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PHYTOSOCIOLOGICAL ANALYSIS OF PLANT COMMUNITIES AND RESURVEY OF HISTORICAL VEGETATION PLOTS ON THE ISLET OF PROIZD (SOUTHEASTERN ADRIATIC)

Running title: Vegetation of a Croatian Islet

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This paper presents the results of a phytosociological study conducted on the southeastern Adriatic islet of Proizd (0.632 km²). Based on 48 phytosociological relevés collected in 2024, following the Braun-Blanquet method, six plant associations, one subassociation, and one community, representing six alliances and classes, were identified. The benthic cormophyte community at depths of 1.5 to 15 meters is characterized by *Posidonietum oceanicae*. The halophytic vegetation of coastal low rocks is dominated by *Plantagino holostei-Limonietum subanfracti*, with a new subassociation, *helichrysetosum italici*, proposed. Forest vegetation is represented by the *Pistacio lentisci-Pinetum halepensis* association, while the maquis is dominated by *Pistacio lentisci-Juniperetum turbinatae*. The garrigue is represented by the *Erico-Rosmarinetum* association and the *Cistus monspeliensis* community. The thermophilous late-summer weed vegetation on sandy soils is represented by the *Portulacetum oleraceae* association. Although historical vegetation plots for *Erico-Rosmarinetum* are limited, recent data do not indicate significant changes in biodiversity at the local community or individual species level.

Keywords: coastal plant communities; distribution; eastern Adriatic; NE Mediterranean; southern Croatia; vegetation diversity

INTRODUCTION

Smaller islands and islets represent a diverse array of environmental and biogeographical conditions, making them valuable 'natural laboratories' for studying island colonization processes and species turnover [1]. Furthermore, these islands function as ideal 'experimental laboratories' for testing the potential impacts of global environmental changes driven by various factors [2]. This is because, relative to the mainland and larger islands, small insular communities and ecosystems are more vulnerable to external disturbances (e.g., storms, nesting seabirds, and invasive species) and environmental stochasticity, which can lead to rapid and contrasting ecological dynamics.

Islands are a key component of Mediterranean biodiversity, particularly due to the presence of range-restricted plant species and unique vegetation types [3, 4]. Croatia, with one of the most indented coastlines in the Mediterranean, has the second-largest number of islands after Greece. It is recognized as a critical center for native and endemic plant species diversity, as well as an essential refuge for wildlife [5]. In Croatia, 21 out of 94 Important Plant Areas (IPAs) encompass insular regions, which include an estimated 155 islands and islets (those smaller than 1 km²) [6]. While the flora of Croatian islands and islets is relatively well-documented, studies on the Mediterranean vegetation diversity in these areas remain limited and underrepresented compared to other regions. Out of Croatia's 1,246 islands [7], only about 110 have been studied for their flora and/or vegetation, often with incomplete data [8]. Consequently, there is still a substantial gap in our knowledge of the vegetation on most Croatian islands and islets.

Previous phytosociological studies documenting the vegetation across entire islands date back over 60 years (e.g., Krk, Rab, Pag) [9–12]. However, in the past decade, phytosociological research on Croatian islands and islets, particularly in the central and southern Adriatic (e.g., Olib, Badija, Vrnik), has gained momentum [13–16]. Most of the recently published data from these regions focus on specific vegetation types, such as maquis and garrigue [17, and references therein], dry grasslands [18, 19], calcareous rocky slopes with chasmophytic vegetation [20], and halophytic vegetation [21, 22].

Vegetation dynamics on Mediterranean islands are influenced by both environmental factors (such as climate and soil types) and local socioeconomic trends driven by human activities. The Mediterranean climate is particularly vulnerable due to its seasonal variability and the harsh, dry summers [23]. Against the backdrop of current global environmental trends, species and communities are facing significant and contrasting stresses, resulting from the intensifying impacts on island ecosystems and biodiversity. The objective of our study was to provide a phytosociological description, syntaxonomic classification, and assessment of the ecological significance of plant communities on the underexplored islet of Proizd in the southeastern Adriatic Sea (Croatia). Additionally, the study evaluates the variation in the structure of the garrigue plant community over a 65-year period by resurveying historical vegetation plots from Horvatić [24], the only available data on the vegetation of this islet.

MATERIAL AND METHODS

Study area

The islet of Proizd (0.632 km² in area; 4.908 km in perimeter; maximum altitude of 23 m a.s.l.) is the largest of a group of 10 islets (ranging from 0.01 to 1 km²) and skerries (<0.01 km²) located near the town of Vela Luka on the westernmost part of the island of Korčula, in the southeastern Adriatic (Figure 1). The coastlines are predominantly low and rocky, with sea depths around the islet ranging from 2 to 15 meters.

Palaeogeographically, the area is part of the Adriatic Carbonate Platform [25]. The island of Korčula is primarily composed of limestone and dolomites that accumulated during the Lower and Upper Cretaceous periods, with sporadic layers of *terra rossa* and Quaternary sands. The most common soil types in the study area include lithosol, *terra rossa*, anthropogenic soils, and brown soils on limestone and dolomites (calcocambisols) [26, 27].

The climate is Mediterranean, with an average annual air temperature of 15.7°C (based on data from the Vela Luka meteorological station, 1952–2018; see Bonacci and Ljubenkov [28]). The lowest average annual temperature (14.1°C) was recorded in 1980, while the highest (16.8°C) occurred in 2018. The highest average monthly temperature is in July (25.1°C), and the lowest in January (7.5°C). Absolute air temperatures have ranged from –7.8°C to 39.0°C. A time series analysis (1952–2018) indicates an upward trend in both annual and monthly air temperatures, with specific increases in mean monthly temperatures observed in June and decreases in December. The average annual precipitation is 838.5 mm (based on data from 1948–2008 [27]). The highest monthly precipitation (80 to 150 mm) occurs between November and March, while the lowest (30 to 45 mm) is recorded from June to August, with some summer months experiencing little to no rainfall. The area receives approximately 2,700 hours of sunshine annually. Southeastern winds (*sirocco*) are the most frequent in this region [29]. Monthly relative humidity ranges between 65 % and 75 %, with an annual average of 71 %.

