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Road verge grasslands in southern Belgium and their conservation value

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ABSTRACT: In Belgium, like in most countries of north western Europe, wildlife habitats are quite well studied, but also rather fragmented as a consequence of the 40 year productivist Common Agricultural Policy. Therefore, even roadside vegetation is gaining a value as wildlife refuges because they escape the negative effects of intensification. Classical phytosociological methods have been used in order to survey, identify and assess conservation value of road verge grassland communities linked to the southern Belgian road network, from highways to small rural roads. The results for four distinct ecological sectors (natural regions) are displayed and discussed. Wild flora and spontaneous grassland vegetation of road verges reflect in a very sensitive way regional and local climate and substrate variations, which is expressed through ecological spectra. Within a given ecological sector, plant associations reflect quite well, through their structure and species combination, the various soil conditions and human influences. Considered as indicator parameters of ecosystem biological quality, species richness and species rarity of road verge grasslands are *(1)* higher than those of intensively used grasslands thanks to their marginal location; *(2)* higher than those of little improved or unimproved grasslands scattered through the rural landscape as areal remnants. Moreover, road verges may contain most of the total grassland flora at local or regional scale.

KEY WORDS: road verges, road ecology, grassland vegetation, biodiversity, ecological network

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INTRODUCTION

In Western Europe, most of wildlife resources, especially plants, are linked to semi-natural grassland ecosystems generated over a period of about 5000 years (3000 BC – 1860 BP) through combination of extensive land use by man and spontaneous or synanthropic immigration of herbaceous plants now considered as indigenous (Fukarek 1980; Kornaś 1983). Therefore, heathland, unimproved dry and humid grasslands, fens and peat-bogs have gained a high conservation value, even higher than semi-natural and subnatural broad-leaved forests.

Yet, the Belgian law on land management (1962) and nature protection (1973, 1976)

is considering most of these ecosystems as part of the productive environment (Odum 1969) legally closed to any interference of nature conservation. Therefore, the Belgian official nature reserves, which amount less than 1% of the whole country (Vlaminck 1990), are consisting mostly of unproductive ecosystems such as limestone cliffs, marshland and oligotrophic peat-bogs, whereas the Common Agricultural Policy (CAP) carried out during nearly 40 years has caused dramatic loss of eco- and biodiversity within the agrarian landscape due to consolidation, intensification, drainage, etc. (Fry 1991; Tanghe 1993a; Baldock 1990).

In the present situation, that of a wildlife clean productive environment and a protective environment consisting of a few nature reserves suffering from fragmentation and isolation, a conservation conscious land management policy should take into account also ecological landscape elements which do not benefit of any protection status, but which have kept or gained their conservation value compared to the intensified agricultural landscape. Among these landscape elements, road verges, especially grassland vegetation, are most interesting according to the still increasing literature devoted to them since the end of the sixties (Way 1969; Rümler 1977; Zonderwijk 1979; Ellenberg *et al.* 1981; Krause 1982; Tanghe 1986; Stottele & Schmidt 1988; Heindl & Ullmann 1991; Sykora *et al.* 1993; Stottele 1995; Godefroid & Tanghe 1995, 2000; Zwaenepoel 1998, etc.).

So, through its choice to study road verges, the Laboratory of Plant Systematics and Vegetation Ecology is considering them as unexpected and precious wildlife habitats complementary to the existing network of protected areas.

After having investigated the grassland vegetation of the Walloon highway network (Tanghe 1986), we stressed the remnants of semi-natural grasslands along secondary roads including small rural roads (Delvaux 1993; Tanghe & Godefroid 1994; Tanghe 1995; Godefroid & Tanghe 1995, 2000; Coquay & Tanghe 1999; Bastin, unpbl.; Capon, unpbl.).

Whereas the secondary road network was favorable to a more fundamental approach (Godefroid 1998), highway ecology gradually became an expertise of our research unit which has been called upon since 1996 for applied research on behalf of the Ministry of Equipment and Transport. As it has been demonstrated that the highest biodiversity is linked with grassland vegetation (Ellenberg *et al.* 1981; Tanghe 1993b), the challenge is to combine the economical and ecological aspects of highway verges management.

Keeping in mind Forman's assertion about the importance of road ecology for the coming decade (Forman 1998), the objective of this paper is a short overview of the present state of our experience as regards road verge grasslands in southern Belgium and their conservation value at least as wildlife refuges.

Road verge grasslands are representative of interregional geobotanical diversity

Wild flora and semi-natural grassland vegetation of road verges are quite representative of the physical characteristics of natural regions. They reflect in a very sensitive way regional and local climate and substrate variations.

