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HORIZONTAL AND VERTICAL SPATIAL DISTRIBUTION AND LOSS OF GRASSLAND IN BOSNIA AND HERZEGOVINA

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Abstract: Two databases related to grassland in Bosnia and Herzegovina (B&H) have been used in this research—the Copernicus Grassland (GRA) and CORINE Land Cover (CLC). The data have been processed by using GIS tools, and the spatial distribution of grass vegetation in relation to three biogeographical and four elevation zones has been determined. By using the Copernicus Water and Wetness (WaW) database, an insight into the coverage of grass vegetation in wetlands has been obtained. In addition, the analysis of changes in databases determined the total amount and location of the largest grassland losses. Based on GRA database, B&H is one of the richest countries, with 22.4% of its territory covered by grassland. According to the CLC database, pastures occupy 6.3% and natural grasslands 5.6% of the territory of B&H. However, grassland is exposed to various anthropogenic and natural processes that affect its distribution, quality, functions, etc. The CLC database has been processed by extracting the grasslands (pastures and natural grasslands) and calculating their spatial coverage and changes which happened during the three six-year periods from 2000 to 2018. The trend of decreasing pasture areas and increasing natural grasslands has been noticed. The pastures are most endangered by the processes of conversion to other types of agricultural land, while natural grassland increased spatial coverage during the period 2012–2018 mostly due to the revitalization and grazing of burned areas in the region of Herzegovina. Grasslands have been particularly targeted for afforestation and cropland conversion at present.

Keywords: grassland distribution; grassland loss; CLC database; Bosnia and Herzegovina

1. Introduction

Grass vegetation plays an important role in biodiversity conservation, agriculture, carbon dioxide absorption, climate change mitigation, etc. Given the increasingly noticeable effects of climate change and the increasing drought periods, which indirectly affect the quantity and quality of grasslands, their monitoring and management will be an important challenge for Bosnia and Herzegovina (B&H) in the future.

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When it comes to types of grass vegetation, most often mentioned are natural grasslands or meadows that have little or no human impact, and pastures that are considered as managed grass vegetation, i.e., used in agriculture and livestock farming, with significant human impact on their maintenance. Grasslands in B&H occupy a significant area and differ in density, type, use, productivity, and management system. They have several functions: to protect the land from erosion, provide grazing for domestic and wild animals, contribute to the richness of biodiversity, have different cultural and recreational values, etc. Therefore, it is necessary to define the communities of natural grasslands (meadows) and pastures in the future as areas important for the preservation of biodiversity and the environment.

Generally speaking, grasslands, in particular the extensive ones with high nature value, are under threat from both agricultural intensification and land abandonment. The distribution and dynamics of grassland (and ultimately also grassland condition and use intensity) is therefore important for a number of European Policies, but also for national and regional applications. The Copernicus Land Monitoring Service (CLMS; 2020a) grassland product can be one relevant dataset to help monitor grassland distribution, extent, and change.

The vegetation structure and plant species composition are influenced by soil moisture, soil nutrient availability, strong biogeographical, and climatic gradients (Škvorc et al., 2020). The floristic composition of grass vegetation depends on the ecological conditions of the habitat, geological base, soil type, terrain slope, and exposition (Aćić, 2019). While grassland area has been heavily reduced during the 20th century all over Europe (Gibon, 2005), those areas are increasing in the Western Balkans, mostly due to depopulation and deagrarization of rural areas (Arsić et al., 2015; Farinella et al., 2017). However, they are not utilized to a significant extent (Vaško & Roković, 2021). Grassland of *Molinio-Arrhenatheretea* in the central Balkans are rich in endemics with 91 taxa (Tomović, 2007).

The primary goal of the paper is to set out the precise spatial distribution of grassland and recent trends relating to the losses and gains of grass vegetation in B&H by using the Copernicus Grassland (GRA) and CORINE Land Cover (CLC) databases. The secondary goal is to analyze the impact of the largest biogeographical (natural) regions and elevation on the distribution of grassland, as well as to notice the areas that are rich in grass vegetation. The importance of the research is related to the fact that the GRA database with a resolution of 10 m used for the first time in B&H has raised the level of accuracy compared to previous research. The paper could potentially have a function in inventorying, monitoring, and managing grassland areas in B&H.

2. Study area

Bosnia and Herzegovina is a country in the Western Balkans, with the area of 51,209 km^2 (European Environment Agency [EEA], 2018). It is composed of two autonomous political entities roughly equal in size: The Federation of Bosnia and Herzegovina (FB&H; 26,075 km^2) and Republika Srpska (RS; 24,641 km^2), including a third unit as well—Brčko District (BDB&H; 493 km^2) governed by the local government (Republika Srpska Institute of Statistics, 2021). Based on the data for 2013, the population of B&H was around 3.5 million (Agency for Statistic of Bosnia and Herzegovina, 2016). It is located at the contact of three large natural zones and geographic regions—the Pannonian Plain, the Adriatic Sea, and the Dinarides Mountains. The relief of B&H is mainly hilly-mountainous, with only 8% of land below 150 m a.s.l. (Drašković et al., 2020). As reported by Bajić & Trbić (2016) average annual air temperatures range from 5 °C in the central mountainous region to over 14 °C in the south of the country. The average

annual precipitation varies from 700 mm in the north along the Sava River, to 2,000 mm in the central and southern regions. In the rest of the country, precipitation ranges from 850 to 1,500 mm. CLC 2018 database for B&H contains five main classes, the forest and seminatural areas cover 64.36%, agricultural areas 33.15%, artificial zones 1.7%, wetland 0.12%, and water bodies 0.67% of country territory (EEA, 2018).

