The Impact of Thinning Type on Bark Stripping Damage Intensity Caused by Red deer (*Cervus elaphus* L.)

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Abstract

The aim of this study was to identify the influence of forest thinning methods on bark stripping damage caused by red deer. It was assumed that spruce stem bark damage would be higher in stands with target trees only than in stands including other non-target (sunken) spruce trees. In the ten-year-old spruce stands four types of thinning were performed (positive, negative, schematic and conical). All tested thinning methods provided attractive refuge for red deer during winter season. The differences in bark stripping damage intensity clearly proved that the presence of indifferent trees in the stand significantly reduces target tree damage. Indifferent trees growing in close proximity to a target tree significantly reduced the risk of bark stripping damage by red deer. Presence of indifferent trees in tested stands had low influence on target trees growth. We recommend leaving of indifferent (sunken) trees in stands endangered by deer bark stripping.

Keywords: bark stripping, thinning method, red deer, spruce, even-aged and structured stands.

Introduction

Forest management is strongly influenced by damage caused by large herbivores, which significantly limits the economy of timber production (Gill 1992, Schaller 2007). Herbivores damage trees mainly by browsing which affects time and costs for the regeneration of forest stands and can have severe impact on palatable tree species. The second main damage is caused by bark stripping which have severe impact on older stands of both deciduous and coniferous tree species. Despite stripping mostly does not destroy the damaged trees and the increment and timber yield of bark-stripped trees could be similar to those of undamaged trees (Welch and Scott 1998, Metslaid et al. 2013), the economic impact of stripping is extensive. The growth losses in damaged Norway spruce stands have been reported to be 14–25 % (Vasiliauskas 2001). More serious problem occurred in Slovenia, where 30–35 % spruce were damaged (Jerina et al. 2008). The main effect of bark stripping on forestry is that the unprotected wood is highly susceptible to fungal infections which can cause stain, discolouration and timber decomposition (Vasiliauskas 2001, Kiffner et al. 2008). Subsequently, the infected trees have low timber quality of the most valuable part of the stem (Vasiliauskas 2001) and high predisposition to breaking (Gill 1992). Economic losses related to bark stripping are extensive (Kató 1969, Knigge 1975). Additionally, stripping leads to complications with recovery and altering the forest structure of severely damaged stands (Mrkva 1996, Akashi and Nakashizuka 1999, Yokoyama et al. 2001, Ando et al. 2003). Therefore, the main target of forest managers is to minimize the number of damaged trees.

To protect the stands, the game abundance control together with fencing and chemical repellents are being used. Minimum attention has been paid to the importance of stand renewal processes, although it is evident that various types of recovery processes significantly influence the impact of herbivores on the forest (Reimoser and Gossow 1996). Modification of forest measurements is always the cheapest forest protection and therefore, it should be used as a basic method for restriction of game-caused-damage (VerCauteren et al. 2006). Other options should only be used if basic prevention proves to be insufficient.

Generally, forests can be cultivated either in the form of even-aged stands or in the form of structurally rich, age-diverse and species-diverse stands. Such a cultivation or management method, with a sufficient stock of trees ready to replace the damaged trees, is the most natural one and reduces the negative impact of game on the forest area (Heikkilä and Härkonen 1996). The aim of this study was to identify the influence of forest thinning methods on bark stripping damage caused by red deer. It was assumed that spruce stems bark damage would be higher in stands with target trees only than in stands with non-target trees as well. Three hypotheses were tested:

1. The use of the studied forest stands by red deer does not depend on the type of thinning. 2. The damage of all trees depends on deer abundance. 3. The damage of the target trees will be lower in stands with undergrowth.

Materials and Methods

To obtain data for the study, Norway spruce (*Picea abies*) stands were sampled at 45 plots situated in the north-east part of the Czech Republic, approximately 700 m above sea level. The plots were situated in stands growing on similar slopes and the attractiveness of plots for large herbivores due to food availability and cover were similar. Stand composition and herbivore density were similar at all selected plots. The stands were of similar age – about 10 years old, formed by natural regeneration. In all stands, the height of target trees ranged from 5 to 7 m and the number of individual target trees was 1,920 per ha. The main ungulate species was red deer (*Cervus elaphus* L.). At some plots small roe deer (*Capreolus capreolus* L.) populations were also present.

