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# Enhancing Forest Conservation Efforts: Mapping of High Conservation Value Forests in the Republic of Moldova

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**Abstract:** The research aims to identify potential High Conservation Value Forests (HCVFs) in Moldova, seen as crucial for biodiversity and providing long-term benefits. Despite the fact that forests only cover 11% of the Moldova's territory, they account for more than 80% of the country's biological diversity and have social, economic, climate, hydrological, and erosion-control benefits. The methodology involved mainly developing identification criteria of these forests, according to the approach developed by FSC, and processing the existing cartographic data using GIS techniques. The findings reveal that almost one-half of Moldova's forests have potential for HCVFs: approximately 175,500 ha of forest land, accounting for 47.3% of the total forested area, were identified as potential HCVFs. Most of these forests are owned and managed by the state. An important outcome of this research is to contribute to the protection of valuable forest ecosystems and establish discussion platforms with stakeholders for their future conservation and long-term resource management. Forest managers, landscape planners, and beneficiaries of forest ecosystem services can use the findings to align management plans, prioritize conservation, and promote sustainable land use. Proper implementation of HCVF principles can attract donors and investors to support Moldova's forestry sector.

**Keywords:** Republic of Moldova; high conservation value forests; forest certification; sustainable forest management; protected areas; forest ecosystem conservation

## 1. Introduction

Forest certification is an effective instrument designed to promote sustainable forest management [1]. There are several forest certification organizations, but the Forestry Stewardship Council (FSC) was the first, and is currently among the largest entities in the field [2] aimed at promoting the use of responsible management in forests worldwide [3]. FSC forest management certification implies a process by which an independent organization confirms through an audit that a certain forest area is managed in accordance with an established standard [4,5]. The standard includes 10 principles and 56 criteria [6] that cover three specific areas of sustainable management: economic, social, and environmental [5]. FSC's Principle 9, referring to high conservation values (HCVs), is an important principle to be followed. According to this principle, management activities in HCVFs must maintain or enhance the identified HCVs.

Although the HCV concept is predominantly used under the FSC certification, it can also be extended beyond the certification process for identifying, managing, and monitoring the high values existing in the forest area [5]. The first practical guide for the identification, management, and monitoring of HCVFs was published in 2003 by a natural resource

management consultancy company, ProForest [7]. Since then, the guide has been translated into several languages and adapted to specific conditions of many countries around the world [8]. All forests provide important benefits to the environment and society, but HCVFs are those with significant biological, ecological, social, or cultural values [9] or are critically important globally, nationally, or regionally [7]. HCV categories 1–3 contain biodiversity values; HCV categories 4 and 5 include forests that have a socioeconomic role; and HCV category 6 contains forests that are critical for cultural values [5].

The HCV concept is recognized as a good instrument to identify priority conservation areas [10]. Although also referring to forests intended for production [11], the concept does not imply excluding these forests from use. Instead, it aims to promote the elaboration of Forest Management Plans (FMPs) based on principles of conservation or improvement of identified HCVs [8], thus focusing the management process on the concept of naturalness in ecosystems rather than the intact state thereof [12]. HCVFs outside the networks of protected areas (PAs) do not necessarily need to be established as PAs; many HCVFs continue to be used commercially, according to management regimes that are recommended after proper assessment [8]. The HCVF concept does not imply creating more PAs; it rather aims to support the assessment of the existing PAs to determine whether they include all the current critical conservation values [8]. HCVF assessments can support governments in achieving their national forest and environmental commitments, such as development of national forest programs, and identification of deficiencies in PA coverage. They also provide recommendations for the reconfiguration of the system of PAs [8]. In addition to promoting the implementation of the best management practices, the HCVF concept can also contribute to greater stakeholder participation in decision-making [13].

Moldova's forests are an important part of the country's natural capital. They are home to over 80% of the country's species and provide social, economic, climate, hydrological, and erosion-control benefits. These forests have been, and continue to be, an important strategic domestic resource. For Moldova, in the absence of forest certification, the HCVF concept can be a key tool for (a) conservation of important areas for species, ecosystems, and landscapes; (b) protection of people against floods and soil erosion; (c) conservation of natural resources of specific importance for the local communities; and (d) conservation of the most valuable areas for communities' identity or cultural heritage [8] and for promotion of sustainable management [14].

Despite being categorized under the national legislation as Group I—forests with primary protective functions, Moldova's forests are still subject to unsustainable management, prompting the authorities to reconsider the country's approach toward reconciling economic development with conservation [15]. By identifying the potential HCVF, this research aims to contribute to the protection of valuable forest ecosystems and establish discussion platforms with stakeholders for their future conservation and long-term resource management. The research is thus supporting the efforts in delimiting forests which are the subject of high conservation from the forest areas designated for protection and/or production purposes, all performing important multidimensional values. It was performed pursuant to the strategy of the Ministry of Environment of the Republic of Moldova for re-evaluating the conservation status of the country's forest ecosystems based on their true significance—a forest management designation that has never been applied before in the country.

The research contributes to the identification of HCVFs, regardless of their ownership or geographic location. It aligns with Moldova's national priorities and international commitments, such as the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCC), which emphasize the importance of sustainable forest management and conservation of biodiversity. The research is built on extensive analysis of publicly available data and authors' compilations.

