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COMPARISON OF SPONTANEOUS REFORESTATION IN TWO FORMERLY CULTIVATED AREAS

ANALISI DELL'INCESPUGLIAMENTO SPONTANEO IN DUE TIPI DIVERSI DI COLTIVI ABBANDONATI

Abstract – The line transect method was applied in drawing up a comparison of spontaneous reforestation in two different areas that used to be cultivated. The first area, on limestone, corresponds to one-time pastures, now abandoned (association *Carici - Centaureetum rupestris*). The second one, on flysch, represents abandoned vineyards, now meadows (association *Bromo - Chrysopogonetum grylli*). The forest is represented by secondary association *Ostryo - Quercetum pubescentis* subass. *cornetosum maris* on limestone and *hieracietosum racemosi* on flysch. The transects were subject to the DCA (detrended correspondent analysis). The gradient in the Karst was found to be much greater and the transition between the grassland and the forest much more abrupt than on flysch where the gradient is smaller and the transition more conjunct. Reforestation is presumably faster on flysch than on limestone: this results from the properties of the two rocks and the corresponding microclimates.

Key words: Karst, Flysch, Spontaneous reforestation, DCA, Slovenia.

Riassunto breve – *Nel lavoro si è voluto studiare la dinamica e il tipo di rimboschimento spontaneo dei coltivi abbandonati del Carso e dei vigneti abbandonati su flysch situati nella zona collinare del Capodistriano. Sul Carso l'associazione prativa del* Carici - Centaureetum rupestris *si incespuglia con le specie boschive dell'*Ostryo - Quercetum pubescentis cornetosum maris. *I vigneti abbandonati su flysch colonizzati* dal Bromo - Chrysopogonetum grylli *subiscono l'incespugliamento da parte dell'*Ostryo - Quercetum pubescentis hieracietosum racemosi. *Sono stati eseguiti più rilievi, ciascuno di 2mq di superficie, lungo un transetto di 5 o 6 metri che si estendeva dal prato verso il bosco. I dati così ottenuti sono stati sottoposti ad analisi multivariata. In base ai risultati ottenuti si può affermare che il passaggio dal prato al bosco su flysch è più continuo che sul Carso: le specie boschive sono distribuite in maniera più uniforme sulla superficie prativa e le specie di margine raggiungono il limite del transetto. Su suolo calcareo invece il passaggio è più discontinuo e le specie di margine tendono a riunirsi in nuclei. La velocità d'incespugliamento è inoltre più elevata su flysch. Le cause sono da ricercarsi nelle caratteristiche del suolo. Lo sviluppo del fenomeno carsico crea nei periodi estivi una situazione di stress idrico risentito dalla vegetazione che appare quasi completamente secca; mentre al contrario su flysch, dove l'acqua viene trattenuta nella profondità del suolo, il ciclo della vegetazione durante il periodo estivo subisce solo un rallentamento.*

Parole chiave: *Carso, Flysch, Rimboschimento spontaneo, DCA, Slovenia.*

Introduction

The problem of spontaneous reforestation of one-time pastures and vineyards, now abandoned grasslands, led us to compare the dynamics of the different reforestation in the two areas. This problem has already been studied in the Karst of Triest by several authors: FEOLI & FEOLI CHIAPELLA (1979); LAUSI et al. (1979); FEOLI et al. (1980); FEOLI & SCIMONE (1982) and FAVRETTO & POLDINI (1986). The so-called line transect method (FEOLI, 1980) was applied. The transects were from 5 to 7 m long with a 2 m^2 record at a meter's length. The counts started in the forest and ended in the meadow. The object of our study was the transition of forest species into marginal species, and of these into meadow species. The results are shown also graphically. They reflect the similarities and differences between single counts and show which species group together. As it may be concluded from the results, the dynamics of reforestation is quite different from one place to another, which might be explained by various ecologic factors.

Study Area

The samples were taken from the Slovene Karst and the flysch Koprsko Gričevje in NW Istria, SW Slovenia.

The air-line distance between the two sample-taking areas was of about 30 km. However, the appearance and properties of these areas are quite different.

The Karst Plateau is a plane or slightly hilly land consisting mostly of Eocene limestone. It abounds in sink-holes, doline, abysses, and other karst phenomena. The altitudes range from 300 m to 600 m. The ground is mostly shallow and rather stony.