The trees in the studied stands were divided into three categories according to their importance: 1. Target trees – the tallest trees with the biggest diameter, the number of such trees was 1920 per ha in all stands; 2. Competitive trees – trees with similar height as target trees and smaller in diameter; 3. Indifferent trees – trees without competitive potential (significantly smaller in height and diameter). The studied localities were divided into a checkerboard-like systematic grid of 20×20 m, where four types of thinning were performed (Table 1.).

The damage inflicted on target and non-target trees was recorded in spring three years after the thinning. Only the fresh bark stripping damage larger than 25 cm^2 was considered for this study. At the same time, winter relative abundance of red deer at each plot was estimated by counting the faecal pellets on three transects of 2×20 m within 14 days after the snow had melted. Each plot was divided into three parts and within each part one transect was randomly situated.

Statistical data processing was performed using the Dell STATISTICA advanced analytics software package.

Table 1. Types of thinning methods

Thinning method	Description	Number of plots
Positive	All competitive trees were cut down.	6
Negative	All competitive trees together with indifferent ones were cut down.	13
Schematic	The area was divided into 2-m wide strips, in each even strip all the trees were cut down; in each odd strip all the trees were left.	11
Conical	Up to 5 indifferent trees growing at a close distance to the target trees were left; all other indifferent and competitive trees were cut down.	15

Data normality was verified by the Shapiro-Wilk test and also by common-probability charts. For data evaluation the ANOVA test was used. If the data did not meet normality, the hypotheses were tested using the non-parametric Kruskal-Wallis test or by using the Mann-Whitney *U*-test. Individual factor significance was evaluated by different tests: the Tukey Post-Hoc test was used for data complying with normality; the HSD test was used for data with different N; and the multiple comparison of *p*-values was applied for non-parametric data. Mutual dependences of factors were defined on the basis of correlation and regression analyses.

Results

Red deer abundance

The collected data on red deer abundance in the studied stands was used to determine both the impact of a particular thinning method on stand use by red deer and the intensity of spruce stands damage expressed for uniformed red deer abundance. We found 563 - 1,144 faecal pellet groups of red deer per ha in individual areas. The type of thinning method had no impact on red deer abundance ($p > 0.05$). Red deer did not show any preference to stands with both target and indifferent trees or stands with target trees only.

Damage intensity

We estimated the relationship between relative deer density and damage by comparison of damage intensity between the stands with different thinning methods applied. The number of damaged trees in all categories depended on red deer abundance in all types of thinning ($r = 0.762$; $p < 0.001$; $R^2 = 0.58$; see Figure 1.).

The number of damaged target trees per hectare differed significantly between tested thinning methods ($p < 0.001$). Number of faecal pellet groups per one ha differed significantly as well ($p < 0.001$; see Figure 2).

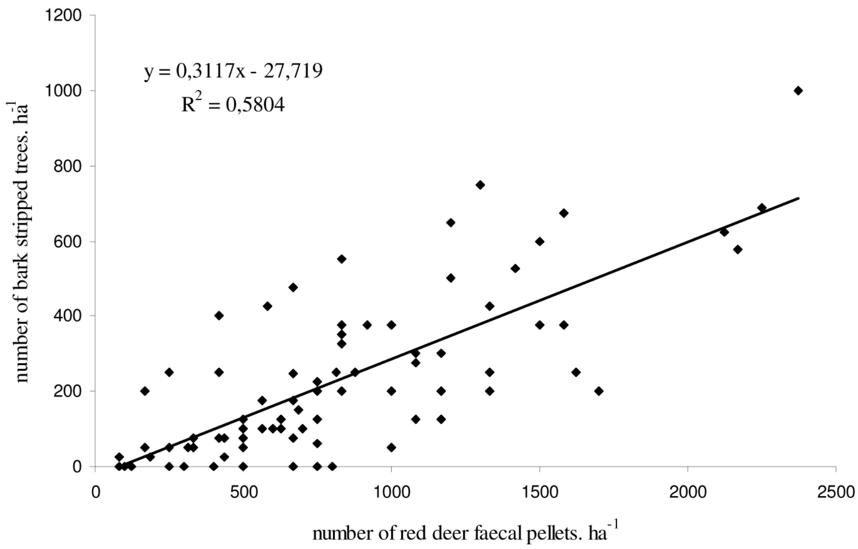

Figure 1. Relationship between the number of red deer faecal pellets and the number of damaged trees