The main types of soil in B&H are: brown soil (about 50% out of which 27% are brown and 23% sour brown), black soil on limestone (16%), hydromorphic soil (20%), ilimerised (7%), and red soil (1.17%; Musa, 2007). Two large floral areas—Eurosiberian and Mediterranean—meet in B&H. According to the same author, there are 3,800 species of flowering plants, 60 species of ferns, 250 mosses, 250 lichens, and 520 species of mushrooms, which ranks B&H among the richest countries in terms of biodiversity. The country is characterized by various soils and climate conditions. Thus, there are many different types of grassland. *Phragmito-Magnocaricetea* wet grasslands can be found in Posavina, in karstic depressions, and along rivers or lakes. *Molinio Arrhenatheretea* grasslands are predominantly situated on lowlands with damp to wet soils and they are used as meadows or pastures. *Festuco-Brometea* grasslands occupy more or less dry areas in hilly and mountain areas (South-East Europe High Nature Value Farming, 2015).

The largest wetness zones in B&H are located in the western part of the country, at the regions of Livanjsko, Glamočko, and Kupreško karst poljes, and Gatačko karst polje in Herzegovina region. There are two main reasons for higher wetness values. Firstly, the annual precipitation of the area of karst poljes is over 1,500 mm, and secondly, limestone geologic layers cannot accept all the water in humid period so water ascends and floods the bottom of poljes (Drašković et al., 2021).

3. Materials and methods

"The Grassland database includes natural, semi-natural, and managed grasslands (according to their origin and utilization), as well as all types of grassland (permanent or seasonal) under highly heterogeneous biogeographic conditions (wet or dry climate, fertile, or poor soil). Grass cover within the context of the product is understood as herbaceous vegetation with at least 30% ground cover and with at least 30% graminoid species such as *Poaceae, Cyperaceae,* and *Juncaceae*. Additional non-woody plants such as lichens, mosses, and ferns can be tolerated" (CLMS, 2020a, para. 2).

The area of grassland by biogeographical zones has been calculated by using the GIS tool Extract and Clip. Within the territory of B&H, the CLC 2018 data have been separated, coded as Pastures or Natural grasslands (2.3.1 and 3.2.1), or in GRA 2018 as Grassland. Then the biogeographical zone has been selected and thanks to the Clip tool, a new layer with grassland within that zone has been created. The obtained data have been exported to Excel and individual areas have been calculated (according to spatial resolution).

The distribution of grass vegetation by elevation zones has been figured out by using the geoprocessing tool for performing raster analysis through the use of a map algebra expression, by setting conditions for two raster layers (CLC 2018 or GRA 2018 and DEM). Only if the conditions are met, a new resulting raster layer is created. For example, in the first layer (CLC 2018), pixels with grass vegetation have been selected (Code = 2.3.1 and/or 3.2.1) and in the second layer (DEM), an elevation zone, e.g., 0–500 m a.s.l., has been chosen. Each pixel has been analyzed separately and those that met the given condition have been selected. If both conditions have been met at the same location, the result is a new raster layer with grassland within a given zone (e.g., pastures within 0–500 m a.s.l.). Finally, the area of grass vegetation has been calculated for each elevation zone (Figure 1).

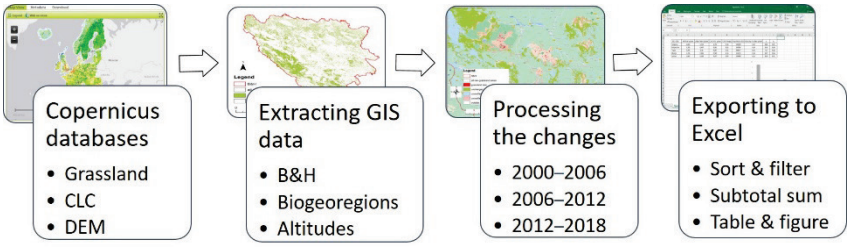

Figure 1. Flowchart of methodology and processing the data.

When it comes to the accuracy of the obtained results, it depends on the input data resolution. For example, if the raster layer CLC 2018 has a resolution of 100 m and the DEM layer of 25 m, then the resolution of the resulting raster layer will be 100 m. In case the resolutions match, as with GRA 2018 and WaW 2018 (10 m), then the product will also have 10 m resolutions. The higher the resolution, the more accurate the results.

The CLC project for the territory of B&H consists of four databases showing the situation on the ground from 2000 to 2006, from 2012 to 2018, as well as a database on interperiodical changes: 2000–2006, 2006–2012, and 2012–2018. In this way, the changes in the types of land cover and land use can be monitored during the different periods. A minimum map unit (MMU) for the CLC is 25 ha and for the CLC–Change map (CHA) is set to 5 ha. In the CLC nomenclature, grassland is divided between two or more subclasses, which is a limiting factor when accuracy is concerned.

