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ENHANCING THE RESILIENCE CAPACITY OF SENSITIVE MOUNTAIN FOREST ECOSYSTEMS UNDER ENVIRONMENTAL CHANGE (SENSFOR)
ES 1203

2012 | 2016

Authors:

M. Zhiyanski, S. Bratanova-Doncheva, A. Kyriazopoulos, G. Broll,

M. Jokinen, M. Nijnik, F. Wielgolaski, S. Sarkki

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Objectives

- Identify main drivers of environmental change at different scales considering consequences for biodiversity, ecosystem functions and services, and sustainable resource use; develop scientific basis for best management practice in sensitive tree-line ecosystems;
- Using Driver, Pressure, State, Impact and Response (DPSIR) framework to analyze changes in tree-line biodiversity, to develop monitoring methodology and scenarios of possible developments and land use changes, to assess consequences for biodiversity conservation and ecosystem services in sensitive tree-line areas;
- Collect and re-interpret Long-Term Socio-Ecological Research (LTSER) databases taking advantage of regional case studies to identify research priorities for managing environmental changes in tree-line areas;
- Synthesize existing knowledge of established networks of tree-line specialists and local stakeholders around Europe; disseminate the results by meetings, workshops and conferences;
- Disseminate synthesized knowledge to users at various levels, i.e. tourist associations, nature conservation bodies, local communities and global change researchers.

Working Group 1

- Analyzing the state and changes in ecosystem structures and functions, focusing on identifying Driver, Pressure, State, Impact and Response (DPSIR) factors in case study regions;
- Collection case studies demonstrating current status of tree-line ecosystems;

Working Group 2

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

Working Group 3

- Organized workshops for researchers and user groups, to develop scenarios of integrated knowledge for use in practice;

Working Group 4

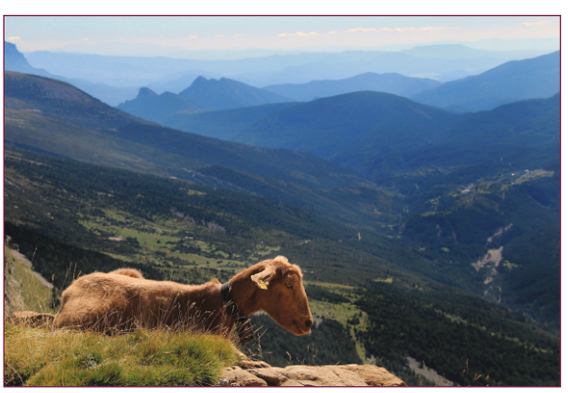
- Dissemination

Research highlights

Climatic tree-line areas are highly responsive to climate change and may be used as indicators of ecological and social-ecological changes. The predicted warmer climatic conditions and the extended growing seasons are assumed to lead to increased forest and tree growth in higher elevations and at northern latitudes. However, the warmer climate will increase the risk of tree pests and diseases in the northern and summer drought in the southern European regions with a negative impact on wildfire resilience of the vegetation. At the same time, tree-line areas may also be used as reference areas for the efficiency of climate change mitigation policies; an altitudinal shift or structural changes of these areas illustratively demonstrates human pressures on the environment. Anthropogenic changes at the tree-line reflect changes in land use such as land abandonment or reforestation of formerly treeless areas. In certain parts of Europe, soil erosion, degradation, overgrazing and mass tourism represent a major factor that puts pressure on the sustainability of these ecosystems. Further challenges caused by land use include marginalization of agricultural and timber production, conflicts for water resources, changes in the protection status of forests, and landscape degradation due to intensification of land use or land abandonment leading to loss of biodiversity.

Tree-line areas are not significant only for the provisioning and regulating of ecosystem services (ESs) but also of cultural ESs. The climatic tree-line ecotone represents an obvious land cover demarcation and characterizes European mountain landscapes. The multifunctional character of tree-line ecosystems calls for the assessment of synergies and trade-offs between different ecosystems and their users, and suggests developing guidelines that help using ESs in a more sustainable and socio-economically fair way. The portfolio of ESs in a certain tree-line area might however vary considerably, depending on the number of factors, e.g. bio-geographical zone, elevation, relief, site conditions, land-use and population density.