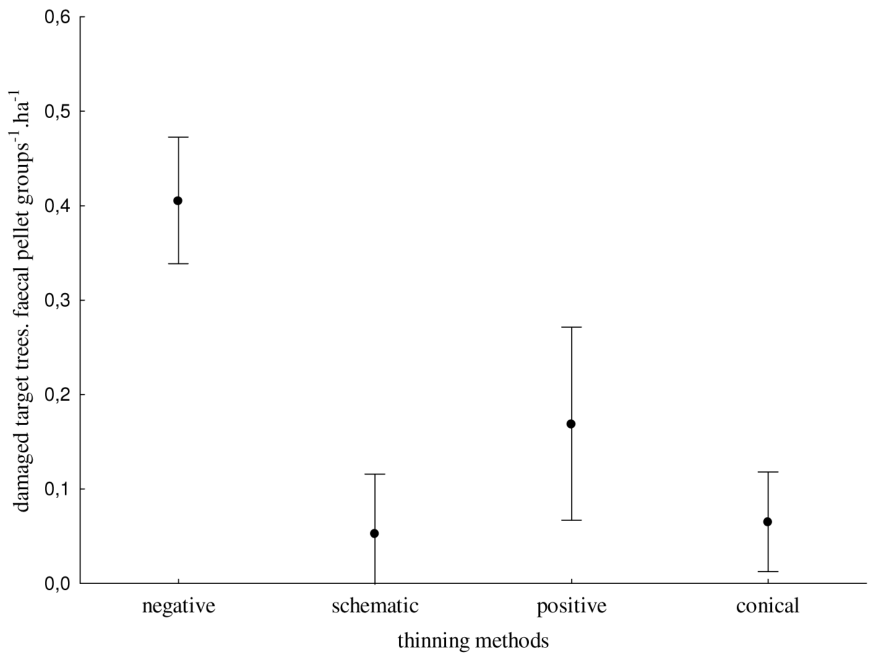

Figure 2. Intensity of bark damage of target trees in forest stands with tested thinning methods

The negative type of thinning, with no indifferent trees, proved to have the highest number of damaged trees per one pellet group and per hectare (0.41 trees; $p = 0.042$). That was 141 % more than in the areas with positive thinning, where indifferent trees were left (0.17 damaged trees). In the stands with schematic type of thinning and in those with the thinning with protective cones the number of damaged target trees was even smaller than in the positive thinning (0.05 trees; $p = 0.032$ and 0.07 trees; $p < 0.001$ respectively). Damage in the stands with schematic thinning and conical thinning was similar ($p = 1.0$).

In the conical thinning, the damage intensity of target trees with one or more protective indifferent trees was eight times lower than in unprotected target trees ($p < 0.001$). We found only several target trees with one protective indifferent tree nearby damaged. Target trees with two or more indifferent trees standing nearby proved to have no bark stripping damage.

The main factor influencing the intensity of the target trees damage was the presence of other trees in the stands. If we grouped methods of thinning, which leave indifferent trees and compared this group with negative thinning, the intensity of damage of target trees was six times higher in negative thinning ($p < 0.001$; Figure 3). The height increment of target trees was not significantly influenced by indifferent trees ($p < 0.001$).

