



WWF

BUSHFIRE
RESPONSE

2020



BURNT ASSETS

The 2019-2020 Australian Bushfires

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WWF is one of the world’s largest and most experienced independent conservation organisations, with over five million supporters and a global network active in more than 100 countries.

WWF’s mission is to stop the degradation of the planet’s natural environment and to build a future in which humans live in harmony with nature, by conserving the world’s biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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VALUING NATURAL CAPITAL LOSSES FROM BUSHFIRES



Summary

- The environmental costs of Australia's 2019-20 bushfire season are immense. Looking at Greenhouse Gas (GHG) emissions from recently burned forests in eastern Australia only, a preliminary analysis suggests that replacing carbon stocks to pre-fire levels would require, in a conservative or base case, an investment of at least A\$300 million.
- If emissions are higher and natural forest regrowth is impaired, as many ecologists fear, due to the severity of the fires and on-going climate change, the replacement of natural carbon stocks lost to the bushfires would cost over A\$ 1 billion. Moreover, if replacing lost carbon drives up carbon offset prices to European levels, the cost would balloon to A\$2.8 billion.
- However, the benefits of this investment would be even greater. Avoiding damages from climate change by replacing the carbon permanently lost to bushfires would deliver global economic benefits between A\$1.5 billion and A\$5.4 billion, depending on the total volume of emissions and expected forest regrowth.
- These estimates are for the four-month period from September 2019 to January 2020 and reflect only the value of carbon emissions from bushfires in eastern Australia, not including the value of biodiversity and ecosystem services, which are likely to be significant. Restoring forest carbon would deliver important co-benefits such as habitat for wildlife, opportunities for outdoor recreation, watershed protection, pollination services to agriculture, etc.
- To put these numbers into perspective, to-date the combined total of Federal and State funding commitments for bushfire recovery, plus private charitable donations, amounts to over A\$3.2 billion, of which a little over 3 percent, or A\$100 million, has been allocated to protect and restore wildlife and habitat.
- If we are realistic about the magnitude of environmental damage from bushfires and the level of investment required to rebuild Australia's natural capital stock, governments at all levels will need to swiftly and significantly increase their emissions reduction and bushfire recovery efforts.
- A massive increase in investment is needed to deliver the restoration required for both people and nature. As a starting point, WWF believes that governments should increase funding for emissions reductions by at least A\$300 million to replace the carbon stocks lost to bushfires, with additional funding for habitat and wildlife recovery.
- Governments should also institutionalise on-going environmental economic accounting of critical natural capital stocks and essential ecosystem services, to inform decision-making about the natural assets that underpin our livelihoods and economic future.

Table 1. Summary of bushfire carbon emissions, prices and value estimates

KEY VARIABLES FOR ESTIMATION	BASE CASE SCENARIO	WORSE CASE SCENARIO	NOTES
Gross bushfire GHG emissions	400 MtCO _{2e}	700 MtCO _{2e}	Expert estimates in January 2020
Net emissions after expected regrowth	20 MtCO _{2e}	70 MtCO _{2e}	95% vs 90% regrowth over 10 years
Offset cost @ A\$15 per tCO _{2e}	A\$300 million	A\$1.05 billion	Australian average ERF ACCU price
Offset cost @ A\$40 per tCO _{2e}	A\$800 million	A\$2.8 billion	EU ETS emission allowance price
Social Cost of Carbon	A\$77 per tCO _{2e}	A\$77 per tCO _{2e}	Climate change damages avoided
Global benefit of offsets	A\$1.54 billion	A\$5.39 billion	Based on social cost of carbon

VALUING NATURAL CAPITAL LOSSES FROM BUSHFIRES



1. Introduction

ECONOMIC ANALYSIS OF BUSHFIRES MUST INCLUDE IMPACTS ON NATURE

The recent bushfires in Australia have attracted worldwide attention. With over 12m hectares burnt so far – roughly the size of England – the bushfires are truly a disaster of global proportions¹. There has been tragic loss of human lives, people severely injured, livestock killed, homes, buildings and infrastructure destroyed, while the impacts on forests and wildlife are almost unimaginable². Understandably, the immediate response focused on rescue, recovery and rapid deployment of humanitarian assistance³.

As rain dampens the fires, many people's thoughts turn to rebuilding. A first step towards recovery is to assess the damage. Early analysis has focused on assessing the bushfire impacts on housing, buildings and infrastructure, the expected loss of farm output, reduction in retail sales, travel and tourism expenditure⁴. Others highlight the impacts of smoke from bushfires on labour productivity⁵ and health, both immediately and over the long-term⁶. Long-term impacts may include higher construction costs in fire prone areas, increased insurance premiums or removal of housing⁷.

Initial published estimates of economic damages from the bushfires range from under 1% of national income (GDP)⁸ up to A\$100 billion, or about 5% of GDP⁹. Perversely, Australia's GDP may actually increase in the aftermath of the bushfires, due to a surge of investment in rebuilding¹⁰. Hence a better metric for estimating the damage from bushfires may be changes in national wealth¹¹.

