Prilozi poznavanju flore Hrvatske / Contributions to the knowledge of the Croatian flora

Anemone sylvestris L. (Ranunculaceae) in eastern Prigorje (Zagreb, Croatia)

original scientific paper / izvorni znanstveni članak

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Abstract

The article summarizes the current status and distribution of the vulnerable plant species *Anemone sylvestris* L. (Ranunculaceae) in the eastern part of the Prigorje region, NE from the Croatian capital, Zagreb. Data were collected during two inventory studies performed in 2015 and 2016 when over 12000 individuals were observed on 130 microlocations. Their distribution is discussed with respect to the borders of protected nature areas within the region. Habitat characteristics are described in relation to plant abundance. The main results indicate that the species prefers open grassland-type habitats of different expositions, with low coverage of woody plants, with abundance increasing on moderately-sloped terrain. We recommend active habitat protection measures and further monitoring.

Keywords: Medvednica, Natura 2000 Ecological Network, Vejalnica and Krč

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Sažetak

Članak sažima trenutni status i rasprostranjenost osjetljive vrste *Anemone sylvestris* L. (Ranunculaceae) u istočnom dijelu regije Prigorje, smještene SI od hrvatskog glavnog grada Zagreba. Podaci su prikupljani u dva terenska istraživanja tijekom 2015. i 2016. godine, kada je opaženo više od 12000 jedinki na 130 mikrolokacija. Diskutira se o njihovoj rasprostranjenosti u odnosu na granice zaštićenih područja prirode u regiji. Opisane su značajke staništa u odnosu na brojnost jedinki. Glavni rezultati ukazuju da vrsta preferira otvorena livadna staništa osunčana iz više smjerova, s niskom pokrovnošću drvenaste vegetacije i većom brojnošću na blago nagnutim padinama. Preporučuju se aktivnosti zaštite staništa i daljnja promatranja.

Ključne riječi: Medvednica, Natura 2000 ekološka mreža, Vejalnica i Krč

Introduction

Anemone sylvestris L. (Ranunculaceae) is a vulnerable (VU) vascular plant in Croatia due to its scarce habitat and reduced distribution (Nikolić & Topić 2005, Borovečki-Voska & Šincek 2014). In eastern Prigorje *A. sylvestris* grows on two habitat types: semi-natural dry grasslands and forest fringes. They are often adjacent, forming a mosaic on hill tops and slopes (Zadravec & Zadravec 2015, 2016, 2017; Zadravec et al. 2016).

The first habitat type is classified as a semi-natural dry grasslands and scrubland facies on calcareous substrates of the class *Festuco-Brometea* Br.-Bl. et R. Tx. 1943 (Natura 2000 habitat code: 6210). This type is also suitable for orchids and in general is among the richest habitats with flora and fauna species in the whole European environment (Anonymous 2015a). So, it is of special community importance and targeted for protection by the Natura 2000 Ecological Network (Anonymous 2014a).

The second habitat is the fringes of thermophilous forests and patches of *Quercus pubescens* Willd. that contain the association of *Geranium sanguineum* L. and *A. sylvestris* (As. *Geranio-Anemonetum sylvestris* Th. Müller 1961). This habitat type is listed in the National Habitats Classification under C.5.1.1.2. (Anonymous 2014a) and is considered to be reduced only to the eastern Prigorje region of Croatia (Anonymous 2014b).

Eastern Prigorje is currently the only known Croatian region where *A. sylvestris* occurs over a larger area and is fairly abundant. There are only two known locations outside this region where *A. sylvestris* had been recently observed in small numbers – one confirmed finding on Ivanščica Mt, in north-western Croatia (Šincek 2013) and one unconfirmed finding on Pakleni otoci, near the island of Hvar in Dalmatia (Ruščić 2007). There are several century-old or older literature references in continental Croatia but none have been confirmed by field observations since.

In Eastern Europe there was some long-term monitoring of *A. sylvestris*. In a three-decade long research in NE Poland the disappearance of *A. sylvestris* was documented from strongly shaded areas (Kwiatkowska-Falinska & Falinski 2007). Another long-term research of dry grassland species distribution with respect to previous and current land usage was conducted in the Czech Republic. Their results show that *A. sylvestris* persists only on the continuously maintained grasslands (Chýlová & Münzbergová 2008). After a dozen years of observations of the grasslands and clearings inside the thermophilous deciduous forests of the “Mierzwice“ nature reserve the observers noticed a decrease in the number of locations and in the abundance of several species, including *A. sylvestris* (Krechowski et al. 2015). The deterioration of the lighting conditions caused by natural succession is considered to be the main cause for that regression of species richness.

Due to the importance of *A. sylvestris*, as an umbrella species, the Public Institution “Maksimir”, responsible for nature protection in eastern Prigorje, supported an inventory and monitoring study. The region contains several nature protection areas: Natura 2000 site „Vejalnica & Krč“, „Goranec“ Significant Landscape, and „Medvednica” Nature Park and Natura 2000 site (Fig. 1). Our survey was conducted both in and outside of the protected areas in order to map the distribution of *A. sylvestris* in eastern Prigorje and to determine the proportion of the unprotected population. Besides only one vegetation screening project on a spatially limited area with *A. sylvestris* at the eastern border of Medvednica Nature Park (Alegro 2012), no wider and more detailed survey has ever been performed before for this plant species in Croatia.

Our goal was to determine the abundance, distribution and ecological preferences of *A. sylvestris* in eastern Prigorje that could serve as a baseline for conservation actions of the species and its habitat in the future. We specifically tried to identify key environmental factors that positively influence the species’ abundance.

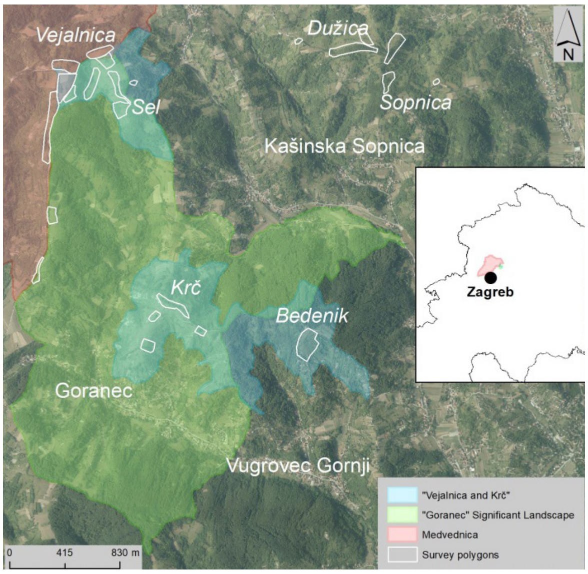

Figure 1. Nature protection sites in the eastern Prigorje region and contours of surveyed plots. Toponyms are written in white text – village names normal, hill names in italic.

Materials and methods

The study area was located between the villages Vugrovec, Goranec, Čučerje, Planina and Kašina. Here, the SE slopes of Medvednica Mt gradually transform into small hills: Vejalnica, Sel, Krč, Bedenik, Dužica, and Sopnica with the peak altitudes varying from 300 to 500 m a.s.l. (Fig. 1).

