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A PROGRESS REPORT ON THE
SOIL DRYNESS INDEX.

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SUMMARY

The Soil Dryness Index (S.D.I.) has been found to be an excellent measure of soil dryness. Soil studies have shown that the S.D.I. is far more sensitive and better represents the field soil situation than the Byram and Keetch Index. Further work is needed to adapt the S.D.I. to local conditions, thereby further increasing its useability.

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INTRODUCTION

Following criticism of the currently used Byram Drought Index (B.D.I.), a study of the Soil Drought Index (S.D.I.) was initiated.

The main criticism of the B.D.I. is its insensitivity and delay. Delaying a prescribed burn for up to 30 days until the index reaches 200 or some such figure is not acceptable as suitable burning days are in great shortage. The B.D.I. lags behind in both the wetting and the drying phases.

The S.D.I. is an index of soil dryness which estimates the amount of rain needed to bring the soil profile back to field capacity. It is based on Keeth and Byrams drought index (1968) and is adjusted to model run-off data and to seasonal variations.

APPLICATION

Soil dryness is related to the moisture contents of forest fuels so is an aid in determining fire hazards and fire behaviour. Being a measure of soil dryness it is a very good guide to the moisture status of living plants, particularly pine plantations.

Droughting and drought stress in Blackwood Valley plantations has a number of deleterious effects. Apart from the obvious effects of individual tree mortality and loss of wood, stands under drought stress are highly susceptible to death by even the mildest of fires. The lack of resistance to fire of pine stands further increases the fire hazard. This study is aimed at;

- a) testing the S.D.I. as developed by Mount (1972) against actual soil conditions, and

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- b) determining at what point^{of} the index Radiata pine is under drought stress.

METHOD

A weather station was set up under an exposed (northerly aspect) unthinned stand of 14 year old P. radiata in the Lewana plantation. Soils were shallow (up to 15") and well drained. Such an exposed site was chosen with the hope of the trees being subjected to drought stress.

Weekly samples of soil and living needle material were taken. Needles were sampled from the upper crown of randomly selected trees using a rifle. The needle material was collected and sealed in plastic bags. Soil samples were taken to depths of 15cm and 30cm and sealed in plastic bags.

The relative turgidity (R.T.) of the needle material was calculated. This R.T. figure is simply a moisture deficit. Initially, soil moisture content was determined using the oven drying technique (Williams and Sedgley 1965). This monitoring was initiated in September 1977. At this time, the S.D.I. was started on data collected by the on site weather station. Rain measurements were made in the open.

The Soil Drought Index

The calculation of the S.D.I. is based on the following equations which are taken from Keetch and Byram (1968) except for the flash run off parameter (F.R.).

$$\text{Effective rainfall (E.F.F.)} = P - I - FR \dots\dots\dots (1)$$

where (P) is the 24 hour rainfall (measured in the morning), (I) is the interception loss and (FR) the flash runoff.

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$P.M. (1) - E.F.F. (2) = A.M. (2) \text{ or } S.C.O. (2) \dots\dots(2).$

where P.M. (1) is the S.D.I. score for the afternoon of day 1 and E.F.F. (2) is the effective rainfall as measured on the morning of day 2. A.M. (2) is the S.D.I. score for the morning of day 2 if E.F.F. (2) is less than P.M. (1). If it is not, A.M. (2) is put at zero and the difference is called soil capacity overflow for that day, S.C.O. (2).

$A.M. (2) + E.T. (2) = P.M. (2) \dots\dots\dots(3)$

where E.T. (2) is the evapo-transpiration corresponding to the maximum temperature for day 2.

For a complete explanation of the derivation and testing of the S.D.I., refer to;

Mount, A.B. (1972). The Derivation and Testing of a Soil Dryness Index Using Runoff Data.
Tasmanian Forestry Commission Bulletin
No. 4, 1972.

RESULTS

Figure 1 displays the relationship between S.D.I. and pf figures. These soil pf's are an average of the shallow nature of the soil on this site, deeper readings could not be obtained. Soil pf sampling was precise so ten soil samples within a radius of 100 metres of the weather station could be taken. Figure 1 shows that the S.D.I. is a reliable measure of soil dryness.

A pf of 1.4 was considered to be the field capacity of these soils. Once the soils had reached this moisture potential, further rain did not lower the figure. The highest point of the S.D.I. was equilibrated to the driest soil reading and the pf.

scale calibrated.

