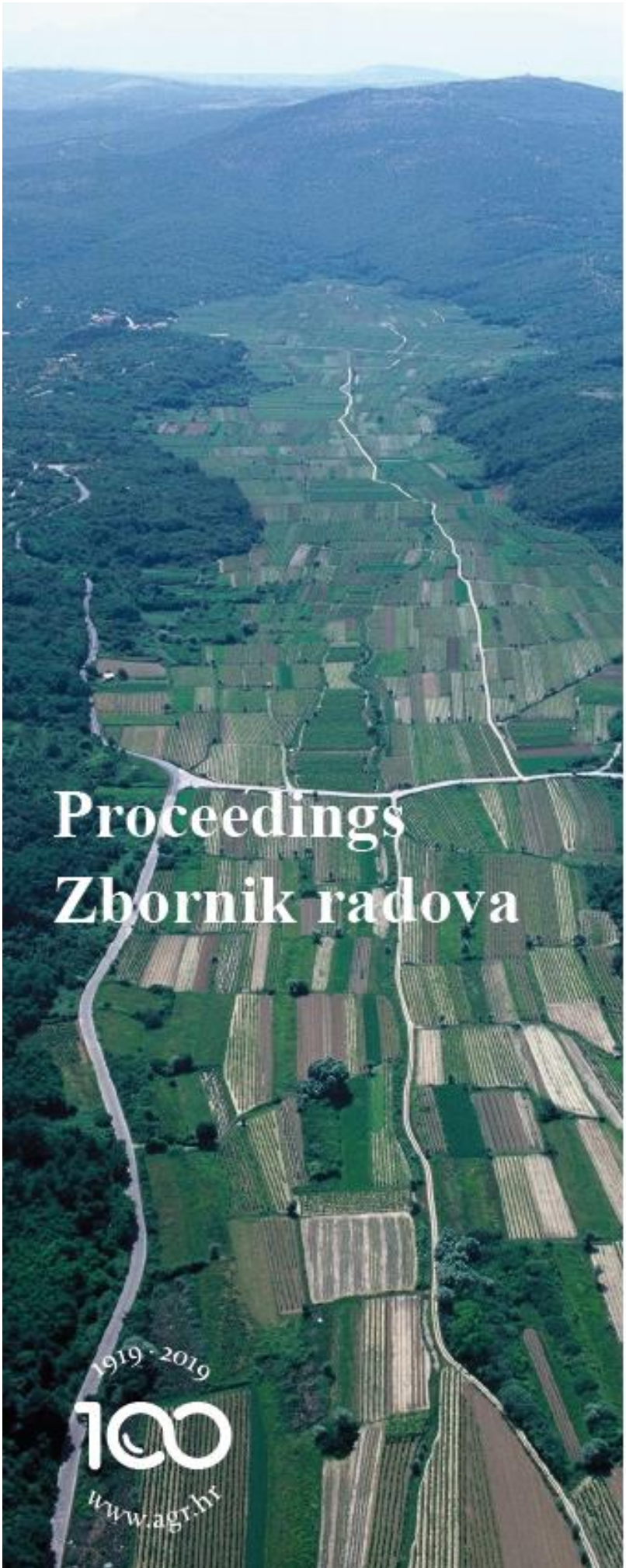


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# Forest succession as a possible factor on chamois population density: Biokovo Mountain as case study

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**Abstract**

In this research, we aimed to assess the influence of forest succession on the density of Balkan chamois population on Mt Biokovo. To calculate the percentage of forest cover increase, we analysed forest vegetation coverage from two periods (1968 and 2016). In 1968, 18% of the analyzed area was covered with forest/shrub, while in 2016 50% of the area was covered. We propose an average forest/shrub progressiveness of 0.66% per year on Mt Biokovo. Since there are various anthropogenic and non-anthropogenic factors that may affect population, it is hard to draw firm conclusions about the importance of forest succession on the changing chamois density trends. Further research based on feeding ecology in relation to existing habitat conditions should be conducted.

Key words: Balkan chamois, population density, Mountain Biokovo, vegetation succession

## Introduction

Successional stages of forest and landscape matrix structure and composition may be crucial for understanding the abundance and movement patterns of ungulate populations. The density of chamois populations depends on various factors such as interspecific competition (Schröder and Kofler, 1984), predation (Molinari-Jobin et al., 2002), disease (Serrano et al., 2015), environmental factors (Mason et al. 2014) and other anthropogenic factors (Romashin, 2001). In recent years, due to extermination of chamois and destruction of their natural habitats, many existing populations have been decreasing (Danilkin, 2005). Intensive use of meadows for tourism, building infrastructure, livestock grazing and poaching contributed to the decline of the chamois population (Sokolov and Tembotov, 1993; Papaioannou and Kati, 2007). The ungulates play an important role in ecosystem processes and their habitat use is dictated by resource availability (Morellet et al., 2011). Therefore, forest transformation represents one of the main factors affecting distribution and quality of resources with respect to animal demands (Banks et al., 2007).

