Proceedings for the 6th International Fire Behavior and Fuels Conference
April 29 – May 3, 2019, Albuquerque, New Mexico USA
Published by the International Association of Wildland Fire, Missoula, Montana, USA

# Managing the Complexities and Consequences of Peat Fires Around Communities

Mark Gunning
Country Fire Authority, Victoria, Australia, m.gunning@cfa.vic.gov.au

## Introduction

In this paper, I wish to share my experiences combatting Peat Fires in the Western District of Victoria, Australia.
At the end of this paper, I hope to have shared our challenges and successes and also to provide stimulus for ongoing discussions and information sharing around this growing problem.
The Western District of Victoria has vast grassland plains with rich volcanic soils that have seen numerous devastating grassland fires over many decades (McArthur, *et al* & CFA).
With successive droughts and increased surface moisture evaporation, swamps have dried to expose peat areas which ignite with the passage of bush and grass fires.
Dense peat areas, once ignited, have a number of specific issues and challenges for fire agencies, land managers and communities, which will be further detailed through this paper.

## What is Peat?

Peat has numerous definitions:

- *"Peat – Decayed Vegetation. The first stage transition of vegetation to coal"* (Dictionary of Fire Technology)
- *"Peat – Vegetable matter partly decomposed in wet acid conditions to form a brown like soil deposit, used for fuel, in horticulture"* (Oxford English Dictionary)
- *"Peat - sedentarily accumulated material consisting of at least 30% (dry mass) of dead organic material"*(International Peatland Society)

I would say an appreciative description for firefighting personnel is that – *Peat is a substance that evolves – it has a start and end point – the start – a soil mass that has reached at least 30% (Dry Mass) of dead organic material – and at the end – it finishes life as peat - and then becomes Coal*.
Whilst coal, and some soils with vegetative content may behave like peat fires – at some point we should collectively define the subject for firefighter's work into the future.
You may experience a peat fire at any stage of its life and the suppression methods employed to achieve success will vary. Sometimes you have to fight the effects and consequences of these fires (smoke/particulate matter) and not the fire itself.

Having spent six weeks in 2014 at a Coal Mine fire, I can attest that Peat and Coal share many similar challenges for firefighting teams. Specifically, some of the common challenges include:

- Flameless (or invisible flame) combustion can be experienced
- High Carbon Monoxide generation
- Fine Micron Particle Matter production in the by-products of combustion (Pm 2.5µ, Pm10µ)
- Difficulty and complexity in suppression

Peat is found throughout the world. One third of the world's soil carbon and 10% of global freshwater resources are found within the World's peat masses. Peatlands are found on every

continent and can be found in Tropical and Arctic areas (Clark & Joosten). My observations will be specific to volcanic plains.

**The Problems**

Climate shift –

- Higher diurnal temperature averages are increasing evaporation and exposing previously wetland peat to fires
- Drying conditions means less surface water to combat Peat Fires – which take great volumes of water to saturate and extinguish

Wildland fire is a growing business – more fires, more often. And this is the story around the world. (Flannigan *et al*)

Communities demand more information from us – about the health effects of smoke, and even about the strategies we use to suppress fire. This leads to greater accountability to government.

Suppression of Peat Fires is laborious, it takes numerous human and physical resources to put these fires out and it is, more often than not, done quickly. In Great Britain it is said of fires in Peat Lands that *"…Unless military or similar assistance is available or considerable civilian help can be obtained, fire brigades will generally be unable, because of the insufficiency of numbers, to extinguish a large…fire*" (Manual of Firemanship 6b).

In mid-2018 at an 18km$^2$ Peat Fire at Saddleworth Moor in Great Britain, the Greater Manchester Fire and Rescue Service asked for military assistance to suppress a fire. The fire disrupted communities and took nearly 4 weeks to extinguish, with over 100 soldiers. (BBC)

We, in Victoria, appear to be experiencing more peat based fires in recent years and for a range of reasons. We are finding that obtaining sufficient resources to deal with these fires is a challenge. The complexity and repetition of issues associated with these emergencies is frustrating some Incident Management Team members. The ground work is laborious, and repetitive, and this suppression activity is not embraced by all firefighting personnel.

