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## Silver fir (*Abies alba* Mill.) shows an increasing long term trend in the JURA mountains

Didier Bert

INRA, Laboratoire de Phytoécologie forestière, Forest Research Centre, 54280 Champenoux, France

### 1. Introduction

Since the past two centuries, the forest "dieback", has been noted several times in Europe. Since 1983, it has been observed in the Vosges mountains, especially on silver fir (*Abies alba* Mill.). In 1983 a french programm started to study this dieback. Some researches deal with natural causes to assess the impact of ecological conditions on forest health. Dendroecological studies, combining phytoecological studies with dendrochronological studies, can assess the impact of pollution on trees radial growth and date the phenomena. Furthermore, they allow the analysis of other factors than pollution action: poor soil fertility, lack of water reserve, ecological and silvicultural conditions of stands... The first dendroecological studies were undertaken in the Vosges mountains, where the soils are often very acid, on the silver fir *Abies alba* (Becker 1987, Becker & Levy 1988). They showed the great influence of climate on silver fir health and radial growth, especially during drought periods (Becker 1989). The present study has been undertaken on the same species in a different phytoecological context: the Jura mountains, where the soils are often calcareous. This region is on the border with Switzerland, eastern France. Silver fir has a large range and an important economic weight in this massif, but it shows disease manifestations.

### 2. Materials and methods

208 sites have been sampled within natural range, taking into account the ecological (elevations between 550 and 1300 m) and stands age variability. The choice of 6 dominant silver firs on each site is independant of tree health, in the aim not to bias the sample. On each site, soil type, vegetation list, topographic position... were carried out. On the 6 trees, the needle loss was noted (with a 5 % step), the foliage yellowing degree, the height, the crown length, the circumference, the competition degree... Each silver fir was bored to the pith at breast height.

The 1,248 cores were planed with a razor and the ring widths measured with a binocular microscope fitted with a "drawing tube" and a digitizing tablet coupled to a computer. After crossdatation, using pointer years, each ring corresponds to the date when it was elaborated.

The biological decreasing of ring width according to age is taken into account by using a standardization method. The curve of ring width according to age is plotted for the whole sample. This curve expresses mainly the relationship between ring width and age because each age was reached at many different dates (the tree ages range from 20 to 468 years) and on many different sites with different ecological conditions. The mean radial growth, from 100 to 150 years old, is

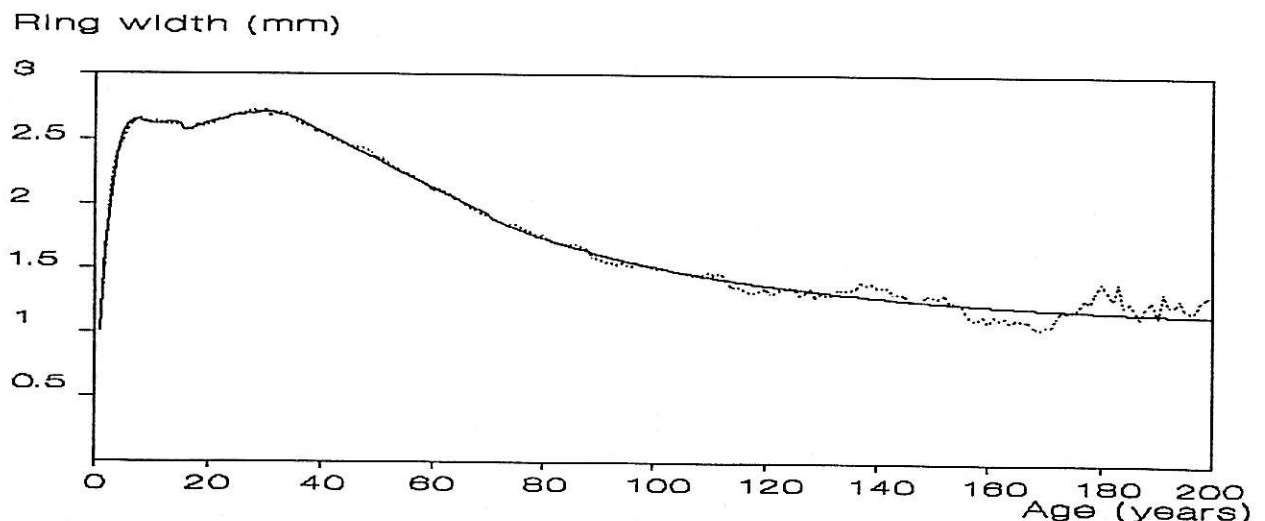


Fig.1. Age effect: ring width according to date (dotted line) and fitted curve (solid line).