Koprsko Gričevje is a hilly flysch land, the flysch being a maritime Eocene sediment falling rapidly apart, so the surface is in a process of continual change. Consequently, the relief is most diverse, including numerous small valleys and brooks. Beside the aqueous and wind erosion much harm has been done by man, who is responsible for an almost complete destruction of the original vegetation. The above-sea level does not generally exceed 400 m. The ground is deep, grey-brown, largely argillaceous, sometimes turning acid. As the ground binds water, it is cooler than on limestone.

The climate of the Karst Plateau resembles that of Koprsko Gričevje. By the sea the precipitation amounts to about 1000 mm per annum and in the hinterland to 1500 mm, decreasing mainly in spring and autumn. The summers are dry and hot, while

winter periods are characterized by strong winds lowering the temperatures and drying up the soil. Diverse geologic ground compositions result in important microclimatic differences, which is essential to the development of vegetation.

The floral elements representing the flora of this region are mainly Eurosiberian, Eurasian and central European on one side, SE Alpine-Illyrian on the other, and Mediterranean and Submediterranean on the third side. The flora is generally richer on limestone, where SE Alpine-Illyrian and Mediterranean species are present in larger numbers.

The present Karst Plateau should be viewed in the light of centennial human interventions. The Karst Plateau must have been overgrown by oak forest. Nowadays, the most widely spread forest association in the mosaic grass-shrubbery-forest image of Karst Plateau is *Ostryo - Quercetum pubescentis*. In these parts the subassociation *cornetosum maris* is the most common form of this association.

The grasslands - former pastures - are covered mainly by *Carici humilis* -

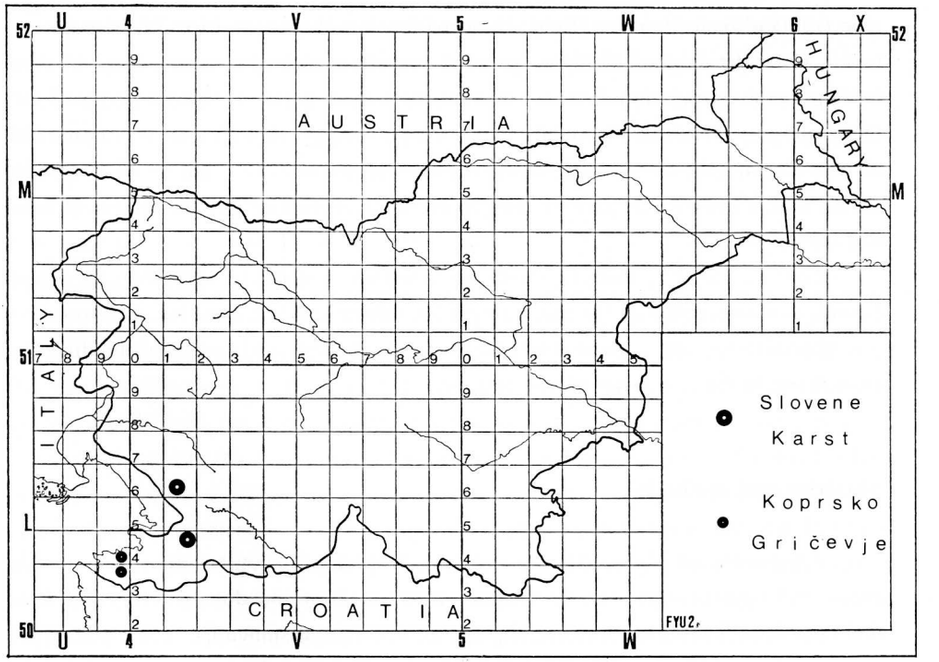

Fig. 1 - A map of Slovenia. The points represent the localities of the transects.
- *Carta della Slovenia. I punti rappresentano la localizzazione dei transetti.*

Centaureetum rupestris, an association generally spread from the Triest Karst to Montenegro. Represented on the Plateau is a lowland variety of this association including several mediterranean species. On the relatively deeper and fresher soil of the Karst Plateau a relatively mesophilic association *Danthonio - Scorzoneretum villosae* has developed. Stands of black pine (*Pinus nigra*) are a common sight in the Karst area. Reforestation by *Pinus nigra* started in the previous century, while its present distribution is also spontaneous.

