LRTAP Long-range Transboundary Air Pollution

wge Working Group on Effects of the Convention on Long-range Transboundary Air Pollution

ICP Forests

Tracing air pollution and climate change effects on forest ecosystems: trend and risk assessments

5th ICP Forests Scientific Conference

10-12 May 2016 - Luxembourg

Abstracts

LE GOUVERNEMENT DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère du Développement durable et des Infrastructures
Administration de la nature et des forêts

10 years TerraData environmetrics

THÜNEN

Tracing air pollution and climate change effects on forest ecosystems: trend and risk assessments

5th ICP Forests Scientific Conference
10–12 May 2016 – Luxembourg

Abstracts

Edited by Walter Seidling and Marco Ferretti

Programme Committee

Marco Ferretti, TerraData environmetrics, Via L. Bardelloni 19, 58025 Monteotondo Marittimo (GR) Italy,

Walter Seidling, PCC of ICP Forests Thünen Institute of Forest Ecosystems, Alfred-Möller-Str. 1, Haus 41/42, 16225 Eberswalde, Germany.

Elisabeth Freymann, Administration de la nature et des forêts, Service des forêts, 81, avenue de la Gare, 9233 Diekirch, Luxembourg.

Juliana Reichert, Administration de la nature et des forêts, Service des forêts, 81, avenue de la Gare, 9233 Diekirch, Luxembourg.

Scientific Committee

Marco Ferretti, TerraData environmetrics, Italy, Chairperson of the Scientific Committee

Nathalie Cools, INBO Belgium

Bruno De Vos, INBO, Belgium

Stefan Fleck, Northwest German Forest Research Institute (NW-FVA), Germany

Nenad Potočić, Croatian Forest Research Institute, Croatia

Marcus Schaub, Swiss Federal Research Institute WSL, Switzerland

Foreword

Forests represent an immense resource for our planet. They provide a number of services from the provision of wood and non-wood products to the protection of biodiversity, habitats, soil and water resources and the regulation of atmosphere and climate processes. Hence, forests are essential for the wellbeing of human society.

The International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) operates under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). Established in 1985, it continuously monitors forest condition and environmental factors across Europe. The data is used by a large and still growing number of scientists investigating various policy relevant research questions.

The 5th ICP Forests Scientific Conference focuses on the value of long-term data in forest ecosystem research. In fact, the impact of air pollutants on forest ecosystems and their interaction with climate fluctuation and change, pests and diseases can only be substantiated by means of long-term data, allowing spatial and temporal trend and risk analyses.

The conference will concentrate on environmental drivers (such as N deposition, ozone, climate) and forest responses (like tree health and growth, nutrient contents, mycorrhiza and diversity aspects). Issues such as sustainability of ecosystem services and forest management options are closely connected to environmental impacts and ecosystem responses and may be discussed.

The conference addresses all scientists in the field of air pollution and climate change research in forests. In particular scientists and experts from ICP Forests, the UNECE ICP community under the Working Group on Effects (WGE), partners and stakeholders, and interested scientists from related fields are encouraged to participate. Particular interest is put on projects, evaluations and modelling exercises that are based on ICP Forests data.

The conference will provide an overview on the latest research in policy relevant fields, such as air pollution trends, trends of response variables and interactions with climate change, as well as on nutrient and water cycles, biodiversity, and forest condition.

Programme

08:00-09:00 Registration

09:00- 9:15 Opening. Chair: W. Seidling

09:00-09:10 Welcome Address (host country Luxembourg) **Camille Gira**
Secretary of State for Sustainable Development and Infrastructure

09:10-09:15 Opening, ICP Forests, Scientific Committee **M. Ferretti**

09:15-09:45 **Keynote: K. Percy**: Forest Health Monitoring in the Alberta Oil Sands, Canada: Design, Results and Linkage to ICP Forests

09:45-11:00 Session 1: Deposition, outputs and effects of nitrogen, sulphur and heavy metals on forest ecosystems. Chair: B. De Vos

09:45-10:00 **J. Johnson et al.:** Temporal trends in soil solution acidity indicators in European forests.

10:00-10:15 **N. Cools et al**.: Do changes in forest soil properties reflect the decrease of acidifying deposition in Flanders?

10:15-10:30 **T.M. Nieminen et al.:** Elevated sulfate and trace element concentrations in soil solution of an acid sulfate forest soil.

10:30-10:45 **N. König et al.:** Long-term monitoring of heavy metal input, retention and output over the last 30 years – results from Lower Saxony, Hesse and North Rhine-Westphalia, Germany.

10:45-11:00 **W. Schröder et al.:** German moss survey: Quality controlled collection of data on heavy metals, nitrogen and persistent organic pollutants.

11:00-11:30 Coffee break

11:30-12:45 Session 2: Deposition, outputs and effects of nitrogen, sulphur and heavy metals on forest ecosystems. Chair: M. Schaub

11:30-11:45 **E. Vanguelova & S. Benham**: Base cations and nitrogen budgets of forest ecosystems in the UK.

11:45-12:00 **I. Hůnová et al**.: Nitrogen deposition to forest ecosystems with focus on its different forms.

12:00-12:15 **A. Verstraeten et al.:** Nitrogen status of Flemish forests is improving.

12:15-12:30 **W. Weis et al.:** Using soil inventory data to calculate linked output of nitrogen, sulphur and base cations in German forests

12:30-12:45 **L. Ukonmaanaho et al.:** Litterfall, defoliation and inorganic nitrogen solute concentration before and after bark beetle outbreak in a Norway spruce forest

12:45-13:45 Lunch

13:45-15:00 Session 3: Ozone levels, risks and effects. Chair: N. Potočić

13:45-14:00 **E. Gottardini & M. Schaub et al.:** Temporal and spatial distribution of ozone symptoms across Europe from 2002 to 2014.

14:00-14:15 **P. Sicard et al.:** An epidemiological assessment of stomatal ozone flux-based critical levels for visible ozone injury in Southern European forests.

14:15-14:30 **S. Bičárová et al.:** Model estimation of POD1 and growing season length.

14:30-14:45 **Q. Hurdebise, et al.:** Ozone concentration extreme events identification and analysis in a temperate mixed forest.

14:45-15:00 **E. Gottardini et al.:** ViburNeT – The *Viburnum lantana* ozone biological response Network in Trentino, Italy.

15:00 -16:00 Coffee break and Poster Session

16:00 – 17:30 Session 4: Climate, climate change and assessment of ecosystem responses. Chair: N. Cools

16:00-16:15 **S. van der Linde et al.:** The large-scale diversity, distribution and environmental drivers of Europe's forest mycorrhizas.

16:15-16:30 **M. Daenner et al.:** Generating of gapless meteorological data for water budget modelling of Level II plots.

16:30-16:45 **N. Clarke et al.:** Modelling climate change effects on the chlorine cycle in a Norway spruce forest soil.

16:45-17:00 **R. Canullo et al.:** Spatial and temporal patterns of plant diversity in the Italian forest monitoring network (CONECOFOR)

17:00-17:15 **P. Merilä et al.:** Light requirements direct the response of understory plants to forest cuttings.

17:15 - 17:30 **N. Augustin et al.:** Improved trend estimation of European spatio-temporal forest health monitoring data

17:30 - 18:00 General discussion and conclusion. Chair: M. Ferretti

Poster Session (poster in alphabetical order)

Z. Galić et al.: Trends of soil moisture content in Hungarian oak stands.

R.M. Inclán & GuMNet Consortium Team: GuMNet - A high altitude monitoring network in the Sierra de Guadarrama (Madrid, Spain).

Z. Jeran et al.: Environmental factors and canopy drip effect on heavy metals in mosses collected in Slovenian forests.

N. König et al.: Long-term monitoring of heavy metal input, retention and output over the last 30 years – results from Lower Saxony, Hesse and North Rhine-Westphalia, Germany.

M. Markovic et al.: Biofungicides in Nursery Production

P. Michopoulos et al.: Concentrations of Cd and Pb in bulk precipitation, throughfall, plant tissues and soil in a remote mountainous fir forest in Greece.

S. Neagu & M. Hanzu: Merging effects of air pollution and climate change on forest growth in Romania.

S. Nickel et al.: Modelling and Mapping Soil Moisture for Observed and Future Periods. A Germany-wide and Regionally Specified Fuzzy Approach.

I. Popa et al.: Trend analysis of trees health status in the ICP Level I network in Romania. Synchronized with climate trend?

S. Rajkovic et al.: Monitoring plot – CRNI VRH – ozone injury.

P. Sicard & L. Dalstein-Richier.: Health and vitality assessment of two common pine species in the context of climate change in Southern Europe.

P. Sicard & P. Rossello: Spatiotemporal trends of surface ozone concentrations and metrics in France.

J. Sintermann et al.: Characterising long-term trends of soil solution acidification at Swiss ICP-Forests sites.

B. Torres et al.: Using data from the European Large-scale forest condition monitoring (Level I) for the modeling of *Cerambyx spp*. suitable habitat under different climate change scenarios.

A. Verstraeten et al.: Increasing dissolved organic nitrogen (DON) concentrations and fluxes in temperate forests under recovery from acidification in Flanders, Belgium.

M. Zhiyanski et al.: Assessing and mapping land cover related carbon stocks in the mountain treeline zone under global change during 1982-2012.

Improved trend estimation of European spatio-temporal forest health monitoring data

Nicole Augustin[1], Alex Griffiths[1], Fin Lindgren[1], Nadine Eickenscheidt[2], Nicole Wellbrock[2]

[1] University of Bath, Department of Mathematical Sciences, Bath, UK;
[2] Thünen Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries, Eberswalde, Germany

European forest health is monitored in Europe by The International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects (ICP Forests) in cooperation with the European Union. The yearly Report on the Forest Condition in Europe, see for the most recent Michel and Seidling (2015), presents statistical analyses of European forest health monitoring data, each year focusing on specific aspects. The European ICP crown condition data pose a number of challenges to the statistical analysis: (1) The response is non-standard, as defoliation is recorded as a percentage in 5% classes estimated by eye using binoculars. (2) The model needs to be able to deal

with data on an irregular grid, with different subsets of grid locations sampled over time because e.g. due to financial constraints, some countries do not submit data in all years. (3) Although assessments of defoliation are nationally consistent, between countries exist systematic differences in the assessment. These differences are due to different environmental or forest conditions, they may also be due to differences in the standards used. Systematic differences between countries are a problem if we are combining data from several countries and want to compare between different countries.

Here we propose a unified modelling approach for the European forest health data enabling to model several countries combined for certain species. Our approach can handle the above challenges in addition to dealing with the possibility of spatial and temporal correlations between survey plots, a differing temporal trend of defoliation between areas because of site characteristics and pollution levels, as well as nonlinear effects of predictors such as tree age. Our work is based on Augustin et al. (2009) who addressed these issues by using a generalized additive mixed model (GAMM) when modelling spatial and temporal trends in crown condition (defoliation) in Baden-Württemberg, a federal state in the south-west of Germany. The approach provides marginal estimates of average defoliation over time and space with credible intervals, hence allowing assessment of changes in trends of defoliation.

