HAZARD NOTE

bushfire&natural HAZARDSCRC

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# ESTIMATING FUEL LEVELS POST-CYCLONE

▲ **Above:** FUELS READY TO BURN IN AN AREA IMPACTED BY SEVERE TROPICAL CYCLONE *MARCIA*. PHOTO: JIM GOULD.

## SUMMARY

This study examined the dynamics of fuel quantity and hazard following Severe Tropical Cyclone *Marcia* in February 2015 in Queensland. The findings have been used to develop a visual field guide that complements the existing fuel hazard guides (Hines *et al.* 2010; Gould *et al.* 2007, 2011). Among the key findings are that increased fuel loading and hazard caused by tropical cyclones can impede access to fire lines and increase fire spread and fire line intensity by 1.5 and 2.5-fold respectively. These additional insights, to be used alongside the existing field fuel hazard guides, are applicable to a variety of fire management applications, including planning hazard reduction burns, pre-season preparedness and suppression strategies for fires burning in cyclone-damaged vegetation. The guide will be an invaluable tool that could be readily adopted by field crews, can be applied quickly and provide data of sufficient accuracy to input into fire models. Information may also be used to assess the potential impacts of other storm-related fire impacts.

## ABOUT THIS PROJECT

This *Hazard Note* summarises the research results from a descriptive study commissioned by the Queensland Fire and Emergency Services (QFES). It focused on five cyclone-damaged locations on the central Queensland coast over four weeks in the aftermath of Severe Tropical Cyclone *Marcia*. This study would not have been possible without the field work assistance of QFES staff and volunteers.

## AUTHOR

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## CONTEXT

The effects of tropical cyclones on bushfire risk and changes in fire behaviour are difficult to interpret. While there are a number of studies that have documented the effects of cyclones on forests, there is limited understanding on the increase in fuel hazard and the behaviour of fires in cyclone-damaged vegetation. Before this project, no framework for assessing the changes in fuel hazard had been developed.

This gap in knowledge constrained the fire and emergency managers charged with devising mitigation and response strategies for cyclone-affected fuels. Other practical factors such as fire weather, smoke management and fire crew safety are also a primary concern when conducting hazard reduction burns and planning suppression strategies in cyclone-damaged fuel. With destructive tropical cyclones (and other storms) in Australia becoming more frequent (Cook and Goyens 2008), emergency managers require a better understanding of how these changes in fuel accumulation and structure affect fire behaviour, in order to be better prepared for subsequent fire seasons.

## BACKGROUND

On 15 February 2015, Tropical Cyclone *Marcia* was identified as a category 1 cyclone and, over the next five days, intensified to a category 4–5, with wind speeds of up to 195 km/h and gusts up to 295 km/h. On making landfall on 20 February it caused significant damage to property, infrastructure and forested vegetation to Queensland communities at Byfield, Cawarral and West Yeppoon.

Intense cyclones, such as *Marcia*, cause massive defoliation, uproot trees and snap off stems and branches, resulting in open-canopy conditions and changes in understorey microclimate conditions (Turton and Dale 2007; Pohlman *et al.* 2008). These changes will have an effect in determining the risk and behaviour of bushfires. They can accelerate the amount of surface and coarse, woody-debris fuel available for combustion, which will affect fire spread, flame structure, fire duration and intensity. Both the load and structure of fuel are important for predicting rate of spread, ease of suppression and threat.

The indicators of cyclone impacts for increasing fuel hazard are:

- increased surface fuel load from leaves and branches, stripped from overstorey canopy,
- reduced canopy cover, which changes the microclimate, allowing more invasive vegetation,
- severely damaged understorey vegetation that creates excessive vertical and ladder fuels, and
- snapped and uprooted trees that impede fire-line construction and increase risks to firefighters.

## BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

In May 2015, approximately two and a half months after *Marcia*, a fuel assessment and data was collected from the areas of Byfield, Cawarral, West Yeppoon, Mount Archer and Mount Morgan, which were in the vicinity of the cyclone's path.

The severity of damage depends on wind speed, tree species, tree size (height and diameter) and topography. This can be assessed visually (i.e., stripped canopy, broken branches, snapped stems, uprooted trees). Such characteristics were used to establish a visual assessment guide, (following the concepts of Turton and Dale (2007) and Pohlman *et al.* (2008)) with five damage categories ranging from 'low' to 'extreme' to provide a subjective assessment of cyclone-damaged forest vegetation (see page 4).

This guide enabled researchers to train local firefighters to assess cyclone damage at 48 sample plots taken from seven vegetation types across the study area.

As part of the process researchers took photographs as examples to help practitioners learn to appraise the different fuel hazard categories. These form a handy guide for fuel hazard in tropical cyclone-damaged forested vegetation.

