Next generation biomaterials

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Learning by Burning

Many of the incidents involving fatalities or injuries to firefighters, farmers and members of the public have been caused by wildfires in scrub fuels burning on steep slopes or in gully systems. Faster than expected fire spread, together with dramatic escalations in fire behaviour, have frequently resulted in people being caught out by such fires. Better knowledge of fire behaviour in these situations will help reduce the number of accidents in future.

Scion and CSIRO fire researchers are leading a large research experiment to improve understanding of fire behaviour on steep slopes. Supported by numerous rural fire agencies, this research has involved setting alight privately-owned scrub over the past summer on Torlesse Station in Canterbury.

As part of the same project Scion is also participating in similar burn experiments conducted by CSIRO bushfire scientists in South Australia.

Project FuSE Scrub Fire Experiments

The New Zealand fire experiments form a key part of a research project known as "Project FuSE" (Fire in Shrub Experiments, with attention to wind (u) and slope). This is a six-year project investigating the behaviour of fires in shrubland vegetation. Project FuSE is a collaborative research project between CSIRO Forest Biosciences and Scion, supported by the Australian Bushfire Cooperative Research Centre (CRC).

This project aims to develop fire behaviour models for scrub and heath fuels by collecting data from a series of experiments in similar vegetation types across Australia and New Zealand. In particular, the New Zealand experiments also aim to improve understanding of fire behaviour in scrub fuels on steep slopes. These models will ultimately contribute to the increased safety of both firefighters and members of the public through an improved understanding of the way these fires burn.

Torlesse Burn Experiments 2008

The Torlesse experiments form the second phase of the New Zealand burning programme being conducted in the Canterbury hill and high country, following the completion of burns at Lake Taylor in North Canterbury in March 2005.

The research is being carried out in collaboration with bushfire researchers from the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO - Forest Biosciences). Project FuSE is funded by the Bushfire CRC in Australia, and in New Zealand by the Foundation for Research, Science and Technology (FRST) and various rural fire agencies. Additional assistance with fire suppression was provided by the Department of Conservation, Selwyn District Council, the Canterbury/West Coast Regional Rural Fire Committee, National Rural Fire Authority and other rural fire authorities from throughout the South Island.

The burn experiments at Mt Torlesse Station, near Springfield, were first established during 2006, but were postponed for the past two seasons due to unsuitable weather conditions. After waiting for the desired conditions, burning was finally possible in February 2008.

In total, four of the six research burn blocks have been burnt. The last two exhibited extreme fire behaviour, which provided good information on fire spread rates and intensities. While one block burned unsuccessfully in unfavourable conditions, even this provided useful information on the conditions required for successful ignition and fire spread, and on the relative power of the wind versus the slope to spread the fire under mild conditions.

Preliminary results

Initial results from the New Zealand experiments have demonstrated that extreme fire behaviour occurs in scrub fuels on steep slopes even under mild weather and fire danger conditions.

Fires at Lake Taylor exhibited rates of spread of 600-1050 m/h, with short runs at up to 2000 m/h and flame lengths in excess of 20 m, despite mild weather and fire danger. Despite having slower spread rates of 440-600 m/h as a result of lesser fire weather and fire danger conditions (see Fig. 1), the fires at Torlesse still produced high fire intensities with flame lengths of 15-20+ m but slower spread rates.

A huge vote of thanks is extended to all the organisations and individuals that have assisted with the project to date, including local fire authorities and their staff, and out-of region suppression resources. We appreciate the ongoing support provided over many years, through often trying times, and we are hopeful that this support will continue in future as we endeavour to complete the remaining burn experiments.