Figure 1. The islet of Proizd is situated on the west of the island of Korčula, in the southeastern Adriatic.

The islet included in this study is part of the Important Plant Areas (IPAs) in Croatia [30] and is also designated as a protected site within the NATURA 2000 network (site code HR3000152 – "Otok Proizd i Privala na Korčuli") due to the presence of *Posidonia* meadows (*Posidonion oceanicae*) (priority habitat type code 1120*) and reefs (code 1170) [31]. Phytogeographically, the islet lies within the thermo-Mediterranean vegetation belt of the *Oleo-Ceratonion siliquae* [30].

Data collection and analysis

Field data were gathered from 48 vegetation sample plots (relevés) sampled in June 2024 and October 2024. Only three historical vegetation plots were available: (i) *"Erico-Rosmarinetum cistetosum monspeliensis pauperatum"*, Tab. I, rels. 4 and 8; (ii) *"Cisto-Ericetum arboreae cistetosum monspeliensis"*, Tab. III, rel. 8 [24]. Vegetation was studied according to the principles of the Braun-Blanquet method [32, 33]. The geographical coordinates of the relevés are provided in Appendix 1, and plant species found outside the relevés are listed in Appendix 3.

The nomenclature of high-rank vegetation units follows the syntaxonomical system (EuroVegChecklist) proposed by Mucina et al. [34] and adopted by Škvorc et al. [35]. Plant taxonomy follows the Plants of the World Online (POWO) [36], except for *Dorycnium hirsutum* (L.) Ser., for which the *Flora Croatica Database* is used [37]. EUNIS habitat types were determined following Chytrý et al. [38] and using the Database of European Flora and Vegetation (www.floraveg.eu). For marine habitats, the EUNIS marine habitat classification 2022 is applied [39]. The classification of vegetation units (alliances) into habitat types listed in Annex I of the Habitats Directive 92/43/EEC was performed according to the List of NATURA 2000 habitats declared by the Croatian Government [31].

RESULTS AND DISCUSSION

A total of 48 relevés (rels.) were analyzed, resulting in the identification of six vegetation types: (1) Aleppo pine forest, (2) maquis, (3) garrigue, (4) halophilous vegetation on bare and very shallow soils, (5) ruderal vegetation, and (6) marine vegetation.

The data revealed the presence of six associations, one subassociation, and one community, all belonging to six alliances and classes. These are presented in the phytosociological tables (Tables 1–4) and discussed below.

Table 1. *Pistacio lentisci-Pinetum halepensis* De Marco, Veri et Caneva 1984.

Relevé number		1	2	3	4	5	6	7
Plot size (m^2)		200	200	200	200	200	200	200
Altitude (m)		9	4	3	4	19	20	14
Aspect		W	E	N	E	.	.	S
Slope (°)		1	1	2	2	.	.	5
Cover tree layer (%)		70	30	60	95	70	80	90
Cover shrub layer (%)		60	60	80	90	90	30	40
Cover herb layer (%)		30	70	20	50	20	20	20
Height tree layer (m)		11	16	12	12	15	20	20
Height shrub layer (m)		3	2	2	3	2	4	2.5
Char. Ass. & *Pistacio-Pinion*								
Pinus halepensis	A	4	3	4	5	4	5	5
Pinus halepensis	B	.	+	+	.	.	.	.
Pistacia lentiscus		2	2	3	4	1	1	2
Pistacia lentiscus	C	1	+	+	.	.	.	+
Pinus halepensis		.	.	.	.	.	+	.
Quercetea ilicis								
Quercus ilex	A	1	.	.	.	.	.	.

Table 1 Continues

Juniperus turbinata		.	.	2	.	.	.	.
Phillyrea latifolia		.	.	.	.	.	1	.
Quercus ilex	B	2	2	1	1	3	2	1
Phillyrea latifolia		3	3	4	1	3	.	2
Asparagus acutifolius		+	+	+	1	+	+	.
Lonicera implexa		+	+	+	.	2	+	.
Erica arborea		1	+	+	.	1	.	.
Juniperus turbinata		1	3	.	.	1	.	.
Arbutus unedo		.	+	.	+	.	+	.
Vibunum tinus		.	.	.	1	.	1	+
Smilax aspera		.	.	1	+	.	.	.
Olea europaea subsp. *europaea*		.	+	.	.	.	.	.
Teucrium flavum		.	.	+	.	.	.	.
Rubia peregrina	C	2	1	1	+	+	1	+
Phillyrea latifolia		2	+	1	1	+	+	+
Carex halleriana		1	+	+	.	+	1	.
Asparagus acutifolius		+	+	+	+	.	+	.
Smilax aspera		+	+	+	+	.	.	.
Quercus ilex		1	+	.	+	.	.	1
Arbutus unedo		+	.	+	.	.	.	.
Juniperus turbinata		+	.	1	.	.	.	.
Teucrium flavum		+	.	.	1	.	.	.
Erica arborea		+	.	.	.	.	.	.
Lonicera implexa		.	.	+	.	.	.	.
Carex distachya		.	.	.	1	.	.	.
Lygeo sparti-Stipetea tenacissimae								
Brachypodium retusum	C	2	4	2	3	1	1	1
Dactylis glomerata subsp. *hispanica*		.	.	.	.	+	.	.
Centaurium erythraea		.	.	.	.	.	+	.
Carlina corymbosa		.	.	.	.	.	+	.
Quercetea pubescentis								
Hippocrepis emerus subsp. *emeroides*	B	1	+	+	1	.	+	.
Hippocrepis emerus subsp. *emeroides*	C	+	.	.	+	+	.	+
Ononido-Rosmarinetea								
Cistus monspeliensis	B	+	+	+	.	.	.	.
Cistus creticus		.	.	.	.	+	.	.
Cistus monspeliensis	C	+	.	.	1	.	.	.
Festuco-Brometea								
Achnatherum bromoides	C	.	.	.	1	.	.	.
Trifolio-Geranietea sanguinei								
Campanula rapunculus	C	.	.	.	.	.	+	.
Polygono-Poetea annuae								
Herniaria glabra	C	.	.	.	.	.	+	.

