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NUMERICAL ANALYSES OF THE FOREST EDGE VEGETATION IN THE PREDINARIC REGION IN SE SLOVENIA

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The paper deals with numerical analyses of the forest edges in SW Slovenia. A large number of relevés made according to the Braun-Blanquet method was collected from different sources and was subject to different analyses (Programme packages SYN-TAX and CANOCO were used). The results show their relations and positions in the cultural landscape.

Introduction

Since there are numerous data on forest edge vegetation in the Predinaric region in Slovenia (Čarni 1994, 1996, submitted, in preparation), it was decided to collect these data and to perform some numerical analyses (ordinations and classifications). For the preparation of this data set the programme package MHP (Hauser 1990) was used, whereas for the analyses the programme packages SYN-TAX 5.0 (Podani 1993) and CANOCO (Ter Braak 1989) were applied.

Study area

The Predinaric region (Fig.1) was defined as proposed by Wraber (1969) in his phytogeographical division of Slovenia. It is bounded on the north and east by the river Sava, on the south by Croatia and on the west by the higher Dinaric region. The Predinaric region is mainly hilly and submountain with altitudes between 200 and 400 m above sea-level. From a phytogeographic point of view it is under the influence of Illyric floristic elements that are less often noticed on mesophilous and nitrophilous sites. The climatic vegetation comprises *Abieti albae-Carpinetum* (Marinček 1976) Marinček 1995 in the lowlands and *Hacquetio-Fagetum* Košir 1962 and *Lamio orvalae-Fagetum* (Ht 1938) Borhidi 1963 in the submountain and mountain vegetation belts.

Fig. 1. The Predinaric region

The bedrock consists of limestone and dolomite in the marginal and partially in the central part. The central part consists mainly of clastical sediments. Central European climate prevails here, the annual precipitation is between 1100 and 1300 mm; the mean temperatures of the coldest month range from –0.6 to –1.1°C and of the warmest from 18.3 to 20.1°C.

Predominant forest associations

1. Hornbeam forests

Hornbeam forests thrive in the lowlands. Since this is the most favourable agricultural land they are often felled. They appear on small surfaces and are called "farmers'forest", because they offer wood for heating and timber to the

local inhabitants in a densely populated area. These forests have a very low economic value.

Vaccinio myrtilli-Carpinetum (M. Wraber 1969) Marinček 1995 – This acidophilous hornbeam association is the most widely spread of all the hornbeam associations. It thrives on the non-carbonate bedrock where the effect of overexploitation is even more evident than on the limestone. The association appears on steep sites that are not very suitable for agriculture. Sometimes it is found also in the lowlands. These are floristically poor communities on acid soils. They appear on all expositions and on altitudes between 200 and 400m above sea-level.

Piceo abietis-Quercetum (M. Wraber 1969) Marinček 1995 – This association is a potential natural on banks of brooks and it depends on the level of ground water level. As to the floristical and ecological conditions this association is very close to the associations *Pseudostellario-Quercetum* Accetto 1975 and *Pseudostellario-Carpinetum* Accetto 1975 which appear in Krakovski gozd.

Abieti albae-Carpinetum (Marinček 1976) Marinček 1995 – The association with a lot of easteuropean-illyric species appears on limestone bedrock. It is spread on small surfaces of shallow carbonate soils. The communities which appear in central Dolenjska and Bela krajina can be classified into the subassociation *Abieti albae-Carpinetum myrtilletosum.* The bedrock is also limestone, but it is covered with a layer of decarbonated, loose rock and with acid soils (Marinček 1980). The well known litter forests in Bela krajina, which belong to the association *Pteridio-Betuletum* Trinajstić et Šugar 1977, and which give a specific appearance to the landscape, represent a phase in the degradation process of this subassociation.

2. Beech forests

Beech forests are very common in this area. They cover the majority of forest areas.

Blechno-Fagetum Ht. ex Marinček 1970 – This association is found in Zasavje on non carbonate rocks where the ground is acid to highly acid. This association depends on the ground conditions and appears on different sea-levels (Marinček 1987).

Castaneo-Fagetum sylvaticae Marinček et Zupančič (1979) 1995 – The association is found on larger surfaces. It appears within the submontain and mountain belts at the altitudes between 200/300 – 700/800 m on non-carbonate bedrock all over Slovenia. These are relatively warmer slopes within the colline belt that are divided by small valleys and ditches. The slopes are fairly steep to steep and since the ground is watertight, there is often a brook or river at the bottom of the valley (Marinček & Zupančič 1979).

Arunco-Fagetum Košir 1962 – The association appears on the dolomite bedrock, on cold northern sites. The dolomite is quite common in the area. With the exception of very steep slopes and ridges, the dolomite bedrock used to be covered with beech forests. Because of the antropogenous influence in

the past, the small cattle pasture and the present exploitation of these surfaces and above all because of the very slow succession of vegetation, forests of hophornbeam and ash, in which beech often appears, can be found on the southern slopes. The northern slopes are covered by dense community of beech, association *Arunco-Fagetum* (Košir 1979). The slopes are fairly steep to very steep, separated by deep ditches. On these slopes, wich are not exposed to the sun, specific micro climatic conditions prevail. In general, they are cooler, however, the extremes are lower than on the sunny sites, the growing season is somewhat longer and the air humidity is high throughout the year (Marinček 1987).

Ostryo-Fagetum Wraber ex Trinajstić 1972 – This continental beech forest thrives in Slovenia, which is fairly rich in precipitation, but only on sunny expositions. The ecology of this association is well defined by the presence of hophornbeam (*Ostrya carpinifolia)* which despite its thermophilous character thrives only in regions with minimal 1100 mm of precipitation and where the summer is not too hot. In drier and warmer sites more thermophilous forests appear, dominated by downy and bitter oaks (*Quercus pubescens, Q. cerris*).

Hacquetio-Fagetum Košir 1962 – The submountain beech forest grows on brown carbonate soils, It spreads up to 600 m above sea-level. With regard to floristical composition, synecology and syndynamics, it differs substantially from hornbeam and mountain beech forests (Marinček 1983). It has been decided to assign to this association also the association *Querco-Fagetum,* which, according to Košir (1979) is an independent association.