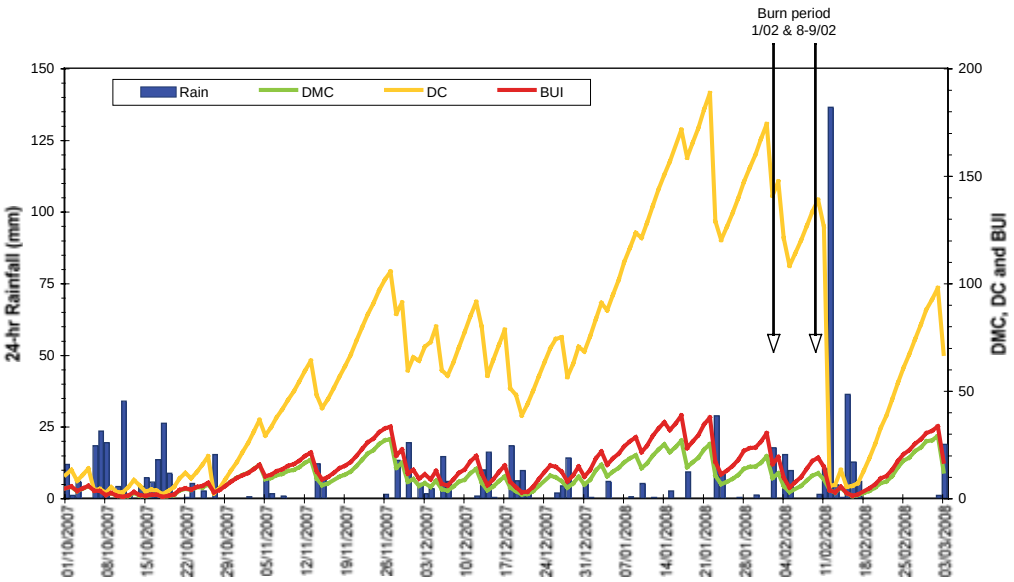
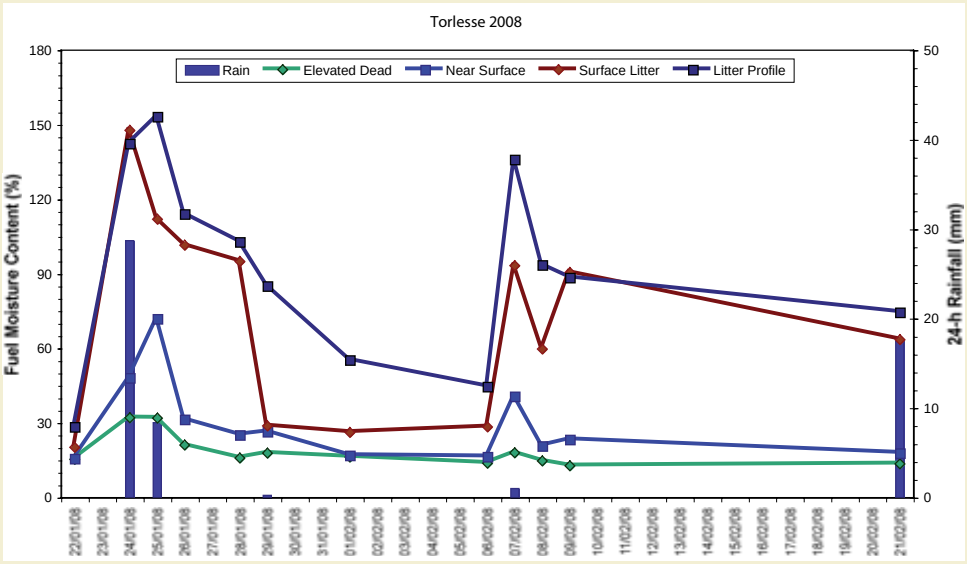


Figure 1. Trends in daily rainfall, and Duff Moisture Code (DMC), Drought Code (DC) and Buildup Index (BUI) components of the FWI System prior to and during the 2008 Torlesse burn experiments.



Key findings

- The moisture content of fine, dead fuels in particular can change rapidly in scrub fuel types, resulting in dramatic escalations in fire behaviour.
- Slope is not always the dominant factor affecting fire spread, hence the importance of considering wind direction and strength relative to slope direction and steepness.

