MANAGEMENT OF TASMANIAN FORESTS AFFECTED BY REGROWTH DIEBACK

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ABSTRACT

Economically, regrowth dieback is the most serious of Tasmania's eucalypt crown dieback diseases. Uncertainty as to the cause of this disease constrains the management of dieback-affected forests. Intensive surveys after droughts may be warranted to check the area and severity of dieback. Decisions could then be made about the need to adjust yield predictions or harvesting schedules. Silvicultural treatments that increase the rate of wood production could be used to help reduce future crop losses due to the disease.

Keywords: dieback; regrowth dieback; management planning; *Eucalyptus obliqua; Eucalyptus regnans.*

INTRODUCTION

Much of the tall-open forest of *Eucalyptus regnans* F. Muell. and *E. obliqua* L'Herit. is now stocked with even-aged stands of regrowth resulting from regeneration after logging or wildfire in the natural forest between 1890 and 1940. These forests are of considerable economic importance to forestry in Tasmania, particularly for the future supply of sawlogs. It is 25 years since the symptoms of a disease, now known as regrowth dieback, were first recognised in these forests (Bowling & McLeod 1968). Since that time the disease has become widespread in Tasmania (Fig. 1) and its economic impact substantial (West & Podger 1980).

Regrowth dieback affects dominant and co-dominant trees of *E. regnans* and *E. obliqua* in regrowth forests older than 30–40 years. It causes higher than expected mortality and reduced growth rates. Diseased trees suffer progressive death of the primary crown coupled with epicormic shoot production of variable longevity. Podger *et al.* (1980) and Palzer (1985) have provided detailed descriptions of the symptoms of the disease.

Despite a considerable research effort, the aetiology of regrowth dieback is unresolved. Podger *et al.* (1980) concluded that occurrence of the disease was not correlated with any particular site or stand factors. Similarly, no potential pathogen or insect pest was constantly associated with the disease (Kile 1974, 1980; Podger *et al.* 1980; C. Palzer and T.J. Wardlaw unpubl. data). There is, however, circumstantial evidence linking the chronology of symptom development with drought events (West 1979; Podger *et al.* 1980; Wardlaw unpubl. data). The random distribution of affected trees within stands (Ratkowski *et al.* 1980) is consistent with such a hypothesis.

Although constrained by uncertainty as to the cause of the disease, adjustments have been made to management planning to account for its impact on wood production. This paper describes the management prescriptions which have been developed for the treatment of forests affected by regrowth dieback to account for the effect of disease on yield and the criteria on which decisions to salvage-log are made.