The moisture deficit study of needle material did not display any signs of the trees being under drought stress, yet many of the samples trees eventually browned off in autumn. Only when the needles showed obvious signs of death (colour change) did their moisture deficits increase steadily from 15%. Obviously there is a delay between needle death and visual signs of death. The actual time interval was determined by delimbing a number of healthy limbs and studying how long it took before yellowing of the needles took place.

It was assumed that delimbing had a similar effect as droughting in that transpiration soon ceased. Although variable, 25 days passed before the needles showed signs of yellowing. By 42 days needles had yellowed and were turning red. Therefore it was assumed that needles were non living some 3 - 4 weeks prior to yellowing. Figure 2 displays the relationship between needle colour, time and moisture deficit. This may have been clouded by the cyclonic winds in April which may have speeded the colour change process. On the basis of Figure 1, it may be assumed (with an unknown degree of confidence) that the needle cells ceased to function at about March 10.

This study could not determine the time at which the trees come under drought stress but many workers have found that *P. radiata* is under moisture stress at pf 4.2. From Figure 1, this is about December 14th. Therefore, the S.D.I. can give a reasonable picture as to the physiological well being of the stand as far as its moisture status is concerned. It would appear that the area hatched in Figure 1 will determine the fate of the stand - whether it will suffer drought or not. This study suggests that the cross hatched area in Figure 1 boarded

by the broken "D" line is the limit for P. radiata. This is on the assumption that yellowing needles are an indication of wilting point. If this is not the case, then the area of tolerance will be much greater. How much greater, it is unknown as the April winds will cloud any estimates.

Therefore, burning under pines could not be tolerated while the S.D.I. is over 490 at least. It is hoped that further studies will determine the "droughting" effect of various intensity fires. It is highly likely that very mild fire (for instance, night burns) could be undertaken at an index of 490 and below. Slightly hotter fires could be tolerated at an index of 200 (tops disposal) etc.

Problems with the S.D.I.

The S.D.I. as seen in Figure 1 uses the evapo-transpiration figures for Perth, which are the highest of any capital city in Australia. These figures are based on pan evaporation rates/month and do not directly account for true stocking rates. From Figure 1, it is evident that even using these high "drying" units, the S.D.I. is slightly behind the real soil dryness. The reasons for this could be;

- a) inaccuracies in our technique of measuring soil dryness.
- b) S.D.I. features are not quite suited to this area.

Reason b) would account for the consistent lag by the index, even though at most it is only nine days. (Comparable to the B.D.I. which lags, at most, by 40 days!)

The S.D.I., although it uses an evapo-transpiration table, does not consider stocking. Further studies under variably stocked stands will enable an adjustment of the evapo-transpiration table. The second anomaly is that the S.D.I. curve in Figure 1

was developed on a very low canopy interception figure. Mount has developed functions based on percentage canopy cover and tree height which yield the amount of rainfall intercepted by the canopy. The canopy cover used in this study was class "F" (which is a very dense canopy cover) but the index was calculated on class "A" (very light canopy cover) as this best fits the soil curve.

A third problem is with seasonal evapo-transpiration. Mount uses a period from February to May and June to January which may not apply to the climate of this study area. In fact pan evaporation rates from Pemberton suggest that the seasons are February to June and July to January.

S.D.I. V's B.D.I.

It can be safely said that the S.D.I. is a far more reliable indication of soil dryness, therefore the dryness of forest fuels, than the B.D.I. Figure 3 is the B.D.I. equivalent of Figure 2. The B.D.I. lags far behind the actual soil condition and approximates the moisture movements of heavy fuels such as large jarrah logs. The S.D.I. climbs (drying stage) and falls (wetting stage) at almost the same rate as the soil (even with the above mentioned anomalies). The soils and the S.D.I. peak and zero almost at the same time. The S.D.I. zeroes seven days after soils reach field capacity whereas the B.D.I. zeroes 43 days after soils have reached field capacity.

Summary of Work to Date

- a) It can be approximated when pine stands, come under moisture stress (at S.D.I. 490),

b) The area between the index and pf 4.2 will determine the fate of pine stands. Due to abnormal winds, the area (cross hatched) in Figure 1 may not be a true indication, the tolerance may be greater. Further work is needed in this area to pinpoint the tolerance of the stand. This may be a guide as to what stands should have priority in thinning programmes, burning programmes, etc.

c) The S.D.I. should replace the B.D.I. as a measure of dryness.

d) Further work is needed on various soil type - for example Karri loams etc, where deeper samples can be taken. Further testing of stocking rates (and stands age) are needed to refine both the drying and wetting phases.