Changes have been recorded in both the CHA and the Grassland Change 2015–2018 (GRAC 1518) database. However, only in the CHA database can the internal structure of changes and conversions from one type of land cover to another be monitored (for example, 2.3.1–2.4.2). The GRAC 1518 database only registers changes, but does not provide insight into the structure, because there are only two types of surface cover—grassland and all non-grassland areas. Thus, only the analysis of the CHA database can identify the causes and trends of changes. For instance, if there was a conversion of Burnt areas (3.3.4) into Natural grasslands (3.2.1) in one period, it can be concluded that there were natural revitalization processes where areas previously covered by fires were overgrown over time.

A Digital Elevation Model (EU DEM v1.1.) with a resolution of 25 m have been used for showing the vertical distribution of grassland. By using the GIS tool Raster Calculator, the areas under grassland have been calculated by elevation zones. Considering the elevation range from 0 to 2,367 m, four elevation zones of 0–500 m (39.47% of the B&H territory), 500–1,000 m (35.53%), 1,000–1,500 m (21.9%), and over 1,500 m (3.1%) have been taken into account.

Soil moisture plays a pivotal role in vegetation dynamics, considering that soil water availability is a crucial limiting factor for plant photosynthesis (Proietti et al., 2019). The WaW 2018 database (CLMS, 2020b), with a resolution of 10 m, has been used providing an overview of permanently and temporarily wet areas. The same resolution of the WaW 2018 and GRA 2018 databases provides the possibility for pixel overlapping in order to get the information regarding the grassland distribution on temporary or permanent wet areas.

4. Results and discussion

Based on the GRA 2018 database (CLMS, 2020c), grassland covers 11,472.9 km^2 or 22.4% of the B&H territory. Of that, 774.52 km^2 (or 6.75% of the total grassland area) is located at temporary wet areas

and 10.69 km^2 (0.09%) at permanently wet areas. Speaking about the B&H entities, according to the same database, 6,504.5 km^2 (or 24.9%) of the territory the FB&H and 4,852.1 km^2 (or 19.7%) of the RS is covered with grassland. In the BDB&H, the grassland covers 116.3 km^2 (or 23.6%). The BDB&H area occupies a small, mostly urban territory, predominantly between 100–200 m a.s.l. The largest grasslands are located in the region of western Bosnia, at the location of karst poljes: Livanjsko, Kupreško, and Glamočko. Wetness of poljes is also partially preserved thanks to the alluvial deposits on their bottoms, which have certain retention capabilities. As stated in the WaW 2018 database, these karst poljes are also known as wetland zones. In addition, considering elevation, the high and medium karst poljes of eastern Herzegovina are covered with grass vegetation: Nevesinjsko, Gatačko, Dabarsko, Fatničko, etc. On the other hand, low poljes in the south of Herzegovina (Popovo, Ljubuško, etc.) are poor in grasslands, primarily due to agricultural activities. Agricultural crops are grown in these poljes with a help of irrigation, so there is not much space left for grassy vegetation.

Within the Grassland database there is the Grassland Vegetation Probability Index (GRAVPI 2018; CLMS, 2020d). The GRAVPI 2018 refers to the grassland occurrence probability based on the data from previous years. Some zones have sparse grass vegetation or do not appear every year, while in others it is dense and constantly present. Based on successive recordings from previous years, the percentage of probability whether and to what extent an area is covered with grassland can be calculated. Figure 2 shows the distribution and the probability of the occurrence of grasslands (darker zones show a higher probability of the occurrence than the lighter ones).

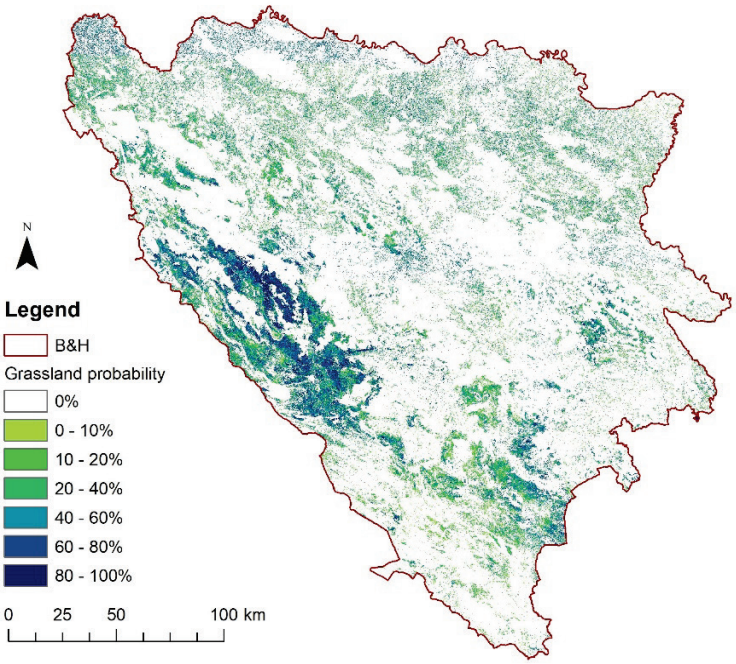

Figure 2. Grassland distribution in B&H.

Note. Visualization based on data from *Grassland Vegetation Probability Index (GRAVPI)*, by Copernicus Land Monitoring Service, 2020d (https://cws-expert.eea.europa.eu/HighResolutionLayers/Grassland/National_Projection/Bosnia_and_Herzegovina/GRAVPI/). In the public domain.

