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UDK 630*188+48 (Quercus robur L.)

DEVELOPMENT OF VEGETATION IN LOCALITES OF PEDUNCULATE OAK DIEBACK IN CROATIA

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Dieback of pedunculate oak forests in lowland Croatia is one of the most important forestry problems today. A synergistic action of various adverse impacts has resulted in the forced felling of some 600,000 m³ of stemwood on 20,000 ha of the most acutely affected areas in the north-west of Croatia over the last thirty years. Dieback has had the most severe impact on the forest association of pedunculate oak and *Genisto elata (Genisto elatae-Quercetum roboris)*. In the majority of localities this association was in a progressive developmental stage towards the forest of pedunculate oak and common hornbeam (*Carpino betuli-Quercetum roboris*). Changes in the vegetation in the localities of forest dieback have led to the disappearance of both pedunculate oak and numerous members of a well-structured phytocoenosis on the one hand, and the expansion of some pioneering floral elements on the other. Among the latter, those growing on more humid, waterlogged and open sites are particularly prominent.

Key words: pedunculate oak, floral composition, vegetation development, indicative values, lowland Croatia

INTRODUCTION

Forests of pedunculate oak (*Quercus robur* L.) extend over about 200,000 ha in the valleys along the rivers Sava, Drava, and Danube and their tributaries, which is 10% of the total area under forests in Croatia. Their overall growing stock amounts to 55million m³ and the current annual increment reaches 1.4million m³. These forests are mixed in terms of their natural and structural characteristics. Apart from the pedunculate oak, there is also common hornbeam (*Carpinus betulus)*, narrow-leaved ash (*Fraxinus angustifolia*), black alder (*Alnus glutinosa*), elms (*Ulmus carpinofolia* and *U. laevis*), poplars (*Populus* sp.), willows (*Salix* sp.) and other species of lowland regions. Water is the principal ecological factor that influences the development of forest associations of pedunculate oak.

In the last hundred and fifty years the lowland region has been affected by various factors, primarily those of anthropogenic origin. The result has been considerable deviations from a normal natural succession. As some of these effects have followed natural processes or have not caused any stresses, the succession can be regarded as natural. This relates, first of all, to the lowland regions of Croatia in general, where the areas under the associations of drier sites have increased in comparison to those of more humid ones. However, man's interference with nature has brought about shocking changes, to which ecological-biological properties of species have not been able to find a satisfactory answer (tolerance threshold). As a result, large forest complexes have suffered dieback. Therefore, plant communities have not progressed; on the contrary, their entire development has been stopped and has often returned to the beginning. In Croatia, the best known localities in this sense are those along the River Drava near Varaždin, the lowland forests in the Pokupsko basin, the forests in the area of Turopolje-Lekenik, Žutica near Ivanič Grad, and partly the forests of Spačva.

The following factors, often combined into synergistic action, are cited as the most common causes of the disturbed natural stability and appearance of associations of pedunculate oak, as well as a cause of the overall destabilisation of the forest ecosystem:

- epidemic mortality of lowland elms (change in the microclimate)
- badly executed regulations of water courses and melioration (lowered levels of groundwater and changes in the natural flood rhythm)
- an increasing frequency of dry periods during the growing season
- intersecting the terrain with a network of hard roads with poor drainage (waterlogging)
- poisoned and polluted water of the River Sava and its tributaries
- excess of polluted air (SO_2, NOx, heavy metals, etc)
- biotic factors (weakened tree resistance opens a path to attacks by harmful entomofauna, primarily of gypsy moths, and plant diseases, first of all mildew)
- large-scale felling, pedunculate oak monocultures, and inadequate forest management in the past (change in the microclimate)

Water is of decisive importance for the growth of pedunculate oak and its associations in Croatia, while differences in the micro-relief condition the occurrence of various associations. Thus, micro-elevations represent fresh sites but with no excess of water, and micro-depressions abound in water in some parts of the year (spring, autumn). The former are suited to the growth of forests of pedunculate oak and common hornbeam (*Carpino betuli-Quercetum roboris*), while the latter are conducive to forests of pedunculate oak and greenweed *(Genisto elatae-Quercetum roboris*), which is the subject of our discussion. The results and models obtained or confirmed by Baričevič (1998 and 1999), Matič *et al.* (1994), Rauš and Vukelič (1989), Rauš *et al.* (1996), Vukelič and Rauš (1993), Vukelič *et al.* (1997) have been party used for this work.

