Forest Decline in the Federal Republic of Germany – Appearance, Extent, Potential Causes

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ABSTRACT: Present forest damage phenomena are observed for many tree species, on all soils and sites as well as in areas with considerable climatic variation. They cannot be explained without assuming a significant contribution of air pollution in particular as consequence of the two- to fourfold higher deposition under forest stands than on adjacent open areas. So far only loss and yellowing of needles or leaves are suitable operational symptoms for forest damage surveys. These indicate that in the Federal Republic of Germany for the period 1984–1987 in the important stands over 60 years of age a reduction of trees without damage symptoms from 31% to 24% occurred in spite of prevailing growth promoting weather. This points to a considerable destabilization of forest ecosystems.

As forests are complex ecosystems rather than just an assemblage of leaves, roots or trees any interpretation of phenomena has to consider the complex and permanently changing interaction between the elements of the ecosystem themselves as well as its basic environmental factors in atmosphere and soils. Field experience shows that for a given situation mostly several of the cause explaining hypotheses appear to be valid. Thus the phenomena are reflecting the influence of an array of stress factors acting directly on the foliage of the tree or indirectly through the soil and often in a synergic pattern. The model of considering anthropogenic increased acid deposition with subsequent acidification of soils, damage of fine roots and impediment of water and nutrient supply of the tree is conclusive and is progressively being verified by experiments. For counteracting the observed destabilization and deterioration of forests a consequent policy of reduction of air pollution in its various forms and avoidance of forest management measures increasing system related acidification of forests are urgently required.

Forest Decline as a new International Phenomenon

Long lasting forest management is one of the outstanding features of forestry in Central Europe in general and in the Federal Republic of Germany (FRG) in particular. Forests have been utilized intensively on large areas for centuries. They are mostly accessible, almost completely under management and regeneration by promotion of natural regeneration through silvicultural methods or planting are common since about 200 years (Klose 1985). Dynamics of natural succession are, therefore, not the only element of causing factors for the development of the present structure of most forest stands in the FRG. However, it has to be realized that almost all broadleaf forests accounting for about 35% of the total forest area and a considerable portion of the remaining conifer forests are located in the respective phytosociological climax zones and were established by natural regeneration. They represent, therefore, ecotypes more or less adapted to the specific site situation and developed in the course of restoring vegetation since the last glacial period.

Managed forests in Germany are characterized by a reduction of number of trees per hectare from about 2 000 to 10 000 at the age of establishment to about 100 to 400 at rotation age which varies according to species between 80 and 200 years. For naturally regenerated stands the number of trees initially growing and subsequently eliminated during their life cycle is normally considerably higher. It can, therefore, not easily be understood why professionals as well as the general public of the country with the longest forest tradition in the world got very much concerned during the last few years about dying trees in the forests. As a result of this the FRG is that country where a comprehensive periodical assessment of the reduction of vitality of forests or “forest decline” was first initiated and relevant large scale research started.

Against this background the following phenomena observed only recently differentiate the present forest
damage situation from that experienced until about a decade ago (Der Rat der Sachverständigen für Umweltfragen 1983; Eichhorn 1987; Forschungsbeirat Waldschäden/Luftverbrennungen 1986; Führer, Brechtel et al. 1988; Prinz 1985; Rehfueß 1988; Ulrich et al. 1979):

- extent and intensity of symptoms increased rapidly since the end of the last decade;
- reduction of vitality is observed for at least 10 broad-leaf or conifer tree species;
- trees of all damage classes occur more or less without a spatial pattern on all sites, all soil types originating from various bedrocks, in all growth regions and under varying conditions of climate and immission;
- damage of fine roots and associated mycorrhiza as well as change of the root system with related needle loss has been proved already for Norway spruce;
- not only trees but also forests as a whole, as ecosystems, are affecte;
- scientific research on establishing clear cause/effect relations is still in the initial phase;
- all evidence on causing factors so far available indicates that reduction of vitality of forests cannot be explained without assuming a significant contribution of anthropogenic air pollution;
- at higher elevations concentrations of ozone and sulfur dioxide have been recorded frequently at levels known to be toxic for trees, and
- acid deposition in forests is on the average two to four times as high as on adjacent open areas reaching under spruce 3.8 kg ha⁻¹ a⁻¹ of H⁺, 250 kg ha⁻¹ a⁻¹ of SO₄²⁻ and 70 kg ha⁻¹ a⁻¹ of (NH₄⁻N) + (NO₃⁻N).

When discussing this development it appears indispensable to differentiate between the various stages of condition in which a forest can presently be found. The most characteristic features for defining condition levels of forests are type and duration of stress factors (Manion 1981), efficacy of internal buffer systems and visibility as well as extent of damage. Applying the definitions outlined in Tab 1 forests in the FRG have been allocated in general to the condition levels “Stressed Forest Condition” and “Forest Damage”. Only limited areas in the Harz mountains, Black Forest and Fichtelgebirge have reached the level of “Forest Decline”. Further deliberations refer, therefore, to forest damage rather than to forest decline.

### Symptoms of Forest Damage

The diagnosis of the new forest damage phenomena is much impeded by the fact that for trees reduction of vitality becomes evident only by very few visible characteristics and can be identified clearly only at a relatively late phase of damage. Consequently, among trees apparently still healthy a high proportion may have already suffered latent injuries. In particular these trees may recover temporarily or permanently if one or more factors of the strongly interrelated complex of natural and anthropogenic stress causes is reduced.

When considering the deterioration of vitality of forests realized since the beginning of this decade two questions arise:

- What is the extent of damage with respect to intensity and area distribution and what are the development trends?
- What are the causes of the phenomena observed in the forests and what are the interactions between themselves and with other environmental factors?

An assessment of extent and development of forest damage was initiated in the FRG in 1982 in the form of an inquiry and continued from 1984 onwards by forest