*Bushfire Front Inc Occasional Paper No 1*

*April 2008*

# Bushfires, Prescribed Burning and Global Warming

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This is not a paper about climate change or the contentious aspects of the climate debate. Our interest is bushfire management. This is an activity into which the debate about climate change, in particular "global warming", has intruded, with potentially damaging consequences.

Australia's recent ratification of the Kyoto Treaty has been welcomed by people concerned about the spectre of global warming. However, the ratification was a political and symbolic action, and will have no immediate impact on the volume of carbon dioxide ($CO_2$) in the atmosphere, and therefore will not influence any possible relationship between $CO_2$ emissions and global temperatures.

However, the ratification could have an impact on Australian forests. Spurious arguments about the role of fire contributing to carbon dioxide emissions could be used to persuade governments and management agencies to cease or very much reduce prescribed burning under mild conditions.

***Decades of research and experience has demonstrated that fuel reduction by prescribed burning under mild conditions is the only proven, practical method to enable safe and efficient control of high-intensity forest fires.***

Two myths have emerged about climate change and bushfire management and are beginning to circulate in the media and to be adopted as fact by some scientists:

1. *Because of global warming, Australia will be increasingly subject to uncontrollable holocaust-like "megafires".*

2. *Fuel reduction by prescribed burning must cease because it releases carbon dioxide into the atmosphere, thus exacerbating global warming and the occurrence of megafires.*

Both statements are incorrect. However they represent the sort of plausible-sounding assertions which, if repeated often enough, can take on a life of their own and lead eventually to damaging policy change.

## Why we have written this paper

Over the last 20 years, there has been a significant reduction in the amount of prescribed burning under mild conditions in Australian forests. This has occurred as a result of changes to the jurisdiction of public forests, and (in some cases) the transfer of responsibility for the control of forest fires from land management agencies to the emergency services.

***The result is that Australia is already experiencing increasing numbers of high-intensity forest fires.***

This situation will worsen if there is a further reduction in the use of prescribed fire, based on a misunderstanding about the relationship between bushfires and $CO_2$ emissions.

In this paper we look at the facts and the science as well as the uncertainties in the relationships between bushfires, prescribed burning, carbon and global warming. Our aim is to counterbalance some of the unsupported assertions currently being presented as fact on this subject.

## Plants and the carbon cycle

Green plants use the energy of the sun to convert $CO_2$ gas from the atmosphere into solid carbon compounds in a process called photosynthesis. Sooner or later, these carbon compounds are broken down and returned to the atmosphere by the processes of:

(i) decay – the slow rotting-away of vegetation;

(ii) respiration - breathing out $CO_2$ by animals which have browsed on plants; or

(iii) combustion - burning by fire.

To ***permanently*** remove carbon from the atmosphere it is necessary to confine it in stable compounds which will not be decayed, respired or burned. The permanent removal of carbon from the atmosphere is referred to as "sequestration".

Carbon can be stored in highly stable structures such as diamonds and graphite (and to a lesser extent charcoal). These are, to all intents and purposes, removed from the carbon cycle. Carbon captured by the forests of past geological times and which became coal was very effectively sequestered - until humans started to dig it out and burn it.

Carbon stored in plants is referred to as "Terrestrial Carbon". The rate at which plants capture and emit $CO_2$ varies between different types of vegetation, and the way the vegetation is managed, especially the frequency and intensity of fire.

**Three typical Australian vegetation types**

The three most widespread natural Australian vegetation types (or "ecosystems") are tropical grasslands, tropical and subtropical savannahs and tall forests.

***(i)*** ***Tropical grasslands*** grow during the wet season, die off in the dry season and rot away or are eaten (and respired) by termites during the next wet season. Each succeeding crop of grass is replaced by a new crop so there is no overall or long-term gain or loss of stored carbon. If the grass is burnt during the dry season (and lightning caused fires are a common feature of tropical areas) the overall situation is no different, because the burnt plants would have decayed anyway.

But even in a grassfire, a small amount of carbon is converted to a stable, graphite-like substance called "black carbon" and incorporated into the soil.