The main research question of this study is how the HCVs are distributed in the forests of the Republic of Moldova. By answering it, the research can support the future implementation of forest certification schemes and improve the management of national

forest, thereby contributing to biodiversity conservation in alignment with national and international environmental commitments. In this context, the HCVF concept under Principle 9 of the FSC certification system, provides a significant opportunity, given its widespread use and testing. In the certification process, identification and proper management of HCVFs is a basic requirement. The moderate values of the forest production indicators and the growing demand for forest products and services require new approaches, deployed through a lens of resource conservation. In this context, the study aims to identify the HCVFs in order to effectively support protection of valuable forest ecosystems through an interdisciplinary approach, as well as to establish dialog platforms with all stakeholders, including the state, local communities, and civil society, to identify balanced solutions to conservation and long-term management of forest resources.

## 2. Moldova's Forests and the Forestry Sector

According to the latest publicly available, data provided by the Agency for Land Relations and Cadastre of the Republic of Moldova, as of 1 January 2023 [16], the area of the National Forest Ground (NFG) [17] totaled 451,651 ha (13.8% of the country's territory), of which 362,770 ha are owned by the state, while 86,132 ha are held as public property of Administrative-Territorial Units (ATUs), and only 2748 ha are on private property. NFG is the English translation for a specific notion used in land/forest legislation and practice in the Republic of Moldova. It includes forests, lands intended for afforestation, and lands under forest management, as well as nonproductive lands, included in forest management plans (FMPs) or in the land cadaster as forests and/or forest plantations (as per the Forest Code). The area of land covered with forests constitutes 362,496 ha, of which 313,702 ha are owned by the state, 47,288 ha are owned by ATUs, and 1506 ha are privately owned. At the same time, Moldova has 50,699 ha of forest vegetation outside the NFG, of which 30,200 ha are shelterbelts and 20,499 ha are other types of forest vegetation.

Agency Moldsilva is the country's central public authority for forestry and hunting, subordinated to the Ministry of Environment of Moldova. Moldsilva owns and manages the majority of the country's forestlands (so-called 'state public forests') through a network of forest state enterprises, including important PAs administrations [18]. After Moldsilva, ATUs are the second largest forest holders in the country (owning the so-called 'communal forests'). ATUs manage mainly forest plantations (primarily with black locust), but some of them traditionally manage natural forests. They are the main player in the country's incentives for forest expansion [17].

All state-owned forests have FMPs, elaborated in accordance with a regulatory framework based on principles of sustainable management [19]. Only a small part of non-state forests have FMPs or forest management administrations [20]. Most of the lands with forest vegetation outside NFG do not have FMPs and are not appropriately managed [19].

Moldova's forest resources have low-value indicators; each inhabitant is attributed 11.3 m$^3$ of standing wood and 0.16 m$^3$ per year of harvested wood [21]. However, most of Moldsilva's income comes from the use of wood [19,21]. Moldsilva still operates under a self-financing mechanism introduced in 1998. This mechanism is seen as imposing a heavy burden on the existing forests [22,23]. According to official reports, the volume of wood harvested from the NFG managed by Moldsilva is close to the annual allowable cut established cumulatively by FMPs [24,25].

The share of the forest ecosystems, accounting for about 11% of the country's overall area [16], is still considered very low [26]. If forestland does not expand, rural areas will be vulnerable to natural hazards (such as land and soil erosion and flooding), especially in some areas of the country where aridification is intensifying and there are already signs of desertification [26]. Representing 11% of its area, Moldova has one of the lowest shares of forest ecosystems in Europe (the European average is estimated at 39.8% [27]). Deciduous species predominate (98%), and oak forests (44%) are the most representative forest ecosystems, contributing over 80% to the country's biodiversity [19,28].

According to Article 14 of the Forest Code of the Republic of Moldova [17], the NFG forests were included in Functional Group I, meaning that the forests have mainly environmental protection functions. The technical forest functionality norms [29] established five categories within Functional Group I, all based on the functions assigned: 1. Forests with water protection functions (1.6%); 2. Forests with land and soil protection functions (7.9%); 3. Forests with protection functions against harmful climate and industrial factors (47.4%); 4. Forests with recreational functions (26.4%); and 5. Forests with functions of scientific interest and protection of the ecologic and genetic pool (16.7%). However, The Biological Diversity Strategy of the Republic of Moldova [30] describes the use of the country's natural resources as irrational, while also highlighting the need for significant improvements in biodiversity conservation. Under the currently limited institutional capacities, as well, insufficient regulatory enforcement, insufficient integration of economic sectors regarding biodiversity conservation, and insufficient general public awareness of the importance of biodiversity conservation, a more constructive and practical approach is needed to define the role of the forests for the national economy and the importance of protecting biological diversity [30]. Biodiversity losses are caused by several factors, primarily by illegal use and misuse of forest resources through illegal logging, poaching and irrational use of game resources, illegal fishing and irrational use of fish resources, abusive grazing, illegal trading of forest products, and degradation, all within the conditions of high natural-resource dependency and poverty [30].

*Moldova's Protected Areas*

Law 1538/1998 on State PAs provides legal grounds for designation and management of PAs, and defines principles and mechanisms of conservation, as well as competences and plenary powers of central and local authority, nongovernmental organizations (NGOs), and citizens in PAs [22]. Under the law, PAs include natural and valuable objects and complexes for (a) the conservation of biodiversity and natural habitats (of international and transboundary importance), including those important for migratory species of animals; (b) the study of natural processes; (c) the restoration of the ecological balance; (d) public environmental education; and (e) the development of ecological tourism [31].

