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Abstract. In Greece, grazing animal nutrition widely derives from a combination of grazing lands, such as grasslands, woodlands, pasturelands, agricultural crops and grazed forests. Grasslands (i.e. land dominated by herbaceous vegetation) and woodlands (i.e. shrublands and forested pastures) constitute the majority of Greece's grazing lands covering more than 40 % of the country's area; they are called rangelands and are public lands, officially under state ownership. Grassland forage has a seasonal variability which produces two feed gaps, the first one during summer and the second one during winter. Shrublands may play an important role to grazing animal production because their shrub component provides green forage (evergreen shrubs: all the year round; deciduous shrubs: summer) when grassland forage is dry and of low nutritive value or absent. Moreover the shrub and herb component of shrublands complement one another ensuring an ideal feed for grazing animals almost throughout the year. Forests are the most common forage resource related to rangelands in Greece, especially when they are in open form, which allows the production of high amounts of forage in their understory composed by both herbaceous and shrubby plants. Stubble fields are used as complementary forage resource during summer while hay and concentrates produced on arable lands are used as supplements during winter. It is suggested that for a specific area the combination of several forage resources on a yearly basis must be organized in order to establish a successful, strong and viable animal husbandry system. National and EU policies have an impact on grazing lands, since land that is being used or managed for livestock farming is not be eligible for payments; since the way of how is determined what is or not eligible is of crucial importance for permanent grasslands, it has to be revised.

Keywords. Grasslands – Fodder plants – Forests – Grazing policy – Pastures – Rangelands – Shrublands.

Les ressources en pâturages et fourrages de la Grèce pour la production animale

Résumé. *En Grèce, la nutrition des animaux brouteurs provient largement d'une combinaison de pâturages, tels que prairies, terres boisées, pacages, cultures agricoles et forêts pâturées. Les prairies (à savoir les terres dominées par la végétation herbacée) et les terres boisées (arbustes et pâturages forestiers) constituent la majorité des pâturages de la Grèce, couvrant plus de 40 % de la surface du pays; on les appelle parcours ou terres publiques, officiellement propriété de l'État. Le fourrage des prairies présente une variabilité saisonnière qui entraîne deux périodes de soudure, la première en été et la seconde en hiver. Les arbustes peuvent jouer un rôle important pour la production d'animaux brouteurs car la composante arbustive apporte du fourrage vert (arbustes à feuilles persistantes: sur toute l'année; arbustes à feuilles caduques: en été) lorsque l'herbe des pâturages est sèche avec une faible valeur nutritive ou est absente. De plus les composantes arbustive et herbacée des zones d'arbustes se complémentent mutuellement assurant un aliment idéal pour les animaux brouteurs sur presque toute l'année. Les forêts sont la ressource fourragère la plus courante liée aux parcours en Grèce, en particulier lorsqu'ils sont ouverts, ce qui permet la production de grandes quantités de fourrage dans leur étage inférieur composé à la fois de plantes herbacées et arbustives. Les chaumes sont utilisées comme ressource fourragère complémentaire en été tandis que le foin et les concentrés produits sur les terres arables sont utilisés comme supplément en hiver. Il est suggéré pour une zone spécifique d'organiser une combinaison de plusieurs ressources fourragères sur une année pour établir un système d'élevage performant, fort et viable. Les politiques nationales ainsi que celles de l'UE ont un impact sur les pâturages, vu que la terre qui est utilisée ou gérée pour l'élevage n'est pas éligible pour les paiements; et vu que la façon de déterminer ce qui est ou n'est pas éligible est d'une importance cruciale pour les pâturages permanents, il faudrait réviser ce point.*

Mots-clés. *Prairies – Plantes fourragères – Forêts – Politique sur le pâturage – Pâturages – Parcours – Arbustes*

I – Introduction

Greece with an area of 132 thousands km^2 is an east Mediterranean country. Its climate is typically Mediterranean, ranging from the arid to the perhumid of Emberger's (1955) classification with a prolonged drought during summer. There are, however, variations among geographic areas (e.g., north - south or mainland - island) and among zones of the same area with different altitude (e.g., low plain, sub-mountainous and mountainous). The most significant of its features from the standpoint of forage production and management is that water is the main limiting and regulating factor for plant growth. Increase in soil water storage could contribute to an increase in biomass production, particularly in the driest zones; through improved evapotranspiration efficiency and greater precocity of plant growth (precipitation is concentrated in winter and early spring). Monthly temperature and rainfall details for specific areas of Greece's are shown in the dataset was produced by the Climatic Research Unit (CRU) of University of East Anglia (UEA): http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Europe&ThisCCode=GRC.

Livestock is economically important to the agricultural population of Greece. According to the Hellenic Statistical Service of Greece (2015), there are about 4.9 million goats which are of mixed indigenous types, 8.8 million sheep which are of mixed breed exhibiting a variety of coat colors and patterns, and 611 thousands cattle. Sheep and goats have many desirable characteristics that favor production in the less - developed regions of the country and can be produced with a low investment in land and labor. Biologically they have proven to be especially well adapted to the poor grazing conditions of the Mediterranean climate.