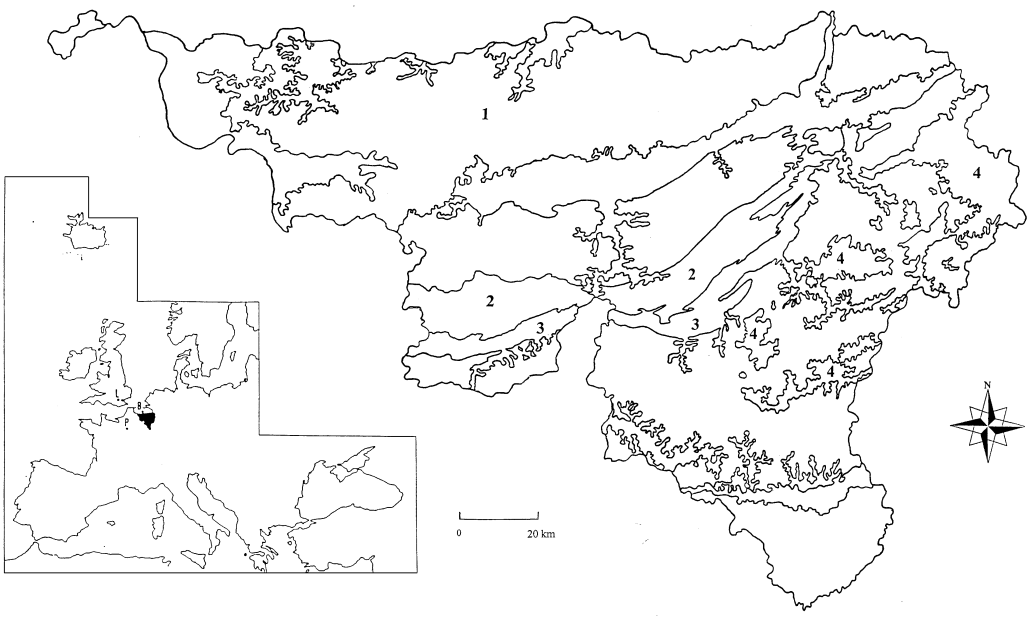

Fig. 1. Location of study area. Limits of ecological sectors redrawn from Delvaux and Galoux (1962). 1: Hainaut-Brabant-Hesbaye; 2: Fagne-Famenne; 3: Calestienne; 4: High Ardennes.

The interregional comparison of road verge grassland flora and vegetation is based upon the physical subdivision of Wallonia (southern part of Belgium) due to Delvaux and Galoux (1962). For our purpose, the most suitable unit of this system is the ecological sector, which is very close to Schlenker's *Wuchsbezirk* (Schlenker 1963), as it is considered as an homogeneous physical landscape unit defined at a scale of 1:500000 by its own geomorphology, regional climate and lithology.

For the purpose of this paper, four ecological sectors on a total number of 20 have been selected : Hainaut-Brabant-Hesbaye, Calestienne, Fagne-Famenne and High Ardennes (Fig. 1). For each sector, most of available roadside vegetation data, consisting of phytosociological relevés, have been processed in order to gather the recorded species according to their ecological requirements, that is according to the socio-ecological groups they belong to (Duvigneaud 1946; Ellenberg 1950; Tanghe 1996). These groups are defined briefly below. Their designation is referring to the syntaxonomical units of the Zürich-Montpellier system mostly for concision reasons.

Phr-Mol-SCn-In-Agr (*Phragmitetea*; *Molinietalia*; *Scheuchzerio-Caricetea nigrae*; *Isoëto-Nanojuncetea*; *Agrostietea stoloniferae*): marshland species (reed beds, unimproved humid and acidocline wet grasslands, acidic mires, etc.).

Che-Sec (*Chenopodietea; Secalietea*): annual and biennial species of annual crops.

Art (*Artemisietea*): herbaceous ruderal species.

LC-Pla (*Lolio-Cynosurion; Plantaginetea*): heavily fertilized and/or trampled grasslands species.

NC (*Nardo-Callunetea*): heathland and mat-grass sward species.

SS (*Sedo-Scleranthetea*): rocks and shallow dry soils species.

FB-TG (*Festuco-Brometea*; *Trifolio-Geranietea*): xerophilous species of rocky and dry calcareous grassland and thermophile forest fringe species.

Arr (*Arrhenatherion*): lowland mesophile hay meadow species.

PT (*Polygono-Trisetion*): submontane hay meadow species.

Epi (*Epilobietea*): felling species.

Aln (*Alnetea*): alluvial and wet forest species.

Fs-Qrp-Qp (*Fagetalia sylvaticae*; *Quercetalia robori-petraeae*; *Quercetalia pubescenti-petraeae*): broad-leaved deciduous forest species.

Ps (*Prunetalia spinosae*): thicket species.

Computing the percentage of species belonging to each of the 13 groups leads to the four graphs of Fig 2. In a way, they correspond to ecological spectra expressing, by means of bioindication, the whole range and dominant ecological conditions displayed into the ecological sectors.

Not only has each ecological sector its own spectrum or qualitative and quantitative ecological combination, but it is also characterized by the relative dominance of one or two specific groups.

"Hainaut-Brabant-Hesbaye"

Ecological sector "Hainaut-Brabant-Hesbaye" (Fig. 2A) is a smoothly undulating plateau at low altitude (50–200 m a.s.l.) and covered with an almost continuous layer of late würmian loess. Its openfield landscape is dominated by heavily fertilized cereal and sugar-beet crops which explains the overwhelming dominance of the *Arrhenatheretalia* group into road verge grasslands along with the relative but significant abundance of nitrophilous ruderals and annual or biennial weeds.

For a more detailed analysis of main plant communities of this sector, see chapter "Case study 1" of the next chapter

"Calestienne"

In contrast, corresponding to a west-east oriented strip of Devonian limestone, ecological sector "Calestienne" (Fig. 2B) is a heavily dissected and hilly region ranging between 190 and 270 m above sea level. Therefore, roadside grassland vegetation is generally linked to embankments with stony soils and rock outcrops. Its ecological spectrum shows significant dominance of *Brometalia* and *Origanetalia* species with *Brachypodium pinnatum* and *Bromus erectus* as structuring species and many others belonging to the submediterranean and steppic floristic elements such as *Sanguisorba minor, Viola hirta, Helianthemum nummularium, Hippocrepis comosa, Teucrium chamaedrys, Bupleurum falcatum, Potentilla neumanniana* and even some rare orchids like *Himantoglossum hircinum, Aceras anthropophorum, Ophrys apifera*, etc.