While environmental policy is well articulated at the high-level discourse, explicit management or policy recommendations for tree-line areas are often missing. Decision makers require fundamental knowledge about ESs to shape their policies and programs. Previous research identified key ESs in European mountain areas, but often found a lack of knowledge of the importance of them (EEA 2010) and policy implications thereof. Therefore, there is a clear need to map ESs and related challenges in different European tree-line areas in order to enhance governance and SENSFOR aims at facing the aforementioned challenges.



Working Group 1 - DPSIR factors in tree-line ecosystems and their services

Wg1 details
Working group Leader
Apostolos Kyriazopoulos
Democritus University of Thrace (GR)

Working group Co-leader
Annika Hofgaard
Norwegian Institute for Nature Research (NO)

Participants

A total of 35 members from 17 European countries (Bulgaria, Czech Republic, Finland, Greece, Iceland, Italy, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden and United Kingdom) are participating in this Working Group.

Background and Objectives

WG1 is analyzing the present state and changes in ecosystem structures and functions with particular emphasize on identifying Driver, Pressure, State, Impact, Response (DPSIR) factors in each case study region.
Seven WG meetings have been held so far. These meetings took place in different regions of Europe (Oulu – Finland, Jaca – Spain, Viterbo – Italy, Brasov – Romania, Krakow – Poland, Aberdeen – Scotland, Sofia – Bulgaria).
SENSFOR researchers have undertaken various activities to complete the task of identifying DPSIR factors for tree-line ecosystems across Europe. A questionnaire (matrix table) was developed to assess DPSIR factors in tree-line areas. The questionnaire included sections on the background of case areas. More specifically, it included sections gathering general information on the location (area size, altitude, latitude, climate, geology) as well as on the dominant tree-line tree species and the major wild herbivores. The questionnaire also included sections with emphasize on land use (grazing, logging, tourism) and climate change (trends in temperature and precipitation) to be assessed and their impacts to be evaluated. A second questionnaire was distributed to all responders of the first one in order to collect information regarding the state and the responses in the tree-line areas of Europe.
Future activities of the WG will include the analysis and the evaluation of the history and present state of ecosystem functions and services, of different land-use and management practices. Furthermore, by identifying current societal responses to issues concerning ecosystems and their services, best management practices could be identified and suggested.

Deliverables and results

The main deliverable of WG1 is a report entitled "Identifying the DPSIR factors for treeline ecosystems and related ecosystem services". It was produced based on the responses of the two questionnaires. This report has been completed in November 2014 and uploaded in the SENSFOR website.
According to the results, the main drivers for the treeline ecotone ecosystems in Europe are the climatic changes and the land use changes. The major pressures related to the climate changes are warmer climate in the north and drought summer in the south, while main pressures related to land use changes are the land abandonment and the increased touristic activities. Among the negative impacts of pressures are the increased tree diseases, the increasing risk of wild fires

especially in the south, as well as the decrease of alpine and subalpine grasslands which results in the reduction of forage production and loss of biodiversity. On the other hand, an advance of treeline ecotones and consequently a potential increase of forested areas have been widely recognized by the respondents as positive, while in a few study cases (e.g. Spain, Greece and Norway) they have been reported among the strongest threats to the ecotone and its biodiversity. Regarding the state of the ecosystem in treeline ecotone ecosystems human activities, such as overgrazing by domestic or semi-domestic animals, and intensive tourism are considered as the main reasons for the problematic conditions. The results of survey enlighten the lack of policies, governance or management instruments (mitigation measures; adaptation practices; restoration projects) specialized on treeline ecotone ecosystems. Responses for 26 different tree-line ecotone areas were received. Half of the responds (13) describe southern European study cases.

Recent publications

Sarkki, S., A. Ficko, K. Grunewald, A.P. Kyriazopoulos, M. Nijnik M (in press). How pragmatism in environmental science and policy can undermine sustainability transformations? The case of marginalized mountain areas under climate and land use change. Sustainability Science.

Kyriazopoulos A.P., O. Skre, S. Sarkki, F. E. Wielgolaski, E.M. Abraham, A. Ficko (submitted). Human-environment dynamics in European treeline ecosystems: a synthesis based on the DPSIR framework. Climate Research.

