The effects of livestock numbers and land cover transformation processes on rangelands in the Balkan Mountains between 1947 and 2012

Auswirkungen der Viehdichte auf Sommerweiden im Balkan während der landwirtschaftlichen Transformationen zwischen 1947 und 2012

Hristo Pedashenko[1,*], Iva Apostolova[1] & Jens Oldeland[2]

[1]*Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Acad. Georgi Bonshev st,bl. 23, 1113 Sofia, Bulgaria, hristo_pedashenko@yahoo.com; iva.apostolova@gmail.com;*
[2]*Biodiversity, Evolution and Ecology of Plants (BEE), Biocentre Klein Flottbek and Botanical Garden, University of Hamburg, Ohnhorststr. 18, 22609 Hamburg, Germany, jens.oldeland@uni-hamburg.de*
**Corresponding author*

Abstract

The historical transition from the Bulgarian Kingdom through the Soviet period to the present state of Bulgaria has affected humans and their land use preferences, leading to repeated transformations of the vegetation. We analysed the proportional change of vegetation types in the Tsentralen Balkan National Park in Bulgaria using aerial imagery over the last 65 years and object based image segmentation. Segments were classified into three land cover classes (vegetation types): shrubland, grassland, and shrub-grassland mosaic. In order to interpret the observed proportional changes of these vegetation types we collated livestock numbers over the same period. The shrub-grassland mosaic constantly decreased over the first 20 years, whereas shrublands and grasslands both increased. During the period 1969–1989, the trend continued and areas covered by the shrub-grassland mosaic decreased by 82%, while shrublands increased by 56% and grasslands increased by 18%. The species rich shrub-grassland mosaics were most affected by the land use changes. The overall land cover diversity pattern reduced to two classes. The period with the least changes was 1989–2012, when changes in landscape cover stabilized after the area was designated a National Park. Livestock numbers varied throughout the study period due to the transformation processes. This probably also affected the change in the vegetation patterns analyzed, as few other drivers are known from the Stara Planina Mts. The aerial imagery time series was helpful to reconstruct the changes in the vegetation of the study area, however, extending the time series would allow for a better correlation with livestock numbers.

Keywords: change detection, image segmentation, land management, Karakachan, shrub encroachment, transhumance

Erweiterte deutsche Zusammenfassung am Ende des Artikels

1. Introduction

National borders within Europe have changed significantly during the last century, which is particularly true for the Balkan Peninsula, where new countries have formed even within the last decade. Until the end of the Ottoman period in the late 19th century there were no

boundaries where national borders now exist. The mountain grasslands of the Balkan Peninsula were mainly used by a transhumant group called the Karakachans as well as other nomadic tribes as summer pastures where they grazed thousands of sheep from May to October (MARINOV 1961, PIMPIREVA 1998). During the rest of the year they used the Aegean lowlands close to the Mediterranean Sea as winter pastures. After the Balkan War in 1912, the borders between the Balkan countries were permanently settled and crossing the borders was only allowed at certain places. Difficulties in mobility, imposed duties for each sheep from the passing herd and efforts of the government to permanently settle nomadic tribes, i.e. forced sedentism, resulted in a constant decrease in sheep numbers in the upland pastures (PIMPIREVA 1998).

This decrease continued after the Socialist Revolution in 1944 when the Kingdom of Bulgaria was declared a Republic. The existing market economy was replaced by a centrally planned economy when production of goods and services were provided by state-owned enterprises (BEROV 1974). Unlike crop cultivation and other sectors of the national economy in which reforms happened quickly, animal husbandry remained relatively unchanged until 1958. After 1958, restructuring finally started and all privately owned animals were taken into state ownership and big collective farms were created (BEROV 1974). Intensification of animal husbandry was initiated with mechanization of farms, starting the usage of antimicrobial agents and medications for animals and implementation of highly productive allochtonous breeds of farm animals which were poorly adapted to mountain conditions (ILIEVA et al. 1997). As a result, an intensive economic growth followed which was observed for the first time in the history of Bulgarian agriculture, lasting until 1970. The number of grazing animals reached high values again and most of mountain pastures were intensively used. 10 years after the beginning of intensification, the potential of collective farming to improve productivity in Bulgaria was exhausted and was followed by a decline in the agricultural sector (DARDZHONOV 1994).

The first ten years of agrarian depression saw a stagnation of the growth in the sector, followed by a crisis that reached its peak in the late 80's and early 90's, when the previously developed planned economy was replaced by a market economy as a result of the democratic changes after the collapse of the Soviet Union. Most of the land and animals were given back to their previous owners or their descendants, although these often no longer had the equipment and knowledge to manage them properly (ILIEVA 2002). About two thirds of sheep were sold at the markets and the majority of land was abandoned.

The Tsentralen Balkan National Park was established in the Balkan Mountains in 1991, and grazing within its territory was only allowed with a special permission. Hence, there was little interest in the rangelands of the Balkan Mountains before 2007, when Bulgaria entered the European Union. Park authorities were afraid of a lack of sufficient grazing intensity to maintain pastures in a good condition. After the EU accession of Bulgaria, farmers started to receive subsidies following the Common Agricultural Policy of the EU, aiming to ensure good agricultural and environmental conditions of mountain pastures. Nowadays, the main concern of the park authorities is overgrazing due to the pressure from farmers who want permission to graze in the rangelands in the park.

Successive transition from extensive to intensive grazing and then the lack of grazing inevitably led to changes in the landscape. Both the (historical) lack of grazing and present overgrazing are potential threats to ecosystem health and should be properly monitored and managed to achieve an optimal balance from a biodiversity management point of view (HENLE et al. 2008; VEEN et al. 2009).

