Assessment of Climate and Air Quality Change Effects on Forest Ecosystem Services in Europe (CEFES)

Wim de Vries
Gert Jan Reinds
The CEFES project
- Background
- Objectives
- Relationships to be investigated

Ecosystem pressures
- climate (e.g. precipitation, temperature)
- air quality (nitrogen, acidity, ozone)

Effects of climate and air quality change on:
- Water and element fluxes; critical loads
- Forest productivity and carbon sequestration (CO$_2$ and N$_2$O) exchange.
- Forest ecosystem health, mortality, seed production and regeneration.
- Diversity of forests and its ground vegetation
Background of CEFES

- CEFES, which stands for “Assessment of Climate and Air Quality Change Effects on Forest Ecosystem Services in Europe” is a project that aims to evaluate data gathered in forest monitoring systems at European scale (ICP forests LII and LI, National Forest Inventories, national databases).

- Various evaluations are available, but mainly limited to water and element fluxes and to a lesser extent growth and carbon sequestration/biodiversity with data up to 2003. Limited attention to ozone.

- Very limited use of results in view of adaptive forest management
Objectives and actions

- The main objectives of CEFES are to provide policy relevant information on:
  - the interactive effects of climate change with air quality change (nitrogen/acid deposition and ozone exposure) on European forest ecosystems and their services (wood production, carbon sequestration, biodiversity and the protective functions of forests)
  - the way in which adaptive and sustainable forest management strategies can be used to mitigate climate and air quality change effects on forest structures and functions
The major actions in CEFES

Pressures
- Climate
- Ozone
- Nitrogen

Impacts
- Soil and water quality
- Growth and carbon sequestration
- Health and vitality
- Biodiversity

Response
- Adaptive forest management
The relationships investigated in CEFES

- CO\textsubscript{2}
- N+S\textsubscript{dep}
- O\textsubscript{3}
- T, P
- N\textsubscript{2}O
- Biodiversity
- Growth
- Health
- N\textsubscript{av}:[N]
- pH
- [Al], [BC]
- water
- N pool
- C pool
- DOC
- DON
Ecosystem pressures
Objectives and actions

Objectives of CEFES are to assess or identify for European forest ecosystems the pressures in terms of:

- Past, present and future climate (precipitation, temperature) based on measurements and interpolations!
- Past, present and future air quality (nitrogen and acid deposition, ozone) based on measurements and modelling
CEFES actions

- CEFES actions will focus on (present ideas):
  - Expand number of meteorological and soil physical measurements at LII plots to allow better drought stress calculations.
  - Apply models to estimate ozone flux at LII plots. Improve canopy exchange model to assess total atmospheric deposition at LII plots.
  - Extrapolate results to Europe (at LI plots) by improving and applying methods to (i) assign/interpolate meteorological data, (ii) model ozone concentration/fluxes and (iii) model atmospheric deposition.
  - Make future predictions of the various stresses in response to scenarios at both LII and LI plots.
Effects of climate and air quality change on water and element fluxes
Specific objectives of CEFES are to assess or effects of climate/air quality pressures on protective functions of soil and water resources of European forests in terms of changes in:

- Hydrological budgets and ground water recharge
- Soil acidity and aluminium/heavy metal release in relation to sulphur, nitrogen and base cation budgets
- Nitrogen leaching/runoff to ground water and surface water
Relations between deposition and leaching
Dynamic soil models can be used to:

- Evaluate development in soil chemical parameters in time as influenced by changing S and N deposition
- Determine the time before chemical criteria are violated (damage delay time) and the time before chemical recovery is achieved (recovery delay time)
Nitrate in soil solution in 1970 and 2030

[NO3], 1970
(eq.m⁻³.yr⁻¹)

(< 0.02
0.02 - 0.04
0.04 - 0.06
0.06 - 0.08
0.08 - 0.1
>= 0.1)

[NO3], 2030
(eq.m⁻³.yr⁻¹)

(< 0.02
0.02 - 0.04
0.04 - 0.06
0.06 - 0.08
0.08 - 0.1
>= 0.1)
CEFES actions

- CEFES actions will focus on (present ideas):
  - Long-term trends in soil and soil solution chemistry linked to deposition
  - Uncertainty/reliability of hydrological budgets and drought stress estimates.
  - Uncertainty/reliability of element budgets
  - Long term impacts of expected climate change, nitrogen, acidity and metal depositions on soil and soil solution chemistry and element leaching using process based model chains.
Effects of climate and air quality change on forest productivity and carbon sequestration
Multivariate regression results at tree level indicating the relative change in stem volume growth per unit change in influencing factor. Note: - implies that the effect was insignificant (p>0.05).