FOREST OF PEDUNCULATE OAK AND GREENWEED (*GENISTO ELATAE-QUERCETUM ROBORIS* HT. 1938)

This association (*Genisto elatae-Quercetum roboris*) is characterised by some of the best known forest stands in Croatia, the sources of the world-renowned Slavonian oakwood. It is distributed in the valleys of large rivers and their tributaries, such as the Sava, Drava, Kupa, Danube, and others. These areas abound in vast forest complexes; for example those in the area of Spaćva, Pokuplje and Česma, the forests of Lipovljani, the forests of Žutica and Repaš, those growing in the region of Našice and Donji Miholjac, and the forests of Slatina.

The terrain of these associations is several meters above the normal water table. It is periodically flooded, but floods are either of short duration or the sites are out of reach of floods, but still abundantly fresh.

In the vegetative succession of lowland forests, this association is a step below the forest of pedunculate oak and common hornbeam. As humidity decreases, it gradually passes into this terminal association within natural progression. However, it is above the forest of narrow-leaved ash and black alder, which grows on a lower terrain and in more humid conditions, in which pedunculate oaks cannot survive.

This highly diverse association has an interesting appearance, composition and value thanks to a mixture of numerous dry and humid vegetative elements. The transition of a micro-elevation into a micro-depression causes the disappearance of common hornbeam and a majority of mesophyllous species of the order *Fagetalia*, and the appearance of hygrophyllous species of the order *Populetalia albae*, which are adapted to floods and raised levels of groundwater.

Pedunculate oak is the dominant species of the very rich tree layer, followed by a considerable proportion of narrow-leaved ash, black alder, lowland elm and spreading elm. The shrub layer is also rich and diverse and is composed, apart from the species from the tree layer, of *Genista elata, Crataegus oxyacantha, Crataegus monogyna, Prunus spinosa, Pyrus pyraster, Viburnum opulus, Frangula alnus,* and other species.

The ground layer is particularly diverse in springtime after floods. It consists of the following species: *Carex remota, Carex strigosa, Rumex saguineus, Cerastium sylvaticum, Valeriana dioica, Lycopus europaeus, Solanum dulcamara, Glechoma hederacea, Galium palustre, Ranunculus repens, Lysimachia numularia, Lysimachia vulgaris, Stachys palustris, Succisa pratensis, Polygonum hydropiper, Mentha aquatica, Aegopodium podagraria, Euphorbia palustris*, and others.

The well-known and described association in Central Europe, that of *Querco-Ulmetum* Oberd. 1953, is very similar to the Croatian association *Genista elatae-Quercetum roboris*, but the differences in their floral composition are evident (*Fraxinus angustifolia, Genista tinctoria ssp.elata*).

The forest of pedunculate oak and greenweed is subdivided into several sub-associations, but decline is present in the following two:

Genisto elatae-Quercetum roboris caricetosum remotae Ht. 1938
Genisto elatae-Quercetum roboris caricetosum brizoides Ht. 1938.

The forest of pedunculate oak and greenweed with quaking sedge (*Genisto elatae-Quercetum roboris caricetosum brizoides* Ht. 1938) thrives on pseudogley and mineral-swampy, slightly acid, non-flooded soils. The sites are usually humid micro-elevations and dry micro-depressions. In the spring and late autumn, the level of groundwater is very high. The differentiating species of the sub-association are *Carex brizoides, Deschampsia caespitosa, Polytrichum attenuatum, Melampyrum silvaticum, Potentilla erecta, Veratrum album*, and others. A typically developed floral composition of this association in undisturbed systems is shown in Table 1, recordings 1 - 3 (Rauš 1993).

The sub-association with remote sedge (*Genisto elatae-Quercetum roboris caricetosum remotae* Ht 1938) grows in flat areas sporadically covered with both flood and stagnant surface water. In the vertical sense, it takes up a position slightly below the previous sub-association, from which it differs by the following genera: *Carex remota, Iris pseudacorus, Cerastium silvaticum, Carex strigosa, Carex elata, Caltha palustris* and other species of more humid sites. The typically developed floral composition of this association in undisturbed ecosystems is shown in Table 2, recordings 1-3 (Rauš 1973).

RESEARCH RESULTS AND DISCUSSION

The succession of lowland forests follows the pattern from the willow "malat" – young germ on sandbanks, through willow forests, poplars, mixed stands of pedunculate oak, elms, black alder and ash, to pedunculate oak-hornbeam forests. The succession or the changes are the result of external ecological factors, but also of an internal development of the association itself. When the development is normal and natural, the succession takes a long time, but the intensive changes of some factors, provided their abruptness and strength do not cause stress, accelerate the process. If the factors that limit the development act continuously, the final association will not develop but will remain in its permanent stage.

