In many places in Tasmania, button grass moorlands occur where trees should be. These areas are likely to have been burnt for many thousands of years by the Tasmanian Aborigines to entice game out of the surrounding forest and scrub to feed on the succulent new shoots that grow after fires. The moorlands are essentially the remains of an early farming system.

Fire, Erosion and the End of the Megafauna

BY PETER D. MCINTOSH

Tasmania's erosion history links ancient Aboriginal burning practices with the demise of Tasmania's megafauna.

People have occupied the Australian mainland for at least 56,000 years, but Tasmania was the last part of Australia to be colonised – the oldest dated habitation layers in the state accumulated about 40,000 years ago.

The ecological effect of human colonisation of Australia has been debated at length, with particularly strong views exchanged on the role of humans in the extinction of the megafauna. Were these beasts hunted to extinction? Or couldn't they cope with a changing climate? Or did humans change the ecology of the landscape so drastically that they starved? Or was a combination of these processes responsible?

The early European visitors to Tasmania remarked on the widespread burning of vegetation by the Aboriginal population. It is highly likely that deliberate fires have been lit for thousands of years and that the frequency of landscape fires increased after human arrival. Fire was the only effective tool the early immigrants had for clearing tracks, flushing out game and producing fresh new growth to entice animals into open areas.

Botanists, soil scientists and archaeologists have all argued that the vegetation and soil pattern in Tasmania is partly a result of fire. The abrupt transition between "wet" eucalypt forests (with a dense fire-sensitive understorey and nutrient-rich bioturbated soils) and "dry" eucalypt forests (with a heathy fire-tolerant understorey and relatively infertile texture-contrast soils) in many parts of Tasmania is probably a result of contrasting fire histories going back many thousands of years.

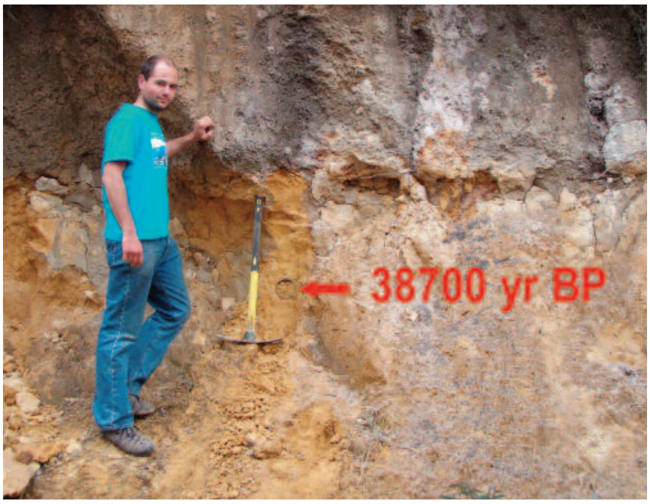
The more a landscape is burnt, the more likely it is to burn again so a feedback process favours fires in those parts of the landscape that have supported previous fires. After many thousands of years, soil properties change and vegetation transformations become harder to reverse.

The long-term effect of frequent fire is graphically revealed by the presence of button grass moorlands at altitudes where one would normally expect tree cover. These are thought to be areas regularly burnt by Aborigines to attract game out of the surrounding scrub and forest. Essentially these moorlands are the remnants of ancient farmed pastures.

Elucidating processes that were operating in past landscapes, particularly those of the last glacial period before about 15,000 years ago, requires specialist techniques. For example, pollen researchers studying the deep peat deposits at Lynch's Crater south of Cairns in Queensland have identified changes in the types of pollen trapped in the peat over time. Wet peat traps regional as well as local pollen, so the pollen record shows how the vegetation has changed in the surrounding region as well as in the peat bog itself.

The Queensland researchers found that charcoal and grass pollen concentrations increased very markedly after 45,000 years

The white silty clay layer in this hill slope deposit in the Styx Valley in south-west Tasmania is a buried soil. This particular soil is very well formed, so it probably developed over many thousands of years. It is buried by a younger slope deposit that has accumulated as a consequence of erosion of the hillside above. At its top, the buried soil contains charcoal from the burnt vegetation that once grew on the soil surface. The charcoal produced an age of 34,900 ± 500 years before present. Assuming that the fire that produced the charcoal also caused the subsequent erosion, this age is the maximum age for the erosion event.