The chamois species usually inhabits high mountain areas with typical mountain climate, but its high level of adaptability allowed them to spread in low-altitude areas, even to sea level (Yockney and Hickling, 2000; B. Šabić, unpublished data). Chamois prefer herbaceous vegetation (grass-like plants) even in forested habitats (Garcia-Gonzales and Cuartas, 1996, Homoloka and Heroldová, 2001), but in general, chamois is considered to be an intermediate feeder. Hence, feeding activity mostly occurs in open areas, like pastures and grasslands, but chamois can adopt its feeding habits to concentrated or fibrous food in forest habitats (Hudson and White, 1985; Hofman, 1989; Parkes and Thomson, 1995). For example, the use of open habitats by white-tailed deer may be associated with its large body size and the structure of male antlers which influence movement and feeding (Bolaños and Naranjo, 2001).

The Balkan chamois (*Rupicapra rupicapra balcanica*) were reintroduced to Mt Biokovo by several successive

translocations from 1964 to 1967, with a total of 48 Balkan chamois from Mt Prenj in Bosnia and Hezegovina (Šabić, 2014). In that time, no mountain ungulates had existed on Mt Biokovo, and the chamois population increased rapidly, reaching around 1100 individuals in the 1990s. In contrast, from that period chamois numbers significantly decreased, with current populations staying constant at around 400 individuals (Šabić and Lalić, 2005). Poaching and wolf (*Canis lupus*) escalation are considered as main factors for such a decrease in chamois density (B. Šabić, unpublished data).

Two shrubland communities dominate in the research area: oriental hornbeam (*Carpinus orientalis*) in lower areas, and thickets of European hop hornbeam (*Ostrya carpinifolia*) in higher areas. The upper border of hornbeam on the mainland side encounters beech (*Fagus sylvatica)* and fir (*Abies alba*) (Trinajstić, 2002). On the coastal side, pine forest is expanding as a pioneer species.

Considering the above-mentioned factors, in this research we aimed to assess the influence of forest succession on the density of Balkan chamois population on Mt Biokovo. Using the available knowledge about the chamois physiological needs, our hypothesis is that: i) if forest succession is taking place on Mt Biokovo then ii) disappearance of the most important chamois feeding sites (i.e. open areas) could negatively affect population density.

## Materials and methods

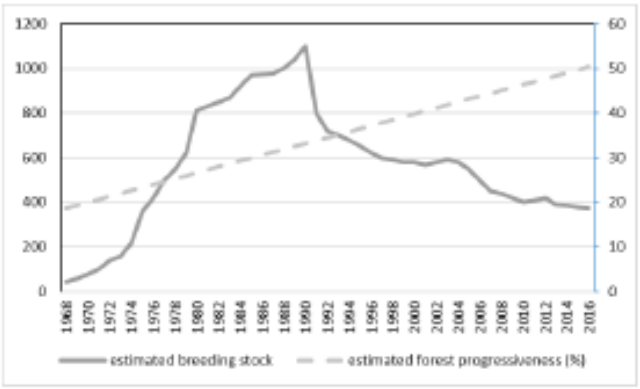
The chamois density on Mt Biokovo was estimated by regular observations twice a year (spring and autumn) and to obtain the population size data, we used official game management plans where all data is stored.

To calculate the rate of forest succession (including shrub cover) we used two different digital ortofoto maps. First map was recorded in 1968 with geometrical resolution of 5-10 m/pixel, and the second in 2016 with geometrical resolution of 0.2-0.5 m/pixel. The high resolution of both maps represented the most powerful and precise method to determine the forest succession rate over the half-century period since we were able to distinguish different vegetation covers precisely. Using Quantum GIS (version 3.0.3), we generated 30 random points on the investigated surface. To describe existing forest areas, square plots of 100 x 100 m were set over each point on the map where polygons were drawn around forest vegetation by hand for each period and overlapped. Then, using the "difference" tool, we detracted "old" (1968) from "new" (2016) polygons, which allowed us to calculate the percentage of forest and shrub progression over time.

## Results and discussion

The chamois population after translocation in 1964 experienced rapid growth (Graph 1), probably due to several factors like intact and unexploited habitat by other ungulates, low – tourism pressure, absence of predators, absence of hunting activities, etc. The greatest decrease of the research population occurred during the "Homeland War" (after 1990) due to the lack of game management and poaching activities. Today, the population is stable with around 400 individuals (B. Šabić, unpublished data).

Through random points, we analysed 30 ha of investigated area. In 1968, forest/shrub covered 5.4 ha (18%) of the analysed area, while in 2016, 15 ha (50%) was covered in forest/shrub (i.e., ~ 0.2 ha of forest and shrub vegetation increase per year). However, due to the deficiency of maps in the period between investigated years, it was impossible to obtain appropriate annual data of vegetation cover in the study area. Still, based on available data we propose an average forest/shrub progressiveness of 0.66% per year on Mt Biokovo (Graph 1). Indeed, this is clear evidence of ecological succession. Recent research by Kavčić et al. (2018) using Copernicus web service high-resolution layers found prevalence of forest areas on Mt Biokovo (~55%), which supports our result obtained from 2016 maps. Other surfaces in the same research were characterized as open areas (45%; grasslands, pastures and rocky areas).