We divided the research area into five regional segments (D, G, K, M, V) with 23 plots of different sizes, covering a total surface area of almost 25 ha (Table 1).

Table 1. Regional segments and surveyed plots.

Segment Name	Significant toponym / oronym	Number of plots	Total plot area (ha)	Plot Names
D	Dužica-Sopnica	**6**	5.5	Da, Db, Dc, Dd, De, Df
G	Goranec	**2**	1.3	Ga, Gb
K	Krč-Bedenik	**5**	5.5	Ka, Kb, Kc, Kd, Ke
M	Medvednica	**3**	5.3	Ma, Mb, Mc
V	Vejalnica-Sel	**7**	7	Va, Vb, Vc, Vd, Ve, Vf, Vg
	Total	**23**	**24.6**	

Plot borders were determined mostly by landscape features, man-made features and borders of protected sites – easily recognisable in the field. Regional segments are marked with the first letter of the most significant toponym (e.g. K for Krč). Plot names are constructed from the capital letter representing the segment name with the addition of a single lowercase alphabet letter (e.g. Df, Ga, Mb). Each plot consists of several neighbouring microlocations.

In 2015 we have previously established the presence of *A. sylvestris* on all plots and in 2016 we performed a detailed inventory of microlocations, counting all individual plants during the peak of the flowering phase at the beginning of May. We recorded the exact GPS coordinates and elevation of our findings using a Garmin eTrex 30 device. The surface area containing all observed plants on a microlocation was recorded as the area of that microlocation. For smaller microlocations the surface area was regarded as a rectangle around all plants and its sides were measured. For larger areas we tracked the areas' borders using the GPS device and later their surface area was calculated using QGIS 2.14.0. Detailed maps of all plots and microlocations in each segment are presented in Appendix 1. The exact area and position of all large groups is known and can be traced for future changes with respect to the plants' propagation and emergence of surrounding woody vegetation.

Plant densities were calculated for each microlocation as the ratio of the plant abundance and microlocation surface area. Then we summarized the density for each regional segment and individual plots. For the segment density we calculated the average value since the related Kolmogorov-Smirnov normality test showed no significant deviation from the normal distribution. However, for plant density correlated to habitat type, the Kolmogorov-Smirnov test showed significant deviation from the normal distribution, so we gave the median value, instead of the average. Before median calculation we cut the lower and upper 1/8 of the data.

To determine the impact of environmental factors upon species abundance and density we recorded basic information about topology (exposition to the sunlight), geography (slope gradient and slope direction) and the coverage of the surrounding vegetation. Concerning the surrounding vegetation, we recorded dominant woody plant taxa and estimated the percentage of their coverage of the microlocation surface, for woody plants below and above 2 m in height, respectively, using the expanded Braun-Blanquet scale (Barkman et al. 1964). However, for the statistical analysis, this had to be reduced to three categories: low, moderate and high.

For the purpose of the statistical analysis, we divided each of the recorded environmental factors in classes (see Table 2). Environmental factors were used as explanatory variables for the species' abundance and density. We also tested for correlation between the two dependent variables (Pearson correlation coefficient, statistical significance set at $p < 0.001$). To define the plant preferences the comparison of absolute frequencies among the predefined classes of each independent variable and abundance classes was performed using the Likelihood ratio statistic. Standardized residuals were used to define the significant contributors to the overall Chi square value. Cells with standard residuals with values $\geq |2.0|$ were considered as significantly important.

Regarding the *A. sylvestris* plants shading by surrounding vegetation we introduced three simple categories for habitat type on microlocations. Those microlocations that are shaded less than 20% we designate as "grassland". Microlocations whose surface area is more than 50% in the shade of nearby trees and shrubs we designate as "fringe". Microlocations where both characteristics are present, but neither is dominant, we designate as the "mixed" type. For distribution quantification we introduce three categories for absolute abundance on a microlocation: low abundance (less than 50 plants), moderate (50–200 plants) and high (more than 200 plants).

The following data tables and graphs were created by Microsoft Excel 2010. The statistical

X^2 test was performed in "IBM SPSS Statistics" software package (version 24). We have tested the dependence of each of the two dependent variables (DV*), upon six independent variables (IV*). All variables and their categorization methods are summarized in Table 2. Pearson's correlation coefficient was used to test the correlation between both dependent variables, plant abundance and density.

Table 2. Variable categorization used for the χ^2 test. DV – dependent variable, IV – independent variable.

Variable	Data	No. of categories	Category Criteria Explanation
DV1	plant abundance	3	low: 0–49; moderate: 50–199; high: ≥ 200
DV2	plant density	3	low: 0–0.9; moderate: 1–9; high: ≥ 10
IV1	slope direction	9	N, S, W, E, NE, NW, SE, SW, flat
IV2	slope gradient	4	none (= flat), low, moderate, high
IV3	exposition	9	E, N, NE, NW, S, SE, SW, W, several (more than one direction)
IV4	habitat type	3	grassland (shade < 20%), fringe (shade > 50%), mixed
IV5	coverage of woody plants < 2 m	3	low: 0–29%; moderate: 30–59%; high: ≥ 60%
IV6	coverage of woody plants > 2 m	3	low: 0–29%; moderate: 30–59%; high: ≥ 60%

Results

The data collected in 2016 presents the most comprehensive and accurate status of the *A. sylvestris* population in eastern Prigorje region performed so far. We report a total of 130 distinct microlocations with 12511 plants counted on them. They are all shown on maps in Appendix 1 and their geographic locations have been precisely listed in the on-line accessible Flora Croatica Database (Nikolić 2018).

Since the Pearson's correlation coefficient showed that plant abundance and plant density are positively correlated ($r = 0.459$, $p < 0.001$; Appendix 2), the Likelihood ratio test results are shown only for plant abundance.

Overall Population Results

Observing the distribution of the *A. sylvestris* population across regional segments, there are two that dominate in total abundance: V and D. Segment D also has the greatest plant density by plot area (Fig. 2).