Sarkki, S., Ficko, A., Wielgolaski, F.E., Abraham, E.M., Bratanova, S., Grunewald, K., Hofgaard, A., Holtmeier, F.-K.,. Kyriazopoulos, A.P., Broll, G., Nijnik, M. Sutinen, M-L. (in press). Assessing the resilient provision of ecosystem services by social-ecological systems: introduction and theory. Climate Research.

Working Group 2 - Indicators

WG2 details:
Working group Leader:
Gabriele Broll,
University of Osnabrück, DE (since 2016)
Marja-Liisa
Sutinen, LUKE, FI (until 2015)

Working group Co-leader:
Mikko Jokinen,
LUKE, FI (since 2016)
Gabriele Broll,
University of Osnabrück, DE (until 2015)

Participants

A total of 29 members from 14 European countries (Bulgaria, Finland, Greece, Iceland, Ireland, Italy, Germany, Norway, Poland, Portugal, Serbia, Slovakia, Slovenia and United Kingdom) in this Working Group.

Background and Objectives

Tree-line ecotones in mountains all over the world are dynamic and in many cases changing due to human impact, but the regional differences are quite strong. Nevertheless, pressures on the tree-line ecotone can be differentiated in abiotic (e.g. wind, fire, drought, avalanche), biotic (e.g. insects, browsing, pathogens) and anthropogenic one (e.g. pollution, overgrazing, global warming).
The main aims of WG 2 were to identify a common set of monitoring indicators, to analyze changes in the tree-line ecotone and to develop monitoring methodologies. Second, the working group should create a holistic set of indicators for the vulnerability and resilience of coupled socio-ecological systems on the basis of the DPSIR framework analysis.

Deliverables and Results

Using and defining indicators:
We introduce indicators that help to understand changes, sustainability issues and resilience of sensitive mountain forest ecosystems. Findings are based on literature, previous and in-project scientific work of SENSFOR working groups and experimental work testing practical validity in several courses and workshops. Discussions focused on the following main questions: what kind of indicators can be identified? Are they useful for stakeholders and policy makers?

Social-economic indicators:

We have listed eight social and cultural indicators that do or might reflect the sustainable conditions and use of tree-line ecotones. These indicators are: (1) stakeholder participation, (2) multi-level governance, (3) local possibilities for nature based subsistence and recreation activities, (4) self-determination, (5) cultural heritage, (6) conflicts and disputes, (7) migration and population structure and (8) economy.
One example for a socio-cultural indicator is a conflict between people who use the land and those people who would like to protect nature and the ecological ecosystem services. An example for an economic indicator would be the reduction of the amount of income of the stakeholders, e.g. due to reduced tourism in high mountain areas, triggered by global warming. Also, the distribution of benefits (in most cases income) among stakeholders could be influenced.
It is important to understand that especially social indicators listed here might be related to tree-line issues. Conflicts can take place at local levels, but changes in economic as well as population structure may level those conflicts out and have nothing to do with the condition or the use of forest ecosystems. This means, that the following indicators do not necessarily indicate the sustainability issues tied to tree-line eco-tones per se. However, there may be connections and causalities between these factors and in each case this potential linkage needs to be assessed.

Ecological Indicators

There is an urgent need for a set of indicators but it is difficult to find indicators for the entire ecosystem. Ecological indicators within tree-line ecotones can be subdivided into those indicating an impact on vegetation, soil or fauna. There can be natural responses of the ecosystem without human impact. One example would be the influence of strong wind on the growth form of trees. Also, there can be responses of ecosystems and related ecosystem services due to human impact. One example in this case would be erosion due to overgrazing. The ecosystem service decomposition affecting the nutrient cycle would be hampered in this case. Usually, trees, their growth form or seedling production, are in the focus but soil indicators such as carbon stock or soil biodiversity are considered more frequently meanwhile.

Plants
It is useful to distinguish short-, medium- and long-term response variables of trees when identifying indicators for changes of plant composition in tree-line ecotones. Short-term responses (≤ year) of ecological indicators (e.g. photosynthesis, carbon allocation) in the tree-line ecotone are not very useful in most cases. On the other hand, data on phenology (e.g. period of shoot extension, date of bud burst, date of needle flush, period of needle growth, maturation of tissue, ripening of seeds) could be helpful indicators for certain research questions. Medium-term response variables (some years to a few decades) however are useful indicators for changes: growth form/habitus change in trees, tree survival/mortality and tree ring chronology.
The following variables were identified as useful indicators for changes in tree-line ecotones: growth form, phenology, tree mortality, tree ring chronology, species composition, regeneration and site patterns such as snow pattern.