Augustin, N., Musio, M., von Wilpert, K., Kublin, E., Wood, S., Schumacher, M. (2009). Modelling spatio-temporal forest health monitoring data. Journal of the American Statistical Society, 104(487):899–911.

Michel, A., Seidling, W. (2015). Forest condition in Europe: 2014 Technical Report of ICP Forests. report under the UNECE convention on long-range transboundary air pollution (CLRTAP). Technical Report, Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries.

Model estimation of POD1 and growing season length

Svetlana Bičárová[1], Hana Pavlendová[2], Zuzana Sitková[2], Pavel Pavlenda[2]

[1] Slovak Academy of Sciences, Earth Science Institute Bratislava, Slovakia, bicarova@ta3.s;
[2] National Forest Centre, Forest Research Institute Zvolen, Slovakia, pavlendova@nlcsk.org, sitkova@nlcsk.org, pavlenda@nlcsk.org

Abstract: The main objective of this work was to estimate the potential impact of ozone on Norway spruce forests in the High Tatra Mts., Slovakia. To achieve this aim the multiplicative deposition model (DO3SE) was applied. Model outputs of Phytotoxic Ozone Dose (POD1) for three forest stands situated in altitudinal profile: Stará Lesná (810 m a.s.l.), Tatranská Javorina (1,100 m a.s.l.) and Skalnaté Pleso (1,778 m a.s.l.) suggest relevant ozone exposure during the year 2015. Test of model parameters shows different values of POD1 in relation to method that specifies start and end of growing season. Specification of growing season length (GSL) was considered for three different periods: GSL1 – according to mean daily air temperature; GSL2 – based on model latitudinal function for forest; GSL3 – range of days from 1 to 365. Very close values of POD1 (15.9 and 15.5 mmol m^{-2} PLA) include model outputs GSL1 (177 days) and GSL2 (173 days) for site Tatranská Javorina (north aspect). Substantially higher POD1 (20.5 mmol m^{-2} PLA) estimated for GSL3 resulted to shift of date of exceedance critical level (8 mmol m^{-2} PLA) nearly a month earlier in comparison with GSL1 or GSL2. Intermittent period GSL3 includes model calculation of stomatal ozone fluxes also for selected hours of winter season with hourly air temperature above 0°C and sufficient solar radiation. At site Stará Lesná (south aspect), phytotoxic ozone period started already in May and at the end of year (GSL3) achieved POD1 value of 20.4 mmol m^{-2} PLA. Final values of POD1 obtained for GSL1 and GSL2 were lower 16.3 and 14.9 mmol m^{-2} PLA, respectively. Experimental area Skalnaté Pleso is situated at the top of altitudinal profile. At this site, continual GS period is shorter due to cold climate that could have influence on reduction of POD1 under level of 15 mmol m^{-2} PLA for both GSL1 and GSL2. Nevertheless, critical level was exceeded at all considered sites and also for all different GSL that indicate high potential risk of ozone for forests in the High Tatra Mts. region.

Acknowledgement
This work was supported by the Slovak Research and Development Agency under the contract No. APVV–0429–12 and by the Grant Agency of the Slovak Republic under the project VEGA No. 2/0053/14. The authors are grateful to the Slovak Hydrometeorological Institute (SHMI) for providing of EMEP data.

Standard presentation

Spatial and temporal patterns of plant diversity in the Italian forest monitoring network (CONECOFOR)

Roberto Canullo[1], Daniele Giorgini[2], Giandiego Campetella[3], Khawla Zouglami[3]

[1] University of Camerino, Italy, roberto.canullo@unicam.it;
[2] University of Siena, Italy;
[3] University of Camerino, Italy

Since 1996, the Italian network CONECOFOR included Ground Vegetation (GV) within the forest monitoring actions, in the frame of ICP Forests. Plant diversity variables have been assessed yearly on 11 of the 31 sites of the intensive network (LII), while a unique survey was realized for the extensive network (LI) in 2007, within the Biosoil-Biodiversity project.

CONECOFOR is presently undergoing a revision process aimed to assure the financial sustainability of reliable information on forest status and trends (SMART4Action, LIFE+ ENV project).

We contribute to the project by analysing spatial and temporal patterns options for GV assessment.

(i) Aims: suggest an affordable number of sites and the best sampling strategy to provide an overview of forest plant diversity within both LII and LI network.

(ii) Objectives: estimate the effect of reduced sampling frequency and size, as well as different sampling designs on GV assessment.

(iii) Methods: previous datasets are examined to test the conformity of LII vs. LI sites, to compare time-trend descriptors, and to estimate the critical number of sites and sampling units (SU). Field cross-surveys in next summer will compare different methods on selected sites.

(iv) Considering LII sites (1999-2102), the reduction from annual to multiple-year surveys provides incomparable regression functions. The effect of reducing SUs numbers within LII sites is variable, due to different understory heterogeneity, and arousing misleading plant diversity description. LII hardly represents the spatial distribution achieved by LI reference (in 2007), due to the “preferential” selection used in the former network. A relevant reduction of LI sites can be achieved (almost 50%) maintaining the representativeness of plant species richness; relevant thresholds have been provided considering the stratification by Biogeographic Regions and the most relevant Forest types (Alpine conifers, Mountinous Beech, and Thermophilous deciduous forests).

The experimental design of the comparative field test will be presented.

Modelling climate change effects on the chlorine cycle in a Norway spruce forest soil

Nicholas Clarke[1], Zora Lachmanová[2], Miroslav Matucha[3]

[1] Norwegian Institute of Bioeconomy Research, P.O. Box 1151, N-1431 Ås, Norway, nicholas.clarke@nibio.no;
[2] Forestry and Game Management Research Institute, Prague, Czech Republic;
[3] Institute of Experimental Botany, Academy of Science of the Czech Republic, Prague, Czech Republic

Links between the carbon and chlorine cycles, especially dissolved organic carbon and dissolved organic chlorine, were investigated in a Norway spruce (*Picea abies* (L.) Karst.) forest ecosystem at the ICP Forests Level II site at Birkenes in southern Norway. Organic chlorine was determined as adsorbable organic halogens, AOX, in solution and total organic halogens, TOX, in soil. The DyDOC model (developed for modelling the C cycle in forest ecosystems) was adapted to include organic chlorine and used to model TOX and AOX concentrations. TOX/AOX concentrations in soil and soil water were in general modelled satisfactorily, except for B horizon soil water for which the modelled AOX concentrations were too low. Modelling suggested that mineralisation of organic Cl and the chlorine content of litter are more important in controlling TOX and AOX than chlorination rate or input via chloride deposition and litter amount. Results from analysis of scenarios with increased temperature, precipitation and litter input will be presented.

Standard presentation

Do changes in forest soil properties reflect the decrease of acidifying deposition in Flanders?

Nathalie Cools, Bruno De Vos, Arne Verstraeten, Peter Roskams

Research Institute for Nature and Forest (INBO), Belgium, Nathalie.Cools@inbo.be

Between 1994 and 2010 the deposition of inorganic nitrogen (N) and sulphate (SO_4^{2-}) strongly decreased at five ICP Forests intensive monitoring (Level II) plots in Flanders, Northern Belgium (Verstraeten et al. 2012). Deposition of SO_4^{2-} declined by 56-68% and NH_4^+ declined by 40-59%. Deposition of NO_3^- decreased by 17-30% in the three deciduous forest plots, but remained stable in the two coniferous forest plots. The deposition of base cations (BC = Ca^{2+} + K^+ + Mg^{2+}) decreased simultaneously, resulting in a 45-74% net decrease of potentially acidifying deposition. In the soil solution, the SO_4^{2-} fluxes declined in all five plots but to a lesser degree than could be expected from the observed decrease in SO_4^{2-} deposition, and a net release of SO_4^{2-} at two deciduous forest plots was found. Fluxes of NO_3^- in the mineral soil decreased significantly at most soil depths in all plots.

In these five Level II plots, description and sampling of the forest floor and mineral soil was conducted in 1989, 1991, 1992, 2004, 2007 and in 2014. Though over this period also the methods for both description and analysis of soil samples evolved. All these data were compiled in one database and will be subjected to trend analysis.

The objective of our study is to evaluate whether significant changes in forest soil properties can be observed and whether these changes comply with the observed trends in deposition and soil solution chemistry.

The following chemical and physical forest soil properties will be compared and discussed:

- pH-H_2O and pH-$CaCl_2$
- Exchangeable cations including base saturation
- Total contents of carbon, nitrogen, macro-nutrients, heavy metals and C:N ratios
- Bulk density, soil water retention characteristics, thickness and mass of the forest floor

Verstraeten, A., Neirynck, J., Genouw, G., Cools N., Roskams, P, Hens, M. 2012. Impact of declining atmospheric deposition on forest soil solution chemistry in Flanders, Belgium. Atmospheric Environment 62: 50-63

Generating of gapless meteorological data for water budget modelling of Level II plots

Max Daenner[1], Stephan Raspe[1] und Peter Waldner[2]

[1] Bavarian State Institute of Forestry, Germany, karl.daenner@lwf.bayern.de, stephan.raspe@lwf.bayern.de
[2] Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Switzerland, peter.waldner@wsl.ch

Gapless and harmonized time series of meteorological common parameters are fundamental precondition for site-specific ecological modelling like the modelling of water flow in soil. However, daily experience teaches us that with in situ measurements we often have to deal with data gaps and inconsistency. With 355 Level II monitoring plots the ICP Forests has one of the biggest forests meteorological times series, which for individual plots reach in the past up to the year 1990. The plots are located over whole Europe and monitoring is done in forest stand and open landscape. Consolidated in the framework of the ICP Forests measurement, storage and data access was harmonized over participating countries with the aim to provide easy access and comparable raw data.

In a multi-level analysis we evaluated the meteorological data and filled identified gaps for all data with a unified method. In a first step we synchronized the data of member countries with the database and corrected or complemented the datasets. The following steps rely on gridded ERA-Interim data provided from the Centre for Medium-Range Weather Forecasts (ECMWF) with a spatial resolution of 0.7 x 0.7 degree. With bilinear interpolation of 4 neighboring cells we extracted for all locations of the ICP forest plots the meteorological parameters air temperature (mean, min, max), precipitation, global radiation, wind speed and direction. Relative humidity was driven from air and drew point temperature. We detected outliers in the ICP Forests data by Mahalanobis distance approach. Remaining gaps were filled with extracted ERA-Interim data and a statistically downscaling method based on kernel distribution mapping. Besides the gap filling within the time series the downscaled data can also be used to retro perspective fill the meteorological parameter up to the year 1979. For ease of usage all methods were compiled in an R package.

Poster presentation

Trends of soil moisture content in Hungarian oak stands

Zoran Galić, Saša Orlović, Zoran Novčić

University of Novi Sad - Institute of Lowland Forestry and Environment, galicz@uns.ac.rs

The aim of this paper are to shown the trends of soil moisture content in hungarian oak stands during past five years in July under different climate conditions.

Data on microclimate indicators were collected from 2010 to 2015 (temperature, relative humidity). Climatological data are analyzed on the basis of annual report of Republic Hydrometeorological Service of Serbia. Soil moisture content (% vol) was determined on 10, 30 and 50 cm of soil depth.

