Conference Proceedings – Speaker Transcript

Quantifying the flammability of fire-sensitive rainforest habitats

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Link to Slides

I'm going to be talking about a project that started in 2013, when I was with the Office of Environment and Heritage, and now is completely run as part of the NSW National Parks Volunteering program with the assistance of many local volunteers and students.

Our brief was to look at issues to do with flammability and the fire management of Gondwanan World Heritage cool temperate rainforests (Slide 2). We wanted to collate and analyse some basic information about fuel loads and flammability. For example, what happens when a rainforest burns, or when a fire is approaching a rainforest ecotone and will potentially enter the rainforest? How does the climate, the fire, weather and the fuels interact? What will be the responses of the rainforest species to burning? What is the likely impacts on the threatened fauna which inhabit the rainforest-eucalyptus forest ecotone. Can we assemble enough information to provide a better opportunity to improve our predictive capabilities around fire behaviour analysis?

I'll be focussing on the *Nothofagus* rainforest estate (Slide 3). That's the extent of it marked in blue on the map - from Barrington Tops north to Werrikimbe, Dorrigo and the Border Ranges. Of about 580,000 hectares of rainforest in New South Wales it only occupies about 6%, so it's relatively uncommon in terms of a rainforest type, and it typically inhabits land above 900 metres, it's a cool, wet, and frequently misty environment.

We've had a couple of discussions this morning, especially from Ross Bradstock, about the role of climate change in changing patterns of fire behaviour. On the top right hand graph (Slide 4) is our data on changes in mean annual temperature from the park from 1960 to present onwards changes in mean annual temperature. Most modelling available for these remote areas is based on extrapolations based on the nearest automatic weather station, which in this case would be taken from Port Macquarie or Armidale Airport. However, in this case we have the advantage of empirical data gathered from instruments maintained by volunteers in the park. The data shows about a half a degree increase in mean annual temperature since 1960, so is very close to the modelled temperature increases associated with modelled global environmental change.

We also know that net primary productivity or litter fall of the rainforest is very tightly in tune with rainfall patterns. So if the climate's going to change we've got a reasonable basis to say that we think the rainforests are going to change as well.

Patterns of rainforest fire in northern New South Wales (Slide 5) are poorly known. It's very hard to get much information about it because there's very little recorded, even though we know it occurs. I went back through historical searches of Trove, the library online databases, picked up records of significant fires that were reported, usually in the regional media. I looked at archival management records from the Forestry Commission and located an interesting reference in 1968 to the conglomerate Coffs Harbour fire: Curly Humphries said "Even the rainforests were burning".

In 2012, a significant amount of dry rainforest burnt in Oxley Wild Rivers NP (Slide 6). So it does occur however it is infrequent (Slide 6).

We also wanted to get some indication as to whether there's a demonstrated change in the fire seasons on the north coast (Slide 7), and credit to the Forestry Commission again for keeping such detailed management records. I went through boxes of old records from the 1950s, and entered all the data for wildfire occurrences from the district records north of Taree, and then compared that to the current mapping that we have in the Rural Fire Service which dates from approximately 2001-2002. The question was: are the changes in the occurrence of wildfires related potentially to changes in fire weather? The answer was yes, and if this analysis is reasonable it looks like the fire season in spring has moved about a month forward.

So we then started a process in 2013 to quantify rainforest fuels (Slide 8) because there was relatively little information available on fuel accession, litter fall, quantities, fractions, etc., compared to eucalyptus forests and other vegetation types. We use different techniques to measure litterfall for leaves, coarse fuels and woody debris on the forest floor.

So in a broad sense they're the figures (Slide 9), about 9 to 11 tonnes per hectare of fine fuels in cool temperate rainforest, and usually double that, 16 to 23 in an equivalent wet sclerophyll or tableland woodland forest type. Monitoring of fuel biomass and litterfall across several national parks continues to be managed by volunteers.

We then started looking in detail at the characteristics of the litter bed (Slide 10), so that we could get a better indication in terms of the predictive abilities of how fire would move through that source. We did an awful lot of collecting of litter, and then started comparing things like bulk density, how well packed is the litter, how aerated is it, which is a key indicator of how the fire will move through, and also changes in percent moisture or fuel moisture in those two types.

We then compiled data both from our own work and also from work National Parks had completed in the 1990s (Slide 11) when Lachlan Copeland established a series of fuel monitoring points, we put that data together and then we realised why there was this fundamental difference in fuel biomass between the two types. The rainforest fuels basically just give you a thin veneer of fuel over the surface. Eucalypt forests have about twice the depth of fuel, which then because of the nature of the fuel, there's more bark, more ribbon bark, more twigs, they're more aerated, and in summary they're easier to burn.