PAs consist of categories of objects and natural systems, established based on several international classifications [31]. According to the International Union for Conservation of Nature classification, Moldova is endowed with scientific research reserves and national parks, nature monuments, landscape reserves, and multifunctional management nature reserves. There are also PAs that are not classified according to the above-mentioned classification, such as dendrological gardens, landscape architectural monuments, and zoological gardens. Other international guidelines and agreements are followed to regulate biosphere reserves (UNESCO Programme) and the wetlands of international importance (Ramsar Convention [31]). Almost all forest-type PAs are established in state forests [19].

The Emerald Network, launched by the Council of Europe and implemented by Moldova [32], accounts for another important mechanism applied to protect the natural environment. This network is a special tool for the protection of Europe's natural environment and is composed of areas of special conservation interest from non-EU countries, matching Natura 2000 network sites [33]. The Emerald Network is a system of coherent and interconnected spaces subject to management, monitoring, and information measures. Initiated under the Bern Convention, the network aims to ensure the long-term survival of species and habitats protected under this treaty, and requires specific conservation measures [33].

## 3. Materials and Methods

### 3.1. General Methodological Framework

Identification of HCVFs at the national level requires analysis of specific values and datasets and ongoing consultations with national experts and forest conservation NGOs [5,9]. This ensures that the opinions or information provided by relevant stakeholders are incorporated into the process [8,34]. When identifying HCVFs in each country,

forest values and their thresholds, that is, the level beyond which the respective forest attribute can be considered as HCV, should be established [5,12]. The thresholds should be determined in a way that does not result in the inclusion of only small forest areas or areas that do not have critical or significant values [12]. The HCV identification and assessment does not require new tools or techniques. It can utilize existing research, and mapping data can be used [8] which should be based on sound information, incorporating and using all relevant local scientific data [34]. While certain categories can be designated based on existing descriptive data in technical documentation, in some cases, when significant data gaps are identified, data collection and field research are required [5,34]. In these cases, a precautionary principle is recommended [34]. In the absence of data or certainty about the sufficiency of attributes, forests should be designated as an HCVF until newly identified information proves otherwise [35].

The FSC criteria for HCV identification constitute the technical framework for our methodology, and served as the foundation for developing a framework for HCVF identification in the Republic of Moldova. The classification criteria used in different countries were also analyzed, compared, and adapted to the context of Moldova. This process included comprehensive country-wide consultations with all relevant key stakeholders (central and local public authorities, civil society, research, and experts from various fields). This preliminary stage sought to define, in the national context, the relevant forest-related values and, for each value, to identify the threshold level, that is, the level above which the respective forest-related value becomes a HCV.

Elaborating the set of criteria for HCVF identification included the review and analysis of a number of similar documents applied in other countries/regions [2,7,9,12,35–38]. According to these guidelines, HCVs were classified in accordance with six categories (Table 1).

**Table 1.** Categories of HCVs [7,12] and thresholds for each relevant forest value for Moldova.

| | HCV Description | HCV Thresholds for Moldova |
|---|---|---|
| HCV 1 | Concentrations of biological diversity including endemic species and rare, threatened, or endangered species that are significant at global, regional, or national levels<br>HCV 1.1. Forests in protected areas<br>HCV 1.2. Forests hosting rare, threatened, or endangered species<br>HCV 1.3. Forests with critical seasonal use | HCV 1.1. Forest lands in PAs that have biodiversity conservation as their main objective<br>HCVF 1.2. and HCVF 1.3. Forests within scientifically designated sites containing superior plant or animal species which, at certain essential stages of their existence, need forest ecosystems |
| HCV 2 | Large landscape-level ecosystems and ecosystem mosaics that are significant at global, regional, or national levels and that contain viable populations of the great majority of the naturally occurring species in natural patterns of distribution and abundance | HCV 2 Large forest landscapes that contain a high degree of naturalness and integrity |
| HCV 3 | Rare, threatened, or endangered ecosystems, habitats, or refugia | HCV 3 Forest units that contain natural forest stands made up of species of major importance for Moldova |
| HCV 4 | Basic ecosystem services in critical situations, including protection of water catchments and control of erosion of vulnerable soils and slopes<br>HCV 4.1. Forests of particular importance for water sources<br>HCV 4.2. Forests critical for preventing and combating erosion<br>HCV 4.3. Forests with critical impact on agricultural land and air quality | HCV 4.1. Forests located in areas of natural hydrological risk<br>HCV 4.2. Forests situated on lands with slope greater than 20°<br>HCV 4.3. Forests in areas with phenomena that negatively influence agricultural production or in areas with air and/or soil pollution phenomena located near settlements |

**Table 1.** *Cont.*

|  | HCV Description | HCV Thresholds for Moldova |
|---|---|---|
| HCV 5 | Sites and resources fundamental for satisfying the basic necessities of local communities or indigenous peoples (for livelihoods, health, nutrition, water, and so on) | HCV 5 Forests that meet the basic needs of local communities, when it is not feasible to obtain resources from other locations |
| HCV 6 | Sites, resources, habitats, and landscapes of global or national cultural, archaeological, or historical significance and/or of critical cultural, ecological, economic, or religious/sacred importance for the traditional cultures of local communities | HCV 6 Forests that surround Moldova's monasteries, within 500 m |

Relevant forest values were established in a specific way for Moldova for each HCV category, and thresholds have been identified for each forest-related value (Table 1). The draft set of criteria for HCVF identification in the Republic of Moldova was then submitted for consultation to relevant stakeholders. All inputs collected from stakeholders (regarding the thresholds for HCV and the minimum management measures) have been incorporated in the final version of the set of criteria. This final version served as basis for the GIS analyses/queries that were carried out to map the forests with the described conservation values.

