Chapter 10

Sustainable Pasture Management

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Abstract

Grasslands which are a major part of the global ecosystem, covering 37% of the earth's terrestrial area, have a significant contribution to food security through providing most of the energy and proteins required by the ruminants used for meat and dairy production. Grasslands are considered to have the potential to play a fundamental role in climate change mitigation, particularly regarding carbon storage and sequestration and for biodiversity preservation. This chapter provides an overview of the causes of the pasture degradation and some essential elements for sustainable management, which aims to improve the quantity and quality of pasture, mitigation of climate change and biodiversity preservation. Another point of this chapter is the grasslands with high nature value that nowadays is a top priority in the European legislation as the European Commission has confirmed that HNV farming will remain a key priority in 2014–2020. We present the situation in Bulgaria because it is one of the first member state countries that have assessed HNV regions and put funding in place to support them.

Keywords: grasslands, grass composition, perennial grasses, uncontrolled grazing, sustainable management, rotational grazing, high nature value (HNV), Bulgarian grasslands

1. Introduction

Future challenges related to the sustainable management of natural resources and investments in food production, agriculture and biotechnology research can be summarized as follows: global population growth (the population of the earth will be about 9.2 billion in 2050), global climate change and its adverse impact on agriculture [1], depletion of natural resources with significant importance for the development of world agriculture (e.g. global phosphorus deposits), food safety and security and new ethical requirements for producers.

Grasslands which are a major part of the global ecosystem, covering 37% of the earth's terrestrial area, have a significant contribution to food security through providing most of the energy and proteins required by the ruminants used for meat and dairy production. Grasslands are considered to have the potential to play a fundamental role in greenhouse gas (GHG) mitigation, particularly regarding carbon storage and sequestration. Conant et al. [2] conclude that grasslands can act as a significant carbon sink with the implementation of improved management. According to the estimation of FAO [3], global carbon stocks in grasslands is about 343 Gt C, which is about 50% more than the amount stored in world forests.

O'Mara [4] indicates that grazing management and pasture improvement have a global technical potential for mitigation of almost 1.5 Gt carbon dioxide equivalents in 2030, with additional reduction possible from the restoration of degraded lands. According to Nordborg and Röös [5], the total carbon storage potential in pastures does not exceed 0.8 tons of C per ha and year or 27 billion tons of C globally. During the last years, many researchers studied the function of grasslands as a carbon sink and the main factors affecting the storage process [2, 5–11, 46]. According to some authors [6, 9, 10, 12, 18, 22, 27], soil's grazing intensity (under- and overgrazing) can lower carbon sequestration or lead to carbon losses. These authors observed effects of grazing mediated by changes in the removal, growth, carbon allocation and flora in pastures and carbon input from ruminant excreta, which affect the amount of carbon in soils [27, 36, 40].

The results of the studies conducted by Alemu et al. [14] indicated that grazing management practices impacted greenhouse gas (GHG) intensity of beef production by affecting diet quality, animal performance and soil C change. It also emphasizes the importance of accounting for all emission sources and sinks within a beef production system when estimating its environmental impacts.

2. Effect of continuous (uncontrolled) grazing on grasslands

Formation and development of grass compositions in meadows and pastures were conditioned with the influence of soil and weather, relief, altitude, plant species interactions, microorganisms, animals and humans. All these factors are interrelated and constantly changing due to variations in the species composition and the quantitative ratio of the different species and groups. Plants in meadows and pastures are changing relatively fast under the influence of different anthropogenic pressures, which can cause both positive and negative changes.

Many high nature value pastures have been abandoned. The meadow mowing has been ceased, which leads to developing of more aggressive grass species, shrubs and trees. Wood and shrub forms begin due to uncontrollable spread or the existence of a forest near the grassland, which gradually spreads from the end to the middle of the area.

Due to the weak animal's grazing efficiency in seminatural grasslands, many of them are degraded and turned into arable land, orchards or vineyards.

This leads to the irreversible loss of diversity of plant species as well as of vertebrate and invertebrate species.

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The economic status of meadows and pastures is determined by different characteristics of the grasses in them, while the most important indicator is the lawn productivity in normal climatic conditions, which depends on the soil fertility and regimen of use.

