished by classification of 83 geographic attributes using Indicator Species Analysis. Only attributes occurring in at least 80% of track class members (10 mile units) are shown. The table is ordered with an index derived from the first axis of a Reciprocal Average Ordination.

	Southern Chalk Uplands	South Eastern	Chilterns	South Coastal	Weald	South Midlands	Midlands & East Anglia	Northern Sandstones	Fens	Eastern Lowlands	Central Southern	South Western	West Coastal	Lancashire Plain	Pennine Coal Measures	Scottish Lowlands	Midland Hills	Pennines	Western Coal Measures	North West Coastal	North Coast Carboniferous	Welsh Uplands	Igneous Coastal	Central Highlands	Highland Coastal	West Highlands
<7·0C January	x	x			x																					
Well drained calc soil	x							x																		
>6·0 hrs sun July	x	x	x	x	x				x		x	x														
Chalk and oolites	x									x																
<10 days snow cover		x		x							x	x	x	x												
Electrified		x	x														x									
<400′ ASL	x				x	x									x				x							
<25′ ASL				x					x																	
Alluvium		x			x								x													
Drift			x	x	x					x	x	x	x					x	x			x				
Stagnogleys					x	x	x								x	x					x					
<6·0 hrs sun July						x		x		x			x	x			x									
<20 days snow cover						x	x	x	x	x					x	x					x		x			
<100′ ASL								x		x	x		x	x	x					x						
Salt marsh								x																		
Bunter														x		x										
Coal measures															x			x	x		x					
<200′ ASL												x			x	x				x					x	
<30 days snow cover																		x								
<6·0C January									x	x						x								x		
Non-calc. brown earths											x	x	x				x			x		x				
<5·5 hrs sun July														x	x	x	x				x					
<6·5C January																	x	x								
Carboniferous & magnesian																	x				x					
Igneous & intrusive																					x					
>400′ ASL																		x						x		
Boulder clay																		x	x	x			x		x	x
Lowland podzols																								x	x	
Heath/rough pasture																			x	x				x	x	x
Single track																						x	x		x	x
Metamorphic																										x
Upland gleys																										x

strictly proportional to the width of the verge, was distributed along each transect. Species, cover and height were recorded, and pH, slope, aspect and certain other environmental measurements were taken. Species lists for entire sites were made and qualitative descriptions written.

In order to increase the chance of visiting as many 'better' sites as possible, the random survey was supplemented with visits to areas of known, or likely, interest. A total of 241 such subjective sites were visited, and sites of particular biological interest (BI) were selected from within both random and subjective surveys (Chapter 5).

Table 3. Area of rural railway verges by track class.

Track class		Area (ha)	Number of units
1	South Eastern	1 386 ± 136	41
2	Southern Chalk Uplands	1 536 ± 167	40
3	Chilterns	1 429 ± 110	32
4	South Western	960 ± 141	40
5	Central Southern	1 292 ± 339	28
6	South Coastal	104 ± 3	6
7	South Midlands	3 710 ± 603	70
8	Midlands and East Anglia	1 756 ± 143	70
9	Eastern Lowlands	1 774 ± 367	28
10	Fens	1 205 ± 307	33
11	Pennine Coal Measures	1 890 ± 225	51
12	Northern Sandstones	899 ± 99	42
13	West Coastal	1 012 ± 140	29
14	Lancashire Plain	559 ± 120	15
15	Pennines	2 217 ± 235	51
16	Western Coal Measures	840 ± 126	36
17	Midland Hills	916 ± 489	29
18	North Coast Carboniferous	759 ± 78	28
19	Scottish Lowlands	1 729 ± 141	56
20	North West Coastal	276 ± 31	16
21	Highland Coastal	879 ± 102	26
22	West Highlands	594 ± 103	24
23	Central Highlands	1 140 ± 82	38
24	Welsh Uplands	507 ± 91	18
25	Igneous Coastal	407 ± 46	16
26	Weald	902 ± 100	30
	Total	**30 678 ± 4524**	**893**

3. Railway plants

A literature search has been made and a list of all plants recorded from active (lines in use at present) BR land compiled. This list has been compared with species found during the current ITE/NCC BR land survey.

In all, 1632 phanerogams (including aggregates, species, subspecies and varieties) have been described from BR land, of which 611 are unique to the literature, 807 were confirmed during the survey, and 214 are newly reported. Cryptogams were less thoroughly described, and, of the 323 species (pteridophytes and bryophytes), 52 occur in the literature only, whilst a further 94 records were confirmed during the survey and 177 new species have been added to the list. This finding rather more than doubles the number of cryptogams previously known to occur on railway land.

More than 200 vascular species gave rise to one or more new 10 km records, whilst, at the present count, there are 56 vice-county records (1st or 2nd, Sargent 1982) and one species new to the United Kingdom (*Hieracium zygophorum;* Sell & West 1980).

Almquist (1957) defined 'railway species' as those plants which 'occur remarkably often in the railway flora, or show a preference for, or are locally exclusive to, such a flora' (translated in Niemi 1969). To examine this idea further, an index of the frequency with which species were found during the survey was compared with the frequency of literature records. In making such a comparison, the null hypothesis was that species would occur equally frequently in both datum sets.

A total of 901 species was common to survey and literature. The hypothesized equivalents were:

Literature		Survey
1-2 records	=	<1% random sites, or BI survey sites only
3-5 records	=	1-2% random sites
6-10 records	=	3-5% random sites
11-20 records	=	6-20% random sites
>20 records	=	>20% random sites

The degree of correspondence in frequency class between coincident literature and survey records is low ($\chi^2=118{\cdot}75$, $P<0{\cdot}1$). The cases when the survey and County Floras correspond are fewer (316, 35%) than those where the survey (287, 32%) or the Floras (293, 33%) recorded relatively more, ie 65% of frequencies did not correspond. This lack of correspondence could suggest that the selected frequency categories are not equivalent. However, lack of correspondence would give a bias in one direction only, not the observed, extensive spread in both directions.

In Table 4, species in the 2 most frequent classes from each source are compared. Residual data, 877 species, are broadly categorized rather than named.

There are 19 species common to the 2 highest frequency classes. They are generally plants of freely draining grassland, although there is a bias towards ruderals in the literature group. *Chamerion angustifolium* (Plate 7.1) is clearly the 'railway species' (*sensu* Almquist) *par excellence.* Two winter annuals, *Erophila verna* and *Arabidopsis thaliana,* found most often along the cess, are included: they are able to complete their life cycles before chemical spraying takes place in early summer. During the desiccating months of high summer, these plants are in a dormant (seed) phase.

The discrepancies within and between the classes are due, in part, to the differing scopes of the investigations. Restricted access (BR land is private property and trespassing is dangerous and carries the risk of a substantial fine) has limited much previous botanical work to station and shunting yards, whilst the present remit has been to survey rural railway verges.

However, several of the plants, which were recorded less frequently than expected during the survey, are declining because of changing railway management practices. *Chaenorhinum minus* and *Convolvulus arvensis* are good examples. *C. minus* is an annual plant usually found on cinder on, or close to, the cess. Although it flowers from May to October, its life cycle is characterized by spring germination (Arnold 1981), and it seems probable that a large proportion of plants are unable to set seed before being killed by herbicide. In the United States, where spraying usually occurs later in the year, *C. minus* is becoming extremely widespread on railway land (Arnold 1981; Muehlenbach 1979). *C. arvensis* is abundant on the Isle of Wight railway, where spray trains are not in use. *Senecio viscosus* (July-September; Plate 1.2), on the other hand, germinates and flowers after the tracks have been sprayed. This plant is abundant along the cess in late summer, and vice-county (93) and 10 km^2 records indicate that it is actively extending its range into Scottish Region.

Table 4. Railway species common to survey and literature. The table groups, by frequency class, the 896 species common to survey and literature: the large aggregates of *Bryum bicolor, Hieracium, Rosa canina, Rubus fruticosus* and *Taraxacum officinale* which were not identified to species level are omitted. The data are reduced from Sargent (1982), where information about the status of all other species observed less frequently on BR land may be found.

Survey sites	Literature records > 20	11–20	≤ 10
>20%	*Chamerion angustifolium*	*Equisetum arvense* *Festuca rubra* *Heracleum sphondylium* *Lathyrus sylvestris*	*Arrhenatherum elatius* *Brachythecium rutabulum* *Bryum argenteum* *Ceratodon purpureus* *Cirsium arvense* *Crataegus monogyna* *Dactylis glomerata* *Funaria hygrometrica* *Galium aparine* *Hedera helix* *Holcus lanatus* *Lophocolea bidentata* *Plantago lanceolata* *Poa pratensis* *Rumex acetosa* *Urtica dioica*
5–20%	*Arabidopsis thaliana* *Leucanthemum vulgare* *Linaria vulgaris* *Senecio viscosus*	*Cardamine hirsuta* *Centaurea nigra* *Daucus carota* *Erophila verna* *Fragaria vesca* *Hypericum perforatum* *Lotus corniculatus* *Potentilla reptans* *Tussilago farfara* *Vicia cracca*	31 species including: 13 forbs 6 grasses 5 woody species 5 bryophytes (cess acrocarps) 2 ferns
<5%	*Cardaria draba* *Chaenorhinum minus* *Convolvulus arvensis* *Diplotaxis muralis* *Echium vulgare* *Fragaria x ananassa* *Lathyrus latifolius* *Linaria repens* *Medicago sativa* *Reseda lutea* *Reseda luteola* *Senecio squalidus* *Valerianella locusta* *Vulpia bromoides* *Vulpia myuros*	103 species including: 91 forbs 6 ferns 3 grasses 1 woody species No bryophytes.	712 species The bulk of less common railway plants recorded by the literature and us. Mainly grassland species and individuals of well-drained soil and cinder.

Several local or rare annuals occur on the railway cess. These include *Dianthus armeria* (July-August), *Linaria supina* (June-September) and *Geranium rotundifolium* (June-July). Although it is recognized that spraying maintains an open, non-competitive habitat, it is clearly very important, if the plants are to survive in this habitat, that the event should be carefully timed.

With the passing of steam, many saxicolous ferns have become less widespread on railway masonry. Other plants, eg *Senecio squalidus* and *Diplotaxis muralis*, have had their dispersal along railway lines well documented (Kent 1957, 1960, 1964; Powell 1931), and may consequently have been rather more zealously included, or overrated, in County Floras, whilst a further group, including *Reseda* spp and *Vulpia* spp, are more characteristic of cinder flats and railway yards than of the rural verges on which the survey was focused.

Examination of the full list (Sargent 1982) of plants occurring more frequently in the literature shows that there is a general bias towards introduced and naturalized species (32% of all species recorded from railway land are not native, Sargent 1982) and towards some taxonomically difficult groups which have been the particular interest of one or more authors. There is also a tendency for larger, or more showy plants, eg *Verbascum* spp and *Melilotus* spp, which may be seen from railway carriage-windows, to be more thoroughly documented.

In the survey, on the other hand, more emphasis is placed on grassland and woodland species, and systematic recording produced many more records for inconspicuous and common plants. In particular, 41% of all non-rare grasses were recorded more frequently during the survey (*Arrhenatherum elatius* occurred at >70% of random sites), whilst much higher abundance is assigned to species of *Carex* (19 out of 23 non-rare), *Juncus* (9 out of 11), *Luzula* (all 4 non-rare) and *Rumex* (5 out of 9).

No bryophytes have more than 4 literature records, and several grassland species very commonly found during the survey, eg *Eurhynchium praelongum, Rhyncostegium confertum, Rhytidiadelphus squarrosus* and *Plagiomnium undulatum*, are not mentioned at all.

The life cycle and habit of some cryptogams enable successful growth on the cess. Certain acrocarpous, endohydric bryophytes are abundant on cinder. These tolerate desiccation and wide diurnal and seasonal fluctuations in temperature (Richardson 1981). *Funaria hygrometrica* is particularly widespread, occurring on a great majority of sites. *Bryum argenteum, B. caespiticium* and *B. capillare* are also very common, as are *Ceratodon purpureus, Barbula convoluta, B. unguiculata* and *Polytrichum juniperinum*. Where drainage is impeded, the thallose hepatic *Marchantia polymorpha* becomes frequent, whilst, in the high rainfall areas of the upland north and west, a very wide variety of bryophytes, including *Dicranella palustris, Dicranum scoparium* and *Polytrichum formosum*, occur on cinder track margins. In these areas, *B. argenteum* becomes rare.

Plants whose range seems to be expanding are more highly rated in the survey, eg *Epilobium brunnescens, E. adenocaulon,* and *Cotoneaster simonsii* (Sargent 1982). New vice-county records are claimed for *Barbarea intermedia* (vc 84; Plate 1.4) and *Bunias orientalis* (vc 75), indicating that these aliens are also spreading. *B. orientalis* is usually restricted to south-eastern England (Perring & Walters 1962), although the Rev G G Graham (pers comm) has information about a railway site in County Durham, suggesting that the plant may have moved along the east coast main line to its new sites in Scottish Region. However, Graham records that the ballast on which *B. orientalis* is growing came from Hartlepool where 'many species were listed as ballast aliens in 1866 by John Hogg'.

The species list for the survey shows that BR land includes more, and varied, grassland, woodland and moorland than an inspection of County Floras, biased toward station yards and the railway cess, would suggest. The proportions are shown graphically in Figure 1.

