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MAPPING THE FLORA OF MONTENEGRO – STANDARDIZATION OF THE MAPPING PROCEDURE, GEOCODING METHODS, UTM AND MTB GRID SYSTEMS

SUMMARY

The paper discusses the mapping of the flora of Montenegro with a focus on the standardization of geocoding methods. The aim was to improve the method of mapping plant species by using real coordinate methods, the UTM and MTB networks, which allow for highly precise localization of sites. The research has shown that the point-based geocoding method and the use of UTM and MTB networks enable high mapping accuracy and are also a prerequisite for integrating data into international databases.

In addition to its fundamental importance, cartographic data also have significant applied value, primarily in the field of environmental protection: in biodiversity monitoring, identification and protection of ecological corridors, monitoring of climate change, environmental impact assessments, as well as in spatial planning, urban development, forestry, agriculture, energy, tourism, and education. These data are also crucial for the preparation of strategically important documents, such as the National Strategy for Sustainable Development of Montenegro, the National Biodiversity Strategy, the National Strategy for Integrated Coastal Zone Management, the Marine Environment Protection Strategy, the Climate Change Strategy, as well as for the development of local environmental protection plans, national forest inventories, and more.

Keywords: Flora mapping, UTM and MTB grids, Montenegro, biodiversity, GIS.

INTRODUCTION

Flora mapping represents a key step in the study and documentation of biodiversity and the conservation of natural resources (Nikolić *et al.* 1998). In Montenegro, the richness of plant life, encompassing over 3,600 species and subspecies, has long been the subject of research (Pulević, 2006). Despite this

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long tradition of botanical studies, one of the major limitations in previous research has been the lack of precise cartographic representations of plant species, which sometimes, even with a good understanding of a species' ecology, hinders its accurate localization in the field. Precise location coordinates serve as a starting point in studies focused on species distribution and population monitoring.

The development of GIS technologies and the availability of satellite imagery have opened up possibilities for detailed flora mapping using various geocoding methods, such as real coordinates (point-based method), the UTM (Universal Transverse Mercator) grid, and the MTB (Messtischblatt) grid (Nikolić *et al.* 1998). The standardization of these methods enables not only more accurate mapping but also their integration into global databases, such as the Atlas of the Flora of Europe (Jalas and Suominen 1972–94, Jalas *et al.* 1996–1999, Kurtto *et al.* 2004–2018).

The importance of this topic lies in the fact that reliable maps of plant species distribution have wide-ranging applications—not only in biology, but also in ecology, geography, spatial planning, environmental protection, and many other scientific disciplines. Accurate mapping can improve ecosystem change monitoring, the assessment of anthropogenic impact, and enable more effective implementation of biodiversity conservation measures. In addition, spatially accurate data on flora are increasingly used in climate change analyses, modeling of ecological factors influencing species distribution, and assessing the risk of invasive plant spread (Dagnino *et al.* 2020).

Previous research by botanists from Montenegro and abroad has resulted in a rich body of literature and herbarium material on the vascular flora of Montenegro (Pulević 1980, 1985; Pulević and Bulić 2004, 2012), but with limited cartographic representation. In some more recent studies, localities have been presented using the UTM grid (Parolly 1991/92, Stevanović *et al.* 1993, Hadžiablahović 2004a, 2004b, 2005, Lakušić 2010, Petrović and Stešević 2010, 2011, Niketić *et al.* 2013, Stešević and Berg 2015, Vuksanović 2016), yet there is still a need for standardization of methods in order to achieve greater precision and comparability with international projects, such as the Atlas Florae Europaeae (Jalas & Suominen 1972, 1973, 1976, 1979, 1980, 1983, 1986, 1989, 1991, 1994; Jalas *et al.* 1996, 1999; Kurtto *et al.* 2004, 2007, 2010, 2013, 2018).

The aim of this paper is to standardize flora mapping procedures in Montenegro through the use of combined geocoding methods, such as real coordinates, UTM, and MTB grids. The paper also reflects on the applied significance of cartography.

