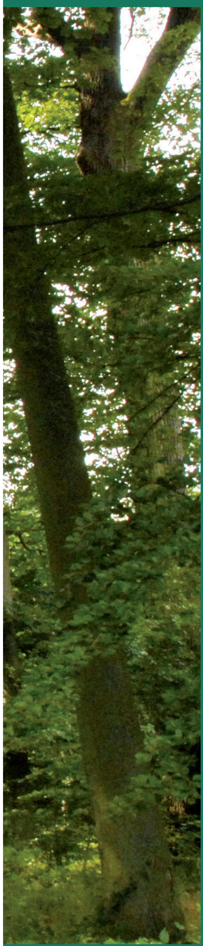
MONITORING EUROPEAN FORESTS:

DETECTING AND UNDER-STANDING CHANGES

Abstracts of the
ICP Forests Conference 2012
29/30 May 2012, Warsaw, Poland



FOREST RESEARCH INSTITUTE IBL

LRTAP Long-range Transboundary Air Pollution

TerraData environmetrics

vTI Johann Heinrich von Thünen-Institut

Institute for World Forestry

Launched in 1985, the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) operating under the UN-ECE Convention on Long-range Transboundary Air Pollution collects data on forest condition (health, growth, diversity, nutrition) and environmental factors (air chemistry, deposition chemistry, meteorology) across Europe. The 1st ICP Forests Conference is held in Warsaw, Poland on 29/30 May 2012. The conference is aimed at scientists of the ICP Forests community, their partners and monitoring stakeholders, and is open to all interested scientists and experts. Successful internal and external projects, evaluations and modelling exercises based on ICP Forests data are presented.

Scientific Committee. Marco Ferretti (TerraData environmetrics, Italy, chair),
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Matthias Dobbertin (WSL, Switzerland), Richard Fischer (vTI, Hamburg, Germany),
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Forest Research Institute
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Programme

29 May 2012

8.00 – 9.00		Registration
9.00 – 9.10		Official welcome speech, Ministry of Environment, Poland
9.10 – 9.30		Opening, ICP Forests Chair (*KOEHL*), Scientific Committee Chair (*FERRETTI*)
9.30 – 12.40		**Session I – Forest response to biotic and abiotic factors (chair:** *R. FISCHER*, **vTI, Germany)**
9.30 - 09.50		*Key note presentation: Jofre CARNICER et al.: Widespread crown condition decline, food web disruption, and amplified tree mortality with increased climate change-type drought (based on Carnicer et al., 2011. www.pnas.org/cgi/doi/10.1073/pnas.1010070108)*
09.50 - 10.05		*WALDNER* et al: Exceedance of critical limits and their impact on tree nutrition.
10.05 - 10.20		*NICOLAS* and *FERRETTI*: A plot scale modeling approach to detect size, extent and correlates of changes in tree defoliation in France
10.20 - 10.35		*SANDERS* et al.: Biotic and abiotic influences on forest vitality
10.35 - 11.00		Coffee break
11.00 - 11.15		*ETZOLD* et al.: Temporal and spatial patterns of tree growth on 18 level II sites in Switzerland during 1995 to 2010
11.15 - 11.30		*GIORDANI* et al.: Detecting the nitrogen critical loads on European forests by means of epiphytic lichens. A signal-to-noise evaluation
11.30 - 11.35	short	*BEUKER* et al.: Effects of temperature and moisture conditions on defoliation and litterfall of Norway spruce (*Picea abies* L. Karst.) forests in Finland
11.35 - 11.40	short	*CANULLO* et al.: Transnational field QA assessment: a tool to interpret spatial and temporal trends in plant diversity
11.40 - 11.45	short	*LIBIETE* et al.: Spatial and temporal defoliation trends of pine, spruce and birch in Latvia
11.45 - 11.50	short	*BRAUN* et al.: Fructification of *Fagus sylvatica*: developments during the last 25 years and their relations to nutrition status, ozone and climate
11.50 - 12.00	short	*NICOLAS* and *LEBOURGEOIS*: Monitoring tree phenology to predict climate change impacts
12.00 - 12.30		**Discussion Session I**

12.30 – 13.30		Lunch
13.30 – 15.30		**Session II – Carbon and climate change (Chair: K. HANSEN, IVL, Sweden)**
13.30 - 13.50		*Key note presentation: G. MATTEUCCI: Do we need to integrate monitoring and research to detect and understand changes in forest ecosystems? Examples and results from ICP-Forests sites in Italy*
13.50 - 14.05		*JANNOT* et al.: The carbon budget of selected ICP Forests Level II plots under changing climate – simulation study using Biome-BGC
14.05 - 14.20		*FLECK* et al.: Evaluation of Soil Water Retention Curves (SWRCs) for water budget modelling on Level II plots
14.20 - 14.35		*OLSCHOFSKY* and *MUES*: Linkage between climate changes models and ICP Forests long term forest monitoring sites
14.35 - 14.50		SCHAUB et al.: DO3SE and AOT40 - ozone flux on contrasting sites in Spain and Switzerland for *Quercus ilex* and *Fagus sylvatica*
14.50 - 15.00	short	REYER et al.: Model-based analysis of forest productivity shifts in Europe under global change
15.00 - 15.05	short	DE VOS et al.: Forest floor and mineral soil organic carbon stocks in European forests:results from the 2004-2008 BioSoil survey
15.05 - 15.10	short	GRÜNEBERG et al.: Regional estimation of soil carbon stocks and changes in Germany`s forest soils based on the National Forest Soil Inventory to provide the greenhouse gas reporting
15.10 - 15.30		**Discussion Session II**
15.30 – 16.00		Coffee break
16.00 – 17.45		**Session III – Nutrient and Deposition (Chair: P. RAUTIO, METLA, Finland)**
16.00 – 16.20		*Key note presentation: N. COOLS et al. Which factors explain C:N ratios in European forest soils?*
16.20-16.35		WALDNER et al.: Trends of nitrogen and sulphur deposition on European ICP Forests Level II plots
16.35 - 16.50		TALKNER et al.: Foliar phosphorus nutrition of beech (*Fagus sylvatica* L.) in Europe
16.50 – 17.05		MERILA et al.: Above and belowground N stocks in coniferous boreal forests in Finland
17.05 - 17.10	short	AHRENDS et al.: Modeling the impact of canopy structure on the spatial variability of deposition
17.10 – 17.15	short	RAITIO et al.: Seasonal variation in the foliar chemical composition of Scots pine and Norway spruce in northern boreal forests.
17.15 – 17.35		**Discussion session III**
17.35 – 17.55		**Workshop summary (Chair: M. FERRETTI, TerraData, Italy)**
17.55 – 18.00		Technical announcements, a.o.b
18.00		End of workshop, ICP Forests Chairman