None of the recent analyses attempt to estimate the value of bushfire impacts on *natural* wealth, despite the enormous destruction of forests, woodland and wildlife. Arguably any comprehensive economic analysis of bushfire impacts and responses must include impacts on nature, as well as human health impacts and damages to buildings and infrastructure. Moreover, just as we distinguish changes in GDP or annual income from losses or gains of wealth, we must also distinguish changes in

¹ <https://www.bbc.com/news/world-australia-50951043>; <https://www.washingtonpost.com/weather/2020/01/24/australia-bush-fires-have-nearly-doubled-countrys-annual-greenhouse-gas-emissions/>; <https://www.theguardian.com/australia-news/datablog/ng-interactive/2019/dec/07/how-big-are-the-fires-burning-on-the-east-coast-of-australia-interactive-map>; <https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2020/2020-global-co2-forecast>

² <https://www.vox.com/science-and-health/2020/1/8/21055228/australia-fires-map-animals-koalas-wildlife-smoke-donate>

³ As this report was being finalised, over 100 fires were still burning across the states of New South Wales, Queensland and Victoria (<https://myfirewatch.landgate.wa.gov.au/map.html>; <https://www.amsj.com.au/australian-bushfire-map/>)

⁴ <https://www.smh.com.au/business/the-economy/economic-cost-of-bushfires-estimated-at-2-billion-and-rising-20200106-p53pac.html>; <https://www.afr.com/companies/tourism/tourism-loses-4-5b-to-bushfires-as-overseas-visitors-cancel-20200116-p53s0s>; <https://www.afr.com/companies/agriculture/tyrrell-s-loses-80pc-of-grapes-due-to-fires-20200122-p53tr1>

⁵ Evidence of bushfire impacts on labour productivity is scant but worrying. See for example: <https://www.semanticscholar.org/paper/Air-Pollution-and-the-Labor-Market%3A-Evidence-from-Borgschulte/0f593c7f1dd8aac35c8c11a6523520e2062638da>

⁶ <https://theconversation.com/we-know-bushfire-smoke-affects-our-health-but-the-long-term-consequences-are-hazy-129451>; <https://www.smh.com.au/national/bushfires-creating-unprecedented-health-crisis-say-doctors-20200111-p53qm5.html>; <https://reneweconomy.com.au/australian-bushfires-drive-up-global-emissions-as-economic-costs-mount-61056/>

⁷ <https://www.afr.com/politics/federal/fires-to-raise-insurance-costs-20200107-p53pi7>; <https://theconversation.com/building-standards-give-us-false-hope-theres-no-such-thing-as-a-fireproof-house-130165>; <https://www.afr.com/property/residential/how-much-it-will-cost-to-protect-your-home-from-a-bushfire-20200115-p53rpp>

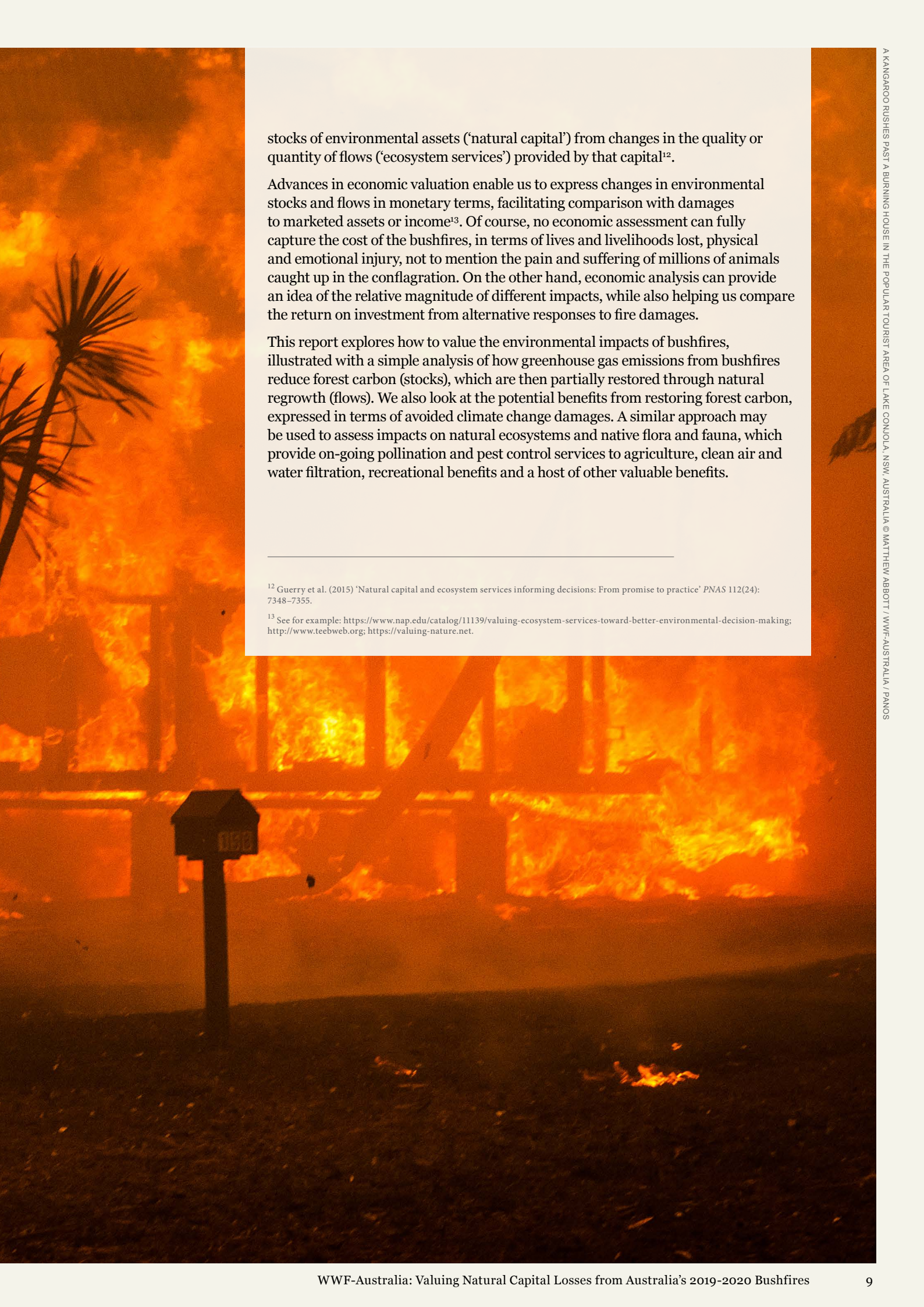
⁸ <https://www.smh.com.au/national/nsw/the-economic-cost-of-bushfires-on-sydney-revealed-up-to-50-million-a-day-and-rising-20191212-p53jbg.html>; <https://www.afr.com/policy/economy/fires-to-knock-0-3pc-off-gdp-goldman-sachs-20200107-p53pex>; <https://www.afr.com/companies/retail/international-fallout-from-bushfires-a-big-risk-for-investors-20200123-p53txo>; <https://www.abc.net.au/news/2020-01-08/economic-bushfires-billions-ross-garnaut-climate-change/11848388>

