Forest Ecology and Management 429 (2018) 511–519

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Intensity of red deer browsing on young rowans differs between freshly-felled and standing individuals

Bohdan Konôpka[a,b,*], Jozef Pajtík[a], Lisa A. Shipley[c]

[a] National Forest Centre, Forest Research Institute, T.G. Masaryka 2175/22, 960 92 Zvolen, Slovakia
[b] Czech University of Life Science, Faculty of Forestry and Wood Sciences, Kamýcká 129, 165 00 Praha – Suchdol, Czech Republic
[c] Washington State University, School of the Environment, Pullman 99164-2812, USA

ARTICLE INFO

Keywords:
Cervus elaphus
Sorbus aucuparia
Herbivory
Bark stripping
Stand cleaning
Slovakia

ABSTRACT

Because red deer (*Cervus elaphus*) forage extensively on woody plants, browsing is a serious problem in forest stands especially in initial growth stages. In Slovakia, rowans (*Sorbus aucuparia*) are the most attractive tree species for red deer, and when present, they may serve to divert the attention of foraging red deer from commercial forest stands. In this study we compared the extent of herbivory by red deer on standing and freshly-felled rowans within a mixed conifer forest. We quantified the biomass of stem bark, branch bark and whole branches consumed by red deer on 60 rowans between 200 and 600 cm tall within young stands that regenerated after a large scale windstorm in the Tatra National Park, Northern Slovakia. We calculated the dry biomass of browsed branches using allometric relationships with branch diameter and browsed bark biomass from the product of the area of consumed bark and specific surface mass of bark. We found that the extent and intensity of browsing was much higher on felled than standing rowans. The number of patches of stripped bark on stems was twice as high (12 ± 6 bites/stem) on felled than on standing trees (6 ± 2 bites/stem). Similarly, red deer consumed more total biomass (i.e., bark stripping on both stem and branches and browsed whole branches) from felled (45 ± 41 g) than standing (28 ± 22 g) rowans. Red deer consumed more mass from stem bark than branches. Total browsed mass on trees (especially on felled ones) increased with their height. Based on our findings, we recommend cutting rowans after most trees exceed 500 cm in height and leaving them in the site. However, if rowans have been intensively damaged by browsing and the forage potential of the stem bark and branches is reduced, trees can be felled before they reach 500 cm. We concluded that cut timing and after-cut arrangement of rowans, and likely other non-commercial tree species attractive to red deer, may substantially mitigate red deer browsing on commercial tree species in young stands.

1. Introduction

Although classified as mixed feeders because they are able to consume large amounts of both graminoids and woody plants (i.e., browse), red deer (*Cervus elaphus*) consume diets of predominately browse within many European forests (e.g., up to 90% seasonally, Finďo and Petráš, 2007; Jamrozy, 1980; Homolka, 1990). Because of their large size (males often weigh > 200 kg; Červený et al., 2013) and high densities in many areas (Holá et al., 2016; Konôpka et al., 2014), browsing by red deer on young trees can have a substantial effect on forest regeneration (Latham et al., 1999; Čermák et al., 2009), with damage exceeding that of other wild herbivores such as roe deer (*Capreolus capreolus*; Prokešová, 2004) and fallow deer (*Dama dama*; Moore et al., 2000). Red deer damage young trees by browsing shoots, foliage, and small branches, whereas larger trees are damaged mainly through bark stripping (e.g., Konôpka et al., 2012). In Slovakia, data from the National Forest Inventory collected in 2015–2016 (Šebeň, 2017) showed that approximately one third of all trees up to 10 years old were affected by browsing by wild herbivores. In general, these effects are greatest in young even-aged and often post-disturbance forests, and can seriously reduce the economic feasibility of tree planting (Gill, 1992; Barančeková et al., 2007).