Soils
The most important soil indicators for changes in the tree-line ecotone are pH, soil organic matter, soil biodiversity and soil biological activity. Also the area of bare soil, often caused by erosion, could be a useful indicator. Among the following European countries, Romania, Bulgaria, Czech Republic, Slovakia and Italy, six case studies from similar mountain regions were selected in order to prove the importance of soil properties as indicators of natural and anthropogenic impacts.

Fauna
Changing wildlife (abundance, species) is also a good indicator for changes in the tree-line ecotone. In practice, it is much more difficult to investigate indicators related to fauna than to study vegetation or soil.

Recent Publications

Holtmeier FKH, Broll G (accepted) Feedbacks of clonal group and tree clusters on site conditions at tree-line: Implications for tree-line dynamics. Climate Research. (IF = 2.5).

Moscatelli MC, Bonifacio E, Chiti T, Cudlin, P, Dinca L, Gömöryova E, Grego S, La Porta N, Karlinski L, Pellis G, Rudawska M, Squartini A, Zhiyanski M, Broll G (submitted) Soil properties as indicators of tree-line dynamics in view of climate change and anthropogenic pressure. Climate Research. (IF = 2.5).

Sarkki S, Ficko A, Wielgolaski FE, Abraham EM, Bratanova-Doncheva S, Grunewald K, Hofgaard A, Holtmeier FK, Kyriazopoulos AP, Broll G, Nijnik M, Sutinen M-L (submitted) Combining the DPSIR framework, indicators and scenario analysis in assessing the resilient provision of ecosystem services by social-ecological systems: introduction and theory. Climate Research. (IF = 2.5).

Working Group 3 - Knowledge integration, scenarios and recommendations for the future

WG3 details:
Leader: Maria Nijnik,
The James Hutton Institute (UK)

Co-leader:
Concepción L. Alados,
Pyrenean Institute of Ecology (CSIC) (ES)

Participants

A total of 33 members from 12 European countries (Finland, Greece, Iceland, Italy, Switzerland, Spain, Germany, Norway, Ukraine and United Kingdom) are participating in this Working Group.

Background and Objectives

SENSFOR Working Group 3 (WG3) is addressing a set of objectives including 1) identification of stakeholder needs and of best practice by stakeholder engagement, 2) creation of scenario storylines relevant for tree-line area stakeholders, and 3) policy recommendations and ecosystem based adaptation measures and policy and management decisions. These objectives are connected by their focus on stakeholders, especially at a local level, through:

- organizing stakeholder workshops
- integrating scientific knowledge with stakeholders' needs and management initiatives
- building bottom-up and top-down scenarios for future climate and land use changes
- elaborate recommendations for the sustainable use of tree-line ecotones

Deliverables and Results

Key stakeholders and their needs and requirements were identified.
Reports on initial assessment of end users' requirements have been produced by means of questionnaire based investigations of stakeholder needs as linked to ecosystem services, governance, and science in European tree-line areas.
Scenarios for future development have been identified and presented at various scales of observation.
A common protocol for the best management practices has been developed.
Policy proposals for sustainable ecosystem management are being elaborated.
Among the follow-ups of SENSFOR and as a result of our fruitful collaboration, the Social Innovation in Marginalized Rural Areas (SIMRA) project has been initiated on 1 April 2016 and is supported from the European Union's Horizon 2020 Programme. SIMRA addresses some of the most important social challenges faced by rural areas, including European tree-lines, and it aims to understand and to enhance social innovations. SIMRA is coordinated by the James Hutton Institute and includes the University of Oulu, Finland. Both partners were active members of the SENSFOR WG 3. The Consortium comprises members from 15 countries from across the European Union and the wider Mediterranean area. A number of other countries from North Africa and Eastern Europe, will be involved as contributors to case studies and SIMRA supporters coming from the south- and south-eastern European Mountain Network, FLEG II, the Carpathian Network S4C, and the UNEP, FAO, IUFRO, ECOFOR, Earth System Governance, and others, including the Ecosystem Services Community Scotland. The project consortium consists of 10 public bodies (8 universities and 2 research institutes), 8 non-profit organizations, 5 small and medium size enterprises, NGOs and networks, and 3 international organizations.