MATERIAL AND METHODS

This study focuses on defining a standardized approach to mapping the flora of Montenegro, with particular emphasis on geocoding plant localities and selecting appropriate spatial grid systems. Analyses were conducted using QGIS 3.34.10, an open-source software platform for spatial data processing and

cartographic visualization. As cartographic base layers, topographic maps and orthophotos from the national geoportal (www.geoportal.co.me) were used, in combination with the Universal Transverse Mercator (UTM) and Messtischblatt (MTB) grid systems.

The UTM grid for the territory of Montenegro was created at multiple spatial resolutions (100×100 km, 10×10 km, and 1×1 km) based on the technical guidelines provided by Nikolić *et al.* (1998). The MTB grid was developed following the model proposed by Bergmeier (1992), with the possibility of subdividing basic units into smaller quadrants (1/4, 1/16, and 1/64), thus enabling more detailed spatial analysis.

Three geocoding approaches were considered as the main methodological tools:

- The point method involves assigning precise geographic coordinates to each taxon locality. It is suitable for mapping rare and spatially restricted species and enables high-resolution visualization that is compatible with international databases such as the Atlas Florae Europaeae (Jalas & Suominen 1972, 1973, 1976, 1979, 1980, 1983, 1986, 1989, 1991, 1994; Jalas *et al.* 1996, 1999; Kurtto *et al.* 2004, 2007, 2010, 2013, 2018).
- The UTM grid system provides a multi-scale spatial structure through standardized square cells of various sizes, making it suitable for GIS-based spatial analysis at different levels.
- The MTB grid system, common in Central European floristic research, offers a consistent spatial framework for organizing plant locality data and enables precise localization through a hierarchical subdivision of units.

Plant locality data used in this study were obtained from relevant scientific literature and floristic inventories of the vascular flora of Montenegro (e.g., Rohlena, 1942; Pulević, 1980, 1985; Pulević & Bulić 2004, 2012; Pulević 2005; Stešević *et al.* 2008; Stešević & Caković 2013; Caković & Stešević 2021, Stešević *et al.* 2025). These records can be geocoded and visualized using the methods described in this paper, enabling standardized and multi-scale presentation of floristic information.

To categorize localities regionally, the phytogeographical division by Marković (1980) was applied, which delineates the territory of Montenegro into six subregions. This classification has already been used in the Catalogue of Vascular Flora of Montenegro (Stešević and Caković 2013; Caković and Stešević 2021; Stešević *et al.* 2025) and provides a suitable framework for the spatial organization of taxonomic data.

RESULTS AND DISCUSSION

This study resulted in the development and clarification of a standardized geocoding system for mapping the flora of Montenegro, tailored to the country's specific spatial and floristic context. As key outputs, the point-based geocoding method and customized grid structures (UTM and MTB) were created,

documented, and tested for their effectiveness in mapping plant species across the national territory.

These mapping frameworks were not only used as tools during the research but were themselves an original contribution—serving as a practical and replicable model for precise geospatial representation of taxon occurrences in Montenegro. The results are presented through the structure and utility of each method, including their relevance for integrating data into European-scale databases.

1. **Geocoding of localities:** The point method, based on assigning exact coordinates to each taxon locality, proved to be the most suitable for mapping rare and spatially limited species across Montenegro. It enables high-resolution mapping and ensures consistency with international datasets, such as the *Atlas Florae Europaeae* (Jalas & Suominen 1972, 1973, 1976, 1979, 1980, 1983, 1986, 1989, 1991, 1994; Jalas *et al.* 1996, 1999; Kurtto *et al.* 2004, 2007, 2010, 2013, 2018). For taxa with a broader distribution, integration with UTM and MTB grids facilitates visual generalization and spatial analysis on different scales.
2. **UTM (Universal Transverse Mercator) grid:** The UTM grid is a global cartographic system that divides the Earth into 60 longitudinal zones (each 6 degrees wide), with each zone extending from 80 degrees south to 84 degrees north latitude. Montenegro is located in UTM zone 34T, which spans from 18° to 24° east longitude. This zone covers the area from the Adriatic Sea to the borders with Serbia and Albania. In terms of latitude, Montenegro lies between 40° and 48° north, which corresponds to UTM field T. For more precise mapping within zone 34T, the UTM grid is divided into smaller squares of 100×100 km, which are designated by letters. The majority of Montenegro falls within the square labeled CN. Other parts of the country are covered by the CP, CM, BN, and DN squares (Fig. 1).

