

CHANGES IN EPICUTICULAR WAX OF *PINUS SYLVESTRIS* EXPOSED TO POLLUTED AIR.

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Scanning Electron Microscopy was used to structural changes in epicuticular wax of *Pinus sylvestris* with time. Changes in the contact angle of water droplets and in cuticular transpiration were also measured. By using material from a polluted and an unpolluted site it was shown that the ageing process occurs faster in polluted air, leading to greater cuticular transpiration and smaller contact angles at polluted sites.

Most leaf surfaces are covered by a layer of epicuticular wax which acts as a barrier between the cuticle and the atmosphere. The surface structure of the epicuticular wax on needles of a single provenance of *Pinus sylvestris* has been studied by scanning electron microscopy for trees growing in polluted air (with about $100 \mu\text{g SO}_2\text{m}^{-3}$) and in unpolluted air (with less than $10 \mu\text{g SO}_2\text{m}^{-3}$). When the newly emerged needle has fully expanded the epicuticular wax structure resembles a carpet of fine rods, approximately $1 \mu\text{m}$ in length, over both adaxial and abaxial surfaces of the needle. Over a period of months this structure begins to deteriorate until there is very little of the rod-like structure visible by the time that needle drop occurs.

Despite the large natural variability, even within similarly aged trees of the same provenance, it has been possible to follow the deterioration with time by assigning a 'structure rating' on the scale 0 (complete) to 4 (totally absent) to electron micrographs of needle surfaces of 'different ages'. It was observed that the initial rate of deterioration was twice as great for surfaces subjected to the polluted air as that for clean air, and that the structure had deteriorated almost totally within one year at the polluted site as opposed to two to three years in clean air (Figure 1). The mean life-time of the needles

was also affected, being 33 months in clean air and only 25 months in polluted air, where life-time is defined as the time required for loss of half the needles from the first order lateral branches.

The total mass of epicuticular wax ($160-200 \mu\text{g cm}^{-2}$), as determined by chloroform extraction, does not show a marked decrease with time, which suggests that removal of wax is not the major process involved but that changes of a physical and/or chemical nature occur *in situ*. The possibility of chemical change is presently under investigation. The wax extraction method also showed the presence of significant quantities of chloroform - insoluble material

