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BIODIVERSITY CHANGE IN AGRICULTURAL AREA IN NORTHERN DALMATIA (CROATIA)

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ABSTRACT

In the last few decades, rapid overgrowing of arable land has been observed in the area of Policnik municipality (northern Dalmatia). Favourable climatic conditions and the geographic position of the Policnik municipality are of paramount importance for the agriculture and the economy. The possibility of mapping vegetation using traditional methods is unlikely due to the size of the surface itself, the available human resources. Thus, the research carried out on the basis of remote sensing footage is more favourable than traditional methods. The mapping of habitats in area of the Policnik municipality was carried out using remote sensing using the archival and recent orthophoto footage in QGIS programme. This research sought to determine the intensity of the succession stage in the period from 1952 to 2019. Also, field research was used to determine whether data obtained by remote sensing matches the one obtained by field observation. The forest areas increased for the last 67 years and especially at the mark 4050 for as much as 0.91 km² or 25.7% of the total 3.5 km² surface area. Surfaces covered with maquis shrubland were in deficit precisely because of the degradation stage of the maquis shrubland transitioning into forest. The biggest change was at the location 4048 where the surface covered with maquis shrubland decreased by as much as 0.53 km², that is, by 15.93% of the total area. The most significant change in terms of the increase of the areas covered in grasslands was at the location 4048 where it amounted to 0.42 km² (10% of the total area). Creating maps has provided a more scenic view of three researched locations. The results correspond to the hypothesis about increasing succession precisely because of anthropogenic factors (lack of maintenance of parcels, abandoning the rural areas and transitioning to urban areas, etc.).

KEYWORDS:
Biodiversity, Traditional agriculture, Succession, GIS, Spatio-temporal analysis

INTRODUCTION

Vegetation dynamics or succession is a change in the direction of development of woody species, but also in the direction of degradation of vegetation into the form of lower vegetation of shorter life span [1-2]. Vegetation succession in Croatia has been studied since the beginning of the development of vegetation ecology and phytocenology in the early 20th century [3-5]. Some of the research focused on successional processes of forest plant communities [6-7], and some examined ecology and changes in grassland communities [8-13], which have recently shown an accelerated healing trend due to the abandonment of agricultural activities [14-16]. Succession needs to be monitored over time, e.g., after abandonment of agricultural activity. In recent decades, there has been an expansion of agricultural activities and loss of open habitats, leading to a decline in species diversity [17-20]. There are many reasons for this, such as the increasing pressure of cities and the migration of young people to rural areas or, conversely, the intensification of modern agriculture and land use. For this very reason, the Mediterranean region is one of the most threatened areas [21-23]. A study of karst plateaus above Trieste, as an example of reforestation after grazing, found that more than 60% of the grasslands became covered with forest in the last 250 years [24]. Colonization and progressive succession to shrubs has been accompanied by the development of pioneer species of oak woodlands [25-28]. In some parts of Europe, the loss of grasslands is so alarming that some researchers value other preserved grasslands as "places to be saved" because they allow grassland species to grow and develop [29]. Endogenous successions are usually progressive and are directly caused by the introduction and spread of species in the habitat, while exogenous successions are caused by changes in the habitat, including anthropogenic influences, and can be both progressive and regressive. Most often, both processes occur simultaneously, so they are successions influenced by both endogenous and exogenous factors [30]. The most common natural factors are climatic or edaphic factors, while anthropogenic factors are mainly mowing, grazing, irrigation, drainage, tillage, deforestation, substrate adaptation, afforestation, etc.

Due to its geographical position, favorable climatic conditions and suitable soil, the municipality of Policnik is extremely important for the cultivation of agricultural crops with the possibility of irrigation. However, in recent decades the area has been overgrown with arable land. The overgrowth of arable land is increasing in the interior of the coast and in the Dalmatian hinterland of Croatia. In order to detect changes in vegetation, it is necessary to systematically study a larger area over several decades. Since such studies are long-term, remote sensing methods provide insight into the dynamics of vegetation based on recorded conditions at different times of its development and changes [31-34]. By using aerial photographs and orthophoto maps, we gain a clearer insight into the actual state of succession in the study area.

