

## Preface to the Special Issue: The Impact of Ungulates and Other Mammalian Herbivores on Forest Ecosystems

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Natural disturbances that vary in size, severity, and frequency play a fundamental role in structuring terrestrial, but also aquatic ecosystems by creating heterogeneity at multiple spatial and temporal scales (Pickett and White 1985). As one of the biotic disturbances, large herbivores are an important factor affecting vegetation cover locally and over the landscape (Grant and Edwards 2008). In herbivore-driven ecosystems in boreal and temperate regions, herbivores may inhibit shrub and tree cover expansion by eating shrub and tree seedlings (Kuiters and Slim 2002). Historically, humans have had a continuous and increasing impact, directly or indirectly, on browsing and grazing herbivores' populations (Danell *et al.* 1998, Schwarz *et al.* 2003, Weisberg and Bugmann 2003, Linnell and Zachos 2011, Brown *et al.* 2012). The character of this impact is related to the goals and intentions humans had for a specific area and the ways to achieve these. Over time, both goals and tools have changed and evolved, altering herbivore populations' composition and size, and hence consumption pressure on vegetation (Angelstam 2002, Edenius *et al.* 2002).

Whether the prehistoric landscape, at least in northern temperate and boreal Europe, consisted of alternated open and fragmentary forested areas (wood-pasture hypothesis, Vera 2000) or closed forest (high forest hypothesis, revived by e.g. Birks 2005, Mitchell 2005) is still under

debate (Bradshaw *et al.* 2003, Samojlik and Kuijpers 2013). Palaeoecological studies utilizing pollen analyses currently make huge progress in the development of techniques to isolate and sequence ancient DNA (e.g. Campos *et al.* 2010), and hence substantially improve the accuracy in the identification of the range of species present in a certain time period. However, reliability uncertainties remain e.g. on assumptions regarding behavioural and dietary evolution (Birks 2005, Janis 2008). Nevertheless, this does not change the idea that drastically enlarged or decimated herbivore and predator populations have a profound impact on ecosystem functioning. The first signs of human impact, in many parts of the world, appeared when land use changed the cover from solely woody vegetation to agricultural patches and livestock herding. In the current issue, Hannon and Bradshaw (2013) illustrate the potential impact of the introduction of livestock around the mid-700s AD to the Faroe Islands that until then had not been grazed by large herbivores.

During the period of forest management targeting continuous wood production, the understanding rose that herbivores are part of the ecosystem and can cause damage to commercial forests (Gill 1992, Angelstam *et al.* 2000). Most studies dealing with ungulates and their influence on the forest ecosystem focus on impacts on tree seedlings and saplings, and hence on con-

sequences for tree density and species composition (Nummi and Kuuluvainen 2013, Metslaid *et al.* 2013a, 2013b). Thus it was perceived that, for economic reasons, trees and their regeneration needed protection. In this issue, Bouchard *et al.* (2013) and Nummi and Kuuluvainen (2013) mention the decline in ungulate numbers or even extirpation of certain species, due to human interference.

Tree regeneration is an economically important issue but understory species make up the majority of stand plant species diversity and provide important habitat for birds and other forest vertebrates (Frerker *et al.* 2013, Newson *et al.* 2012). Furthermore, the interaction between understory vegetation and tree regeneration can alter due to browsing and grazing (Barton and Hanley 2013). Besides forestry purposes, the attention is now gradually moving towards halting or even reversing vegetation loss (both in cover and species diversity), the effects of herbivores on soil and other ecosystem processes, like the system's trophic balances and ecosystem vulnerability (Frelich *et al.* 2012, Bouchard *et al.* 2013, Köster *et al.* 2013).

Finally, over the past two decades a multitude of initiatives have focused on multi-purpose land use, ecosystem and landscape management, integrating social and ecological sustainability with more conventional commercial management (Angelstam 2002, Weisberg and Bugmann 2003, Stout *et al.* 2013). Approaches to achieve these goals have developed from top-down solutions to stakeholder engagement and adaptive management (Stout *et al.* 2013), and more attention is paid to sustaining natural processes by maintaining naturally sound levels of herbivore (and other, e.g. predator) populations (Bouchard *et al.* 2013, Köster *et al.* 2013, Nummi and Kuuluvainen 2013). As a future goal, the effects of environmental change on the adaptation and migration of herbivore populations should be further explored (Coulson *et al.* 2011, Brodie *et al.* 2012, Frelich *et al.* 2012), and the interactions with herbivores regarding carbon contents and sequestration (Cahoon *et al.* 2012, Köster *et al.* 2013).

Given the potentially serious impacts of ungulate herbivory, their ecological effects, including disturbances, must be better understood in order to make sustainable management

of forest ecosystems possible. It is important to monitor levels of browsing pressure and consequent changes in species abundances and community composition. Furthermore, a baseline to track these effects through time should be established. This collection of papers is based on the presentations delivered at a joint meeting covering current research and findings on the impact of ungulates and other mammalian herbivores on forest ecosystems held in Järvselja, Estonia, on 8–12 October 2012. The Nordic Forest Research Co-operation Committee, Järvselja Training and Experimental Forest Centre of the Estonian University of Life Sciences and Department of Forest Biology of Estonian University of Life Sciences hosted this international meeting. This workshop was an activity of the EFINORD-SNS network “Natural Disturbance Dynamics Analysis for Forest Ecosystem Management”, cooperating with the Nordic Working Group on the History of Primeval Boreal Forests (PRIFOR), and The Forest Ungulate Research Network (FURN) which consists of researchers from Nordic and Baltic countries in Europe and researchers from North America.

The papers presented in this special issue deal with large herbivores as one of the main disturbance factors across the boreal and northern temperate zone (Nummi and Kuuluvainen 2013, Bouchard *et al.* 2013), consequences of herbivore disturbance to the forest regeneration (Stout *et al.* 2013), and short and long term grazing and browsing effects on forest ecosystem development (Metslaid *et al.* 2013, Köster *et al.* 2013, Hannon *et al.* 2013).

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