The importance of acquiring data on historical ecosystem states to guide future land-management practices has been receiving increased attention (PARSONS et al. 1999). However, data with an adequate temporal depth on the historical composition and distribution of vegetation types across the landscape is scarce (LANDRES et al. 1999). Plant ecologists have long recognized the importance of aerial photographs as a data source for studying vegetation dynamics (DUNN et al. 1990; GREEN et al. 1993) because they provide the largest source of information available today for research of long-term changes. Aerial photographs are an important source of information about landscapes as they combine high spatial resolution, landscape scale extent, and often long-term coverage (KADMON & HARARI-KREMER 1999). Aerial photographs are now commonly used for the analysis and interpretation of landscape change worldwide. Most valuable for landscape change analysis are now bi-temporal change detection methods (LU et al. 2005). Few such approaches have been used on the territory of the Balkan peninsula, most of which were related to forestry management and dealing with shorter time frames (PANAYOTOV et al. 2011, TSVETANOV et al. 2011, LYUBENOVA et al. 2014, HILL et al. 1998, MIHAI et al. 2007).

In this study, we were interested in the parallel changes in landscape and livestock numbers over the last 65 years. We hypothesize that the historical development of the country should be reflected in the development of the landscape. Hence, we analysed the proportional change of land cover types in the Tsentralen Balkan National Park using aerial photographs from the last 65 years and compare with livestock numbers for the same spatio-temporal extent of our study. Our aims were twofold; (1) to analyse the proportional change of land cover types and (2) relate the changes in land cover types to the dynamics of livestock numbers and their historical development.

2. Material and Methods

2.1 Study area

The study was conducted in central Bulgaria, in the center of the Balkan Mountains (i.e. Stara planina Mt.) an area belonging to the municipalities of Lovech and Karlovo (Fig. 1). The study area is located on both sides of the main ridge above the timberline, which is part of the second biggest national park in Bulgaria (Tsentralen Balkan, IUCN category II).

The climate is a mountain variety of the temperate continental climate. The high altitude (1300–1600 m a.s.l.) results in cold winter and cool summer temperatures (annual average +7.5ºC) and a narrow annual temperature amplitude (average January -8 ºC, average July 10 ºC). For the last 30 years, the average annual rainfall was 1139 mm with a precipitation maximum in May (177.9 mm) and a minimum in October (85.7 mm) The area is also characterized by long lasting snow cover (142 days / 41 cm), low air pressure, strong winds (annual average 5 m/s) and high relative air humidity (VELEV 2002). The geology of the area mainly consists of granite, granodiorite, schist and sandstone. The soils are a mosaic of Humic Cambisols and Lithic and Rendzic Leptosols with a sandy-clay structure (RADUKOVA 2012). The potential natural vegetation in the area is Balkan-Macedonian krummholz-scrub (BOHN et al. 2004). Some authors consider that the upper timberline has been artificially reduced after forest cutting and burning in the past. As a result, the high-mountain grazing area has been further enlarged and secondary grass communities have developed. The current phase of the vegetation cover development is characterized by a rich variety of plant communities with a high floristic diversity and sufficient forage resources. *Juniperus communis* ssp. *nana* is present in large numbers in the region alongside a mosaic of subalpine communities. *Nardus stricta* is also widespread, and forms communities where it is a dominant or sub-dominant species. Other dominant species include *Festuca rubra*, *Agrostis capillaris*, *Bellardiochloa variegata*, *Luzula luzuloides* or *Festuca airoides*. Large areas are

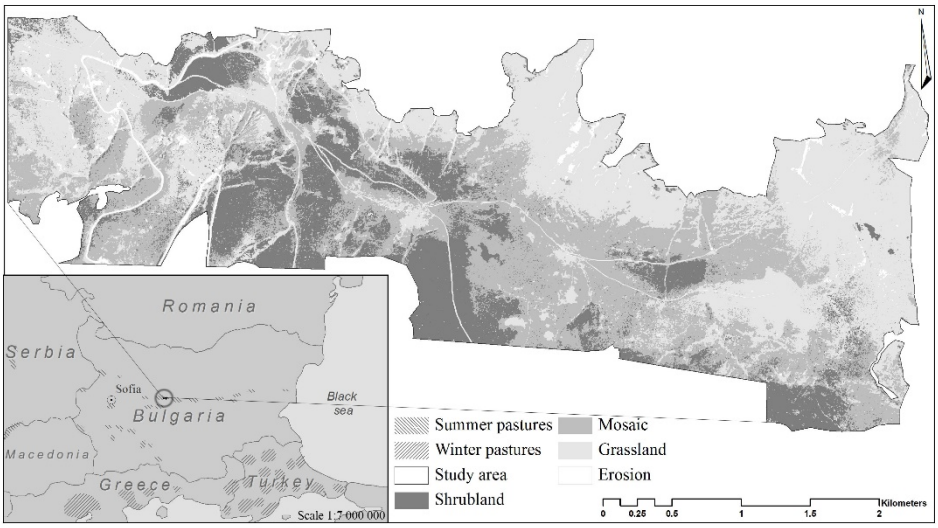

Fig. 1. Map of the study area with reconstruction of main land cover types from 1947 based on aerial photographs. Inset map shows the location of study area and sheep pastures before 1912 by MARINOV (1964).

Abb. 1. Karte des Untersuchungsgebietes mit den anhand der Luftbilder aus dem Jahr 1947 rekonstruierten unterschiedenen Vegetationstypen. Die kleine Karte zeigt die Lage des Untersuchungsgebiets und das Vorkommen von Sommer-Schafweiden (nach MARINOV 1964) um das Jahr 1912 an.

occupied by dwarf shrubs *Vaccinium myrtillus*, *V. vitis-idaea* and *Bruckenthalia spiculifolia*, mixed with *Avenella flexuosa*, *Agrostis capillaris*, *Luzula luzuloides* and diversity of forbs. Patches of carbonate substrate are occupied by communities dominated by *Sesleria latifolia* or *Koeleria eriostachya*. Their vegetation is remarkably diverse but has been less used as pasture (MESHINEV et al. 2000).

