Establishment and Tending of Subalpine Forest: Research and Management.
H. Turner and W. Tranquillini, eds.
Proc. 3rd IUFRO Workshop P 1.07-00, 1984. Eidg. Anst. forstl. Versuchswes., Ber. 270 (1985): 189-192.

# DIAGNOSIS AND DISTRIBUTION OF CONIFER DECAY IN THE SWISS RHONE VALLEY

## A DENDROCHRONOLOGICAL STUDY

F.H. Schweingruber*
R. Kontic
M. Niederer
C.A. Nippel
A. Winkler-Seifert

*Swiss Federal Institute of Forestry Research, Birmensdorf, Switzerland.
Institute of Botany, University, 4000 Basel, Switzerland.

## ABSTRACT

Abrupt, long-term growth reductions evident in annual ring sequences were visually identified and dated. The simple method used allowed relationship of the frequency of such reductions to site and industry. In the Valais, the first damage occured as early as 1921, with the greatest damage concentrated in the early seventies. From 1977 onwards, recovery is apparent in annual ring sequences from the Valais but not from the Swiss Mittelland. No clear relationships between abrupt growth reduction and site or climate were found. Annual ring analysis indicates local and regional pollution as the cause of the reductions.

## INTRODUCTION

In 1903 Haselhoff and Lindau observed abrupt reduction of cambial activity in trees growing in the vicinity of smoke-emitting industrial plants, but their report received little attention. The phenomenon was re-discovered by Kienast *et al.* (1981) and Johnson *et al.* (1981). Kienast *et al.* (1981), studying dying pines in the Valais, found that the onset of growth reduction was typically limited to a few particular years. Further studies on forest damage in the Valais were carried out by Kontic (1983) on pine, Winkler (1983) on fir, and Niederer and Nippel (1984) on spruce. Schweingruber *et al.* (1983) compared forest damage in the Valais and the Swiss Mittelland. Simple dendrochronological methods were employed to determine the state of health of a large number of trees growing under a variety of ecological conditions. In the case of the Valais, annual ring sequences from 2.500 trees were analysed.

## METHODS

Trunk discs and core samples were examined for abrupt changes in growth, and the onset of any reduction or recovery was dated by means of annual ring counts using pointer years as points of reference. Annual ring width as such was not measured. The extent of growth reduction or recovery was estimated by comparing the total width of the rings formed after the change with the total width of the same number of rings preceding it (Figure 1). Visual tests showed

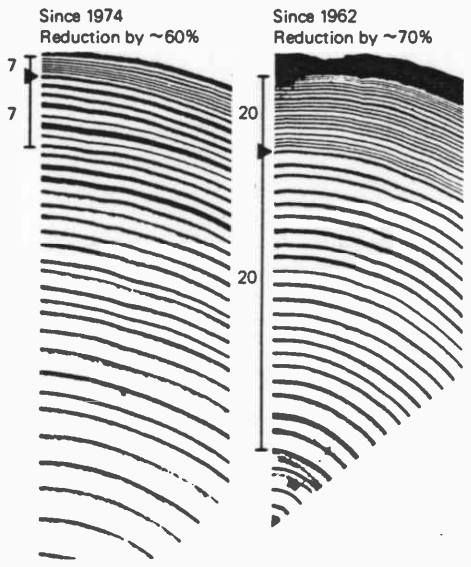


Figure 1. Annual ring sequences from diseased firs. The total width of the narrow rings formed after the abrupt growth reduction is compared with the total width of the same number of rings preceding it (figures left). Photo-offset of polished trunk discs. After Schweingruber *et al.*, 1983.

that growth changes of 70% or more can be reliably determined by this method, though changes of 30% or less cannot be identified with certainty (Figures 2a, 2b).

For each site a pie chart showing the percentages of damaged and recovering trees was constructed. Histograms illustrate the number of trees undergoing abrupt and permanent damage or recovery in any given year.

## SOME RESULTS

With the exception of cembran pine (*Pinus cembra*), all conifer species growing in the Valais (*Abies alba, Pinus sylvestris, Picea abies, Larix decidua*) are

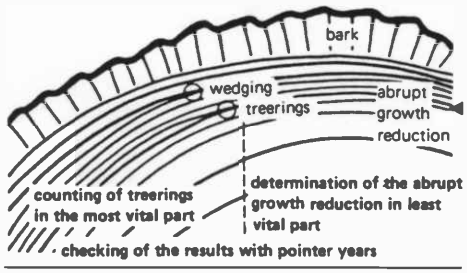


Figure 2a. Schematic representation of the dating of abrupt growth reductions. After Schweingruber *et al.*,1983.