Figure 2. Moisture contents of various fuel components sampled and daily rainfall measured during the 2008 Torlesse burn experiments.

Fuel moisture

Despite occurring under higher FWI conditions, fuels during the Torlesse burns (Fig. 2) were generally more moist than those at the time of the Lake Taylor burn experiments. While dead elevated (Torlesse 13-14% cf. Lake Taylor 14-20%) and near surface fuels (14-23% cf. 15-23%) had similar moisture contents, litter fuels (both litter surface and profile) were much wetter at Torlesse (20-91%) compared with Lake Taylor (16-50%). This demonstrates the important role this fuel layer plays in fire development and spread. Live shrub fuels also had higher moisture contents at Torlesse (131-158%) than at Lake Taylor (96-100%).

The effect of fuel moisture on fire spread and subsequent fire intensity was particularly apparent at Torlesse. Whereas ignitions struggled to sustain and spread one day, they were able to ignite and spread much more easily (and with much greater fire behaviour) the next, after just one extra day of drying. These observations, together with data from daily fuel moisture sampling (see Fig. 2), show just how rapidly the moisture content of fine, dead fuels in particular can change in these scrub fuel types, resulting in dramatic escalations in fire behaviour.

Wind versus slope

A key feature of both sets of experiments was the influence of wind versus slope effects, especially under moderate to high fuel moisture conditions. On steep slopes (>20º) at Torlesse, the initial fires struggled to spread when winds were downslope or light and variable. In several instances, ignitions were self-extinguishing due to the fire front being pushed back downslope by the wind (and into already burned fuels). In these cases the power of the wind was greater than the power of the slope. However, when wind and slope were more closely aligned, often as a result of only minor changes in wind direction, the fires spread much more readily and with much higher rates of spread and intensity.

Fires at Lake Taylor also spread rapidly downhill with high intensity under the influence of moderate winds on lesser slopes (<15º). This highlights the fact that slope is not always the dominant factor affecting fire spread, and shows the importance of considering the effects of wind direction and strength relative to slope direction and steepness when winds are across or downslope.

Ngarkat, South Australia Burns 2008

A major CSIRO - Forest Biosciences research study in the Ngarkat Conservation Park, South Australia, was under way for its fourth year this March. Research into prescribed burning at the Ngarkat Park is part of Project FuSE. This year the Ngarkat project involved research into fire behaviour, aerial suppression, and firefighter wellbeing during very high fire danger conditions. The aim of the research is to investigate the effect of fuel dynamics (structure and moisture) on fire behaviour to develop a prescribed burning guide for mallee and heath fuel types.

High intensity fires were observed over the course of the burn experiments. Spreading heath fires with constant wind direction formed perfect parabolic shapes that were clearly observed by infrared and video cameras from the helicopter above.

While rates of spread for fires in mallee and heath were similar, fire intensities were dependent on fuel age and subsequent fuel load. For example, a fire in 9 year old mallee-heath had a spread rate of about 45 m/min (2700 m/h) and flame heights of around 4 m, whereas a fire in 22 year old mallee-heath had a rate of spread of about 50 m/min (3000 m/h) and flame heights of 8 m.

As with the New Zealand burn experiments, a large number of personnel and resources were involved in the project. Researchers who participated came from CSIRO; Deakin, Royal Melbourne Institute of Technology and Melbourne Universities; University of Catalunya (Spain); and Scion (NZ). Several fire agencies from South Australia, Victoria, New South Wales and Western Australia also took part in the study. Two fixed-wing bombers, an observer plane and helicopter for research observation and thermal imaging were present during the aerial suppression experiments involving retardant, gel and foam. The Ngarkat and Torlesse projects are under the umbrella of the Bushfire CRC Project A1.1 – Fuel and Fire Behaviour Modelling, and data from both experiments will be combined to increase our understanding of fuels and fire behaviour in heath and scrub fuels.

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