*3.2. Specific Criteria, Collecting and Processing Cartographic Data for HCVF Identification in the Republic of Moldova*

**National Forest Ground Cartographic Data**

The HCVF mapping started with the collection of available cartographic or descriptive information. Further on, collected data and maps were aggregated through a complex consolidation process using appropriate GIS techniques. The whole process, which relied on the quality of initial data, resulted in maps produced from original data and compilations. Based on the cartographic resources, other data, and appropriate GIS techniques, the research provides the maps of the HCVF categories and supports them with a detailed analysis.

The map of the State-Owned Forests was developed based on the management maps provided by the Forest Research and Management Institute (ICAS). NFG management planning maps provided by ICAS were used for HCV identification of state-owned NFG. Because forest management planning is carried out every 10 years with only about 35,000 ha covered per year, the cartographic data corresponding to FMPs are out-of-date for about nine years. To produce a complete national-level map, data at the level of the forestry district were taken for each forest management unit. By merging the cartographic data corresponding to all forestry districts containing detailed description of stands, a national-level map was developed for the state-owned NFG—an area of 337,925 ha. Other land categories, except for forests, were excluded (in total, 31,531.3 ha) from the map.

The map of Non-State Forests (owned by ATUs and other holders) was developed based on the land use maps designed by the Agency for Land Relations and Cadastre and the management maps for ATUs that have undergone forest management planning. To elaborate a map of forests belonging to owners other than the state, the first step was to obtain cartographic data regarding the NFG owned by the 41 ATUs having GIS-based management plans for their forest lands. Combining all corresponding cartographic data for each ATU resulted in an area of 10,492.8 ha, of which 8956.18 ha are forests. For the remaining area of land covered by forests of non-state holders, the land use map (published in 2017 by the Agency for Land Relations and Cadastre) was used. Deciduous, coniferous, mixed, and dense forests were selected. The resulting forest area is 364,854 ha (including Transnistria). Several processing steps were performed to obtain a vector layer, the first being the exclusion of Transnistrian areas. Subsequently, the state-owned NFG areas were excluded according to the FMP maps, as were the areas overlapping with the

urban/communal area and cadastral parcels in the cadaster database of the Republic of Moldova to correct the resulting GIS layer As a result of this process, which was automatically carried out using the QGIS 3.28.10 software, there were some non-corresponding areas, due to the difference between the original land use map and the corresponding state-owned NFG. These areas were manually corrected. The resulting area covered by non-state forests is 38,210.5 ha. This map was used to identify the corresponding forest areas, based on the classification of each HCVF category.

**HCVF 1**

Forest lands proposed to be designated as HCVF 1.1 are included in PAs that have biodiversity conservation as their main objective [7,12,34]. In Moldova, such areas can be found in the following: (i) scientific reserves: aimed at maintaining intact natural sites and systems and conserving biodiversity; (ii) nature reserves: intended to ensure optimal conditions for the protection and restoration of nationally significant species and plant and animal communities; (iii) botanical nature monuments: representative sectors with forest vegetation—territories designated for protection to conserve unique or typical habitats of relict plant species, their communities, and rare or endangered plant species and secular trees. According to PA re-evaluation, it has been proposed to transfer these to the category of nature reserves [39]; (iv) national parks: for Orhei National Park, Zones A and B1 were considered. Zone A includes unique natural areas that preserve their natural character and influence and serve as a natural repository for the preservation of the gene pool of native plants and animals; in Zone B1, for protection and recreation, natural processes are prioritized, with ecological reconstruction and rehabilitation being the only interventions allowed [40]. For Lower Nistru NP, only Zone A was considered because Zone B1 only has recreational objectives [41]; and (v) landscape reserves: according to the PA re-evaluation, it is proposed that these should be upgraded to nature reserves, with the main protection objectives or values of conserving natural forests, rare plant and animal populations, and landscape [39].

For the identification of forest areas to be included in HCVF 1.1, the PA (pursuant to Law 1538/1998) maps in GIS format could not be found. Upon specific request, the central environment protection authority has provided the PA re-evaluation forms developed under the UNDP/GEF project 'Strengthening institutional capacities and representativeness of the protected areas system in Moldova', carried out between July 2010 and December 2012, to identify the current state of PAs in Moldova, as well as to suggest proposals and recommendations for optimizing biodiversity conservation [39]. This re-evaluation was not officially recognized in the legislation; hence, in this research, PAs from the above categories were included according to Law 1538/1998, but their projection on the map was made based on the recommendations made as part of the re-evaluation process. These recommendations are timely, as they provide an updated status of PAs. Using the information in the re-evaluation forms, a map of PAs of interest for this category of HCVFs was produced (PAs that were proposed to be excluded from the list of 'protected areas' and areas on the territory of Transnistria—due to lack of positioning data—were not included). Based on the PA location in the re-evaluation forms, and following the FMP maps, a GIS map containing the boundaries of PAs of interest was produced. The area for these PAs is different from that included in the re-evaluation forms. Boundaries of most of the forest subunits, proposed to be included in the PA system, have been adjusted during forest management planning works, resulting in changes in the surface area. At the same time, the authors of the re-evaluation asserted that the surfaces might be modified if the proposals for reclassification of the PAs are considered [39]. For the National Parks' inclusion in the GIS map, data from the corresponding normative acts (that is, GD 923/2014 for Orhei National Park and GD 144/2022 for Lower Nistru National Park) were used.

