Co-funded by the European Union

Analysis of the Current Status and Management Systems of Grasslands in Partner Countries

SMART STEP

Climate-Smart Steps in Grassland Management and Improvement

Contents

A. Introduction

This Project Result provides a comparable overview of the status and management systems of semi-natural grasslands (SNGs) in the partner countries (Austria, Poland, Serbia, Spain and Türkiye). The purpose is to support agricultural and environmental practitioners, advisory services, protected-area managers and policy makers in evaluating their own context and identifying management approaches that can be adapted and applied elsewhere. Across countries, grasslands remain a key forage base for extensive livestock systems and a core component of high-nature-value habitats, but they are increasingly exposed to intensification, abandonment, overgrazing and climate-related pressures.

Each partner prepared a national chapter using the common template. The chapters are based on official statistics, national/EU policy documents and strategies, and relevant scientific literature, as reported in each country's reference list. This consolidated report keeps the national chapters intact and adds an editorial comparative synthesis to ensure cross-country readability and comparability.

In this report, SNGs are used in an operational sense: grassland systems with high ecological value maintained through active management (extensive grazing and/or mowing), without regular ploughing and reseeding, and providing both production and ecosystem functions. A key limitation is that SNGs are often not a standalone statistical category. Therefore, the report uses country-relevant proxies where needed (e.g., extensively managed grasslands or permanent grasslands), and explicitly notes these proxies to avoid false precision. For comparability, the editorial synthesis applies a minimum set of common indicators (area/share, spatial concentration, main types, trends/pressures, governance instruments, and available productivity/use indicators). Where data are not available or not reported consistently, this is stated as n/a.

B. Analysis of the Current Status and Management Systems of Grasslands in Partner Countries

Analysis of the Current Status and Management Systems of Grasslands in Austria

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I. INTRODUCTION

Permanent grassland covers about 1.32 million hectares and is Austria's most important agricultural land-use type by area, shaping mountainous regions and the Alpine cultural landscape. It is the main forage base for nearly half of all farms and is essential for sustainable milk and meat production. Depending on site conditions, management ranges from intensive meadows to very extensive alpine pastures. In addition to forage, grassland provides key ecosystem services such as erosion control, water protection, carbon sequestration, and biodiversity conservation, while also enhancing landscape aesthetics and tourism in Alpine regions. For agriculture, permanent grassland enables site-adapted use of low-yield soils, provides species-rich, fibre-rich roughage suited to young and dry livestock, supplies valuable minerals and trace elements from botanically diverse meadows, and allows manure to be used more efficiently on higher-yielding sites through graded management [1].

Semi-natural grasslands in Austria are increasingly threatened by both intensification in accessible areas and abandonment in remote regions. Intensive management reduces biodiversity, while abandonment—especially in the Alps—leads to shrub encroachment and loss of species-rich cultural landscapes. Climate change intensifies these pressures through warming, drought, and extreme events, altering species composition and favouring thermophilic and invasive species. As a result, valuable grasslands face growing risks from intensification, abandonment, land conversion, and soil sealing, with Alpine grasslands particularly vulnerable due to above-average warming [1].

Beyond environmental factors, social and economic pressures pose major challenges for future grassland management in Austria. Widespread uncertainty in farm succession and the predominance of small, part-time farms limit both generational continuity and the potential for income-stabilizing intensification.

Austrian grassland is a multifunctional production and cultural landscape, ranging from intensive forage systems in accessible regions to extensive, labour-intensive alpine pastures shaped by historical land use. While market-oriented farms rely on intensive dairy production and modern machinery, small farms often manage grassland extensively, and in some areas land abandonment leads to succession and reforestation.

II. GRASSLAND PRESENCE

Semi-natural grasslands are not a separate statistical category in Austria; they are best approximated by extensively managed grasslands with high species richness, low management intensity (max. two cuts per year), and high importance for biodiversity and ecosystem services [2]: a. Total area of permanent grassland (including leys): 1.32 million ha; b. Share of extensively managed grassland (including alpine forage areas and mountain hay meadows): 47%, corresponding to 0.62 million ha; c. Share of intensively managed grassland: 53%, corresponding to 0.70 million ha (see Figure 1).

Extensively used permanent grassland covers about 0.62 million hectares in Austria, roughly half of all grassland. These semi-natural systems are managed at low intensity, with little fertilisation, and support high biodiversity. Species-rich hay meadows, alpine pastures, wet and dry grasslands, and common pastures are among Austria's most valuable agricultural habitats, but many are declining. Intensification, nutrient inputs, drainage, and abandonment—often leading to reforestation—threaten their biodiversity, ecological functions, and cultural landscape value, despite some gains in carbon sequestration.

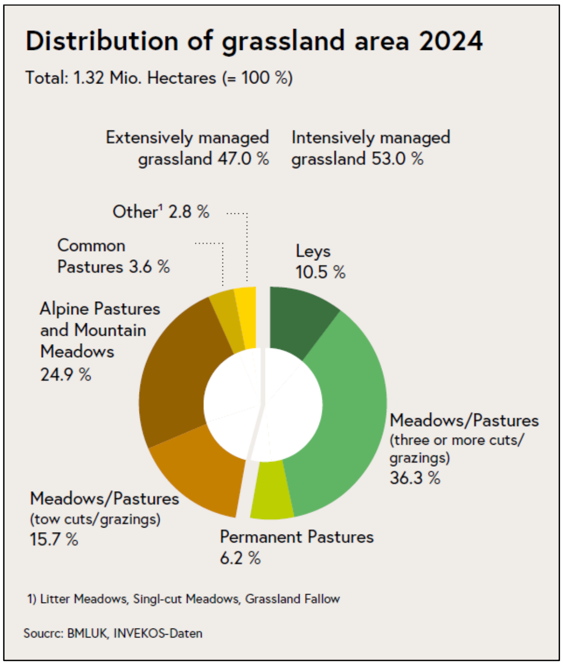

Figure 1. Distribution of grassland types [3].

- Spatial distribution – regions where SNGs are concentrated

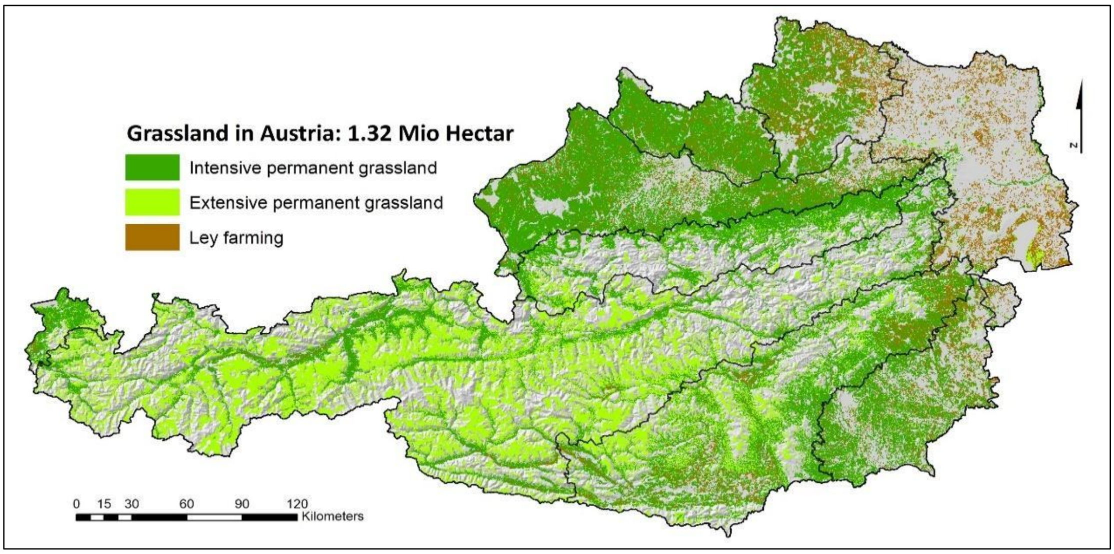

Figure 2. Spatial Distribution of grassland types in Austria. Source: Author's own elaboration

Semi-natural grasslands in Austria are concentrated mainly in the Alpine and pre-Alpine regions, with important areas in Styria, Salzburg, Tyrol, Carinthia, and Vorarlberg, especially in foothills and inner-Alpine valleys (see Figure 2). Significant but threatened remnants of species-rich meadows also persist in the eastern lowlands, particularly in the Pannonian region. Styria hosts Austria's largest semi-dry grassland networks, while Salzburg and Upper Austria have substantial areas of extensively managed grassland. In Lower Austria, permanent grassland is more limited but includes diverse meadow types across lowland and foothill regions [4].

Extensive grasslands are among Austria's most species-rich habitats, offering key refuges for many plant and animal species. Dry grasslands and extensively managed mountain and alpine meadows are especially diverse, with alpine grasslands in the Northern Limestone and Central Alps forming major biodiversity hotspots. Species richness is significantly higher in alpine and mountain grasslands than in intensively managed valley meadows and generally increases with elevation. Although overall diversity is high, it is mainly driven by common, site-typical species, while the share of Red List species is relatively low; grasslands with minimal human influence remain of exceptional conservation value [5].

Over recent decades, extensively managed grassland in Austria has declined sharply due to land abandonment and afforestation in marginal areas, as well as agricultural intensification. Permanent grassland decreased by more than 1 million hectares, with extensive grassland particularly affected (-882,722 ha); common pastures and single-cut meadows declined by 82% and 90%, respectively (see Table 1). In mountain regions, farm abandonment driven by low income prospects and a lack of successors is the main cause, whereas in more favourable areas intensification and conversion to energy crops prevail. These developments have led to substantial biodiversity losses and increasing shrub encroachment [6].

Table 1. Austrian grasslands over the last seven decades [3]

Land use categories (hectares)	1960	1970	1980	1990	1999	2010	2020
Utilised Agricultural area (UAA)	4,051,911	3,696,453	3,509,987	3,521,570	3,389,905	2,879,895	2,602,666
Forest area	3,141,725	3,060,990	3,036,258	3,239,435	3,260,301	3,405,750	3,413,606
Other land	1,111,929	969,936	1,104,714	793,811	868,409	1,061,891	924,622
Total area	**8,305,565**	**7,727,379**	**7,650,959**	**7,554,815**	**7,518,615**	**7,347,536**	**6,940,893**
Permanent Grassland	**2,297,898**	**2,097,178**	**1,949,089**	**2,017,282**	**1,916,792**	**1,440,582**	**1,209,980**
Intensively managed grassland	**780,657**	**863,655**	**862,741**	**877,024**	**909,754**	**569,902**	**575,460**
Multi-cut meadows	726,504	818,920	823,271	839,757	835,907	499,360	496,404
Intensively managed pastures	54,153	44,735	39,470	37,267	73,847	70,542	79,056
Extensively managed grassland	**1,517,241**	**1,233,523**	**1,086,348**	**1,140,258**	**1,007,038**	**870,680**	**634,519**
Alpine pastures and mountain meadows [1]	921,004	848,249	764,445	889,609	833,393	468,051	326,280
Common pastures	289,809	187,220	140,148	112,945	103,105	72,220	53,171
Single cut meadows	282,186	171,558	121,359	92,848	53,429	35,919	27,600
Pastures/meadows with two types of use [2]						281,509	214,161
Litter meadow	24,242	26,496	16,003	10,381	17,111	9,483	5,010
GAEC grassland area [3]						4,284	4,284
Grassland no longer in use [4]			44,393	34,474	39,777	109,338	204,795

[1] The decline in alpine pasture area after 2010 is due to a change in the recording methodology for alpine forage areas.

[2] In the 2010 Agricultural Structure Survey, mown pastures/meadows with two uses and those with three or more uses are reported separately and, in accordance with EU regulations, assigned to extensively managed grassland.

[3] Permanent grasslands taken out of production while complying with the minimum requirements of Good Agricultural and Environmental Condition (GAEC).

[4] Grassland no longer in use has not been included in utilised agricultural area (UAA) since 1995 due to an EU methodological change. Data for 1960 and 1970 are not available; for 1980, grassland from notional shares is included.

III. LEGAL STATUS

In Austria, there is no uniform environmental law category for semi-natural grassland; depending on the context, such areas are classified as permanent or extensive grassland, species-rich (unimproved) meadows, or under other conservation categories.

In Austria, nature conservation falls under the responsibility of the nine federal states, leading to differing grassland regulations within provincial nature conservation laws. Protection is ensured through instruments such as provincial nature conservation acts and species protection ordinances, with EU directives integrated into provincial legislation following Austria’s EU accession. Semi-natural grassland (SNG) is generally not designated as a separate category but is protected via specific habitat types (e.g. species-rich, wet, or dry meadows) or through biotope catalogues.

Nature and landscape conservation aim to protect biodiversity, landscapes, and abiotic resources such as soil and water, while promoting their sustainable use as essential foundations of life. This is implemented through protected areas, targeted management measures, and public awareness activities that also enhance public health and quality of life. In Austria, protected areas cover about 29% of the national territory, with strong regional variation and the highest share in Styria (around 45%).

Austria has six national parks (IUCN Category II) covering 2,382 km², with Hohe Tauern National Park being the largest. Natura 2000 sites, designated under the EU Habitats and Birds Directives, cover more than 15% of the country and are present in all federal states, with the highest shares in Burgenland and Lower Austria.

In addition, federally regulated nature conservation areas protect rare species and characteristic landscapes, while landscape protection areas preserve the visual and ecological character of regions important for recreation and tourism. Forty-seven nature parks across Austria (except Vienna) combine conservation with education, regional development, and recreation, complemented by smaller protected landscape features that safeguard specific local sites [7].

Austria has four biosphere reserves (Vienna Woods, Großes Walsertal, Salzburg Lungau & Carinthian Nockberge, and Lower Mur Valley), structured into core, buffer/management, and development zones. They aim to conserve biodiversity and cultural diversity while promoting sustainable development, education, and research. [8].

Austrian protected areas are closely linked to EU policies, particularly the Natura 2000 network established under the Birds and Habitats Directives. Around 15% of Austria's territory is designated as Natura 2000 sites, often overlapping with national parks and nature conservation areas. Their management is strongly influenced by the Common Agricultural

Policy (CAP), which connects agricultural practices with biodiversity conservation. Within the CAP Strategic Plan 2023–2027, the Austrian Programme for Environmentally Friendly Agriculture (ÖPUL) supports farmers through targeted agri-environmental measures and conditionality requirements to help achieve Natura 2000 objectives [8]. The Natura 2000 network in Austria comprises 353 sites (as of 2024/2025) and protects rare habitats, such as dry grasslands and peatlands, as well as threatened species. Many of these sites are shaped by agricultural land use, particularly bird protection areas, making farming practices crucial for their conservation status. Through ÖPUL, farmers receive financial incentives for biodiversity-friendly management, including extensive use, hedge maintenance, and wet meadow preservation, while compliance with environmental standards (GAEC) and voluntary agri-environment-climate measures further support Natura 2000 goals [9].

The Federal Ministry of Agriculture and Forestry, Climate and Environmental Protection, Regions and Water Management is responsible for setting the policy framework, implementing the Common Agricultural Policy (CAP), and fulfilling international nature conservation obligations. The designation, management, monitoring, and enforcement of protected areas, including Natura 2000 sites, are mainly handled by the nature conservation departments of the federal states, with support from national park administrations, regional mapping authorities, and sometimes NGOs.