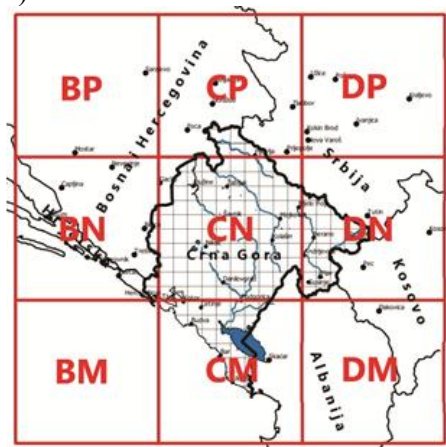


Figure 1. UTM Grid of Montenegro (100×100 km)

Each 100×100 km square is further subdivided into smaller 10×10 km squares, which are labeled using a combination of two letters (for latitude and longitude) and numbers indicating the position within the larger square (Fig. 2). The smallest units in the UTM grid are 1×1 km squares, which are used for high-precision mapping. These units are labeled using a combination of two letters and four numbers.

The UTM grid is used worldwide, which allows for the easy integration of data from Montenegro into international databases, such as the Atlas Florae Europaeae (Jalas & Suominen 1972, 1973, 1976, 1979, 1980, 1983, 1986, 1989, 1991, 1994; Jalas *et al.* 1996, 1999; Kurtto *et al.* 2004, 2007, 2010, 2013, 2018). Establishing mapping standards through the UTM grid facilitates easier analysis and comparison of data at both national and international levels.

The reason we select UTM zone 34N instead of 34T in GIS software for Montenegro lies in the designation standards used by the UTM system for the northern and southern hemispheres.

The "T" in 34T refers to a specific geographic band in the Military Grid Reference System (MGRS), which divides the Earth into smaller fields for military use. This system uses letters (A to Z, excluding I and O) to indicate latitude bands, with the letter T covering the area between 40° and 48° north latitude. Designations such as 34T are primarily used for military mapping and coding purposes. The "N" in the designation 34N in GIS software refers to the Northern Hemisphere. In GIS tools, UTM zones are labeled with numbers from 1 to 60 (longitude), along with the addition of "N" for the Northern Hemisphere and "S" for the Southern Hemisphere.

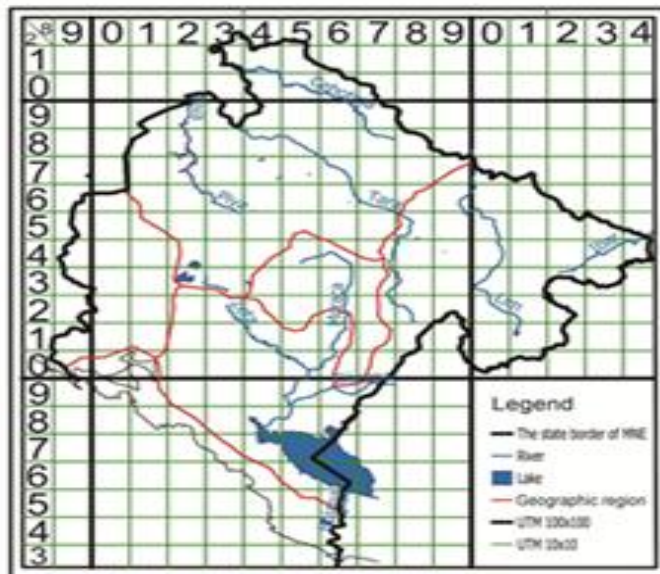


Figure 2. UTM Grid of Montenegro (10×10 km)

Thus, 34N refers to UTM zone 34 in the Northern Hemisphere, which covers the territory of Montenegro. In GIS software, selecting zone 34N (Northern Hemisphere) is correct for Montenegro, as "N" is used to indicate all UTM zones in the Northern Hemisphere. The letter "T" in systems like MGRS refers to a specific latitude band, but it is not applicable in standard GIS software for civilian purposes.

3. The position and designations of the territory of Montenegro within the **MTB fields (*Messtischblätter*)** are defined according to a specific division system used for mapping in Europe, particularly in Central and Southeastern Europe. The MTB grid (or *Messtischblätter*) is a territorial division into square units that facilitates systematic mapping of flora and fauna.