Lamio orvalae-Fagetum (Ht. 1938) Borhidi 1963 – This association of mountain beech forests appears in a humid mountain climate which is also very suitable for beech tree. The average annual temperatures are still high enough and the vegetation period is long enough. In comparison to the submountain beech forest, the average annual temperature is lower (6 to 7°C) but more uniform. There is always enough humidity in the ground, even during the summer drought. In the Predinaric region this association builds a well defined vegetation belt between 600 and 800 m above sea-level.

Ranunculo platanifolii-Fagetum Marinček et al. 1993 – In this area this association builds the subsequent vegetation belt, which appears only at the top of the Gorjanci mountain ridge.

3. Pine tree forests

In Slovenia the pine tree (*Pinus sylvestris*) appears only on extreme sites. The competition ability of the pine tree is rather low and it is often ousted by the beech tree, which is the dominant species of our forests.

Genisto januensis-Pinetum sylvestris Tomažič 1940 – This association is fragmentarily spread in Zasavje on dolomite bedrock. The plant species that can be found there are explicit specialists, such as *Crepis incarnata, Chamaecytisus purpureus, Daphne blagayana etc.*

Vaccinio myrtilli-Pinetum sylvestris (Kobendza 1942) var. geogr. *Castanea sativa* (Tomažič 1942) Zupančič 1995 – This is an acidophilous pine tree

association. The sites of this association are completely different from the previous one, since it thrives on non-carbonate bedrock. It is also an initial association like the previous one, but there appear species that show acidiphility of the site, such as *Lycopodium complanatum*, *Vaccinium vitis-idaea*, *Dicranum spurium*, *D. polysetum* etc. This is a primary association, but it can also appear as a secondary association on the sites of acidophilous beech forest.

4. Oak forests

Lathyro nigrae-Quercetum petraeae Ht. (1938) 1958 – When Horvat (1938) first described *Querco-Ostryetum* this association was only a subassociation, but later on he considered it as an independent association. The sites are deep and clayey and often slightly acid. Although the association thrives on southern slopes, there are some heliophilous and thermophilous plant species which are characteristic of the association *Querco-Ostryetum* missing. In the communities the hophornbeam and downy oak rarely appear; while oak, bitter oak and flowering ash are fast growing trees due to the good water supply. The hornbeam and beech do not appear because they cannot survive the summer drought. These communities have greater economic values than downy oak forests (*Querco-Ostryetum*).

Melampyro vulgati-Quercetum petraeae (Puncer et Zupančič 1979) Zupančič 1994 var. *Epimedium alpinum* Zupančič 1994 – The association is spread on warm south-western slopes, on the hilly ground at the foot of the Gorjanci range and on smaller surfaces elsewhere in the Predinaric region. These are secondary communities on the sites of acidophilous beech forests *Castaneo-Fagetum sylvaticae*. These are warm, acidophilous oak tree communities, where chestnut, trembling poplar and birch can also be found.

5. Ash forests

Hacquetio-Fraxinetum excelsioris Marinček in Wallnöfer et al. 1993 – This association appears in cool and humid valleys in the Gorjanci region. The bedrock consists of limestone and dolomite. The soil layer is shallow and there is often bedrock protruding on the surface. The association is found at the bottom of the valleys along the brooks.

6. Alder forests

Carici elongatae-Alnetum glutinosae Koch 1926 – The alder forest, found in this area, can be classified with the upper association only provisionally. These communities can hardly be classified as this association because there the species from the class *Querco-Fagetea* dominate and there appear only a few species which are classified within the class *Alnetea glutinosae*.

7. Willow forests

The willow forests thrive along brooks and rivers. Two associations were noticed.

Salicetum triandrae (Malc. 1929) Noirf. 1955 – The association appears along the rivers Krka and Kolpa. It thrives on the banks immediately above the water surface and in the river mud.

Salicetum albae Issl. 1926 – This association is found higher above the water level and it is a further step in the progressive succession.

Methods and material

The data set was organised with the help of the programme package MHP (Hauser 1990). The ordination was elaborated with Principal coordinates analysis and classification with a Complete link, both taken from the statistical package SYN-TAX 5.0 (Podani 1993). For the similarity index the option similarity ratio was chosen in both cases. In the case of nitrophilous fringe association the Correspondence analysis from the package CANOCO (ter Braak 1989) was applied. In order to get a general idea we calculated the van der Maarel values (van der Maarel 1985) for each of the associations and then these values were entered into the analysis. The results of the Principal coordinates analysis are presented in diagrams. In all of them two most significant axes are shown. The classification is shovn in dendrograms.

The associations of the forest edge taken into consideration:

Nitrophilous fringe

class *Artemisietea* Lohm., Prsg., et R. Tx in R. Tx 1950

order *Glechometalia hederaceae* R. Tx in R. Tx. et Brun-H. 1975

alliance *Aegopodion podagrariae* R. Tx. 1967

Urtico-Aegopodietum R. Tx. ex Oberd. in Oberd. et al. 1967 var. geogr. *Lamium orvala* Čarni 1994

Urtico-Cruciatetum laevipedis Dierschke 1974

Heracleo-Sambucetum ebuli Brandes 1983

Chaerophylletum bulbosi R. Tx. 1937

Anthriscus sylvestris community

Chaerophylletum aurei Oberdorfer 1957

Phalarido-Petasitetum officinalis Schwickerath 1933

Chaerophyllo-Petasitetum officinalis Kaiser 1926 var. geogr. *Knautia drymeia* subsp. *drymeia* Čarni 1994

Urtico-Lamietum orvalae Čarni 1994

alliance *Alliarion* Oberd. (1957) 1962 emend. Siss. 1973

Torilidetum japonicae Lohm. in Oberd. et al. 1967 ex Görs et Müller 1969 var. geogr. *Epimedium alpinum* Čarni 1994