⁹ <https://edition.cnn.com/2020/01/10/perspectives/australia-fires-cost/index.html>

¹⁰ <https://www.smh.com.au/business/the-economy/caution-required-when-gauging-economic-impact-of-fires-20200109-p53q6t.html>

¹¹ Just as personal (net) wealth is a better indicator of individual or business solvency than monthly income, which can fluctuate widely, so too economists consider changes in per capita wealth to be a better measure of macroeconomic performance than average income or aggregate consumption (GDP/capita), which is not only volatile but can be deeply misleading if it includes the liquidation of capital. See: World Bank (2006) *Where is the wealth of nations? Measuring capital for the 21st century*. The World Bank: Washington, D.C.





stocks of environmental assets ('natural capital') from changes in the quality or quantity of flows ('ecosystem services') provided by that capital¹².

Advances in economic valuation enable us to express changes in environmental stocks and flows in monetary terms, facilitating comparison with damages to marketed assets or income¹³. Of course, no economic assessment can fully capture the cost of the bushfires, in terms of lives and livelihoods lost, physical and emotional injury, not to mention the pain and suffering of millions of animals caught up in the conflagration. On the other hand, economic analysis can provide an idea of the relative magnitude of different impacts, while also helping us compare the return on investment from alternative responses to fire damages.

This report explores how to value the environmental impacts of bushfires, illustrated with a simple analysis of how greenhouse gas emissions from bushfires reduce forest carbon (stocks), which are then partially restored through natural regrowth (flows). We also look at the potential benefits from restoring forest carbon, expressed in terms of avoided climate change damages. A similar approach may be used to assess impacts on natural ecosystems and native flora and fauna, which provide on-going pollination and pest control services to agriculture, clean air and water filtration, recreational benefits and a host of other valuable benefits.

¹² Guerry et al. (2015) 'Natural capital and ecosystem services informing decisions: From promise to practice' *PNAS* 112(24): 7348-7355.

¹³ See for example: <https://www.nap.edu/catalog/11139/valuing-ecosystem-services-toward-better-environmental-decision-making>; <http://www.teebweb.org>; <https://valuing-nature.net>.

VALUING NATURAL CAPITAL LOSSES FROM BUSHFIRES



2. Which Ecosystems Have Been Affected By The Recent Fires?

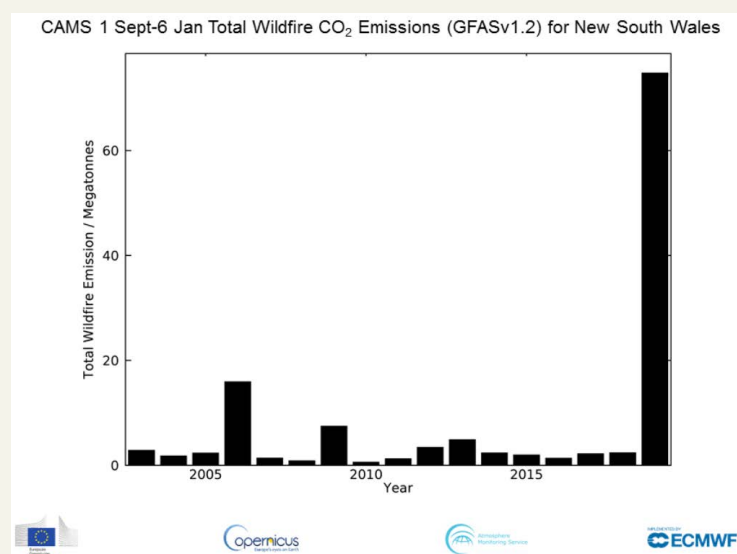
The latest reports suggest that Australia's bushfires have so far burnt around 12 million hectares, including "more than 5.2 million hectares in New South Wales, 2.5 million ha in Queensland, 2.2 million in Western Australia, 1. 4 million in Victoria and about half a million in South Australia"¹⁴. National parks, reserves and native forests have been particularly hard hit, as well as the wildlife that live there¹⁵.