***Thus, although the overall situation is just about carbon-neutral, even grassland fires effectively sequester some carbon.***

***(ii)*** ***Tropical and subtropical savannahs*** add a level of complexity to this scene. A savannah is "a natural parkland", that is an area of grassland dotted with trees. In terms of area, number and frequency, most Australian bushfires occur in the savannahs of our north and inland regions. Many savannah fires are "natural" being started by lightning, but there is also extensive prescribed burning undertaken in these areas, especially savannahs used for cattle grazing, and on Aboriginal reserves. Over time, the carbon balance of savannah fires is also just about neutral. In some years more $CO_2$ is emitted to the atmosphere from fires than is absorbed by post-fire regrowth, while in other years more carbon is taken up by regrowth than is lost to the atmosphere from fire (including prescribed burning and wildfires).

The difference depends upon the climatic conditions, particularly rainfall in the early regeneration period. Where fires are followed by high-rainfall years and heavy regeneration, more carbon is stored in vegetation than was released in the fire. However, taken over many years, the carbon released in fires in tropical savannahs is virtually the same as the carbon absorbed in regrowth.

If fire is deliberately excluded from these areas (which is difficult but has been achieved on some small experimental areas) there is an increase in bushfire fuels over time. Dead material on the ground rots or is consumed by termites, but fire fuel accumulates as bark on fibrous-barked eucalypts and in the woody shrubs that develop when fire is excluded. This increase in the fuel load means that late dry-season fires are more intense, causing death and damage to live trees, and burning down dead trees. Intense fires will rapidly consume logs and branches on the ground which may otherwise have taken years to rot away. Late dry-season fires in savannahs will therefore release $CO_2$ to the atmosphere from the long-term carbon store; this carbon is will not immediately balanced by post-fire regrowth.

***The management approach that will optimise storage of carbon in Australian savannahs is one of low-intensity, early dry-season burning under mild weather conditions. This protects the overstorey trees and woody shrubs which are consumed by hot late-season fires.***

***(iii)*** ***Tall forests*** store carbon in tree trunks, bark, branches and roots, in woody shrubs and mid-storey vegetation and in the litter and accumulated organic debris on the ground. Eventually all old trees begin to decay from within, and in the absence of fire, the accumulated litter on the forest floor begins to rot away. At this point, the rate of release of carbon through decay exceeds the rate of storage of carbon by new growth. Thus Australia's "old growth" eucalypt forests eventually stop being a carbon sink and become a source of $CO_2$.

Australian eucalypt forests are naturally subject to periodic fire. Fires are started by lightning or humans. The material consumed in the fire is mostly the dead leaves, twigs, and limbs which have accumulated on the forest floor, plus the bark on fibrous-barked trees such as stringybarks.

Bushfires vary in their size, speed and intensity. This variation is mostly determined by the amount of "fine fuel" (defined as combustible material less than 6 mm in diameter). If there is no fine fuel present, then larger dead fuel (such as old logs and branches) or the living fuel in the trunks and canopies of the shrubs and trees will not ignite and burn. This is why even an intense fire goes out when it reaches an area which was burned recently, and carries no fine fuel.

However the total amount of fuel consumed by a bushfire depends on the amount of moisture in the fuel. Dry fuels burn more intensely, and these intense fires dry out and burn the fine green fuels in front and above them.

Fuel reduction by prescribed burning employs low-intensity fires lit under mild weather conditions at a time when there is still some moisture in the fuel. This ensures that the flames are generally less than a metre high and the fire is confined to the surface layer of fine fuel and the green material in the low shrubs.

*A prescribed burn in wandoo forest, Western Australia*

A properly managed prescribed fire will be conducted at a time when organic matter (including charcoal) in the soil will not burn. The ideal prescribed burn consumes only the surface fuels, leaving behind a layer of ash protecting the soil and the heavy logs.

***The amount of $CO_2$ released by a low-intensity fire is small and the store of carbon on the forest floor is rapidly replaced as the fine fuels re-accumulate and the low shrubs regrow.***

By comparison, a hot summer bushfire burning under drought conditions will consume all of the surface fuels, including large logs and the organic matter in the soil which may have accumulated carbon for thousands of years. An intense summer bushfire will even consume the canopies of the tallest trees.

The amount of $CO_2$ produced by a fire is directly proportional to the total amount of fuel consumed in the fire.

***Thus a hot summer bushfire will release massive amounts of carbon. For example, the Victorian Alpine wildfires of 2006 released over 40 million tonnes of carbon dioxide into the atmosphere. To this will be added the carbon released over time from the decay of fire-killed trees.***

If a tall forest regenerates following the fire, the carbon released by the fire will only be depleted for a hundred years or so. Unfortunately, the next 100 years is the very time in which computer models suggest maximum storage of terrestrial carbon is essential.