The MTB grid divides land into squares based on a geographic coordinate system. Each basic grid square corresponds to one map sheet at a 1:25,000 scale. These squares are sized 10' (minutes) of latitude by 6' of longitude. Each basic MTB field is labeled with a unique four-digit number representing its position within the broader grid framework, where each number corresponds to a specific location on the map (Fig. 3). In addition to numerical codes, each field may also carry the name of a larger settlement or geographical feature located within it, which further aids in identification. Each field can be further divided into smaller units (e.g., 1/4, 1/16, 1/64) for more precise mapping (Fig. 4). By using the MTB grid, researchers can collect data on floristic localities more efficiently.

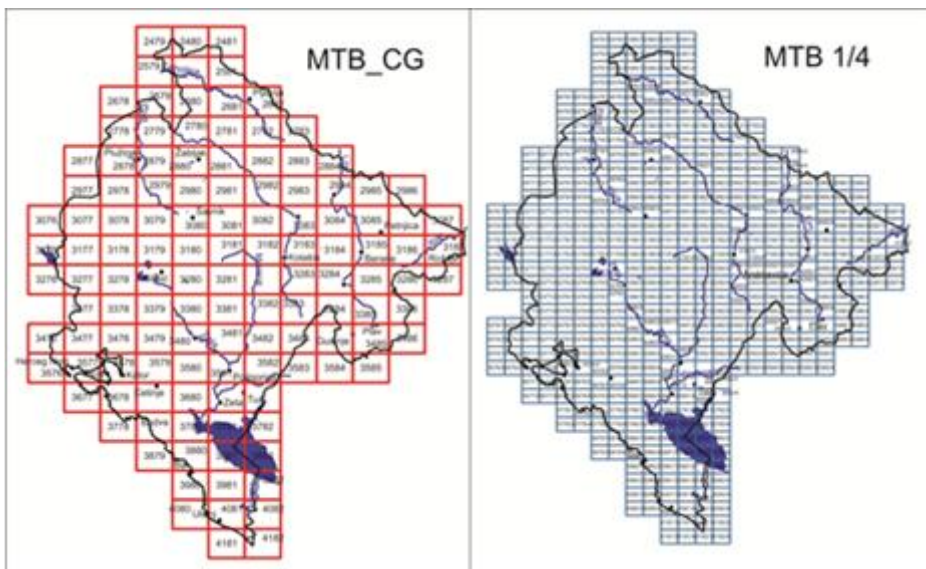


Figure 3. MTB Grid of Montenegro (Basic MTB Field and MTB 1/4 Subdivision)

For example, if a field is labeled as CG23, it designates a specific area that researchers can use for geocoding plant species within that field.

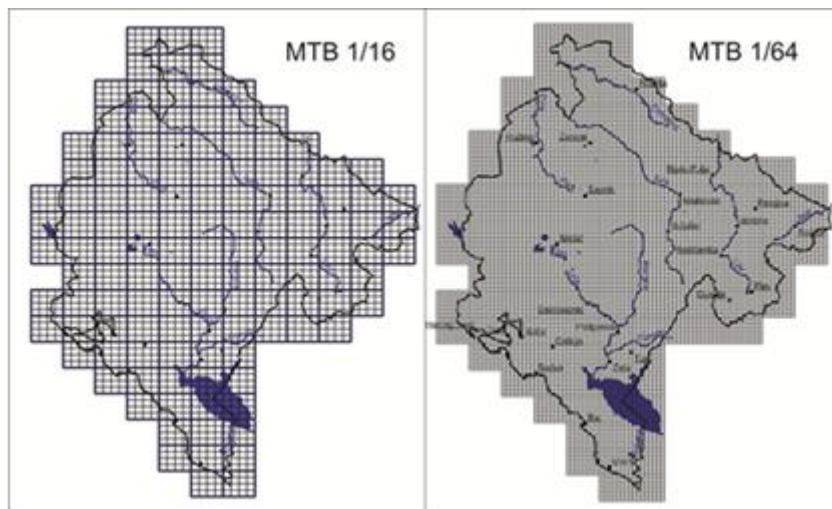


Figure 4. MTB Grid of Montenegro (MTB 1/16 and MTB 1/64 Subdivisions)