In the European Union, forested areas occupy about 1/4 of the total area, while grassland is the second largest vegetation cover. In the last thirty years, remote sensing of pastures and other vegetation types has been used [35]. Satellite remote sensing is a very effective method, and satellite imagery is a useful tool for monitoring and studying vegetation biomass [36]. The thematic use of satellite imagery in vegetation depends on the resolution or resolving power and spectral range in which the imagery was acquired. Fine resolution imagery (about 1 km) is used for global observations and studies of vegetation. An indirect method for monitoring succession is to use historical documents such as old vegetation maps, historical aerial photographs, and satellite imagery. Given the very common lack of past vegetation data and the paucity of direct long-term studies of vegetation change, these indirect measures are necessary to study succession and determine successional stages and phases, especially for changes that have occurred over several decades [37]. The hypothesis of this study is that changes in the type and intensity of vegetation use cause intense changes in vegetation and species diversity over time. Therefore, the aim of this study was to determine the changes in vegetation caused by the abandonment of agricultural land and depopulation of the Policnik municipality. This area was chosen as an example of the Dalmatian hinterland of Croatia. The abandonment of agricultural land due to depopulation was mainly due to the consequences of the war period and the economic conditions in the country.

MATERIALS AND METHODS

Study area. The municipality of Policnik (hereafter abbreviated to MP) is located in northern Dalmatia, northeast of the city of Zadar, in the most prominent part of Ravni kotari, characterised by its lowland features, and covers an area of 82.02 km² (Figure 1). Geomorphologically, the MP includes an area where carbonate and flysch ridges are exchanged, which rarely exceed 100 m above sea level, giving this area a flat and hilly appearance [38]. Wide valleys are usually covered deeper with marls and sandstones. This geological-geomorphological structure leads to a main feature of the Policnik municipality, namely a significant amount of arable land.

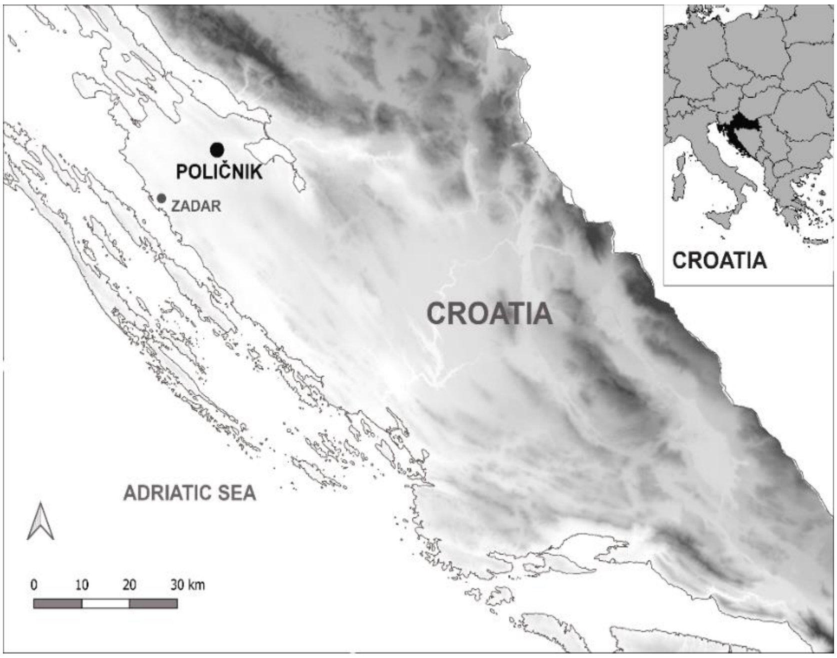

FIGURE 1
The geographical position of the Policnik municipality in Croatia and Europe

