Australian Government
Department of Industry, Science, Energy and Resources

Estimating greenhouse gas emissions from bushfires in Australia's temperate forests: focus on 2019-20

Technical Update

April 2020

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Cover image: Photo of forest during a bushfire at Narrow Neck. Credit: Getty.

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Executive summary

This technical update provides information on how net greenhouse gas emissions from bushfires affecting Australia's temperate forests are estimated and reported to meet our international commitments. It focusses on the 2019-20 bushfire season in Australia.

The update relates to Australia's National Greenhouse Accounts, a series of comprehensive reports and databases that account for Australia's net, human-induced greenhouse gas emissions.

Key points

- The 2019-20 bushfires will have negligible impact on Australia's progress towards its 2020 or 2030 target.
- Bushfires release significant amounts of carbon dioxide, but generally recover over time, generating a significant carbon sink in the years following the fire.
- Australia's National Greenhouse Accounts include carbon emissions and post-fire sequestration associated with bushfires, based on satellite monitoring of fires across Australia and advanced carbon modelling of fire-prone ecosystems.
- Consistent with international rules and international practice, the national inventory used to track progress towards the Government's targets applies the natural disturbances provision in reporting net emissions from infrequent, extreme bushfires in temperate forests, which are beyond control.
- Under the natural disturbances provision, the Government reports the long-run trend in carbon stock change in the forests, reflecting the balance of the carbon lost in the fire and that re-absorbed by regrowth.
- To ensure transparency, all net emissions data – both with and without the natural disturbances provision - will be reported in the Government's annual submission under the Paris Agreement.
- The future recovery of the forest is expected to be complete. However, the department will actively monitor the forest recovery from the bushfires to ensure that any future human disturbances, such as salvage logging, future fire disturbance and the impacts of changes in climate are taken into account.
- The latest empirical evidence will also be incorporated into the estimation process and the department has contracted CSIRO for this purpose using funding provided in the 2019 Budget.

Bushfires in Australia

Fires are a natural part of the Australian environment and have been used by indigenous Australians for land management for thousands of years. Many Australian tree species are fire resistant, and many require fires to reproduce.

Greenhouse gas emissions from the land sector can be very high in years in which the largest bushfires occur. These emissions are not only beyond control, but are also highly variable and unpredictable.

Burned forest after a bushfire in the Blue Mountains. Image credit: Getty.