The highest mean annual air temperature was recorded in 2012. The average monthly temperature in July was the lowest in 2014 (20.9ºC), and the highest in 2012 (25.0ºC). The average monthly relative humidity in July was the lowest in 2013 (57,7%), and the highest in 2014 (81,9%). The highest FAI index was recorded in 2012 (11,44), and the lowest in 2014 (3,33).

The quantity of soil moisture content depended on hydrological conditions throughout the year. The highest average moisture content on 10 cm depth was recorded in 2015, on 30 cm in 2010 and on 50 cm in 2014. The lowest average content of soil moisture on all depth was recoreded in 2012.

In two years (2010 and 2014) hydrological conditions were closer to normal and the soil moisture was higher.

** This study is results of project III 43007 financed by Ministry of Education, Science and Technological development of Republic Serbia.*

Key words: hungarian oak, soil moisture, air temperature, relative humidity

Temporal and spatial distribution of ozone symptoms across Europe from 2002 to 2014

*Elena Gottardini[1], Vicent Calatayud[2], Marco Ferretti[3], Matthias Haeni[4], Marcus Schaub[4]**

[1] Research and Innovation Centre, Fondazione Edmund Mach (FEM), Italy Research and Innovation Centre, Fondazione Edmund Mach (FEM), Via E. Mach 1, 38010 San Michele all'Adige, Italy;
[2] Fundación Centro de Estudios Ambientales del Mediterráneo (CEAM), Parque Tecnológico, Paterna, SPAIN;
[3] TerraData environmetrics, Via L. Bardelloni 19, 58025 Monterotondo M.mo (GR), Italy;
[4] Swiss Federal Research Institute WSL, Zuercherstrasse 111, 8903 Birmensdorf, Switzerland; marcus.schaub@wsl.ch

One of the aims of ICP Forest is to estimate the potential risk of ozone on European forest ecosystems. In this respect, ozone-induced, visible foliar injury is one of the most considered response indicator to assess ozone impact on vegetation. In the present study, we analyse visible injury data from the Light Exposed Sampling Sites (LESS) installed close to the Level II monitoring plots, and where ozone concentration and meteorological parameters are also measured.
Over the period of 2002-2014, nineteen European countries participated in the field assessment of ozone visible injury according to the ICP Forests standardized methodology (Schaub *et al*., 2010). Overall, 295 woody species were recorded, of which 28% are being reported as symptomatic*. In 2009, the year with the highest number of countries participating in the field campaign, 60% of the countries reported the presence of ozone symptoms in some plants. In the same year, 12.4% (24 out of 194) of the woody species were symptomatic.
Preliminary results for temporal trends reveal that four out of five countries with at least eight years of data show a decreasing trend in frequency of symptomatic woody species, statistically significant for two countries. Enhanced data quality control is being carried out to perform further analyses to better quantify the spatial and temporal distribution of ozone symptoms across European forests, also in relation to ozone exposure (cf. Schaub *et al*., 2015).

** Not all symptomatic species were validated.*

Schaub M, Calatayud V, Ferretti M, Brunialti G, Lövblad G, Krause G, Sanz MJ (2010) Monitoring of Ozone Injury. Manual Part X, 22 pp. In: Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests. UNECE ICP Forests Programme Co-ordinating Centre, Hamburg. ISBN: 978-3-926301-03-1. [http://www.icp-forests.org/Manual.htm].

Schaub M, Haeni M, Ferretti M, Gottardini E, Calatayud V (2015) Ground level ozone concentrations and exposures from 2000 to 2013. In: Michel A, Seidling W (eds) Forest Condition in Europe: 2015 Technical Report of ICP Forests. Report under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). Vienna: BFW Austrian Research Centre for Forests. BFW Dokumentation 21/2015. 182 p.

Standard presentation

ViburNeT – The *Viburnum lantana* ozone biological response Network in Trentino, Italy*

Elena Gottardini[1], Fabiana Cristofolini[1], Antonella Cristofori[1], Marco Ferretti[2]

[1] Fondazione Edmund Mach, Research and Innovation Center, Italy, elena.gottardini@fmach.it;
[2] TerraData environmetrics, Italy, ferretti@terradata.it

A network based on the native, widely distributed ozone sensitive species *Viburnum lantana* L. was installed in 2010 in Trentino, Northern Italy (Gottardini et al., 2014). The network was planned over the entire Trentino region (6 X 10^3 km^2) to detect the biological response of vegetation to tropospheric ozone on the basis of visible foliar symptoms. Sites were selected according to a stratified (two elevation ranges x three ozone exposure ranges) random sampling design: originally, 30 sites were selected and visited in 2010; subsequently, a subsample of 10 sites was retained and visited in 2012, 2014 and 2015.

The full survey undertaken in 2010 allowed to detect a significantly higher frequency of symptomatic plants at sites with higher estimated ozone exposure (Gottardini et al., 2014). Subsequent surveys carried out in 2012 and 2014 confirmed the previous results. In 2015, the very hot and dry summer could have affected plants' response: where soil moisture conditions were very dry, frequency of symptomatic plants resulted significantly lower than in moderately dry situations. Symptoms data were further evaluated in relation to ozone levels in the region measured by the six conventional monitors of the local Environmental Protection Agency. The time pattern of mean frequency of symptomatic plants over the period 2010-2014 is consistent with the April-July mean ozone concentrations.

**Activity partially supported by Servizio Foreste e fauna, Autonomous Province of Trento (Italy).*

Gottardini E, Cristofolini F, Cristofori A, Ferretti M., 2014. Ozone risk and foliar injury on *Viburnum lantana* L.: A meso-scale epidemiological study. *Science of the Total Environment*, 493: 954–960.

Standard presentation

Nitrogen deposition to forest ecosystems with focus on its different forms

Iva Hůnová, Pavel Kurfürst, Vojtěch Stráník

Czech Hydrometeorological Institute, Prague, Czech Republic, hunova@chmi.cz

The biogeochemical cycle of nitrogen (N) has been changed substantially due to human activity in recent decades. Currently the contribution to the release of reactive nitrogen by humans is comparable to natural. Though N is an essential plant nutrient and participates in many reactions in living cells, its overload might be detrimental to ecosystems for many reasons as discussed in numerous studies.

The aim of our contribution is to analyze the spatial patterns and temporal changes of N in Central European forests, particularly in Czechia, with focus on changes in relative shares of different forms (wet and dry), and different compounds contributing to N deposition flux. We examine the ratio between NH_4^+ and NO_3^- in wet atmospheric deposition as an essential indicator of atmospheric chemistry, reflecting the share of emission sources (Du et al., 2014), and an important factor regarding the N deposition environmental impacts, reflecting the differential effects of reduced and oxidised N forms on vegetation independent of N load (van den Berg et al., 2016). The ratio of NH_4^+ / NO_3^- in precipitation has changed in the long term and most monitoring sites have recorded the increasing importance of NH_4^+ contribution.

For our analysis, we used the results of long-term monitoring of ambient air pollutant concentrations and precipitation chemistry within the national ambient air quality network (Hůnová et al., 2014).

Acknowledgements
We would like to acknowledge the grant GA14-12262S – Effects of changing growth conditions on tree increment, stand production and vitality – danger or opportunity for the Central-European forestry? for partial support of this contribution. The input data used for the analysis were provided by the Czech Hydrometeorological Institute.

Du, E., de Vries, W., Galloway, J.N., Hu, X., Fang, J., 2014. Changes in wet nitrogen deposition in the United States between 1985 and 2012. Environmental Research Letters 9, 095004.

Hůnová, I., Maznová, J., Kurfürst, P., 2014. Trends in atmospheric deposition fluxes of sulphur and nitrogen in Czech forests. Environmental Pollution 184, 668–675.

van den Berg, L.J.L., Jones L., Sheppard, L.J., Smart, S.M., Bobbink, R., Dise, N.B., Ashmore, M.R., 2016. Evidence for differential effects of reduced and oxidized nitrogen deposition on vegetation independent of nitrogen load. Environmental Pollution 208, 890–897.

Ozone concentration extreme events identification and analysis in a temperate mixed forest

Quentin Hurdebise[1], Benjamin Bergmans[2], Marc Aubinet[1]

[1] University of Liège, Gembloux Agro-Bio Tech, Terra, Gembloux (Belgium), quentin.hurdebise@ulg.ac.be;
[2] Cellule Emissions Atmosphériques, Institut Scientifique de Service Public, Liège (Belgium)

Understanding how temperate forests react and will react in a changing environment is essential. That requires long-term monitoring of the environment and tropospheric ozone is one parameter to monitor as it affects the forest by inducing oxidative stress once inside the leaves.

Using 16 years of continuous data from an air quality monitoring station of the AWAC[1]–ISSEP[2] network located inside a mixed forest in east Belgium, we identified ozone concentration extreme events and we investigated their occurrence frequency as well as their relation with climatic variables and air components.

As variables are subjected to daily, yearly and inter-annual dynamics, anomalies were used to detect extreme events. To obtain anomalies, we removed the previously mentioned dynamics from half-hourly data.

Daily and yearly dynamics were removed first and explained 40% of the variability observed in half-hourly ozone concentrations. Then, the inter-annual dynamic was obtained by computing the yearly mean of the residuals, it accounted for 2% of the variability. A significant decreasing trend was observed for these residuals. Determining if that trend is site specific or regionally observed can be done by applying the same analysis to the other sites from the AWAC-ISSEP network.

Extreme events were defined as events when the anomaly was higher than the 97.5 percentile of all the anomalies. No significant trend was observed in the yearly frequency and intensity of extreme events. Significant relations were found between ozone concentration anomalies and climatic variables anomalies as well as other air components concentration anomalies during extreme events.

[1] Walloon Air and Climate Agency
[2] Scientific Institute of Public Service

Poster presentation

GuMNet - A high altitude monitoring network in the Sierra de Guadarrama (Madrid, Spain)

Rosa María Inclán[1] and the GuMNet Consortium Team

[1] CIEMAT, Spain, rm.inclan@ciemat.es

The Guadarrama Monitoring Network (GuMNet) is an observational infrastructure focused on monitoring the state of the atmosphere and the ground in the Sierra de Guadarrama, 50 km NW of the city of Madrid. The network is composed of 10 stations ranging from low altitude (900 m a.s.l.) to high mountain climate (2400 m a.s.l.).

