

THE FLORISTIC COMPOSITION OF GRASSLAND OF THE OPEKA ARBORETUM (VINICA, NW CROATIA)

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During the vegetation seasons 2008 and 2009 the floristic composition of the grasslands of Opeka Arboretum was surveyed. In total, 276 plant taxa were found, and 223 taxa were recorded for the first time for the investigated area. The taxa were classified into 66 families, the *Poaceae* (10.51%), *Asteraceae* (6.52%) and *Lamiaceae* (6.16%) families appearing among them with a relatively high number of taxa. In the Arboretum Opeka, 12 red-listed native herbaceous plant taxa were found. There were also 36 species protected and 9 species strictly protected by law. Non-indigenous plants made up 14.13% of the flora of the investigated area: 6 archaeophytes, 6 neophytes, 28 cultivated species and 8 of them were invasive alien species. Floristic composition of native herbaceous vegetation in Opeka Arboretum should be maintained by regular mowing of grasslands.

Key words: vascular flora, grassland, Opeka Arboretum, north-western Croatia

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Tijekom vegetacijskih sezona 2008. i 2009. istraživana je floristički sastav travnjaka Arboretuma Opeka. Utvrđeno je 276 biljnih svojiti, a 223 svojite su zabilježene prvi put za istraživano područje. Svojite su svrstane u 66 porodica, a među njima su s relativno visokim brojem svojiti porodice *Poaceae* (10,51%), *Asteraceae* (6,52%) i *Lamiaceae* (6,16%). U Arboretumu Opeka je zabilježeno 12 svojiti autohtonih zeljastih biljaka s Crvenog popisa, 36 vrsta zaštićenih i 9 vrsta strogo zaštićenih vrsta. Alohodne biljke čine 14,13% flore istraživanog područja: 6 arheofita, 6 neofita, 28 kultiviranih vrsta i 8 invazivnih stranih vrsta. Floristički sastav prirodne zeljaste vegetacije u Arboretumu Opeka trebao bi biti održavan redovitim košnjom travnjaka.

Gljučne riječi: vaskularna flora, travnjak, Arboretum Opeka, sjeverozapadna Hrvatska

INTRODUCTION

Opeka Arboretum is a park architectural monument situated in the north-west part of Varaždin County in the Vinica district, about 20 kilometres from the town of Varaždin (Fig. 1). The total area of the arboretum is 64 ha and it is situated on the hills of Haloze which gradually turn into the plain land of Podravina (ŠČITAROCI, 2005). The arboretum can be divided into two parts: lower plain land is a cultivated garden in the informal or English style, while the upper part presents a natural forest of sessile oak (*Quercus petraea* (Matt.) Liebl.) and chestnut (*Castanea sativa* Mill.) arranged as park-forest (POSAVEC *et al.*, 2012). Opeka Castle is situated between natural forest and cultivated garden. The first castle was built there in the late 17th century, but the present building originates from the 18th century when the Drašković family built a new castle. In the past time this regi-



Fig. 1. The location of the Opeka Arboretum.

on was also known for the brickyards (opeka = brick). The clay pit was turned into a lake, which has recently also become a part of the arboretum complex (ŠĆITAROCI, 2005).

The beauty and importance of Opeka Arboretum was recognized in 1947 when the castle of the Drašković family and its surroundings were proclaimed a protected natural rarity. In 1961 Opeka Arboretum was protected by law as the park architectural monument (BENKO *et al.*, 2006).

The arboretum area has a temperate humid climate with a warm summer (Cfa) according to Köppen's climate classification (ŠEGOTA & FILIPČIĆ, 2003). According to the results of measurements of the meteorological station in Varaždin for the period 1998–2008 the average annual temperature is 11.2 °C and the average annual precipitation is 776.0 mm/m².

The dominating geological substratum of the investigated area is limestone and it is covered with various soil types. According to the pedological map of the county the most important are hydromorphic (amphigley, hypogley, semigley) and automorphic (rendzinas, black and brown soils) types of soils (ANONYMOUS?).

Previous botanical research in Opeka Arboretum considered mostly dendroflora (ŠILER, 1987; BENKO *et al.*, 2006). The first research was made in 1947 when the arboretum was also proclaimed a protected natural rarity. Two hundred and fifty different taxa of trees and bushes (altogether 10158 plant individuals: 2621 of deciduous and 7180 of softwood trees and shrubs) were registered. In 1963 182 taxa of dendroflora (altogether 14016 plant individuals: 4927 deciduous and 8651 softwood trees and shrubs) were found in the arboretum. The last inventory of dendroflora was made 2006 and 2861 plant individuals of deciduous trees and shrubs) were found (BENKO *et al.*, 2006).

The grassland of Opeka Arboretum has not hitherto been systematically researched. The only accessible data referring to the grassland of this locality are those from ŠILER (1987) who investigated the entomofauna of the arboretum. This author identified her-

baceous vegetation as the association *Arrhenatheretum elatioris* Br.-Bl. 1925 and made records of 27 of the most common weed, grass and legume plant taxa (ŠILER, 1987).

In the last decades, the grasslands of the arboretum have not been continuously mown, and as a consequence the woody and herbaceous species have partly overgrown the grassland and the composition of the grassland community has changed. The aim of this research was to define floristic composition of the grassland in the Arboretum and to suggest management of the protected area.

MATERIALS AND METHODS

The researched grassland area is roughly quadrangular, approx 1.4 ha, and is situated in the central part of the Opeka Arboretum (Fig. 2). The central position and the major