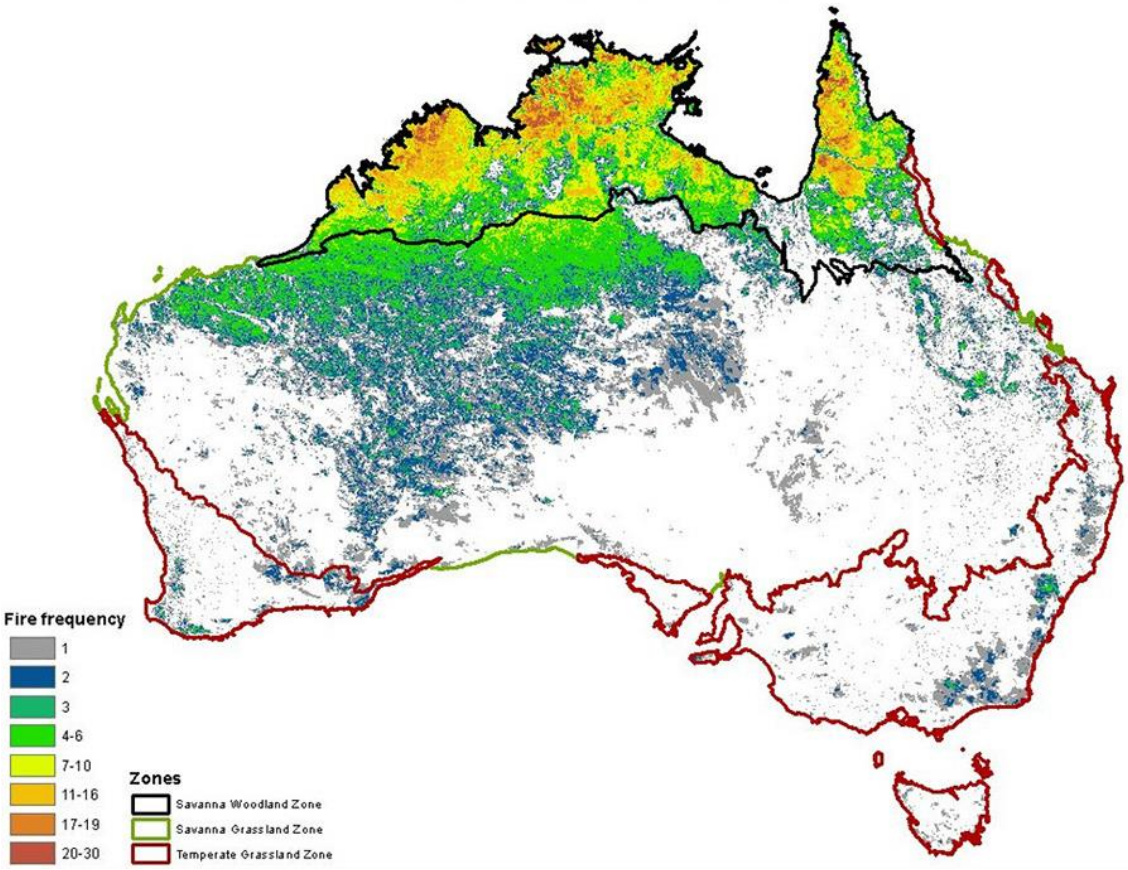
Fires in different climate zones

Bushfires burn large areas each year across Australia, however the majority of these fires occur in the woodlands and grasslands of northern and central Australia (Figure 2). These ecosystems are adapted to frequent fires under natural fire regimes and under traditional indigenous land management practices. Satellite data shows that some of these areas have been burnt nearly every year (Figure 1).

Because fires in northern and central Australia are so frequent, there is less build-up of fuel, and carbon sequestration by regrowth from previous fires is generally in balance with annual emissions from new fires. Therefore, even though they burn a much larger area, the net emissions are less than those from bushfires in our carbon-dense temperate forests, which are the focus of this technical update.

Temperate forests lie within the 'Temperate Zone'[1] under the Interim Biogeographic Regionalisation for Australia (IBRA) developed by the Department of Agriculture, Water and Environment (outlined in red in Figure 1).

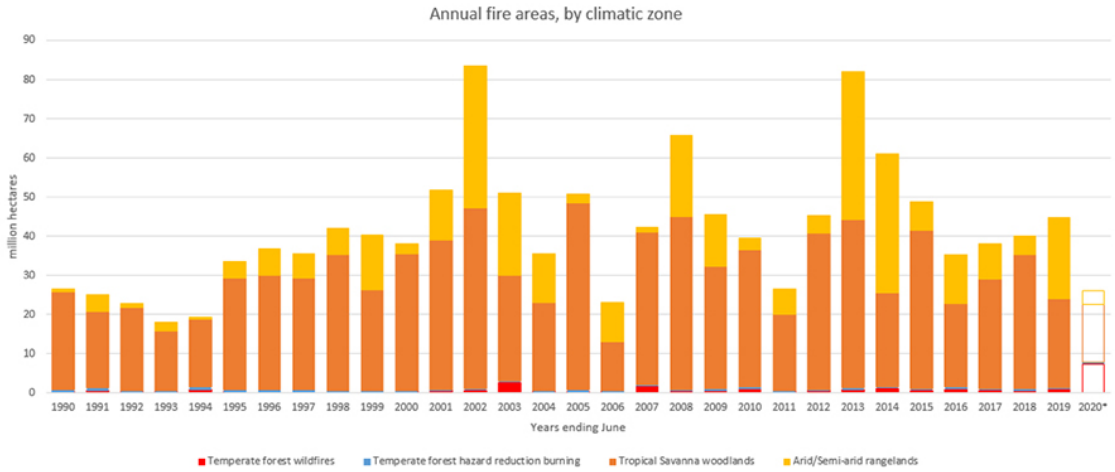
Figure 1: Fire extent and frequency 1988-2019, showing IBRA climate zones.



Source: DISER using satellite data supplied by Landgate, and Department of Agriculture, Water and Environment IBRA zones.

[1] IBRA version 4.1, AEZ 4 and AEZ zones 7-10.

Figure 2: Annual fire areas by IBRA climate zones.

