FIRE NOTE

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DETERMINING GRASSLAND FIRE DANGER WITH PLANT MODELS

SUMMARY

This project addresses a gap in knowledge about the rate of natural die-off (senescence) in common grass species and provides a way to adapt agricultural modelling tools to predict curing rates across the temperate grasslands of southern Australia and New Zealand.

It provides new capabilities in assessing fire danger and managing fire prevention. It will be possible to supplement other sources of curing assessment which may be irregular or less reliable, provide curing estimates at local levels, and predict curing levels using current or forecast weather.

This all improves the timeliness, scale and detail of drying estimates across the landscape, building essential information for fire authorities trying to schedule prescribed burns and set fire restriction dates.

ABOUT THIS *FIRE NOTE*

This research is from Project 1.4 Grassland Curing, within Bushfire CRC Program A: Safe Prevention, Preparation and Suppression.

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◄ **Figure 1:** Senescence progressing in an annual ryegrass plant in the glasshouse.

CONTEXT

As curing percentage increases, fuel moisture content falls, and the likelihood of fire ignition and propagation increases while the chance of fire suppression decreases. Curing is incorporated in the Grassland Fire Danger Meter and the rate of fire spread functions predicted using the CSIRO Grassland Fire Spread Meter.

The potential exists to predict grassland curing levels using agricultural plant growth models. This relies on adapting these models by developing reliable algorithms, or formulas, to model the die-off process in common grass species.

BACKGROUND

Agricultural plant growth models can aid fire management if they can be adapted to model the curing of grasslands. These models currently treat the dying off process in grasses very simplistically, so that it is not possible to determine the degree of curing (percentage dead). There is also a lack of knowledge about the rate of die-off in common grassland species and no means of predicting levels of curing in advance. This project aims to provide formulas to allow the agricultural models to be adapted so that grassland curing can be modelled across the temperate zones of southern Australia and New Zealand.

BUSHFIRE CRC RESEARCH

A study of commonly available agricultural plant growth models revealed that they were not yet calibrated to produce die-off values for grasses, or treated die-off as a lag phase between flowering in one year and resumption of growth in the next. To adapt these tools to predict current and future grassland curing levels, more detailed senescence data was required.

In a glasshouse trial the researcher compared four common grasses with differing growth habits. The aim was to determine the leaf turnover rates of these grasses under ideal growing conditions. The annual grasses were wheat, with a highly synchronous life cycle or phenology (see 'Definitions' box); and annual ryegrass (Figure 1, above) which is more asynchronous (see 'Definitions' box). Perennial grasses were the introduced but naturalised phalaris and a native wallaby grass.

Plants were regularly measured for length of green and dying-off leaf components from the three-leaf stage that follows germination until the natural death of the plants, in some cases up to six months later.

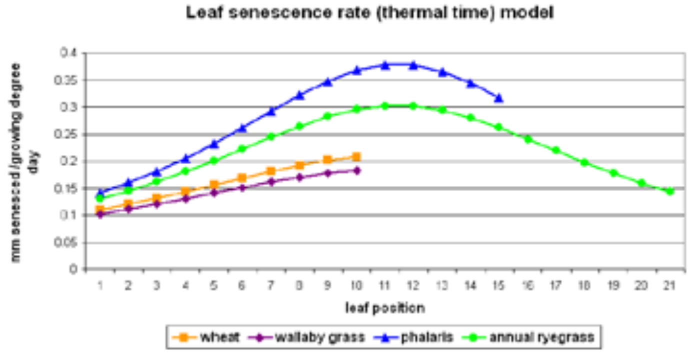
Rates of leaf appearance, elongation, life span and die-off were calculated and leaf and tiller (see 'Definitions' box) numbers counted. The stage of the plants within their life cycle was noted and samples were harvested and measured for dry matter and moisture content.

A further glasshouse trial imposed water stress on the same species to determine how this affected the onset and duration of die-off.

Field sites in the mid-north and south-east of South Australia were also established to provide data under field conditions and similar species were monitored fortnightly. This data will be used to modify glasshouse-derived rates to better suit real-world applications. Curing was assessed at these sites both visually and using a modified Levy rod technique (Bushfire CRC *Fire Update 5*, 2005 or see 'Definitions' box).

RESEARCH OUTCOMES

Equations have been developed from the glasshouse trial to describe a number of leaf growth and die-off characteristics of grasses. Significant variation in rate of leaf appearance,



▲ **Figure 2:** Leaves cure at different rates depending where they are on the plant. Senescence rates vary between species. Scale is mm dead leaf / unit of thermal time (growing degree day).