In the past, rangelands were extensively used by nomadic shepherds. The Karakachans were the most numerous of the nomadic tribes and used a small local sheep breed, the karakachan zackel sheep. Later they were crossbred with sheep with fine (merino) or semi-fine fleece (DERMENDZHIEV 1981) to meet the growing needs of the woolen textile industry (RAYCHEV et al. 1992, PANAYOTOV 1996). As a result, six new breeds of sheep were created and widely implemented in the country (RAYCHEV et al. 1992). Today the area is under the governance of the Tsentralen Balkan national park authorities and grazing is limited by the rules stated in the management plan.

2.2 Image processing

We used 18 historical aerial photos taken in 1947, 1969 and 1989, available from the Military Topographic Department of the Bulgarian Ministry of Defense, unit 24430 - Trojan. For the year 2012, we used desaturated orthophotos from the Ministry of Regional Development archive. Historical aerial photos were orthorectified with the LPS-module of ERDAS Imagine 9.1. Histogram matching was used for the radiometric normalization during the process of mosaic creation. Changes in position of the timberline in the study area were not detected, which is why forests were excluded from the study area. We calculated three image texture parameters, i.e. variance, homogeneity and entropy which are based on gray level co-occurrence matrices (HARALICK 1979) from each mosaic in order to improve the quality of the subsequent segmentation.

Subsequent analyses were conducted using the free software SAGA-GIS (CONRAD 2006). All aerial photograph mosaics were classified individually using geographical object based image segmentation (HAY & CASTILLA 2008) applying a Simple Region Growing algorithm (BECHTEL et al. 2008). The

attributes from the images, i.e. the RGB and texture values, were assigned to the resulting segments. Then, all polygons were classified into ten groups using a hierarchical clustering method implemented in SAGA-GIS. The resulting clusters were then compared with the corresponding images in a post-hoc approach resulting in an aggregation of clusters to a total number of four comprehensive land cover classes/vegetation types, i.e. shrubland, grassland, shrub-grassland mosaic and erosion and roads. However, erosion and roads covered less than five percent of the study area so we did not analyze any further changes. We obtained four land cover maps, one for each year based on the available aerial photographs. Resulting land cover maps were overlain on the original aerial photograph and the classification of the image segments was manually improved until we reached a sufficient map accuracy above 85 % correctly classified polygons for the four target classes. The manual correction was based on a subset of 100 randomly placed points per category.

Final maps were then compared over periods of two years using a standard post-hoc comparison approach (LIU & MASON 2009). This led to land cover change maps and tables for each period i.e. 1947–1969, 1969–1989, 1989–2012 and 1947–2012. The history and extent of changes in land cover are represented by trajectories following the polygon-based model of KÄYHKÖ & SKÅNES (2008).

In order to interpret the proportional changes of the vegetation types in the study area, we collated the sheep numbers in the studied rangeland for the last 65 years. The data were gathered from publications of the National Statistical Institute - GENERAL DIRECTORATE OF STATISTICS (1940, 1948), CENTRAL STATISTICAL OFFICE (1957, 1980–1988), the COMMITTEE FOR UNIFIED SYSTEM OF SOCIAL INFORMATION (1980, 1984), NATIONAL STATISTICAL INSTITUTE (1994, 1995) and AGRO STATISTICS (2005, 2012). The spatial extent of the data, coinciding with the boundaries of the two municipalities in which the study area is situated, is wider than the studied rangelands. Nonetheless, the mountain pastures make up over 80% of the pastures of the municipalities and supported most of the sheep. Due to the absence of fences and any other kinds of boundaries in the rangeland territories, we assumed that the livestock has been evenly distributed over the mountain pastures and thus the studied area has been equally affected by livestock. For a better interpretation in the light of the historical events during the same periods, we visualized the livestock data and the historical events as a time series chart.

3. Results

Three land cover classes were created: (i) shrubland (*Juniperus communis* subsp. *nana* dominated vegetation with more than 40% shrub cover), (ii) grassland (including a variety of phytosociological associations dominated by *Nardus stricta*, *Bellardiochloa variegata*, *Avenella flexuosa*, *Agrostis capillaris* in combination with dwarf shrubs like *Bruckenthalia spiculifolia*, *Vaccinium myrtillus* and *V. vitis-idaea*) and (iii) shrub-grassland mosaic (more open *Juniperus communis* subsp. *nana* communities of up to 40% shrub cover mixed with grassland).

3.1 Changes in land cover

The comparison of land cover maps from the first 40 years of the study period revealed that areas covered by the shrub-grassland mosaic were constantly decreasing, whilst shrublands and grasslands both increased (Fig. 2 and Table 1). For the last 20 years, the trend was reversed. The highest percentage of transformation occurred between 1947–1969 when 56% of the territory changed its land cover type (Table 1).

Unlike the overall changes in percentage area, the biggest individual land cover type change occurred during the period 1969–1989 when areas covered by the shrub-grassland mosaic decreased by 81%, shrublands increased by 56% and grasslands increased by 18%. In contrast, the period with the least changes was 1989–2012, when shrub-grassland mosaic increased by 132% while shrublands and grasslands decreased by 2% and 12%, respectively (Fig. 2).

Table 1. Vegetation changes between main land cover categories and in total during the study period in percentages. Grey colour cells indicate unchanged areas.