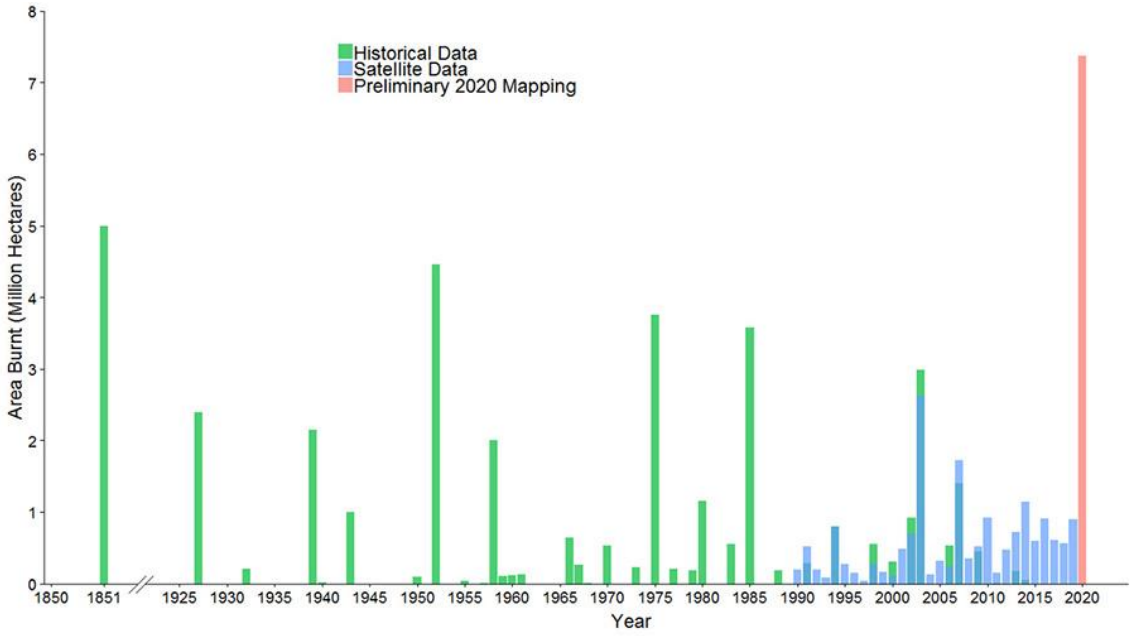


*2020 estimates are incomplete, based on preliminary data to 11 February 2020.
Source: DISER using satellite data from Landgate, and Department of Agriculture, Water and Environment IBRA zones.

Fires in temperate forest areas

Based on data supplied by Landgate and the Emergency Management Spatial Information Network Australia (EMSINA), the department estimates the current bushfire season affected around 7.4 million hectares of temperate forests across Australia up to 11 February 2020. Figure 3 shows the historical variability in the annual area burnt in Australia's temperate forests.

Figure 3: Annual area burnt by bushfires in Australian temperate forests.



Source: Satellite data: DISER using data supplied by Landgate.
Preliminary 2020 data: DISER using data supplied by Emergency Management Spatial Information Network Australia (EMSINA).
Historical data: based on a range of sources, including a mixture of historical records, anecdotal evidence, and satellite imagery. Updated (with corrections) from Roxburgh et al 2014.

Most of the area affected by this season's fires lies within national parks and conservation areas (Table 1). A further significant portion is in State Forests managed for timber production.

Table 1: Estimated area burnt, Australian temperate forests, by land-use, September 2019 to January 2020.

Land use type	Millions of hectares
Production native forests (State Forests)	1.81
Plantations	0.03
National Park	3.14
Other conservation and natural environments	1.86
Agriculture and other intensive uses	0.53
Total	**7.38**

Source: DISER using data supplied by Landgate and mapping by EMSINA, and ABARES Catchment-Scale Land Use Mapping.

Forest recovery

In Australia, the post-fire recovery of our forests generates a large carbon sink as, in general, Australian eucalypt forests are fire-adapted and can recover quite quickly (Figure 4).

Bushfires mainly affect debris and grasses or understorey vegetation, and sometimes forest canopy (leaves, twigs), which all rapidly build up carbon again following fire – within 10-15 years.[2] Even in rare patches of fire-induced mortality, there is minimal loss of carbon at the landscape level, which is usually balanced within a few years by fast-growing regrowth.[3]

This is quite different to fires used for land clearing in tropical forest or fires occurring in boreal (high-latitude) forests that are less adapted to fire.

Climate change impacts, including droughts or more frequent and more intense fires, can affect the ability of forests to recover after fire - these impacts will continue to be monitored into the future and reflected in updates to the National Greenhouse Accounts.

Figure 4: Eucalyptus obliqua, showing recovery one year after fires – Kinglake, Victoria (CSIRO).