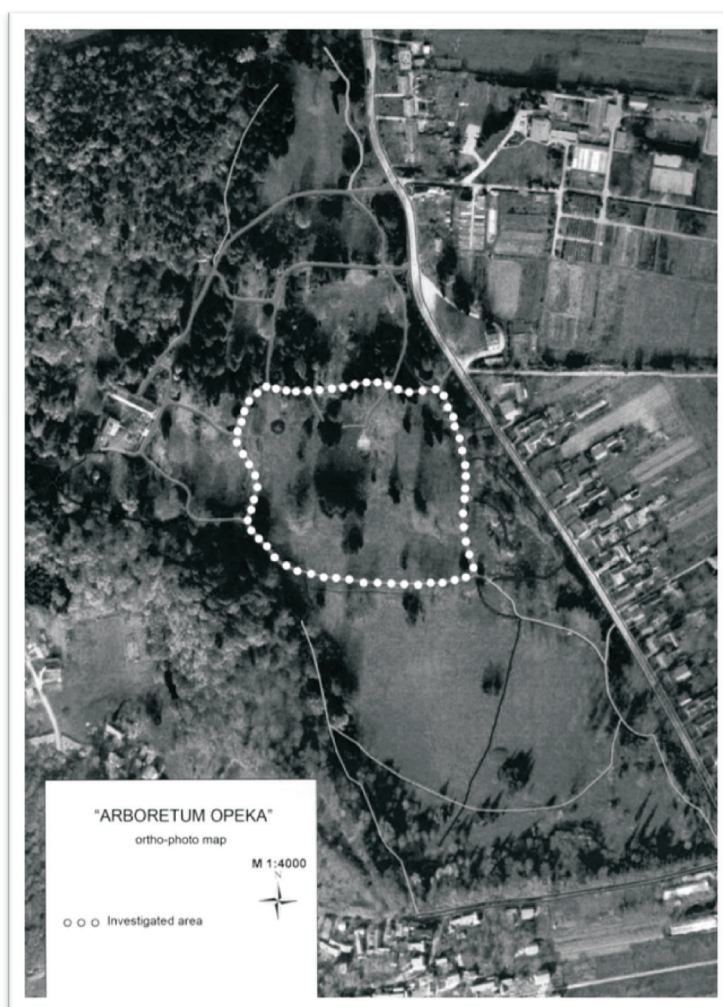


Fig. 2. Investigated area of the Opeka Arboretum.

anthropogenic influence due to the proximity of the castle and the lake were the main reasons for the choice of this part of arboretum as the beginning of floristic research which should expand in the future to all the grassland area in the Opeka Arboretum. Grassland vegetation dominates but there are solitaire trees and shrubs and also groups of them in the area.

The floristic survey was performed during the vegetation seasons 2008 and 2009. For identification of the plant species standard keys were used: ALEGRO (2003 a,b,c); ALEGRO *et al.* (2003); BOGDANOVIĆ (2003); DOMAC (2002); EGGENBERG & MÖHL (2007); JÁVORKA & CSAPODY (1991); LAUBER & WAGNER (2007); MARTINČIĆ (2007); MIŠIĆ & LAKUŠIĆ (1990); ROTHMALER (1995); RUSSEL & CUTLER (2004); ŠILIC (1990); TUTIN *et al.* (1964–1993). Some plants were compared with herbarium specimens in *Herbarium Croaticum* of the Department of Botany, Faculty of Science, University of Zagreb (ZA).

The nomenclature used follows NIKOLIĆ (2012) and ERHARDT *et al.* (2000). Families, genera, species and subspecies in the list of flora are given in alphabetical order within the higher systematic taxa.

Life forms categories of Raunkier's system (RAUNKIER, 1934) were interpreted according to ELLENBERG *et al.* (1991) and OBERDORFER (2001): **T** – Therophyta, **G** – Geophyta, **H** – Hemicryptophyta, **C** – Chamaephyta, **P** – Phanerophyta and **N** – Nanophanerophyta.

Chorological types follow the system proposed by HORVATIĆ (1963) and HORVATIĆ *et al.* (1967/1968), and consider also ALEGRO *et al.* (2006), MARTINKO (2009), ŠEGULJA *et al.* (1998), TOMAŠEVIĆ (1998) and VLAHOVIĆ (2007):

- 1 – Mediterranean floral element
- 2 – Illyrian-Balkanic floral element
- 3 – South European floral element
- 4 – East European-Pontic floral element
- 5 – Central European floral element
- 6 – European floral element
- 7 – Euroasian floral element
- 8 – Circum-Holarctic plants
- 9 – Widespread plants
- 10 – Cultural & adventitious plants

Ecological indicatory values were given according to ELLENBERG *et al.* (1991): **R** – soil reaction, **T** – temperature, **L** – light value, **N** – nutritional value of the soil and **F** – soil moisture.

The red listed taxa (NIKOLIĆ & TOPIĆ, 2005; 2012) were quoted and marked with corresponding IUCN category: Vulnerable (**VU**), Near Threatened (**NT**), Least Concern (**LC**) and Data Deficient (**DD**).

Species protected by the Croatian law (ANONYMOUS, 2009) are denoted as “Z” (protected) and “SZ” (strictly protected).

Non-indigenous taxa are presented according to NIKOLIĆ (2012) and marked with symbol * and invasive alien species were interpreted according to BORŠIĆ *et al.* (2008), MIŠIĆ *et al.* (2008) and NIKOLIĆ (2012): arh – archaeophytes, neo – neophytes, inv – invasive alien species, kult – cultivated plants. Origins of the alien species were also quoted: Af – Africa, Am – America, Az – Asia, Eu – Europe.

Plant species recorded during the previous researches and publications were marked in the list of flora by symbols: ¹ for ŠILIC (1987) and ² for BENKO *et al.* (2006).

RESULTS AND DISCUSSION

The list of flora of the Opeka Arboretum

PTERYDOPHYTA**EQUISETACEAE**

Equisetum arvense L. (G; 8; Rx; Tx; L6; F6; N3)

ASPIDIACEAE

Athyrium filix-femina (L.) Roth (H; 8; Rx; Tx; L3; F7; N6)

DRYOPTERIDACEAE

Dryopteris filix-mas (L.) Schott (H; 9; R5; Tx; L3; F5; N6; Z)

SPERMATOPHYTA – CONIFEROPHYTINA**CUPRESSACEAE**

Juniperus horizontalis Moench² * (N; 10; R?; T?; L?; F?; N?; kult; Az)

Juniperus sp. ² (N; ?)