We know that bushfires are a natural phenomenon across much of Australia¹⁶. Our eucalypt forests, woodlands and savannahs have evolved with and are well-adapted to fire. Many species of native plants will only germinate after fire. However, the recent fire season is unprecedented in terms of both the areas affected and the severity of the fires (Figure 1)¹⁷.

Due to climate change and drought, the conditions in which Australia's ecosystems evolved may be changing¹⁸. Fires are becoming more frequent and intense. Global modeling suggests that climate change will result in warmer and dryer woodlands and savannahs, with Australia singled out as the continent with the highest proportion of land area likely to experience increased risk of wildfire¹⁹. There is concern that some unique, remnant rainforests on Australia's east coast – many badly damaged by the bushfires – may not regrow but will be replaced by drier eucalypt forests.

While long-term changes in Australia's forests due to fires and climate change remain uncertain, we can assess some of the more direct and immediate impacts of recent bushfires. One obvious impact is the emission of climate warming greenhouse gases (GHG) from the combustion of biomass.

Figure 1. Total carbon dioxide released by wildfires in New South Wales between 1 September and 6 January over the past 17 years. (Source: Copernicus Atmosphere Monitoring Service/ECMWF)



¹⁴ <https://www.smh.com.au/environment/climate-change/australia-s-bushfires-to-push-global-emissions-to-new-high-met-office-20200124-p53ub2.html>

¹⁵ <https://www.smh.com.au/politics/federal/bushfires-affect-habitat-of-more-than-100-threatened-species-department-estimates-20200120-p53t0i.html>; <https://www.theguardian.com/environment/2020/jan/17/its-heart-wrenching-80-of-blue-mountains-and-50-of-gondwana-rainforests-burn-in-bushfires>

¹⁶ van der Werf, G.R. et al. (2017) 'Global fire emissions estimates during 1997–2016' *Earth Syst. Sci. Data*, 9, 697–720 (<https://www.earth-syst-sci-data.net/9/697/2017/>)

¹⁷ <https://www.theaustralian.com.au/inquirer/fire-weather-worsening-more-heat-less-rainfall/news-storyd24476d26c8ac788c8e485434cc4fa6d>

¹⁸ <https://theconversation.com/yes-native-plants-can-flourish-after-bushfire-but-theres-only-so-much-hardship-they-can-take-129748>

¹⁹ Gonzalez, P., Neilson, R.P., Lenihan, J.M., and Drapek, R.J. (2010) 'Global patterns in the vulnerability of ecosystems to vegetation shifts due to climate change' *Global Ecol. Biogeogr.* 19:755–768 (<https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1466-8238.2010.00558.x>). See also: Grimm et al (2013) 'The impacts of climate change on ecosystem structure and function' *Frontiers in Ecology & the Environment* 11(9):474–482.

VALUING NATURAL CAPITAL LOSSES FROM BUSHFIRES



3. How Much Carbon Was Released By The Bushfires?

EMISSIONS FROM
BUSHFIRES
WERE AT LEAST
400 MILLION
TONNES OF CO₂

The carbon stored in soils and in living and dead biomass, primarily woody vegetation, forms an important part of Australia's stock of natural capital²⁰. Flux of biological carbon – due to fires, land clearing or reforestation, for example – represents positive or negative ecosystem services, which increase or decrease natural carbon stocks²¹.

One credible report estimates that emissions from bushfires in eastern Australia during the period from 1 September 2019 to 6 January 2020 were at least 400 million tonnes (Mt) of CO₂²². More recent reports are even higher, with some observers estimating emissions of over 700 Mt and at least one expert suggesting that emissions “could hit 1 billion tons by the end of the season”²³.

Bushfire emissions typically account for only a small fraction of the total carbon stored in affected forests and woodland, although this varies depending on the intensity of the burn²⁴. A ground fire generates lower emissions than a canopy burn. Very intense fires will release more carbon and may sterilise the soil surface as well as killing trees.

Even relatively modest emissions per hectare are significant when aggregated across a large area. To put these estimates in context, reported CO₂ emissions over the period from September 2019 to January 2020 are equivalent to at least three-quarters of Australia's annual ‘man-made’ emissions during the twelve months to June 2019, which amounted to 530 MtCO₂e. Put another way, in terms of carbon alone Australia appears to have lost a significant portion of its natural capital over just four months.

²⁰ “A total stock of 21,949 million tonnes of carbon (MtC) was stored in Australia's forests at the end of June 2016.” (<https://www.agriculture.gov.au/abares/forestsaustralia/sofr/sofr-2018>). This is equivalent to 80.5 billion tonnes (Gt) of CO₂ (<https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references>).