30 May 2012: Excursion Białowieża National Park

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Modeling the impact of canopy structure on the spatial variability of deposition

Bernd Ahrends[1], Henning Meesenburg[1] & Karin Hansen[2]

An important nutrient input to forest ecosystems occurs through deposition. Thus, the prediction and regionalization of deposition is of fundamental importance for forest management and environmental policy. The most influencing stand parameters affecting dry deposition to forests need to be quantified in order to assess the impact of forest management on total deposition and to regionalize deposition using forest inventory data. Generally, dry deposition to the canopy is related to atmospheric turbulence. Important factors affecting atmospheric turbulence are canopy closure, stand and single tree height, leaf area index (LAI), frontal area index (FAI), crown density and volume. For practical applications models relating deposition to the above canopy structure parameters should mainly require easy-available forest inventory data and meteorological parameters like precipitation or annual sum of wet deposition. The study has the following objectives: (1) identification of predictor variables with mix-effect models, (2) combination of deposition scenarios with scenarios of stand development, (3) identification of tree species effect on deposition, (4) impact of stand/canopy structure on deposition, (5) suitability of stand information for regionalization of deposition. The impact of canopy structure on the spatial variability can best be tested for sites where continuous measurements of throughfall deposition are available, and where the main forest characteristics (height, diameter at breast height, density, LAI) are well known. We used annual deposition measurements conducted under different site and stand conditions from ICP Forests Level II Intensive Monitoring plots in order to test the transferability of the developed functions. Mixed effect models are used for model development taking the "pseudo-replicated" deposition and stand data at every single monitoring site into account. Finally, the applicability of the developed modeling approach will be demonstrated for the Harz Mountains in central Germany.

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Effects of temperature and moisture conditions on defoliation and litterfall of Norway spruce (Picea abies L. Karst.) forests in Finland

Egbert Beuker[1], Alix Bell[2], Martti Lindgren[3], Seppo Nevalainen[5], Antti-Jussi Lindroos[3], Mike Starr[4], Liisa Ukonmaanaho[3]

Climate change will not only alter temperatures, but also the availability water for forest growth and vitality. Defoliation and the litterfall flux are indicators of forest vitality. Changes in defoliation are the result of differences in needle production and needle litterfall. In addition to temperature and water availability, needle production and litterfall are affected by stand age, soil nutrient status occurrence of damaging agents, and forest management practices.

The aim of this paper is to study how soil temperature, soil moisture and meteorological factors affect defoliation and litterfall in Norway spruce forests in Finland. Soil moisture, soil temperature, precipitation, air temperature, defoliation and needle litterfall were assessed from 1996 to 2008 on 3 plots of the ICP Forests intensive monitoring network (Level II), located in Southern Finland. These stands are of similar age (about 70 years) and stem volume (300 m^3 ha^{-1} to 390 m^3 ha^{-1}), and have been subject to similar management practice. During the study period, defoliation varied from 8.9 to 18.2 %, annual needle litterfall from 151 to 350 g m^{-2}, mean annual soil temperature (at 20 cm) from 3.9 to 5.7 ºC, and precipitation from 395 to 889 mm. Based on meteorological parameters and soil characteristics the water balance of each plot was calculated using the water balance model, WATBAL. Annual fluctuations in defoliation and litterfall will be related to the environmental parameters and the results presented.

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Fructification of Fagus sylvatica: developments during the last 25 years and their relations to nutrition status, ozone and climate

Sabine Braun[1], Walter Flückiger[1]

The data presented here come from a forest observation network which was initiated in 1984 by cantonal forest authorities in Switzerland (www.waldbeobachtung.ch). It includes currently 188 observation plots of *Fagus sylvatica*, *Picea abies* and *Quercus* sp.. In 72 beech plots a continuous and quantitative time series of fructification partly extends back to 1987. From the same plots, data on nutrition and stem growth (both every 4 years) and soil chemistry are available.

The time series shows a strong increase of fructification during the last 10 years, with the year 2011 being the year with the highest fructification ever observed, two years after the second highest fructification. In a year with full masting beech nuts may contribute more than half of the nutrient cycling and thus may affect nutrient availability. On the other hand, the nutrition status may also influence fructification. The two effects are difficult to separate. However, they can be analysed by stratification of the plots according to their nutrient status or of the years according to the level of fructification. In a year following a full mast, the foliar concentrations of nitrogen were significantly decreased whereas phosphorus showed no response. Trees with deficient foliar concentrations of P in the three consecutive harvests 2003, 2007 and 2011 had lower fructification than trees with sufficient P concentrations in all three years, thus suggesting that P nutrition plays an important role in fructification. High N concentrations in leaves, too (>23 mg g^{-1}) were associated with lower fructification.

Modelled ozone flux (Phytotoxic Ozone Dose at threshold Y, PODY) was negatively correlated with fructification. At a POD1 of 20 mmol m^{-2}, the average number of fruits per short shoots was 0.09 whereas at 8 mmol m^{-2} it was 0.25.

Several publications have emphasized that the masting intervals in beech have shortened drastically during the second half of the last century (1, 2). The current time series confirms the shorter intervals but also describes an increased masting intensity. The minimum masting interval was two years. A period with high average temperatures in early summer before the year of fructification and with low average temperatures two years before was correlated with masting. This confirms observations from southern Sweden by Drobyshev et al. (3) but the time window needed for this trigger was much sharper in the current study (mid June to beginning of July).

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3. Drobyshev, I., Övergaard, R., Saygin, I., Niklasson, M., Hickler, T., Karlsson, M. and Sykes, M. T. (2010). Forest Ecology and Management 259, 2160-2171.

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Transnational field QA assessment: a tool to interpret spatial and temporal trends in plant diversity

***Roberto Canullo*[1]*, Maria Cristina Allegrini*[1]*, Elia Angelini*[1]*, Giandiego Campetella*[1]**

Maintenance of comparability and variability ranges in long-term studies is a major target. Monitoring forest ground vegetation has problematic facets which may lead to misinterpretation of plant diversity trends. When covering European scale programmes, methodological differences by Countries can introduce large bias, leading to consider this factor as a covariate.

In the frame of the Life+ project *FutMon*, a first transnational inter-comparison course on plant diversity assessments was held, to test the differences between countries/surveyors.
Objectives.

Assess the accuracy and precision rates of vascular species density; inspect the sources of variation due to both different design\methods and observers; define Data Quality Indicators.
Methods.