Table 2. *Pistacio lentisci-Juniperetum turbinatae* Trinajstić 1987 ex Asensi, Díez-Garretas et Quézel 2007.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Plot size (m²)	50	50	100	50	100	100	100	100	200	200	50	50	50	50	50	50	50
Altitude (m)	1	2	4	5	12	20	10	5	10	9	5	2	2	1	6	5	4
Aspect	.	.	.	.	.	NW	N	S	E	SE	.	.	S	.	NW	NW	E
Slope (°)	.	.	.	.	.	5	3	3	20	5	.	.	2	.	10	8	3
Vegetation cover (%)	95	95	90	90	95	100	100	100	100	100	100	100	100	95	100	100	95
Height of vegetation (m)	1.5	1.5	3	2	3	4	3	3	3	3	2	1.5	2	1.5	2	2	2
Char. Ass.																	
Juniperus turbinata	4	3	4	4	4	4	3	4	4	5	5	5	4	4	4	4	4
Oleo-Ceratonion*, *Pistacio-Pinion																	
Pistacia lentiscus	3	4	+	+	1	1	3	2	3	2	1	2	2	3	1	1	1
Pinus halepensis	2	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Quercetea ilicis																	
Quercus ilex	2	2	4	4	3	3	2	2	1	1	1	2	3	3	2	3	2
Smilax aspera	+	2	.	.	+	.	.	1	+	+	+	1	1	+	+	1	1
Arbutus unedo	1	.	.	.	2	+	.	.	2	1	1	1	1	+	+	+	2
Phillyrea latifolia	.	.	.	.	3	+	.	3	1	1	2	1	.	1	2	2	2
Rubia peregrina	1	+	.	.	+	.	.	.	+	.	+	+	1	.	1	+	+
Erica arborea	2	.	+	.	1	2	.	.	.	.	2	.	1	+	1	2	.
Asparagus acutifolius	+	.	.	.	.	+	.	+	+	+	1	+	.	+	.	.	+
Lonicera implexa	+	.	.	.	1	1	.	.	.	.	+	.	+	.	+	+	+
Prasium majus	.	.	.	.	.	.	.	.	.	.	2	.	+	+	+	+	+
Osyris alba	.	.	.	.	.	.	1	.	+	+	.	.	.	.	+	.	1
Teucrium flavum	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.
Carex distachya	1	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex halleriana	.	.	.	+	+	.	.	.	.	.	1	.	.	.	.	.	.
Arisarum vulgare	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Others																	
Ononido-Rosmarinetea																	
Cistus monspeliensis	1	.	+	1	.	1	.	3	1	+	3	.	.	.	.	.	+
Dorycnium hirsutum	+	.	.	.	.	.	+	+	+	1	.	.	+	+	.	.	.
Cistus creticus	.	.	.	.	.	+	+	1	+	+	.	.	.	+	.	.	.
Salvia rosmarinus	.	.	.	1	.	.	.	.	2	+	.	.	.	.	.	.	+
Thymelaea hirsuta	.	.	1	+	.	.	.	.	+	+	.	.	.	r	.	.	.
Fumana ericifolia	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cistus salviifolius	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Lygeo sparti-Stipetea tenacissimae																	
Brachypodium retusum	2	3	1	1	1	1	.	1	1	.	4	1	2	+	1	1	1
Dactylis glomerata subsp. *hispanica*	+	.	+	.	.	.	+	.	.	.	+	.	+	.	.	.	.
Centaurium erythraea	+	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.
Quercetea pubescentis																	
Hippocrepis emerus subsp. *emeroides*	+	.	+	.	+	+	.	.	+	.	+	1	+	+	1	1	1
Festuco-Brometea																	
Helichrysum italicum	.	.	1	1	.	.	.	.	.	+	.	.	.	.	.	.	.
Juncetea maritimi																	
Thinopyrum acutum	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crithmo-Staticetea																	
Daucus carota subsp. *hispanicus*	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Allium commutatum	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.

Table 3. *Erico-Rosmarinetum* (Horvatić 1958) Trinajstić 1977 (rels. 1–4), *Cistus monspeliensis* community (rels. 5–6).

Relevé number	1	2	3	4	5	6
Plot size (m²)	25	16	16	16	25	50
Altitude (m)	5	5	6	2	11	11
Aspect	NW	N	N	.	.	.
Slope (°)	7	5	5	.	.	.
Vegetation cover (%)	100	75	70	100	95	100
Height shrub layer (m)	1.5	1	1	0.8	1.2	1
Char. Ass.						
Salvia rosmarinus	3	3	3	3	.	.
Cistus monspeliensis	3	+	2	3	5	5
Ononido-Rosmarinetea						
Cistus creticus	+	+	1	.	.	.
Cistus salviifolius	1	.	1	.	.	.
Dorycnium hirsutum	+	+	.	.	.	.
Thymelaea hirsuta	.	+	+	.	.	.
Fumana ericifolia	.	.	+	.	.	.
Others						
Quercetea ilicis						
Pistacia lentiscus	1	1	+	1	+	1
Quercus ilex	2	2	2	.	.	.
Juniperus turbinata	2	1	2	.	.	.
Erica arborea	2	1	+	3	.	.
Carex halleriana	.	2	2	.	.	.
Arbutus unedo	.	+	2	.	.	.
Teucrium flavum	+	+	.	.	.	.
Smilax aspera	+	+	.	.	.	.
Osyris alba	.	+	.	.	.	.
Lonicera implexa	.	+	.	.	+	+
Phillyrea latifolia	.	.	.	2	1	.
Asparagus acutifolius	.	.	.	+	1	1
Arisarum vulgare	.	.	.	.	+	+
Carex distachya	.	.	.	.	+	.
Lygeo sparti-Stipetea tenacissimae						
Brachypodium retusum	2	3	.	1	1	3
Centaurium erythraea	.	1	.	.	.	.
Quercetea pubescentis						
Hippocrepis emerus subsp. *emeroides*	1	+	.	.	.	.
Festuco-Brometea						
Helichrysum italicum	+	.	+	.	.	.
Euphorbia spinosa	+	.	+	.	.	.
Petrorhagia saxifraga	.	+	.	.	.	.
Teucrium capitatum	.	+	.	.	.	.
Catapodium rigidum	.	.	r	.	.	.
Bellis sylvestris	.	.	.	+	1	+
Hypericum perforatum	.	.	.	.	+	1
Crithmo-Staticetea						
Daucus carota subsp. *hispanicus*	.	.	+	.	+	+
Poetea bulbosae						
Leontodon tuberosus	.	.	.	+	.	.