Under HCVF 1.2 and HCVF 1.3, a set of criteria was proposed to include forests within scientifically designated sites containing superior plant or animal species which, at certain essential stages of their existence, need forest ecosystems [7,12]. These rare, threatened, or endangered species are protected by the state and are included in Annex 3 of the law

on PAs [31] and in the Red Book of the Republic of Moldova [42]. The illustration of these species can be found also in books describing PAs from the Republic of Moldova [43]. The Emerald Network was used to identify these forest types. To map the Emerald Network sites, representing Areas of Special Conservation Interest in non-EU countries compatible with the Natura 2000 network sites, the European Environment Agency website was accessed and the cartographic data and standard forms for each Emerald site were downloaded [44]. All downloaded files were combined, resulting in a common map of 61 sites.

In addition, important areas for birds and biodiversity were also analyzed [45]. The aim is to ensure the long-term conservation of sites of significant importance for birds and biodiversity. These areas are selected by applying ornithological criteria based on the latest knowledge of the bird population sizes and trends. These criteria ensure that the selected areas are of significance for the international conservation of bird populations and provide a common system, thus creating consistency between sites and allowing comparisons to be made at national, continental, and global levels [45]. As many as 11 such areas have been identified in Moldova, with a total cover of 124,438 ha containing 236 bird species (of which 149 species are terrestrial, 87 are water species, and 16 are marine species), with 208 species being migratory, 12 of which are globally threatened bird species [46]. To produce the map of Important Bird and Biodiversity Areas (IBAs), designated for the long-term conservation of sites that are of significant importance for birds and biodiversity, data were requested and received from the datazone.birdlife.org platform [47]. The threshold for these categories is the presence of a habitat of national or international interest that supports significant concentrations of rare, threatened, or endangered plant species or supports a high concentration of animal species during a critical period of its existence; the location of this habitat should be in a scientifically designated site recognized as supporting nationally or regionally significant concentrations (these must be considered cumulatively).

**HCVF 2**

In this category are included large globally, regionally, or nationally significant forest landscapes that retain needed characteristics (that is, structures, compositions, and processes) of natural ecosystems, including viable populations of native species in their natural form in terms of distribution and density [7,12]. According to the general guidelines for HCVF 2 identification [7,9] and those developed at the national level [2,12], to be included in this category, forests must meet spatial criteria (in some cases, they must be at least 50,000 ha) and contain a high degree of naturalness and integrity. As a result, these forests must be relatively large in area (to meet the first condition) and as little affected by recent human activities as possible, with outstanding features in this respect at regional or national level (to meet the 'significant' condition). The purpose of the designation is not to remove humans from the forest, but only to ensure a form of management that maintains the 'naturalness' of this ecosystem.

The Forest Landscape Integrity Index map was used to identify forest areas that meet these criteria. The corresponding map was downloaded from the forestintegrity.com platform. The Forest Landscape Integrity Index is useful for this purpose, as it integrates data on forest pressures and loss of forest connectivity, and generates a continuous index of forest integrity as determined by degree of anthropogenic modification [48].

**HCVF 3**

In most cases, only part of rare ecosystems are included in existing PAs that aim to conserve biodiversity. Therefore, it is necessary to manage these ecosystems rationally outside the network of PAs to cover the necessary surface area and, especially, their entire range [7,12]. In our case, HCVF Category 3 includes forest units that contain natural forest stands made up of species of major importance for Moldova: pedunculate oak (*Quercus robur* L.), sessile oak (*Q. petraea* (Matt.) Liebl.), downy oak (*Q. pubescens* Willd.), and beech (*Fagus sylvatica* L.). These forests are considered as rare, threatened, or endangered ecosystems [43], and must be monitored so that their area is not reduced.

**HCVF 4**

Regarding HCVF Category 4 (with three subcategories) the following criteria were considered. The threshold for forests to be included in the first subcategory (4.1) is their location in areas of natural hydrological risk, including forests of particular importance for water sources. These forests were identified by overlaying the map of natural hydrological-risk areas with the forest maps. The map of these areas was compiled using the data available on the geodata.gov.md portal, provided by the Moldovan Water Agency. The boundaries of these areas also include the forest areas with special water protection functions or those located in the Prut and Nistru River meadows.

The second subcategory (4.2) includes forests located on deep eroding land and on steep slopes. As a threshold, all forests situated on lands with a slope greater than 20° are considered. To identify these forests, a slope-gradient map was produced, based on the Land Relations and Cadastre of the Republic of Moldova national digital elevation model, with a pixel size of 10 m, and was overlaid with the forest maps.

The third subcategory (4.3) refers to forests in areas with phenomena that negatively influence agricultural production (strong winds, drought, and shifting sands) or in areas with air and/or soil pollution phenomena located near settlements.