For the purpose of comparing the data from different periods, their completeness and compatibility is required. Due to the increase in resolution from 20 m to 10 m and the reduction of the minimum cartographic unit from 1 ha in 2015 to 0.03 ha in 2018, these two databases were not completely comparable and the data may differ significantly by individual regions. The overlapping of the pixels of different sizes (thanks to different resolutions) displayed the uncovered zones, i.e., so-called unverified changes that usually do not represent real changes. Comparing the data in order to monitor trends and overlapping these two layers, we can find two types of changes—real and technical. Two reasons for changes to be assigned to the unverified are: (1) the difference between the two high-resolution layers has not been confirmed as real change and (2) the detected change patch is smaller than the MMU of 1 ha which was applied in 2015. Therefore, vegetation indices and data on ploughing during previous years are used for verification. The unchanged grassland area, judging by the Grassland Change database in the period 2015–2018 (CLMS, 2020e), is 3,804.76 km^2 (33.16% of total grassland). The losses amount to 9.19 km^2 (0.08%), unverified losses are 1,281.15 km^2 (11.17%), and unverified gains come to 8,629.77 km^2 (75.22%). Unclassifiable zones in any of parent status layers is 8.92 km^2 (0.08%).

The largest identified grassland losses are recorded in the areas with the elevation over 1,500 m, in the territory of the Blidinje Nature Park on Čvrsnica Mountain and on the neighboring mountain of Prenj. The reason for the decrease may be vegetation succession. In the interest of maintaining a floristically diverse grass vegetation, it is necessary to stimulate seasonal migrations of livestock. As reported by Dubljević et al. (2020), hay and pastures are the most important fodder, in addition to cereals and concentrated food, which have a smaller share. The reduction of pasture grazing was also influenced by the extinction of nomadic practices, which is especially characteristic of sheep breeding (Vaško & Roković, 2021). Bearing in mind that the grasslands potential is a base for ruminant nutrition, quite a significant reduction of the livestock population directly affected the condition and degree of the use of meadows. The next slightly larger loss zone has been observed in the wetlands of Livanjsko and Glamočko poljes. This can be explained by the fact that nowadays these habitats are under the influence of hydro melioration activities and natural vegetation succession. Other losses occur sporadically and in a smaller area.

In addition, within the GRA 2018 there is the layer indicating ploughing events on grassland patches (PLOUGH 2018) which provides the thematic information on ploughing during the period 2012–2017 (CLMS, 2020f). Agricultural land that is not cultivated over time is grassed and is recognized as grassland. In line with this source, 91.42 km^2 has not been cultivated in the last six years. However, these data also differ in the manner of the resolution, because for the years 2017 and 2016 the resolution was 10 m, and for the previous years it had been 20 m. Therefore, the data for the last two years are more accurate, and it is shown that the spatial coverage for one year since not being cultivated (2017) is 55.72 km^2 and for two years since not being cultivated (2016) it is 24.12 km^2. For earlier years, this is a significantly smaller spatial coverage.

When it comes to the CLC database, the grassland vegetation is divided between two main classes, based on the CLC nomenclature of EEA (2019): Agricultural areas (Code 2) and Forests and seminatural areas (Code 3). Within the Agricultural land, the grass vegetation mainly belongs to the subclass of Pastures (Code 2.3.1) with 6.3% of the territory of B&H, and within the Forests and seminatural areas there are mainly Natural grasslands (Code 3.2.1) with

5.6% of the territory of B&H (data for 2018). Within the FB&H, Pastures cover 7.2% and Natural grassland 7.9%. In the RS, Pastures cover 5.46% and Natural grassland is present on 3.2% of the territory (Drašković et al., 2020). Both Pastures and Natural grassland in BDB&H area comprise less than 1% of the territory.

In the period 2000–2018, Pastures reduced their area from 7.98% to 6.33%. At the expense of Pastures, Transitional woodland/shrub (3.2.4), Discontinuous urban fabric (1.1.2), and Mineral extraction sites (1.3.1) were expanded, and a part of Pastures was affected by fires and converted into Burnt areas (3.3.4). However, Pastures were most endangered by other types of agricultural land, especially in the first period (2000–2006), primarily by Complex cultivation patterns (2.4.2) in the amount of 27.24 km^2 and Non-irrigated arable land (2.1.1), with 8.11 km^2 (Figure 3).

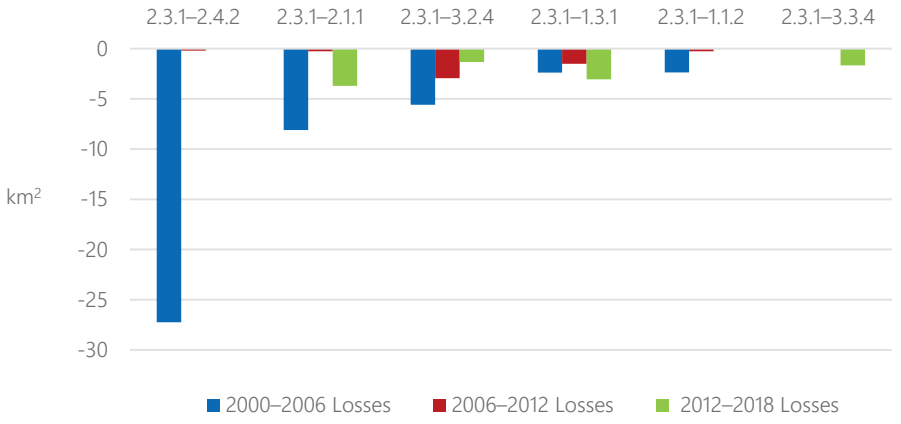

Figure 3. Structure of Pasture losses (code 2.3.1) by periods.