*Graph 1. Trend of chamois density (left scale) and predicted succession rate in % (right scale).*

High habitat quality is considered as one of the most important factors that promotes success of reintroduction (Wolf et al., 1996). When reintroduced to Mt Biokovo, chamois populations encountered extensive open areas and much higher grass-dominated vegetation communities, which according to our result has changed and possibly affected chamois food availability. On the other hand, chamois are well adopted to forest areas and as an intermediate eater capable of adapting its digestive system to different food resources (concentrate or roughage forages) behaving like a 'grazer' or a 'browser' depending on the season (Garcia-Gonzales and Cuartas, 1996). Successional change is often characterized by progressive dominance of annual and perennial herbs, shrubs, and trees, although all of these species are typically represented throughout the entire sequence of forest stand development (Halpern, 1988). Interestingly, research by Herrero et al. (1996) found chamois mainly in mountain pine forests and clearcuts, and very rarely in beech and fir forests, suggesting the spreading of pine forest on Mt. Biokovo as a positive factor affecting chamois distribution.

The reintroduction of chamois is the main reason for reappearance of large predators on Mt Biokovo (Apollonio et al., 2014). Indeed, wolves are considered as one of the most important factors affecting chamois density on Mt Biokovo. In the past decade wolves has begun to appear, and nowadays they are constantly present with two resident packs (B. Šabić, unpublished data). This claim may be supported by Palmegiani et al. (2013) who found that majority of a wolf`s diet in Grand Paradiso National Park is based on chamois (78%).

The expansion of wild boar (*Sus scrofa*) populations in Europe (Massei et al., 2015) has also become evident on Mt Biokovo in recent decades. Today, their population is increasing, probably due to habitat transformation, which may have influenced chamois daily activity patterns (Šprem et al., 2015) and induce them to use suboptimal feeding strategies (Chirichella et al., 2013). Besides, human interface could strongly affect regular rhythms of grazing and ruminating in chamois (Caderna and Lovari, 1985). Since Mt Biokovo was declared a Natural Park in 1981, tourism pressure is constantly increasing. As proved by Zwijacz-Kozica et al. (2013) tourism activities can cause habitat disturbance and influence chamois behaviour. Additionally, the sudden population decline in the 1990s (Graph 1) is very likely linked to socio-political drivers (see discussion in Kinzig and McShane, 2015), which encouraged poaching activities that are, for instance, considered a major threat to chamois survival in Greece (Papaioannou and Kati, 2007).

Taking into account the existing knowledge about the chamois movement patterns and high adaptability to various habitat conditions, we suggest Mt Biokovo as a rich and favorable habitat for Balkan chamois existence, regardless of the ecological succession rates. Moreover, the influence of environmental and climate change (global warming) should be considered, since it can seriously affect chamois behaviour or physiology and lead to decline in body mass (Mason et al., 2014). However, available data is too sparse to draw firm conclusions of responsible factors that affected chamois density in the past. Forest succession may modify chamois behaviour patterns and consequently affect population size. Hence, further clarification of this statement should be confirmed with future research.

## Conclusions

We found clear evidence of forest succession on Mt Biokovo, with 32% progression in the past 48 years. To clarify the influence of forest succession on chamois density, further research based on feeding ecology in relation to habitat conditions should be conducted. In addition, it would be desirable to link the movement/migration patterns of chamois in response to habitat change. In conclusion, the density of chamois on Mt Biokovo is shaped by several mentioned factors, which may be limiting for the local population and should be considered in management.

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# Sukcesija šume kao mogući čimbenik gustoće populacije divokoza: Biokovo kao studija slučaja

**Sažetak**

Cilj ovog istraživanja na Biokovu bio je ustanoviti utjecaj sukcesije šume na gustoću populacije Balkanske divokoze. Kako bi izračunali širenje pokrova, crtani su poligoni oko šumske vegetacije tijekom dva perioda (1968. g. i 2016. g.). Istraživani pokrov 1968. godine zauzimao je 18%, dok je 2016. godine pokrivenost iznosila 50%. Prosječna progresija šumskog/grmolikog pokrova na Biokovu iznosila je 0,66% godišnje. S obzirom da je istraživana populacija pod utjecajem raznih antropogenih i prirodnih čimbenika, teško je donijeti jasne zaključke o važnosti sukcesije šume na mijenjajući trend gustoće populacije divokoza. Potrebna su buduća istraživanja temeljena na ekologiji hranjenja divokoza u odnosu na postojeće uvjete staništa.

Ključne riječi: Balkanska divokoza, gustoća populacije, planina Biokovo, sukcesija vegetacije