These linear vegetation elements appear as remnants of the semi-natural and species rich calcareous grasslands which were covering most of the limestone outcrops as unimproved and extensive pastureland until the early 20th century. Therefore, they may be considered as precious complements to the 5 or 10% really protected areas of this most

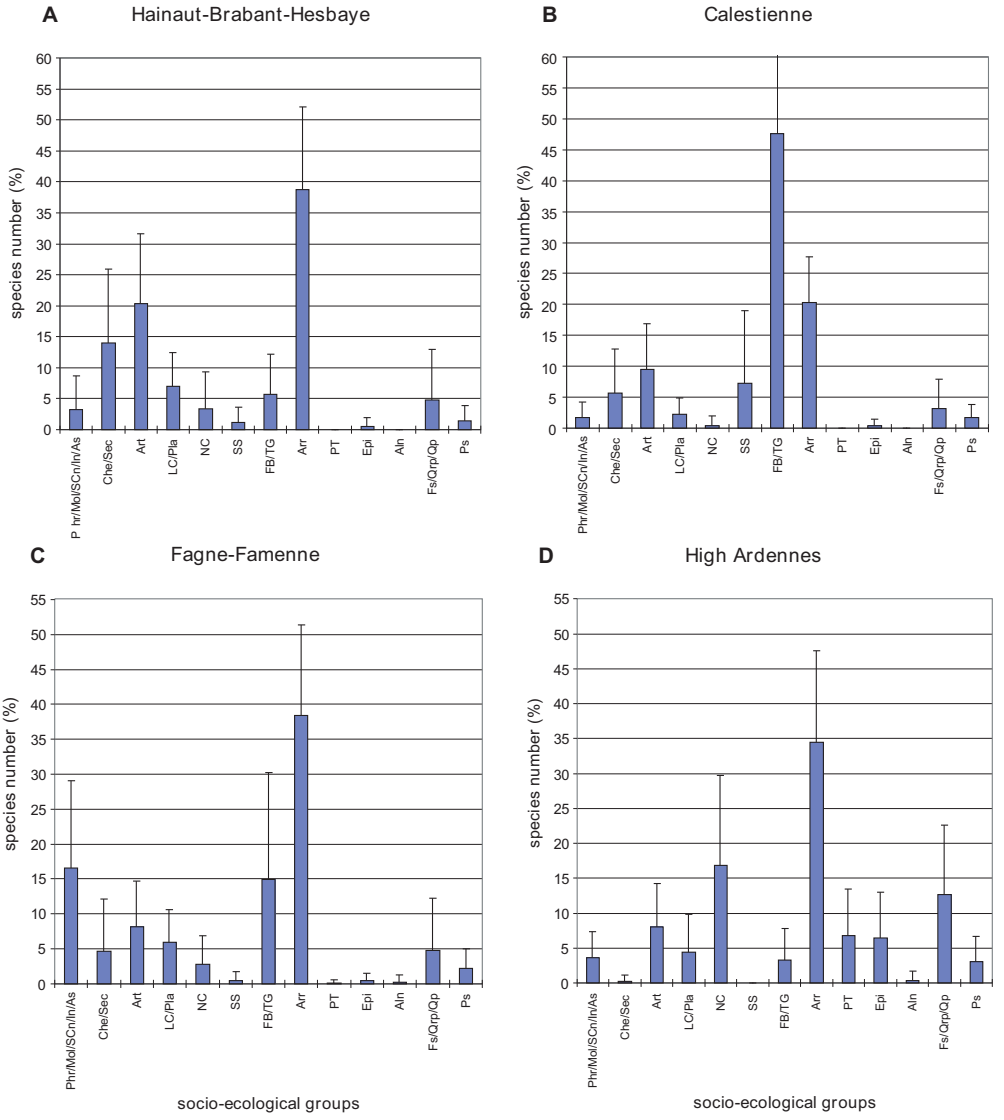

Fig. 2. Socio-ecological group spectra of road verge grasslands for four ecological sectors of southern Belgium. A: Hainaut-Brabant-Hesbaye (n = 46); B: Calestienne (n = 22); C: Fagne-Famenne (n = 17); D: High Ardennes (n = 41). Bracketed vertical lines indicate 1 SD. For abbreviations and group explanations, see text.

interesting ecosystem. Moreover, whereas calcareous grassland reserves are requiring specific management measures carried out by volunteers or at the expense of the nature conservancy administration, annual mowing of road verge calcareous grasslands is only part of the compulsory maintenance measures ensuring road security (Tanghe 1995).

"Fagne-Famenne"

Ecological sector "Fagne-Famenne" (Fig. 2C) is a flat depression due to heavy erosion of soft Devonian shale and ranging between 160 and 200 m above sea level. As most of soils are clayey and hydromorphic in contrast with previous sector, roadside grassland vegetation is linked to flat verges generally coupled with a drainage ditch.

A semi-natural species rich grassland association belonging to the *Arrhenatheretalia* and described by Sougnez and Limbourg (1963) under the not generally admitted name of *Colchico-Brometum racemosi* is considered to be the most characteristic of the Fagne-Famenne sector. Until the sixties, it was widespread in this area as a lightly improved hay meadow, but nowadays mostly converted to intensively managed and species poor pasture related to the *Lolio-Cynosurion* alliance. In that way, road verge *Colchico-Brometum* grassland gains here too a rather high conservation value.

Peculiarity of its species combination is simultaneous presence and constancy of *Molinietalia* species and *Brometalia-Origanetalia* species within a background of *Arrhenatheretalia* species. First group contains true *Molinion* characteristics like *Colchicum autumnale, Silaum silaus, Selinum carvifolia* and *Succisa pratensis,* whereas the second one is composed of *Primula veris, Carex flacca, Galium verum, Trifolium medium,* etc. This combination is likely to express the alternating wet-dry water economy of calcium and magnesium rich, but phosphorus poor clay soils (Tanghe & Godefroid 1994).

