Conference Proceedings – Speaker Transcript

Landscape Variation in Plant Flammability: Will Gullies be Safe Refugia for Native Fauna?

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Link to Slides

I'm a Senior Lecturer in ecology. Today I'm presenting some work that I'm doing in collaboration with a PhD student under my supervision, Dan Krix (Slide 1).

Without doubt, we're entering a new bushfire age in Australia (Slide 2). It doesn't take long with a Google search to find expressions like 'unprecedented', 'catastrophic' and even 'weather on steroids' in relation to the changing nature of bushfire conditions in Australia. What I want to do is ask the question 'what does this new bushfire era mean for places in the landscape that, historically, have been less fire prone?' (Slide 3). In particular, what I want to focus on is gully vegetation and the habitat it provides for native fauna in areas such as temperate forested areas of New South Wales.

To examine the potential fate of gully habitats, we need to look at three key drivers of bushfires. The first of these are the weather conditions (Slide 4). Weather that's hot, dry, windy and low in humidity is the sort of weather common in the summer months, and provides ideal conditions for bushfires. Just focussing on temperature, ideal hot conditions for bushfires are becoming much more frequent in Australia. We're seeing long term trends towards an overall warmer climate. We're seeing more frequent and severe very hot days. And we're seeing unseasonably hot days extending into spring and autumn.

These hotter conditions are leading to increases in bushfire ignition events from lightning. With every 1°C of climate warming, there's going to be a 5% to 6% increase in global lightning activity. The hotter conditions are also going to lead to increases in bushfire spread and intensity, with hotter conditions producing drier vegetation which ignites much more readily.

The second factor that's linked to bushfires and variation across the landscape is topography (Slide 5). With each 10 degree of uphill slope, fire doubles in rate of spread. And with each 10 degree of downhill slope, fire halves in rate of spread. Also contributing to this topographic effect is that gullies are sheltered from winds. They receive less direct light to dry out vegetation. They're much more humid environments than surrounding ridges and slopes. This slide (Slide 6) shows the kind of habitat I'm talking about: we've got gully habitat on the left and nearby ridge habitat on the right.

They're obviously very different looking vegetation types. One outcome of the topographic features is that, historically, vegetation in areas like gullies has been less likely to burn when compared with the surrounding vegetation on ridgetops.

If we consider the future of gully vegetation (Slide 7), we know that with respect to bushfire driver one, weather conditions, they're becoming more ideal for bushfires, bringing about the unprecedented catastrophic and 'steroid weather' mentioned before. We also know that bushfire driver two, topography, isn't changing. So with respect to these two bushfire drivers alone, increasing bushfire conditions may override the effects of topography to potentially threaten what was once less fire prone vegetation. Areas of vegetation like the gullies you see here, that have burned less frequently in the past may become more fire prone.

Importantly, what we also must consider is the contribution that plant fuel makes to the potential risks of gully vegetation burning (Slide 8). Bushfires are fuelled by vegetation, and plants are the primary source of fuel. What if gully plant species provide a highly flammable fuel source under these changing conditions? This would have the potential to exacerbate the effects of the changing weather conditions. Ultimately, what it would do is place gullies at even higher risk of catastrophic bushfire.

Why might we expect the flammability of gully plant species to differ from the flammability of ridgetop plant species (Slide 9)? Just from observations, they look different. I've got a couple of examples here. Many of you will be familiar with these. This is *Lambertia formosa* on the top, which is commonly found along ridgetops and on some of the slopes, especially up around the Blue Mountains. And this is a species, *Astrotricha latifolia*, which is very common in gullies. They look different. Their leaves look very different. Previous work on leaf flammability morphology in my lab has shown that leaves that are broader tend to ignite more quickly than more narrowed leaved species.

The second reason why they might differ is that plant traits that increase flammability may exist in plant communities that are rarely burnt. Bowman and colleagues have suggested that "… plant traits that increase flammability may exist in plant communities that are rarely burnt, suggesting they have evolved independently of landscape fire". The idea here is that leaf traits that have evolved for other plant functions may, incidentally, increase plant flammability in these kinds of habitats.

To determine the potential for high intrinsic flammability of gully plant species to increase bushfire risk in gullies, we asked a couple of questions (Slide 10). We asked, are leaves of gully plant species more flammable than leaves of ridgetop species? We also asked whether three important leaf traits can explain variations in observed flammability.

Our study region was the lovely Blue Mountains (Slide 11). This slide shows a nice picture of the Blue Mountains (with some invasive *Coreopsis* taking in the view!). We located our study sites here, around the Faulconbridge area. We had 25 gully sites and 25 ridge sites. The idea of setting these sites up was to obtain enough species to do leaf flammability experiments. We looked at a total of 93 plant species, 35 that only occurred in gullies, and 58 that only occurred in ridgetops.

The focus of this work was on intrinsic leaf flammability (Slide 12). Plant leaves are an important flammable plant structure. They provide a large amount of fuel and, more often than not, they're the first plant structure to ignite. Leaf flammability on its own is just one component of the flammability of populations and communities. When you're resource limited, it's a good place to start to do some experiments on flammability.

We measured three leaf flammability attributes: ignitability, which was the time taken to first combustion; sustainability, which is burn duration, how long an individual leaf burned for; and combustibility, which is mass loss rate, ie how much mass is lost in a given unit of time.

The ways that we collected leaves, ran our experiments of flammability as well as measurements of the leaf traits themselves followed established protocols, which we've listed here (Slide 13). The flammability experiments go back to Malcolm Gill's pioneering work back in the mid-'90s.