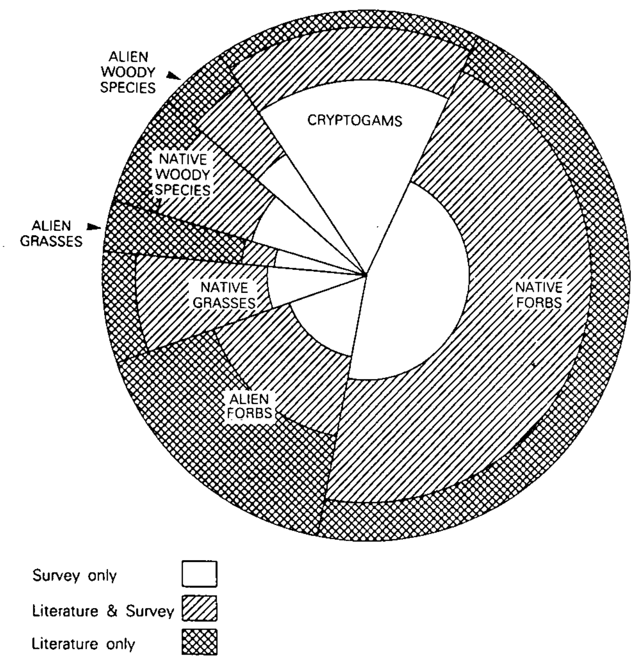


Figure 1. The proportions of phanerogams and cryptogams found on BR land during the survey and reported in the literature. Total species = 1955.

4. Vegetation

4.1 Introduction

Data from 3502 stands (4 m^2 quadrats) for 667 vascular plant species were collected from within the random stratified survey. Bryophytes were not recorded during the first 2 years of the survey, and are therefore not included in the analysis. Plant cover was estimated visually in the field to the nearest 5%, with discrete categories being given to scores of 1% and 2%. For analysis, the information was reduced to 5 possible cover abundance states for each species:

$<1\% = 1$
1-5% = 2
6-20% = 3
21-50% = 4
$>50\% = 5$

The scale is weighted toward the lower end, where variability is likely to be most relevant.

During classification and evaluation, these cover states were treated as 'pseudospecies', *Arrhenatherum elatius* at level 2, for example, being considered a distinct species from *A. elatius* at level 4. This gave a raw data array of 3502 × 667 × 5, or 11 679 170 components, a number too large for processing with available software and computing facilities.

A step-wise classification was therefore devised in which it was intended first to classify a stratified (by track class) random subset of data, then to ascribe the remaining data to the classification by virtue of a derived key, and subsequently to re-sort the resulting major vegetation groups.

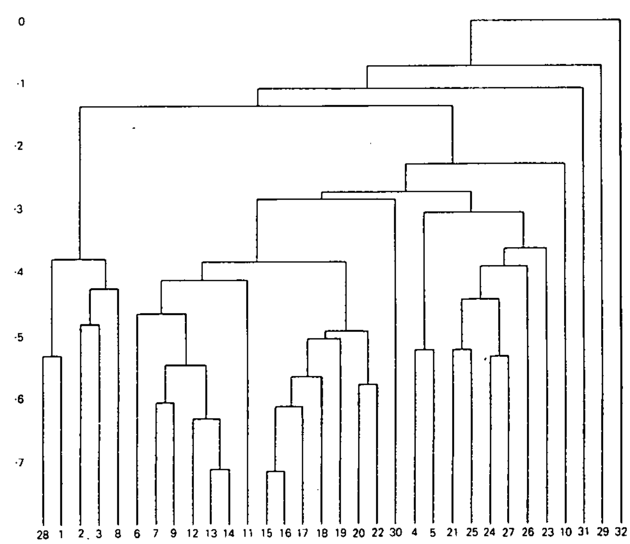
A subset of 937 samples and 442 species was taken and classified with TWINSPAN (Hill 1979), a polythetic divisive method which groups both stands and species. The program defines and divides with respect to a number of indicators. These indicators effectively form a key which may be used to ascribe further information to the classification. With the data subset used, it was found that the maximum number of indicators allowed for in the program (15) gave the least amount of mis-classification (ie samples recognized by the program as occurring in the wrong category). The indicator species key was tested by returning the 937 samples used to erect the classification through the key. Only 78% of samples went back to their original position, and so the key was discarded.

A preferred method of ascribing information was found with the Czekanowski similarity coefficient, when 90% of samples returned to their original, or next closest, position. Six major vegetation groups were distinguished:

Heath and basifugous vegetation (*noda** 1-5)
Fine-leaved grasslands (*noda* 6-11)
Coarse false oat grasslands (*noda* 12-18)
Tall herb and bramble (*noda* 19-22)
Scrub and secondary woodland (*noda* 23-27)
Miscellaneous (*noda* 28-32)

The remainder of the datum set, 2565 samples, was ascribed to these groups using the Czekanowski coefficient. Each group was then classified with TWINSPAN. After inspection and some empirical adjustment, 32 vegetation *noda* were delimited from the 6 independent classifications. Czekanowski between-group similarity was calculated and the results are shown dendrogrammatically in Table 5. Average linkage was used to determine phytosociological relationships.

Table 5. Dendrogram showing mean Czekanowski similarity between *noda*. Variants of subcommunities generally show an average linkage greater than ·58, although amongst the Rhamno-Prunetea (21, 24-27) this drops to ·52. Associations show an internal similarity greater than ·39, whilst all classes are distinguished at ·37. Vegetation descriptions in the text follow the order shown by the similarity coefficient.



A conspectus of the vegetation types is given in Table 6. Railway *noda* are classified as subcommunities of associations (-etum) and classes (-etea) of the Zürich-Montpellier system, except where the vegetation occurs too infrequently on BR land for accuracy. The subcommunity is used for 3 reasons.

*Footnote: The term *nodum* is used as a collective noun to describe delimited vegetation units which are not strictly Zürich-Montpellier *syntaxa*.

Table 6. A conspectus of vegetation types found on BR land during 1976-1981. The objectively collected information is classified in subcommunities, avoiding confusion with the subjective *syntaxa* of the Zürich-Montpellier school. However, the subcommunities are placed with appropriate associations (–etum) and classes (–etea), to show the relationship with that system. *Noda* 29 and 32 occurred too rarely (4 and 2 stands respectively) for accurate classification.

Class	Association	Subcommunity	*Noda*
Oxycocco-Sphagnetea Br-Bl et R Tx 1943			
	Trichophoro-Callunetum McVean et Ratcliffe 1962		
		Molinia caerulea subcommunity	28
	Calluno-Molinietum Hill et Evans 1978		
		Salix aurita subcommunity	1
Vaccinio-Piceetea Br-Bl, Siss et Vl 1939			
	Vaccineto-Callunetum McVean et Ratcliffe 1962		
		Molinia caerulea subcommunity	2
	Callunetum vulgaris McVean et Ratcliffe 1962		
		Deschampsia flexuosa subcommunity	3
	Agrosto-Festucetum McVean et Ratcliffe 1962		
		Senecio jacobaea subcommunity	8
Molinio-Arrhenatheretea R Tx 1937			
	Arrhenatheretum elatioris Br-Bl 1919		
		Holcus mollis subcommunity	6
		Agrostis capillaris subcommunity	7, 9
		Festuca rubra subcommunity Rodwell	12, 13, 14
		Brachypodium pinnatum subcommunity	11
		Equisetum arvense subcommunity	15, 16
		Chamerion angustifolium subcommunity	17, 18
		Filipendula ulmaria subcommunity Rodwell	19
		Urtica dioica subcommunity Rodwell	20, 22
Quercetea robori-petraeae Br-Bl et R Tx 1943			
	Fago-Quercetum R Tx 1937		
		Dryopteris filix-mas subcommunity	4, 5
Rhamno-Prunetea Rivas Goday et Borja Carbonell 1961			
	Arrhenathero-Rosetum *assoc nov prov* Sargent		
		Prunus spinosa subcommunity	21, 25
		Hedera helix subcommunity	24, 27
		Clematis-Viburnum subcommunity	26
Querco-Fagetea Br-Bl et Vl 1937			
	Fraxino-Ulmetum Oberd 1953		
		Dryopteris filix-mas subcommunity	23
Phragmitetea R Tx et Preising 1942			
	Scirpo-Phragmitetum W Koch 1926		
		Equisetum arvense subcommunity	30
Trifolio-Geranietea sanguinei Th Mull 1962			
	Trifolio-Agrimonietum Th Mull 1962		
		Arrhenatherum elatius subcommunity	10
Chenopodietea Br-Bl 1951			
	Sagino-Bryetum argentei Diemont, Siss et Westhoff 1940		
		Senecio viscosus subcommunity	31
Rhododendron ponticum stands			29
Asteretea tripolii Westhoff et Beeftink 1962			32

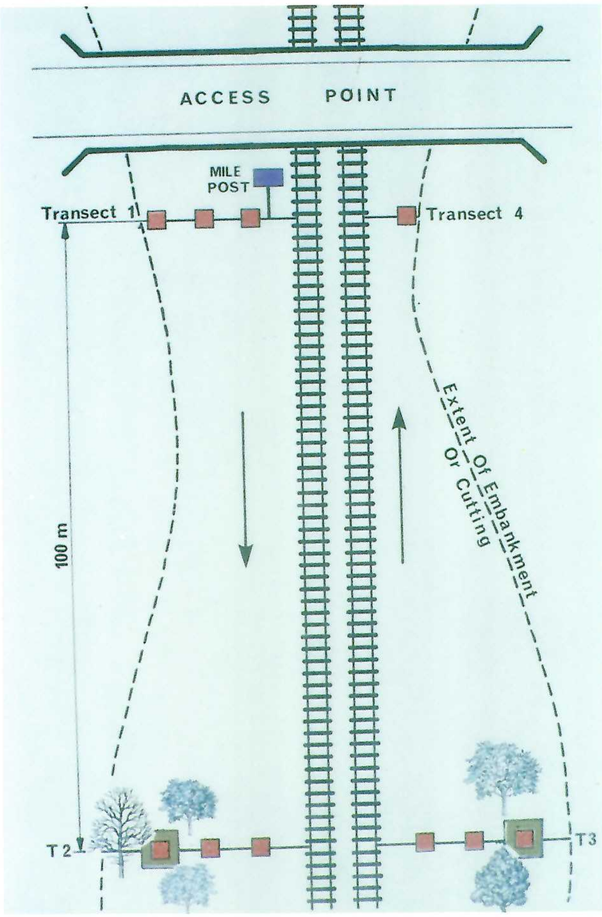
1. The information was collected with a stratified random method, not by *rélevé* (subjective stands), and is therefore not strictly comparable with Zürich-Montpellier *syntaxa*. However, it was considered of interest to relate British railway vegetation to vegetation elsewhere in Europe, and the most appropriate association, together with class, is therefore given.

2. BR vegetation is seldom identical with European *syntaxa*. This is because the combination of oceanic edaphic conditions, disturbance and management is unique. Thus, for example, *Cynosurus cristatus*, a character species of the Arrhenatheretum elatioris (Braun-Blanquet 1919) which is intolerant of burning (Grime & Lloyd 1973), is notably absent from railway stands, whilst *Poa angustifolia*, which is not affected by such treatment, is unusually abundant. Amongst more acid grasslands, a comparable absence of *Nardus stricta* and abundance of *Molinia caerulea* can be observed.

3. Both because quadrats are randomly distributed (and do not necessarily fall on a homogeneous vegetation unit), and because railway vegetation is disturbed and heterogeneous, stands tend to include more species, and these are often less consistently associated. As a result, railway subcommunities tend to be less discrete than European associations.

The 32 vegetation *noda* are defined with the help

Plate 1. SAMPLING



1. *Stylized diagram of 100 m long, stratified random sampling site, showing distribution of transects and quadrats. The arrows indicate the direction in which the team walked, facing oncoming traffic for safety.*

2. *Railway cess with* Senecio viscosus. *March yards. (Photograph Caroline Sargent)*

3. *Calluno-Molinietum,* Salix aurita *subcommunity* (nodum 1), *with transect and bags for collecting soil samples. West Highland line. (Photograph Caroline Sargent)*

4. Barbarea intermedia, *a new record for vice-county 84, growing on spent ballast. (Photograph Caroline Sargent)*

1. *Spraying from specialized train to control scrub. (Photograph Caroline Sargent)*

2. *Effects of burning. Bramble and gorse (nodum 22) have given way to a false oat sward (nodum 15). (Photograph J M Way)*

3. *Scything, now seldom carried out (nodum 14). (Photograph Caroline Sargent)*

4. *Scrub and secondary woodland clearance (nodum 27). (Photograph Caroline Sargent)*

1. *Vaccineto-Callunetum,* Molinia caerulea *subcommunity* (nodum *2*). *Dalnacardoch. (Photograph Caroline Sargent)*

2. *Callunetum vulgaris,* Deschampsia flexuosa *subcommunity* (nodum *3*). *Shap summit. (Photograph Caroline Sargent)*

3. *Fago-Quercetum,* Dryopteris filix-mas *subcommunity,* Betula pubescens *variant* (nodum *4*). *Pont-y-pant. (C. Sargent)*

4. *Arrhenatheretum elatioris,* Agrostis capillaris *subcommunity* (nodum *7*). *Scart. (Photograph Caroline Sargent)*

Plate 4.