Note. Data in figure are calculated based on *Land Cover Change (LCC) 2000-2006, Version 2020_20u1*, by Copernicus Land Monitoring Service, 2019a (https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2000-2006); *Land Cover Change (LCC) 2006-2012, Version 2020_20u1*, by Copernicus Land Monitoring Service, 2019b (https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2006-2012); *Corine Land Cover Change (CHA) 2012 - 2018, Version 2020_20u1*, by Copernicus Land Monitoring Service, 2019c (https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2012-2018). In the public domain.

On the other hand, Natural grasslands (3.2.1) increased the spatial distribution from 4.85% to 5.63% in the same period. This mostly refers to the conversion of previously Burnt areas (3.3.4) into Natural grasslands which covered a large area (61.66 km^2) in the last period 2012–2018, as well as the transition of a small area of Land principally occupied by agriculture, with significant areas of natural vegetation (2.4.3) into Natural grassland in the period 2000–2006 (2.26 km^2). Losses of Natural grasslands were small: 5.55 km^2 in the first period, 2.77 km^2 in the second, and 1.14 km^2 in the third, or a total of 9.46 km^2. Thus, the analysis of the gain-loss ratio shows that the gains are significantly higher and amount to a total of 54.46 km^2. Natural grasslands are mainly converted to: Transitional woodland/shrub (3.2.4), Discontinuous urban

fabric (1.1.2), Mineral extraction sites (1.3.1), Dump sites (1.3.2), Non-irrigated arable land (2.1.1), Pastures (2.3.1), Complex cultivation patterns (2.4.2), Construction sites (1.3.3), and Vineyards (2.2.1; Figure 4).

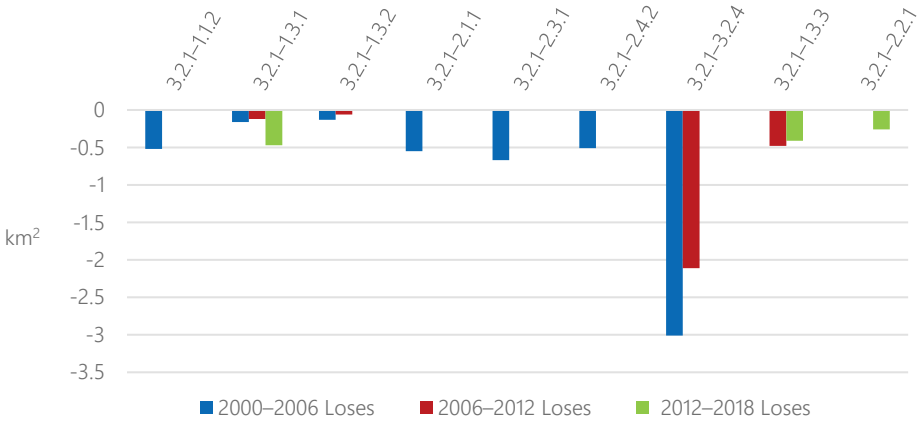

Figure 4. Structure of Natural grassland losses (code 3.2.1) by periods.

Note. Data in figure are calculated based on *Land Cover Change (LCC) 2000-2006, Version 2020_20u1*, by Copernicus Land Monitoring Service, 2019a (https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2000-2006); *Land Cover Change (LCC) 2006-2012, Version 2020_20u1*, by Copernicus Land Monitoring Service, 2019b (https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2006-2012); *Corine Land Cover Change (CHA) 2012 - 2018, Version 2020_20u1*, by Copernicus Land Monitoring Service, 2019c (https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2012-2018). In the public domain.

4.1. Spatial distribution of grassland by biogeographical regions and elevation

Regarding to EEA (2016) biogeographical regions, the territory of the B&H is divided into three zones: northern (Continental, 33.4% of the country territory), central (Alpine, 50.6%), and southern (Mediterranean, 16.0%). The target overall accuracy of the GRA dataset in each biogeographical zone is 85% (CLMS, 2020g). One of the aims of this study was to determine the influence of these regions on the occurrence and density of grassland (Figure 5). The geographical position, climate, relief, geology, elevation, anthropogenic activities, and other factors have influenced significant differences in the distribution and types of grassland by zones.

As stated in the GRA 2018 database, most of the grassland is located within the largest central Alpine region, so 46.9% of the total grassland belongs to this zone. The Continental and Mediterranean regions participate with 32.7% and 20.4%, respectively. However, it should be mentioned that the Alpine region is also rich in forest vegetation, while there are not many forests in the north and south.

