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STUMP TREATMENT AGAINST FOMES: A COMPARISON OF COSTS AND BENEFITS, by

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Abstract

Treatment of freshly cut conifer stumps is common practice in Britain in order to protect against Fomes root and butt rot. An analysis of costs and benefits is presented which suggests that on strictly commercial grounds stump treatment may only be justified on sites with high risks of disease. However, on other sites non-market benefits may be an important consideration and make treatment worthwhile.

Introduction

1. Stump protection against Fomes root and butt rot caused by *Heterobasidion annosum* was introduced in the early 1960s. The impetus for control came from losses experienced in pine at Thetford Forest and from surveys which showed that disease caused by Fomes was occurring elsewhere in the country and in species other than pine. Although it was recognised that soil has a major influence on the severity of disease, there was insufficient evidence available in the 1960s to define the circumstances under which disease risks might be low enough to justify excluding certain site types from treatment. At about this time, extensive areas of first rotation crops planted since 1945 were reaching the first thinning stage. These crops were free of the disease, but would be susceptible to infection when thinned. Stump protection was therefore introduced as an insurance, pending further research, to prevent infection of these plantations. A policy to this effect has since been followed throughout the Forestry Commission's estate and may have played a part in maintaining the disease at its present low level. Information is now available from a 20-year Forestry Commission research programme which permits losses to be predicted for the major soil types, thus enabling a better comparison to be made of the costs and benefits of protection.

Modelling disease development

2. The commercial benefits of stump protection can be estimated by calculating the losses which would otherwise occur in the absence of protection. For Sitka spruce, sufficient information is now available from observations and experiments to estimate losses by assigning 'probabilities of occurrence' to each of seven stages in a model of disease development based on the Fomes life cycle (Pratt *et al.*, 1989). Thus, in the model, a proportion of freshly cut stumps is assumed to be infected by spores at each thinning and at clear felling. Some of these stumps are sufficiently colonised by the fungus to act as sources of infection for neighbouring trees via root contacts. Trees infected in this way may or may not become decayed before they are felled. Stumps from such trees may also infect adjacent healthy trees. At the end of the first rotation, a proportion of infected stumps carries the disease over into the following crop. A crucial difference between the first rotation and all subsequent rotations is that young trees planted next to stumps from the previous crop may be infected and decayed even before the first thinning provides fresh stumps for infection by spores. Thus disease levels in the second and subsequent rotations exceed those in the first rotation. It is the ability of the fungus to carry over the disease from one rotation to the next that makes it such a hazard in the long term.

3. Certain assumptions have had to be made about the disease cycle to simplify the model, and the values chosen for each probability are derived from information of varying quality. Nevertheless comparison with the few written accounts of the disease in Sitka spruce suggests that levels predicted by the model fall within the ranges observed in practice.

Factors affecting disease

4. The major factors affecting the incidence of disease in Sitka spruce are the risk of stump infection by spores and the effect of soil on below-ground spread of the fungus via root contacts.

5. Recent trials have shown that while the incidence of spore infection in untreated Sitka spruce thinning stumps is generally low, usually < 10%, it can exceed 60% on some sites. There is evidence that low levels of infection are primarily due to a lack of spores and that high levels are related to the presence of local spore sources. Thus, as more forests enter the second rotation, spore loads, and consequently the risk of stump infection, can be expected to increase generally – a process which may accelerate with any reduction in the area of forest protected by stump treatment.

6. The risk of below-ground spread is strongly related to soil type (Redfern, 1984): deep peats present the lowest risk whereas mineral soils, especially gleys, permit high rates of spread. This is illustrated in Figure 1 which shows disease incidence modelled over three rotations, assuming two levels of risk for spore-infection of stumps and two levels of risk for below-ground spread. The graphs demonstrate three important features of the disease:

   1) losses build up during the course of each rotation;

   2) disease incidence increases with successive rotations;

   3) the risk of below-ground spread, through the influence of soil type, has an overriding effect on disease development.