[2] Tolhurst, 1994; Gould and Cheney, 2008; Sullivan et al, 2012, Volkova and Roxburgh et al, 2019.
[3] Keith et al 2014

Estimating bushfire emissions

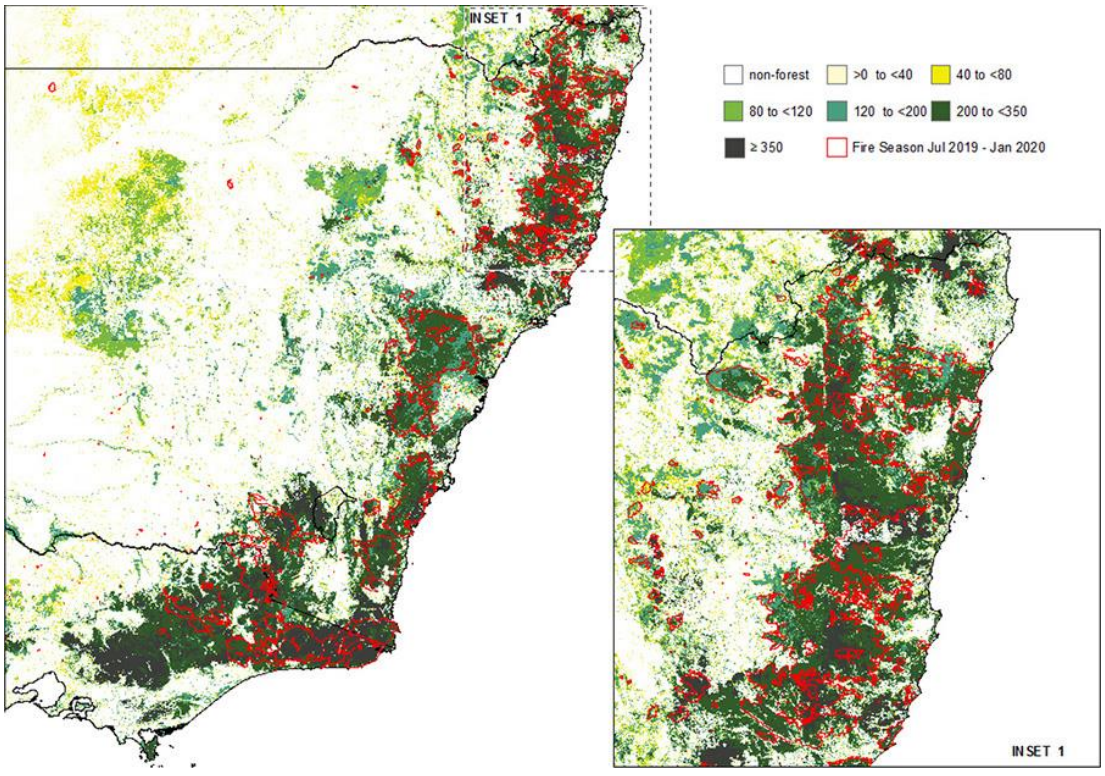
The National Greenhouse Accounts use data from the satellite monitoring of fires - supplied by Landgate (the WA land authority) - to identify the annual areas burnt.

The burnt area data is an input to the Department's Full Carbon Accounting Model (FullCAM) modelling framework. FullCAM is an advanced (tier 3) model which tracks carbon in forest and agricultural ecosystems in accordance with Intergovernmental Panel on Climate Change (IPCC) guidelines and is informed by the latest science relating to carbon losses due to fire.

The department has made a preliminary estimate of net emissions for the 2020 fire season of around 830 million tonnes of carbon dioxide equivalent ($MtCO_2$-e) (based on the fires up to 11 February 2020), and noting that affected forests are expected to recover over time, generating a significant carbon sink in the coming years.[4]

This season's fires have affected some of Australia's highest-biomass forests with an average above-ground biomass and debris estimated at around 300 tonnes per hectare (Figure 5). The fires are estimated to have burnt an average of around 20 per cent of the above-ground biomass and debris, resulting in average emissions of around 130 tonnes of CO_2-e per hectare of forest burnt.

Figure 5: Biomass in forests affected by fire in NSW and Victoria (above ground biomass and debris; tonnes of dry matter per hectare).