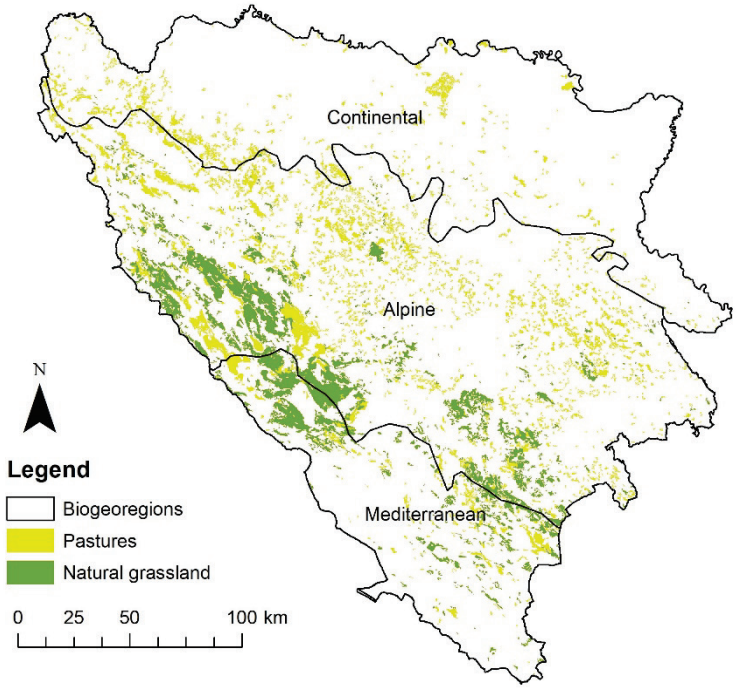

Figure 5. Distribution of Pastures and Natural grasslands by the biogeographical regions.
Note. Visualization based on data from *Corine Land Cover (CLC) 2018, Version 2020_20u1*, by Copernicus Land Monitoring Service, 2019d (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018). In the public domain.

The analysis of the CLC 2018 data on grasslands by regions and elevations shows that Natural grasslands (3.2.1) are mainly distributed in the Alpine region (70.2%) and at elevations above 1000 m a.s.l. (about 80%). Pastures (2.3.1) are also mostly positioned in the Alpine region (69.8%) and at the elevations below 1,000 m a.s.l. (over 63%; Table 1 and 3). The northern Continental region has very few natural grasslands (Table 1).

Table 1. Spatial distribution of grasslands by biogeographical regions

	Mediterranean		Alpine		Continental		Total	
	km^2	%	km^2	%	km^2	%	km^2	%
Area	8,209.3	16.0	25,911.1	50.6	17,088.6	33.4	51,209	100.0
Pastures	345.3	10.7	2,258.7	69.8	632.5	19.5	3,236.5	6.3
Natural grassland	848.3	29.5	2,018.2	70.2	6.4	0.2	2,872.9	5.6
Grassland	2,335.2	20.4	5,385.6	46.9	3,752.1	32.7	11,472.9	22.4

Note. Data for Pastures and Natural grassland are calculated based on *Corine Land Cover (CLC) 2018, Version 2020_20u1*, by Copernicus Land Monitoring Service, 2019d (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018). In the public domain. Data for Grassland are calculated based on *High Resolution Layer: Grassland 2018*, by Copernicus Land Monitoring Service, 2020c (https://land.copernicus.eu/pan-european/high-resolution-layers/grassland/status-maps/grassland-2018?tab=mapview). In the public domain.

Elevation and differences in climate certainly affect the appearance and types of grassland. The GRA 2018 and EU–DEM database (CLMS, 2016) shows that grasslands are evenly distributed by elevation zones. Grasslands are most widespread at lower elevations, within the zone 0–500 m a.s.l. with 37.7%. Within the zones of 500–1,000 m a.s.l. and 1,000–1,500 m a.s.l. grassland appear with 31.3% and 26.7%, respectively. In mountainous areas above 1,500 m a.s.l. grasslands occupy 4.3%.

From Table 2. it can be seen that Pastures prevail to Natural grasslands in the zone 0–500 m a.s.l. (24.1% vs. 1.7%) and as the elevation increases, this ratio changes in favor of Natural grasslands, especially in the zone over 1,500 m a.s.l. (0.9% vs. 16.7%). In the zone of 500–1,000 m a.s.l., larger territory is covered by Pastures, and from 1,000–1,500 m a.s.l. a larger area is covered by Natural grasslands.

Table 2. Distribution of grassland by elevations

	0–500 m		500–1,000 m		1,000–1,500 m		>1,500 m		Total
	km^2	%	km^2	%	km^2	%	km^2	%	km^2
Area	20,212.8	39.5	18,194.1	35.5	11,215.1	21.9	1,587	3.1	51,209
Pastures	782.3	24.1	1,572.2	48.5	857.1	26.4	29.4	0.9	3,241.0
Natural grassland	48.3	1.7	678.5	23.5	1,672.9	58.1	481.5	16.7	2,881.3
Grassland	4,325.0	37.7	3,594.2	31.3	3,064.7	26.7	489.1	4.3	11,472.9

Note. Data for Pastures and Natural grassland are calculated based on *Corine Land Cover (CLC) 2018, Version 2020_20u1*, by Copernicus Land Monitoring Service, 2019d (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018). In the public domain. Data for Grassland are calculated based on *High Resolution Layer: Grassland 2018*, by Copernicus Land Monitoring Service, 2020c (https://land.copernicus.eu/pan-european/high-resolution-layers/grassland/status-maps/grassland-2018?tab=mapview). In the public domain.