The original appearance of the flysch of Koprsko Gričevje, too, has been subject to substantial changes, mostly because of its fertile soil. The forests growing here nowadays represent above all the association *Ostryo - Quercetum pubescentis* s. int., with a subassociation *hieracietosum racemosi*. As a result on flysch rock the stands are more humid, here and there even sour. In the areas most open to the sun and on eroded surfaces (shallow ground, water draining away) the stands may be drier, though not to the same degree as on limestone. In the ravines, even more humid and less sunny, there develop hornbeam (*Carpinus betulus*) associations.

Almost all the grass surfaces found on flysch represent just a stage in succession from cultivated surface (field, vineyard) back to the forest. Most of them are terraced, since the original field or vineyard grounds occupied terraces. Most of them belong to the association *Bromo - Chrysopogonetum grylli*. It should be noted that *Chrysopogon gryllus* is a basically thermophilic species, though it thrives quite well also in a relatively humid soil. Wherever the ground is wetter, above all on eroded slopes with a constant or periodic oozing of water, there appears the species *Molinia arundinacea*.

Thus we can state that grasslands on limestone pastures reclaimed by the forest, as well as those on flysch (former vineyards), follow a succession line back to forest. The objective for our study was to state the way, rapidity and causes of the differences arising in the two types of this process.

Material and methods

7 transects on Karst Plateau and 5 in Koprsko Gričevje were selected. The choice fell upon typical, well developed transitions from meadow to forest. We decided upon 5 to 7 m long transects, depending upon the distance from forest at which the meadow is still optimally developed. The record surface in a transect was 1 m long and 2 m wide (2 m^2). Coverage was assessed by standard central european method.

All layers were duly taken into account. The transects were marked by letters; namely, A-G for the Karst area, M-R for the flysch area, whereas single meters were marked by the numbers: 1 - in the forest, 7 - in the meadow.

Localities of single transects: A, B - Podgorje, C-G - Sežansko-Komenski Kras (C - Kazlje, D - Stari Boršt, E - Gabrovica, F - Dutovlje, G - Štorje); M, N - Dovin, Dragonja Valley, O, P - Drnica Valley, R - Šared upon Izola.

Subsequently, each plane was treated as an independent count. The Braun-Blanquet scale was adapted as suggested by VAN MAAREL (1979). The data were subject to multivariate statistic package - modified version of DCA (Detrended Correspondence Analysis), CANOCO program (TER BRAAK, 1988).

The nomenclature of species in this work follows EHRENDORFER (1973), and that of syntaxa POLDINI (1989).

Results and Discussion

As already mentioned in the introduction, the present article deals with the problem of spontaneous reforestation in secondary grasslands. In both types the forest progression is relatively swift. In the meadow there first appear large-leaved plants and among them also shrubs that soon prevail over others. A marked capacity of conquering an ever vaster territory is typical of the species *Cotinus coggygria*. Afterwards there appear forest species, first arboreal then herbaceous. The border between the meadow and the forest – the "front" of reforestation – is well marked by marginal species belonging to the alliance *Geranion sanguinei*.

In the Karst area the transects were taken from the forest association *Ostryo - Quercetum pubescentis*. The spatial arrangement of the counts (empty circles marking the counts on limestone) in Diagram 1 indicates that in the Karst area the circumstances are more stabilized, the arrangement of forest and marginal species being less irregular. Compared to the flysch area, the transitions are sharper and more abrupt. The diagram evidences a clear step-like transition between the 1st and 2nd, 2nd and 3rd meter. The arrangement of counts along axis x shows that here the gradient is greater than on flysch, which coincides with the fact that the transition is more step-like. From a visual point of view, the Karst forest reveals a more pronounced compactness and more regular arrangements of the marginal species on the border between the meadow and the forest.

It should be explained, however, why one of the most characteristic marginal

species, i.e. *Geranium sanguineum*, appears in the middle of the diagram: it is present both on a Karst as well as a flysch ground (contrary to the species *Dictamnus albus* found exclusively on limestone). For this reason, *Geranium sanguineum* is positioned neither in the upper left part of the diagram nor below axis x, reserved for flysch groups. The species, relatively evenly present in both types of reforestation, can be find some place between the upper and the lower group of dots positioned along axis y.

