

AN ENDANGERED RICH FEN HABITAT ALONG THE JARAK STREAM (NATURE PARK ŽUMBERAK-SAMOBORSKO GORJE, CROATIA)

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This study presents the results of floristic research into a flat fen along a part of the Jarak stream in Žumberak-Samoborsko gorje Nature Park. This fen belongs to order *Caricetalia davallianae* Br.-Bl. 1949, alliance *Caricio davallianae* Klika 1934, association *Eriophoro latifolio-Caricetum panicae* Horvat ex Trinajstić 2002. The area was researched in 2007/2008 and it was divided into four subareas: fen and three succession stages, *Phragmites* subarea, transitional stage between common reed (*Phragmites australis*) and young forest, and young forest. During the winter period of the research the overgrowing woody vegetation on three subareas was cut, because that action should prevent further succession and help the restoration of the fen. The following year, floristic changes were monitored. Recorded plants were taxonomically analyzed and ecological indicator values according to Landolt were calculated. During this study 222 plant species were found, out of which 15 were endangered (according to IUCN categorization) and 59 protected or strictly protected in Croatia. The summarized ecological indicator values according to Landolt showed only minor differences between the subareas, out of which only the young forest subarea stood out. The removal of the plants resulted in low floristic changes, present mostly in the young forest subarea, where species of open habitats enlarged their abundance, but no characteristic fen species were recorded. It is concluded that the fen along the stream Jarak should be protected, because of its rare vegetation type, but also because of the endangered and protected species found in this area. It is also necessary to carry out regular removal of overgrowing vegetation from all the subareas and multiple mowing to protect the fen and even enlarge its surface.

Key words: fen, Žumberak-Samoborsko gorje Nature Park, flora, preservation, protection, management

Šoštarić, R., Sedlar, Z. & Mareković, S.: Ugroženi bazofilni cret uz potok Jarak (Park prirode Žumberak-Samoborsko gorje, Hrvatska). *Nat. Croat.*, Vol. 21, No. 2., 335–348, 2012, Zagreb.

U ovom radu su prikazani rezultati florističkog istraživanja bazofilnog ravnog creta uz dio potoka Jarak, u Parku prirode Žumberak-Samoborsko gorje. Ovaj cret pripada redu *Caricetalia davallianae* Br.-Bl. 1949, svezi *Caricio davallianae* Klika 1934, zajednici *Eriophoro latifolio-Caricetum panicae* Horvat ex Trinajstić 2002. Područje je istraživano tijekom 2007. i 2008. godine te je, za tu svrhu, podijeljeno u četiri potpodručja: cret i tri faze sukcesije: sastojina s običnom trskom, prijelazni stadij između sastojine obične trske (*Phragmites australis*) i mlade šume te sastojina mlada šuma. Za vrijeme zimskog perioda, tijekom trajanja istraživanja, posječena je i odstranjena drvenasta vegetacija koja zarašćava cret na tri potpodručja, a sljedeće su godine praćene promjene u florističkom sastavu. Flora je analizirana taksonomski, ekološki na temelju indikatorskih vrijednosti prema Landoltu te su istaknute zakonom zaštićene i vrste sa Crvenog popisa. Tijekom istraživanja zabilježene su 222 biljne vrste, od kojih 15 s nekim statusom ugroženosti i 59 zaštićenih ili strogo zaštićenih u Republici Hrvatskoj. Ekološke indikatorske vrijednosti su pokazale samo manje razlike između potpodručja,

a najviše se izdvojila mlada šuma. Otvaranje staništa rezultiralo je malim florističkim promjenama, prisutnim uglavnom u mladoj šumi, gdje su jedino vrste otvorenih staništa povećale svoju pokrovnost, ali nije došlo do pojavljivanja karakterističnih cretnih vrsta. Zaključeno je da bi cret uz dio potoka Jarak trebalo zaštititi zbog prisutnosti rijetkog tipa vegetacije, ali i zbog ugroženih i zaštićenih biljnih vrsta zabilježenih na tom području. Kako bi se cret očuvao, pa čak i povećao svoju površinu, predloženo je da se redovito odstranjuju drvenaste vrste sa sva četiri potpodručja te da se provodi i redovita košnja. Tim bi se postupkom spriječila daljnja sukcesija i zaraštanje creta.

Ključne riječi: cret, Park prirode Žumberak-Samoborsko gorje, flora, konzervacija, zaštita, upravljanje

INTRODUCTION

Mires

Mires and wetlands are very diverse and represent a special type of transitional, amphibious ecosystem with habitats between uplands and water stream, where organic matter tends to accumulate because of the waterlogged, often poorly aerated conditions (RYDIN & JEGNUM, 2006).

