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Marshland vegetation of Plitvice Lakes National Park (Croatia)

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Abstract

STANČIĆ, Z., K. ŽGANEC & S. GOTTSTEIN (2010). Marshland vegetation of Plitvice Lakes National Park (Croatia). *Candollea* 65: 147-167. In English, with English and French abstracts.

The Plitvice Lakes National Park is located in a mountainous region of Croatia, and is of world renown for its karstic lakes separated by tufa barriers, and its waterfalls. In many places around the lakes, and along the streams, marshland vegetation of the class *Phragmito-Magnocaricetea* Klika 1941 has developed. This vegetation has been studied in accordance with the Braun-Blanquet methodology. As a result, 13 communities were distinguished, three being found for the first time in Croatia: *Caricetum rostratae* Rübel 1912, *Eleocharitetum uniglumis* E. G. Almq. 1929 and *Equisetetum fluviatilis* Steffen 1931. Through numerical classification it was found that traditionally accepted communities match very well with the clusters obtained. Some ecological characteristics of the communities were estimated by calculating Ellenberg indicator values. Through analysis of plant life forms, specific features of marshland communities were also derived, especially at the level of vegetation alliances. The most common association of the study area is *Phragmitetum australis* Schmale 1939, which spreads in habitats of *Ligularia sibirica* (L.) Cass., a rare and threatened species throughout Europe. From the aspect of nature conservation, marshland vegetation in the Plitvice Lakes shows both positive and negative features. There is a positive effect in the enrichment of biodiversity, while most communities have developed as a consequence of the eutrophication of oligotrophic karstic lakes, which must be considered negative.

Key-words

Phragmito-Magnocaricetea – Plitvice Lakes National Park – Croatia – Vegetation – Phytosociology

Résumé

STANČIĆ, Z., K. ŽGANEC & S. GOTTSTEIN (2010). La végétation des marais du Parc National des Lacs de Plitvice (Croatie). *Candollea* 65: 147-167. En anglais, résumés anglais et français.

Situé dans la partie montagneuse de la Croatie, le Parc National des Lacs de Plitvice est mondialement connu pour ses lacs karstiques séparés par des barrières de tufs et ses cascades. En maints endroits, autour des lacs et le long des ruisseaux, se sont développées des roselières (*Phragmito-Magnocaricetea* Klika 1941). Les études, conduites selon la méthodologie Braun-Blanquet, ont permis de faire apparaître 13 communautés végétales, dont trois associations qui ont été relevées pour la première fois en Croatie: *Caricetum rostratae* Rübel 1912, *Eleocharitetum uniglumis* E. G. Almq. 1929 et *Equisetetum fluviatilis* Steffen 1931. Les groupements observés du peuplement végétal selon les méthodes traditionnelles sont montrés comme similaires aux groupements issus de la classification numérique. Certaines caractéristiques écologiques ont été estimées par valeurs indicatrices d'Ellenberg. Les formes de vie végétale ont été analysées et les spécificités des communautés végétales caractérisées, notamment en ce qui concerne les alliances végétales. L'association la plus commune relevée sur la station est celle de *Phragmitetum australis* Schmale 1939 qui se propage sur l'habitat de *Ligularia sibirica* (L.) Cass., espèces rares et menacées dans toute l'Europe. Au plan de la conservation de la nature, la végétation des marais des Lacs de Plitvice montre des effets positifs et négatifs, soit d'une part, un enrichissement de la biodiversité, et d'autre part un développement de communautés en réponse à une eutrophisation des lacs oligotrophes karstiques.

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Introduction

Marshland vegetation is one of the most endangered habitat types in Croatia (MARTINIĆ, 2000) and in Europe (ANONYMOUS, 1992). The main threats are various anthropogenic activities and vegetation changes connected with natural succession.

All data on marshland vegetation of the class *Phragmito-Magnocaricetea* Klika 1941 in Croatia have recently been summarised in a paper by STANČIĆ (2007). Due to insufficient investigation of marshland vegetation, there is a clear need for further systematic research, especially in areas of great natural value, such as the Plitvice Lakes.

The marshland vegetation of the Plitvice Lakes has already been partly investigated. HORVAT & al. (1974) recorded two associations: *Cladietum marisci* P. Allorge 1922 and *Caricetum paniculatae* Wangerin 1916. Two associations were recorded by BLAŽENČIĆ & BLAŽENČIĆ (1990-1991, 1992): *Cladietum marisci* and *Phragmitetum australis* Schmale 1939. Later on, ŠEGULJA (2005) established five communities: *Caricetum elatae* W. Koch 1926, *Caricetum paniculatae*, *Caricetum vesicariae* Chouard 1924, *Cladietum marisci* and stands of *Equisetum hyemale* L. A study of experimental removal of marshland vegetation around the Plitvice Lakes and along the banks of the Bijela rijeka stream as a response to eutrophication was published by PAVLUS & NOVOSEL (2006). There are no relevés in any of the publications mentioned, nor – except for PAVLUS & NOVOSEL (2006) – precise descriptions of localities.

The area of the Plitvice Lakes was declared a national park in 1949. Due to its extraordinary biological value, in 1979, UNESCO placed the Plitvice Lakes on the list of the world's cultural and natural heritage sites. The central natural phenomenon of the national park is a flow of carbonate-supersaturated water down a large, irregular river system, giving rise to tufa precipitation formations (barriers), forming a chain of sixteen barrage lakes with numerous waterfalls and cascades. The crucial role of freshwater organisms in the process of tufa formation was recognised very early (PEVALEK, 1925, 1935). SRDOČ & al. (1985) established that periphyton that grows on mosses and other objects produces mucopolysaccharides in which precipitated microcrystals of calcium carbonate are trapped. Tufa forms by gradual accumulation of these crystals (EMEIS & al., 1987). This process is very sensitive to natural changes and to increased concentration of organic substances (HORVATINČIĆ & SRDOČ, 1990-1991). In other words, further eutrophication could destroy the process of tufa formation.

Several publications on trophic levels (PATRIK, 1958: 49-171; STILINOVIĆ, 1979; HABDIJA & al., 1990-1991) established that the Plitvice Lakes are primarily oligotrophic, with a tendency towards mesotrophy in the summer months. In the second half of the twentieth century, different studies indicated an increased level of eutrophication (enrichment of water with nutrients, mostly phosphorus and nitrogen compounds). This is supported by numerous publications, on microbiological investigations (PAVLETIĆ & STILINOVIĆ, 1965; STILINOVIĆ, 1979; STILINOVIĆ & FUTAČ, 1989), by an increase of phytoplankton biomass (EMILI, 1958), in a change in abiotic factors (HABDIJA, 1983), in zoological research (PRIMC & al., 1984), in research on macrophytes (BLAŽENČIĆ & BLAŽENČIĆ, 1990-1991, 1992). Spreading of the marshland vegetation around the lakes was mentioned in publications by STILINOVIĆ (1998) and PAVLUS & NOVOSEL (2006).

During the recent botanical research in the Plitvice Lakes National Park it was observed that this region is rather rich in various marshland communities, some of which are very rare, and some were even found for the first time in Croatia. Therefore the aims of this paper are: (1) to provide a review of marshland vegetation of the class *Phragmito-Magnocaricetea* in the Plitvice Lakes National Park; (2) to compare traditionally accepted marshland communities with the results of numerical classification; (3) to examine the influence of some ecological factors using Ellenberg's indicator values; (4) to detect the proportions of life forms in the data set and (5) to analyse the marshland vegetation from the aspect of nature conservation.

Material and methods

Study area

The Plitvice Lakes National Park is located in the mountainous region of Lika, near the border with Bosnia and Herzegovina (Fig. 1). It covers an area of 295 km^2, with a lowest ground point of 367 m and a highest point of 1280 m. The

Fig. 1. – Geographical position of Plitvice Lakes National Park.