The SIMRA team will study what characterizes successful social innovation, in areas as varied as north-west Europe and Scandinavia, the Mediterranean and North African region, the Alpine region, and central and Eastern Europe. Further information on SIMRA is available at the following EU webpages and media releases:

SIMRA: http://www.simra-h2020.eu/index.php/partners/
Cordis: http://cordis.europa.eu/project/rcn/200385_en.html
Facebook: https://www.facebook.com/SIMRAeu/posts/923882071050196
Twitter: https://twitter.com/simra_eu/status/753903906443370496
LinkedIn: https://www.linkedin.com/…/8546…/8546624-6159676893563015168
A SIMRA brochure (published in several languages) is available at
http://www.simra- h2020.eu/wp-content/uploads/2016/08/SIMRA-brochure.pdf.
The first SIMRA newsletter has been published.

- **Recent Publications**

Sarkki S, Ficko A, Grunewald K, Nijnik M (2016) Benefits from and threats to European tree-line ecosystem services: An exploratory study of stakeholders and governance. Regional Environmental Change 16(7):2019-2032. doi:10.1007/s10113-015-0812-3. (IF = 2.7).

Nijnik A, Nijnik M, Kopiy S, Zahvoyska L, Sarkk S, Kopiy L, Miller D (in press) Identifying and understanding attitudinal diversity on multi-functional changes in upland woodlands. Climate Research. (IF=2.5).

Nijnik M, Nijnik A, Sarkki S, Munoz-Rojas J, Miller D (in press) Assessing heterogeneity of expert attitudes towards forest related decision-making in European tree-line areas using Q-methodology. Forest Policy and Economics. (IF = 2).

Sarkki S, Ficko A, Grunewald K, Kyriazopoulos A, Nijnik M (in press) Trap of the day: European tree-line area scenarios and pragmatic barriers for transformations in science and policy. Sustainability Science. (IF = 2.5).

Zahvoyska L, Nijnik M, Sarkki S, Nijnik A, Pelyukh O (2015) Insights into tree-line ecosystem services of the Ukrainian Carpathians from a stakeholders' perspective: an analysis of challenges for adaptive governance. Proceedings of the Forestry Academy of Sciences of Ukraine. Collection of Research Papers 13:193-200. (Ukr.).

Zahvoyska L, Sarkki S, Zhyla T (2014) Perceptions of tree-line ecosystem services and their governance: focus on Ukrainian Carpathians. In: I. Kruhlov and B. Prots (eds). Local Responses to Global Challenges: Proceedings of Forum Carpaticum' 2014. Ukrayinskyy Bestseler, Lviv. p. 65-69.

Working Group 4 - Dissemination

WG4 details:
Leader:
Miglena Zhiyanski,
Forest Research Institute-BAS (BG)

Co-leader:
Frans Emil Wielgolaski
University of Oslo (NO)

Participants

A total of 18 members from 13 European countries (Bulgaria, Bosnia and Herzegovina, Greece, Finland, Iceland, Italy, Germany, FYR Macedonia, Switzerland, Slovenia, Turkey and United Kingdom) are participating in this Working Group.

Background and Objectives

Disseminating knowledge collected through the Working Groups 1 to 3 by STSMs, web pages, publications, leaflets and reports.

Deliverables and Results

A SENSFOR website was developed and regularly updated at www.sensfor-cost.eu for the use by both, MC- and WG-members as well as stakeholders (open access) (i) to interact with the COST office and the partners and to promote their active participation; (ii) to organize project meetings, conferences, STSMs, training schools and reporting; (iii) to information about all developments of the COST Action in all its various facets and to allow a more active participation of all partners in those developments.
SENSFOR flyers and leaflets were prepared and disseminated.
Thematic workshops of WGs, e.g. arranged in association with the General SENSFOR Meetings, where research results are translated into practical tools and guidelines for implementation, is an important mean of (i) informing interested and participating stakeholders, and (ii) demonstrating the use and implications of the project results and guidelines to stakeholders and participants outside of the WGs 1 to 4.