²¹ Ajani, J.I., Keith, H., Blakers, M., Mackey, B.G., and King, H.P. (2013) ‘Comprehensive carbon stock and flow accounting: A national framework to support climate change mitigation policy’ *Ecological Economics* 89 (2013) 61–72 (<https://www.sciencedirect.com/science/article/pii/S092180091300030X>). See also: Keith, H., Vardon, M., Lindenmayer, D., Mackey, B. (2019) ‘Accounting for carbon stocks and flows: storage and sequestration are both ecosystem services’, Paper for the 25th Meeting of the London Group on Environmental Accounting, Melbourne, 7-10 October 2019 (https://seea.un.org/sites/seea.un.org/files/carbon_accounts_london_group_oct_2019_hkeith.pdf)

²² <https://atmosphere.copernicus.eu/wildfires-continue-rage-australia>. Based on an affected area of at least 10 million ha, this implies emissions of about 40tCO₂e/hectare on average, which is conservative when compared to an average of 100tCO₂/ha in the 2009 ‘Black Saturday’ fire in Victoria, reported by Surawski et al. (2016); see: <https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2016JD025087>

²³ <https://www.newscientist.com/article/2231267-australias-fires-may-accelerate-a-jump-in-co2-forecasted-in-2020/>; <https://www.washingtonpost.com/weather/2020/01/24/australia-bush-fires-have-nearly-doubled-countrys-annual-greenhouse-gas-emissions/>; <https://www.nbcnews.com/science/environment/australia-wildfires-unleash-millions-tons-carbon-dioxide-n1120186>

²⁴ A study of the ‘Black Saturday’ fire in 2009 by Keith et al. (2014) estimated that emissions equalled 8.5% of the pre-fire total biomass carbon stock. See: <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0107126>

²⁵ <https://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/quarterly-update-australias-nggi-jun-2019>. In 2018/19, Australia's emissions were mainly from electricity generation (33.8%), other stationary energy (18.9%), transport (18.9%) and agriculture (12.7%). About 3% of Australia's net GHG emissions come from seasonal bushfires, mainly in tropical savannahs (<https://theconversation.com/burn-bush-reduce-emissions-evaluating-costs-and-benefits-of-prescribed-burning-1098>).

VALUING NATURAL CAPITAL LOSSES FROM BUSHFIRES



4. How Long Will Bushfire Emissions Remain In The Atmosphere?

GHG emissions from forest fires are not the same as emissions from burning fossil fuels. Burnt forests will regrow, pulling carbon out of the atmosphere, while the emissions from burning fossil fuels are effectively permanent²⁶. However, natural regrowth and carbon capture in biomass can take several years or decades, even in the best circumstances²⁷. Until then the emissions will add to global GHG concentrations and climate change.

Long-term trends in natural carbon storage and emissions from land use in Australia are uncertain. On the one hand, changing climatic conditions may reduce natural carbon storage capacity in some areas, particularly if carbon-dense moist forests are replaced by fire climax woodlands, savannahs or even grasslands²⁸. Others maintain that despite potential ecological shifts and increased fire risk, natural carbon stocks in Australia are likely to grow over the coming years, due to shifting rainfall patterns and the ‘fertilisation’ effect of higher CO₂ concentrations in the atmosphere²⁹.

Future changes in land use may also result in changes in natural carbon storage capacity. The most important driver of change is the ongoing expansion of agriculture, which typically removes native vegetation and reduces soil carbon stocks. We may also see a reduction in natural carbon stores as a result of efforts to reduce ‘fuel loads’ and lower the risk of bushfires, such as ‘salvage’ logging of burnt areas or ‘thinning’ in native forests, easing restrictions on grazing cattle in national parks, increased or more frequent hazard reduction burning³⁰ or land clearing near residential areas³¹.

In the absence of definitive data on the volume of this season’s bushfire emissions or the pace and scale of regrowth, we can bracket high and low estimates using the latest reports, together with a stylised (simplified) forest regrowth curve (Figure 2)³². In a conservative or ‘base’ case, we assume a total of 400 Mt of emissions, as reported by the EU’s Copernicus Atmosphere Monitoring Service, with 95 percent regrowth over ten years. This level of regrowth is consistent with historical rates but could also reflect the ‘fertilisation effect’ of higher CO₂ levels in the atmosphere, which stimulate plant growth³³. In this conservative scenario, we would expect net emissions of 20 Mt CO₂e over the period 2020-30.

NATURAL
REGROWTH
AND CARBON
CAPTURE CAN
TAKE YEARS

²⁶ <https://theconversation.com/fact-check-do-bushfires-emit-more-carbon-than-burning-coal-11543>

²⁷ Roxburgh, S.H., Volkova, L., Surawski, N.C., Meyer, C.P. & Weston, C. (2015) *Review of fuel loads, burn efficiencies, emissions factors and recovery functions used to estimate greenhouse gas emissions and removals associated with wildfire on temperate forested lands*. Report prepared for the Department of the Environment (<https://publications.csiro.au/rpr/download?pid=csiro:EP178326&dsid=DS3>). See also: <https://www.smh.com.au/politics/federal/bushfires-spew-two-thirds-of-national-carbon-emissions-in-one-season-20200102-p530ez.html>

²⁸ Liang et al. (2017) ‘Potential decline in carbon carrying capacity under projected climate-wildfire interactions in the Sierra Nevada’ *Nature Scientific Reports* 7:2420. Available at: <https://www.nature.com/articles/s41598-017-02686-0>; <https://www.npr.org/2020/01/12/794665203/australias-wildfires-are-releasing-vast-amounts-of-carbon-emissions>.