World livestock production is based in forage, which is produced in grazing lands and crops. The term grazing land refers to areas producing forage from native or introduced plants and harvested directly by animals without reference to land tenure or other land uses (Allen *et al.*, 2011). On a worldwide basis, grazing lands encompassing about 60% of the land area of the earth (Vallentine, 1990) and according their vegetation type are classified into several grazing land types (Stoddart *et al.*, 1975). In Greece, grazing lands have been separated into categories such as rangelands, pasturelands, grazed forests and grazed croplands. Rangelands determined as non-arable lands on which the present forage stand is projected for unlimited continuation (Vallentine, 1990) or according to Allen *et al.* (2011), as land on which the indigenous vegetation (climax or sub-climax) is predominantly grasses, grass-like plants, forbs or shrubs that are grazed or have the potential to be grazed, and which is used as a natural ecosystem for the production of grazing livestock and wildlife. Pasturelands are distinguished from rangelands by the fact that periodic cultivation is used to maintain introduced (non-native) forage species, and agronomic inputs such as irrigation and fertilization are applied annually (Holecheck *et al.*, 2004). Grazed forests and crop fields are lands providing forage as a secondary product which can be used during certain periods (e.g., grazing after the primary crop is harvested in a wheat field). Greece's grazing lands were never systematically surveyed and mapped, and only estimations are done by data collection from different sources. An authoritative estimation was done by Papanastasis and Pittas (1984) and according to that grazing lands cover more than 7.0 million ha but only a 5.2 million ha should be considered as rangeland, i.e. uncultivated land that will provide the necessities of life for grazing and browsing animals, for which scientific management could be applied (i.e. manipulation of rangeland components to obtain the optimum combination of goods and services for society on sustained basis; Holecheck *et al.*, 2004).

Over-grazing by livestock has caused major land degradation and soil erosion and this has a negative effect on animal production. Low livestock production levels and poor conditions are generally found throughout the country. The purpose of this study is to identify the forage/grazing resources of Greece and their use by grazing animals; and how it is affected by the National and European policies.

II – Ruminant livestock grazing systems

Ruminant livestock production is a major segment of Greek agriculture. The 2012 Census of Agriculture counted 179,525 farms with 14,284,805 animals (Table1). Cattle number has slightly reduced in the last years (2010 - 2012; reduction 3%); similarly, a reduction in sheep and goats was observed (1.4 and 4.5%, respectively). Sheep and goats are considered as the most significant livestock sector in Greece. Sheep and goat husbandry systems found in country have a strong tradition and they can be classified into four basic categories (Papanastasis, 1990; Hatziminaoglou *et al*., 1995), namely, (i) home-fed, (ii) intensive/semi-intensive (9 % of the sheep and 19 % of the goat population is estimated to classify into these two livestock production systems), (iii) extensive without transhumance (the majority of sheep (82 %) and goats (73 %) are classified into this system) and (iv) extensive with transhumance (nomadic system; nowadays only 8 % of Greece's goat and 9 % of sheep population are classified into this system). Both latter systems are found in less favored areas, in rather small sized flocks, based on the natural vegetation of grazing lands and produce both meat and milk which is transformed mainly into Feta cheese. In the extensive without transhumance, the animals stay in permanent installations near the villages and graze nearby. The grazing period ranging from 5 to 12 months, depending on the topography of the area where the farm is located and the grazing land types are found. In the extensive system with transhumance, the animals belong to hardy local breeds and are usually moved from low altitude areas to high altitude areas, exploiting the differences of vegetation growth. The animals remain in the high altitudes from May to September and their nutrition is mainly based on grazing, and only during late pregnancy and early lactation are they offered some supplementary feed while in the rest use the grazing lands of the low altitudes and/ or they are fed indoors.

Table 1. Number of livestock farming and animal population in Greece in 2012 (Hellenic Statistical Service of Greece, 2015)

Animal species	Farm number	Total heads	Heads/farm
Cattle	17,241	611,131	35
Sheep	90,911	8,778,430	97
Goats	71,373	4,895,244	69
Total	179,525	14,284,805	

Grazing cattle (approximately 350,000 heads) consists of suckled cows, which belong to indigenous local cattle breeds or cross-bred of Limousin, Simental, Schweiz, Charolais and Hereford and represents a low cost pastoral beef production system (Zervas, 1998). Feed for maintenance of herds of beef cattle and the production of their offspring comes primary from grazing lands. In general, the offspring of ruminants kept in grazing systems are nursed by their mothers, suckled with milk, learn to forage early in their life, have social contact with other young and mature animals and have space enough to exercise and play.

The total meat production of cattle, sheep and goats in 2012 was 70,000, 92,100 and goats 52,000 tons, respectively while the milk production was 779,000, 778,000 and 462,900 tons, respectively. There are not data for the contribution of grazing lands on the livestock products but it is estimated that the grazing land forage consumed by grazing ruminants contributes about 35% to the livestock products but it has the potential to increase to 60%.