1. *Fago-Quercetum*, Dryopteris filix-mas *subcommunity*, Betula pendula *variant* (nodum *5*). *Loch Garve.* *(Photograph J O Mountford)*

2. *Arrhenatheretum*, Holcus mollis *subcommunity* (nodum *6*). *Mouldsworth.* *(Photograph Caroline Sargent)*

3. *Agrosto-Festucetum*, Senecio jacobaea *subcommunity* (nodum *8*). *Achantoul.* *(Photograph Caroline Sargent)*

4. *Arrhenatheretum*, Agrostis capillaris *subcommunity*, Achillea millefolium *variant* (nodum *9*). *South Brent.* *(Photograph Caroline Sargent)*

1. *Trifolio-Agrimonietum,* Arrhenatherum elatius *subcommunity* (nodum *10*). *Polhill.* *(Photograph Caroline Sargent)*

2. *Arrhenatheretum,* Brachypodium pinnatum *subcommunity* (nodum *11*), *with recently burnt area. Wennington.* *(Photograph J M Way)*

3. *Arrhenatheretum,* Festuca rubra *subcommunity,* Anthoxanthum odoratum *variant* (nodum *13*). *Thurmaston.* *(Photograph Caroline Sargent)*

4. *Arrhenatheretum,* Festuca rubra *subcommunity,* Vicia cracca *variant* (nodum *14*). *Wor-plesdon.* *(Photograph A Marsden)*

1. *Arrhenatheretum,* Festuca rubra *subcommunity,* Poa angustifolia *variant with* Gymnadaenia conopsea (nodum *12*). *Dudland.* *(Photograph Caroline Sargent)*

2. *Arrhenatheretum,* Equisetum arvense *subcommunity* (nodum *16*), *with* Chamerion angustifolium *subcommunity* (nodum *17*) *on lower slopes. Denton.* *(J M Way)*

3. *Arrhenatheretum,* Urtica dioica *subcommunity* (nodum *20*). *Kirkham Priory.* *(Photograph J M Way)*

4. *Arrhenathero-Rosetum,* Clematis-Viburnum *subcommunity* (nodum *26*). *Shepherdswell. (Photograph Caroline Sargent)*

1. *Arrhenatheretum,* Chamerion angustifolium *subcommunity* (nodum 17). *Wood End.* *(Photograph Caroline Sargent)*

2. *Arrhenatheretum,* Chamerion angustifolium *subcommunity,* Holcus mollis *variant* (nodum 18). *Gayton.* *(Photograph Caroline Sargent)*

3. *Arrhenatheretum,* Filipendula ulmaria *subcommunity,* Carex riparia *variant* (nodum 19). *Marsh Benham.* *(Photograph A Marsden)*

4. *Arrhenathero-Rosetum,* Prunus spinosa *subcommunity,* Chamerion angustifolium *variant* (nodum 21). *Horden.* *(Photograph J M Way)*

Plate 8.

1. *Fraxino-Ulmetum,* Dryopteris filix-mas *subcommunity* (nodum *23*). *Toadhole Furnace. (Photograph Caroline Sargent)*

2. *Arrhenathero-Rosetum,* Hedera helix *subcommunity,* Crataegus monogyna *variant* (nodum *24*). *Bekesbourne. (Photograph A Marsden)*

3. *Arrhenathero-Rosetum,* Prunus spinosa *subcommunity* (nodum *25*). *Harbury. (Photograph Caroline Sargent)*

4. *Arrhenathero-Rosetum,* Hedera helix *subcommunity,* Quercus robur *variant* (nodum *27*). *Beaconsfield. (Photograph Caroline Sargent)*

of 5 synoptic tables. Complete phytosociological tables are held at ITE Monks Wood Experimental Station, and the raw data are filed on magnetic tape.

Each *nodum* is identified by number and by constant species. The numbers (1-32) relate to the order in which the *noda* were first described (Sargent 1982), and are retained to avoid confusion with the preliminary nomenclature used at that time. Constant species are given in 4 classes:

V = present in >80% of samples
IV = 61-80%
III = 41-60%
II = 21-40%

The notation is comparable with that used for the National Vegetation Classification (Rev J S Rodwell, Lancaster University, pers comm). For simplicity, species occurring in 20%(1) or fewer stands are not included.

The synoptic tables also give the total number of species and stands, the average number of species in each 4 m^2 stand, mean soil pH and approximate area covered by each *nodum*. The areas covered by each vegetation class (*sensu* Zürich-Montpellier), and by the subcommunities of the Arrhenatheretum elatioris are also shown graphically in Figure 2, and the distribution of *noda* within track classes is tabulated in Figure 3, which shows a gradual change from vegetation in lowland south-eastern to upland north-western track classes, although more disturbed vegetation (ie *noda* 14, 15, 20 and 22) occurs throughout much of BR. The distribution of track classes is shown on the colour maps following page 00. A diversity index 'K' has been calculated from the species area equation $S=CA^K$, where S is the total number of species, A the total area, and C the number of species in the initial (4 m^2) area, for each vegetation type (given in the synoptic tables). Where K is large, the relative increment of species in an increasing area, and hence diversity of the *nodum*, is high. K tends to be highest for woodland vegetation where the initial number of species is low, and low amongst the disturbed railway grasslands. This is partly an artefact of the comparatively large area (A) covered. The lowest K is given by the herb- and species-rich *Arrhenatherum elatius* subcommunity of the Trifolio-Geranietea (*nodum* 10). There are 35 species constant at or above level II, confirming that the increment with area is likely to be low in this *nodum*. It also suggests that the subcommunity is homogeneous and approaches the concept of the Zürich-Montpellier *syntaxon*. The *noda* are described below, in the order corresponding to the Czekanowski between-group similarities (Table 5).

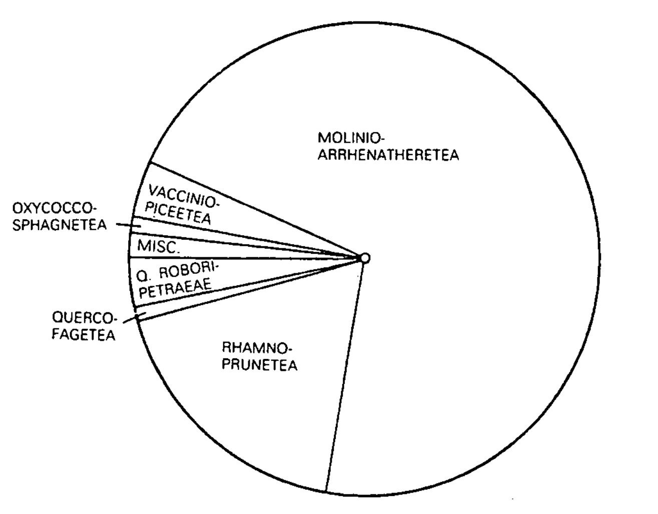
4.2 Oxycocco-Sphagnetea

a. Trichophoro-Callunetum

I. *Molinia caerulea* subcommunity, Table 7, *Nodum* 28

This ombrogenous mire occurs on poorly drained flats along railways in upland and highland areas of Scottish Region. It is similar to the Campylopo-Ericetum tetralicis, Birse et Robertson 1976, all vascular species and many cryptogams described by them being present in the railway data. However, the railway stands are floristically richer.

Birse and Robertson (1976) considered that, in the highlands, this *nodum* forms part of both the Trichophoro-Callunetum and the Molinieto-Callunetum. Seven of the railway stands with *Trichophorum cespitosum, Narthecium ossifra-*



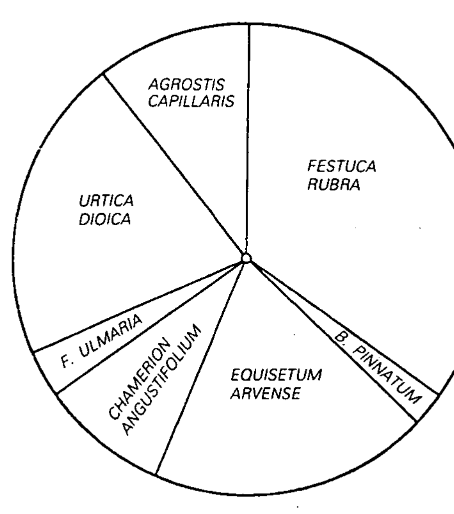


Figure 2. The proportional area of BR verges covered by different vegetation classes (*sensu* Zürich-Montpellier), and by subcommunities of the Arrhenatheretum elatioris. The calculated verge area is 30 700 ha (30 678 ± 4524), of which approximately 21 800 ha support Arrhenatheretum.

	2	7	26	5	6	1	14	4	3	20	16	9	10	8	11	17	18	13	12	25	19	15	24	21	22	23	Area (ha)
10	★																										180
26	★																										190
24	★	×	★	+																							1350
31		×			★																						90
27		★		★		★	+	★																			1570
30	×					×				★																	250
22	★		+	+	+				+	+	+																2050
19	×	×									★	★															780
20		★				+						+		+	+	+											2470
12		★	+			+			+			+	★				+										1890
25		×			+																×						820
15		★	+	+		+	+	+	+		+	+		★	+	+		+	+	+	+						3500
13								+						×			★		+	+	★	★		+			2040
7										+				×				★		+	×				×		1130
14										+	+	+			+		★		+	+	★	+		+		★	3610
11													★						★								470
18														×	×						×						890
16														×							×						760
32															×			×									40
17															×						×						1040
6														×	×		×								×		580
21																	+				★	★		+			1630
23															×		×				×				×		220
29																	×				×				×		80
4																					×		+	×	×		320
3																						+			×	×	390
5																								×	×		590
28																								×	×		210
1																								×	×	×	160
2																								×	×	×	360
9																									×		590
8																									★	×	450
Area (ha)	1540	3710	900	1290	100	1390	560	960	1430	280	840	1770	1210	1760	1890	920	760	1010	900	410	1730	2220	510	880	590	1140	30 700

(30 678 ± 4524)

Figure 3. The distribution of vegetation *noda* within BR track classes. A key to the track classes will be found in Table 3, and their distribution is shown on the maps following page 00. A conspectus of vegetation types, with *nodum* numbers is given in Table 6. x = 10% of one vegetation type present in one track class. + = 10% of one track class covered by one vegetation type. ★ implies both cases. Less frequent, or casual, occurrences are not plotted. The area covered by each class is given in ha.

gum, Myrica gale and *Eriophorum angustifolium* (all at IV) could be placed in the former, whilst a further 12 have *Succisa pratensis* at IV and might more correctly belong in the latter *nodum*. However, Hill and Evans (1978) considered the Campylopo-Ericetum tetralicis broadly equivalent to the Trichophoro-Callunetum, and, although there are clearly syntaxonomic difficulties within the group, for simplicity their treatment is followed.

Molinia caerulea is present at constancy V, and, to distinguish the rather heterogeneous railway vegetation, a separate subcommunity is named for this species. A railway facies (4 stands) with *Viola palustris, Juncus effusus* and *Galium saxatile* (all V) is transitional with *noda* in the Nardo-Callunetea Preising 1949.

The rare sedge *Carex pauciflora* was recorded from 2 stands, and bryophytes included *Sphagnum rubellum, S. papillosum, Gymnocolea inflata* and *Odontoschisma sphagni*.

b. **Calluno-Molinietum**

I. *Salix aurita* subcommunity, Table 7, *Nodum* 1, Plate 1.3

This is very close to the *Molinia-Myrica nodum* defined by McVean and Ratcliffe (1962), although many of the railway stands include *Salix aurita* which 'had been largely eradicated by human influence' from the stands on which the *nodum* was erected. Hill and Evans (1978) split *Molinia-Myrica*, placing part in their new association, the Junco-Molinietum (Molinio-Arrhenatheretea Tüxen 1937), although only one of the type stands included *Juncus acutiflorus*, and the remainder in the Calluno-Molinietum. The railway stands, where *J. acutiflorus* and associated species are uncommon, are probably more correctly placed in the latter association.

Table 7.

Class	Oxycocco-Sphagnetea			Vaccinio-Piceetea	
Nodum number	28	1	2	3	8
Potentilla erecta	IV (1–2)	V (1–3)	IV (1–3)	III (1–3)	IV (1–5)
Agrostis canina	II (2–5)	II (1–2)	IV (1–5)		
Molinia caerulea	V (2–5)	V (5)	V (1–5)		III (1–5)
Succisa pratensis	II (1–5)	III (1–2)	II (1–5)		II (1–2)
Galium saxatile	II (1–4)		II (1–3)	II (1–3)	III (1–4)
Juncus effusus	II (1–5)				II (1–5)
Calluna vulgaris		III (1–5)	IV (1–5)	V (1–5)	III (1–5)
Erica cinerea		II (1–3)	II (1–5)	II (1–3)	
Deschampsia flexuosa		II (1–3)	II (1–5)	IV (1–5)	
Festuca ovina		II (1–3)		II (1–5)	III (1–5)
Hypericum pulchrum			II (1–2)	II (1–2)	II (1–2)
Anthoxanthum odoratum			II (1–4)	II (1–5)	IV (1–5)
Trichophorum cespitosum	II (1–3)				
Narthecium ossifragum	II (1–4)				
Eriophorum angustifolium	II (1–5)				
Viola palustris	II (1–2)				
Erica tetralix	II (1–5)	III (1–4)			
Myrica gale	III (2–5)	V (1–3)			
Oreopteris limbosperma		II (1–3)			
Salix aurita		III (2–4)	II (1–5)		
Blechnum spicant		II (1–2)	II (1–2)		
Pteridium aquilinum		II (2–5)	III (2–5)		
Betula pubescens			II (2–5)		
Sorbus aucuparia			II (1–5)		
Dryopteris dilatata			II (1–2)		
Rubus fruticosus			II (1–3)		
Betula pendula			III (2–5)	II (1–5)	
Anthoxanthum odoratum			II (1–4)	II (1–5)	
Vaccinium myrtillus			II (1–5)	II (1–3)	
Vaccinium vitis-idaea				II (1–5)	
Rubus idaeus				II (1–2)	
Agrostis capillaris				II (1–5)	V (1–5)
Viola riviniana				II (1–2)	II (1–2)
Festuca rubra					III (1–5)
Poa pratensis					II (1–2)
Rumex acetosa					III (1–4)
Plantago lanceolata					II (1–3)
Holcus lanatus					IV (1–5)
Hypochoeris radicata					II (1–2)
Festuca vivipara					II (1–5)
Luzula multiflora					II (1–3)
Ranunculus repens					II (1–4)
Senecio jacobaea					II (1–2)
Number of species	74	40	88	100	133
Number of samples	24	18	41	44	57
Mean species sample^{-1}	10	7	10	7	14
Diversity index 'K'	0·63	0·6	0·59	0·7	0·57
Mean pH	6·4	4·4	4·5	5·2	5·0
Calculated area (ha)	210	160	360	390	450

In addition to the type, a better drained railway facies (4 stands) with *Calluna vulgaris* and *Festuca ovina* (both V) was recorded. Common bryophytes include *Campylopus pyriformis, Hypnum cupressiforme* var. *ericetorum* and *Dicranum scoparium.*

4.3 Vaccinio-Piceetea

a. Vaccineto-Callunetum

I. *Molinia caerulea* subcommunity, Table 7, *Nodum* 2, Plate 3.1

This damp heather moor is characterized by abundant *Calluna, Molinia* and *Myrica. Erica tetralix* and *Vaccinium* spp are present at constancy II. The railway character is shown in the frequency of birch, sallow and bramble, and in the virtual absence of *Nardus stricta.* Three facies are distinguished; *Anthoxanthum odoratum, Viola riviniana* and *Betula pubescens* characterize the majority of stands, whilst a group occurs in which *Pteridium aquilinum* replaces *Calluna vulgaris.* In a third, *Betula pendula, Erica cinerea* and *Teucrium scorodonia* become common. *Hypnum cupressiforme* var *ericetorum, Dicranella heteromalla* and *Hylocomium splendens* were recorded frequently. *Breutelia chryso-*

coma occurred occasionally and *Pohlia drumondii* was recorded from one site (R323, Glenfinnan).