4. Geographical Regionalization of Montenegro: The regionalization of Montenegro by Marković (1980) was used in the preparation of the Catalogue of Vascular Flora of Montenegro (Stešević & Caković 2013, Caković & Stešević 2021, Stešević *et al.* 2025). According to this classification, the territory of Montenegro is divided into two main regions: the Mountain-Valley Region (11,372 km²) and the Coastal Region (2,440 km²). These are further divided into six geographical subregions (Fig. 5): Mediterranean (ME), Sub-Mediterranean (SM), Central (C), Eastern (E), Northern (N), and Western (W). Based on this regionalization, the present study provides a precise delineation of subregional boundaries.

The *Mediterranean Subregion* (884 km²) stretches along the southern coastline from Prevlaka to the mouth of the Bojana River into the Adriatic Sea. The eastern boundary follows the Bojana River upstream from its mouth, tracing the national border up to Sukobin. From Sukobin, the northern boundary continues over the peak of Suka e Made, then across Granica to the summit of Crna Brt, and further along the ridges of the Rumija range via the peaks Maja e Rahit, Liponjak, Kozjak, and Ljuti Krš. The northern boundary continues over Čugagolina and Kunor, then above Sutorman, passing through Bješkez and Plavnik, along Gluhi Do to the summit of Rastolac. From there, the boundary continues across Štedinje to Brajići and Mainski Vrh, then below Koložunjska Greda and Branjevina. From Branjevina, the boundary heads northwest, passing above the Lovćen and Kotor slopes, over Velji and Mali Zalaz and Bijeje Lazine, reaching Kozarina Glava and Stražnica. From Valjenak, the boundary descends through Graben toward Poljice, then turns southwest, continuing above the bay

through Sniježnica, Mandići, Ratkovići, to the Sutorina Plain, and further across Košara to Cape Kobilja.

The *Sub-Mediterranean Subregion* (2,593 km²) is bordered to the south by the previously described northern boundary of the Mediterranean Subregion, from Bijele Lazine to Sukobin. The eastern boundary coincides with the national border with Albania up to the Cijevna River. The northern boundary of this subregion follows the Cijevna River westward to the points Čeu and Prases, then across Zatrijebač and over Suka to Dinoša. From there, it continues northward across Đutez, Gradina, Vrbica, Zabrdica, Dolovi, and Bunac to Bratonožići, then from Momačke Strane across Lutovo to the Kruševački Stream in the Platije Gorge. From this point, the boundary turns westward, crossing the Morača River, point 1075, and Jasenov Do to the peak M. Bovan. It then continues in a south-southwestern direction across Boan, Velji Rebrčnik, and Ruiški Gvozd to Cerovija. From Cerovija, the boundary heads west across Dobri Do and Javork to Poljice, and then continues northwest across Rudinice, Obješenik, Vjetreno Brdo to Ponikvica. From there, it proceeds west across Siljevac, Smrekovac above the Ostroške Grede, and further across Povija, Pandurica, and Budoš to Broćanac near Nikšić. The western boundary starts at Broćanac and moves south through Gradina, Crna Osoja, Povrh Biljega, Lazinica, Mrka Ploča, Kosijer, and Čamiska Cave, ending above Bijele Lazine.

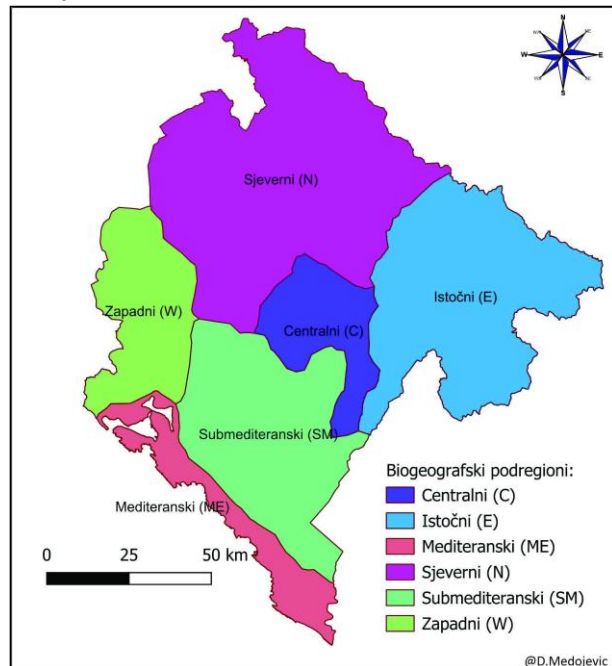


Figure 5. Geographical Subregions in Montenegro

The *Western Subregion* (1,454 km²) is bordered to the south by the previously described western boundary of the Mediterranean Subregion, from