Notably, the subassociation *Plantagino holostei-Limonietum subanfracti helichrysetosum italici* is described for the first time (Table 4, rels. 10–17). Based on phytosociological surveys covering the entire islet, a vegetation map was created (Figure 2), and the physiognomy of the associations is illustrated in Figure 3. The complete syntaxonomic scheme is provided below:

***Pinetea halepensis* Bonari et Chytrý in Bonari et al. 2021**
Pinetalia halepensis Biondi, Blasi, Galdenzi, Pesaresi et Vagge in Biondi et al. 2014
Pistacio lentisci-Pinion halepensis Biondi, Blasi, Galdenzi, Pesaresi et Vagge in Biondi et al. 2014
***Pistacio lentisci-Pinetum halepensis* De Marco, Veri et Caneva 1984**

***Quercetea ilicis* Br.-Bl. ex A. Bolós et O. de Bolòs in A. Bolòs y Vayreda 1950**
Pistacio lentisci-Rhamnetalia alaterni Rivas-Mart. 1975
Oleo-Ceratonion siliquae Br.-Bl. ex Guinochet et Drouineau 1944
***Pistacio lentisci-Juniperetum turbinatae* Trinajstić 1987 ex Asensi, Díez-Garretas et Quézel 2007**

***Ononido-Rosmarinetea* Br.-Bl. in A. Bolòs y Vayreda 1950**
Cisto-Micromerietalia julianae Oberd. 1954
Cisto cretici-Ericion manipuliflorae Horvatić 1958
***Erico multiflorae-Rosmarinetum officinalis* (Horvatić 1958) Trinajstić 1977**
***Cistus monspeliensis* community**

***Crithmo-Staticetea* Br.-Bl. in Br.-Bl. et al. 1952**
Crithmo-Staticetalia Molinier 1934
Limonion anfracti-cancellati (Horvatić 1934) Mucina in Mucina et al. 2106
***Plantagino-Limonietum subanfracti typicum* Terzi et al. 2020**
***P.h.-L.s. helichrysetosum italici* subass. nov. hoc loco**

***Zosteretea* Pignatti 1953**
Posidonietalia oceanicae Den Hartog ex Mucina in Mucina et al. 2016
Posidonion oceanicae Br.-Bl. ex Molinier 1960
***Posidonietum oceanicae* (Funk 1927) Molinier 1958**

***Chenopodietea* Br.-Bl. in Br.-Bl. et al. 1952**
Eragrostietalia J. Tx. ex Poli 1966
Eragrostion Tx. in Oberd. 1954
***Portulacetum oleraceae* Felföldy 1942**

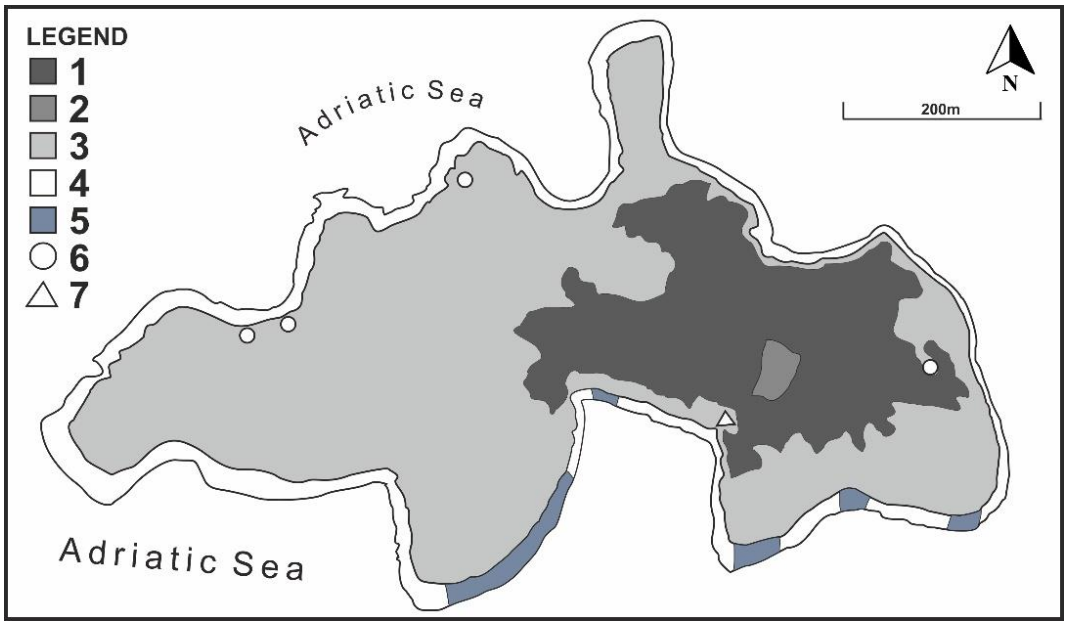

Figure 2. Vegetation map of the islet based on the phytosociological survey conducted in 2024: 1 – *Pistacio lentisci-Pinetum halepensis*; 2 – *Cistus monspeliensis* community; 3 – *Pistacio lentisci-Juniperetum turbinatae*; 4 – *Plantagino-Limonietum subanfracti typicum*; 5 – *Plantagino-Limonietum subanfracti helichrysetosum italici*; 6 – *Erico-Rosmarinetum*; 7 – *Portulacetum oleraceae*.