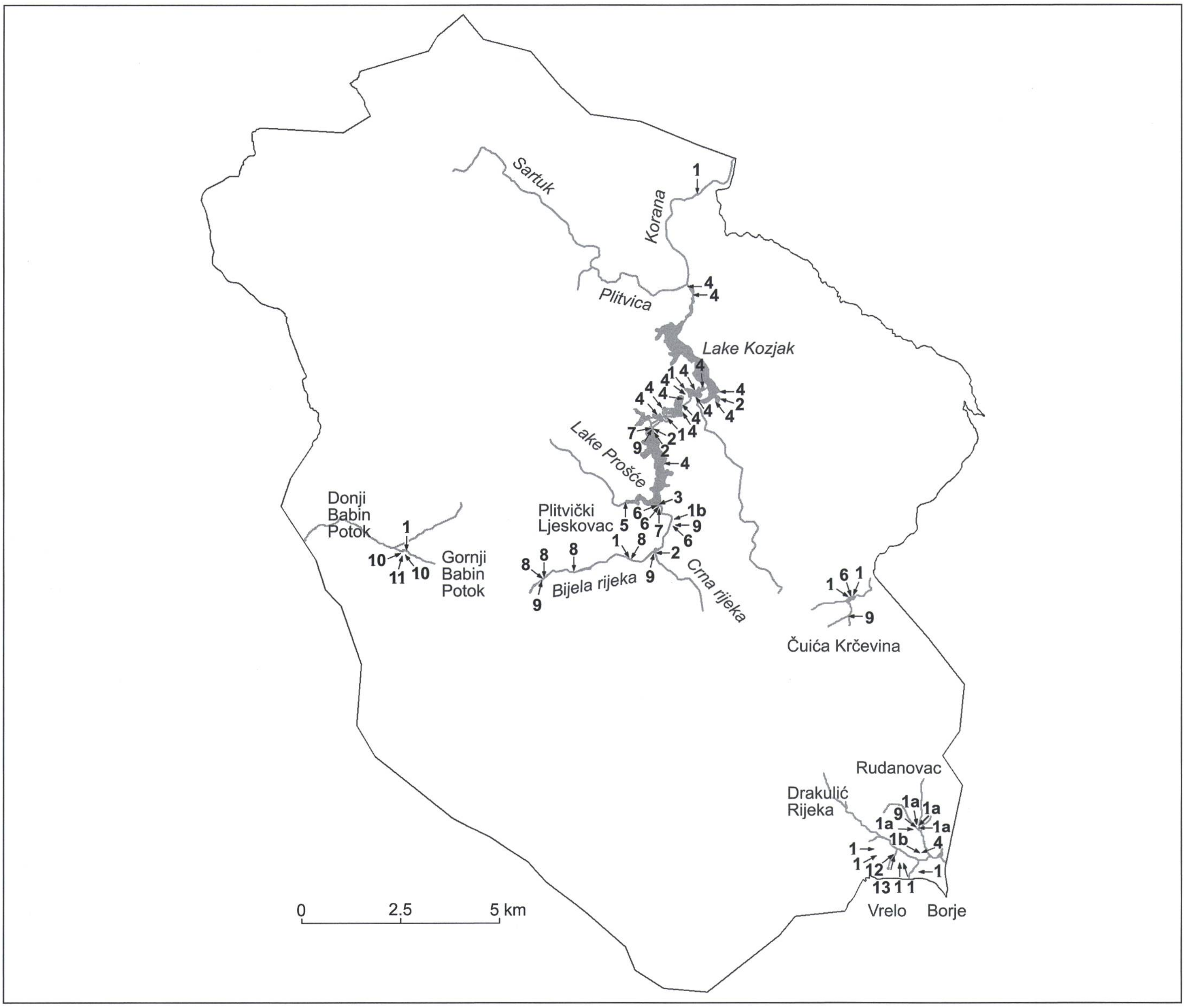

Fig. 2. – Distribution of sampled marshland communities in the Plitvice Lakes National Park. The numbers indicate the following communities: **1.** Ass. *Phragmitetum australis* Schmale 1939; **1a.** Stands of *Ligularia sibirica* (L.) Cass.; **1b.** Stands of *Menyanthes trifoliata* L.; **2.** Ass. *Typhetum latifoliae* A. G. Lang 1973; **3.** Ass. *Scirpetum lacustris* Chouard 1924; **4.** Ass. *Cladietum marisci* P. Allorge 1922; **5.** Ass. *Sparganietum erecti* H. Roll 1938; **6.** Ass. *Equisetetum fluviatilis* Steffen 1931; **7.** Ass. *Caricetum elatae* W. Koch 1926; **8.** Ass. *Caricetum paniculatae* Wangerin 1916; **9.** Ass. *Caricetum rostratae* Rübel 1912; **10.** Ass. *Eleocharitetum uniglumis* E. G. Almq. 1929; **11.** Ass. *Phalaridetum arundinaceae* Libbert 1931; **12.** Ass. *Glycerietum plicatae* (Kulcz. 1928) Oberd. 1954; **13.** *Veronica beccabunga* community.

climate is intermediate between continental and Mediterranean. A maritime influence is expressed due to the close proximity to the sea (about 60 km). It is characterised by mild, sunny summers and relatively long, severe, snow-rich winters. The annual precipitation for the period 1999-2004 (data obtained from the Croatian Meteorological and Hydrological Service) was between 1000 and 2000 mm, and the average annual temperature was 9.5° C. The geological base is built almost entirely of Mesozoic carbonate rocks, and consists of two geomorphological units: mostly rudist limestone below the lower lakes, and dolomite below the upper lakes (Roglić, 1974; Frančišković-Bilinski & al., 2004). Around 80% of the area is covered by forest vegetation. The zonal forest communities belong to *Fagus sylvatica* L. forest at the lower altitudes, and to mixed *Fagus sylvatica-Abies alba* Mill. forest at the higher altitudes (Prpić, 2002). The rest of the area of the national park, around 20%, is covered by grassland, marshland, ruderal, segetal and other types of vegetation. Marshland vegetation develops mostly in the flood zones of streams, along lake shores, and on wet meadows that are no longer mown.

In the Plitvice Lakes and their tributaries, average annual water temperatures increase in the downstream direction, from 8.1° C in the Matica stream to 9.5° C in Lake Prošće, 10.6° C in Lake Kozjak, and 9.7° C in the River Korana. During the summer, water temperature in the streams is no higher than 14° C, whereas in the lakes it rises as high as 21° C. The depths of the lakes are: Lake Prošće, 37 m; Lake Okrugljak, 15 m; Great Lake (Veliko jezero), 8 m; Little Lake (Malo jezero), 10 m; Lake Galovac, 24 m; Lake Gradinsko, 10 m; Lake Kozjak, 46 m; Lake Kalušerovac, 13 m; Lake Novakovića Brod, 3 m; accumulation in Čuića Krčevina, 2.5 m. The position of the lakes and watercourses is shown in Figure 2. Values of pH gradually increase downstream from around 7.5 in springs to around 8.4 in most downstream lakes and in the Korana (Srdoč & al., 1985). Total alkalinity gradually decreases from around 250 mg $CaCO_3$ L^{-1} in springs to around 190 mg $CaCO_3$ L^{-1} in the Korana (Ivekovič, 1958: 227-274). Oxygen content ranges between 8 and 15 mgL^{-1}, and the water is always near saturation or oversaturated (Patrik, 1958: 49-171; Srdoč & al., 1985). Nutrient concentrations in the upper lakes (Matoničkin Kepčija, 2006) are as follows: nitrites 0.002-0.03 mgL^{-1}, nitrates 0.07-1.1 mgL^{-1}, and phosphates 0.002-0.027 mgL^{-1}.

Communities and relevé data

Field research was carried out during 2004, 2005 and 2006. The relevés were done in accordance with the Zürich-Montpelier methodology (Horvat, 1949; Braun-Blanquet, 1964). The floristic composition of those communities with more than three relevés in the data set is shown in analytical tables (Tables 1-6) which were processed by the JUICE program (Tichý & Holt, 2006). Communities with one, two or three relevés are quoted in the text. The distribution of communities in the Plitvice Lakes is shown on the map (Fig. 2). The list of relevé localities is presented in Appendix 1.

Statistical analysis

In order to verify the traditional syntaxonomic system of marshland communities, the relevés were classified by numerical methods. The complete linkage method and similarity ratio distance coefficient in the SYN-TAX 2000 programs (Podani, 2001) were applied. The results are shown in a dendrogram (Fig. 3). Differences between groups obtained in classification were tested by analysis of similarities (ANOSIM) in the PRIMER program (Clarke & Warwick, 2001; Clarke & Gorley, 2001).

For the statistical detection of diagnostic values of particular species to specific marshland communities, fidelity was calculated using the JUICE program (Tichý & Holt, 2006). As a measure of fidelity, the phi coefficient (Chytrý & al., 2002) based on presence/absence of plant species data was used. The results are presented in a synoptic table (Table 7), but only for those species with fidelity values higher than 50 in at least one of the given communities.

Ecological factors for marshland communities were analysed using Ellenberg indicator values (Ellenberg & al., 1991). The mean values for light, temperature, moisture, soil reaction and nutrient content were evaluated. In the calculations, values were weighted with cover values of plant taxa. The results are presented in box-plots (Fig. 4).

For the characterisation of the marshland communities, plant life forms taken from the BIOLFLOR database (Klotz & al., 2002) were also analysed. The life forms were separated into the following groups: hydrophytes, geophytes, hemicryptophytes, chamaephytes, phanerophytes and therophytes. In the calculation of life-form proportions, cover values of plant taxa were taken into consideration. The results are shown in Figure 5.

Threat status and nomenclature of plant species and communities

The threatened marshland community was classified on the basis of negative trends in population number and size of dominant and character species (IUCN, 2001, 2005). Rare marshland communities are considered to be those which have less than 10 recorded localities throughout Croatia (Stančić, 2007).

Threatened plant species of marshland vegetation are indicated in the data set in accordance with Nikolić & Topić (2005) and marked in the text and analytical tables with the following abbreviations: CR (critically endangered), EN (endangered), VU (vulnerable), NT (nearly threatened), and DD (data-deficient). Neophytes are labelled with an "N".

The names of plant communities and their syntaxonomic positions mainly follow Balátová-Tuláčková & al. (1993), Philippi (1998), Oberdorfer (2001) and Stančić (2007). Full Latin names, with names of authors and year of first valid description, are given at least once in the text.

The nomenclature of plant species follows Tutin & al., (1964-1980, 1993).

Table 1. – Ass. *Phragmitetum australis* Schmale 1939 (relevés 1-12), stands of the species *Ligularia sibirica* (L.) Cass. (relevés 13-16), and stands of the species *Menyanthes trifoliata* L. (relevés 17-18).

Number of relevé	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Cover value [%]	100	100	100	100	100	100	100	100	100	100	70	80	100	100	100	100	80	95
Relevé area [m²]	9	9	9	9	9	9	9	9	9	6	9	9	25	36	36	25	9	4
Relevé shape	3×3	3×3	3×3	3×3	3×3	3×3	3×3	3×3	3×3	2×3	3×3	3×3	5×5	6×6	6×6	5×5	3×3	2×2
Altitude [m]	670	680	680	680	700	780	680	606	585	400	700	700	660	660	660	660	670	638
Depth of water [cm]	0-5	0	0	0	5	10-30	0-4	20	50	0-50	0	10-15	5	10	0	0	10	5
Number of species	8	8	15	10	9	4	6	2	8	6	13	6	14	19	16	20	4	11
***Phragmitetum australis* Schmale 1939**																		
Phragmites australis (Cav.) Steud.	5	5	5	5	5	5	5	5	4	4	4	4	4	2	2	2	2	1
Ligularia sibirica (L.) Cass. (CR)	.	.	.	.	.	.	.	.	.	.	.	.	1	2	3	+	.	.
Menyanthes trifoliata L. (EN)	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	4	5
***Phragmito-Magnocaricetea* Klika 1941**																		
Mentha aquatica L.	+	.	.	.	.	.	.	+	+	.	1	1	+	+	.	+	.	.
Lycopus europaeus L.	.	.	.	.	.	.	1	.	+	.	+	.	+	1	.	.	.	.
Equisetum fluviatile L.	.	.	.	.	+	.	.	.	.	.	+	2	.	.	.	.	.	+
Carex riparia Curtis (VU)	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.
Carex paniculata L.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	+
Carex rostrata Stokes (VU)	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+
Galium palustre L.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+
Phalaris arundinacea L.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Companions																		
Lysimachia vulgaris L.	3	2	.	1	.	.	1	.	.	+	+	.	3	2	1	1	.	+
Equisetum palustre L.	1	+	+	1	+	+	+	.	.	.	.	.	.	.	+	.	.	.
Eupatorium cannabinum L.	1	.	.	.	.	.	.	.	+	+	+	.	1	+	+	+	.	.
Molinia arundinacea Schrank	.	1	.	+	.	.	.	.	.	4	.	.	4	4	4	5	.	.
Caltha palustris L.	.	1	+	.	2	+	2	.	.	.	+	+	.	.	.	.	.	.
Lythrum salicaria L.	.	.	.	.	1	.	.	.	.	.	1	1	+	+	.	.	.	+
Filipendula ulmaria (L.) Maxim.	.	.	.	3	.	.	4	.	.	+	+	.	.	.	.	.	.	+
Angelica sylvestris L.	+	.	1	.	.	.	.	.	+	.	.	.	+	.	.	+	.	.
Veratrum album L. s. l.	+	2	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
Valeriana dioica L.	+	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	+
Carex panicea L. (VU)	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	1	1	.
Potentilla erecta (L.) Räusch.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	+	1	.	.
Cirsium oleraceum (L.) Scop.	.	2	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Epipactis palustris (L.) Crantz	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	+	.	.
Myosotis scorpioides aggr.	.	.	+	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.
Alnus glutinosa (L.) Gaertn.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.
Cirsium palustre (L.) Scop.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.
Deschampsia cespitosa (L.) P. Beauv. (DD)	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Equisetum telmateia Ehrh.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Festuca rubra aggr.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.
Frangula alnus Mill.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	.	.	.
Petasites hybridus (L.) P. Gaertn., B. Mey. & Schreb.	.	.	.	.	.	.	.	.	+	2	.	.	.	.	.	.	.	.
Ranunculus acris L.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.
Scilla litardierei Breistr. (NT)	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.