Experimental field design in a Beech stand on Cansiglio plateau (Italy), was based on a common sampled area of 200 m^2. (A) Three 50*50m plots devoted to surveys applying Country's own sampling and assessment methods (including observer's and methodological effects). (B) One 50*50m plot used for surveys applying a common sampling design and method (highlighting observer's effects). (A)-(B) estimated the effect due to different methods. A "consensus species list" was used as standard reference. Accuracy was considered as the expression of the overall error, composed by precision (variance of species density) and bias (respect to the reference).
Main results.

Both precision and accuracy for the species density estimates were much lower on (B). Sources of variation were depicted as the mean performance of an ICP-Forests GV observer: the expected error, in terms of CV%, had a 49%magnitude, ⅔ due to the observer's errors, and ⅓ due to methodological aspects.

Tentative definition of Data Quality Indicators was discussed, although the indications from a unique international exercise are still unstable. The foreseen objective of 90% of observers achieving a MQO threshold of 30% respect to the reference, seems reasonable when a standardized sampling area is adopted.

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Widespread crown condition decline, food web disruption and amplified tree mortality with increased climate-change-type drought

Jofre Carnicer[1,2], Marta Coll[1], Miquel Ninyerola[3], Xavier Pons[4], Gerardo Sánchez[5] & Josep Peñuelas[1]

Climate change is progressively increasing severe drought events in the Northern Hemisphere, causing regional tree die-off events and contributing to the global reduction of carbon sink efficiency of forests. There is a critical lack of integrated community-wide assessments of drought-induced responses in forests at the macroecological scale, including defoliation, mortality and food web responses. We will report a generalized increase in crown defoliation in southern European forests during 1987-2007. Forest tree species have consistently and significantly altered their crown leaf structures, showing increased percentages of defoliation in the drier parts of their distributions in response to increased water deficit. The demographic responses of trees associated with increased defoliation in Southern European forests will be specifically assessed in the Iberian Peninsula region. We observe that defoliation trends are paralleled by significant increases in tree mortality rates in drier areas, which are related to tree density and temperature effects. Furthermore, we show that severe drought impacts are associated with sudden changes in insect and fungal defoliation dynamics, creating long-term disruptive effects of drought on food webs. Our results reveal a complex geographical mosaic of species-specific responses to climate-change driven drought pressures on the Iberian Peninsula, with an overwhelmingly predominant trend towards increased drought damage. We will also report recent studies on genetic, recruitment and growth data in Iberian peninsula.

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Which factors explain C:N ratios in European forest soils?

Nathalie Cools[1], Bruno De Vos[1], Lars Vesterdal[2], Elena Vanguelova[3]

The C:N ratio of forests soils in an important index of decomposition and nutrient availability in forest ecosystems. It is also considered as an indicator of nitrogen leaching as a response to high atmospheric N deposition loads. Though the C:N ratio is potentially affected by a range of other site-related factors.

This study aimed to unravel factors determining the C:N ratio of forest floor, mineral soil and peat in more than 4000 plots of the ICP Forests large-scale monitoring network surveyed during the EU Forest Focus BioSoil demonstration project (2006-2009). The first objective was to characterise soil C:N ratios across European forests and the second objective was to determine the main factors influencing C:N ratio in forest soils. Furthermore, the extent to which the C:N ratios in the forest soil are influenced by atmospheric deposition was determined.

By applying a boosted regression tree analysis including more than 20 site and environmental variables, tree species keyed out as the most important explaining variable at the plot level for the C:N ratio in forest floors as well as mineral and peat soils. C:N ratios in the forest floor below 20 were found in black locust and black alder stands, both nitrogen fixing tree species. The highest C:N ratios in forest floors were found in pine (>30), eucalypt and cork oak stands (≈ 35). Soil type was the second most important explaining variable where soil types influenced by high groundwater table (Fluvisols, Gleysols, Stagnosols) showed low C:N ratios (< 25) whereas well-drained soil types (Arenosols, Podzols) and soil typical of drier climatic regions (Kastanozems, Calcisols) had high C:N ratios (≥ 30) in the forest floor. Further this investigation suggested that forest floor and soil C:N ratio were not directly related to climatic variables at the European level.

The study showed that the influence of deposition on the C:N ratios is tree species dependent. A preliminary analysis indicated that the soil C:N ratio under coniferous tree species was more sensitive to atmospheric deposition of N and S than under broadleaved tree species. An in-depth study based on measured stand deposition, soil, C:N and NO_3 leaching data from the European Level II intensive monitoring plots could provide further insights into these relationships and validate the use of C:N ratio as indicator for N saturation in forests.

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Forest floor and mineral soil organic carbon stocks in European forests:results from the 2004-2008 BioSoil survey

Bruno De Vos[1], Nathalie Cools[1], Hannu Ilvesniemi[2], Lars Vesterdal[3], Elena Vanguelova[4], Stefano Carnicelli[5]

Accurate assessment of forest soil organic carbon (SOC) stocks and their change is crucial in understanding climate change mechanisms, SOC accounting as well as land-use change and forest management impacts on soil carbon. At the European scale, very few studies based on measured carbon pools exist.

We estimated forest SOC stocks in forest floor, mineral and organic (i.e. peat) soils at plot level, and upscaled stocks to the European level based on the soil data of ~5000 plots gathered during the 2004-2008 BioSoil survey.

Like in most other SOC inventories, we also missed essential data such as (i) fine earth bulk density, (ii) coarse fragment content, (iii) effective soil depth, and/or (iv) C concentrations, predominantly for deeper soil layers. Therefore, we calculated SOC stocks in two ways: (1) using the available, originally measured and reported data only and (2) using a data set completed by application of pedo-transfer functions and other inter-relationships. This approach resulted in (1) conservative and (2) progressive stock estimations.

By using profile depth distribution functions, we extrapolated carbon density to estimate 1-m carbon stocks (IPCC). These stocks were stratified according to WRB Reference soil groups and humus types providing European benchmark values. Average values for SOC stocks are 21-23 t C ha^{-1} in forest floors, 108 t C ha^{-1} in mineral soils and 633 t C ha^{-1} in peat soils. Relative to 1-m stocks, vertical distribution patterns confirmed global observations for forest soils: about 50% of SOC is stored in the upper 20 cm, and 60% in the upper 30 cm of soil. Assuming 148 Mha of European forest, we estimated total stocks at 3.5-3.7 Gt C in forest floors and 20-25 Gt C in mineral and peat soils down to 1 meter soil depth.