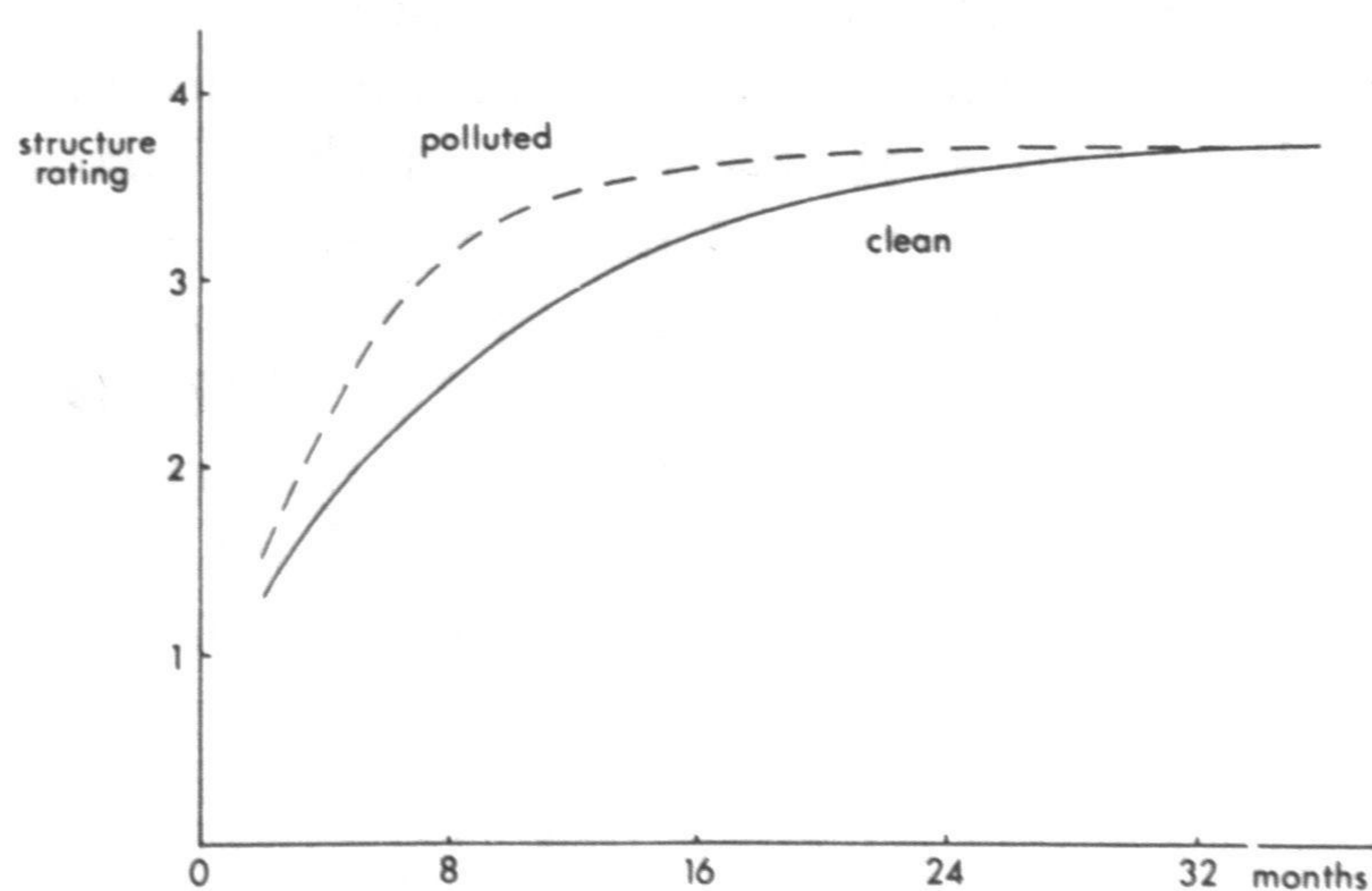


Figure 1. Rate of change in epicuticular wax structure at a polluted and an unpolluted site. The scale ranges from 0 (perfect structure) to 4 (no structure).

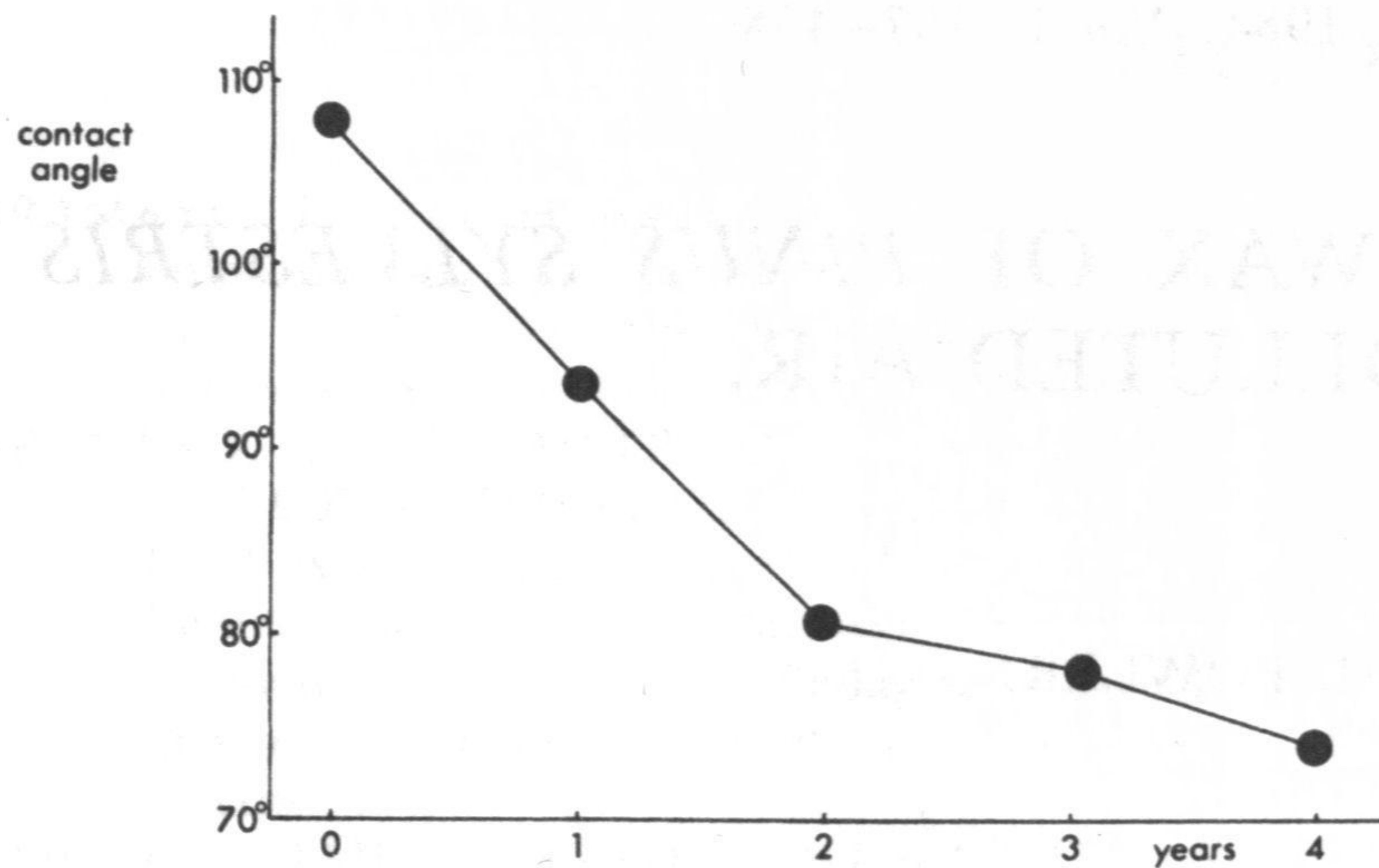


Figure 2. Rate of change in contact angle of a water droplet on the surface of a needle.