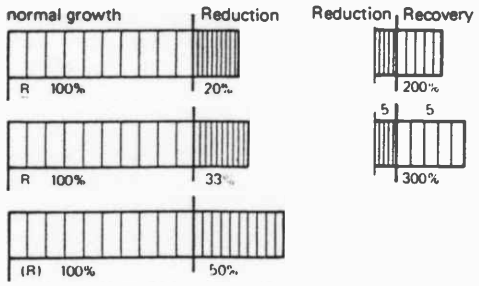


Figure 2b. Quantification of growth reduction and recovery. Reductions of more than 25% can be established. R, R. and (R) represents the degree of reduction. After Kontic, 1983.

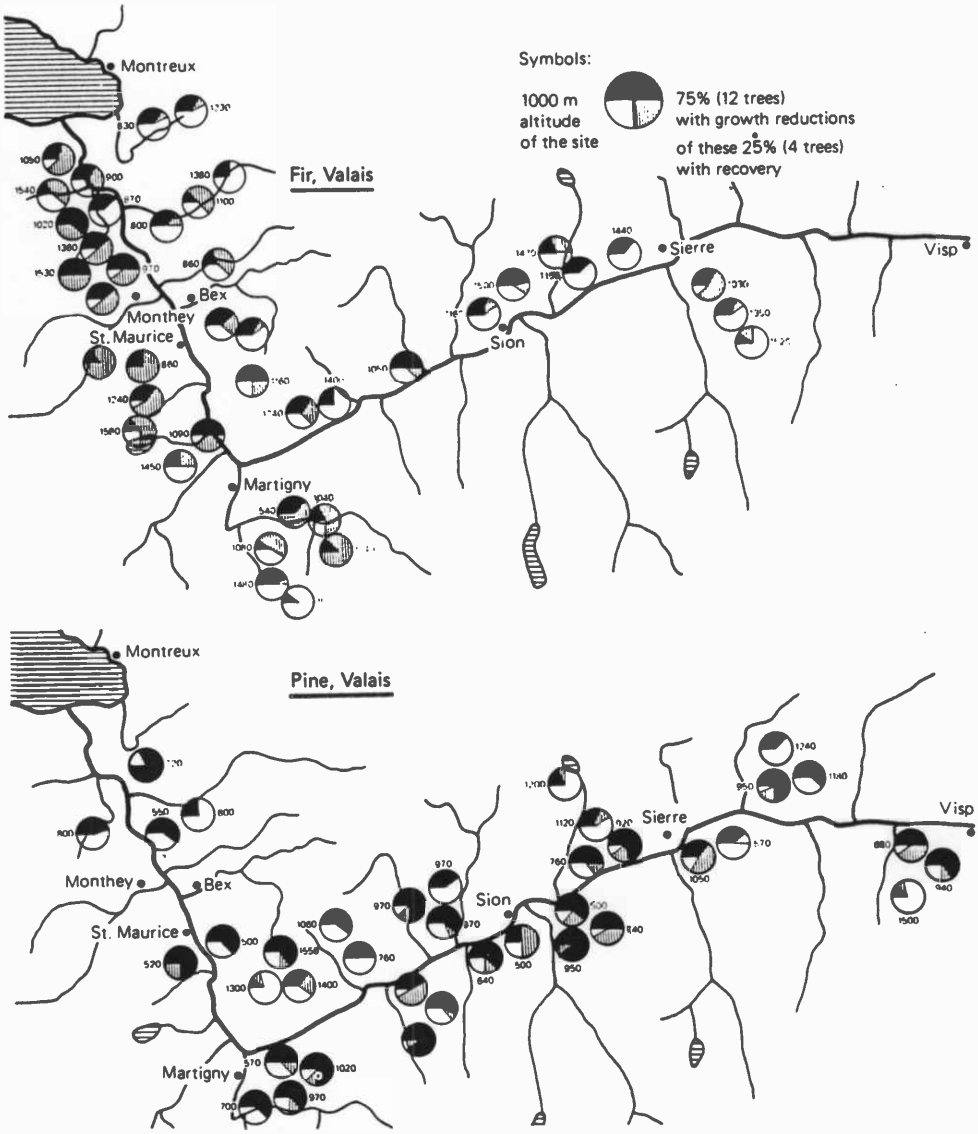


Figure 3. Percentages of firs and pines with abrupt growth reduction and recovery in the Lower and Central Valais. At each site samples were taken from 16 dominant and co-dominant trees. After Winkler 1983 and Kontic 1983.

damaged to a greater or lesser degree.

a) Geographical distribution of damage and regeneration (Figure 3).
In fir and spruce, damage is greatest in the Lower Rhone Valley on the left-hand slope (geographically seen). In pine, damage is evenly distributed over the whole valley. On average, 53% of the firs and pines and 23% of the spruces exhibit reduced cambial vitality. In all species, regeneration is evenly distributed over the whole valley.

b) Temporal distribution of damage and regeneration (Figures 4a, 4b).