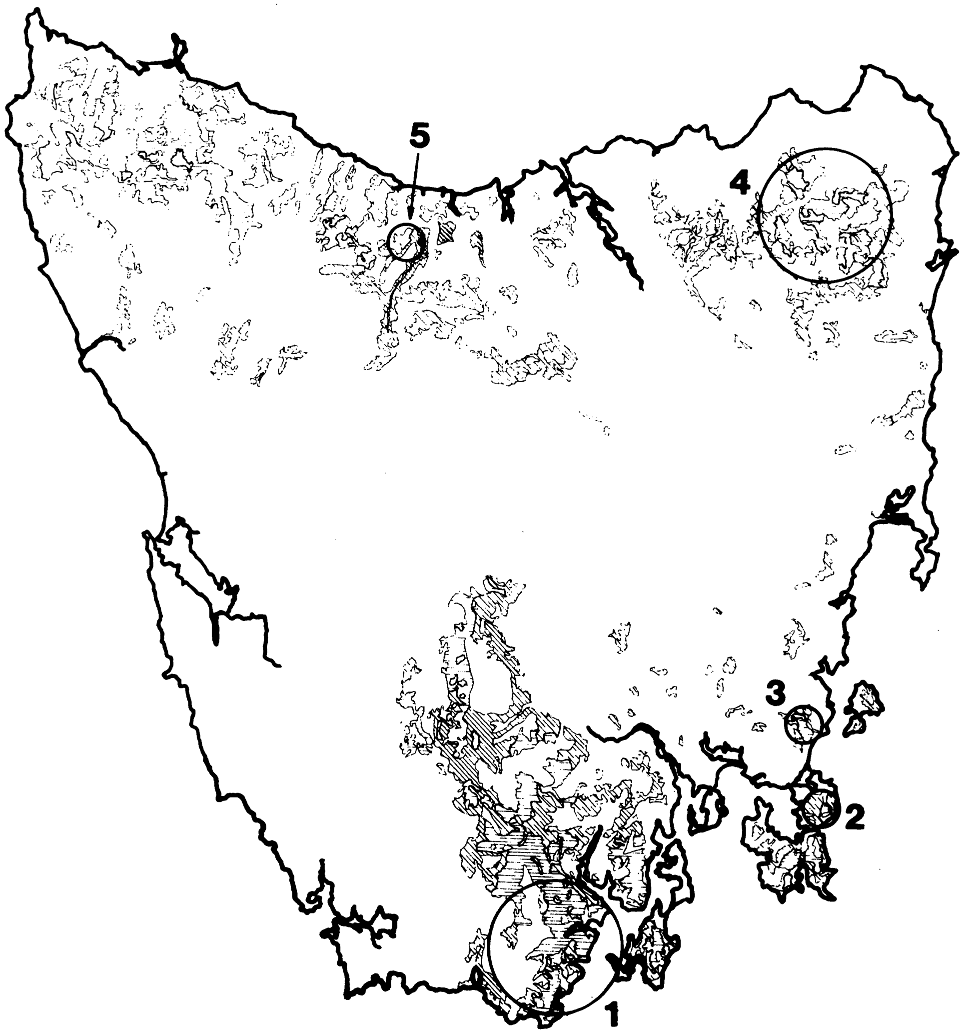

FIG. 1 — Location of *Eucalyptus obliqua–E. regnans* tall forests (based on Kirkpatrick & Dickinson 1984). Main centres of regrowth dieback activity are circled and the numbers correspond with Southern Forests (1), Forestier Peninsula (2), Wielangta (3), Scottsdale District (4), and Castra (5).

MANAGEMENT IN EXISTING REGROWTH FORESTS

In the absence of retrogressive conditions, fully stocked *E. regnans* - *E. obliqua* regrowth forests are managed as even-aged stands with a rotation of 80–110 years. The crop is usually harvested at the end of the rotation in a clearfelling operation to yield sawlogs and pulpwood. The preferred order in which regrowth forests within a site-quality class are harvested is from the oldest to youngest, but with adjustment to harvest at an earlier age damaged, diseased, or understocked forests.

A primary objective of management planning is to provide a uniform supply of sawlogs and pulpwood to industry on a sustaining basis. Working plans, revised every 10 years, allocate an annual quota of area of different forest types available for harvesting. To achieve sustained yields, working plans are based on projected yields at each decade of the rotation for different forest types. Projected yields for the different forest types are calculated by "growing-on" assessed tree volumes in permanent inventory plots using yield tables based on age, site quality, and plot volumes at the date of last assessment (Forestry Commission of Tasmania 1983).

Regrowth dieback impinges on both the harvesting sequence and future yield and therefore needs to be accounted for in management planning. For this to be done requires firstly the detection of dieback and secondly an assessment of the area and severity of dieback, before any adjustments can be made to predicted future yields and harvesting sequences.

Detection

Detection of dieback activity is based entirely on chance observation by staff during their routine field duties. The lack of any distinct association between regrowth dieback and site or stand characteristics precludes the development of hazard ratings which would allow a more directed approach to surveys. The close coincidence of severe drought episodes and the appearance of regrowth dieback symptoms, however, could simplify the timing and location of surveys.

Assessment of Tree Health

The extent and severity of disease have been assessed both by ground-based survey and by aerial photography. CSIRO Division of Forestry and Forest Products (formerly Division of Forest Research) have assessed, from the ground, crown health of individual trees in permanent plots using a four-part rating consisting of:

(1) The proportion of the primary branches which has died back (in 10% steps);

(2) The proportion of the current tree crown which is of epicormic origin (in 10% steps);

(3) The length of dead top (in metres);

(4) Current crown as a proportion of the estimated original crown (in 10% steps).