Recent Publications

The SENSFOR MC group has decided to present the scientific analyses of the work carried out within this project in a special issue of a high ranked international journal, and Professor F.E. Wielgolaski from Norway was elected to be the guest editor of that issue. He contacted various journals, and the MC group accepted the best offer by the journal 'Climate Research' (IF = 2.5). In total, 12 manuscripts from various mountain tree-line areas of Europe have been prepared by the participating researchers and have been processed, through both internal and external reviews. They are now being revised and prepared for the final decision by the reviewers.
Five Deliverable Reports were prepared and published on the web-site of SENSFOR COST Action.

Short-Term Scientific Missions (STSMs)

STSM manager: Svetla Bratanova-Doncheva - IBER (BG).
The following 17 STSM's have been organized during the 4 years of the SENSFOR – COST Action (home country / country of host institution):

Name	Background	Period	Home
Dr Alessandra Bottero	Forest management	20 May - 14 June 2013	Dept. of Agriculture, Forest and Food Sciences (DISAFA) - University of Torino, Italy
Dr Bogdan Wertz	Forest ecology	4 November – 25 November 2013	University of Agriculture in Krakow -Faculty of Forestry Department of Biometry and Forest Productivity - Poland
Eli Kachaunova	Phyto-sociology	9 November – 22 November 2013	Institute of Biodiversity and Ecosystem Research – BAS, Division "Ecosystem research", Sofia, Bulgaria
Dr Simo Sarkki	Forest ecology	2 September – 14 September 2013	Thule Institute Oulu, Finland
Krishna Babu Shrestha	Plant ecology	4 August – 25 August 2014	Faculty of Mathematics and Natural Sciences, University of Bergen, Thormøhlensgate 53A, N 5020, Bergen, Norway
Gabriel Sangesa Barreda	Forest Ecology	February -April 2014	Instituto Pirenaico de Ecology (CSIC), Zaragoza - Jaka, Spain
Yulia Shvediuk	Environment	7 July - 18 July 2014	Ukrainian National Forestry
Lora Naydenova	Ecology	22 September - 17 October 2014	Forest Research Institute - BAS, Sofia, Bulgaria
Marko Kebeert	Forest ecology	6 October - 27 November 2014	Institute of lowland forestry and environment (ILFE), Novi Sad, Serbia
Dr Serhiy Kopiy	Forest ecology	6 October - 1 November 2014	Ukrainian National University of Forestry - St. Skrypnyka 15/20, 79049, Lviv, Ukraine
Paulina Szydlowska	Forest ecology	1 October – 31 October 2014	University of Agriculture in Krakow -Faculty of Forestry Department of Biometry and Forest Productivity - Poland
Francesca Ferranti	Env. management	1 October – 31 October 2015	Open University of the Netherlands
Kremena Boyanova	Geography	14 September – 11 October 2015	Institute of Geography, Geology, Geodesy – BAS Bulgaria
Marko Kebeert	Forest ecology	14 September – 10 October 2015	Institute of lowland forestry and environment (ILFE), Novi Sad, Serbia
Dr Lyudmyla Zahvoyska	Ecological Economy	24 June – 4 July 2015	Ukrainian National Forestry University, Lviv
Dr Srdjan Keren	Forest ecology	1 September – 30 September 2015	Faculty of Forestry, 78000 Banja Luka (BA)
Vladimir Stojanovski	Forest ecology	21 September – 21 October 2015	Forest Faculty in Skopje University, 1000 Skopje (MK)