Another indicator of the economic status of meadows and pastures is the quality of green mass and hay, which is determined by the degree of acceptance by the animals, nutritional value (protein, vitamins, mineral, salts) and digestibility of the plant species which are part of the grassland.

Many plant species from different botanical families are found in natural meadows and pastures. In comparatively similar areas, soil and climatic conditions, the number of species in grasslands often exceed 50–60. Meadow and pasture grasses are divided into three groups, cereals, legumes and grasses, from other botanical families, which are referred to as "various plants."

The widest distribution among grasslands has the species from Poaceae family up to 50–90% of the grass [15, 16]. This is due to their highly competitive ability, longer shelf life and durability of unfavorable climatic and soil conditions. Cereal grasses are wanted component in the grasslands because they supply the animals with easily digestible and rich of nutritions biomass. They also protect the soil from water and wind erosion due to dense grass they develop.

Legumes have the highest nutritional value but are less widespread—very often with 6–10%. Their seldom occurrence in meadows and pastures is due to their greater rigor to the environment and the less durability of most species in the family. Only in conditions very favorable to their development, they can reach 50–60% [15, 16]. Compared to cereals and various plants (from other botanical families), legumes are less common in meadows and pastures. They are not a constant element of grasslands, and their participation is strongly influenced by climatic conditions—in wet years, the so-called clover years are more abundant, and in dry years, their involvement is insignificant. Increasing legumes is a way to improve the quality of grassy biomass, as they are rich in proteins, minerals and vitamins. Their higher number in grasslands improves the nitrogen balance of the soil and promotes the more active development of the other species.

The distribution of the various species (from other botanical families), in grasslands, is determined by the peculiarities of the environment—their participation varies from 10 to 60% [15, 16]. This group is distinguished by a great variety of species—there are about 200, with different nutritional values [15]. This group is represented in mountain meadows and high mountain pastures as well as in wet meadows and pastures.

In the grass cover of meadows and pastures, the perennial grasses of these groups prevail. One-year species rarely occur, with greater participation in degraded grasslands as well as in abandoned orchards. These species are important for early grazing in the southern and southeast parts of Bulgaria [16, 28].

Proper and regulated pasture loading is of paramount importance for ensuring quality grazing with valuable botanical composition, conservation of species diversity and longer use. Still, in many countries, free grazing is applied, which damages both the grasses density and species proportion in grasslands.

Also, soil compaction leads to a change in its physical properties, which affects the development of the grass. Species that require better aeration quickly drop out of grasslands and in their place develop more stable grasses that are less productive and inferior in quality. In this way of grazing, only 40% of the grass is used [45].

Grazing has a strong influence on grass composition. Changes in grassland under the grazing influence depend on the kind of animals, the time and the way of grazing, the soil conditions, the grassland peculiarity, etc. [44]. Grazing early in the spring can suppress some valuable species and allow domination of the weeds [16, 18].

The soil compaction increases the number of rhizomatous grasses that are less sensitive to soil aeration and reduces the participation of the demand in this regard of rhizome and high-growth bunch grasses.

In moderately wet pastures, grazing contributes to consolidation and compaction of the sward, and in damp pastures, trampling can lead to swamping and allow invasion of some weeds, casing poaching. In the dry grasslands, the steady treading leads to shattering a grass cover. The unfavorable influence of treading strongly occurs at unsystematic grazing when the animals move freely and stay for a long time in the pasture. It is stronger when the pasture was used by cattle. The grass composition in grasslands significantly changes with the grazing and species selection from the animals during grazing. Under the influence of grazing some plants, fall off the grassland. During the grazing, the animals eat almost entirely the leaves of tall grasses, which make their recovery difficult, and they are relatively quickly dropped out of the grassland. Low-growth and rosette plants are recovering faster as they retain their basal leaves and take the lead in grassland. They are well preserved in pastures and species with creeping, rooting stems and inflorescences near the soil surface (white clover, knotgrass, etc.).