The *nodum* is restricted to Scottish Region and occurs preferentially on flats and cuttings with moderate to steep slopes (better drained stands), and very little management or disturbance.

b. **Callunetum vulgaris**

I. *Deschampsia flexuosa* subcommunity, Table 7, *Nodum* 3, Plate 3.2

Although the railway vascular species list is considerably longer than that given by McVean and Ratcliffe (1962), there is a strong affinity between the 2 sets of data. The original authors placed the *nodum* in the Vaccinio-Piceetea, although more recent treatments (Birse & Robertson 1976; Hill & Evans 1978) have considered the Nardo-Callunetea to be a more appropriate position. The phytosociological tables given by McVean and Ratcliffe and the railway data include more woody species than does the synonymous (*sensu* Hill & Evans 1978) Carici binervis-Ericetum cinereae Birse et Robertson 1976, and between-group similarities (Table 5) further suggest that the railway vegetation, at least, is more correctly placed in the Vaccinio-Piceetea.

Many samples are dominated by *Calluna vulgaris*, although *Deschampsia flexuosa* frequently becomes the most abundant species. Common bryophytes are *Hylocomium splendens*, *Pleurozium schreberi*, *Polytrichum commune*, *Pseudoscleropodium purum* and *H. cupressiforme* var *ericetorum*. *Racomitrium lanuginosum*, *Barbilophozia floerkei* and *Lophozia ventricosa* were recorded from some rather better drained samples, whilst *Sphagnum palustre*, *Riccardia chamedryfolia* and *Odontoschisma sphagni* occurred in wetter areas.

The samples were mainly from steeply sloping cuttings on base-poor soils in the upland north and west.

c. **Agrosto-Festucetum**

I. *Senecio jacobaea* subcommunity, Table 7, *Nodum* 8, Plate 4.3

McVean and Ratcliffe placed this association in the Vaccinio-Piceetea, but qualified their decision, suggesting that the Arrhenatheretalia elatioris might be an equally appropriate position. Between-group similarities (Table 5) indicate that the Vaccinio-Piceetea is more correct for the railway subcommunity. However, the majority of railway bent/fescue grasslands (*Noda* 6, 7 and 9) has a high proportion of *Arrhenatherum elatius*, *Dactylis glomerata* and *Poa pratensis*, and is included in the Arrhenatheretum elatioris.

The railway subcommunity is recognized largely by the species richness of the samples. Common additional plants include *Hypochoeris radicata*, *Senecio jacobaea*, and *Agrostis canina*. Two facies are recognized: in one, the frequency of *Festuca ovina*, *Galium saxatile*, *Rumex acetosella* and *Calluna vulgaris* is high, whilst in the other *Holcus lanatus*, *Plantago lanceolata* and *Viola riviniana* become more constant.

The subcommunity occurs preferentially on flat formations, with some light ballast tipping and little management being recorded.

4.4 Molinio-Arrhenatheretea

a. **Arrhenatheretum elatioris**

In the National Vegetation Classification, Rodwell (pers comm) gives 4 constant species for the Arrhenatheretum elatioris in Britain. These are:

Arrhenatherum elatius
Dactylis glomerata
Holcus lanatus
Heracleum sphondylium

His approach is followed here*, and all railway *noda* with this combination of constant** species are placed in the association. Other treatments of the Arrhenatheretum have been prepared by O'Sullivan (1965) for Ireland and Page (1980) for England and Wales.

Rodwell recognizes 5 subcommunities, of which 3, *Festuca rubra*, *Urtica dioica*, and *Filipendula ulmaria*, are widely distributed on BR land. A further 5, reflecting the environmental conditions found on verges, are described here. Two base-poor *noda*, characterized, respectively, by *Holcus mollis* and *Agrostis capillaris*, occur principally in the upland north and west, whilst *Equisetum arvense* and *Chamerion angustifolium* subcommunities are more widely distributed. In the final *nodum*, which may be synonymous with the Brachypodietosum of the Cirsio-Brometum, described by Shimwell (1971), *Brachypodium pinnatum* is usually dominant, or co-dominant with *A. elatius*.

These 8 subcommunities are divided into 14 variants, and the average linkage between all groups (Czekanowski coefficient, Table 5) is greater than 0.39. Two major subgroups occur. In one, *Poa pratensis* and *Plantago lanceolata* are consistently present (Table 8), whilst the other is characterized by *Cirsium arvense*, *Urtica dioica*

---

*This definition extends the sense in which the railway Arrhenatheretum was previously defined by the author (Sargent 1982).

**In some more extreme environments (eg low pH, heavy disturbance), *H. lanatus* and *H. sphondylium* become less common, and are present only at constancy level I (<20%), which is not shown in the synoptic tables.

and *Elymus repens* (Table 9). The *P. pratensis* group is usually found on cutting slopes, whilst those with *C. arvense* are more common along embankments. Constant species for the railway Arrhenatheretum as a whole (in addition to those given by Rodwell) are *F. rubra* and *Rubus fruticosus* agg. Observations indicate that *Brachythecium rutabulum, Eurhynchium praelongum* and *Lophocolea bidentata* are also good association species.

The Arrhenatheretum covers approximately 21 800 ha, which is 71% of the calculated area of BR verges.

I. *Holcus mollis* subcommunity, Table 8, *Nodum* 6, Plate 4·2

Although affinity is shown with the bent-fescue grasslands described by Tansley (1949), consistent occurrence of false oat and cocksfoot places the *nodum* here, whilst the abundance of *H. mollis* and *C. angustifolium* (both likely a consequence of previous burning (Tansley 1949)) suggests that this is a distinct form of railway vegetation.

The grassland was found most often on flats or south-westerly slopes with a moderate incline. The soil is humic or peaty with a low pH, and very commonly strewn or partially covered with old (not recently tipped) spent ballast. Some spraying was recorded in samples adjacent to the track; elsewhere, little recent management was observed.

II. *Agrostis capillaris* subcommunity, Table 8, *Noda* 7 and 9, Plates 3.4 and 4.4

The type and a variant (*Achillea millefolium*) of this subcommunity are recognized. The type (7) is widely distributed, with some bias toward lines in the upland north and west. It occurs mainly on freely draining, gently sloping cuttings, or flats, with a comparatively low base status. Constant species are *Rumex acetosella* and *Anthoxanthum odoratum*. *Hypochoeris radicata* is differential for the subcommunity. Light vole and rabbit grazing was recorded, with little active management, although some swards were ballast-strewn. Amongst bryophytes, acrocarpous species were most often found, with *Bryum capillare* and *Polytrichum juniperinum* being common.

The *Achillea millefolium* variant (9) occurs on land with a slightly higher pH. It is more heavily grazed, with a majority of stands being recorded from the browse margin. This is a strip of land, grazed, but not dunged or trampled, by animals on adjacent pastoral land. *Luzula campestris, Senecio jacobaea, Trifolium repens* and *Daucus carota* are amongst differential species, with *Rhytidiadelphus squarrosus* being present in a majority of stands.

III. *Festuca rubra* subcommunity, Table 8, *Noda* 12, 13 and 14, Plates 6.1, 5.3, 5.4

Three variants of the type defined by Rodwell (pers comm) were delimited from data collected on BR verges. The *Poa angustifolia* variant (12) is very species-rich ($\bar{x}=19$), occurring on warm (predominantly south-facing), freely draining cutting slopes, with a mean soil pH of 7·3. Moderate ballast tipping, recent burning and scrub cutting were frequently recorded. The burning is of particular interest. Grime and Lloyd (1973) point out that *Poa angustifolia* is 'very common in grassland subject to burning, but is absent from grazed sites'. It is widespread in neutral to calcareous railway swards, and becomes very frequent in this particular *nodum*. *Potentilla reptans* and *Vicia sativa* spp *nigra* are differential for the variant, where a total of 275 vascular species were recorded from the 215 stands examined.

The *Anthoxanthum odoratum* variant (13) occurs on rather more acid soils on moderately sloping, north-facing formations (usually cuttings). Disturbance by ballast tipping was recorded, although burning and scrub cutting were less important than in the previous *nodum*. Differential species are *A. capillaris, Viola riviniana, Hieracium* Section *Vulgata* spp, *Lotus corniculatus, Angelica sylvestris* and *Tussilago farfara*. Among bryophytes, *Lophocolea bidentata* and *Rhytidiadelphus squarrosus* were commonly found.

The *Vicia cracca* (14) is a coarse variant on rather deeper, circumneutral, soils on flats, and low cuttings or embankments. The majority of samples fell into east- or west-facing quadrants. Tipping, varying from light to severe, was fairly consistently recorded, whilst the most frequent form of management noted was selective spraying of scrub and woody species. The variant is distinguished from other members of the subcommunity by the presence of *Elymus repens* and *V. cracca*. It is considered the railway type.

IV. *Brachypodium pinnatum* subcommunity, Table 8, *Nodum* 11, Plate 5.2

These grasslands have a limited distribution, occurring on calcareous cuttings in Eastern Region, where the soil is usually clay and the pH above neutral. Differential species include *Bromus erectus, Convolvulus arvensis, Viola hirta* and *Festuca arundinacea*. Individual stands are rather species-poor ($\bar{x}=12$), although at one site *Ophrys apifera* occurred abundantly, whilst elsewhere *Cirsium eriophorum* and *Genista tinctoria*

Table 8.

Class	Molinio-Arrhenatheretea						
Nodum number	6	7	9	12	13	14	11
Arrhenatherum elatius	III (1–5)	III (1–5)	II (1–5)	V (1–5)	V (1–5)	V (1–5)	IV (1–5)
Poa pratensis	II (1–5)	III (1–5)	III (1–5)	III (1–5)	III (1–5)	IV (1–5)	II (1–3)
Dactylis glomerata	II (1–5)	III (1–5)	III (1–5)	IV (1–5)	V (1–5)	V (1–5)	III (1–4)
Festuca rubra	IV (1–5)	IV (1–5)	V (1–5)	V (1–5)	V (1–5)	V (1–5)	
Agrostis capillaris	IV (1–5)	V (1–5)	IV (1–5)		II (1–4)		
Rubus fruticosus	II (1–5)	II (1–5)		III (1–5)	III (1–5)		III (1–5)
Rumex acetosa	II (1–2)		III (1–4)	II (1–2)	III (1–3)	II (1–3)	
Chamerion angustifolium	II (1–5)				II (1–5)	II (1–5)	
Holcus lanatus		III (1–5)	III (1–5)	II (1–5)	III (1–5)	III (1–5)	
Plantago lanceolata		III (1–5)	III (1–5)	V (1–3)	IV (1–3)	II (1–3)	II (1–2)
Rumex acetosella		II (1–5)	II (1–3)				
Anthoxanthum odoratum		III (1–5)	III (1–5)		III (1–5)		
Centaurea nigra			II (1–5)	III (1–5)	III (1–5)	III (1–5)	III (1–4)
Lathyrus pratensis			II (1–2)	II (1–4)	III (1–4)	III (1–4)	II (1–3)
Heracleum sphondylium			II (1–2)	II (1–4)	III (1–4)	III (1–4)	II (1–2)
Taraxacum officinale			II (1–2)	II (1–2)	II (1–2)	II (1–2)	
Achillea millefolium			III (1–5)	IV (1–2)	II (1–2)		
Viola riviniana			II (1–3)		II (1–2)		
Hieracium Section Vulgata spp			II (1–5)		II (1–3)		
Lotus corniculatus			II (1–5)		II (1–3)		II (1–3)
Leucanthemum vulgare			II (1–2)	III (1–4)			II (1–4)
Cerastium fontana			II (1–2)	II (1–2)			
Equisetum arvense				II (1–4)	II (1–4)	II (1–5)	
Poa angustifolia				IV (1–5)			II (1–2)
Holcus mollis	V (1–5)						
Pteridium aquilinum	II (1–5)						
Hypochoeris radicata		II (1–5)	II (1–4)				
Ranunculus repens			II (1–2)				
Senecio jacobaea			II (1–2)				
Trifolium repens			II (1–5)				
Luzula campestre			II (1–2)				
Daucus carota			II (1–2)				
Hieracium pilosella			II (1–4)				
Fragaria vesca			II (1–4)				
Potentilla reptans				III (1–5)			
Vicia sativa spp *nigra*				II (1–4)			
Angelica sylvestris					II (1–2)		
Tussilago farfara					II (1–3)		
Elymus repens						II (1–5)	
Vicia cracca						II (1–2)	
Brachypodium pinnatum							IV (3–5)
Bromus erectus							II (1–5)
Cirsium arvense							III (1–4)
Convolvulus arvensis							III (1–5)
Festuca arundinacea							II (1–4)
Viola hirta							II (1–3)
Number of species	132	215	195	275	255	256	133
Number of samples	66	129	67	215	233	411	54
Mean species sample^{-1}	11	18	13	19	16	13	12
Diversity index 'K'	0·59	0·51	0·64	0·5	0·5	0·5	0·6
Mean pH	5·5	5·3	6·3	7·3	6·4	6·5	7·8
Calculated area (ha)	580	1130	590	1890	2040	3610	470

are interesting associates. Amongst bryophytes, *Homalothecium lutescens, Campylium chrysophyllum* and *Eurhynchium striatum* are important. Although little management and no tipping was recorded, it is likely that burning has, in the past, played some role in the development of the sward.