Tabelle 1. Flächenveränderungen von drei unterschiedenen Vegetationstypen in Prozent. Grau hinterlegte Zellen bedeuten unveränderte Flächen.

Period		Shrublands	Mosaic	Grasslands	Total area changed
1989–2012	Shrublands	67	12	21	36
	Mosaic	41	17	42	
	Grasslands	20	12	67	
1969–1989	Shrublands	78	4	18	48
	Mosaic	47	7	47	
	Grasslands	17	5	77	
1947–1969	Shrublands	46	27	27	56
	Mosaic	29	30	41	
	Grasslands	15	28	57	

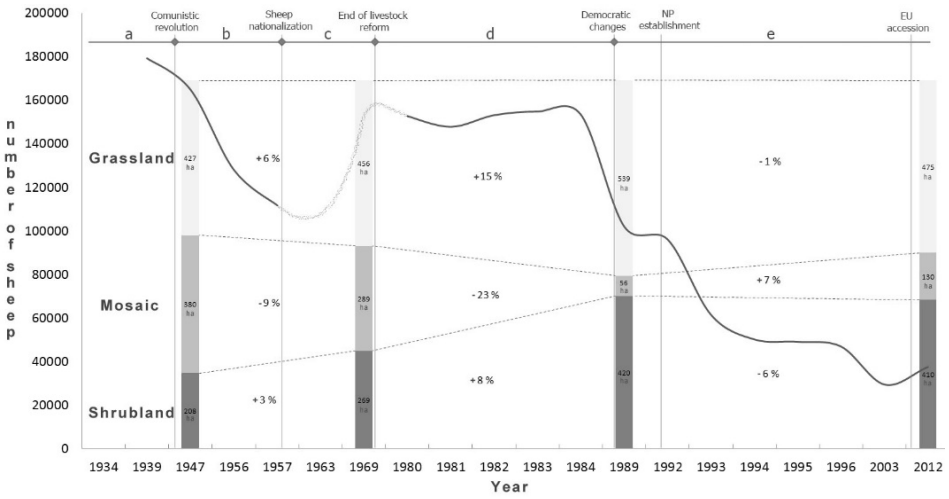

Fig. 2. Sheep numbers in counties within the study area (black line) and the areas of the main land cover types in the study area during the study period. Numbers in bars show the area that each land type covers in hectares and numbers between bars show the percentage of change for each land cover type on the basis of the whole territory. **a** – Bulgarian Kingdom period (extensive management); **b** + **c** + **d** – communist period; **b** – extensive management period; **c** – agrarian reform period; **d** – intensive management period; **e** – democratic period (low intensity management).

Abb. 2. Entwicklung der Anzahl der Schafe in den Verwaltungsbezirken, deren Gebiet das Untersuchungsgebiet (schwarze Linie) beinhaltet, sowie Entwicklung der Flächenanteile der Landbedeckungsklassen während des Untersuchungszeitraumes. Die Zahlen in den Balken zeigen die Fläche jeder Landbedeckungsklasse in Hektar an; die Zahlen zwischen den Balken zeigen die Flächenveränderung jeder Klasse in Prozent in Bezug auf das gesamte Untersuchungsgebiet. **a** – Periode des Bulgarischen Königreichs; **b** – kommunistische Periode mit extensivem Management; **c** – kommunistische Periode der Agrarreform; **d** – kommunistische Periode mit intensivem Management; **e** – demokratische Periode mit extensivem Management.

3.2 Periods and transformations between vegetation types

During the first period (1947–1969), the shrub-grassland mosaic was the most transformed land cover category as only 30% of its area remained unchanged. The shrub-grassland mosaic became either shrubland or grassland while about half of the latter two categories remained unchanged (Table 1). Shrublands were equally transformed into shrub-grassland mosaic or grasslands, whereas grasslands transformed twice as much to shrub-grassland mosaic than to shrubland.

The second period (1969–1989) is characterized by a strong modification of shrub-grassland mosaic equally into shrublands and grasslands while only 7% of the shrub-grassland mosaic class remained unchanged and only a small amount of the other two categories became shrub-grassland mosaic (Table 1). Many areas switched from grasslands to shrublands or vice versa, but scarcely any changed into the shrub-grassland mosaic.

In the third period (1989–2012), the shrub-grassland mosaic continued to transform into shrubland and grassland, but here the latter two categories also changed into shrub-grassland mosaic, leading to an increase in the proportion of this vegetation type (Fig. 2 and 4f, Table 1). Again, almost equal amounts of grassland changed into shrubland and shrubland into grassland.

3.3 Land cover trajectories

Transitions between vegetation types during the study period are shown in Figure 4. The shrub-grassland mosaic turned to be the most unstable category (Fig. 4c) as less than 1% of the area originally covered by mosaic remained the same until the end of the period. On the contrary, grasslands appeared to be the most stable category (15% of the original area remained unchanged) but at the same time it changed into the other two categories in all periods (Fig. 4b). Nowadays, mosaic has developed in places covered by grassland until 1989, whereas present shrublands originate from its initial areas of distribution as well as from the other two categories at different times in the past (Fig. 4d–f).

3.4 Sheep numbers and vegetation changes

Dynamics in sheep numbers show differences over the three periods (Fig. 2). The largest number of sheep occurs at the beginning of the study period (1947) followed by a steep decrease until the early 60's. Then a period of a rapid increase is replaced by a plateau in 1970 for the next 14 years. From then on, the number of animals constantly decreased until it reached its lowest point in 2003. Until 2012, again there was an increase in sheep number.