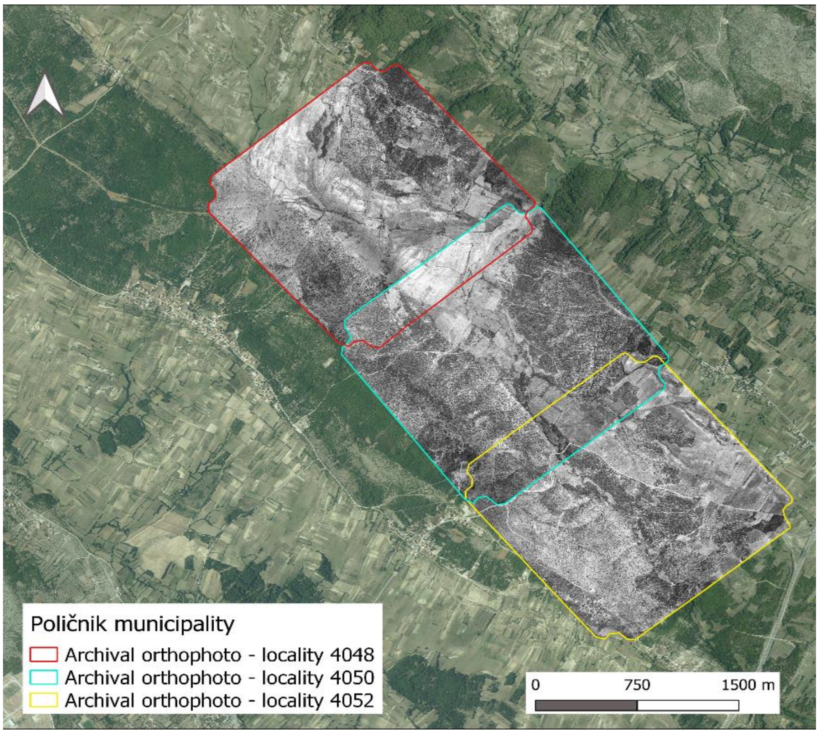

FIGURE 2
Position of three georeferenced archival orthophotos from 1952 and their location on the current aerial photograph's maps from 2019 of Policnik municipality

The MP is geographically located at the crossroads of the eumediterranean and submediterranean climatic zones, so the MP has the characteristics of both zones in the form of vegetation. According to the Köppen's classification, the area of MP belongs to the Cfa climate and so-called "moderately warm, humid climate with hot summers". The weather and climate in this area are strongly influenced by the proximity of the sea. The effects can be seen in the weakening of temperature contrasts and thus the refreshing effect of the sea on the area of MP. Of the mountain factors in this area, the most important is Mount Velebit. With its length, height and location near the coast, Velebit is a very effective and important climatic barrier between the sea and land climate in this area. The mountain of Velebit prevents the mixing of these two climatic zones and the gradual transition from one to the other. The presence of the huge mainland area of Ravni kotari is shown mainly by the thermal effect [39]. The average annual temperature of MP (Zadar) is 16.3°C (DHMZ), while the average annual precipitation is 948.3 mm. Precipitation is higher in the colder part of the year, which is a characteristic of the maritime precipitation regime.

The main development potential of MP results from its natural characteristics and favorable spatial location. Among the natural resources, the soil suitable for growing crops with the possibility of irrigation stands out. Population development and density in the area are related to the economic potential of the natural base and social events in the past and present.

Data collection. The survey was conducted at three sites of orthophotos in the municipality of Policnik, designated 4048, 4050 and 4052. The total area of each study site is 3.5 km^2. The survey was conducted by photo interpretation of archival orthophotos from 1952 and more recent orthophotos from 2019 (Figure 2).

Field research on flora and vegetation was conducted during the growing season (April, May and June) in 2019. Plant taxa were determined according to [40-42]. Plant species names were adjusted according to the Flora Croatica Database [40]. Vegetation was sampled according to the standard Central European method, the Zürich-Montpellier method [43]. The size of the plots where the vegetation of forests, maquis and grasslands was studied was 15 x 15 m. Habitat types were harmonized according to the National Habitat Classification (NHC) of four's revised version (NN 88/14) with the corresponding NHC code.

Spatio-temporal analysis. Digital vector maps were created based on the collected data, providing insight into the successional changes that occurred over a 67-year period. Habitat mapping was performed using the remote sensing method in the QGIS 3.10.2 program. Operations and photo interpretations over raster layers from different periods formed the final vector layers GIS on an area of about 3.5 km^2 per plot. The official HTRS96 / Croatia TM, EPSG: 3765 coordinate reference system was used in the development of the habitat map and successional stages. According to the collected data, an analysis of the state of vegetation was performed for each period, i.e. for 1952 and 2019. The results of the 1952 and 2019 analyzes were compared, and these data were used to determine the percentages of altered areas over a 67-year period.

The spatial and temporal changes are based on aerial photographs taken in 1952. The black and white aerial photographs are from 1952 (Military Geographical Institute, Belgrade), while the colour aerial photographs (georeferenced and orthorectified) are from 2019 (State geodetic directorate, Zagreb). Prior to spatial analysis, the black & white aerial photographs (three photographs for 1952) were digitised at 300 dpi resolution, orthorectified and georeferenced by overlaying them on topographic maps (1:25000) and 2019 aerial photographs using QGIS 3.10.2. Land cover mapping required processing of the base layer. Aerial imagery was analysed using the SAGA automated geoscience analysis software package [44]. Unsupervised classification [45] was performed using the mean resampling method (cell area weighted) based on previously recorded vegetation, resulting in a grid (10 × 10 m) for each processed year. The grid was vectorized for photo interpretation control and corrections as needed. The mapped land cover was classified into 10 classes (Table 1) and used for further analysis. Temporal changes were recorded using change detection analysis applied to the gridded data. Qualitative and quantitative changes in land cover categories were detected by overlapping land cover maps for two different years, resulting in transition paths.