Sutorina to above Bijele Lazine. From that point, the eastern boundary of this subregion begins and extends northward, coinciding with the previously described western boundary of the Sub-Mediterranean Subregion up to Broćanac. From Broćanac, the eastern boundary continues across Ponikvica, Pandurica, Kobilja and Mešanova Glava, Lednica, Šiljeva Glava, and Mali Jastreb to Kita. From this point, the northern boundary of the subregion extends gently westward. It follows the route: Krstati and Ružin Do, M. Planinica and Grabova Glava, Goslić, Cerovo Brdo, Ravni Krstac, Čarađe, Gradac, up to Orlina and the national border. The western boundary of this subregion coincides with the national border between Montenegro and Bosnia and Herzegovina.

The *Central Subregion* (1,024 km²) is bordered to the south by the previously described northern boundary of the Sub-Mediterranean Subregion, from the peak of Siljevac to the peaks Ćeu and Prases. From this point, the eastern boundary of the subregion extends northward along the following route: Rćefja, Poljekuša, Raušnik, Čafa Nikića, Kunj, Bojova Plana, Žijovo, Šila, Grope, and Zagon.

It then continues northwest over Brskutska Planinica, Lijeve Rijeka, Kosman, Tuzi Ljevorečke, Katnice, Zlo Mjesto, Mrčava, Lička Kosa, Velika and Mala Pješčanica, across Pčinja to the summit of Jasenovi. From there, the northern boundary of the Central Subregion extends westward through Vagan, Gomilica, Tisov Krš, Đedov Do, Prijeko Brdo, Crna Greda, Vrmac, Brdeljak, Rađenovo Brdo, and across Osijek to the summit of Čučkovi. From this point, the western boundary heads south through Razvršje, Pandurica, Parinog, Trpezarija, Gackove Grede, Vjetrena Glava, Konjsko, Rozi Vrh, Jaroš, Oblatno, Dubrava, Liverovići, Ravno Brdo, and across Konjušnica back to the peak of Siljevac.

The *Northern Subregion* (4,649 km²) covers the largest area. Its southern boundary extends along the previously described northern and part of the eastern boundary of the Western Subregion, from the national border across the point Orlina to Broćanac. It then follows part of the previously described northern boundary of the Sub-Mediterranean Subregion from Broćanac to Siljevac. From there, it continues along the described western and northern boundary of the Central Subregion, from Siljevac to the point Jasenovi. From Jasenovi, the eastern boundary of the Northern Subregion extends northward via Blatina, Bistrica Lipovska, Gusar, Đevojačka Glava, Veliki Prepran, Štitarica, Večerinovac, Bojkovača, Polje, across the Tara River to Mekića Kula, and then via Krsc, Lisa, Bureta Kapa, Međugvožđe, Breza, Potrka, Tomaševo, Grančarevo, Ujnička Kosa, Koševina, Kanj, and up to Dobrakovo. The northern boundary coincides with the national border with Serbia, while the western boundary follows the national border with Bosnia and Herzegovina.

The *Eastern Subregion* (3,208 km²) is bordered to the south by the entire previously described eastern boundary of the Central Subregion, from the summit of Jasenovi to Rćefja, and then by part of the previously described northern boundary of the Sub-Mediterranean Subregion, from Ćeu and Prases to the Cijevna River and the national border with Albania. The eastern and northern

boundaries of this subregion coincide with the national borders with Albania, Kosovo, and Serbia.

Flora mapping in Montenegro, while necessary, remains a challenging process with numerous difficulties that must be addressed in future stages of research. One of the main challenges is the positioning of older literature records, which are often imprecise and lack geocoding. When the locality of a taxon is described in general terms (e.g., an entire mountain massif such as Durmitor), determining accurate coordinates becomes problematic. A lack of precision regarding geological and pedological characteristics, as well as elevation, affects the accuracy of geocoding.