A defining feature is the differentiated system of protected area categories established under provincial nature conservation laws. Protected areas are designated by ordinances with specific protection rules and include both nationally uniform categories (e.g. nature conservation and landscape protection areas) and regional categories such as nature parks and protected landscape features. While agricultural and forestry use is often allowed, these areas enable targeted ecological management and sustainable land use [7].

ÖPUL 2023 is part of the CAP Strategic Plan 2023–2027 and is financed by the EAGF and EAFRD. It implements EU requirements on eco-schemes, agri-environment and climate measures, animal welfare, Natura 2000 and the Water Framework Directive, compensating farms for voluntary services beyond legal standards. Active since 1 January 2023, the programme includes 26 measures across all nine federal states with an annual budget of EUR 614 million, of which EUR 100 million is allocated to eco-schemes. Funding comes from the EU as well as federal and provincial authorities, while eco-schemes are fully EU-funded. Participation is voluntary and open to all agricultural holdings, aiming at broad ecological improvements across arable land, grassland and permanent crops, covering over 80% of Austria's agricultural area [10].

During the AMA main payment in December 2024, Austrian farmers received a total of EUR 1.386 billion, including EUR 573.1 million in direct payments, EUR 406.2 million under the agri-environment programme ÖPUL, and EUR 217.9 million in compensatory allowance payments. Further funding comprised reimbursements for CO_2 pricing and the soil cultivation levy (EUR 130.5 million), emergency aid for frost damage in the fruit and wine sectors (EUR 10 million), project-based payments (EUR 43.2 million), and smaller amounts from instruments such as the Forest Fund, sugar beet support, the Common Market Organisation for Wine, and the EMFAF. Under the Austrian CAP Strategic Plan, support schemes include agri-environment and climate measures and eco-schemes promoting extensive grassland management, biodiversity, and reduced inputs, complemented by provincial project-based nature conservation schemes and EU programmes such as LIFE and Interreg that compensate farmers for specific management requirements on high-value grassland and pasture areas.

Austria's agricultural sector faces major challenges, including volatile markets, increasing bureaucracy, declining consumer willingness to pay, and climate change. In response, the Austrian Minister of Agriculture launched VISION 2028+ to provide clear agri-policy direction. The initiative aims to strengthen farm entrepreneurship, high-quality production, climate and environmental protection, value creation at farm level, resilient rural areas, and the use of digitalisation, research, and innovation, while improving dialogue with society. Farmers see excessive regulation, market uncertainty, climate impacts, high workloads, and limited planning certainty as key obstacles, as policy and framework conditions change faster than the capital-intensive agricultural sector can adapt [11].

The key policy gaps and challenges with specific regard to grassland systems and semi-natural grasslands (SNG) are:

- Intensification vs. biodiversity conservation: Productive grassland regions face ongoing intensification (higher stocking rates, earlier and more frequent mowing, increased input use), which threatens species-rich semi-natural grasslands. Current support schemes often struggle to sufficiently reward low-intensity management that maintains biodiversity and ecosystem services.
- Abandonment in marginal and alpine areas: In mountain and structurally weak regions, low profitability and high labour requirements lead to land abandonment, shrub encroachment, and loss of open landscapes. Existing compensation mechanisms (e.g. ANC payments, agri-environmental schemes) do not always fully offset natural handicaps and rising production costs.
- Regional disparities between federal states: Grassland systems differ significantly between western alpine regions and eastern lowland areas. Uniform policy instruments sometimes fail to adequately reflect these structural, climatic, and socio-economic differences, leading to uneven uptake and effectiveness of measures.
- Economic viability of extensive systems: Extensive grassland-based livestock farming delivers high public goods (carbon storage, water regulation, biodiversity), yet farm incomes remain highly dependent on direct payments. Limited market premiums for grassland-based and biodiversity-friendly products weaken long-term economic sustainability.

IV. PRODUCTIVITY

Around 2.4 million hectares of Austria's agricultural land are managed as grassland, producing about 6–7 million tonnes of dry biomass annually and providing the feed base for roughly 2.5 million animals. Grassland dominates farm structures, with 69% of grassland farms having more than 60% grassland, while a further 14% have 30–60%. In addition, 17% of arable farms also manage grassland, and around 10% of grassland farms operate under organic farming principles [12]. Productive grassland comprises intensively managed multi-cut meadows and improved pastures, mainly used in dairy systems with frequent cutting, slurry application, and high feed quality. In contrast, extensive grassland—including single-cut and mountain hay meadows, alpine pastures, and rough grazing—is managed at low intensity and primarily supports site-adapted forage production, biodiversity conservation, and landscape management. Alpine pasture farming uses high-altitude areas for seasonal grazing (2.5–3.5 months) and fulfils ecological, touristic, and cultural functions beyond forage supply [13].

Extensive continuous grazing involves long grazing periods with little paddock division and low management effort. A key challenge is adjusting stocking density, which is typically around 1 livestock unit per hectare. Undergrazing leads to uneven swards, forage losses, reduced species diversity, and the spread of undesirable or toxic plant species, requiring targeted pasture maintenance. Extensive pastures have low yield potential and are therefore best suited for dry cows, young stock, heifers, and extensively managed suckler cows.

In Austria, grassland management intensity varies greatly by region, ranging from two to three cuts per year in mountain areas to five to six cuts in highly productive lowland and valley regions. Although productive grassland accounts for only about 55% of the forage area, it provides roughly 75% of the annual feed for ruminant livestock. Extensive grassland types—such as single-cut meadows, traditional orchard meadows, and alpine pastures—cover large areas but contribute less than 10% to total forage production. Alpine pastures comprise around 830,000 ha and face increasing scrub encroachment, while about 40,000 ha of lowland grassland is no longer managed. Without continued extensive management, this ecologically valuable grassland is at risk of long-term loss [12].

Grassland forage quality varies strongly with management intensity, ranging from high-energy feed to more structural, lower-performing roughage. Forage quality and animal productivity are mainly influenced by nutrient supply, cutting regime, and careful harvesting, conservation and storage. In the context of climate change, resource scarcity and rising costs, grasslands are gaining importance not only for high-quality forage production but also for recreation and habitat provision. Early cutting in intensively managed grassland yields highly digestible, energy- and protein-rich forage that supports high animal performance, while later cutting increases fibre content and reduces energy and protein, resulting in lower productivity. High-quality forage also provides valuable nutrients such as omega-3 fatty acids, vitamins and minerals, improving milk and meat quality. In contrast, poor harvesting or conservation reduces hygienic quality, causes feed losses and may impair animal health; late-cut forage can still be used as structural feed but is less suitable for high performance [14].

Both land abandonment and management intensification reduce agricultural biodiversity, highlighting the need for a balanced approach between production and conservation. Grassland biodiversity is strongly influenced by site conditions and especially by management practices such as mowing and grazing. Site-adapted, low-intensity management—including traditional alpine pasture use, biodiversity areas, uncut strips, delayed mowing, and appropriate nutrient management—is crucial for maintaining species-rich habitats. Landscape elements and edge structures further enhance habitats for plants and animals. ÖPUL supports grassland biodiversity through targeted payments, particularly for biodiversity areas, delayed mowing, reduced fertilisation, and the preservation of landscape elements [15].

Benefits for biodiversity: Grassland provides important habitats and breeding sites for many species, including insects, birds, bats, and amphibians. Extensive management, such as delayed cutting, supports reproduction, plant regeneration, and a stable food supply across the food web. Benefits for agriculture: Grassland allows site-adapted use of low-yield soils and supplies species- and fibre-rich forage suited to young and non-lactating livestock. Botanically diverse swards enhance mineral supply and feed intake, while targeted management improves manure use on productive sites.

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Analysis of the Current Status and Management Systems of Grasslands in Poland

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I. INTRODUCTION

Permanent grasslands (PG) are a vital component of agricultural land (UAA), providing both productive and environmental functions [1,2]. Their biomass is mainly used as feed for ruminants, especially cattle, but also for energy purposes [3]. PG play a key role in biodiversity conservation, soil and water protection, and carbon sequestration [4,5]. The main threats in Poland include conversion to arable land, rural urbanisation, and changes in land use [4]. Climate change, particularly longer and more frequent droughts, also reduces their sustainability. Traditionally, meadows and pastures were managed extensively through mowing and grazing, supporting habitat stability in river valleys, wetlands, and mountains. Today, both intensive and extensive management coexist, with extensive grasslands mainly serving environmental and landscape functions under the influence of the Common Agricultural Policy (CAP).

II. GRASSLAND PRESENCE

In Poland, PG cover over 2.61 million hectares, representing roughly 20% of total UAA, including 2.29 million hectares of meadows and 0.32 million hectares of pastures [6]. Most PG are semi-natural systems shaped and maintained over many years through extensive management, primarily via mowing and grazing.

The typological classification constitutes the principal system, as it takes into account habitat conditions and the key environmental factors shaping meadow communities [7]. Within this approach, the term "meadows" encompasses all grasslands, irrespective of whether they are used for mowing, grazing, or a combination of both. Depending on water regime and soil conditions, four main types are distinguished: flooded, dry, post-peatland, and peatland meadows (Table 1).

Table 1. Possible uses of different types of meadow habitats in Poland [8]

<table>
<tr><td colspan="2" rowspan="3">Type of PG</td><td colspan="4">Ways of use</td></tr>
<tr><td colspan="2">number of cuts per meadow</td><td colspan="2">number of sward regrowths on pasture</td></tr>
<tr><td>natural</td><td>current</td><td>natural</td><td>current</td></tr>
<tr><td rowspan="4">Flooded meadows</td><td>dried</td><td>2</td><td>3</td><td>3</td><td>5-6</td></tr>
<tr><td>proper</td><td>2</td><td>3</td><td>–</td><td>–</td></tr>
<tr><td>with flowing water</td><td colspan="4">nature-use areas</td></tr>
<tr><td>with stagnant water</td><td colspan="4">nature-use areas</td></tr>
<tr><td rowspan="4">Dry meadows</td><td>impoverished</td><td>1</td><td>1-2</td><td>2</td><td>3</td></tr>
<tr><td>proper</td><td>2</td><td>3</td><td>3</td><td>5</td></tr>
<tr><td>post-flooded</td><td>2</td><td>2</td><td>3</td><td>5</td></tr>
<tr><td>waterlogged</td><td>2</td><td>2</td><td>–</td><td>–</td></tr>
<tr><td rowspan="4">Post-peatland meadows</td><td>drying moorshed meadows</td><td>1</td><td>2-3</td><td>2-3</td><td>3-4</td></tr>
<tr><td>degraded</td><td>1</td><td>2</td><td>2-3</td><td>3-4</td></tr>
<tr><td>proper moorshed meadows</td><td>2</td><td>3</td><td>3</td><td>5</td></tr>
<tr><td>re-flooded moorshed meadows</td><td>2</td><td>3</td><td>–</td><td>–</td></tr>
<tr><td rowspan="4">Peatland meadows</td><td>inundated fens</td><td colspan="4">nature-use areas</td></tr>
<tr><td>bogs</td><td colspan="4">nature-use areas</td></tr>
<tr><td>proper</td><td colspan="4">nature-use areas</td></tr>
<tr><td>flooded</td><td colspan="4">nature-use areas</td></tr>
</table>

Explanations: "–" – impossible for grazing

The phytosociological classification is based on plant community composition and follows the Braun–Blanquet methodology [7]. The basic unit is the plant community, identified by characteristic and diagnostic species and grouped into higher syntaxonomic units (associations, alliances, orders, classes). The most important meadow communities belong to the class *Molinio-Arrhenatheretea*, comprising semi-natural hay and pasture meadows. Fresh meadows are associated with *Arrhenatherion elatioris*, while wet and semi-wet meadows belong to *Molinion caeruleae*. In mountain areas, communities of *Polygono-Trisetion* are characteristic. More intensively used grasslands are classified within *Cynosurion*, whereas wet and floodplain communities are represented by the classes *Phragmitetea* and *Scheuchzerio-Caricetea nigrae*. This classification supports habitat assessment, grassland management planning, and the identification of conservation-priority habitats, including those within the Natura 2000 network.

The functional (utilitarian) classification refers to the agricultural use and management of PG. Grasslands are categorized according to their primary mode of use and management intensity. Three main types are distinguished: hay meadows (mown for forage), pastures (grazed by livestock), and mixed hay–pasture systems.

The distribution of PG in Poland is uneven and strongly influenced by habitat conditions, particularly water availability. Their occurrence depends more on persistent high groundwater than on total precipitation. The most favourable conditions are in river valleys, where elevated groundwater and periodic flooding supply nutrients. In lowland Poland, PG are concentrated in river and glacial valleys, forming extensive meadow and pasture complexes. In mountainous regions, they occupy a relatively large share of agricultural land despite the absence of wide valleys, as higher rainfall, lower temperatures, and terrain constraints limit intensive cropping and favour grass and meadow vegetation.

The highest proportions occur in north-eastern Poland and foothill and mountain regions. In south-eastern Poland, they account for 38–41% of UAA, reflecting hilly terrain, cooler climate, and limited suitability for cropping. In north-eastern regions, grasslands cover about 33–37% due to wetlands and hydrogenic soils, favouring cattle breeding, particularly dairy production. In central and north-western Poland, grasslands make up 20–25% of UAA, while in western regions their share falls below 20% due to fertile soils. The lowest shares, below 10%, are in Kujawy and Opole, where mechanised arable farming predominates (Fig. 1).

PG are mainly meadows for hay production, covering around 2.26 million hectares (over 87%), with highest concentrations in southern and north-eastern Poland. Pastures are less common, covering about 2.8% of UAA, with the largest share (nearly 10%) in north-eastern Poland and generally below 3–4% elsewhere.

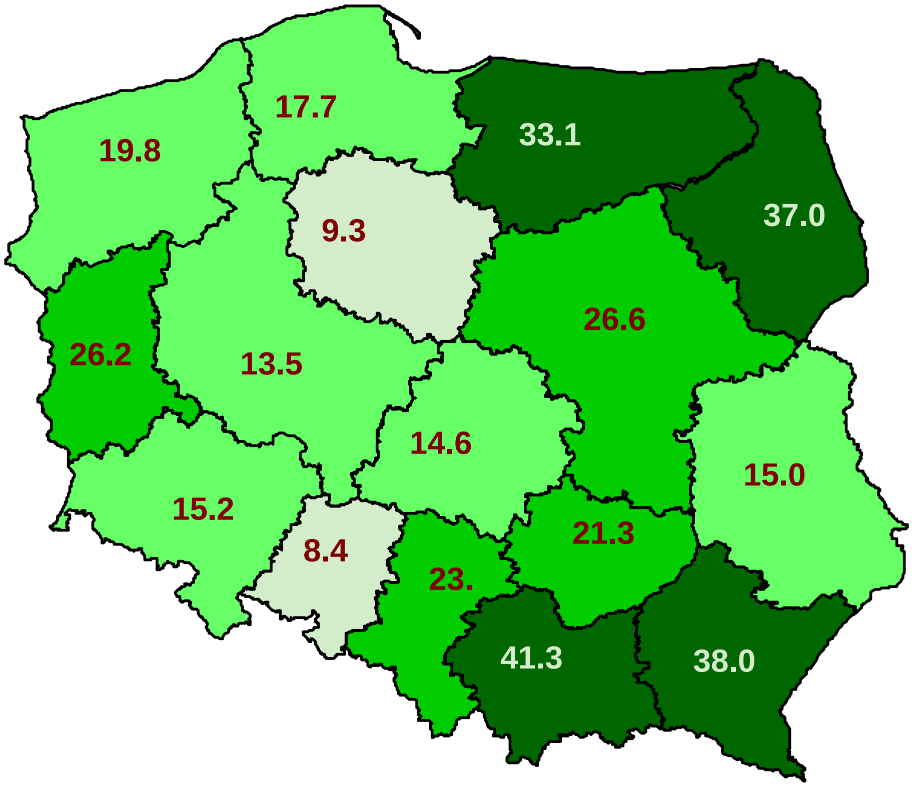

Figure 1. Share of PG in UAA (%) by province, 2023 [6]

In recent decades, the area of PG decreased from 3.85 million ha in 2000 to 2.61 million ha in 2024 (-32%). Meadows declined slightly from 2.52 to 2.29 million ha (-9%), while pastures dropped sharply from 1.33 million ha (7.7% of UAA) to 0.32 million ha (2.3%), a reduction of 76% (Table 2). Thus, the overall loss occurred mainly at the expense of pastures. Contributing factors include statistics covering only pastures in good agricultural condition and the concentration of cattle production in year-round TMR systems based on preserved roughage, particularly maize silage [9]. As a result, grazing has declined and distant pastures are often converted into hay meadows.

