



Evaluating forest management intensity on an umbrella species: Capercaillie persistence in central Europe



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ABSTRACT

Deforestation and fragmentation of forests worldwide are negatively impacting biodiversity. The capercaillie (*Tetrao urogallus*) is an endangered umbrella species of montane forests in central Europe. Despite its status, it has largely been overlooked in forest management planning in the Carpathian Mountains, a biodiversity hotspot within the European Union. Previous investigations of timber management effects on capercaillie have shown contradictory results within Europe; habitat loss and fragmentation due to intensive forest management have been implicated in population declines, while other studies have suggested neutral or positive effects. In Romania, recent changes in forest management have shifted from extensive, selective logging to intensive clearcutting; this change provides the opportunity to assess the effects of harvesting on capercaillie numbers across a full range of forest management intensities, thereby addressing discrepancies in the literature. Across the Southern and Eastern Carpathian mountains from 2009–2011, we used spring counts of capercaillie males at leks to evaluate the impact of forest management, other human activities, and habitat at two spatial scales – stand (~2 ha) and landscape (~300 ha). At the landscape level, the proportion of forest clearcuts and intensity of tourism had significant negative effects on the number of capercaillie males in the lek. In contrast, low intensity selective logging had a positive effect at the local stand (lek) level. Large scale (landscape level) forest clear-cutting had a negative effect on the capercaillie population – areas comprised of clearcuts of 30% reduced male lek counts by 76%. The protection of intact mature and old-growth forests, and forest management practices that emulate natural disturbance processes are recommended to support habitat of this critical umbrella species and associated biodiversity.

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1. Introduction

Over the past century, global declines in mature forested area (Hansen et al., 2013) and biodiversity related to habitat loss, fragmentation, and overexploitation are causing increased concern among natural resource managers and conservationists (Wilcove et al., 1998). Large-scale clear-cutting of forested landscapes has driven the vast majority of forest species losses (Lamberson and McKelvey, 1992; Wallenius et al., 2010) and much attention has

been devoted to alternative harvest strategies and associated management to retain forest species within landscapes (e.g. Franklin and Johnson, 2012). In areas such as central Europe that historically have been heavily forested but now have limited and increasingly fewer areas of old-growth forest cover (Mackey et al., 2014), identifying management impacts and alternatives is a priority. Here, we use the capercaillie, *Tetrao urogallus*, to evaluate the effects of logging old forests on mating habitat selection. The capercaillie is considered an umbrella species within the region and an indicator of structurally rich forest conditions (Suter et al., 2002). Capercaillie populations in central Europe have declined rapidly in recent decades (Storch, 2007a). Identifying

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forestry practices that may aid in maintaining viable population levels of this species within forested landscapes are vital to ensure their persistence in the landscape alongside many other species commonly represented in these habitat types.

Capercaillie inhabits forests of Eurasia, and they are associated with extensive natural, old-growth or young open canopy forests, characterized by high levels of structural heterogeneity, particularly, multistoried tree layers and abundant cover of ericaceous understory shrubs (Bollmann et al., 2005; Klaus et al., 1989; Storch, 2002; Suter et al., 2002). Because capercaillie is strongly associated with open canopy forest and has a relatively large home range, it is considered an indicator species for high biodiversity and protection of its habitat will benefit other old-growth forest species as well (Pakkala et al., 2003; Suter et al., 2002).

Lek sites, where males display in spring, are particularly vulnerable to disturbance by humans and may be readily abandoned, as is common with many species of grouse with this mating system (e.g. Hess and Beck, 2012; Klaus et al., 1989). Anthropogenic activities, especially the intensification of forest management, have resulted in the significant loss and fragmentation of suitable capercaillie habitat in many parts of western and central Europe (Storch, 2007a). In many European countries, capercaillie populations are now artificially maintained using release projects, specialized habitat management measures, or predation control (Klaus, 1997; Marshall and Edwards-Jones, 1998; Siano and Klaus, 2013; Storch, 2000). Capercaillie is a red-listed species in Annex I of the EU Birds Directive in most European countries, and it is a specific designated feature of many of the Natura 2000 sites (Storch, 2007a).