FOREST OF PEDUNCULATE OAK AND GREENWEED WITH QUAKING SEDGE (*GENISTO ELATAE-QUERCETUM ROBORIS CARICETOSUM BRIZOIDES* HT. 1938)

Research in the localities of pedunculate oak dieback in the forest of pedunculate oak and greenweed with quaking sedge in Turopoljski Lug have shown that both the floral composition of stands and their physiognomy and structure have completely lost the character of a typically developed sub-association *caricetosum brizoides.* Plants such as *Salix cinerea, Juncus effusus, Cirsium palustre* and *Peucedanum palustre* that are atypical for this association (Table 1, recordings 4, 5 and

6), are permanently present. Corkscrew rush (*Juncus effusus*), normally a regular occurrence in the lowland forests of Croatia, covers up to 100% of dried sites. The eco-indicative properties of the present species point to a waterlogged biotop, which was not the case before. This is testified by the presence of a stunted common hornbeam occurring here some ten to twenty years previously, and whose development was abruptly ended. It has been replaced with *Salix cinerea, Frangula alnus* and *Alnus glutinosa.*

As seen from the above, the stressful changes of ecological factors and their impact on stands and sites in a normal succession have had very serious consequences. In place of standard representatives, plants that indicate changes in the biotop, namely waterlogging, dominate the floral composition. Excess moisture is primarily the result of badly executed hydrotechnical and infrastructural interventions in the stands. This was additionally increased many times over by the degradation of pedunculate oaks, which had utilised humidity from the soil.

This is confirmed by the presence of species that indicate humid sites in the localities of dieback in the Pokupsko basin (Table 1, recordings 7 and 8), the forests of Posavina around Sunja and Dubica (Table 1, recordings 9 and 10), and in the forest of ŷutica (Baričevič 1998). Apart from the mentioned differentiating species, a large proportion of the following was noted: *Frangula alnus, Polygonum hydropiper, Myosotis scorpioides, Galium palustre, Lysimachia vulgaris, Carex elongata, Stachys palustris, Ranunculus repens, Lytrum salicaria* and others. More mesophyllous elements from typically structured associations were absent.

A drastic example of changes of this kind is the forest of ŷutica. The site of the sub-association with quaking sedge established some thirty years ago (Medvedovič 1975) is today taken up by a forest of black alder on 50 ha, a forest of narrow-leaved ash on 30 ha, and a more humid sub-association with quaking sedge on 120 ha. On the other hand, the normal progression of the association is found on 40 ha where ecological changes were not so drastic. About 20 ha of the site are covered by the more arid sub-association with common hornbeam, and a further 20 ha by the association of pedunculate oak and common hornbeam.

FOREST OF PEDUNCULATE OAK AND GREENWEED WITH REMOTE SEDGE (*GENISTO ELATAE-QUERCETUM ROBORIS CARICETOSUM REMOTAE* HT. 1938)

Phytocoenological recordings and analyses of floral compositions in the localities of dieback in the forest region of Kalje and the Forest Office Sunja also show changes. These changes have taken two directions (Table 2, recordings 4-9):

I. There is a vast presence of species that are not present in this sub-association under normal and healthy conditions, such as *Amorpha fruticosa, Carex riparia, Carex elata, Filipendula ulmaria* and *Lytrum salicaria.* The analysis of auto-ecological properties of these species according to Ellenberg (1979), Oberdorfer (1983), Zolyomi *et al.* (1967) shows that all these species are linked exclusi-

vely to wet, regularly flooded sites, and some are moreover cited as indicators of floodplain regions. The floral composition of this sub-association also contains a higher than normal proportion and coverage of the following species: *Bidens tripartita, Polygonum hydropiper, Alisma plantago-aquatica* and *Juncus effusus*. The auto-ecological properties of these species also indicate that these are the plants of very wet and flooded sites and that they do not occur in drier sites. In terms of their relation to light, these species show that they favour semi-light and light conditions.

II. Species that are otherwise permanently present in normally structured stands are either absent or occur in an incomparably smaller coverage and proportion. These are *Carex strigosa, Solanum dulcamara, Ranunculus repens, Geum urbanum, Circaea lutetiana, Glechomoma hederacea, Aegopodium podagraria, Carex remota* and *Lysimachia nummularia*. These are plants of mostly humid sites and none is an indicator of flooded sites. The analysis of the relationship of these plants to light shows completely different relations than is the case with newly present plants in these sites. They are mostly plants of semi-shade, while *Carex remota, Carex strigosa* and *Lysimachia nummularia* are plants of the shade.