Although peatlands are widespread in North and Central Europe (MONTANARELLA *et al.*, 2006), in Croatia peatlands are very rare, have small surfaces and are counted among critically endangered habitats, and a large part of their characteristic plant and animal species are also classified as critically endangered (ANTONIĆ *et al.*, 2005; NIKOLIĆ & TOPIĆ, 2005).

Depending on variation in wetness, aeration and pH, base richness, nutrient availability and origin of ground water and trophic classes, different authors (RYDIN & JEGNUM, 2006; CHARMAN, 2002; RADOVIĆ, 2000) give various names to similar habitats: wetland, peatland, mire, fen, bog, marsh, swamp, moor etc. We decided to classify our peatland habitat in Jarak as a rich (spring) fen because it is a basophilous habitat developed under the influence of limestone waters and does not contain the peat bog moss *Sphagnum*.

During the last few decades the phenomena of rapid succession and extinction of peatland areas have been seen in Croatia and in the whole of Europe. The reasons are partly related to the changes in water regimes (melioration and similar interventions), increased input of nutrients through water and polluted atmosphere, and abandonment of traditional livestock farming resulting in natural succession (LÜTKE & TWENHÖVEN, 1992; LÜTT, 1992). TOPIĆ & STANČIĆ (2006) indicate that basophilous flat fens are not in such critical state as acidophilous fens. However, they are still often destroyed by human activities, particularly by drainage for conversion to grasslands for agricultural usage.

Research area

The fen along the Jarak stream is situated in the Žumberak-Samoborsko gorje Nature Park, which is located in the west part of Central Croatia, has a total area of 333 km² (Fig. 1) and includes both the southern mountain parts of Mount Žumberak and the entirety of Samoborsko gorje (ANONYMOUS, 2010). Mount Žumberak is an indented massif whose length is 40 km and width 15–20 km. It has a NE-SW orientation, Dinaride tectonics and karst characteristics (VRBEK, 2005). Most of its surface is covered with middle Triassic dolomite, Cretaceous and Lithothamnium

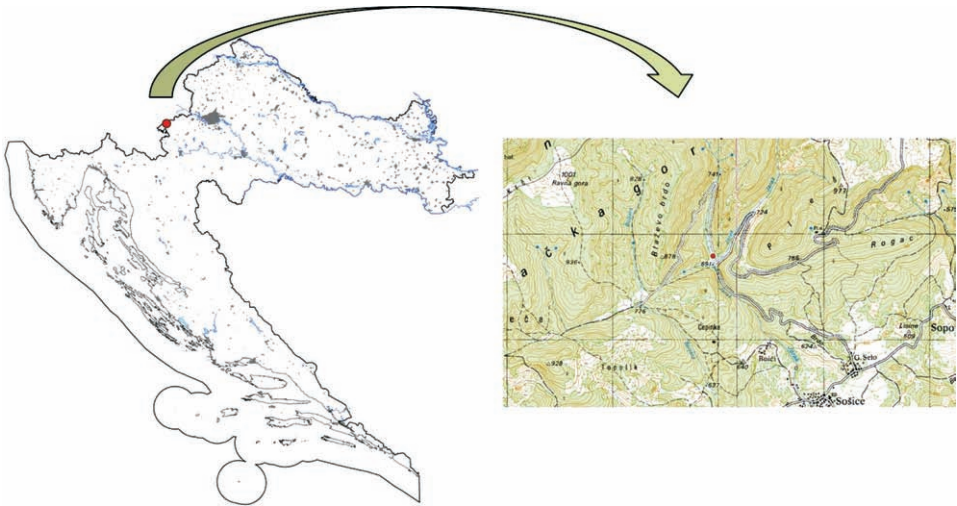


Fig. 1. The location of Jarak flat fen

limestone, which are suitable for genesis of karst. However, deep karst and karst phenomena are rarely found anywhere in the Nature Park (DUGAČKI, 1949/50).

Vegetation of the fen in Jarak belongs to the order *Caricetalia davallianae* Br.-Bl. 1949, alliance *Caricio davallianae* Klika 1934, association *Eriophoro latifolio-Caricetum panicae* Horvat ex Trinajstić (TRINAJSTIĆ, 2002 & 2008). According to the literature



Fig. 2. The location of 4 subareas: 1 – flat fen; 2 – common reed aubarea; 3 – transitional stage between common reed and young forest; 4 – young forest.

this association was recorded in several areas in Croatia: Rečica, behind the Obruč massif (HORVAT, 1962); two localities in Samoborsko gorje (ŠUGAR, 1972); Plitvička jezera National Park (TRINAJSTIĆ, 2002; ŠEGULJA, 2005); and five localities in the area of Žumberak (VRBEK, 2005).