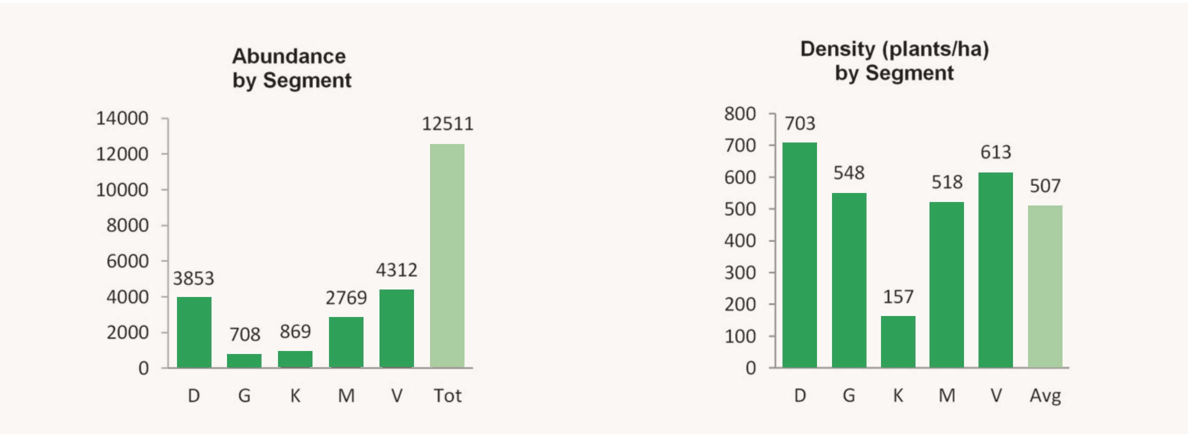

Figure 2. Abundance and density of *A. sylvestris* findings across regional segments. Tot – total number of counted plants. Avg – Average plant density. Segment names are explained in Table 1.

The result of Kolmogorov-Smirnov test for normal distribution for density per segment data set is p = 0.105, so the average value appropriately expresses the central tendency for density (Appendix 2). Four plots substantially contribute to the total population size: Dc, Dd, Mb and Va. Among all plots, Dc stands out in regard to both plant count and density (Fig. 3).

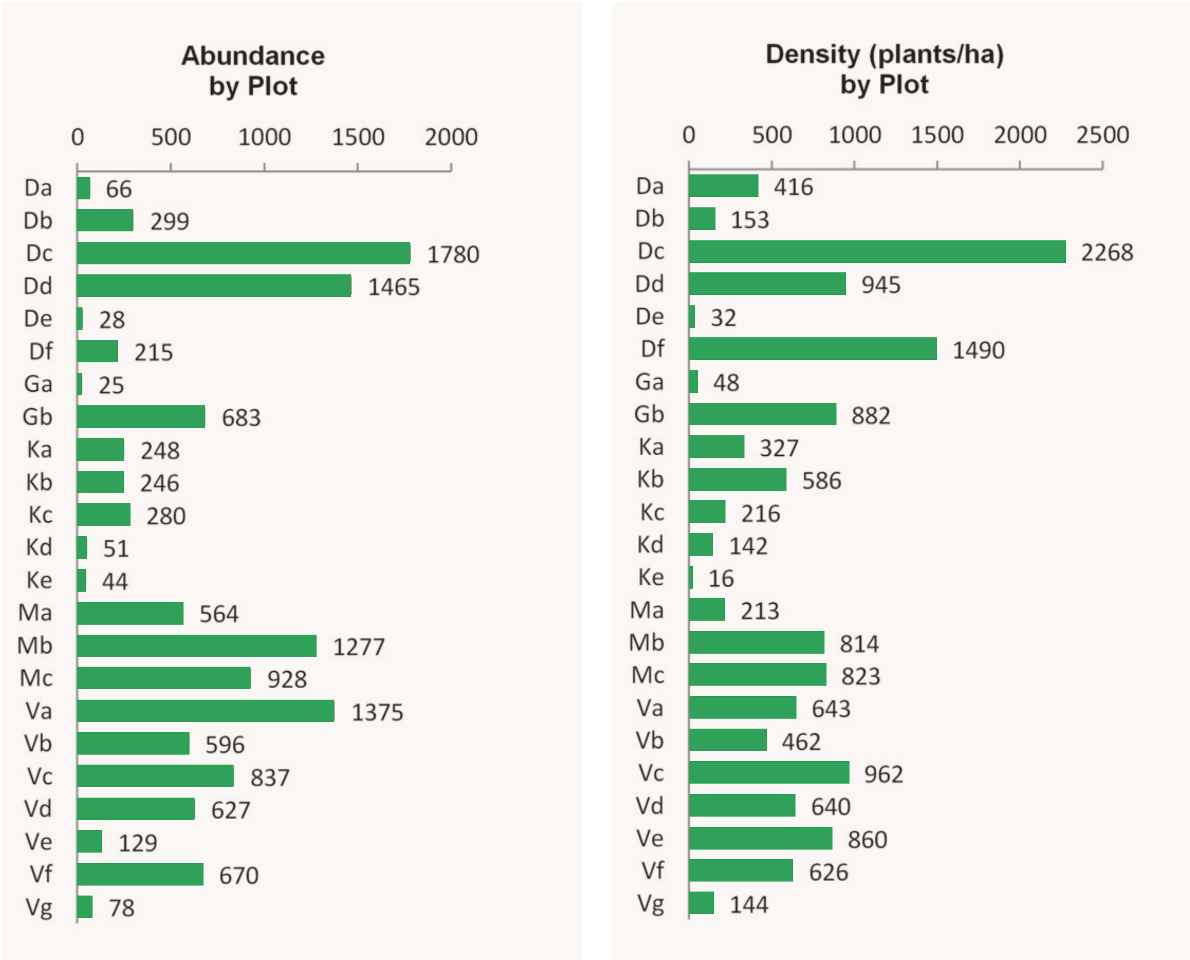

Figure 3. Abundance and density of *A. sylvestris* across plots.

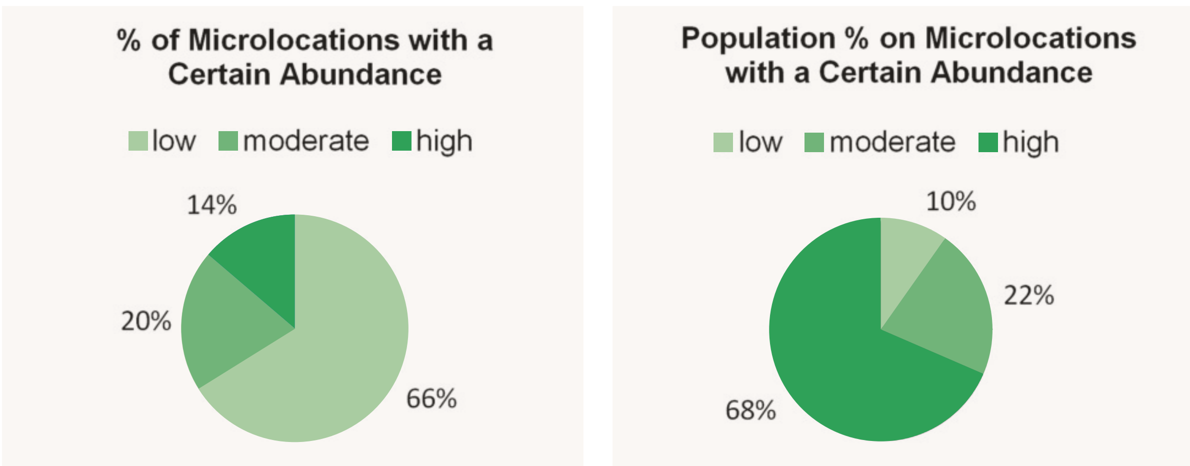

Figure 4. The percentage of microlocations with a certain abundance and the percentage of the population of *A. sylvestris* per abundance category.