Host	Title	Superviser in host institution
Forest Ecology, Department of Environmental Systems Science, ETH Zurich, (CH)	*Living and dying at treeline: characterization of deadwood at the treeline across the Italian Alps*	Prof. **Dr. Harald Bugmann** Chair of Forest Ecology, Department of Environmental Systems Science, ETH Zurich, Switzerland
Finnish Forest Research Institute , Vantaa (METLA)	*Potential (plasticity) in birch populations by reciprocal transplantation between transplant gardens, located in treeline forests at different latitude, altitude and oceanity in northern Fennoscandia*	Assoc. Prof. **Marja-Liisa Sutinen** - Ph.D., Senior Researcher, Finland
Global change research center (CzechGlobe) - CzAS – Ceske Budejovice, (CzR)	*Exchange of professional experience in the approaches and methodology used for treeline studies in the Pirin Mountains*	Assoc. Prof. **Pavel Cudlín,** Head of the Department of Landscape Carbon Deposition, Global Change Research Center – ASCR, Czech Republic
Instituto Pirenaico de Ecology (CSIC), Zaragoza - Jaka, Spain	*Enhance sustainable governance of sensitive treeline ecosystems and related ecosystem services, and building the capacity of local and regional actors to cope with future climate and land-use changes.*	Dr**. Concepción L. Alados** - Pyrenean Institute of Ecology, Spain
Swiss Federal Research Institute – WSL, Bimensdorf (CH)	*Wood anatomic techniques for analyzing arctic and alpine plants*	Dr**. Holger Gärtner** WSL, Switzerland
Swiss Federal Research Institute – WSL, Bimensdorf (CH)	*Long-term growth and establishment dynamics of high elevation Pyrenean forests*	Dr. **Ulf Büntgen,** WSL, Switzerland
Global change research center (CzecGlobe) - CzAS – Ceske Budejovice, (CzR)	*Cost-Benefit Analysis (CBA) methodology to forestry projects: case study of Western Ukraine*	Assoc. Prof. **Pavel Cudlín,** Head of the Department of Landscape Carbon Deposition, Global Change Research Center – ASCR
Federal Department of Economic Affairs, Education and Research – EAER, Agroscope, Zurich (CH)	*Identifying the human activity pressure on soil organic matter content and composition under grassland ecosystems*	**Dr Jens Leifeld** Agroscope, Zurich (CH)
Department of Biological, Geological and Environmental Sciences, BOLOGNA, Italy	*Altitude-dependent photo-oxidative stress in beech leaves*	Assoc. Prof. **Stefania Biondi**
James Hutton Institute, Aberdeen, Craigiebuckler, Aberdeen AB15 8QH, Scotland (UK)	*Advancing sustainability of mountain forest ecosystems*	Prof. **Maria Nijnik**, Principal Social-Economic Research Scientist Hutton (UK)
Finnish Forest Research Institute, Oulu (Finland)	*Enhance sustainable governance of sensitive treeline ecosystems and related ecosystem services*	Assoc. Prof. **Marja-Liisa Sutinen** - Ph.D., Senior Researcher, Finland
Department of Agriculture, Forestry and Food Sciences of the University of Torino	*Environmental change in sensitive mountain forests: integrating scientific and practical knowledge to inform policy makers*	Prof. **Renzo Motta**, Italy
CAU – Kiel, Germany- Institut für Natur- und Ressourcenschutz Abteilung Ökosystemmanagement Hausanschrift: Kiel (Germany)	*Development of methods for quantification of water-related ecosystem services in mountain areas through the application of output variables from existing hydrological models as indicators for the quantification of selected ecosystem services.*	Dr. **Benjamin Burkhard,** University of Kiel, Germany
Natural Resources Institute Finland, Luke, Rovaniemi (FI)	*Altitude effect on the foliar phenolics composition in Fagus sylvatica on five Serbian mountains*	Assoc. Prof. **Marja-Liisa Sutinen** - Ph.D., Senior Researcher, Finland
The James Hutton Institute, Aberdeen, AB158QH (UK)	Instruments of adaptive and holistic natural resource management	Prof. **Maria Nijnik**, Principal Social-Economic Research Scientist, UK
Biotechnical Faculty, University of Ljubljana, Ljubljana (SI)	Differences between old-growth and managed forests in the upper mountain zone of Bosnian Dinaric Mountains	Prof. Dr. **Jurij Diaci**, Chair of Silviculture, University of Ljubljana, Slovenia
Forest Research Institute - BAS, 1756 Sofia (BG)	Being entrepreneur in nature based tourism sector: Case studies from Macedonia and Bulgaria	Assoc. Prof. Dr **Miglena Zhiyanski**, FRI-BAS, Bulgaria

Training schools

The 1st training school of SENSFOR was about "Drivers, pressures and indicators for monitoring tree-line ecosystems". It was held in Thessaloniki, Greece during 15 – 19 September 2014. It included 3 working days with lectures and 2 field trips in a tree-line ecotone in northern Greece. The lectures were about identification of drivers and pressures on tree-line ecotone ecosystems, their effects on biodiversity (floristic and fauna, genetic biodiversity of tree-line marginal populations) and ecosystem services. Additionally, lectures about bio-indicators in forest trees and indicators of soil quality to assess impact of climate and/or land use changes for monitoring the tree-line ecotone ecosystems were also included. A total of 27 trainees and 13 trainers (5 from abroad and 8 from Greece) participated in the training school.