Table 2. Changes in PG area and share in UAA in Poland (2010–2023) [10]

Year	Area (thousand ha)			Share in UAA (%)		
	PG	Meadows	Pastures	PG	Meadows	Pastures
2010	3,229	2,578	651	21.8	17.4	4.4
2015	3,093	2,658	435	21.3	18.3	3.0
2018	3,149	2,754	395	21.5	18.8	2.7
2019	3,128	2,764	364	21.3	18.8	2.5
2020	3,203	2,788	415	21.4	18.6	2.8
2023	3,014	2,670	344	20.4	18.1	2.3

Semi-natural meadow communities

Fresh meadows. Species-rich fresh meadows occur in lowland and lower montane areas. Two main types are distinguished: lowland fresh hay meadows (*Arrhenatherion elatioris*, Natura 2000 habitat 6510) and mountain fresh hay meadows (*Polygono-Trisetion*, habitat 6520). Pasture communities of the *Cynosurion* alliance are also included. Fresh meadows dominate in lower mountain regions, whereas their extent in lowlands has declined due to conversion to high-yield grasslands or arable land. They typically develop on mineral, non-flooded soils, on flat or sloping terrain, combining high biodiversity with moderate productivity. These meadows support rare and protected species. The main threats include management intensification (often involving reseeding), conversion to arable land, and abandonment of mowing, which promotes encroachment by competitive species [11].

Wet meadows. Wet meadows of the *Calthion palustris* alliance (marsh-marigold meadows) occur throughout Poland in waterlogged depressions, river valleys, floodplains, and partially drained fens. They develop in habitats with high groundwater tables, especially in spring and autumn. Extensively managed and relatively productive, these meadows are floristically diverse and provide important habitats for wetland plants and insects, including butterflies. Their conservation status is generally favourable in mountain areas but unfavourable in lowlands. Major threats include drainage leading to habitat desiccation, expansion of undesirable species, and abandonment or insufficient mowing, resulting in overgrowth and vegetation changes [11].

Intermittently wet meadows. These include Molinia meadows (habitat 6410) and *Cnidion dubii* meadows (habitat 6440), which differ in water regime and substrate. Molinia meadows are widespread in lowlands and occur in habitats with strong seasonal groundwater fluctuations, typically on nutrient-poor mineral or organic soils. They are highly valuable and species-rich. *Cnidion dubii* meadows occur mainly in large river valleys and floodplain depressions on fertile soils enriched by river alluvia. Forage quality is low, although hay has moderate value. Their conservation status is generally unfavourable due to abandonment, expansion of competitive species, management intensification, and river regulation or embankment construction that disrupt natural flooding [11].

Grasslands are non-forest plant communities dominated by low grasses and dicotyledons. Typically low and dense, they are shaped by harsh habitat conditions and extensive management, particularly grazing. Most are semi-natural and require continued human use, such as grazing or mowing, to persist. Many of these grasslands harbour rare and protected plant species, particularly in mountain regions of Poland [12].

Grasslands include several groups of plant communities. On mineral substrates, these comprise primary and secondary grasslands such as Euro-Siberian calamine grasslands (*Violetea calaminariae*), sand grasslands (*Koelerio glaucae–Corynephoretea canescentis*), and sward communities (*Polygonion avicularis*). Other important types include floodplain grasslands (*Agropyron–Rumicion crispi*), high-mountain calcareous grasslands (*Seslerietea variae*), and xerothermic grasslands (*Festuco–Brometea*). Semi-natural and anthropogenic mat-grass communities dominated by *Nardus stricta* and heathlands belong to *Nardo–Callunetea*, while thermophilous edge communities are classified within *Trifolio–Geranietea sanguinei*. Due to their high biodiversity and risk of decline, many grasslands are protected under Natura 2000 and supported by agri-environment-climate schemes. The most valuable habitats include xerothermic grasslands (6210), xeric sand calcareous grasslands (6120), inland dunes with open *Corynephorus* and *Agrostis* grasslands (2330), species-rich *Nardus stricta* grasslands (6230), European dry heaths (4030), and juniper scrub on heaths or calcareous grasslands (*Juniperus communis* formations; 5130). These habitats are threatened by abandonment, intensification (fertilisation, excessive grazing), scrub encroachment or afforestation. They require extensive use [11].

Overall, the condition of grassland habitats in Poland is unsatisfactory. Only a portion of properly managed sites retains favourable ecological parameters. Extensive grazing is crucial to maintain their natural values, while mowing can limit succession but may also alter vegetation structure.

III. LEGAL STATUS

In Polish law, PG are classified as a type of UAA. They include areas with grasses or other herbaceous forage crops not included in crop rotation for at least five years (from March 2026 to seven years). The definition covers both self-sown and sown vegetation and allows shrubs or trees if grasses remain dominant. It is consistent with EU and CAP regulations. In practice, PG are often part of semi-natural grasslands (SNGs) and may include, among others:

– Lowland and mountain meadows (*Arrhenatherion elatioris*) – extensively used; Natura 2000 habitat code 6510.

– Xerothermic grasslands – habitat code 6210; require extensive grazing or mowing later in the growing season.

– Molinia meadows on calcareous, peaty or clayey-silt soils (*Molinion caeruleae*) – habitat code 6410; particularly sensitive to intensification of use.

In Polish law, PG are not a separate protection category but are often included in various forms of nature protection, which impose additional restrictions that indirectly safeguard these areas. Key national forms of protection:

- National parks – Protect entire ecosystems, including meadows and pastures; grazing and mowing allowed only for conservation, often with traditional sheep or goat grazing.

- Nature reserves – Cover valuable habitats (xerothermic grasslands, Molinia meadows, peat bogs); management only for conservation (late mowing, extensive grazing).
- Landscape parks – Permit agricultural use under sustainable practices; conversion to arable land or buildings generally prohibited unless specified in the conservation plan.
- Protected landscape areas – Restrict intensive development, drainage, and habitat destruction; extensive PG are key landscape elements.
- Ecological land – Small, scattered fragments of meadows, peat bogs, wet pastures, and grasslands, supporting biodiversity.
- Nature and landscape complexes – Protect whole spatial systems, including permanent grasslands.

PG in Poland are closely linked to EU policy, which shapes their protection and management.

Natura 2000 – protection of semi-natural habitats Natura 2000 safeguards the most valuable PG habitats, including:

6510 – lowland and mountain extensively used meadows

6210 – xerothermic grasslands

6410 – Molinia meadows

6230 – species-rich Nardus grasslands

Management requires extensive practices, such as mowing, grazing, and preventing overgrowth.

CAP subsidies and protection mechanisms EU measures support PG through:

Conversion ban – Valuable PG, including those in Natura 2000, cannot be ploughed or converted without consent.

Cross-compliance (GAEC) – Key standards:

GAEC 1 – protection of permanent grasslands nationally

GAEC 2 – protection of wetlands and peatlands

GAEC 6 – maintenance of plant cover

GAEC 8 – landscape features supporting biodiversity

Ecoschemes (from 2023) – Measures include water retention on UAA, extensive meadow and pasture use, protection of high-natural-value UAA, and diversified crop structure [13].

Agri-environment-climate (AEC) measures – Options for extensive meadows and pastures, protection of specific habitats (moor grass, salt meadows), and conservation of farmland birds.

Key institutions responsible for the management, monitoring, and enforcement of GAEC regulations in Poland include:

- Ministry of Agriculture and Rural Development – oversees national agricultural policy, implements the CAP, and enforces GAEC rules, including eco-schemes and interventions.
- Agency for Restructuring and Modernisation of Agriculture – monitors compliance with subsidy rules and cross-compliance, including restrictions on converting GAEC land.
- General and Regional Directorates for Environmental Protection – supervise Natura 2000 sites, reserves, and protected landscapes; approve conservation plans and control activities affecting meadow and pasture habitats.
- National Park Directorates – manage meadows, pastures, and grasslands within park areas, often using mowing and traditional grazing for habitat conservation.

IV. PRODUCTIVITY

PG can be used as hay meadows or pastures, with utilisation intensity depending on habitat conditions, fertilisation, and fodder purpose. Meadows are generally classified as intensive, semi-intensive, or extensive [14,15].

- Intensive meadows – Fertile, well-moistened sites; high mineral fertilisation (180–200 kg N, 40 kg P, 100 kg K/ha/year); 3–4 cuts per season (May, June/early July, August, optionally October). Mainly used for hay and silage. Swards often renovated by overseeding or full reseeding to ensure high yield and quality.
- Semi-intensive meadows – Most common; moderate fertilisation (80–100 kg N, 30 kg P, 80 kg K/ha/year); 2–3 cuts per season, sometimes supplemented by grazing. First cut late May–early June, second in July, occasional third in September. Produces good-quality hay and silage.
- Extensive meadows – Low or no fertilisation (40–50 kg N·ha^{-1} for first cut only, no P or K); usually 2 cuts per season combined with 1–2 grazing rotations. First cut late (late June–July); fodder of lower nutritional value; sward renovation not practised.

Livestock grazing typically lasts 130–180 days/year (up to 230 days for beef cattle), starting in early May when grass reaches 10–12 cm. Dairy cattle are most common. Grazing systems vary with farm type and intensity and include rotational (paddocks) and continuous grazing. Typical characteristics by intensity:

Intensive: 5–7 rotations per season; dosed grazing; ~180 kg N·ha^{-1}.

Semi-intensive: 4–5 rotations; paddock grazing, rationed or tethered; ~120 kg N·ha^{-1}.

Low-intensity: 2–3 rotations; tethered or guarded; ~60 kg N·ha^{-1}.

Extensive: free grazing without fertilisation.

On intensive farms, grazing is limited to a few hours/day with barn feeding. On extensive farms, particularly in north-eastern, foothill, or crop-unsuitable areas, cattle may graze all day.

In Poland, PG are the main source of feed for herbivorous livestock, primarily cattle and sheep. In 2024, the cattle population ranged from 5.5 to 6.5 million, including about 2.1 million dairy cows, while sheep numbered 220,000–290,000 (Table 3).

Table 3. Livestock population in Poland (thousands of heads) [6,16]

Year	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cattle	5,562	5,763	5,970	6,036	6,183	6,262	6,279	6,379	6,448	6,268	6,191
including dairy cows	2,636	2,303	2,304	2,341	2,417	2,406	2,391	2,289	2,172	2,396	2,101
Sheep	-	221	244	269	267	268	278	288	266	271	270

Stocking density is a key aspect of PG management. In 2023, cattle density averaged 208 animals per 100 ha, including 79.5 dairy cows, while sheep density was about 9 animals per 100 ha (Table 4). Although fewer in number, sheep play an important role in semi-intensive and extensive meadows by controlling dominant species and supporting biodiversity.

Table 4. Livestock density on PG in Poland (physical numbers per 100 ha) [10]

Year	2010	2015	2018	2019	2020	2023
Cattle	172	186	196	200	196	208
including dairy cows	81.6	74.5	76.8	76.9	74.6	79.5
Sheep	-	7.15	8.48	8.57	8.68	8.99

PG productivity in Poland is influenced by weather (especially precipitation), utilisation intensity (particularly nitrogen fertilisation), and the habitat's inherent production potential [18-20]. Productivity also depends on sward composition, with species-rich meadows containing high-yielding grasses and legumes providing greater feed value and higher yields [21,22]. Well-moistened, fertile meadows with appropriate fertilisation and management can reach yields of 8–10 t DM·ha^{-1} per year. Currently, only about 60% of the production potential of PG in Poland is utilised.

Table 5. Hay and green fodder yields from PG in Poland (t·ha^{-1}), 2015–2024 [22]

Year	Hay yield (t·ha^{-1})				Green fodder yield from pastures (t·ha^{-1})
	1st cut	2nd cut	3rd cut	Total	
2015	2,5	1,14	0,54	4,19	14,6
2016	2,51	1,84	0,89	5,24	18,3
2017	2,56	1,91	0,95	5,42	18,3
2018	2,44	1,41	0,79	4,71	15,7
2019	2,45	1,25	0,76	4,46	16,0
2020	2,41	1,72	0,97	5,09	17,0

2021	2,83	1,95	1,12	5,91	18,1
2022	2,9	2,01	1,22	6,13	19,6
2023	2,8	1,91	1,17	5,88	19,6
2024	2,79	1,92	1,21	5,91	19,4

Note: Original data were reported in dt/ha and converted to t/ha for international readability. 1 dt/ha = 0.1 t/ha.

Average annual yields over the past 10 years ranged from about 42 to more than 60 dt·ha^{-1} (Table 5). The first cut contributes the largest share (25–29 dt·ha^{-1}), while the second cut is lower and the third cut, although the smallest, still contributes to the total yield. Biomass from PG in Poland is used mainly for hay (≈50%) and silage (≈23%), with the remainder used as fresh fodder or for grazing. Only a small fraction, mainly from the third cut, remains unharvested. Green fodder yields from pastures ranged from 146 to 196 dt·ha^{-1} (Table 5).

Traditional management practices play a key role in maintaining biodiversity in permanent grasslands (PG). One of the most important measures is extensive mowing, which is essential for the conservation of semi-natural meadows because it affects light availability, nutrient cycling, plant growth, and the occurrence of rare species [23]. The timing and frequency of mowing strongly influence floristic diversity. Most meadows require at least one cut per year, while fertile or wet habitats may require a second cut to limit the development of undesirable or invasive plant species. The optimal mowing period is between June and August, preferably in late June or July. Appropriate cutting height is also important: in moor grass meadows it should be at least 10 cm, while in other meadow types it should not be lower than 5 cm; autumn mowing should be slightly higher (6–8 cm).

Equally important is the harvesting of biomass. Removing hay from the meadow enables seed dispersal, contributes to the replenishment of the soil seed bank, supports the regeneration of species-rich plant communities, and prevents habitat degradation. Sustainable grazing is another traditional practice supporting biodiversity in grasslands. Extensive grazing helps maintain sward structure, limits the encroachment of shrubs and trees, and promotes floristic diversity. Grazing intensity and timing should be adapted to habitat conditions, including soil type, water availability, vegetation composition, and local farming practices. Fertile mineral soils are generally suitable for regular grazing, whereas moist organic soils should be grazed only occasionally. In many cases, post-mowing grazing or periodic grazing can help maintain species-rich communities.