   Soil type is therefore of considerable importance, with peaty soils being at little risk even with high levels of spore infection. There is some evidence that the amelioration of peats by ploughing can increase the rate of disease spread on these soils, but the importance of this effect is not known.

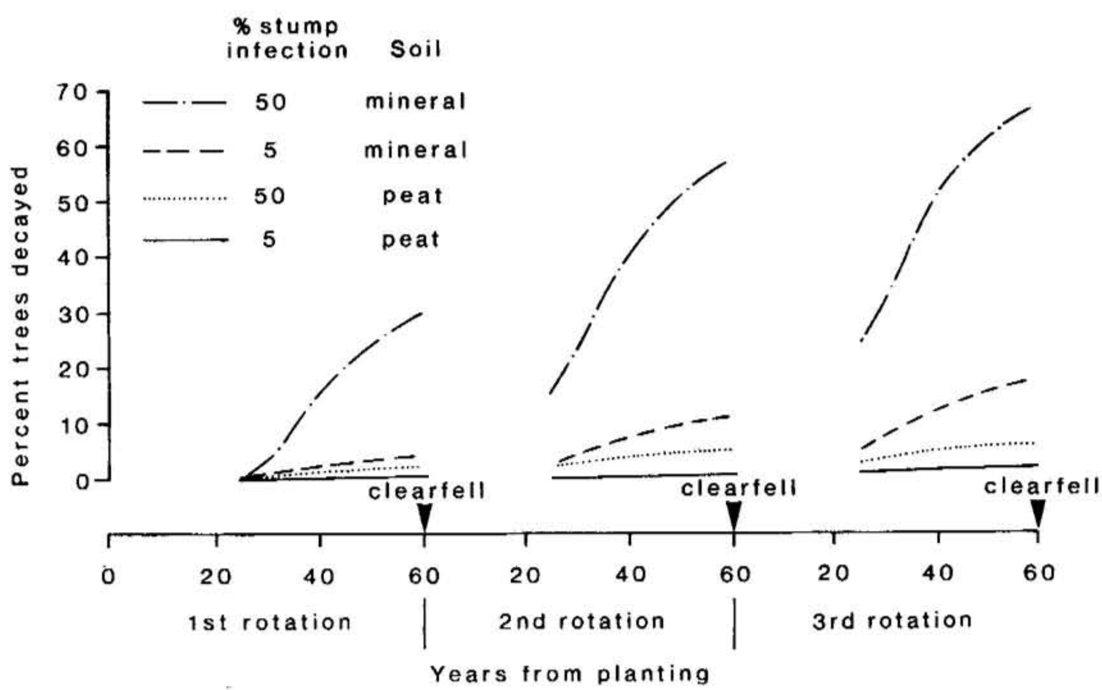

Figure 1. Four predictions of disease development in Sitka spruce showing the effects on disease development of two soils and two frequencies of stump infection by spores.

Cost–benefit analysis

7. Stump treatment costs vary, especially between manual and machine application. The costs of manual application are not difficult to quantify, but techniques of machine application are still being developed and estimates of costs are unavoidably imprecise. They may change in future.

8. Benefits are less readily quantified. Not only do they extend over several rotations but they could also include presently unquantifiable, indirect advantages such as a generally healthy forest. At the simplest level, benefits consist of the volume and value of timber that would be lost in the absence of protection. This loss can be calculated from the disease incidence predicted by the biological model using yield tables and prevailing timber prices.

9. The model was used to predict disease incidence over two rotations on peat soils and on mineral soils, which have low and high risks of below-ground spread respectively. Four levels of spore infection risk (5%, 12%, 25% and 50%) were used to provide a range between the low and high levels of incidence referred to earlier.

10. Some test analyses, based on a comparison between the current costs of treatment and direct losses over two rotations, were conducted for Yield Classes 8, 12, 16 and 20 Sitka spruce, at two metre spacing and thinned according to management tables. Non-thinned crops of Yield Classes 8 and 12 were also considered. A 6% discount rate was used and two treatment costs, £0.20 m^{-3} and £0.30 m^{-3}, were tested.