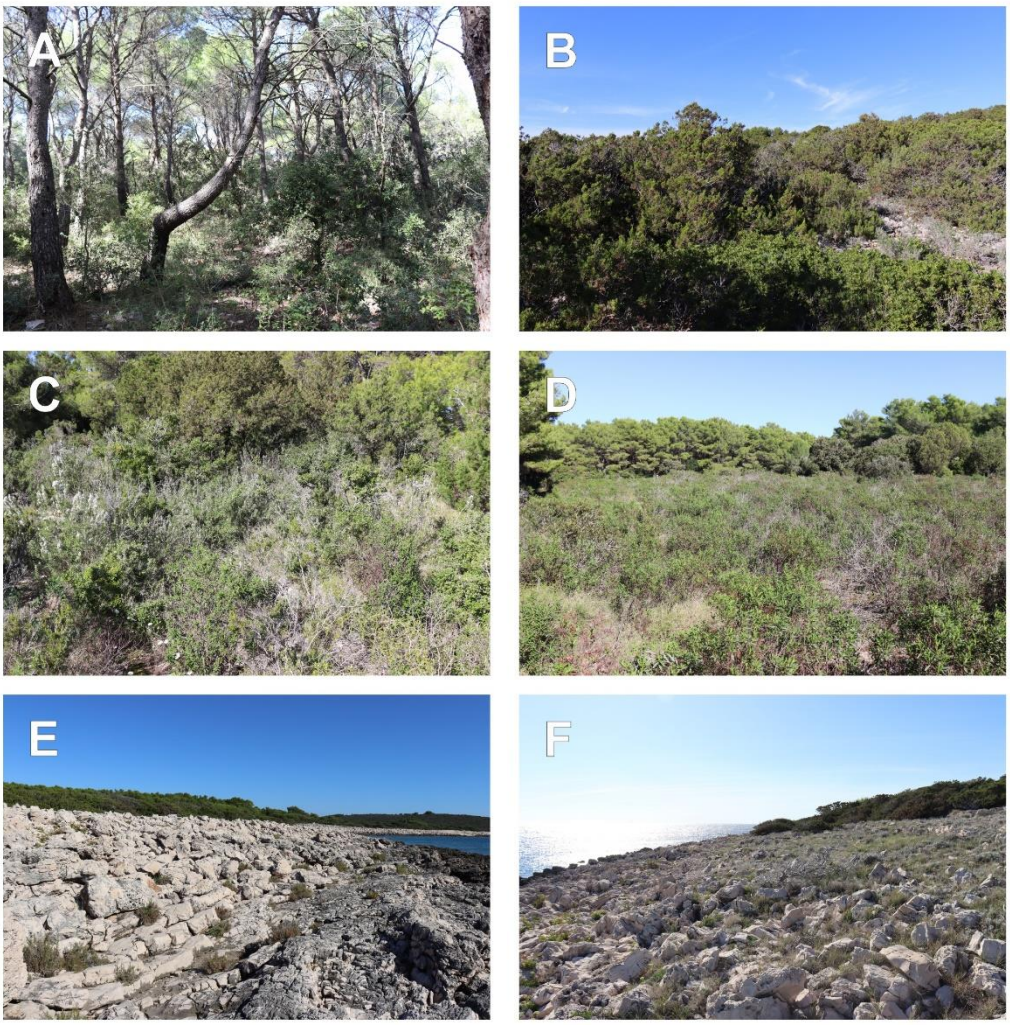

Figure 3. Physiognomy of the main vegetation types on the islet of Proizd: A – *Pistacio lentisci-Pinetum halepensis*; B – *Pistacio lentisci-Juniperetum turbinatae*; C – *Erico-Rosmarinetum*; D – *Cistus monspeliensis* community; E – *Plantagino-Limonietum subanfracti typicum*; F – *Plantagino-Limonietum subanfracti helichrysetosum italici* (photo: N. Jasprica).

Six alliances were assigned to five EUNIS habitat types: (1) *Pistacio lentisci-Pinion halepensis* [EUNIS 2020 habitat code: T3A, habitat type name: Mediterranean lowland to submontane *Pinus* forest]; (2) *Oleo-Ceratonion siliquae* [S51, Mediterranean maquis and arborescent matorral]; (3) *Cisto cretici-Ericion manipuliflorae* [S63, Eastern garrigue]; (4) *Limonion anfracti-cancellati* [N32, Mediterranean and Black Sea rocky sea cliff and shore]; and (5) *Posidonion oceanicae* [MB252, Biocenosis of *Posidonia oceanica*].

These alliances are also associated with four habitat types listed in Annex I of the Habitats Directive 92/43/EEC (EC 1992): (1) Vegetated sea cliffs of the Mediterranean coasts with endemic *Limonium* spp. [habitat code 1240]; (2) Mediterranean pine forests with endemic Mesogean pines [habitat code 9540]; (3) *Olea* and *Ceratonia* forests [habitat code 9320]; and (4) *Posidonia* beds (*Posidonion oceanicae*) [priority habitat 1120*].

Pistacio lentisci-Pinetum halepensis

The *Pistacio-Pinetum halepensis* forest community, which can reach heights of up to 20 meters, occupies the eastern part of the island on relatively flat terrain. *Pinus halepensis* is the dominant species in the tree layer, while *Pistacia lentiscus*, *Phillyrea latifolia*, and *Quercus ilex* are significant contributors to the shrub layer. *Brachypodium retusum* is a constant species in the herbaceous layer. This forest community has also been studied on the islands of the Korčula archipelago [15] and in the surrounding region [22], revealing a similar structure and floristic composition.

Pistacio lentisci-Juniperetum turbinatae

This community covers most of the island, with vegetation cover ranging from 90 % to 100 %. The maquis typically reaches heights of up to 3 meters and is often dense and impassable. The association is dominated by a small number of species, with the overall floristic composition being relatively poor, with only 8 to 18 species (average of 13) recorded per relevé. *Juniperus turbinata*, *Quercus ilex*, and *Pistacia lentiscus* show the highest cover and greatest presence. These findings are consistent with other studies [40, 41, etc.]. In the ground layer, *Brachypodium retusum* is a constant species.