V. *Equisetum arvense* subcommunity, Table 9, *Noda* 15 and 16, Plates 2.2 and 6.2

This is a comparatively species-poor subcommunity whose distribution includes ballast tips and heavily sprayed verges. A type (16) and variant (15) were delimited. A majority of stands was recorded from close to the cess, where disturbance is usually greatest. The vegetation was found in all Regions of BR and on all track classes except 24 (Welsh uplands). It covers approximately 4260 ha.

Bramble (*Rubus fruticosus* agg) is ubiquitous in the type, which occurs preferentially on ballast-tipped embankment slopes. The soil is circumneutral, and the most frequently associated bryophytes are *Brachythecium rutabulum* and *Eurhynchium praelongum*.

The variant is named *Elymus repens*, after the most commonly found differential species. Other differentials include *Poa trivialis*, *Lathyrus pratensis*, *Anthriscus sylvestris* and *Alopecurus pratensis*. The vegetation is often heavily sprayed, falling within the 3 m strip of verge controlled by spray train. *Equisetum arvense* shows considerable resistance to this form of management, and is commonly found on the cess itself, as are *Funaria hygrometrica*, *Ceratodon purpureus* and *Bryum capillare*, which further characterize the variant. These cryptogams are physiologically adapted to the periodically desiccating conditions found near and along the track bed.

VI. *Chamerion angustifolium* subcommunity, Table 9, *Noda* 17 and 18, Plates 7.1 and 7.2

This subcommunity is distinguished from related *noda* by the constant occurrence of *Chamerion angustifolium*. A type (17) and a variant on more acid soils with *Holcus mollis* (18) are differentiated. The type is found on embankment (and occasional cutting) slopes, with variable, but consistently colonized, tipping. No preferred aspect or particular form of management was recorded, although the establishment of this kind of community almost certainly depends on disturbance (tipping, burning).

The *Holcus mollis* variant has a rather more north-westerly distribution, and is not found in Southern Region. Management was recorded as minimal, and, although no preferred formation or aspect was noted, the *nodum* was not found on steep inclines, and only occurred close to the cess in cuttings. Very few bryophytes were recorded.

VII. *Filipendula ulmaria* subcommunity, Table 9, *Nodum* 19, Plate 7.3

This subcommunity has been defined by Rodwell (pers comm). The railway form is generally similar, although the constancy of most species varies. In particular, *Epilobium hirsutum*, *Rumex acetosa* and *Poa trivialis* are less common, whilst *Carex riparia* becomes differential, suggesting that the railway datum set includes more deep water sites. These are generally borrow pits, from which soil has been excavated to build embankments. The majority of stands, however, was recorded from ditches and embankment footings, sometimes 'mulched' with discarded ballast. The *nodum* is fairly widespread, occurring in all Regions of BR.

VIII. *Urtica dioica* subcommunity, Table 9, *Noda* 20 and 22, Plate 6.3

Two variants of Rodwell's subcommunity are

Table 9.

Class	Molinio-Arrhenatheretea						
Nodum number	15	16	17	18	19	20	22
Arrhenatherum elatius	V (1–5)	V (1–5)	V (1–5)	V (1–5)	V (1–5)	V (1–5)	IV (1–5)
Urtica dioica	II (1–5)	II (1–5)	III (1–5)	III (1–4)	II (1–5)	V (1–5)	V (1–5)
Rubus fruticosus	II (1–5)	V (1–5)	V (1–5)	IV (1–5)	III (1–5)	II (1–5)	V (1–5)
Cirsium arvense	IV (1–5)	II (1–4)	III (1–5)	III (1–4)	III (1–5)	II (1–5)	II (1–5)
Festuca rubra	III (1–5)	III (1–5)	II (1–5)	II (1–5)	II (1–3)	II (1–5)	
Dactylis glomerata	II (1–2)	II (1–2)	II (1–2)	II (1–5)	II (1–4)		
Heracleum sphondylium	III (1–4)	II (1–4)	II (1–4)	III (1–3)		III (1–5)	
Equisetum arvense	IV (1–5)	II (1–5)			II (1–2)	II (1–2)	
Elymus repens	IV (1–5)		V (1–3)	II (1–3)	III (1–5)	II (1–5)	
Lathyrus pratensis	II (1–2)				II (1–4)		
Anthriscus sylvestris	II (1–2)				II (1–3)	II (1–5)	
Galium aparine		II (1–4)	III (1–4)		III (1–5)	IV (1–5)	IV (1–5)
Chamerion angustifolium			V (1–5)	IV (1–5)		II (1–5)	
Poa pratensis	II (1–4)						
Poa trivialis	II (1–5)						
Alopecurus pratensis	II (1–5)						
Holcus mollis				IV (1–5)			
Carex riparia					II (1–5)		
Vicia cracca					II (1–3)		
Filipendula ulmaria					V (1–5)	II (1–5)	
Number of species	306	114	146	180	157	234	201
Number of samples	399	87	118	101	89	282	234
Mean species sample^{-1}	13	11	12	13	11	10	8
Diversity index 'K'	0·53	0·52	0·52	0·57	0·59	0·56	0·59
Mean pH	6·7	6·3	6·3	6·2	6·9	6·5	6·6
Calculated area (ha)	3500	760	1040	890	780	2470	2050

found on BR land. The railway type (22) has much bramble (*Rubus fruticosus* agg), and a variant with *Anthriscus sylvestris, Equisetum arvense, Elymus repens, Chamerion angustifolium* and *Filipendula ulmaria* is differentiated. This is very much a vegetation of mid and lower embankment slopes, into which chemical and organic wastes from the cess drain. Spray drift from adjacent agricultural land may also be intercepted, and there is often a layer of spent ballast retaining moisture. The subcommunity occurs throughout BR, and covers approximately 4500 ha.

4.5 Quercetea Robori-Petraeae

a. Fago-Quercetum

I. *Dryopteris filix-mas* subcommunity, Table 10, *Noda* 4 and 5, Plates 3.3 and 4.1

Although this vegetation shows similarity with the Galio-saxatilis-Quercetum Birse et Robertson 1976, it is disturbed and anthropogenic, and is probably best considered a railway subcommunity of the Fago-Quercetum. Constant species are *Dryopteris filix-mas, Viola riviniana, Rubus fruticosus, R. idaeus, Pteridium aquilinum* and *Epilobium montanum*. Two variants are delimited, and are conveniently named for the differential birches, *Betula pubescens* (4) and *Betula pendula* (5).

The *B. pubescens* variant has a woodland ground flora including *Teucrium scorodonia, Blechnum spicant* and *Solidago virgaurea*. It was found on a wide range of mineral soils, with *Trientalis europaea* and *Goodyera repens* occurring at the more acid extreme, and *Gymnocarpium robertianum* and *Polygonatum multiflorum* being found in woodland on oolitic limestone. Bryophytes showed an equally wide habitat range, with more commonly recorded species including *Thuidium tamariscinum, Dicranum scoparium* and *Dicranella heteromalla. Orthodontium lineare* was found on peaty soils and *Ctenidium molluscum* on limestone. *Dryopteris filix-mas* was particularly frequent in this variant. In high rainfall areas, it is a common plant of railway slopes, and observations suggest that it shows some resistance to commonly sprayed herbicides (Table 1). This may account for its more consistent inclusion in the railway subcommunity described here, than in comparable forms elsewhere.

The *B. pendula* variant is a more disturbed vegetation, generally occurring on freely draining, base-poor soils. It includes stands which are broadly comparable with the Pteridietum defined by Tansley (1949). Amongst bryophytes, *Rhytidiadelphus squarrosus, Brachythecium rutabulum* and *Hylocomium splendens* were common. The variant is widespread, occurring in all Regions of BR, although few stands were recorded from slopes with a northerly aspect.

4.6 Rhamno-Prunetea

a. Arrhenathero-Rosetum *assoc. nov. prov.* Sargent

Circumneutral scrub, woodland edge and secondary woodland communities retaining a grassland element are placed in the Rhamno-Prunetea. Railway woodlands are of recent origin and seldom extensive enough for a mature flora to have developed. In consequence, they are heterogeneous and, although trends toward recognizable, named associations can be seen, are probably best grouped within a single railway association. This is called the Roso-Arrhenatheretum, incorporating differential (*Rosa canina* agg.) and constant (*A. elatius*) species. The association belongs within the Prunetalia spinosae R. Tx. 1952, having *Prunus spinosa, Crataegus monogyna* and *Rosa canina* in common. The Arrhenathero-Rosetum is further characterized by *Fraxinus excelsior, Urtica dioica* and *Hedera helix*.

It is inherently difficult to place disturbed, anthropogenic vegetation within a systematic classification, and it may be argued that such an attempt is unwise. However, the intention is to show the general relationship with recognized European forms. It is not suggested that this vegetation would remain stable in an undisturbed environment, or that it would occur spontaneously without interference. The majority of component species occur casually, and are not consistently associated.

Three subcommunities, including the type, are delimited.

I. *Prunus spinosa* subcommunity, Table 10, *Noda* 21 and 25, Plates 7.4 and 8.3

Typically (*nodum* 25), this vegetation has no differential species from the association; however, a variant of *Chamerion angustifolium* (*nodum* 21) occurs which is very disturbed, with none of the tree species of the association occurring at a constancy greater than I.

The type is found on flat and gently sloping formations with no preferred aspect. Tipping was generally recorded, with some scrub cutting and spraying. Although widespread, the *nodum* was rarely found in Scottish Region. Common bryophytes include *Brachythecium rutabulum, Eurhynchium praelongum, Lophocolea bidentata, Plagiothecium denticulatum* and *Amblystegium serpens*.

The *C. angustifolium* variant showed more consistent signs of management. It was found on rather better drained, ballast-tipped slopes, with a slight bias toward a southerly aspect. It covers approximately 1630 ha throughout BR.

Table 10.

Class	Quercetea robori-petraeae			Rhamno-Prunetea				Querco-Fagetea
Nodum number	4	5	21	25	24	27	26	23
Rubus fruticosus	II (1–4)	IV (1–5)	IV (1–5)	V (1–5)	V (1–5)	V (1–5)	V (1–5)	II (1–3)
Dryopteris filix-mas	IV (1–5)	II (1–2)	II (1–5)		II (1–4)			III (1–5)
Epilobium montanum	II (1–2)	II (1–2)			II (1–2)			II (1–4)
Viola riviniana	III (1–2)	II (1–3)						III (1–2)
Fraxinus excelsior	II (1–5)			II (1–5)	III (1–5)		II (1–5)	IV (1–5)
Galium aparine		II (1–4)	II (1–5)	II (1–2)	II (1–4)			
Chamerion angustifolium		II (1–4)	III (1–5)				V (2–5)	
Betula pendula		II (1–5)				III (1–5)		
Urtica dioica			III (1–5)	III (1–5)	III (1–4)			
Arrhenatherum elatius			II (1–5)	III (1–5)	III (1–5)	II (1–4)	II (1–4)	
Rosa canina				III (1–5)	II (1–5)	II (1–4)	IV (1–5)	
Hedera helix				II (1–5)	IV (1–5)	IV (1–5)	II (1–5)	
Crataegus monogyna				III (1–5)	V (1–5)		V (1–5)	III (1–5)
Betula pubescens	III (3–5)							
Quercus petraea	II (1–5)							
Larix decidua	II (2–5)							
Salix caprea	II (1–5)							
Salix cinerea oleiifolia	II (1–5)							
Blechnum spicant	II (1–2)							
Teucrium scorodonia	II (2–4)							
Solidago virgaurea	II (1–2)							
Fragaria vesca	II (1–3)							
Deschampsia flexuosa	II (1–5)							
Dactylis glomerata	II (1–3)							
Agrostis canina	II (1–3)							
Rubus idaeus	II (1–2)	II (1–5)						
Pteridium aquilinum	II (1–5)	IV (2–5)						
Digitalis purpurea		II (1–2)						
Anthoxanthum odoratum		II (1–3)						
Agrostis capillaris		II (1–5)						
Holcus lanatus		II (1–5)						
Holcus mollis		II (2–5)						
Prunus spinosa				II (1–5)	II (1–5)			
Acer pseudoplatanus					III (1–5)			
Arum maculatum					II (1–4)			
Mercurialis perennis					II (1–5)			
Quercus robur						IV (1–5)		
Corylus avellana						III (1–5)		
Lonicera periclymenum						II (1–5)		
Brachypodium sylvaticum						II (1–4)		
Primula vulgaris						II (1–4)		
Clematis vitalba							IV (3–5)	
Prunus avium							II (2–5)	
Viburnum lantana							IV (1–5)	
Glechoma hederacea							II (1–2)	
Veronica chamaedrys							II (1–4)	
Ulmus glabra								IV (1–5)
Number of species	147	126	175	124	204	189	61	77
Number of samples	62	47	186	94	154	179	22	25
Mean species sample^{-1}	13	14	9	8	9	10	7	9
Diversity index 'K'	0·59	0·57	0·57	0·6	0·62	0·57	0·7	0·67
Mean pH	5·5	5·0	6·6	6·7	6·4	5·8	7·7	6·6
Calculated area (ha)	320	590	1630	820	1350	1570	190	220

II. *Hedera helix* subcommunity, Table 10, *Noda* 24 and 27, Plates 8.2 and 8.4

In this subcommunity, *Hedera helix* becomes constant at level IV, and *Fissidens taxifolius* is a useful differential. Two variants of *Crataegus monogyna* and *Quercus robur* are distinguished.

Differential species in the *C. monogyna* variant are *Acer pseudoplatanus, Arum maculatum* and *Mercurialis perennis.* The vegetation tends toward ash wood (*sensu* Ratcliffe 1977), occurring on calcareous slopes with some bias toward a western distribution. It is not found in the large, eastern lowland classes (Figure 3), and has a fairly restricted distribution in Scottish Region. Moderately inclined, north-facing slopes are slightly preferred, usually with some spent ballast. Little evidence of recent management was found.