(up to $30 \mu\text{g cm}^{-2}$), particularly at the polluted site, which had presumably been deposited from the atmosphere on the needle surface.

Another indication of the change in surface structure is the change in contact angle of water droplets. This was observed to decrease from $108^\circ \pm 4^\circ$ to $78^\circ \pm 7^\circ$ during three years' exposure, and greatly affects the amount of water which may be retained on a needle surface, the smaller contact angle resulting in a several-fold decrease in water on the needle surface, even although the surface is then well wetted. (Figure 2).

The epicuticular wax also acts as a barrier to cuticular transpiration, and the cuticular resistance to transpiration has been measured for needles of different ages by following the

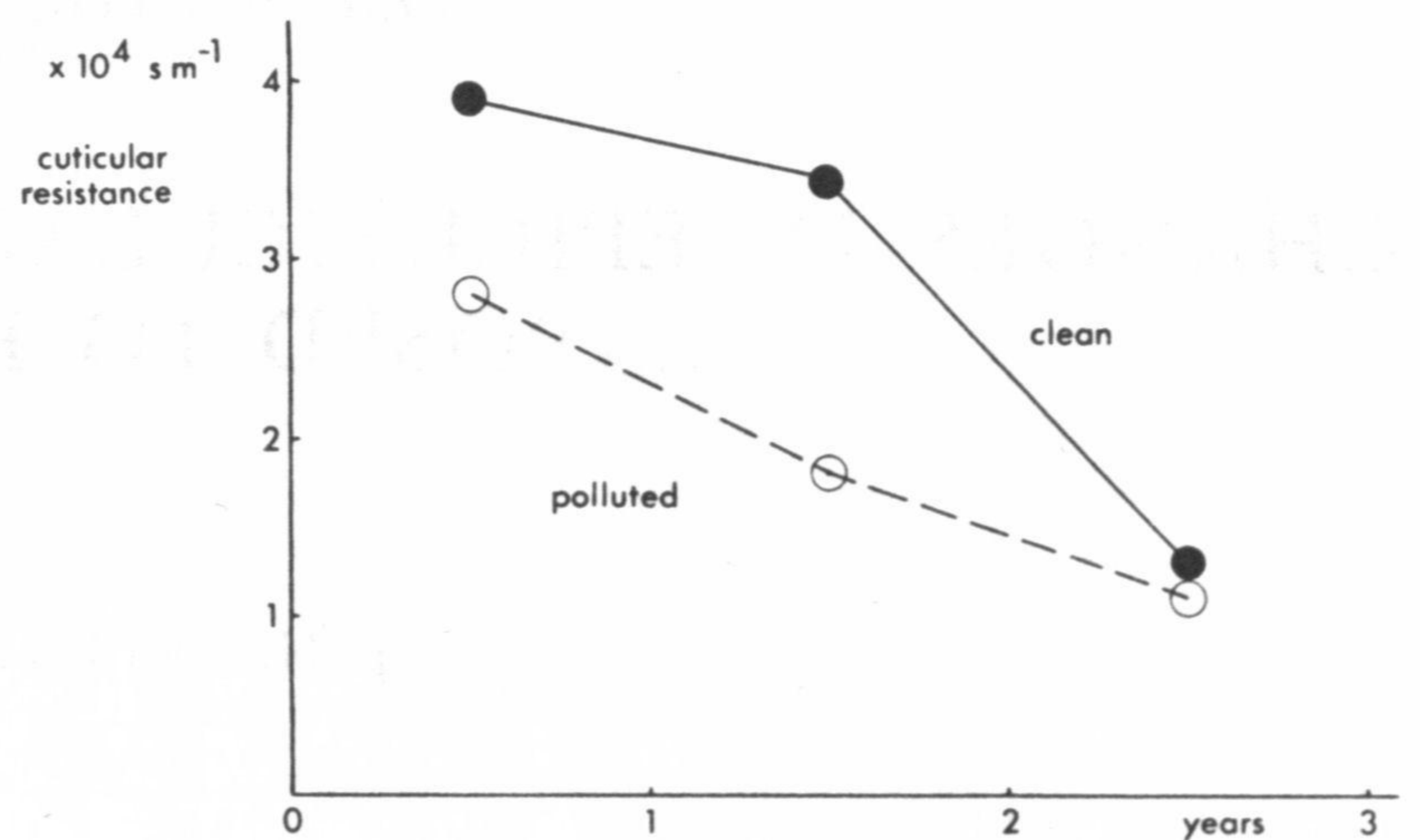


Figure 3. Rate of change in cuticular resistance ($r_{\text{CU}} \text{ s m}^{-1}$) of needles from a polluted and an unpolluted site.

loss of water vapour to air of known humidity. Although the cuticular resistance was generally large (10^4 – 10^5 s m^{-1}), there was a decrease with time which followed the changes in epicuticular wax structure, being greater for needles from the polluted site (Figure 3). This enhanced uncontrollable loss of water vapour may result in additional stress which may be significant for trees already under stress.

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