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INTRODUCTION

Enhancing the resilience capacity of sensitive mountain forest ecosystems under environmental change (SENSFOR)

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ABSTRACT: The treeline ecotone and all treeline ecosystems (i.e. mountain forests) are important indicators of environmental change. They are heavily affected by environmental drivers, in particular by changes in climate and in land use (the latter change often being land abandonment, resulting in natural reforestation). The Europe COST Action ES1203 (Enhancing the resilience capacity of SENSitive mountain FORest ecosystems under environmental change; SENSFOR) initiative focused on treeline ecosystems in relation to such changes. SENSFOR evaluated drivers and the extent of contemporary and future environmental changes in European mountain forests, and developed methods for estimating forest resilience and defining the consequences for society. The outcome of the SENSFOR initiative provides a scientific basis on which management strategies can be developed and adjusted in cooperation with regional and local stakeholders. In addition, SENSFOR provides recommendations for policy makers at European and national levels. Through application of the DPSIR (Driver, Pressure, State, Impact, Response) framework, the findings of the SENSFOR network (consisting of 24 countries) contribute to strategy development for ecosystem service preservation and biodiversity conservation in sensitive European treeline areas.

KEY WORDS: Treeline · Climate change · Land use · Resilience · DPSIR framework

Current challenges for mountain forest ecosystems

Mountain forests (i.e. treeline ecosystems) range from the area close to the upper timber line, through the treeline ecotone with a more sparse tree cover and generally lower trees, to the tree species line and low alpine areas above (Wielgolaski et al. 2017, this Special). Climatic treelines are highly responsive to changes in climate, and can be used as indicators of ecological and socio-ecological changes in all mountain forests (Zhiyanski et al. 2017). Indicators of ecological change include trees, their growth form and seedling production, biodiversity of plants and animals, and soil indicators such as carbon stock and soil biodiversity (Broll et al. 2016). The variability of stakeholder incomes — due to, for example, changes in tourism caused by land use and climate change — can be a valuable indicator of economic change (Sarkki et al. 2017c, this Special). An important indicator of socio-ecological change is the conflict level (cf. Sarkki et al. 2015, 2017a) between different user groups (stakeholders) over the use of ecosystem services (ESs).

Warmer climatic conditions and longer growing seasons through time are believed to increase the limits of the mountain forests and treelines to higher elevations and latitudes (Holtmeier 2009, Körner

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2012). However, warmer climate increases the occurrence of tree insects and diseases (e.g. Ayres & Lombardero 2000, Wielgolaski et al. 2017) and—in middle and lower latitudes—also summer droughts, which have a negative impact on the wildfire resilience of the vegetation (e.g. Skre et al. 2002). At the same time, treeline ecosystems are also used as a reference for the efficacy of climate change mitigation policies (Skre et al. 2017, this Special). The altitudinal shift and/or structural change of treeline ecosystems reflect anthropogenic pressure on the environment, both through human-induced climate and land use changes. Consequently, anthropogenic treelines may be a result of changes in land use such as land abandonment with natural reforestation of strongly grazed area (Wielgolaski et al. 2017). In parts of Europe, sustainability of treeline ecosystems is threatened by erosion and soil degradation, due to overgrazing and other environmental drivers (e.g. Theurillat & Guisan 2001). Land-use-induced challenges to treeline ecosystems include marginalization of agricultural and timber production, water conflicts, changes in the protection status of forests and landscape degradation due to intensification of land use or land abandonment, frequently leading to changes in biodiversity (cf. Sarkki et al. 2015, 2017a, Wielgolaski et al. 2017).

Treeline ecosystems are important both for provisioning, regulating and cultural ESs; cf. Sarkki et al. (2017b, this Special) for definitions. The multifunctional character of mountain forest calls for an assessment of synergies and trade-offs between different ecosystems and their users. The development of policy guidelines for stakeholders of treeline ecosystems should result in a more sustainable and socially fair use of mountain forest ESs. The portfolio of ESs in treeline ecosystems may, however, vary considerably, depending on factors such as biogeographical region, elevation, relief, site conditions, population density and land use. While environmental policies are often clearly expressed from a broad-scale perspective, explicit management or policy recommendations for mountain forests are often missing (Sarkki et al. 2017a,c). Decision makers need fundamental knowledge about the ESs of these ecosystems to shape their policies and programs. Previous research has identified key ESs in European mountain areas, but there is often a lack of awareness of the importance of ESs (EEA 2010), and the policy implications that result from this. Thus there is a clear need to map ESs—along with the challenges related to these ESs—in different European treeline ecosystems, in order to enhance local governance.

The SENSFOR initiative

This CR Special is based on scientific case studies and syntheses of results from the 4 yr EU COST Action ES1203 project 'Enhancing the resilience capacity of sensitive mountain forest ecosystems under environmental change' (SENSFOR) (Zhiyanski et al. 2017) in which representatives from 24 European countries participated (Fig. 1). Several studies of European mountain treeline ecotone forests (Fig. 2) are presented in this CR Special. The studies included investigations of ecological processes in the highest elevated or northernmost patches of trees in undisturbed landscapes, the similarities and differences between treeline areas in Europe, and impacts of land use and climate change pressures on ecosystem processes.