11. In all non-thinned crops, and in thinned crops on peat soils, predicted losses were too low to justify treatment at even the highest level of spore infection assumed. However for thinned crops on mineral soils (see Table 1), in which losses are higher, treatment provides a financial benefit for all except the lowest levels of spore infection.

Table 1. Expected profitability (£ ha^{-1}) of stump treatment over two rotations of Sitka spruce on mineral soil for four levels of spore infection (5%, 12%, 25% and 50%) and two costs of treatment (20p m^{-3}, 30p m^{-3})

Treatment cost	*20p*				*30p*			
Spore infection %	*5*	*12*	*25*	*50*	*5*	*12*	*25*	*50*
YC8 NT	-3.3	-3.1	-2.9	-2.4	-4.9	-4.8	-4.6	-4.1
YC12 NT	-5.8	-5.6	-5.1	-3.9	-8.8	-8.6	-8.1	-6.8
YC8 MTT	-3.3	**1.2**	**10.2**	**21.3**	-5.6	-1.3	**7.9**	**18.9**
YC12 MTT	-3.3	**1.5**	**23.0**	**53.8**	-8.6	-3.4	**18.2**	**49.0**
YC16 MTT	-10.7	**3.4**	**29.6**	**72.3**	-18.6	-4.5	**21.7**	**64.4**
YC20 MTT	-14.6	-0.7	**34.9**	**99.1**	-25.3	-11.4	**24.1**	**88.4**

Notes: NT non-thin
MTT thinned according to management table prescription
Figures in bold show profitable treatments, i.e. improvements in the market value of timber which are directly attributable to stump treatment

Discussion and conclusions

12. The analysis presented here suggests that on strictly commercial grounds, stump protection in Sitka spruce appears to be justifiable on mineral soils subject to high ambient spore loads, but not on peat soils. However, a more general use of stump treatment might be appropriate if costs fall, or if the non-market benefits of treatment, such as the value attached to maintaining generally disease-free crops, are taken into consideration. It is also relevant, as already mentioned, that an element of uncertainty exists about disease development on peat sites prepared by modern techniques, since the effect of site amelioration on the behaviour of *H. annosum* has not yet been fully explored.

13. Where a decision is taken to exclude some crops from treatment, the selection should clearly be based mainly on soil type. In the uplands, where peat and mineral soils are frequently intermingled over relatively small areas, a compromise between operational constraints and biological ideals may be necessary in the choice of sites.

14. In practice the spore infection risk is difficult to quantify, but as a general guide the presence of local spore sources can be expected to increase the risk greatly. Such sources are likely to exist in places where forests include second and third rotation crops. However, they can develop even in first rotation forests since logs discarded in thinning or felling operations can readily become colonised and subsequently form basidiocarps (Redfern, unpublished). In practice it is therefore probably best to assume that spore infection risks are uniformly high.

15. Although the research work on which this report was based was solely concerned with decay in Sitka spruce, there is little reason to believe the disease would develop differently in Norway spruce or in the larches. In pines the picture is rather different. Pines are subject to killing attacks and rarely become decayed. Mortality is particularly serious on high pH soils, and effective treatment is essential on these sites. By contrast, on acidic soils mortality is likely to be much lower. However pine stumps are particularly susceptible to spore infection, and losses may be very high where spruce is mixed with pine or succeeds it in later rotations.

16. It should be noted that if stump treatment is abandoned on a site and losses are then found to be unacceptably high, there will be little benefit in resuming treatment. Once a site becomes infested, disease can only be reduced in future rotations by stump removal, an operation which is not normally practicable, or by using resistant species such as broadleaves.

17. Further information and advice on risk assessment for individual crops or larger areas can be provided by the Forestry Authority, Research Division, Pathology Branch, Northern Research Station, Roslin, Midlothian EH25 9SY; telephone: 0131 445 2176.

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