Concerning the microlocation level it is obvious that the majority of microlocations have a low abundance, with very few microlocations standing out as very rich, containing several hundreds of plants. Just 14% of all microlocations with a high absolute abundance comprise 68% of the overall *A. sylvestris* population. The majority of microlocations are with low or moderate absolute abundance (86%) but they comprise only 32% of the total population (Fig. 4). These results show that future changes on a small number of microlocations with a high abundance would have a greater impact on the total *A. sylvestris* population.

Results Regarding Ecological Factors

The *A. sylvestris* habitat on each microlocation consists of a mix of grasslands with shrubs and trees, but in further analysis we relate to the predominant habitat type on each microlocation. Overall, there is an even distribution of “fringe” and “grassland” microlocations (Fig. 5).

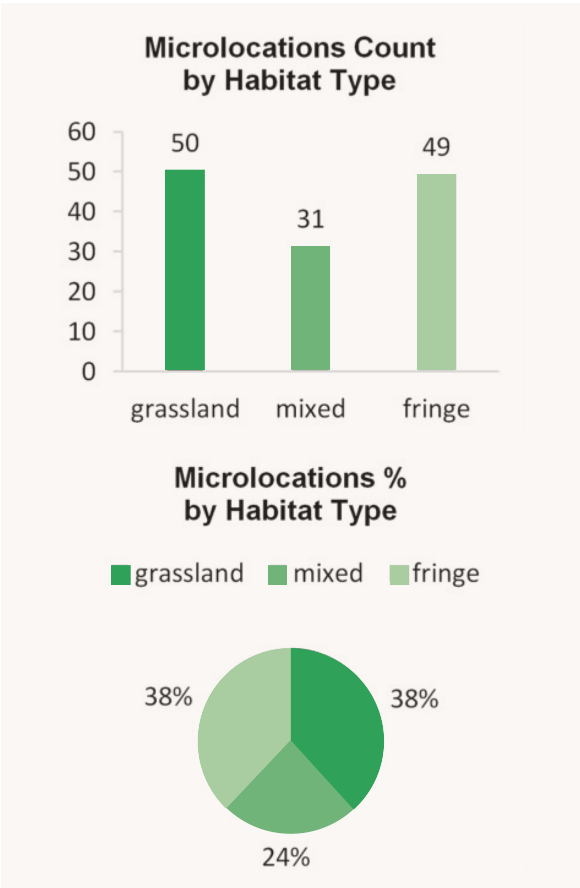

Figure 5. Microlocations related to dominant habitat type.

“Fringes” contribute far less to the whole *A. sylvestris* population (7%) because of the smaller abundance. The “grassland”microlocations have a much higher abundance and represent a substantial majority of the whole population (65%) (Fig. 6). The influence of habitat type on plant abundance is statistically significant ($p < 0.001$; Appendix 2). Fringe habitats often have low abundance. Grassland habitats often have high abundance and only rarely low density. These results suggest the future protection measures should prioritize the “grassland” habitat type.

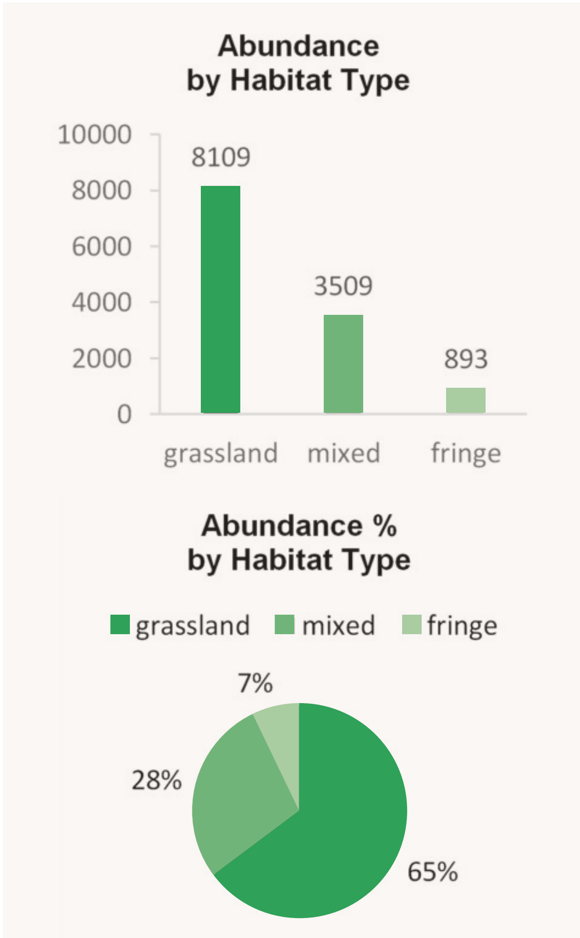

Figure 6. Abundance related to dominant habitat type.

On *A. sylvestris* microlocations we have observed the following terrain characteristics and calculated their influence on plant abundance: slope gradient, slope direction and exposition. There are more flat and weakly sloping microlocations than the others (Fig. 7).

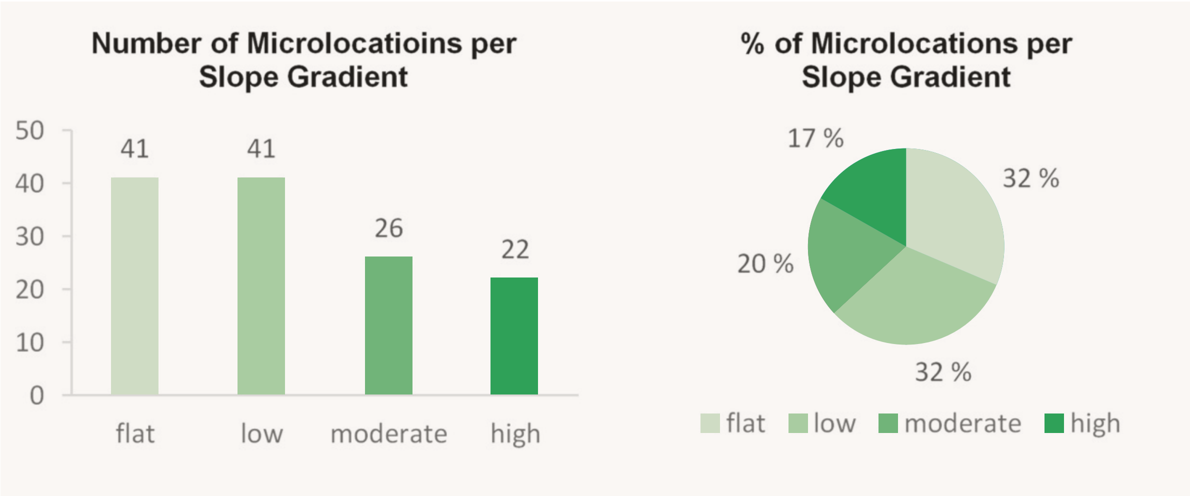

Figure 7. Microlocations related to slope gradient.