In Slovakia, forest managers have attempted to mitigate damage by red deer and other wild herbivores using techniques such as protecting individual trees using olfactory repellents or placing plastic caps on the tree terminus and protecting groups of trees using fencing (Finďo and Petráš, 2007). However, these techniques are expensive and time-consuming to build and maintain, thus the use of fencing and barriers has declined over the last two decades (Ministry of Agriculture and Rural Development of the Slovak Republic, 2017). During the same time

* Corresponding author at: National Forest Centre, Forest Research Institute, T.G. Masaryka 2175/22, 960 92 Zvolen, Slovakia.
E-mail address: bkonopka@nlcsk.org (B. Konôpka).

https://doi.org/10.1016/j.foreco.2018.07.048
Received 23 May 2018; Received in revised form 23 July 2018; Accepted 27 July 2018

period, red deer populations have increased forest management and game management (Konôpka et al., 2015a), as has been reported in other European countries (Burbaite and Csányi, 2010; Schulze et al., 2014; Holá et al., 2016). Although reducing red deer populations has the potential to reduce tree damage in some forests, this measure is not equally supported by different interest groups (e.g., hunters, environmentalists, forest owners, farmers) in many countries such as Slovakia (Finďo and Petráš, 2007).

Therefore, alternative methods for reducing forest damage by red deer are needed. One possibility is to purposely boost alternative desirable food to lure red deer away from commercially-valuable tree species. This might be accomplished by promoting mixed stands containing both commercially-valuable tree species and tree species attractive to herbivores but with low economic value (Čermák et al., 2009). On such attractive but low value species is rowan (*Sorbus aucuparia*), a deciduous tree that is a highly preferred forage by red deer and other large herbivores (e.g., Heroldová et al., 2003; Motta, 2003; Myking et al., 2013). Rowan naturally regenerates in post-disturbance areas within Slovakian forests (Konôpka et al., 2015b; Pajtík et al., 2015). In managed forests, rowan trees are usually cut down within the cleaning (i.e., removal of less desirable individuals during the sapling stage to prevent them from over-topping favoured saplings) at around 10 years post-regeneration or in the first thinning at about 20 years post-regeneration and left in the stands. Therefore, the standing or felled rowans (~1 year post-felling) may provide a temporary attractive alternative to the commercial species, allowing the commercial species to grow past their most vulnerable stage (i.e., stand rotation time is about 90 years for coniferous species and 110 years for hardwood broadleaved species). However, as yet the relative accessibility and attractiveness of standing and felled rowans as deer forage has not been evaluated.

In this study we compared consumption of felled and live standing rowans by free-ranging red deer recorded 11 years after a windstorm disturbance (i.e., trees were < 11 years old). We hypothesized that red deer would browse more intensely on felled rowan trees than live standing trees because they would take less effort to acquire bark and branch biomass and a greater proportion of the tree would be accessible to red deer. Moreover, we expected that differences in intensity of damage on stems and crowns between standing and felled individuals would be positively related to tree height because the taller the tree, the greater proportion of unreachable mass to total tree mass in standing but not in felled individuals. Understanding the value of standing and felled rowans to red deer will allow us to frame recommendations on timing of cut and after cut arrangement of rowans.

2. Material and methods

2.1. Site and forest description

Our research was conducted in the central part of a post-disturbance area that arose after a large-scale windstorm that occurred on 19 November 2004 in the Tatra National Park (TNP) in northern Slovakia. The storm damaged spruce-dominated forests located mainly in elevations ranging from 700 to 1,400 m in a relatively continuous belt oriented in a West-East direction, nearly 35 km long and 5 km wide (Šebeň, 2010). The forest soils consit mainly of cambisols, the bedrock is granodiorit. The climate is continental with mean annual temperature of about 4.0° C. Precipitation averages 800–1,200 mm annually with nearly 140 days of snow cover (Vološčuk et al., 1994). During our study in 2015, 11 years post-disturbance, the area was covered mostly by young forest stands originating from both natural regeneration predominately of rowan, a variety of birches (primarily silver birch (*B. pendula*)), goat willow (*Salix caprea)* and trembling aspen (*Populus tremula)*, and from planting mainly Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*) and European larch (*Larix decidua)*. Scattered open areas among the young forest stands were covered by grasses (e.g., *Calamagrostis* sp., *Avenella flexuosa, Luzula luzuloides*), forbs (e.g., *Epilobium angustifolium, Senecio nemorensis, Rubus idaeus*) and shrubs (mostly *Vaccinium myrtillus, Sambucus racemosa*). The population density of red deer in the TNP in 2015 was estimated at 21 individuals per 1000 ha, a 75% increase in estimates made in a before the wind disaster episode (i.e., 12 individuals per 1000 ha in the reference year 2000; Headquarters of the TNP, pers comm.).