Moderate fertilisation may also play a role in maintaining the productivity and stability of grassland ecosystems. Nutrient supply (N, P, K) should be adjusted to habitat conditions and soil fertility. Both excessive fertilisation and complete omission can negatively affect plant diversity, particularly in ryegrass-dominated meadows. Over-fertilisation often leads to the dominance of a single grass species and the decline of dicotyledonous plants and legumes.-In contrast, fertilisation is generally not recommended for moor grass meadows or periodically flooded *Cnidion dubii* meadows.

Another important aspect of biodiversity protection is the control of invasive species. Alien plants such as *Heracleum sosnowskyi* and *Reynoutria* spp., as well as some expansive native species including *Urtica dioica*, *Rumex acetosa*, *Anthriscus sylvestris*, and tree or shrub seedlings, may spread rapidly when mowing or grazing intensity declines. Their expansion reduces plant diversity and may accelerate shrub and forest succession. Effective management therefore includes timely mowing, removal of biomass, controlled grazing, careful fertilisation, and, when necessary, mechanical removal or selective pruning of invasive plants.

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Analysis of the Current Status and Management Systems of Grasslands in Serbia

SMART STEP

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I. INTRODUCTION

Semi-natural grasslands (SNGs) are a strategically important component of Serbia's agricultural and natural landscapes, providing the main roughage base for extensive livestock systems while also supporting high-nature-value habitats. Meadows and pastures are among the country's floristically richest ecosystems and may exhibit exceptionally high local plant species richness [1, 2] . Key pressures include land-use intensification (higher inputs, reseeding and fertilisation), abandonment and successional overgrowth, overgrazing in locally vulnerable areas, and increasing climatic variability—especially drought—which jointly affect both biodiversity and forage productivity [3]. Current management is characterised by a mosaic of haymaking, grazing, and mixed mowing–grazing systems: mowing predominates in lowlands, freer grazing is more common in mountain regions, and mixed regimes prevail in hilly–mountain areas. Historically, traditional extensive management (low inputs, later mowing, moderate stocking rates) maintained diverse plant communities and landscape heterogeneity, but typically with lower and more variable biomass yields than intensified systems.

II. GRASSLAND PRESENCE

According to the 2023 Agricultural Census, meadows and pastures cover 469,228 ha, representing 14.5% of Serbia's utilised agricultural area. As shown in Table 1 and Figure 1, grasslands are concentrated primarily in Central (Šumadija) and Western Serbia, followed by South and Eastern Serbia, whereas the northern lowland regions contribute only a minor share. In addition, grasslands are managed by a large number of agricultural holdings, indicating a highly fragmented management context—particularly in the Belgrade region (~1.2 ha/holding), whereas Vojvodina shows a larger average grassland area per holding (~8.2 ha/holding).

Table 1. Regional distribution of meadows and pastures in Serbia: area (ha), and dominant grassland type [4].

Regions*	Area (ha)	Dominant grassland type**
North Serbia (Vojvodina)	40,248	Lowland
North-central Serbia (Belgrade region)	12,475	Mainly lowland (lowland–hilly transition)
Central (Šumadija) and Western Serbia	270,662	Mainly Hilly
South and Eastern Serbia	145,843	Mainly Mountain
Total in Serbia	469,228	

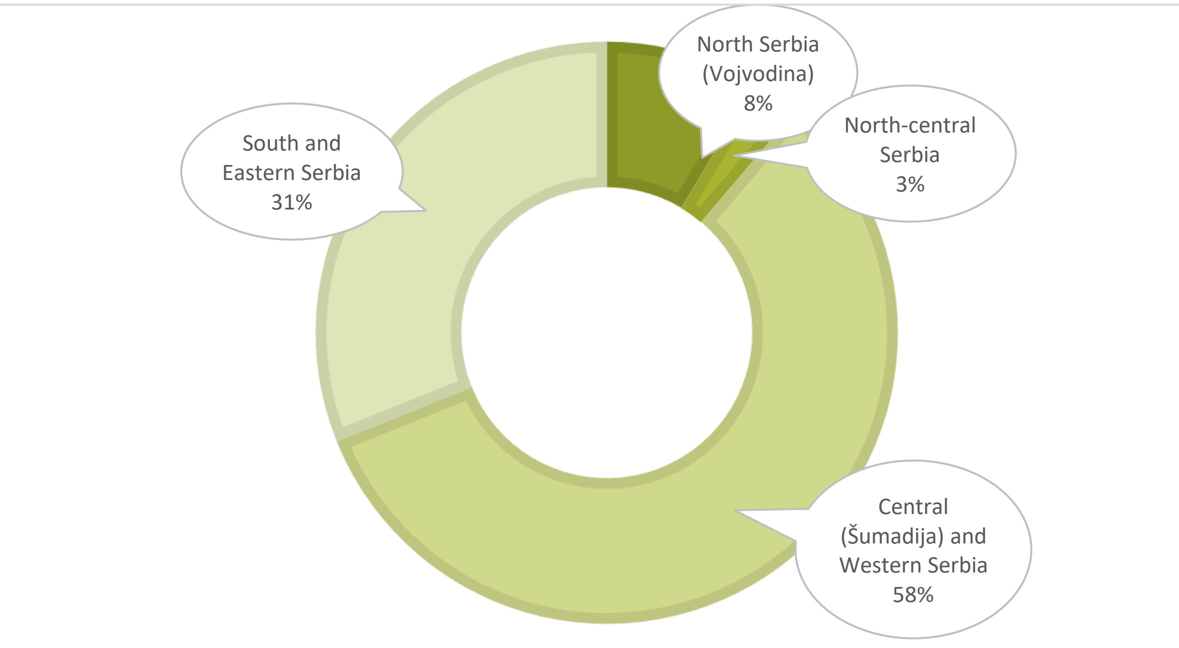

Figure 1. Regional distribution of SNGs area in Serbia (% of total) [4].

Semi-natural grasslands in Serbia include a wide range of meadow and dry grassland communities. In phytosociological terms, communities associated with classes such as *Molinio-Arrhenatheretea* (often linked to higher yields and feeding value) and *Festuco-Brometea* (frequently dry, species-rich grasslands) are reported across the country [5]. National meadow vegetation has been described through a large number of associations and subassociations, reflecting strong ecological and management gradients [6]. The types of grasslands and pastures across different regions of Serbia are shown in Table 2.

Table 2. Types of grasslands and pastures across different regions of Serbia [7].

Zone	Grassland/pasture types (associations)
Wetland zone	*Phalaridetum arundinaceae, Beckmannietum erucaeformis, Caricetum vulpinae-ripariae, Agrostidetum-Juncetum effusi, Molinietum coeruleae, Deschampsietum caespitosae*
Basin–lowland zone	*Cynosuretum cristati, Alopecuretum pratensis, Arrhenatheretum elatioris, Agrostidetum albae, Festucetum pratensis, Agrostidetum vulgare, Festucetum pseudovinae*
Hilly zone	*Agrostidetum vulgare, Agrostideto-Chrysopogonetum grilli, Chrysopogonetum grilli, Danthonietum calycinae, Festucetum vallesiacae, Brometum erecti*
Mountain zone	*Danthonietum calycinae, Agrostidetum vulgare, Festucetum sulcatae–Potentilla rectae, Festucetum rubra–fallax, Brometum erecti, Festucetum vallesiacae, Poetum violaceae, Festucetum spadiceae, Nardetum strictae, Festuco–Armerietum canescentis*

From a floristic perspective, grasses (*Poaceae*) represent a major component of Serbian grassland flora, with economically relevant genera including *Festuca, Lolium, Dactylis, Phleum, Bromus, Arrhenatherum, Poa* and *Agrostis* [8]. Legumes are present but often underrepresented in semi-natural swards, which has implications for both nitrogen dynamics and forage quality [9]. Several field-based assessments indicate that legume share is frequently below 10% in hay samples from different regions (e.g., Lučani municipality; Pešter highlands; Jadar–Azbukovica), while some species-rich meadows may still show functional imbalance (dominance of forbs and grasses with low legume contribution) [10, 11, 12, 13]. These patterns illustrate that high species richness does not necessarily translate into a functionally balanced sward structure from the perspective of forage production, and they provide an important context for interpreting productivity and forage quality outcomes.

Semi-natural grasslands in Serbia, especially those in hilly–mountainous zones, are described as the floristically richest vegetation units in the country. They include widely distributed communities that have been evaluated as highly diverse and as holding considerable stocks of medicinal and aromatic plants, while biodiversity patterns are strongly shaped by management intensity (overgrazing/fertilisation vs. abandonment) [1].

At the national scale, Serbia is recognised as a major centre of vegetation diversity in Europe, with 1,399 plant associations described and a highly diverse flora (3,272 species and 390 subspecies); medicinal and aromatic taxa are particularly well represented in meadow communities of the hilly–mountain belt, where they may account for up to 50% of the floristic spectrum (with more than 300 taxa recorded) [2].

Evidence of exceptionally high species richness is also documented at local scales in Serbian grasslands: in the Serbian Carpathians, the reported local species pools reach 187 and 158 vascular plant species (two sites), and a 100 m^2 plot recorded 120 vascular plant species, close to the upper values reported for Balkan grasslands; bryophyte and lichen richness is also notable (up to 29 bryophytes and 3 lichens at site level) [2].

Serbia hosts several local and steno-endemic vascular plants associated with open habitats (dry rocky grasslands and montane/subalpine meadows), although their direct linkage to semi-natural managed grasslands should be confirmed using floristic and Red List habitat descriptions. As an emblematic Balkan endemic, *Ramonda serbica* reflects the high conservation value of such habitat mosaics, but it is primarily confined to rocky canyon/cliff microhabitats. By contrast, endemics more closely tied to grassland-type habitats include *Seseli serbicum*, *Nepeta rtanjensis* (Figure 2), *Helleborus multifidus subsp. serbicus* (Figure 3) and *Paeonia officinalis subsp. banatica* (pending habitat-level verification).

Figure 2. *Nepeta rtanjensis* [14]

Figure 3. *Helleborus multifidus Vis. subsp. serbicus* [14]

Regarding trends in grassland extent over 2020–2024, the figure indicates an overall decline, driven mainly by pastures. Meadow area remains relatively stable, decreasing by only ~6% across the period. In contrast, pasture area drops markedly, with an overall reduction of ~27% from 2020 to 2024. The sharpest change occurs between 2022 and 2023, when pasture area falls by ~28%, followed by only a minor rebound (~1%) in 2024. This abrupt year-to-year shift may reflect a combination of real land-use dynamics and a possible break in series due to definitions, reclassification, or reporting procedures in the underlying statistical sources.

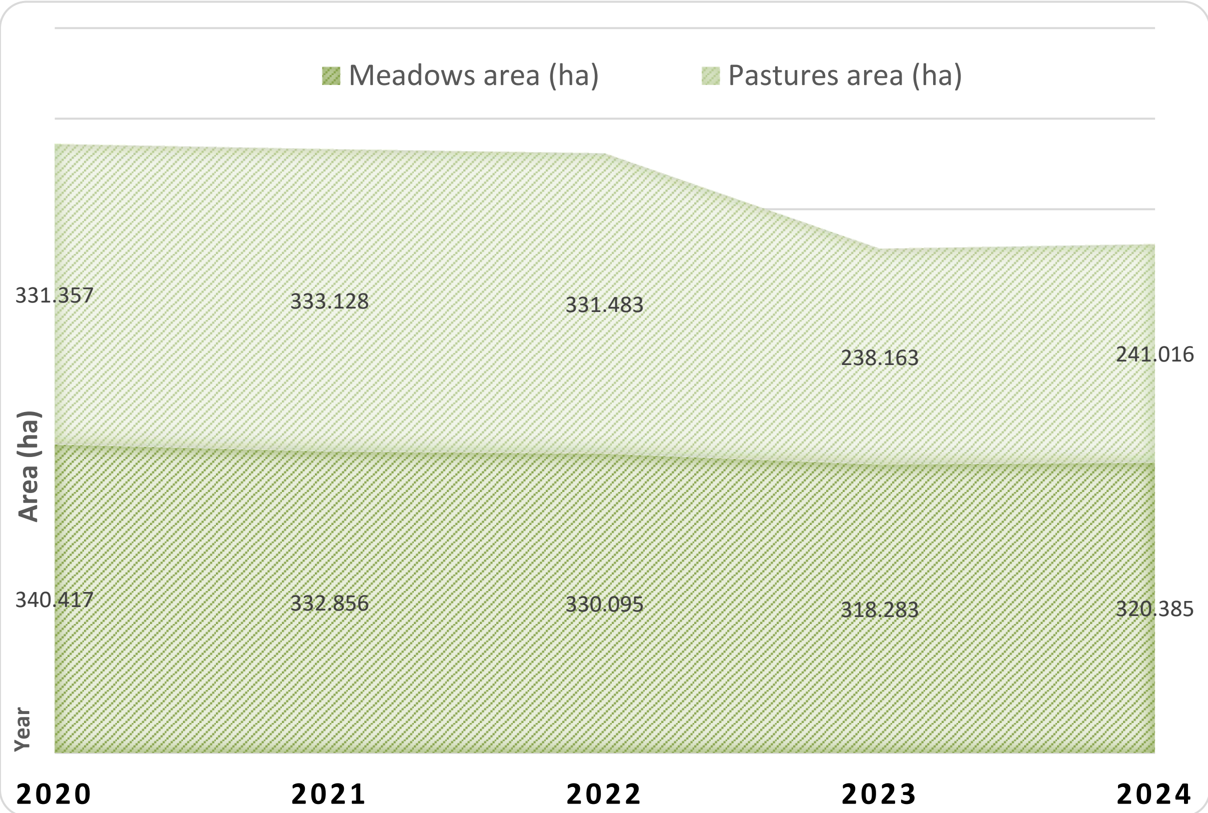

Figure 4. Trends in the area of meadows and pastures in Serbia, 2020–2024 (ha) [15, 16].

III. LEGAL STATUS

In Serbia, semi-natural grasslands (SNGs) are classified in national legislation as agricultural land—meadows and pastures [17, 18]. The Rulebook on the Code of Good Agricultural Practice defines a pasture as agricultural land covered by natural grasses used exclusively for grazing, while permanent grasslands are classified as meadows and pastures dominated by perennial grasses [19].

Semi-natural grasslands in the Republic of Serbia do not constitute a distinct legal category; therefore, their protection and management are provided through the general nature conservation framework. Under Article 27 of the Law on Nature Protection, SNGs may fall within protected-area categories such as national parks, strict and special nature reserves, protected habitats, landscapes of outstanding features, and nature parks [20]. Article 28 further stipulates that areas with significant biological and ecosystem diversity—including grassland habitats—may be designated as protected areas of general interest [20]. Protection of semi-natural grasslands as habitat types is additionally addressed by Article 16, which regulates the conservation and protection of habitat types and the identification of priority and threatened habitats [20]. Moreover, Article 18(3) and (5) emphasize the importance of conserving meadows and pastures within agroecosystems and forest clearings to maintain biological and landscape diversity [20].

Beyond protection through designated protected areas under the Law on Nature Protection, semi-natural grasslands are also covered by the integrated environmental protection framework established by the Law on Environmental Protection [21]. Pursuant to Article 2(1) and Article 9(3), the preservation of natural values—including biodiversity and habitats—is an obligation within sustainable natural resource management [21]. Article 26 highlights biodiversity and habitat protection as an integral part of safeguarding the biosphere, while Articles 33 and 34(1) and (2a) require spatial and urban planning to introduce specific land-use regimes and integrated landscape protection measures—particularly relevant for conserving semi-natural grasslands as characteristic elements of agrarian landscapes [21].