Table 1 (cont.). – Ass. *Phragmitetum australis* Schmale 1939 (relevés 1-12), stands of the species *Ligularia sibirica* (L.) Cass. (relevés 13-16), and stands of the species *Menyanthes trifoliata* L. (relevés 17-18).

Number of relevé	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Cover value [%]	100	100	100	100	100	100	100	100	100	100	70	80	100	100	100	100	80	95
Relevé area [m²]	9	9	9	9	9	9	9	9	9	6	9	9	25	36	36	25	9	4
Relevé shape	3×3	3×3	3×3	3×3	3×3	3×3	3×3	3×3	3×3	2×3	3×3	3×3	5×5	6×6	6×6	5×5	3×3	2×2
Altitude [m]	670	680	680	680	700	780	680	606	585	400	700	700	660	660	660	660	670	638
Depth of water [cm]	0-5	0	0	0	5	10-30	0-4	20	50	0-50	0	10-15	5	10	0	0	10	5
Number of species	8	8	15	10	9	4	6	2	8	6	13	6	14	19	16	20	4	11
Companions																		
Scrophularia umbrosa Dumort.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Sesleria caerulea (L.) Ard.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.
Solanum dulcamara L.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.
Vicia cracca aggr.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.

[Species in only one relevé: **Relevé 3:** *Sambucus ebulus* L. – 2, *Urtica dioica* L. – 2, *Ajuga reptans* L. – +, *Carex hirta* L. – +, *Erigeron annuus* (L.) Pers. (N) – +, *Poa trivialis* L. s. l. – +, *Valeriana officinalis* L. s. l. – +; **Relevé 4:** *Crepis paludosa* (L.) Moench – 2; **Relevé 9:** *Petasites albus* (L.) Gaertn. – +; **Relevé 11:** *Lysimachia nummularia* L. – +; **Relevé 14:** *Leucojum aestivum* L. – +, *Mentha longifolia* (L.) Huds. – +; **Relevé 15:** *Equisetum arvense* L. – +, *Euonymus europaeus* L. – +, *Juniperus communis* L. – +, *Rubus caesius* L. – +; **Relevé 16:** *Carex flacca* Schreb. – +, *Eriophorum latifolium* Hoppe (EN) – +; **Relevé 17:** *Carex flava* aggr. – +; **Relevé 18:** *Salix cinerea* L. – +]

Table 2. – Ass. *Typhetum latifoliae* A. G. Lang 1973.

Number of relevé	**19**	**20**	**21**	**22**
Cover value [%]	70	80	100	80
Relevé area [m²]	9	10	9	9
Relevé shape	3×3	5×2	3×3	3×3
Altitude [m]	637	535	640	637
Depth of water [cm]	50	30	5	15
Number of species	2	3	7	3
***Typhetum latifoliae* A. G. Lang 1973**				
Typha latifolia L.	5	4	4	4
***Phragmito-Magnocaricetea* Klika 1941**				
Mentha aquatica L.	+	.	+	2
Carex rostrata Stokes (VU)	.	.	1	.
Cladium mariscus (L.) Pohl	.	+	.	.
Phragmites australis (Cav.) Steud.	.	+	.	.
Companions				
Lysimachia vulgaris L.	.	.	1	.
Solanum dulcamara L.	.	.	1	.
Lythrum salicaria L.	.	.	+	.
Equisetum palustre L.	.	.	+	.
Oenanthe fistulosa L.	.	.	.	1

Table 3. – Ass. *Cladietum marisci* P. Allorge 1922.

Number of relevé	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Cover value [%]	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Relevé area [m^2]	9	9	9	7.5	4	10	9	9	9	9	9	10	7.5	10	9
Relevé shape	3×3	3×3	3×3	5×1.5	4×1	5×2	3×3	9×1	3×3	3×3	3×3	5×2	5×1.5	5×2	3×3
Altitude [m]	582	670	637	613	605	585	585	585	552	535	553	510	553	535	504
Depth of water [cm]	5-10	5	0-50	50	60	50	40	40	40	40	40	40	40	30	40
Number of species	5	2	2	2	3	3	4	4	4	2	6	3	7	4	6
***Cladietum marisci* P. Allorge 1922**															
Cladium mariscus (L.) Pohl	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4
***Phragmito-Magnocaricetea* Klika 1941**															
Phragmites australis (Cav.) Steud.	.	+	.	.	.	.	.	.	.	.	+	1	1	+	.
Mentha aquatica L.	.	.	.	.	.	+	+	+	.	.	+	.	.	.	.
Scirpus lacustris L.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Typha latifolia L.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Carex pseudocyperus L.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Carex elata All.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Companions															
Lysimachia vulgaris L.	.	.	+	+	1	.	.	.	+	+	+	.	+	.	+
Solanum dulcamara L.	1	.	.	.	.	+	+	.	+	.	+	+	.	.	+
Eupatorium cannabinum L.	+	.	.	.	.	.	.	+	.	.	+	.	.	.	+
Petasites albus (L.) Gaertn.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	+
Alnus glutinosa (L.) Gaertn.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.

[Species in only one relevé: **Relevé 24:** *Fraxinus excelsior* L. – +; **Relevé 30:** *Mentha longifolia* (L.) Huds. – +; **Relevé 36:** *Thelypteris palustris* Schott – 1, *Molinia arundinacea* Schrank – +; **Relevé 38:** *Petasites hybridus* (L.) P. Gaertn., B. Mey. & Schreb. – +]

Table 4. – Ass. *Equisetetum fluviatilis* Steffen 1931.

Number of relevé	**40**	**41**	**42**	**43**
Cover value [%]	90	90	100	80
Relevé area [m²]	4	4	9	9
Relevé shape	2×2	2×2	3×3	3×3
Altitude [m]	637	637	700	638
Depth of water [cm]	30-50	50	10-20	0
Number of species	4	3	10	13
***Equisetetum fluviatilis* Steffen 1931**				
Equisetum fluviatile L.	5	5	5	5
***Phragmito-Magnocaricetea* Klika 1941**				
Mentha aquatica L.	.	.	2	2
Scirpus lacustris L.	+	.	.	.
Carex rostrata Stokes (VU)	.	.	+	.
Carex vesicaria L. (VU)	.	.	+	.
Phragmites australis (Cav.) Steud.	.	.	+	.
Alisma plantago-aquatica L.	.	.	.	+
Galium palustre L.	.	.	.	+
Companions				
Myriophyllum verticillatum L.	1	3	.	.
Potamogeton sp.	1	1	.	.
Lysimachia vulgaris L.	.	.	+	2
Lythrum salicaria L.	.	.	+	1
Myosotis scorpioides aggr.	.	.	+	1
Ranunculus repens L.	.	.	+	1

[Species in only one relevé: **Relevé 42:** *Dactylorhiza majalis* (Rchb.) P. F. Hunt & Summerh. (EN) – +; **Relevé 43:** *Agrostis stolonifera* L. – 1, *Valeriana dioica* L. – 1, *Carex flava* aggr. – +, *Lysimachia nummularia* L. – +, Solanum dulcamara L. – +]

Table 5. – Ass. *Caricetum paniculatae* Wangerin 1916.

Number of relevé	**46**	**47**	**48**	**49**
Cover value [%]	100	100	100	95
Relevé area [m²]	16	16	16	16
Relevé shape	4×4	4×4	4×4	4×4
Altitude [m]	700	680	660	720
Depth of water [cm]	0	0	0	0
Number of species	15	16	15	14
***Caricetum paniculatae* Wangerin 1916**				
Carex paniculata L.	4	4	4	4
***Phragmito-Magnocaricetea* Klika 1941**				
Lycopus europaeus L.	+	.	+	+
Mentha aquatica L.	+	.	+	.
Galium palustre L.	.	+	+	.
Equisetum fluviatile L.	.	.	2	.
Companions				
Lythrum salicaria L.	1	1	1	+
Mentha longifolia (L.) Huds.	+	1	1	+
Eupatorium cannabinum L.	1	+	+	+
Ranunculus repens L.	+	+	+	+
Scrophularia umbrosa Dumort.	2	1	.	1
Lysimachia nummularia L.	1	+	.	1

Table 5 (cont.).

Myosotis scorpioides aggr.	+	+	.	+
Filipendula ulmaria (L.) Maxim.	1	.	+	.
Caltha palustris L.	+	.	.	+
Galium aparine L.	+	.	.	+
Hypericum tetrapterum Fr.	+	.	+	.
Angelica sylvestris L.	.	+	+	.

[Species in only one relevé: **Relevé 46:** *Equisetum arvense* L. – +, **Relevé 47:** *Galeopsis pubescens* Besser – 2, *Myosoton aquaticum* (L.) Moench – 2, *Urtica dioica* L. – 2, *Cirsium oleraceum* (L.) Scop. – +, *Epilobium ciliatum* Raf. (N) – +, *Solanum dulcamara* L. – +, **Relevé 48:** *Succisella inflexa* (Kluk) Beck – 3, *Lysimachia vulgaris* L. – 2, *Valeriana dioica* L. – +, **Relevé 49:** *Equisetum palustre* L. – 1, *Poa trivialis* L. s. l. – +, *Ranunculus acris* L. – +]

Table 6. – Ass. *Caricetum rostratae* Rübel 1912.

