



Litterfall traps installed at a fir plot in Greece. Parameters for tree reactions to environmental changes like defoliation, discoloration, mortality, fructification, occurrence of pests and diseases, phenology, litterfall and forest growth are currently assessed on a European wide scale. Continuation of these assessments and their integrated evaluations need to be ensured in the future.

## TREE REACTIONS TO ENVIRONMENTAL CHANGES

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### Key messages

Forests have always been subject to different natural impacts resulting in changes of ecosystems and adaptation to new conditions. Tree reactions to different environmental impacts are a normal phenomenon in forest ecosystems. However, these reactions can also indicate disturbances and can be used as key indicators of forest ecosystem health and vitality. It is necessary to improve our knowledge on tree reactions especially to identify and quantify disturbances more accurately and separate them from “normal” reactions.

Human activities, like deforestation, forest management, air pollution, and climate change dramatically increase the pressure on forest ecosystems. Therefore observation, measurement, analysis and interpretation of tree reactions to these impacts can actively contribute to the protection of forest ecosystems. Better integration of the existing European forest monitoring systems, especially EU/ICP Forests Level I, Level II and National Forest Inventories should be

achieved. Monitoring of climate change effects and changes in biodiversity in forests should be integrated into the existing systems.

As a result of more than 20 years of forest condition monitoring (ICP Forests), continuous forest inventories and forest ecosystem research, a tremendous amount of data on tree reactions to ecosystem changes is already available. Analysis and more effective utilization of these databases should be promoted and also used for future development of the monitoring systems in Europe.

Several parameters for tree reactions have already been identified and applied successfully in research and monitoring activities, and their assessment has to be continued. Research towards additional, sensitive tree reaction parameters is necessary.

### Summary of presentations

The effect of climate change on the health status and the distribution of beech in Hungary was demonstrated. A xeric limit and tolerance index for beech was developed. Re-

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sults show that distribution of beech is determined by short term dry periods rather than climatic means. Expected future distribution of beech was calculated for the middle and the end of the present century. A dramatic reduction of beech distribution is predicted for the future. Level I data were also used for this study.

Growth patterns of forest stands are the biological system response to pollutants and climatic impact. This was demonstrated based on German Level II plots. Comprehensive analysis of tree and stand growth patterns proved to be appropriate tools to provide findings on the impact, especially of climate change and air pollution patterns. Time series of retrospective tree ring growth were successfully related to climatic impacts. Models can be used to forecast future tree and stand vitality.

Tree responses (birch, alder, beech) to elevated atmospheric carbon dioxide in a free air enrichment experiment (FACE) were investigated in Wales. After 3 years of CO<sub>2</sub> enrichment, a clear increase of both, above and below ground biomass, was observed. A mixture of tree species resulted in higher growth rates as compared to those predicted from single species measurements. Increased litterfall and longer leaf retention of birch were observed in the elevated CO<sub>2</sub> treatment.

## Recommendations

- The general knowledge on vulnerability or resistance and adaptability of trees to environmental impacts needs to be further improved.
- To achieve this goal, the time series of continuous and periodic monitoring of tree reactions are essential.
- Existing European forest monitoring systems, especially EU/ICP Forests Level I, Level II and NFIs should consider and properly address new monitoring issues, like climate change or biodiversity, therefore the development of a more comprehensive European monitoring system is required. This new or adjusted system should provide reliable and representative time series of tested and verified parameters, especially on tree – forest ecosystem – reactions to environmental impacts.
- Valuable and available data already collected in forest condition monitoring (ICP Forests), in continuous forest inventories and in forest ecosystem research have to be used more effectively to clarify effect–response relationships.
- Integrative parameters for tree reactions to environmental changes, like defoliation, discoloration, mortality, fructification, pests and diseases, injuries, phenology, litterfall or growth remain valuable in the future.

Several examples proved the relevance of these parameters. Correlations to environmental impacts were verified.

- Non specific response parameters should be better related to specific impacts. Therefore accurate and reliable data on impact parameters, as well as on stand and site history are essential.
- Research towards additional, sensitive tree reaction parameters and their application in monitoring systems is necessary. They include carbon allocation in trees and ecosystems, shoot growth, dendroecology, fine roots, ectomycorrhizae, fungi, leaf area index, competitiveness, stand structure, and regeneration.
- Remote sensing and additional area related information have to be considered and applied to complete plot based monitoring data in large scale analysis of forest ecosystem responses to environmental impacts.