Erico-Rosmarinetum

The *Erico-Rosmarinetum* community has been studied along the eastern Adriatic coast by Horvatić [24, 42] and Trinajstić [43]. On the islet of Proizd, Horvatić [24] recorded three relevés of garrigue communities: two of *Erico-Rosmarinetum cistetosum monspeliensis pauperatum* and one of *Cisto-Ericetum arboreae cistetosum monspeliensis*. During our phytosociological survey of the islet, we confirmed Horvatić's [24] findings that stands of *Erico-Rosmarinetum cistetosum monspeliensis pauperatum* represent a species-poor form of the association, lacking diagnostic species such as *Erica multiflora*, *E. manipuliflora*, *Thymbra capitata*, and *Fumana arabica*. These stands are limited to small patches (less than 20 m²) typically surrounded by *Pistacio lentisci-Juniperetum turbinatae* maquis. Despite the limited number of historical vegetation plots for these stands, recent data suggest no significant changes in biodiversity at the level of local communities or individual species.

According to Trinajstić [43], the core of *Erico-Rosmarinetum* stands along the eastern Adriatic Basin is located on the islands of Hvar and Vis, while on other islands (e.g., Brač) and the Pelješac peninsula, it exists at the edge of its distribution range. Pandža (personal communication, April 19, 2019) reported a well-structured stand of *Erico-Rosmarinetum* on the Mid-Adriatic island of Rivanj (Zadar archipelago). Trinajstić [43] further notes the absence of this community on the nearby island of Korčula. In terms of syntaxonomy, Trinajstić [43, 44] transferred *Erico-Rosmarinetum* from the previously attributed alliance *Cisto cretici-Ericion manipuliflorae* [42] to the western Mediterranean alliance *Rosmarino-Ericion multiflorae* (syn. *Rosmarinion officinalis*, *Rosmarinetalia officinalis*). However, Škvorc et al. [35] did not recognize the presence of the *Rosmarinetalia* order in Croatia.

The *Cisto-Ericetum arboreae cistetosum monspeliensis* stand reported by Horvatić [24] on the islet, based on a single relevé, can no longer be identified there today. Specifically, such communities along the eastern Adriatic coast are now at least partly or mostly attributed to the *Erico arboreae-Arbutetum unedonis* association (*Oleo-Ceratonion siliquae*). However, this association is not recognized on the islet [see 44]. The *Erico arboreae-Arbutetum unedonis* association is understood as a progressive stage following the burning of *Pinus halepensis* stands or as part of the natural succession processes in habitats of the *Cisto-Ericetum arboreae* association [44–46].

Cistus monspeliensis community

In a small area (approximately 0.32 ha) within a forest clearing surrounded by *Pinus halepensis* forest, stands dominated by *Cistus monspeliensis* have developed, characterized by a limited number of species. These stands show some resemblance to the *Erico manipuliflorae-Cistetum monspeliensis* association described by Trinajstić [44] from the island of Lastovo.

Plantagino-Limonietum subanfracti

The rocky coasts host the *Plantagino-Limonietum subanfracti* plant association, dominated by *Limonium subanfractum*, a species endemic to the central parts of the eastern Adriatic coast [47]. This species forms dense, low-spreading formations that colonize cracks in the rocks. Distinct belts can be identified based on their distance from the sea, particularly on the southern and western slopes of the islet.

The first belt, closest to the sea, is characterized by relevés dominated by *Arthrocaulon macrostachyum*. The second belt, further inland, features *Limonium subanfractum* and *Crithmum maritimum* (Figure 3E). The third belt, furthest from the sea and bordering the maquis, is dominated by a high cover of *Helichrysum italicum*. In our relevés, *H. italicum* is considered the differential taxon of the newly proposed plant subassociation *helichrysetosum italici* Jasprica et Dolina hoc loco (Table 4, holotypus relevé no. 17; Figure 3F).

Table 4. *Plantagino-Limonietum subanfracti typicum* Terzi et al. 2020 (rels. 1-9); *helichrysetosum italici* subass. nov. hoc loco (rels. 10-17, *holotypus rel. no. 17).

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17*
Plot size (m²)	16	16	16	16	16	16	20	20	20	25	20	20	20	20	16	25	25
Altitude (m)	0.5	1	2	2	2	1	1	2	1	4	2	2	1	3	4	2	3
Aspect	E	N	N	N	NE	NW	S	S	S	N	SW	S	S	SE	N	NW	NE
Slope (°)	7	3	3	40	20	10	2	2	2	2	2	3	3	3	10	3	10
Vegetation cover (%)	10	50	10	30	40	20	40	50	30	80	60	60	50	60	20	70	80
Char. Ass.																	
Limonium subanfractum	.	2	1	2	2	+	3	3	2	2	2	2	3	3	1	2	2
subass. *helichrysetosum italici*																	
Helichrysum italicum	.	.	.	.	.	.	.	.	.	3	4	3	2	3	2	4	4
Limonion anfracti-cancellati																	
Crithmum maritimum	2	3	+	2	3	2	2	2	1	2	2	2	2	3	1	.	1
Silene vulgaris subsp. *angustifolia*	+	.	.	+	.	+	.	.	.	.	.	.	.	.	+	1	2
Lotus cytisoides	.	.	.	+	.	+	+	.	.	.	.	.	.	.	+	+	2
Capparo orientalis-Aurinion leucadeae																	
Capparis orientalis	.	.	.	.	.	1	.	1	1	.	1	1	.	+	.	.	.
Crithmo-Staticetea																	
Allium commutatum	.	+	+	.	1	+	+	.	.	+	.	+	.	.	+	.	.
Daucus carota subsp. *hispanicus*	.	.	.	.	.	.	2	.	.	2	.	.	+	+	.	.	+
Vincetoxicum hirundinaria subsp. *adriaticum*	.	.	.	.	.	.	1	.	.	1	.	.	.	.	+	+	.
Others																	
Salicornietea fruticosae																	
Arthrocaulon macrostachyum	1	.	2	+	.	.	+	+	2	.	.	.	2	1	.	.	.
Limbarda crithmoides	2	2	+	.	.	.	.	.	.	.	.	+	1	.	.	.	1
Atriplex portulacoides	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Juncetea maritimi																	
Thinopyrum acutum	.	2	.	.	.	.	+	2	.	.	2	2	+	2	.	.	.
Chenopodietea																	
Cynodon dactylon	.	2	.	.	.	.	.	.	.	.	+	2	1	2	.	.	2
Sonchus asper	.	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.
Melilotus italicus	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Festuco-Brometea																	
Anthyllis vulneraria subsp. *rubriflora*	.	.	.	.	.	.	.	.	.	1	.	.	.	.	+	2	1
Teucrium capitatum	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.
Valantia muralis	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.	.
Euphorbia spinosa	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.
Aethionema saxatile	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Hypericum perforatum	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Allium paniculatum	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Bellis sylvestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Ononido-Rosmarinetea																	
Thymelaea hirsuta	.	.	.	.	1	.	.	.	.	.	.	+	2	.	.	.	1
Dorycnium hirsutum	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	1	1
Fumana ericifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.
Cistus salviifolius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
Cistus monspeliensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Lygeo sparti-Stipetea tenacissimae																	