The future holds promise to further explore this EU $BioSoil^{+}$ carbon dataset, predominantly for validation of (forest) soil carbon models.

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Temporal and spatial patterns of tree growth on 18 level II sites in Switzerland during 1995 to 2010

Sophia Etzold[1], Peter Waldner[1], Anne Thimonier[1], Maria Schmitt[1], Christian Hug[1], Matthias Dobbertin[1]

Forest growth is affected by various concurrent and counteracting climate change related factors and the overall impact of the environmental changes on forest growth is still uncertain. We analysed 15 years (1995 – 2010) of tree growth data of 18 level II plots in Switzerland, spanning a wide range of altitude, temperature and precipitation conditions. This long data set offers the possibility to study the recent trend of forest growth in Switzerland, as well as the reactions and ability of regeneration of different forest types to severe weather anomalies. Stem diameter of all trees within the level II plots was measured during the non-growing season usually every 5 years. All other above- and belowground parts of the trees were modelled by allometric relationships and validated with measurements when available. Net primary production (NPP) of the forest was calculated as the sum of carbon gain by tree growth.

Generally, no trend of productivity increase could be observed for the three growth periods. Forest management and other events (insect pests, storms, root rot) overshadowed the climate impact on NPP. When looking at the individual trees, a clear decrease of the basal area increment (bai) was observed for most of the sites. Bai was reduced in the second inventory period (2000-2005) compared to the first one for 2 to 30% (mean 18.8%) and in the third period for 6 to 43% (mean 19.3%). Possible causes are increasing stand density over time and a general effect of increasing size and age of the trees. Thus, increased tree growth at a few sites could be related to growth enhancement after stand density reducing events, such as storms or thinning. The spatial variability of NPP was best explained by temperature, water conditions and N availability, and could be approximated well by the site altitude (r^2=0.80, $p < 0.001$).

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Evaluation of Soil Water Retention Curves (SWRCs) for water budget modelling on Level II plots

Stefan Fleck[1], Henning Meesenburg[1], Bernd Ahrends[1], Markus Wagner[1], Stephan Raspe[2], Bruno de Vos[3]

Soil water retention curves are essential input data for the simulation of the water budget and to determine the plant water availability in forest soils. They express the layer-specific relationship between the water adhesive forces of the soil matrix (matrix potential, ψ_M) and the actual soil water content Q. Modelling results are very sensitive to this soil property and it needs to be carefully implemented therefore. However, the direct measurement of SWRCs is very time-consuming and is therefore rarely performed for forest management applications.

About 30 different equations exist for the approximation of the measured relationship with a retention function in water budget models, out of which the Mualem / van Genuchten function is probably the most often used formulation. While it is appealing due to the low number of only two parameters to estimate, it is also less flexible than other formulations and the question arises, therefore, if the representation of the measurements is always good enough. This question arises especially for forest soils, since they are systematically less compacted than agricultural soils and no comprehensive investigation of forest SWRCs over larger regions does yet exist. The SWRC measurements on all Futmon core plots of the ICP Forests Level II Intensive Monitoring program provided the unique opportunity to identify the appropriate type of retention function for different types of forest soils on a European scale.

On other Level II plots, where no direct SWRC measurements have been performed, retention functions must be parameterized based on pedotransfer functions involving bulk density, organic carbon content, and soil texture for the parameter derivation. Six different pedotransfer functions are used on the total dataset in order to identify the pedotransfer function that is most appropriate on the scale of European forest soils.

The small scale spatial variability of the measured SWRCs and soil conditions is an additional factor influencing the accuracy of water budget models and its influence is as well quantified based on the spatially replicated measurements for each core plot.

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Detecting the nitrogen Critical Loads on European Forests by means of epiphytic lichens. A signal-to-noise evaluation

Paolo Giordani[1], Vicent Calatayud[2], Silvia Stofer[3], Walter Seidling[4], Oliver Granke[5], Richard Fischer[4]

Lichens are considered to be among the most sensitive organisms at ecosystem level for several types of pollutants. In this work, we analyzed a dataset of 292 epiphytic lichen species observed on 1155 trees at 83 Level II plots. The data were collected between 2004 and 2006 in ten countries according to the ForestBIOTA sampling protocol.

We aimed at establishing for which amount of nitrogen deposition a significant variation of the relative diversity of nitrophytic vs. oligotrophic epiphytic lichens in the sampled plots is expected. Moreover we were interested in knowing how much variance of these diversity variables can be explained by nitrogen depositions only. We therefore used hierarchical partitioning to evaluate the relative importance of environmental predictors in explaining variation in lichen diversity descriptors. The analysis splits the variation explained by each variable into a joint effect together with the other explanatory variables, and into an independent effect not shared with any other variable.

The effects of nitrogen compounds significantly interacted with the amount of throughfall precipitation as well as with the forest type. It was shown that approx. 80% of the ForestBIOTA Level II plots are affected by an unsustainable throughfall nitrogen deposition. The occurrence of oligotrophyc lichen species provided information on the actual impact of reduced nitrogen compounds (mainly ammonia). In particular, a percentage of 40% oligotrophs seemed to be related to throughfall nitrogen deposition of approx. 3.8 kg ha^{-1} yr^{-1}.

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Regional estimation of soil carbon stocks and changes in Germany`s forest soils based on the National Forest Soil Inventory to provide the greenhouse gas reporting

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The National Forest Soil Inventory provides Germany's greenhouse gas reporting with estimated C stocks of organic layer and mineral soil (30 cm) on basis of about 1.800 soil sampled from 1987-1992 and resampled from 2006-2008 in a nationwide grid of 8 x 8 km. Carbon stocks of the organic layer were classified into forest stands and regionalized with CORINE land cover data. The estimated C stocks were attributed to soil groups according to the Soil Map of Germany 1:1,000,000 and subsequently related to Germany`s forest area. We identified the organic layer as CO_2 source due to significant declining C stocks from 19.4 ± 0.4 to 18.4 ± 0.4 t C ha^{1}. The C loss comprises about 1022661.5 t and indicates an annual change of 0.10 ± 0.02 t ha^{1}. The mineral soils sequestered approx. 2761186.2 t C. The C stocks increased significantly from 52.8 ± 1.3 to 57.2 ± 1.4 t ha-$^{-1}$, revealing an annual C accumulation of 0.27 ± 0.07 t ha^{-1}. While we observed increasing organic layer C stocks at sandy lowland or mid-range mountain sites, the values for calcareous soils declined. High C stocks were detected at calcareous and clayey, or at high-range mountains soils but sandy soils revealed low values. Information about causes that modify soil C dynamics at regional scale is scarce. Here we assume a high C sequestration due to (i) higher biomass production caused by N deposition and climate change, (ii) acidifying effect of airborne N depositions, (iii) changed forest management, or (iv) changed environmental and climatic conditions. There are still uncertainties in the estimation due to sampling errors or incomplete datasets. Nevertheless, the site-specific approach is reliable to merge European wide grid-plot based soil information to estimate C sequestration rates throughout a time period of forest soils.

