ANDYSEZ 44

FIRE AND KARST

- Andy Spate

The following passages are taken from Pounder, DJ, 1985, The 1983 South Australian bushfire disaster, *American Journal of Forensic Medicine and Pathology* *6*(1)77-92. His citations have been omitted and some emphases have been added in square brackets.

> Natural bushfires initiated by lightning have probably occurred ever since there has been vegetation on earth. Certainly, there is archaeological evidence of bushfires in the Blue Mountains of New South Wales at least 17,000 BP, and the age rings on the giant sequoia trees of California show that extensive high intensity fires swept the area in the years A.D. 245, 1441, 1580 and 1797. The earliest written reference to a bushfire is to be found in the Bible (Joel 1:19) - "Lord, to thee I cry: for the fire hath devoured the pastures of the wilderness, and the flame hath burned all the trees of the field" [I suspect this would not be the earliest written reference. And we know that there is with-in cave evidence of naturally occurring fire going back at least half a million years or so].
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> In modern Europe, forests and natural bushland areas are small compared with those in Australia and North America and are cared for more intensively. As a result bushfires of any significance are rare. Very little is on record of European bushfires before the 19th century. One serious fire occurred in the Austrian Tyrol in 1811 and destroyed 64 villages, but there are no records of deaths. In 1949, in one of the few serious bushfires in modern Europe, a forest fire at Landes (France) covered 137,000 hectares, killed 84 people and destroyed 269 homes. [Fires are more important in the Mediterranean region than Pounder suggests.]
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> North America has suffered heavy losses of life from bushfires in the past. The disaster of the Great fire of Chicago that broke out on October 8, 1871, and killed 250 people has tended to overshadow the nearby forest fire which killed 1,500 people that same night, including 750 people in the village of Peshtigo. The Peshtigo fire was undoubtedly the worst bushfire the modern world has known. In 1894 in Wisconsin and Minnesota, bushfires claimed 700 lives and in 1910 71 fire fighters perished in the Cote d'Alene forest fire in northern Idaho. In the eastern Canadian province of New Brunswick in 1825, 160 persons were killed when fires destroyed 800,000 hectares of forest and 600 buildings and the Haileybury (Ontario) fire of October 4, 1922, destroyed 6,000 homes and claimed 44 lives.
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> Australia, like North America, has the natural potential for wildfires in excess of 100,000 hectares. The 1939 Victorian bushfires burned almost 1.5 million hectares of land and claimed 71 lives. *During 1961 one bushfire, burning in sparsely inhabited country of no economic importance near the Western Australia-South Australia border, covered 1.62 million hectares of land and travelled 240 kilometres over 50 days* [italics mine - see below]. One hundred and seventeen million hectares, representing 15.2% of the Australian continent, were burned during the bad bushfire season of 1974-75. [117,000,000 hectares = 1,170,000 square kilometres = 485 times the size of the Australian Capital Territory] In Australia as a whole, these fires claim an average of 20 lives per annum, although heavier losses of life and property have occurred from time to time. For example, the Hobart (Tasmania) bushfire of February 7, 1967, claimed 63 lives, burned 263,000 hectares, and destroyed 1,400 homes and other buildings.
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> [The Ash Wednesday fires February 1983 claimed 71 lives and more than 5,000 homes and other significant buildings. The Canberra fire of 18 January 2003 destroyed more than 530 homes, destroyed many public buildings including the scientifically and historically important Mount Stromlo Astronomical Observatory and took four lives.]
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> Conflagration bushfires in Australia typically occur under certain weather conditions. There has usually been an extended drought period of 6-8 weeks; the temperature of the day is over 40°C with a relative humidity of less than 18% and an average wind speed of over 55 kph. The atmospheric conditions are unstable and there is abundant well distributed fuel."

Since Pounder's paper of 1985 there have been a number of notable other fire events in Australia culminating in the events of summer 2002/2003 with more than 3,000,000 ha burnt (and still burning in eastern Victoria at the time of writing (20/02/2003) but thankfully very few lives lost. There were many other fires across the rest of the continent (explore www.sentinel.csiro.au and the links therein). Even this summer's three million ha in southeastern in Australia (~twice the area of the infamous Black Friday fires of 1939) is small beer when put against the nationwide figure for the

1974/75 season when fire affected 15.2% of the continent – 117,000,000 ha = 5 times the size of Victoria (Loane, IT and JS Gould, 1986, *Aerial Suppression of Bushfires - Cost-Benefit Study for Victoria*, National Bushfire Research Unit, CSIRO Division of Forest Research, Canberra).

Note that all these quoted figures of areas burnt are gross areas – there will be a variety of patches left unburnt, lightly burnt and so on until completely consumed.