The very aggressive *Amorpha fruticosa* in the shrub layer has taken over completely, while the genera of the order *Crataegus*, and even *Genista elata*, the carriers of this layer's structure in normal stands, are missing.

The research carried out in the forest Žutica in 1998 showed similar conditions and changes in this association.

According to Prpić (1989, 1996) and Prpić *et al.* (1994), these changes are the result of a drop in minimal levels of groundwater. The same is true for many other sites of the lowland region, where deep man-made drainage canals have had adverse effects on forests. If the level of groundwater in an oak site decreases significantly in the summer season, trees of pedunculate oak physiologically weaken and then die, which is especially dangerous for middle-aged and old stands. As in the previous association, the surface has become waterlogged due to the inability of forest trees and other members of the biocoenosis to utilise water.

The second type of pedunculate oak dieback and changes in the development of the association were found in the stands established artificially on pastureland or on the site of narrow-leaved ash with autumn snowflake. These stands were established by building mounds, that is, by elevating the terrain for the purpose of avoiding surface and floodwater. The association was developing progressively until 30 years ago, when large-scale disturbances in the ecosystem took place (regulation of the River Sava, building of canals, dams and forest roads, polluted water flooding the forest and other events). This has led to the physiological weakening of the existing phytocoenosis and the beginning of the regression of the entire association. The unstable ecosystem of the pedunculate oak (artificially-raised forest) caved in under the constant pressure of unfavourable synecological factors, and abrupt dieback of pedunculate oak took place some fifteen years ago, culminating in 1985 and 1986, when almost the entire oak community died.

After cutting standing deadwood, the site was prepared and seedlings of black alder and narrow-leaved ash, as well as some pedunculate oaks, were artificially planted, resulting in the present mixed young stand of satisfactory structure and stability.

In the Spaćva basin in the eastern part of Croatia, ecological changes that would have led to large-scale dieback similar to that in the north-west did not take place. However, in the last twenty years this sub-association has undergone succession and has transformed into drier associations of *Genisto elatae-Quercetum roboris aceretosum tatarici* and *Carpino betuli-Quercetum roboris* over 21% of the area (Rauš 1990).

CONCLUSIONS

Research into the development of vegetation in the localities of pedunculate oak dieback in Croatia has revealed fundamental deviations from natural succession. They are the result of the adverse synergistic action of a combination of ecological factors that have led to a change in the water regime.

Interventions of a hydro-technical and other infrastructural nature in the forests and adjacent areas have caused a drop in groundwater levels in one part of the stands and site waterlogging in the other. Stands of pedunculate oak of 80 years or more have degraded, and narrow-leaved ash and black alder as pioneering species have, either naturally or artificially, replaced pedunculate oak in the sites that are too moist for the latter. In many places the physiognomy and structure of the stands' floral composition have lost the character of typically-developed associations. A large number of species indicating increased humidity or degraded sites have abundantly covered the site. These *are Amorpha fruticosa, Bidens tripartita, Filipendula ulmaria, Carex riparia, Myosotis scorpioides, Galium palustre, Peucedanum palustre, Juncus effusus, Polyganum hydropiper,Lytrum salicaria, Alisma plantago aquiatica, Carex elata* and others.

As a declining trend continues (but to a lesser extent), areas under more humid associations are expected to increase in the future. For this reason, it is necessary to manage the water regime (drain waterlogged areas, prevent a drop in groundwater levels, minimise water pollution) in order to maintain the stability of lowland ecosystems.

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Table 1.