Natural fringe

class *Trifolio-Geranietea* T. Müller 1961

order *Origanetalia* T. Müller 1961

alliance *Geranion sanguinei* R. Tx. in T. Müller 1961
Geranio-Peucedanetum cervariae (Kuhn 1937) T. Müller 1961 var. geogr. *Knautia drymeia* subsp. *drymeia* Čarni 1995
Knautio drymeiae-Dictamnetum Čarni 1995

alliance *Trifolion medii* T. Müller 1961
Trifolio-Agrimonietum eupatorii T. Müller (1961) 1962 var. geogr. *Knautia drymeia* subsp. *drymeia* Čarni 1993
Knautio drymeiae subsp. *drymeiae-Melampyretum nemorosi* Čarni 1995
Agrimonio-Vicietum cassubicae Pass. 1967 var. geogr. *Knautia drymeia* subsp. *drymeia* Čarni 1993

alliance *Teucrion scorodoniae* De Foucault et al. 1979
Cruciato-Melampyretum pratense Passarge 1979 var. geogr. *Knautia drymeia* subsp. *drymeia* Čarni 1993

Mantle

class *Querco-Fagetea* Br.-Bl. et Vlieg. 1937

order *Quercetalia pubescentis* Br.-Bl. (1931) 1932

alliance *Ostryo-Carpinion orientalis* Horvat 1958
Brachypodio-Ostryetum Čarni 1995

order *Prunetalia spinosae* R. Tx. 1952

alliance *Berberidion* Br.-Bl. 1950
Ostryo-Cornetum Čarni 1994
Omphalodo vernae-Coryletum avellanae Čarni 1994
Ligustro-Prunetum spinosae R. Tx. 1952 var. geogr. *Knautia drymeia* subsp. *drymeia* Čarni 1993

alliance *Pruno-Rubion fruticosi* R. Tx. 1952 corr. Doing 1962
Carpino-Prunetum spinosae R. Tx. 1952 var. geogr. *Knautia drymeia* subsp. *drymeia* Čarni 1993 subvar. geogr. *Epimedium alpinum* Čarni 1996
Rubo-Coryletum avellanae Oberd. 1957 var. geogr. *Knautia drymeia* subsp. *drymeia* čarni 1996

Nitrophilous associations from the order *Prunetalia spinosae* R. Tx. 1952
Cornus sanguinea community
Sambucus nigra community

Results

Nitrophilous fringe

The nitrophilous fringe associations are very common in this region. Because of intensive nitriphication (overmanuring, litter dumping etc.), these associations are expanding very fast in this region. Since they often appear

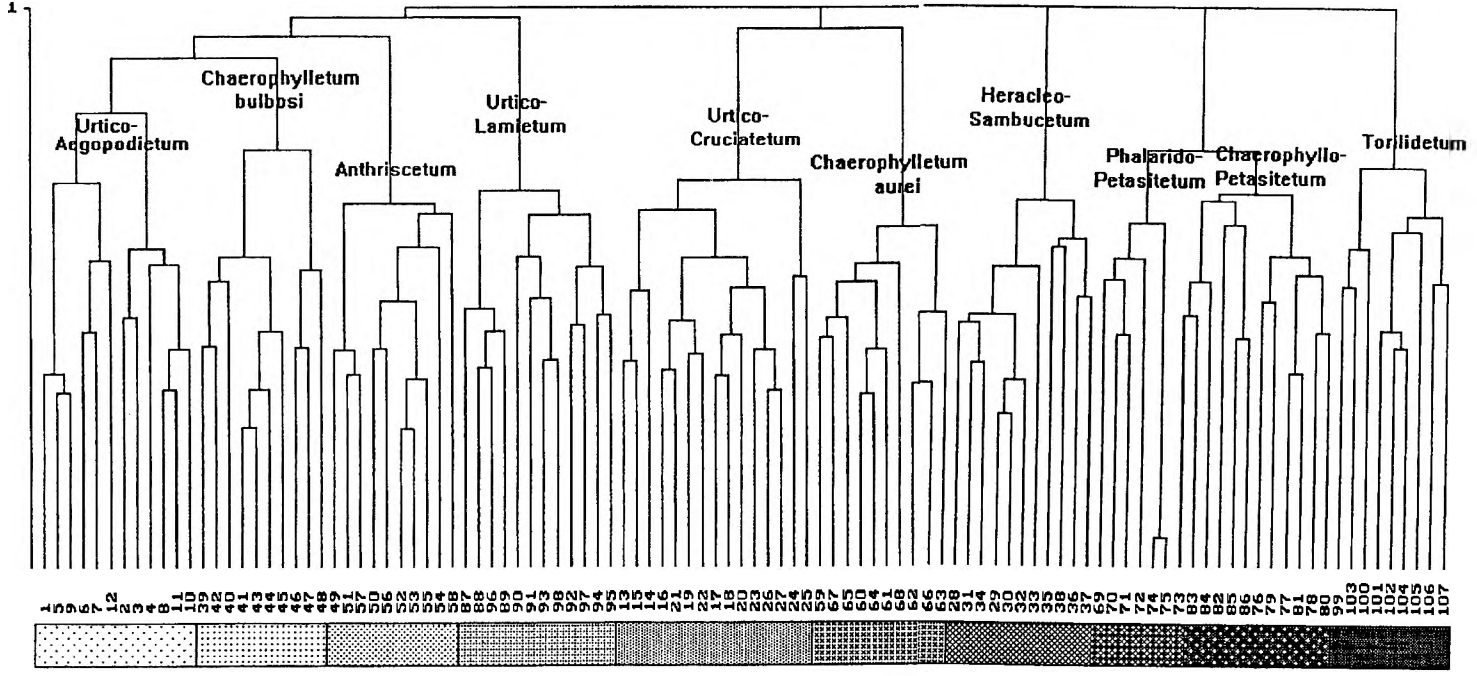

Fig. 2. Classification of nitrophilous fringe communities. The relevés are taken from Čarni 1994: Tab. I *Urtico-Aegopodietum* (N° in the dendrogram 1-12); Tab. II *Urtico-Cruciatetum* (13-27); Tab. III *Heracleo-Sambucetum* (28-38); Tab. IV *Chaerophylletum bulbosi* (39-48); Tab. V *Anthriscus sylvestris* comm. (49-58); Tab. VI *Chaerophylletum aurei* (59-68); Tab. VII *Phalarido-Petasitetum* (69-75); Tab. VIII *Chaerophyllo--Petasitetum* (76-86); ; Tab. IX *Urtico-Lamietum* (87-98); Tab. X *Torilidetum japonicae* (99-107).