Number of relevé	**50**	**51**	**52**	**53**	**54**	**55**
Cover value [%]	100	100	100	80	100	100
Relevé area [m²]	16	9	16	9	9	9
Relevé shape	4×4	3×3	4×4	3×3	3×3	3×3
Altitude [m]	670	720	640	637	638	700
Depth of water [cm]	5-10	15	10-15	25	0	15
Number of species	11	4	8	3	8	6
***Caricetum rostratae* Rübel 1912**						
Carex rostrata Stokes (VU)	5	5	5	5	5	5
***Phragmito-Magnocaricetea* Klika 1941**						
Mentha aquatica L.	2	+	3	+	1	.
Galium palustre L.	+	.	1	.	.	.
Typha latifolia L.	.	.	+	1	.	.
Alisma plantago-aquatica L.	+	.	+	.	.	.
Equisetum fluviatile L.	.	.	.	.	2	.
Lycopus europaeus L.	+	.	.	.	.	.
Veronica beccabunga L.	.	+	.	.	.	.
Companions						
Lythrum salicaria L.	1	.	2	.	1	+
Lysimachia vulgaris L.	1	.	+	.	2	+
Equisetum palustre L.	2	.	1	.	.	+
Caltha palustris L.	+	2	.	.	.	.
Valeriana dioica L.	+	.	.	.	+	.

[Species in only one relevé: **Relevé 50:** *Agrostis stolonifera* L. – 1, **Relevé 54:** *Gratiola officinalis* L. – 1, *Myosotis scorpioides* aggr. – +, **Relevé 55:** *Salix cinerea* L. – +, *Salix purpurea* L. – +]

Table 7. – Synoptic table of marshland communities from the Plitvice Lakes National Park with fidelity values expressed as phi coefficient. The table presents only those species that reach fidelity values higher than 50 in any of the given communities. The communities are labelled with the same numbers as in Figure 2.

Communities number	**1**	**1a**	**1b**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Numbers of relevés	12	4	2	4	1	15	1	4	2	4	6	2	1	1	1
***Phragmition* W. Koch 1926**															
Phragmites australis (Cav.) Steud.	45.6	45.6	45.6	.	.	4.8	.	.	.	.	.	.	.	.	.
Ligularia sibirica (L.) Cass. (CR)	.	100	.	.	.	.	.	.	.	.	.	.	.	.	.
Menyanthes trifoliata L. (EN)	1.1	.	95.8	.	.	.	.	.	.	.	.	.	.	.	.
Typha latifolia L.	.	.	.	81.2	.	3.2	.	.	.	.	21.2	.	.	.	.
Scirpus lacustris L.	.	.	.	.	86.2	.	.	15.3	.	.	.	.	.	.	.
Cladium mariscus (L.) Pohl	.	.	.	16.1	.	88.6	.	.	.	.	.	.	.	.	.
Sparganium erectum L.	.	.	.	.	.	.	96.6	.	.	.	.	.	.	.	.
Equisetum fluviatile L.	5	.	22.5	.	.	.	.	57.5	22.5	5	.	.	.	.	.
***Magnocaricion elatae* W. Koch 1926**															
Carex elata All.	.	.	.	.	.	.	.	.	96.6	.	.	.	.	.	.
Carex paniculata L.	.	.	34.3	.	.	.	.	.	.	77.8	.	.	.	.	.
Carex rostrata Stokes (VU)	.	.	23.2	5.5	.	.	.	5.5	23.2	.	58.6	.	.	.	.
Eleocharis uniglumis (Link) Schult. (CR)	.	.	.	.	.	.	.	.	.	.	.	100	.	.	.
Phalaris arundinacea L.	1.1	.	.	.	.	.	.	.	.	.	.	.	95.8	.	.
***Sparganio-Glycerion fluitantis* Braun-Blanq. & Sissingh 1942 [nomen inval.]**															
Glyceria plicata (Fr.) Fr. (VU)	.	.	.	.	.	.	.	.	.	.	.	.	.	68.1	68.1
Veronica beccabunga L.	.	.	.	.	.	.	.	.	.	.	1.7	.	.	65	65
Others															
Molinia arundinacea Schrank	15.3	86.2	.	.	.	.	.	.	.	.	.	.	.	.	.
Epipactis palustris (L.) Crantz	.	85.8	.	.	.	.	.	.	.	.	.	.	.	.	.
Potentilla erecta (L.) Räusch.	3.2	81	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex riparia Curtis (VU)	.	69.5	.	.	.	.	.	.	.	.	.	.	.	.	.
Cirsium palustre (L.) Scop.	.	69.5	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca rubra aggr.	.	69.5	.	.	.	.	.	.	.	.	.	.	.	.	.
Scilla litardierei Breistr. (NT)	.	69.5	.	.	.	.	.	.	.	.	.	.	.	.	.
Sesleria caerulea (L.) Ard.	.	69.5	.	.	.	.	.	.	.	.	.	.	.	.	.
Frangula alnus Mill.	.	64.8	.	.	.	4	.	.	.	.	.	.	.	.	.
Veratrum album L. s. l.	15.9	59.1	.	.	.	.	.	.	.	.	.	.	.	.	.
Eupatorium cannabinum L.	11.3	58.4	.	.	.	6.6	.	.	.	58.4	.	.	.	.	.
Carex panicea L. (VU)	.	52.7	31.9	.	.	.	.	.	.	.	.	31.9	.	.	.
Salix cinerea L.	.	.	59.1	.	.	.	.	.	.	.	15.9	.	.	.	.
Carex flava aggr.	.	.	55.2	.	.	.	.	24.5	.	.	.	.	.	.	.
Myriophyllum verticillatum L.	.	.	.	.	80.2	.	.	35.6	.	.	.	.	.	.	.
Epilobium hirsutum L.	.	.	.	.	.	.	100	.	.	.	.	.	.	.	.
Lycopus europaeus L.	4.7	22	.	.	.	.	56.6	.	.	39.3	.	.	.	.	.
Potamogeton sp.	.	.	.	.	.	.	.	69.5	.	.	.	.	.	.	.
Peucedanum palustre (L.) Moench	.	.	.	.	.	.	.	.	69.5	.	.	.	.	.	.
Teucrium scordium L.	.	.	.	.	.	.	.	.	69.5	.	.	.	.	.	.
Galium palustre L.	.	.	21.9	.	.	.	.	4.6	56.4	4.6	.	21.9	.	.	.
Oenanthe fistulosa L.	.	.	.	24.5	.	.	.	.	55.2	.	.	.	.	.	.
Mentha longifolia (L.) Huds.	.	14.6	.	.	.	3.8	.	.	.	83.9	.	.	.	.	.

Table 7 (cont.). – Synoptic table of marshland communities from the Plitvice Lakes National Park with fidelity values expressed as phi coefficient. The table presents only those species that reach fidelity values higher than 50 in any of the given communities. The communities are labelled with the same numbers as in Figure 2.

Communities number	**1**	**1a**	**1b**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Numbers of relevés	12	4	2	4	1	15	1	4	2	4	6	2	1	1	1
Galium aparine L.	–	–	–	–	–	–	–	–	–	69.5	–	–	–	–	–
Epilobium ciliatum Raf. (N)	–	–	–	–	–	–	–	–	–	69.5	–	–	–	–	–
Lysimachia nummularia L.	–	–	–	–	–	–	–	12.6	–	56.1	–	34.3	–	–	–
Myosotis scorpioides aggr.	11.8	–	–	–	–	–	–	33.1	–	54.3	4.7	–	–	–	–
Centaurea jacea L.	–	–	–	–	–	–	–	–	–	–	–	100	–	–	–
Deschampsia cespitosa (L.) P. Beauv. (DD)	–	15.1	–	–	–	–	–	–	–	–	–	85.6	–	–	–
Juncus articulatus L.	–	–	–	–	–	–	–	–	–	–	–	69.5	–	–	–
Oenanthe silaifolia M. Bieb.	–	–	–	–	–	–	–	–	–	–	–	69.5	–	–	–
Potentilla reptans L.	–	–	–	–	–	–	–	–	–	–	–	69.5	–	–	–
Taraxacum palustre aggr.	–	–	–	–	–	–	–	–	–	–	–	69.5	–	–	–
Carex hirta L.	6.1	–	–	–	–	–	–	–	–	–	–	63.7	–	–	–
Succisella inflexa (Kluk) G. Beck	–	–	–	–	–	–	–	–	–	24.5	–	55.2	–	–	–
Poa trivialis L. s. l.	–	–	–	–	–	–	–	–	–	15.1	–	–	–	85.6	–
Scrophularia umbrosa Dumort.	3.1	–	–	–	–	–	–	–	–	49.8	–	–	–	69.8	–
Berula erecta (Huds.) Coville	–	–	–	–	–	–	–	–	–	–	–	–	–	–	100
Caltha palustris L.	26.3	–	–	–	–	–	–	–	20.6	20.6	9.4	–	–	–	54.4

Results

Syntaxonomic survey

In the area of the Plitvice Lakes National Park, the following marshland communities were found:

Class *Phragmito-Magnocaricetea* Klika 1941

Order *Phragmitetalia* W. Koch 1926

1. Alliance *Phragmition* W. Koch 1926
   - 1.1 Ass. *Phragmitetum australis* Schmale 1939
   - 1.2 Ass. *Typhetum latifoliae* A. G. Lang 1973
   - 1.3 Ass. *Scirpetum lacustris* Chouard 1924
   - 1.4 Ass. *Cladietum marisci* P. Allorge 1922
   - 1.5 Ass. *Sparganietum erecti* H. Roll 1938
   - 1.6 Ass. *Equisetetum fluviatilis* Steffen 1931
2. Alliance *Magnocaricion elatae* W. Koch 1926
   - 2.1 Ass. *Caricetum elatae* W. Koch 1926
   - 2.2 Ass. *Caricetum paniculatae* Wangerin 1916
   - 2.3 Ass. *Caricetum rostratae* Rübel 1912
   - 2.4 Ass. *Eleocharitetum uniglumis* E. G. Almq. 1929
   - 2.5 Ass. *Phalaridetum arundinaceae* Libbert 1931
3. Alliance *Sparganio-Glycerion fluitantis* Braun-Blanq. & Sissingh 1942 [nomen inval.]
   - 3.1 Ass. *Glycerietum plicatae* (Kulcz. 1928) Oberd. 1954
   - 3.2 *Veronica beccabunga* L. community

Description of marshland communities

Marshland vegetation of the class *Phragmito-Magnocaricetea* in the Plitvice Lakes National Park comprises 13 communities, falling into three alliances within the order *Phragmitetalia*. The whole data set has 60 relevés and 95 plant taxa. All marshland communities are briefly described in the following text.

1. *Phragmition*

Stands develop mainly in deeper water, and they are poor in species. Physiognomically, the communities are tall, except for the *Sparganietum erecti* and *Equisetetum fluviatilis*. In the study area, the alliance contains 6 associations.