Pine
Years with damage 1921,1933,1942,1962,1972
Years with recovery 1951, 1972-1981

Spruce
Years with damage 1921, 1962,1970-1976
Years with recovery 1951,1953,1977-1983

Fir
Years with damage (1962), 1970-1976
Years with recovery 1977-1983

More or less permanent damage was caused by isolated events before 1970 and a series of events in the years 1972-1976. A general trend of recovery is evident from 1977 onwards. In the fifties, especially in 1951, recovery is apparent in those species with damage at that time (pine, spruce). Different species seem to react differently to damage events. Pine and spruce behave similarly in that they both react quickly to harmful factors, and differ mainly in the extent of the damage. Pine is by far more sensitive than spruce.

c) Temporal-geographical onset of damage and recovery.
So far only spruce has been investigated in this respect. In the lower part of the Rhone Valley around Monthey and Bex, damage is concentrated in 1974, and around Martigny in 1962. In the vicinity of Brig damage occured as early as 1921. Recovery is evenly distributed over the whole valley.

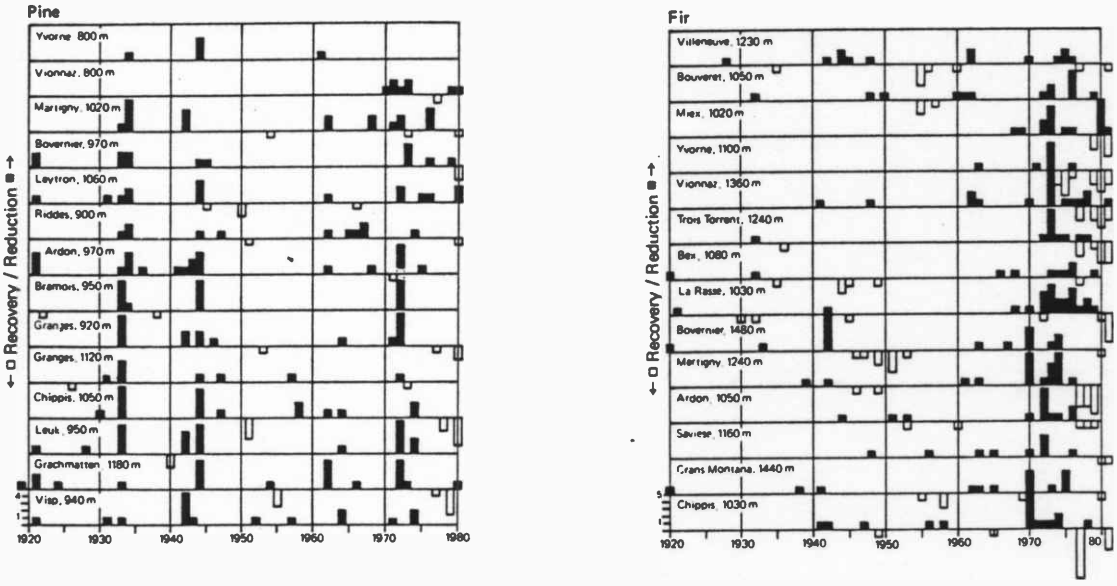


Figure 4a, 4b. First appearance of growth reductions (black bars) and recovery phases (white bars) in annual ring sequences from 1920 onwards. The bars represent the number of trees in which events could be dated.

Pine

The extent of damage appears practically the same over the whole of the Valais.
On average, half to three-quarters of all trees on each site are damaged.
Damage began around 1920 and increased markedly in 1921, 1933, 1934, 1942, 1944, 1962 and 1972. As in fir, damage is more frequent after 1970. Some pines (fewer than fir) are recovering, especially those on better sites at low altitudes (N and W exposition, deep soils).
Approximately half of all pines are not recovering at present.