Regarding EU policies, Article 4(16a) of the Law on Nature Protection defines Natura 2000 as ecologically important areas of the European Union designated for the conservation of habitats and species [21]. However, this provision serves only for terminological alignment and does not constitute the formal establishment of the Natura 2000 network in Serbia. Although Serbia is not an EU Member State, Natura 2000 principles have been incorporated into national legislation through provisions on ecologically important areas and the ecological network [21]. The ecological network is to be defined and will become part of the European Natura 2000 ecological network upon Serbia's accession to the European Union [21].

Agricultural land, including pastures and meadows, may be privately or state-owned. In all cases, the owner or user of agricultural land must cultivate the land regularly, act in accordance with the principles of good agricultural practice, and comply with other measures prescribed by the competent ministries. State-owned agricultural land may be leased to a natural or legal person for a period of not less than one year and not more than 30 years, provided this is in accordance with the annual program for the protection, development and use of agricultural land. The procedure for leasing or using state-owned agricultural land is conducted by the local government body [18].

Responsibilities for management, monitoring, and enforcement related to semi-natural grasslands in Serbia are distributed among several institutions. The Ministry of Agriculture is responsible for agricultural land use and the implementation of agro-environmental and rural development measures, while the Ministry of Environmental Protection is responsible for nature conservation, habitat protection, and the nature monitoring system. Inspection oversight and enforcement are carried out by competent inspection bodies at the national, provincial, and local levels, in accordance with the Law on Agriculture and Rural Development, the Law on Agricultural Land, the Law on Nature Protection, and the Law on Environmental Protection.

In Serbia, farmer support and agro-environmental measures relevant to the conservation and sustainable use of grasslands are implemented under the Law on Agriculture and Rural Development, which defines sustainable management of natural resources and environmental protection as objectives of agricultural policy [17]. These measures are delivered through rural development measures planned and implemented under the National Rural Development Programme (Article 6) and financed as structural incentives pursuant to Article 12, including measures supporting biodiversity protection and sustainable agricultural practices [17]. The law also provides a specific framework for the implementation of IPARD (EU Instrument for Pre-Accession Assistance for Rural Development), aimed at agricultural modernization, rural development, and gradual alignment with EU agricultural policy.

Responsibility for management, control, and payment of funds lies with the Ministry of Agriculture and the Directorate for Agrarian Payments, using EU pre-accession assistance and the national budget [17].

Despite their considerable ecological value, semi-natural grasslands are not recognized as a distinct legal category in any of the relevant laws. Instead, they are treated either as agricultural land (meadows and pastures) or within the broader nature conservation framework, resulting in a fragmented approach to management. Coordination between agricultural and environmental policy remains insufficient: the Law on Agriculture and Rural Development provides only a general framework for agro-environmental and rural measures, without specific, targeted incentives dedicated exclusively to the conservation of semi-natural grasslands.

IV. PRODUCTIVITY

Semi-natural grasslands represent a key feed resource supporting extensive livestock production in Serbia, particularly in hilly–mountain and mountain areas where intensive arable farming is limited. They are used directly for grazing and indirectly as a source of roughage, mainly hay. Free grazing predominates in mountain areas, while mowing is more common in lowlands; mixed grazing–mowing systems are frequent in hilly–mountain zones [3].

Grasslands are mainly used for cattle and sheep grazing, as their botanical composition and feed value provide a key forage base for these ruminants [22]. Sustainable use requires aligning herd size with grassland production potential to avoid overgrazing and long-term degradation. Based on national livestock numbers expressed in livestock units (LU), Serbia shows a comparatively high stocking pressure (1.58 LU/ha of grassland), exceeding the Western Balkans average (0.88 LU/ha) and a commonly cited benchmark of around 1 LU/ha at national scale [23]. However, this is a macro-indicator derived from national statistics and may not reflect actual grassland use intensity at regional level or the uneven spatial distribution of livestock. In practice, field observations and available analyses suggest that parts of the grassland resource are only partially used or underused, due to uneven access, fragmented parcels, and labour constraints in rural areas. Therefore, any further expansion of ruminant numbers should not be based on assumed ‘unused’ grassland capacity, but rather on improving grassland quality (e.g., increasing legume share where feasible, better grazing management) and productivity per animal, while safeguarding high-nature-value grasslands.

In practice, recommended grazing rates vary by grassland type, season length, and management goals. For cattle in extensive and semi-intensive systems, a typical reference range is 0.5–1.0 LU/ha [24]. For sheep and goats in extensive systems in hilly–mountain and mountain regions, higher nominal rates are indicated (0,5–1 LU/ha) depending on local conditions and calculation method [24]. Additional guidance suggests minimum and maximum thresholds outside protected areas [25], while farm-level recommendations depend on pasture quality and climatic variability [26, 27]. Horses and ponies are locally present in mountain grazing systems; an indicative requirement is >0.8 ha per horse under grazing to maintain pasture condition and animal welfare [28]. Traditional forest–pasture pig grazing persists only in specific, culturally relevant landscapes and is currently marginal in agricultural practice [29].

According to official statistics, average dry matter (DM) yield in 2024 was 1.5 t/ha on meadows and 1.1 t/ha on pastures, with regional differences [16]. Over 2020–2024, yields varied substantially, with a pronounced peak in 2020 and a low in 2022 for both meadows and pastures [15]. Reported typical DM yield ranges are approximately 1.4–2.2 t/ha for meadows and 0.4–1.0 t/ha for pastures [3]. Long-term analyses suggest slow future growth in meadow and pasture yields in Serbia overall, with potential regional divergence [30].

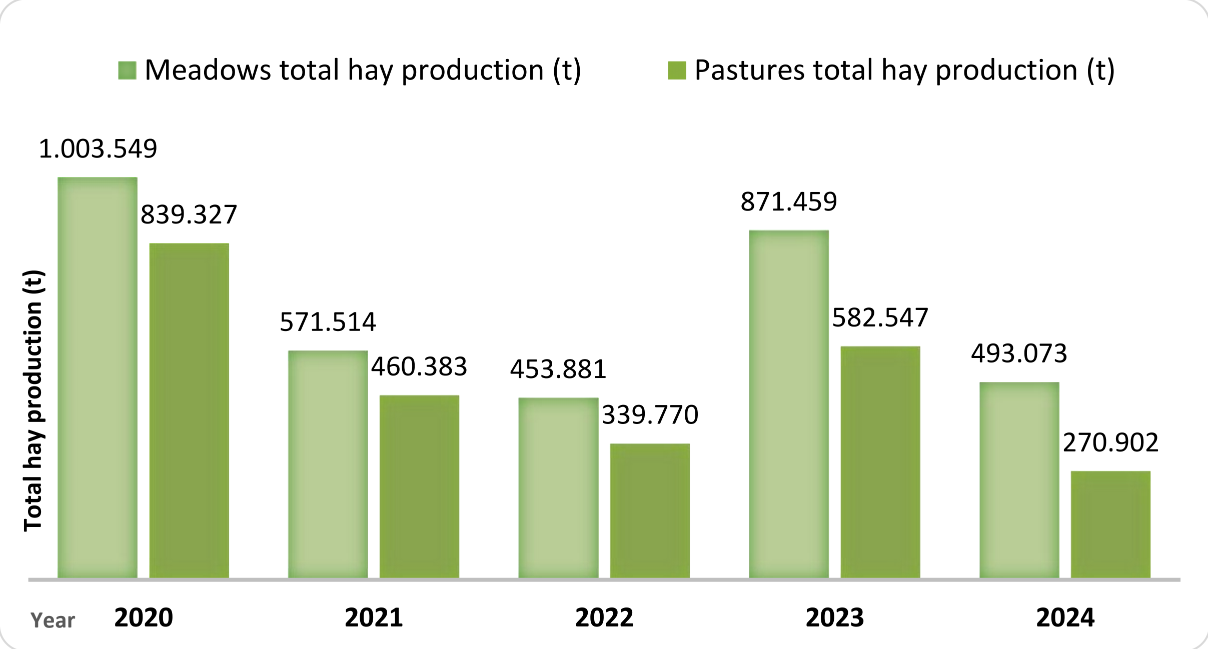

Figure 5. Total hay production of meadows and pastures in Serbia (2020–2024) [15, 16].

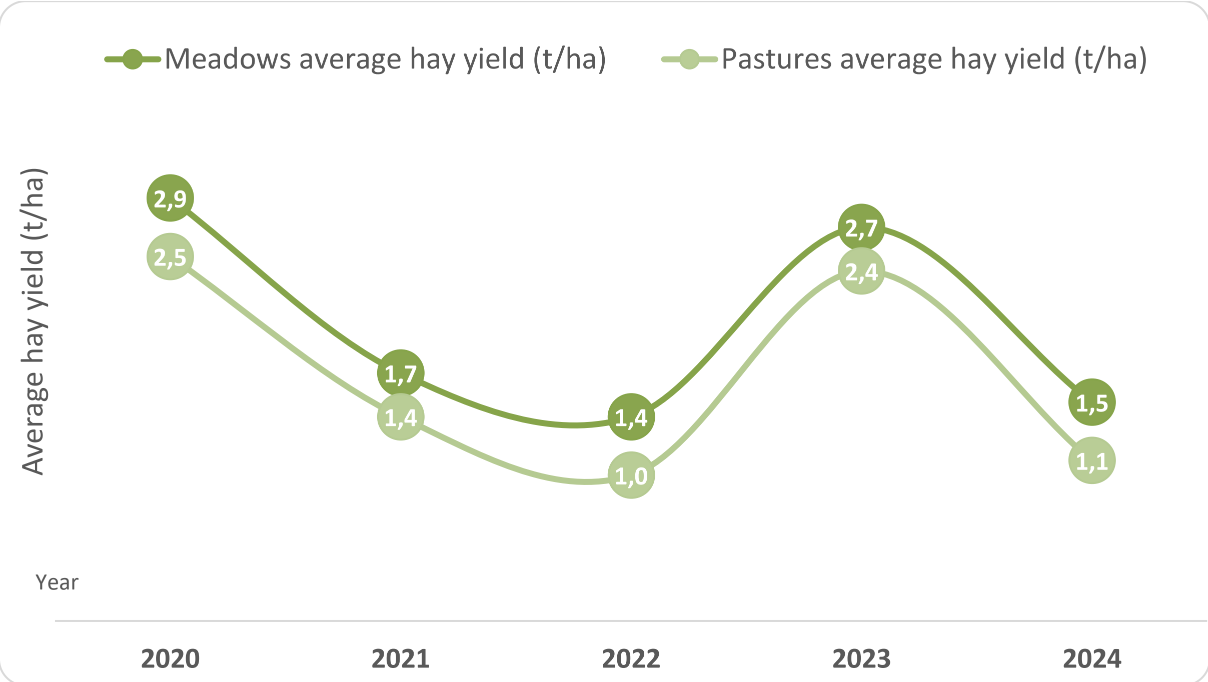

Figure 6. Average hay production of meadows and pastures in Serbia (2020–2024) [15, 16].

Table 3. Average hay yields across different types of grasslands in Serbia [7].

Area	Pastures	Hay yield
	Meadows	(t/ha)
Wetlands	Pastures	3.5
	Meadows	4.5
Valley-lowlands area	Pastures	2
	Meadows	3.2
Hilly area	Pastures	0.9
	Meadows	1.6
Mountain area	Pastures	0.7
	Meadows	1.2

Table 4. Chemical composition of meadow forage biomass at the Jastrebac and Sokolovica sites-South-East Serbia [31].

Area	Association	Mineral matter (%)	Moisture (%)	Crude protein (%)	Crude fat (%)	Nitrogen-free extract (%)	Crude fibre (%)
Jastrebac	*Agrostio–Juncetum effusi* Cinc. 1959	5.12	7.98	7.02	1.69	47.18	31.05
Jastrebac	*Trifolio–Agrostietum stoloniferae* Lj. Mark. 1973	9.09	8.82	12.01	2.21	37.47	30.4
Jastrebac	*Agrostietum vulgaris* Z. Pavl. 1955 (sensu lato)	8.33	7.82	10.04	2.28	41.71	29.82

Jastrebac	*Festuco–Agrostietum* Horv. (1952) 1982 em. Trinajst. 1972	8.53	8.01	8.7	1.8	40.83	32.13
Sokobanja	*Festuco–Agrostietum* Horv. (1952) 1982 em. Trinajst. 1972	4.93	7.74	5.78	1.23	41.26	39.05

Low productivity is primarily linked to climatic constraints (notably drought years), low soil fertility—particularly phosphorus limitation—and frequent acidity, combined with a generally low intensity of basic agronomic measures on semi-natural grasslands [32, 33, 34]. Forage quality is also a limiting factor: several studies report a substantial proportion of hay samples with crude protein below 8%, indicating restricted nutritive value for high-demand categories of livestock unless supplemented [10, 11]. Site-specific studies show large variability among grassland associations and locations [31].

Fertilisation generally increases biomass yield and can improve nutritive value, but high nitrogen inputs may reduce plant diversity and shift community structure. Evidence from semi-natural grasslands in Serbia indicates that nitrogen and combined mineral fertilisation can increase yields, alter species dominance, and improve forage quality indicators, while excessive N may promote tall competitive species and reduce diversity [35, 10]. Organic fertilisation—particularly manure—can be an effective and more biodiversity-compatible strategy to increase hay yield and improve forage quality, with studies reporting significant yield increases relative to unfertilised controls [36, 37, 38]. Findings on microbial fertilisers are inconsistent and therefore not currently recommended as a standard measure [34].

Mowing regime strongly affects both yield and forage quality. Earlier mowing generally improves nutritive quality, whereas later mowing may increase total biomass at the expense of feeding value; recommendations therefore vary by altitude zone and target use [34, 3, 35]. Overseeding (introducing grasses/legumes into existing swards) is used to restore degraded grasslands and improve yield and quality, particularly in hilly and mountain regions, but requires appropriate timing and temporary grazing exclusion [39, 40]. Liming is relevant on acidic soils; evidence suggests benefits may be delayed and context-dependent, but combined liming and fertilisation can increase yields and support more favourable functional composition [41, 42, 3, 10].

Grazing management (type, timing, and stocking pressure) is decisive for long-term productivity. Uncontrolled grazing can trigger floristic and production degradation, whereas controlled grazing—often in combination with mowing—supports higher and more stable productivity. Mixed-species grazing can contribute to more even utilisation of vegetation and reduce weed encroachment [43]. Examples from Serbia indicate that extensive grazing systems can also support biodiversity and cultural landscapes, including traditional breeds and conservation-oriented grazing initiatives [44, 45]. Rotational grazing guidance recommends moving animals at ~40–50% utilisation to support regrowth and sustained yield [27]. Experimental work shows that yield and forage composition vary strongly across cuts/cycles within a season, underlining the importance of timing and adaptive management [46, 47].

Overall, the agrotechnical measures described above account for the observed responses in SNGs in Serbia. Nevertheless, the extent and direction of these effects vary depending on habitat type, altitude, and the floristic composition of the grasslands.

Traditional extensive management (low inputs, later mowing, moderate grazing) supports high plant diversity and ecosystem stability, but typically results in lower biomass yields and more variable forage quality compared with intensified systems. In high-nature-value contexts, reduced yields can be interpreted as the “cost” of maintaining biodiversity, landscape values, and resilience under climatic variability [3, 10].