Kile *et al.* (1981) showed that parameters (1), (2), and (4) were highly correlated, and usually the proportion of primary branch dieback (primary crown dieback rating; PCD) is used to express crown health (e.g., West 1979; West & Podger 1980; Podger *et al.* 1980).

Podger *et al.* (1980) partitioned the PCD into three classes, viz<20%, 20–40%, and >40% corresponding to healthy, affected, and severely affected trees. Wardlaw (unpubl. data) has shown that the PCD is a strong determinant of rates of basal area growth of trees within the severely affected class (>40% PCD) but that at 40% PCD or less, PCD has a much weaker correlation with growth (Fig. 2). This suggests that two classes — <40% and >40% — may provide sufficient resolution for the routine assessment of crown health.

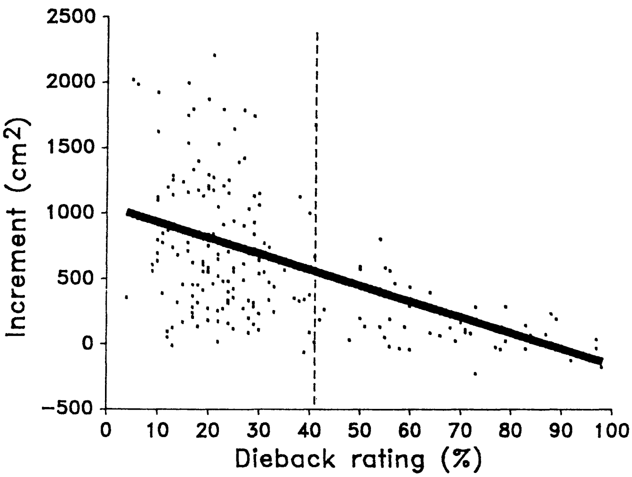

FIG. 2 — Plot of average primary crown dieback rating (from annual measurements between 1971 and 1982) on 1971–82 basal area increment, based on data from dominant and co-dominant trees on CSIRO plots O060, O063, E009, and E015 (*see* West 1979 for plot details). The solid line represents the regression equation Y = 1054 − 12.1 (X).

Myers & Bird (1978) demonstrated that, with experienced photo-interpreters, it was possible, at about 80% accuracy, to classify individual trees into four crown-health classes — healthy, dieback-affected, advanced dieback, and dead — from large-scale colour aerial photographs.

On the basis of the preliminary study by Myers & Bird a prescription for aerial photography was developed (Table 1) for assessing dieback severity in regrowth forests. Using this prescription some 23% of the regrowth area (approx. 10 000 ha) of the Southern Forests was photographed in 1979 to provide information on the extent and severity of dieback for use in the 1983 revision of the Working Plan for the Southern Forests. The photocentre of each photograph was used as the centre of a variable sized plot, each plot having 15–30 trees. Each tree in the plots was examined and assigned to one of the four dieback classes used by Myers & Bird (1978). The intention was that the interpretation results would provide information on the proportion of the regrowth area affected as well as the average proportion of each dieback class within affected forests. It was found, however, that the interpretation of this photography yielded

TABLE 1—Summary of recommendations for aerial photography for regrowth dieback assessment

Parameter	Types compared and recommended type*	Reason for recommendation
Film type	Normal* / Infrared colour transparencies	Greater exposure/processing consistency. Better definition in shaded areas.
Scale	1:1000 – 1:8000 1:4000 *	Only dead and healthy trees are reliably recognised at scales smaller than 1:4000. No gain in crown health information at scales larger than 1:4000.
Illumination	Sunlit * / Shadowless	Shadowless superior but rejected because of the scarcity of suitable days during summer.

results which were inconsistent with local knowledge of the disease. Although the reasons for the discrepancies are unknown, the extreme tedium experienced by the photo-interpreters during the assessment of the large number of photographs (A. Rainbird pers. comm.) may have been a factor. It is likely that this factor alone would preclude the future use of aerial photography for assessing dieback severity over large areas.