Flysch meadows are mostly terraced. Here the forest first develops between terraces where the ground was never cultivated, thus having a certain "temporal" advantage since in the meantime an abandoned field or vineyard has to go through the entire succession series starting from the class *Artemisietea* (in these parts *Dauco - Picridetum* is the most frequent association to be found in abandoned vineyards) to class *Festuco - Brometea* with the association *Bromo - Chrysopogonetum grylli* as developed nowadays. The forest usually spreads to the terraces also from the sides, i.e. from terraces and ditches already covered with the forest.

The flysch area is to be noted for a constant and abundant presence of species *Peucedanum cervaria.* This Umbellifera with larger leaves, that belongs to alliance *Geranion sanguinei*, is the first step to reforestation; it is an indicator of richer and

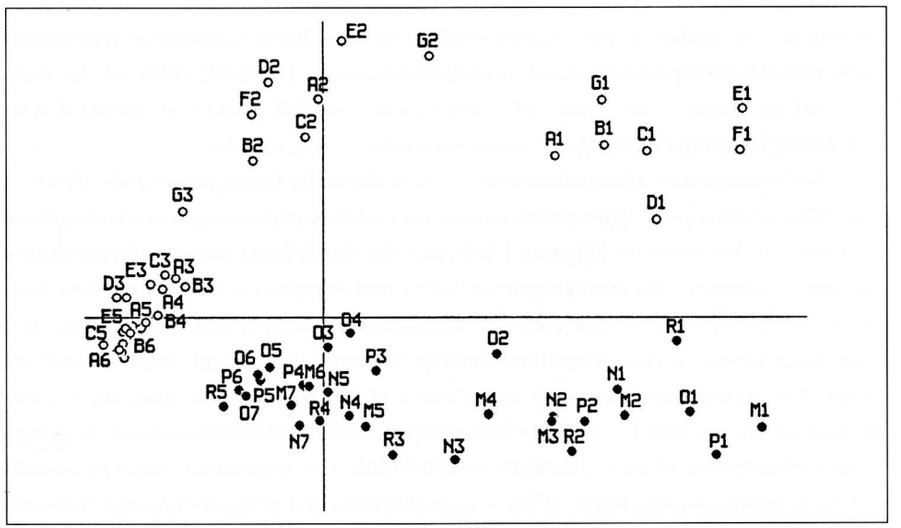

Fig. 2 - Ordination of the relevées.
- *Ordinamento dei rilievi.*

eventually deeper ground, which results in a swifter progression of the forest. On flysch terraces the species *Peucedanum cervaria* is often spread over the entire meadow, which seems to indicate a relatively high speed of reforestation favoured by the soil.

The ground on limestone is shallow, rocky and permeable to the water which easily leaks into the interior while the surface remains dry. For this reason it is susceptile to warming up, thus providing (contrary to flysch) a suitable substratum for certain xerophilic and thermophilic species. The vegetal cover is low, made up of a single layer, creating no such microclimates as were specially favourable to plants with large leaves. Such conditions occur only in sinkholes where the water flowing towards the bottom carries with it also soil. The forest, thanks to its shadow falling