Thuja plicata Donn ex D. Don ² * (P; 10; R?; T?; L?; F?; N?; kult; Am)

PINACEAE

Abies nordmanniana (Steven) Spach ² * (P; 10; R?; T?; L?; F?; N?; kult; Eu)

Picea abies (L.) H. Karst.² (P; 7; Rx; T3; L5; Fx; Nx)

Picea abies (L.) H. Karst. ‚Inversa‘ ² * (P; 10; Rx; T3; L5; Fx; Nx; kult; Eu)

Picea jezoensis (Siebold et Zucc.) Carrie ² * (P; 10; R?; T?; L?; F?; N?; kult; Az)

Picea obovata Ledeb.² * (P; 10; R?; T?; L?; F?; N?; kult, Az, Eu)

Picea omorika (Pančić) Purk.² * (P; 10; R?; T?; L?; F?; N?; kult; Eu)

Pinus nigra J.F. Arnold ² (P; 3; R9, T7, L7; F3, N2)

Pinus sylvestris L. ² (P; 7; Rx; Tx; L7; Fx; Nx)

Pseudotsuga menziesii (Mirb.) Franco ² * (P; 10; R?; T?; L?; F?; N?; kult; Am)

Tsuga canadensis (L.) Carriere ² * (P; 10; R?; T?; L?; F?; N?; kult; Am)

TAXACEAE

Taxus baccata L.² (P; 7; R7; T5; L4; F5; Nx; VU; SZ)

SPERMATOPHYTA – MAGNOLIOPHYTINA**MAGNOLIATAE****ACERACEAE**

Acer campestre L. ² (P; 6; R7; T6; L5; F5; N6)

Acer palmatum Thunb. Ex Murray ‚Atropurpureum‘ ² * (P; 10; R?; T?; L?; F?; N?; kult; Az)

Acer platanoides L. ² (P; 6; Rx; T6; L4; Fx; Nx)

Acer pseudoplatanus L. ‚Atropurpureum‘ ² * (P; 10; Rx; Tx; L4; F6; N7; kult)

APIACEAE

- Aegopodium podagraria* L. (H; 7; R7; T5; L5; F6; N8)
Astrantia major L. (H; 7; R8; T4; L6; F6; N5)
Chaerophyllum temulum L. (T; 6; Rx; T6; L5; F5; N8)
Daucus carota L. (H; 7; Rx; T6; L8; F4; N4)
Hacquetia epipactis (Scop.) DC. (H; 2; R?; T?; L?; F?; N?)
Heracleum sphondylium L. (H; 7; Rx; T5; L7; F5; N8)
Pastinaca sativa L. (H; 7; R8; T6; L8; F4; N5)
Pimpinella major (L.) Huds. (H; 6; R7; T5; L7; F5; N7; Z)
Pimpinella saxifraga L. (H; 7; Rx; Tx; L7; F3; N2; Z)
Sanicula europaea L. (H; 9; R8; T5; L4; F5; N6; Z)
Torilis japonica (Houtt.) DC. (T; 7; R8; T6; L6; F5; N8)

APOCYNACEAE

- Vinca minor* L. (C; 5; R7; T6; L4; F5; N8; Z)

ARALIACEAE

- Hedera helix* L. (P; 6; Rx; T5; L4; F5; Nx)

ARISTOLOCHIACEAE

- Asarum europaeum* L. (H; 7; R7; T6; L3; F5; N6; Z)

ASTERACEAE

- Achillea millefolium* L. ¹ (H; 9; Rx; Tx; L8; F4; N5)
Arctium lappa L. (H; 7; R7; T6; L9; F5; N9)
Artemisia vulgaris L. (C; 9; Rx; T6; L7; F6; N8)
Bellis perennis L. (H; 5; Rx; Tx; L8; F5; N6)
Centaurea subjacea (Beck) Hayek (H; 7; R8; T7; L8; F3; N2)
Chamomilla recutita (L.) Rauschert (T; 9; R5; T6; L7; F5; N5)
Cirsium arvense (L.) Scop (G; 7; Rx; T5; L8; Fx; N7)
Cirsium oleraceum (L.) Scop. (H; 7; R8; Tx; L6; F7; N5)
Conyza canadensis (L.) Cronquist * (T; 10; Rx; T6; L8; F4; N5, inv; neo)
Erigeron annuus (L.) Pers. * (H; 10; Rx; T6; L7; F6; N8; inv; neo)
Galinsoga ciliata (Raf.) S.F.Blake * (T; 10; R6; T6; L7; F4; N7, inv; neo)
Leontodon autumnalis L. (H; 7; R5; Tx; L7; F5; N5)
Leucanthemum vulgare Lam. ¹ (H; 7; Rx; Tx; L7; F4; N3)
Rudbeckia lacinata L.* (H; 10; R7; T6; L7; F8; N7; inv, neo)
Solidago gigantea Aiton * (H; 10; Rx; T6; L8; F6; N7; inv; neo)
Solidago virgaurea L. (H; 7; Rx; Tx; L5; F5; N4)
Telekia speciosa (Schreb.) Baumg. (H; 5; R7; T6; L7; F7; N7)
Tussilago farfara L. (G; 7; R8; Tx; L8; F6; Nx)

BERBERIDACEAE

- Berberis thunbergii* DC. ‚Atropurpurea’ ² * (N; 10; R?; T?; L?; F?; N?; kult, Az)
Mahonia aquifolium (Pursh) Nutt. ² * (N; 10; R?; T?; L?; F?; N?; kult, Am)

BETULACEAE

Coryllus avellana L. ² (P; 6; Rx; T5; L6; Fx ;N5)

BORAGINACEAE

Myosotis arvensis (L.) Hill (T; 7; Rx; T6; L6; F5; N6)

Myosotis sparsiflora Pohl (T; 7; R7; T6; L5; F6; N7)

Pulmonaria officinalis L. (H; 6; R8; T6; L5; F5; N6)

Symphytum officinale L. (H; 6; Rx; T6; L7; F8; N8)

Symphytum tuberosum L. (G; 3; R?; T?; L?; F?; N?; Z)

BRASSICACEAE

Alliaria petiolata (M.Bieb) Cavara et Grande (H; 7; R7; T6; L5; F5, N9; Z)

Capsella bursa-pastoris (L.) Medik. * (H; 10; Rx; Tx; L7; F5; N6; arh)

Cardamine bulbifera (L.) Crantz (G; 5; R7; T5; L3; F5; N6)

Cardamine impatiens L. (H; 7; R7; Tx; L5; F6; N8)

Cardamine pratensis L. (H; 9; Rx; Tx; L4; F9; Nx)

Sisymbrium officinale (L.) Scop. (T; 9; Rx; T6; L8; F4; N8)

BUXACEAE

Buxus sempervirens L. ² * (N; 10; R8; T8; L5; F4; N4; kult; Eu, Af, Az)

CAMPANULACEAE

Campanula persicifolia L. (H; 7; R8; T5; L5; F4; N3)

Campanula trachelium L. (H; 7; R8; Tx; L4; F6; N8)

CAPRIFOLIACEAE

Sambucus nigra L. (P; 6; Rx; T5; L7; F5; N9)

CARYOPHYLLACEAE

Cerastium brachypetalum Pers (T; 3, R8; T7; L9; F4; N2)

Cerastium glomeratum Thuill (T; 9; R5; T5; L7; F5; N5)

Cerastium sylvaticum Waldst. et Kit. (C; 3; R?; T?; L?; F?; N?)