The worst possible outcome is repeated intense summer bushfires which not only kill the tall forest trees, but also sterilise the soil and incinerate soil-stored seed. By this means, a tall forest may eventually be converted to woodland and shrubland and the loss of stored carbon will be permanent.

***Thus from the point of view of carbon storage in grasslands, savannahs and tall forests, the best management approach is one in which large high-intensity wildfires are minimised by periodic prescribed burns carried out under mild weather conditions.***

### What about the Kyoto Protocol?

When it comes to bushfires and carbon accounting, the Kyoto Protocol is flawed. This is because $CO_2$ emissions from uncontrolled bushfires are exempt from Kyoto accounting, while the emissions from prescribed burning are not. Under Kyoto "rules" a wildfire is considered to be a "natural" and unpreventable event like a volcano,; moreover, Kyoto is based on the concept that most fires around the world are grassfires or relatively low-intensity fires in savannah woodlands or open forests. Kyoto argues that carbon released by grass and woodland fires would have been released by natural decay and is soon replaced by regrowth within one or two growing seasons.

***Kyoto accounting fails to take into account the large, long-term(and sometimes permanent) loss associated with high-intensity bushfires and fails to recognise that, under Australian conditions, such fires can be prevented.***

Scientific research and long-experience in Australian eucalypt forests has demonstrated that forest management incorporating prescribed burning under mild conditions always reduces wildfire size and intensity. Where prescribed burning is regularly carried out, the risk of a high-intensity bushfire at a later date is greatly reduced.

There is also an important philosophical point here. Exempting wildfires from Kyoto carbon budgets ignores the profound role of humans for tens of thousands of years as contributors to the Earth's fire regimes. It is odd reasoning that there can only exist a natural regime (good) and a human-affected regime (bad). This argument leaves no room for changing human impacts.

## Why is prescribed burning feared?

Some people oppose prescribed burning, and through political influence are able to restrict burning programs by land management agencies. Opposition is based on a fear that periodic mild fires "damage the environment". This view is generally held by people who have no personal experience of the way the Australian bush is adjusted to (indeed thrives on) periodic mild fires.

The assertion that prescribed burning should cease due to its impact on global warming is relatively new. The argument is two-fold:

(i) That prescribed burns generate smoke which contains $CO_2$ and this is therefore "bad"; and

(ii) The amount of $CO_2$ released from a bushfire will be equal to the sum of the $CO_2$ that is released from the fuel reduction burns that replace the wildfire, so you might just as well have the bushfire.

At first glance, the second of these assertions appears likely to be true. However like all processes in nature the real situation is far more complicated, especially when more accurate carbon accounting is undertaken.

Fire is a powerful ecological agent. Depending on the intensity, a fire will mineralize nutrients in the litter, stimulate or inhibit germination and change the light and moisture regime on the forest floor. These variables in turn will determine the composition and rate of growth of the post-fire biota.

***We believe it would be premature to consider managing fire for carbon sequestration without first considering other important factors. These include the impact of high-intensity fires on flora and fauna, soil erosion, water quality and the protection of life and community assets.***

To date, insufficient research has been made into the differential impacts on the carbon cycle of bushfires and of prescribed burning in tall forests. The distinction between intense wildfires and mild prescribed burns is almost never made in the climate literature. Fires of vastly different size and intensity are lumped together simply as "fire", and it is assumed that the impacts and consequences are equal. They are not and the innumerable combinations of factors that make up a fire regime (such as intensity, frequency, patchiness, size, season and so on), and the interactions of fire with different soils and vegetation types, makes the research task difficult and complex.

**What about smoke?**

Scientists are only just beginning to realise how complicated and subtle is the role of smoke and gases emitted from bushfires and prescribed burns. There are numerous interactions (some positive and some negative) between bushfire smoke, rainfall, ultraviolet radiation and the global radiation balance. Further complexities erupt when you consider the effect on incoming solar radiation of the smoke particles and gasses emitted from bushfires and prescribed burning. It is now also well known that bushfire smoke is a powerful agent encouraging the germination of many Australian native plants.