The period with the intensive management regime (1969–1989) coincides with the largest and the quickest structural changes in land cover (Table 1, Fig. 2 and 3). In contrast, an extensive management regime (1947–1969) and gradual abandonment of the area (1989–2012) maintained vegetation cover in more stable condition (Table 1).

4. Discussion

We distinguished two main groups of events with respect to the changes during the studied period: first, nationalization of private sheep herds (1957) and a consequent livestock farming reform (1958); second, privatization of land and livestock after democratic changes

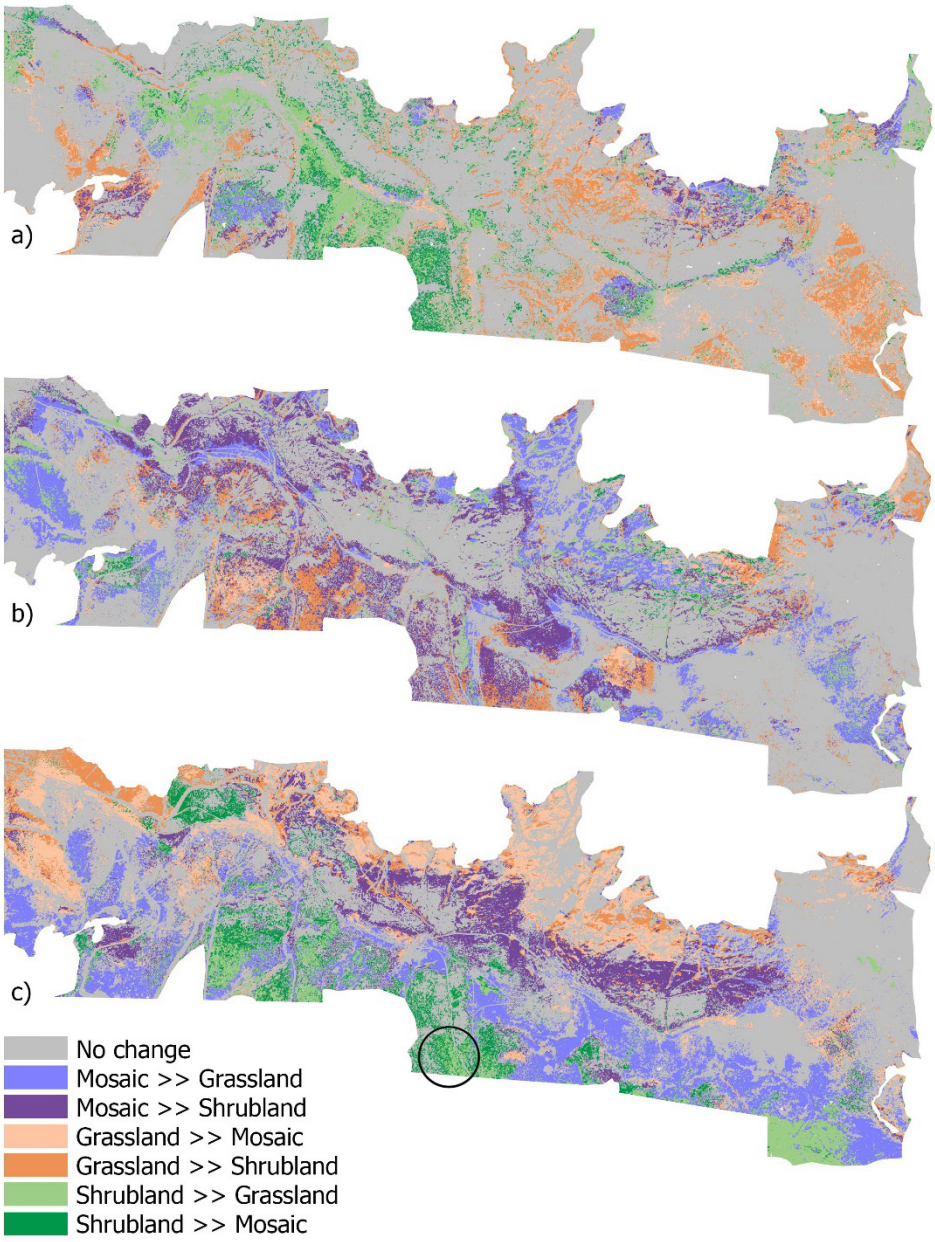

Fig. 3. Maps of land cover changes during the periods: **a)** 1989–2012, **b)** 1969–1989, **c)** 1947–1969. The circle shows the field experiment of DIMOV et al. (1970).

Abb. 3. Vegetationsveränderungen in den Perioden **a)** 1989–2012, **b)** 1969–1989, **c)** 1947–1969. Der schwarze Kreis zeigt den Bereich des Experiments von DIMOV et al. (1970).