Lychmis flos-cuculi L. ¹ (H; 7; Rx; T5; L7; F7; Nx)

Silene dioica (L.) Clairv. (H; 7; R7; Tx; Lx; F6; N8)

Silene latifolia Poir. ssp. *alba* (Mill.) Greuter et Bourdet (H; 7; R?; T?; L?; F?; N?)

Silene noctiflora L. (T; 7; R8; T6; L7; F3; N5; DD; SZ)

Stellaria graminea L. (H; 7; R4; Tx; L6; F4; N3)

Stellaria holostea L. (H; 7; R6; T6; L5; F5; N5)

Stellaria media (L.) Vill. (T; 9; R7; Tx; L6; Fx; N8)

CHENOPODIACEAE

Chenopodium album L. (T; 9; Rx; Tx; Lx; F4; N7)

Chenopodium polyspermum L. (T; 7; Rx; T6; L6; F6; N8)

CICHORIACEAE

Aposeris foetida (L.) Less (H; 3; R6; T4; L4; F5; N5)

Crepis biennis L. (H; 5; R6; T5; L7; F5; N5)

- Hieracium caespitosum* x *piloseloides* (H; ?)
Hieracium of. *umbellatum* L. (H; 9; R4; T6; L6; F4; N2)
Hypochaeris radicata L. (H; 3; R4; T5; L8; F5; N3)
Lactuca sativa L. * (T; 10; R2; T?; L?; F?; N?; kult.; Az, Af)
Lapsana communis L. * (T; 10; Rx; T6; L5; F5; N7; arh)
Mycelis muralis (L.) Dumort (H; 7; R5; T6; L4; F5; N6)
Picris hieracioides L. (H; 7; R8; Tx; L8; F4; N4)
Sonchus oleraceus L. (T; 9; R8; T6; L7; F4; N8)
Taraxacum officinale Weber ¹ (H; 9; Rx; Tx; L7; F5; N7)
Tragopogon pratensis L. ssp. *orientalis* (L.) Čelak. (H; 7; R7; Tx; L7; F5; N6)

CONVOLVULACEAE

- Calystegia sepium* (L.) R. Br. (H; 9; R7; T6; L8; F6; N9)
Calystegia silvatica (Kit.) Griseb. (G; 3; R?; T?; L?; F?; N?)

CORNACEAE

- Cornus mas* L. ² (P; 6; R8; T7; L6; F4; N4)
Cornus sp. (P, ?)

CORYLACEAE

- Carpinus betulus* L. ² (P; 6; Rx; T6; L4; Fx; Nx)

DIPSACACEAE

- Knautia arvensis* (L.) Coult. (H; 7; Rx; T6; L7; F4; N4)
Knautia drymeia Heuff. (H; 2; R?; T?; L?; F?; N?)

EUPHORBIACEAE

- Euphorbia angulata* Jacq. (H; 3; R?; T?; L?; F?; N?)
Euphorbia dulcis L. (H; 5; R8; T5; L4; F5; N5)
Euphorbia esula L. (H; 7; R8; T6; L8; F4; Nx)
Euphorbia verrucosa L. (H; 3; R9; T6; L8; F3; N3)

FABACEAE

- Lathyrus pratensis* L. (H; 7; R7; T5; L7; F6; N6)
Lathyrus venetus (Mill.) Wohlf (G; 4; R8; T3; L8; F5; N4)
Lotus corniculatus L. ¹ (H; 9; R7; Tx; L7; F4; N3)
Lupinus polyphylus Lindl. * (H; 10; R4; T5; L7; F5; Nx; kult; Am)
Medicago lupulina L. ¹ (T; 9; R8; T5; L7; F4; Nx)
Trifolium arvense L. * (T; 10; R2; T6; L8; F3; N1; arh)
Trifolium dubium Sibth. (T; 3; R6; T6; L6; F5; N5)
Trifolium pratense L. ¹ (H; 7; Rx; Tx; L7; Fx; Nx)
Trifolium repens L. ¹ (H; 9; R6; Tx; L8; F5; N6)
Vicia cracca L. (H; 7; Rx; T5; L7; F5; Nx)
Vicia grandiflora Scop. (T; 4; Rx; T7; L7; F4; Nx)
Vicia oroboides Wulfen (H; 2; R8; T5; L6; F5; N?)

Vicia segetalis L. ssp. *segetalis* (Thuill.) Corb. (T; 6, R?; T?; L?; F?; N?)

Vicia sepium L. (H; 5; R7; T6; L4; F5; N8)

Wisteria sinensis (Sims) Sweet²* (P; 10; R?; T?; L?; F?; N?; kult; Az, Am)

FAGACEAE

Fagus sylvatica L.² (P; 5; Rx; T5; L3; F5; Nx)

Quercus petraea (Matt) Liebl.² (P; 5; Rx; T6; L6; F5; Nx)

Quercus robur L.² (P; 6; Rx; T6; L7; Fx; Nx)

FUMARIACEAE

Corydalis bulbosa (L.) Dc. (G; 5; R?; T?; L?; F?; N?; Z)

GERANIACEAE

Geranium dissectum L. (T; 10; R8; T6; L6; F5; N5)

Geranium phaeum L. (H; 3; R6; Tx; L6; F5; N5)

Geranium robertianum L. (H; 9; Rx; Tx; L5; Fx; N7; Z)

GINKGOACEAE

Ginkgo biloba L.²* (P; 10; R?; T?; L?; F?; N?; kult; Az)

HAMAMELIDACEAE

Liquidambar styraciflua L.²* (P; 10; R?; T?; L?; F?; N?; kult; Am)

HIPPOCASTANACEAE

Aesculus hippocastanum L.² (P; 10; R?; T?; L?; F?; N?; kult; arh; Eu)

HYDRANGEACEAE

Philadelphus coronarius L.²* (N; 10, R?; T?; L?; F?; N?; kult; Eu)

JUGLANDACEAE

Pterocarya fraxinifolia (Lam.) Spach²* (P; 10; R?; T?; L?; F?; N?; kult; Eu)

Juglans regia L.* (P; 10; R7; T8; L6; F7; N6; kult; Az, Eu)

LAMIACEAE

Ajuga genevensis L. (H; 7; R7; Tx; L8; F3; N2)

Ajuga reptans L. (H; 7; R6; Tx; L6; F6; N6)

Betonica officinalis L. (H; 6; Rx; T6; L7; Fx; N3)

Clinopodium vulgare L. (H; 9; R7; Tx; L7; F4; N3)

Galeopsis pubescens Besser (T; 5; Rx; T5; L7; F5; N6)

Galeopsis speciosa Mill (T; 6; Rx; Tx; L7; F5; N8)

Glechoma hirsuta Waldst. et Kit. (H; 3, R?; T?; L?; F?; N?)