**HCVF 5**

For HCVF 5, criteria were defined to include forests that meet the basic needs of local communities: (a) energy for heating homes and cooking, (b) material for various constructions, and (c) raw material for the production of products that provide necessary income for the subsistence of the population [7,12]. As a threshold, HCVF 5 is established when it is not feasible to obtain resources from other locations for the mentioned situations.

**HCVF 6**

The threshold for forests to be included in HCVF 6 is the following: (a) there are historically important celebrations and customs taking place in the area of the forest under assessment which are essential events for the local cultural identity; (b) the forest under assessment (identified by legislation or literary works) has a clear cultural value (local or national), which has been transmitted through legends or literary works; and (c) there are historical monuments or places of worship and pilgrimage in the area of the forest under assessment or in its immediate vicinity. Following these criteria, Moldova's monasteries and the forests that surround them within 500 m were included in this category.

## 4. Results and Discussion

All resulting GIS layers with the forests in each HCVF category were merged into a common layer (Figure 1). The total potential HCVF area for state-owned forests is 166,517 ha, while the total potential HCVF area of non-state holders is 8979.15 ha. Together, they cover 175,496.15 ha. Therefore, approximately 175,500 ha of forest land (representing 47.3% of the country's total forested area) may have the potential to be classified as HCVF. The majority of these forests are owned and managed by the state.

In Moldova, forest management ranges from intensive to close-to-nature, and entails the need to reach a compromise and contribute to the well-being of the population. Civil society and local communities are increasingly demanding the conservation and preservation of forests as critical zones for biodiversity. Besides the fact that this research can be used in the eventuality of a certification process, identifying and mapping these forest areas could serve as a turning point in designing a network of important ecological areas in the country and modernizing the national legislation governing PAs. This would also support future biodiversity conservation efforts, such as implementing strategic documents under CBD or afforestation/reforestation initiatives.

**HCVF 1**

Overlaying the map of PAs with the map of forests provided a forest area of 58,078.31 ha, which was included in HCVF 1.1 category (see Figure S1 in the Supplementary Material). For these forests, management measures are recommended to be established through the management plans for PAs.
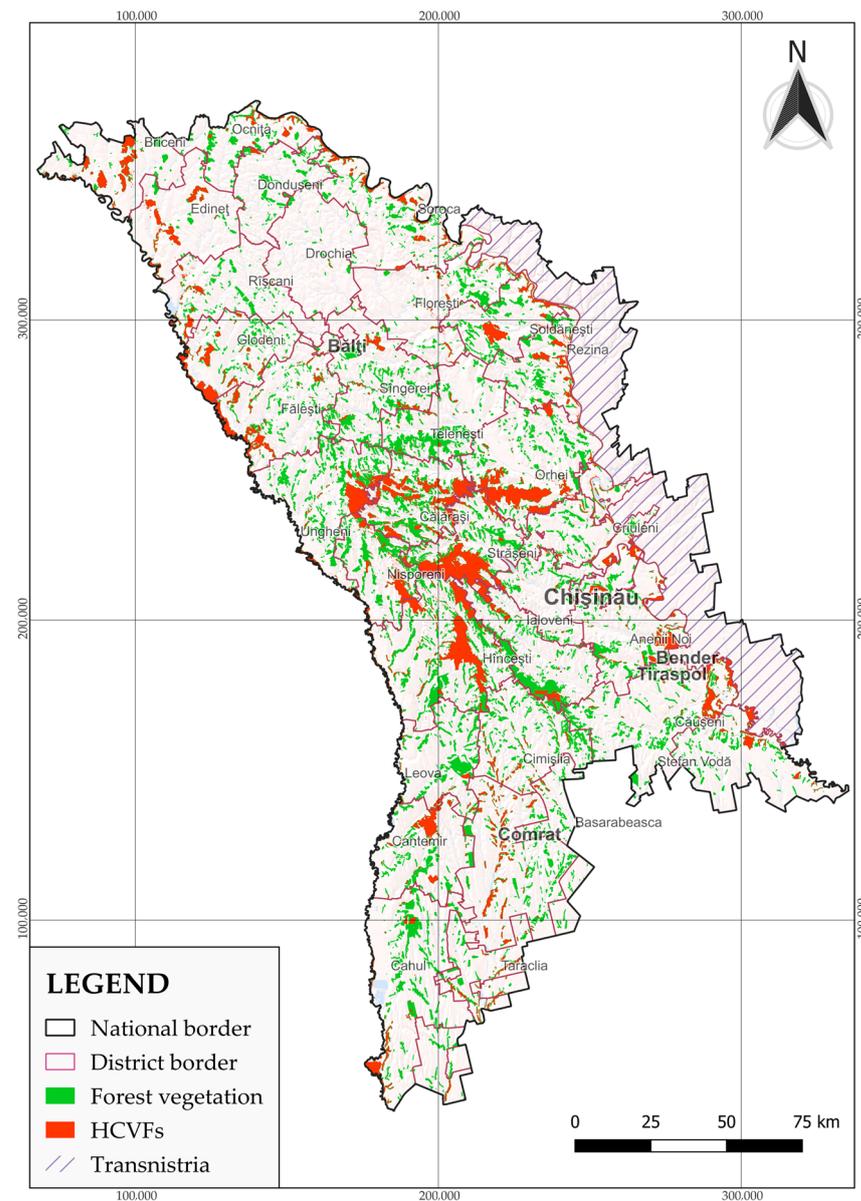
**Figure 1.** HCVF area distribution.