III – Forage/ grazing resources

The vegetation in Greece is typical of Mediterranean regions and consists of a rich variety of plant species which are well adapted to the climatic conditions. A series of vegetation manipulations by man throughout the centuries, such as irrational felling of woody plants, overgrazing and extensive clearing for formation of crop-fields, have contributed the most to today's landscape, which consists of a variety of vegetation types. The main land uses of the country, which are related with livestock, are agricultural crops, forests and rangelands (Table 2). Up to 1991, rangeland data were separately collected by Statistical Service of Greece but after that a part of rangelands (10.9% of land area) is recorded as agricultural land and the largest part of them (30.3% of land area) is recorded as forest land (Geotechnical Chamber of Greece, 2014).

Table 2. Evolution of land uses (ha) in Greece from 1961 to 1991 (source: Statistical Service of Greece)

Year of survey	Agricultural land	Forests	Rangelands
1961	3,909,252	2,826,283	5,507,291
1971	3,962,080	2,971,560	5,269,566
1981	3,948,873	2,958,353	5,256,359
1991	3,948,873	2,945,146	5,216,738
Mean (%)†	29.8	22.2	43.5

†Percentage (%) of Greece's total land area.

1. Rangelands

Rangelands in Greece are one of the most important natural resources covering more than 40 % of the country's land area (Geotechnical Chamber of Greece, 2014). They are broadly classified into (i) grazing lands dominated by herbs and phrygana and (ii) wooded rangelands (dominated by woody plants), which are composed of shrublands and forested rangelands and expand in all geographical divisions and elevation zones of the country. There are not accurate data concerning the surface of them but according to the Geotechnical Chamber of Greece (2014) it is estimated that the grazing lands dominated by herbaceous species add up 1.4 million ha and the grazing lands dominated by woody plants 3.7 million ha. It is valuable that in '60s the grazing lands dominated by herbaceous vegetation amounted to 1.7 million ha, which means that a part of them transformed to woodlands due to their misuse.

A. Grasslands

Grasslands are covered predominantly with herbaceous plants, such as grasses, grass-like plants and forbs, in a percentage at least 80% while woody species are present in percentages ranging from 10 to 20% (Papanastasis and Ispikoudis, 2012). This definition is similar to that is given by Holecheck *et al*. (2004) for grasslands and include grazing land, which is described by Allen *et al*. (2011) and Peeters *et al*. (2014) as native/ natural grassland. Among herbaceous plants sovereign in terms of biomass are the grasses, while broad-leaved (legumes and other forbs) dominate species number. The vegetation of the grasslands consists of a wide variety of plant species which are annuals or perennial. In general, in lowland (0-600 m) grasslands dominate the annual plants, in sub-mountainous (600-800 m) are found both annual and perennial while in the sub-alpine zone (1,500 m) are found only perennial plants. Among grasses, which contribute much more than other herbaceous plants in forage production, dominate species belonging to the genera of *Festuca*, *Bromus*, *Brachypodium*, *Poa*, *Phleum*, *Agrostis*, *Stipa* and *Dactylis* (Papanastasis and Ispikoudis, 2012).

The annual forage production of grasslands depends on the climate zone, the composition of the vegetation, the soil type and their use from grazing animals. Their main use is grazing by farm and wild animals. The total area of grasslands in Greece is estimated to be 1.4 million hectares or 27 % of Greece's total rangeland area and include lowland plain, hilly transition sub-mountainous and mountainous/sub-alpine pastures - half of them found in northern Greece. Their forage has a seasonal variability depending on the bioclimatic - elevation zone as well as a yearly one depending on the climatic conditions. Papanastasis (1982) reported that herbage yields of 1,100 kg/ha in the lowland grasslands, 1,300 kg/ha in the sub-mountainous grasslands and 3,000 kg/ha in the mountainous grasslands are typical in Northern Greece, while Nastis (1990) reported that herbage production of the three grassland categories were estimated to be 2,000, 3,000 and 5,000 kg/ha, respectively. Based on research data throughout the country, it is estimated that the herbage production of lowland grasslands ranges from 500 to 1,500 kg/ha, of sub-mountainous grasslands from 1,500 to 2,500 kg/ha and mountainous grasslands from 2,500 to 3,500 kg/ha.

The most important decision for successful rangeland management is setting a proper stocking rate. The stocking rate affects rangeland health and productivity, livestock production, and economic returns (Holecheck *et al*., 2004). The number of animals a piece of land can support on a long-term basis without causing damage to the grazing resource is the carrying capacity of the land. Stocking rate is the relationship between the number of animals and the total area of the land in one or more units utilized over a specified time; an animal-to-land relationship over time (Allen *et al*., 2011). In other words, the stocking rate is the number of animals (livestock or wildlife) a land manager places or maintains on a piece of land over a specified period of time while carrying capacity is set by Mother Nature, through soil and climate characteristics. The stocking rate is expressed as animal units (AU) per section of land. The term AU is widely used in grazing management, but there is not universal agreement on the quantity it expresses. For example, in USA, AU is defined as a 450 kg beef cow with or without a nursing calf with a daily requirement of 11.8 kg of dry matter forage; but in Greece a 400 kg beef cow with or without a nursing calf with a daily requirement of 10 kg of dry matter forage. Recently, Allen *et al*. (2011) defined that an AU is one mature, non-lactating bovine (middle-third of pregnancy) weighing 500 kg and fed at a maintenance level for zero gain (8.8 kg dry matter per day). The amount of forage required by one animal unit (AU) for one month is called an Animal Unit Month (AUM); thus the term AUM according to the latter definition is equal to 264 kg.