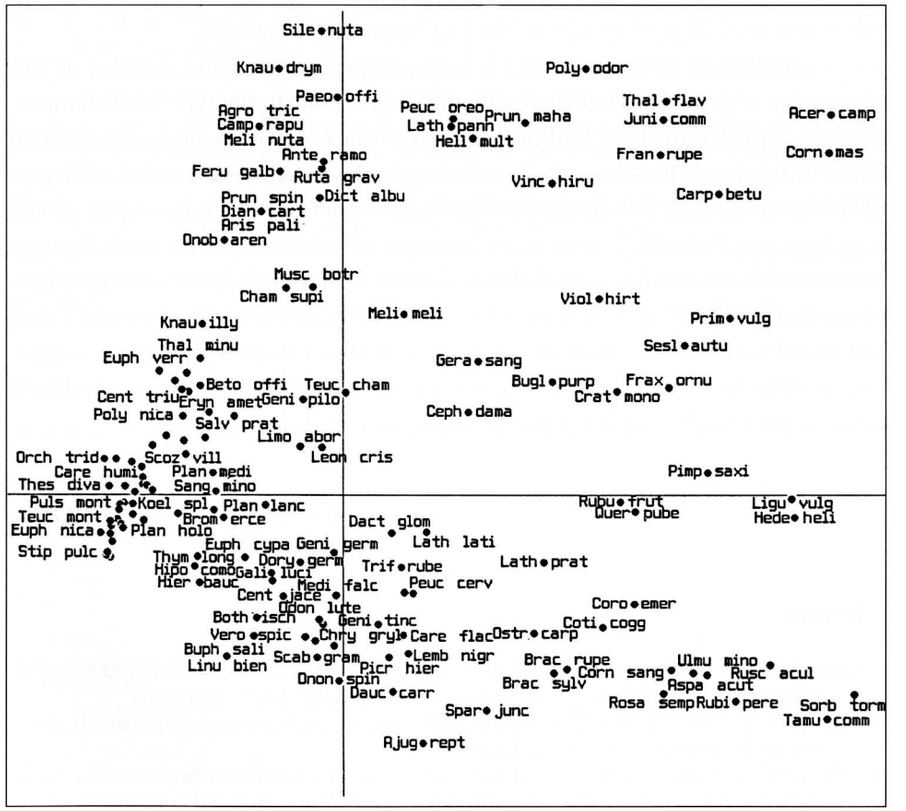

Fig. 3 - Ordination of the species, present in the relevées.
- *Ordinamento delle specie presenti nei rilievi.*

on its margin where shrubs, marginal species, and high Umbelliferae stringing upon favorable conditions, spreads into meadow, "enlarging". Though only on its margin, the composition of Karst meadow undergoes changes that undermine its stability.

Contrary to the Karst Plateau, flysch retains water, so the soil is deep and humid. The termophilic species do not thrive here as on limestone, even though the sea is not far away and the altitude is low. Sometimes the soil is slightly clayey and acid. This is proven by the species *Lembotropis nigricans*, *Chamaespartium sagittale* and *Odontites lutea*. The stability of such meadow is lower in itself; plants with large leaves and other marginal species can spread faster, no gradual ground evolution is to be provided since the place is perfectly "ready" for the penetration of shrubs and trees. The soil is closely associated with the corresponding microclimate, a decisive factor of vegetal dynamics. Another aspect to be considered is the influence of regional climate upon microclimate, as well as the important role of bedrock.

Characteristic of the study area is a dry summer period with a month's or longer absence of precipitation or else with precipitations of stormy type. Karst meadow becomes perfectly dried out for limestone layers cannot retain so much rain as might fall in this period. The seasonal vegetation dynamics clearly reminds that of steppe. So it is by no accident that the ecologic similarity is confirmed by some steppic genera (e.g. *Stipa* and *Pulsatilla*). What is the consequence of steppic effect upon the reforestation of Karst meadows? Doubtlessly a negative one, since from a purely temporal point of view, it shortens down the vegetational development by two months a year. The situation is less critical on flysch since the ground retains water and the vegetation is more mesophilic. During summer months its development, though slowed down, is not brought to a standstill, as may be observed on limestone.