nearly twice as great than in the Vosges mountains. Then, this mean curve is fitted by stepwise regression. The equation is used to convert the ring width into "growth indices". On a core, the ring width elaborated when the tree was e.g. 50 years old is divided by the value given by the fitted equation for the same age and then, becomes an index in percentage (Fig. 1).

### 3. Results

The standardization allows to calculate the mean curve of the whole sample with the 1,248 individual growth index curves (Fig. 2). This mean curve shows strong annual variations, in relationship with annual climatic conditions, and several crises, with various severity and term at the decade time scale (1922, 1948 and 1976). During a pointer year, the growth variation direction occurs for more than 75 percent of trees, it can be a year with good growth (1925 or 1955), or with bad growth (1956 or 1976). Those pointer years (especially with bad growth) were also found by several authors in other study areas (Becker *et al.* 1990).

At the century scale, the mean curve shows an increasing long term trend between 1870 and 1930. From 50 % before 1860, the growth index increases to 110 % after 1930, i.e. an increase of 140 % (Fig. 3). Since 1940, the curve shows a plateau around 100-110 %. Thus, on an average, the silver fir forests vitality in the Jura mountains is not decreasing. The last crisis, in a more general context, is rather strong but not exceptional. From a radial growth point of view, it seems finished; since 1982 the growth of silver firs has come back to the 20th century mean level.

Radial growth index (%)

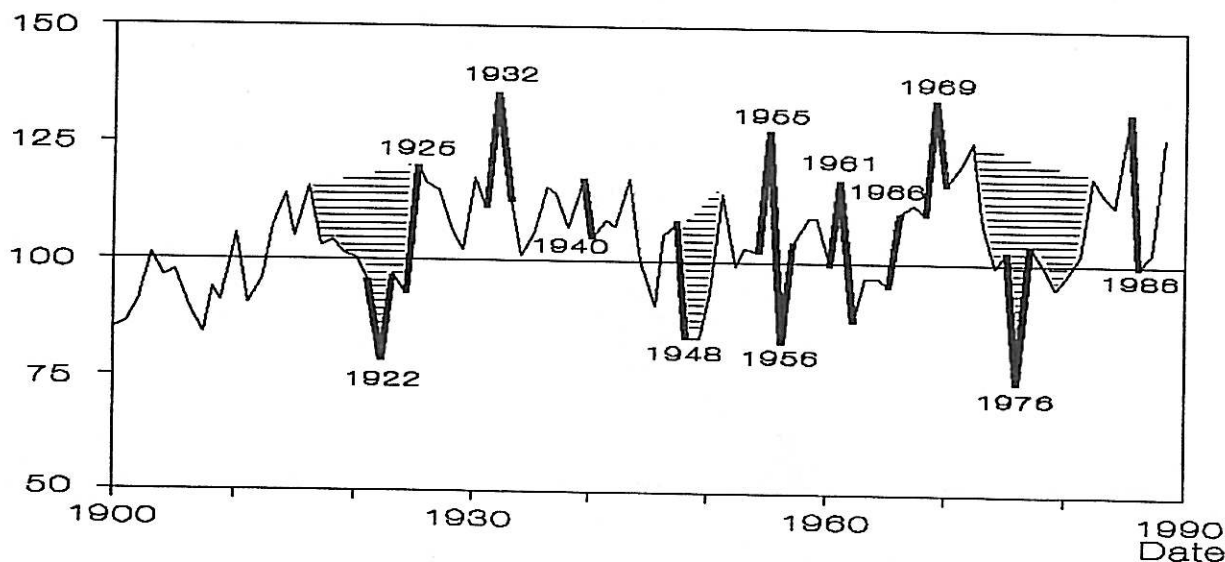


Fig.2. Pointer years and crisis: radial growth index according to date at the 20th century scale (1248 silver fir in 1988). Bold line and inside graphic printed dates indicate pointer years (occurring in more than 75 % trees); areas with hatchings show crisis periods.