◄ **Figure 3:** Senescence progressing in a field of barley (unmown on left and mown on right) in a demonstration plot at Black Springs, South Australia, October 2008.

growth and die-off has been found between grass species.

Rates of leaf growth and die-off were best explained in terms of thermal time (growing degree days), which reflects the temperature (°C) accumulated by the plant in a given time (the daily temperature the plant is exposed to over a given period is added up). Plants growing at 25°C will grow and reach developmental milestones faster than those growing at 15°C. Thermal time allows results to be extrapolated to other climatic conditions.

One example of the models derived in the glasshouse is that of leaf senescence rate (LSR). The rate at which leaves die off from the leaf tip to its base varies with leaf position on the tiller and species, as shown in Figure 2 (above).

The results show for each species when each leaf will appear, the length it will grow and how long that will take, when it will begin to die off and how long it will take to die. The onset and duration of senescence for each leaf of these species can now be established, and the percentage of the leaf that will be green or dead at any given time can be calculated.

These data can be used to model the percentage of dying material present in a pure sward of these individual species on any given day with a high degree of precision.

The leaf turnover formulas represent what happens to leaves of individual species growing under ideal conditions. The water stress study and field work component of the project will be used to test the formulas under conditions experienced by grasses in the real world to understand the impact of field stressors such as water, nutrient status, light and competition.

HOW THE RESEARCH COULD BE USED

Modifying agricultural modeling tools such as GrassGro™ (Moore, Donnelly & Freer 1997) with these formulas will allow the curing process to be modelled for temperate grasslands. Current and forecast weather conditions can be used to assess current levels of curing or predict future levels. These tools give the probability of a certain outcome occurring. For example, fire agencies will be able to gauge with greater certainty when grasslands have cured sufficiently to allow prescribed burning, or when they have cured to the extent that such burning might no longer be safe. In this case, the program may predict a 75 percent probability that a given area of grassland will have cured to 75 percent within a fortnight of a hot north wind in October in southern Australia. This will be vital information for fire agencies wishing to conduct timely but safe prescribed burning. This predictive capability will also help agencies make decisions related to prevention and preparedness.

END USER STATEMENT

"This research, when combined with seasonal forecasts (supplied by the Bushfire CRC and Bureau of Meteorology as input) and the real-time satellite curing mapping (from CRC project A1.4) should produce predictive models/tools for fire agencies to predict the timing of grassland curing. This information is needed to predict when to best conduct prescribed burns and for setting dates for fire restrictions."

– Mike Wouters, Senior Fire Ecologist, Fire Management, Regional Conservation Delivery Directorate, Department for Environment and Heritage, South Australia.

Fire Note is published jointly by the Bushfire Cooperative Research Centre (Bushfire CRC) and the Australasian Fire and Emergency Service Authorities Council (AFAC).

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DEFINITIONS

Asynchronous: development stages are different between plants.

Levy rod sampling: counting live and dead grasses that come in contact with a thin steel rod placed vertically into the ground at various points.

Phenology: grass plant developmental stages, such as germination, stem elongation, reproductive phases, senescence, etc.

Synchronous: development stages all occur together.

Thermal time (growing degree days): amount of temperature (°C) accumulated in a given time.

Tiller: a subsidiary stem arising at or near the base of the primary stem or one of its earlier subsidiaries.

FUTURE DIRECTIONS

The work to date has focused on single species growing in ideal conditions. It is necessary to understand how senescence operates in multi-species grasslands, which are more common than monocultures in the landscape, and in a range of other grasslands found across Australia and New Zealand. Some of this can be achieved with current modelling tools once the results of this study are incorporated.

Scoping of agronomic methods to manipulate the onset and duration of curing may provide a further arsenal of tools for land managers to manage fire risk. This work will supplement other methods of curing assessment (see Bushfire CRC *Firenote 51*) to provide continuity of information, while increasing regional coverage of curing assessment, and extending to provide new information in the form of short to medium term prediction of curing rates.

REFERENCES / FURTHER READING

Moore, A.D., Donnelly, J.R. & Freer, M. (1997), 'GRAZPLAN: Decision support systems for Australian grazing enterprises. III Pasture growth and soil moisture sub models, and the GrassGro DSS.' *Agricultural Systems*, (55)4: 535-582.