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Analysis of the Current Status and Management Systems of Grasslands in Spain

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I. INTRODUCTION

Semi-natural grasslands (Semi-Natural Grasslands, SNGs) constitute in Spain a structural component of Mediterranean and Atlantic extensive livestock systems, providing forage and essential ecosystem services such as soil conservation, hydrological regulation, carbon sequestration, and the maintenance of biodiversity associated with high nature value agricultural landscapes [1]. These systems are maintained through extensive grazing and, in certain cases, occasional mowing, without systematic ploughing or reseeding, which promotes high floristic and functional diversity.

The most representative silvopastoral system is the dehesa, a mosaic of permanent grasslands with scattered holm oak (Quercus ilex) and cork oak (Quercus suber) trees, historically managed through grazing, traditional pruning, and shrub control, and recognised as a habitat of Community interest (6310) within the Natura 2000 Network [1]. Tree cover modulates the microclimate (thermal buffering and moisture conservation) and provides strategic resources (acorns and browse) that are particularly relevant during critical periods.

At present, many SNGs show an unfavourable conservation status due to combined pressures from agricultural intensification, conversion to cropland, and rural abandonment, which reduce structural heterogeneity and promote shrub encroachment [2]. Climate change exacerbates these pressures by increasing the frequency and intensity of droughts and wildfire risk, reducing forage availability and advancing seasonal senescence [3,4].

In addition, insufficient tree regeneration and the spread of diseases such as “oak decline” (Phytophthora cinnamomi) compromise the long-term viability of dehesas, particularly under insufficient or discontinuous management [1]. The loss of extensive livestock farming associated with these systems can increase wildfire risk and trigger abrupt releases of stored carbon, undermining their role as net carbon sinks [5,6]. Therefore, the diagnosis of SNGs in Spain must simultaneously address their productive dimension and their socio-ecological dimension (ecosystem services, cultural landscapes, and the persistence of rural livelihoods).

II. GRASSLAND PRESENCE

In Spain there is no single, homogeneous statistical estimate that identifies SNGs as a differentiated category. Official statistics use the concept of permanent grasslands, defined as surfaces occupied by forage herbaceous vegetation for at least five years without systematic ploughing, which acts as a partial proxy for SNGs, although it also includes improved grasslands and other permanent forage uses [7].

According to the Survey on Crop Areas and Yields (ESYRCE), in 2024 Spain had 8.53 million hectares of permanent grasslands and meadow, mainly concentrated in Castile and León, Extremadura, Andalusia, Aragon, and Castile-La Mancha [8] (Figura 1). By contrast, Eurostat estimated a lower area for 2020 (7.5 million hectares), highlighting relevant methodological differences between national and European sources [9]. These divergences reflect, in part, that grassland accounting is shaped by administrative criteria and does not always capture effective pastoral use, especially in silvopastoral systems with trees and shrubs.

The area officially recorded as permanent grasslands is conditioned by SIGPAC eligibility criteria and by the application of the Pasture Eligibility Coefficient (CAP), which may underestimate the area that is actually grazeable in Mediterranean silvopastoral systems where trees and shrubs are accessible to livestock.

Several recent works indicate that, if grasslands, stubble fields, fallows, and grazed forest lands are considered jointly, the area effectively used by extensive livestock farming could approach 30 million hectares (close to 60% of national territory). This figure is not derived from official statistics and is mentioned here solely to highlight a major information gap concerning the actual pastoral use of Spanish territory [4,10].

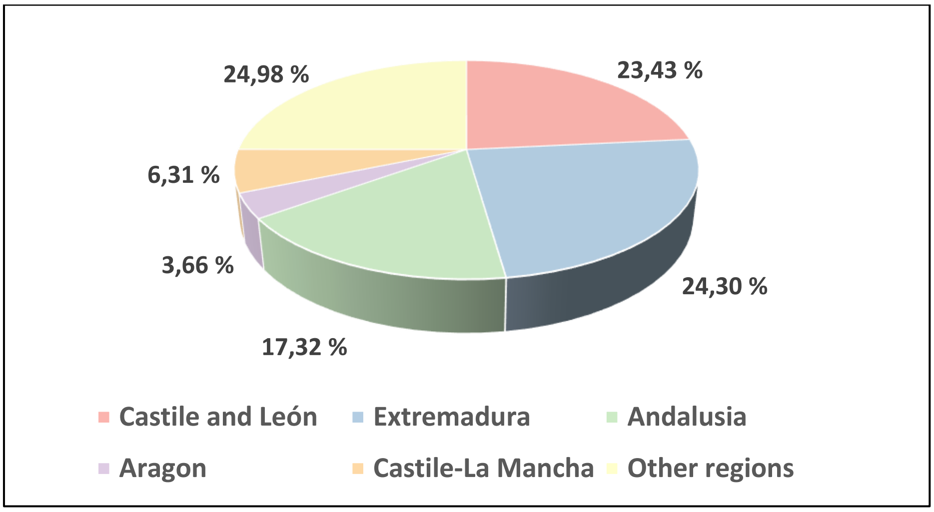

Figure 1. Permanent grasslands and meadows, Spain 2024 (ha and % of total) [8].

Within this context, the dehesa constitutes the most representative SNG in south-western Spain. While official forest statistics assign a wooded area of 2.8 million hectares [1], other sources estimate the area under effective pastoral use at close to 4 million hectares [4]. It is located mainly in Extremadura, western Andalusia, Castile-La Mancha, and Castile and León, with additional enclaves in the Central System and other plateau areas.

SNGs in Spain comprise a diverse set of herbaceous and silvopastoral systems whose structure and functioning depend on the maintenance of active extensive livestock management. Many of these typologies are recognised as habitats of Community interest in Annex I of Directive 92/43/EEC, underscoring their relevance for biodiversity conservation at the European scale [11].

Among the main SNG typologies present in Spain are the following [4,12]:

• Mediterranean annual grasslands (habitat 6220*). Communities dominated by annual grasses and legumes adapted to poor soils and pronounced summer drought, with a high diversity of therophytes. They are maintained through extensive grazing and are fundamental for sheep grazing in lowland and wintering areas.

• Evergreen Quercus wood-pastures (habitat 6310). Agro-silvopastoral systems integrating grasslands, crops, and scattered trees. Their persistence depends on rotational grazing and formative pruning to ensure regeneration and acorn production [12].

• Mediterranean wet meadows (habitat 6420). Tall herbaceous communities (rushes and perennial grasses) associated with areas of temporary edaphic moisture, essential as a forage reserve during summer drought.

• Lowland hay meadows (habitat 6510) and mountain hay meadows (habitat 6520). Traditional mesophilous hay meadows linked to mowing and, in many cases, summer grazing through short-distance seasonal movements or transhumance. These habitats are currently declining due to the abandonment of traditional management practices.

These typologies show heterogeneous distributions shaped by climate and soils, but share a strong dependence on livestock management to prevent shrub encroachment and loss of ecological value [11].

SNGs in Spain harbour high levels of plant and animal biodiversity and constitute high nature value agricultural landscapes. In particular, dehesas are internationally recognised as biodiversity hotspots, combining a highly diverse herbaceous layer of grasses and legumes with scattered trees [12]. This diversity sustains complex trophic networks and provides critical habitat for protected fauna; indeed, grazing has been shown to contribute directly to the conservation of predators such as the Iberian lynx (Lynx pardinus) by maintaining the habitat of its prey [11].

The botanical composition of SNGs, with a relevant presence of forage legumes, promotes biological nitrogen fixation, improves soil fertility, and contributes to higher forage nutritional quality, strengthening resilience to drought and climatic variability [4].

Furthermore, SNGs provide key ecosystem services: soil protection against erosion, hydrological regulation, wildfire prevention through the maintenance of open vegetation structure, and carbon sequestration. Permanent herbaceous cover and, in dehesas, scattered tree cover contribute to carbon storage in soil and biomass, reducing net greenhouse gas emissions [13].

Figure 2. Goats browsing on holm oak in a Mediterranean oak wood-pasture (dehesa). Source: authors' photo.

Although there is no homogeneous national estimate that accurately quantifies the total loss of SNG area, multiple indicators point to a decline in active management and a degradation of ecological quality. The main pressures include:

Rural abandonment and shrub encroachment. The abandonment of extensive livestock activity promotes shrub encroachment, loss of open grasslands, and increased fuel loads, with negative effects on open-habitat biodiversity and a higher risk of wildfires [13,14]. At the European scale, the Joint Research Centre (JRC) estimates that up to 11% of agricultural land could be abandoned before 2030, with Spain among the most affected countries [15].

Localised agricultural intensification. In the most productive areas, SNGs have been transformed through overgrazing, intensive fertilisation, or conversion to crops, resulting in simplified plant communities and soil degradation. The European Environment Agency identifies intensification as one of the main pressures on high nature value grasslands in southern Europe [16].

Climate change. Rising temperatures, more frequent droughts, and irregular precipitation reduce productivity and shorten vegetation growth periods, especially in Mediterranean regions [3]. In systems such as the dehesa, water stress also affects tree regeneration [3,13].

Phytosanitary issues and loss of traditional practices. The expansion of "oak decline" and insufficient tree regeneration constitute structural threats in dehesas, exacerbated by the progressive disappearance of traditional practices such as pruning, transhumance, or shrub management [1,13].

At the regional scale, case studies in northern Spain document drastic losses in traditional landscapes, including a 68.5% reduction in hay-meadow area since the mid-20th century due to abandonment and intensification in representative areas such as the Picos de Europa. Overall, both excessive intensification and abandonment, which in these same areas has led to the disappearance of 99% of traditional crops, drive biodiversity loss, reduced functionality, and diminished ecosystem services, reinforcing the need for policies that support adaptive extensive management [17].

III. LEGAL STATUS

In Spanish agricultural legislation, SNGs do not constitute a specific legal category. For the purposes of the Common Agricultural Policy (CAP), these systems are included within the category of permanent grasslands [7]. This classification is operational for direct payment eligibility but does not adequately distinguish semi-natural grasslands, improved grasslands, or complex silvopastoral systems.

At the European scale, a substantial share of SNGs in Spain is included under Directive 92/43/EEC (Habitats Directive) as habitats of Community interest, hosting 40% of EU grassland habitat types. Notable typologies include codes 6220*, 6310, and 6420, which form part of the Natura 2000 Network and where extensive livestock farming is a structural element required to maintain favourable conservation status [11].

The main administrative instrument for CAP implementation in Spain is SIGPAC, which delineates eligible land for subsidies. On this basis, the CAP is applied, regulated by Royal Decree 1075/2014, which deducts areas considered non-grazeable due to slope, rock outcrops, or impenetrable vegetation.

Although in 2018 the definition of permanent grassland was expanded to include woody vegetation accessible to livestock, the CAP remains controversial in Mediterranean silvopastoral systems. It has been argued that it may underestimate the truly grazeable area in dehesas and open woodlands by penalising tree cover and functional shrub vegetation within the production system.

To address these limitations, European regulations include Established Local Practices (PLE), intended to recognise traditional grazing situations in woody pastures where herbaceous forage is not predominant [18]. However, implementation has been uneven across autonomous communities, creating uncertainty and a lack of territorial coherence in the support provided to extensive livestock farming [10].

An additional structural challenge concerns the agronomic conceptualisation of pasture within Mediterranean silvopastoral systems under the CAP framework. Several analyses identify a fundamental contradiction: regulations tend to treat dehesa pastures as passive forest land rather than recognising them as complex forage systems requiring active management and specialised technical knowledge [20]. This approach has generated paradoxes in direct payment implementation, favouring annual forage crops on arable land, which involve tillage and higher erosion risk, while penalising regeneration or improvement of permanent pastures in silvopastoral systems through the CAP. Regulations should evolve to recognise that the improvement and management of dehesa pastures deserves at least the same support as annual forage crops, without penalties derived from the structural presence of scattered trees, which are key to climatic and productive resilience [20].

The management, monitoring, and implementation of SNG-related regulations in Spain is undertaken by the Ministry of Agriculture, Fisheries and Food (MAPA), Spanish Agricultural Guarantee Fund (FEGA), Ministry for the Ecological Transition and the Demographic Challenge (MITECO), and the autonomous communities.

The CAP Strategic Plan 2023–2027 includes voluntary eco-schemes supporting practices compatible with SNG conservation. These include the Extensive Grazing eco-scheme (minimum grazing days and adapted stocking-rate ranges), as well as sustainable mowing measures aimed at biodiversity protection [2].

Key challenges include: the absence of a specific legal category, limitations of CAP in reflecting real grazing in woody systems, territorial heterogeneity in criteria and eco-schemes, and difficulties in reconciling conservation objectives with administrative requirements. These constraints affect the effectiveness of current policies in ensuring the long-term maintenance of SNGs.

IV. PRODUCTIVITY

SNGs are primarily used through extensive grazing and, in certain typologies, combined with mowing for hay and mixed systems. In agro-silvopastoral systems such as the dehesa, use integrates complementary resources such as acorns, browse, and shrub biomass, which form part of the annual feed balance of livestock [11].

Given increasing rainfall irregularity and earlier seasonal senescence, conserving spring pasture surplus through haymaking or silage has become a key adaptation strategy to ensure feed self-sufficiency and reduce farms' economic vulnerability [20,4]. In this context, integrated crop–livestock practices are becoming consolidated, such as the use of dual-purpose forage crops (e.g., triticale) that allow winter grazing followed by grain or hay production in spring, increasing forage self-sufficiency and reducing dependence on external inputs [20].

In addition to sedentary systems, livestock mobility (transhumance and short-distance seasonal movements) remains relevant in mountain and foothill areas, optimising the use of phenologically complementary resources and contributing to ecological connectivity at the territorial scale [21].

SNGs sustain extensive systems based mainly on sheep and beef cattle, with an important role for goats in scrubland and shrub-dominated areas and for Iberian pigs in dehesas during the montanera. These systems often rely on rustic local breeds adapted to climatic variability and diets based on diverse natural resources [11].

Sustainable stocking rates vary according to farming model, potential productivity, livestock species, and management. In dehesa systems, indicative ranges around 0.30–0.50 LSU/ha have been reported, with warnings that higher rates can compromise tree regeneration unless seasonal adjustments and appropriate management strategies are applied [22–24].

There is no homogeneous national system providing comparable forage yields for SNGs, as they are usually integrated into broad permanent grassland categories. In practice, productivity depends on interannual rainfall, typology, and management.

Livestock management is not merely biomass extraction, but an active tool for agronomic and ecological grassland improvement. Compared with abandonment, rational grazing induces measurable physiological improvements in herbaceous vegetation, increasing soil cover in autumn and winter, maintaining pasture at younger phenological stages, and improving digestibility and protein content [20].

Figure 3. Ewes and lambs grazing in a Mediterranean dehesa. Source: authors' photo.

Similarly, well-adjusted management enables more efficient use of spring moisture surpluses, extending the availability of green pasture into early summer. Traditional practices such as majadeo or night-time folding have also been confirmed as effective strategies to increase soil organic carbon and fertility in poor areas, with greater sustainability than conventional chemical fertilisation [4].

In silvopastoral systems, tree–pasture interactions are complex but predominantly positive. Although competition may locally reduce herbaceous biomass under the canopy, shade buffers thermal stress and maintains soil moisture [25]. In addition, strategic resources such as acorns and browse increase the overall energy balance of the system, reducing dependence on external inputs and offsetting a substantial share of livestock-production emissions [23,26].