The standardization of scientific research procedures is essential for future mapping. Therefore, it is necessary to introduce geocoding standards for localities, as well as provide training for researchers in the use of GIS tools. The issue of geocoding imprecise localities (such as large mountainous areas) requires careful analysis, including ecological data and habitat preferences of the taxa, to avoid misplacing lowland or hilly species in the summit zones of mountain massifs, or aquatic and wetland species in arid areas. For this reason, generalization and assigning a central coordinate to spatially extensive and topographically dynamic localities is avoided.

Floristic mapping involves the use of different levels of data accuracy. For example, in the Flora Croatica Database (Nikolić 2025), there are 11 levels of precision, where the most accurate data have deviations of only a few meters, while lower-accuracy records may deviate by several kilometers. In the Atlas Florae Europaeae (Jalas & Suominen 1972, 1973, 1976, 1979, 1980, 1983, 1986, 1989, 1991, 1994; Jalas *et al.* 1996, 1999; Kurtto *et al.* 2004, 2007, 2010, 2013, 2018), a grid of squares approximately 50 km × 50 km is used, with the level of accuracy expressed through concentric circles of varying diameters, indicating the reliability of the data. This approach enables standardized mapping of vascular flora in Europe and ensures compatibility with international databases. In addition to these, other examples of geocoding systems can be found in projects such as Flora Iberica (<http://www.floraiberica.es/>) and Flora of North America (<http://floranorthamerica.org/>), which apply similar methods for assessing data accuracy.

The integration of GPS applications into mobile phones has significantly facilitated spatial positioning and thus the recording of locations. The accuracy of mobile GPS devices today generally ranges from 3 to 10 meters under optimal conditions, while professional GPS receivers (Differential GPS – DGPS) can have deviations of less than 1 meter. However, in urban areas, canyons, or dense forests, mobile GPS may have greater deviations due to signal reflection (multipath effect) and weaker satellite reception (Zrinjski *et al.* 2019).

Compared to standard GPS devices, mobile phones often use Assisted GPS (A-GPS), which improves location fix time by utilizing mobile networks and Wi-Fi signals. This allows for faster positioning, but not necessarily greater accuracy. Professional geodetic GPS receivers, on the other hand, use multi-frequency

signals and correction data, enabling significantly higher precision—often below 30 cm (van Diggelend, 2021).

Nevertheless, for the purposes of floristic mapping and standard geocoding of localities, modern mobile GPS devices provide sufficiently accurate data, especially when post-processing correction is applied or when additional high-precision external receivers are used. Therefore, the differences between mobile and professional GPS devices for such purposes are often minimal in practice—except in cases where millimeter-level precision is required, such as in geodetic surveying.

In addition to floristic research, species distribution data are also collected through vegetation studies. In the past decade, vegetation research in Montenegro has intensified (Stanišić-Vujačić *et al.* 2023), and with the precise positioning of phytosociological relevés, information on species distribution is simultaneously being gathered.

Further work on geocoding is primarily important for the national scientific community, and the ultimate outcome of detailed vascular flora mapping will be the development of a phytogeographical division of Montenegro and the definition of chorion boundaries. Due to the lack of chorological data in current botanical literature that focuses on cataloguing species and infraspecific taxa of vascular flora in Montenegro (Stešević & Caković 2013, Caković & Stešević 2021, Stešević *et al.* 2025), the geographical regionalization by Marković (1980) is used. In addition to Marković's classification, other approaches to the regionalization of Montenegro should also be taken into account. Radojičić (1996) identified five relief units, while in a later work (Radojičić, 2002), he conducted further systematization and divided Montenegro into two macroregions — the southwestern and the northeastern. Within them, he distinguished four regions: the Montenegrin coast, the central region, the high mountains and plateaus, and the valley of the Čehotina, Lim, and Ibar rivers with the surrounding mountains and plateaus.

By comparing these approaches, it can be concluded that Marković's regionalization is more focused on the physical-geographical characteristics of the area, while Radojičić's later classification includes a broader context, considering both relief and biogeographical aspects. In this sense, for the purpose of flora mapping in Montenegro, a combination of these approaches can yield the most precise results, enabling better spatial classification and a clearer connection with floristic and ecological characteristics.