In grazing, animals prefer certain plants, while others avoid. In the case of unsympathetic grazing, the species that animals avoid form seeds, and the grasses they prefer reduce their vitality and gradually fall out of grass. In rotational grazing, the influence of the animal selection during grazing is almost eliminated, while the rest of the plants were harvested, until they are re-grazed and with the practice of cutting the grass, left after the grazing, is complete in each grazing cycle. In case of free grazing, the influence of the different animals on grassland components is also more pronounced. It was known that the sheep graze the grass shallow, making it difficult to restore the common pasture grasses, but cattle partially plucked up some species during grazing.

This effect was observed in many investigations [4, 19, 20], reduced growth, tiller numbers, plant cover and changes in botanical composition.

Early spring and late autumn grazing reduce the participation of valuable pasture grasses, which have not accumulated enough reserves to overcome early grazing and survive during winter. This grazing leads to an increase in the participation of the first developed annual species that grow up by seeds.

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In cattle grazing, hard stools have some adverse effects. The plants below them suffocate and die, and some nitrophilic species develop around them. The larvae of some insects and helminths that cause animal diseases develop in the field. The urine, rich in nitrogen, favors the development of valuable species.

Intensive grazing is depleting the soil, despite the fact that part of the grass-fed nutrients was restored to the soil with animal stools. Soil degradation reduces the participation of valuable pasture grasses which are demanding for the presence of nutrients and increases the involvement of the low-productive, medium-quality, densely tufted grasses.

The negative consequences of nonsystemic, uncontrolled grazing can only overcome by introducing an appropriate grazing regime. Systematic and organized grazing (regular or parcel) would help to preserve species diversity and grass density.

3. Grazing management

Grazing management—combining animal, plant, soil and other environmental components and the grazing methods by which the system is managed to achieve specific goals—improved pasture condition, higher forage yields and animal production with ecological concern [16].

The sustainable grazing management includes a proper stocking rate, livestock type and recovery time for grass regrowth after grazing. It is important to consider the effect of grazing management on pasture growth, tiller density, pasture quantity and quality and soil properties. Many factors affect quantity and quality of pastures like farm topography, weather variation among the seasons, botanical composition, herbage cover, stocking rate, seasonal grazing, anti-quality compounds in grasses and application of different practices [23, 24].

Rotational grazing was a component of the institutional and scientific response to severe rangeland degradation at the turn of the twentieth century, and it has since become the professional norm for grazing management [25, 31].

What is rotational grazing—all cases in which only one part of pasture is grazed while all other parts rest? That means that the pasture is divided into a certain number of small areas (paddocks), and the livestock can use only one of them. In this case, the grazing animals are moved from one paddock to another and are thus forced to graze much of the grass. In all other (resting) parts, the grass can renew its energy reserves deepen the root system and in the future time to give a maximum production.

Why use rotational grazing? All over the world, people with livestock and grazing land can benefit from rotational grazing. This has some advantages, called benefits such as economic benefits, time savings, environmental benefits, esthetics and human health benefits, better animal health, etc.

A rotational grazing system is preferred in pasture-based animal production because meat from cows and lambs has better quality with less fat, more vitamin E [26, 29] and higher levels of omega-3 and conjugated linoleic fatty acids than grain-finished products [17, 21, 30].

The fundamental advantage for the animals in grazing systems is that the livestock in pastures is healthier than these housed in confinement. The key of sufficient rotational grazing is determination of the number and size of paddocks, water supply for livestock and fence type. Determination of the suitable number of paddocks depends on the time required for grass regrowth (**Table 1**) and grazing period that is varied from 4 to 6 days.

Many authors in their publications present different grazing management models with the consideration of periods of strong growth and animal pressure [7, 43]. Many farmers in countries with hill pastures applied adopted regime with 3 days per paddock and high stocking rate [23].

Jacobo [32] observed that productivity and sustainability might be compatible by replacing continuous with rotational grazing. The reason is that rotational grazing promoted functional groups composed of high forage value species and reduced bare soil through the accumulation of plant residues. These changes indicate an improvement in rangeland condition and in carrying capacity.