Classification of dieback severity on a stand basis has been used routinely in ground surveys to map dieback severity over large areas. However, M. Stone (pers. comm.) cautions the use of such survey data in yield predictions because the presence of relatively few dead or dying trees, which can significantly reduce yield, can be masked in areas of predominantly healthy trees.

Yield Prediction

Where the extent and severity of regrowth dieback in an area of forest are known, estimates of yield prediction can be adjusted provided that a relationship between dieback severity and growth rates has been established and that further development of the disease can be modelled.

The relationship between dieback severity and growth rates from three independent studies, all based on measurements of CSIRO permanent yield plots in the Southern Forests, is summarised in Table 2 (see West 1979 for plot details). The relationship calculated by Stone (pers. comm.) was used to adjust yields for the 1983 revision of the working plan for the Southern Forests (Forestry Commission of Tasmania 1983). The reduction of growth rates with increasing dieback severity is considerably higher in the measured data of Podger *et al.* (1980) and Wardlaw (unpubl. data) than the comparatively minor effects in the modelled data of Stone. This apparent over-estimation of yield from severely affected trees, using Stone's data, warrants investigation prior to its further application in discounting future yield from dieback-affected areas.

The constancy of yield depression over time in trees severely affected by dieback needs to be considered also when applying yield discounts. Podger *et al.* (1980)

Table 2—Summary of the relationship between growth rates and primary crown dieback (PCD) rating established in three independent studies

Ratio of growth rates for dieback severity classes A:B:C*	Study	Method used for calculating ratio
0.86 : 0.84 : 0.55	M. Stone (unpubl. data)	Ratio of observed : predicted yields in increment periods 1971–78. Predicted yields based on a single-tree growth model (West 1981) for trees unaffected by regrowth dieback. Dieback class at start of increment period.
1 : 0.5 : 0.17	Podger *et al.* (1980)	Proportion of diameter increment (over a 31-month period) achieved by trees in dieback classes B and C relative to trees in dieback class A. Dieback class at start of increment period.
0.89 : 0.62 : 0.18	T. Wardlaw (unpubl. data)	Calculated from the regression of relative basal area increment (1971–82) on average dieback class (calculated from PCD measured annually between 1971 and 1982).

* Dieback classes: <20% (A), 20–40% (B), >40% (C).

observed no recovery in growth rates in severely dieback-affected trees leading them to the conclusion that once present the disease is irreversible. This conclusion is supported by unpublished data of the author which shows similar depressions in basal area increment rates over 11 years both in trees severely affected throughout the 11-year period and in trees which became severely affected later in the period.

M. Stone (pers. comm.) used the observed behaviour of individual trees in moving between dieback severity classes over time to calculate the probabilities of trees moving between dieback classes in the future (Markov chain). The validity of this approach required that two assumptions be made:

(1) The condition of any one tree is independent of another;

(2) The development of regrowth dieback is independent of time.

The first assumption, although not proven, is consistent with random distribution of affected trees (Ratkowski *et al.* 1980). The second assumption, however, is difficult to sustain. An examination of the development of regrowth dieback in four CSIRO permanent plots measured annually between 1971 and 1982 led Wardlaw (unpubl. data) to the conclusion that regrowth dieback symptoms intensify rapidly over a short time period and then slowly stabilise (Fig. 3) rather than develop uniformly over time. In the last few years (early 1980s and beyond) symptoms appear to be stabilising in the Southern Forests (the late D.E. McLeod and P. Rowe pers. comm.). For the purposes of yield prediction it would seem more appropriate to consider regrowth dieback to be a short-term response (decade) to an event rather than an ever-present disease which continues to develop as the stand ages.

