CSIRO PyroPage
Putting science into practice

www.csiro.au

Number 36 | **April 2024**

Development and appraisal of methods to quantify retardant effectiveness in controlled experiments

Four methods for quantifying the effectiveness of retardant using fires in bushfire fuels in a combustion wind tunnel were developed and evaluated using two example retardants. The methods considered both direct and indirect retardant applications as well as the effect of longevity and different application coverage depths. Appraisal of the proposed test methods demonstrated low variability in fire conditions and the ability to provide clear and reliable comparisons between products and treatments.

Wildfire retardants

Wildfire retardants are chemicals designed to inhibit combustion processes in bushfire fuels. These are usually applied by aircraft to unburned fuels in the path of a fire (i.e., not directly on a fire). They differ chemically and functionally from suppressants, such as foams and gels, which are applied directly on burning fuels to extinguish flames through cooling. Retardants are also occasionally applied directly onto the flaming perimeter of a wildfire, particularly when it is small and direct attack is determined to be the most effective tactic.

Wildfire retardant products are assessed by the US Forest Service (USFS) to ascertain if a product is suitable for general use. This is done via a range of tests investigating aspects such as chemical toxicity, stability, corrosivity, visibility, air drop consistency and combustion retarding effectiveness. While the list of recommended retardants is also used in other nations, including Australia, the USFS testing regime only considers indirect application and does not consider longevity or the effect of coverage level.

Main methods

A comprehensive evaluation regime comprised of four separate tests was developed to investigate both direct and indirect tactical uses and other beneficial traits of chemical retardants for operational firefighting. All testing was conducted in the CSIRO Pyrotron combustion wind tunnel, using fine (< 6 mm diameter) eucalypt leaf litter at a load of 12.5 t/ha and moisture content in the range 7-9% oven dry weight) and a 1.0 m/s (3.6 km/h) airflow to provide burning conditions for a standardised fire. Appraisals of the tests were undertaken using two commercially available retardants as examples.

Figure 1. Retardant being sprayed onto the head of a standard laboratory fire (spreading toward the camera) during the appraisal of the direct suppression test.

Results

Direct suppression test

This test was designed to determine the minimum amount of retardant required to directly extinguish a standard fire, with water used as the control. Treatments were delivered directly onto the actively propagating flame front of the head fire (Fig. 1).

Quantification of effectiveness was determined from the total mass of product required to halt fire spread and extinguish flaming combustion. The best performing product requires the least mass to extinguish the fire.

Indirect suppression test

In this test, fuels were pre-treated with retardant and their ability to resist fire spread when impacted by a standard fire was quantified (Fig. 2). The performance of retardant treatments was benchmarked against untreated and water-treated fuels exposed to the same conditions. The effectiveness of treatments was assessed using, in order of importance, the distance that fire penetrated into treatment areas, the percent of the treatment area burned, and the change in the fire's forward spread rate within the treatment area. The best performing product exhibits least penetration and area burned and slowest fire spread.

Figure 2. Overhead view of the head of a standard fire approaching litter fuels treated with two different retardants during the appraisal of the indirect suppression test.

Longevity test

This test investigated how retardant effectiveness varied with time since application and involved standard flaming firebrands (burning cotton balls moistened with ethanol) being dropped into retardant treated fuels at intervals after treatment. Testing stopped when an ignition sustained and time since treatment noted. The best performing product resists ignition for the longest time after treatment.

Coverage level test

The coverage level test compared the ability of fuels treated with retardant at different coverage depths to resist the same flaming firebrands as used in the longevity test. Testing stopped when an ignition sustained, and the coverage level noted. The best performing product resists ignition at the lowest coverage depth.

Appraisal of methods

These methods were evaluated in a series of appraisal tests using two commercially available wildfire retardants as examples. Analysis showed that that the four tests provide a comprehensive and quantitative basis for comparison of retardant performance in operationally relevant use cases. Low variance in the test performance measures indicate the methods are reliable and reproducible.

This set of assessment tests provides a sound basis for comparing different retardant products and retardant applications (i.e., concentrations and coverage depths). Additional testing in the field would be useful to verify results at an operational scale, particularly for the indirect suppression tests where field testing could also consider higher intensity fire fronts.

Further reading

Plucinski, MP, Sullivan, AL (2024) Methodologies for quantitatively comparing the effectiveness of chemical retardants for direct and indirect wildfire suppression using a combustion wind tunnel. *Fire Safety Journal* 143, 104056.

CONTACT US

t 1300 363 400
+61 3 9545 2176
e enquiries@csiro.au
w www.csiro.au

AT CSIRO WE SHAPE THE FUTURE

We do this by using science to solve real issues. Our research makes a difference to industry, people and the planet.

FOR FURTHER INFORMATION

Environment
Dr Andrew Sullivan
t +61 2 6246 4051
e Andrew.Sullivan@csiro.au
w https://www.csiro.au/en/about/people/business-units/Environment

An archive of this and previous CSIRO PyroPages is available from: http://research.csiro.au/pyropage