The 2nd training school of SENSFOR was about "DPSIR factors to fulfill stakeholder needs in the different mountain areas in Europe". It was held in the Kopaonik Mountain, Serbia during 1 – 5 September 2015. It was hosted by the University of Novi Sad (UNS) and the Institute of Lowland Forestry and Environment of Novi Sad. It included 3 working days with lectures and 1 field trip in tree-line ecotone ecosystems in the Kopaonik Mountain. The lectures were about ecosystem services supply by tree-line ecosystems, stakeholders' needs in different mountain regions and responses by different stakeholders in terms of sustainable management of low- and high-land systems. A total of 13 trainees and 4 trainers (2 from abroad and 2 from Serbia) participated in the training school.

The 3rd training school of SENSFOR was a joint cooperation between SENSFOR and the Italian Association of Soil Science (SISS), hosted by University of Tuscany about "Advanced methods and new integrated approaches to study the soil processes in mountain ecosystems". It was held at the Alpine Study Center in Pieve Tesino, near Trento, Italy during 26 – 30 June 2016. It included three working days with lectures and a field trip to Passo Broconi, near the tree-line in the Italian Dolomites. The lectures included topics comprising soil microbiology, mineralogy, soil and landform mapping, soil hydrology, organic matter in soil and disturbance (fire, erosion and avalanches). Prof. Oddvar Skre gave a lecture on soil/plant relationships in mountain areas, and prof. Stefano Grego informed about the SENSFOR Action. A total of 29 trainees and 16 trainers (2 from SENSFOR and 14 from SISS) participated in the training school.

SUCCESS STORY: Regeneration of interdisciplinary mountain research landscape

Professor Kari Laine, the chair of the SENSFOR COST Action (2012-2016), stressed in the kick-off meeting that "we face a challenging task to truly integrate natural and social sciences". In order to meet this goal the SENSFOR Action organized set of capacity building activities targeted for consortium members and early career scientists to understand resilience and sustainability of coupled social-ecological treeline systems in Europe.

SENSFOR facilitated natural-social science interactions throughout the project and arranged three training schools with 72 participants, and facilitated 17 short term scientific missions where early career scientists made short visits to other organizations part of the consortium.

The benefits of these activities include new networks and knowledge for scientists to develop holistic and interdisciplinary expertise. The natural scientists do not anymore consider people as a mere threat to fragile ecosystems, but understand people as integral component of the treeline landscapes, and social scientists understand key ecological processes that are vital foundations for ecosystem services and human well-being.

Promising concepts employed in SENSFOR to integrate social and natural sciences include "Drivers, Pressures, State, Impacts and Responses" approach that helps to systematically assess links between global drivers, local social-ecological impacts, and governance responses that mitigate pressures, help people to adapt to change and restore preferable state.

Another promising approach has been to assess resilience of treeline social-ecological systems to sustain ecosystem services. People do not only consume ecosystem services, but also produce them for example by traditional grazing and also by environmental engineering by management decisions and practices (e.g. flood, avalanche and wild fire control).

Finally, the idea of heritage associated to treeline landscapes combines past, current, social and ecological issues and holds promise to function as a fertile ground for developing nature-based solutions and innovations that are beneficial for local people and economy as well as ecologically sustainable.

At the end of the project, SENSFOR consortium is in a situation where distinct social and natural science inputs are not merely piled next to each other. Instead, the consortium members are building on the previously alien expertise and strengths across natural-social science divide leading to cross-fertilization and positive spiral resulting to truly interdisciplinary outputs.

Participants in the SENSFOR – COST Action ES 1203

Participators

Country

Austria, Bosnia and Herzegovina, Bulgaria, Czech Republic, Finland, FYR Macedonia, Germany, Greece, Iceland, Ireland, Italy, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom

Total: 23

COST Near Neighbor Countries

Institution Name	Country
Ukrainian National Forest Universty	Ukraine
Ukrainian National Forest Universty	Ukraine
Ukrainian Research Institute of Mountain Forestry	Ukraine