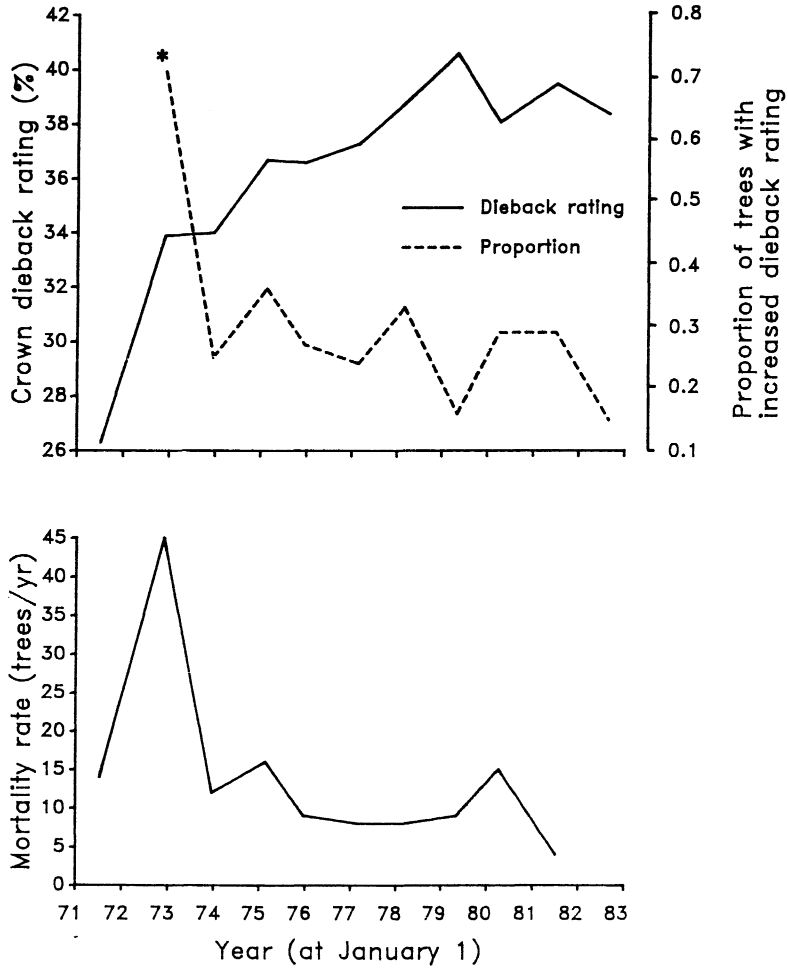

FIG. 3 — Time series of primary crown dieback ratings, proportion of the trees with increasing dieback ratings, and mortality rate based on data from dominant and co-dominant trees on CSIRO plots O060, O063, E009, and E015 (*see* West 1979 for plot details). The asterisk corresponds to the plot measurements at the end of a period of severe water stress.

Salvage of Dieback-affected Areas

Salvage logging is an appropriate treatment in dieback-affected areas when:

(1) Nett wood production, on an area basis, is static or decreasing due to mortality or severe primary crown dieback;

(2) The retrieval of sawlogs and pulpwood in dead or dying trees prior to degradation beyond merchantability is an economic proposition.

Because the level of dieback severity at which wood production becomes static or declines is not known, salvage operations in the Southern Forests have been determined primarily on the basis of standing volume of dead and severely affected trees, but with consideration of other operational constraints (R. van Schie pers. comm.). In the absence of operational constraints, salvage is based upon the following considerations:

(1) That salvage of merchantable sawlogs is the primary objective;

(2) That sawlog quality does not deteriorate in living trees no matter how severely dieback-affected (Kile *et al.* 1981);

(3) Severely dieback-affected trees are more likely to die in future episodes of regrowth dieback than are healthy trees.

(4) That dead trees rapidly degrade below sawlog standards, mainly through the formation of suncracks (Podger *et al.* 1980).

The following protocol, in decreasing order of priority (conditioned by timber volumes available and the cost of providing access), is proposed for planning salvage:

(1) Dead but merchantable sawlogs, with the proviso that access is already established;

(2) Merchantable sawlogs in trees with severe primary crown dieback (> 40% primary crown loss);

(3) Dead or severely dieback-affected trees containing merchantable pulpwood.