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The carbon budget of selected ICP Forests Level II plots under changing climate – simulation study using Biome-BGC

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The carbon budget of 28 selected ICP Forests level II plots was simulated using Biome-BGC (version ZALF). For model initialization and calibration data of the ICP Forests level II database on meteorology, soil temperature, stand precipitation, soil moisture, soil properties, forest growth, litterfall, leaf area index, phenology, and some other data were used. The effects of climate change on the carbon budget were simulated using climate scenarios (A1B and B1) of the FutMon_CLM dataset for the time periods 2040-2059 and 2080-2099 compared to 1990-2009 as reference scenario.

The gross primary production was calculated to an average of 14.3 t C ha^{-1} a^{-1} during the calibration period 1996 – 2009. 39% of GPP leaves the ecosystem as maintenance respiration, 14% as growth respiration, and 28% as heterotrophic respiration. The net primary production amounts 6.7, the net ecosystem production 2.7 and the net biome production 1.8 t C ha^{-1} a^{-1}. The carbon pool change rates average to +1.5 t C ha^{-1} a^{-1} for vegetation, +0.4 t C ha^{-1} a^{-1} for the litter + coarse woody debris pools, and to -0.1 t C ha^{-1} a^{-1} for the soil.

Under changed climate (A1B scenario, 2080-2099 compared to 1990-2009) the carbon fluxes were simulated to be accelerated on average by +35% for GPP, +55% for maintenance respiration, +22% for growth respiration, +20% for heterotrophic respiration, +26% for NEP, and +35% for NBP. Compared to the reference scenario, the increase of carbon stocks accelerates by 47% for vegetation and by +17% for leaf+fine root litter pools. In contrast, the increase is diminished for coarse woody debris, and the decrease is accelerated for soil organic carbon.

The simulation results on the aboveground carbon budget can be assessed as reliable, whereas the results on the belowground carbon budget are relatively uncertain. The reasons are discussed.

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Spatial and temporal defoliation trends of pine, spruce and birch in Latvia

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Crown condition of trees is one of the most easily assessable parameters to serve as an early warning signal for forest health decline. In Latvia, large scale forest condition monitoring (Level I monitoring) according to ICP Forests methodology has been carried out since 1990 in approximately 350-400 permanent sample plots all over the country, distributed along a 8X8 km grid (95 of those sample plots being so-called European level plots distributed along a 16X16 km grid). In 2009, crown condition assessment was introduced in 115 sample plots of National Forest Inventory (NFI) within Life+ co-financed project *Further Development and Implementation of an EU-level Forest Monitoring System* (FutMon). According to the amendments in Latvian forestry legislation, large scale forest condition monitoring will be part of a National Forest Monitoring programme starting in 2012. Future assessments will be carried out in the new FutMon plots as well as the old 16X16 km grid plots.

Scots pine (Pinus sylvestris L.), Norway spruce (Picea abies (L.) Karst.) and birch (Betula pendula Roth., Betula pubescens Ehrh.) are the main tree species in Latvian forests, constituting 29%, 17% and 28% of the total forest area, respectively. Pine, spruce and birch forests provide a variety of wood and non-wood forest products and environmental services; consequently, their health is of great importance. In this paper we analyze general temporal defoliation trends of these aforementioned tree species from 1991onwards, as well as the spatial pattern of crown condition on a regional scale. Data from the old Level I plots and the new FutMon plots established in 2009 are used for the analysis.

Key words: defoliation trends, crown condition, Scots pine, Norway spruce, birch

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Do we need to integrate monitoring and research to detect and understand changes in forest ecosystems? Examples and results from ICP-Forest sites in Italy

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Forest ecosystems play a major role in the global carbon cycle and are important in the cycle of other greenhouse gases (O_3, N_2O, CH_4) and for filtering anthropogenic pollutants. At the same time, forests are exposed to natural (climate, meteorology, site features) and anthropogenic factors (pollution, nitrogen deposition, management, climate change) that affect their functioning and that can modify their geographic distribution and biodiversity.
Since the 90s' of the last century, research and monitoring of forest ecosystems gained new momentum due to the establishment of experimental sites to investigate their functionality, the drivers of primary productivity and responses to climate and to local and transported pollution. Furthermore, in the recent past (2005-2011), in order to promote a more efficient and resource-effective use of the existing forest monitoring networks (level I and II), European (ForestFocus, LIFE+ FutMon) and national initiatives have fostered i) further implementation of the performed surveys, ii) combined data analysis and iii) modelling exercises.
The strategic view is that investigation and understanding of the response of forests to the global and complex challenges (natural and anthropogenic) to which they are currently exposed need to be addressed by integrated approaches, putting together research, monitoring, modern data policies and modelling.

The presentation will address "integrated" results obtained in Italy at single level II sites where coupled research and monitoring approaches are applied, results from integrated and combined evaluation of data over the Italian level II network (Conecofor programme) and results coming from large scale level I surveys within the BioSoil ForestFocus project.
In the future, sites were both research and monitoring are carried out should become Multilevel Research and Monitoring Platforms to study in detail processes and responses to natural and anthropogenic disturbances. The benefit of the integration of research and monitoring and of the long-term perspective will be discussed.

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Above and belowground N stocks in coniferous boreal forests in Finland

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Nitrogen (N) is typically the growth limiting factor in boreal forest ecosystems. Therefore, knowledge on forest N stocks and fluxes is crucial in order to predict and evaluate the effects of different anthropogenic factors (e.g. climate change, deposition, forest management practices) on the condition, development and sustainability of boreal forests. In this study, we evaluated the amount and distribution of N and biomass in different compartments of forest ecosystem, including not only tree stand and soil, but also such rarely reported N stocks as litter layer, ground vegetation and fine root biomass. The study included 7 Scots pine and 8 Norway spruce dominated stands belonging to the UN-ECE ICP Forests Level II programme in Finland. The mean effective temperature sum of the sites ranged from 658 on northernmost to 1351 on the southeastern site. The stand age ranged 55–200 yrs.

