



Review

Determinants of deer impact in European forests – A systematic literature analysis



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ABSTRACT

Little comprehensive research on forest-ungulate interactions has been undertaken to gain a holistic and deep understanding of the ecological, social and economic interdependencies regarding this sensitive topic. The understanding is mainly constrained by the complexity of the topic, which is further determined by large temporal and spatial scales. For future research as well as for practical implementation, a set of more than a few factors have to be included in study designs.

The aim of this study is to present a comprehensive overview of factors and mechanisms which can be modified to address deer impact in function-oriented silviculture. We used the approach of vote-counting to assess not only numerical data from primary literature, but also descriptive findings from conclusions and discussions in the numerous but heterogenic literature on the topic. To mitigate bias introduced in such literature surveys by individual researchers, we used group discussions to extract commonly agreeable results. We surveyed 38 studies from Europe dealing with red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*) and fallow deer (*Dama dama*). We found 185 mentions of 80 distinct factors determining browsing, bark stripping and fraying impact of these large ungulates. We provide an overview of the factors, describe the way in which they are correlated with deer impact and suggest ways to incorporate our findings in future research and management practice. Most of the broad variety of factors were related to forest properties and structure, but also disturbance and site features were relevant. We found evidence that most factors are modifiable by silvicultural means but can be overruled where deer density or disturbance of the deer population are locally in excess. Thus, our literature survey highlights the necessity of research and management approaches that integrate forest management, hunting and other stakeholder effects on deer impact.

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Contents

1. Introduction	174
1.1. Deer impact in the context of function-oriented silviculture	174
1.2. Incorporating interdisciplinary research results	174
2. Methods	174
2.1. Vote-counting and expert discussion	174
2.2. Factor counting and grouping- Aggregated Influence Factors	175
2.3. Grouping and synthesis – control mechanism groups	175
3. Results	176
3.1. Overview	176
3.2. Forest structure, spatial patterns and forage supply	176
3.2.1. Forage properties	176
3.2.2. Tree properties and tree species	177
3.2.3. Cover and canopy properties	177
3.2.4. Regeneration properties	177
3.2.5. Edge properties	178

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3.2.6.	Forest structure	178
3.2.7.	Management regime	178
3.2.8.	Vegetation structure	178
3.2.9.	Infrastructure	178
3.2.10.	Woody debris	179
3.3.	Disturbance, deer population and hunting properties	179
3.3.1.	Deer density	179
3.3.2.	Hunting regime	179
3.3.3.	Disturbance	179
3.3.4.	Population properties	180
3.4.	Site factors	180
3.4.1.	Terrain	180
3.4.2.	Climate	180
3.4.3.	Altitude	180
4.	Discussion and conclusion	180
4.1.	Methods	180
4.2.	Management opportunities	181
4.3.	Conclusion	185
	Acknowledgements	185
	Appendix A	185
	References	185

1. Introduction

1.1. Deer impact in the context of function-oriented silviculture

Forest functions, i.e. the supply of specific services or products, often conflict with each other and silvicultural techniques or other management measures applied to achieve the fulfilment of a function, may counteract the attainment of others (Gerhardt, 2009; Glück, 2000). They are determined not only by forestry concerns but also interests and aims of stakeholder groups outside forestry (Führer, 2000), and do not necessarily ‘follow in the backwash’ of timber production oriented forestry. With regard to sustainability, consequently silvicultural treatments have to be adapted to preserve the full potential of a forest to fulfil all functions in the future that it fulfils now (Sekot, 1991; Wagner, 2004, 2007).

When silviculture is used to form a forest in order to optimise a function, foresters may traditionally only plant or harvest trees. With this fairly limited set of tools, a great variety of factors can be changed. Structural features, such as canopy layer arrangement or stand density, will alter soil composition, light regime, and understorey growth (Jennings et al., 1999). Accordingly, latter will most likely have a broad-scaled impact on animal distribution patterns (Kuijper et al., 2009), population density (Bobek et al., 1984), and animal behaviour (Langvatn and Hanley, 1993), thus changing the relationship between forest and deer.

Deer impact plays a major role in forest ecosystems and can change the composition and structure of the vegetation significantly (Gill and Beardall, 2001; Hofmann, 1989; Putman et al., 2011). Therefore, it is an important factor that needs to be considered when management measures are focussed on certain forest functions. To exemplify, high stand densities may occur where early thinnings are skipped for ‘economic reasons’, but this will lower the light availability in the understorey and thus food availability for large herbivores. These may then browse or bark strip forest regeneration that may be crucial for forest functions like erosion control, high value timber production or other management goals (Partl et al., 2002).

Due to this multitude of interactions between forests and wildlife, it is crucial that forest management is based on broad understanding of the influences that manipulation of each factor could have. This study helps forest practitioners and researchers, as well as other stakeholder groups, to gain an overview of the state of

knowledge about forest-ungulate interactions in Europe. It depicts factors that determine these interactions and thus can be modified to make a forest capable of fulfilling targeted functions.

1.2. Incorporating interdisciplinary research results

While the silvicultural means are well established, it is often not known which factors need to be addressed to achieve a specific goal.

Here, deer impact can serve particularly well as an example: as has been mentioned, it strongly influences environment and society related forest functions, but also timber production, traditionally the very heart of forestry.

Nonetheless, there are ongoing debates about its causes, in which stakeholders most often demand solutions from others without noticing their own possibilities. This makes clear how important it is to make interdisciplinary and objective knowledge available for silvicultural practice and other stakeholder groups (Nopp-Mayr et al., 2011). We believe that a comprehensive overview of proven findings can objectify the debate whether and how forest management can act to control deer impact and contribute to the sustainment of desired forest functions.

In the past, there have been studies that tried to find out key mechanisms that determine deer impact on forest ecosystems, but most of these studies dealt with single or few influential factors. However, it is a major issue in forest management and it has already been made clear that deer impact can only be controlled by addressing a multitude of such factors (Weisberg et al., 2003). To our present knowledge, there has been no systematic analysis of literature that describes factors influencing deer impact. Here, we use a simple and objective method to gather factors and synthesise an overview to identify management possibilities or fields where research is needed.

2. Methods

2.1. Vote-counting and expert discussion

In this review we chose to systematically assess a representative literature sample, i.e. not only to review past research narratively, but to include also studies that were aimed to deliver information on the topic, but that might not come to any conclu-

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