Association:	*Genisto elatae - Quercetum roboris*									
Subassociation:	*caricetosum brizoides* Ht. 1938									
Number of recording:	1	2	3	4	5	6	7	8	9	10
Area:	Bedenik	Žablji lug	Lubardenik		Turopoljski lug		Pokupski bazen		Sunja	Dubica
Plot size (m2):	400	400	400	400	400	400	400	400	400	400
Cover (%):										
Tree layer	90	80	90	20	30	50	100	100	60	70
Shrub layer	30	10	10	20	30	30	10	2	30	20
Ground vegetation layer	100	100	100	100	100	100	100	100	100	100
FLORAL COMPOSITION										
Characteristic species of the association, alliance (*Alno-Quercion*) and order (*Alnetalia glutinosae*):										
Quercus robur L. A	5	5	3	2	2	3	4	5	3	4
Alnus glutinosa (L.) Gartn.	.	.	+	1	+	+	1	.	+	1
Frangula alnus Mill. B	+	1	.	1	1	1	1	+	.	+
Genista tinctoria subs. *elata* L.	+	.	+	.	1	+	+		1	.
Alnus glutinosa (L.) Gartn.	.	.	.	+	.	+	1	.	.	1
Fraxinus angustifolia Vahl.	.	.	.	.	.	.	.	.	1	1
Ulmus carpinifolia Gled.	R	.	.	.	+	.	.	.	R	+
Quercus robur L.	.	.	.	.	1	+	.	.	.	3
Viburnum opulus L.	.	.	.	+	.	+	.	.	.	.
Acer tataricum L.	+	.	.	.	.	.	.	.	.	.
Ulmus laevis Pall.	.	.	.	.	.	.	.	.	.	+
Carex brizoides L. C	4	5	3	.	1	+	3	2	2	+
Quercus robur L.	+	.	+	.	1	+	1	+	.	.
Rumex sanguineus L.	.	.	.	.	+	.	+	+	+	+
Cerastium silvaticum W.K.	.	.	+	.	.	.	.	+	+	+
Lycopus europaeus L.	.	.	.	+	+	+	.	1	1	+
Impatiens noli tangere L.	.	.	+	.	.	.	.	.	.	.
Lysimachia nummularia L.	+	.	+	.	.	.	+	1	.	.
Angelica silvestris L.	+	.	+	.	.	.	.	.	.	+
Dryopteris carthusiana	.	.	.	+	1	1	.	.	.	+
Nephrodium spinulosum Strem.	1	+	.	.	.	.	+	1	+	.
Solanum dulcamara L.	.	.	.	.	+	+	+	+	+	.
Glechoma hederacea L.	R	+	.	+		+	.	.	+	.

Rubus ceasius L.	R	.	.	.	+	.	1	.	+	.
Carex strigosa Huds.	.	.	.	.	.	.	.	.	+	+
Valeriana dioica L.	.	.	.	.	.	.	.	1	+	.
Viburnum opulus L.	.	.	.	+	.	.	.	.	.	
Carex remota L.	.	.	.	.	.	.	.	.	+	
Frangula alnus L.	.	.	.	.	.	.	+	.	.	.
Characteristic species of the order (*Fagetalia*) and class (*Querco-Fagetea*):										
Carpinus betulus L. A	+	.	2	.	+	.	.	.	+	+
Fagus silvatica L.	.	.	R	.	.	.	.	.	.	.
Carpinus betulus L. B	3	2	2	.	2	1	.	.	R	.
Acer campestre L.	+	.	.	.	.	.	.	.	R	.
Crataegus monogyna Jacq.	+	1	.	.	.	.	+	.	+	1
Euonimus europaea L.	.	.	.	.	.	.	1	.	.	.
Crataegus oxyacantha L.	1	+	.	.	.	.	.	+	.	.
Pirus pyraster (L.) Borkh.	+	.	.	.	.	.	+	1	.	R
Corylus avellana L.	.	.	.	.	.	.	3	+	.	.
Fagus silvatica L.	.	.	+	.	.	.	.	.	.	.
Aegopodium podagraria L. C	+	+	+	.	.	.	+		R	.
Urtica dioica L.	.	.	+	.	.	.	.	.	+	+
Dryopteris filix mas (L.) Sch.	.	.	+	.	.	.	+	.	.	.
Circaea lutetiana L.	+	.	+	+	.	.	+	+	.	.
Viola reichenbachiana Jor.	.	.	.	.	.	.	.	+	.	.
Ajuga reptans L.	.	.	.	.	.	.	+	+	.	.
Veronica montana L.	.	.	+	.	.	.	.	+	+	.
Lamiastrum galeobdolon L.	.	.	+	.	.	.	.	+	.	.
Brachypodium silvaticum R.S.	.	.	+	.	.	.	.	.	.	.
Stellaria holostea L.	.	.	+	.	.	.	+	.	.	.
Scrophularia nodosa L.	.	.	.	.	+	.	1	+	+	+
Geranium robertianum L.	.	.	.	.	.	.	.	+	.	.
Corylus avellana L.	.	.	.	.	.	.	+	.	.	.
Species - indicators of changes:										
Salix cinerea L. B	.	.	.	1	+	+	.	+	.	.
Peucedanum palustre Monch. C	.	.	.	1	+	2	1	1	+	+
Juncus effusus L.	.	.	.	5	3	4	1	1	1	+
Polygonum hydropiper L.	+	.	.	1	+	+	1	2	+	+