Management intensity affects short-term productivity and medium-to-long-term sustainability. Intensification can increase production in the short term, but is often associated with loss of floristic diversity, soil degradation, and lower drought resilience [27]. Conversely, prolonged abandonment or underuse promotes shrub encroachment and increases wildfire risk due to the accumulation of combustible biomass [28].

In Mediterranean contexts, degradation of the herbaceous layer has been linked to inappropriate management and unsuitable agricultural practices, effects aggravated by climate change through a shortened pasture cycle and earlier senescence. Therefore, productivity should also be assessed using functional indicators (cover, interannual stability, and recovery capacity).

Traditional extensive practices have historically helped sustain a balance between production and biodiversity. Among these, majadeo or night-time folding (nocturnal movement of herds within portable enclosures) can enhance fertility and increase soil organic matter, promoting the growth of high-value forage species [4,29]. Traditional pruning (pollarding) and the use of browse, as well as seasonal shrub grazing to reduce fuel loads, are also relevant.

A clear trade-off exists between intensity and ecosystem services: maximising production through high stocking rates or vegetation simplification tends to drastically reduce biological diversity and climatic resilience [30,17]. In contrast, maintaining moderate stocking rates and adapted extensive management supports stable long-term productivity while conserving high ecological values and multifunctionality.

SNGs constitute one of the ecological and productive pillars of extensive agricultural systems in Spain. Their relevance goes beyond forage production, providing essential ecosystem services related to biodiversity conservation, water-cycle regulation, erosion prevention, climate change mitigation, and the maintenance of landscapes and rural socio-economic fabric.

This analysis highlights structural limitations in their recognition, monitoring, and effective support. The absence of a specific statistical and legal category forces the use of "permanent grasslands" as an approximation, making it difficult to identify SNGs and real pastoral land use, particularly in silvopastoral systems with trees and shrubs.

From a regulatory standpoint, the CAP remains a critical element. Although mechanisms such as PLE exist, a mismatch persists between administrative criteria and the functional reality of Mediterranean woody pastures. In the CAP 2023–2027, eco-schemes for extensive grazing and sustainable mowing represent progress, but their effectiveness depends on coherence with eligibility criteria and adaptation to territorial diversity.

Climate change increases vulnerability (droughts, early senescence, and wildfires) and reinforces the need for active, adaptive management. Practices such as stocking-rate adjustment, seasonal pasture use, conservation of spring surpluses, and tree management remain key to system sustainability.

The following priority recommendations are identified:

1. Improve knowledge and mapping of SNGs by integrating agricultural and forest sources (SIGPAC, Forest Map, Natura 2000) and distinguishing semi-natural grasslands from other permanent forage uses.
2. Adjust eligibility and admissibility criteria, strengthening effective implementation of PLE and ensuring that CAP reflects real pastoral use, especially in Mediterranean silvopastoral systems.
3. Reinforce coherence between conservation and production by aligning CAP, Natura 2000, and climate strategies to avoid contradictions between requirements and sustainable practices.

4. Promote active management and regeneration of SNGs by supporting practices that maintain herbaceous cover, tree regeneration, and shrub control, recognising the role of extensive grazing in wildfire prevention and carbon sequestration.
5. Recognise and valorise SNG ecosystem services more explicitly in public support instruments and rural development strategies.

Overall, SNGs should be understood as strategic green infrastructure for the sustainability of Spain's agricultural and territorial systems. Their future will depend on policies capable of recognising their functional complexity and supporting management that combines economic viability, biodiversity conservation, and climate change adaptation.

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Analysis of the Current Status and Management Systems of Grasslands in Türkiye

SMART STEP

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I. INTRODUCTION

Türkiye is recognized among the countries with the highest levels of biological diversity worldwide, owing to its pronounced topographic heterogeneity and its position at the intersection of three major phytogeographical regions: the Euro-Siberian, Mediterranean, and Irano-Turanian regions. Rangelands, which represent one of the most important components of this ecological richness, cover approximately 17% of the country’s total land area [1]. Rangelands constitute the most important and cost-effective source of roughage, which is a fundamental input in livestock production. In addition to supporting animal production, they perform multiple ecological functions, including the conservation of natural resources, the maintenance of ecosystem sustainability, the preservation of biodiversity and genetic resources, and the provision of suitable habitats for wildlife [2]. It is also widely acknowledged that rangeland ecosystems represent one of the most important vegetation types for mitigating global environmental risks such as soil erosion, vegetation fires, and floods [3,4]. In Türkiye, rangeland vegetation, which is generally dominated by perennial grasses, plays a critical role in stabilizing soils within the erosion-prone Anatolian landscape. Furthermore, it has been emphasized that, when appropriate management practices are applied, rangelands can sequester atmospheric carbon in soils [5] and may be as effective as forests in mitigating climate change [6,7,8].

Historically, rangelands have played a pivotal role in the formation and long-term sustainability of states. In the contemporary context, they are widely recognized as an indicator of national development, and in Türkiye, their condition reflects the broader social and economic dynamics of rural communities. Owing to pressures associated with resource use and legal regulations, a portion of Türkiye’s rangelands has been converted into arable land or incorporated into forest boundaries [9]. At the same time, a substantial share of the remaining rangeland areas has undergone a significant decline in productivity, largely due to prolonged uncontrolled use and persistent excessive grazing pressure. Grazing conducted before the onset of the growing season of rangeland plants, typically in early spring, has been reported to deplete carbohydrate reserves stored in the roots. This practice can lead to a substantial decline in rangeland productivity, with reductions estimated at 50–70% [10]. Another major threat to rangelands is climate change. Projections developed by Şen (2013) suggest that rising temperatures, combined with a projected decline in precipitation, particularly in the southern parts of Türkiye that include Central Anatolia and Southeastern Anatolia, will intensify drought conditions [11]. These changes are expected to increase the severity, frequency and duration of drought events, thereby posing additional risks to rangeland productivity and ecological stability. Consequently, rangeland ecosystems, most of which are situated in the arid and semi-arid regions of Türkiye, are becoming increasingly vulnerable to degradation. Under these conditions, the growth and development of plant species within rangeland communities are adversely affected, forage production declines, and pronounced shifts emerge in botanical composition. The use of semi-natural grasslands (SNGs) in Türkiye has been shaped by a nomadic (transhumant) culture that was transferred from Central Asia to Anatolia over thousands of years. Following permanent settlement in Anatolia, the tradition of transhumance (the seasonal movement of livestock to high-altitude, cooler pastures during the summer months) became established. This system created a natural form of rotational grazing by allowing low-altitude pastures (winter rangelands) to rest and recover [12]. However, from the mid-20th century onwards, increased mechanization in agriculture, the transition to a sedentary lifestyle, and broader socio-economic changes have weakened this traditional rangeland rotation cycle. The disruption of traditional grazing practices has intensified grazing pressure on rangelands located near villages, leading to rapid degradation of these areas. In Türkiye, the legal framework governing the conservation and management of rangelands is based on the Rangeland Law No. 4342, enacted in 1998. This law was introduced to ensure the use of rangelands in accordance with their intended purpose, to define their boundaries, and to implement improvement and rehabilitation measures. It designates rangelands as public common property and explicitly prohibits their sale, leasing, or use for non-rangeland purposes [13].

II. GRASSLAND PRESENCE

Grassland and rangeland ecosystems, which collectively encompass nearly 24% of the Earth's terrestrial surface [14], constitute a resource of considerable strategic significance for Türkiye. According to recent assessments, the total rangeland area in Türkiye for which cadastral identification studies have been completed is reported to be 13.2 million hectares [15]. This figure corresponds to approximately 17% of the country's total land surface.

Table 1. Changes in rangeland areas by region in Türkiye [15].

REGION	1970 Rural Services	1991 Agricultural Survey	2001-TÜİK Survey	1998-2024 Rangeland Area Identified under the Grassland Law
	Area (ha)	Area (ha)	Area (ha)	Area (ha)
EGE	1.027.900	615.900	802.879	424.722
MARMARA	463.600	564.100	552.662	291.660
AKDENİZ	1.002.400	434.300	659.334	589.507
İÇ ANADOLU	5.884.200	3.890.300	4.570.182	4.240.265
KARADENİZ	1.993.100	1.556.000	1.533.605	1.124.302
DOĞU ANADOLU	9.162.100	4.573.400	5.485.449	5.748.320
GÜNEYDOĞU ANADOLU	2.165.100	743.600	1.012.576	850.908
TOTAL	**21.698.400**	**12.377.600**	**14.616.687**	**13.269.685**

Throughout the Republican period, the most substantial shifts in land use have occurred within grassland and rangeland areas, largely to the detriment of rangeland resources. In Türkiye, the enactment of the Land Distribution to Farmers Law in 1945 resulted in the conversion of approximately 9 million hectares of rangeland into agricultural land. Additionally, the establishment of the Ministry of Forestry in 1969 led to the reclassification of 7.5 million hectares of shrubland as forest and scrubland. Consequently, the extent of rangelands identified in different periods has exhibited substantial variation over time.

Estimates produced by the General Directorate of Rural Services in 1970 reported a rangeland area of 21.6 million hectares. In contrast, the rangeland area identified under the Rangeland Law in 2024 declined to 13.2 million hectares, indicating an overall reduction of approximately 39%. At the regional scale, the most pronounced losses have occurred in the Central Anatolia Region (Table 1).

Whereas the grasslands of Europe generally occur under humid climatic conditions, the rangelands of Türkiye are predominantly characterized by arid and semi-arid steppe formations. The rangeland vegetation of Türkiye comprises a synthesis of diverse ecosystems, including the characteristic plain and mountain steppes of Central Anatolia, alpine and subalpine grasslands at higher elevations, and maquis/shrub–steppe transition zones in the Mediterranean region [16]. In terms of spatial distribution, rangelands in Türkiye are concentrated primarily in the Central Anatolia and Eastern Anatolia regions, where continental climatic conditions predominate. The Eastern Anatolia Region, owing to its high elevation and rugged topography that restrict the availability of land suitable for cultivation, encompasses approximately 35.42% of the country's total rangeland area [17].

Türkiye's rangelands constitute ecosystems of substantial global significance owing to their exceptional levels of biodiversity. Steppe rangelands located within the Irano–Turanian phytogeographical region are especially notable for their high species richness and levels of endemism. Anatolia hosts more than 3,000 endemic plant species [18], a substantial proportion of which are distributed within semi-natural steppe ecosystems. The endemism rate in the Central Anatolia Region is approximately 30% [19]. Moreover, these rangelands provide essential habitats for numerous rare plant and animal species that are considered to be of high conservation priority.

However, despite this rich ecological heritage, a dramatic decline in rangeland areas has been observed over the past century. In Türkiye, grassland–rangeland areas amounted to 44.2 million hectares between 1927 and 1934, corresponding to 58.12% of the country's total land area; by the 1950s. This figure had declined to 37.8 million hectares due to increasing agricultural mechanization and population pressure [20]. Between 1927 and 1950, grassland and rangeland areas decreased by 14.71% [21]. Over the past 70–80 years, grassland–rangeland areas have declined by approximately 60–70%, reaching a level of about 14.6 million hectares [1]. This reduction represents not only a loss in spatial extent but also a significant decline in biodiversity.

III. LEGAL STATUS

In Türkiye, rangelands are under the sovereignty and control of the state, while their usufruct rights are granted to one or more villages or municipalities [22]. Prior to the enactment of the Rangeland Law No. 4342 in 1998, which represented a major turning point for both environmental protection and the livestock sector, substantial losses occurred in rangeland areas throughout the country. According to the Rangeland Regulation issued pursuant to this law, rangelands are classified into four main categories based on their intended use and seasonal patterns of utilization:

1. Rangeland: Areas allocated or traditionally used for grazing livestock and harvesting forage, generally located near settlements and situated on plains or slopes.

2. Summer Pasture: Areas allocated or traditionally used for grazing livestock and forage utilization during the summer season, where farmers reside temporarily with their animals; these areas are typically located at higher elevations.

3. Winter Pasture: Areas allocated or traditionally used for sheltering and grazing livestock during the winter season, usually characterized by milder climatic conditions and sheltered locations.

4. Grazing Land: Public grassland and grazing areas used for livestock grazing that do not fall under the definitions of rangeland, summer pasture, or winter pasture.

In Türkiye, rangelands are classified as public common property that cannot be subject to private ownership and are under the sovereignty and control of the State. The registration and protection of these areas are primarily governed by the provisions of the Rangeland Law No. 4342, and, in special cases, are further supported by other conservation legislation such as the National Parks Law No. 2873. Under the Rangeland Law, rangelands are not registered in the standard land registry but are instead recorded in a special Rangeland Registry, with only an annotation indicating their “rangeland” status entered in the land register. This legal arrangement renders the sale, transfer, or seizure of such land legally impossible. Furthermore, areas registered as rangelands are, with very limited exceptions (e.g., mining activities, energy infrastructure, or natural disasters), prohibited from having their rangeland status altered or being opened to construction. When a rangeland also falls within a protected area designation, conservation measures become even more stringent. If a rangeland is located within the boundaries of a National Park, Nature Park, or Wildlife Development Area, the provisions of the National Parks Law No. 2873 apply in addition to those of the Rangeland Law No. 4342. In such cases, the applicable Long-Term Development Plan takes precedence over standard rangeland use regulations. For example, even if grazing is permitted under the Rangeland Law, a national park management plan may completely prohibit grazing in a specific area to protect an endemic plant species.

In Türkiye, the Tek Tek Mountains National Park in Şanlıurfa and the Kızılkuyu Wildlife Development Area are steppe ecosystems that exhibit rangeland characteristics while simultaneously being subject to strict conservation regimes aimed at preserving biodiversity.

As Türkiye is not a member of the European Union, Natura 2000 and the Common Agricultural Policy (CAP) are not directly binding; however, de facto implementation exists through harmonization legislation and programmes such as IPARD. Natura 2000 represents the European Union’s most important nature conservation network. In Türkiye, the establishment of this network remains at the “preparatory” stage, with potential Natura 2000 sites being identified within the framework of the EU accession and harmonization process.

Pilot studies have been conducted particularly in forest and wetland ecosystems. The Anatolian steppes possess a level of biological diversity far exceeding that of their counterparts within the European Union. One of the most concrete examples of adapting the Natura 2000 approach to Turkish rangelands is the "Conservation and Sustainable Management of Steppe Ecosystems Project," implemented through cooperation between the Ministry of Agriculture and Forestry and FAO. This project underscores the concept of "Protected Rangelands." Currently, Turkish legislation does not include a formal designation equivalent to "Natura 2000 sites." Instead, conservation objectives are pursued through alternative legal classifications such as "Strictly Protected Sensitive Areas" and "Qualified Natural Protection Areas," both of which serve functions broadly comparable to those of Natura 2000.

The cross-compliance rules related to rangelands under the EU's Common Agricultural Policy (CAP) are applied in Türkiye indirectly. The EU's rural development grant programme, IPARD, is implemented in Türkiye, and enterprises benefiting from this fund are required to comply with EU environmental standards. In order to be eligible for support, farmers must adhere to the standards of Good Agricultural and Environmental Conditions (GAEC). For rangelands, these standards include implementing erosion control measures, maintaining the organic matter status of rangeland soils, and preventing the pollution of water resources, particularly nitrate contamination.

While farmers in the European Union receive direct area-based payments in return for conserving rangelands, an equivalent system has not yet been fully implemented in Türkiye. Instead, support related to rangeland management is provided primarily through indirect mechanisms, including forage crop subsidies and shepherd support schemes.