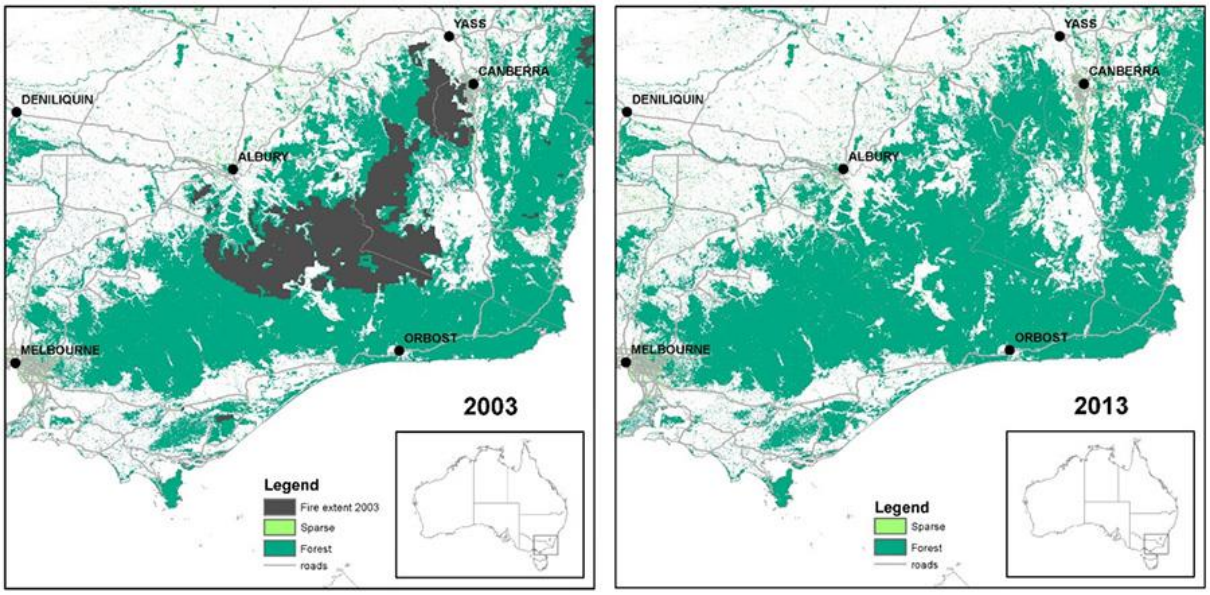
Source: DISER modelling

[4] The total *net* emissions of 830 Mt CO_2-e includes absolute emissions of around 940 Mt CO_2-e, comprised of carbon dioxide emissions of 850 Mt CO_2-e, 81 Mt CO_2-e of methane and 9 Mt CO_2-e of nitrous oxide, as well as carbon dioxide sequestration equivalent to *negative* 110 Mt CO_2-e resulting from recovery after this season's and previous seasons' fires.

Estimating post-fire carbon sequestration

Generally, over time and in the absence of new disturbances, Australia's eucalypt forests re-absorb carbon to balance the carbon emitted during the fires. Forests burnt this year are expected to continue sequestering carbon over the next decade and beyond as they recover.[5] As an example, more than 98 per cent of forest cover was observed to return within 10 years after the 2002-03 bushfires (Figure 6).

Figure 6: Forest cover before and after 2002-03 bushfires—over 98 per cent of forest cover returned within 10 years.



Source: DISER forest cover data, and fire data from Landgate.

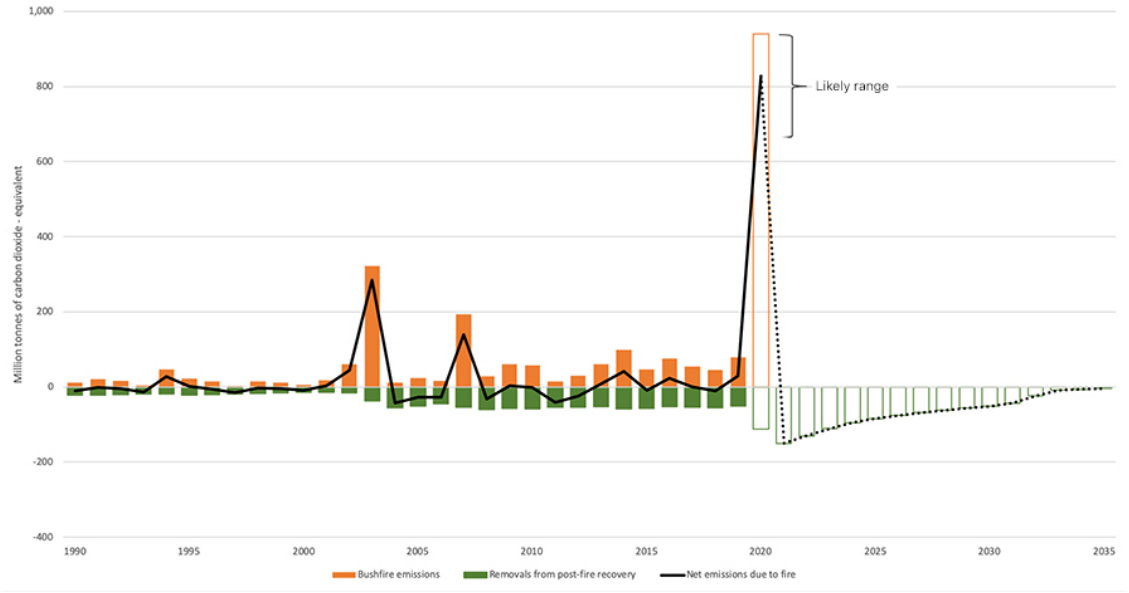
The National Greenhouse Accounts use satellite data and the FullCAM model to estimate the carbon sequestration in vegetation recovering from past fires at a high (25m x 25m) resolution. In some years, especially in years following major bushfires (for example in 2004 and 2005, following the 2003 bushfires), carbon sequestered by post-fire forest regrowth can exceed the emissions from fire in that year (Figure 7).