At this point we will refer to my italics in Pounder's paragraph above. "During 1961 one bushfire, burning in sparsely inhabited country of no economic importance near the Western Australia-South Australia border, covered 1.62 million hectares of land and travelled 240 kilometres over 50 days." Astute karstic readers will realize that the "country of no economic importance" is the Nullarbor Plain! I am sure that the pastoralists would have had other views on the economics and the fire certainly did little to save the already over-grazed native vegetation communities. The effects of this fire can see be seen today – forty years later.

We also have had fires that have significantly impacted upon karst in the Mount Gambier area, in Tasmania and elsewhere over the past four or five decades.

In January 2002 I had some involvement over fires in Deua National Park, southeastern New South Wales that had the potential to badly affect a number of karst areas. Thankfully (perhaps) almost all remained unburnt through a combination of good-luck, hard-work, terrain, weather, vegetation and probably other factors. We will come back to the "perhaps"...

In January and February 2003 I was again involved in fires that had some impact on karst areas in southern New South Wales and probably Victoria. This involvement – see elsewhere in this issue – has prompted me to devote this ANDYSEZ to fire and karst.

We all know that karst is the result of a complex interplay between rock, soil, climate, vegetation, topography and other factors – normally over very long time frames. Fires are episodic, short term and vary widely in intensity and distribution. What then might be the impact of fires on caves and karstic landscapes?

Direct impacts of fire passing over the karst

Obviously any impacts of the fire front and subsequent burning of fuel will very much dependant on the amount of fuel and the fire intensity. Fire behaviour is complex but follows the basic rules of physics – it would require too much space to discuss here – any many predictions can be made dependent on weather, fuel, slope and so on. What can be affected? Rock outcrop, cave microclimate and sediment movement following the fire. There will be some rock movement on cliffs and steeper slopes as the support from above and below ground vegetation is removed. Of more consequence is the potential for widespread soil movement once rain occurs again. Even this is subject to many variables such as rainfall intensity and duration, infiltration rates (which may be greatly influenced by the extent of fire effect on soils), time since fire, degree of destruction of vegetation etc.

Ernie Holland (Holland E, 1994, The Effects of Fire on Soluble Rock Landscapes, *Helictite*, *32*(1)3-9) discusses the direct effect of fire on bedrock outcrop. These relate largely to calcining of the surface of the outcrops. Calcining is the process of converting calcium carbonate – limestone – to lime – calcium oxide usually by heating it in a kiln or by your campfire stones. In bushfires calcining probably only occurs where there is a large fuel mass such as a log burning up against the outcrop surface. [see the image with my Report on the recent bush fires – this Journal).

There is little scientific information on this occurring in nature but Ernie more than adequately canvasses the consequences of directly heating rock outcrops and his paper should be consulted by those interested. [Back issues of *Helictite* (which every cave management group should have!) can be obtained via John Dunkley (john.dunkley@effect.net.au).

I will cite Ernie's conclusions in full (although not necessarily agreeing with them completely).

> Conclusions
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> The degree to which vegetation fires will cause erosion on [destroy] the limestone [surface] has been shown to depend upon the purity of the limestone, its inclination and its degree of karstification. Laboratory studies have shown that the spalling of limestone with clay facies occurs at relatively low temperatures. Harding and Ford (1993) have shown that hot fires do considerably more damage and in some cases short term (until the next glaciation) irreversible damage. Taken in the total context fires are a major component of erosion with the associated potential for ground water disturbance and all fires on limestone should be avoided.