"High Ardennes"

Ecological sector "High Ardennes" (Fig. 2D) corresponds to a precretaceous peneplain almost flat and higher than 500 m above sea level (500–694 m). Except the relatively extent peaty soils which are not taken into account here, main soil types belong to the acidic brown earths on lower Devonian and Cambrian siliceous rocks (shales, quartzites and quartzophyllites) embedded in a loess cover variable in thickness. Except the protected peat-bogs and associated heathland vegetation, the landscape is mostly composed of spruce plantations and improved grassland intensively used as hay meadows and pastureland.

Roadside grasslands are linked to both flat verges subject to some eutrophication and embankments with steep slopes and their original, undisturbed acidic soils. Therefore the ecological spectrum displays significant dominance of *Nardo-Callunetea* ecological group with *Galium saxatile, Deschampsia flexuosa, Vaccinium myrtillus, Calluna vulgaris,* etc. on the one hand and, on the other hand, the *Arrhenatheretalia* group where *Geranium sylvaticum, Alchemilla vulgaris, Polygonum bistorta* and others appear as differential species with respect to the low altitude *Arrhenatheretalia* grasslands, for instance those belonging to the "Hainaut-Brabant-Hesbaye" sector.

For a more detailed analysis of the different plant communities of sector "High Ardennes" see "Case study 2" of the next chapter.

ROAD VERGE GRASSLANDS SHOW INTRAREGIONAL COMMUNITY DIVERSITY

Within a given ecological sector, plant communities (plant associations) reflect quite well, through their structure and species combination, the various soil conditions and present, as well as past, land use techniques.

Case study 1 : ecological sector "Hainaut-Brabant-Hesbaye"

Table 1 contains a selection of road verge relevés issued from four subregions of the same ecological sector which is characterized by an almost continuous quaternary loess cover locally interrupted by tertiary sand outcrops, the latter being mostly leached and acidified.

Besides soil texture and soil acidity, man is influencing species composition when the road verge grasslands, as part of the agricultural landscape, are subject to the side effect of crop fertilization.

In that way, one can distinguish four grassland communities:

– on strongly acidic and oligotrophic sandy soils, a mat-grass sward with *Festuca filiformis* and *Jasione montana* belonging to the *Violion caninae* Schwickerath 1944 (Table 1, relevés 1–3) and the grassy heath association with *Molinia caerulea, Vaccinium myrtillus, Calluna vulgaris* belonging to the *Genisto pilosae-Callunetum* Oberdorfer 1938 *nom. inv.* (Table 1, relevés 4 and 5);

– on unfertilized but naturally oligo-mesotrophic loamy soils, a rather dense but short grassland association with *Festuca rubra, Arrhenatherum elatius* and *Pimpinella saxifraga* related to the *Festuco-Cynosuretum* Tüxen *in* Bücker 1942 (Table 1, relevés 6–12);

– on fertilized and hence eutrophic loamy soils, preceding association is replaced by a dense, tall and very productive grassland with *Arrhenatherum elatius, Heracleum sphondylium* and *Urtica dioica* as dominant species (Table 1, relevés 17–20); it is of course belonging to the *Arrhenatherion elatioris* W. Koch 1926 alliance, but contains many fallow species and annual or biennial weeds because of the irregular mowing regime and closeness of crops.

Third association is variable because of the varying number of *Festuco-Brometea* species. Relevés 13 to 16 belong to an unfertilized or little fertilized *Arrhenatheretum* grassland, whereas relevés 6 to 12, where this ecological group is well developed, correspond to the *Festuco-Cynosuretum sensu stricto*. It is assumed (Tanghe 1995; Coquay & Tanghe 1999) that this association was widespread on road embankments in the middle Belgian loess area until the first half of the 20th century, that is before eutrophication due to intensification of agriculture was reducing its area to some scattered relics amongst the ruderalized *Arrhenatherion* grasslands.

Case study 2: road verge plant associations of ecological sector "High Ardennes"

Thirty five road verge relevés of Table 2 are issued from a 553 ha sampling area belonging to the above described ecological sector (see section "High Ardennes"). They are ranging

Table 1. Mat-grass sward, dry heath, oligo-mesotrophic grassland and eutrophic hay meadow in road verges of the Hainaut-Brabant-Hesbaye ecological sector. Species name according to Lambinon *et al.* (1992); syntaxonomical nomenclature follows Oberdorfer (1978, 1983).