MANAGEMENT OF YOUNG FORESTS TO MINIMISE IMPACT OF FUTURE EPISODES OF REGROWTH DIEBACK

Silvicultural treatments which increase the rate of wood production may be useful for the management of regrowth dieback. The rationale for this suggestion is that regrowth dieback is age, not size, dependent so that in faster-grown crops there is an increased likelihood that a merchantable crop will develop before regrowth dieback occurs.

Thinning

The incidence of regrowth dieback is largely independent of stand density (Podger *et al.* 1980). This is reflected in several surveys done by the Forestry Commission in which no significant differences in dieback severity were found between thinned and adjacent unthinned stands (Table 3). This holds for stands thinned prior to the expression of crown dieback symptoms (i.e., no selection was possible for dieback-affected trees), or after the development of crown dieback symptoms (where the more severely dieback-affected trees could be removed).

The use of thinning in forests affected by regrowth dieback or with the potential to become affected (young stands) must be seen as risk management. The principal benefit of thinning — the production of merchantable sawlogs at a younger age — must be balanced against the risk of creating understocked stands after episodes of active dieback at an age when few or none of the trees are of merchantable sawlog size and the risk of damage to retained trees associated with the thinning operation. Nett gains from thinning are likely to be greatest on the most productive sites. This conclusion is based on the principle referred to earlier, i.e., that the onset of dieback susceptibility is age and not size dependent.

Table 3—Percentage of trees severely dieback-affected or dead in thinned and unthinned plots in the Hastings area

Compartment or plot name	Year thinned	Year assessed	Dieback Thinned (%)	Dieback Unthinned (%)
H4q	1965	1969	31	33
H31q	1963	1978	17	17
H28s	1965	1978	41	53
H24p	1965	1978	17	28
0058/59	1936–47	1966	19	33
0060/62	1942–47	1966	38	23
0064/65	1939	1966	6	0

Selection for Dieback Resistance

Although species such as *E. globulus* Labill. and *E. viminalis* Labill. exhibit a high level of resistance to regrowth dieback (Bowling & McLeod 1968), the superiority of *E. obliqua* and *E. regnans* for sawn timber production necessitates their continued use for regeneration. No difference in susceptibility has been reported between *E. regnans* and *E. obliqua* in the Southern Forests. However, in the north of the State, *E. regnans* appears to be more severely dieback-affected than *E. obliqua.* In that situation the adjustment of species mixtures to favour *E. obliqua* for regeneration after logging would seem to be justified.

Opportunities for the selection, within susceptible species, for greater resistance to regrowth dieback are limited due to the long time required for expression of susceptibility. Selection on the basis of growth rate might indirectly assist in the management of regrowth dieback.

Other Silvicultural Treatments

Attempts to examine growth responses after the application of fertiliser and thinning treatments have been constrained by the masking effect of high levels of defoliation by the paropsine, *Chrysophtharta bimaculata* (Olivier) (W.A. Neilsen pers. comm.). Preliminary results of an integrated control programme for *C. bimaculata* in young trees have indicated that large gains in growth can be expected with insect control (H.J. Elliott pers. comm.).

CONCLUSIONS

Both future yield predictions and harvesting schedules may require adjustment in forests affected by regrowth dieback. In the first instance, detection of dieback activity within susceptible forests relies on chance observation during routine field duties, although more intensive surveys after severe droughts may be warranted. When active dieback is detected, ground-based surveys which measure the proportion of trees that are dead or have severe primary crown dieback (>40% primary crown loss) provide the most reliable means of assessing the area and severity of dieback. Once the area and severity of regrowth dieback are known, decisions can be made about the need to adjust yield predictions or harvesting schedules. The process by which such decisions can be made is charted in Fig. 4.