The plant abundance is similar on flat terrain and slightly inclined (low) slopes but much greater on moderate slopes and even more reduced on steep (high) slopes compared to flat and low (Fig. 8). Statistical results show a noticeably significant influence of moderate-gradient slopes on plant abundance ($p < 0.001$; Appendix 2).

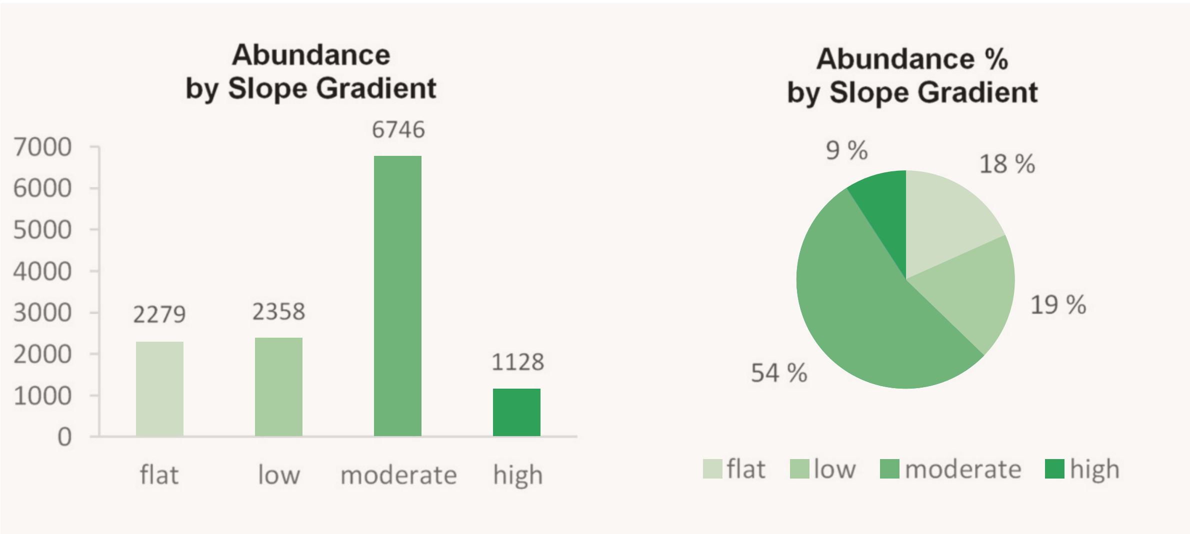

Figure 8. Abundance related to slope gradient.

Regarding slope directions there is no evidence that *A. sylvestris* prefers any of them. Microlocations on flat terrain slightly dominate by count over any other slope direction but such microlocations do not contribute predominantly to the overall plant abundance (Fig. 9). Statistics shows no significant influence of slope direction to plant abundance (Appendix 2).

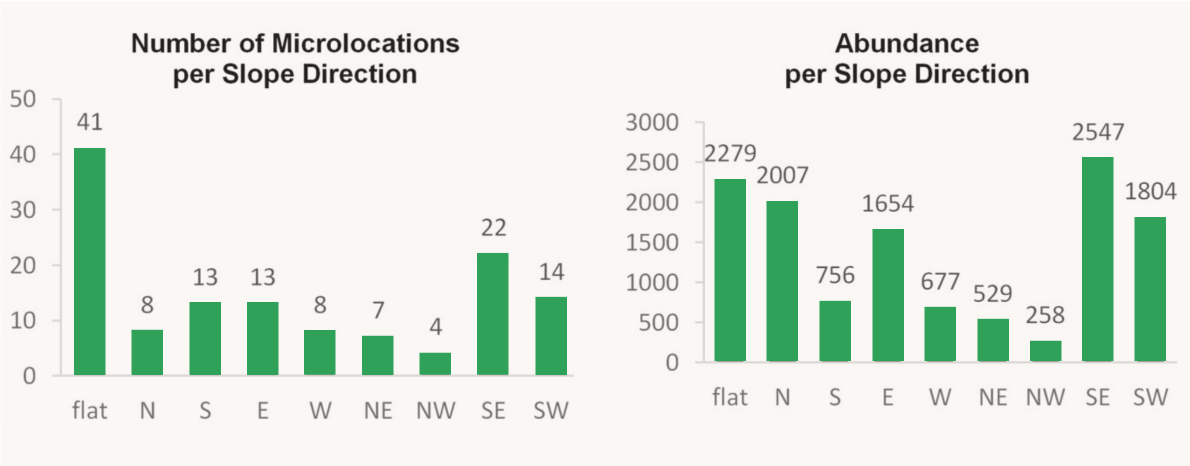

Figure 9. Microlocations and abundance related to slope direction.

Regarding exposition, the data shows that *A. sylvestris* prefers sunlight from several directions. The majority of microlocations are exposed to sunlight from several direction and they contribute dominantly to the overall plant abundance (Fig. 10). Statistics shows that exposition from several directions strongly increases the chances for high and moderate plant abundance and reduces the chance for low abundance ($p < 0.001$; Appendix 2).

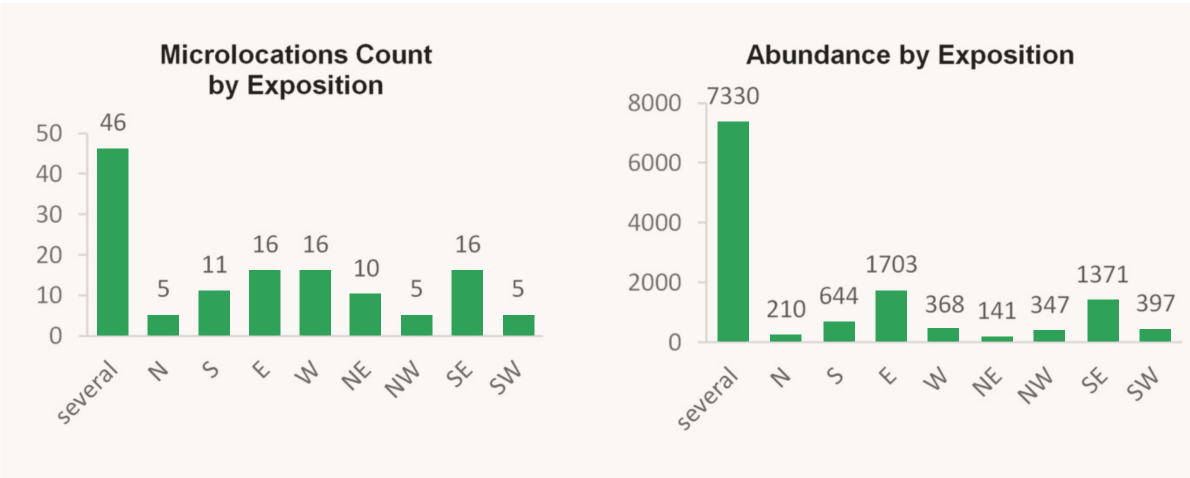

Figure 10. Microlocations and abundance related to exposition.