The investigated spring fen along the Jarak stream has not been systematically researched before. The only accessible data referring to this locality are those from VRBEK (2005) who investigated the non-forest vegetation of Žumberak and reported a few relevés of the mentioned spring fen.

METHODS

The study area was divided into four subareas: 1. fen, 2. common reed (*Phragmites australis*) stand, 3. transitional stage between common reed-dominated stand and young forest and 4. young forest (Fig. 2).

Initial floristic research was carried out in 2007. During the winter period 2007/2008 woody and herbaceous species overgrowing the fen were removed in subareas 1, 3 and 4. The removal of the woody and herbaceous species was undertaken to ensure the rehabilitation of the fen area and to stop the succession, which is threatening the indigenous vegetation of the rich fen. In the year 2008 the floristic research was continued to find out if the cutting had helped in the (re)colonization of the fen species. For determination of the plant species, standard keys and iconographies were used: DOMAC, 1994; JAVORKA & CSAPODY, 1991; MERTZ, 2000; OBERDORFER, 1998 & 2001; PIGNATTI, 1982; TRINAJSTIĆ, 1975–1986 and TUTIN *et al.*, 1968–1980, 1993. The nomenclature follows the Flora Croatica database (FCD) (NIKOLIĆ, 2010).

Soil samples were taken in May, August and October to measure pH values of subareas 1, 3 and 4.

The following ecological indicator values according to LANDOLT (1977) were analyzed: soil moisture (F), soil reaction (R), light value (L), temperature (T), continentality (K), nutritional value of the soil (N), moisture variability (W), humus (H) and aeration (D).

Red-listed (NIKOLIĆ & TOPIĆ, 2005 & 2012) and protected taxa (ANONYMOUS, 2005 & 2008)) have been quoted.

RESULTS

In total, 222 plant species were recorded: 81 in the common reed stand, 117 in the transitional reed-forest stand, 12 in the young forest stand, and 74 in the fen (Tab. 1).

There were 15 red-listed species (Tab. 1): critically endangered (CR) *Eriophorum angustifolium* and *Tofieldia calyculata*; endangered species (EN) *Carex hostiana*, *Carex lepidocarpa* and *Eriophorum latifolium*; near threatened species (NT) *Cyclamen purpurascens*, *Daphne mezereum*, *Gentiana asclepiadea* and *Scirpus holoschoenus*; vulnerable species (VU) *Carex panicea*, *Glyceria fluitans* and *Glyceria plicata*; and data deficient species (DD) *Juncus anceps*, *Potentilla carniolica* and *Veratrum album*.

In the research area, 42 species were protected and 17 strictly protected by the Croatian law (Tab. 1).

Tab. 1. Plant species recorded on all four subareas: 1 (flat fen), 2 (*Phragmites* subarea), 3 (transitional stage between common reed (*Phragmites australis*) young forest), 4 (young forest), with their presence in each subarea, IUCN categorization and protection level.

FAMILY	SPECIES / SUBAREA; ENDANGERMENT; PROTECTION	1	2	3	4	IUCN Category	Protection
Aceraceae	<i>Acer campestre</i> L. (G)				+	+	
	<i>Acer pseudoplatanus</i> L. (G)				+	+	
Apiaceae	<i>Angelica sylvestris</i> L.		+			+	
	<i>Chaerophyllum aureum</i> L.	+		+	+		
	<i>Daucus carota</i> L.				+	+	
	<i>Heracleum sphondylium</i> L.					+	
	<i>Laserpitium latifolium</i> L.				+	+	
	<i>Laserpitium prutenicum</i> L.		+			+	
	<i>Pastinaca sativa</i> L.					+	
	<i>Peucedanum oreoselinum</i> (L.) Moench			+			
	<i>Sanicula europaea</i> L.					+	P
	<i>Asarum europaeum</i> L.					+	P
Asteraceae	<i>Achillea millefolium</i> L.					+	
	<i>Arctium minus</i> Bernh.					+	
	<i>Artemisia vulgaris</i> L.					+	+
	<i>Bidens tripartita</i> L.		+			+	
	<i>Bupthalmum salicifolium</i> L.			+		+	
	<i>Cirsium oleraceum</i> (L.) Scop.		+			+	+
	<i>Cirsium palustre</i> (L.) Scop.					+	
	<i>Doronicum austriacum</i> Jacq.					+	
	<i>Erigeron annuus</i> (L.) Pers.					+	+
	<i>Eupatorium cannabinum</i> L.		+	+		+	+
	<i>Leucanthemum</i> sp.					+	
	<i>Leucanthemum vulgare</i> Lam.						+
	<i>Petasites hybridus</i> (L.) P.Gaertn., B.Mey. et Schreb.		+	+		+	+
	<i>Senecio ovatus</i> (P.Gaertn., B.Mey. et Scherb.) Willd.					+	+
	<i>Solidago gigantea</i> Aiton		+			+	
<i>Tussilago farfara</i> L.			+	+	+		
Betulaceae	<i>Betula pendula</i> Roth		+			+	
Boraginaceae	<i>Echium vulgare</i> L.					+	
	<i>Myosotis discolor</i> Pers.					+	
	<i>Myosotis laxa</i> Lehm. ssp. <i>cespitosa</i> (C.F.Schultz) Nordh.		+			+	+
	<i>Myosotis scorpioides</i> L.						+
	<i>Myosotis sylvatica</i> Hoffm.						+
	<i>Omphalodes verna</i> Moench						+
	<i>Pulmonaria officinalis</i> L.		+				+