Current number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Recording number	29	39	2	3	4	1	1b	20	26	17	29b	11	24	2b	2c	38	3	41	1c	6
Nardetea																				
Rumex acetosella	2	+	+	+	.	2	.	+	.	.	.	1	.	.	.	.	.	.	.	.
Festuca filiformis	3	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Molinia caerulea	+	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deschampsia flexuosa	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calluna vulgaris	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cytisus scoparius	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Holcus mollis	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rubus idaeus	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Teucrium scorodonia	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Danthonia decumbens	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Jasione montana	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vaccinium myrtillus	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuco-Brometea, Trifolio-Geranietea																				
Hieracium pilosella	.	.	.	.	.	2	.	.	.	2	1	+	.	+	.	.	.	.	.	.
Lotus corniculatus	.	.	.	.	.	.	1	+	.	1	.	.	.	1	.	.	.	.	.	.
Pimpinella saxifraga	.	.	.	.	.	.	1	1	.	+	.	1	.	.	.	.	.	.	.	.
Galium verum	.	.	.	.	.	.	2	1	.	1	.	.	.	.	.	.	.	.	.	.
Campanula rotundifolia	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Thymus pulegioides	.	.	.	.	.	.	.	.	.	+	2	+	.	.	.	.	.	.	.	.
Medicago lupulina	.	.	.	.	.	.	.	.	+	.	1	.	1	.	.	.	.	.	.	.
Ranunculus bulbosus	.	.	.	.	.	.	+	+	2	1	.	.	.	.	.	.	.	.	.	.
Agrimonia eupatoria	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.
Origanum vulgare	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+
Cerastium arvense	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.
Saxifraga granulata	.	.	.	.	.	.	.	.	2	+	.	.	.	.	.	.	.	.	.	.
Avenula pubescens	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Sedo-Scleranthetea																				
Ornithopus perpusillus	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aira caryophyllea	1	2	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Myosotis ramosissima	.	.	.	.	.	.	.	+	.	+	.	.	.	+	.	.	.	.	.	.
Arenaria serpyllifolia	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Aira praecox	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arrhenatherion -etalia oligo-mesotrophic																				
Festuca rubra	.	4	.	.	.	1	1	3	2	1	3	+	2	2	.	.	.	.	2	+
Agrostis capillaris	2	+	1	1	2	1	.	2	.	1	2	.	.	.	3	.	.	.	1	.
Hypochoeris radicata	2	1	1	.	.	2	.	.	.	1	1	+	1	+	1	.	.	.	.	.
Plantago lanceolata	.	.	.	.	.	+	+	+	2	1	1	1	2	2	1	.	.	.	+	.
Achillea millefolium	.	.	.	.	.	+	+	1	1	1	2	+	.	+	.	.	.	.	+	+
Anthoxanthum odoratum	.	+	.	.	.	.	.	+	.	1	+	.	1	+	.	.	.	.	.	.
Luzula campestris	.	.	+	.	+	2	+	.	.	2	2	.	.	.	.	.	.	.	.	.
Rumex acetosa	.	.	.	.	.	.	.	1	.	1	+	.	1	+	.	.	+	.	.	.
Senecio jacobaea	.	.	.	.	.	+	.	+	.	+	+	1	.	1	.	.	.	.	.	.
Poa pratensis	.	.	.	.	.	.	+	1	1	+	+	.	1	1	.	.	.	.	.	.

Table 1. Continued.

Current number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Centaurea pratensis	.	.	.	.	.	.	.	+	.	+	+	1	.	+	.	.	.	.	.	.
Trisetum flavescens	.	.	.	.	.	.	.	+	.	1	1	.	.	1	+	.	.	.	.	.
Campanula rapunculus	.	.	.	.	.	1	.	.	.	.	.	.	.	1	+	.	.	.	+	.
Leucanthemum vulgare	.	.	.	.	.	.	.	.	1	.	1	+	2	2	.	.	.	.	.	.
Knautia arvensis	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.
Trifolium campestre	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	1	.	.	.	.
Arrhenatherion-etalia mesotrophic																				
Arrhenatherum elatius	.	.	1	+	.	.	2	2	2	+	1	1	3	2	1	3	1	3	3	2
Dactylis glomerata	.	+	.	.	+	.	+	+	.	+	1	+	+	+	+	+	+	+	+	1
Holcus lanatus	.	.	2	.	.	1	.	1	1	+	.	.	1	1	1	2	.	+	+	+
Cerastium fontanum	+	+	.	.	.	1	+	+	1	+	+	.	1	.	.	1	.	.	+	.
Crepis capillaris	.	.	+	.	.	+	.	+	+	+	1	+	+	+	1	+	.	.	+	.
Trifolium dubium	.	1	.	.	.	+	+	+	.	2	+	+	1	1	+	.	.	.	.	.
Vicia sativa	.	+	.	.	.	.	1	1	1	+	+	+	.	1	+	.	.	.	+	.
Heracleum sphondylium	.	.	.	.	.	.	+	1	.	.	.	.	.	+	.	+	2	2	1	2
Anthriscus sylvestris	.	.	.	.	.	.	+	2	.	.	.	.	.	.	.	+	3	+	.	1
Trifolium pratense	.	.	.	.	.	.	.	+	.	.	+	.	4	1	1	2	.	.	.	.
Bromus hordeaceus	.	.	.	.	.	.	1	1	.	.	.	.	1	2	+	.	.	.	.	.
Poa trivialis	.	.	.	.	.	.	+	+	.	.	.	.	1	.	.	.	+	.	1	.
Lathyrus pratensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+
Pimpinella major	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	1
Ranunculus acris	.	.	.	.	.	.	.	.	+	.	1	.	1	.	.	.	.	.	.	1
Festuca arundinacea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Vicia tetrasperma	.	.	.	.	.	.	.	.	+	.	.	.	.	1	+	+	.	.	.	.
Stellaria graminea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.
Artemisietea – Galio-Urticenea																				
Galium aparine	.	.	.	.	.	.	1	+	.	.	.	.	.	+	.	+	1	2	.	1
Urtica dioica	.	.	.	.	.	.	1	+	.	.	+	.	.	.	.	.	2	3	1	2
Rumex obtusifolius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.
Cynosurion																				
Ranunculus repens	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	1	+	2	+	+
Taraxacum officinale	.	.	.	.	.	.	+	.	+	+	.	.	.	2	+	+	.	.	+	+
Lolium perenne	.	.	.	.	.	.	.	.	.	+	.	.	+	+	+	+	.	.	+	.
Trifolium repens	.	.	.	.	.	.	.	+	+	1	+	.	+	.	1	.	.	.	+	.
Cynosurus cristatus	.	.	.	.	.	.	.	.	.	1	1	.	2	.	.	.	.	.	.	.
Bellis perennis	.	.	.	.	.	.	.	.	+	.	+	.	1	.	.	.	.	.	.	.
Artemisietea – Artemisienea																				
Equisetum arvense	.	.	.	.	.	.	.	.	.	.	1	.	+	1	1	+	1	+	1	1
Cirsium arvense	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	+	+	+	1
Artemisia vulgaris	.	.	.	.	.	.	+	+	.	.	.	+	.	.	+	.	.	+	.	+
Convolvulus arvensis	.	.	.	.	.	.	1	.	.	.	+	.	.	+	1	.	.	.	2	+
Elymus repens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	1	+	1
Hypericum perforatum	.	.	.	.	.	.	+	.	.	.	.	1	.	+	+	.	.	.	+	.
Lapsana communis	.	.	.	.	.	.	2	+	.	.	.	.	.	.	.	+	+	.	+	.
Daucus carota	.	.	.	.	.	.	.	+	.	.	1	.	.	+	+	.	.	.	.	.
Picris hieracioides	.	.	.	.	.	.	1	.	.	.	.	.	.	+	.	.	.	.	.	.
Linaria vulgaris	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	+	.

between 520 and 560 m above sea level and are concentrated within the administrative limits of Robertville.