Among the study sites the total biomass ranged from 194000 kg ha^{-1} to 518000 kg ha^{-1}, the respective range for N stock being 2170–7440 kg ha^{-1}. Mineral soil contained the major pool of N (ca. 70%). The major living biomass N stock was in stems in pine stands and in needles in spruce stands. N stored in tree biomass accounted for 9–15% of the total ecosystem N stock. The proportion of N stored in potential logging residues or biofuel (needles, living and dead branches, stumps and coarse roots) was 67±4% and 53±1% of the tree N stock in northern spruce stands and in southern pine stands, respectively. The understorey vegetation N stock was the largest in northern spruce stands, and lowest in southern spruce stands.

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Monitoring tree phenology to predict climate change impacts

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Climate change has raised new concerns about the capacity of resistance and adaptation of forest ecosystems and renewed the need for ecological monitoring. In particular, changes in the growing season length may affect the sensitivity to biotic and abiotic stresses, the biomass production and the ability for carbon sequestration. In France the level II network (RENECOFOR) has become the main source of phenological data for forest trees with observations up to 1997 on 100 plots. Leaf unfolding and yellowing dates – for deciduous trees – have been yearly assessed at the plot scale, on the basis of 36 trees of the dominant tree species per plot. These data were recently used for (i) modelling phenological occurrences with geographical and meteorological predictors, (ii) mapping spatial variations at the national scale by tree species or grouped tree species, (iii) forecasting phenological shifts according to climate change scenarios. Moreover assessments detailed by individual tree have been collected since 2009 and will allow further research about phenological variations within each stand and for correlations with tree growth and health parameters.

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A plot scale modeling approach to detect size, extent and correlates of changes in tree defoliation in France[a]

Manuel Nicolas[1] and Marco Ferretti[2]

Traditional approaches to evaluation of Level II forest monitoring consider data from different aggregation of plots, averaged over a defined time window, and used in statistical models to identify significant predictors of selected response variables. A different, plot-based approach was developed for the RENECOFOR programme in France. Defoliation data collected on 102 managed forest plots were investigated to identify annual changes and medium term (15 years) trend, and detect correlates to such changes/trends. Methodological aspects (assessed trees, methods and reporting units, observers, date of assessment) were considered. To account for inherent plot specificity, an individual plot approach was adopted before analysing all individual results at the scale of the whole network. Wilcoxon rank-sum test (variations between adjacent years), simple linear regression and Spearman R (time trends), and meta-analysis (to synthesize individual plot results) were used. Partial Least Square regression (PLS) was used for modelling defoliation at plot level, and Generalized Linear Models and Linear Mixed Models were used to investigate the results obtained after the PLS. Results showed high frequency of statistically significant and methodologically meaningful defoliation changes across the monitored period. Although both positive and negative defoliation trends were found among plots, the meta-analysis revealed a generalized tendency towards an increasing defoliation. Precipitation-related variables of current, 1- and 2 years before the assessment and tree density resulted the most frequent correlates of defoliation. Frequency of trees with reported damage symptoms was the other most frequent one. Despite this general pattern, interactions between predictors and the direction of their effect vary on a plot basis. The plot-based approach avoid the bias that affects traditional cross-sectional, correlative studies, and allowed to incorporate forest management. The ability to estimate correlates of change at the scale of individual plots makes the approach powerful for generating and testing ideas and hypothesis.

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Linkage between climate changes models and ICP long term forest monitoring sites

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Various studies demonstrated ongoing long term climatic changes and their impact on forest ecosystems. Climate changes will be one major driving force for changes in the vitality and productivity of forests. Thus forest management activity needs to consider potential climate changes for the coming decades. This can be achieved by modeling. Any modeling of potential developments like for example on forest monitoring sites like the ICP Forests plots needs integration of climate change modeling results. As the future development cannot be predicted, climate change scenarios need to be used. These consider a probable range of assumptions, like for example the IPCC-SRES Scenarios.

In this study the regionalized outputs of the ECHAM5 model for Europe (CLM) are linked to ICP Forests plots and a plot specific calibration is applied. Additionally the climate changes for the forest regions as defined by CORINE forest types and bio geographical regions are calculated. Statistical comparisons for the total precipitation between plots and regions are used for bias quantifications.

As result statistics and maps of the impact of climate change in terms of changes in total precipitation for ICP Forests plots towards 2100 for the SRES Scenarios A1B and B1 are presented. Plot wise calibrations results can be used in coming investigations as bases for water budget modeling considering temperature, precipitation, wind speed , radiation and soil type. In a first approach the vegetation type per plot must be assumed to be unchanged to exclude the impact of management activities.

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Seasonal variation in the foliar chemical composition of Scots pine and Norway spruce in northern boreal forests

Hannu Raitio[1], Päivi Merilä[1] & Pasi Rautio[1]*

Inadequate nutrient supply may be a direct cause for low tree vitality or a factor which exposes trees to adverse air pollution effects. On the other hand excess amount of elements might also lower tree vitality. To detect any of the above cases one needs information about foliar element levels, and that is why chemical foliar analyses are a widely used diagnostic and monitoring method both in forestry and environmental studies. The aim of our investigation was to investigate the seasonal variation in the size and chemical composition of Scots pine and Norway spruce needles under different climatic conditions and this way to improve the sampling and the interpretation of the chemical foliar analysis. Tree-specific samples were collected in 6 plots from 25 randomly selected trees per sample plot at two-week intervals during the growing season and once a month during rest of the year. Above sampling procedure lasted for one year. The pattern of seasonal variation in element concentrations was rather similar in both tree species. As changes in the needle dry weight were reflected in opposite changes in the concentrations of nutrients this puts the well known facts about nutrient retranslocation into new light. Especially in southern plots retranslocation based on the needle content, instead of concentration, was not evident. This highlights the importance of measuring foliar content in addition to concentration. Further it was found that biotic diseases may have drastic effects on the foliar chemical composition of infected needles before the appearance of visual symptoms. To ensure the comparability of the results of needle nutrient analysis it is essential to sample needles during the dormant period when there is no needle dry weight fluctuation and nutrient retranslocation.

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Model-based analysis of forest productivity shifts in Europe under global change

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Understanding and predicting trends in forest productivity, their uncertainty under different global change scenarios and their spatial extent is crucial for understanding forest carbon cycling and for adapting forest management to climate change. We present synthesis information from a literature review on future productivity shifts in Europe as simulated with process-based, stand-level forest models and a scenario analysis of productivity changes at 132 forest sites (mostly ICP Level II plots) in Europe with the process-based forest model 4C.

A validation of 4C showed good correspondence of the simulated net primary production under recent climate (1971-2000) with published data. We then applied 4C to simulate the impact of climate change and elevated atmospheric CO_2 concentration ([CO_2]) under two realizations of the A1B and B1 scenario respectively.