The atmospheric instrumentation includes sensors for air temperature, air humidity, 4-component net radiation, precipitation, snow height and wind speed and direction. The surface and subsurface infrastructure includes temperature and humidity sensors distributed in 9 trenches up to a maximum of 1 m depth and additionally temperature sensors in 15 PVC cased boreholes down to 20 m and 2 m with a higher vertical resolution close to the surface. All stations are located in exposed open areas except for one site that is in a forested area for measuring air-ground fluxes under forest conditions. High altitude sites are focused on periglacial areas and lower altitude sites have emphasis on pastures. One of the low altitude sites is equipped with a 10 m high tower with 3D sonic anemometers and a CO_2/H_2O analyzer that will allow the sampling of wind profiles and H_2O and CO_2 eddy covariance fluxes, important for estimation of CO_2 and energy exchanges over complex vegetated surfaces. The network is connected via general packet radio service to the central lab in the Campus of Excellence of Moncloa and management software has been developed to handle the operation of the infrastructure. The data provided by GuMNet will help to improve the characterization of atmospheric variability from turbulent scales to meteorology and climate at high mountain areas, as well as land-atmosphere interactions. The network information aims at meeting the needs of accuracy to be used for biological, agricultural, hydrological, meteorological and climatic investigations in this area with relevance for ecosystem oriented studies. This setup will complement the broader network of meteorological stations of the Spanish National Meteorological Agency (AEMET), mostly distributed in the lower latitude range.

This initiative is supported and developed by research groups integrating the GuMNet Consortium from the Complutense and Polytechnical Universities of Madrid (UCM and UPM), the Energetic Environmental and Technological Research Centre (CIEMAT), AEMET, and the National Park Sierra de Guadarrama (PNSG) which provided the initial foundations of this network. GuMNet will be operational in 2016.

Web: http://www.ucm.es/gumnet/

Environmental factors and canopy drip effect on heavy metals in mosses collected in Slovenian forests

Zvonka Jeran[1], Darja Mazej[1], Mitja Skudnik[2] & Damijana Kastelec[3]

[1] Jožef Stefan Institute, Department of Environmental Sciences, Jamova 39, 1000 Ljubljana, Slovenia, zvonka.jeran@ijs.si;
[2] Slovenian Forestry Institute, Department of Forest and Landscape Planning and Monitoring, Večna pot 2, 1000 Ljubljana, Slovenia; mitja.skudnik@gozdis.si;
[3] University of Ljubljana, Biotechnical Faculty, Department of Agronomy, Jamnikarjeva 101, 1000 Ljubljana, Slovenia; damijana.kastelec@bf.uni-lj.si

Moss samples of *Hypnum cupressiforme* were collected at more than 100 locations distributed on a regular 16 km × 8 km grid in the Slovenian forests, including 11 locations near plots of the Intensive Monitoring Programme of Forest Ecosystems in Slovenia (UN-ECE ICP-Forest Level II plots) and analysed for As, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, Pb, Sb, Se, Sr, Ti, Tl, V and Zn using ICP- MS (Agilent, 7500 CE). The influence of canopy drip and other environmental factors that could have an influence on elemental levels in mosses were investigated by a systematic sampling approach. Namely, at each sampling location moss samples were taken i) in the forest openings, as far as possible outside the area of the tree canopy projection and ii) within the forest stand inside the area of the tree canopy projection. All moss data were divided in four groups (categories) according to distances of moss collection location to the nearest tree crown projection as follows: i.) within forest stand (0 m) and three categories within the forest openings, ii.) < 1m, iii.)1-3 m, iv) > 3m.

It was found, that except for Mg, for all other elements on average between 12 % (Sr) up to 38% (Cu) lower elemental levels were found ($p< 0.05$) in mosses collected at a distance between 1-3 m from the canopy in comparison to those collected below canopy in the forest stand. Especially for elements like Cu, Hg, Ni, Se in V a distinctive decrease in elemental levels with increasing distance from the tree canopy projection was observed for all three categories of distance and pointed for high contribution from canopy drip. Similar behaviour was seen also for Co, Cr, Fe and Sb.

Other environmental characteristics that might have an influence on elemental levels in mosses exposed that for Zn, Cu and Mo higher concentrations were found below coniferous trees in comparison to broadleaves. For Cu also the amount of precipitation significantly increases the levels of this element in mosses below the canopy. For elements such as Mn, Ni and Se the type of bedrock together with the amount of precipitation play an important role in elemental levels in mosses.

Temporal trends in soil solution acidity indicators in European forests

Jim Johnson[1], Arne Verstraeten[2], Henning Meesenburg[3], Lars Vesterdal[4], Karin Hansen[5], Elena Vanguelova[6], Mathieu Jonard[7], Elisabeth Graf Pannatier[8], Jörg Sintermann[8], Tiina M. Nieminen[9], Stefano Carnicelli[10], Guia Cecchini[10], Nicholas Clarke[11]

[1] ERM, UCD School of Agriculture & Food Science, Belfield, Dublin 4, Ireland, jim.johnson@ucd.ie;
[2] INBO, Research Institute for Nature and Forest, Belgium;
[3] Northwest German Forest Research Institute, Germany;
[4] Department of Geosciences and Natural Resource Management, Denmark;
[5] IVL Swedish Environmental Research Institute, Sweden;
[6] Forest Research, UK;
[7] UCL-ELI, Université catholique de Louvain, Earth and Life Institute, Belgium;
[8] Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Switzerland;
[9] Natural Resources Institute Luke, Finland;
[10] Earth Sciences Department, University of Florence, Italy;
[11] Norwegian Forest and Landscape Institute, Norway

Atmospheric deposition of inorganic nitrogen and sulphur compounds was one factor in the acidification of temperate forest soils in large parts of Europe during the second half of the 20th century. By acting on mineral weathering and exchangeable element equilibrium, acidifying deposition mobilizes base cations (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}) and aluminium into soil solution thereby enhancing base cation loss by leaching and the aluminium toxicity (mainly Al^{3+}) to fine roots and mycorrhizal fungi. Soil solution composition is thus a key indicator for the effects of air pollution on forest ecosystems and provides “real time” information about the equilibrium between solid/liquid soil phases, leading to change in soil chemistry over time.

In recent decades, sulphur and nitrogen deposition has strongly decreased in forests in western central Europe, but hasn’t changed or has slightly increased in eastern and northern Europe (Waldner et al. 2014). The aim of this study is to evaluate the acidity status of soil solution chemistry in response to changes in deposition at ICP Forests intensive monitoring (Level II) plots where soil solution has been collected over the past two decades. Data from approximately 177 sites in 17 countries with at least 10 years of data have been selected for this study.

To date, data for analysis has been prepared; values reported as below detection limit or ‘zero’ have been replaced, collection dates added to earlier years and information relating to sampler depth, type and layer has been checked. Initial analysis confirms a significant decline in sulphate in soil solution. The next step is to assess changes in acidity over the monitoring period. This will be achieved by applying the Seasonal Mann-Kendall test to indicators of acidity (pH, BC:Al, ANC) with months as seasons. The sites will be grouped in categories of soil acidity based on pH and base saturation for this test.

Evaluation of factors driving the trends will be carried out by relating temporal trends in soil solution acidity to environmental factors such as atmospheric deposition, climate as well as stand and soil conditions using linear mixed models. In addition, indicators of temporal trends in soil solution acidity will be related to decadal changes in bulk soil acidity at a subset of plots where soil data are available from the first and second ICP Forests Level II soil condition surveys. Preliminary results of soil solution acidity indicators trends, and likely controlling factors at the European scale, will be presented.

Long-term monitoring of heavy metal input, retention and output over the last 30 years – results from Lower Saxony, Hesse and North Rhine-Westphalia, Germany

Nils König[1], Henning Meesenburg[1], Birte Scheler[1], Heike Fortmann[1], Markus Wagner[1], Uwe Klinck[1], Joachim Gehrmann[2]

[1] Northwest German Forest Research Institute, Göttingen, Germany;
[2] Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen, Recklinghausen, Germany

Due to a restrictive environmental legislation, deposition of heavy metals, originating from power plants, industry and traffic, has been reduced during the last decades. In order to quantify the reduction and detect effects of heavy metal input on forests, heavy metal fluxes with throughfall, litterfall and stemflow have been observed at Level II plots in Lower Saxony, Hesse and North Rhine-Westphalia, Germany.

Inventories of heavy metal stocks in the organic layers and mineral soils of Level II plots as well as plots of the National Forest Soil Survey (BZE) indicate an accumulation of most heavy metals in the upper mineral soil.

Concurrent with this finding, decreasing trends of heavy metal concentrations in the soil solution were observed at some plots. The output fluxes of mobile elements such as cadmium and zinc were sometimes higher than the deposition rates, whereas input-output budgets for other elements suggest an ongoing accumulation in the upper mineral soil.

Biofungicides in nursery production

Miroslava Markovic[1], Snezana Rajkovic[1], Ljubinko Rakonjac[1]

[1] Institute for Forestry, Kneza Viseslava 3, 11030 Belgrade, Republic of Serbia, mira013@gmail.com, srajkovic1@gmail.com, ljrakonjac@yahoo.com

The experiments were set on oak seedlings in two nurseries located in Central Serbia, where control of oak powdery mildew *Microsphaera alphitoides* Griff. et Maubl. had been conducted through alternative protection measures by means of various dosages of AQ-10 biofungicide, with and without added polymer (which has so far never been used in this country for control of oak powdery mildew). To date, the Republic of Serbia has registered no fungicides for suppression of pathogens in the forest ecosystems [1]. In order to introduce proper use of new disease-fighting agents into a country, certain relevant principles, requirements and criteria prescribed by the Forest Stewardship Council (FSC) must be observed, primarily with respect to measures of assessment and mitigation of risks, the list of dangerous and highly dangerous pesticides with the possibility of alternative protection. One of the main goals of the research was adjustment of the protective measures to the FSC policy through selection of eco-toxicologically favourable fungicides, given the fact that only preparations named on the list of permitted active matters are approved for use in certified forests [2]. Examinations were performed by standard OEPP methods PP1/69 (2) (1997) [3]. The results of the research have demonstrated that AQ-10 biofungicide can be used as a part of integrated disease management programmes as an alternative, through application of several treatments during vegetation and combination with other active matters registered for these purposes, so as to curtail the use of standard fungicides for control of powdery mildews on oak seedlings in nurseries. The best results in suppression of oak powdery mildew were attained through use of AQ-10 biofungicide (dose 50 or 70g/ha) with added polymer Nu Film-17 (dose 1.0 or 1.5 l/ha). If the treatment is applied at the appropriate time, even fewer number of treatments and smaller doses will be just as efficient.

Key words: Oak Powdery Mildew, Biofungicides, Polymers

[1] Rajkovic, S., Tabakovic-Tosic, M., Markovic, M., Milovanovic, J., Mitic, D. (2010): Application of AQ-10 biofungicide on *Quercus robur L. seedlings*, Fresenius Environmental Bulletin, Vol.19; No 12a, pp 2987-2992

[2] Patteberg, P. (2005): What Role for Private Rulke-Making in Global Environmental Governance? Analysing the Forest Stewardship Council (FSC), International Environmental Agreements: Politics, Law and Economics, Issue 2, pp 175-189

[3] *EPPO* (1997): Guideline for the efficacy evaluation of fungicides – *Podosphaera leucotricha*, No. PP 1/69 (2) in Guideline for the efficacy evaluation of Plant Protection Products, pp 100-102.