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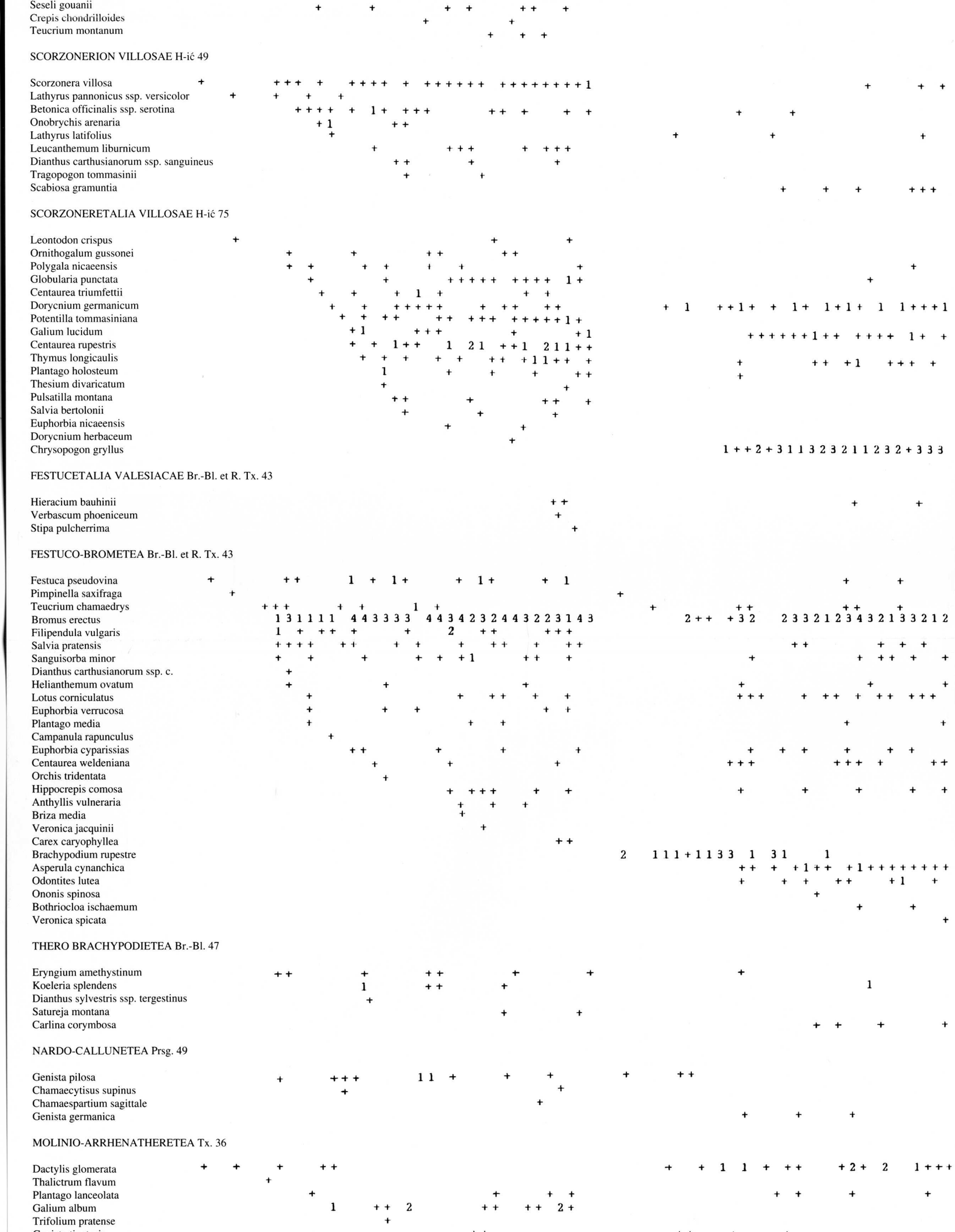
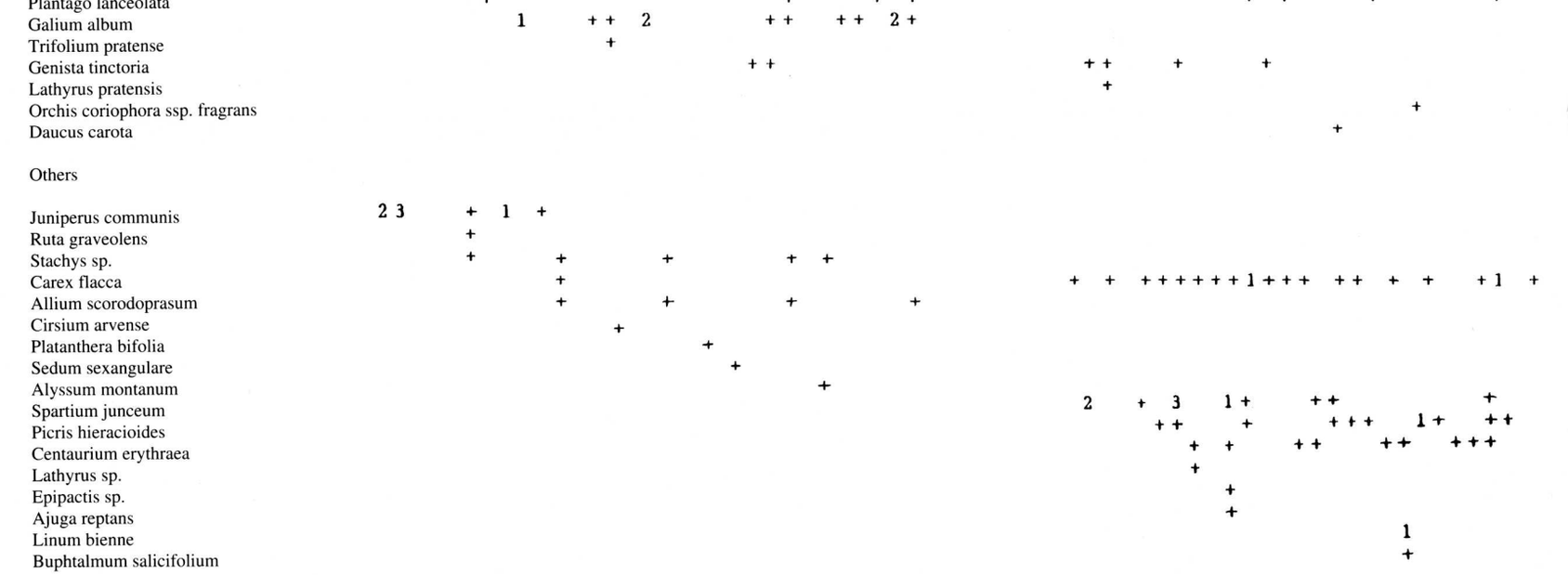
A. ČARNI, M. KALIGARIČ - COMPARISON OF SPONTANEOUS REFORESTATION IN TWO FORMERLY CULTIVATED AREAS