Myosotis scorpioides L.		.	.	.	.	.	.	+	1	1	
Galium palustre L.		.	.	.	.	.	.	1	1	+	+
Ranunculus repens L.		.	.	.	+	+	+	.	1	+	.
Lysimachia vulgaris L.		.	.	.	.	.	+	1	+	+	+
Lytrum salicaria L.		.	R	.	+	+	+	+		+	+
Poa palustris L.		.	.	.	.	.	.	+	+	1	+
Stachys palustris L.		.	.	.	+	.	.	1	1	+	+
Cirsium palustre (L.) Scop.		.	.	.	+	1	1	.	.	.	.
Other species of wet and flooded sites:											
Deshampsia caespitosa Beau.	C	1	+	1	.	1	+	1	1	1	1
Iris pseudacorus L.		.	.	.	.	.	+	.	.	+	+
Festuca gigantea (L.) Vill.		R	.	.	.	+	.	.	.	+	+
Carex elongata L.		.	.	.	.	.	.	.	.	+	.
Euphorbia palustris L.		R	.	.	.	.	.	.	.	.	.
Alisma plantago aquiatica L.		.	.	.	.	.	.	.	.	+	.
Lychnis flos cuculi L.		.	.	.	1	+	1	.	.	.	.
Mentha aquiatica L.		.	.	.	.	.	.	.	+	+	+
Other species:											
Rubus fruticosus L.	B	.	.	.	+	2	1	+	1	.	+
Rhamnus cathartica L.		.	.	.	.	.	.	.	.	R	.
Amorpha fruticosa L.		.	.	.	.	.	.	.	.	3	.
Rosa canina L.		.	.	.	.	.	.	.	.	+	.
Galeopsis tetrahit L.	C	+	.	+	.	2	+	+	.	+	+
Geum urbanum L.		.	.	.	.	1	+	.	.	+	+
Hypericum quandragulum L.		.	.	.	.	.	.	.	.	1	+
Agrostis alba L.		.	.	.	.	.	.	.	.	1	1
Athyrium filix femina (L.) Roth.		.	+	+	.	.	.	+	.	.	.
Eupatorium canabinum L.		.	.	.	.	.	.	.	+	.	.
Rubus hirtus W.K.		.	.	1	.	.	.	.	.	.	.
Pulmonaria officinalis L.		R	.	.	.	.	.	.	.	+	.
Euphorbia amygdaloides L.		+	.	.	.	.	.	.	.		.
Galium vernum L.		.	.	+	.	.	.	.	.	.	.
Fragaria vesca L.		.	.	.	.	2	+	.	.	.	.
Carex hirta L.		.	.	.	.	2	+	.	.	.	.
Melampyrum nemorosum L.		.	.	.	.	.	+	+	.	.	.

Potentilla erecta (L.) Hampe.	.	.	.	.	.	.	+	.	.	.
Cynanchum vincetoxicum (L.) Pers.	.	.	.	.	.	.	+	.	.	.
Verbatum album L.	.	.	.	.	.	.	+	.	.	.
Bidens tripartita L.	.	.	.	.	.	.		.	+	+
Stenactis annua (L.) Ness.	.	.	.	.	.	.	.	.	1	+
Prunella vulgaris L.	.	.	.	.	.	.	.	+	+	+
Oxallis stricta L.	.	.	.	.	.	.	.	.	+	+

Explanation of abbreviations:
A - Tree layer
B - Shrub layer
C - Ground vegetation layer
*+, 1, 2, 3, 4, 5 - Combined assessment of abundance and cover (Braun-Blanquet 1964)

Table 2.

Association:		*Genisto elatae- Quercetum roboris*											
Subassociation:		*caricetosum remotae* Ht. 1938											
Number of recording:		1	2	3	4	5	6	7	8	9	10	11	12
Area:		Opeke	Žutica	Pokupski		Kalje			Sunja			Turopoljski lug	
Plot size (m2):		400	400	400	400	400	400	400	400	400	400	400	400
Cover (%):													
Tree layer		90	80	90	30	25	20	20	25	20	90	75	70
Shrub layer		30	40	20	30	20	30	60	50	60	60	15	60
Ground vegetation layer		100	100	100	100	100	100	100	90	95	80	100	100
FLORAL COMPOSITION													
Characteristic species of the association, alliance (*Alno-Quercion*) and order (*Alnetalia glutinosae*):													
Quercus robur L.	A	5	5	4	2	1	1	1	1	1	4	4	4
Fraxinus angustifolia Vahl.		1	.	.	.	+	+	.	.	.	+	+	+
Alnus glutinosa (L.) Gartn.		.	.	1	+	1	1	.	+	.	1	+	.
Ulmus carpinifolia Gled.		1	.	.	.	.	.	.	R	.	.	.	.
Ulmus laevis Pall.		.	.	.	1	.	.	.	.	.	.	3	3
Fraxinus angustifolia Vahl.	B	2	+		1	1	2	.	+	.	2	.	.
Ulmus carpinifolia Gled.		.	1	1	.	.	.	.	.	.	.	1	1
Alnus glutinosa (L.) Gartn.		+	.	.	1	1	3	.	.	.	1	.	+
Viburnum opulus L.		.	.	+	+	.	.	.	.	.	+	+	+
Genista tinctoria subs. elata L.		2	3	.	R	.	.	.	.	+	+	.	+
Quercus robur L.		.	.	.	.	.	.	.	+	.	+	+	.
Frangula alnus Mill.		.	.	+	+	1	1	.	.	.	2	+	.
Ulmus laevis Pall.		.	.	.	2	.	.	.	.	.	.	.	.
Carex remota L.	C	5	1	2	.	.	.	1	.	.	.	+	.
Quercus robur L.		2	1	+	.	.	.	.	.	.	.	.	.
Rumex sanguineus L.		1	.	.	+	R	.	.	.	.	.	+	1
Lycopus europaeus L.		+	1	1	+	+	+	1	.	1	1	.	.
Lysimachia nummularia L.		2	.	+	+	.	.	+	.	.	+	.	.
Leucoium aestivum L.		+	.	.	1	1	.	.	.	.	+	.	+