separated from the forest edge on the sites of a nitrophilous character, it is difficult to define with which association they are in syndynamical contact. The certainly thrive as a fringe of the nitrophilous mantle associations like *Sambucus nigra* community, *Cornus sanguinea* community, *Rubo-Coryletum avellanae sambucetosum nigrae, Ligustro-Prunetum sambucetosum nigrae, Carpino-Prunetum rubetosum caesii.* They often appear on the edges of forests if there are enough nutrients in the ground. This is often the case, since they can easily be transported by water from neighbouring fields, or sometimes the litter is thrown in the forest, etc. This happens mostly on the edges of the mesophilous lowland forests such as *Vaccinio-Carpinetum, Abieti-Carpinetum, Piceo-Quercetum, Castaneo-Fagetum sylvaticae, Hacquetio-Fagetum,* etc.

Classification of nitrophilous fringe communities is presented in Fig.2.

Correspondence analysis is shown in Fig.3. On the abscissa there is a gradient from the associations growing on dry sites (*Torilidetum japonicae* and *Heracleo-Sambucetum*) to the associations appearing on wet sites (*Phalarido--Petasitetum* and *Chaerophyllo-Petasitetum*), whereas the ordinate shows the gradient between the heliophilous associations *Heracleo-Sambucetum* and *Urtico-Cruciatetum* and the association *Torilidetum japonicae* appearing on shady sites.

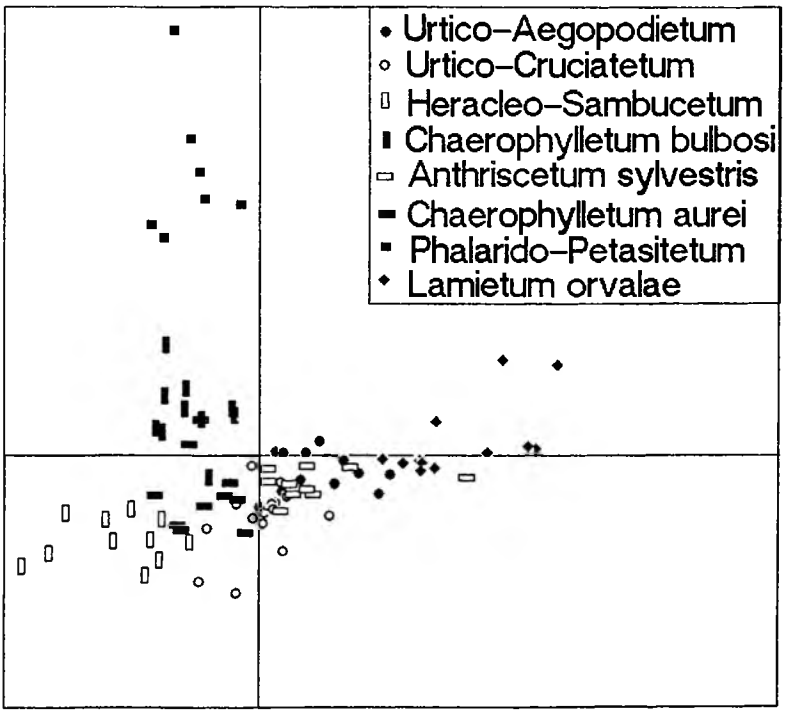

Fig. 3. Correspondence analysis of nitrophilous fringe communities.

Correspondence analysis without associations *Torilidetum japonicae* and *Chaerophyllo-Petasitetum* is presented in Fig.4. On the abscissa there is a gradient from the heliophilous *Heracleo-Sambucetum* to the sciophilous *Urtico-Lamietum*. On the ordinate there is a gradient from the associations *Heracleo-Sambucetum* and *Urtico-Cruciatetum* growing on dry sites to *Phalarido-Petasitetum* appearing on wet sites on brook and river banks.

In the dendrogram five main groups are shown. The first one contains *Urtico-Aegopodietum, Chaerophylletum bulbosi, Anthriscetum sylvestris* and *Urtico-Lamietum* which are nitrophilous associations appearing on more nitrophilous and shadier sites. The other group contains *Urtico-Cruciatetum* and *Chaerophylletum aurei* which are more heliophilous and less nitrophilous, the third group is formed by the association *Heracleo-Sambucetum* appearing on dry sunny sites in summer. It is rarely found on forest edges. The fourth group is formed by *Phalarido-Petasitetum* and *Chaerophyllo-Petasitetum*. These two associations form one group because they thrive on the banks of brooks and rivers and both of them contain species thriving on wet sites. In fact, these associations are quite different from each other. The former appears on more