IV. PRODUCTIVITY

The current utilization patterns of semi-natural rangelands in Türkiye vary according to the legal classifications defined under the Rangeland Law No. 4342, as well as the geographical and socio-economic characteristics of each region; however, they are generally characterized by intensive grazing and a focus on roughage production. Across Turkish rangelands, continuous and unplanned grazing practices, commonly described as free grazing, remain widespread. These practices prevent vegetation from setting seed and impede the natural regeneration of plant communities. High-altitude summer pastures are typically grazed during the summer months, whereas winter pastures are used for sheltering livestock and limited grazing during the winter. This seasonal pattern reflects the persistence of the historical transhumance tradition. Meadows, which are classified as a distinct land-use category under the Rangeland Law, are used primarily for hay production through mowing rather than for direct grazing. Nevertheless, meadow areas in Türkiye remain relatively limited in extent and are estimated to cover approximately 1.5 million hectares [23]. In some cases, rangelands are managed for multi purposes. For instance, a portion of a rangeland may be allocated to hay production for several years following improvement practices, while other sections are reserved for controlled grazing. This approach enables farmers to meet their winter feed requirements while avoiding continuous grazing pressure on the entire rangeland area.

In Türkiye, the total livestock population, which amounted to 57.4 million head in 1994 (12.2 million cattle and 45.2 million small ruminants), declined to 35.0 million head by 2009 (10.8 million cattle and 24.2 million small ruminants), and subsequently increased steadily to reach 71.8 million head (16.9 million cattle and 54.9 million small ruminants) [1]. In contrast, the continuous decline of rangeland areas until the 1990s, followed by their stabilization in the subsequent period, has led to a progressive reduction in rangeland area per livestock unit. While 3.38 hectares of rangeland were available per livestock unit (LSU) in 1940, this figure has decreased to approximately 0.29 hectares at present [1]. This trend indicates a substantial increase in grazing pressure on rangelands and a corresponding weakening of vegetation cover. Indeed, large-scale assessments have shown that only 12.4% of Türkiye's rangelands are capable of producing high-quality forage for livestock, whereas the remaining 87.6% are classified as being in moderate or poor condition [14].

At the global scale, the condition of rangelands has reached a critical threshold due to climatic factors and the impacts of grazing animals on vegetation. Minea et al. (2022) reported that approximately 20% of rangeland areas have been degraded by factors such as overgrazing, soil compaction, and erosion, with this degradation being particularly severe in arid and semi-arid regions [24,25]. However, recent reports indicate that the situation is even more alarming. According to United Nations assessments, nearly 50% of the world's rangelands are currently classified as degraded [26], and only about 10% are effectively safeguarded against these threats [27]. In Türkiye, the situation is considerably more severe, with rangeland degradation rates reaching up to 85% [27]. Studies conducted across different rangeland ecosystems in the country have reported wide variation in vegetation ground cover. Şahin Demirbağ et al. (2025) reported ground cover rates ranging from 8.2% to 28.3% [23], while Taşdelen and Özyazıcı (2022) reported values between 67.10% and 76.60% in Siirt Province[28]. Similarly, Dönmez and Hatipoğlu (2024) reported vegetation cover ranging from 32.3% to 66.3% in different rangeland ecosystems [29].

It is a well-established fact that a substantial proportion of rangelands that have been intensively utilized over long periods throughout Anatolian history have gradually degraded and now rank among the world's low-quality rangeland types [30]. Studies conducted in different grassland ecosystems in Türkiye report that dry grass yield varies between 500 and 1,500 kg/ha in free-grazing grasslands and between 2,000 and 3,500 kg/ha in protected areas. In grazing areas, crude protein yield is low and ADF and NDF ratios are high, while in protected areas, crude protein yield is high and ADF and NDF ratios are low [31,32].

Although the Rangeland Law and related regulations impose various restrictions aimed at rangeland conservation, uncontrolled and unrestricted use continues in practice in many regions. According to the legislation, adherence to prescribed grazing start and end dates and the avoidance of stocking rates that exceed the carrying capacity of rangelands are mandatory requirements. However, these regulations are often not effectively enforced in practice. This situation has particularly increased soil loss in the sloping rangelands of Central Anatolia and has substantially weakened the natural regeneration capacity of these ecosystems. Although penalties equivalent to three times the minimum grazing fee per animal are stipulated for illegal grazing, inadequate monitoring and enforcement have rendered this provision largely ineffective in most regions. As a result, adverse processes such as thinning of vegetation cover, increased soil erosion, and declining ecosystem productivity continue to prevail in rangelands. Nevertheless, it should also be noted that the complete exclusion of grazing may allow a limited number of species to dominate, ultimately leading to a reduction in biodiversity.

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C. Editorial comparative synthesis

I. KEY INDICATORS

Table 1 summarises the minimum comparable indicators on grasslands/SNGs across partner countries. Since SNGs are often not captured as a stand-alone statistical class, the table relies on the most relevant proxy categories (e.g., extensively managed grasslands, permanent grasslands, meadows and pastures, rangelands), which are explicitly indicated. The overview highlights both differences in data sources/definitions and shared long-term pressures, particularly the balance between intensification in accessible areas and abandonment in marginal areas.

Table 1. Key indicators: cross-country overview

Country	Proxy/ category used	Area (ha)	Share	Main concentration	Trend / note
Austria	Extensively managed grasslands (proxy for SNGs)	0.62 million ha (of 1.32 million ha permanent grassland)	ca.47% of permanent grassland extensive	Alpine & pre-Alpine regions (e.g., Styria, Salzburg, Tyrol, Carinthia, Vorarlberg)	Long-term decline; intensification vs abandonment
Poland	Permanent grasslands	2.61 million ha (2.29 Mha meadows; 0.32 Mha pastures)	ca.20% of agricultural land	NE Poland and mountain/Carpathian areas with higher shares	Decline from ca.3.85 Mha (2000) to ca.2.61 Mha; strong reduction in pastures
Serbia	Meadows and pastures (proxy for SNG resource base)	469,228 ha (Agricultural Census 2023)	14.5% of UAA	Central and Western Serbia (highest), then SE Serbia	2020–2024: pastures −ca.27% (possible break in series); meadows more stable

Country	Proxy/ category used	Area (ha)	Share	Main concentration	Trend / note
Spain	Permanent grasslands as proxy; SIGPAC/CAP eligibility criteria influence mapping	8.53 million ha (ESYRCE 2024)	n/a (varies by source/definition)	Castile and León, Extremadura, Andalusia, Aragón, Castile-La Mancha	Methodological differences (ESYRCE vs Eurostat) and administrative criteria may underestimate silvopastoral grazing areas
Türkiye	Rangelands registered under Rangeland Law	13.2 million ha (cadastral identification completed)	ca.17% of territory	Central and Eastern Anatolia	Long-term decline (e.g., 21.6 Mha in 1970 to 13.2 Mha in 2024; ca.−39%)

Table 2 outlines how SNGs are typically used (mowing, grazing, or mixed systems) and which policy instruments most directly influence management decisions. These differences in policy design and enforcement capacity help explain why similar pressures (e.g., abandonment, overgrazing, or intensification) can lead to different outcomes across countries, and they set the stage for the comparative analysis of pressures and responses presented in the following section.

Table 2. Dominant use and key policies / instruments (SNG proxy)

Country	Dominant use	Key policies / instruments
Austria	Mowing and grazing; dairy multi-cut meadows; mountain hay meadows (1–2 cuts); alpine summer grazing.	CAP 2023–27; ÖPUL agri-environment; GAEC; Natura 2000; provincial nature laws.
Poland	Hay meadows (2–3 cuts); grazing on pastures; mixed hay–pasture; rotation where feasible.	CAP GAEC (PG protection); eco-schemes (from 2023); AECM; Natura 2000; protected areas.
Serbia	Mowing and grazing mosaic: mowing in lowlands; freer grazing in mountains; mixed use in hilly areas.	Agricultural Land Law; Agriculture & Rural Development Law (IPARD); Nature Protection & Environment laws; GAP rulebook.

Country	Dominant use	Key policies / instruments
Spain	Extensive grazing (sheep/beef/goats; dehesa); some mowing/hay; hay/silage from spring surplus.	CAP 2023–27; eco-schemes (extensive grazing, sustainable mowing); SIGPAC+PEC; PLE; Natura 2000.
Türkiye	Mainly grazing (often continuous); seasonal summer/winter pastures (transhumance); limited hay meadows.	Rangeland Law 4342 and Registry; Rangeland Regulation; National Parks Law (where relevant); IPARD (GAEC-type conditionality).

II. COMPARISON OF PRODUCTIVE PARAMETERS

Table 3 compares the available indicators of management intensity, productivity and biodiversity relevance across partner countries. Because metrics are not collected in the same way everywhere, and SNGs are often not reported as a separate statistical class, the table combines reported values with clearly labelled proxy indicators, and uses n/a where information is not available. The overview shows that productivity and intensity benchmarks are most explicit in Poland and Serbia, while Türkiye provides strong pressure and condition signals through rangeland-specific indicators, and Spain offers system-level stocking references (e.g., dehesa) rather than harmonised national yields. These differences are essential for interpreting cross-country pressures and for assessing which management practices are realistically transferable.

Table 3. Dominant use and key policies / instruments (SNG proxy)

Country	Dominant management (proxy)	Stocking / use intensity (available)	Productivity indicator (available)	Biodiversity proxy / note	Main limitation for comparability
Austria	Intensive vs extensive systems; extensive = proxy SNG	n/a	ca.6–7 million t DM/year (macro)	Extensive systems linked to SNG conservation	Macro total, not per ha; not SNG-only

Country	Dominant management (proxy)	Stocking / use intensity (available)	Productivity indicator (available)	Biodiversity proxy / note	Main limitation for comparability
Poland	Mainly mowing and mixed use (context-dependent)	208 cattle/100 ha; ca.9 sheep/100 ha	8–10 t DM/ha/yr (fertile meadows); ca.60% potential used	High nature value depends on low-intensity regimes	Values not specific to SNG subset everywhere
Serbia	Meadows/pastures; mixed mowing & grazing	1.58 LU/ha (macro)	2024: 1.5 t DM/ha (meadows); 1.1 t DM/ha (pastures)	Biodiversity varies strongly by site/management	National averages; strong regional heterogeneity
Türkiye	Rangelands; often continuous grazing	ca.0.29 ha/LSU (pressure proxy)	500–1,500 kg/ha (free - grazing grasslands); 2,000–3,500 kg/ha (protected areas)	Only small share in good condition (degradation signal)	Different unit system; condition-based reporting
Spain	Permanent grasslands proxy; dehesa key system	Dehesa: ca.0.30–0.50 LSU/ha	n/a (no uniform national yield system for SNG)	Intensification ↑ production short-term but ↓ biodiversity/resilience	Lack of harmonised yield data; admin criteria affect stats

III. MAIN PRESSURES AND TYPICAL MANAGEMENT RESPONSES

Across countries, the dominant trade-off is between intensification in accessible areas and abandonment in marginal areas, compounded by climate stress. The table 4. summarises the most frequently reported pressures and the typical management responses.

Table 4. Main pressures and management responses

Pressure / issue	Typical manifestation	Typical responses (management and policy)	Notes on transferability
Abandonment or underuse leading to shrub encroachment	Loss of open habitats; succession; reduced management in marginal zones	Extensive mowing and controlled grazing; shrub control; targeted incentives for active management	Highly transferable; requires continuity and local capacity
Overgrazing or uncontrolled grazing	Vegetation degradation; reduced regeneration; soil erosion	Carrying-capacity setting and monitoring; seasonal rules (start and end dates); rotational or adaptive grazing; enforcement	Transferable where monitoring and compliance mechanisms exist

Pressure / issue	Typical manifestation	Typical responses (management and policy)	Notes on transferability
Intensification and conversion	Higher inputs and mowing frequency; fertilisation; drainage; conversion to arable/forage crops	Agri-environment measures and eco-schemes rewarding low intensity; restrictions in protected areas; guidance on input levels	Transfer depends on policy instruments and farmer uptake
Climate-related stress (drought, heat, and Mediterranean wildfires)	Earlier senescence; yield variability; higher fire risk; steppe vulnerability	Feed planning and conservation of spring surplus (hay/silage); adaptive stocking; maintain vegetation cover; fire-prevention grazing	Transferable but context-dependent (aridity, infrastructure, markets)
Data and definition gaps (SNGs not reported as a separate statistical category)	Different proxies and mapping criteria across countries	Transparent proxy use; harmonised minimum indicators; integration of multiple datasets and maps	Transferable as a reporting standard; improves comparability

IV. TRANSFERABLE METHODS

Transferable methods are practical management approaches or policy instruments that have proven useful in one context and can be adapted to another, provided key enabling conditions are met.

Table 5. Examples of transferable methods

Method	Country example	Preconditions for transfer	Expected benefit	Limitations / risks
Carrying-capacity based grazing and seasonal rules	Türkiye (rangeland law; start/end dates and carrying capacity rules)	Local capacity assessments; monitoring and enforcement; user coordination	Reduced degradation and erosion; improved vegetation recovery	Weak enforcement undermines effectiveness
Agri-environment incentives for extensive management	Austria (ÖPUL/CAP support for biodiversity-friendly grassland use)	Administrative instrument and budget; clear eligibility and controls	Stabilises extensive management and biodiversity outcomes	Bureaucracy; risk of paying for paper compliance
Conservation of spring surplus as hay/silage	Spain (adaptation to drought and earlier senescence)	Mowing and storage logistics; feed planning; labour and mechanisation	Higher feed security in dry years; resilience to variability	Upfront costs and labour demand
Extensive mowing with biodiversity-oriented timing	Poland (timing and frequency of mowing for habitat maintenance)	Agreement on objectives; access to machinery; compliance in protected areas	Maintains plant diversity and prevents succession	Rigid timing may not fit all sites and years

Method	Country example	Preconditions for transfer	Expected benefit	Limitations / risks
Adaptive or rotational grazing (livestock moved at ca. 40–50% utilisation)	Serbia (recommendation for pasture management)	Fencing and water supply; planning; labour	Improved sward recovery and more stable production	Higher management complexity and infrastructure needs
Transparent use of proxies and multi-source mapping	Spain (permanent grassland proxy; SIGPAC/CAP mapping constraints)	Data integration; methodological transparency; GIS capacity	More realistic resource picture; better policy targeting	Regional heterogeneity; differing criteria

V. CONCLUSION - KEY MESSAGES AND RECOMMENDATIONS

The comparative review confirms that semi-natural grasslands across partner countries are simultaneously a production resource and a key green infrastructure for biodiversity and climate resilience. The most common pressures follow a similar pattern: intensification in accessible areas and abandonment in marginal areas, while climate change increases variability and risk (especially drought and fire in Mediterranean contexts and vulnerability of steppe systems in arid zones). A practical transferable core package of solutions includes:

1) grazing pressure aligned with carrying capacity and seasonal rules supported by monitoring,
2) incentives that reward actual management outcomes (e.g., extensive mowing and grazing, and habitat openness),
3) drought-adaptation through feed planning and conservation, and
4) transparent reporting and proxy use to improve cross-country comparability.

Recommendations:

- Ensure that support instruments are linked to actual management outcomes (e.g., habitat openness and biodiversity-friendly mowing and grazing), rather than to administrative categories alone.

- Strengthen monitoring and enforcement where rules exist but implementation is weak.
- Prioritise adaptive management to address drought and fire risks through feed conservation and seasonal planning.

SMART STEP

Climate-Smart Steps in
Grassland Management and Improvement

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