Nephrodium spinulosum Strem.		.	.	+	.	+	.	.	.	.	.	.	+
Carex strigosa Huds.		1	.	1	.	.	.	.	.	.	.	.	.
Solanum dulcamara L.		.	.	.	.	R	+	.	.	.	+	+	.
Valeriana dioica L.		3	2	.	+	+	.	.	.	.	.	.	.
Glechoma hederacea L.		2	2	1	+	.	.	.	.	.	.	.	+
Rubus ceasius L.		.	+	2	+	.	.	.	.	.	.		
Fraxinus angustifolia Vahl.		3	.	.	.	.	.	.	.	.	+		
Ulmus carpinifolia Gled.		+	.	.	.	.	.	.	.	.	.	.	.
Viburnum opulus L.		.	.	.	.	.	.	.	.	.	+	+	+
Characteristic species of the order (*Fagetalia*) and class (*Querco-Fagetea*):									.			+	.
Carpinus betulus L.	A	.	.	+	.	.	.	.	.	.	.	+	.
Pirus pyraster (L.) Borkh.		.	.		.	.	.	.	R	.	.		
Acer campestre L.	B	.	.	+	.	.	.	.	.	.	.		
Crataegus monogyna Jacq.		.	.	1	.	.	.	.	.	.	.	.	.
Crataegus oxyacantha L.		+	.	1	+	.	.	.	.	.	.	.	.
Carpinus betulus L.		.	.	1	.	.	.	.	.	.	.	.	.
Pirus pyraster (L.) Borkh.		.	.	+	.	+	.	.	.	.	.	.	.
Corylus avellana L.		.	.	1	.		.	.	.	.	.	.	.
Urtica dioica L.	C	+	+	+	+	+	.	.	.	+	.	.	.
Circaea lutetiana L.		.	+	+	.	R	.	.	.	.	.	.	.
Ajuga reptans L.		.	.	+	.	.	.	.	.	.	.	.	.
Aegopodium podagraria L.		+	.	+	+	+	+	.	.	.	.	.	.
Scrophularia nodosa L.		.	.	2	.	.	.	.	.	.	.	.	.
Carex maxima		.	.	+	.	.	.	.	.	.	.	+	
Species - indicators of changes:												.	.
Amorpha fruticosa L.	B	.	.	.	3	.	.	3	2	3	.	.	.
Carex riparia Curt.	C	.	.	.	2	3	3	.	2	1	3		
Juncus effusus L.		1	+	.	+	1	+	2	+	1	1		
Polygonum hydropiper L.		+	+	+	+	+	1	2	2	3	1	.	+
Bidens tripartita L.		.	+	.	+	2	1	1	1	+	1	+	.
Lytrum salicaria L.		.	1	.	.	.	+	+	+	+	1	1	+
Alisma plantago aquiatica L.		+	.	.	1	1	1	+	+	+	+		+