With regard to those reported above, we estimate that the proper stocking rate for grasslands should be 3.3 (AUM)/ha. However, this estimation may provide rangeland managers with a partial basis for making management decisions because on one hand, the herbage produced in grasslands is concentrated in the spring and summer while on the other, the herbaceous material starts to dry out by late spring thus its nutritive value declines. It has been found (Papanastasis, 1982; Forest Research Institute, unpublished data) that the forage abundance lasts from May to August in the lowland and sub-mountainous grasslands, but by June crude protein content of herbage begins to decline and is insufficient to meet even basic maintenance requirements of grazing animals. In the mountainous grasslands forage abundance lasts from June to October and its crude protein content seems to be sufficient for animal maintenance requirements, but not for any production or weight gain. Generally, the forage production of grasslands in Greece has a seasonal growth causing two feed gaps - the first one during summer (related to nutritive value) and the second one during winter (related to availability).

B. Phryganic lands

Fhryganic lands are dominated by brushwood (or phrygana), which is dwarf-shrubs that display the phenomenon of seasonal dimorphism, i.e. the replacement of large winter leaves with small summer leaves in late spring, in order to reduce the transpiration (loss of water) and to cope with so long and dry summer. The main phryganic rangeland types of Greece are those that dominated by *Sarcopoterium spinosum*, *Phlomis fruticosa*, *Thymus vulgaris* and *Cistus* spp.,

and they are found in xerothermic areas of the country, for example Aegean islands, Crete and/ or in western and southern part of the inland. There is no data concerning their surface and the largest part of them included in the grassland surface (i.e. in the rangeland type described just before). Their annual forage production ranges from 300 to 800 kg/ha in lowlands, from 800 to 1,300 kg/ha in sub-mountainous and from 1,300 to 1,800 kg/ha in mountainous areas. The proper stocking rate for this rangeland type should be 1.7 AUM/ha. Because the phryganic forage is of low palatability, fire has been used by herders in attempts to improve its nutritive value by replacement of other vegetation types; however, there is evidence that this management deteriorate the rangeland conditions.

C. Shrublands

The landscape of the low, and a part of the sub-mountainous and mountainous elevation zone of Greece is dominated by woody vegetation which is a complex mix of evergreen or deciduous shrubs with an herbaceous understory. The area of these grazing lands is estimated to be the half of the wooded rangelands reported above. Both woody (browse) and herb (herbage) components of shrublands are vitally important for small ruminant production in the region. The annual forage production of shrublands ranges from 600 to 1,200 kg/ha in lowlands, from 1,200 to 1,800 kg/ha in sub-mountainous and from 1,800 to 2,000 in mountainous areas and it is suggested to be stocked by 3.2 AUM/ha.

The evergreen kermes oak (*Quercus coccifera* L.), is the predominant vegetation of a large part of shrublands, covering 50 % of Greece's total shrubland area. A combination of kermes oak pastures of varying cover over the total shrubland area considered ensures not only forage but water for off-site use, wildlife habitat, soil protection of erosion and wood production as well (e.g., firewood, fence posts). This suggests that removing a part of the woody vegetation in Mediterranean shrublands results in increased forage production (available herbage and useable browse) and improved forage quality and availability for small ruminants. Goats seem to be the appropriate animal species for grazing on such rangelands, since they have the ability to consume large amounts of kermes oak browse throughout the year (diet content ranging from 46.8 % in spring to 73.7 % in winter). Moreover, levels of crude protein of goats' diets grazing in shrublands satisfy the maintenance or/ and part of production requirements for goats during all seasons (Papachristou and Nastis, 1993b; Papachristou and Nastis, 1996). In summary, shrublands appear to be a significant forage resource ensuring forage throughout the year and according to our estimation (assumption that the produced forage is accessible to animals) their carrying capacity is of about 17 million goat unit months.

D. Forested rangelands

Forested rangelands called the grazing lands that carries an overstory of forest trees with a canopy cover lower than 40%; therefore, they have a rich understory of either herbaceous or shrubby species that supplies forage to grazing animals. The forested rangelands are represented by three broad types in respect of the overstory vegetation, (i) the coniferous forested rangelands are characterized by evergreen pines mostly of the species *Pinus halepensis*, *Pinus brutia* and *Pinus nigra*, (ii) the broadleaf evergreen forested rangelands with an overstory of evergreen oaks and (iii) the broadleaf deciduous forested rangelands whose the overstory consists mainly by deciduous oaks. This type of grazing land is of great economic value because it is used by all animal species and covers large areas. Also they produce and other goods and services such as wood products, water, wildlife habitat, soil protection and recreation. They are found at all elevations and mainly on the fringes of forests, which means that they come from forests, which are thinned in excess, due to various anthropogenic actions. Forested rangelands have the potential to be a valuable forage resource and according to our estimations the annual forage production of forested rangelands ranges from 400 to 1,000 kg/ha in lowlands, from 1,000 to 1,600 kg/ha in sub-mountainous and from 1,600 to 2,200 in mountainous areas and it is suggested to be stocked by 2.2 AUM/ha.