The comparison between the mean evolution of radial growth and meteorological datas (annual precipitations and mean year temperature) shows that a drought years series between 1971 and 1976 has launched a radial growth decrease since 1973; it has been named forest dieback. During the following years, more wet, the growth came back normal. These observations and results about climatic aftereffects (Becker 1989) allow to understand older crises: 1962-1965 (drought years 1961-62-64), 1956 (froze in february), 1948 (1948 and 1949 were drought years)..

### 4. Discussion

The long term trend occurred during the same period in the Vosges mountains and in the Jura mountains; this increase of primary productivity was also shown by other authors on different sites from northern hemisphere: Hari *et al.* 1984, Larmarche *et al.* 1984, Kenk 1987, Hornbeck 1987, Jozsa & Powel 1987, d'Arrigo *et al.* 1987, Hartmann & Schneider 1990... The northern hemisphere surface air temperature shows a similar trend during the same time series; this global warming could have two effects on radial growth:

- \* in the Jura mountains, the growth increase was stronger on the coldest stations than on the warmer ones. This observation is coherent with a weak climate warming which could improve radial growth;
- \* on the driest stations, the growth increase was stronger than on the others. We can think that more abundant precipitations had allowed better growth.

The radial growth long term trend can be interpreted as a result of an increase of air temperature going with a weak increase of rainfall, in relationship with the greenhouse of CO<sub>2</sub>. Therefore, pollutants would be predisposing or aggravating factors towards climatic stresses or/and unfavourable sylvicultural conditions. The direct action of CO<sub>2</sub> on radial growth and photosynthesis has to be more investigated to distinguish it from climatic results.

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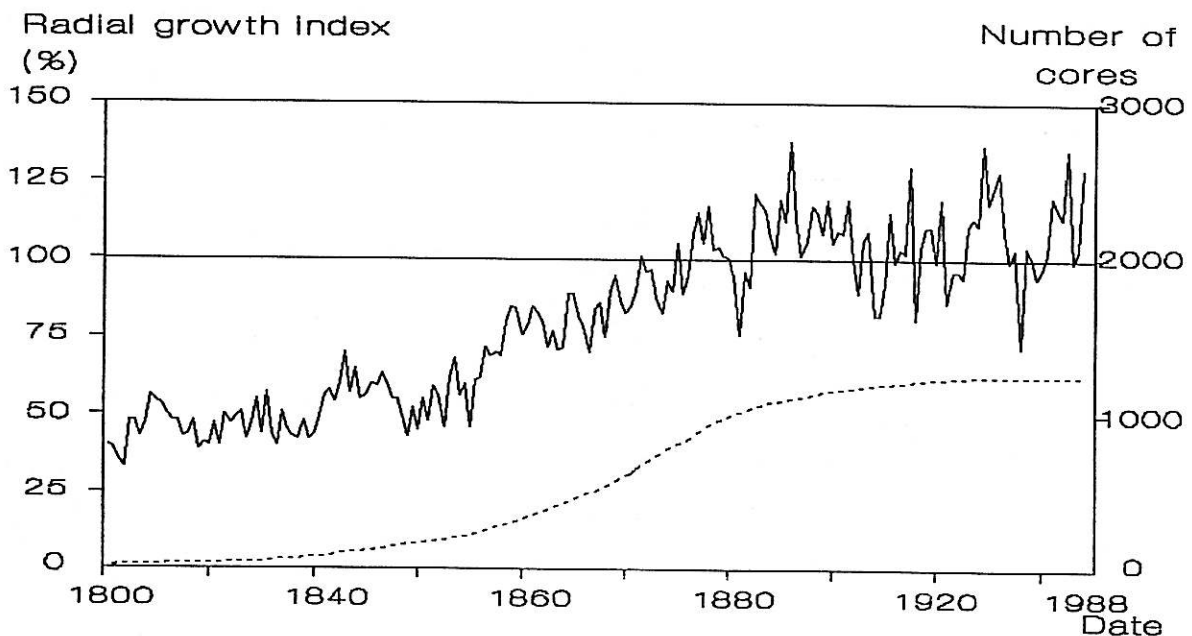


Fig.3. Long term trend: radial growth index (solid line) and number of tree rings (dotted line) according to date from 1801 to 1988.