1.1 *Phragmitetum australis* (Table 1)

This is the most widespread marshland community in the area of Plitvice Lakes National Park. It occurs in many sites, usually over small areas, the only exception being the large area between Vrelo and Drakulić Rijeka. The community shows a very wide ecological range. Thus, stands grow in water up to a depth of 1 m, in stagnant and running water, and in humid habitats outside it. *Phragmites australis* invades the stands of the critically endangered species *Ligularia sibirica* (relevés 13-16), and the endangered species *Menyanthes trifoliata* (relevés 17 and 18) (Nikolić & Topić, 2005). Although relevés 13 to 18 do not belong to the association *Phragmitetum australis,* as they represent successive stages, they are nevertheless grouped together. Accordingly, these relevés are not used in most of the numerical analyses.

1.2 *Typhetum latifoliae* (Table 2)

This community was recorded in the Plitvice Lakes over small areas. It develops in habitats with an accumulation of organic matter, i.e. on ground rich in nutrients. Depth of water ranges between 0.05 and 0.5 m.

1.3 *Scirpetum lacustris*

The association was observed in stagnant water near the shoreline of Lake Prošće in small fragments. A small number of species occur in the floristic composition, and these are mostly submerged plants of the class *Potametea* Tüxen & Preising 1942.

Only one relevé was recorded: [Relevé 23: cover value 60%; relevé shape 2×2 m; altitude 637 m; water depth 0.6 m; number of species 2. Floristic composition: *Scirpus lacustris* L. – 3, *Myriophyllum verticillatum* L. – 3].

1.4 *Cladietum marisci* (Table 3)

The community was recorded in several locations within the national park. It develops in habitats poor in nutrients, on substrates rich in calcium carbonate (Balátová-Tuláčková, 1991). The community is characterised by a very small number of species per relevé, dominated by *Cladium mariscus*. The stands are very dense, with a considerable amount of dry remains of plants. The community grows in wet habitats along the shore, and in water up to a depth of 0.6 m. Around the lakes, a zonation was observed: *Cladietum marisci* (deeper water) – *Phragmitetum australis* (shallower water).

1.5 *Sparganietum erecti*

This association was present with only one stand, at the place where a stream flows into Lake Prošće. Organic matter is deposited there by water flow, i.e. the conditions are eutrophic.

Only one relevé was recorded: [Relevé 39: cover value 100%; relevé shape 3×3 m; altitude 637 m; water depth 0.3-0.4 m; number of species 4. Floristic composition: *Sparganium erectum* L. – 5, *Epilobium hirsutum* L. – +, *Lycopus europaeus* L. – +, *Lythrum salicaria* L. – +].

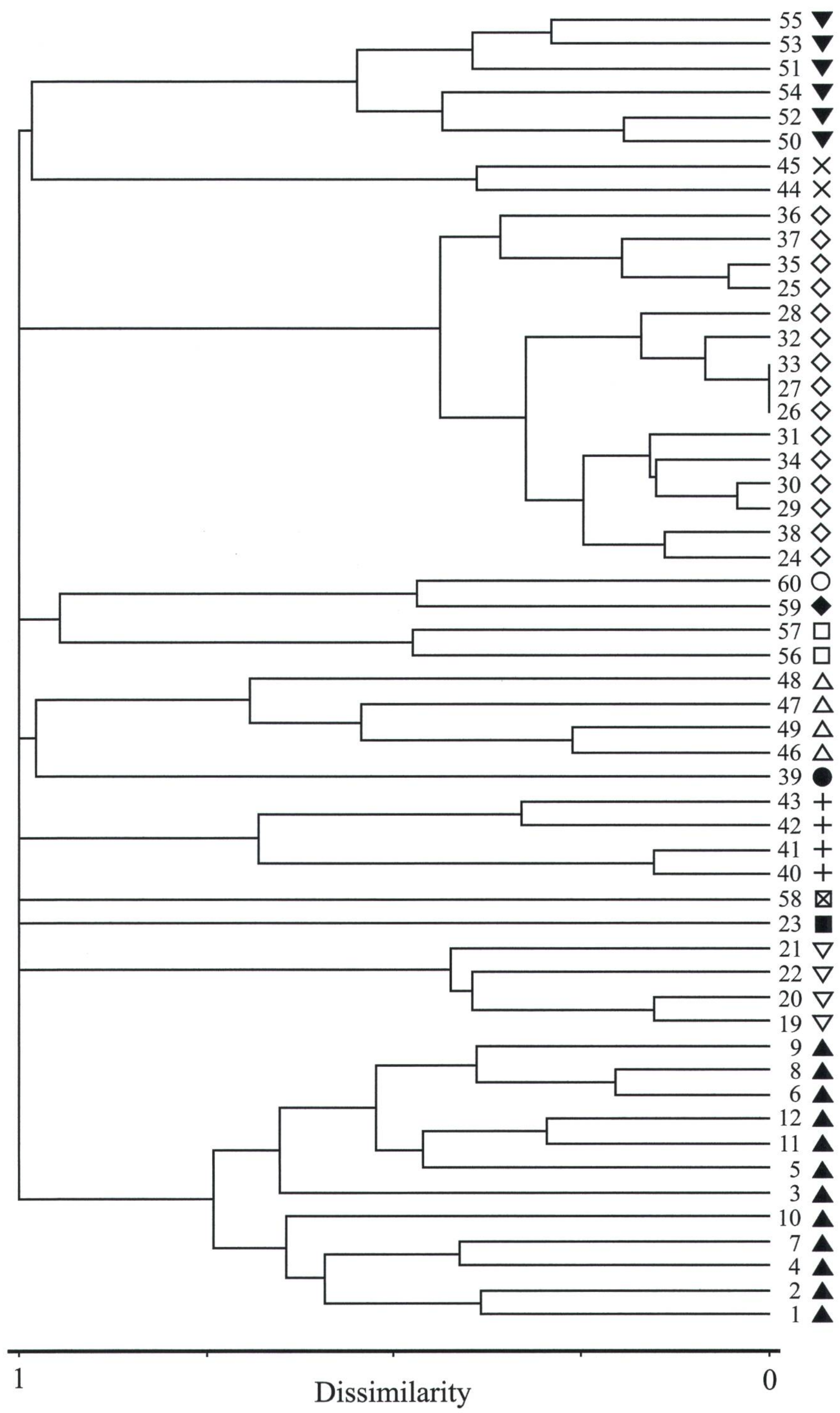

Fig. 3. – Dendrogram produced by the complete linkage method and the similarity ratio distance coefficient in the SYN-TAX program. The communities have been labelled with the following symbols: (▲) ass.*Phragmitetum australis* Schmale 1939; (▽) ass. *Typhetum latifoliae* A. G. Lang 1973; (■) ass. *Scirpetum lacustris* Chouard 1924; (◇) ass. *Cladietum marisci* P. Allorge 1922; (●) ass. *Sparganietum erecti* H. Roll 1938; (+) ass. *Equisetetum fluviatilis* Steffen 1931; (×) ass. *Caricetum elatae* W. Koch 1926; (△) ass. *Caricetum paniculatae* Wangerin 1916; (▼) ass. *Caricetum rostratae* Rübel 1912; (□) ass. *Eleocharitetum uniglumis* E. G. Almq. 1929; (⊠) ass. *Phalaridetum arundinaceae* Libbert 1931; (◆) ass. *Glycerietum plicatae* (Kulcz. 1928) Oberd. 1954; (o) *Veronica beccabunga* community.

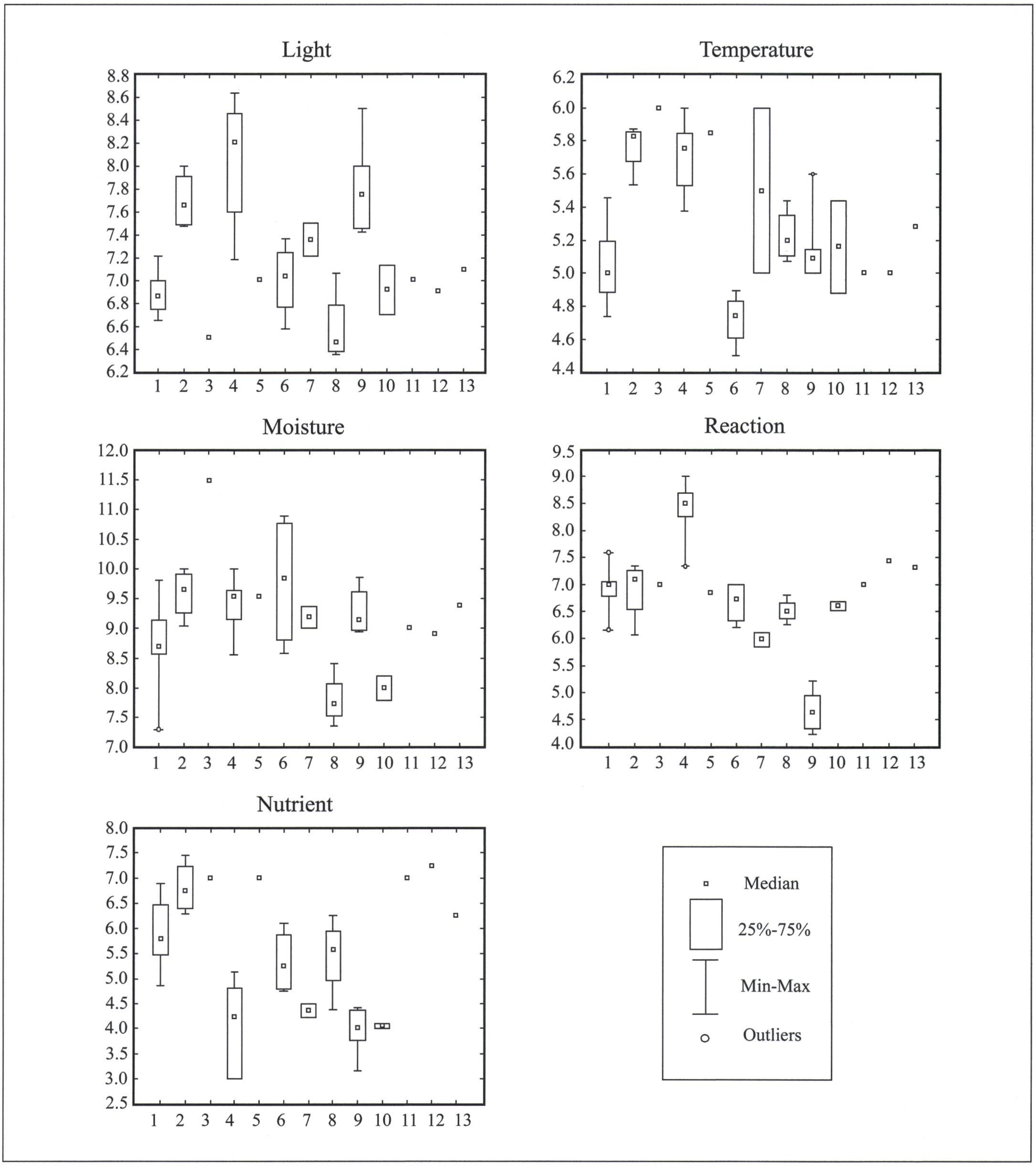

Fig. 4. – Box-plots for light, temperature, moisture, soil reaction and nutrient content obtained by calculating Ellenberg indicator values. Graphs show the medians, boxes the range of 25-75%, and whiskers with minimal and maximal values. Some communities contain only one relevé in the data set, and they are presented only with a sign for the median. The marshland communities are labelled with the same numbers as in Figure 2.