This index has application not only for fire protection but but for 1) pine planting, 2) soil damage in the Karri, 3) soil damage in pine logging, 4) Karri planting, 5) thinning schedules in overstocked stands, and 6) when runoff into catchments is taking place and how much (flood forecasting).

W.D. Barrow

Added Fire Research

Soils reached field capacity 19/
SDI reached 0 at 29/5/78.
(Using table 'A' & Pen-EET).

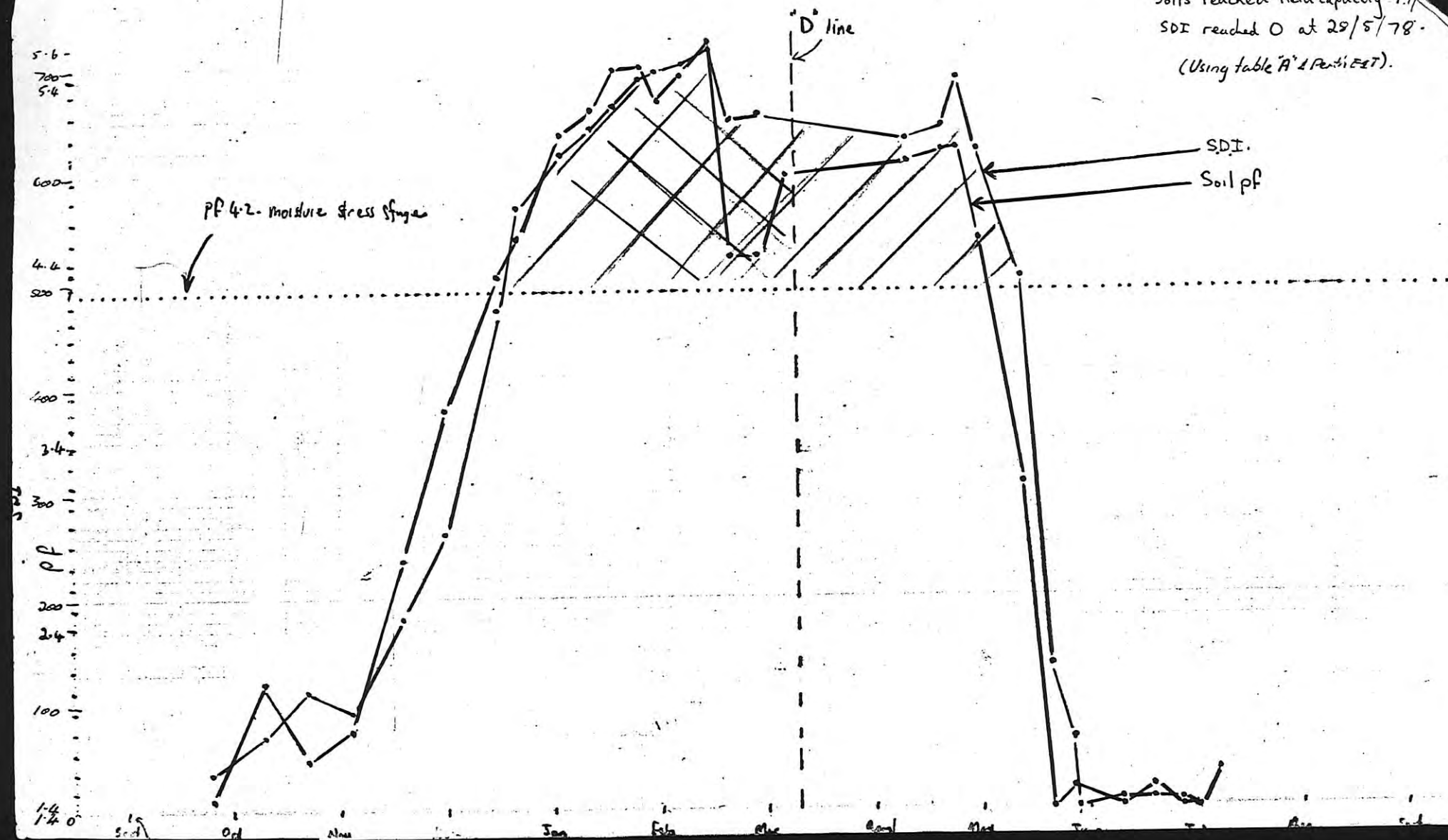


Fig 2.