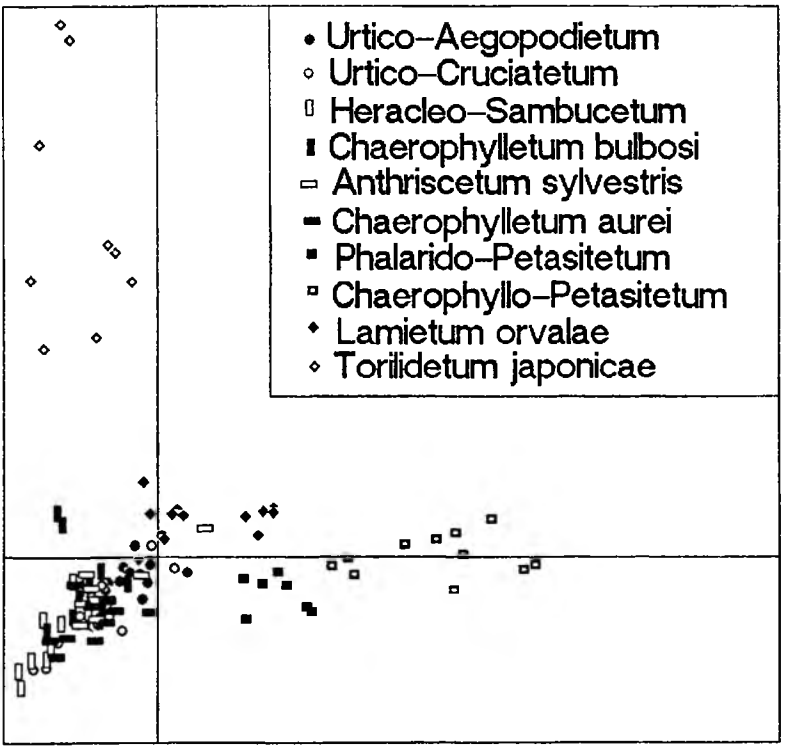

Fig. 4. Correspondence analysis of nitrophilous fringe communities without associations *Torilidetum japonicae* and *Chaerophyllo-Petasitetum.*

degraded sites with more ruderal and nitrophilous species. The latter thrives on natural sites. Like all other associations from the alliance *Aegopodion* in this area, the former can be classified with the suballiance *Lamio albae-Aegopodienion* (R. Tx. 1967) Siss. 1973 and *Chaerophyllo-Petasitetum* is classified under the suballiance *Sileno dioicae-Aegopodienion* (R. Tx. 1967) Siss. 1973. The fifth group includes *Torilidetum japonicae,* a sciophilous, ruderal association from the alliance *Alliarion.*

Natural fringe

This fringe from the class *Trifolio-Geranietea* thrives on more natural sites. More often it appears on forest edges, but it can also be found independently as a stage of the secondary progressive succession (reforestation).

Classification of the releves is presented in Fig. 5.

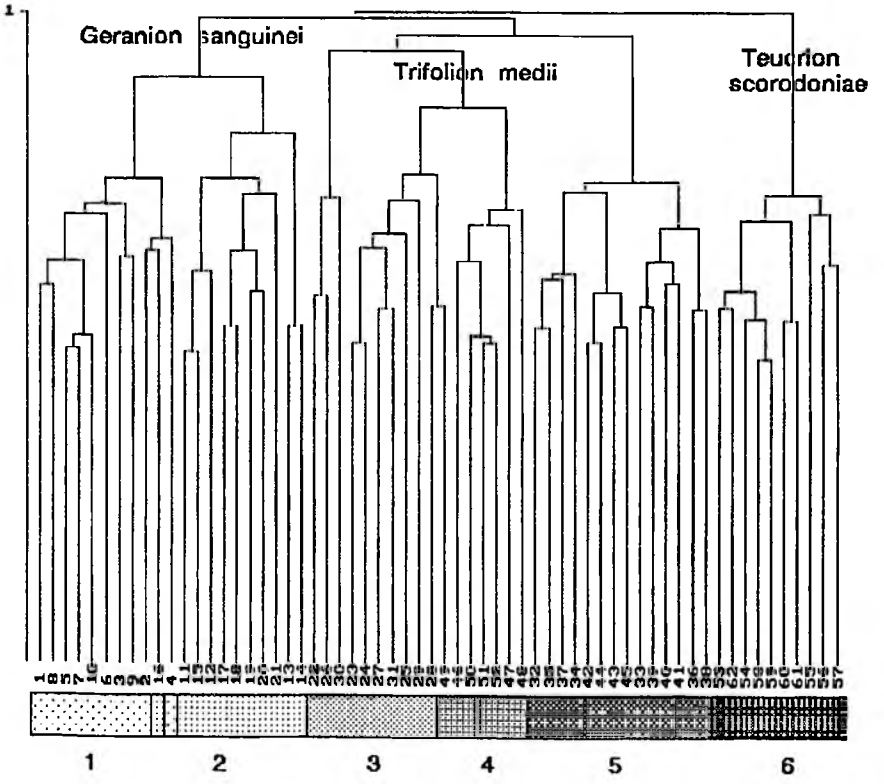

Fig. 5. Classification of natural fringe communities. The relevés were taken from Čarni (submitted): 1. *Geranio-Peucedanetum* (Tab. 1; 1-10 in the dendrogram); 2. *Knautio-Dictamnetum* (Tab. 2; 11-21); 3. *Trifolio-Agrimonietum* (Tab. 4; 22-31); 4. *Agrimonio-Vicietum* (Tab. 5; 46-52); 5. *Knautio-Melampyretum* (Tab. 3; 32-45); 6. *Cruciato-Melampyretum* (Tab. 6; 53-62).

Ordination of relevés is presented in Fig. 6. The caption is the same as for Fig. 5. The abscissa shows a gradient from *Knautio-Dictamnetum* and *Geranio-Peucedanetum* belonging to the alliance *Geranion sanguinei* and thriving on warm sites on limestone and dolomite to *Cruciato-Melampyretum* from the alliance *Teucrion scorodoniae* appearing on colder, acid soils. Even within the associations there is a gradient from the warmest and richest in bases *Knautio-Melampyretum peucedanetosum* (rel. n° 42-45) over transitional *knautietosum* (39-41) to the most acid *solidagetosum* (32-38), and within *Trifolio-Agrimonietum* from the warmer and richer in bases *Trifolio-Agrimonietum teucrietosum* (22-28) to the poorer *veronicetosum* (29-32). On the ordinate there is a gradient from *Knautio-Melampyretum* that grows on the richest soils to *Cruciato-Melampyretum* that grows on poor, acid soils.