1.6 *Equisetetum fluviatilis* (Table 4)

The Plitvice Lakes are, so far, the only area in Croatia where this association has been found (Stančić, 2007). It grows in stagnant water at a depth of 0.3-0.5 m, and at one place in a microdepression of terrain which is flooded only a part of the year. The community is characterised by a small number of species, and by the presence of submerged plants of the class *Potametea*. During the field work, zonations of marshland communities were also observed. In Lake Prošće: *Scirpetum lacustris* (deeper water) – *Equisetetum fluviatilis* (shallower water). Along the shore of the accumulation in Čuića Krčevina: *Equisetetum fluviatilis* (deeper water) – *Phragmitetum australis* (shallower water).

2. *Magnocaricion elatae*

The alliance includes communities that develop in shallow-flooded habitats or in humid sites without flooding. In the floristic composition, species of the genus *Carex* L. prevail. Physiognomically, this is vegetation of lower growth, except for *Phalaridetum arundinaceae*. In the area of the Plitvice Lakes National Park, the alliance contains 5 communities.

2.1 *Caricetum elatae*

The stands of this association develop in habitats with stagnant water: in the littoral zone where organic matter accumulates and enables the maintenance of eutrophic conditions. The association was noted along the shores of Lake Prošće over small areas, and individual tussocks of the species *Carex elata* All. can be found along the edges of other lakes as well.

Two relevés were recorded: [1. Relevé 44: cover value 90%; relevé shape 4×4 m; altitude 637 m; water depth 15 cm; number of species 11. Floristic composition: *Carex elata* All. – 5, *Equisetum fluviatile* L. – 1, *Lysimachia vulgaris* L. – 1, *Peucedanum palustre* (L.) Moench – 1, *Valeriana dioica* L. – 1, *Caltha palustris* L. – +, *Equisetum palustre* L. – +, *Filipendula ulmaria* (L.) Maxim. – +, *Galium palustre* L. – +, *Lythrum salicaria* L. – +, *Mentha aquatica* L. – +; 2. Relevé 45: cover value 80%; relevé shape 3×3 m; altitude 637 m, water depth 15 cm; number of species 7. Floristic composition: *Carex elata* All. – 5, *Carex rostrata* Stokes (VU) – 1, *Galium palustre* L. – +, *Lysimachia vulgaris* L. – +, *Mentha aquatica* L. – +, *Oenanthe fistulosa* L. – +, *Teucrium scordium* L. – +].

2.2 *Caricetum paniculatae* (Table 5)

In the study area, stands of this association have developed at several sites in the narrow valley along the Bijela rijeka stream. The community has a tussocky appearance. It grows in places which are periodically flooded, and for part of the year are still moist, but without surface water. The stands are no longer influenced by occasional mowing and pasture, and are exposed to overgrowth by *Phragmites australis* and woody species of the genus *Salix* L. Therefore, this association can be considered highly threatened.

2.3 *Caricetum rostratae* (Table 6)

The present paper brings the first records of this association in Croatia. The community was found in the Plitvice Lakes area at several localities, where it forms relatively small stands. It develops along the edges of streams and lakes. The water depth in the habitat is about 10-20 cm, and it very rarely dries up during the summer months (July, August). The soil is poor in nutrients. The community develops in contact with different marshland vegetation types. Several examples of zonation are noted here. Communities are ordered by decreasing water depth, starting with the communities that develop in deeper water, followed by those developing in shallower water and in wet habitats outside the water. Along Bijela rijeka: *Caricetum rostratae – Caricetum paniculatae – Phragmitetum australis*. Along Crna rijeka: *Caricetum rostratae – Typhetum latifoliae*. Lake Prošće: *Caricetum rostratae – Caricetum elatae – Typhetum latifoliae* or in some places *Caricetum rostratae – Typhetum latifoliae*. In a microdepression of terrain near Lake Prošće: *Caricetum rostratae – Equisetetum fluviatilis*.

2.4 *Eleocharitetum uniglumis*

This association is also recorded for the first time in Croatia. The community was sampled at only one locality with two relevés. It develops in shallow ditches with slow water flow, at a water depth of about 10 cm. The habitats are poor in nutrients. The community was surrounded by wet meadow vegetation dominated by the species *Molinia arundinacea* Schrank.

Two relevés were recorded: [1. Relevé 56: cover value 95%; relevé shape 2×2 m; altitude 780 m; water depth 10 cm; number of species 12. Floristic composition: *Eleocharis uniglumis* (Link) Schult. (CR) – 5, *Ranunculus repens* L. – 3, *Deschampsia cespitosa* (L.) P. Beauv. (DD) – 1, *Juncus articulatus* L. – 1, *Lythrum salicaria* L. – 1, *Succisella inflexa* (Kluk) Beck – 1, *Carex hirta* L. – +, *Centaurea jacea* L. – +, *Galium palustre* L. – +, *Lysimachia nummularia* L. – +, *Oenanthe silaifolia* M. Bieb. – +, *Potentilla reptans* L. – +; 2. Relevé 57: cover value 80%; relevé shape 3×3 m; altitude 780 m; water depth 10 cm; number of species 9. Floristic composition: *Eleocharis uniglumis* (Link) Schult. (CR) – 4, *Centaurea jacea* L. – 2, *Mentha aquatica* L. – 2, *Ranunculus repens* L. – 2, *Agrostis stolonifera* L. – +, *Carex panicea* L. (VU) – +, *Deschampsia cespitosa* (L.) P. Beauv. (DD) – +, *Ranunculus acris* L. – +, *Taraxacum palustre* aggr. – +].

2.5 *Phalaridetum arundinaceae*

In the area of the national park, only one stand of this association is established. It was found along stream banks, in shallow water.

Only one relevé was recorded: [Relevé 58: cover value 100%; relevé shape 3×3 m; altitude 780 m; water depth 15 cm; number of species 1. Floristic composition: *Phalaris arundinacea* L. – 5].

3. *Sparganio-Glycerion fluitantis*

This alliance includes marshland vegetation that develops on the banks of streams, and is exposed to periodic floods and water flow, which affect the floristic composition of the vegetation. In the Plitvice Lakes, the alliance contains only two communities.

3.1 *Glycerietum plicatae*

This association occurs at only one site in the Plitvice Lakes, along the bank of a stream. The stand grows on a small area of several square metres on soil rich in nutrients. The habitat is occasionally flooded.

Only one relevé was recorded: [Relevé 59: cover value 90%; relevé shape 1×4 m; altitude 680 m; water depth 0 cm; number of species 5. Floristic composition: *Glyceria plicata* (Fr.) Fr. (VU) – 5, *Veronica beccabunga* L. – 2, *Ranunculus repens* L. – 1, *Poa trivialis* L. s.l. – +, *Scrophularia umbrosa* Dumort. – +].

3.2 *Veronica beccabunga* community

In the Plitvice Lakes this community covers a small site in shallow water along a stream bank. The community grows on a layer of nutrient rich soil of about 10 cm thick developed above the gravelly substrate. The following zonation was observed during the field work: *Veronica beccabunga* community (deeper water) – *Glycerietum plicatae* (shallower water).

Only one relevé was recorded: [Relevé 60: cover value 90%; relevé shape 2×1 m; altitude 680 m; water depth 20 cm; number of species 6. Floristic composition: *Veronica beccabunga* L. – 5, *Glyceria plicata* (Fr.) Fr. (VU) – 1, *Ranunculus repens* L. – 1, *Berula erecta* (Huds.) Coville – +, *Caltha palustris* L. – +, *Mentha aquatica* L. – +].

Numerical classification

The clusters obtained by numerical classification match very well with the traditionally accepted vegetation communities. In the dendrogram (Fig. 3) all communities are clearly distinguished, except the *Glycerietum plicatae* and *Veronica beccabunga* community. *Cladietum marisci* is the most distinct in the investigated data set. In the analysis of similarities (ANOSIM), a global R = 0.985 ($P < 0.001$) was obtained. It shows that marshland communities differ significantly with respect to their species composition.

The analysis of fidelity (Table 7) indicates that the character and monodominant species of traditionally accepted marshland communities have high fidelity values. Among them, the only exception is *Phragmites australis,* with a fidelity value below 50. In the synoptic table (Table 7), there are also species with high fidelity values but low frequency in the data set. For example, in stands of *Ligularia sibirica*, high fidelity values are shown by species typical of very wet meadows of the order *Molinietalia* W. Koch 1926.

Analysis of ecological factors

The influence of ecological factors on the development of marshland communities was analysed by use of Ellenberg indicator values (Fig. 4). These showed that the highest light intensity is characteristic of the association *Cladietum marisci*, followed by *Caricetum rostratae* and *Typhetum latifoliae*. In contrast, *Caricetum paniculatae* shows the lowest indicator values for light. The highest temperature values were indicated for *Scirpetum lacustris*, *Sparganietum erecti*, *Typhetum latifoliae* and *Cladietum marisci*, and the lowest value for *Equisetetum fluviatilis*. With regard to moisture, the associations *Phragmitetum australis* and *Equisetetum fluviatilis* show the largest range. The stands of both communities develop in water and in humid habitats outside it. The highest values of moisture are indicated for the association *Scirpetum lacustris,* which develops mostly in water. The lowest moisture values are found for *Caricetum paniculatae* and *Eleocharitetum uniglumis*, which are only occasionally flooded. With respect to substrate reaction, *Cladietum marisci* shows a very high value, *Caricetum rostratae* shows a very low reaction value, while the values for the other communities are more or less similar, i.e. located at an intermediate position on the graph. Marshland communities differ considerably in relation to nutrient content. The communities with high nutrient values are: *Typhetum latifoliae*, *Scirpetum lacustris*, *Sparganietum erecti*, *Phalaridetum arundinaceae*, *Glycerietum plicatae* and *Veronica beccabunga* community. The communities with low nutrient values are: *Cladietum marisci*, *Caricetum rostratae* and *Eleocharitetum uniglumis*.