Standard presentation

Light requirements direct the response of understory plants to forest cuttings

Päivi Merilä[1], Tiina Tonteri[2], Ville Hallikainen[3], Pasi Rautio[3], Leila Korpela[2], Maija Salemaa[2]

Natural Resources Institute Finland (Luke), [1]Oulu; [2]Vantaa; [3]Rovaniemi; firstname.lastname@luke.fi

We analysed the driving forces for the temporal change in the cover of abundant or common forest plant species in Finland during 21 years. The data are based on vegetation surveys carried out on the same 443 permanent ICP Forests Level I sample plots located in forests on mineral soils in 1985–86 and in 2006. Our focus was in analysing the effects of forest cuttings of different intensity i.e., intermediate cuttings (IC) and regeneration cuttings (RC), on 11 understory plant species and their recovery after cuttings in climate and site fertility classes. Generalized linear models (GLM) were used in modelling the change in cover of the plants. RC caused a much larger change in understorey vegetation than IC. Further, the plant species showed contrasting responses to RC and IC according to their light requirements, which also accounted for the time required for a species to recover from cutting disturbance. After RC, shade-tolerant and semi-shade-tolerant species (*Oxalis acetosella, Hylocomium splendens,Vaccinium myrtillus*) decreased strongly (>70%) and recovered relatively slowly, but increased 30–70% after IC. Semi-light-requiring species (*Dicranum polysetum, Pleurozium schreberi, Vaccinium vitis-idaea*) decreased 20–60% immediately after RC, but recovered relatively fast, reaching the cover found in old forests at the stand age of ca. 30 years. These species increased after IC. Light-requiring species (*Empetrum nigrum, Calluna vulgaris, Deschampsia flexuosa*) increased after RC and decreased after IC. Light-requiring species benefited from RC showing even >100% increases in their cover in comparison to their abundance in the old forests. The cover of *Cladina* spp. remained stable or decreased in all treatments except in the recent RC in southern part of Finland.

Concentrations of Cd and Pb in bulk precipitation, throughfall, plant tissues and soil in a remote mountainous fir forest in Greece

Panagiotis Michopoulos[1], Marios G. Kostakis[2], Athanassios Bourletsikas[1], Kostas Kaoukis[1], George Karetsos[1], Nikolaos S. Thomaidis[2], Ioannis N. Passias[2]

[1] H.A.O. DEMETER-Institute of Mediterranean Forest Ecosystems, Terma Alkmanos, Athens 115 28, Greece, mipa@fria.gr;
[2] Laboratory of Analytical Chemistry, Department of Chemistry, National and Kapodistrian University of Athens, Athens 157 71, Greece

The total concentrations of Cd and Pb were determined in bulk precipitation, throughfall deposition, plant tissues and soil in a remote mountainous fir forest stand in the area of Karpenisi, central Greece. The average concentrations of Cd and Pb in bulk deposition were 0.044 and 0.275 μg L^{-1}, whereas those in throughfall 0.026 and 0.854 μg L^{-1}, respectively. So, the Pb concentrations were enriched in throughfall but not those of Cd. This was due to the way of deposition and leaching of the two metals in throufhall. Lead is deposited in dry deposition at a high percentage, whereas Cd in wet deposition. Moreover, Cd can be circulated inside trees much easier than Pb. This fact was confirmed from the enrichment of the old needles of fir with Pb. The average concentrations of these metals in needles were found: for Cd 0.033, 0.037 and 0.063 mg kg^{-1} for the current year, second year and past years, respectively. For Pb the results were: 0.612, 1.56 and 3.26 mg kg^{-1} for the same categories of needles. The concentrations of both metals in all plant tissues types are not considered high according to what has been found in literature. In the ground vegetation Pb had the highest concentrations in herbs and Cd in ferns. In soils the highest concentrations for both metals (extracted with HF acid) were determined in the FH horizon (0.591 for Cd and 38.6 mg kg^{-1} for Pb). The concentrations of Cd in soils were a bit higher than those reported in literature for remote forests, whereas those of Pb at normal levels. The concentrations of the two metals were found reduced with soil depth. In general, the concentrations of both metals followed the order: soil>plant tissues>throughfall>bulk precipitation.

Itoh, Y., Miura, S., Yoshinaga, S. 2006. Atmospheric lead and cadmium deposition within forests in the kanto district, japan. J. For. Res. 11: 137-142.

Martin, M.H., Duncan, E.M., Coughtrey, P.J. 1982. The distribution of heavy metals in a contaminated woodland ecosystem. Environ. Pollut. 3: 147-157.

Michopoulos, P., Baloutsos, G., Economou, A., Nikolis, N., Bakeas, E.B., Thomaidis, N.S. 2005. Biogeochemistry of lead in an urban forest in Athens, Greece. Biogeochemistry 73: 345-357.

Poster presentation

Merging effects of air pollution and climate change on forest growth in Romania

Stefan Neagu[1], Mihai Hanzu[1]

[1] National Research and Development Institute in Forestry, Romania, stefanneagu@live.com

Climate change and air pollution are gradually intensifying and amplifying the effects of severe weather events in Romania, driving the tree morbidity and mortality, and resetting the elusive forest ecosystems' stability. The research on the patterns, causes and effects on tree growth in the selected ecosystems of the Romanian monitoring network is intended to outline the impact of the intermediate and explanatory indicators (e.g. climate, depositions, and nutrients) and their significance, in order to describe their impact upon forest growth in relation to integrated natural and anthropogenic disturbances.

The research methods involved are described in detail in the ICP-Forests manual concerning the sampling and analysis of meteorological, deposition, foliar, soil solution, crown condition and tree growth data.

The preliminary results highlighted the significance of the explanatory indicators on the forest growth concerning the air pollution and climate change parameters, and revealed the high sensitivity and the remarkable ability of the trees to recover after austere site conditions and extended weather stress.

Modelling and mapping soil moisture for observed and future periods. A Germany-wide and regionally specified fuzzy approach

Stefan Nickel[1], Winfried Schröder[1], Martin Jenssen[2]

[1] Chair of Landscape Ecology, University of Vechta, Germany, stefan.nickel@uni-vechta.de;
[2] Waldkunde-Institut Eberswalde, Germany

Soil moisture is an essential environmental factor affecting the condition of forests throughout time. Dynamic modelling of soil moisture even with rather simple models need a lot of data which often are not available for areas of large spatial extent. Therefore, within the context of a methodology for evaluating the effects of climate change and atmospheric deposition on forest condition (Jenssen et al. 2013; Schröder et al. 2015), the objective of this investigation was to develop an approach for modelling and mapping of soil moisture which can be applied with available data covering the territory of Germany and which can be specified for the regional scale.

A fuzzy rule-based model was developed allowing the combination of a pedological and an ecological soil moisture classification (Nickel et al. 2016). The fuzzy modelling approach was applied for mapping soil moisture at two spatial scales: Soil moisture was modelled and mapped on a scale of 1 : 500.000 across Germany and regionally specified on a scale of 1 : 25.000 for the Kellerwald National Park for 1961-1990, 1991-2010, 2011-2040 and 2041-2070. The model allows mapping soil moisture at the national and regional scale as shown by example of Germany and the Kellerwald across observed and future times. It should be tested at the European scale.

Jenssen M et al. 2013. Bewertungskonzept für die Gefährdung der Ökosystemintegrität durch die Wirkungen des Klimawandels in Kombination mit Stoffeinträgen. UBA-Texte 87/2013:1-381

Nickel S et al. 2016. Fuzzy modelling and mapping soil moisture for observed and future periods. An alternative for dynamic modelling at the national and regional scale? Submitted to Ann Forest Sci

Schröder W et al. 2015. Methodology to assess and map the potential development of forest ecosystems exposed to climate change and atmospheric nitrogen deposition: a pilot study in Germany. Sci Tot Environ 521-522: 108-122

Standard presentation

Elevated sulfate and trace element concentrations in soil solution of an acid sulfate forest soil

Tiina M. Nieminen[1], Kirsti Derome[2], Antti-Jussi Lindroos[1], and Päivi Merilä[2]

[1] Luke, Natural Resources Institute , P.O.Box 18, 01301 Vantaa, Finland;
[2] Luke, Natural Resources Institute, P.O.Box 413, 90014 Oulun yliopisto, Finland, tiina.m.nieminen@luke.fi

Finland has the largest known occurrence of acid sulfate soils in Europe (Andriesse & van Mensvoor 2006), roughly 500 000 ha according to a recent estimation. Most of these soils are in agricultural use but the share of forest land is estimated to be more 200 000 hectares.

The aim of this study was to investigate the quality of soil solution in a Norway spruce (*Picea abies* L. Karst.) stand located on an acid sulfate soil.

Seven sites chosen for this study were spruce dominated forests belonging to the Finnish monitoring programme of the UN-ECE ICP Forests Level II network (Merilä et al. 2007). At one of the sites the chemical properties of the soil have been reported to reflect the formation of an acid sulfate (AS) soil (Lindroos et al. 2007) .The soil texture of the AS-site is till with a relatively high proportion of silt and sand. Although the age of the soil is only ca. 300-400 years, clearly distinguishable podsolic horizons have developed in the surface soil as a result of the spruce cover (Lindroos et al. 2007). Soil solution samples were taken in 2000-2010 at 4-week intervals during the snow free period using both zero tension and suction cup lysimeters at depths of 20 and 40 cm. Soil solution samples were filtered through a 0.45 µm membrane filter, and Al, Fe, and Ni concentrations were determined by ICP/AES. SO_4-S was analyzed by ion cromatography. The pH was measured from unfiltered subsamples.

We found clearly lower pH values, and higher concentrations of SO_4-S, Al, Fe, and Ni in soil solution of the AS site compared to background spruce sites on podsolic soil. According to our results Norway spruce appears to tolerate extremely low pH and elevated concentrations of metals in the soil solution.

Andriesse W. & van Mensvoort, M.E.F 2006. Acid sulfate soils: distribution and extent R. Lal (.Ed.), Encyclopedia of Soil Science, (2. ed.), Taylor & Francis Group, New York, p. 14–19.

Lindroos, A-J., Derome, J., Raitio H. & Rautio, P.. 2007. Water, Air, and Soil Pollut. 180: 155-170.

Merilä, P., Kilponen T. & Derome, J.. (Eds.) 2007. Working Papers of the Finnish Forest Research Institute 45.

Forest health monitoring in the Alberta Oil Sands, Canada: Design, results and linkage to ICP Forests

Kevin E. Percy

Wood Buffalo Environmental Association, Canada, kpercy@wbea.org

The Wood Buffalo Environmental Association (WBEA) has monitored air quality and forest health in northeastern Alberta, Canada since 1998. WBEA operates an integrated monitoring program with measurements along the air pollutant pathway from oil sands emission sources to Boreal Forest pollutant receptors including upland jack pine (*Pinus banksiana* Lamb.) interior stand and forest edge plots. The plots are stratified between 55^0N and 58^0N latitudes across pollutant deposition zones, and they extend outwards up to 150 km from mines and bitumen upgraders. The WBEA Forest Health Network (FHN) is designed to detect, quantify, and predict above- and below-ground change in the xeric, acid sensitive jack pine-bearberry (*Arctostaphylos uva-ursi* (L.) Spreng.) ecotype. Through plot-level co-measurement of inputs, meteorology, and response indicators, the FHN is designed to determine cause-effect in order to inform environmental management. The approach is described in Tkacz ert al. 2013). Procedures used and results from a recent intensive sampling are available at http://dev.wbea.org/resources/terrestrial-monitoring-reports. Changes in soil and vegetation indicators reported are further informed by the use of forensic receptor modelling for source apportionment of *Hypogymnia physodes* elemental/stable isotope chemical fingerprints back to emission source fingerprints. This presentation will review current above- and below-ground results from the WBEA FHN. The presentation will also highlight the similarities in the WBEA and ICP designs, and outline possible areas for immediate cooperation outlined in the WBEA – ICP MOU.