The literature review and the 4C simulations reveal that the mean response of individually studied sites to global change shows a distinct geographical pattern. Most studies in the boreal zone show productivity increases whereas the response to global change is positive and negative in the temperate zone. In the Mediterranean, the response of productivity to global change is also ambivalent and depends strongly on [CO_2]. However, in this region our analysis covers only a limited number of sub-regions and tree species.

Generally, the magnitude of the response to global change differs a lot in between models. The reviewed studies and our own simulation experiments with 4C show that the effects of a changing climate alone lead to both positive and negative productivity changes. Positive responses can be mostly explained by enhanced photosynthesis and longer growing seasons while negative responses result from water limitations. Furthermore, the effects of climate change and increasing [CO_2] almost always result in positive changes induced by CO_2-fertilization and improved water-use efficiency.

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Biotic and abiotic influences on forest vitality

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Multiple factors influence forest yield but it is the impact of biotic and abiotic factors on the individual tree, which ultimately decided on stand vitality and economic productivity. Concentrating on the four main forest tree species beech, oak, spruce and pine we provide examples for different stressor-reaction combinations.

While the discussion often addresses the forest as an ecosystem as a whole the differentiation between the different age classes and species forming it might allow for a better prediction of forest yield in the future. It therefore is important to use a small scaled approach to understand the varying influence on individual trees and the variance of environmental impacts over time.

Up to now annual tree-growth of over twenty plots in Germany and the UK were analysed. Special emphasis lays be on the impact of soil characteristic and nutrient availability for climate-growth reactions. Additional examples will comprise of the impact of deposition and insect defoliation.

Annual growth is a suitable parameter to estimate biotic and abiotic impacts on forest growth. Using known past events recovery times can be linked between trees of different species. The comparison of different age groups allows an insight in the variation of site productivity depending on the time of plantation. Yield curves vary depending on site properties and especially soil characteristics modify the climatic impact specifically in extreme years. This knowledge can be used for a species selection. Recovery from heavy airborne pollution is shown, as well as the adaptation to changing climatic conditions using climate scenarios.

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DO3SE and AOT40 - ozone flux on contrasting sites in Spain and Switzerland for Quercus ilex and Fagus sylvatica

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The DO_3SE (Deposition of O_3 for Stomatal Exchange) model - an established tool for estimating ozone (O_3) deposition, stomatal flux and impacts to a variety of vegetation types across Europe has recently been complemented by a module estimating soil moisture status and its influence on g_{sto} for a variety of forest tree species (Büker et al 2011). DO_3SE may contribute to fulfilling objective 1 of ICP Forests, i.e. providing a periodic overview on the spatial and temporal variation of forest condition in relation to air pollution (here O_3) by means of European-wide and national large-scale representative monitoring on a systematic network (see Lorenz 2010). First ozone risk assessments comparing AOT40- and O_3 flux-approaches have been conducted on selected sites in Switzerland, Spain and Italy in 2007 (Schaub et al 2007). The comparison of the outcome for both, the AOT40- as well as the O_3 flux-approach demonstrated not only the strong dependencies of plant response to O_3 on environmental factors such as drought and increasing temperatures under current climate change scenarios but also the lack of harmonized and complete data sets within the ICP Forests database. However, during the last years (FutMon project, LIFE+, 2009-2011), strong efforts have been made to harmonize and improve existing measurement and monitoring methods towards more efficient and precise data collection.

This study aims to assess ozone risk by means of AOT40 as well as O_3-flux (with DO_3SE) based on up to 10 years of harmonized and quality checked ICP Forest data from the EPs air quality, meteorology, soil, and phenology. The assessment will be conducted for Quercus ilex and Fagus sylvatica, grown on differing sites and under contrasting climatic conditions in Spain and Switzerland. Results will be compared with the output from EMEP, meteotest.ch for the same plots for validation and quality control purposes.

This study will allow us to gain a better idea of the feasibility and quality of modeling O_3 risk with DO_3SE based on ICP Forests data for different tree species, countries, and contrasting climatic conditions. This know-how will be essential for a) the further development of DO_3SE, b) further harmonization of the ICP Forest data (hourly resolution for soil data is anticipated), and c) for running DO_3SE across Europe to produce an O_3 risk map to be compared with EMEP.

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Foliar phosphorus nutrition of beech (Fagus sylvatica L.) in Europe

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Increased forest soil acidification, atmospheric nitrogen (N) deposition and climate change are supposed to affect foliar phosphorus (P) nutrition of forest trees. This presumption is supported by low foliar P contents and high N/P ratios that have been observed in different European countries and are suspected to cause reduced growth or instability of forest stands. European beech (*Fagus sylvatica* L.) is one of the most widely distributed tree species in Europe. Beech foliage nutrient content has been analyzed on ICP Forests Level II Intensive Monitoring plots since the early 1990s. The present data evaluation aims at describing the level and the temporal trend of foliar P nutrition across Europe. Linear mixed effects models with "plot" as random effect were used to analyze the temporal trend.

The levels in foliar P contents of beech plots differed across Europe and ranged from 0.81 to 1.67 mg g^{-1} dw (plot median). The coefficient of variation of the whole dataset was 19%. More than half of the plots showed foliar P contents in the deficiency range (Forstliche Standorts-kartierung 2003): 48 out of 77 plots had P contents less than 1.3 mg g^{-1} dw and 9 plots even less than 1 mg g^{-1} dw. Plots in northern Europe tended to have higher foliar P contents than plots in central and southern Europe. In addition, the foliar P content was significantly decreasing all over Europe ($p<0.001$). The linear mixed effects model revealed that this temporal trend was similar on all Intensive Monitoring plots in Europe.

Altogether, P nutrition of beech seems to be impaired in Europe. Possible drivers of this development might be high atmospheric N deposition and climate factors. Therefore, in the next step data on deposition, meteorology, soil chemistry and tree growth will be used to seek explanations for the variation in foliar P levels as well as for the observed spatio-temporal trends.

Keywords: forest nutrition, temporal trend, nutrient deficiency

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Trends of nitrogen and sulphur deposition

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Atmospheric deposition of acidifying compounds (e.g. S), nitrogen (N) as a nutrient and base cations (e.g. Ca) to forests is a major driver for many processes in forests. In Europe, various measures have been taken to reduce S and N deposition since the late 1980ties. Trend analyses are regularly performed based on measurement in open field by EMEP and in forests by ICP-Forests. However, various trend analyses techniques are in use.