The recovery of the forest is expected to be complete. However, the department will continue to monitor forest recovery every year, using satellite imagery of the burnt areas to support accurate estimates of emissions and removals.

Where human impacts such as land clearing or salvage harvesting, or failure of the forest to recover within 10-15 years, are observed, the associated emissions are accounted for in these estimates. (The case study in the next section illustrates the detection of post-fire land-use change after the 2003 fires in the ACT). If some forests only recover part of the carbon lost through fires, this will be reflected in the National Greenhouse Accounts.

[5] Crisp et al, 2010; Burrows 2013; Volkova and Roxburgh et al, 2019.

Figure 7: Bushfire emissions and post-fire sequestration (removals) in temperate forests (Million tonnes CO_2-e).



Source: DISER modelling

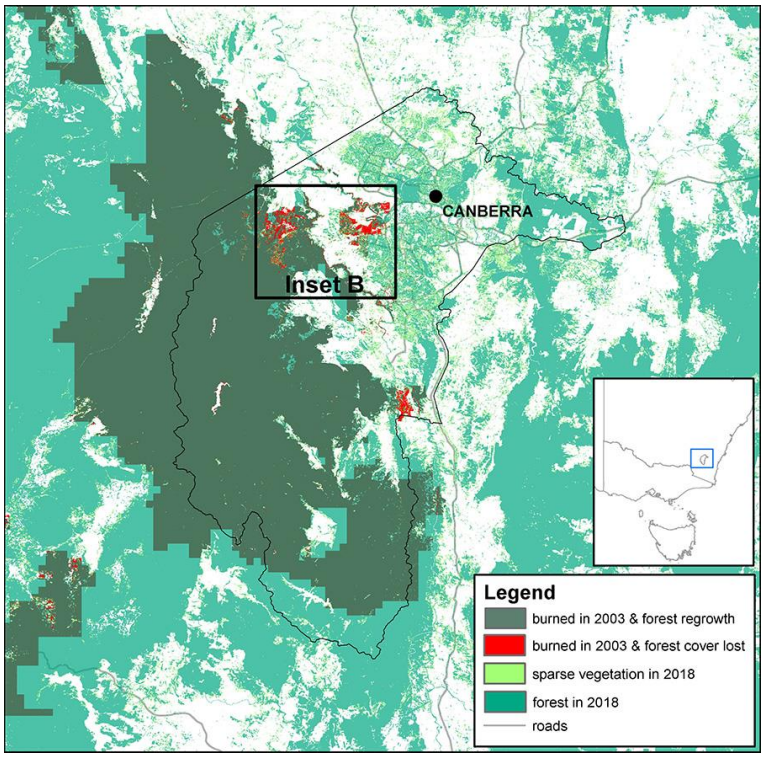
Case study: Emissions from 2003 bushfires in the ACT

The 2003 bushfires affected large parts of NSW, Victoria and the ACT. These fires were also considered to be 'natural disturbances' under the IPCC guidelines.

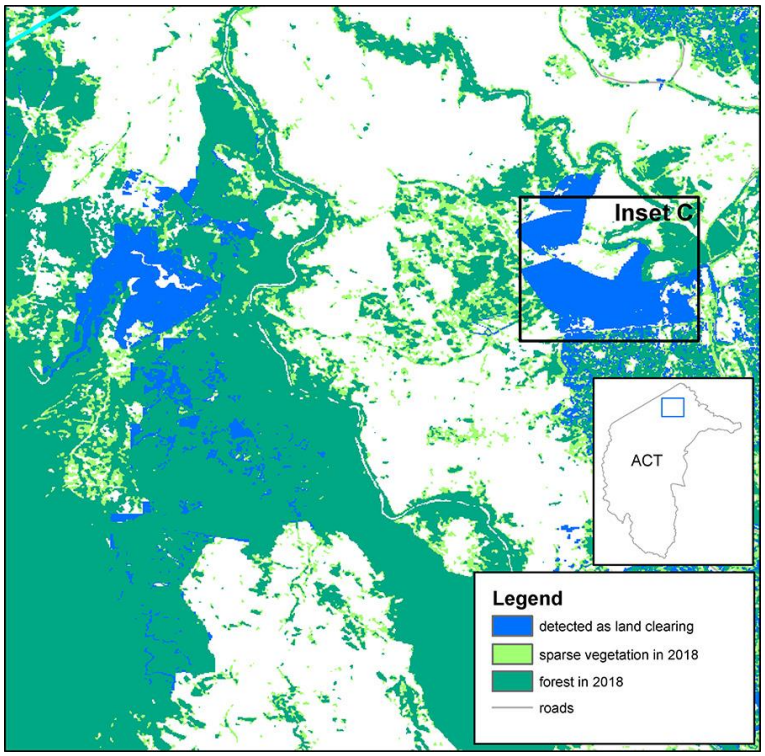
Focusing on the ACT, Figure 8 shows that a small portion of the forests affected by fire were replaced by other land-uses, such as urban expansion. The National Greenhouse Accounts spatial monitoring systems identified these land-use changes and the full emissions associated with clearing and converting these forests were accounted for in the national inventory as deforestation that occurred in 2003-4.