Other aspects of the research included an assessment of individual tree damage. Fallen trees and branches are a major component of cyclone-damaged vegetation. QFES Predictive Services provided historical fire weather from 1972 to 2010 for the Rockhampton region. This data set was used to investigate the impact of cyclone-damaged fuels on fire behaviour and suppression difficulty.

## GATHERING VISUAL AND HISTORICAL DATA

Visual assessment showed that *Marcia* caused large structural changes in both continuous and fragmented forested vegetation, although the amount of damage varied considerably both between and within sites. The major damage included both frequent uprooted and snapping of trees some metres above ground.

As there was limited data on pre-cyclone fuel conditions, cyclone damage fuel score one (low) was used as a benchmark to determine if there was an increase in fuel load and hazard.

The cyclone damage scores did not reflect a change in the surface and elevated fuel hazard scores which were either a score of two or three. The most significant change in the fuel hazard score was the near-surface fuel score of two (moderate fuel hazard rating) with the scattered suspended leaves and twigs in the low cyclone damage score of one. In the very high cyclone damage forest score value of four, there were large amounts of leaves, twigs and bark that obscured logs, rocks and holes resulting in a fuel hazard score of four (extreme fuel hazard rating). Combined surface and near-surface fuel load increased steadily from 11.8 tonnes per hectare (t/ha) to 18.8 t/ha with increasing cyclone damage scores. The fresh tops of fine leaves and twigs from fallen cyclone-damaged branches added to the elevated fuel layer. This additional fuel contributed an extra two to three t/ha of fine fuel in the elevated fuel strata. There was very little difference in the elevated fuel loads between cyclone damage scores and the elevated visual hazard score was predominately two (moderate rating). There was no significant change in fuel depth and height of the surface, near-surface and elevated fuel respectively.

The overall fuel hazard rating (Hines *et al.* 2010) increased from moderate in the low damaged areas to very high in the high and very high cyclone-damaged areas in the native forest vegetation.

## RESEARCH OUTCOMES

### Fire behaviour

The historic fire weather records from 1972 to 2010 for the Rockhampton region indicate that the 2015 fire season will start in early August. By then, most of the accumulative fine fuels from *Marcia* will be ready for combustion and fine fuel moisture will respond to daily changes (the temperature highs and lows) in ambient weather. The increase in fuel loading, and warmer and windier understorey microclimate, point to fire behaviour that will be quite different to pre-cyclone fuel conditions.

Applying the default (but best guide available) fuel values developed through this research to fire behaviour models estimates that the spread rate and fire-line intensity would increase by 1.5 and 2.5-fold respectively between the 'low' and 'very high' cyclone damage classes.

▲ **Above:** CYCLONE DAMAGED CANOPY TOPS ADDING TWO TO THREE TONNES PER HECTARE OF FINE FUEL. PHOTO: JIM GOULD.

These increases of fuel load and fire behaviour estimates (predictions) will probably be sustained for two to three years after *Marcia*. By then, the fuels will have decomposed to pre-cyclone conditions.

There will be conditions where the observed fire behaviour will differ significantly from the predicted values using the assumed weather and fuel conditions, if, for example, conditions at the fire front are quite different to the predicted values. The spatial variability of cyclone-damaged fuel is high because of the patch-wave nature of cyclones. Fire behaviour analysis that overestimates fire behaviour predictions can be easily readjusted without serious consequences; underestimates of behaviour can be disastrous both to incident controllers and the credibility of the person predicting.

**Fire suppression**

Changes in potential fire behaviour after a cyclone will depend on both the total quantity of fuel available and the change in the understorey microclimate. In cyclone-damaged forest, where the understorey microclimate is drier and windier (Pohlman *et al.* 2008), these changed conditions may accelerate the rate of fire growth. Fresh cyclone damage to large, downed woody material may restrict the initial development of fires and impede fire-line access. In post-cyclone years, the downed woody material will become combustible and burn out slowly. This additional burning fuel can develop convective centres behind the flame zone, which will draw the local winds along flanks and push the flame towards the burnt ground, thus restricting the lateral development of the fire and increasing the burn-out time and intensity.

In cyclone-vegetation fires, the impeded access to the fire ground and increased fuel hazard make it critical that the first attack is rapid and well resourced. In post-cyclone vegetation, the chances of aerial suppression being successful diminish with delay, as the fire size increases.

## USING THE CYCLONE DAMAGE SCORE

The current visual field guides systematically assess fuel hazard in the context of suppression difficulties and predicted fire spread

Ideally, cyclone-damaged forest should be assessed within the first three months after the cyclone. Developing a sampling design to measure the magnitude of change in fuel hazard and loading following cyclones would be difficult, costly and time consuming. However the cyclone damage score developed by this research (see page 4) can supplement these existing field guides in a post-cyclone situation. Visual assessment can be easily taught to field crews, quickly implemented and is accurate enough to use as input for fire models.

This proposed field guide relies on visual assessment and is therefore subject to human error. To minimise this, practitioners should apply these field guides along with a good sampling design.