Three plant associations have been identified. As soil physical characteristics, such as bedrock and texture, are broadly the same everywhere, species combination is likely to express the side effect of fertilization-eutrophication and cutting regime (grazing or mowing) through local topography of road verge and distance from both the road and the intensively managed grassland.

Along flat road verges, more or less regularly mown and subject to some nutrient input from the road itself, most frequent grassland association is a submontane mesotrophic hay meadow which appears, according to Oberdorfer (1983), as a western Hercynian and floristically impoverished form of the *Geranio-Trisetetum flavescentis* Knapp 1951 (Table 2, relevés 1–14).

Oligo-mesotrophic mat-grass sward dominated by *Festuca rubra, Galium saxatile, Holcus mollis, Deschampsia flexuosa* and *Meum athamanticum* and related to the *Meo-Festucetum* Bartsch 1940 (Table 2, relevés 15–23) is frequent along little used rural roads and along fences, where it is escaping fertilization but subject to grazing, at the boundary between previous association and improved agricultural grasslands.

Although *Vaccinium vitis-idaea* is lacking from relevés 24 to 35, but as these relevés lie within the Belgian area of this subboreal species, they should be related to an impoverished form of the *Vaccinio-Callunetum* Bücker 1942. This submontane grassy heathland association is linked to unmanaged road embankments whose stony and very acidic soils are escaping phosphorus and nitrogen input from agriculture thanks to their topography and marginal location.

When comparing ancient staff maps and the present situation, it is clear that all three road verge plant communities are remnants of different forms of the extensive land use which were maintained in High Ardennes until the early 20th century. As such they have gained a high conservation value.

Road verges and species richness and rarity

Considered as indicator parameters of ecosystem biological quality, species richness and rarity have been compared for unimproved roadside grasslands, for their areal counterpart and for improved meadows within our 553 ha sampling area belonging to the High Ardennes ecological sector. Species richness (or species density) is simply the number of species within a single 4m^2 vegetation sample, whereas species rarity is quantified by means of an eleven degree scale (10 = very common to 0 = very rare) according to Stieperaere and Fransen (1982). Our results show that mean species richness for a 4m^2 sample plot is 23 (± 7.93 SD) for unimproved linear (roadside) grasslands, 19 (± 4.08) for unimproved areal grasslands and 16 (± 3.29) for improved grasslands (Fig. 3A), while mean species rarity is respectively 7.41 (± 0.41), 7.95 (± 0.60) and 9.52 (± 0.22) (Fig. 3B). Hence, species richness and rarity of road verge grasslands are (1) higher than those of intensified grasslands thanks to their marginal location allowing them to escape the nega-

Table 2. Submontane hay meadow, mat-grass sward and dry heath in road verges of the High Ardennes ecological sector. Species name according to Lambinon *et al.* (1992); syntaxonomical nomenclature follows Oberdorfer (1978, 1983).

Current number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Recording number	HA 24	HA 09	HA 54	HA 53	HA 41	HA 51	HA 35	HA 49	HA 26	HA 11	HA 01	HA 52	HA 29	HA 38	HA 57	HA 47	HA 06	HA 39	HA 30	HA 45	HA 22	HA 50	HA 46	HA 28	HA 33	HA 44	HA 40	HA 02	HA 32	HA 42	HA 16	HA 13	HA 17	HA 03	HA 36
Nardo-Callunetea																																			
Holcus mollis	2	3	.	.	3	.	1	.	3	1	+	1	1	3	4	3	2	2	4	2	2	3	2	3	2	2	1	1	3	3	3	3	2	1	3
Galium saxatile	.	.	.	.	+	.	+	.	1	.	.	.	.	.	+	2	.	3	2	1	3	3	4	2	2	2	4	2	+	4	1	1	2	+	2
Agrostis capillaris	1	.	.	.	.	1	2	2	1	.	+	1	1	2	.	2	1	1	1	1	.	1	1	2	.	1	1	2	1	1	.	.	.	.	1
Potentilla erecta	.	1	.	.	.	2	2	.	.	.	+	+	.	.	.	.	1	.	1	.	1	.	1	.	1	.	3	1	1	.	.	2	1	+	2
Cytisus scoparius	.	.	.	.	+	.	.	.	+	.	.	.	.	.	+	1	+	2	1	1	1	.	.	2	1	.	1	+	.	.	1	1	1	.	.
Meum athamanticum	.	2	.	.	.	2	3	.	.	1	2	.	.	.	3	2	3	1	.	.	.	.	.	.	.	.	+	2	3	.	1	.	1	.	1
Deschampsia flexuosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	2	3	1	3	2	+	.	2	.	2	1	3	2	3
Vaccinium myrtillus	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	3	.	.	+	1	2	2	4	2	4	1
Luzula campestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	+	.	+	1	.	1	.	+	.	1	1	.	.	.	+
Hypericum maculatum	.	.	.	.	.	.	+	.	.	.	+	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.
Calluna vulgaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	.	.	.	.	.	.	.	.
Rumex acetosella	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.
Veronica officinalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	2	.	.	.	.	.	.	.	.	.
Carex pilulifera	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Danthonia decumbens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca filiformis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Molinio-Arrhenatheretea																																			
Festuca rubra	1	1	1	+	1	1	1	2	2	1	1	1	1	1	.	3	2	3	1	+	1	1	1	1	2	1	1	3	.	3	2	+	.	+	1
Poa pratensis	.	.	3	1	1	1	+	+	1	1	1	1	.	2	.	1	1	+	1	.	1	1	.	+	.	.	.	+	.	1	1	.	.	.	1
Stellaria graminea	.	.	.	.	1	.	1	1	+	.	+	1	1	+	.	1	+	1	1	.	.	1	1	1	.	.	2	+	+	+	.	.	.	.	+
Dactylis glomerata	+	1	1	3	1	2	2	1	+	+	2	1	2	1	.	.	+	+	.	.	.	.	.	+	.	.	1	+	.	.	.	.	.	.	.
Veronica chamaedrys	.	1	2	.	1	1	1	1	.	.	1	1	.	1	+	1	.	+	1	.	.	.	1	.	.	.	1	+	.	.	.	.	.	.	.
Rumex acetosa	.	1	+	.	+	.	.	.	+	.	1	+	.	+	.	.	1	.	.	.	+	.	.	.	.	.	1	1	+	.	+	+	+	.	.
Ranunculus repens	.	+	+	.	+	.	.	1	.	.	1	+	.	.	.	1	.	.	.	.	.	+	+	.	.	+	2	+	+	.	.	.	.	.	1
Anthoxanthum odoratum	.	1	1	.	.	1	+	.	+	1	+	.	.	.	.	.	+	.	.	.	.	.	.	+	.	1	.	+	.	.	1	.	+	.	.