Table 4 Continues

Reichardia picroides	.	.	.	.	.	.	.	.	.	1	.	.	.	+	+	1	1
Centaurium erythraea	.	.	.	.	.	.	.	.	.	1	.	.	.	.	+	1	.
Dactylis glomerata subsp. *hispanica*	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.
Brachypodium retusum	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.
Carlina corymbosa	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Blackstonia perfoliata	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Cakiletea maritimae																	
Atriplex prostrata	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Salsola kali	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pinetea halepensis																	
Pinus halepensis	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.
Pistacia lentiscus	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Quercetea ilicis																	
Smilax aspera	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Juniperus turbinata	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	r	.
Asparagus acutifolius	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.
Carex halleriana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Osyris alba	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Prasium majus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Saginetea maritimae																	
Parapholis incurva	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Catapodium marinum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Dittrichietea viscosae																	
Dittrichia viscosa	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Stipo-Trachynietea distachyae																	
Lotus ornithopodioides	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Trifolium campestre	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Orobanche minor	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Helianthemetea guttati																	
Linum trigynum	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.

A total of 42 taxa were recorded in the relevés sampled within this subassociation, with significant contributions from species in the *Festuco-Brometea* and *Ononido-Rosmarinetea* classes. The syntaxonomic position of various vicariant associations of the *Crithmo-Limonietum* s.l., which exhibit a high cover and presence of *Helichrysum italicum* [13, 22] along the eastern Adriatic coast, warrants further detailed analysis. On the western Adriatic coast, *Helichrysum italicum*-dominated calcareous rocky coastal communities are linked to the halotolerant vegetation of the *Helichrysetalia italici* order [48, and references therein].

Posidonietum oceanicae

Posidonia oceanica meadows are found at depths ranging from 1.5 to 15 meters along the coasts of the islet (see *P. oceanica* sites in Appendix 1). The accumulation of plant debris composed of dead *P. oceanica* leaves is also observed along these coastlines. *Posidonia oceanica* is a keystone species in a major ecosystem, providing various ecosystem services due to its high primary production, biodiversity [49], and its ability to store and sequester carbon for millennia [50].

In general, the primary causes of regression in *Posidonia* meadows are related to water quality, coastal infrastructure development, underwater pipelines and cables, anchoring, aquaculture, and trawling. For further details, see [51].

Portulacetum oleraceae

This thermophilous late-summer weed vegetation (*Eragrostion*) was found in the islet's port (Figure 2). The stands of *Portulacetum oleraceae* are not in their typical form but represent a significantly impoverished version of the community, dominated by *Portulaca oleracea* [October 14th, 2024: coordinates 42.983406 N, 16.618943 E; plot size 5 m²; altitude 8 m; sandy substrate; vegetation

cover 80 %]. The floristic composition includes: *Portulaca oleracea* (4), *Trifolium campestre* (+), *Erodium cicutarium* (+), *Conyza* sp. (+), and *Chenopodium album* var. *album* (+).

CONCLUSION

This study offers valuable new insights into the vegetation of small islands in the northeastern Mediterranean region. Although the area under investigation is relatively small, the findings should be considered in the context of the growing anthropogenic influences that are becoming increasingly prevalent across the Mediterranean basin. The islet's plant communities are characterized by the presence of only a few alien species (e.g., *Conyza* spp.) or are entirely free of non-native species, and the associations have not yet been significantly impacted by tourism, which is emerging as an industry in the area. Our vegetation map provides a robust foundation for the management and long-term monitoring of these protected habitats.

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Appendix 1.

Coordinates and date of sampling vegetation relevés. Tab. 1. ***Pistacio lentisci-Pinetum halepensis***. 28.6.2024: rel. 1. 42.983334 N, 16.619661 E; rel. 2. 42.983521 N, 16.621332 E; rel. 3. 42.983500 N, 16.623029 E; rel. 4. 42.983781 N, 16.618229 E; rel. 5. 42.985035 N, 16.614823 E; rel. 6. 42.983418 N, 16.619762 E; 14.10.2024: rel. 7. 42.984144 N, 16.617058 E. **Tab. 2.** ***Pistacio lentisci-Juniperetum turbinatae.*** 28.6.2024: rel. 1. 42.983605 N, 16.623536 E; rel. 2. 42. 985462 N 16,622769 E; rel. 3. 42.984671 N, 16.608484 E; rel. 4. 42.983868 N, 16.607970 E; rel. 5. 42.984944 N, 16.617543 E; rel. 6. 42.984657 N, 16.615153 E; rel. 7. 42.985470 N, 16.611475 E; 14.10.2024: rel. 8. 42.983858 N, 16.616767 E; rel. 9. 42.982490 N, 16.614769 E; rel. 10. 42.982943 N, 16.611395 E; rel. 11. 42.982609 N, 16.619438 E; rel. 12. 42.981754 N, 16.618868 E; rel. 13. 42.981986 N, 16.619943 E; rel. 14. 42.982154 N, 16.623149 E; rel. 15. 42.986380 N, 16.616918 E; rel. 16. 42.986839 N, 16.617301 E; rel. 17. 42.987613 N, 16.617978 E. **Tab. 3.** ***Erico-Rosmarinetum*****.** 28.6.2024: rel. 1. 42,986979 N, 16,614041 E; rel. 2. 42.984725 N, 16.610940 E; rel. 3. 42.984727 N, 16.609535 E; 14.10.2024: rel. 4. 42.983449 N, 16.623270 E. ***Cistus monspeliensis*** **community.** 14.10.2024: rel. 5. 42.984080 N, 16.619843 E; rel. 6. 42.983663 N, 16.619606 E. **Tab. 4.** ***Plantagino-Limonietum subanfracti.*** 28.6.2024: rel. 1. 42.984460 N, 16.623623 E; rel. 2. 42.985663 N, 16.622661 E; rel. 3. 42.985543 N, 16.620619 E; rel. 4. 42.984867 N, 16.610873 E; rel. 5. 42.984203 N, 16.607652 E; rel. 6. 42.985197 N, 16.611209 E; rel. 7. 42.983207 N, 16.618338 E; 14.10.2024: rel. 8. 42.981690 N, 16.619403 E; rel. 9. 42.981775 N, 16.619782 E; rel. 10. 42.985537 N, 16.621442 E; rel. 11. 42.982308 N, 16.621047 E; rel. 12. 42.981983 N, 16.622759 E; rel. 13. 42.983634 N, 16.616825 E; rel. 14. 42.981843 N, 16.615455 E; rel. 15. 42.986795 N, 16.617026 E; rel. 16. 42.987348 N, 16.617342 E; rel. 17. 42.987280 N, 16.618406 E. ***Posidonietum oceanicae***. (Station 1) Uvala Veliki Bili Bok 42.987360 N, 16.616213 E; (Station 2) Uvala Batala 42.986946 N, 16.620142 E; (Station 3) Uvala Perna 42.982801 N, 16.617202 E; (Station 4) Vraca 42.983687 N, 16.624926 E; (Station 5) Rt (Cape) Proizd 42.982884 N, 16.606002 E.