Lamium galeobdolon (L.) L. (C; 6; R7; T5; L3; F5; N5)

Lamium galeobdolon (L.) L. ssp. *montanum* (Pers.) Hayek (C; 6; R7; T4; L3; F4; N6)

Lamium maculatum L. (H; 7; R7; Tx; L5; F6; N8)

Lamium orvala L. (H; 2, R?; T?; L?; F?; N?)

Mentha arvensis L. (H; 8; Rx; Tx; L7; F8; Nx)

Prunella vulgaris L. (H; 9; R7; T6; L6; F5; N5)

Salvia glutinosa L. (H; 7; R7; T5; L4; F6; N7)

Salvia pratensis L. ¹ (H; 6; R8; T6; L8; F3; N4)

Stachys sylvatica L. (H; 7; R7; Tx; L4; F7; N7)

Thymus pulegioides L. ssp. *montanus* (Benth.) Ronniger (C; 7; R?; T?; L?; F?; N?)

LORANTHACEAE

Viscum album L. (H; 7; Rx; T6; L7; Nx)

OLEACEAE

Fraxinus excelsior L. ² (P; 3; R7; T5; L4; Fx; N7)

Fraxinus excelsior L. 'Pendula' ² * (P; 10; R7; T5; L4; Fx; N7, kult)

ONAGRACEAE

Circaea luteiana L. (G; 9; R7; T5; L4; F6; N7)

Epilobium lanceolatum Sebast et Mauri (H; 3; R3; T7; L8; F4; N3)

Epilobium parviflorum Schreber (H; 7; R8; T5; L7; F9; N6)

OXALIDACEAE

Oxalis acetosella L. (H; 9; R4; Tx; L1; F5; N6; Z)

PAPAVERACEAE

Chelidonium majus L. (H; 9; Rx; T6; L6; F5; N8)

PHYTOLACCACEAE

Phytolacca americana L. * (H; 10; R?; T?; L?; F?; N?; kult; inv; Am)

PLANTAGINACEAE

Plantago lanceolata L. ¹ (H; 9; Rx; Tx; L6; Fx; Nx)

Plantago major L. (H; 9; Rx; Tx; L8; F5; N6)

Plantago media L. (H; 7; R7; Tx; L7; F4; N3)

PLATANACEAE

Platanus x hispanica Münchh. ² * (P; 10, R?; T?; L?; F?; N?; kult; Am)

POLYGONACEAE

Polygonum aviculare L. (T; 9; Rx; T6; L7; F4; N6)

Polygonum persicaria L. * (T; 10; R7; T6; L6; F5; N7)

Rumex acetosa L. (H; 9; Rx; Tx; L6; Fx; N6)

Rumex conglomeratus Murray (H; 9; Rx; T6; L8; F7; N8)

Rumex obtusifolius L. (H; 7; Rx; T5; L7; F6; N9)

PRIMULACEAE

Cyclamen purpurascens Mill. (G; 2; R9; T6; L4; F5; N5; NT; Z)

Lysimachia nummularia L. (C; 6; Rx; T6; L4; F6; Nx)

Lysimachia vulgaris L. (H; 7; Rx; Tx; L6; F8; Nx)

Primula vulgaris Huds. (H; 9; R7; T5; L6; F5; N5)

RANUNCULACEAE

- Actaea spicata* L. (H; 7; R6; T5; L3; F5; N7; Z)
Anemone nemorosa L. ¹(G; 9; Rx; Tx; Lx; F5; Nx; Z)
Clematis vitalba L. (P; 5; R7; T6; L7; F5; N7)
Helleborus odoratus Waldst. et Kit. Ex Wild (H; 4; R?; T?; L?; F?; N?; Z)
Ranunculus acris L. (H; 9; Rx; Tx; L7; F6; Nx; Z)
Ranunculus ficaria L. (G; 6; R7; T5; L4; F6; N7; Z)
Ranunculus lanuginosus L. (H; 5; R7; T6; L3; F6; N7; Z)
Ranunculus repens L. (H; 9; Rx; Tx; L6; F7; Nx, Z)

ROSACEAE

- Agrimonia eupatoria* L. (H; 8; R8; T6; L7; F4; N4; Z)
Crataegus sp. (P; ?)
Filipendula vulgaris Moench (H; 7; R8; T6; L7; F3; N2)
Fragaria vesca L. (H; 9; Rx; Tx; L7; F5; N6)
Geum urbanum L. (H; 9; Rx; T5; L4; F5; N7; Z)
Potentilla micrantha Ramond ex Dc. (H; 3; R8; T7; L5; F4; N4)
Potentilla reptans L. (H; 9; R7; T6; L6; F6; N5)
Pyracantha coccinea M. Roem ² * (N; 10; R?; T?; L?; F?; N?; kult; Eu)
Rosa arvensis Huds. (C; 5; R7; T5; L5; F5; N5; Z)
Rubus caesius L. (C; 6; R8; T5; L6; Fx; N7)

RUBIACEAE

- Cruciata glabra* (L.) Ehrend. (H; 9; R7; T6; L7; F5; N5)
Cruciata laevipes Opiz (H; 7; R6; T5; L7; F6; N7)
Galium album Mill. (H; 6; R7; Tx; L7; F5; Nx)
Galium aparine L. (T; 9; R6; T6; L7; Fx; N8)
Galium laevigatum L. (T; 3; R?; T?; L?; F?; N?)
Galium mollugo L. (H; 7; R7; T6; L7; F4; N?)
Galium odoratum (L.) Scop. (H; 7; R6; T5; L2; F5; N5; Z)
Galium parisiense L. (T; 9; R5; T7; L8; F3; N2)
Galium verum L. (H; 9; R7; T6; L7; F4; N3; Z)

SALICACEAE

- Populus alba* L. (P; 7; R8; T7; L5; F7; N6)

SAXIFRAGACEAE

- Chrysosplenium alternifolium* L. (H; 7; R7; T4; L4; F8; N5)

SCROPHULARIACEAE

- Lathraea squamaria* L. (G; 7; R7; T5; L3; F6; N6)
Scrophularia umbrosa Dumort. (H; 7; R8; T6; L7; F9; N7; DD)
Verbascum nigrum L. (H; 6; R7; T5; L7; F5; N7; Z)
Veronica arvensis L. (T; 7; R?; T?; L?; F?; N?)