The *Q. robur* variant includes a few stands attributable to the Quercetum roboris of Tansley (1949), although the majority are disturbed or deflected with scrub, grassland and some ruderal species associated. The variant is differentiated by *Corylus avellana, Lonicera periclymenum, Brachypodium sylvaticum* and *Primula vulgaris.* A facies with *Betula pendula* is found in some better drained areas, and, because of ground flora similarities, several stands of beech wood (Plate 8.4) are included. The vegetation occurs preferentially in southern Britain: 75% of stands occur in 4 track classes, South Eastern (1), South Western (4), Central Southern (5) and South Midlands (6). It is virtually absent from Eastern Region, and occurs only locally in Scottish Region.

The woodland is found on all formations, although the samples show some slight preference for embankments. Recorded slope and aspect were variable, although in the latter a small bias toward the south-west was observed. Light tipping with some scrub clearance and felling was common.

III. *Clematis-Viburnum* subcommunity, Table 10, *Nodum* 26, Plate 6.4

This is a subcommunity of chalk scrub (*sensu* Tansley 1949), with a local distribution on lines in southern Britain. In addition to *Clematis vitalba* and *Viburnum lantana, Prunus avium, Glechoma hederacea* and *Veronica chamaedrys* are differential at level II. *Crataegus monogyna* and *Chamerion angustifolium* are present in more than 80% of stands, the latter indicative of a disturbed railway community. A majority of stands were recorded on flat or gently sloping formations, with tipping on those close to the cess. Although each stand was comparatively species-poor ($\bar{x}=7$), the total number of vascular species recorded in the *nodum* was large in relation to the number of stands and area of verge covered. This gave a comparatively high diversity index (K=0·7, Table 10), showing that a high rate of recruitment of new species occurred in an increasing area.

4.7 Querco-Fagetea

a. Fraxino-Ulmetum

I. *Dryopteris filix-mas* subcommunity, Table 10, *Nodum* 23, Plate 8.1

A small (220 ha), comparatively homogeneous, group of ash/elm woodlands occur in which the grassland element is not apparent. This has been placed in the Querco-Fagetea, a class which includes the majority of circumneutral broadleaved woodlands in north-western Europe. The *nodum* shows closest affinity with the subassociation Ulmetosum glabrae J. Bakker 1961, although the differential taxa *Sanicula europaea* and *Actaea spicata* are not present (*A. spicata* is a rare species of limestone pavement in Britain), and the vegetation has therefore been placed in a separate subcommunity of *Dryopteris filix-mas.*

The woodland has a north-westerly distribution, and is found on embankment, and occasionally cutting, slopes, with a moderate incline and preferential north aspect. Ballast tipping was frequently recorded over soil with a mean pH of 6·6.

4.8 Phragmitetea

a. Scirpo-Phragmitetum

I. *Equisetum arvense* subcommunity, Table 11, *Nodum* 30

Although *Schoenoplectus (Scirpus) lacustris* was rarely recorded in railway ditches, the affinity of this *nodum* is almost certainly with the Scirpo-Phragmitetum. Koch (1926) gives *Typha latifolia* and *Rumex hydrolapathum* as association species, both of which occurred occasionally. However, the railway *Phragmitetum* is characterized by *Arrhenatherum elatius, Urtica dioica, Rubus fruticosus* and *Equisetum arvense,* suggesting that the stands are more disturbed, eutrophic and not entirely homogeneous.

These reed beds were found in all Regions of BR, although outside Southern and Eastern Regions distribution was very local. Comparatively little management was recorded.

4.9 Trifolio-Geranietea

a. Trifolio-Agrimonietum

I. *Arrhenatherum elatius* subcommunity, Table 11, *Nodum* 10, Plate 5.1

The affinity of this extremely species-rich ($\bar{x}=26$), calcicolous vegetation is with the Trifolio-Agrimonietum. The vegetation occurs on chalk cuttings in Southern Region, where the sward is often kept open by slippage. Although dominated by herbs, *Festuca rubra* and *Arrhenatherum elatius* are present in 80% of stands. A further 33 species are constant at level II or higher, indicating a very homogeneous vegetation. Amongst these species are *Clinopodium vulgare, Bellis perennis, Senecio erucifolius, Hieracium pilosella* and *Fragaria vesca. Viburnum lantana* and *Clematis vitalba* are commonly invasive.

Czekanowski similarity (Table 5) indicates that this subcommunity is not closely related to either the calcicolous grasslands (*noda* 11 and 12) or the chalk scrub (*nodum* 26).

4.10 Chenopodietea

a. Sagino-Bryetum argentei

I. *Senecio viscosus* subcommunity, Table 11, *Nodum* 31, Plate 1·2

Ephemeral communities on BR land, which occur largely along the cess, were undersampled for safety constraints dictated by BR. These are generally characterized by *Bryum argenteum, B. caespiticium, Funaria hygrometrica, Sagina* and *Senecio* spp, and may include casual, seaside, alien and introduced species. *Cochlearia danica, Saxifraga granulata, Bunias orientalis* and *Cynodon dactylon* were amongst plants observed occasionally.

This vegetation occurred throughout BR, although in Scottish Region the number and variety of bryophytes were found to be much greater. It is almost certain that more intensive sampling would have shown the vegetation to be syntaxonomically more complex than inclusion in a single subcommunity would imply.

4.11 ***Rhododendron ponticum* stands,** Table 11, *Nodum* 29

Four stands with *Rhododendron ponticum* and some bramble (*Rubus fruticosus* agg) were recorded on base-poor, freely draining soils.

4.12 **Asteretea tripolii,** Table 11, *Nodum* 32

Two stands of salt marsh vegetation, probably belonging within the Asteretea tripolii, were recorded. The pH was high at 9·5, and no disturbance or tipping was noted.

Table 11.

Class	Phragmitetea	Trifolio-Geranietea	Chenopodietea	*Rhododendron ponticum* stands	Asteretea tripolii
Nodum number	30	10	31	29	32
Arrhenatherum elatius	III (1–5)	V (1–5)			
Rubus fruticosus	III (1–5)			II (1–2)	
Phragmites australis	V (2–5)				
Urtica dioica	III (1–5)				
Equisetum arvense	II (1–5)				
Festuca rubra		V (1–5)			
Plantago lanceolata		V (1–2)			
Fragaria vesca		V (1–4)			
Leucanthemum vulgare		V (1–5)			
Clinopodium vulgare		V (1–2)			
Rumex acetosa		IV (1–2)			
Daucus carota		IV (1–2)			
Hieracium pilosella		IV (1–3)			
Lotus corniculatus		IV (1–3)			
Bellis perennis		IV (1–2)			
Hypericum perforatum		IV (1)			
Dactylis glomerata		III (1–4)			
Senecio erucifolius		III (1–2)			
Betula pubescens		III (1–2)			
Poterium sanguisorba		III (1–2)			
Viburnum lantana		III (1–3)			
Senecio viscosus			V (1–2)		
Teucrium scorodonia			IV (1–4)		
Senecio jacobaea			III (1–3)		
Cerastium fontanum			II (1–2)		
Sagina procumbens			II (1–4)		
Poa annua			II (2–3)		
Rhododendron ponticum				V (5)	
Matricaria maritima					V (1)
Number of species	83	92	48	6	7
Number of samples	26	21	10	4	2
Mean species sample^{-1}	7	26	10	2	5
Diversity index 'K'	0·76	0·42	0·68	—	—
Mean pH	7·4	7·4	7·8	5·4	8·2
Calculated area (ha)	250	180	90	—	—

18 species present at level II in *nodum* 10, and 6 species present at level III in *nodum* 32 (ie in one type only) are, for brevity, not listed.

5. Conservation of railway vegetation

5.1 Introduction

The intention of this work has been to provide an inventory of railway species and vegetation on which a general strategy for conservation and management of railway verges could be based. Some preliminary value judgements were made by us, and, in addition to the documentation of species and vegetation, 185 sites of particular biological interest (BI) have been identified.

In this chapter, the implications for conservation of the relationship between BI sites and the railway network as a whole are considered. Information collected in Southern and Western Regions during 1977 and 1981 is then described, and a Markov model, predicting vegetation population changes, is given. The chapter concludes with a discussion about changing vegetation structure in relation to conservation and management.

5.2 Biological interest sites

BI sites were selected from within random and subjective surveys in the following proportions:

	Subjective	Random	Total
Eastern Region	31	35	36
Southern Region	1	10	11
Western Region	15	12	27
London Midland	32	12	47
Scottish	19	18	37
Total BI sites	98	87	185
Total sites visited	241	480	721
% sites designated	**41**	**18**	**26**

Although the numbers of BI sites from within the parallel surveys are comparable, a considerably greater proportion of sites occurred in the subjective than the random survey. Identification of BI sites followed discussion and agreement between all members of the team, and depended on the following criteria.

1. Inclusion of rare or local taxa, or *noda*.
2. Inclusion of taxa, *noda*, or habitat types not locally common.
3. Inclusion of many taxa—diversity.
4. Area—constrained by ± parallel boundaries and a restricted length of track in randomly visited sites; this criterion was not used except insofar as a minimum verge width, allowing for edge effects, is found in all BI sites.

Detailed descriptions and management advice have been prepared, and the preservation of these sites is at present subject to negotiation between BR and NCC. A majority of the sites are shown in red on the maps following page 00. Some cartographic licence has been exercised in their location.

The distribution of BI sites within track classes (Chapter 3) was examined. A direct comparison between numbers of BI sites and track classes is artificial, as all track classes are of different sizes. Correlation was therefore sought between numbers of BI sites and track class length (r=0·667) or verge area (r=0·752). The stronger correlation with area indicates that verge width is of some importance, although the contribution (mean verge width: numbers of BI sites: r=0·351) is small. Although numbers of vegetation types (preliminary classification) are correlated with track class area (r=0·524; Sargent 1983), there is little correlation between numbers of vegetation types and BI sites (r=0·171), and a diversity index, obtained by dividing area by vegetation types, gives a weaker correlation (r=0·665) than area alone. When the largest track class (South Midlands) is omitted from the calculation, the correlation between area and BI sites diminishes (r=0·541).

The regression of BI sites against track class area is shown in Figure 4. The classes which include proportionally more BI sites have a predominantly western distribution, and are upland or coastal. The lowland southern and eastern classes support rather fewer BI sites, despite the introduction of some bias, during the subjective survey, toward sites close to Monks Wood (Cambridgeshire), where the team was based. The inclusion of Fens (F) amongst the 'better' classes probably reflects this bias, but may also be due to the comparatively high diversity of the railway in relation to surrounding arable land.

Pennines (P) and Pennine Coal Measures (PCM) are amongst the 'least interesting' classes, although some outstanding lines, including the Blackburn-Hellifield and part of the Skipton-Carlisle, and some excellent sites, eg R203 Wye Dale, occur in Pennines. Pennines is the second largest track class. Its position in the regression may be due in part to under-sampling during the subjective survey. Nevertheless, in common with Pennine Coal Measures, much of the track in Pennines crosses industrialized and, sometimes, derelict land, where the verges are disturbed and support tall herb, bramble and scrub (*noda* which are not deemed to be of particular biological interest).

When the distribution of BI sites against railway formations is examined, 43% of sites are found to occur on cuttings, whilst a further 31% are on mixed formations dominated by cuttings. The distribution is as follows:

Formation		BI sites	% total
Cuttings		79	42·7
Embankments		10	5·4
Flats and ditches		11	5·9
Mainly cuttings	mixed	58	31·4
Mainly embankments	mixed	11	5·9
Mainly flats	mixed	16	8·7
Totals		**185**	**100·0**

Mineral soil and less ballast and waste tipping (Chapter 2), together with greater verge width (sloping formations are usually wider than flats), contribute to the strong bias towards cuttings as sites of interest.

The preponderance of upland hilly track classes, having proportionately more BI sites (Figure 4), is associated with the comparatively larger numbers of cuttings these classes support.

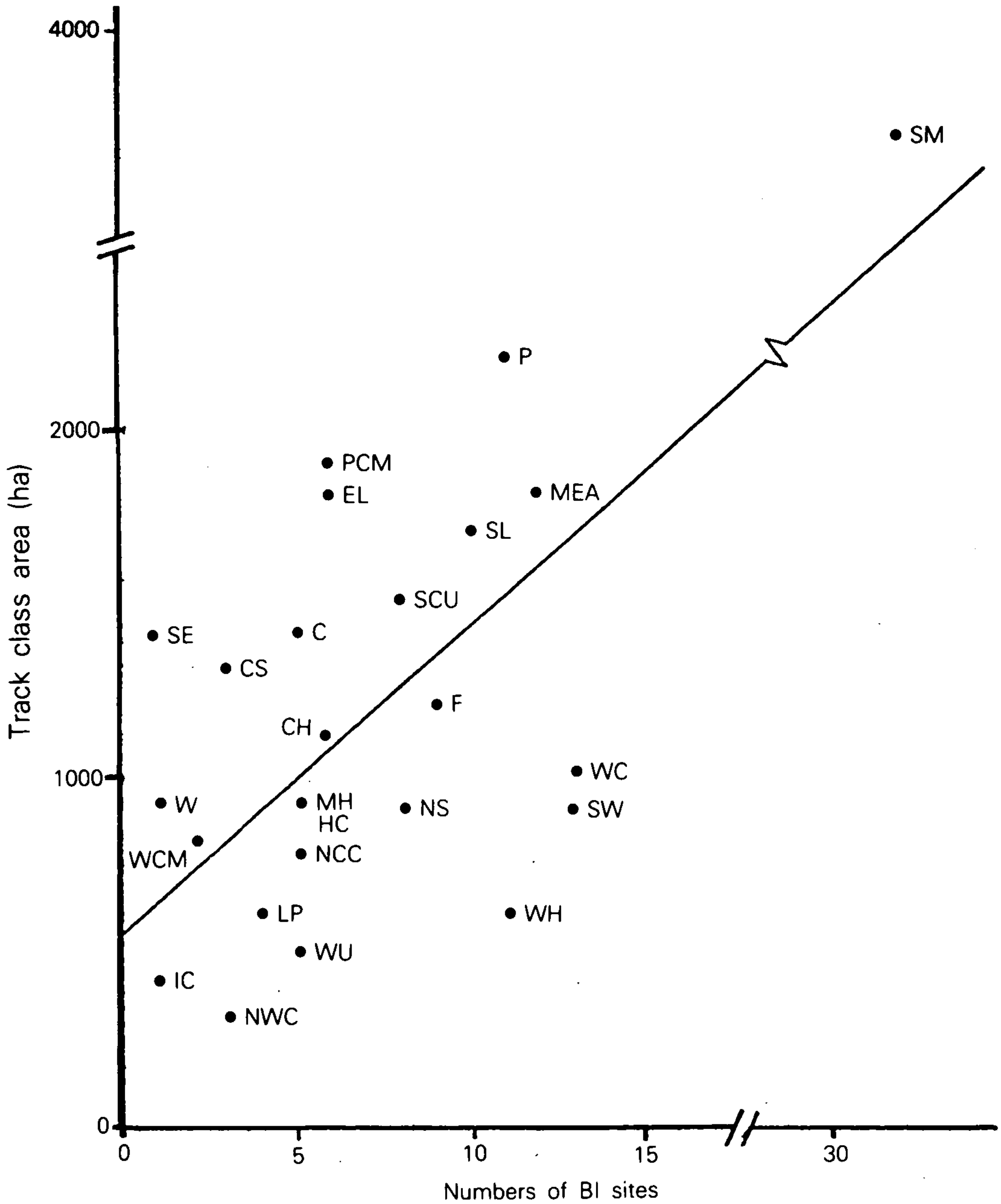


Figure 4. BI sites within track classes

The numbers of designated BI sites plotted against the area of the track classes in which they occur, r = 0·752. If the large track class, SM, is omitted from the calculation, the correlation diminishes and r = 0·541. Track class 6, South Coastal, has no BI sites and is omitted from the diagram.