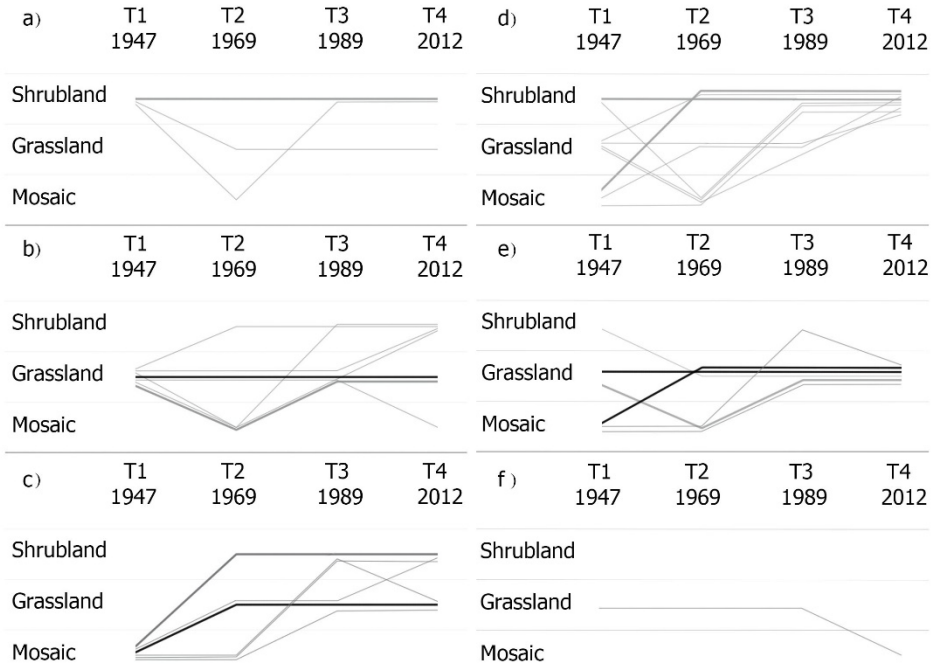

Fig. 4. Trajectories of land cover types on the basis of land cover maps from T1 to T4. Width and color of lines corresponds to percent of trajectories belonging to the certain land-cover category. Changes larger than 7% are shown with thick black lines, transitions between 5–7% with thick gray lines, 2–4% with thin gray lines. Trajectories below 2% are not included in the figure. **a)–c):** trajectories of changes of the three vegetation types; **d)–f):** retrospective trajectories of present-day vegetation types.

Abb. 4. Entwicklungsverläufe von drei Vegetationstypen auf Grundlage von Luftbildern aus vier Zeiten (T1 bis T4). Breite und Farbe der Linien entsprechen dem Prozent der Entwicklungsverläufe einer entsprechenden Landbedeckungsklasse. Veränderungen größer 7 % sind mit dicken schwarzen Linien dargestellt, Übergänge zwischen 5 und 7 % mit dicken grauen Linien, 2–4 % mit dünnen grauen Linien. Entwicklungsverläufe unter 2 % sind in der Darstellung nicht enthalten. **a)–c)** Entwicklungsverläufe der drei Landbedeckungsklassen; **d)–f)** Entwicklungsverläufe der heutigen Landbedeckungsklassen.

in the country (1989) and declaration of the study area as part of a National Park (1991). These events distinguish three time frames, not completely coinciding with the periods delimited by the available aerial photo imagery (Fig. 2).

4.1 Land cover changes

Two opposite trends in land cover changes were observed (Table 1, Fig. 2). The first one appeared during the initial 40 years of the study period when grasslands and shrublands increased at the expense of the shrub-grassland mosaic category. Initially (1947–1969), the process was slow but after 1969 it became more rapid until it reached its highest point in 1989 when only 14% of the initial area covered by shrub-grassland mosaic remained the same and almost half of the territory was converted into different land cover categories (Fig. 4). This pattern coincided with the period of intensive management when not only transhumance was stopped but also some new practices were implemented: e.g. public-cooperative animal management, the import of large, productive sheep breeds and their

interbreeding with the local small breeds well-adapted for the mountain conditions, and the attempt to maintain large numbers of animals through artificial insemination (PIMPIREVA 1998, PANAYOTOV 1996, RAYCHEV et al. 1992). After the introduction of the six new breeds of sheep with higher nutritional requirements, the grazing regime of pastures changed, leading to an increase in grazing intensity. The rapid decline of the shrub-grassland mosaic after 1969 coincides also with the publication of DIMOV et al. (1970), who performed an experiment in 5 ha of the study area, aiming at establishing the feasibility of mechanical means for clearing juniper scrub (*Juniperus communis* subsp. *nana*). They tested two shrub cutters working with productivity of about 0.2 ha per hour. Results from this study are visible on the orthophotos from 1969 and can be seen at Figure 3c.

The opposite trend appeared after 1989 when the study area was subjected to a low intensity management as part of Tsentralen Balkan National Park, leading to a continued decrease in the number of sheep. Re-establishment of the areas covered by the shrub-grassland mosaic occurred much more slowly, and took more than twice as long as the reduction in mosaic took (Fig. 2). Similar patterns were observed by BORCHARDT et al. (2011) and DÖRRE & BORCHARDT (2012) who reported denser shrub layer in mountain pastures as a result of lower grazing impact.

The processes driving the reduction of one land cover category and the increase of others are performed simultaneously and the final balance is only part of the whole picture. To fully understand transformation of land cover categories it is also important to reveal how much of each category is transformed, and into which other category.

4.2 Effect of different management types

During the first half of the first study period (1947–1958), grasslands were used extensively, mainly by nomadic shepherds. They used an ancient sheep breed with relatively small size (average 56.5 cm height and 30 kg weight) which requires relatively little fodder (HLEBAROV 1942). Despite the fact that this period had the largest number of sheep of the studied periods, the ratio between the three land-cover categories was such that grasslands and areas of shrub-grassland mosaic dominated the landscape, and areas covered by dense shrubs had lowest cover. We explain this as an extensive management practice despite the large number of animals, because the native Karakachans possessed their own understanding of the optimal sheep density on pastures (i.e. carrying capacity) acquired by their long experience as shepherds (MARINOW 1961). This traditional knowledge ensured an extensive management regime over centuries. Each family renting an area of land invites a number of other families according to the number of animals they possess in order to achieve a suitable total number of sheep for the rented pasture (PIMPIREVA 1998). Furthermore, a collective herd was separated into several smaller herds according to lambing, shearing, and age which were often grazed far away from each other. Pastures were also separated according to the type and quality of grass growing on them. Barren sheep were grazed at higher altitudes, i.e. on mountain peaks and ridges where nutrient poor, tussock grasses, such as *Nardus stricta* and *Bellardiochloa variegata* dominate. Lamb and dairy sheep were grazed on slopes closer to the timberline on pastures with a higher nutrient content. In addition, the Karakachans practiced night grazing which allows a more even distribution of the use of pastures during the day.