- Veronica chamaedrys* L. (C; 7; Rx; Tx; L6; F5; Nx)
Veronica persica Poir. * (T; 10; R7; Tx; L6; F5; N7; neo; inv)
Veronica serpyllifolia L. (H; 9; R5; Tx; Lx; F6; Nx)

SOLANACEAE

- Solanum nigrum* L. (T; 9; R7; T6; L7; F5; N8; Z)

TILIACEAE

- Tilia cordata* Mill. ² (P; 6; Rx; T5; L5; F5; N5)
Tilia platyphyllos Scop. ² (P; 5; Rx; T6; L4; F6; N7)

URTICACEAE

- Urtica dioica* L. (H; 9; R7; Tx; Lx; F6; N8)

VALERIANACEAE

- Valeriana dioica* L. (H; 6; R5; Tx; L7; F8; N2)

VIOLACEAE

- Viola alba* Beser (H; 1; R7; T7; L5; F5; N6)
Viola odorata L. (H; 6; Rx; T6; L5; F5; N8; Z)
Viola reichenbachiana Jord. ex Boreau (H; 7; R7; Tx; L4; F5; N6)
Viola riviniana Rchb. (H; 6; R4; Tx; L5; F4; Nx)

VITACEAE

- Parthenocissus quinquefolia* (L.) Planchon * (C; 10; R?; T?; L?; F?; N?; kult; inv; Am)

LILIATAE

AMARYLLIDACEAE

- Galanthus nivalis* L. (G; 7; R7; T6; L5; F6; N7; LC; Z)
Leucojum vernum L. (G; 6; R7; T5; L6; F6; N8; Z)
Narcissus cv. (G; 10)

CYPERACEAE

- Carex digitata* L. (H; 7; Rx; Tx; L3; F5; N4)
Carex divulsa Stokes (H; 9; R5; T6; L6; F5; N6)
Carex flacca L. (G; 9; R8; Tx; L7; F6; Nx)
Carex hirta L. (G; 7; Rx; T6; L7; F6; N5)
Carex sylvatica Huds. (H; 6; R6; T5; L2; F5; N5)
Carex vulpina L. (H; 9; R5; T6; L9; F8; N5)

DIOSCOREACEAE

- Tamus communis* L. (G; 3; R8; T8; L6; F5; N5; Z)

JUNCACEAE

- Luzula campestris* (L.) DC. (H; 9; R3; Tx; L7; F4; N2)
Luzula forsteri (Sm.) DC. (H; 3; R5; T8; L4; F4; N2)
Luzula luzuloides (Lam.) Dandy et Wilmot (H; 5; R3; Tx; L4; F5; N4)

LILIACEAE

- Allium ursinum* L. (G; 5; R7; Tx; L2; F6; N8)
Erythronium dens-canis L. (G; 3; R2; T?; L?; F?; N?; Z)
Fritillaria meleagris L. (G; 1; R7; T7; L8; F8; N5; VU; SZ)
Gagea lutea (L.) Ker Gawl. (G; 7; R7; T5; L4; F6; N7)
Lilium martagon L. (G; 7; R7; Tx; L4; F5; N5; VU; SZ)
Paris quadrifolia L. (G; 7; R7; Tx; L3; F6; N7; Z)
Polygonatum multiflorum (L.) All. (T; 9; Rx; T6; L7; F4; N6; Z)
Polygonatum odoratum (Mill.) Druce * (T; 10; R7; T6; L6; F5; N7; Z; arh)
Ruscus hypoglossum L. (C; 1; R?; T?; L?; F?; N?; NT; Z)
Scilla bifolia L. (G; 3; R7; T7; L5; F7; N6)
Veratrum album L. (H; 7; R7; T4; L7; Fx; N6; DD; SZ)

ORCHIDACEAE

- Cephalanthera damasonium* (Mill.) Druce (G; 3; R7; T6; L3; F4; N4; NT; SZ)
Epipactis helleborine (L.) Crantz. (G; 7; R7; T5; L3; F5; N5; SZ)
Listera ovata (L.) R.Br. (G; 7; R7; Tx; L6; F6; N7; SZ)
Platanthera bifolia (L.) Rich (G; 7; R7; Tx; L6; F5; Nx; VU; SZ)

POACEAE

- Agrostis gigantea* Roth (H; 8; R7; T5; L7; F8; N6)
Alopecurus pratensis L. (H; 7; R6; Tx; L6; F6; N7)
Anthoxanthum odoratum L. (H; 7; R5; Tx; Lx; Fx; Nx)
Arrhenatherum elatius (L.) P. Beauv. Ex J.Presl et C. Presl¹ (H; 6; R7; T5; L8; F5; N7)
Avenula pubescens (Dumort.) Dumort. (H; 7; Rx; Tx; L5; Fx; N4)
Briza media L. (H; 7; Rx; Tx; L8; Fx; N2)
Bromus arvensis L. * (T; 10; R8; T6; L6; F4; N4; arh)
Bromus erectus Huds. ssp. *erectus* (H; 9; Rx; T5; L8; F3; N3)
Bromus hordeaceus L. (T; 9; Rx; T6; L7; Fx; N3)
Bromus hordeaceus L. ssp. *hordeaceus* (T; 9; Rx; T6; L7; Fx; N3)
Bromus racemosus L. (H; 9; R5; T6; L6; F8; N5)
Bromus sterilis L. (T; 9; Rx; T6; L7; F4; N5)
Cynosurus cristatus L.¹ (H; 9; Rx; T5; L8; F5; N4)
Dactylis glomerata L.¹ (H; 7; Rx; Tx; L7; F5; N6)
Deschampsia caespitosa (L.) Beauv. (H; 9; Rx; Tx; L6; F7; N3)
Digitaria sanguinalis (L.) Scop. (T; 9; R5; T7; L7; F4; N5)
Echinochloa crus-galli L. var. *longisetum* Döll (T; 9; Rx; T7; L6; F5; N8)
Festuca arundinacea Schreb. (H; 7; R7; T5; L8; F7; N4)
Festuca pratensis Huds. ssp. *apenina* (Notrais) Hack. et Hegi (H; 7; R7; T3; L8; F6; N7)
Festuca pratensis Huds. ssp. *pratensis* (H; 7; Rx; Tx; L8; F6; N6)
Holcus lanatus L.¹ (H; 7; Rx; T6; L7; F6; N4)