FAMILY	SPECIES / SUBAREA; ENDANGERMENT; PROTECTION	1	2	3	4	IUCN Category	Protection	
Brassicaceae	<i>Cardamine amara</i> L.				+	+		
	<i>Cardamine bulbifera</i> (L.) Crantz					+		
	<i>Cardamine hirsuta</i> L.					+		
	<i>Cardamine impatiens</i> L.					+		
	<i>Cardamine pratensis</i> L.	+	+			+		
	<i>Cardamine trifolia</i> L.					+		
	<i>Cardaminopsis arenosa</i> (L.) Hayek					+	+	
Campanulaceae	<i>Campanula trachelium</i> L.			+	+			
Caprifoliaceae	<i>Lonicera alpigena</i> L.					+		
	<i>Lonicera xylosteum</i> L.	+	+	+	+			
	<i>Sambucus nigra</i> L.					+	+	
	<i>Viburnum lantana</i> L. (G)	+	+	+	+		P	
	<i>Viburnum opulus</i> L.					+		
Caryophyllaceae	<i>Lychnis flos-cuculi</i> L.			+		+		
	<i>Silene latifolia</i> Poir. ssp. <i>alba</i> (Mill.) <i>Greuter et Bourdet</i>					+		
	<i>Silene vulgaris</i> (Moench) Garcke					+		
	<i>Aposeris foetida</i> (L.) Less.					+		
Cichoriaceae	<i>Cichorium intybus</i> L.					+		
	<i>Crepis paludosa</i> (L.) Moench					+	+	
	<i>Leontodon autumnalis</i> L.					+		
	<i>Mycelis muralis</i> (L.) Dumort.					+		
	<i>Taraxacum officinale</i> Weber	+				+	+	
Cistaceae	<i>Helianthemum nummularium</i> (L.) Mill. ssp. <i>obscurum</i> (Čelak.) Holub					+		
	Clusiaceae	<i>Hypericum perforatum</i> L.			+	+	+	P
<i>Hypericum tetrapterum</i> Fr.						+		
Colchicaceae	<i>Colchicum autumnale</i> L.					+	P	
Corylaceae	<i>Carpinus betulus</i> L.	+				+		
	<i>Corylus avellana</i> L. (G)	+				+	+	
Crassulaceae	<i>Sedum sexangulare</i> L.					+	P	
	<i>Sedum telephium</i> L. ssp. <i>maximum</i> (L.) Krock.					+		
Cupressaceae	<i>Juniperus communis</i> L. (G)	+	+					
Cuscutaceae	<i>Cuscuta epithymum</i> (L.) L. ssp. <i>epithymum</i>					+		
Cyperaceae	<i>Carex caryophyllea</i> Latourr.	+	+					
	<i>Carex flacca</i> Schreb.	+	+	+	+			
	<i>Carex hirta</i> L.					+		
	<i>Carex hostiana</i> DC.	+	+				EN SP	
	<i>Carex lepidocarpa</i> Tausch					+	+	EN SP
	<i>Carex panicea</i> L.					+		VU SP
	<i>Carex paniculata</i> L.	+	+					