2. Grazed forests

Livestock grazing is an old practice in the forests of the Mediterranean region and any attempt to exclude it by Greek forests it was failed. Liacos (1980) stated that the livestock is an integral part of Mediterranean forests and argued that it is beneficial for some forest types, since grazing animals are helpful to the functioning of such grazed forest ecosystems because they contribute to nutrient cycling and thus to an increase of their productivity. Also, he argued that grazing animals can be used as silvicultural means because they control the undergrowth vegetation and eliminate its competition with trees for water, which is a critical factor in the Mediterranean environment. Moreover, the role of domestic herbivores in reducing fuel is somewhat that is need more attention and there is evidence that the lack of grazing leads in increase of fuel material, therefore, results in frequent fires and increase of burnt forest areas (Papanastasis, 2009). However, the environmental and ecological impacts of grazing activity within forests need further research and the social, cultural and economical conditions of each area have to be taken into account for successful integration.

According to Papanastasis and Pittas (1984) a large part of the forests (approximately 1.9 million ha than those of Table 2) is used for grazing and a secondary income is provided by the livestock grazing to the people living close to forests. This happens because the understory vegetation, composed of shrubby and herbaceous species, can be grazed during periods when other forage resources (e.g., grasslands) do not meet animal requirements. However, their understory forage production varies according to forest type and tree species. Experimental data (Liacos, 1980) indicate that the forage production in pine forests (*Pinus brutia* Ten.) is 2,500 kg/ha when the canopy tree cover is open (3 x 3 m) and can result in a meat production of 60 kg/ha. Nastis (1990), also, reported that pine forests with shrubby and herbaceous understory carry approximately 1,000 kg/ha and 1,500 kg/ha, respectively.

In grazed coppice oak forests, Papachristou and Platis (2011a) found that the herbage availability was similar in forest stands with different coppicing age 2, 5 and 8 yrs after the clear cutting and averaged 2,614 kg/ha (). However, there was a significant difference in forage production among seasons of year; the lowest herbage production was recorded in spring (1,546 kg/ha) and the highest in autumn (3,214 kg/ha) while intermediate production was recorded in summer and winter (2,845 and 2,851 kg/ha, respectively). The foraging behavior of grazing animals may be an important management tool which can help livestock and forestry integration. For example, Papachristou and Platis (2011a) found that cattle grazing on coppice oak forests were taking almost the whole of their bites on herbage for all periods but goats had a greater number of bites on oak sprouts (37 bites/min) than herbage (19 bites/min).

3. Pasturelands

Pasturelands (i.e. land (and the vegetation growing on it) devoted to the production of introduced or indigenous forage for harvest by grazing, cutting, or both; Allen *et al*. 2011), with grasses or legumes are grown on arable lands, cover an area of 0.05 million ha and their forage production is estimated to be 3,000 kg/ha. Although these grazing lands have the potential to produce great amounts of forage of high nutritive value, there is a tendency to be reduced and used rather for crop fields than livestock production.

4. Other forage resources

In Greece there are several short-term grazing lands and/ or forage resources, which are arable lands on which grazing is presently being realized, but under limited duration or they are seeded by fodder plants that harvested and stored to be used as animal feed. Introduced forage species are mostly utilized, but native species responsive to high management and cultural inputs maybe included (Papachristou, 2000). This land covers an area of 0.4 million ha (Hellenic Statistical Service of Greece, 2015) and consists of: (1) New-sown leys, which are lands

temporarily under barley, oats and vetch and used by grazing animals during winter with a forage production amount to an average of 4,000 kg/ha, (2) Meadows, which are usually natural and used for grazing by animals after the spring hay harvest and their forage production is estimated to be 2,500 kg/ha and (3) Hay crops with alfalfa (*Medicago sativa* L.) and vetch (*Vicia sativa* L.) are the most important resources for hay. These lands have the potential to produce great amounts of forage (> 10,000 kg/ha), especially when they are irrigated. This material is harvested, stored and given to grazing animals during critical periods (e.g., winter) or to indoor animals on a yearly basis.

Also, a significant temporarily grazing resource is fallow lands that are ploughed fields, not sown temporarily, and estimated to cover an area of about 0.4 million ha with a forage production of 1,500 kg/ha. In the same category is cereal stubble which is estimated to be 1.2 million ha and is used by grazing animals during summer after the cereal harvest.

IV – Grazing land management

Grazing management is principally involved in managing and manipulating the grazing animal-forage plant-soil complex to obtain specified objectives. This is accomplished by blending ecological, economic and animal management principles. Common to the management of all grazing lands must be forage plant consideration such as plant growth requirements, providing for plant vigor and reproduction, defoliation and other animal impacts, and seasonality and fluctuations in forage production. But equally high in priority are animal considerations including animal performance, animal behavior, nutrient intake levels, forage quality relative to animal needs, and forage palatability/ animal preference. However, grazing is applied in the whole of the country's grazing lands without established principles of proper utilization. Consequently, rangeland productivity has deteriorated, as has the productivity of other forage resources such as forestlands. Grazing animals, especially goats, are considered despoilers of grazing lands. However, with good management all grazing animals can make a positive contribution to the natural resource base by enhancing soil quality and increasing plant and animal biodiversity (El Aich and Waterhouse, 1999; Papanastasis *et al.*, 2015).