²⁹ Kelley, D.I., and Harrison, S.P. (2014) ‘Enhanced Australian carbon sink despite increased wildfire during the 21st century’ *Environ. Res. Lett.* 9 104015 (<https://iopscience.iop.org/article/10.1088/1748-9326/9/10/104015>)

³⁰ <https://www.smh.com.au/politics/federal/prime-minister-says-hazard-reduction-burns-are-climate-action-20200121-p53tha.html>; <https://www.smh.com.au/politics/nsw/adapting-to-the-new-normal-nsw-to-review-land-management-20200105-p53p0l.html>; <https://www.afr.com/politics/federal/hazard-reduction-a-burning-issue-as-bushfire-crisis-continues-20200108-p53pqv>

³¹ <https://theconversation.com/to-reduce-fire-risk-and-meet-climate-targets-over-300-scientists-call-for-stronger-land-clearing-laws-113172>

³² The regrowth curve is adapted from data and models estimated for NSW and Victoria by Roxburgh et al (2015) *Op cit*.

³³ Kelley and Harrison (2014) *Op cit*. See also: Kim, J.B., Monier, E., Sohngen, B., Pitts, G.S., Drapek, R., McFarland, J., Ohrel, S., and Cole, J. (2017) ‘Assessing climate change impacts, benefits of mitigation, and uncertainties on major global forest regions under multiple socioeconomic and emissions scenarios’ *Environ. Res. Lett.* 12:045001 (https://www.fs.fed.us/pnw/pubs/journals/pnw_2017_kim001.pdf)

In a worse case scenario, we assume 700 Mt of emissions³⁴ with 90 percent regrowth by the year 2030, which implies 70 Mt of net emissions over the same period. The latter assumptions may reflect the severity of the recent fires, as well as climate change predictions of higher average temperatures and lower precipitation, which some believe will result in more frequent fires, less tree cover and less carbon-rich environments, compared to recent history. Long-term trends are even less clear, which is why we confine this analysis to the next 10 years³⁵.

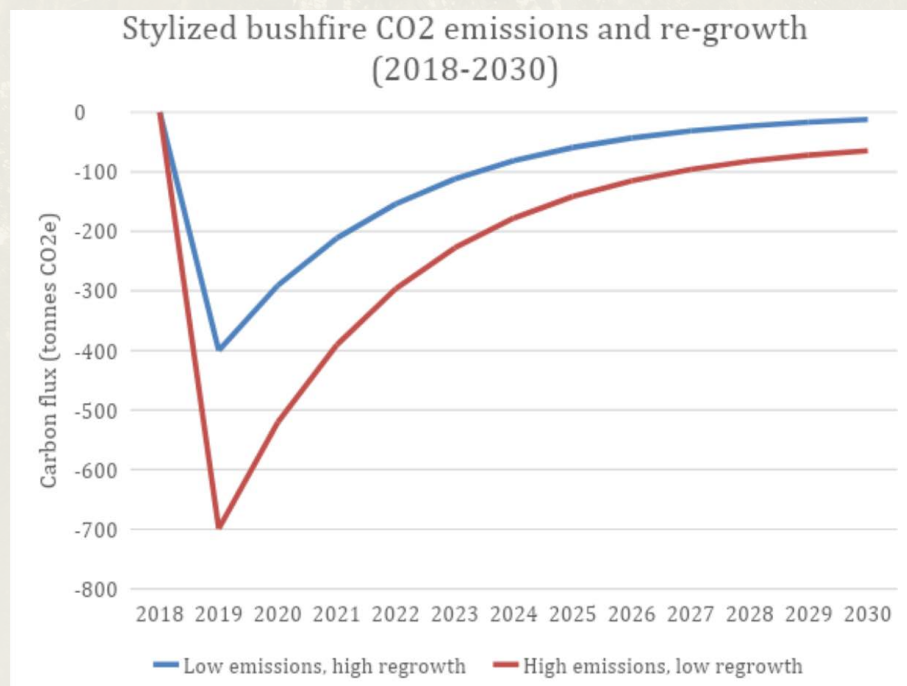


Figure 2. Stylised graph of forest carbon emissions due to bushfire, followed by regrowth over 10 years. Adapted from models and data provided in Roxburgh et al (2015)³⁶.