FAMILY	SPECIES / SUBAREA; ENDANGERMENT; PROTECTION	1	2	3	4	IUCN Category	Protection
	<i>Juncus anceps</i> Laharpe		+			DD	SP
	<i>Juncus articulatus</i> L.			+			
	<i>Juncus inflexus</i> L.	+	+	+	+		
	<i>Scirpus holoschoenus</i> L.		+			NT	P
	<i>Scirpus sylvaticus</i> L.				+		
<i>Dipsacaceae</i>	<i>Knautia drymeia</i> Heuff.		+	+	+		
	<i>Scabiosa columbaria</i> L.	+		+			
	<i>Succisa pratensis</i> Moench	+	+	+	+		
<i>Dryopteridaceae</i>	<i>Dryopteris filix-mas</i> (L.) Schott	+			+		
<i>Equisetaceae</i>	<i>Equisetum palustre</i> L.		+	+	+		
	<i>Equisetum sylvaticum</i> L.				+		
<i>Ericaceae</i>	<i>Erica herbacea</i> L.	+	+		+		P
<i>Euphorbiaceae</i>	<i>Euphorbia amygdaloides</i> L.		+	+	+		
	<i>Euphorbia cyparissias</i> L.		+	+			
	<i>Mercurialis perennis</i> L.	+		+	+		
<i>Fabaceae</i>	<i>Chamaecytisus hirsutus</i> (L.) Link		+	+			
	<i>Coronilla varia</i> L.		+				
	<i>Genista januensis</i> Viv.		+				
	<i>Lathyrus pratensis</i> L.				+		
	<i>Lotus corniculatus</i> L.	+	+	+			
	<i>Medicago lupulina</i> L.			+	+		
	<i>Trifolium pratense</i> L.	+	+	+	+		
	<i>Trifolium repens</i> L.			+	+		
	<i>Vicia cracca</i> L.				+		
	<i>Vicia oroboides</i> Wulfen				+		
<i>Fagaceae</i>	<i>Fagus sylvatica</i> L. (G)	+			+		
<i>Gentianaceae</i>	<i>Gentiana asclepiadea</i> L.		+		+	NT	P
<i>Geraniaceae</i>	<i>Geranium columbinum</i> L.			+			
	<i>Geranium phaeum</i> L.				+		
	<i>Geranium robertianum</i> L.	+		+	+		P
<i>Hederaceae</i>	<i>Hedera helix</i> L.				+		
<i>Hypolepidaceae</i>	<i>Pteridium aquilinum</i> (L.) Kuhn	+					
<i>Lamiaceae</i>	<i>Ajuga genevensis</i> L.				+		
	<i>Betonica officinalis</i> L.	+					P
	<i>Glechoma hederacea</i> L.	+			+		
	<i>Lamium maculatum</i> L.			+			
	<i>Mentha aquatica</i> L.		+	+			P
	<i>Mentha longifolia</i> (L.) Huds.		+	+			P
	<i>Mentha x dumetorum</i> Schult.			+			
	<i>Origanum vulgare</i> L.				+		
	<i>Prunella grandiflora</i> (L.) Scholler		+				
	<i>Salvia glutinosa</i> L.	+			+		