The second half of the first period (1959–1969), when most of the changes happened, saw the consolidation of previously developed cooperative farms into bigger units. These were developed to use the advantages of the large-scale socialist economy in terms of the

complex and complete application of mechanization, use of chemical technologies and work organization (YORDANOV 1981). It was a transitional period, whereby the number of animals reached its minimum in the area at the beginning, and its maximum at the end (Fig. 2). It was also the time when extensive land use was replaced by intensive management. These might be the reasons why the sum of hectares that remained unchanged during the period was the smallest (Table 1, Fig. 3c).

The next period (1969–1989) was a time with a constant high intensity of management in the area and increase in agricultural production (DARDZHONOV 1994). Unlike the previous period when the growth of agricultural production was due to an increase in the number of animals, here it was determined mainly by the increase in average yields per head of livestock. The number of animals in the area reached high values again and became stable for about 15 years (Fig. 2). After such an intensification of management regimes it was inevitable that this period had the greatest changes in vegetation during the whole study period (Table 1, Fig. 2). It is obvious in Figure 3b that grasslands developed throughout the territory mainly at the expense of the shrub-grassland mosaic (Fig. 2), which decreased more than five times (23% of the whole territory) and nearly disappeared. Other studies also suggest that overgrazing in high mountain pastures, e.g. in the SW Tien Shan mountains where a continuous increase in livestock numbers reinforced the degradation of mountain pastures (BORCHARDT et al. 2011, CINGOLANI et al. 2013, AKASBI et al. 2013). Table 1 also shows us that despite the highly intensive management during this period, there were still places where grasslands became shrublands or shrub-grassland mosaic, which is a sign of selective abandonment. These areas were mainly close to the timberline (where Karakachans deliberately centered part of their herds) or in areas of cleared shrublands or shrub-grasslands mosaic during the previous period (Fig. 3b and c). We assume that there is a tendency for re-establishment of shrublands or shrub-grassland mosaic, which is the potential natural vegetation here (BOHN et al. 2004), in places subjected to abandonment. On the other hand, there were also small areas where shrublands reduced in density or even became grasslands (Table 1), probably as a result of cutting of shrubs to create new pastures which was a common practice during 1969–1989 (DIMOV at al. 1970).

During the third period (1989–2012), for the first time the area covered by shrub-grassland mosaic increased in size mainly in place of former grasslands. This process coincided in time with a large drop in the number of animals (Fig. 2 and 3). This was the period when grazing was limited due to the regulations in the management plan of the park on one hand, and by the agrarian crisis in the country on the other. It seems logical that areas of shrublands or shrub-grassland mosaic that were cleared to create new pastures then become overgrown again after a reduction in grazing pressure, as was observed by KAHMEN & POSCHLOD (2008). The same process was found in grasslands which turned into shrublands (Table 1, Fig. 3). The development of a patchy mosaic of different vegetation structures after the implementation of low-intensity grazing was also found by LEDERBOGEN et al. (2004). Even under low intensity management in some areas, shrublands continued to reduce their density and also became grasslands (Table 1, Fig. 3) but this time mainly due to accidental fires, not cutting. Since stands of *Juniperus communis* subsp. *nana* represent the EU habitat type 4060 - Alpine and Boreal heaths from directive 92/43/EEC (Habitat Directive), they are not allowed to be cut. In order to prevent juniper encroachment in pastures of the western Balkan Mts., complying with the same restriction, VASSILEV et al. (2011) proposed yearly rotational extensive grazing (sheep density >0.15 ha^{-1} animal units) ensuring regular movement of the herds throughout the whole grasslands.

Along with the outcomes of our study, we should also note some of its limitations. For example we were not able to test whether the established changes in landscape cover were truly due to changes in the grazing intensity; however, livestock seemed to be the most obvious explanation as no other land management practice, e.g. fuelwood collection, was applied in these rangelands. Further, we should acknowledge that if we had a more detailed time series, i.e. more images from additional years, it might have helped to reveal more changes in greater detail. Nevertheless, that would also have increased the amount of images to process and classify, potentially leading to more errors and misclassifications. Hence, in the light of our results, we regard these and our interpretations as satisfying enough to make sound conclusions regarding the developments of the past 65 years.

5. Conclusions

Historical series of aerial photographs are a useful source for the identification or reconstruction of historical changes in landscape cover, even from 65 years ago. The land cover trajectories obtained helped to interpret grazing intensity pattern. After 65 years of inconsistent management, the land cover became less diverse and reduced from 3 equally represented vegetation types to domination of only 2 types.We found that mosaic patches of shrub- and grasslands were the most affected by the land cover changes. We interpreted land cover change by looking at the development of sheep numbers in the area and described associations between vegetation and political/economic developments. In terms of landscape maintenance, this knowledge is useful for the National Park authority for further determination of the carrying capacity of mountain pastures.

