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The Effect of Grazing on Old Oak Forests from Eastern Rhodopes Mountains, Bulgaria

Georgi Hinkov[1], Vania Kachova[1], Ivaylo Velichkov[1], Lucian Dinca[2]*

1 - Forest Research Institute – Bulgarian Academy of Sciences,
Blvd. Kliment Ohridski 132, 1756 Sofia, BULGARIA
2 - National Research and Development Institute in Forestry "Marin Dracea", ROMANIA
*Corresponding author: georgihi@abv.bg

Abstract. The present study focuses on the old oak forests within the territory of Krumovgrad State Forestry Unit (SFU), located in the central part of the Eastern Rhodopes Mountains. Field measurements were performed in both abandoned and ongoing pens, covered by *Quercus petraea* and *Quercus frainetto* dominated forests with ages ranging between 120-130 years. The aim of the study was to identify the consequences of long-term practiced grazing in old oak forests (forest pastures) after their abandonment as well as the perspectives in terms of their preservation, restoration, regeneration and future maintenance. The study confirmed the negative effect of intensive grazing over old oak forests within the territory of SFU Krumovgrad, related with soil exhaustion and erosion, suppression of seeds production/successful regeneration and severe forest degradation. However, it also revealed the preserved valuable genotypes, forest structures and regeneration potential of these forests. Furthermore, it was proved that during the last 20-30 years, since grazing had been abandoned or not intensively practiced, forests' health condition have improved, canopy closure has increased and old stands were able to successfully regenerate on their own. In addition, significant similarities between the characteristics of studied old oak forests and those of old-growth forests were observed. This could reasonably justify some old oak forests' areas within the SFU Krumovgrad managed territory to be protected from commercial logging by declaring them old-growth forests that are part of Natura 2000 network or covering them by the upcoming Forest Stewardship Certification.

Key words: old oak forests, grazing, natural regeneration, livestock, Eastern Rhodopes Mts.

Introduction

During last two decades, the number of studies concerning old-growth forests is increasing globally, including in Bulgaria (RAEV *et al.*, 2005; RAEV 2007; ZLATANOV *et al.*, 2013; 2016; 2018; PANAYOTOV *et al.*, 2016; WWF, 2019). Performed studies have provided information on the important role of these forests for gene conservation, biodiversity maintenance and carbon sequestration, together with a better understanding of forest successions and reactions to climate change (VEEN *et al.*, 2010; SABATINI *et al.*, 2018). Despite the fact that oak forests are widespread throughout Bulgaria, the area of old oak forests (aged more than 100 years) is decreasing (KOSTOV & RAFAILOVA, 2009). The main reason for the negative changes in old oak forests' area is their past and present management related with to uprooting, grazing, logging, etc. The current study was mainly focused on the effect of grazing on old oak forests.

Livestock grazing in Bulgarian forests was common practice in past times (FETFADZHIEV, 1910) and until the 1950s it had a great importance for the country's economy (STOYANOV, 1932; 1968). This form of agroforestry practice has its ecological and socio-economic importance and requires specific management and regulation at legislative level (RIGUEIRO-RODRÓGUEZ *et al.*, 2009; SKALOŠ & ZACHAROVÁ, 2015). Despite of the advantages of silvopastoralizm, the excessive grazing (especially by goats) is directly related with forest devastation (PEEV, 1914; DIMITROV, 1923-1924; TASLAKOV, 1928; STOYANOV, 1932; RADKOV, 1949; JAZIREI, 2001), deforestation and desertification (TASLAKOV, 1928; ASNER *et al.*, 2004). Grazing could change the ratio between plant species (JONES *et al.*, 2011; DARABANT *et al.*, 2007), the ecosystem processes and the biodiversity (KUMAR *et al.*, 2004, POLASKY *et al.*, 2011; MOSQUERA-LOSADA *et al.*, 2009). Natural forest regeneration is also affected by grazing (RADKOV, 1949; GARELKOV, 1957; ROSS *et al.*, 1970) and directly dependent on grazing intensity. In most cases, natural regeneration occurs only after grazing cessation (RADKOV, 1949). At present, grazing in Bulgarian forests is a rarely observed practice.