The area of state-owned forests included in HCVF 1.2 and HCVF 1.3 categories was identified by overlapping the state forests map with the Emerald Network map. The overlapping surfaces that benefit from the presence of the most important species—oak, downy oak, sessile oak, beech, willow, and alder—corresponding to the forest habitat types of European interest for which Emerald sites, have been declared: (i) riverine willow woodland; (ii) middle-European stream ash–alder woods; (iii) alder swamp woods not on acid peat; (iv) mixed oak–elm–ash woodland of great rivers; (v) beech woodland; (vi) thermophilus deciduous woodland; and (vii) oak–ash–hornbeam woodland on eutrophic and mesotrophic soils. These were included in HCVF 1.2. For the ATU-owned forests that have FMPs in place, a similar procedure was used. It was not possible to identify the presence of alder using only the FMP maps. The area of Emerald sites is 325,197 ha [32]. Of this area, forests of interest for HCVF 1.2 represent 93,186.5 ha.

The same approach was used to identify the forest areas overlapping with important areas for birds and biodiversity. Forests overlapping with these areas represent 38,192.5 ha.

The layers obtained for both HCVF 1.2 and HCVF 1.3 were combined, resulting in a forest area of 95,218.4 ha. This area indicates a significant potential in terms of protecting

species of conservation interest, but it should be noted that only the field validation of the presence of HCV, with the application of the precautionary principle, should determine the application of restrictions in terms of management of these forests.

**HCVF 2**

In Moldova, there are no intact forest landscapes [49]. Also, there are no compact areas larger than 50,000 ha. These findings are also supported by the Forest Landscape Integrity Index, which shows that in Moldova, there are no high-forest integrity areas and only limited areas of medium integrity in terms of anthropogenic modification level, and most are low-integrity forests. For the area identification, the region corresponding to the medium-integrity level was overlaid with the forest map, resulting in a forest area of 31,709.7 ha.

Because of the small extent of medium-integrity forest landscapes, these forests are considered for inclusion in HCVF Category 2 and for proper monitoring for integrity preservation. In these forests, appropriate intervention measures are recommended to be implemented so that the forest's natural characteristics are preserved, to promote the natural forest types. In the HCVF Category 2 (see Figure S2 in the Supplementary Material), the research has identified nearly 3400 ha of valuable forests that are not assigned a special protection/monitoring status. This finding should inform protection measures (including inclusion in the legal framework that is under development) carried out by authorities to prevent forest degradation.

**HCVF 3**

This category includes forest units that contain natural forest stands made up of species of major importance for Moldova: pedunculate oak (*Quercus robur* L.), sessile oak (*Q. petraea* (Matt.) Liebl.), downy oak (*Q. pubescens* Willd.), and beech (*Fagus sylvatica* L.). These forests were identified based on the provisions of the FMPs and the current state of forest types 1–3. These forests are considered as rare, threatened, or endangered ecosystems, and must be monitored so that their area is not reduced. Forests proposed to be included in this category represent an area of 86,596.8 ha (see Figure S3 in the Supplementary Material).

The potential HCVF 3 should be seen as the basis of a network of biodiversity/conservation nodal zones consisting of rare ecosystems, specific to Moldova, especially those that still retain their naturalness due to the presence of beech and oak species. However, it is believed that a large part of this area does not necessarily represent rare, threatened, or endangered ecosystems, and, therefore, requires further field validation of the obtained cartographic data before a different management system can be adopted.

**HCVF 4**

The total area proposed for this category is 44,116.54 ha (See Figure S4 in the Supplementary Material).

The first subcategory (4.1) includes forests of particular importance for water sources. These forests were identified by overlaying the map of natural hydrological-risk areas with the forest maps, to identify areas of state-owned forests, resulting in an area of 27,507.9 ha, as well as with the map of non-state forests, resulting in an area of 7064.61 ha. The location of the forests included in HCVF 4.1 represents a total area of 34,572.51 ha.

The second subcategory (4.2) refers to forests that are critical for preventing and mitigating soil erosion processes. FMP maps helped locate areas covered by state-owned forests within the HCVF 1.2 category. Of these, all forests situated on lands with a slope greater than 20° were included, resulting in an area of 7616.66 ha. The map of lands with a slope greater than 20° was overlaid with the map of ATU-owned forests, resulting in an area of 1927.37 ha.

Moldova's specific geomorphological features require continuous monitoring of the risks of flooding and torrential rainfall. Based on this research and further field validation, identifying forests that can help mitigate the effects of these natural hazards, along with their appropriate management, is recommended; this also applies to forests that are critical for preventing and combating soil erosion.

The third subcategory (4.3) refers to forests with critical impacts on agricultural land and air quality, where shelterbelts are of specific interest. They cover an area of 30,200 ha [16] outside the NFG, but, currently, there is no cartographic information on their location, except in the central and southern part of the country. Although in many respects agricultural shelterbelts do not fall into the category of forests, these areas are highly important for the country's agriculture and other sectors; however, due to limited data on mapping of these areas, continued efforts to inventory these areas and to implement a management system that allows them to perform their role are recommended.