RESULTS

In this study, the progressive succession of vegetation was noted, as evidenced by the significant changes in land cover between 1952 and 2019, which is reflected in the decrease in plant diversity in the municipality of Policnik (Figure 3).

A total of 10 habitat types were identified for which the NHC code was determined, of which two belong to the closed or pulsating-closed type and four to the open type (Table 2). Four habitat types refer to residential buildings, etc. and occupy only a small share of 0.07% in 1952 and 0.41% in 2019.

The greatest changes were observed in the closed land-cover types of mediterranean shrubs and forests. In 1952, mediterranean shrubs were the predominant land cover, occupying more than 42.95% (4.51 km^2) of the total study area and will decrease to less than 11.9% in 2019. Forests and shrubs gradually increase from 20.29% (2.13 km^2) in 1952 to 40.38% in 2019. Agricultural land decreases from 22.76% (2.39 km^2) in 1952 to 14.86% in 2019. However, the percentage of vineyard land has increased strongly throughout the study period and is about 10%. In 2019, the number of residential buildings has increased, as well as the number of business facilities and industrial areas which did not exist in 1952.

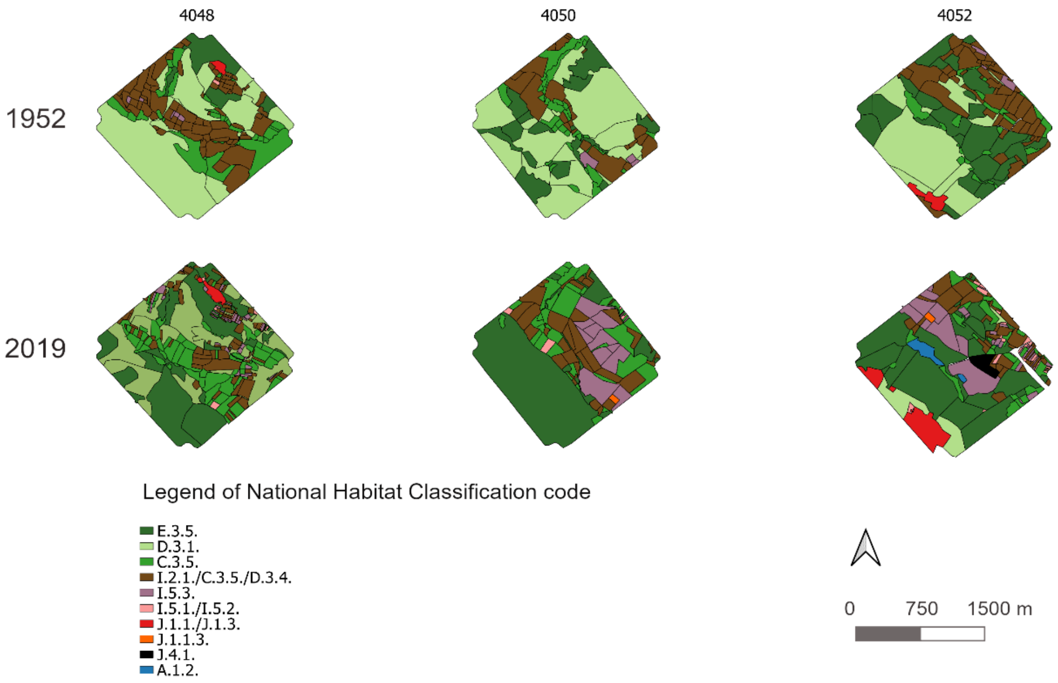

FIGURE 3
Land-cover and change maps based on field research and aerial photographs photointerpretation from 1952 and 2019

TABLE 1
Area covered by each land-cover type and vegetation unit, for each study year. The category "other" includes areas that could not be determined. Area is expressed as percentage of total study area

Vegetation units	NHC code	Area (%) in 1952	Area (%) in 2019	Succession area (km^2)
Forests and shrubs	E.3.5.	20.29	40.38	2.11
Mediterranean shrubs	D.3.1.	42.95	11.90	-3.26
Dry and rocky grasslands	C.3.5.	10.38	15.81	0.57
Farm land	I.2.1./C.3.5./D.3.4.	22.76	14.86	-0.83
Vineyard	I.5.3.	0.95	10.19	0.97
Orchard	I.5.1./I.5.2.	0.38	1.05	0.07
Residential area	J.1.1./J.1.3.	0.67	2.67	0.21
Economic facilities	J.1.1.3.	-	0.09	0.009
Industrial zone	J.4.1.	-	0.57	0.06
Water surface	A.1.2.	-	0.57	0.06
Other	-	1.62	1.91	-