Lolium perenne L. ¹ (H; 6; R7; T6; L8; F5; N7)
Melica nutans L. (H; 7; Rx; Tx; L4; F4; N3)
Milium effusum L. (H; 8; R5; Tx; L4; F5; N5)
Poa annua L. (T; 9; Rx; Tx; L7; F6; N8; LC)
Poa pratensis L. ¹ (H; 9; Rx; Tx; L6; F5; N6)
Poa trivialis L. (H; 7; Rx; Tx; L6; F7; N7)
Setaria pumila (Poir.) Schult. (T; 9; R5; T7; L7; F4; N6)
Trisetum flavescens (L.) P.Beuv. (H; 8; Rx; Tx; L7; Fx; N5)

During the investigation 276 taxa of vascular plants from 66 different families were found. The largest group is dicots (*Magnoliatae*) with 202 taxa from 53 families or 73.19% of total flora found. Monocots (*Liliatae*) are represented by 57 taxa from seven families, or 20.65% of total flora found, followed by gymnosperms (*Coniferophytina*) with 14 taxa and by ferns (*Pteridophyta*) with 3 taxa. Families with relatively high numbers of taxa were *Poaceae* (10.51%), *Asteraceae* (6.52%) and *Lamiaceae* (6.16%) (Tab. 1).

Life form analysis was performed only for grassland species (Fig. 3) to demonstrate the ecological conditions in natural grasslands under this climate and to show changes due to lack of mowing. This analysis showed that hemicryptophytes were predominant (145 taxa, 61.18%), followed by therophytes (43 taxa, 18.14%), geophytes (30 taxa, 12.66%), chamaephytes (12 taxa, 5.06%), and phanerophytes (7 taxa, 2.95%).

Tab. 1. Families with more than five different taxa in the flora of grassland of the Opeka Arboretum

| Family | Number of taxa | % |
|-----------------------------|----------------|-------|
| POACEAE | 29 | 10.51 |
| ASTERACEAE | 18 | 6.52 |
| LAMIACEAE | 17 | 6.16 |
| FABACEAE | 15 | 5.43 |
| CICHORIACEAE | 12 | 4.35 |
| LILIACEAE | 11 | 3.99 |
| APIACEAE | 11 | 3.99 |
| ROSACEAE | 10 | 3.62 |
| CARYOPHYLLACEAE | 10 | 3.62 |
| PINACEAE | 10 | 3.62 |
| RUBIACEAE | 9 | 3.26 |
| RANUNCULACEAE | 8 | 2.90 |
| SCROPHULARIACEAE | 7 | 2.54 |
| BRASSICACEAE | 6 | 2.17 |
| CYPERACEAE | 6 | 2.17 |
| OTHER (with 5 or less taxa) | 97 | 35.14 |
| TOTAL | 276 | |

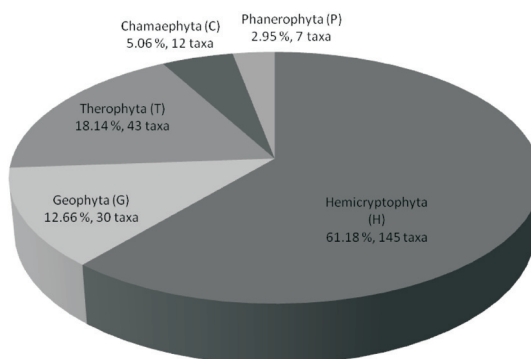


Fig. 3. Life form spectrum of grassland of the Opeka Arboretum.

The numbers of therophytes and chamaephytes are as expected however the number of hemicytopytes is higher than expected, and the number of geophytes is lower than expected for this region, in comparison with HORVAT (1949). Domination of hemicytopytes is typical for grasslands (ŠUGAR *et al.*, 2005). According to DUJMOVIĆ PURGAR (2010) reduced mowing practices cause gradual predominance of hemicytopytes and perennials. This is probably one of the reasons for hemicytopytes predominance and the lower number of geophytes in the grassland life form spectrum. Other reason is overgrowing the grassland by woody and herbaceous species.

Phytogeographical analysis showed that the Euroasian floral element predominated (86 taxa, 31.16%), followed by widespread plants (59 taxa, 21.38%), cultivated & adventive plants (40 taxa, 14.49%) and European floral element (31 taxa, 11.32%) (Fig. 4). Composition of floral elements confirmed that the research area belongs to Euro-Siberian-North-American region of Holarctic (HORVATIĆ, 1967).

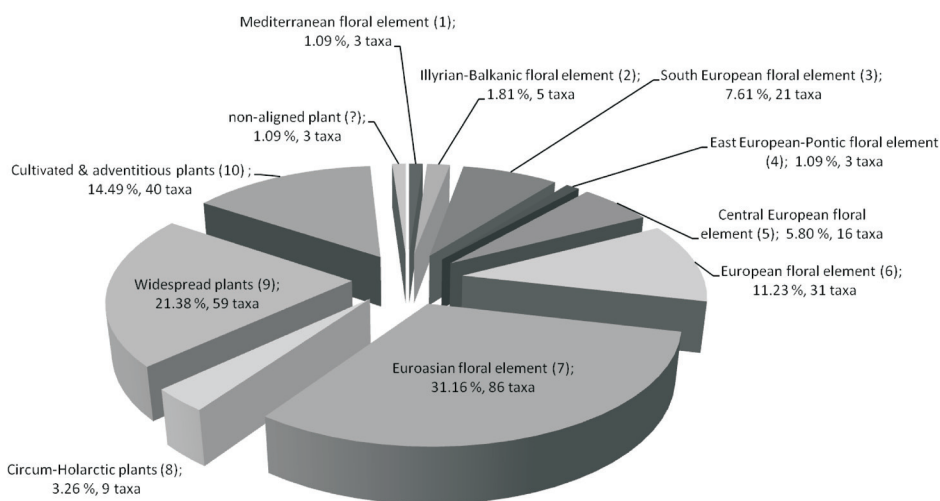


Fig. 4. Chorological spectrum of grassland of the Opeka Arboretum.