Moisture of Needle tissue

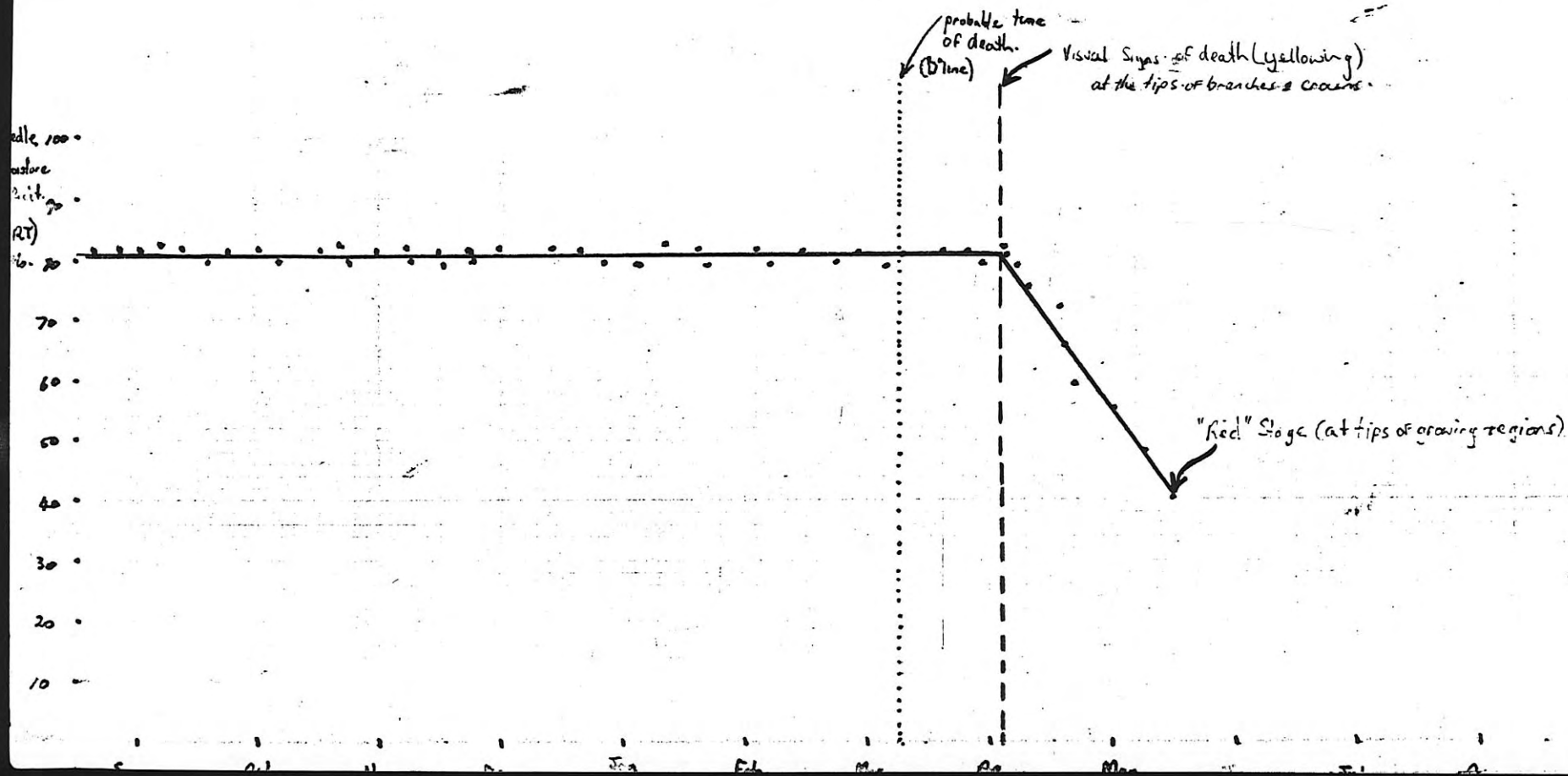


Fig 5

BDI vs Soil pf