FAMILY	SPECIES / SUBAREA; ENDANGERMENT; PROTECTION	1	2	3	4	IUCN Category	Protection
	<i>Stachys sylvatica</i> L.			+	+		
	<i>Teucrium chamaedrys</i> L.		+				P
	<i>Thymus pulegioides</i> L. ssp. <i>chamaedrys</i> (Fr.) Guşul.		+	+			P
Lentibulariaceae	<i>Pinguicula alpina</i> L.	+					P
Liliaceae	<i>Paris quadrifolia</i> L.			+	+		P
	<i>Veratrum album</i> L.				+	DD	SP
Linaceae	<i>Linum catharticum</i> L.	+			+		P
Lythraceae	<i>Lythrum salicaria</i> L.	+	+	+			P
Oleaceae	<i>Fraxinus</i> sp.	+					
Onagraceae	<i>Epilobium hirsutum</i> L.		+	+			
	<i>Epilobium parviflorum</i> Schreber		+	+			
Orchidaceae	<i>Dactylorhiza maculata</i> (L.) Soó	+		+	+		SP
	<i>Epipactis atrorubens</i> (Hoffm.) Besser	+			+		SP
	<i>Epipactis greuteri</i> H.Baumann et Künkele	+					SP
	<i>Epipactis palustris</i> (L.) Crantz	+					SP
	<i>Gymnadenia conopsea</i> (L.) R.Br.	+	+	+			SP
	<i>Listera ovata</i> (L.) R.Br.				+		SP
Parnassiaceae	<i>Parnassia palustris</i> L.	+	+		+		P
Pinaceae	<i>Pinus sylvestris</i> L. (G)	+					
Plantaginaceae	<i>Plantago lanceolata</i> L.			+	+		
	<i>Plantago major</i> L.			+			
Poaceae	<i>Agrostis gigantea</i> Roth			+			
	<i>Agrostis stolonifera</i> L.			+			
	<i>Brachypodium pinnatum</i> (L.) P.Beauv. ssp. <i>rupestre</i> (Host) Schübl. et M.Martens				+		
	<i>Brachypodium sylvaticum</i> (Huds.) P.Beauv.				+		
	<i>Briza media</i> L.	+					
	<i>Bromus benekenii</i> (Lange) Trimen				+		
	<i>Calamagrostis varia</i> (Schrad.) Host		+				
	<i>Dactylis glomerata</i> L.			+			
	<i>Deschampsia cespitosa</i> (L.) P.Beauv.				+		
	<i>Eriophorum angustifolium</i> Honck.	+	+			CR	SP
	<i>Eriophorum latifolium</i> Hoppe	+	+		+	EN	SP
	<i>Festuca pratensis</i> Huds.				+		
	<i>Glyceria fluitans</i> (L.) R.Br.				+	VU	SP
	<i>Glyceria plicata</i> (Fr.) Fr. subsp. <i>declinata</i>	+	+	+	+	VU	SP
	<i>Hierochloa australis</i> (Schrad.) Roem. et Schult.		+				P
	<i>Luzula sylvatica</i> (Huds.) Gaudin				+		
	<i>Melica nutans</i> L.			+			
	<i>Molinia caerulea</i> (L.) Moench			+			

FAMILY	SPECIES / SUBAREA; ENDANGERMENT; PROTECTION	1	2	3	4	IUCN Category	Protection
	<i>Phragmites australis</i> (Cav.) Trin. ex Steud.		+	+	+		
	<i>Poa pratensis</i> L.		+	+	+		
	<i>Poa trivialis</i> L.				+		
Polygalaceae	<i>Polygala amara</i> L.		+		+		P
	<i>Polygala amarella</i> Crantz	+					
	<i>Rumex crispus</i> L.				+		
Primulaceae	<i>Cyclamen purpurascens</i> Mill.		+	+		NT	P
	<i>Lysimachia vulgaris</i> L.	+	+	+			
	<i>Primula vulgaris</i> Huds.	+	+	+	+		
Ranunculaceae	<i>Anemone nemorosa</i> L.	+		+	+		P
	<i>Anemone ranunculoides</i> L.				+		P
	<i>Aquilegia nigricans</i> Baumg.			+	+		P
	<i>Caltha palustris</i> L.	+	+	+	+		P
	<i>Ranunculus acris</i> L.		+		+		P
	<i>Ranunculus lanuginosus</i> L.				+		P
	<i>Ranunculus repens</i> L.		+	+	+		P
	<i>Thalictrum aquilegifolium</i> L.	+		+	+		P
Rosaceae	<i>Agrimonia eupatoria</i> L.	+			+		P
	<i>Filipendula ulmaria</i> (L.) Maxim.	+		+			P
	<i>Fragaria vesca</i> L.				+	+	
	<i>Geum rivale</i> L.					+	
	<i>Malus sylvestris</i> Mill. D					+	
	<i>Potentilla anserina</i> L.				+		P
	<i>Potentilla carniolica</i> A. Kern.	+	+			DD	SP
	<i>Potentilla erecta</i> (L.) Raeuschel	+	+	+	+		P
	<i>Potentilla recta</i> L.				+		
	<i>Potentilla reptans</i> L.			+	+		
	<i>Rosa</i> sp. G	+	+				
	<i>Rubus</i> sp.	+	+	+			
	<i>Sorbus aria</i> (L.) Crantz	+					
Rubiaceae	<i>Cruciata glabra</i> (L.) Ehrend.					+	
	<i>Cruciata laevipes</i> Opiz			+	+	+	
	<i>Galium album</i> Mill.						
	<i>Galium aparine</i> L.				+		
	<i>Galium lucidum</i> All.	+	+	+			
	<i>Galium mollugo</i> L.	+					
	<i>Galium sylvaticum</i> L.				+	+	
	<i>Galium verum</i> L.			+			P
Salicaceae	<i>Salix aurita</i> L. (G)	+	+		+		
	<i>Salix caprea</i> L. (G)	+					
	<i>Salix cinerea</i> L. (D)				+		
	<i>Salix eleagnos</i> Scop. (G)					+	