³⁴ <https://www.newscientist.com/article/2231267-australias-fires-may-accelerate-a-jump-in-co2-forecasted-in-2020/>

³⁵ Even the pessimistic scenario may be too optimistic in the case of severe wildfires. See: Bennett, L.T., Bruce, M.J., Machunter, J., Kohout, M., Krishnaraj, S.J., Aponte, C. (2017) 'Assessing fire impacts on the carbon stability of fire-tolerant forests' *Ecological Applications* 27(8): 2497-2513 (<https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/eap.1626>). And also: <https://theconversation.com/yes-native-plants-can-flourish-after-bushfire-but-theres-only-so-much-hardship-they-can-take-129748>

³⁶ Roxburgh et al. (2015) *Op cit.*





VALUING NATURAL CAPITAL LOSSES FROM BUSHFIRES



5. How Should We Value Bushfire Emissions?

Once we have established a range of estimates of how much carbon has been lost due to bushfire emissions, the next step is to value that loss. From an economic perspective we should consider both the costs of restoring or replacing net carbon losses due to bushfire emissions, as well as the benefits of doing so.

The good news is that almost all of the carbon lost due to recent bushfires – based on the assumptions defined above – will be restored at virtually zero cost, simply by letting nature take its course and watching regeneration happen. This is one of many free gifts that nature provides.

As for the remaining 5-10% of emissions, which may not be restored through natural regrowth, a simple approach to valuation is to apply the price of carbon credits or ‘offsets’ under the federal government’s Emissions Reduction Fund (ERF), which is currently around A\$15 per tonne of CO₂ (tCO₂)³⁷. This is the price the Australian government pays polluters to reduce their emissions, or landholders to reduce emissions and sequester carbon in soils and vegetation³⁸.

A SIMPLE
APPROACH IS TO
APPLY THE PRICE OF
CARBON
CREDITS

At the ERF price we obtain a conservative (base case) estimate of A\$300 million to purchase sufficient offsets to replace 20 MtCO₂ of net emissions. In the worse-case scenario, with higher emissions and lower regrowth, as defined above, the cost would rise to A\$1.05 billion (i.e. 70 MtCO₂ @ A\$15/tCO₂).

The ERF price is probably at the low end of the scale of costs for offsetting net bushfire emissions³⁹. Moreover, any attempt to purchase such a large volume of carbon credits would stretch the capacity of existing suppliers and probably drive up domestic carbon prices. This in turn would attract more supply into the market but could also oblige the buyer (most likely government) to seek additional supply offshore, where prices are generally higher.

It is unclear where domestic carbon prices might settle with increased demand for offsets. However, we can refer to prices in other jurisdictions to gauge the potential implications of higher prices on the costs of replacing the (net) carbon lost to bushfires. In California’s Cap-and-Trade program, for example, the November 2019 auction settlement price was US\$17/tCO₂ (about A\$25), while the current price of an emission allowance in the European Union’s Emission Trading Scheme is EU24.85/tCO₂ (about A\$40)⁴⁰. ***At these higher prices, the cost of purchasing carbon credits sufficient to offset the ‘permanent’ portion of this season’s bushfire emissions would rise to between A\$500 million (20 Mt @ A\$25/tCO₂) and A\$2.8 billion (70 Mt @ A\$40/tCO₂).***

³⁷ <http://www.cleanenergyregulator.gov.au/Infocentre/Markets/Pages/Buying%20ACCUs/ACCUs%20market%20updates/Australian-Carbon-Credit-Units-Market-Update---October-2019.aspx>

³⁸ Projects funded by the ERF include tree planting and revegetation, cool season savannah burning, capturing waste methane emissions from landfill and livestock, and energy efficiency measures by industrial polluters. (<http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/project-register>). There is concern that some existing carbon offset projects may have been damaged by the bushfires (<https://www.afr.com/companies/energy/regulator-assesses-fire-damage-to-emission-fund-projects-20200122-p53tlz>).

³⁹ Busch, J. Engelmann, J., Cook-Patton, S.C., Griscom, B.W., Kroeger, T., Possingham, H., and Shyamsundar, P. (2019) ‘Potential for low-cost carbon dioxide removal through tropical reforestation’ *Nature Climate Change*, 9(June): 463–466 (<https://www.nature.com/articles/s41558-019-0485-x>)

⁴⁰ https://www3.arb.ca.gov/cc/capandtrade/auction/results_summary.pdf; <https://markets.businessinsider.com/commodities/co2-european-emission-allowances>. In contrast, the December 2019 auction clearing price for CO₂ allowances in the US Regional Greenhouse Gas Initiative (RGGI) was US\$5.61 per short ton of CO₂ (<https://www.eia.gov/todayinenergy/detail.php?id=42255>), or about A\$8/tCO₂.

VALUING NATURAL CAPITAL LOSSES FROM BUSHFIRES



6. Is Restoring Forest Carbon A Good Investment?

The cost of replacing carbon losses by purchasing compensatory credits or offsets is one side of the coin. The other side is the *benefit* obtained from doing so. Measuring the benefits of compensatory offsets requires that we consider the economic damages from climate change, which would be reduced to the extent that emissions are reduced or offset.

To this end we can use the ‘social cost of carbon’ (SCC), which represents the contribution of GHG emissions to climate change and the resulting economic impacts. Based on sophisticated models that link demographic, economic and physical variables, the SCC approach recognises that climate change has wide ranging impacts and imposes long-term costs on society, entirely separate from the cost of reducing GHG emissions⁴¹.