Thus, the aim of the present study was to identify the consequences of long-term practiced grazing in old oak forests after its abandonment and the perspectives for these forests in terms of their preservation, restoration, regeneration and future maintenance.

Material and Methods

Field studies of old oak forests were performed in 2018 within the territory of Krumovgrad State Forestry Unit (SFU KRUMOWGRAD, 2008), located in the central part of the Eastern Rhodopes Mountains (Fig. 1). ANGELOV *et al.* (1964) has described several areas within SFU's managed territory (along the Bulgarian – Greek border) as old forests. The forests subject of the current study are dominated by oak species such as *Quercus petraea* Liebl., *Quercus frainetto* Ten., *Quercus cerris* L. and *Quercus pubescens* Willd. Besides, European beech (*Fagus sylvatica* L.) forests are found in the southernmost part of the territory. Forest areas artificially planted for erosion control with local pines, mostly Black pine (*Pinus nigra* Arn.) and to a lesser extent Scots pine (*Pinus sylvestris* L.), are also common for this part of Bulgaria (PETKOV & BACHVAROV, 1984).

By 1980, more than 25 000 ha of functioning forest grazing areas called "forest pastures" were present in the Eastern Rhodopes region (PETKOV & BACHVAROV, 1984). These areas were used by domestic animals, with the exception of goats. Most of the current study field objects belonged to that category of "forest pastures" in the past and have been actively grazed and used as livestock shielings. Selected forests (Table 1) subject to current study have also been predominantly used for grazing areas in the past, while the majority of them were just recently abandoned (20-30 years ago). In the field, more abandoned and less still functioning pens (e.g. in sub-compartments 663-b, 663-zh, 664-z) were observed.

Thus, three permanent sample plots (PSPs) have been established within the most typical and well-preserved parts of SFU's old oak forests following a methodology described by ZLATANOV *et al.* (2013). A preliminary selection of sub-compartments with old forests listed in the SFU's valid Forest Management Plan (SFU KRUMOVGRAD, 2008) was followed by a visualization using electronic maps and images, and finally a field study was performed. Each PSP covers an area of 1.7 ha. Measurements were implemented in a grid of 25 circles sized 100 m² each. The distance between their centers was of 30 m. Forest structure and regeneration were estimated by applying standard silvicultural methods such as tree height measurement, diameter at breast height (DBH) measurement, etc. and further calculations (ZLATANOV *et al.* 2013) Forest regeneration was assessed by using the coefficients described by VELICHKOV *et al.* (2018).

PSPs were situated in old forests, dominated by *Quercus petraea* (two PSPs) and *Q. frainetto* (one PSP) (Table 2). PSP 1 represents *Quercus petraea* forest growing on a North-facing slope used more than 20 years ago mainly for grazing during summertime (Photo 1). PSP 2 (Photo 2) and PSP 3 represent *Q. petraea* and *Q. frainetto* forests respectively. Compared to PSP 1, these two PSPs are situated on South-facing slopes and were intensively used for winter grazing more than 30 years ago.