Filipendula ulmaria (L.) Max.		.	.	.	2	1	1	.	.	.	2	+	.
Myosotis scorpioides L.		.	.	.	+	+	+	.	.	.	.	.	+
Carex elata All.		.	1	.	+	+	1	+	.	+	+	.	1
Other species of wet and flooded sites:												+	1
Salix cinerea L.	B	.	.	1	+	+	.	.	R	.	+	+	.
Deshampsia caespitosa Beau.	C	.	.	.	.	.	.	.	.	.	.	+	+
Galium palustre L.		3	+	1	1	+	+	.	.	.	+	1	+
Peucedanum palustre Monch.		.	+	+	+	+	+	.	.	.	+	.	.
Iris pseudacorus L.		.	+	+	.	.	.	R	+	+	+	+	+
Ranunculus repens L.		+	2	+	1	+	+	.	.	+	1	.	.
Lysimachia vulgaris L.		2	.	1	+	+	+	+	.	.	+	.	.
Poa palustris L.		.	.	.	R	+	.	+	.	.	.	.	+
Stachys palustris L.		.	1	+	1	+	.	.	.	.	+	.	.
Carex elongata L.		1	.	.	+	1	+	.	+	.	.	+	.
Symphytum officinale L.		+	+	.	+	1	.	+	.	.	.	1	.
Caltha palustris L.		.	.	+	.	.	.	.	.	.	.	1	+
Euphorbia palustris L.		1	.	.	+	.	.	.	.	.	.	4	4
Succisa pratensis Mch.		2	1	1	+	+	.	.	.	.	+	.	.
Cirsium palustre (L.) Scop.		.	.	.	.	.	+	.	.	.	.	.	+
Lychnis flos cuculi L.		.	.	.	.	.	.	.	.	.	+	.	.
Mentha aquatica L.		+	+		+	.	.	.	+	+	.	.	.
Glyceria fluitans (L.) R. Br.		.	.	+	.	.	.	.	.	.	.	2	+
Veronica longifolia L.		.	.	.	1	+	+	.	.	.	.	.	.
Carex vesicaria L.		.	.	.	+	1	.	.	.	.	.	.	.
Carex vulpina L.		.	.	.	R	+	.	.	.	.	.	.	+
Senecio palustris D.C.		.	.	.	+	.	+	.	.	.	.	.	.
Other species:													
Rhamnus cathartica L.	B	.	.	.	R	.	.	.	.	.	.	.	.
Cornus sanquinea		.	.	+	.	.	.	.	.	.	.	.	.
Geum urbanum L.	C	+	.	+	.	.	+	.	.	.	+	.	.
Hypericum acutum L.		.	.	.	.	R	.	+	.	.	.	.	.
Agrostis alba L.		.	.	.	.	R	.	+	+	+	.	.	.

Solidago sp.	.	1	.	.	.	.	.	.	.	.	.	.
Acer tataricum L.	+	.	.	.	.	.	.	.	.	.	.	.
Scutellaria galericulata L.	.	.	.	.	.	.	+	+	+	.	.	.
Stenactis annua (L.) Ness.	.	.	.	.	.	.	+	.	+	.	+	.
Ranunculus ficaria L.	1	.	.	.	.	.	.	.	.	.	.	.
Erigeron annuus (L.) Pers.	.	.	.	.	.	.	.	.	.	1	.	.
											+	+

Explanation of abbreviations:

A - Tree layer
B - Shrub layer
C - Ground vegetation layer
"+, 1, 2, 3, 4, 5 - Combined assessment of abundance and cover (Braun-Blanquet 1964)

J. Vukelić, D. Baričević: Development of vegetation in localites of pedunculate oak dieback in Croatia. Glas. šum. pokuse 37: 277–293, Zagreb, 2000.

RAZVOJ VEGETACIJE U LOKALITETIMA SUŠENJA HRASTA LUŽNJAKA U HRVATSKOJ

Sušenje je šuma hrasta lužnjaka u nizinskoj Hrvatskoj jedan od najznačajnijih šumarskih problema našega doba. U posljednih je trideset godina sinergističko djelovanje različitih nepovoljnih čimbenika dovelo do prisilne sječe oko 600 000 m^3 drva na 20 000 ha u sjeverozapadnoj Hrvatskoj, području koje je najteže pogođeno. Sušenje je osobito pogodilo šumsku zajednicu hrasta lužnjaka i velike žutilovke (*Genisto elatae-Quercetum roboris*). Na većini lokaliteta ta je asocijacija bila u progresivnoj razvojnoj fazi prema šumi hrasta lužnjaka i običnoga graba (*Carpino betuli-Quercetum roboris*). Zbog promjena u vegetaciji na lokalitetima na kojima se šuma suši nestao je hrast lužnjak, ali i brojni članovi dobro strukturirane fitocenoze, a proširile su se neke pionirske vrste, među kojima se posebno ističu one koje rastu na vlažnijim, zamočvarenim i otvorenim staništima.

Ključne riječi: hrast lužnjak, florni sastav, razvoj vegetacije, indikativne vrijednosti, nizinska Hrvatska