The authors contributing to this CR Special are both social and natural scientists. Different disciplines are bridged through innovative approaches to the ES concept. Examples of research methodologies used in the Special include data processing, vegetation analyses, soil sampling, case studies and scenarios, GIS based assessments of treeline changes, and modelling of climate-change and land-use-change impacts. Investigations of multifunctional land use, synergies and trade-offs pertaining to the use of ESs and of ecosystem-based management and governance are also included. This CR Special consists of 12 contributions, including both review and original case studies, investigating the 4 SENSFOR objectives:

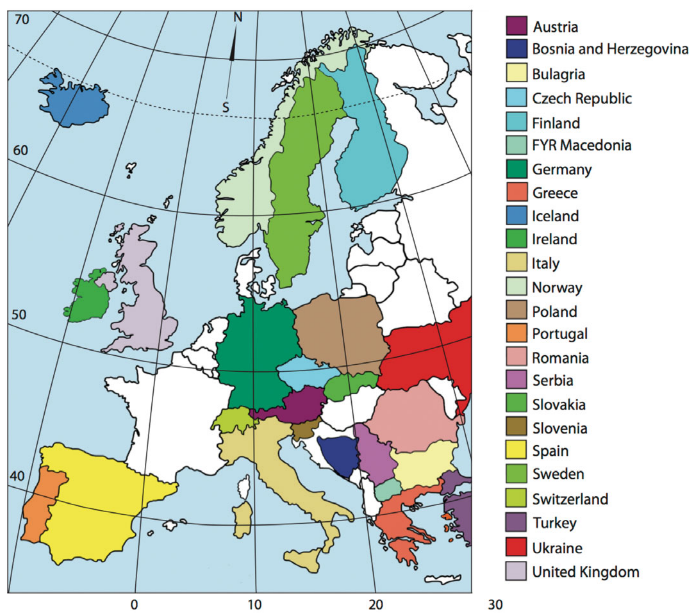

Figure 1. Countries participating in the SENSFOR project

Fig. 2. Examples of treeline ecotones. Left southern Europe (Photo: O. Skre), right northern Europe (Photo: K. Laine)

(1) Identifying main drivers of environmental change at different scales. Considering consequences for biodiversity, ecosystem functions and services, and sustainable resource use. Developing a scientific basis for best management practice in sensitive treeline ecosystems (i.e. mountain forests). Selected case studies on European high-altitude (Dinca et al. 2017, Fleischer et al. 2017, Holtmeier & Broll 2017) and on sub-polar ecosystems (Holtmeier & Broll 2017, Karlsen et al. 2017, Skre et al. 2017) were performed as part of this objective. In addition, Cudlín et al. (2017) and Wielgolaski et al. (2017) evaluated functions and processes of the treeline ecotones across Europe.

(2) Using the DPSIR (i.e. driver, pressure, state, impact, response) framework to analyse changes in treeline biodiversity, to develop monitoring methodology, to build scenarios of possible developments and land use changes, and to assess consequences for biodiversity conservation and ES in sensitive treeline areas (i.e. mountain forests). Synthesizing existing data on how the state of a treeline ecotone may function as an indicator of climate change effects on ecosystems (Moscatelli et al. 2017), and as an indicator of land-use-change-driven anthropogenic pressures on, and responses of, treeline areas (Kyriazopoulos et al. 2017, Sarkki et al. 2017b).

(3) Collecting data and re-interpreting LTSER (long-term socio-ecological research) databases using regional case studies to identify research priorities for managing environmental changes in treeline areas. Comparing different treeline forest areas in Europe in terms of ES effects of climate change and land use development, and examining which features of ecosystems will work as a basis for wide ranging services (Cudlín et al. 2017, Kyriazopoulos et al. 2017).

(4) Synthesizing knowledge of established networks of treeline specialists and local stakeholders throughout Europe. Disseminating the results in meetings, workshops and conferences. Working out policy recommendations for best management practises in these areas, including eco-sociological examinations of the synergies and trade-offs between different ES beneficiaries. Proposing ways to enhance governance at various institutional levels from the EU level to decision making at a local level (Sarkki et al. 2017c).

It is important to note that envisioning the future and working to transform potential scenarios in science and policy may be seriously limited by the pragmatic constraints of pre-existing science and policy (Nijnik et al. 2017).

In order to fulfil the SENSFOR objectives, the following working groups (WGs) were established:

WG1. Analysing the state of and changes in ecosystem structures and functions, focusing on identifying DPSIR factors in case study regions, in order to demonstrate the current status of treeline forests.

WG2. Creating a holistic set of indicators for vulnerability and resilience of coupled socio-ecological systems, based on DPSIR framework analyses.

WG3. Organizing workshops between researchers and user groups, to develop scenarios of integrated knowledge for management practices.

WG4. Disseminating knowledge from the SENSFOR COST Action to users at various levels (e.g. tourist associations, nature conservation bodies, local communities and climate change researchers).

The main results from the SENSFOR COST Action are published in a summary report (Zhiyanski et al. 2017) from the COST office, as well as in various deliverables and in this CR Special.

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