From a syndynamical point of view *Knautio-Dictamnetum* is found on the warmest sites in the region, in the Kolpa valley, together with *Carpinus orientalis* and on some other sites exposed to the sun. *Geranio-Peucedanetum* also thrives on extreme warm sites. These associations appear as a fringe of *Brachypodio-Ostryetum* and *Querco-Ostryetum*. *Knautio-Melampyretum* thrives on rich, mesophilous sites which are rich in bases. It forms the fringe of *Carpino-Prunetum, Ligustro-Prunetum, Ostryo-Cornetum,* on sites of *Abieti-Carpinetum, Hacquetio-Fagetum, Melampyro-Quercetum* and rarely of acidophilous beech and hornbeam forests. *Trifolio-Agrimonietum* is found as a fringe on poorer sites. It forms the fringe of *Carpino-Prunetum, Ligustro-Pru-*

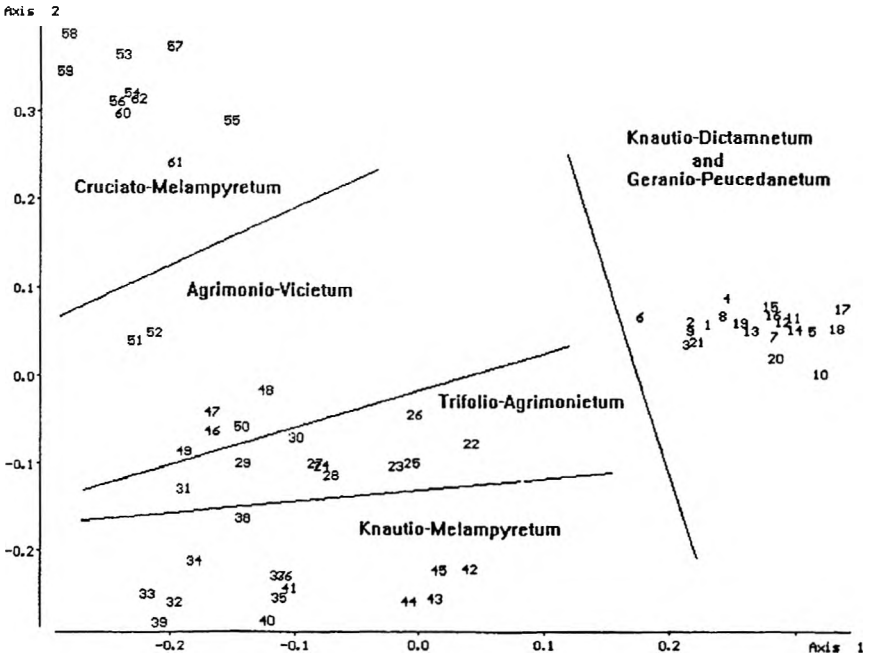

Fig. 6. Ordination of relevés. The caption is the same as for Fig. 5.

netum and the fringe of all mesophilous and acidophilous hornbeam and beech forests. *Agrimonio-Vicietum* is found on the forest edge of poor *Castaneo-Fagetum, Vaccinio-Carpinetum* and *Pteridio-Betuletum. Cruciato-Melampyretum* is found on the most acid and poorest sites in the region. It forms the fringe of *Castaneo-Fagetum, Vaccinio-Carpinetum, Pteridio-Betuletum* and *Vacccinio-Pinetum.*

Mantle associations

In this case the results are shown only in the ordination diagram (Fig. 7). In the diagram on the abscissa there is a gradient from the most nitrophilous *Sambucus nigra* community to the least nitrophilous *Brachypodio-Ostryetum.* This division clearly indicates three or even four types of succession in the area (see text below). On the ordinate there is a development of vegetation. At the bottom there are two communities dominated by cornel (*Cornus sanguinea*) that are initial mantle associations and there are communities dominated by hazel (*Corylus avellana*) at the top.

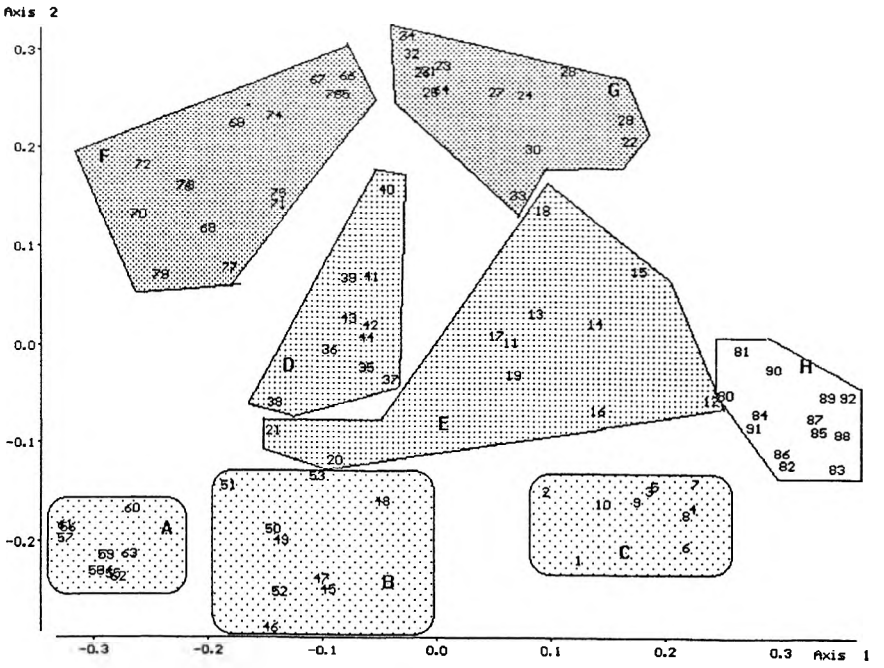

Fig. 7. Ordination of the mantle associations in the region. The relevés were taken from A *Sambucus nigra* community (Čarni 1996: Tab. IV/1-10; in the ordination diagram 54-63); B *Cornus sanguinea* community (Čarni 1996: Tab. III/1-9; 45-53); C *Ostryo-Cornetum* (Čarni in prep.: Tab. II/1-10; 1-10); D *Carpino-Prunetum* (Čarni 1996: Tab. I/1-10; 35-44); E *Ligustro-Prunetum* (Čarni in prep.: Tab. IV/1-11; 11-21); F *Rubo-Coryletum* (Čarni 1996: Tab. II/1-16; 64-79); G *Omphalodo-Coryletum* (Čarni in prep.: III/1-13; 22-34); H *Brachypodio-Ostryetum* (Čarni in prep.: Tab. I/1-13; 80-92).