TABLE 2
Land cover and habitat description with list of determined taxa in the agricultural area of Policnik municipality

Land cover/habitat	NHC code	Description	Taxa
Forests and shrubs	E.3.5.	Coastal, thermophilic forests and shrubs of *Quercus pubescens* (*Ostryo-Carpinion orientalis* Ht. (1954) 1959). Deciduous forests developed in the form of various stages of degradation due to centuries of exploitation for firewood or to obtain pasture. The progressive stage of vegetation towards shrubs and forests is due to the abandonment of livestock and the cessation of the use of wood for fuel.	1. *Acer campestre* L. 2. *Acer monspessulanum* L. 3. *Ailanthus altissima* (Mill.) Swingle 4. *Asparagus acutifolius* L. 5. *Asparagus tenuifolius* Lam. 6. *Carpinus orientalis* Mill. 7. *Clematis flammula* L. 8. *Cornus mas* L. 9. *Cornus sanguinea* L. 10. *Coronilla emerus* L. ssp. *emeroides* Boiss. et Spruner 11. *Festuca heterophylla* Lam. 12. *Ficus carica* L. 13. *Fraxinus ornus* L. 14. *Hedera helix* L. 15. *Juniperus oxycedrus* L. 16. *Lonicera etrusca* Santi 17. *Malva sylvestris* L. 18. *Morus alba* L. 19. *Paliurus spina-christi* Mill. 20. *Pinus halepensis* Mill. 21. *Prunus mahaleb* L. 22. *Prunus spinosa* L. 23. *Quercus cerris* L. 24. *Quercus pubescens* Willd. 25. *Robinia pseudoacacia* L. 26. *Rosa canina* L. 27. *Rosa sempervirens* L. 28. *Rubia peregrina* L. 29. *Rubus ulmifolius* Schott 30. *Ruscus aculeatus* L. 31. *Sambucus ebulus* L. 32. *Satureja montana* L. 33. *Sesleria autumnalis* (Scop.) F. W. Schultz 34. *Smilax aspera* L. 35. *Ulmus minor* Mill.
Mediterranean shrubs	D.3.1.	Mediterranean shrubs (*Rhamno-Paliurion* Trinajstic (1978) 1995). Shrubs of coastal areas, built of distinct prickly, thorny or aromatic plants unsuitable for grazing, primarily goats. These are very widespread set of habitats within the sub-mediterranean vegetation zone as one of the degradation stage of *Quercus pubescens* and *Carpinus orientalis* forests.	1. *Acer monspessulanum* L. 2. *Ailanthus altissima* (Mill.) Swingle 3. *Ajuga reptans* L. 4. *Argyrolobium zanonii* (Turra) P. W. Ball 5. *Asparagus acutifolius* L. 6. *Asphodelus aestivus* Brot.

			7. *Betonica officinalis* L. ssp. *serotina* (Host) Murb. 8. *Bromus erectus* Huds. 9. *Carduus pycnocephalus* L. ssp. *pycnocephalus* 10. *Carpinus orientalis* Mill. 11. *Carlina corymbosa* L. 12. *Carthamus lanatus* L. 13. *Centaurea solstitialis* L. 14. *Chrysopogon gryllus* (L.) Trin. 15. *Clematis flammula* L. 16. *Convolvulus arvensis* L. 17. *Crataegus monogyna* Jacq. 18. *Cyclamen repandum* Sibth. et Sm. 19. *Daucus carota* L. 20. *Dorycnium herbaceum* Vill. 21. *Echium italicum* L. 22. *Eryngium campestre* L. 23. *Foeniculum vulgare* Mill. 24. *Fraxinus ornus* L. 25. *Galium lucidum* All. 26. *Geranium purpureum* Vill. 27. *Helichrysum italicum* (Roth) G. Don 28. *Hieracium pilosella* L. 29. *Hippocrepis comosa* L. 30. *Hypericum perforatum* L. 31. *Juniperus oxycedrus* L. 32. *Koeleria splendens* C. Presl 33. *Marrubium incanum* Desr. 34. *Muscari comosum* (L.) Mill. 35. *Ornithogalum collinum* Guss. 36. *Paliurus spina-christi* Mill. 37. *Phillyrea latifolia* L. 38. *Picris hieracioides* L. 39. *Pistacia terebinthus* L. 40. *Prunus mahaleb* L. 41. *Punica granatum* L. 42. *Quercus pubescens* Willd. 43. *Rhamnus intermedia* Steud. et Hochst. 44. *Rubus heteromorphus* Ripart ex Genev. 45. *Ruscus aculeatus* L. 46. *Salvia officinalis* L. 47. *Scolymus hispanicus* L. 48. *Sesleria autumnalis* (Scop.) F. W. Schultz 49. *Silene latifolia* Poir. ssp. *alba* (Mill.) Greuter et Bourdet 50. *Smilax aspera* L. 51. *Stachys thirkei* K. Koch 52. *Teucrium polium* L. 53. *Thlaspi praecox* Wulfen 54. *Thymus longicaulis* C. Presl
Dry and rocky grasslands	C.3.5.	Sub-mediterranean and epimediterranean dry grasslands (*Scorzoneretalia Villosae* H-ic. 1975 (=*Scorzonero-Chrysopogonetalia* H-ic. et Ht. (1956) 1958). Vegetation with sporadic shrubs and herbaceous species suitable for grazing, which are on shallow carbonate soil.	1. *Agrimonia eupatoria* L. 2. *Ailanthus altissima* (Mill.) Swingle 3. *Anacamptis pyramidalis* (L.) Rich. 4. *Aristolochia rotunda* L. 5. *Aster squamatus* (Spreng.) Hieron. 6. *Astragalus muelleri* Steud. et Hochst. 7. *Avena barbata* Link 8. *Bromus erectus* Huds. 9. *Calamintha nepetoides* Jord. 10. *Centaurea calcitrapa* L. 11. *Chenopodium album* L. 12. *Chrysopogon gryllus* (L.) Trin. 13. *Cichorium intybus* L. 14. *Cirsium vulgare* (Savi) Ten. 15. *Conyza bonariensis* (L.) Cronquist 16. *Conyza canadensis* (L.) Cronquist 17. *Cruciata laevipes* Opiz 18. *Cynodon dactylon* (L.) Pers.