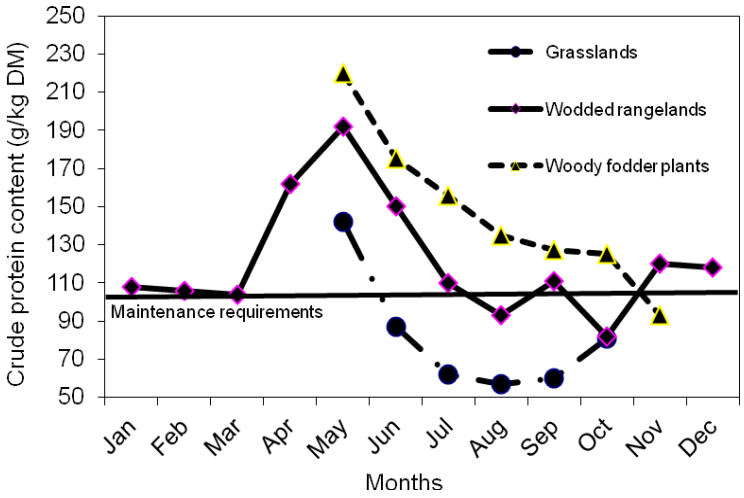

Fig. 1. Combination of different forage resources grazed by goats in an area with altitude 600 m in Northern Greece.

Over the past decades, considerable research data have appeared in the literature on the ecology and management of grazing lands of Greece. These studies indicate that there is the scientific basis for the application of sustainable grazing management which will ensure the optimum combination of goods and services for society (e.g. Papachristou *et al*., 2005; Papanastasis *et al*., 2015). An important finding is that browse is an important forage source for goats throughout the year and for sheep during the dry periods when herbage was limited. Especially, in kermes oak shrublands the available forage (browse and herbage) is not a limiting factor to animal production (Liacos *et al*., 1980; Papachristou and Nastis, 1993a). Papachristou and Nastis (1993a) found that the forage availability in a shrubland area with a shrub cover ranging from 50 to 70 % was 1,170 (browse: 953; herbage: 217) kg/ha in spring, 2,212 (browse: 1,813; herbage: 399) kg/ha in summer, 2,009 (browse: 1,869; herbage: 140) kg/ha in autumn and 1,611 (browse: 1,436; herbage: 175) kg/ha in winter. In this shrubland, grazing goats selected large amounts of browse, mainly kermes oak, throughout the year (from 46.8 % in spring to 73.7 % in winter). However, goats selected a diet of 53 % herbs (grass: 23.0 and forbs: 30.0 %) during spring (April - June), when they were green and in abundance. During summer, although the herbage availability was high, herbs in the goats' diet decreased (35 %) because of maturity. Dietary levels of crude protein exceeded maintenance requirements for goats during all seasons (Fig. 1), but when digestibility was considered the forage of kermes oak shrubland is questionable regarding meeting animal requirements during other seasons except in spring (Papachristou and Nastis, 1993b). During summer and autumn, the nutritional status of goats is elevated when they graze shrublands dominated by deciduous broad-leaved species such as *Carpinus* sp. and *Fraxinus* sp. (Papachristou and Nastis, 1996).

The proportion of woody and herbaceous vegetation and seasonal changes in Mediterranean rangelands affect the diet selection and nutrition of grazing animals (Papachristou and Nastis, 1993 a, b). Therefore, it was suggested that the creation of a heterogeneous landscape, which increases and diversifies forage production, increases livestock production (Liacos *et al*., 1980; Kirmse *et al*., 1987; Tsiouvaras, 1987; Schacht and Malechek, 1989; Papachristou *et al*., 1997), limits the risk of uncontrolled fires, and ensures other services such as wildlife habitat or aesthetic landscapes (Liacos, 1982). A creation of such diversified shrubland (shrub density ranging from 20 to 60%) was achieved by Papachristou (1997) and Papachristou *et al*. (1997) using clear cutting and slashing. Clearing and slashing resulted in higher amounts of available herbaceous forage and useable browse. Herbaceous biomass was generally 2–3 times higher in the treated shrublands than in the control at least for 3 years after vegetation improvement, and while browse biomass was slightly less (1,078 versus 1,533 kg/ha), the forage was easily accessible because of the open structure and the lower height of the sprouting shrubs; therefore, grazing animals (sheep and goats) had a higher bite rate (15.7 vs. 8.6 bites/min). Forage selected by animals grazing on treated, as opposed to untreated, shrublands was higher in crude protein, more digestible and lower in NDF, ADF and lignin. Based on these studies, they suggest that the woody component of rangelands should to be maintained at less than 50% of the total land cover as this produces the best overall foraging conditions and animal performance due to enhanced plant diversity. A further improvement by augmenting woodlands with evergreen or deciduous fodder shrubs and tree species can be achieved (Papachristou and Papanastasis, 1994; Papachristou *et al*. 1999; Papanastasis, 1999a). It was proposed for kermes oak shrublands that goats can be allowed to graze in them during the day and then at the end of the day, be allowed to have access to pastures with different browse combinations of fodder woody species. In this way, a mixing of plant species is ensured and the goats are provided with different types of biochemicals that enhance food intake.