The result is three or four types of succession (abscissa) with three steps (ordinate). The first one is *Brachypodio-Ostryetum*. It appears as a mantle of thermophilous associations such as *Lathyro-Quercetum* and *Ostryo-Fagetum*. It is in syndynamical contact with grasslands from the class *Festuco-Brometea*, fringe from the alliance Geranion sanguinei on the one side and with the above mentioned thermophilous forest on the other. The second is a less thermophilous line with initial *Ostryo-Cornetum* that is followed by *Ligustro-Prunetum* and *Omphalodo-Coryletum*. The last one cannot be interpreted as a mantle association in the narrowest sense. The hazel-stage is already a further stage of the reforestation process. It can have its own mantle association, in our case *Ligustro-Prunetum*. These associations appear mainly on the sites of more thermophilous submountain and mountain beech forests: *Hacquetio-Fagetum, Lamio orvalae-Fagetum* and partly *Ostryo-Fagetum*. It should be mentioned that *Ligustro-Prunetum* has a large ecological distribution, it can appear on thermophilous sites as subassociation *brachypodietosum rupestre*, on mesophilous sites as *quercetosum roboris* and on nitrophilous sites as *sambucetosum nigrae*. The mesophilous types of the succession are not so clear, since the pollution with too many nutrients (nitrification) often takes place. In our opinion there is a line of succession that goes through *Cornus sanguinea* communities to *Carpino-Prunetum* and ends in mesophilous beech and hornbeam forests: *Hacquetio-Fagetum, Castaneo-Fagetum, Abieti-Carpinetum* etc. On acid soil there is a possibility that the succession goes over an acidophilous hazel-stage (*Rubo-Coryletum*). On brook and river banks very often the development from *Cornus sanguinea* community to the nitrophilous *Rubo-Coryletum sambucetosum nigrae* can be noticed. The last group is formed by *Sambucus nigra* community and it is hard to believe that it can develop further. It is the final stage of the pollution with nutrients.

General view

Dendrogram of forest edge vegetation in Predinaric region is presented in Fig. 8.

Ordination of the forest edges in Predinaric region in Slovenia is shown in Fig. 9. In this case there is not much to be seen, since the gradient is too long. From the diagram presenting the ordination it can be seen that the mantle association from the order *Prunetalia spinosae* has a wider ecological niche than fringe associations from the classes *Artemisietea* and *Trifolio-Geranietea*. In fact, the associations from the order *Prunetalia spinosae* are in contact with the associations from both type of fringes.

In the dendrogram the *Sambucus nigra* community was transferred into the group of nitrophilous fringe association. it is logical because *Sambucus nigra* dominates in this community and hardly any other shrub species can be found there. The herb layer is dominated by *Urtica dioica* and other nitrophilous species from the class *Artemisietea*. The other mantle association *Brachy-*

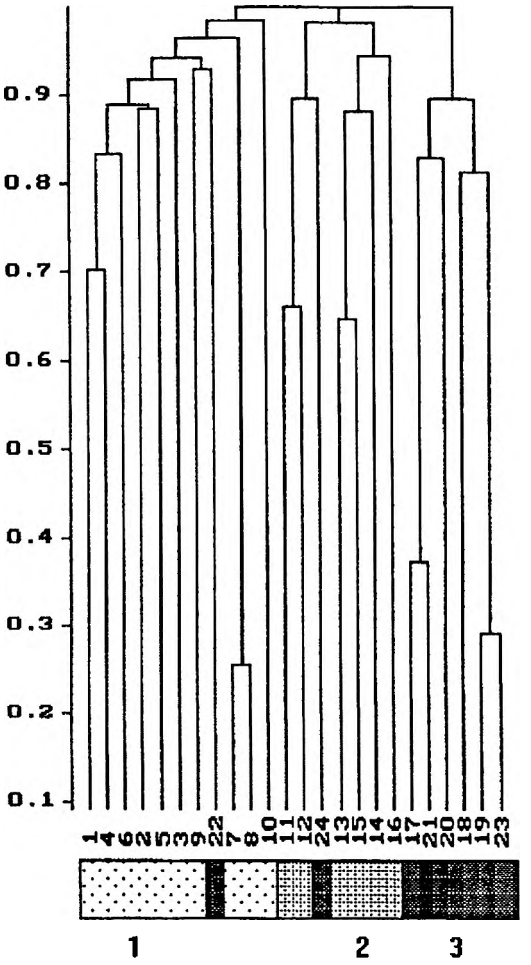

Fig. 8. Dendrogram of forest edge vegetation in Predinaric region.
1 Nitrophilous fringe (1 *Urtico-Aegopodietum*, 2 *Urtico-Cruciatetum*, 3 *Heracleo-Sambucetum*, 4 *Chaerophylletum bulbosi*, 5 *Anthriscus sylvestris community*, 6 *Chaerophylletum aurei*, 7 *Phalarido-Petasitetum*, 8 *Chaerophyllo-Petasitetum*, 9 *Urtico-Lamietum*, 10 *Torilidetum japonicae*). 2 Natural fringe (11 *Geranio-Peucedanetum*, 12 *Knautio-Dictamnetum*, 13 *Trifolio-Agrimonietum*, 14 *Knautio-Melampyretum*, 15 *Agrimonio-Vicietum*, 16 *Cruciato-Melampyretum*). 3 Mantle (17 *Ostryo-Cornetum*, 18 *Ligustro-Prunetum*, 19 *Omphalodo-Coryletum*, 20 *Carpino-Prunetum*, 21 *Cornus sanguinea community*, 22 *Sambucus nigra community*, 23 *Rubo-Coryletum*, 24 *Brachypodio-Ostryetum*).

podio-Ostryetum is in the group of thermophilous fringe associations. This is easy to explain since it is not classified into the order of mantle communities *Prunetalia spinosae*, but into the order *Quercetalia pubescentis*. In this association numerous fringe species from the class *Trifolio-Geranietea* appear.