Our estimation results of the total woody plant coverage on all plots and each microlocation are shown in Fig. 11. There are plots of all coverage levels but those below 50% dominate. The majority of microlocations with *A. sylvestris* findings are with a coverage below 25%. That is also in concordance with the established preference of *A. sylvestris* towards less shaded positions.

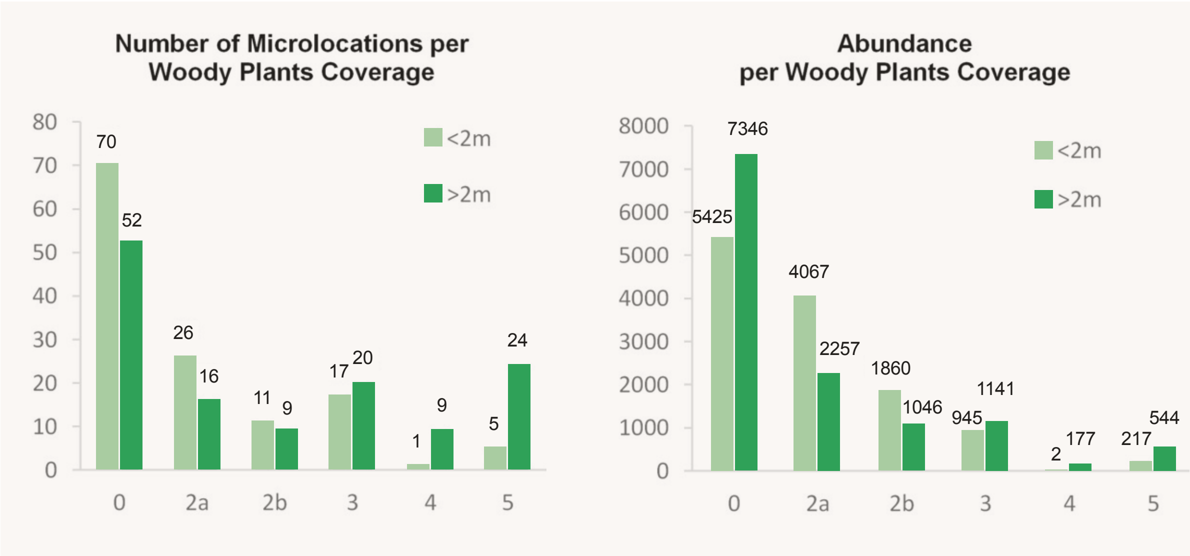

Figure 11. Microlocations count and abundance related to woody plants coverage levels according to the standard scale: 0 = no coverage; 2a = 5–15%; 2b = 16–25%; 3 = 26–50%; 4 = 51–75%; 5 = 76–100%.

The number of microlocations and abundance related to woody plants coverage expressed in the reduced scale is given in Fig. 12, emphasizing more the statistically significant influence of shading. The increase in the coverage of woody plants above 2 m strongly reduces chances for high plant abundance ($p < 0.001$; Appendix 2) while the coverage of woody plants below 2 m has no statistically significant influence.

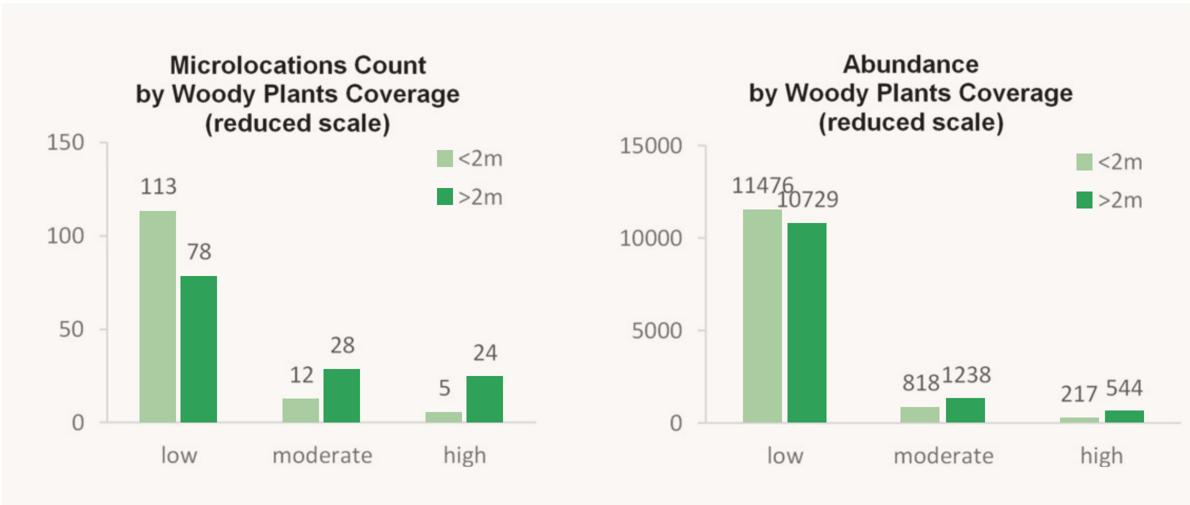

Figure 12. Number of microlocations and abundance related to woody plants coverage expressed in the reduced scale: low = 0–29%; moderate = 30–59%; high = 60–100%.

The most dominant woody plants on the majority of plots and microlocations are listed in particular order from the most to less frequent ones, based on personal observations in the field: *Quercus* sp., *Viburnum* sp., *Cornus* sp., *Fraxinus* sp., *Crataegus* sp. and *Juniperus communis* L., *Rosa* sp., *Pyrus* sp., *Berberis* sp., *Carpinus betulus* L. and *Prunus spinosa* L. are all frequent, while *Corylus avellana* L., *Ligustrum vulgare* L., *Pinus* sp., *Robinia pseudoacacia* L., *Ulmus* sp., *Betula pendula* Roth and *Sorbus torminalis* (L.) Crantz. are present only occasionally.

A. sylvestris plants in eastern Prigorje usually grow in the form of small isolated groups with a density of 1–10 plants/m2. There are some exceptions on unshaded grasslands when plants create densely covered islands with 10–20 plants/m2. In the northernmost microlocation of plot Dc there were 1080 plants in an area of just 15 m2 which gives an extreme density of 72 plants/m2 (Fig. 13).

Figure 13. *Anemone sylvestris* dense “carpet” on the northernmost microlocation of plot Dc (Photo: V. Zadravec, 6 May 2016).

On some microlocations *A. sylvestris* plants grow individually but occur over a wider area, resulting in the median density below 2 plants/m^2 regardless of the habitat type (Table 3).

Table 3. Median plants density regarding habitat type.

Habitat type	Median density plants/m^2	Min (12th percentile) (lowest 1/8)	(88th percentile) Max (highest 1/8)
Grassland	1.9	0.1 (0.7)	(5.0) 72.0
Mixed	0.8	0.1 (0.16)	(8.2) 17.8
Fringe	1.6	0.2 (0.4)	(5.1) 13.6

The results of Kolmogorov-Smirnov test for normal distribution for each habitat type deviates significantly from the normal distribution: grassland test statistic = 0.36 ($p<0.001$), mixed test statistic = 0.335, ($p<0.001$), fringe test statistic =0.230 ($p<0.001$). Detailed statistics regarding habitat type are in Appendix 2.