Research data from Greek grasslands indicate that their productivity varies widely depending on the particular climatic and soil conditions. In general, grasslands in lower altitudes have less herbage production than the higher ones and there is a great variation for the same grassland between years (Papanastasis, 1999b). Moreover, the nutritive value of herbage may not follow the trends of forage production. For example, the quantity of forage in grasslands located in areas with altitudes lower than 800 m is adequate from May to August but its content in CP

decline from May (130 g/kg DM) to August (70 g/kg DM). However, in the grasslands found in altitudes higher than 800 m the quantity of forage is adequate from June to October and its content in CP ranging in relatively high amounts (90 – 130 g/kg DM).

In conclusion, the use of several grazing land types satisfies better the requirements of grazing animals in both forage allowance and nutritive value throughout the year. In the past, it was achieved by transhumance, i.e. the seasonal movement of grazers with their livestock between fixed summer and winter grasslands exploiting the ecological differences of grasslands located in different altitudes. Nowadays, the livestock production systems are extensive without transhumance, which means that animals use the grazing lands that are available in the wider area from the barn. Therefore, the best management is the combined used of different grazing land types. For example, a realistic approach for a goat farm located in northern Greece in an area with altitude 600 m is the use of grasslands, shrublands, forested rangelands and artificial plantations with woody fodder species; this combination ensures sufficient amount of forage of high nutritive value (Fig. 1).

V – Impact of national and EU policy on grazing lands

1. National policy

The majority of rangelands (75%), which are the largest forage resource of grazing lands, are state-owned areas. The right of distribution of these public rangelands to the grazers belongs to the municipalities whereon rangelands are located and the right of grazing belongs to the livestock owners of each municipality. Public rangelands are freely grazed, which means that every shepherd utilize freely the rangeland that is allocated to him. However, this leads to uncontrolled grazing and degradation of rangelands because municipalities and/ or users do not follow any guideline of proper rangeland/ grazing management.

Up to now any attempt for appropriate rangeland management has failed although there is the scientific basis from research data to be applied. The only management efforts were limited in the establishment of facilities for watering livestock and vegetation improvements throughout fertilization, seeding and control of undesirable plants (Papanastasis, 2001). However, even these attempts had poor performance either because to faulty design or to the following uncontrolled grazing.

The most important of all grazing management decisions from the standpoint of vegetation, livestock, wildlife and economic return is the setting of the appropriate stocking rate. Recently (117394/ 2932 Ministerial decision, 2014), the state recognized the rangeland importance for livestock and decided to manage them with an appropriate way. According to this decision for the rangeland use of each municipality is needed a management plan, which will include (1) classification of rangelands into the types reported above, (2) estimation of carrying capacity for each rangeland type and for the total of rangelands in a specific municipality, (3) numeration of livestock using rangelands for each municipality and the grazing system applied, (4) calculation of stocking rate, i.e., the number of livestock that can graze on rangelands surveyed for the desired grazing period, (5) establishment of facilities (watering holes, shade shelters, stables, roads) and (6) proposition for the appropriate vegetation and grazing management according to the health/ condition of a specific rangeland.

2. Common agricultural policy (CAP)

As it was reported, grazing lands include a range of vegetation types and shrubs and trees (browse, as distinct from herbage) have been an integral part of grazing systems for centuries. The CAP has supported farming on the full range of grazing lands for several decades in Greece like it did in other countries such as France, UK and Spain. When support was paid

per head of livestock, there was no question of an active farmer not receiving CAP support because his grazing land had the wrong type of vegetation. The farmer and his stock could and did receive support while using any legally available grazing land. But with the move away from coupled payments per head of livestock to decoupled area payments, the delineation of eligible land has becomes a far more significant issue. Nowadays, decisions need to be taken about what land is eligible to claim support.

During the period of CAP ended in 2013, some Member States have taken a more restrictive approach and have excluded considerable areas of grazing lands with shrubs and trees from support, probably influenced by a combination of the CAP definition of permanent pasture and its focus on "herbaceous grazing lands", plus the Commission guidance on eligibility. In Greece, for example, from a total 5.2 million ha grazing lands only a 25% was considered as eligible. There are major inconsistencies between Member States in the way that grazing lands with shrubs and trees are treated in relation to Pillar 1 payments. Some take an inclusive approach, and include large areas of actively-farmed wooded pastures in their eligible areas, while very large areas of similar farmland are excluded from Pillar 1 support in other Member States. These inconsistencies in the CAP have important implications for the achievement of EU goals for biodiversity and ecosystems, because many of the excluded types of grazing lands are habitats of European importance that require continued farming use for their conservation. It is recognized that there is a decline tendency of permanent pastures under active farming use, especially in more marginal farming situations. There is a concern for that by authorities and general public, therefore, mechanisms are introduced in CAP by 2003 to maintain permanent pasture and to prevent their conversion to arable land; however, the increasingly abandonment of grazing shrublands or wooded pastures and their forestation did not take in account that biodiversity may also declines as woody plants colonize rangelands and transform them into dense and impenetrable wood stands. There is evidence that the Greece's rangeland landscape has changed due to the abandon of grazing lands, which were exempted by the CAP Direct Payments. The lack of proper grazing management results in (i) the concentration of grazing livestock on eligible "permanent pastures", (ii) the livestock decline in some remote areas causing social structural changes and (iii) the invasion of woody plants into grasslands.