Erweiterte deutsche Zusammenfassung

Einleitung – Das Grasland des Balkans stellt als Sommerweidegebiet seit Jahrhunderten eine wichtige Grundlage für die Wanderweidewirtschaft dar (MARINOV 1961). Seit der Zeit des bulgarischen Königreichs über die Sowjetzeit bis heute hat sich die Nutzung des Graslands des Balkans wiederholt geändert. In den letzten 65 Jahren wechselten im Gebiet v. a. ökonomische Krisen und Aufschwünge einander ab (BEROV 1974, DARDZHONOV 1994). Diese führten in den Sommerweidegebieten zu unterschiedlichen Vieh- insbesondere Schafsdichten. Als im Stara Planina-Gebiet im Jahr 1989 der Tsentralen Balkan National Park eingerichtet wurde, nahm die Schafsdichte zuerst stark ab und später dann, ab 2007, wieder etwas zu. Heute herrscht im Gebiet eher Über- als Unterbeweidung. Diese Veränderungen der Landnutzung bewirkten auch Veränderungen der Vegetation, die jedoch für das Gebiet bisher kaum dokumentiert wurden. Das Ziel dieser Studie war es, die Anteile von drei auf Luftbildern erkennbaren Vegetationstypen – Strauchsteppe, Grassteppe und Strauch-Grassteppe-Mosaik – über einen Zeitraum von 65 Jahren zu quantifizieren und die Ergebnisse in Beziehung zur Schafsdichte zu interpretieren.

Methoden – Wir analysierten Flächenänderungen der Strauchsteppe, Grassteppe und Strauch-Grassteppe-Mosaike im Tsentralen Balkan National Park mithilfe von Luftbildern aus den Jahren 1947, 1969, 1989 und 2012 mittels objektbasierter Luftbildsegmentierung (OBIA). Die Anteile der Vegetationstypen wurden mithilfe eines post-hoc Kartenvergleichs in einem Geographischen Informationssystem analysiert. Die Entwicklungsverläufe der drei Vegetationstypen wurden jeweils einzeln untersucht und aus zwei verschiedenen Blickwinkeln interpretiert: erstens der Entwicklungsverlauf ausgehend von einem Vegetationstyp und zweitens hinführend zu einem Vegetationstyp. Um die Veränderungen zu interpretieren, wurden für die gleichen Zeiträume die Schafsdichten anhand von lokalen Berichten ermittelt und diese visuell mit den sich ergebenden Trends aus der Bildanalyse verglichen.

Ergebnisse – Zwischen 1947 und 1969 hatte das Strauch-Grassteppe-Mosaik kontinuierlich ab- und sowohl die Strauch- als auch die Grassteppe kontinuierlich zugenommen. Dieser Trend setzte sich in der Periode 1969–89 fort, wobei das artenreiche Strauch-Grassteppe-Mosaik insgesamt am stärksten von den Landnutzungsänderungen betroffen war. Während schließlich nur noch 18 % der ursprünglichen Fläche des Strauch-Grassteppe-Mosaiks vorhanden waren, hatten die Strauchsteppe in diesem Zeitraum um 56% und die Grassteppe um 18 % zugenommen (Tab. 1). Die Zahl der Schafe im Untersuchungsgebiet schwankte zwischen 1947 und 1989 um die 140.000 Tiere. Im Zeitraum von 1989–2012, nach der Errichtung des National Parks, nahm die Schafsdichte dann von über 180.000 Tieren auf ca. 40.000 Tiere stark ab (Abb. 2). Die Entwicklungsverläufe der Vegetationstypen (Abb. 4) zeigten, dass das Strauch-Grassteppe-Mosaik häufiger in Gras- als in Strauchsteppe umgewandelt wurde. Dies geschah vor allem in der Periode 1947–1969. Ein geringer Anteil der Grassteppe entwickelte sich ab 1989 wieder zu Strauch-Grassteppe-Mosaik wohingegen Strauchsteppe nie in Strauch-Grassteppe-Mosaik überführt wurde.

Diskussion – Zwei gegensätzliche Trends ließen sich beobachten: In den Jahren bis 1989 nahmen sowohl die Strauch- als auch die Grassteppe auf Kosten des Strauch-Grassteppen-Mosaiks zu. Diese Veränderung ging einher mit steigenden Viehzahlen aber auch neuen viehwirtschaftlichen Praktiken, die in dieser Zeit im Gebiet getestet wurden, z. B. mikrobielle Futterzusätze, widerstandsfähigere Schafsrassen, mechanisierte Kollektivwirtschaft etc. (ILIEVA et al. 1997). Im Zeitraum von 1989 bis 2012, nach Gründung des Nationalparks, zeigte die Strauch- und die Grassteppe die geringsten Veränderungen der Flächenanteile. Das artenreiche Strauch-Grassteppe-Mosaik nahm in dieser Zeit leicht zu, ohne jedoch seinen ursprünglichen Anteil auch nur annährend zu erreichen. Zunahmen von Patch-Mosaik-Strukturen durch extensive Beweidungen wurden bereits aus anderen Gebieten beschrieben (z. B. LEDERBOGEN et al. 2004, VASSILEV et al. 2011). Dem Nationalpark kann extensive Beweidung daher als Managementmethode empfohlen werden, um Strauch-Grassteppe-Mosaike zu fördern.

Schlussfolgerungen – Anhand einer Luftbildserie konnten Landschaftsveränderungen über einen Zeitraum von 65 Jahren rekonstruiert werden. Anhand von drei Vegetationstypen – Grassteppe, Strauchsteppe und Strauch-Grassteppe-Mosaik – konnte gezeigt werden, dass die Landschaftsveränderungen vor allem auf Kosten des Strauch-Grassteppe-Mosaiks verliefen. Erst ab der Errichtung des Nationalparks im Jahre 1989 konnte sich dieser artenreiche Vegetationstyp (aus Grassteppen) wieder regenerieren. Obwohl nur visuell/korrelativ festgestellt, stellt die saisonale Beweidung durch Schafe im Stara Planina-Gebirge einen wichtigen Faktor für die Vegetation dar. Es sollten weitere Untersuchungen zur Entwicklung der Vegetation in Abhängigkeit von der Viehdichte im Stara Planina-Gebirge folgen.

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