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USE OF CP IN LITTORAL FORESTS

Further to our discussion last week and as a prelude to our visit to Lossie, you will be interested to see this abstract from an article by Low and Greig summarising the results at Thetford from about 1960.

The rate of growth of CP compared with SP on the same site is such that we are probably justified in persevering with it.

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## SPRING FROSTS AFFECTING THE ESTABLISHMENT OF SECOND ROTATION CROPS IN THETFORD CHASE.

J D Low and B J W Greig

### Summary

Spring frosts in Thetford Chase cause a major reduction in the growth of young Corsican pine and very severe frosts or repeated frosting may kill the trees. Records of temperatures taken on a range of sites and in different conditions have shown that (a) spring frosts occur every year at Thetford, but the severe frosts which kill trees outright may only occur once every few years, (b) frost damage to plants mainly occurs when the trees are less than 18 in (45 cm) tall, (c) forest clearings larger than 5 acres (2 ha) do not act as artificial frost hollows, (d) cold air flows down slopes of more than 1° and accumulates at the bottom, forming a frosty zone.

Studies showed that frost damage can be minimized by (a) complete cultivation, (b) deep ploughing, (c) underplanting, and (d) strip felling. The benefits of these measures are demonstrated by temperature records and by measurements of tree growth.

### Discussion

The frequency and severity of spring frosts in the period 1921-30 when many of the first-rotation crops were established, were compared with the period 1958-65 by Hurst (1966). He concluded that the early period was just as frost-prone as the later period when the second rotation crops were being established.

The main damage by frost occurs on young trees less than 18 in tall, which are growing on sites covered with low grass/herb vegetation. These studies have shown that changes in the plants' environment can readily be made which will reduce frost damage. The most important factor appears to be the vegetation cover and if this is removed to give bare soil conditions, there is less frost damage. There is a rapid radiation loss from grass or litter which cools the adjacent air, the temperature eventually falling below freezing. Soil has good heat retention and thermal conductivity and can replace some of the radiation loss at the bare soil surface, the temperature of which does not fall as low as that of superficial litter of low grass/herb vegetation and thus prevents the build-up of a layer of freezing air. Also the young trees themselves are warmed directly by heat radiating up from the bare soil, while the grass or litter acts as an insulating mat, cutting off this supply.

Deep ploughing which produces a large surface area of bare soil gives similar results to complete bare soil in terms of tree growth and frost risk. The bottom of deep-plough furrows is warmer than that of the furrows made by shallow ploughing, and gives favourable conditions for tree growth.

Frost damage can also be reduced by use of shelter, either overhead shelter from standing trees or side shelter giving protection in narrow rides or strip fellings. Protection is reduced as the number of trees left standing is reduced and as the width of strips is increased. Only the smaller clearings of approximately 0.5 acres give protection; clearings of between 1 and 3 acres were especially cold. Increase in size of clearing above 4 acres did not appear to influence the severity of frost damage.

Frost damage was often greatest at the bottom of slopes in clearings, for it was

shown that cold air would flow down slopes exceeding  $1^{\circ}$  and accumulate at the bottom on nights when frosts occurred. These areas may be identified and planted with Scots pine which are more frost-hardy than Corsican pine.

It has clearly emerged that on most sites frost damage is restricted to a shallow zone close to the ground. Once a plant has grown above this zone, further check to growth by frost is unlikely to occur. The arrays of thermometers demonstrated this gradient of increasing temperature with height and plants were frequently observed with undamaged leading shoots growing strongly above the frost zone, even though damage was still occurring to some lower shoots.

Each of the methods shown in this paper to be capable of reducing frost damage would require changes in either harvesting or establishment techniques. The most important change is the provision of bare soil, which we consider essential if vigorous, well stocked crops of Corsican pine are to be established without cover in areas where damaging spring frosts regularly occur. This applies to both first and second rotation plantings. Bare soil may be achieved by complete cultivation or by ploughing using machines which produce deep, broad furrows giving almost 100 per cent exposure of soil. Experiments have shown that these operations can be achieved at moderate costs. There is evidence that with these bare soil conditions, establishment costs may be considerably lower than with traditional methods. On some sites in Thetford in recent years, deeper ploughing has been carried out and excellent establishment and growth of Corsican pine has occurred. However, where ploughing has not been adequate (in terms of exposure of bare soil) then growth and survival has been poor. The effect of ploughing on soil aeration in freely drained soils of Thetford Chase is likely to be minimal and not a factor influencing tree growth. On the shallow soils in Thetford Chase, particularly those of the Newmarket Series, deep ploughing may not be practicable.

We consider that the main benefit of the bare soil conditions is in the amelioration of temperatures and that the control of vegetation competition also gained by these operations is of less importance to tree growth. General observations supported by some evidence from artificial frosting experiments (author's unpublished data) suggest that trees suffer only minimal damage from frost in the first spring after planting. Trees flush later and have only limited shoot growth in the first year and frost damage occurs mainly in the second and subsequent seasons. Thus the benefits afforded by the bare soil conditions are not immediately apparent for there is generally very little difference in height growth between plants on bare soil and sites with grass or other coverings at the end of the first growing season. However, there are important differences in the condition of plants at this stage; examination of plants showed that both root growth and bud formation are generally superior in the trees grown on the bare soil and these factors enable the plant to grow more strongly in the second and subsequent seasons. Plants on bare soil grow quickly and are usually above the damaging frost zone of  $18^{\circ}$  in within 2 to 3 years. Plants on grassy areas, however, may be within the frost zone close to the ground for several years and therefore be subjected to repeated frosting. Additional research is required to determine the full effect of maintaining bare soil conditions for several years after planting.

It may be possible by producing bare soil conditions to extend the use of frost-susceptible species on sites conventionally considered too risky and where a lower yielding species has been the accepted choice. Replanting under an overwood or in felled strips are satisfactory alternative methods of establishing a wide range of conifer species on frosty sites. The benefits of the reduced frost risk on underplanted Corsican pine are offset by the possible etiolation of the plants caused by the reduction in light. A balance needs to be kept between the light requirement of Corsican pine and the amount of shelter needed for protection against frost.

On some felled areas where ploughing is carried out, concern has been expressed regarding the risk of *Fomes annosus* infecting damaged or disturbed stumps or broken

roots. Pine stumps should be treated at felling with a suspension containing *Peniophora gigantea*, a competitive fungus which will combat *F. annosus* and decay the stumps (Rishbeth, 1963). With this treatment the risk of *F. annosus* developing in the stumps will be reduced and if some of the stumps are totally removed from the ground by ploughing the level of *F. annosus* infection on the site may be still further lowered.

*F. annosus* grows in the stumps of felled trees and the disease can be eradicated from badly infested sites by mechanical removal of these stumps. The operation of stump removal incidentally produces bare soil, and once the stumps are out of the ground, the site can easily be levelled and cultivated. Stump removal to control *F. annosus* with resulting bare soil conditions can be achieved using several methods and types of machines. Recent trials in Thetford Chase have shown that the operation is feasible, and can be achieved at acceptable cost (Greig and Burdekin, 1970).

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