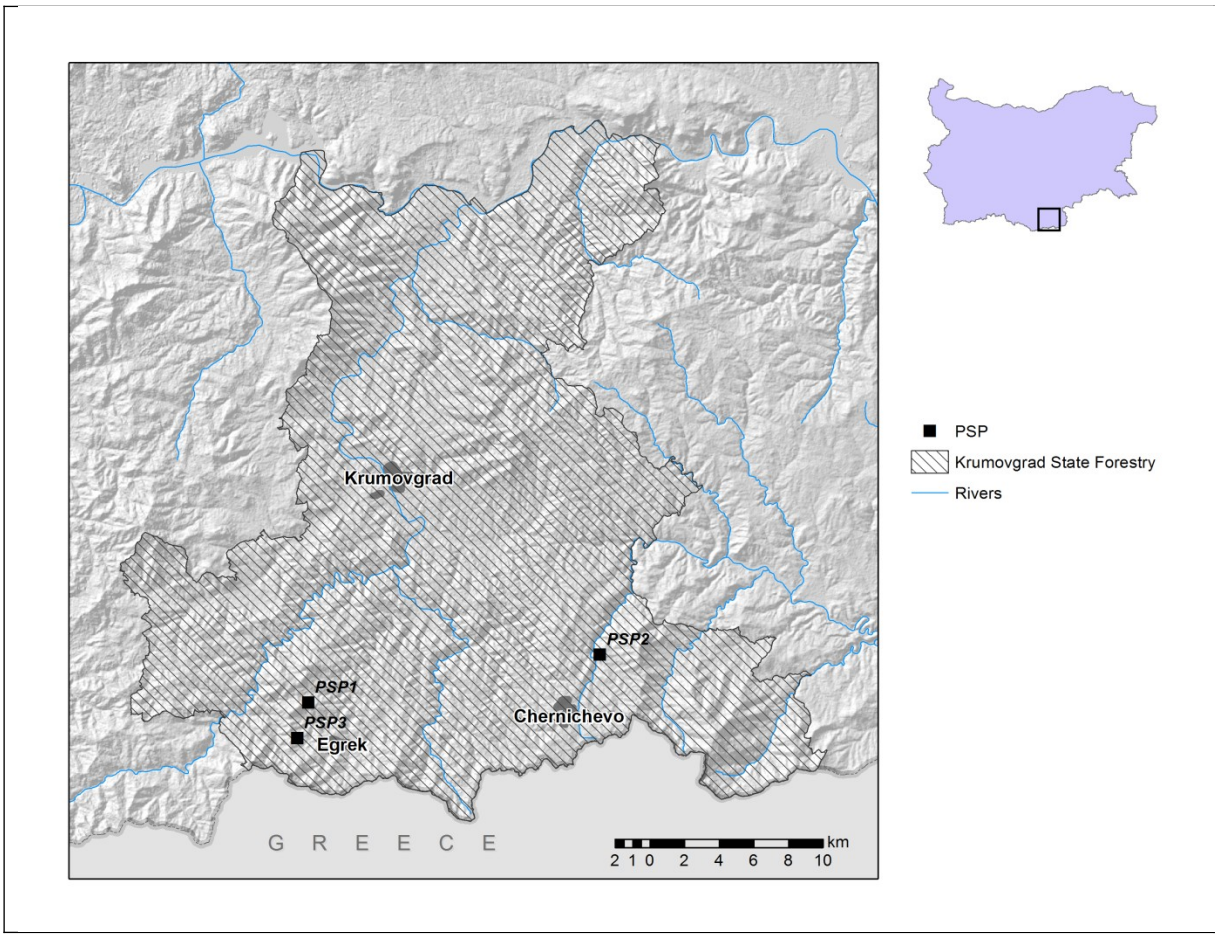

Fig. 1. Map of territory of Krumovgrad State Forestry Unit, including the location of the permanent sample plots (PSPs).

Table 1. Main characteristics of studied old oak forests.

Compartment/ Sub-compartment	Area (ha)	Altitude a.s.l. (m)	Slope aspect	Tree species composition	Average age (years)	Usage of the area
318 "g", "e"	21.6	600	S	*Quercus petraea* 7 *Q. frainetto* 3 *Prunus avium* L.	130	Former pen and winter pasture
598 "d"	20.2	645	NE	*Q. petraea* 10 *Q. frainetto* *Q. cerris*	120	Former pen and summer pasture

598 "b"	19.1	500	NW	*Q. petraea* 10 *Q. frainetto* *Q. cerris*	120	Former summer pasture
652 "zh"	0.9	460	S	*Q. frainetto* 10 *Q. petraea* *Sorbus domestica* L.	100	Former pen, winter pasture
663 "b"	1.3	500	SE	*Q. frainetto* 7 *Q. petraea* 3 *Fagus sylvatica*	120	Ongoing pen, winter pasture
663 "zh"	3.7	550	S	*Q. frainetto 7* *Q. petraea* 3	110	Ongoing pen, winter pasture
663 "к"	3.3	550	S	*Q. frainetto* 9 *Q. petraea* 1	110	Ongoing pen, eroded winter pasture
664 "z"	10.0	500	N	*Q. frainetto* 10 *Q. petraea*	110	Ongoing pen, winter pasture
740 "p"	12.3	550	S	*Q. frainetto* 7 *Q. petraea* 3 *Q. cerris*	120	Ongoing pen

Photo 1. Former pen remains in PSP 1.