In this study the trends of bulk and throughfall N and S deposition on ICP-Forests level II sites have been investigated. Sulphur deposition showed a decreasing trend from 2001 to 2010 that has been identified to be significant for the majority of the about 50 sites with continuous data (linear regression, 95% sign. Level). The mean thoughfall of theses sites decreased from about 12 kg S ha^{-1} a^{-1} in 2001 to about 6 kg S ha^{-1} a^{-1} (about 6% a^{-1}). For N this value decreased from about 15 kg N ha^{-1} a^{-1} to about 12 kg N ha^{-1} a^{-1} (about 2.5% a^{-1}), however, decreasing trends were identified to be significant for much fewer sites.

In order to estimate the minimal detectable trend, p-values were plotted against the relative slope. Most p-values were in a similar bell-shaped band for time series with the same length for most ions. For time series with 10 years S deposition data, the band falls below 0.05 at relative slope larger than about 3% a^{-1}. With 6 years of data, relative slopes need to be larger to reliably attain $p<0.05$.

Further, we will compare linear regression and Seasonal Mann-Kendall techniques and discuss common patterns in the long-term and short-term evaluation of the deposition.

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Exceedance of critical limits and their impact on tree nutrition

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For N limited stands, enhanced N supply may stimulate the production of above-ground biomass. However, in excess, N loads may lead to nutrient imbalances and sensitivity to frost, insects, and fungi may increase (N saturation hypothesis, postulated by Aber et al., 1989).

This study aims on investigating the following relations based on the level II network

- Relations between exceedances of critical loads and indicators for actual N saturation and soil acidification status
- Relations between exceedance of critical limits for soil solution and tree responses

For these purpose the measurement of throughfall deposition, soil solution, foliar analyses, damage cause assessment, crown condition and soil classification on the ICP-Forests level II plots between 2006 and 2010 as well as critical loads calculated with SMB method have been used.

For plots with higher N throughfall (>20 kg N ha^{-1} a^{-1}), nitrate concentrations lowest lysimeters more often exceed critical limits for N saturation. About half of the level II plots with critical loads exceeded already show indication of N saturation while the other half may still be in the phase of accumulation. Similarly, proportion of plots with BC/Al criterion exceeded (BC/Al<0.8 in more than 80% of the samples) seems to be higher among the plot with exceedance of critical loads of acidity.

At plots with exceedance of critical limits in soil solution the N in foliage is more often in than below optimum for Spruce, Pines and or above then in optimum for Oak. For Mg it is vice-versa for Spruce, Pines, and Beech. For the tree species groups of Spruce and Pines the percentage of plots with foliar N concentrations below optimum is significantly lower for plots with critical limits exceeded.

In the presentation the tendency to more frequent appearance of light green to yellow discolouration as well as possible reasons will be discussed.

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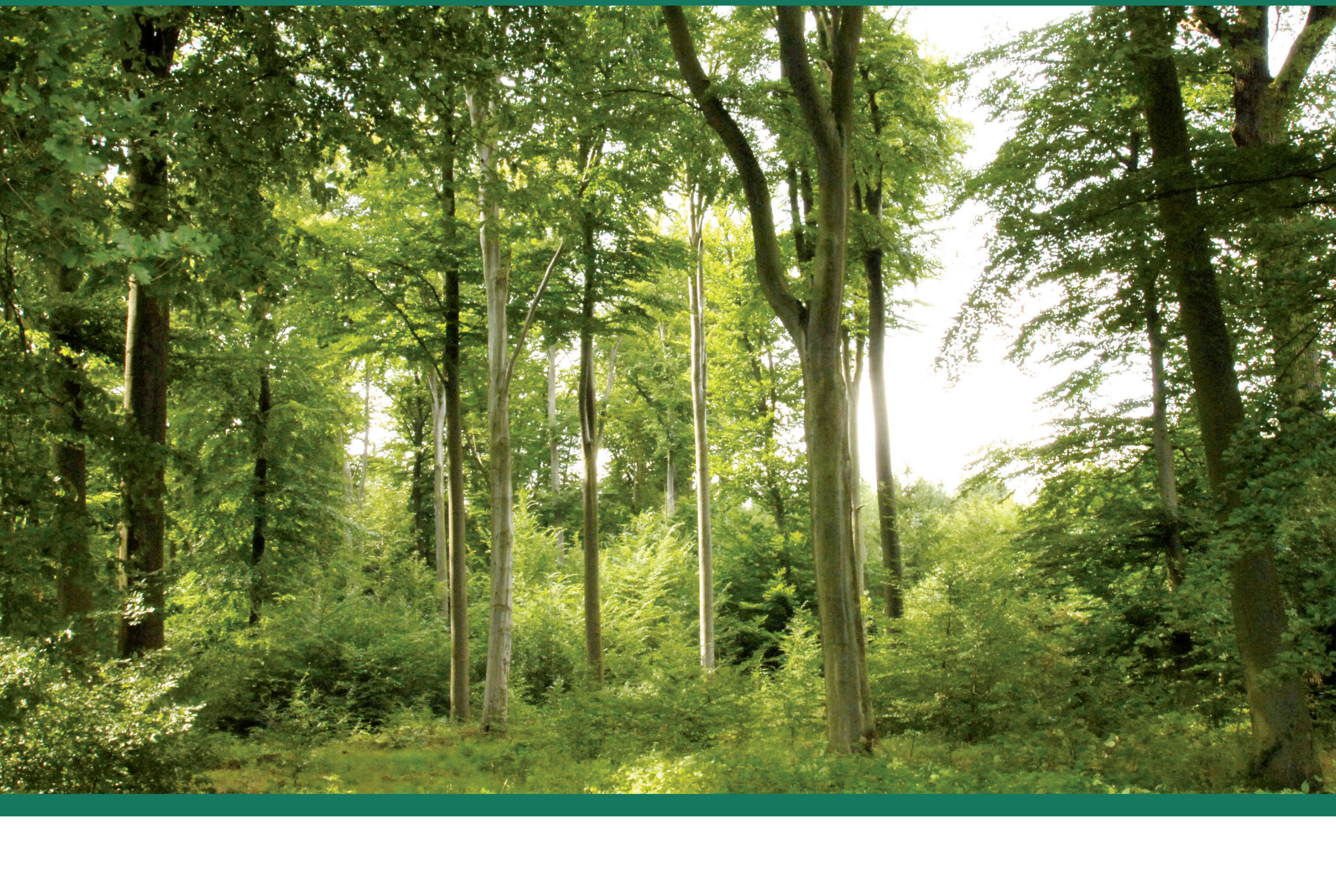

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