Since fire behaviour in rainforests is closely linked to fire behaviour on the eucalyptus forest margins, we looked at how fuels change across the boundary (Slide 12) because we knew if rainforest was going to burn the fire had to then propagate through the eucalypt forest into that ecotone. There is a reasonable linear relationship of increasing fuel biomass from about nine tonnes per hectare in rainforest, 11 tonnes per hectare in the ecotone, and depending on where you are, 13 tonnes plus in the eucalypt forest.

We also did the classic litter burial experiments and that's how we generate the fuel equilibrium curves, by determining the rate at which fuel decomposes (Slide 13). I've avoided sewing all my life but I had to sew 600 litter bags, so those litter bags were put together to capture a range of different types of fuel types and they were buried and the young man in yellow is my oldest son who was taken on a field trip as a Year 10 work experience project - parents can be awfully cruel can't they? I said "Here's a great opportunity for you to do some research in a national park". And there he was all day on his own labelling and setting out the experiment and didn't complain once.

That experiment ran for a year, and every month we collected a series of bags for testing in the laboratory. Importantly, what that told us was that litter turnover was relatively fast in the rainforest, the K value is about 0.4 for those of you who are interested. It means that the litter's turning over every two and a half years or so and because of that there's quite a large proportion of heavily decomposed litter. That laboratory experiment indicated quite clearly that as the litter becomes more decomposed, it's a lot harder to burn, so that's another insight in terms of why rainforests aren't burning.

In general, the proportion of more decayed litter increases in rainforest, although the trend is reversed for the advanced decay stage (Slide 14).

The key point this litter burial experiment highlighted was the important role litter decay stage has in the flammability properties of the litter bed (Slide 15).

We then looked at the seasonal patterns around litter accession (Slide 16). We have a network of stations where every month, for about 14 years, we collect litter fall and we sort the fractions, and we determine the importance of weather etc, on litter fall and productivity. We then realised that spring was the peak season for litter fall in these cool temperate rainforests. That also happens to be the peak season for ignition in rainforests. We also know that in spring the fuels are generally at their lowest moisture content, because they go through a dry winter period and until the coastal or north coast storm season arrives these areas are relatively dry. We also know that at this time the humidity is relatively low. We now have a situation where we have a lot of fuel mass in spring, it's dry, and humidity is low.

So we then looked at patterns over several years now that we've got a larger data set, and we started to get some quite significant relationships in terms of the accumulation rate of fuels, and mean annual rainfall (Slide 17). And at times the r square values were about 0.97 and those of you who work with ecological datasets will know that's really rare and that means go and check your data because that normally doesn't happen. But they were correct. We're getting very strong relationships between rainfall patterns and litter accession.

We scaled up this relationship by comparing fuel equilibrium biomass across the two forests types in northern NSW (Slide 18). As mean annual rainfall increases, so does fuel equilibrium biomass.

So we then started having a look at moisture conditions (Slide 19) across the rainforest to eucalyptus forest ecotone, and in general the rainforest fuels were about twice as moist in terms of fuel moisture content, as those in eucalypt forest for sampling undertaken at the same time.

We quantified the microclimate across these boundaries by installing a series of sensors, and again these are completely managed by volunteers (Slide 20). We have a sensor that measures temperature and humidity, right at the boundary layer of the litter, so it's sitting about two centimetres above the ground, and then we have another one at 1.5 metres. We also have other sensors measuring temperature and moisture content in the soil. This is another attempt at getting a much better indication as to what's happening to the microclimate as you move from the eucalypt forest into the ecotone and into the rainforest.

What we found was that the sensitivity of the environment is incredibly in tune with the rainfall and the humidity (Slide 21), so the rainforest fuels are very sensitive to changes in air and humidity and rainfall.

We then took our study from the field into the laboratory, where we worked with research partners at the University of Sydney (Tina Bell's lab) and CSIRO's pyrotron in Yarralumla in the ACT. We also set up temporary lab facilities in a machinery shed with the assistant of Landcare volunteers in Port Macquarie.

I am going to skip through the detail here to simply highlight the relevant results. Using Malcolm Possell's lab at Camden University of Sydney, we identified that rainforest fuels and slower to ignite, release less heat as they combust and burn more slowly than eucalyptus forest fuels (Slide 22).

We then burnt leaves of each rainforest canopy tree species in large to obtain data on maximum temperatures, flame height and other variables (Slide 23). Eucalyptus fuels release for more heat for a given mass of dry leaves than rainforest leaves.