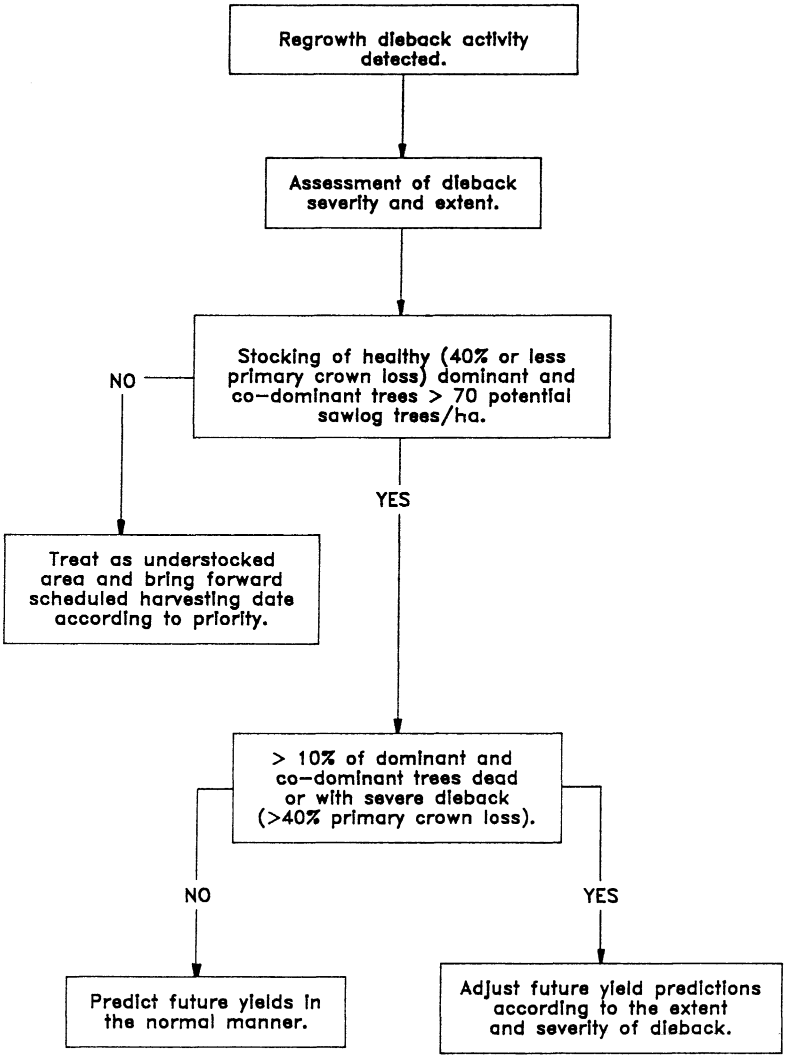

FIG. 4 — Process required for making decisions about the need to adjust yield predictions or harvesting schedules as a result of regrowth dieback.

Yield predictions are adjusted by discounting expected yields (in the absence of disease) according to the relationship between dieback severity and growth rates for the proportion of regrowth forest assessed to be affected by disease. The relationship between dieback severity and growth rates currently used for discounting yields, that calculated by M. Stone (pers. comm.), needs to be re-examined in view of its apparent under-estimation of growth rate reductions in trees severely affected by regrowth dieback. Discounts for the impact regrowth dieback has on yields should be applied uniformly for the duration of the rotation on the basis that (a) recovery of growth rates is unlikely in severely affected trees and (b) onset of active dieback is event-related, rather than an ever-present condition which continues to develop independently of time.

The adjustment of harvesting schedules to minimise loss of merchantable timber as a result of disease should be made on a priority basis with dead trees still merchantable as sawlogs growing in stands with ready access having the highest priority. Merchantable sawlogs in trees with severe dieback, and dead or severely dieback-affected trees containing only merchantable pulpwood, follow in decreasing order of priority. These priorities need to be conditioned by the volume of wood available and the cost of providing access.

Silvicultural treatments for young forests which can directly influence the future incidence of regrowth dieback are unavailable for the preferred species, *E. regnans* and *E. obliqua*. Treatments which increase growth rates may, however, indirectly lessen the future impact of regrowth dieback on timber yields given that regrowth dieback is age rather than size dependent.

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