THE CONCEPT OF DROUGHT INDEX IN WEST AUSTRALIAN FORESTS

by

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INTRODUCTION

In 1968 Byram and Keetch (U. S. Forest Service) published the format for a drought index which expresses fuel dryness in forests. This index received favourable comment and is recognised in the Eastern States and U. S. A. as a valuable aid for planning of fire control. It is being tried experimentally at West Australian forest centres.

The first part of this article will review what the index means and its possible application in Western Australia.

The application of a drought index depends on the moisture fluctuations of fuel variables being comparable and of particular importance, that the different fuels are in phase. This consideration will be the basis of the second part of the article.

THE DROUGHT INDEX

Statements in this section are summaries of points in publications by Byram and Keetch (1) and by McArthur (2). More detailed explanations can be obtained by reading the publication listed at the end of this article.

The drought index is a number representing the nett effect of evapotranspiration and rainfall in producing a cumulative moisture deficiency in deep duff and upper soil layers. Primarily, drought index relates to the flammability of organic material in the ground.

This organic material includes humus, buried wood and heavy logs, all of which add to suppression problems when dry. The relative dryness of these fuels is a direct effect of drought because their drying is a much slower process than in flash fuels.

A prolonged drought affects fire intensity by making more fuel available for combustion. This increased intensity adds to the difficulty of holding firelines, hence suppression.

The purpose of drought index is to provide managers with a continuous scale of reference for estimating deep drying in litter profiles.

The drought index is a scale of zero to 800. A zero index means saturated fuels where eight inches of water are available in the soil for transpiration. An index of 800 is the maximum drought possible with plants at wilting point. At any point on the scale the amount of nett rainfall (total less 20 points) in points is that required to reduce the index to zero, or saturation.

Additions and subtractions to the index depends on rainfall in the past 24 hours and on maximum temperature. Full explanation of these calculations are provided in the publications listed below:

Byram and Keetch's conclusions were:-

1. Droughts develop after extended periods of little or no rain when daily maximum temperatures exceed 50°F.

2. Consistently high daily maximums exceeding 70°F are required for appreciable drought development.

3. Drought has a variable significance depending on whether duff fuels are present in the area.

McArthur (2) defined the drought index as representing a cumulative moisture depletion in deep forest litter, heavy fuel components, living vegetation and the upper soil layers. Byram and Keetch suggested the foliar moisture content of chamise to vary with drought index.

McArthur suggested the drought index as a good indicator of quantity of fuel available for combustion. An index of 400 represented full fuel availability in *P. radiata* stands.

Controlled burning restrictions should be imposed when the drought index exceeded 100 in spring and not relaxed before it fell below 100 in autumn. These limits were intended as a broad guideline rather than as restrictions for particular forests.

THE DROUGHT INDEX CONCEPT

There seems little doubt that the drought index is a good concept for duff and heavy wood fuels. These dry slowly and are likely to be in phase with a cumulative index of this type.

Heavy fuels add to suppression problems when they ignite. They usually burn behind the main fire front and for a considerable period. This adds heat to the convection column increasing the convective preheating of unburnt fuels and to the updraft carrying spot fires ahead.

These differences are quite evident in the difficulty of control of fires burning in early spring and similar spreading fires in late summer.

The significance of a drought index will depend on the presence of heavy fuels. Duff is being steadily reduced by controlled burning, not necessarily by the burn itself which usually leaves the duff intact, but by the accelerated decomposition which seems to accompany exposure of it. Measurements suggest that in regularly burnt jarrah the small depth of duff is of little significance as a fuel factor compared with pine plantations or karri.

In West Australian forests severe droughts on the Byram scale seem to be quite common during summer. For three seasons at Dwellingup (1962 - 1965) the drought index exceeded 700 in February and March. For five seasons at Pemberton (1964 to 1969) the index exceeded 600 in February and March.

In each of these seasons the rise of drought index was fairly regular, starting in September and rising to peak in February and March. Thereafter it fell steadily to zero in May or June. These trends are unlikely to represent 1969-70 where drought effects are already well known.

While drought index should represent rates of drying in the heavier fuels; trends in scrub need further investigation. Rates of litter drying are quite different in jarrah, karri and pine plantations each of which needs a separate definition to define fuel availability on the Byram scale.

FUELS

Several fuel components have been suggested as being affected by the drought index and these will be considered in turn.