The brown silty deposits in this road section in the Florentine Valley in southern Tasmania have been dated to 38,700 ± 2500 years before present by the thermoluminescence method, which measures the amount of energy that has accumulated in quartz grains since their last exposure to the sun. The deposits probably accumulated as alluvium and are overlain by undated weakly cemented angular gravels, representing a different process – probably the erosion of nearby hills. This later erosion event may be related to conditions during the coldest period of the last glacial period about 20,000 years ago, or could relate to Aboriginal burning in the area.

ago. The increases did not coincide with any known change of climate, and the researchers attributed them to people arriving in the area for the first time – people burnt the forest and scrub, and in many places a grassy understorey replaced the previous woody vegetation. Because of the topographic isolation of the peat bog in Lynch's Crater it was not possible to tell whether fires coincided with increased erosion.

In Tasmania, no long and continuous pollen records have been dated with sufficient precision to tell us about the possible environmental effects of Aboriginal arrival. The pollen record in a peat core from Lake Selina in western Tasmania almost certainly spans the whole of the last glacial period, but radiocarbon ages obtained from the core's peaty sediment could not be used with any confidence to date layers older than 15,000 years before present. However, charcoal concentrations in the record increase in a period that most probably dates to around 30,000–45,000 years before present, so when people arrived in Tasmania they may have behaved very similarly to the people who first arrived in Queensland – they burnt the vegetation.

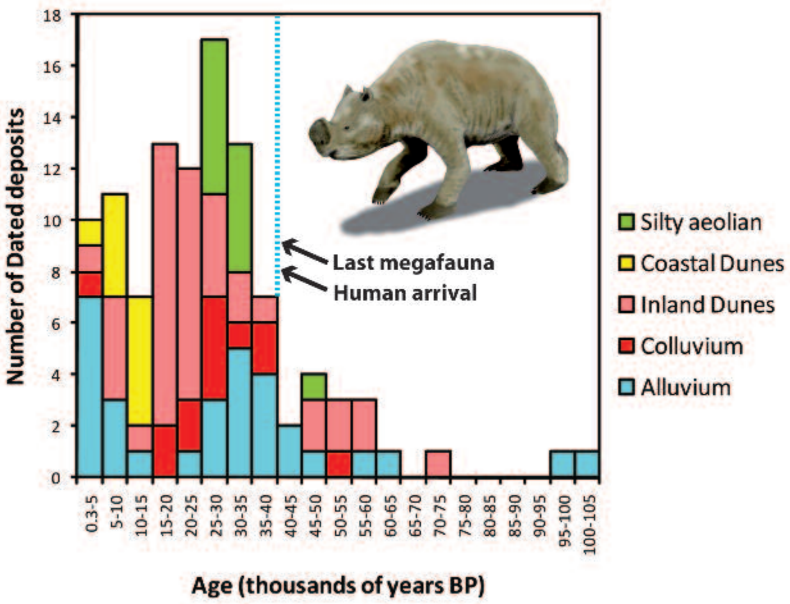
To gain more information on the pattern of erosion over time a group of scientists from Tasmania and Wollongong decided to describe and date new exposures of a variety of erosion deposits such as dunes, hillslope deposits, alluvium and aeolian silts, many of them in road cuttings on forestry roads. These new ages were pooled with previously published ages for similar deposits. All ages were carefully checked for reliability. When doing this we excluded ages obtained on high-altitude glacial deposits such as moraines and boulders – we were interested only in those deposits that were potentially sensitive to human influence.

We were aware of a couple of pitfalls that could trap the unwary when using this approach. The first possible pitfall is that radiocarbon dating is most dependable and applicable for dating samples less than about 45,000 years before present (especially for ages obtained several years ago, when laboratory techniques were not so well developed). Thus the presence of a large number of dates less than 45,000 years could be an artefact of using this dating method. We don't believe this limitation affected our spread of ages because we included in our plots ages obtained with alternative techniques, and there was no marked decline in the number of ages obtained at 45,000–50,000 years before present.

The second possible pitfall is the natural tendency to sample only what one can see, which is inevitable unless one has a budget for drilling deep cores. This biases samples to younger layers near the surface. There is no doubt that this occurred in our study to some extent, but it is unlikely to explain the distribution of ages obtained.