Life forms

The analysis of plant life forms showed that the communities of the *Phragmition* alliance are dominated by hydrophytes, followed by a considerable proportion of geophytes (Fig. 5). In the communities of the *Magnocaricion* *elatae* alliance, hemicryptophytes predominate. In the communities of the *Sparganio-Glycerion fluitantis* alliance, hemicryptophytes and hydrophytes prevail.

Nature conservation and the problem of eutrophication

The only threatened marshland community in the study area is *Caricetum paniculatae*. The rare marshland communities are considered to be: *Caricetum rostratae*, *Eleocharitetum uniglumis*, *Equisetetum fluviatilis* and *Glycerietum plicatae*.

In the floristic composition of the investigated data set, there is a total of 12 taxa from the NIKOLIĆ & TOPIĆ (2005). Two of them are critically endangered (*Eleocharis uniglumis* (Link) Schult. and *Ligularia sibirica* (L.) Cass.), three are endangered (*Dactylorhiza majalis* (Rchb.) P. F. Hunt & Summerh., *Eriophorum latifolium* Hoppe and *Menyanthes trifoliata* L.), five are vulnerable (*Carex panicea* L., *C. riparia* Curtis, *C. rostrata* Stokes, *C. vesicaria* L. and *Glyceria plicata* (Fr.) Fr.), one is nearly threatened (*Scilla litardierei* Breistr.), and one is data-deficient (*Deschampsia cespitosa* (L.) P. Beauv.).

In the marshland vegetation of Plitvice Lakes, only two neophytes have been found: *Epilobium ciliatum* Raf. and *Erigeron annuus* (L.) Pers. They are not frequent in the investigated data set, and are not present with great cover values.

The increased rate of eutrophication of the Plitvice Lakes has become one of the main problems for nature conservation, most probably causing the spread of marshland vegetation along the banks of the lakes. Currently, eight associations adapted to different trophic levels occur around the lakes (not including communities in other places within the national park): *Caricetum elatae, Caricetum rostratae, Cladietum marisci, Equisetetum fluviatilis*, *Phragmitetum australis, Scirpetum lacustris, Sparganietum erecti* and *Typhetum latifoliae*. The best-represented are *Cladietum marisci* and *Phragmitetum australis*, whereas the other communities are noted mostly at single localities.

Discussion

Croatian marshland vegetation of mountainous regions is very sparsely researched (STANČIĆ, 2007). The karst terrain dominating in the Dinaric Alps is not favourable for the development of such vegetation, and therefore marshland communities are not very common in that part of the country. In the Plitvice Lakes National Park, in spite of numerous water ecosystems, the marshland vegetation covers relatively small areas, which explains the relatively small number of recorded relevés. Various and rare ecological conditions enable the development of different types of marshland vegetation, some of which occur nowhere else in Croatia. During the research from 2004 to 2006, 13 communities were determined. Among the communities noted, *Phragmitetum australis* is the most widespread in the area of Plitvice Lakes National Park, as well as in Croatia (STANČIĆ, 2007). From a nature conservation perspective, it shows both positive and negative effects on the environment (GÜSEWELL & KLÖTZLI, 2000). The positive effects are enrichment of the vascular flora and vegetation diversity, and providing habitats for various animals, whereas the negative effect is the spreading of *Phragmitetum australis* to areas of other marshland communities of lower growth, to wet meadows that are no longer mown, to species-rich fens and to other wetlands. The spreading of *Phragmites australis* in habitats of *Ligularia sibirica* and *Menyanthes trifoliata*, which are rare and threatened species in Croatia (NIKOLIĆ & TOPIĆ, 2005), is documented in this paper (Table 1). It should be mentioned that the only locality in Croatia for *Ligularia sibirica* lies within the Plitvice Lakes National Park (ŠEGULJA & KRGA, 1990a, b). It is equally rare throughout Europe (WAGENITZ, 1987; HENDRYCH, 2003) and included in the Bern Convention list (ANONYMOUS, 1979) and the Habitat Directive list (ANONYMOUS, 1992). *Menyanthes trifoliata* is characteristic of the very rare and highly threatened fen vegetation of the class *Scheuchzerio-Caricetea fuscae* Tüxen 1937 (OBERDORFER, 2001).

The second most widespread marshland community in the researched area is *Cladietum marisci*. It is distributed in marshland vegetation along the Croatian Adriatic coast, and in the continental part of the country only in the area of Plitvice Lakes National Park (STANČIĆ, 2007).

In this paper, for the first time in Croatia, three new associations are recorded: *Equisetetum fluviatilis*, *Caricetum rostratae* and *Eleocharitetum uniglumis*. The small number of documented localities in the study area indicates that all three communities can be considered as rare. The association *Equisetetum fluviatilis* is distributed in Central Europe from plains to mountains up to 2400 m (MERTZ, 2002). The main distribution area of the association *Caricetum rostratae* is in the mountainous and subalpine regions of Central Europe (PHILIPPI, 1998). The association *Eleocharitetum uniglumis* is known from Bavaria in Germany (BRAUN, 1968; PHILIPPI, 1998) but is poorly studied (PHILIPPI, 1998). The species *Eleocharis uniglumis* has a very wide ecological range and also grows in other marshland communities of the class *Phragmito-Magnocaricetea* (PHILIPPI, 1998), in saline grasslands of the class *Festuco-Puccinellietea* Vicherek 1973, and wet meadows of the alliance *Deschampsion cespitosae* Horvatić 1930 (CHYTRÝ, 2007). It is characteristic of all three communities that they occur in habitats more or less poor in nutrients (PHILIPPI, 1998).

Also found in the Plitvice Lakes National Park was a rare marshland community, *Glycerietum plicatae*. Besides the study area, it has been recorded in the Strahinšćica area in North-Western Croatia (REGULA-BEVILACQUA, 1978). All the rare communities mentioned here should be monitored in future investigations, and it should be established whether they are threatened.

Caricetum paniculatae was designated a threatened community due to negative trends in the population size of *Carex paniculata* L. in the Plitvice Lakes, and in Croatia as a whole. Other findings of the community are known from the area of Vukomeričke gorice (ŠEGULJA, 1974, 1976).

Our results confirm the records of *Caricetum elatae*, *Caricetum paniculatae*, *Cladietum marisci* and *Phragmitetum australis* in the Plitvice Lakes National Park which have been published by HORVAT & al. (1974), BLAŽENČIĆ & BLAŽENČIĆ (1990-1991, 1992), ŠEGULJA (2005) and PAVLUS & NOVOSEL (2006). However, ŠEGULJA (2005) has recorded *Caricetum vesicariae* and stands of *Equisetum hyemale* that were not found in our field data collection. Verification at the same localities showed records of *Caricetum rostratae* and *Equisetetum fluviatilis*, and therefore the former records can be regarded as misidentifications.

The results of classification and fidelity analysis support, in our opinion, the existence of the traditionally accepted marshland associations. The only exceptions are the *Glycerietum plicatae* and *Veronica beccabunga* community. In the dendrogram, these two communities are placed in the same cluster (Fig. 3). Also, in the fidelity calculation these two communities share common diagnostic species. Such a result could be explained by the communities being represented by a single relevé, and their stands being located very close to each other. They differ in dominant species and water depth in the habitat. These are the reasons why these two communities were taken separately in this paper, although there remains the possibility of their being merged into a single community due to considerable overlap in the species composition.

The results of the numerical classification in this paper do not support the grouping of communities into traditional alliances, i.e. *Phragmition*, *Magnocaricion elatae* and *Sparganio-Glycerion fluitantis* (STANČIĆ, 2007). However, for an assessment of the structure of higher syntaxonomic categories, a huge amount of data of all types of marshland vegetation from a wider region is required.

The traditional marshland communities of the class *Phragmito-Magnocaricetea* are mostly based on one and the same character and dominant species. In the calculation of species fidelity it was confirmed that a number of species with high phi coefficients overlap very well with diagnostic species of specific marshland communities (STANČIĆ, 2007). In the synoptic table, these species are separated according to their phytosociological affinity into vegetation alliances (Table 7). Based on this fact, it could be concluded that the diagnostic species of traditionally described marshland communities are well supported. Among them, the only exception is *Phragmites australis*. This could be explained by the fact that this species occurs with the highest frequency in the association *Phragmitetum australis*, but also in stands of *Ligularia sibirica* and *Menyanthes trifoliata*. Therefore its fidelity is statistically lower than the specified threshold. However, high fidelity values are also shown by some species with low frequencies in the whole data set as well as within the communities in which they appear. This effect is a consequence of the small number of relevés of some marshland communities, and the presence of some species which are more characteristic of other vegetation types (OBERDORFER, 2001). Fidelity values can also be used to derive explanations of some vegetation processes. In stands of *Ligularia sibirica* a considerable number of wet meadow species with high fidelity values indicate that the initial stage of this habitat was a wet meadow of the *Molinietalia* order. After the abandonment of the extensive land use that was optimal for the maintenance of the threatened *Ligularia sibirica*, *Phragmites australis* started to spread, leading to the development of the marshland community *Phragmitetum australis* and the displacement of *Ligularia sibirica*.