The satellite data shows that forest cover has returned in other areas (or was never lost). In these areas, by 2019, it is estimated that 96% of initial carbon emissions has been balanced out by carbon sequestration from forest recovery (Table 2).

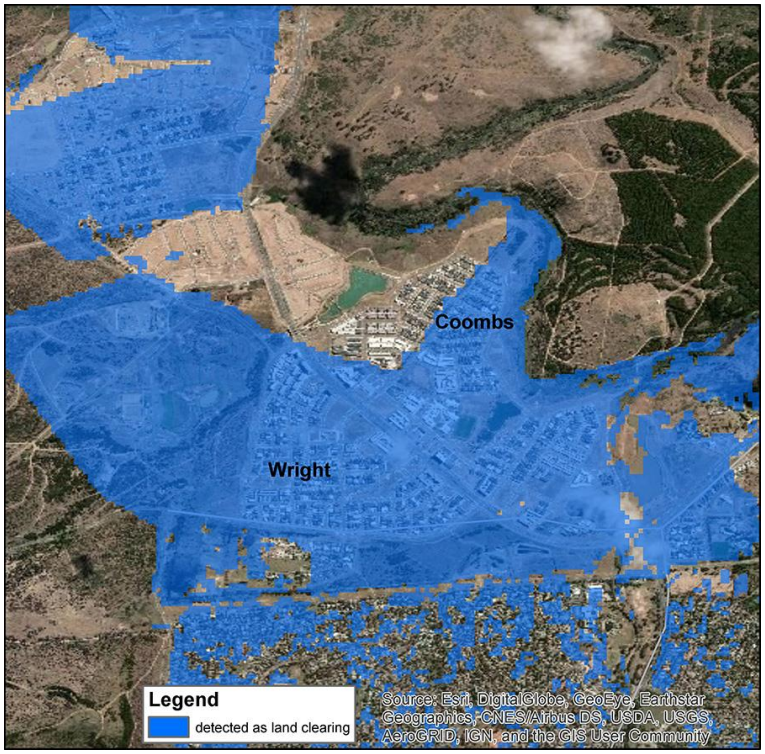
Figure 8: 2003 fire area, showing forest regrowth and urban expansion where the forest has been converted to other land uses.



Map A: 2003 bushfire area (grey & red), showing return of forest cover by 2018 (grey) in most areas, and patches of forest cover loss (red).



Inset B: Detailed view of areas that lost forest cover following 2003 fires, showing that these areas are detected as land clearing in the National Greenhouse Accounts systems (blue).



Inset C: Detailed aerial photo of areas detected as land clearing in the National Greenhouse Accounts systems in the ACT—these areas correspond to urban expansion.

Table 2: Estimated carbon dioxide emissions due to the 2003 bushfires in the ACT, and subsequent carbon sequestration through forest recovery after 2003 (millions of tonnes of CO_2)

Year	Carbon emissions (Mt CO_2)	Carbon sequestration due to regrowth (Mt CO_2)	Net carbon lost during disturbances including regrowth (Mt CO_2)	Percent recovery
2003	20.2	0.0	20.2	0%
2004	0.0	-2.9	17.3	14%
2005	0.0	-2.6	14.7	27%
2006	0.0	-2.1	12.6	38%
2007	0.0	-1.7	10.9	46%
2008	0.0	-1.6	9.3	54%
2009	0.0	-1.4	7.9	61%
2010	0.0	-1.3	6.6	67%
2011	0.0	-1.2	5.4	73%
2012	0.0	-1.1	4.3	79%
2013	0.0	-1.1	3.2	84%
2014	0.0	-1.0	2.3	89%
2015	0.0	-0.7	1.6	92%
2016	0.0	-0.3	1.3	94%
2017	0.0	-0.2	1.1	95%
2018	0.0	-0.2	0.9	96%
2019	0.0	-0.2	0.7	96%

Reporting bushfire emissions in the National Greenhouse Accounts

The National Greenhouse Accounts include annual emissions and post-fire sequestration from all fires, estimated and reported using technical guidance from the Intergovernmental Panel on Climate Change (IPCC), rules under the UN Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. The estimates are reviewed by international experts.