<table>
<thead>
<tr>
<th>Tree species</th>
<th>BAL(^1)</th>
<th>SDI</th>
<th>C/ Nsoil(^2)</th>
<th>N dep</th>
<th>Temp(^3)</th>
<th>Temp change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway spruce</td>
<td>-0.39</td>
<td>-0.00056</td>
<td>-0.023</td>
<td>0.013</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Scots pine</td>
<td>-0.29</td>
<td>-0.00066</td>
<td>-</td>
<td>0.015</td>
<td>0.053</td>
<td>-</td>
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<tr>
<td>Common beech</td>
<td>-0.16</td>
<td>-</td>
<td>-</td>
<td>0.012</td>
<td>-</td>
<td>0.064</td>
</tr>
<tr>
<td>Oak</td>
<td>-0.38</td>
<td>-0.00062</td>
<td>-</td>
<td>0.013</td>
<td>0.080</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^1\)BAL is basal area of larger trees (m\(^2\) ha\(^{-1}\)), \(^2\)C/N soil is the C/N ratio of the mineral topsoil (0-30cm) and \(^3\)Temp is average temperature 1993-2000 (\(^\circ\)C). For common beech, the effect was almost significant at p = 0.05 (p=0.77).

20.7 and 25.8 kg C per kg N deposition

D. Laubhann et al., (2007)
CEFES actions

CEFES actions will focus on (present ideas):

- Evaluate historic and present impacts of climatic stress, ozone exposure and deposition of nitrogen and acidity: expanding earlier study by including: (i) results from the 2005 increment survey (ii) annual growth readings from girth bands and (iii) ozone exposure as stress factor.

- Evaluate long term impacts of expected climate change, ozone exposure and deposition of nitrogen and acidity using process based model chains (model validation/(Bayesian) calibration, uncertainty analysis, scenario analyses.
Effects of climate and air quality change on forest ecosystem health
Objectives and actions

- Objectives of CEFES are to assess or identify for European forest ecosystems the effects of climate and air quality change on:
  - Tree condition: crown condition, insects, abiotic agents, mortality
  - Ecosystem condition: regeneration, seed production, fertility, ecosystem functioning in relation to tree species impacts
Examples of work

Examples of research carried out is:

- Multivariate model assessment of effects of stand and site factor and atmospheric deposition on forest crown condition at ICP Forests Level I (Klap et al., 2000).
- Statistical model (Principal Components) analysis relating percentage of damaged trees to various abiotic (storm, frost, drought) and biotic agents (pests and diseases) at ICP Forests Level I plots (Jactel et al., 2007).
Effects of climate and air quality change on diversity of forests and its ground vegetation
Objectives and actions

Objectives of CEFES are to assess or identify for European forest ecosystems the effects of climate and air quality change on

- The species diversity of trees (forests)
- The species diversity of ground vegetation (also in terms of their nature conservation value).
Evaluation of ground vegetation data

■ Assessment of:
  ● Relationships between the ground vegetation composition and environmental factors, using various statistical techniques.

■ Division between relations with:
  ● The occurrence probability of individual species: multiple regression analyses
  ● The species composition of the ground vegetation: multivariate correspondence analyses
Occurrence of species and environmental factors
CEFES actions

- CEFES actions will focus on (present ideas):
  - Evaluate historic and present impacts of climatic stress, ozone exposure and deposition of nitrogen and acidity: Expanding earlier study by including: (i) results from the 2005 ground vegetation survey and (iii) ozone exposure as stress factor.
  - Evaluate long term impacts of expected climate change, ozone exposure and deposition of nitrogen and acidity using process based model chains, such as SMART-MOVE/NTM and ForSAFE-VEG (model validation/ (Bayesian) calibration, uncertainty analysis, scenario analyses.)
Goals for the Future; biodiversity

• Enlarging the response function database with European data (especially from the South of Europe) based on combined soil and vegetation measurements

• Estimation of interaction effects

• Ecological meaning of the shape of the response curves

• Cooperation with research groups in Europe
CEFES preparations

- Discuss the set-up with LIFE+ in view of its constraints. Discuss also possible budget and time.
- Further meeting at Berlin (June 26-27) with interested partners in the project.
- Submission of the project before the next LIFE+ deadline (End November).
- Wim.deVries@wur.nl