Key—SE= South Eastern; W = Weald; SCU = Southern Chalk Uplands; C = Chilterns; SW = South Western; CS = Central Southern; SM = South Midlands; MEA = Midlands and East Anglia; EL = Eastern Lowlands; F = Fens; PCM = Pennine Coal Measures; NS = Northern Sandstones; WC = West Coastal; LP = Lancashire Plain; P = Pennines; WCM = Western Coal Measures; MH = Midland Hills; NCC = North Coast Carboniferous; SL = Scottish Lowlands; NWC = North West Coastal; HC = Highland Coastal; WH = West Highlands; CH = Central Highlands; WU = Welsh Uplands; IC = Igneous Coastal.

It is apparent that considerably more BR land is of interest than was within the resource of the survey to record. This is shown by the correlation between numbers of BI sites and track class area, the implication being that, if more area is examined, further BI sites will be found. The BI designation given to 18% of randomly visited sites implies that almost one fifth of BR land is of local, or, occasionally, national, interest.

Any conservation strategy should not, therefore, rely solely on the individual site listings prepared by us, but should include a generalized management policy in which particular attention is paid to cuttings. A booklet giving management advice has been prepared for distribution within BR (Sargent 1982, Appendix).

5.3 Changes in railway vegetation

Underlying this work has been the concern 'that much conservation interest in terms of herb-rich grassland may be affected by the development of coarser vegetation and scrub in the absence of regular management' (Way & Sheail 1977). The idea of the loss of herb-rich (fine-leaved, *noda* 6–11) grassland was echoed by Gulliver (1980), who suggested that 'without mowing, the short, railside grasses quickly changed to tall grassland. Very soon, one or two aggressive grasses, such as false oat grass (*Arrhenatherum elatius*) and cocksfoot (*Dactylis glomerata*), came to dominate these swards'.

To examine changes occurring under the present *ad hoc* management regime, 30 randomly distributed sites in Southern and Western Regions, first recorded during 1977, were visited again in 1981; 283 quadrats were relocated by careful measurement and scored as previously.

All data (2 × 283 quadrats) were ascribed to the initial classification using the Czekanowski similarity coefficient (Chapter 4), and the fate of each quadrat between 1977 and 1981 followed. A total of 265 pairs of quadrats occurred in or remained amongst the 4 major vegetation groups occurring in Southern and Western Regions. The other 18 pairs of quadrats were classified elsewhere or moved into or out of these groups or states, and are not included in the analysis. The 4 vegetation states are:

1. Fine-leaved grassland, *noda* 6-11
2. Coarse, false oat grassland, *noda* 12-18
3. Tall herb and bramble, *noda* 19-22
4. Scrub and secondary woodland, *noda* 23-27

The analysis examines changes between these states. In Figure 5, a matrix showing quadrat movement is given. In row 1, for example, 24 quadrats remained as fine-leaved grassland, whilst 4 became false oat, 2 went to tall herb, and one became classified as scrub or secondary woodland. Recruitment to fine-leaved grassland is given in column 1. The row totals, therefore, give the population in 1977, whilst the column totals describe the situation in 1981. Thus, it may be seen that there was a net recruitment of 8 quadrats into the fine-leaved grassland population during the time in question.

	1	2	3	4	
1	24	4	2	1	31
2	9	52	11	4	76
3	1	20	36	5	62
4	5	7	7	77	96
	39	83	56	87	265

Figure 5. Transition matrix showing the movement of quadrats between the 4 major vegetation groups in Southern and Western Regions during 1977-1981. The groups are: 1, fine-leaved grasslands; 2, coarse false oat grasslands; 3, tall herb and bramble; 4, scrub and secondary woodland. The row totals give the population size in 1977, whilst column totals show the population in 1981. In row 1, for example, 24 quadrats remained unchanging during the time in question, whilst 4 were lost to vegetation type 2, and 2 and 1 to 3 and 4 respectively. Increments to the population are given in column 1, and it may be seen that there was a net gain to the population of 8 quadrats.

The information in the matrix was used to build a Markov model (Horn 1975; Usher 1979), which assumes that at some future time the populations will stabilize, and predicts the distribution of quadrats within those populations (ie the size) when they do so. The results are shown graphically in Figure 6, and it may be seen that between the years 2009 and 2013 no further change occurs.

Various criticisms of the model and preliminary collection of information can be made, although use of a coarse level of classification eliminates error in allocating quadrats.

The criticisms include the following points.

1. Clementsian succession is assumed.
2. There were only 2 datum collections and the time span between the 2 dates was short. A temporary reversal in long-term trends may have been picked up.

3. The Markov model tends, inherently, to emphasize short-term trends during projection. A minor fluctuation may become exaggerated.
4. The information is from Southern and Western Regions only, and so almost certainly shows a geographical bias.
5. Although careful measurements were made (the position of all quadrats is recorded in relation to, and lies within, 100 m of a BR mile post), some small error will have occurred during relocation.
6. The model assumes that the transition probabilities are stationary in both space and time.

The model depends, however, on what actually took place at the randomly selected sites, and, if the argument is restricted to Southern and Western Regions, and allowance is made for perturbation and exaggeration during projection, the results lead to interesting hypotheses, which are contrary to the expectations of Way and Sheail (1977) and of Gulliver (1980).

Prior to 1960, verge management generally took the form of annual burning, grass cutting and scrub clearance. Cutting was done during early summer to prevent spread and germination of seeds on the cess. Cutting is no longer carried out, burning is only occasional or accidental, and scrub and woodland clearance is on an *ad hoc* basis, although Western Region has always kept tree and scrub growth reasonably under control. Southern Region has narrower verges and for a number of years no effective action was taken. Major work has now become essential, leading to some unnecessary clearance which is causing consternation to, amongst others, the Tree Council (C Beagley, pers comm).

It is probable that the model has picked up this increased activity; 19 quadrats were lost from scrub and secondary woodland between 1977 and 1981, whilst only 9 were recruited to the population. The loss is towards all other vegetation groups, and the direction is almost certainly dependent on the original character of the scrub or woodland, together with grazing pressures and other disturbances in the intervening period. Some cleared woodland, retaining a characteristic ground flora and woody seedlings, will have continued to be classified within the group.

Thirty-two per cent (20 quadrats) of the tall herb population moved to false oat grassland, whilst 14% (11 quadrats) of the initial false oat population moved in the reciprocal direction. Tall herbs and false oat grass include primary colonizers of recently burnt and ballasted areas. At the top of slopes, where tipped ballast is usually deepest, false oat, and sometimes bramble, colonize. Lower down, where ballast forms a thinner layer and serves to mulch the underlying soil, *Urtica dioica, Filipendula ulmaria* and *Galium aparine* compete (Chapter 2). *Chamerion angustifolium* establishes successfully on spent ballast with a high proportion of cinder and small particled material. It is less frequently associated with burnt sites (see below).

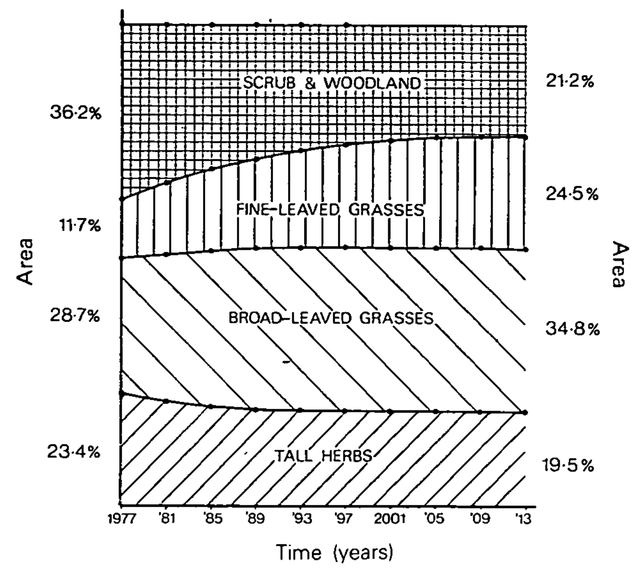


Figure 6. Predicted population changes between the 4 major vegetation groups occurring in Southern and Western Regions. The Markov model (see text) is based on information collected in 1977 and 1981 from 265 quadrats, and projects trends occurring between these 2 dates. The model stabilizes between the years 2009 and 2013, at which time the % loss or increment has been calculated.

Although some *noda* within the tall herb and false oat groups will be comparatively stable (Chapter 3), those developing in response to the outlined disturbances and giving rise to the observed fluctuations between groups are clearly less so. In a recovering, or less disturbed, environment, the natural succession seems to be towards false oat grassland, although scrub may also develop. *Fraxinus excelsior* seedlings and saplings were frequently noted on spent ballast tips, whilst bramble may encroach and provide a nurse crop for some woody species.

The net movement from coarse to fine-leaved grassland is, perhaps, the least expected result from this study. Whilst 4 fine-leaved grassland quadrats went to false oat, 9 moved in the opposite direction. False oat grass withstands annual scything (Pfitzenmeyer 1962) and cessation of this activity is unlikely to have led directly to a change in this category (although it will clearly facilitate the development of woody plants). More frequent mowing (Gulliver 1980) was an unusual management strategy, but the concomitant removal of litter may have been more important. On some railway verges, false oat has formed a tussock grassland, with very few other plants surviving in the intervening, litter-thatched troughs. This phenomenon may be associated with inhibition of microbial activity by SO_2, as it was more often observed in industrialized areas (eg Derbyshire coalfields).

The recovery of rabbit populations from myxomatosis began in the early 1960s, at about the same time that verge cutting stopped. More recently, BR has begun to erect rabbit-proof fencing in response to complaints from neighbouring farmers and land-owners. Although false oat appears to survive vole (usually *Microtus agrestis*) grazing (there is abundant evidence of voles in most false oat railway swards), increased rabbit pressure is probably favouring the spread of *Festuca rubra*. Ferns (1976), on the other hand, has shown that *F. rubra* may be an important component of vole diet.

Rabbit scrapes and the numerous ant hills (usually *Lasius flavus)* lend diversity and provide alternative habitats for some fine-leaved ephemerals (eg *Aira caryophyllea, Vulpia bromoides*) and cess annuals under pressure from heavy chemical spraying (Chapter 2).

However, a more important factor in the increase of fine-leaved grasslands may be the reduction of burning. Of 157 quadrats recorded during the random survey as 'recently burnt' (ie within the past 18 months), 111 occurred in false oat grasslands, 30 in the tall herb group, 9 amongst heath and base-poor vegetation, and 7 amongst the fine-leaved grasslands (Table 12). These figures depart significantly from the null hypothesis that the distribution of recently burnt quadrats between groups would be proportional to their distribution in the entire data set ($P<0{\cdot}1$). The number of false oat quadrats is considerably more than expected, whilst the number of fine-leaved quadrats is fewer. Tall herb is somewhat less than expected, whilst base-poor vegetation remains strictly proportional. Others have no representatives amongst the recently burnt quadrats. The distribution of vegetation types in recently burnt quadrats is not comparable with the overall distribution ($\chi^2=54{\cdot}2$, $P<0{\cdot}1$).

The foregoing suggests that burning favours the spread of coarse false oat grassland, ie stands

Table 12. The distribution of vegetation types in recently (within 18 months) burnt quadrats.

Groups	Number of quadrats observed	Number of quadrats expected
Base-poor	9	9
Fine-leaved	7	17
False oat	111	71
Tall herb	30	35
Scrub	0	14
Miscellaneous	0	2
Total	**157**	**157**

without *Poa pratensis* and with comparatively little *F. rubra*. It is well established that *Brachypodium pinnatum* grasslands are encouraged by burning, but no reference could be found in the literature to the development of an Arrhenatheretum under such conditions. However, the bulbous form of *Arrhenatherum elatius* or 'onion couch' (*A. elatius* var *bulbosum* (Willd) Spenn) is widespread on railway verges, and it is likely that this is a response to the frequent burnings of the past, the bulb lending some resistance to burning.