When we plotted all ages considered reliable we found that the number of erosion events per 5000-year period rose slightly after 40,000 years before present and strongly after 35,000 years before present. The rise is unlikely to be a result of sampling bias as such a bias, if present, would result in a gradual increase in the number of dated events towards the present, not a sudden increase.

Nor does the rise coincide with a recorded change in climate, so climate alone is not the reason for the increased number of dated erosion events. Another argument against the climate explanation is that we found no increase in the number of erosion events around 65,000 years before present, which was a particularly cold time. The only explanation that seems to be reasonable



The distribution of dated erosion events in Tasmania over the past 105,000 years in relation to human arrival and the extinction of the megafauna. Note the increase in the number of erosion events after 40,000 years ago and the absence of a peak in erosion events in the cold period around 65,000 years ago. The image of the giant marsupial *Zygomaturus trilobus* is by Nobu Tamura.

is that the rise in the number of erosion events after 40,000 years before present has a human cause.

The oldest ages obtained for habitation layers in Tasmania are 39,900 years before present at Warreen Cave in the Maxwell Valley of south-west Tasmania and 39,300 years before present from Parmerpar Meethaner Cave in the Forth River Valley of northern Tasmania. However, the presence of artefacts below the oldest dated layer at Warreen Cave suggests earlier human arrival – sometime after 43,000 years before present when the land bridge between mainland Australia and Tasmania was walkable for the first time in the last 60,000 years as a result of water being locked up in ice sheets.

The evidence, published in *Quaternary Science Reviews* in 2009, strongly suggests that increased erosion after 40,000 years before present was caused by humans lighting fires. In the last glacial period most of mid- and low-altitude Tasmania above present sea level would have had low-productivity subalpine vegetation. In the severe climate at this time, devastating fires would have spread quickly and the vegetation would have recovered more slowly than in the present temperate and generally moister conditions. (The evidence for greater dryness is the presence of sandy dunes in areas presently receiving more than 1000 mm mean annual rainfall.) Extensive erosion would have been inevitable.

If erosion and vegetation change is accepted as occurring at this time, what was the effect on Tasmania's fauna?

Because of the difficulty of dating old bone by radiocarbon methods, it has been difficult to pinpoint the timing of the extinction of the megafauna in Tasmania. However a 2008 paper by Chris Turney and other researchers described how they used a combination of optically stimulated luminescence (OSL) techniques and sophisticated radiocarbon dating to obtain two independent ages for a skull of a giant kangaroo (*Protemnodon anak*) discovered in a cave at Mt Cripps in north-west Tasmania. The OSL technique, applied to sands found within the skull, yielded an age of 36,000 years before present. Duplicate radiocarbon ages obtained were in the range 42,900–40,900 years before present.

Turney and his colleagues argued that the sands within the skull accumulated some time after burial, and that the radiocarbon ages provide the best dates for the death of the Mt Cripps megafauna, which died in the period 40,000–43000 years before present. They further argued that this age range coincides closely with the time of Aboriginal arrival and that the two are related. Other megafaunal remains in Tasmania were dated by the same radiocarbon methods and the team found that no assemblage was younger than the remains at Mt Cripps.

In the absence of high quality younger ages supporting a contrary argument, the results of Turney and his colleagues strongly suggest that early humans were responsible for the extinction of the last megafauna in Tasmania. But as the most recent ages for the remains of other species found at other sites extend back to 56,000 years before present, an alternative process for some extinctions cannot be ruled out, although it is possible that for these species younger bone remains like those at Mt Cripps simply have not yet been found.

Whether humans killed the megafauna by hunting them is not known, as no artefacts incontrovertibly associated with killed megafauna have been found. However, the Aboriginal people would surely not have ignored a large free lunch ambling (or hopping) by.

The erosion studies described here strongly suggest that hunting was not the only way the megafauna met their end. In the already bleak last glacial landscape, fires and consequent erosion must have put stress on the Tasmanian megafaunal populations. Both the amount of habitat suitable for supporting large animals and the vegetative production essential for supporting large herbivores and carnivores in the food chain are likely to have declined after human arrival.

In summary, the compelling circumstantial evidence of dated erosion events, the time of human arrival and the time of megafaunal extinction favours a combination of fire-induced ecological change and hunting as an explanation for the decline and rapid extinction of the megafaunal population in Tasmania about 40,000 years ago.

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