Even when presented solely in the context of geographic distribution, cartographic data are invaluable in the field of environmental conservation and protection, as well as in the identification of biodiversity-rich areas. Mapping of species and habitats within the NATURA 2000 network is essential for the identification and protection of biodiversity-important areas. These data enable precise planning of conservation measures, monitoring of population and habitat status, and the integration of nature conservation into sectoral policies such as agriculture, forestry, and tourism.

In Montenegro, activities toward establishing the NATURA 2000 network are currently underway. Assessments indicate that a large portion of the Montenegrin territory meets the criteria for inclusion in this network, considering the well-preserved forests, landscapes, and natural habitats and species of European importance (Milanović *et al.* 2021).

Habitat mapping is a crucial step in this process. So far, NATURA 2000 habitats have been mapped across approximately 75% of Montenegro's territory. These data form the basis for identifying areas that require specific protection and sustainable management measures (Milanović 2023), and they are also important for the development of the Red List of Montenegro. Accurate data on the distribution and condition of habitats enable an objective assessment of extinction risk for certain species, identification of priority conservation areas, and the planning of adequate protection measures. The integration of data from NATURA 2000 mapping with existing geocoded information provides a comprehensive approach to the development of the Red List, thus contributing to more effective biodiversity conservation in Montenegro.

Current cartography in Montenegro is exclusively based on field surveys. Nevertheless, in a global scale, mapping of vegetation and habitats has increasingly relied on the integration of GIS and remote sensing technologies (Xie *et al.* 2008, Vanden Borre *et al.* 2011). The use of remote sensing imagery, UAV (Unmanned Aerial Vehicle) based surveys, and geospatial models enable researchers not only to map, but to monitor spatial patterns, analyze vegetation dynamics, assess habitat quality, and detect ecological changes over time with high precision (Haest *et al.* 2017, Felix *et al.* 2021, Lamenkova 2024).

Further work on geocoding is important not only for the national scientific community but also for the international scientific community, as Montenegro is one of the centers of diversity for endemic and relict flora and vegetation (Stevanović *et al.* 1995a, b). This makes it a crucial spatial link in understanding the complex historical circumstances that have shaped the present-day plant life of the Balkan Peninsula and Southeastern Europe.

In addition, international scientific collaborations and the obligations arising from them require standardized data that are compatible with global databases. Precise geocoding enables not only the development of a national flora catalog but also contributes to regional and global databases, including the future Red Data Book of the Flora of Montenegro.

Cartographic data have wide applications beyond the scientific sphere, particularly in the development of strategic documents. Accurate information on the distribution of plant species is essential for spatial planning, sustainable development, and environmental protection. For example, Montenegro's National Strategy for Sustainable Development, the Climate Change Strategy, and the National Strategy for Integrated Coastal Zone Management all rely on data concerning the ecological characteristics of the territory.

In addition to nature conservation, cartographic data can be used in the tourism sector (e.g., development of ecotourism routes), agriculture (sustainable

land use), as well as in education and the popularization of science through digital interactive maps and educational platforms.

In recent decades, vegetation mapping has increasingly relied on the integration of GIS and remote sensing technologies (Xie *et al.* 2008). The use of remote sensing imagery, UAV (Unmanned Aerial Vehicle) based surveys, and geospatial models enable researchers not only to map, but to monitor spatial patterns, analyze vegetation dynamics, and detect ecological changes over time with high precision (Lamenkova 2024, Felix *et al.* 2021)

CONCLUSIONS

Mapping the flora of Montenegro using three geocoding approaches – the point method, UTM, and MTB grids – enabled a comparative analysis of their advantages and limitations. Each of these systems offers different spatial resolutions, compatibility, and potential for integration with historical or regional data. The point method allows for precise localization of data and is most suitable for rare and endemic taxa. The UTM system provides a standardized, internationally recognized framework that facilitates integration into global databases. Although used less frequently today, the MTB grid allows for historical comparison with older studies from Central Europe.

By combining these systems, a flexible and comprehensive approach to flora mapping is achieved. Such methodological integration enhances data usability, supports spatial analysis, and enables the creation of consistent and standardized botanical databases that are relevant at both national and international levels.

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