Nature Protection and Environmental Impact

The nature protection status of all regional segments and the population percentage of *A. sylvestris* found in them are given in Table 4.

Table 4. Nature protection status of all surveyed *A. sylvestris* segments.

Segment	Nature Protection Status	Protected since	% of total area	% of population	Responsible institution
D	none	–	21	31	–
G	Significant Landscape “Goranec”	1977	5	6	Public Institution “Maksimir”
K	Natura 2000 “Vejalnica & Krč”	2013	21	7	Public Institution “Maksimir”
M	Nature Park “Medvednica” & Natura 2000 “Medvednica”	1981 2013	24	22	Nature Park “Medvednica”
V	Natura 2000 “Vejalnica & Krč”	2013	29	34	Public Institution “Maksimir”

Thirty-one percent of the total *A. sylvestris* population and 21% of the total surface area is currently outside of any official nature protection. Public Institution “Maksimir” is currently responsible for segments: G, K, and V, containing 47% of population on 55% of the surface area. Nature Park “Medvednica” is responsible for the segment M, with 22% of population on 24% of the surface area.

With respect only to the Natura 2000 Ecological Network, the following charts illustrate that nearly half of the *A. sylvestris* plot surface area and nearly half of the population reside inside the “Vejalnica & Krč” site. About one third of both the surface area and the population is outside the Natura 2000 Ecological Network (Fig. 14).

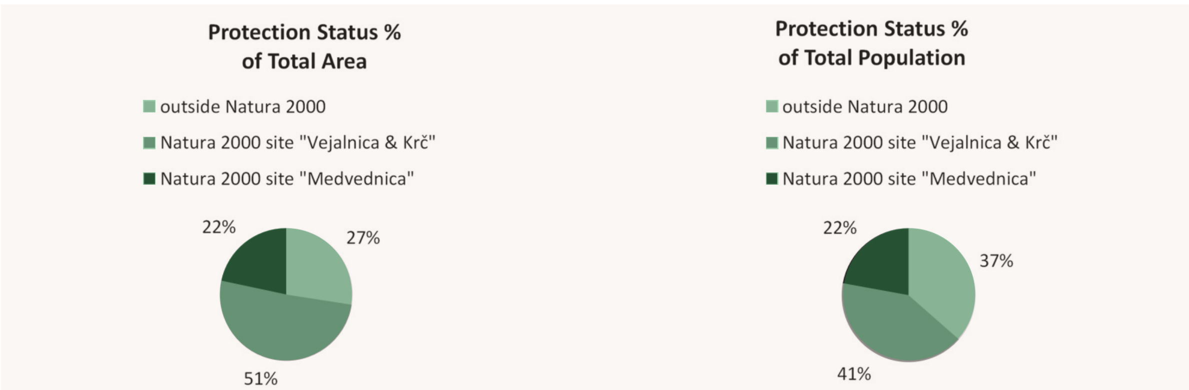

Figure 14. Natura 2000 protection status of all *A. sylvestris* findings.

The majority of grasslands in eastern Prigorje have not been maintained for several decades and they are exposed to the natural succession of woody species. We can confirm that only ten out of 130 *A. sylvestris* microlocations (8%) were recently mowed and they contain 11% of the total plant count. So 92% of all microlocations are abandoned and under some stage of succession.

The next important problem on the "grassland" microlocation type in eastern Prigorje is the occasional traffic of recreational vehicles. They damage the gentle plants and compact the soil, which prevents the emergence of plants the following seasons. This problem is noticed and documented on microlocations of plots Ke, Kc and Dd.

For "fringe" microlocations the greatest problem is soil erosion on fringes of roads, paths and trails. There are 20% of such microlocations where the soil is eroded by heavy rainfall or human disturbance during road maintenance. Those microlocations are also much more susceptible to flower picking damage than are other less noticeable ones.

There are traces of a wildfire that burned the herbaceous and short woody vegetation several years ago on most of the northern slopes of Dužica Hill. We noticed that after those burning events the grass coverage changes on those slopes in favour of the aggressive *Carex* sp. and the originally present Bromus sp. disappears. The most recent fire event was in mid-April 2016 on plot Df, after which the northernmost microlocation was devoid of *Anemone*.

Discussion

Anemone sylvestris plants tolerate some shade made by low and high woody plant coverage from any direction but their abundance tends to drop because of it. When high shade dominates from several directions, they tend to regress. The most intense regression is on the intensely overgrowing plot Ga which had only three microlocations in 2016 out of 12 previously documented four years ago (Alegro 2012). Our results about the *A. sylvestris* abundance drop due to increased shading are in concordance with other European research cases (Kwiatkowska-Falinska & Falinski 2007, Chýlová & Münzbergová 2008, Krechowski et al. 2015).

A. sylvestris grows together with orchids on the same plots. Since orchid habitats are already considered as a protection target within the Natura 2000 Ecological Network, *A. sylvestris* should benefit from the same protection measures used for orchids. But a significant area in eastern Prigorje rich in both *A. sylvestris* and orchids is not included in any nature protection sites. As such, we suggest the borders of protected site "Vejalnica & Krč" to be enlarged to include also plots in the Goranec region. Dužica and Sopnica regions should be designated as a new subsite within the "Vejalnica & Krč" Natura 2000 site, or as a new Natura 2000 site. Although *A. sylvestris* itself is not listed on the Annexes of the Habitats Directive (Anonymous 1992), it is endangered in Croatia, holding the status of "vulnerable", strictly protected by the law, listed under Section 3.2 Other important species of flora and fauna in the Standard Data Form for "Vejalnica & Krč" (Anonymous 2015b), and it occurs on a priority habitat type along with orchid species which are on the Annexes II and/or IV of the Habitats Directive (Anonymous 2015b). Therefore such an expansion in nature protected areas will be beneficial for all.

A. sylvestris disperses by wind-dispersible diaspores so all these separated segments should be regarded as an integral population and should be monitored and managed by joint efforts of all responsible nature protection institutions. We urge them to: restrict the passage of motor vehicles inside protected zones, especially off-road motorized "excursions", and to encourage landowners to properly maintain their land in favour of the future existence of the vulnerable *A. sylvestris.*

A continuous periodical monitoring should be established in the whole eastern Prigorje Region in order to determine the population trend with respect to various human influences. Soil composition analysis and a phytocoenological assessment should be performed to better understand the characteristics of the habitat and its co-dependence on surrounding plants.

Conclusion

The *A. sylvestris* population in eastern Prigorje is fairly abundant but narrowly distributed only on a few neighbouring hills. Because of the plant's preference towards the less shaded dry grassland habitat we consider the observed advanced succession by woody plants the greatest risk for the *A. sylvestris* population. Appropriate habitat maintenance measures based on the species' preferences should be implemented and enforced as soon as possible.