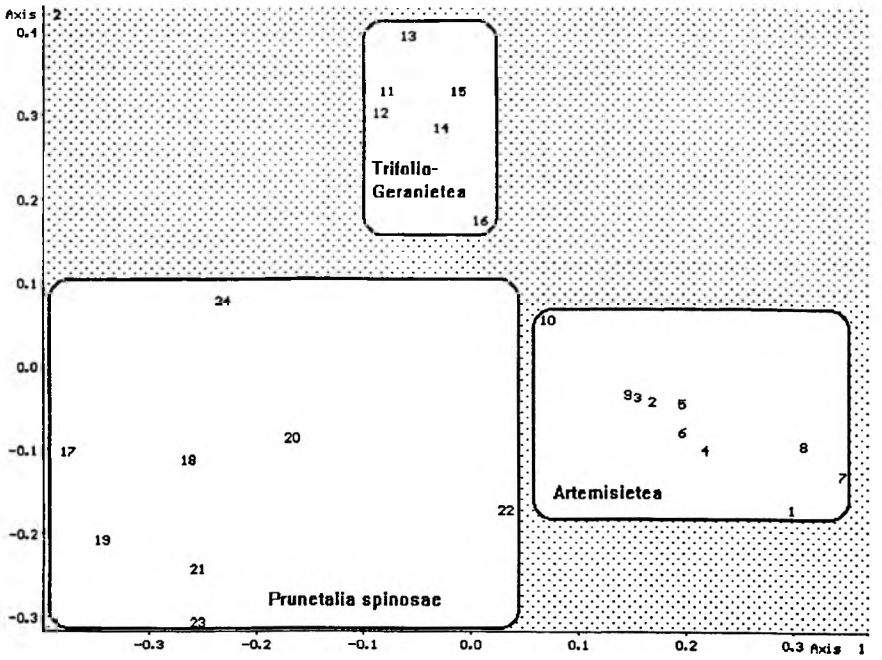

Fig. 9. Ordination of the forest edges in Predinaric region in Slovenia.

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SAŽETAK

NUMERIČKA ANALIZA VEGETACIJE ŠUMSKIH RUBOVA PREDDINARSKOG PODRUČJA U JUGOISTOČNOJ SLOVENIJI

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Predstavljena je vegetacija šumskih rubova u preddinarskom fitogeografskom području Slovenije. Fitocenološke snimke te vegetacije, skupljene iz različitih izvora, podvrgnute su numeričkoj analizi. Rezultati analize ukazuju na međusobne odnose pojedinih zajednica i njihov položaj u kulturnom krajoliku.

Najprije su ukratko prikazane najčešće šumske zajednice preddinarskog područja Slovenije, na čijim rubovima raste istraživana vegetacija. To su: *Vaccinio myrtilli-Carpinetum* (M. Wraber 1969) Marinček 1995, *Piceo abietis-Quercetum* (M. Wraber 1969) Marinček 1995, *Abieti albae-Carpinetum* (Marinček 1976) Marinček 1995, *Blechno-Fagetum* Ht. ex Marinček 1970, *Castaneo-Fagetum sylvaticae* Marinček et Zupančič (1979) 1995, *Arunco-Fagetum*

Košir 1962, *Ostryo-Fagetum* Wraber ex Trinajstić 1972, *Hacquetio-Fagetum* Košir 1962, *Lamio orvalae-Fagetum* (Ht. 1938) Borhidi 1963, *Ramunculo platanifolii-Fagetum* Marinček et al.1993, *Genisto januensis-Pinetum sylvestris* Tomažič 1942, *Lathyro nigrae-Quercetum petraeae* Ht. (1938) 1958. *Melampyro vulgati-Quercetum petraeae* Puncer et Zupančič ex Zupančič 1994, *Hacquetio-Fraxinetum* Marinček in Wallnöfer et al. 1993, *Carici elongatae-Alnetum glutinosae* Koch 1926, *Salicetum triandrae* (Malc. 1929) Noif. 1955 i *Salicetum albae* Issl. 1926.

Ordinacija nitrofilnih zajednica šumskih rubova (sl. 3) pokazuje gradijent od zajednice najvlažnijeg staništa *Chaerophyllo-Petasitetum*, preko zajednica *Phalarido-Petasitetum, Urtico-Lamietum orvalae, Anthriscetum sylvestris, Urtico-Aegopodietum, Chaerophylletum aurei, Chaerophylletum bulbosi* do zajednica *Heracleo-Sambucetum* i *Torilidetum japonicae* na razmjerno najsušim staništima. Osim toga prikazan je na ordinati gradijent od najheliofilnije zajednice *Heracleo-Sambucetum* do najskiofilnije zajednice *Torilidetum japonicae.*

Dijagram ordinacije zajednica prirodnih šumskih rubova (sl. 6) pokazuje na apscisi podjelu na termofilne zajednice sveze *Geranion sanguinei* (*Geranio-Peucedanetum* i *Knautio-Dictamnetum*) i mezofilne zajednice sveza *Trifolion medii* i *Teucrion scorodoniae* (*Knautio-Melampyretum, Trifolio-Agrimonietum, Agrimonio-Vicietum* i *Cruciato-Melampyretum*). Na ordinati je vidljiv gradijent od zajednice koja raste na najbogatijem tlu (*Knautio-Melampyretum nemorosi*) do zajednice *Cruciato-Melampyretum*, koja raste na siromašnom i kiselom tlu.

Ordinacija zastornih zajednica (sl. 7) pokazuje tri ili četiri tipa sindinamskih kontakata: a) *Brachypodio-Ostryetum*, b) *Ostryo-Cornetum, Ligustro-Prunetum, Omphalodeo-Coryletum*, c) *Cornus sanguinea* – zajednica, *Carpino-Prunetum* ili *Rubo-Coryletum*, d) *Cornus sanguinea* – zajednica, *Rubo-Coryletum sambucetosum nigrae.*

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