In line with our results, within the western part of Bosnia, at Livanjsko, Kupreško, and Glamočko poljes (Tropolje area), on the territory occupied by only 8.3% of B&H there is about 48% of the total area of Natural grasslands and about 16% of Pastures, so this is the location with the largest grassland area in the country. There are many authors who have researched this topic in B&H: Lakušić et al. (1978), Mišić and Lakušić (1990), Barudanović et al. (2015), etc. The pastures of the karst poljes belong to the vegetation order *Trifolio-Hordeetalia* Horvatić 1963 and the connection *Molinio-Hordeion secalini* Horvatić 1934, which develop primarily on floodplains. Hygromesophilic and floodplain meadows of lowland areas and karst poljes provide the highest yields in agricultural production. They represent an important resource in animal husbandry and are necessary for obtaining fodder and, indirectly, meat, milk, wool, leather, honey, etc. Čarni et al. (2021) found out that forage quality highly correlates with humidity, the proportion of weed and ruderal species, the proportion of sedges and stress tolerant species, and mowing. Communities of *Molinietalia caeruleae* Koch 1926 are developing on flooded terrains and heavy (bumpy) soils in lowland areas. The vegetation of hygrophilous natural grasslands of the class *Molinio-Arrhenatheretea* Tx. 1937 usually occurs after natural or artificial drainage of wetlands.

Table 3. Distribution of Pastures and Natural grassland by elevation within biogeographical regions

Grassland type	Biogeoregions	Mediterranean		Alpine		Continental	
	Elevation (m)	km^2	%	km^2	%	km^2	%
Pastures	0–500	49.4	14.3	178.6	7.9	550.6	87.1
	500–1000	232.3	67.3	1,257.3	55.7	81.9	12.9
	1000–1500	63,7	18.4	793.5	35.1	0.0	0.0
	>1500	0.0	0.0	29.4	1.3	0.0	0.0
	Total	345.3	100.0	2,258.7	100.0	632.5	100.0

Table 3. Distribution of Pastures and Natural grassland by elevation within biogeographical regions (*Continued*)

Grassland type	Biogeoregions	Mediterranean		Alpine		Continental	
	Elevation (m)	km^2	%	km^2	%	km^2	%
Natural grassland	0–500	45.1	5.3	0.5	0.0	2.3	35.3
	500–1000	284.5	33.5	392.6	19.5	4.1	64.1
	1000–1500	485.5	57.2	1,180.2	58.5	0.0	0.6
	>1500	33.3	3.9	444.8	22.0	0.0	0.0
	Total	848.3	100.0	2,018.2	100.0	6.4	100.0
Grassland	0–500	331.8	13.3	421.2	7.8	3,595.2	95.8
	500–1000	1,102.2	47.2	2,346.6	43.6	156.0	4.2
	1000–1500	870.2	37.3	2,182.9	40.5	0.9	0.0
	>1500 m	51.1	2.2	434.0	8.1	0.0	0.0
	Total	2,335.2	100.0	5,385.6	100.0	3,752.1	100.0

Note. Data for Pastures and Natural grassland are calculated based on *Corine Land Cover (CLC) 2018, Version 2020_20u1*, by Copernicus Land Monitoring Service, 2019d (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018). In the public domain. Data for Grassland are calculated based on *High Resolution Layer: Grassland 2018*, by Copernicus Land Monitoring Service, 2020c (https://land.copernicus.eu/pan-european/high-resolution-layers/grassland/status-maps/grassland-2018?tab=mapview). In the public domain.

Within Herzegovina (Mediterranean) region, Natural grasslands dominate (about 29.5% of the share in B&H; Table 1) and mostly above 1,000 m a.s.l. (Table 3). On the other hand, pastures are represented by 10.7% (Table 1), mainly in the 500–1,000 m zone (Table 3). The most common thermophilic natural grasslands are *Xero-Bromion* and grasses on rocky soils that find life optimum in the Mediterranean, sub-Mediterranean, and Mediterranean-Mountain geographical zone (Lakušić et al., 1978). The ecosystem of coastal pastures on rocky soil belongs to the vegetation class *Scorso* Horvatić 1963 and consists of a mixture of rocky soil and pasture community of grasses and annual plants that develop on shallow soils within the Mediterranean vegetation area. The sub-Mediterranean grasslands on rocky soil in the syntaxonomic sense are included into *Satureion montanae* Horvat 1962, as well as sub-Mediterranean natural grasslands with *Scorzonerion villosae* Horvatić ex Kovačević 1959, while Mediterranean-Mountain grasslands on rocky soil are included into *Saturejion subspicatae* Tomić-Stanković 1970 (Lakušić et al., 1978). Mediterranean climate with dry summers is not conducive to grassland area development. This is the region of "heavy karst" without much greenery on the surface due to the water-permeable limestone layers. This is supported by the data on forest coverage, a few of which are in the south, and having in mind that, as stated in the CLC database, almost 50% of the country territory is covered by forests.

In the Alpine region, predominated by the mountain-valley landscape, Natural grasslands cover 70.2% of grasslands in B&H, while Pastures are widespread with 69.8% (Table 1). Within the region, Natural grassland predominate in the 1,000–1,500 m zone with 58.5% while Pastures are most common in the 500–1,000 m zone with 55.7% (Table 3). Pastures are located in the mountain, subalpine, and alpine zones and are included in the vegetation class *Elyno-Seslerieta Br.-Bl.* 1948 developed on limestone and *Juncetea trifidi class* Hadač in Klika et Hadač 1944 (syn. *Caricetea curvulae*) developed on silicate geological substrate (Lakušić et al., 1978). The mountain natural grassland of the *Pancicion serbicae* Lakušić 1966 association include mesophilous grasses of the upper part of the mountain and the lower part of the subalpine zone. At lower elevations of the hilly and lower part of the mountain zones, there are mesophilous communities of

Arrhenatherion elatioris Luquet 1926 and *Cynosurion cristati* Tx develop. 1947. These communities are added into the *Molinio-Arrhenatheretea* Tx class. 1937 (Lakušić et al., 1978).