The ideal management approach in Australian forests is one that incorporates periodic prescribed burning under mild weather conditions. Firstly, this will best protect environmental and human assets. But flowing on from this will be protection of the carbon store in the forest which is lost in hot summer bushfires. Although the precise data is still being developed, this fact is readily deduced from studying grassland and savannahs, where excellent research has been done.

This research confirms that mild early season burning is preferable to late season wildfires for all reasons, especially for its ecological benefits, but also including its role in protecting carbon storage.

## Is "global warming" leading to increased occurrence of "megafires"?

Some environmentalists suggest that global warming is leading to an increase in the number of "megafires" (large, high intensity and unstoppable holocaust-like bushfires).

However, if the current climate change models are correct, there will only be an increase in average annual temperatures of between 2 and 4 degrees over the next 100 years. The effect of this on bushfire behaviour, by itself, will be trivial. Fire intensity is far more significantly affected by fuel quantity, fuel dryness and wind strength, than it is by temperature.

Some climate change computer models also suggest a significant reduction in rainfall, leading to increased fuel drying and increased fuel availability at lower temperatures. This is the same effect as that of drought, a phenomenon which is common in Australia.

***Drought does result in more intense fires…..but only if nothing is done to reduce fuels before the fire occurs.***

When it comes to rainfall and bushfires, the critical factor is seasonality of rain. In Australia's temperate regions, increased rainfall in late summer will generally lead to higher decay rates and generally lower fire dangers, while a corresponding decrease in winter rainfall will provide an extended opportunity for mild low-intensity burning.

***The factor which "doomsday" commentators ignore is the opportunity for land managers to get in first, and reduce fuels before a potential megafire starts. In other words, the potential megafire can be forestalled, simply by the adoption of a program of fuel reduction prescribed burning under mild weather conditions.***

Putting numbers to the relative carbon balance associated with prescribed burning and wildfire in Australian forests is extremely complex, and has the potential to engage science for at least another decade. In the meantime, we know intuitively that more $CO_2$ is emitted in high-fuel consuming summer bushfires than from low-fuel consuming prescribed burns. However, any accounting must consider not only the frequency (i.e. more low intensity vs. fewer wildfires with greater emissions) but also the rate of decomposition of unburnt biomass and rate of carbon absorption by regrowth.

Although the principles are clear, precise data is still lacking. However, practical observations in the bush are not lacking. Land management policies can be guided by decades of records of severe forest and water catchment damage by high-intensity fires and by long experience in the management of forests to meet ecological objectives, and protection of the public at large.

## Bushfires, burning and global warming

There are many complexities, but conclusions can be drawn from the research done to date and from a first-principles understanding of carbon pathways in natural ecosystems. We conclude:

1. It is likely that the carbon emission and absorption situation found in savanna ecosystems will also apply in forests. In other words, over time, the overall situation will be carbon-neutral. But prescribed burning under mild conditions is still favoured over hot summer bushfires because less fuel is consumed, and less carbon emitted in the short term.

2. The carbon released by mild prescribed burns is recovered quickly; carbon released by large high-intensity forest fires may take decades to be replaced. Looking ahead from 2008, these decades are precisely the ones in which carbon storage needs to increase if the global warming computer models are correct. Preventing large high-intensity fires should therefore be an essential part of carbon management policy.

3. Not enough is known about the role of smoke in modulating climate. However, there is a growing body of research which shows that bushfire smoke helps to block incoming solar radiation (which heats the earth) and is an important catalyst for the regeneration of Australian plants. I

4. Fire has always been a factor in the Australian environment, and historical records indicate that it is only recently that frequent mild fire has been deliberately taken out of the forest, to be replaced by infrequent high-intensity fire.

5. The argument that wildfires are exempt, but the $CO_2$ emitted by prescribed burns must be added-in to the national carbon accounts, is crooked thinking and is rejected.

Finally, we advocate that the Precautionary Principle must apply: this means playing safe while the research is being done.

***The safe approach is not to ban prescribed burning because of an unsupported assertion that it may increase atmospheric $CO_2$ levels, but to promote prescribed burning because it reduces the size and intensity of wildfires.***

Even if new research demonstrates little difference between large high-intensity wildfires and prescribed burning in terms of the carbon balance, high-intensity fires should still be prevented. This is because of their over-riding and devastating impacts on wildlife, soils, waterways and landscapes, their capacity to kill and injure humans, the cost and danger of suppression and the damage they inflict on community and private social and economic assets.

***For more information on bushfires and bushfire management, please visit our website:***
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