			19. *Dactylis glomerata* L. 20. *Dactylis glomerata* L. ssp. *hispanica* (Roth) Nyman 21. *Dasypyrum villosum* (L.) P. Candargy 22. *Desmazeria rigida* (L.) Tutin 23. *Dichanthium ischaemum* (L.) Roberty 24. *Diplotaxis tenuifolia* (L.) DC. 25. *Dittrichia graveolens* (L.) Greuter 26. *Eragrostis minor* Host 27. *Euphorbia spinosa* L. 28. *Euphorbia prostrata* Aiton 29. *Festuca valesiaca* Gaudin 30. *Helichrysum italicum* (Roth) G. Don 31. *Heliotropium europaeum* L. 32. *Lolium perenne* L. 33. *Lophochloa cristata* (L.) Hyl. 34. *Marrubium incanum* Desr. 35. *Melica ciliata* L. 36. *Medicago orbicularis* (L.) Bartal. 37. *Ophrys bertolonii* Moretti 38. *Ophrys fuciflora* (F. W. Schmidt) Moench 39. *Ophrys scolopax* Cav. ssp. *cornuta* (Steven) E. G. Camus 40. *Ophrys sphegodes* Mill. 41. *Orchis coriophora* L. 42. *Orchis laxiflora* Lam. 43. *Panicum capillare* L. 44. *Petrorhagia saxifraga* (L.) Link 45. *Phleum pratense* L. 46. *Platanthera chlorantha* (Custer) Rchb. 47. *Plantago holosteum* Scop. 48. *Plantago lanceolata* L. 49. *Plumbago europaea* L. 50. *Polygonum aviculare* L. 51. *Portulaca oleracea* L. 52. *Salvia officinalis* L. 53. *Sanguisorba minor* Scop. ssp. *muricata* Briq. 54. *Satureja montana* L. 55. *Scilla autumnalis* L. 56. *Scorpiurus muricatus* L. 57. *Scorzonera villosa* Scop. 58. *Setaria viridis* (L.) P. Beauv. 59. *Sherardia arvensis* L. 60. *Spiranthes spiralis* (L.) Chevall. 61. *Stipa pennata* L. ssp. *eriocaulis* (Borbás) Martinovský et Skalický 62. *Torilis nodosa* (L.) Gaertn. 63. *Verbena officinalis* L. 64. *Xanthium strumarium* L. ssp. *italicum* (Moretti) D. Löve
Farm land	I.2.1./C.3.5./D.3.4.	Mosaics of different cultures on small plots, in spatial alternation with elements of rural settlements and natural and semi-natural vegetation / sub-mediterranean and epimediterranean dry grasslands / low, evergreen shrubs on a basic substrate, as one of the degradation stages of evergreen forest vegetation. They are built of semi-shrubs that mainly belong to the families of *Cistaceae*, *Ericaceae*, *Fabaceaae* and *Lamiaceae* (*Erico-Cistetea* Trinajstic 1985).	1. *Allium ascalonicum* L. 2. *Allium cepa* L. 3. *Allium porrum* L. 4. *Allium sativum* L. 5. *Apium graveolens* L. 6. *Beta vulgaris* L. ssp. *vulgaris* 7. *Brassica cretica* Lam. ssp. *botrytis* (L.) O. Schwarz 8. *Brassica oleracea* L. ssp. *acephala* (DC.) O. Schwarz 9. *Brassica oleracea* L. ssp. *bullata* DC. 10. *Brassica oleracea* L. ssp. *capitata* (L.) Duchesne 11. *Brassica oleracea* L. ssp. *gemmifera* (DC.) O. Schwarz 12. *Capsicum annuum* L. 13. *Cicer arietinum* L.