2.2. Estimation of basic stand characteristics

To describe stand condition on the site (49° 08′ N and 20° 13′ E) located close to the Starý Smokovec village, we established a research transect in the early spring 2015. The site belongs to the Smokovce Protective Unit managed by the State Forests of the TNP. Orientation of the belt transect was from Northwest to Southeast at elevations between 925 and 970 m. The transect was 4 m wide and 300 m long. Along the transect, we established 25 plots of 4 × 4 m spaced 8 m apart to increase independence of plots. We measured height, stem diameter at 130 cm from the ground (DBH, hereafter) and stem diameter at ground level (d_0 hereafter) of all trees inside the plots (approximately 600 total). We repeated these measurements in the early spring 2016, following a cleaning procedure performed by forest managers the previous summer. This cleaning targeted large rowans and goat willow which were cut with a chainsaw. Felled trees were left in the stands.

2.3. Measurement of browsing on rowan trees

Browsing by red deer on the stem bark (stem bark browsing; hereafter SBB), on the branch bark (branch bark browsing; hereafter BBB), and on small branches cropped completely off and eaten (whole-branch browsing; hereafter WBB, see Fig. 1 for explanation) occurred during the winter of 2015–2016. In the early spring of 2016 we measured 60 rowan trees within the belt transect, including 30 lying (felled) and 30 standing (live) trees. Selected trees were ≥200 cm tall because most smaller trees were not browsed by red deer.

For each felled tree selected we measured its height using a measure pole (precision ± 10 mm) and d_0 and DBH (precision ± 0.1 mm) by digital calipers. The stem was divided into 20-cm long segments starting from the stem base, which were marked by chalk on the stem surface. We calculated the area of bark removed by red deer by measuring the length and width of all bark patches (SBB, an area of continuous debarking by red deer) on the stem using digital calipers (precision ± 0.1 mm) and recorded SBB by stem segment based on distance from the stem base (e.g., 0–50 cm, 50–100 cm, 100–150 cm etc.). In addition, in the middle of each stem segment, we measured the stem diameter in two perpendicular directions using digital calipers (± 1.0 mm). The same measurements were performed for BBB. Then, all branches

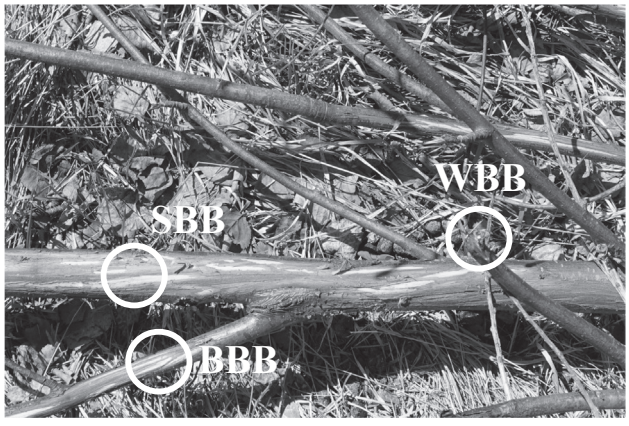

Fig. 1. Example of bark browsing on stem (SBB), on branch (BBB), and browsing of whole branches (i.e. both wood and bark were consumed; WBB).