These results are relevant to the other authors. As an example, Pavlů et al. [13] studied continuous stocking and rotational grazing. On the base of the databases, authors conclude that vegetation varied as a result of time and differences between treatments. Several prostrate dicotyledonous species (*Trifolium repens* L., *Taraxacum* sp., *Bellis perennis* and *Leontodon autumnalis*) increased under continuous stocking. This treatment also promoted the growth of the perennial grass *Lolium perenne* L., which was able to cope with frequent defoliation. Tall grasses sensitive to frequent defoliation (*Poa trivialis* L., *Holcus mollis* L., *Alopecurus pratensis* L., *Dactylis glomerata* L. and *Elytrigia repens* L.) were more abundant in rotationally grazed paddocks. Species diversity was not significantly influenced by the different grazing systems. The decrease in the potential sward height under continuous stocking revealed the replacing of tall dominants by lower species. Information about pasture management should, therefore, involve not only grazing intensity but also the grazing system used.

The new opportunity to improve the management and welfare of extensively produced beef cattle is to combine technologies for monitoring the spatial behavior of livestock with technologies that monitor pasture availability. According to Manning et al. [33], the Global Navigation Satellite System (GNSS) technology could determine livestock grazing preference and hence improve management and paddock utilization. The cattle behavior changed, highlighting how technologies that monitor these two variables may be used in the future as management tools to assist producers better manage cattle and to manipulate grazing intensity and paddock utilization.

Species	Cool weather	Hot weather
Cool season grasses	14	35–50
Warm season grasses	35–40	21
Legumes	21–28	21–28

Source: Blanchet et al. [31].

Table 1. Optimal rest period for forage species in days.

Sustainable pasture management including the application of new technologies has several environmental advantages over tilled land—significantly decrease soil erosion, require minimal pesticides and fertilizer usage and reduce the amount of barnyard runoff. This leads to the conclusion that, taking advantage of wildlife, we can also increase the pasture productivity.

4. High nature value (HNV) grasslands in Bulgaria

By definition high nature value (HNV) farmland represents areas where "agriculture is a major (usually the dominant) land use and where that agriculture supports, or is associated with, either a high species and habitat diversity or the presence of species of European, and/or national, and/or regional conservation concern, or both" [34, 35]. The majority of HNV farmland and in Europe comprises seminatural pastures, meadows and orchards as well as various landscape elements [35, 38]. Around one-third of the agricultural area in Bulgaria is potentially of high nature value, and the most significant share of it is seminatural pastures and meadows [41, 45]. The figures below visualize high nature value grasslands in Bulgaria: flower-rich meadows in Elena municipality (**Figure 1**), species-rich pastures in Central Balkans (**Figure 2**) and species-rich pastures in Eastern Stara Planina (**Figure 3**).

HNV grasslands are of particular importance for nature conservation and the European ecological network of protected areas of Natura 2000. There are 18 habitats of natural and seminatural grassland ecosystems in the Bulgarian Natura 2000 sites, which cover between 15 and 20% of their territory [37].

Key features of the HNV farming systems are the low inputs, low outputs and high labor requirements usually resulting in a significant number of species and structural diversity in space and time [38]. The practices most often associated with HNV pastures and meadows are extensive grazing as presented on **Figure 4** and cutting hay (mowing) once or twice per year. **Figure 5** shows traditional hay storage still preserved in Western Stara Planina.

Figure 1. Flower-rich meadows in Elena municipality (June 2012, Y. Kazakova).

Figure 2. Species-rich pastures in Central Balkans (July 2016, Y. Kazakova).

Figure 3. Species-rich pastures in Eastern Stara Planina (June 2012, Y. Kazakova).

However, the modernization of agriculture inevitably leads to the intensification of the traditional practices and decrease in the high nature value. For example, over 90% of the grassland habitats in the European ecological network Natura 2000 are in unfavorable conservation

Figure 4. Extensive sheep grazing in Central Stara Planina (July 2016, Y. Kazakova).

Figure 5. Traditional hay storage still preserved in Western Stara Planina (November 2014, Y. Kazakova).

status [37]. The two extreme examples are the loss of HNV grasslands due to conversion to intensive meadows or even arable land and the abandonment of farming in areas unsuitable for intensification. **Figure 6** presents scrub overgrowth and closure of landscapes in abandoned grasslands in Western Stara Planina.