**HCVF 5**

No forests have been identified in this category. Recent research [50] shows that non-wood products are less essential for meeting the basic needs of local communities compared to wood products. In Moldova, NTFPs, although important, are not essential for local communities, and represent only 1% of their income. However, wood resources, especially firewood, are important. Households with modest incomes have to spend, on average, 22.6% of their income on this resource [50]. These needs have been identified in several localities across different parts of the country, and all of the country's forests meet a major social need. Generally, wood resources are of crucial importance for local communities, as concluded in other studies [51–53].

However, even if the wood resources around a locality become scarce, purchasing wood from the neighboring areas will remain feasible, especially due to the relatively short distances between forest bodies. It is important to note that members of local communities can harvest non-wood products (especially fruit/berries, medicinal herbs, or food plants) in the forests for their vital needs, in reasonable quantities, and the availability of these accessory forest resources is closely related to the quality of forest ecosystems and their management.

**HCVF 6**

In this category, only forests within 500 m of religious sites were included, totaling 802.83 ha (see Figure S5 in the Supplementary Material). This area includes Moldova's monasteries and the forests that surround them. The general management recommendation for this category is to maintain and expand forests in these areas. Forests play an important role in the history and culture of the country's population. Therefore, further efforts to complete a ground-level inventory of these forests and take the necessary actions to implement appropriate management measures for the optimization of the forests' sociocultural functions are recommended.

Initially, this area of forests can be considered as significant in terms of their proximity to important religious sites. Consideration and inclusion of other forest areas in this category, given their historical and cultural link to the people of Moldova, can be a subject of further studies. Continued efforts to inventory these forests and to establish appropriate measures for their management to optimize their sociocultural functions are recommended.

## 5. Conclusions

This research aimed to identify Moldova's potential HCVFs and evaluate the conservation status of the country's forest ecosystems based on their true significance—a forest management designation that has been applied in the country for the first time. Despite being categorized under the national legislation as Group I forests with primary protective functions, Moldova's forests are largely used for production purposes too (supplying communities with basic needs with respect to food, primarily fuelwood), and are still subject to unsustainable management, prompting the authorities to reconsider the country's approach toward reconciling economic development with conservation.

This research's findings reveal that almost one-half of Moldova's forests have the potential to be HCVFs, and provide a classification of these forests according to the approach developed by FSC. Based on many sources of descriptive and spatial data on forests in Moldova, with additional processing based on GIS techniques, the study evaluated the potential of the country's forests to provide multiple benefits (from biodiversity con-

servation to economic and climate benefits, as well as hydrological, and erosion control). Moldova has significant forested areas that have the potential to be HCVFs. Considering overlaps, they are estimated at 175,500 ha (or 47.3% of the existing forest area). This attests to the significant environmental, social, and cultural importance of forests in the national context. Maintaining and expanding forest cover will strengthen the environmental and economic security of the country, by providing sustainable benefits and livelihoods. All this will support the country's capacity to adapt to climate and water-shortage challenges. This study has identified an area of about 3400 ha of medium-integrity forests which, as of the publication date of this research, have no protection/monitoring status; therefore, monitoring, and, if necessary, the implementation of appropriate management measures to ensure their continuity, are recommended.

The identification of potential HCVFs can serve as a starting point to inform future biodiversity conservation planning efforts, such as strategic documents on biodiversity conservation as required by the CBD and ratified by the Republic of Moldova. Forests play an important role in the history and culture of Moldova's people, and continued efforts to inventory these forests and to establish appropriate measures for their management to optimize their sociocultural functions are recommended. Overall, the HCVF identification seeks to provide additional safeguards to ensure that forests containing exceptional or critical values are not (or will not be) degraded or adversely affected by their management. The designation of sectors/areas as HCVFs does not automatically preclude management operations such as wood harvesting (which is sometimes the main source of energy for the rural population), but rather adjusts/coordinates planning and implementation of socioeconomic activities.

Based on comprehensive country-wide consultations with all key stakeholders, this research developed the first-ever set of criteria for HCVF identification in the Republic of Moldova, informed by the experience of countries in a similar geographical region. However, it is necessary to further refine this set of criteria through a participatory process, and adapt the HCVF identification criteria to the country's environmental and socioeconomic context.

These findings and recommendations can be readily adopted by various user groups, according to the way they access forest resources:

- Forest managers (especially Moldsilva and some ATUs), in aligning forest management plans with the identified potential HCVF within their range to ensure an appropriate planning of relevant works (for example, promotion of native species, conservation of certain resting areas, and preservation of old seed stands);
- Landscape planners, in establishing priorities for land users to design conservation measures and promote sustainable use of land (for example, adjustment of urban plans, hydrographic approach, and rationalization of infrastructure and construction projects);
- Beneficiaries of forest ecosystem services including HCVFs, in considering various potential risks associated with income generation, prompting precautionary measures under applicable law (for example, operators of tourist companies or businesses dealing with harvesting wood/non-wood products, including hunting activities).
- Finally, the HCVF identification needs to be complemented by updated national HCVF standards, which would open more opportunities to attract donors or investors in the development of Moldova's forestry sector, based on the principles of supporting healthy and biologically/ecologically diverse forests.

The study was limited solely to HCVF identification. A future scientific and field-based inventory of HCVFs in Moldova is essential to establish an adequate management system that supports an active conservation of valuable forests, considering the low forest cover and high demand for forest products and services.

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