(cont.)

Table 2. Continued.

Current number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Vicia cracca	.	1	.	.	+	1	1	1	+	.	2	1	1	.	.	.	+	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	+
Centaurea jacea s.l.	.	.	.	.	1	2	1	+	.	.	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago lanceolata	.	.	.	.	1	.	.	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	1
Holcus lanatus	.	.	.	.	.	1	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus acris	.	.	.	.	+	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Taraxacum officinale s.l.	.	.	+	1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypochoeris radicata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.
Festuca pratensis	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Trifolium pratense	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polygono-Trisetion																																			
Geranium sylvaticum	.	2	3	2	2	.	2	2	1	2	2	2	2	3	.	.	.	.	1	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.
Alchemilla vulgaris s.l.	.	+	1	1	2	+	.	+	+	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Sanguisorba officinalis	.	.	.	.	2	.	.	.	.	1	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.
Polygonum bistorta	2	2	.	.	1	.	.	3	.	2	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Phyteuma nigrum	.	.	.	.	+	.	.	1	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Trisetum flavescens	.	.	.	.	1	.	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Arrhenatheretalia																																			
Heracleum sphondylium	.	1	.	2	.	2	+	1	.	.	+	2	2	.	+	1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Cerastium fontanum	.	.	.	.	.	+	.	+	.	.	1	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	1	+	.	.	+	.	+	.	.
Achillea millefolium	.	.	.	.	+	1	.	1	.	.	1	1	.	.	.	1	.	1	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+
Leucanthemum vulgare	.	.	1	.	1	1	1	1	1	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium repens	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Anthriscus sylvestris	.	.	.	.	+	.	.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago major	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pimpinella major	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Molinietalia																																			
Deschampsia cespitosa	+	1	.	.	.	1	+	1	1	1	1	1	1	.	1	1	.	.	.	.	1	2	.	.	.	.	1	+	+	.	.	.	1	.	1
Juncus effusus	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Achillea ptarmica	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Festuco-Brometea																																			
Lotus corniculatus	.	.	.	.	2	2	.	2	.	1	1	2	1	.	.	.	+	.	1	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	+
Campanula rotundifolia	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	+	.	.	+	+	.	+	.	.	.	+
Rhinanthus minor	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1
Knautia arvensis	.	1	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Artemisietea																																			
Galeopsis tetrahit	1	+	.	1	1	1	2	1	+	.	+	1	1	.	1	1	1	1	.	+	.	1	+	.	+	.	1	+	+	.	.	1	1	+	1
Vicia sepium	.	.	.	.	1	.	1	.	+	.	.	1	1	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Urtica dioica	.	.	2	+	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Linaria vulgaris	.	.	.	.	.	.	+	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Hypericum perforatum	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.
Elymus repens	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Galium aparine	.	.	+	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rumex obtusifolius	.	.	.	2	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Silene dioica	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Epilobium hirsutum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Epilobietea																																			
Epilobium angustifolium	1	.	3	2	.	.	.	1	.	3	1	+	1	1	1	.	.	.	1	.	.	.	1	1	.	.	.	+	.	.	.	.	1	+	+
Rubus idaeus	1	+	+	2	.	.	.	.	.	.	.	+	.	+	1	.	2	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	1	.
Senecio ovatus	2	1	.	.	1	.	.	+	+	.	+	+	2	.	+	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.
Digitalis purpurea	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