**Our Case Studies and Learning**

The Case studies presented herein will cover 3 firescapes.

At all of these fires I was the Incident Controller for the majority of suppression time. I will describe each of the sites and then list the challenges and successes.

**Fire – Kaladbro**

Kaladbro is a property name – the property is in a farming area and is used for grazing and some cropping in Far Western Victoria just inside our border with South Australia. In late 2015 this fire burnt for a week without detection. Investigations showed lightning had hit a disused fence line in a corner of a 400 hectare dried peat swamp.

Peat Profile

The geological form of this swamp was not insignificant. The depth of the peat varied between one and three meters. Under the peat was a thick clay base, below that were other soil strata, and below that an aquifer of fresh ground water. That part of the peat on fire was only 11 hectares and at its deepest part was only 1.8-1.9m. The area was of cultural significance with Indigenous burial sites on the eastern jet lines of the swamp. By understanding the peat mass, we were able to use the geological features to advantage. The peat was aged, very dense and black with

vegetative content visible only in the very top stratum. It was rich black peat soil at 20-30cm, and further, below the surface.

**Fire - Yeodene**

Yeodene peat swamp is along Boundary Creek, South East of Colac in the Otway's Region of Victoria, just north of our Great Ocean Road. It is a very different body of peat than Kaladbro. In parts it is at least 8 meters deep. It burned down to 5m at some of the deep parts of the fire, it has forested vegetation on the North and South Side and it is in a really bad ignition location for our high risk coastal communities. It has ignited numerous times – 10 October, 1997 a fire of 80 ha occurred and in the middle of that, along the creek, was the peat. Treatments at the time were limited as it had been a very dry season and water was in short supply. Mineral earth breaks were constructed, areas were back burned in surrounding vegetation and some trenching was undertaken.

After three weeks it was thought extinguished, when there was no visible fire, and no heat was detected on a number of aerial operations with Forward Looking Infrared. In March 1998, it reignited, burning 680 hectares. It reignited in 2006, and again in 2010. Before 1997, other fires reported that had no obvious cause on the same site had been documented in March 1881, and on January, 5, 1886. (Cecil, Colac Herald)

**Fire - St Patrick's Day Fires**

On the evening of St Patrick's Day 2018 ferocious winds lashed the Western District of Victoria. Twenty-two fires were started by disruption to power lines and fallen trees hampered fire response. Three of these fires, in my area, became large – Garvoc Fire 4064Ha, Terang-Cobden 6655Ha and Bullen-Merri 418Ha. Twenty-seven homes were lost, 40 sheds, over 4000 livestock and numerous bales and tonnes of fodder.

Eleven peat fires were detected within the 3 large fires, but three of these are of greatest significance:

- Lake Elingamite – a fresh water lake – used for fishing and water recreation - with Peat around it's edges that has some eucalypt trees and raised embankments
- Cobrico Swamp – a swamp with multiple farms immediately around it and a freshwater lake on the East with deep peat on the remaining sides
- Lake Bullen Merri (& Lake Gnotuk) – a dried out swamp within an extinct volcanic crater that has two lakes – Gnotuk to the North (salt water) and Bullen Merri (fresh water) to the South used for recreation including golf course, equestrian, cricket, fishing, water skiing and lawn bowls. This site is also associated with Aboriginal Dreamtime Stories

The Challenges

Suppression

- Trenching was a containment and suppression support strategy employed across all three fires with varied success. Water placed in parts of the trench was quickly absorbed in the peat soil in the bases of trenches, save Kaladbro which had a clay base

- Direct application of Class A foam was used with varying efficiency. Class A foam, however, was essential – the lower rates <0.3% were most effective – applied with water jets – not foam branches – penetration was also enhanced. CAFS is a limited resource in Victoria
- Water applied alone was sometimes ineffective, except post foam usage with sprinklers to keep ground saturated, or when peat depths were shallow
- Hazmat teams for atmospheric monitoring are not immediately available to rural fire grounds
- Crews could not see flame, some days they could not see smoke – they would ask "*why are we here?*" or "*what are we fighting?*" – use of thermal imaging videos and pictures were used to brief crews
- Mineral earth breaks could not always be established where break outs were predicted because of cultural sites
- Underground water tables were sensitive to overuse, use of firefighting water from such sites had to be tempered with possible long term environmental damage
- Firefighters need to work upwind of the fire, and with wind as the greatest influence in fire behaviour, the suppression efforts were often complicated
- Water is critical for firefighting, and copious amounts of it. During dry times this can be a challenge, especially for initial attack