One of the remaining strongholds of capercaillie populations in central Europe is the Carpathian Mountains that stretch from the Czech Republic east to Ukraine and extend to southern Romania. The Carpathian Mountains possess one of the largest areas of old-growth and natural forests in Europe with thriving populations of brown bears (*Ursus arctos*), lynx (*Lynx lynx*), grey wolves (*Canis lupus*), european bison (*Bison bonasus*) (Veen et al., 2010), and, historically, a stable and self-sustaining capercaillie population. Historic land uses, such as grazing and selective logging, maintained habitat conditions suitable for capercaillie (Hancock et al., 2011; Klaus et al., 1989). However, management practices have changed in the last few decades, with more large scale clearcuts and associated landscape fragmentation taking place, mainly due to new post-communist forest restitution laws (privatization of forest lands) and increasing accessibility by new forest roads (Knorn et al., 2012a,b).

Habitat loss and fragmentation related to logging activities have been shown to negatively impact the reproductive success of capercaillie in boreal forests (Lakka and Kouki, 2009). Similarly, in western and central Europe, a decline of capercaillie populations also has been linked to habitat loss through fragmentation and logging (Storch, 2007a). In contrast, recent evidence from boreal forests indicates that the capercaillie is relatively tolerant to changes in forest management regimes and populations will persist in the long term, even in landscapes with large-scale clearcutting (Miettinen, 2009; Wegge and Rolstad, 2011). However, capercaillie distribution in boreal forests is continuous and not as fragmented as in other areas of Europe (Storch, 2007a), and boreal forest regeneration patterns and dynamics is different compared to temperate regions of Europe.

Given clear declines of capercaillie associated with intensification of forest management over the last two decades, the main objective of this study was to identify the most important predictors influencing capercaillie male numbers in the leks in the Southern and Eastern Carpathians. We focused on stand and landscape features surrounding lek centres where mating occurs because they are critically important for sustaining local

populations (Miettinen et al., 2005; Picozzi et al., 1992; Saniga, 2003). Specifically, we were interested in how human land use, intensity of forest management, habitat fragmentation, and loss of suitable habitat affect capercaillie abundance at the display grounds. Outcomes from this study highlight threats to capercaillie and identify forest management practices compatible with conservation goals.

2. Methods

2.1. Study area

Across the Southern and Eastern Carpathians within Romania, we sampled forests of 11 separate mountains. The potential size of suitable habitats (mountain forests with elevation >1000 m above sea level) was estimated on 190,113 ha; total area of all studied lek centres (1 km radius around the lek centres) was 6594 ha. The climate of Romania ranges from temperate to continental, and cold winters and high precipitation are typical for mountainous areas. The mean winter temperature is -5.2 °C with mean winter precipitation of 355 mm, while mean summer temperature is 13.9 °C and summer precipitation of 1095 mm in the study area (Toader and Dumitr, 2005).

2.2. Capercaillie population in the study area

Based on hunting surveys across Romania, the total population of Capercaillie was estimated to be ~10,000 birds as of 2007 (Storch, 2007b). During our the study period, hunting of capercaillie was legal in Romania; however, since 2012, hunting of capercaillie has been prohibited, although ongoing illegal hunting may still have serious effects on capercaillie populations in some regions. The lek centres studied were located at altitudes ranging from 1320 to 1722 m above sea level. The prevalent vegetation type was Norway spruce (*Picea abies* (L.) Karst.) forest (86%), mixed European larch (*Larix decidua* Mill.)–Norway spruce forest (9.5%), and mixed Norway spruce–Silver fir (*Abies alba* Mill.)–European beech forest (*Fagus sylvatica* L.) (4.5%).

2.3. History of forest management in the study area

The capercaillie habitats in the Carpathians are mostly high elevation natural forests with old-growth characteristics, such as large amounts of dead wood, elevated root plates, and multi-cohort open canopy stands (see the Appendix). Only 9% of the lek centres occurred in areas of naturally regenerated open canopy stands (~60 years old) resulting from abandonment of grazing of montane pastures. In the past, all stands were difficult to access and forest management was predominantly selective single-tree or group logging made by the shepherds who used the surrounding mountain pastures during the summer (Huband et al., 2010). Forest management practices changed considerably in the studied area after the collapse of communism in 1989. New forest roads were built into formerly inaccessible areas and large areas of state forest were restituted to prior owners resulting in increased forest harvesting at large spatial scales (Griffiths et al., 2014; Knorn et al., 2012a,b). In addition, some forested areas were officially categorized as pastures, thus enabling owners to make large clearcuts without any control, and illegal logging has occurred during the post-communist era. Extensive clearcutting forestry has also occurred in protected areas, such as national parks. Based on remote sensing data (Landsat imagery; Table 1, Griffiths et al., 2014), in our study plots the mean percentage of clearcuts after 1990s in protected areas is higher (24.6%), compared to unprotected areas (16.4%). Based on the forest ownership

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