Ecological indicator values according to ELLENBERG *et al.* (1991) were defined for 84% of the taxa. In the investigated grassland of the Opeka Arboretum indifferent species (Ellenberg value X) for soil reaction (84 taxa, 30.43%) and temperature (78 taxa, 28.26%) were dominated, followed by half-light species (Ellenberg value L 7; 72 taxa, 26.09%), plant indicators of fresh soil of average dampness (Ellenberg value F 5; 86 taxa, 31.16%) and plant indicators of sites of intermediate fertility (Ellenberg value N 5; 41 taxa, 14.86%).

In the researched area 12 (4.35%) red-listed taxa were found: vulnerable (VU): *Fritillaria meleagris*, *Lilium martagon*, *Platanthera bifolia*, *Taxus baccata*, near threatened (NT): *Cephalanthera damasonium*, *Cyclamen purpurascens*, *Ruscus hypoglossum*, data deficient (DD): *Scrophularia umbrosa*, *Silene noctiflora*, *Veratrum album* and least concern (LC): *Galanthus nivalis* and *Poa annua*.

There were also 36 species protected (Z) and nine species strictly protected (SZ) by the Croatian law. Non-indigenous plants (39 taxa) made 14.13% of the flora of the investigated area: six archaeophytes (arh), six neophytes (neo), 28 cultivated species (kult). In the investigated grassland of the Opeka Arboretum eight invasive alien species (inv) were found: *Conyza canadensis*, *Erigeron annuus*, *Rudbeckia lacinata*, *Solidago gigantea*, *Phytolacca americana*, *Veronica persica*, *Parthenocissus quinquefolia* and *Galinsoga ciliata*. Regular mowing of meadows is necessary for habitat conservation and can also reduce the spreading of invasive species. Lack of mowing leads to floristic homogenisation of the system or to slow succession and further to the loss of characteristic meadow species in favour of successional and ruderal species (VITASOVIĆ KOSIĆ *et al.*, 2011; 2012).

Analysis of the origin of the non-indigenous plants shows that all of them originate from the Northern Hemisphere: eight from North America, seven from Europe but not indigenous in Croatia, seven from Asia and three of them are distributed on two or all three northern continents.

This floristic investigation confirmed 37 woody and 16 herbaceous species included in earlier publications (BENKO *et al.*, 2006; ŠILER, 1987) for the area of the Opeka Arboretum and 223 taxa were recorded for the first time.

BENKO *et al.* (2006) carried out an inventory of the dendroflora of the Opeka Arboretum and for that research the arboretum was divided in subareas and each registered tree or shrub got the individual code. The grassland area of this recent investigation is identical with subarea no. 11 of previous dendrological inventarisation. Comparison of the findings from 2006 with those of 2008/2009 lists shows that the number of different woody taxa as well as the number of plant individuals decreased: in 2006 there were 43 different woody taxa and 190 individuals registered, in 2008/2009 39 taxa and 177 individuals – four taxa and 13 individuals less. They were probably cut down in the meantime but the reason for that remains unknown, it was most possibly due to illness or horticultural desdue and not to preservation activity. There are still too many taxa overgrowing the remaining grassland area e.g. *Wisteria sinensis*, *Parthenocissus quinquefolia*, *Rubus caesius*, which readily self-propagate.

According to floristic composition, its ecological values, the present and earlier observations the investigated grassland is a hay meadow (*Arrhenatheretum elatioris* association in broad sense) whose persistence is ensured by regular mowing. The dominant species are *Arrhenatherum elatius*, *Knautia arvensis*, *Pastinaca sativa*, *Trifolium pratense*, *Dactylis glomerata*, *Poa pratensis*, *Daucus carota* and many other taxa are present.

In the investigated area rare and valuable plants of Croatian flora also occur. Some of them are characteristic for moist grasslands, e.g. *Fritillaria meleagris*, some are forest

species, e.g. *Lilium martagon*, *Platanthera bifolia*, *Cephalanthera damasonium*, *Cyclamen purpurascens*. It is necessary to emphasize the tendency of woody and herbaceous species to overgrow the grassland and change the grassland composition due to lack of mowing. The grasslands of the Opeka Arboretum are an important part of this park architecture monument and contribute to its aesthetic value. Moreover, grasslands are habitats rich in different plant and animal species and it is important to preserve them.

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SAŽETAK**Floristički sastav travnjaka Arboretuma Opeka
(Vinica, sjeverozapadna Hrvatska)**

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Tijekom vegetacijske sezone 2008. i 2009. istraživana je vaskularna flora dijela travnjačkih površina Arboretuma Opeka kao doprinos poznavanju i očuvanju nedendrološke flore arboretuma koja do sada nije bila sustavno istraživana. Pronađene su ukupno 276 biljne svojte iz 66 porodica, a 223 svojte zabilježene su po prvi put. Vrstama je najbogatija porodica Poaceae (29 svojti, 10,51%).

Na Crvenom popisu nalazi se 12 nađenih svojti, a zakonom je zaštićeno 36 i strogo zaštićeno devet svojti. Od 39 alohtonih svojti zabilježenih na istraživanom području, njih 28 su kultivirane i podrijetlom iz različitih područja sjeverne hemisfere, šest svojti su arheofiti, šest neofiti, a osam ih ima status invazivnih. Sve alohtone svojte potječu iz sjeverne hemisfere: osam iz Sjeverne Amerike, sedam iz područja Europe, ali nisu autohtone u Hrvatskoj, sedam iz Azije, a tri su rasprostranjene na dva ili sva tri kontinenta. Veliku vrijednost području arboretuma daju i livade košanice u kojima su zabilježene neke rijetke i zaštićene vrste hrvatske flore. Zbog nedostatka redovite košnje floristički sastav tipične travnjačke zajednice ugrožen je zaraštavanjem visokih zeljastih i drvenastih biljaka.