In the Continental region (Peripannonian lowland in the north of the country), Natural grasslands occupy only 0.2% of the total area of this vegetation in B&H. The Pastures in this zone have a higher distribution, about 19.5% share in B&H (Table 1). Within the region, Pastures are observed mostly in the 0–500 m zone with 87.1% while Natural grassland predominate in the 500–1000 m zone with 64.1% (Table 3). Within the river valleys, there are the wettest grasslands that are under the constant influence of groundwater and flood water. *Molinio-Arrhenatheretea* Tx 1937 class communities have developed in these habitats. Lowland parts are characterised by the communities of *Molinietalia caeruleae* Koch 1926. The cultivated grasslands of lowland and valley areas belong to the *Arrhenatherion elatioris* Luquet 1926 (Lakušić et al., 1978).

According to the GRA database, Grassland is mainly distributed in the Mediterranean and Alpine regions within the 500–1,000 m and 1,000–1,500 m zones, while in the Continental region almost all grassland is located below 500 m. Above 1,500 m Grassland appears mainly in the Alpine region (Table 3).

4.2. Discussion

As it can be seen from the results in the CLC and GRA databases, the differences in the spatial coverage of grassland are large. Based on the GRA, the area of grassland is almost twice larger compared to the CLC. The differences mainly occur due to two reasons: different resolutions and different nomenclature. Judging by the CLC database, in order for an area to be characterized as Pasture or Natural grassland, this class has to occupy at least 50% of the territory within a MMU of 25 ha (0.25 km^2). In the GRA database there is no such differentiation, but each 10 × 10 m area is registered either as Grassland or as All non-grassland area. This means that the grassy area in city parks or at a football stadium would be registered as Grassland, while, according to the CLC database, it would be recognized as a Green urban area (1.4.1) or a Sport and leisure facility (1.4.2). Another reason for the different results is that the CLC nomenclature has been created pursuant to the principle of dominance within the MMU, so that grassland can be represented within other classes as well. Among other subclasses at the third level of the CLC nomenclature, grass vegetation can be included within the Complex cultivation patterns (2.4.2), Land principally occupied by agriculture, with significant areas of natural vegetation (2.4.3), Agroforestry areas (2.4.4), Moors and heathland (3.2.2), Sclerophyllous vegetation (3.2.3), Transitional woodland/shrub (3.2.4), etc. Due to the partial participation in the mentioned subclasses whose elements are not further separated, it is not possible to set out the precise coverage of grassland within them.

The GRA database could be implemented by users who work with the preservation of natural resources and of biodiversity. Also, the GRA database can support and complement other more locally projects like the dynamics of land use and land cover patterns, Natura 2000, etc. The differentiation between grassland types are still difficult to implement due to the high intra-seasonal dynamics of this type of vegetation. The CLC database provides an overview of all land cover types on different levels and an insight into the structure of change over the six years periods. It is more appropriate for regional and large-scale projects as well as for monitoring trends of spatial development. It aims to provide information for policy-makers involved in national and regional planning and evaluation processes of e.g., land management, environmental management, agriculture, etc.

5. Conclusion

The paper analyzes the two databases on grass vegetation in B&H—GRA and CLC. According to the GRA database (10 m resolution), which does not differentiate between the types of grass, Grassland covered 22.4% of the territory of B&H in 2018. Of this, about 6.8% was in wetlands, mostly in the area of seasonally flooded karst poljes in the west part of the country. On the other hand, the CLC database divides grasslands into two main types—Pastures cover (6.3%) and Natural grassland cover (5.6% of B&H). When it comes to vertical zonation, grasslands are equally distributed within the zones between 500–1,000 m and 1,000–1,500 m. Natural grasslands predominate in the higher areas and Pastures in the lower ones. In the period 2000–2018, Pastures recorded a decrease in the area due to human activities, while Natural grasslands increased the area because fire-affected areas in the initial stages of revitalization were restored by natural processes or the appearance of grassy vegetation. The differences between the two databases occur because the GRA is comprehensive and more precise, while the CLC, in addition to the two subclasses (Pastures and Natural grasslands), may include grass vegetation in several other subclasses.

In relation to the three large biogeographical regions, the central (Alpine) zone has the largest coverage of grasslands, especially its western part. This is the richest grassy vegetation area in the country, within the zone of large karst poljes: Livanjsko, Kupreško, and Glamočko. The climatic, hydrological, and geological characteristics of the terrain, as well as the relief dominated by flooded karst poljes, have contributed to the most of this. This region also has the largest temporary and permanent wetland, which affects the density of grass vegetation. Areas of grass vegetation in B&H should be defined in the future as zones of high biodiversity. Grasslands provide important ecosystem services. They are highly at risk of conversion to grazing areas, cropland, and the land for growing biomass/bioenergy crops.

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