**Above:** SNAPPED OFF CANOPY AND BRANCHES WITH RESPROUTING LEAVES, TWO MONTHS AFTER *MARCIA*. PHOTO: JIM GOULD.

## FURTHER READING

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Turton SM, Dale A (2007) An assessment of the environmental impacts of Cyclone Larry on the forest landscapes of northeast Queensland with reference to natural resources management issues in the aftermath. Report submitted to the Bureau of Meteorology (March, 2007) JCU/CSIRO Tropical Landscape Joint Venture, James Cook University, Far North Queensland Natural Resource Management Ltd

## END USER STATEMENT

Before this research there was significant uncertainty about the increased severity of bushfires in the years after Severe Tropical Cyclone *Marcia*. This project has provided a better understanding of post-cyclone fuel hazards and generated many benefits. Its findings are informing our continued hazard reduction burning in the cyclone-affected areas. They are also helping us to promote a shared responsibility approach to community risk reduction. QFES staff and volunteers have gained valuable knowledge from working on the project and community information sessions have disseminated findings of this pressing issue.

– Andrew Sturgess, Predictive Services, Queensland Fire and Emergency Services.

## VISUAL ASSESSMENT FIELD GUIDE TO CYCLONE-DAMAGED FUELS

**This field guide is for assessing bushfire fuel hazard in tropical cyclone-damaged forested vegetation.**

| PHOTOGRAPH EXAMPLES | CYCLONE DAMAGE SCORE | CYCLONE DAMAGE RATING | DESCRIPTION<br>***LARGE TREES*: DBH >5 CM**<br>***SMALL TREES* (SAPLINGS): DBH <5 CM** | INPUT VALUES FOR FIRE MODELS |
|---|---|---|---|---|
| | 0 | Nil | Intact – no obvious damage | |
|  | 1 | Low | *Large trees:* minor branch damage of <25% branch lost;<br>*Small trees:* few trees (<10%) bend and unbroken | Surface fuel hazard rating: High (3)<br>Near-surface fuel hazard rating: High (2.5)<br>Overall fuel hazard rating: Moderate<br>Near-surface fuel height (cm): 25<br>Elevated fuel height (cm): 100<br>Total fine fuel load (< 6mm) t/ha: 15<br>Down woody material (> 25 mm) t/ha: 15 |
|  | 2 | Moderate | *Large trees*: 25–50% branches lost, few trees (<10%) bend <45°, <10% of trees trunk snapped off, no uprooted trees;<br>*Small trees*: substantial part of the canopy stripped off part of the small trees beneath other debris, 10–30% bend and unbroken | Surface fuel hazard rating: High (3)<br>Near-surface fuel hazard rating: High (3)<br>Overall fuel hazard rating: High<br>Near-surface fuel height (cm): 30<br>Elevated fuel height (cm): 100<br>Total fine fuel load (< 6mm) t/ha: 17.5<br>Down woody material (> 25 mm) t/ha: 25 |
|  | 3 | High | *Large trees:* 50–75% branches lost, >75% of the canopy leaves stripped off, 10–30% of trees trunk snapped off, <10% of trees uprooted;<br>*Small trees:* >75% of branches lost, no fine twigs and small branches present, >30% bend and/or snapped | Surface fuel hazard rating: Very High (3.5)<br>Near-surface fuel hazard rating: Very High (3.5)<br>Overall fuel hazard rating: Very High<br>Near-surface fuel height (cm): 30<br>Elevated fuel height (cm): 120<br>Total fine fuel load (< 6mm) t/ha: 20<br>Down woody material (> 25 mm) t/ha: 40 |
|  | 4 | Very High | *Large trees*: no visible signs of twigs and small branches <10 cm, scattered large branch material on the ground, 30–50% of trees trunk snapped off, 10–30% of trees uprooted;<br>*Small trees*: trunk snapped off low to ground or 30-50% uprooted trees | Surface fuel hazard rating: Extreme (4)<br>Near-surface fuel hazard rating: Extreme (4)<br>Overall fuel hazard rating: Very High<br>Near-surface fuel height (cm): 35<br>Elevated fuel height (cm): 120<br>Total fine fuel load (< 6mm) t/ha: 25<br>Down woody material (> 25 mm) t/ha: 50 |
|  | 5 | Extreme | *Large trees*: >30% of trees are uprooted and flattened to ground;<br>*Small trees*: > 50% uprooted or snapped off | Surface fuel hazard rating: Extreme (4)<br>Near-surface fuel hazard rating: Extreme (4)<br>Overall fuel hazard rating: Very High<br>Near-surface fuel height (cm): 35<br>Elevated fuel height (cm): 120<br>Total fine fuel load (< 6mm) t/ha: 25<br>Down woody material (> 25 mm) t/ha: 80 |

DBH: diameter at breast height (i.e., 1.5 m above ground). t/ha: tonnes per hectare

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