Whether the present lack of burning is advantageous to *F. rubra* requires experimental testing. However, *Festuca* spp do compete successfully with *A. elatius* in some localities. Peterken and Rorison (1982), working with *Festuca ovina*, have suggested recently that one explanation could be the ability of *F. ovina* to continue some metabolic processes at lower temperatures than *A. elatius*.

The mechanisms underlying vegetation change on railway land are not fully understood. The vegetation is extremely diverse and the number of variables involved is very large. However, assuming some scrub control is practised, there seems, under present conditions of grazing by small mammals and comparatively little burning, to be a gradual succession towards fine-leaved grassland. There is also some increase in coarse grasslands, but this is largely at the expense of scrub and tall herbs.

The implications of this work for the conservation of railway verges are large, and ITE (funded by Science Vote) has therefore set up a number of monitoring sites distributed throughout BR land, which will enable detailed long-term studies to be made. A programme of experimental work designed to examine interactions between key railway species under disturbance (ballasting, burning, grazing) and recovery is also being started.

References

Nomenclature throughout follows Flora Europaea for vascular plants and Smith (1978) for bryophytes. Syntaxa are as named by the particular author.

Almquist, E. 1957. Järnvagsfloristika notiser. Ett apropos till järnasgsjubleet. *Svensk. bot. Tidskr.*, **51,** 223–263.

Arnold, R.M. 1981. Population dynamics and seed dispersal of *Chaenorhinum minus* on railway cinder ballast. *Am. Midl. Nat.*, **196,** 80–90.

Bakker, J. 1961. Quoted in: Westhoff & Den Held 1969, 268.

Birse, E.L. & Robertson, J.S. 1976. *Plant communities and soils of the lowland and southern upland regions of Scotland.* Aberdeen: Macaulay Institute for Soil Research.

Brandes, D. 1979. Bahnhöfe als Untersuchungsobjekte der Geobotanik. *Mitt. Tech. Univ. Carola-Wilhelmina, Braunschweig,* **14** (3/4), 49–59.

Braun-Blanquet, J. 1919. Quoted in: Westhoff & Den Held 1969, 186.

Braun-Blanquet, J. 1951. *Pflanzensociologie.* Vienna: Springer.

Braun-Blanquet, J. & Tüxen, R. 1943. Ubersicht der höheren Vegetationseinheiten Mitteleuropas (Unter Ausschluss der Hochgebirge). *Commun. Stn int. Géobot. médit. alp.*, **84.**

Braun-Blanquet, J. & Vlieger, J. 1937. Quoted in: Westhoff & Den Held 1969, 261.

Braun-Blanquet, J., Sissingh, G. & Vlieger, J. 1939. *Klasse der Vaccinio-Piceetea, Madelholz- and Vaccinien-Heiden. Verbände der eurosibirisch-nordamerikanischen Region.* (Prodromus der Pflanzengesellschaften 6). Montpellier.

Caspers, N. & Gertstberger P. 1979. Floristische Untersuchungen auf den Bahnhöfen des Lahntales. *Decheniana,* **132,** 3–9.

Clapham, A.R., Tutin, T.G. & Warburg, E.F. 1962. *Flora of the British Isles.* 2nd ed. Cambridge: Cambridge University Press.

Dony, J.G. 1955. Notes on the Bedfordshire railway flora. *Beds. Nat.*, **9,** 12–16.

Dony, J.G. 1974. Some problems of a railway flora. In: *Research and management in wildlife conservation, 2.* Herts. & Middx Trust Symposium no. 2.

Ferns, P.V. 1976. Diet of a *Microtus agrestis* population in south-west Britain. *Oikos,* **27,** 506-511.

Fuller, R.M. 1975. The Culbin shingle bar and its vegetation. *Trans. bot. Soc. Edinb.*, **42,** 293–305.

Grime, J.P. 1979. *Plant strategies and vegetation processes.* Chichester: John Wiley.

Grime, J.P. & Lloyd, P.S. 1973. *An ecological atlas of grassland plants.* London: Edward Arnold.

Gimingham, C.H. 1972. *Ecology of heathlands.* London: Chapman & Hall.

Gulliver, R. 1980. Once the trains have gone. *Ctry Life,* **167,** 294–295.

Hill, M.O. 1979a. *TWINSPAN: a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes.* Ithaca, N.Y.: Section of Ecology and Systematics, Cornell University.

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

Hill, M.O. & Evans, D.F. 1978. *Types of vegetation in the southern uplands of Scotland.* (CST report no. 150). Banbury: Nature Conservancy Council.

Hill, M.O., Bunce, R.G.H. & Shaw, M.W. 1975. Indicator species analysis, a divisive polythetic method of classification and its application to a survey of native pinewoods in Scotland. *J. Ecol.*, **63,** 597–613.

Horn, H.S. 1975. Forest succession. *Scient. Am.*, **232,** 90–98.

Kent, D.H. 1957. *Senecio squalidus* L. in the British Isles. 3: East Anglia. *Trans. Norfolk Norwich Nat. Soc.*, **18** (5), 30–31.

Kent, D.H. 1960. *Senecio squalidus* L. in the British Isles. 2: The spread from Oxford (1879-1939). *Proc. bot. Soc. Br. Isl.*, **3,** 375-379.

Kent, D.H. 1964. *Senecio squalidus* L. in the British Isles. 4: Southern England (1940–). *Proc. bot. Soc. Br. Isl.*, **5,** 210–213.

Klötzli, F. 1970. Eichen–, Edellaub und Bruchwälder der Britischen Inseln. *Schweiz. Z. Forstwes.*, **121,** 329–366.

Koch, W. 1926. Die Vegetationseinheiten der Linthebene unter Berücksichtigung der Verhältnisse in der Nordostschweiz. *Jb. St Gall. naturw. Ges.*, **61,** (2).

Kreh, W. 1960. Die Pflanzenwelt des Güterbahnhofs in ihrer Abhängigkeit von Technik und Verkehr. *Mitt. flor.-soz. ArbGemein.*, **8,** 86–109.

Kreutzpointner, J.B. 1876. Notizen sur Flora Munchens. *Flora, Jena,* **59,** 77-80.

Lehmann, E. 1895. Flora von Polnisch-Livland. *Arch. Naturk. Liv-Est- u. Kurlands. Ser. 2. Biol. Naturk.*, **11,** 1–442.

Lejmbach, B., Rurka, Z., Siedkecjka, B. & Sijka, J. 1965. The flora of the railway tracks of the Eastern Pomeranian Coast. *Fragm. flor. geobot.*, **21,** 53-66.

Lienenbecker, H. & Raabe, U. 1981. Vegetation auf Bahnhöfen des Ost-Munsterlandes. *Ber. naturw. Ver. Bielefeld,* **25,** 129–141.

Matthies, H. 1925. Die Bedeutung der Eisenbahnen und der Schiffahrt für die Pflanzenverbreitung in Mecklenburg. *Arch. Ver. Freunde Naturg. Mecklenb.*, N.S., **1,** 27–97.

McVean, D.N. & Ratcliffe, D.A. 1962. *Plant communities of the Scottish highlands: a study of Scottish mountain, moorland and forest vegetation.* (Monographs of the Nature Conservancy no. 1). London: HMSO.

Mellanby, K.M. 1981. *Farming and wildlife.* (New naturalist no. 67). London: Collins.

Messenger, K.G. 1968. A railway flora of Rutland. *Proc. bot. Soc. Br. Isl.*, **7,** 325–344.

Meyer, K. 1931. Die Einschleppung von Pflanzen mit Sudfruchtsendungen. *Ost. bot. Z.,* **80,** 265–270.

Muehlenbach, V. 1979. Contributions to the synanthropic (adventive) flora of the railroads in St. Louis, Missouri, USA. *Ann. Mo. bot. Gdn,* **66,** 1–108.

Muirburn Working Party. 1977. *A guide to good muirburn practice.* Edinburgh: HMSO.

Niemi, A. 1969. On the railway vegetation and flora between Esbo and Inga, S. Finland. *Acta bot. fenn.,* **83,** 1–28.

Oberdorfer, E. 1953. Der europäische Auenwald. *Beitr. naturk. Forsch. SüdwDtl.,* **23,** 141–187.

Noirfalise, A. & Vanesse, R. 1976. *Heathlands of western Europe.* (Nature and environment series no. 12). Strasbourg: Council of Europe.

O'Sullivan, A.M. 1965. *A phytosociological survey of Irish lowland meadows and pastures.* PhD thesis, University College Dublin.

Page, M.L. 1980. *Phytosociological classification of neutral grasslands.* PhD thesis, University of Exeter.

Parliamentary Debates. 1961. *Official report (Hansard).* Commons, **638,** 219.

Perring, F. & Walters, S.M. 1962. *Atlas of the British flora.* London: Nelson, for the Botanical Society of the British Isles.

Peterken, G.F. 1981. *Woodland conservation and management.* London: Chapman & Hall.

Peterken, J.H. & Rorison, I.H. 1982. *Annu. Rep. Unit comp. Plant Ecol. 1982,* 16–17.

Pfitzenmeyer, C.D.C. 1962. *Arrhenatherum elatius* (L.) J. & C. Presl. *Biol. Flora Br. Isl.,* no. 81.

Powell, H.W. 1931. The wanderings of plants. *Country-side,* N.S., **9,** 114.

Preising, E. 1949. *Nardo-Callunetea. Mitt. flor.-soz. ArbGemein.* N.F., **1,** 82–94.

Ratcliffe, D.A., ed. 1977. *A nature conservation review: the selection of biological sites of national importance to nature conservation in Britain.* Vol. 1. Cambridge: Cambridge University Press.

Richardson, D.H. 1981. *The biology of mosses.* Oxford: Blackwell Scientific.

Rivas, G. & Borja, C. 1961. Quoted in: Westhoff & Den Held 1969, 238.

Sargent, C. 1982. *British Rail land—biological survey. Final report.* (CST report no. 534). Banbury: Nature Conservancy Council.

Sargent, C. 1983. The British Rail land survey. In: *Ecological mapping from ground, air and space,* edited by R.M. Fuller, 47–56. (ITE symposium no. 10). Cambridge: Institute of Terrestrial Ecology.

Sargent, C. & Mountford, J.O. 1979. *British Rail land—biological survey. Third interim report.* (CST report no. 248). Banbury: Nature Conservancy Council.

Sargent, C. & Mountford, J.O. 1980. *British Rail land—biological survey. Fourth interim report.* (CST report no. 293). Banbury: Nature Conservancy Council.

Sargent, C. & Mountford, J.O. 1981. *British Rail land—biological survey. Fifth interim report.* (CST report no. 325). Banbury: Nature Conservancy Council.

Segal, S. 1966. Ecological studies of peat-bog vegetation in the north-western part of the province of Overijsel (The Netherlands). *Wentia,* **15,** 109–114.

Sell, P.D. & West, C. 1980. *Hieracium zygophorum* Hyl. new to the British Isles. *Watsonia,* **13,** 27–29.

Sheail, J. 1979. *British rail land—biological survey. Interim report. The history of the railway formations.* (CST report no. 276). Banbury: Nature Conservancy Council.

Shimwell, D.W. 1971. *Festuco-Brometea* Br.-Bl. & R. Tx. in the British Isles: the phytogeography and phytosociology of limestone grasslands. *Vegetatio,* **23,** 29–60.

Smith, A.J.E. 1978. *The moss flora of Britain and Ireland.* Cambridge: Cambridge University Press.

Suominen, J. 1969. The plant cover of Finnish railway embankments and the ecology of their species. *Ann. bot. fenn.,* **6,** 183–235.

Tansley, A.G. 1949. *The British islands and their vegetation.* Vol. 2. Cambridge: Cambridge University Press.

Thellung, A. 1905. Einteilung der Ruderal– und Adventivflora in genetische Gruppen. *Vjschr. naturf. Ges. Zürich,* **50,** 232–305.

Thellung, A. 1919. Beiträge zur Adventivflora der Schweiz (3). *Vjschr. naturf. Ges. Zürich,* **64,** 684–815.

Tüxen, R. 1937. Die Pflanzengesellschaften Nordwestdeutschlands. *Mitt. flor.-soz. ArbGemein.,* no. 3, 1–170.

Tüxen, R. 1957. Zur systematischen Stillung des *Sagino-Bryetum argentei. Mitt. flor.-soz. ArbGemein.,* N.F., **6/7,** 170–171.

Tüxen, R. & Preising, E. 1942. Grundebegriffe und Methoden zum Studium der Wasser- und Sumpfpflanzengesellschaften. *Dt. WassWirt.,* **37,** 57–69.

Usher, M.B. 1979. Markovian approaches to ecological succession. *J. Anim. Ecol.,* **48,** 413–426.

Walters, S.M. 1969. Cambridgeshire ferns—ecclesiastic and ferroviatic. *Nature Cambs.,* **12,** 22–25.

Wolkinger, F. & Plank, S. 1981. *Dry grasslands of Europe.* (Nature and environment series no. 21). Strasbourg: Council of Europe.

Way, J.M. & Sheail, J. 1977. *British Rail land—biological survey. First interim report.* (CST report no. 90). Banbury: Nature Conservancy Council.

Way, J.M., Mountford, J.O. & Sheail, J. 1978. *British Rail land—biological survey. Second interim report.* (CST report no. 178). Banbury: Nature Conservancy Council.

Westhoff, V. 1964. Nederlande Spoorwegen. *Levende Nat.,* **67,** 104–110.

Westhoff, V. & Beeftink, W.G. 1962. Quoted in: Westhoff & Den Held 1969, 168.

Westhoff, V. & Den Held, A.J. 1969. *Planten Gemeenschappen in Nederland.* Zutphen: Thieme.

Zonneveld, I.S. 1960. De Brabantse Biesbosch. Een studie van bodem en vegetatie van een zoet-watergetijdendelta. *Bodemk. Stud.* no. 4; *Belmontia* Section 2 no. 6. (English summary).

NERC

Britain's railway vegetation

Caroline Sargent

NB ISBN 0 904282 76 7

Price £3.50 net