Photo 2. *Quercus frainetto* old forest in PSP 2.

Results

Basic PSPs' characteristics obtained in this study are presented in Table 2. Some of their specific features are the following: PSP 1 is characterized by the highest percentage (45%) of eagle fern's (*Pteridium aquilinum* (L.) Kuhn) area coverage and the lowest number (12 600 seedlings/ha) of forest regeneration. The presence of livestock (respectively manure) in the past is related with the current presence of eagle fern, which inhibits the natural forest regeneration. The number of seedlings is not sufficient to successfully regenerate the old forest according to the national forestry legislation (the valid Fellings' Regulation published, 2011) and the studies of RADKOV (1949), PENEV (1956), KOSTOV & STIPTSOV (2004). However, our estimation is that this old stand could be successfully regenerated in future due to the good condition of observed seedlings. PSP 2 and PSP 3 are characterized by regeneration (28 400 seedlings/ha and 15 700 seedlings/ha, respectively), which is more abundant than in PSP 1 and sufficient to naturally regenerate the old stands according to the applicable forestry legislation and other studies. The presence of eagle fern is insignificant (5% average coverage area) in both PSP 2 and PSP 3, which contributes to their better regeneration.

Table 2. Characteristics of selected permanent sample plots.

Characteristics	Permanent sample plots		
	PSP 1	**PSP 2**	**PSP 3**
Compartment/ sub-compartment	598 "d"	318 "e", "g"	740 "p"
Tree species composition (%)	*Quercus petraea* (100%) *Fraxinus ornus* L. *Sorbus torminalis* *S. domestica* L. *Prunus avium*	*Q. petraea* (85%) *Q. frainetto* (10%) *Q. cerris* (2%) *S. torminalis* (1%) *S. domestica* (1%)	*Q. frainetto* (96%) *Q. petraea* (4%) *S. torminalis* *S. domestica* *P. avium*
Number of trees per ha	696	780	956
Average diameter at breast height (DBH) (cm)	26	21	17
Number of trees with DBH above 50 cm	48	68	24
Average canopy closure (%)	77	71	71
Number of gaps	0	3	2
Gap size (m^2)	-	from 150 to 300	from 100 to 150
Species composition of natural regeneration	*Quercus petraea* (84%) *Fraxinus ornus* (6%) *Sorbus torminalis* (6%) *S. domestica* (2%) *Prunus avium* (1%) *Ju. oxycedrus* L. (1%) *Cornus mas* L. *Quercus frainetto*	*Quercus petraea* (83%) *Q. frainetto* (12%) *Sorbus torminalis* (1%) *S. domestica* (1%) *Ju. oxycedrus* (3%)	*Q. frainetto* (88%) *Q. petraea* (8%) *Fagus sylvatica* (1%) *Prunus avium* (1%) *Ju. oxycedrus* (2%) *Cornus mas*
Number of natural regeneration (seedlings/ha)	12 600	28 400	15 700
Share of damaged seedlings from total number of seedlings (%)	5	1	10
Eagle fern average area coverage (%)	45	5	5
Dead wood (m^3/ha) (incl. decomposed dead wood)	59 (19)	104 (24)	66 (31)
Performed activities within last 20 years			
Fellings	No	Yes, with low intensity	Yes, with low intensity
Disbranching for fodder gathering	No	No	No
Gathering of dead wood	No	No	Yes