Appendix 2. Syntaxa quoted in the text and tables (in alphabetical order), but not in scheme.

Cakiletea maritimae Tx. et Preising in Tx. ex Oberd. 1952; *Capparo orientalis-Aurinion leucadeae* Lovrić ex Terzi, Bogdanović, D'Amico et Jasprica 2020; *Dittrichietea viscosae* Trinajstić, B.Foucault et Jasprica 2019; *Erico arboreae-Arbutetum unedonis* Allier et Lacoste 1980; *Erico manipuliflorae-Cistetum monspeliensis* Trinjastić

2008; *Festuco-Brometea* Br.-Bl. et Tx. ex Soó 1947; *Helianthemetea guttati* Rivas Goday et Rivas-Mart. 1963; *Helichrysetalia italici* Biondi et Géhu in Géhu et Biondi 1994; *Juncetea maritimi* Br.-Bl. in Br.-Bl. et al. 1952; *Lygeo sparti-Stipetea tenacissimae* Rivas-Mart. 1978 nom. conserv. propos. (*Thero-Brachypodietea* Br.-Bl. in Br.-Bl. et al. 1947); *Poetea bulbosae* Rivas Goday et Rivas-Mart. in Rivas-Mart. 1978; *Polygono-Poetea annuae* Rivas-Mart. 1975; *Quercetea pubescentis* Doing-Kraft ex Scamoni et Passarge 1959; *Rosmarinetalia officinalis* Br.-Bl. ex Molinier 1934; *Rosmarinion officinalis* Molinier 1934 (=*Rosmarino-Ericion multiflorae* Br.-Bl. ex Br.-Bl. et al. 1952); *Saginetea maritimae* Westhoff et al. 1962; *Salicornietea fruticosae* Br.-Bl. et Tx. ex A. Bolos y Vayreda et O. de Bolos in A. Bolos y Vayreda 1950; *Stipo-Trachynietea distachyae* S. Brullo in S. Brullo et al. 2001; *Trifolio-Geranietea sanguinei* T.Müller 1962.

Appendix 3. Species found on the islet outside of the relevés. *Ajuga iva* (L.) Schreb., *Beta vulgaris* L. subsp. *vulgaris* (syn: *Beta maritima* L.), *Chenopodium murale* L., *Narcissus serotinus* L., *Phragmites australis* (Cav.) Trin. ex Steud., *Posidonia oceanica* (L.) Delile, *Romulea bulbocodium* (L.) Sebast. et Mauri, *Vitex agnus-castus* L.

ФИТОЦЕНОЛОШКА АНАЛИЗА НА РАСТИТЕЛНИТЕ ЗАЕДНИЦИ И ПОВТОРНО ИСТРАЖУВАЊЕ НА ИСТОРИСКИТЕ ВЕГЕТАЦИСКИ ПОВРШИНИ НА ОСТРОВОТ ПРОИЗД (ЈУГОИСТОЧЕН ЈАДРАН)

Наслов: Вегетација на хрватско островче

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Во овој труд се презентирани резултатите од фитоценолошката студија на островчето Произд (0,632 km²) во југоисточниот Јадран. Врз основа на 48 фитоценолошки снимки направени во 2024 година, по методот на Braun-Blanquet, идентификувани се шест растителни асоцијации, една субасоцијација и една заедница (community), претставници на шест сојузи и класи. Бентосната заедница на кормофити на длабочини од 1,5 до 15 метри е претставена со асоцијацијата *Posidonietum oceanicae*. Во халофитната вегетација на крајбрежните ниски карпи доминира *Plantagino holostei-Limonietum subanfracti*, со предложена нова субасоцијација, *helichrysetosum italici*. Шумската вегетација е претставена со асоцијацијата *Pistacio lentisci-Pinetum halepensis*, додека во макијата доминира *Pistacio lentisci-Juniperetum turbinatae*. Гаригата е претставена од асоцијацијата *Erico-Rosmarinetum* и со заедницата *Cistus monspeliensis* community. Термофилната доцнолетна плевелна вегетација на песочни почви е претставена со асоцијацијата *Portulacetum oleraceae*. Иако историски вегетациските површини од *Erico-Rosmarinetum* се ограничени, сепак неодамнешните податоци не укажуваат на значителни промени во биолошката разновидност на ниво на локална заедница или на ниво на поединечни видови.

Клучни зборови: крајбрежни растителни заедници; дистрибуција; источен Јадран; СИ Медитеран; јужна Хрватска; вегетациска разновидност