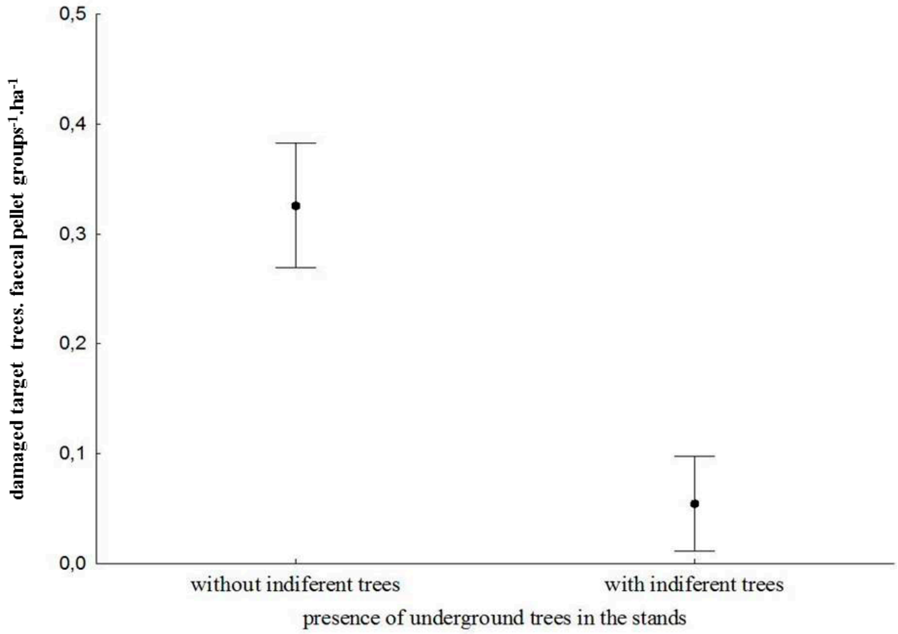

Figure 3. The intensity of damage of target trees in stands with and without indifferent trees

Discussion

Bark stripping damage has significant economic impact on forest management (Mrkva 1996, Welch and Scott 2008). Stripping reduce the quality of the timber due to staining of the wood caused by fungal growth (Čermák et al. 2004), damaged strands are unstable and extensive bark damage can lead to the death of the tree (Verheyden et al. 2006, Shibata and Torazawa 2008). Bark damage intensity depends on many factors, particularly on herbivore density, food availability, bark nutrition value, migration possibilities beyond the forest allowing gaining food, weather during winter and the structure of the stand (Gill 1992, Ando et al. 2003, Saint-Andrieux et al. 2009). The aim of this study was to evaluate possibilities of reducing stands damage by modification of thinning. Therefore, four types of thinning methods were performed in the studied stands. The number of target trees in these stands was identical, however, the presence, layout and number of non-target trees in each stand was different.

Generally, the number of damaged target trees was much smaller in the stands with two or more indifferent trees near the target trees than in the stands with standalone target trees. Even one indifferent tree left a short distance from a target tree significantly diminished the risk of bark stripping damage. If at least two or more indifferent trees were left, in a so called protective cone around a target tree, the risk of target tree damage was minimal. The number of damaged target trees in protected stands was similar for all three thinning methods, where indifferent trees remained in stands (0.05–0.17). For the intensity of bark stripping the presence of indifferent trees is much more important than their placement in the stand. We can confirm that bark stripping intensity increases excessively in sparse stands (Heikkilä and Mikkonen 1992). Comparison between the negative thinning method with target trees only and other tested thinning methods with target and indifferent trees show great effect of indifferent trees on the proportion of damaged target trees.

Low damage of target trees has three different causes: 1. dilution of the deer impact; 2. thinner trees have more delicate bark and the target trees are avoided; 3. the target trees are mechanically protected against deer.

The performed types of interventions were chosen in relation to their technical and economic feasibility for usual forest management. Apart from the bark damage itself, red deer abundance was also observed. The impact of studied thinning methods type on bark damage in stands was assessed and the number of damaged trees was calculated per uniformed red deer abundance. Expressing results per uniformed red deer abundance proved to be necessary, as there were significant differences in red deer abundance between the studied localities. Performed interventions did not have any impact on red deer stand usage, as the differences in the red deer abundance were caused by other factors, e.g. suitable position, sufficient tranquillity or vicinity of attractive food resources.

Conclusions

All tested thinning method provided attractive refuge for red deer during winter season. The differences in bark stripping damage intensity clearly proved that the presence of indifferent trees in the stand significantly reduces target tree damage.

Indifferent trees growing in close proximity to a target tree significantly reduced the risk of bark stripping damage by red deer. Two or more indifferent trees growing around a target tree minimise its damage risk.

We did not find any negative effect of indifferent trees on target trees growth and, therefore, recommend leaving of indifferent trees in stands endangered by deer bark stripping.

Other research is required for optimizing the number of indifferent trees and their distribution in stands.

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