With respect to the ecological factors in the marshland vegetation habitats of the Plitvice Lakes National Park, moisture, water depth and water table fluctuations are certainly very important. Ellenberg indicator values for moisture were the highest within the alliance *Phragmition*, lowest within the alliance *Magnocaricion elatae*, and moderate within the alliance *Sparganio-Glycerion fluitantis* (Fig. 4). Such results are in accordance with our field observations and literature sources (PHILIPPI, 1998). As for the amount of nutrients, communities such as *Cladietum marisci*, *Caricetum rostratae* and *Eleocharitetum uniglumis* grow near springs and in nutrient-poor habitats. Conversely, in places with shallow stagnant water, and with deposited organic matter, communities adapted to higher trophic levels are found: *Caricetum elatae, C. paniculatae, Equisetetum fluviatilis, Glycerietum plicatae, Phalaridetum arundinaceae, Phragmitetum australis, Scirpetum lacustris, Sparganietum erecti, Typhetum latifoliae* and *Veronica beccabunga* community. It is important to point out that the Plitvice Lakes National Park is not a typical marshland area like Kopački rit (TOPIĆ, 1989), Lonjsko polje (TRINAJSTIĆ & PAVLETIĆ, 1991), the Neretva river delta (JASPRICA & al., 2003) and others. On the contrary, the principal characteristics of the investigated area are the mountain streams and the karstic barrage lakes. Concerning the soil reaction only two communities show extreme values: higher concentrations of calcium carbonate, and therefore higher pH values, are characteristic of *Cladietum marisci*, and low pH values and low amounts of calcium carbonate in the soil are characteristics of *Caricetum rostratae* (PHILIPPI, 1998). Ellenberg indicator values for light intensity and temperature are less clearly related to the community division of the marshland vegetation. Examples of this discrepancy are listed here. The communities of the *Phragmition* alliance are developed in the lakes with relatively high water temperature during the vegetation season (Fig. 4). However, the single exception is *Equisetetum fluviatilis*, which shows a low temperature value, in spite of the fact that this community grows in the same water ecosystem and in the same microclimatic area as most of the others. Within the *Magnocaricion elatae* alliance, *Caricetum paniculatae* shows a low light value, and *Caricetum rostratae* a high value, although both communities grow in the same locality, close to each other. In the interpretation of the ecological conditions of specific communities, through the use of Ellenberg indicator values, it must be borne in mind that ecological indices only give an estimate, and do not fully reflect the conditions in the habitats, which are the result of very complex interactions (SCHAFFERS & SYKORA, 2000). Furthermore, some ecological indices, such as values for temperature, reflect phytogeographical distribution patterns, although some plant species may be adapted to specific local environmental conditions in different geographical areas.

Life forms reflect the adaptation of plants to habitat conditions (RAUNKIAER, 1934). According to our analysis, every marshland community, as well as every alliance, has a specific life-form spectrum (Fig. 5). The common feature of all investigated marshland communities is the dominance of hemicryptophytes, hydrophytes and geophytes. The small proportion of phanerophytes indicates initial stages of succession, while therophytes develop in *Caricetum paniculatae* within the tussocks, where the vegetation cover is not very dense.

From the perspective of nature conservation, marshland vegetation in the Plitvice Lakes National Park has a dual character. The positive effect reflects in the considerable diversity of marshland flora and vegetation, rare and threatened plant species and communities, all of which contributes to the biological value of this area. From that point of view, some marshland communities, like most other non-forest vegetation types of the Plitvice Lakes, are suppressed by vegetation changes caused by progressive succession. During the Croatian War of Independence (1991-1995), a large number of inhabitants left the national park, and those that returned engaged much less in traditional cattle breeding and agriculture than before. This resulted in the spread of shrub and forest vegetation, leading to the loss of habitats and plant species. Furthermore, considering the occurrence of alien plant species, which is becoming an increasingly serious global problem (REJMÁNEK & al., 2005), only a small number of neophytes were recorded in the species composition of the marshland vegetation.

The negative effect of marshland vegetation spreading is, in fact, that some marshland communities are expanding in the habitats of rare and threatened plant species and vegetation types. This is the case with *Phragmitetum australis,* already mentioned in the text above.

In the Plitvice Lakes, another negative is the occurrence of eutrophication. This process is caused by anthropogenic influence due to effluence of polluted water in the catchment area of the Lakes (STILINOVIĆ & FUTAČ, 1989; STILINOVIĆ, 1998). As a consequence of eutrophication, marshland communities are spreading around the lakes. There are no exact records on previous states of vegetation around water ecosystems. However, according to observations by the Park's inhabitants and employees, made 20 or 30 years ago and in recent times, the marshland vegetation is rapidly spreading along the lake shores (STILINOVIĆ, 1998). In order to reduce the consequences of eutrophication, during 2002-2004 stands of *Cladium mariscus, Phragmites australis* and, to a lesser extent, of *Scirpus lacustris,* were experimentally removed (PAVLUS & NOVOSEL, 2006). One to two years after vegetation removal, it was observed that the population of *Cladium mariscus* was considerably reduced, the population of *Phragmites australis* was even more luxuriant than before, and the population of *Scirpus lacustris* had diminished only insignificantly. As a positive effect, the authors (PAVLUS & NOVOSEL, 2006) note an increase in water flow over waterfalls and cascades. However, there was no preliminary ecological research before the removal, nor continuous monitoring after it.

Eutrophication could lead to destruction of the process of tufa formation (SRDOČ & al., 1985), the unique natural phenomenon in the karst. For this reason it is necessary to undertake a mapping of the marshland vegetation near all water bodies, especially near lakes, to set up continuous monitoring, create management plans, and to undertake protective measures. For all these purposes, this paper could serve as a starting point.

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Appendix 1. – The list of relevé localities. Data are ordered as follows: relevé number, locality name, Gauß-Krüger coordinates, and date of sampling.

Relevé 1: Vrelo; 5554521, 4958540; 16/06/2006;

Relevé 2: Vrelo; 5553367, 4958804; 17/06/2006;

Relevé 3: Vrelo-Drakulić Rijeka; 5553044, 4958988; 17/06/2006;

Relevé 4: Vrelo-Drakulić Rijeka; 5552946, 4959280; 17/06/2006;

Relevé 5: along Bijela rijeka; 5547023, 4966551; 17/06/2006;

Relevé 6: Gornji Babin Potok-Donji Babin Potok; 5541500, 4966480; 17/06/2006;

Relevé 7: Borje-Vrelo; 5553879, 4958688; 25/06/2006;

Relevé 8: Veliko jezero; 5548039, 4969968; 24/07/2006;

Relevé 9: Galovac; 5548437, 4970658; 20/08/2004;

Relevé 10: Korana; 5548813, 4975577; 18/07/2005;

Relevé 11: Čuića Krčevina, west shore of the accumulation; 5552560, 4965328; 16/06/2006;

Relevé 12: Čuića Krčevina, west shore of the accumulation; 5552592, 4965345; 16/06/2006;

Relevé 13: Rudanovac-Vrelo; 5554341, 4959448; 24/06/2006;

Relevé 14: Rudanovac-Vrelo; 5554339, 4959475; 24/06/2006;

Relevé 15: Rudanovac-Vrelo; 5554156, 4959466; 24/06/2006;

Relevé 16: Rudanovac-Vrelo; 5554339, 4959429; 24/06/2006;

Relevé 17: Rudanovac-Vrelo; 5554400, 4959043; 16/06/2006;

Relevé 18: Plitvički Ljeskovac, wet habitat at the southeastern shore of Lake Prošće (Prošćansko jezero); 5548111, 4967553; 17/06/2006;

Relevé 19: Lake Prošće, northern part; 5547636, 4969716; 24/07/2006;

Relevé 20: Lake Kozjak, southeastern part; 5549287, 4970505; 20/08/2004;

Relevé 21: Plitvički Ljeskovac, along Crna rijeka; 5547743, 4966583; 24/07/2006;

Relevé 22: Lake Prošće, northern part; 5547705, 4969739; 24/07/2006;

Relevé 23: Lake Prošće, south shore; 5547719, 4967730; 26/09/2005;

Relevé 24: Galovac; 5548490, 4970493; 24/07/2006;

Relevé 25: Rudanovac-Vrelo; 5554415, 4959032; 16/06/2006;

Relevé 26: Lake Prošće, along the southeastern shore; 5547957, 4968857; 24/07/2006;

Relevé 27: Okrugljak; 5547788, 4970024; 20/08/2004;

Relevé 28: Malo jezero; 5547912, 4970200; 20/08/2004;

Relevé 29: Galovac-Gradinsko jezero; 5548420, 4970492; 20/08/2004;

Relevé 30: Galovac; 5548418, 4970311; 20/08/2004;

Relevé 31: Galovac; 5548371, 4970133; 20/08/2004;

Relevé 32: Burgeti; 5548956, 4970762; 20/08/2004;

Relevé 33: Lake Kozjak, southeastern part; 5549365, 4970622; 20/08/2004;

Relevé 34: Gradinsko jezero; 5548698, 4970487; 20/08/2004;

Relevé 35: Velike kaskade; 5548642, 4973037; 20/08/2004;

Relevé 36: Gradinsko jezero; 5548662, 4970646; 20/08/2004;

Relevé 37: Lake Kozjak, southeastern part; 5549237, 4970380; 20/08/2004;

Relevé 38: Kaluđerovac-Novakovića brod; 5548519, 4973240; 20/08/2004;

Relevé 39: Lake Prošće, southwestern part; 5546940, 4967855; 24/07/2006;

Relevé 40: Lake Prošće, south shore; 5547602, 4967768; 26/09/2005;

Relevé 41: Lake Prošće, south shore; 5547637, 4967729; 26/09/2005;

Relevé 42: Čuića Krčevina, western shore of the accumulation; 5552531, 4965321; 16/06/2006;

Relevé 43: Plitvički Ljeskovac, a microdepression in terrain at the southeastern part of Lake Prošće; 5548174, 4967308; 17/06/2006;

Relevé 44: Plitvički Ljeskovac, southern part of Lake Prošće; 5547666, 4967635; 17/06/2006;

Relevé 45: Lake Prošće, northern part; 5547674, 4969734; 24/07/2006;

Relevé 46: along Bijela rijeka; 5544817, 4965971; 26/09/2005;

Relevé 47: along Bijela rijeka; 5545662, 4966118; 26/09/2005;

Relevé 48: along Bijela rijeka; 5547080, 4966481; 26/09/2005;

Relevé 49: along Bijela rijeka; 5544787, 4965946; 17/06/2006;

Relevé 50: Rudanovac-Vrelo; 5554267, 4959452; 16/06/2006;

Relevé 51: along Bijela rijeka; 5544783, 4965935; 17/06/2006;

Relevé 52: Plitvički Ljeskovac; 5547744, 4966566; 17/06/2006;

Relevé 53: Lake Prošće, northern part; 5547677, 4969736; 24/07/2006;

Relevé 54: Plitvički Ljeskovac, a microdepression in terrain at the southeastern part of Lake Prošće; 5548163, 4967317; 24/07/2006;

Relevé 55: Čuića Krčevina; 5552636, 4964975; 24/06/2006;

Relevé 56: Gornji Babin Potok-Donji Babin Potok; 5541526, 4966462; 25/06/2006;

Relevé 57: Gornji Babin Potok-Donji Babin Potok; 5541465, 4966494; 17/06/2006;

Relevé 58: Gornji Babin Potok-Donji Babin Potok; 5541488, 4966460; 25/06/2006;

Relevé 59: Vrelo; 5553694, 4958777; 25/06/2006;

Relevé 60: Vrelo; 5553695, 4958777; 25/06/2006.