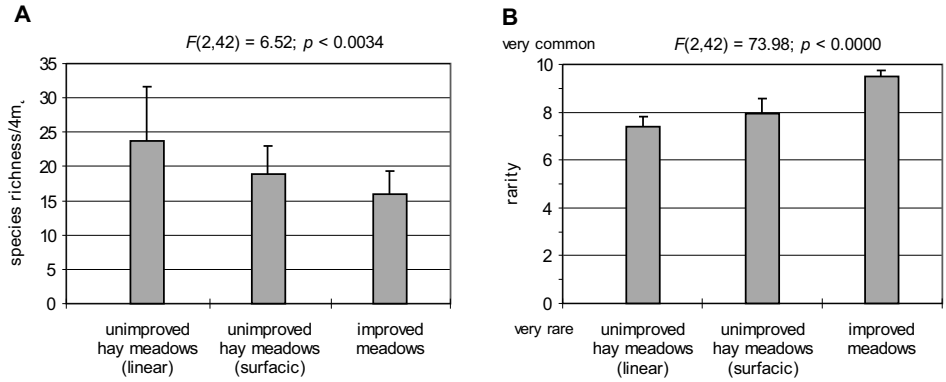

Fig. 3. Species richness (A) and rarity (B) for linear (road verges) compared to areal elements of unimproved hay meadows (*Polygono-Trisetion*) and to improved meadows (*Lolio-Cynosurion*). Rarity classes according to Stieperaere & Fransen (1982), for southern Belgium. 0 = very rare; 10 = very common. The data were analysed by one-way ANOVA under null hypothesis that there are no significant differences in species richness and rarity, respectively, among compared categories of the both characteristics; $\alpha = 0.05$. Unimproved hay meadows: $n = 17$; improved meadows: $n = 11$. Bracketed vertical lines indicate 1 SD.

tive effects of intensification (fertilization and herbicides); (2) higher than those of little improved or unimproved grasslands scattered through the rural landscape as areal remnants of the same ecosystems, whether they are protected or not.

On the other hand, road verges may contain most of the total grassland flora at local or regional scale. A grid system of 500 × 500 m squares has been superimposed on the

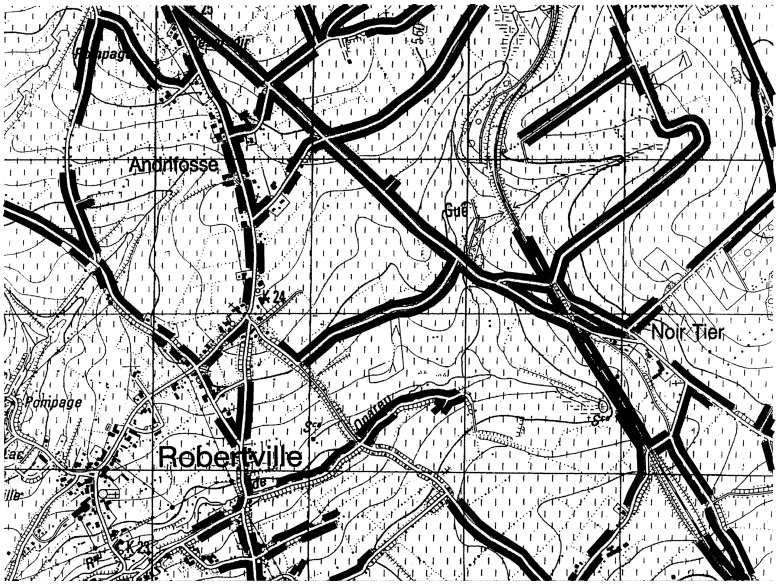

Fig. 4. Linear elements of submontane hay meadows in a sampling area of High Ardennes. Scale: 1/10000. Squares of 500 × 500 m (25 ha) are used as landscape units for comparing species richness (linear vs. areal).

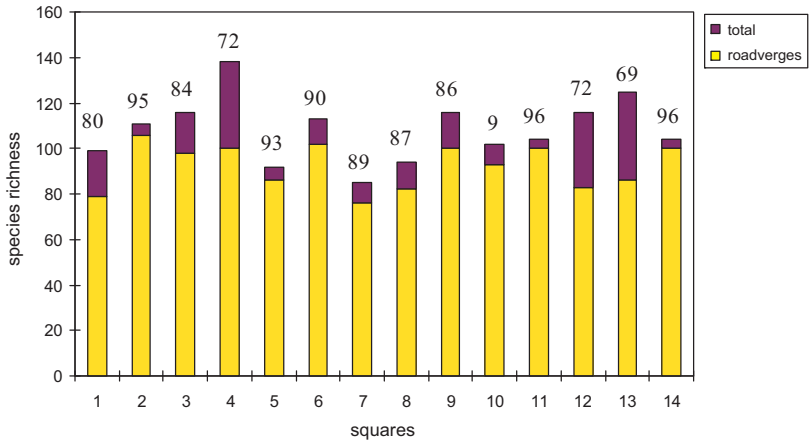

Fig. 5. Species richness of road verges compared to total species richness of 500 × 500 m (25 ha) squares in a sampling area of High Ardennes. Numbers above each bar are in percent and represent the proportion of each square flora occurring in road verges.

1:10000 scale staff map of the same 553 ha sampling area (Fig. 4). Within each square, vascular plants were recorded, first on the whole quadrant surface and then, only along road verges. Floristic investigations carried out within the 14 landscape subunits revealed a total species richness ranging between 85 and 138 with an average of 108. From this total flora, the species proportion which occur along road verges is ranging between 69 and 96% with an average of 83% (Fig. 5). In other words, from the 231 species recorded in the sampling area, only 40 were never collected in roadside linear elements, that is to say 17% of the total flora.

Conclusion

In the west European agricultural landscape generated by a 40 year productivist CAP, wildlife habitats are more and more fragmented and isolated.

Along with hedgerows, ditches, railway embankments, etc., road verges escape the negative influence of intensification on biodiversity thanks to their marginal location. Moreover, road verges belong to the public domain and their maintenance (once or twice a year mowing), beneficial to wildlife conservation, is simply a security constraint. In thatway, they keep or gain significant conservation value without involving additional expenses.

These small vegetation elements which are frequently remnants of native vegetation are generally disregarded when applying land management especially through consolidation processes (Froment 1983).

Therefore, road verges should be integrated in the ecological network which is a suitable land planning concept for conservation purposes in rural and woodland as well as in urban landscapes.

Since 1996, applied university research is supported by the Ministry of Equipment and Transport aiming at a more ecological management and wildlife development of highway verges. This is indeed a relevant contribution to the development of the ecological network at least at regional level.

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