Tkacz, B., Riiters, K., Percy, K.E. 2013. Forest monitoring methods in the US and Canada: An overview. In: Ferretti. M, Fischer, R. (eds.) *Forest monitoring for terrestrial investigations in Europe and overview of North America and Asia*. Elsevier, Amsterdam, 49-73.

Poster presentation

Trend analysis of trees health status in the ICP Level I network in Romania. Synchronized with climate trend?

I. Popa, O. Badea, S. Leca, D. Silaghi

National Institute for Research and Development in Silviculture Marin Dracea, Romania, popaicas@gmail.com

Analysis of trees health status dynamics in ICP Level I network in Romania show a clear decreasing trend starting with 2003 both of group species (broadleaves and coniferous) and individually. Our objective was to establish if this trend is generally present in most of the plots or only in some regions of the country. Database is represented by the mean defoliation and share of damage trees from level I network (16x16 km) during the period 1995-2015. Climate data for the same period was extracted from grid database ROCADA with 10x10 km spatial resolution. As statistical methods we use Mann-Kendall test for trend analysis and for the change point analysis the Bayesian approach was tested.

During the growing season the trend of temperature increase for whole Romania, except the western and southern part of the country, where no trend detected. In the same period precipitation recorded an increasing trend during the vegetation season only in Eastern Carpathians. Also, the same increase was observed in the southern part of Romania (including southern Carpathians) for winter and spring period.

Based on trend analysis it was established that the national decreasing trend of tree status health indicators (mean defoliation and share of damage trees) isn’t generally present at plot level. For spruce a statistical significant trend (decreasing) was observed only in the Eastern and Southern Carpathians. In case of oak species this decreasing trend is present only in the south- western part of Romania. This spatial distribution of defoliation trend can be explained by some synchronization with precipitation trend.

Keyword: trend analysis, Bayesian change point analysis, defoliation, climate

Poster presentation

Monitoring Plot – CRNI VRH – Ozone injury

Snezana Rajkovic[1], Miroslava Markovic[1], Ljubinko Rakonjac[1]

[1] Institute of Forestry, Kneza Viseslava 3, Belgrade, 11030, srajkovic1@gmail.com

The results attributed to Level II Serbia – CRNI VRH sites will be documented in maps covering Europe, characterizing areas of increased ozone risk for European forest ecosystems. The assessment of ozone visible injury serves therefore as a means to estimate the potential risk for European ecosystems that are exposed to elevated ambient ozone concentrations and has to be considered in the context of ICP Forests aiming among others to document the presence of environmental drivers that may affect forest condition across Europe. For the injury data being accepted for the international database and evaluations, National Focal Centres and their scientific partners that are participating in the UNECE ICP Forests program must follow the methods and apply the manual described herein. The assessment for visible ozone injury on main tree species is conducted on the leaves from the same branches where foliar analysis is carried out. The samples for foliar injury are collected every second year from the upper sun exposed crown. Methodologies, including quality assurance, such as data harmonization, completeness and plausibility tests have been applied according to the ICP Forests Manual, Parts VIII - Assessment of Ozone Injury. Specific targets are set as follows: quantification of injuries ozone on the selected parcel level II in Europe; detection of temporal trends in the selected plot level II in Europe (significant changes within 10 years with a 95% level of significance of individual plots). Results from a Level II will be documented in maps covering Europe, characterized by an area of increased risk of ozone to European forest ecosystems.

Key words: injury, experimental plot, ozone.

Standard presentation

German moss survey: Quality controlled collection of data on heavy metals, nitrogen and persistent organic pollutants

Winfried Schröder[1], Stefan Nickel[1], Gudrun Schütze[2]

[1] Chair of Landscape Ecology, University of Vechta, Germany, Stefan.nickel@uni-vechta.de;
[2] German Environment Agency, Dessau, Germany

This paper aims at (1) outlining the methodological basis of biomonitoring atmospheric deposition of heavy metals (HM), nitrogen (N) and persistent organic pollutants across spatial scales; (2) sketching the meta-documentation of data collected; (3) presenting exemplary correlations between concentrations of HM and N in moss, leaves / needles, soil and modelled deposition; and (4) drafting the sampling design of the German Moss Survey (GeMS) 2015 / 2016.

Mainly focusing on Germany, data derived by deposition modelling and biomonitoring were evaluated. The model LOTOS-EUROS (LE) yielded data on HM deposition at a spatial resolution of 25 km by 25 km throughout Europe and 7 km by 7 km for Germany. The European Monitoring and Evaluation Programme (EMEP) provided model calculations on 50 km by 50 km grids. Corresponding data on HM concentrations in moss, leaves, needles and soil were derived from the European Moss Survey (EMS), the German Environmental Specimen Bank (ESB) and the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests). The modelled HM deposition and respective concentrations in moss (EMS), leaves and needles (ESB, ICP Forests) and soil (ICP Forests) were investigated for statistical relationships.

Biomonitoring data were stronger correlated to LE than to EMEP. For HM concentrations in moss, highest correlations were found for associations between geostatistical surface estimations of HM concentration in moss and deposition (LE). Canopy drip effects accounting for small scale variation were investigated by example of North Western Germany. The network of GeMS 2015 / 2016 comprises sites from the campaigns 1990, 1995, 2000, and 2005, added by core areas for investigating canopy drip effects, HM, N and POPs as well as by links to the ICP Forests network.

Nickel S, Schröder W 2016. Integrative evaluation of data derived from biomonitoring and models indicating atmospheric deposition of heavy metals. *Environ Sci Pollut Res, DOI: 10.1007/s11356-015-6006-1.*

Poster presentation

Health and vitality assessment of two common pine species in the context of climate change in Southern Europe

Pierre Sicard[1] and Laurence Dalstein-Richier[2]

[1] ACRI-HE, 260 route du Pin Montard, 06904 Sophia Antipolis cedex, France, pierre.sicard@acri-he.fr;
[2] Groupe International d'Etudes des Forêts Sud-européennes, 60 Avenue des Hespérides, 06300 Nice, France

The Mediterranean Basin is expected to be more strongly affected by ongoing climate change than most other regions of the earth. The South-eastern France can be considered as case study for assessing global change impacts on forests. Based on non-parametric statistical tests, the climatic parameters (temperature, relative humidity, rainfall, global radiation) and forest-response indicators (crown defoliation, discoloration and visible foliar ozone injury) of two pine species (*Pinus halepensis* and *Pinus cembra*) were analyzed. In the last 20 years, the trend analyses reveal a clear hotter and drier climate along the coastline and slightly rainier inland. In the current climate change context, a reduction in ground-level ozone (O_3) was found at remote sites and the visible foliar O_3 injury decreased while deterioration of the crown conditions was observed likely due to a drier and warmer climate. Clearly, if such climatic and ecological changes are now being detected when the climate, in South-eastern France, has warmed in the last 20 years (+ 0.46-1.08°C), it can be expected that many more impacts on tree species will occur in response to predicted temperature changes by 2100 (+ 1.95-4.59°C). Climate change is projected to reduce the benefits of O_3 precursor emissions controls leading to a higher O_3 uptake. However, the drier and warmer climate should induce a soil drought leading to a lower O_3 uptake. These two effects, acting together in an opposite way, could mitigate the harmful impacts of O_3 on forests. The development of coordinated emission abatement strategies is useful to reduce both climate change and O_3 pollution. Climate change will create additional challenges for forest management with substantial socio-economic and biological diversity impacts. However, the development of future sustainable and adaptive forest management strategies has the potential to reduce the vulnerability of forest species to climate change.

An epidemiological assessment of stomatal ozone flux-based critical levels for visible ozone injury in Southern European forests

Pierre Sicard[1], Alessandra De Marco[2], Laurence Dalstein-Richier[3], Francesco Tagliaferro[4], Elena Paoletti[5]

[1] ACRI-HE, 260 route du Pin Montard, 06904 Sophia Antipolis cedex, France, pierre.sicard@acri-he.fr;
[2] Italian National Agency for New Technologies, Energy and Sustainable Economic Development, 76 Lungotevere Thaon de Revel, Rome, Italy;
[3] Groupe International d'Etudes des Forêts Sud-européennes, 60 Avenue des Hespérides, 06300 Nice, France ;
[4] Istituto per le Piante da Legno e l'Ambiente, Corso Casale 476, 10132 Turin, Italy;
[5] Consiglio Nazionale delle Ricerche - Istituto per la Protezione Sostenibile delle Piante, Via Madonna del Piano 10, 50019 Sesto Fiorentino, Italy

Southern forests are at the highest ozone (O_3) risk in Europe where ground-level O_3 is a pressing sanitary problem for ecosystem health. Exposure-based standards for protecting vegetation are not representative of actual field conditions. A biologically-sound stomatal flux-based standard has been proposed, although critical levels for protection still need to be validated. This innovative epidemiological assessment of forest responses to O_3 was carried out in 54 plots in Southeastern France and Northwestern Italy in 2012 and 2013. Three O_3 indices, namely the accumulated exposure AOT40, and the accumulated stomatal flux with and without an hourly threshold of uptake (POD1 and POD0) were compared. Stomatal O_3 fluxes were modelled (DO3SE) and correlated to measured forest-response indicators, i.e. crown defoliation, crown discoloration and visible foliar O_3 injury. Soil water content, a key variable affecting the severity of visible foliar O_3 injury, was included in DO3SE. Based on flux-effect relationships, we developed species-specific flux-based critical levels (CLef) for forest protection against visible O_3 injury. For O_3 sensitive conifers, CLef of 19 mmol m^{-2} for *P. cembra* (high O_3 sensitivity) and 32 mmol m^{-2} for *P. halepensis* (moderate O_3 sensitivity) were calculated. For broadleaved species, we obtained a CLef of 25 mmol m^{-2} for *Fagus sylvatica* (moderate O_3 sensitivity) and of 19 mmol m^{-2} for *Fraxinus excelsior* (high O_3 sensitivity). We showed that an assessment based on PODY and on real plant symptoms is more appropriated than the concentration-based method. Indeed, POD0 was better correlated with visible foliar O_3 injury than AOT40, whereas AOT40 was better correlated with crown discoloration and defoliation (aspecific indicators). To avoid an underestimation of the real O_3 uptake, we recommend the use of POD0 calculated for hours with a non-null global radiation over the 24-h O_3 accumulation window.