FAMILY	SPECIES / SUBAREA; ENDANGERMENT; PROTECTION	1	2	3	4	IUCN Category	Protection
	<i>Salix purpurea</i> L. (G)		+	+	+		
	<i>Salix rosmarinifolia</i> L.	+	+				
	<i>Populus tremula</i> L. (G)	+	+		+		P
Saxifragaceae	<i>Chrysosplenium alternifolium</i> L.			+	+		
Scrophulariaceae	<i>Euphrasia</i> cf. <i>kernerii</i>	+					
	<i>Euphrasia rostkoviana</i> Hayne		+		+		P
	<i>Melampyrum nemorosum</i> L.				+		
	<i>Melampyrum sylvaticum</i> L.				+		
	<i>Odontites vernus</i> (Bellardi) Dumort.		+	+	+		
	<i>Rhinanthus angustifolius</i> C.C.Gmel.				+		
	<i>Scrophularia nodosa</i> L.				+	+	
	<i>Verbascum nigrum</i> L.				+		P
	<i>Veronica anagallis-aquatica</i> L.		+				
	<i>Veronica beccabunga</i> L.	+	+	+	+		P
	<i>Veronica chamaedrys</i> L.				+	+	
	<i>Veronica serpyllifolia</i> L.				+		
Solanaceae	<i>Solanum dulcamara</i> L.				+		
Thymelaeaceae	<i>Daphne mezereum</i> L.	+	+	+	+	NT	P
Tofieldiaceae	<i>Tofieldia calyculata</i> (L.) Wahlenb.	+	+			CR	SP
Ulmaceae	<i>Ulmus glabra</i> Huds.				+		
Urticaceae	<i>Urtica dioica</i> L.	+		+	+		
Valerianaceae	<i>Valeriana officinalis</i> L.	+	+	+	+		P
	<i>Valeriana tripteris</i> L.				+		
Violaceae	<i>Viola hirta</i> L.		+				

G – shrub, D – tree; CR – critically endangered species, EN – endangered, NT – near threatened, VU – vulnerable and DD – data deficient species; P – protected and SP – strictly protected species.

The species *Pinguicula alpina* is particularly interesting, as characteristic for this type of habitat and rare in the Croatian flora, as are 6 orchid species.

Brown moss species characteristic of basiphyllous fens were also recorded: *Rhytidadelphus triquetrus* (Hedw.) Warnst., *Cratoneuron commutatum* (Brid.) G. Roth var. *falcatum* (Brid.) Mönk., *Drepanocladus sendtneri* (Schimp.) Warnst., *Hygrohypnum palustre* Loeske (= *H. luridum*) and *Calliergonella cuspidata* (Hedw.) Loeske.

The soil pH values on the fen subarea did not show significant variations during the vegetation period, with the mean value of 7.05 in water and 6.75 in KCl. This confirms that the fen along the stream Jarak is a basophilous flat fen. The soil pH values for the subareas 3 and 4 were also neutral or slightly basophilous. On subarea 3 the pH values were slightly higher (7.71 in water and 7.35 in KCl) than in subarea 4 (7.55 in water and 7.14 in KCl).

The ecological values according to LANDOLT (2007) revealed some deviations in aeration, moisture, nutrients, light and humus. The rich fen was characterized by higher ecological value for humus and moisture, but also with lower values for nutrients and aeration. The fen values were followed in aeration, nutrients and

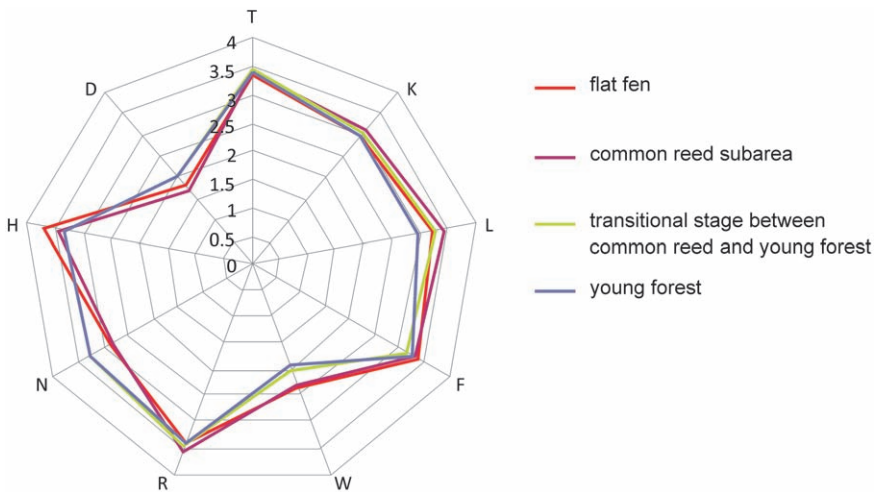


Fig. 3. Diagram of ecological values according to Landolt for the year 2007. (F – moisture, L – light, T – temperature, W – moisture variability, K – continentality, R – reaction, N- nutrients, H -humus and D – aeration).

moisture by reed stand. The forest differs from others, with a lower ecological value for light (Fig. 3).