Fir

Damage is concentrated on the left slope (orographically seen) of the Lower Rhone Valley. On average over two thirds of the trees on each site are damaged. On all other sites a third to a half of the trees display growth reductions.
Damage in the Valais began shortly before or at the beginning of the seventies.
Many of the damaged firs began to recover in around 1977; recovery is greater in the Lower Rhone Valais, where damage is also greatest.
Approximately a quarter of the firs investigated are not recovering at present.

d) Relationship between abrupt growth reduction and climate.
Investigations on samples from semi-arid zones have shown that periods extreme drought reduce cambial activity for at most 3 years. In contrast, the samples from the Valais exhibit phases of growth reduction often lasting several decades, e.g., 1921-1983. Very dry years may trigger a long-term reduction, but do not necessarily always do so. On the other hand, physiological damage has occured to many trees in periods with favourable growth conditions, e.g., after 1972.

e) Relationship to phytosociological elements.
Damage occurs to more or less the same degree on all sites, whether dry or moist.

f) Relationship to underlying rock.
No statistically confirmed correlations could be found.

g) Relationship to altitude.
Damage decreases above 1500 m a.s.l. At low altitudes, young spruces seem more severely damaged than older ones.

h) Relationship to age of tree.
On average, young trees (40-70 years old) seem as much affected as older ones in all species. Only in the case of spruces on low altitude sites do the younger trees display more damage than the older ones.

i) Relationship to industrial plants.
On the whole, damage is greater in areas with many industrial plants than in more remote regions with less industrialisation. It is noticeable that the first damage occured during the early years of industrial development. Recovery phases in pine correlate with decrease in the fluoride content of apricot leaves. In the present study, we found local concentrations of damage, despite the thorough mixing of the air in the Rhone Valley due to the mountain wind system.

j) Comparison of damage in the Valais and the Mittelland.
Comparisons have only been made for fir. In the Mittelland, abrupt growth reductions begin in 1956 and increase more or less continuously year for year (Figure 5). In the Valais, on the other hand, damage is noticeably concentrated in particular years, and in a wave lasting from 1972 to 1976. We consider the damage in the Valais to be regionally limited and 'home-made'. The damage in the Mittelland may be a result of the high density of population and industry and the high air pollution levels between the Lake of Geneva and the Lake of Constance. In the Mittelland, as in the Valais, damage is less in the more remote areas, such as the Emmental. In both regions there seems to be a close relationship between direct pollution and growth reduction. The damage to the trees can in no way be solely attributed to acid rain.

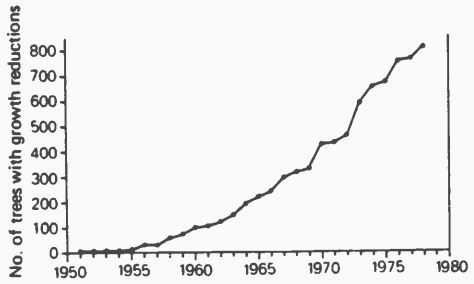


Figure 5. Number of firs with incipient growth reduction in the Swiss Mittelland and the northern Jura. Cumulative representation. Severe damage began in 1956, and there is an obvious increase after 1970. After Schweingruber *et al.*, 1982.

LITERATURE CITED

Haselhoff, E. und G. Lindau. 1903. Die Beschädigung der Vegetation durch Rauch. Berlin, Leipzig. Bornträger. 412 pp.

Johnson, A.H. and T.G. Siccama. 1983. Acid deposition and forest decline. Environmental Science and Technology 17: 294A-305A.

Kienast, F., H. Flühler und F.H. Schweingruber. 1981. Jahrringanalysen an Föhren (*Pinus silvestris* L.) an immissionsgefährdeten Waldbeständen des unteren Wallis (Saxon, Schweiz). Eidg. Anst. forstl. Versuchswes. Mitt. 57: 415-432.

Kontic, R. 1983. Jahrringanalytische Studien über Waldföhren (*Pinus silvestris* L.) von ausgesuchten Standorten im immissionsbetroffenen Rhonetal zwischen Visp und Genfersee (Kantone Wallis und Waadt, Schweiz). Diplomarbeit, Universität Basel, Botanisches Institut, unveröffentlicht.

Niederer, M. und C.A. Nippel. 1984. Jahrringanalytische Studien über Fichten (*Picea abies*) von ausgesuchten Standorten im Rhonetal zwischen Grimsel und Genfersee. Master Thesis, University Basel, Institute of Botany. Unpublished.

Schweingruber, F.H., R. Kontic und A. Winkler-Seifert. 1983. Eine jahrringanalytische Studie zum Nadelbaumsterben in der Schweiz. Eidg. Anst. forstl. Versuchswes., Ber. 253: 29 pp.

Winkler-Seifert, A. 1983. Jahrringanalytische Studie über Weißtannen (*Abies alba* Miller) an ausgesuchten Standorten im immissionsbetroffenen Rhonetal zwischen Sierre und Genfersee (Kantone Wallis und Waadt, Schweiz). Master Thesis, University Basel, Institute of Botany, unpublished.