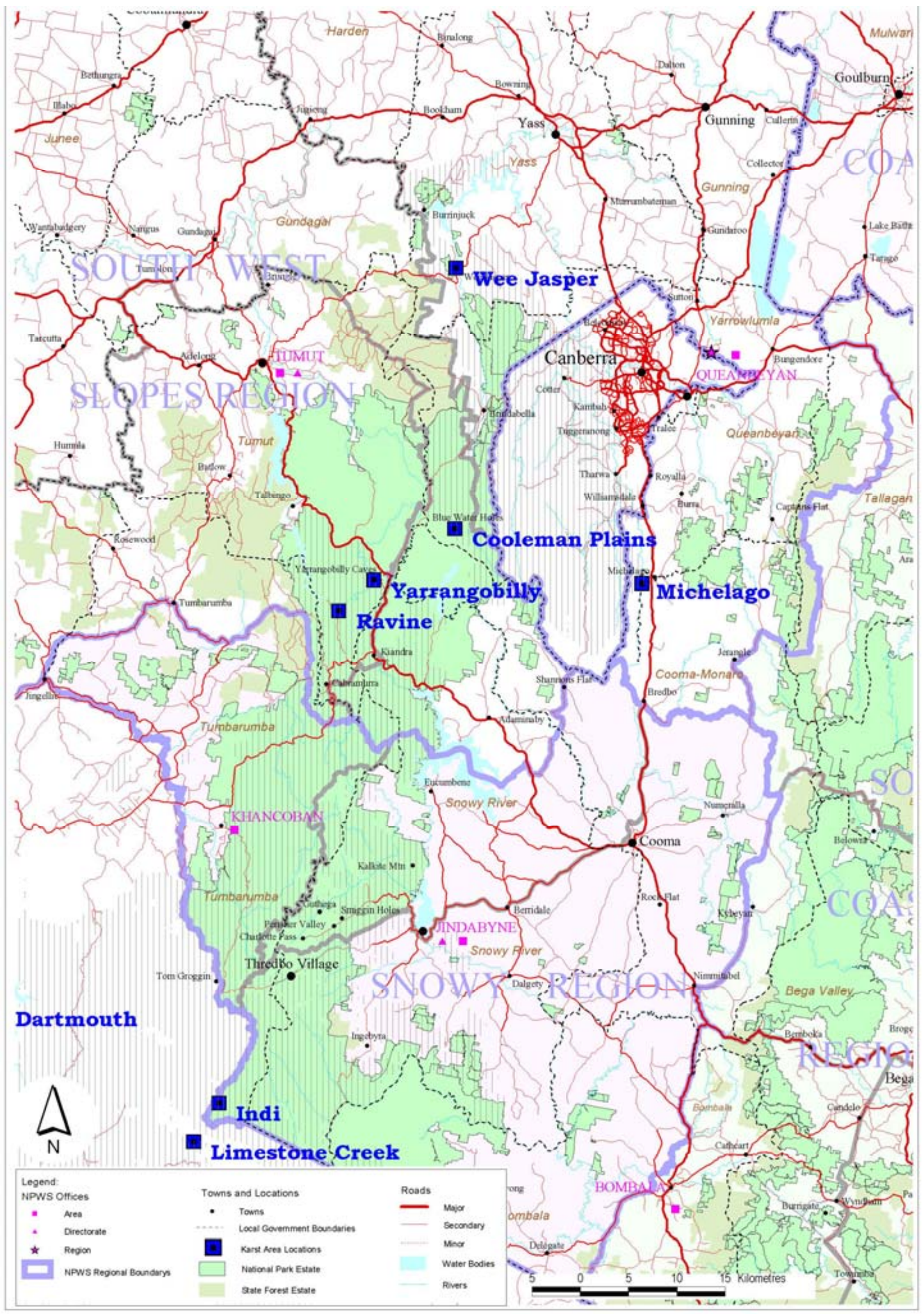
What other direct effects might there be? Hard to think of many other than the usual impacts of fire such as catchment instability and soil erosion, loss of plant and animal communities, weed invasion and so on. There could also be deposition of bushfire smoke – organic carbon and silica – in the caves such has occurred so spectacularly in Jersey Cave, Yarrangobilly, and, less dramatically, elsewhere across Australia. Not to be confused with smoke deposited in a cave in the Sierra Nevada, California, apparently derived from burning of dried urine deposits left behind by the extinct giant ground sloth (pers. comm. George Moore – the man who coined the term 'speleothem' for which we should all be grateful!).

The smoke deposits in Jersey Cave provide a record of bushfires stretching back hundreds of thousands of years. Curiously, the recent fires burnt over the top of Jersey Cave but did not appear to fill the cave with smoke as did the 1985 fires some 15-20 km distant?

So could there be indirect effects? Of course! How did you guess that it wasn't going to be simple? As you all know by now karst development depends on soil and vegetation conditions as well as the presence of limestone, suitable topography, climate, the availability of water and time. Fire will not, of course, affect these latter factors.

Fires do remove vegetation and may heat the soil surface especially if there are heavy surface fuel loads or highly organic soils. The depth of heating is probably not great and as a result fires probably have little influence on life in the soil other than the fact that there will be a very great increase in the availability of decaying roots etc. There will be a decrease in root respiration – so the availability of carbon dioxide may increase on one hand and decease on the other. The infiltration of rain into the soil may increase and there could well be short to medium changes in water chemistry. More limestone may dissolve leading to an increase in calcite deposition in the caves. Or infiltration waters may be more aggressive with consequent resolution of George's speleothems. How and when rain occurs over the immediate months following the fire will be an important factor also – especially in terms of soil erosion.

Much to think about here....



Location of the principal fire ravaged karst areas of southeast New South Wales, and a small part of Victoria. Map courtesy of Jo Caldwell.