The trend is best revealed by the statistical data on grasslands in Bulgaria, presented in **Figure 7** (BANCIK MAF, 2000–2016). The total area of grasslands in Natura 2000 was just over 1.8 million hectares. In 2015, it was down to 1.36 million hectares, a decrease of 24% [41].

Overall, grasslands cover around one-third of the agricultural area in Bulgaria. In the agricultural land use surveys, they are divided into four grassland groups:

1. Permanent productive meadows, which can be natural or planted for longer than 6 years and can be used either for mowing or for grazing. Their area decreased by 38% from 2000 to 2015. Due to their high productivity, they are often converted to arable land.

Figure 6. Grasslands abandonment leads to scrub overgrowth and closure of landscapes in Western Stara Planina (April 2015, Y. Kazakova).

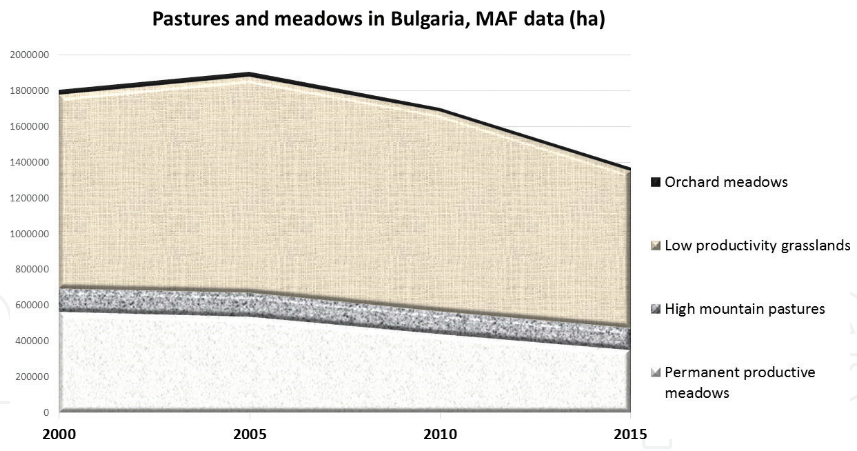

Figure 7. Total area of grasslands in Bulgaria (2000–2015).

2. High mountain pastures are located at altitudes between 1000 and 1500 m a.s.l. and are used for summer grazing of livestock. Their area is most stable in comparison to other grassland groups—it decreased by only 6% from 2000 to 2015.
3. Low productivity grasslands—usually used for grazing.
4. Due to their low productivity, they are never mown. They decreased by 19% from 2000 to 2015 mostly due to an abandonment of farming (**Figure 7**).
5. Orchard meadows, which are permanent productive pastures in orchards with less than 100 trees per hectare. Their area decreased the most, by 46%, from 2000 to 2015.

Another negative tendency for the loss of HNV grasslands is their sale for development. The extensive land use and the species-rich grasslands, as well as the site's characteristics, often create landscapes that are attractive for tourists as shown in **Figure 8**. This creates development pressure, and the values that attracted visitors ultimately were lost.

Figure 8. Grasslands for sale: the attractive high nature value landscapes stimulate tourism development (June 2012, Y. Kazakova).

When HNV farmlands were first identified in 2007 in Bulgaria, the area of HNV grasslands was estimated at 951,256 ha [39]. Only 5 years later, in 2012, the HNV grassland area decreased to 809,530 ha [37]. Even if there were some methodological differences, the decreasing trend is unquestionable.

To preserve and maintain grassland areas of high nature value and the associated species, measures financed under the Bulgarian Rural Development Programme (2014–2020) [42] are being undertaken to promote or restore traditional management practices for seminatural grassland, as follows:

- Keeping the density of livestock units at 0.3–1 LU/ha according to the natural, climatic and soil conditions to ensure the good ecological status of meadows and pastures and maintenance of a permanent grass cover.
- A ban on the use of mineral fertilizers and pesticides.
- Cleaning of undesirable grass and shrub vegetation.
- Consecutive grazing.

Overall, HNV grasslands in Bulgaria require targeted policy support and improved management both from agricultural and conservation point of view to improve the current situation where the forage resources are decreasing because of the loss of grassland area; the natural quality of the remaining grasslands is also declining due to the intensification or abandonment of extensive, low-input practices.

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