For the flammability experiments, we used a muffle furnace set to a radiant heat of 700°C. This picture shows a leaf entering into the muffle furnace and igniting. We used digital video recordings of the burns which we then analysed to get good estimates of the time to ignition and burn duration. The mass loss rate was measured as the pre-burn weight of a leaf divided by the time that it burnt for.

The three leaf traits we measured are classic ecological functional traits. We looked at field moisture content of a leaf; leaf mass per area (LMA); and leaf area. In terms of the gully/ridgetop divide, field moisture content and leaf area were significantly larger in the gully plant species compared to the ridgetop species. But leaf mass per area was significantly higher in the ridgetop species.

Moving on to some of our results (Slide 14 & 15). Time to ignition - how long it took combustion to take place. On the left: in the blue, we have gully species. In the red, we have the ridgetop species. This is a log scale. These dark lines represent the means. The most important thing that we found with time to ignition was that gully species ignited significantly more quickly than ridgetop species. The sorts of species I'm talking about are *Stenocarpus salignus*, with its broad leaves, which ignited very quickly; and *Petrophile pulchella*, which ignited much more slowly.

On the right, we have some scatter graphs relating each of the three leaf traits we measured – field moisture content, LMA and leaf area –to time to ignition. These are residuals on the y-axis. They are regressions of residuals against the leaf traits. What that means is that in this relationship between, say, leaf moisture and time to ignition, it's the unique relationship between the two partialling out the influences of the other two traits, leaf area and LMA.

What was really interesting for us was that time to ignition was strongly and positively correlated with LMA. The partial R^2 – which represents the variation in time to ignition attributable uniquely to LMA – was about 78%. Leaves with low LMA were quicker to ignite. We did find the classic relationship with leaf water content. Lower leaf water content related to faster ignition. We also did find, confirming previous results, that broader leaves ignited more quickly, but the R^2 value here is only about 5%.

Moving to burn duration (Slide 16), we found no significant difference in burn duration between gully species and ridgetop species. In terms of the predictive traits, we found that leaf mass per area and leaf area were significantly related to burn duration. Leaf water content wasn't related to burn duration.

Similarly, leaf water content was not related significantly to mass loss rate. However, mass loss rate (Slide 17 & 18), and therefore combustibility, was significantly different between gully and ridge species. What we found, surprisingly, was that gully species were more combustible than the ridgetop species. Species like *Astrotricha longifolia* were highly combustible, whereas species such as *Brachyloma daphnoides* was not as combustible.

To summarise these key findings (Slide 19-21), leaves of gully species ignited significantly faster than leaves of ridgetop species. Leaves with lower leaf mass per area, lower water content and broader area ignited more quickly. Low leaf mass per area means less dense tissue with lower thermal mass which takes less time to heat up and combust. High leaf area means thicker boundary layers with higher average temperatures which makes it harder for large leaves to lose heat – the larger and hotter the leaf, the easier it ignites. Low leaf water content predicts fast ignition, because less heat needs to be absorbed before sufficient energy input needed to vaporise leaf water. But, gully species had significantly higher leaf water content than ridgetop species. Thus, leaf mass per area and leaf area combine and are much more important for predicting time to ignition than leaf water content. There was no difference in burn duration between leaves of gully and ridgetop species. Leaves of gully species were more combustible than leaves of ridgetop species. Leaves with larger leaf area and higher leaf mass per area lost mass more quickly. Gully species have more overall leaf mass from their bigger area. Gully and ridgetop species have similar burn durations. Thus, gully species must lose more mass than ridgetop species in that given time.

One other thing to throw into the mix is that gullies are susceptible to exotic plant invasion (Slide 22). Some of our previous work has shown that leaves of exotic plants, when dry, are significantly more ignitable.

What are the implications for gullies as refugia (Slide 23)? Leaves of gully species are more flammable than leaves of ridgetop species. Intrinsic leaf flammability of gully plants has the potential to exacerbate the impacts of changing weather conditions. So, there's a triple threat from climate change, gully plant flammability and exotic plant invasion that could lead to catastrophic losses of gully habitat from bushfire. This has consequences for the conservation of native plant biodiversity in gullies (Slide 24). Recent work is showing that gullies play a critical role in preserving structurally complex stands of vegetation for fauna. This means we potentially will see some serious impacts on fauna that use gullies as refugia.

In conclusion, our work is providing some early evidence and support for the notion that gullies may not be safe refugia in the future.

I'd like to thank these people and places (Slide 25). Thank you.

Questions from audience

Question: Hugh Paterson, NCC representative on the Blue Mountains Bush Fire Management Committee and also an experienced crew leader in the Rural Fire Service. We looked at leaf characteristics, but there's a lot more to vegetation than leaf characteristics. And there's a lot more to flammability of the landscape than vegetation. Experience tells me that fires tend to go out under hazard reduction type conditions down in gullies. Obviously, I've had experience in different vegetation types in gullies. I come from this area, Springwood, where your research is going on. The question is can you compare, say, a vegetation community which is warm temperate rainforest to a vegetation community that might be something like a *Gahnia* dominated sedgeland in a gully only 50m apart?

Brad: That's a really good question. As I stated, our work is just looking at leaf flammability. I have no doubts whatsoever that the question is much larger than that. We're looking now to try and scale the work from leaves to branches to whole plants to community levels. We're resource limited, so if anyone wants to get involved in some of this research with us at UTS, that would be wonderful. But imagine though, if it all comes down to leaf flammability, you build a scale of leaves, you could then also find low flammability species to put in your gardens. Thank you.