Discussion

Studied oak forests have been subjected to limited logging (mostly for personal needs related with the use of firewood or construction material for the local population) and as a source of livestock fodder. Intensive commercial logging was not practiced due to the local population's resistance in applying a conservative way of livelihood, related with traditional area management. The lack of enough pastureland in the region led to the use of dried tree branches with leaves as fodder for livestock during wintertime (DIMITROV, 1923-1924). That practice was widespread in the region of the Eastern Rhodopes until less than 20-40 years ago and throughout the whole country 60-70 years ago. Both the *Quercus frainetto* and the *Q. petraea* forests were used as fodder sources (PEEV, 1914; RUSKOV, 1935; STOYANOV, 1954). For example, more than 6 million cubic meters of such fodder were harvested in Bulgaria in 1962 (RADKOV, 1964). The fodder collected in August and September was used to provide additional livestock food or was stored as a winter food reserve, and as a source of vitamins (RADKOV, 1964; DINEV & PATRONOV, 1984). One important advantage of this type of livestock food was the easy way to obtain and store it for the winter. Up to 10-12 meters of the tree stem was disbranched in late summer, while collected branches were stored upon other trees or in piles on the ground. Thus, branches and their leaves provided both livestock fodder and firewood. Oak forests were considered more resistant to summer droughts than grasslands, which contributed to the annual use of their leaves and branches. Some studies (FETFADZHIEV, 1910; RUSKOV, 1935; RADKOV, 1964) indicate that oaks' leaf mass is preferable to that of other broad-leaved tree species and contains high nutritional values. In Bulgaria, a strong criticism of the application of this type of forest management aimed at fodder gathering existed since the beginning of 20th century. In most cases, it was related with soil exhaustion and erosion, suppression of seeds production/successful regeneration and severe forest degradation (PETROV, 1905; PEEV, 1914; RUSKOV, 1935; PENEV, 1956). Observed ongoing livestock pens (sub-compartments 663-k, 664-z, and 740-p) in our field studies were characterized by low canopy closure (less than 0.5), intensive branch cutting for leaf fodder, dieback, soil erosion and overall forest degradation. Thus, one of the negative effects of such forest management was confirmed in this study.

The plots are situated at longer distances from the villages which makes them not easily accessible and favors the natural processes. Despite that, PSP 3 is still occasionally used for grazing, as confirmed by interviews with local shepherds and observations. However, observed seedlings' damages in PSP 3 caused by grazing are not a major obstacle for the successful regeneration of the forest.

Coppice forest management (related with periodical clear cuttings) has been rarely applied in the studied region, due to the necessity of continuous forest cover maintenance over the pastureland. As such, the prevailing part of preserved old forests are high-stemmed or of mixed seed/coppice origin. Some *Quercus petraea* or *Q. frainetto* trees are characterized by breast height diameters of up to 80-100 cm, while their age exceeds 350 years (FRYOLIH, 1925; PANAYOTOV *et al.*, 2016). In the past, local people used to preserve old trees within the livestock's pens and the pastureland regularly distributed to provide shade, shelter, and leaf fodder. Maintained forest canopy also ensured water preservation during summertime and suitable habitat for wintertime to guarantee enough light, heat, rapid ground surface drying, and a lee from cold winds. Crucial for the existence of the old forests in studied region is the preservation of the local population and its traditional forms of forest management related with grazing, livestock pens usage and leaf fodder gathering by branch cutting.

Currently, the prevailing part of the old oak forests in SFU Krumovgrad subject to this study are in a good health condition, with an average canopy closure of 0.7 and sufficient standing and fallen deadwood (Table 2). Numerous large sized trees regularly distributed within forest stands closely resemble the old-growth forests' structure described by RAEV (2007), VEEN *et al.* (2010), ZLATANOV *et al.* (2013; 2016), PANAYOTOV *et al.* (2016). Along with the negative effect, the consequences of the applied specific agroforestry practice possess also advantages: the old oak forests of seed origin and unique spatial structure are preserved together with the genotypes of more than 350 years old trees. As confirmed by this study, once abandoned, these forests have the potential to successfully regenerate within 20-30 years after their abandonment. Their future development is closely related with the presence or lack of human intervention and silvicultural activities.

Conclusions

The current study has confirmed the negative effect of intensive grazing over old oak forests within the territory of SFU Krumovgrad, related with soil exhaustion and erosion, suppression of seeds production/successful regeneration and severe forest degradation. However, it also revealed the preserved valuable genotypes, forest structures and regeneration potential of these forests. It was proved that since grazing is abandoned or not intensively practiced during last 20-30 years, forests' health condition improves, canopy closure increases and old stands are able to successfully regenerate on their own. In addition, significant similarities between the characteristics of studied old oak forests and those of old-growth forests were observed (e.g. presence of large-size old trees, dead wood, gaps, oaks and their satellites' natural seed regeneration, etc.). This could reasonably justify some old oak forests' areas within SFU Krumovgrad managed territory to be protected from commercial logging by declaring them old-growth forests that are part of Natura 2000 network or covering them by the upcoming Forest Stewardship Certification.

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