Fire Behaviour

- The fires increased in size, more often driven by wind rather than heat and low humidity
- Topography was relevant at all sites where it channeled wind across burning surfaces
- The fires regularly crossed trenched containment lines if not correctly managed. Extension of the fire beyond any established trench was because of one, or both, of these reasons:
    - Radiant heat from the wall of one side of the trench – although flameless, it was igniting the unburnt side up to distances of about 1-1.5m from radiant heat transfer
    - Unstable weather conditions and heating of the soil and dust were causing whirlwinds to form –this would spread burning materials across containment lines
- When winds hit fire grounds dust would blow off and expose more peat as a new fuel source for fire, and ground cracks oxygenated deeper peat which would also burn

Safety

- Basic PPE – is challenged – the usual wildland PPC with goggles, gloves and particle masks
    - Particle masks required frequent changing
    - Where irritable dusts were present clothing required frequent washing
- Soil stability, due to fire affecting integrity of the soil structure, was an issue
- Carbon Monoxide (CO) levels were high, up to 300ppm in some locations close to the fire
- Older, unburnt peat produced fine dusts that were irritating to skin and respiratory systems
- Burning peat produced smoke and when the ash dust blew, fine micron particulate matter
- Dust and Carbon Monoxide levels made wind the critical factor of where it was safe to work
- Personal CO monitors were employed for fire-fighting, farm, and plant contractor personnel and Health monitoring was on site by trained paramedics measuring, primarily, carboxyhemoglobin

- Communities were exposed to the same health issues as firefighting personnel during peat fires
- Locals, used to bushfire smoke with a eucalypt perfume, smelt the stench of the peat fire smoke and knew something was different. What did this mean for their health, they asked?

The Learnings – successes

- The complexities of health issues, suppression challenges, impacted communities and a myriad of peat profiles mean that you have to absolutely profile your fires, their impacts and consider all of the options open to you. The peat profiles at all locations were different – like peat is – different depth, different access, different soil stability, different water access, trenchable areas and areas that can't be trenched
- The public get concerned when you talk to them about acute and long term health effects – some of these messages, delivered to stressed, fire affected communities have to be technical but must be also demystified by experts, or the messaging will be ignored. When it comes to messages about fire suppression you have to explain things clearly and in plain language
- Consistent Safety and Health warnings for FF's and communities should be issued. Health monitoring is vital for crews working around peat fires – by undertaking base line Carboxyhemoglobin and $O^2$ saturations you can identify build ups of CO in the blood
- Water is key, copious amounts of water for filling trenches, for flooding, for our fire trucks, for sprinklers, for hoses – Peat fires will absorb large amounts of water before it cools to a level where it extinguishes
- Dry firefighting can be effective in initial stages before large quantities of peat are ignited – once ignited to more than 5 -10cm deep, water is critical for suppression success, dry tactics appear of limited, or no success beyond this threshold. Early removal of surface fuels to prevent fire extending downward can be effective if the fire is still only in the fine fuels just on, or above the surface
- Use of Experts for community confidence - bringing in experts can be reassuring – for both the IMT and the community and they assist in clarifying complex, or highly technical issues
- Suppression – making water work means applying it copiously, and trying to cover it with CAFS after application. After water application, steam will rise from the peat minutes later, or even an hour later. Often this steam release occurs after crews, or aircraft, have left the area
- Long reach excavators can turn soil over, like bread dough, and dig out hot spots and utilize water on smaller compartments of peat
- Mapping is vital – map your fires – set up grids to map hot spots and to track your progression – close out your fire suppression in a systematic way – or as ash blows away, fresh peat can ignite under areas already burnt, but insufficiently extinguished – share the information of success with crews so perceived lack of progress does not affect morale or work ethics
- Use of Environment Protection Authority, community based atmospheric and, air quality monitoring involves community and shows transparency in health and safety warnings

## Conclusion

In conclusion, Peat Fires appear increasingly prevalent, and communities expect more of emergency management agencies than ever before. These agencies are often working in a "do more with less" government framework. I am confident our industry has many people experiencing similar challenges and coming up with solutions through trial and error, as we have done in Victoria.