			14. *Citrullus lanatus* (Thunb.) Matsum. et Nakai 15. *Cucurbita pepo* L. 16. *Cucumis melo* L. 17. *Cucumis sativus* L. 18. *Cynara scolymus* L. 19. *Daucus carota* L. 20. *Fragaria* x *ananassa* Duchesne 21. *Helichrysum italicum* (Roth) G. Don 22. *Lactuca sativa* L. 23. *Lagenaria vulgaris* Ser. 24. *Pastinaca sativa* L. 25. *Petroselinum crispum* (Mill.) A. W. Hill 26. *Phaseolus vulgaris* L. 27. *Pisum sativum* L. 28. *Secale cereale* L. 29. *Solanum lycopersicum* L. 30. *Solanum melongena* L. 31. *Solanum tuberosum* L. 32. *Spinacia oleracea* L. 33. *Triticum aestivum* L. 34. *Vicia faba* L. 35. *Vigna unguiculata* (L.) Walp. 36. *Zea mays* L. / dry grasslands / 1. *Ailanthus altissima* (Mill.) Swingle 2. *Althaea officinalis* L. 3. *Amaranthus albus* L. 4. *Amaranthus retroflexus* L. 5. *Ambrosia artemisiifolia* L. 6. *Cistus incanus* L. 7. *Cistus monspeliensis* L. 8. *Cistus salviifolius* L. 9. *Fumana procumbens* (Dunal) Gren. et Godr. 10. *Genista sylvestris* Scop. ssp. *dalmatica* (Bartl.) H. Lindb. 11. *Ononis antiquorum* (L.) Arcang. 12. *Ononis minutissima* L. 13. *Rosmarinus officinalis* L. 14. *Salvia verbenaca* L. 15. *Trifolium angustifolium* L.
Vineyard	I.5.3.	Areas intended for grapevine cultivation with traditional or intensive cultivation methods.	1. *Vitis vinifera* L. ssp. *vinifera*
Orchard	I.5.1./I.5.2.	Areas intended for fruit growing by traditional or intensive cultivation methods / areas intended for olive cultivation.	1. *Juglans regia* L. 2. *Actinidia chinensis* Planch. 3. *Citrus deliciosa* Ten. 4. *Citrus sinensis* (L.) Osbeck 5. *Malus pumila* Mill. 6. *Pyrus communis* L. 7. *Prunus armeniaca* L. 8. *Prunus avium* (L.) L. 9. *Prunus cerasus* L. 10. *Prunus dulcis* (Mill.) D. A. Webb 11. *Prunus persica* (L.) Batsch / 1. *Olea europaea* L.
Residential area	J.1.1./J.1.3.	Rural areas where the rural way of life has been maintained.	
Economic facilities	J.1.1.3.	Rural buildings with economic function (farms, greenhouses etc.).	
Industrial zone	J.4.1.	Industrial areas.	
Water surface	A.1.2.	Freshwater lakes, ponds or parts of such waters of natural origin that are sometimes dry.	

The highest plant diversity was found in the open habitat type, i.e. rocky pastures, where the largest number of plant taxa was found (64). A total of 36 taxa of cultivated plants were identified on habitat type I.2.1. - Mosaics of different crops on small plots, spatially alternated with elements of rural settlements and natural and semi-natural vegetation. There were also identified 12 species of fruits, which gives a total of 48 species of cultivated plants, from which it can be concluded that area of Policnik municipality has a great potential for cultivation of cultivated plants (Table 2).

DISCUSSION

The problem with vegetation mapping is habitat types that are transitional in nature and do not have a strict syntaxonomic position, but they are indeed habitat, so they must be accepted as habitats. These are often different stages in the succession of vegetation or transitional communities in places where geographically or ecologically two or more plant communities meet [46-47].