In the new CAP 2014-2020 (Regulation EU, 2013), the definition of Permanent Pasture is "permanent grassland and permanent pasture (together referred to as permanent grassland) means land used to grow grasses or other herbaceous forage naturally (self- seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for five years or more; it may include other species such as shrubs and/or trees which can be grazed provided that the grasses and other herbaceous forage remain predominant as well as, where Member States so decide, land which can be grazed and which forms part of established local practices where grasses and other herbaceous forage are traditionally not predominant in grazing areas". Moreover, Member States have to establish criteria to be met by farmers in order to fulfill the obligation to maintain permanent grassland suitable for grazing and to define the minimum activity to be carried out on permanent grassland naturally kept in a state suitable for grazing. During, this period Greece's authorities have to decide which of the rangeland types reported above will be considered as eligible for CAP support and which of established local practices rationalize the eligibility of wooded rangelands. However, in order to be ensured legal certainty for all these, the Commission shall be empowered to adopt delegated acts.

Up to now the major problem with farm inspections in Greece was that land eligibility was the main issue during the inspection. Wooded rangelands were usually classed as ineligible land regardless of the grazing and their contribution to livestock. Therefore, in the current CAP, all these lands or at least a great part of them have to be included to the eligible land under Single Farm Payment. This aspect is supported by the fact that wooded rangelands in Mediterranean region are important forage resources because they supply green forage either throughout the year when they are dominated by evergreen shrubs or in the critical summer period when they are occupied by deciduous woody plants (Papachristou and Nastis, 1993a, b; Papachristou and Nastis, 1996; Papachristou, 1997; Papachristou *et al.*, 1999). A good example is the kermes

oak shrublands, which are suitable grazing land for goats and for cattle and sheep when they are sparse. The browse of kermes oak and accompanied woody plants in mixture with herbage consist an ideal feed for goats. For example, Papachristou *et al*. (1999) and Papachristou and Platis (2011b) found that goats gained weight (approximately 100 g/d) when they ate browse of kermes oak and deciduous browse species, such as *Carpinus orientalis*, *Fraxinus ornus*, *Robinia pseudoacacia, Morus alba* in contrast to the goats ate only kermes oak (lost weight, 70 g/d). Therefore, it was suggested not only the maintenance of the woody component on such rangelands but the introduction of woody fodder plants of high nutritive value into grasslands.

Greek shrublands not only meet the needs of animals in forage in periods when the herbaceous plants are absent but they give in the produced livestock products especially quality characteristics. For example, the milk produced is high-casein, which contributes to the production of high quality cheese and high fat ingredients. Ecosystems, in addition to the production of forage and livestock products, through control of biomass via livestock grazing also serve several other ecosystem functions of particular interest. Among these are: (a) reduction of fire risk and subsequent release of carbon and soil erosion, (b) preserving open landscapes with a variety of vegetation and high aesthetic value and (3) maintenance of high biodiversity habitats, which are ruled by Directive 79/409 (1979) and 92/43 (1992) for the birds and habitats directives, respectively. Therefore, it is important all these grazed ecosystems to continue to be grazed because otherwise they become impenetrable and environmental and socioeconomic values that constitute indispensable public goods will be lost. On the other hand, there is the risk to qualify the eligibility rules of EU support system such grazing lands to be managed irrationally. For example, eradication of woody vegetation in unorthodox ways (e.g. fire) and creation of eligible open grazing lands. In this case and the goal will not be achieved, as woodland will immediately be declared for forestation, since they are ruled by forest law, and the environmental and economic consequences will be the same, if not more, devastating, like the withdrawal of grazing. For this reason, the national and Community policy should aim to preserve the environmental role of these areas and the simultaneous production of products (e.g. milk, meat, firewood).

VI – Conclusions

The forage/grazing resources in Greece consist of a variety of vegetation types and the combined use of them can support viable animal agricultural systems. Therefore, the establishment of combined forage resources including rangelands, fodder shrub plantations, pastures, grazed forests and arable lands is a promising alternative for the Greek pastoral systems. In the past, shepherds achieved this with the temporal and spatial movement of their flocks and the combination of more than one resource grown in different ecological environments and elevation zones. However, nowadays the animal agricultural systems are rather extensive without transhumance, which means that animals have to satisfy their feed requirements in the wider grazing land area, but not too far from the permanent stall. In this case the herder has to combine the available forage resources in this given area enduring the restricted factors (e.g., short grazing period). National and EU policies have to ensure the integrity of all grazing lands that support livestock by including them in the payments schemes of Pillars I and II.

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