Poster presentation

Spatio-temporal trends of surface ozone concentrations and metrics in France

Pierre Sicard[1] and Philippe Rossello[2]

[1] ACRI-HE, 260 route du Pin Montard, 06904 Sophia Antipolis cedex, France, pierre.sicard@acri-he.fr;
[2] GeographR, 1 rue de Taulignan, 84000 Avignon, France

Ozone pollution appears as a major air quality issue in Europe. A few issues about O_3, such as a better understanding of surface trends and a better assessment of O_3 impacts, are still challenging. The objectives of this work were to i) quantify the spatio-temporal trends in ground-levels O_3 concentrations, associated with potential impacts on human health and vegetation, and to ii) assess the impact of the changing precursor emission on the time trends. For the first time, a long-term spatio-temporal analysis of annual trends were performed in 61 rural, 92 suburban and 179 urban background stations in metropolitan France over the time-period 1999-2012. We focused on annual surface O_3 metrics (mean concentrations, hourly maxima, median and 98th percentile), O_3 human health metrics (SOMO35, i.e. the annual Sum Of daily maximum 8-h Means Over 35 ppb and EU60, i.e. the number of exceedances of daily maximum 8-h values greater than 60 ppb) and O_3 vegetation impact metrics (AOT40, i.e. sum of the hourly exceedances above 40 ppb for daylight hours during the assumed growing season for sensitive crops and forests) at individual sites.

Long-term analysis of hourly surface O_3 data from 332 background air pollution monitoring sites in France showed that annual mean concentrations decreased by 0.12 ppb.year^{-1} at rural sites. Suburban stations increased annual averages (+ 0.10 ppb.year^{-1}) and at urban sites, mean concentrations increased (+ 0.14 ppb.year^{-1}) over time. In all station types, a significant reduction in peak concentrations, largely attributed to the reduction in NO_x and VOC emissions within the European Union which started in the early 1990s, was found at more than 70% of stations. We demonstrated that the O_3 control measures are effective at rural sites, while O_3 concentrations are still increasing in the cities. The human health and vegetation impact metrics showed a downward trend at the national level for all stations, with the slowest decrease at urban stations. The generation of realistic spatio-temporal O_3 maps is a valuable tool for risk assessment resulting from O_3 exposure. The spatial interpolation approach, concatenating local regression and kriging of residuals, is an effective way and a valuable tool to provide spatio-temporal mapping of O_3 metrics. This method was successfully applied, from 332 monitoring stations, over whole domain at 250 m of spatial resolution.

Characterising long-term trends of soil solution acidification at Swiss ICP-Forests sites

Jörg Sintermann, Peter Waldner, Elisabeth Graf Pannatier

Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland

Atmospheric deposition of acidifying substances has led to soil acidification in the past. In Switzerland, reactive nitrogen deposition – showing minor reductions over past decades – dominates the deposition of acidifying substances. Graf Pannatier et al. (2011) evaluated soil solution trends between 1999 and 2007 at 7 mature forest sites in Switzerland. Trends for basic cations to aluminium molar ratio (Bc:Al = $\sum Ca_2^+ + Mg_2^+ + K^+$) were found at only two sites. Here, we present an updated trend-analysis until the end of 2014.

Monthly means of Bc:Al in biweekly soil solution samples from four depths (0, 0.15, 0.5, 0.8 m) were analysed. The first 12 months after site installation were excluded. Seasonal patterns and noise could obscure a trend component. Hence, data were pre-filtered, separating random-noise, seasonal and trend (T) using an innovations state space modelling framework (TBATS; De Livera et al., 2011). T as well as the original data (O) were tested for monotonic trends using the Seasonal Mann-Kendall Test (SMKT, month as season). In addition, to qualitatively characterise time courses, three models were fitted to T: a linear (lin), second-order polynomial (p2), and a combination of two linear functions allowing for one breakpoint in-between (b1) (Verbesselt et al. (2010), minimum period 6 years). The best model was selected by Akaike's Corrected Information Criterion.

Analysing O with SMKT, 21 significant trends (out of 28 time series) at all 7 sites were found for Bc:Al. Analysing T with SMKT increased trend significance levels and yielded one additional significant trend. 7 (O) to 8 (T) trends showed a positive sign whereas 14 (O and T) showed a negative sign. Among the AICc-selected model fits, a linear trend was the best approximation only in 4 cases, while p2 (10 cases) and b1 (14 cases) were a better approximation of the time course.

De Livera, A. M., Hyndman, R. J. and Snyder, R. D.: Forecasting Time Series With Complex Seasonal Patterns Using Exponential Smoothing, *Journal of the American Statistical Association*, 106(496), 1513–1527, doi:10.1198/jasa.2011.tm09771, 2011.

Graf Pannatier, E., Thimonier, A., Schmitt, M., Walthert, L. and Waldner, P.: A decade of monitoring at Swiss Long-Term Forest Ecosystem Research (LWF) sites: can we observe trends in atmospheric acid deposition and in soil solution acidity?, *Environmental Monitoring and Assessment*, 174(1-4), 3–30, doi:10.1007/s10661-010-1754-3, 2011.

Verbesselt, J., Hyndman, R., Newnham, G. and Culvenor, D.: Detecting trend and seasonal changes in satellite image time series, Remote Sensing of Environment, 114(1), 106–115, doi:10.1016/j.rse.2009.08.014, 2010.

Poster presentation

Using data from the European Large-scale forest condition monitoring (Level I) for the modeling of *Cerambyx* spp. suitable habitat under different climate change scenarios.

Belén Torres[1]; María José Manzano[2]; José Manuel Prieto[3]

[1] Ministerio de Agricultura, Alimentación y Medio Ambiente, Spain, BTorres@magrama.es;
[2] Estudios Medioambientales sl (ESMA), Spain, mjmanzano@esmasl.es;
[3] Estudios Medioambientales sl (ESMA), Spain, jmprieto@esmasl.es

Species Distribution Models (SDM) are a tool used in conservation in order to infer potentially suitable areas according to their environmental characteristics. In addition, they are used to obtain ecologic and evolutionary knowledge, with distribution forecasts through the landscapes, for that, they are extrapolated in space and time. Model realism and strength are influenced by the selection of relevant variables and modeling method, the scale considered the management system of the interaction between environmental and geographic factors and the extrapolation rate.

Data from the European Large-scale forest condition monitoring (Level I) have been used for the Spanish territory, by selecting the damaging agent *Cerambyx* spp. which affects to *Quercus* genus species.

As environmental predictors, interpolated climate data from Worldclim have been used, both for the present time and forclimate projections of the Global Climate Models (GCM), with four representative scenarios of concentration of greenhouse gases (RCP), as well as data taken from the digital elevation model derived from the SRTM mission.

General Linear Models (GLM) have been applied in order to elaborate the present suitable habitat model for subsequently , infering it to the different emission scenarios of climate change, analyzing the variation of the suitable habitats for this species.

Finally, when comparing the present and future models, a reduction of the optimum habitat area has been noticed according to the variables used for the elaboration of the model.

Key words: Species Distribution Models, GLM, Large-scale forest condition monitoring, Worldclim, GCM, RCP, STRM, *Cerambyx* spp.

Standard presentation

Litterfall, defoliation and inorganic nitrogen solute concentration before and after bark beetle outbreak in a Norway spruce forest

Liisa Ukonmaanaho, Tiina M. Nieminen, Antti-Jussi Lindroos, Seppo Nevalainen, Martti Lindgren, Kirsti Derome, Pasi Rautio, Päivi Merilä

Natural Resources Institute Finland, Viikinkaari 4, 00790 Helsinki, Finland, e-mail firstname.surname@luke.fi

Studies on ecosystem changes associated with forest dieback caused by insect attacks or decay fungi usually begin after an outbreak, and data on the dynamics of forest decay prior to and during infestations are lacking. Such dynamics may represent an important ecosystem factor, controlling nutrient inputs to forest floor and consequently the rate and duration of biochemical changes in soils. As a part of the long-term ecological monitoring (ICP Forests Level II Programme), forest health status, deposition, soil percolation water and litterfall have been monitored in Finland since 1996. The aim on this study was to report trends in defoliation %, litterfall flux and inorganic nitrogen (N) concentration in deposition and soil water before and after a bark beetle outbreak (*Ips typographus*) in a spruce forest at Juupajoki, central Finland. In addition we report results from Tammela site, which was not infected by bark beetle.

The collection and analysis of deposition, soil water and litterfall, as well as the assessment of tree defoliation were conducted according to the ICP Forests manual. Results cover period 1996–2014 (Fig 1). Results showed that although N deposition was at the same level at both sites, especially the soil water NO_3-N concentration started to increase already before the bark beetle outbreak at the infected site (Juupajoki), but not at the uninfected site (Tammela). In addition litterfall flux and defoliation % increased at the attacked site. The results indicate that changes in soil water inorganic N concentrations may predict incidence of tree vitality loss symptoms, such as insect infection.

The large-scale diversity, distribution and environmental drivers of Europe's forest ectomycorrhizas

Sietse van der Linde[1,2], Tine Grebenc[3], Karin Hansen[4], Henning Meesenburg[5], Päivi Merilä[6], Elena Vanguelova[7], Arne Verstraeten[8], Martin I. Bidartondo[1, 2]

[1] Department of Life Sciences, Imperial College London, UK, s.van-der-linde@imperial.ac.uk;
[2] Jodrell Laboratory, Royal Botanic Gardens Kew, UK;
[3] Slovenian Forestry Institute, Večna pot 2, SI-1000 Ljubljana, Slovenia;
[4] IVL Swedish Environmental Research Institute, Box 210 60, 100 31 Stockholm, Sweden;
[5] Northwest German Forest Research Station, Grätstr. 2, D-37079 Göttingen, Germany;
[6] Natural Resources Institute Finland (Luke), P.O. Box 413, 90014 Oulu, Finland;
[7] Forest Research, Alice Holt Lodge, Farnham, GU10 4LH, UK;
[8] INBO, Research Institute for Nature and Forest, Kliniekstraat 25, 1070 Brussels, Belgium

Monitoring mycorrhizal fungi is challenging mainly because of their predominantly below-ground nature. With optimised molecular ecology techniques, DNA sequences from ectomycorrhizal (ECM) roots can now be collected and analysed on a large scale. The long-term intensive European forest ICP Level II monitoring network provides a unique opportunity to study ECM diversity, community composition and distribution at a continental scale and determine the environmental drivers of ECM tree-fungi symbioses, using the networks' long-term environmental datasets. Root samples were collected from 103 Level II forest stand plots, with either predominantly European beech (n = 35), Scots pine (n = 32) or Norway spruce (n = 36). The sampling incorporated 18 countries, covering all European climatic regions. A total of 29,664 ECM roots were collected, examined and molecularly identified. The ECM fungal diversity associated with Europe's major tree species were assessed and the dominant fungi determined. The ECM fungal community data and the ICP Forests monitoring data are now being combined with different predictions of environmental change to understand the processes that control these below-ground symbioses and their likely fate in our changing forests. We will initially use Level II environmental plot data on six key variables to test the determinants of mycorrhizal diversity: nitrogen availability from soil and nitrogen deposition (nitrate and ammonium), mean annual temperature, pH in the soil organic layer, elevation and stand age. Here we will present the first results of this study and reveal the role and impact of environmental drivers on ECM fungi across Europe's forests

Standard presentation

Base cations and nitrogen budgets of forest ecosystems in the UK

Elena Vanguelova and Sue Benham

Forest Research, Alice Holt Lodge, Farnham, GU10 4LH, UK, elena.vanguelova@forestry.gsi.gov.uk

There is growing concern that available base cation pools in soil are declining and that some forests are approaching nitrogen (N) saturation due to the combined effects of acid deposition and harvesting. To assess these concerns in the UK, elemental mass balances for calcium (Ca), magnesium (Mg), potassium (K), and N were calculated from more than 10-years monitoring data from the UK's ICP Forest Intensive Monitoring (Level II) plots.