I trust this paper achieves what it set out to do – share our experiences and start a worldwide conversation on how we can, cooperatively, solve or mitigate the complex problem of peat fires and their consequences to emergency management agencies and to the communities we serve.

## References

Books

- *"Dictionary of Fire Technology"*, Institution of Fire Engineers, 3rd Ed, (1979)
- *"The Oxford English Reference Dictionary"*, 2nd Ed, Judy Pearsall and Bill Trumble, Eds, Oxford University Press (1996)
- *Flammable Australia - Fire Regimes, Biodiversity and Eco Systems in a Changing World*, p264, Ross A Bradstock, A Malcolm Gill and Richard Williams Eds, CSIRO (2014)
- K L Cecil, "*The Red Steer – Bushfires Along the Great Ocean Road Volume 1*", p16, Anglesea & District Historical Society Inc (1993)
- *Manual of Firemanship – Part 6b: Practical Firemanship – II*, pp2-3 Fires in Rural Areas, Home Office (Fire Department), Her Majesty's Stationary Office (1975)
- Stephen J. Pyne, "*Between Two Fires*", University of Arizona Press 2015
- Australian Academy of Science, "*Fire and the Australian Biota*", Gill, A.M. *et al*, 1981

Journals & Reports

- A.G. McArthur, N.P. Cheney, J. Barber, "*The Fires of 12 February 1977 in the Western District of Victoria*", CSIRO and Country Fire Authority, (Published CSIRO 1982),
- *"The Major Fires of 16 February, 1983*", Country Fire Authority (December 1983)
- "*2009 Victorian Bushfires Royal Commission Final Report*", The Hon. Bernard Teague AO, Ronald McLeod AM, Susan Pascoe AM, Government Printer for the State of Victoria (July 2010)
- International Peatland Society, *"What is Peat?",* International Peatland Society, Finland,
- <http://www.peatsociety.org/peatlands-and-peat/what-peat> at 28/12/18
- Donal Clarke and Hans Joosten, *"Wise Use of Mires and Peatlands",* International Peatland Society, Finland, (2002)
- Mike D Flannigan, Meg A Krawchuk, William J de Groot, B Mike Wotton and Lynn M Gowman, "*Implications of changing climate for global wildland fire*", International Journal of Wildland Fire (2009), 18 pp483-507 at 501
- *Medical Information on Carbon Monoxide"* _Email report from CFA Medical Officer - Dr Michael Sargeant
- Xinyan Huang and Guillermo Rein, "*Downward spread of smouldering peat fire: the role of moisture, density and oxygen supply*", International Journal of Wildland Fire 2017, 26, 907–918
- Yuqi Hu, Nieves Fernandez-Anez, Thomas E. L. Smith and Guillermo Rein, "*Review of emissions from smouldering peat fires and their contribution to regional haze episodes*", International Journal of Wildland Fire 2018, 27, 293–312
- *Yeodene Peat Fire Briefing Note* – Country Fire Authority Victoria, District 6 – accessed December 2018

Websites

*" http://www.bom.gov.au/climate/data/ "* Bureau of Meteorology Australia

BBC "*Saddleworth Moor fire: Dozens of residents evacuated from huge fire*" <https://www.bbc.com/news/av/uk-44624210/saddleworth-moor-fire-dozens-of-residents-evacuated-from-huge-fire> at 27 June 2018

The complete paper, pictures and mapping is available by contacting the writer, who is not a researcher with a website that can readily share the full findings. In inviting you to seek the full paper, I do so in furtherance of learning more about this growing problem. If you have read to this point, I thank you for your interest and support.