Table of the transects - *Tabella dei transetti.*

ASSOCIAZIONI	A B C D E F G A B C D E F G A B C D E F G A B C D E F G A B C D E F G A B C D E F G A B	M N O P R M N O P R M N O P R M N O P R M N O P R M N O P R M N O P R M N O P R M N O P M N O
	1 1 1 1 1 1 1 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 5 5 5 5 5 5 5 5 6 6	1 1 1 1 1 2 2 2 2 2 3 3 3 3 4 4 4 4 4 5 5 5 5 5 6 6 6 6 7 7 7
QUERCETEA ILICIS Br.-Bl. 47		
Asparagus acutifolius		1 + + + + + 1 + +
Rosa sempervirens		1 1 + + +
Ruscus aculeatus		+
Rubia peregrina		+ 1
OSTRYO-CARPINION ORIENTALIS Horvat 54 em. 58		
Sesleria autumnalis	2 1 + + + + +	+ 1 + + +
Frangula rupestris	+ + + +	
Paeonia officinalis	+	
Aristolochia pallida	+	
Knautia drymeia	+	
Coronilla emerus ssp. emeroides		+ 1
Ostrya carpinifolia		2 1
QUERCETALIA PUBESCENTIS Br.-Br. (31 n.n.) 32		
Quercus pubescens	5 4 3 2 + + 1	2 4 4 4 4 3 2 2 2 1 + 1 + + + + + + +
Fraxinus ornus	+ 2 3 4 1 3 + 1 2	3 1 1 3 1 2 1 +
Cornus mas	1 1	
Buglossoides purpurocoerulea	+	+
Limodorum abortivum	+	
Melittis melissophyllum	+ +	+
Arabis turrita	+	+
Sorbus torminalis		+
BERBERIDION Br.-Bl. 50		
Prunus mahaleb	+ 3 1 + 1 3	
Ligustrum vulgare	1	+ + 2
Cotinus coggygria	+ +	2 2 2 1 3 3 3 3 3 2 + 2 1 + +
Cornus sanguinea		+ 1 2 + + + + + +
PRUNETALIA SPINOSAE R. Tx. 52		
Crataegus monogyna	1 3 +	1 + +
Rubus fruticosus	+ 1	+ + + +
Prunus spinosa	+	
Tamus communis		+ +
FAGETALIA SYLVATICAE Pawl. 27		
Carpinus betulus	+	
Primula vulgaris	+	
Melica nutans	+	
Brachypodium sylvaticum		+ +
QUERCO-FAGETEA Br.-Bl. et Vlieg. 37		
Cephalanthera damasonium	+	
Hedera helix	+ +	+
Acer campestre	+	1 + 1
Ulmus minor		+
TRIFOLIO-GERANIETEA SANGUINEI Th. Müller 61		
Dictamnus albus	1 + 3 2 + 2 1 + + + + + 1 +	
Helleborus multifidus	+ + + +	
Vincetoxicum hirundinaria	+ + 2	1
Viola hirta	1 + + 1	+ +
Peucedanum oreoselinum	+ 1	
Geranium sanguineum	+ + 2 + + 1	+ + + + + + + + + +
Polygonatum odoratum	1 +	
Peucedanum cervaria	+ 2	+ + 1 + + 1 + + 3 + 1 + + 3 1 + 2 2 + 1
Thalictrum minus	+ +	+ + + + + + +
Trifolium rubens	+ +	+ + + + + + +
Ferulago galbanifera	+ 2 + 1 + +	
Silene nutans	+ +	
Agropyron trichophorum	+	
Anthericum ramosum	+ +	
Lembotropis nigricans		+ + + + + + + +
Medicago falcata		+ +
SATUREION SUBSPICATAE Ht. 62 et SATURENION SUBSPICATAE Poldini 89		
Muscari botryoides	+ + + + +	
Knautia illyrica	+ + + + + + + + +	
Anthyllis montana ssp. jacquinii	+ +	+
Scorzonera austriaca	+ +	
Carex humilis	+ + 1 2 1 + 3 2 2 1 1 + 3 3 3 2 3 + + 2 3 4	