Out of the nine sites investigated negative Ca balances were observed in the three sites with the most acid geology and nutrient poor soils, also being heavily acidified in the past. Mass balance calculations generally indicated positive Mg, K and Na balance. Ca and K removal by tree biomass dominated the Ca and K outputs in most sites whilst leaching was the dominant output for Mg. Ca, Mg and K site budgets were significantly ($p<0.01$) positively related to soil exchangeable cations and soil base saturation status. At present, there is sufficient Ca in the soil exchangeable pool to sustain forest growth at most sites, however, continued losses of Ca due to leaching and harvesting at the present rate may ultimately threaten the health and productivity of the forest within just a few decades.

Long term N deposition across the sites varied between 3 and 17 kg N ha^{-1} y^{-1} with leaching losses 2 and 51 kg $ha^{-1}y^{-1}$. Nitrogen in tree biomass was between 7 and 39 kg N ha^{-1} y^{-1}. About 30% of the N was unaccounted for and likely to be produced by other inputs such as N fixation and mobilisation from litter and organic soil layers. Important losses such as N accumulation into soils and gaseous N releases have also being quantified at some sites. Currently three out of nine sites are showing signs of N saturation.

Nitrogen status of Flemish forests is improving

Arne Verstraeten[1,2], Johan Neirynck[1], Nathalie Cools[1], Peter Roskams[1], Steven Sleutel[2], Stefaan De Neve[2]

[1] INBO, Research Institute for Nature and Forest, Kliniekstraat 25, 1070 Brussels, Belgium;
[2] University of Ghent, Department of Soil Management, Coupure Links 653, 9000 Ghent, Belgium

Atmospheric depositions of sulphate (SO_4^{2-}) sharply decreased in European forests during the past two decades, enabling local recovery from acidification. Depositions of inorganic nitrogen (N) decreased at a slower pace and critical loads and limits for inorganic N are still exceeded on about a third to half of ICP Forests Level II plots. N saturation is thus still a major issue in European forests and it is currently unclear whether forests forest N status is improving. We collected samples of the deposition (precipitation, throughfall and stemflow) and soil solution (forest floor and three depths in the mineral soil) two times per month in five Level II plots in Flanders, Northern Belgium and measured the concentrations of dissolved organic carbon (DOC), dissolved organic nitrogen (DON), nitrate (NO_3^-) and total nitrogen (TN). We evaluated trends in the DON:TN ratio (2005−2014) and DOC:NO_3^- ratio (2002−2014). The DON:TN ratio showed a negative correlation with inorganic N deposition and generally increasing trends in deposition and soil solution, suggesting initial recovery from N saturation. The DOC:NO_3^- ratio showed increasing trends in soil solution and passed the critical inflection point for heterotrophic soil bacteria in four plots, suggesting an improvement in forest N status.

Increasing dissolved organic nitrogen (DON) concentrations and fluxes in temperate forests under recovery from acidification in Flanders, Belgium

Arne Verstraeten[1,2], Pieter Verschelde[1], Bruno De Vos[1], Johan Neirynck[1], Nathalie Cools[1], Peter Roskams[1], Maarten Hens[1], Gerald Louette[1], Steven Sleutel[2], Stefaan De Neve[2]

[1] INBO, Research Institute for Nature and Forest, Kliniekstraat 25, 1070 Brussels, Belgium;
[2] University of Ghent, Department of Soil Management, Coupure Links 653, 9000 Ghent, Belgium

Atmospheric deposition of sulphate (SO_4^{2-}) on temperate forests in large parts of Europe and the US decreased during the past two decades, enabling an initial chemical recovery of the forest soil solution. The complex interplay of biological and physico-chemical factors that influence dissolved organic carbon (DOC) and nitrogen (DON) cycling, make it difficult to predict the net effects of shifts in climate or deposition onto vertical dissolved organic matter (DOM) balances. Long-term data from intensive monitoring plots accounting for all these potential environmental drivers, are crucial to forward our understanding of changing DOC and DON fluxes in forests. We monitored the concentrations and fluxes of DOC and DON in the deposition and soil solution of five ICP Forests Level II plots in Flanders, Northern Belgium. The primary aim was to confirm positive postulated trends in DON levels and the DOC:DON ratio under on-going recovery from acidification. Samples of deposition and soil solution were collected two times per month between 2005 and 2013 and analyzed for DOC and DON. The Seasonal Mann-Kendall test was used to evaluate long-term trends of DON concentrations and fluxes and of the DOC:DON ratio in throughfall and 4 soil horizons. Concentrations and fluxes of DON showed a generally increasing trend in the forest soils. Given the decrease in inorganic N deposition over the monitoring period, the generally decreasing trend in DOC:DON ratio in throughfall and soil solution does not appear to result from an altered N-balance. Also, no major shifts in air temperature were observed. We therefore argue that recovery from acidification may be the most plausible explanation for observed shifts in DON and DOC:DON trends over this 9-year period. Whether or not the observed trends and patterns of DON also apply to a wider spatial scale will need to be further investigated, including its dependency on factors like latitude, level of N deposition, and hydrology.

Standard presentation

Using soil inventory data to calculate linked output of nitrogen, sulphur and base cations in German forests

Wendelin Weis[1], Paul Schmidt-Walter[2], Klaus von Wilpert[3]

[1] Bavarian State Institute of Forestry, Germany, Wendelin.Weis@lwf.bayern.de;
[2] Northwest German Forest Research Station, Paul.Schmidt-Walter@nw-fva.de;
[3] Forest Research Institute of Baden-Wuerttemberg, Klaus.Wilpert@forst.bwl.de

During the second half of the 20th century European forests were confronted with high inputs of nitrogen and sulphur from combustion processes and fertilization. Even though sulphur emissions decreased considerably, high amounts of sulphate and nitrate are still moved through the soil with seepage water. These strong anions are accompanied by cations and losses of base cation nutrients are unavoidable. Meanwhile, the harvesting exports of nutrients increase due to modern harvesting techniques and a rising demand of crown material used for energy production from biomass. To guarantee nutritional sustainability sites with high nutrient losses caused by surplus nitrogen and sulphur have to be identified and managed accordingly.

In Germany the output of nitrogen, sulphur and base cations was assessed for 886 sites linking forest soil inventory data to seepage water chemistry from long-term monitoring plots and seepage water studies. The statistical approach used generalized additive models and multiple linear regressions. Seepage water concentrations of chloride, nitrate and sulphate was calculated from water extracts of dry soil (mass ratio water to soil 2 : 1) and hydrogen carbonate from soil pH. The relative concentration of cations was estimated from their percentage in cation exchange capacity and scaled to anion sum. Ion concentrations were multiplied by site specific water fluxes derived from the water balance model Brook90.

Functions including soil physical properties and interactions between strong anions gave acceptable results for sulphate and nitrate, but less so for chloride. Quality increased if actual water content or field capacity was considered. For cation contents the interaction between cations was sufficient to explain most of the statistical variance. Results were best for calcium, acceptable for magnesium, but unsatisfying for potassium. On average, sulphate and nitrate were responsible for more than 50% of the cation losses at sites not dominated by carbonates, the impact of sulphate being twice as high as the effect of nitrate.

Assessing and mapping land cover related carbon stocks in the mountain treeline zone under global change during 1982-2012

Miglena Zhiyanski[1], Alexander Gikov[2], Stoyan Nedkov[3], Petar Dimitrov[2], Lora Naydenova[1]

[1] Forest Research Institute – Bulgarian Academy of Sciences, zhyanski@abv.bg;
[2] Space Research and Technology Institute – Bulgarian Academy of Sciences;
[3] National Institute of Geophysics, Geodesy and Geography – Bulgarian Academy of Sciences

Climate regulation, i.e. the ability of ecosystems to either sequestering or emitting greenhouse gases is a key service currently under discussion. Mountain treeline zones are assumed to be particular sensitive to environmental changes. In the context of ecosystem services, biophysical evaluation of the current state of forest ecosystems is the first step before valuating the benefits.

The aim of the present study was to analyse and map changes in land cover, species composition, and carbon stocks of forests in the key area of Beklemeto (Central Balkan Mountain, Bulgaria) for 1982-2012. Land cover data were analysed with orthorectified aerial photographs combining digital and satellite images of WorldView-2 sensor. The assessment of carbon stocks for the different ecosystems was performed with InVest modeling based on CORINE LC 4th level data and reference data to characterize ecosystems, forest stands, tree species, and forest soil types (ICP Forests Level I and permanent experimental plots).

For the indicated 30 years period, the area of broadleaved forests with continuous canopy increased from 22.5% to 43.0% mainly due to the transition of young and naturally regenerated forests to mature stands. For biodiversity, a negative tendency was observed with a decrease of open areas covered by natural grasslands, young trees and shrubs, and sparse vegetation on rocks. Among the 11 investigated land cover classes at the treeline, forest ecosystems have the highest potential to store carbon. Evaluations of the current state showed that the mean carbon stock was highest in broadleaved forests (241 tC/ha), followed by mixed (212 tC/ha), and coniferous forest ecosystems (197 tC/ha). Aboveground parts of forest vegetation and forest soils are the main accumulators of carbon. Forest floors stored 33 tC/ha in coniferous forests, compared to 23 tC/ha in mixed, and 18 tC/ha in mono-dominant beech forests. Our study revealed that changes in climatic factors (temperature and precipitation) and in land-use during 1982-2012 have significantly affected the carbon storage potential at the treeline of Beklemeto. The combined analyses of long-term forest monitoring with remote sensing, GIS, and advanced modeling proved to be a powerful tool for assessing forests' carbon stocks under global change.

Author index

Contact

Dr. Walter Seidling, Alexa Michel
Programme Coordinating Centre (PCC) of ICP Forests
Thünen Institute of Forest Ecosystems
Alfred-Möller-Str. 1, Haus 41/42
16225 Eberswalde, Germany
www.icp-forests.net

The conference is hosted by
Administration de la nature et des forêts
Service des forêts
81, avenue de la Gare,
9233 Diekirch, Luxembourg
elisabeth.freymann@anf.etat.lu

Meeting venue
Ministry of Sustainable Development and Infrastructure -
Department of the Environment
4, place de l'Europe
1499 Luxembourg
http://www.environnement.public.lu/functions/apropos_du_site/mev/index.html

Layout: Marieanna Holzhausen, Serina Trotzer
Cover layout: Walter Seidling, Tanja Sanders

Printed in Germany


Walter Seidling