After the removal of overgrowing woody species during the winter period of 2007/2008, the floristic composition changed very little. However, broad leaved herbaceous species of open habitats, like *Eupatorium cannabinum*, *Artemisia vulgaris*, *Cirsium oleraceum*, *Epilobium hirsutum*, *E. parviflorum*, *Lythrum salicaria*, *Mentha longifolia* etc., spread after the cutting of the woody species. Characteristic fen species *Eriophorum latifolium* and *Parnassia palustris* were found only at the edge of the stand of young forest. It can be concluded that (re)colonization was not possible in such a short period, especially because only the woody plants were removed and only once, and no multiple mowing during the year was organized.

DISCUSSION

From a comparison the total species number found on subarea 1 (fen), with the number of species of the same association *Eriophoro latifolio-Caricetum panicae* recorded earlier on Žumberak, (10 relevés by VRBEK, 2005) and Plitvička jezera, (8 relevés by TRINAJSTIĆ, 2002), it is obvious that the species number varies only slightly in the different areas: Jarak 74, Žumberak 85, and Plitvička jezera 75 species. However, the average number of species in relevés is 26. This difference between the total number of recorded species and average number found on particular sites indicates the high variability in habitat conditions where the researched association is found. Although it appears as an association with highly specialized species, because of the many rare, endangered and protected characteristic species, numerous accompanying species with different niches are found here.

The presence of 15 (6.7 %) red-listed species and 59 (26.5 %) protected, shows the importance of the conservation of this site. Out of these numbers, 23 protected and

strictly protected, and 7 species with some endangerment status are found only in the fen area. Some of the found species, like *Erica herbacea*, *Viburnum lantana* and *Populus tremula* are protected species, but they can be classified as elements of succession, because they do not belong to the fen flora and are overgrowing the rich fen.

In a similar association studied in Plitvička jezera (TRINAJSTIĆ, 2002), 16 protected or strictly protected species, and 6 red listed species were found. In previous research of Jarak VRBEK (2005) recorded 16 protected or strictly protected and 5 red-listed species.

This difference in the number of protected and red-listed species is presumably a consequence of the different durations of the research activities. VRBEK (2005) and TRINAJSTIĆ (2002) recorded the vegetation only once, while our research was executed during two vegetation seasons. However, this higher number of protected and strictly protected species indicates the importance of the protection of this habitat. It is also important to try to enlarge the fen surface to neighbouring successional vegetation units by cutting and removing woody vegetation and regular cutting of the reed.

The diagram of ecological values (Fig. 3) shows the highest variance in ecological value for humus, which is completely expected, because fens have a large amount of organic substance (COOPER & WOLF, 2006; KIVIAT *et al.*, 2010).

The second highest variance on the diagram (Fig. 3) is connected to the higher amount of nutrients in young forest (subarea 4), which is the advanced stage in the fen succession. In order to remove excess nutrients, regular removal of woody and herbaceous plants, which accelerate succession, should be organized in all subareas. Woody plants should be regularly removed from all subareas during the late autumn or winter time. Common reed should be completely removed during autumn or winter time, or at least regularly cut in May, at its most sensitive stage. Herbaceous plants that accelerate succession, especially in subareas 3 and 4, should be cut and taken out at least three times a year (comp. HUTTER *et al.*, 2002). The fen area should be cut in late autumn. This will enable fen plants to recolonise stands under succession, enabling the area of this rare and endangered habitat to increase.

CONCLUSION

Flat fens are critically endangered habitats in Croatia, so the flat fen along the Jarak stream should be protected and managed to prevent present succession to reed beds and forest. In the research area 222 plant species were found, out of which 26.5 % species are protected and 6.7% have some endangerment status according to IUCN categorization. Measures for protection of this site are primarily the removal of overgrowing woody and herbaceous vegetation. These actions should be regularly conducted and should provide not only continuation of the existing state, but could also assure the enlargement of the rich fen area.

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