We then scaled up to burn whole litter beds in the pyrotron (Slide 24) to replicate under controlled laboratory conditions how fuels from the different forest types behave.

This demonstrated that there are some quite clear patterns in terms of rate of spread of fuels collected in eucalyptus forests, rainforest and the ecotone between them (Slide 25).

We also implemented a trial hazard reduction burn in the rainforest to get a better indication as to response of fuels and plant species to this type of low intensity burning. Again just presenting an overview of the experiment, we established four permanent trial plots (Slide 26), burnt three and retained one as a control.

Under benign conditions, the ground fire moved very slowly only occasionally burning hot where it met heavy fuels such as branch and log debris (Slide 27)

The most at risk trees were the largest mature trees in the stand (Slide 28-29) which at times burnt through hollow buttresses resulting in tree collapse. The volunteers are also monitoring ongoing tree health, mortality and regeneration of the understorey and changes in fuel biomass.

Following wildfire, canopy scorch in rainforest led to a massive spike in litter fall equal to three years litter inputs in a two week period.

I will now provide some insight to the November 2013 Brushy Mountain complex wildfire (Slide 31) which entered our main study area just as we were completing our experiments. The fire burnt 13,000 ha of Eucalyptus forest, woodland, heath and moorland from the tablelands spreading east towards the coast. It also burnt into rainforest.

Our environmental monitoring of soil moisture (Slide 32) indicated a soil moisture of 9% on the day the fire started which was the lowest value recorded in over three years of monitoring of rainforest soils. The previous lowest value recorded in 2012 also saw rainforest burning on the same day further west (Slide 6). This provides a powerful insight into the type of soil moisture conditions required for rainforest to burn.

The fire entered rainforest patches after a canopy wildfire swept across from the west (Slide 33).

Rainforest canopy trees were scorched to a distance of approximately 50 m into the rainforest stands (Slide 34). The volunteers plan to continue to monitor the health of these stands into the future.

In some parts of the landscape, rainforests were the only vegetation type not to burn (Slide 35).

Getting to the conclusions: what did we find (Slide 36)? Rainforests have a lower rate of fire spread. The heat output, ignitability, mass loss, etc, all the classic measures of flammability are much lower in rainforest. There's less depth, less fuel and it's less aerated. Is climate change relevant? We think it is because we've got this really quite tight relationship now, especially between ambient humidity and rainfall, and the productivity of those stands. We know a lot more about the response to fires because as part of another project we're looking at regeneration responses to our experimental burn. So what do we do? Well we think strategically there's an opportunity now to start listing these rainforest stands in these World Heritage parks as assets within the bush fire risk management plans, and in doing so National Parks can potentially develop treatment plans and seek funding to provide a better risk strategy to address their inherent vulnerability to wildfire.

Thank you.

Questions from audience

Question: Penny Richards, from the CFA, and a student at Melbourne Uni. I'm just interested, did you notice any evidence of regeneration from rainforest trees, in particular *Nothofagus,* when fire had got into your rainforest gullies? Because after Black Saturday, which was a very intense fire, with our community walks we ran as part of bushfire recovery I was surprised to notice rainforest species and cool temperate rainforest around Marysville actually resprouting, whereas the belief had always been rainforests are killed outright by fire.

Ross Peacock: Yes. The large *Nothofagus* burls did resprout, but the regeneration is heavily browsed, so that's the first answer. The second answer is the areas that were burnt on the edge of the rainforest, were one of the few areas that we found true seedlings of *Nothofagus,* generally *Nothofagus* seedlings when they do occur, and they only occur twice a decade, die within about three months, just due to shading and litter burial, and they're growing here. We've now got seedlings with about 3-4 leaf pairs. So there was both a seedling recruitment response and a coppice response. We will need to monitor both to see if it is sustained.

Question: We've noticed that use of aerial ignition from helicopters, which is increasingly used by the fire agencies in National Parks for prescribed burning and also for reaction to bushfires, means that you get the introduction of fire into these gullies, the same ones that Brad and Dan were talking about earlier. Have you got any comment on firefighting responses? You were proposing that these rainforests could be listed as assets in the risk plan, so that presumably the firefighting agencies are aware of that and avoid them. Have you got any comment on that?

Ross: I was going to try and hand that over to one of my National Park fire management colleagues, because that's really a question for how their fire management strategies are put together and how the response capacity to a wildfire is implemented. These are wilderness areas, so there are a whole set of restrictions in terms of the activities surrounding the hazard reduction process. There are also some restrictions that occur around the response process, and I don't know whether Max Beukers from National Parks wants to say something to address your question since he is best qualified here to do so. Perhaps Max and I can talk to you about that afterwards.