Open habitat types such as *Scorzoneretalia Villosae* H-ic. 1975 are suitable habitats for many orchids [48-49] and can be used as rocky pastures (Figure 4). Such pastures are habitats that greatly enrich plant and landscape diversity. However, in the MP area, these habitats are threatened by the abandonment of traditional livestock production. A moderate sheep grazing intensity of one to two (animals/ha) or 0.1 livestock units is recommended as the optimum for such grasslands, as suggested by [11]. Such grazing intensity contributes not only to the conservation of plant diversity, but also to the improvement of ecological sheep production and habitat sustainability in the successional process. In recent decades, significant changes in grazing use have occurred in these areas. In fact, due to the development of tourism, sheep grazing was abandoned and the number of sheep per unit area decreased drastically, leading to a succession process, especially for woody species in the first stage (Figure 4).

Much of the area is already covered with shrubs and forests and it is more difficult to convert it back to open habitat types (Figure 4). In the last 67 years, the grassland has been reforested with species such as *Juniperus oxycedrus*, *Rosa canina*, *R. sempervirens*, *Paliurus spina-christi*, *Fraxinus ornus*, etc. Therefore, it is necessary to preserve at least the pastures that have not yet been consumed to a great extent. In general, for all rocky pastures that form heliophilous plants, it is necessary to create open habitats, mainly by sheep grazing, since the possibility of mowing on such habitats is excluded. Unfortunately, with the loss of such habitats, plant diversity is declining and the open landscapes of the sub-mediterranean region are being lost. The conservation of these habitats is possible with the slash-and-burn method, but only on limited areas and under strict control.

Land abandonment initially involved open land-cover types, which initially change more rapidly than closed types [50-51]. Declines in pasture and cropland after land abandonment have been reported elsewhere [16, 20, 30], with landscape changes triggered by socioeconomic factors [18]. The results obtained suggest that socioeconomic factors are the main drivers of land-cover change, while environmental parameters determine the nature of the change [52-53]. The consequences of land abandonment on land-cover changes observed in this study can also be observed in numerous depopulated areas along the eastern Adriatic coast.

FIGURE 4
Successive stadium with woody species on the dry and rocky grassland of *Scorzoneretalia Villosae* H-ic. 1975

On the dry and rocky grassy areas of MP, where the possibility of mowing is unprofitable for economic reasons, moderate grazing with native breeds of sheep is recommended, which contributes to the preservation of plant diversity and habitats, but also to the development of ecological sheep farming. The cattle select the herbs they like and carry them to the pasture, leaving poisonous, prickly or stingy plants, which then spread rapidly [4]. In any case, intensive grazing hinders the development of plant growth and causes major changes that can lead to the complete destruction of plant communities [54-55]. Moderate grazing pressure favors plant diversity and direct consumption of dominant species, which indirectly affects plant species competition and promotes plant coexistence [56-57].

Mechanical removal of undesirable species should be applied to woody species such as *Ailanthus altissima* when they grow sporadically in meadows. Cuttings of such species should be applied as soon as possible, because the process is much more difficult and lengthy in the later stages of succession and development of dense maquis. It is also necessary to mechanically remove alien and invasive plant species from MP. Allochthonous species can be expected in habitats under greater anthropogenic influence, along the road and roadsides [58-59]. To date, none of the established allochthonous species have been detected in larger areas and at high population densities. However, the species *A. altissima* is expected to spread faster because it is an extremely opportunistic, adaptable, and aggressive species that displaces autochthonous taxa in its vicinity, thus reducing biodiversity and the value of natural ecosystems [60]. The method of burning is also effective in removing unwanted vegetation from macquis that has developed in the process of progressive succession. It is positive to remove unwanted vegetation quickly and create a habitat for new species, while the negative side is a radical deterioration of biodiversity and, moreover, fires can be carried out only on limited areas.

CONCLUSIONS

Remote sensing used in this study and combined with the geographic information system allowed the use of data obtained from different sources and dating from different periods. Archived and current aerial photographs and orthophoto maps were used for the study. The main objective of the study was to determine the dynamics of vegetation during the period 1952-2019.

Depopulation and land abandonment at MP lead to secondary succession, which results in a decrease in species diversity and changes in land cover. Species diversity analysis showed high species diversity in open vegetation units such as dry and rocky grasslands, followed by a slight increase in semi-open vegetation (mediterranean shrubs) and a decrease in closed vegetation (forests and shrubs). The results of the study provide insight into the process of secondary succession triggered by land abandonment and highlight the potential threats to biodiversity if this process continues. Areas covered by open vegetation are shown to be strongly associated with agro-pastoral activities. With the depopulation of MP, the forested vegetation with low biodiversity occupies the landscape, leading to the loss of habitat and species. Further studies and application of various methodologies are needed to determine the extent of biodiversity threats.

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