Seseli gouanii
Crepis chondrilloides
Teucrium montanum
SCORZONERION VILLOSAE H-ić 49
Scorzonera villosa
Lathyrus pannonicus ssp. versicolor
Betonica officinalis ssp. serotina
Onobrychis arenaria
Lathyrus latifolius
Leucanthemum liburnicum
Dianthus carthusianorum ssp. sanguineus
Tragopogon tommasinii
Scabiosa gramuntia
SCORZONERETALIA VILLOSAE H-ić 75
Leontodon crispus
Ornithogalum gussonei
Polygala nicaeensis
Globularia punctata
Centaurea triumfettii
Dorycnium germanicum
Potentilla tommasiniana
Galium lucidum
Centaurea rupestris
Thymus longicaulis
Plantago holosteum
Thesium divaricatum
Pulsatilla montana
Salvia bertolonii
Euphorbia nicaeensis
Dorycnium herbaceum
Chrysopogon gryllus
FESTUCETALIA VALESIACAE Br.-Bl. et R. Tx. 43
Hieracium bauhinii
Verbascum phoeniceum
Stipa pulcherrima
FESTUCO-BROMETEA Br.-Bl. et R. Tx. 43
Festuca pseudovina
Pimpinella saxifraga
Teucrium chamaedrys
Bromus erectus
Filipendula vulgaris
Salvia pratensis
Sanguisorba minor
Dianthus carthusianorum ssp. c.
Helianthemum ovatum
Lotus corniculatus
Euphorbia verrucosa
Plantago media
Campanula rapunculus
Euphorbia cyparissias
Centaurea weldeniana
Orchis tridentata
Hippocrepis comosa
Anthyllis vulneraria
Briza media
Veronica jacquinii
Carex caryophyllea
Brachypodium rupestre
Asperula cynanchica
Odontites lutea
Ononis spinosa
Bothriocloa ischaemum
Veronica spicata
THERO BRACHYPODIETEA Br.-Bl. 47
Eryngium amethystinum
Koeleria splendens
Dianthus sylvestris ssp. tergestinus
Satureja montana
Carlina corymbosa
NARDO-CALLUNETEA Prsg. 49
Genista pilosa
Chamaecytisus supinus
Chamaespartium sagittale
Genista germanica
MOLINIO-ARRHENATHERETEA Tx. 36
Dactylis glomerata
Thalictrum flavum
Plantago lanceolata
Galium album
Trifolium pratense


Plantago lanceolata
Galium album
Trifolium pratense
Genista tinctoria
Lathyrus pratensis
Orchis coriophora ssp. fragrans
Daucus carota
Others
Juniperus communis
Ruta graveolens
Stachys sp.
Carex flacca
Allium scorodoprasum
Cirsium arvense
Platanthera bifolia
Sedum sexangulare
Alyssum montanum
Spartium junceum
Picris hieracioides
Centaurium erythraea
Lathyrus sp.
Epipactis sp.
Ajuga reptans
Linum bienne
Buphtalmum salicifolium