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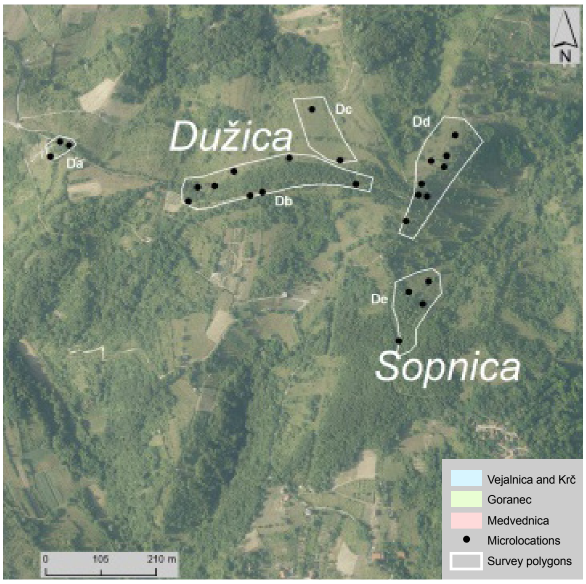
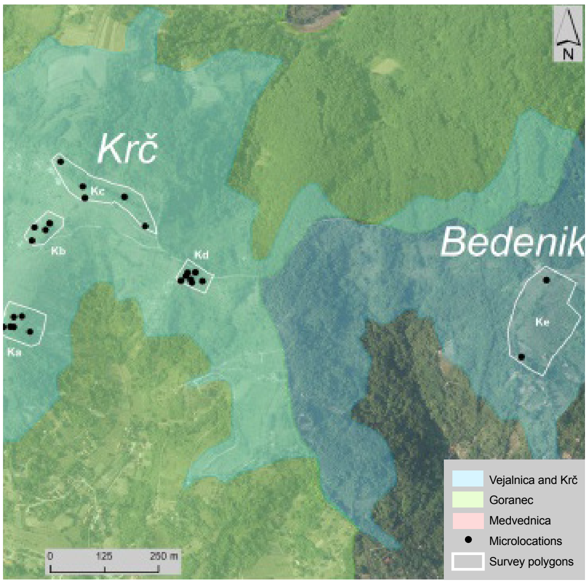
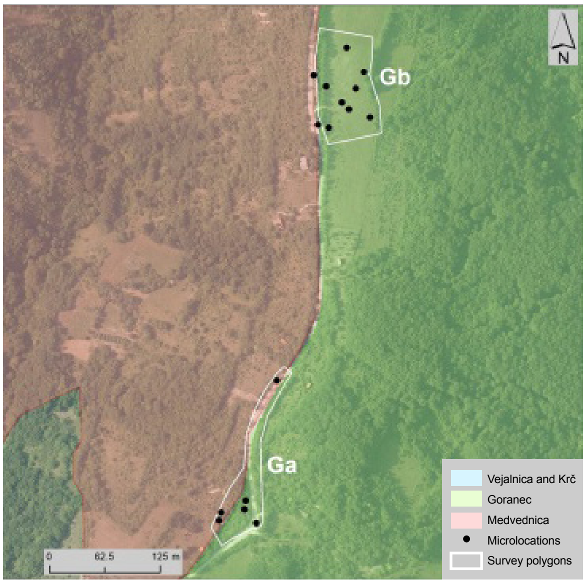
Appendix 1. Detailed maps of segments with microlocations and hill names written in italic.



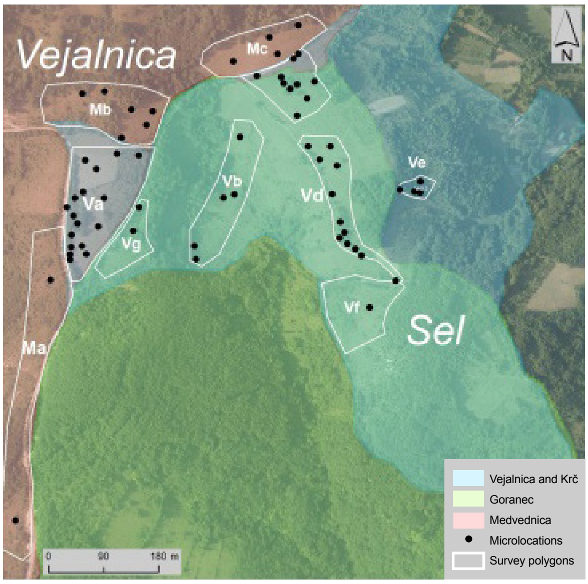
Segment D



Segment K



Segment E



Segment M & V

Appendix 2. Statistical results for plant abundance (DV1) dependency of IV1-IV5:

IV*→DV1	Categories	Likelihood ratio value	df	Likelihood ratio	Dependency	Significant influences (std. res. > |2.0|)
Slope direction (IV1)	9	23,2	16	0,108	no	no
Slope gradient (IV2)	4	**13,8**	6	**0,033**	**noticable**	moderate slopes increase the chance for high abundance (std. res. = 2.3)
Exposition (IV3)	9	156,9	16	**< 0.001**	**strong**	exposition from above increases the chances for high (std. res. = 4.3) and moderate (std. res. = 3.5) abundance and reduces chance for low abundance (std. res. = -2.6), the opposite stands for NE (std. res. are -2.8 and -3.2 for high and moderate abundances, respectively, and 2.0 for low abundance) and W (std. res. are -3.9 and -3.7 for high and moderate abundances, respectively, and 2.5 for low abundance) expositions
Habitat (IV4)	**3**	**34,3**	4	**<0.001**	**strong**	fringe habitat often increases the chance for low (std. res. = 2.2) and decreases the chance of moderate (std. res. = -2.0) and high (std. res. = -2.6) abundance; grassland habitat increases the chance for high abundance (std. res. = 2.3)
Woody plants < 2m (IV5)	3	2,1	4	0,724	no	no
Woody plants > 2m (IV6)	**3**	**22,8**	4	**<0.001**	**strong**	high coverage reduces chances for high abundance (std. res. = -1.8)

bold values – statistically significant results.

Statistical results for plant density regarding habitat type:

Habitat Type:	Grassland	Mixed	Fringe
N Valid	49	29	44
N Missing	0	0	0
Mean	4,1551	2,4517	2,3727
Std. Error of Mean	1,47222	0,75966	0,42343
Median	**1,9**	**0,8**	**1,6**
Std. Deviation	10,30554	4,0909	2,80874
Skewness	6,22	2,591	2,615
Std. Error of Skewness	0,34	0,434	0,357
Kurtosis	41,196	6,897	7,715
Std. Error of Kurtosis	0,668	0,845	0,702
Minimum	**0,1**	**0,1**	**0,2**
Maximum	**72**	**17,8**	**13,6**
12 Percentiles	0,7	0,16	0,4
25 Percentiles	1,1	0,35	0,625
50 Percentiles	1,9	0,8	1,6
75 Percentiles	3,4	2,25	3
88 Percentiles	5	8,2	5,1

bold values – statistically significant results.