Based on IPCC Guidance agreed in May 2019, countries can report two inventories - net emissions with, and net emissions without the application of a natural disturbances provision.

The natural disturbances provision applies to large, infrequent bushfires that are beyond human control despite the best efforts of policy makers, land managers and emergency services and allows countries to account for the year-to-year variability in emissions and post-fire sequestration. For these natural disturbance fires, the Government will report the long-run trend in carbon impacts, reflecting the balance of the carbon lost and later re-absorbed by future regrowth.

National Inventory totals presented *without* the natural disturbances provision display the emissions and removals resulting from a natural disturbance event in each year, providing a clear picture of the annual emissions and removals resulting from such a fire.

National Inventory totals presented *with* the natural disturbances provision allows a clear presentation of the national emissions trend, which can be swamped by the variability caused by natural disturbances in National Inventory totals presented without the natural disturbances provision.

The modelled net emissions from wildfires reported with and without the natural disturbances provision are illustrated in Figure 9.

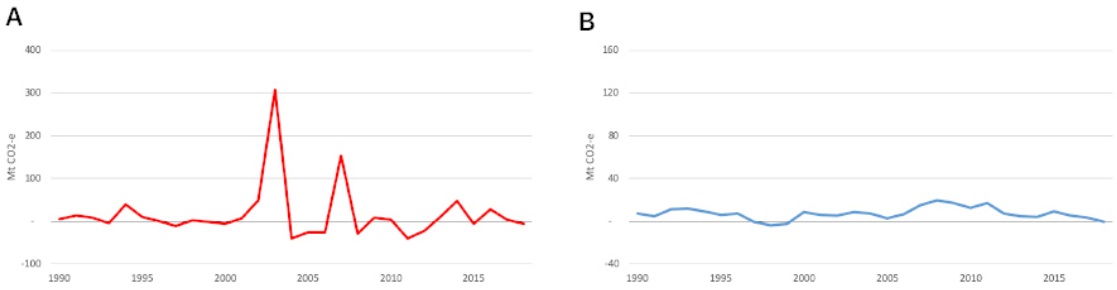
The Australian Government indicated in 2015 that it would use the National Inventory with the application of the natural disturbances provision in tracking progress towards the Government's Paris target.

The European Union will also apply the natural disturbances provision for the Paris Agreement as they have done for the 2013-20 Kyoto Protocol reporting period. Australia will use an inclusive approach that better reflects the average long-run change in carbon stocks - an approach which has similarities to the estimation and reporting methods used by the United States. The inclusive approach ensures that if the forest does not grow back, then this will be reflected in the Accounts.

Australia's 2020 target (covering the period from 2013 to 2020) includes emissions and removals on forests managed for timber production (plantations and State Forests) as a legacy of the Kyoto Protocol rules. Therefore, emissions from fires on other forest tenures are outside the scope of this target. Australia's 2021-30 target under the Paris Agreement is comprehensive and includes all forests and other land types.

Official estimates emissions from the 2019-20 fire season are due to be finalised and reported to the UNFCCC in the April 2022 National Inventory Report. The principles described here will be applied to calculating the impact of the 2019-20 fire season with and without natural disturbances.

Figure 9: Net emissions from wildfire showing: with inter-annual variability (A); and long-run trend in carbon impact after applying the natural disturbances provision (B).



Source: DISER modelling

Next steps

In the 2019-20 Federal Budget, the Government committed to a four-year program to enhance the modelling of carbon in forests using the Full Carbon Accounting Model (FullCAM).

As part of this program, the department has contracted the CSIRO to undertake a work program to improve the modelling of fire emissions using the latest data and science.

Recent work by the CSIRO has already contributed to significant advances in FullCAM modelling capability for fires. Since 2018, emissions estimates have been spatially explicit, meaning that the modelling of fire emissions reflects site-specific factors including productivity, fire history and fuel loads at the time of burning. Carbon sequestered in the recovering forest over time is also modelled spatially, reflecting site-specific factors.

Over the coming years, the department will focus on further developing the fire model to reflect the latest scientific data relating to fire intensity, frequency and climate impacts on post-fire recovery.

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