Scrub

McCormick (3) showed foliar moisture content to be important in regulating rates of burning for scrub foliage. Fluctuation between seasons, species and diurnally were recorded. The amplitude of the seasonal fluctuation was much greater than the diurnal one for most of the test species, suggesting seasonal differences in inflammability.

With the exception of ti-tree the test species showed high foliar moisture contents in spring, during the period of growth flush, and decreases in late summer and autumn starting about January. This suggests the test species were least inflammable in spring.

Foliar moisture content was in opposite phase to drought index until January, after which both were in phase. The "in phase" period was probably introduced by moisture stress and seemed to occur at an index exceeding 600.

Drought index may indicate the dryness of scrub foliage once it rises above 600. These species are adapted to drought however and their growth habit in spring precludes a relationship between rising index and foliar moisture content in these months.

Terminal leaves of jarrah were measured weekly over a 2-year period to record seasonal moisture changes. There was little significant change except during leaf replacement in summer, when the highest moisture contents were recorded. These trends were not "in phase" with drought index.

Litter Fuels

In both jarrah and karri trends in profile moisture contents of heavy litter fuel were studied for relationships with drought index.

For karri there was some correlation providing the fuel was heavy with thick duff. Lighter fuels in both jarrah and karri were influenced primarily by day to day weather and can be excluded as not representative of the drought index concept.

In karri a drought index of 50 in spring approximated a moisture content of 200%, or saturation, and 400 about 25%, or full availability (Van Didden, 4). There were marked fluctuations about these values due to the influence of daily weather. Unfortunately, duff was not measured separately which might have produced a better result.

The observations for karri were made at one site and variations on the above values could be expected in others.

At present the evidence suggests that jarrah litter dries faster under forest conditions than does karri. This seems to be primarily an environmental control and drying curves for the two types are dissimilar in form. This poses some mathematical problems in interpretation of drought index.

It may be possible, site considerations aside, to fix points along the index scale at which karri and jarrah fuels become fully available. If the drying curves for the two types were parallel and similar to the drought index one, then simple corrections could be employed to describe relative dryness at any point on the scale. At present this does not seem possible for profile moisture content although duff may be quite different when treated as a separate component.

Whether the Byram scale presents any better measure of fuel availability than the karri A, B, C drought index in current use is doubtful for this forest type, although the question has yet to be resolved. Its structure makes it unlikely that it will describe fuel dryness in autumn any better than the present table.

Bark

Trends in the moisture content of outer dead bark on jarrah trees was plotted for one season. There was a seasonal trend with reasonably regular monthly decreases from spring to summer and rises after the autumn rain.

The period of inflammability appeared to lie above a drought index of 300.

Logs

As yet measurements of log moisture content have not extended sufficiently to comment. McArthurs suggestion that logs are dry at an index of 400 is the best indicator available.

DISCUSSION

The concept of drought index is a valuable one for planning fire control, particularly suppression. Its interpretation in practical terms is not so easy to conclude.

The main value of drought index appears to be in heavy duff fuels which follow a prolonged drying trend rather than in light litter which fluctuates with daily weather.

Drought index attempts to define the availability of additional fuels which chang the fire model. The burning of heavier fuels increases heat input into the convection column. This adds to the convective preheating of unburnt fuel (as distinct from radiation), updraft and spot-fires. "Mop up" commitments are increased.

The Byram index suffers from extending a standard format for drying into a range of forest types where these rates are quite dissimilar. As such it is not possible to do other than identify points on the scale where certain fuels are likely to become available for burning. The range of scale behind that point may be quite inaccurate for defining relative dryness.

Some suggested points on the drought index scale were given for trial in the last section. One of these suggested an index exceeding 400 as representing full fuel dryness in deep karri litter. This does not mean necessarily that 200 represents half availability, as the form of the drying curve for litter may be quite different to the form of the drought index curve during the intermediate stages. This has yet to be investigated.

Drought index cannot be interpreted as a precise measure of fire behaviour. The ignition and spread of a fire is primarily influenced by the weather and fuel variables in fire danger ratings. What a drought index should do is indicate the likelihood of the fire model described by the danger rating changing to something more intense e.g. accelerated convectional activity and spot fires. Whether the Byram index will provide any better measure of this than the current karri drought index remains to be investigated.

REFERENCES

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5. McCormick, J., "Seasonal Trends in Scrub Moisture Content". Forest Notes Vol. 4, No. 4, 1966.