In effect, the SCC represents the marginal economic impact of an additional tonne of GHG emissions (or the marginal benefit of reducing emissions by one tonne). The SCC can be seen as a measure of the *demand* for emissions reductions, while the marginal cost of offsets, such as the price paid under the Emissions Reduction Fund, cited above, represents the *supply*.

Estimates of the SCC vary but the most often cited numbers come from the US Federal Government, which reports a value for 2020 of US\$42 per metric tonne of CO₂ emissions (in 2007 U.S. dollars)⁴². After adjusting for inflation⁴³ and exchange rates⁴⁴, this equals A\$77 in current Australian dollars. Note that this number excludes the direct co-benefits of restoring forest carbon stocks, including biodiversity conservation and ecosystem services.

As above, we can bracket the true benefit of replacing or restoring the carbon lost due to bushfires, using low and high estimates of permanent emissions. On this basis, ***the SCC approach implies that the global economic benefit of replacing or offsetting carbon emissions due to Australia’s recent bushfires would be A\$1.54 billion in the base case scenario, where forests regrow normally, or up to A\$5.39 billion in the worse-case scenario, where 10 percent of all emissions are permanent***⁴⁵.

CLIMATE DAMAGES
WOULD BE
REDUCED
TO THE EXTENT THAT
EMISSIONS ARE OFFSET

⁴¹ Climate change impacts are systemic, affecting every sector of the economy. Some sectors and jurisdictions may benefit, while others lose out. For example, agriculture in some locations may benefit from warmer temperatures or higher rainfall, while other areas suffer increased drought or floods. Sea level rise, increasing storm frequency and intensity will affect coastal buildings and infrastructure. Higher temperatures will affect human health. Meanwhile, economic growth will affect people’s willingness and ability to pay for adaptation and damage avoidance. For an overview of how economists model the impacts of climate change to determine the Social Cost of Carbon, see: <https://www.carbonbrief.org/qa-social-cost-carbon>

⁴² This estimate comes from a 2017 report by the ‘Interagency Working Group on the Social Cost of Greenhouse Gases’, available at: <https://www.nap.edu/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of>

⁴³ 1.27 between January 2007 and December 2019, according to: <https://data.bls.gov/cgi-bin/cpicalc.pl>

⁴⁴ 1.45 AUD/USD on 15 January 2020, according to: <https://www.x-rates.com>

⁴⁵ Other credible estimates of the social cost of carbon are much higher. For example, Ricke et al (2018) report a median global SCC of US\$417/tCO₂ (<https://www.nature.com/articles/s41558-018-0282-y>)

VALUING NATURAL CAPITAL LOSSES FROM BUSHFIRES



7. Are We Investing Enough in Forest Restoration?

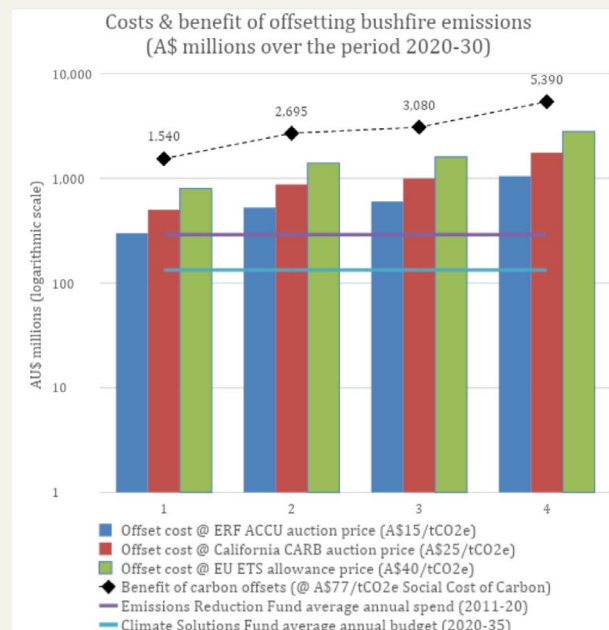
The analysis above indicates that the global economic benefit of replacing carbon lost to bushfires, in terms of avoided climate change damages, would comfortably exceed the cost, based on current market prices of carbon credits or offsets (Figure 3). This is true even at relatively high international prices of carbon credits.

Figure 3 also shows the average annual investment in climate mitigation by the Australian federal government since 2011, under the Emissions Reduction Fund⁴⁶, as well as planned investment in additional emission reductions over the coming 15 years, under the new Climate Solutions Fund⁴⁷. Except under the most optimistic assumptions about net bushfire emissions and carbon offset prices, the data suggest that **the federal government's ambition falls far short of the investment required to compensate for recent bushfire carbon emissions, let alone other sources of GHG.**

Carbon dioxide emissions from bushfires are considered a natural disturbance event under the rules of the UN Climate Convention, so technically Australia is not obliged to account or make up for these emissions⁴⁸. However, climate change does not care about technicalities and the impacts are felt no matter where the carbon emissions come from.

While the results of cost-benefit analysis seem clear, we must acknowledge that most of the benefit of slowing climate change by restoring forest carbon or offsetting emissions will accrue to people overseas, who far outnumber Australians⁴⁹. This is equally true, however, of emissions reductions in other countries, which benefit Australia at no cost to us. We must also recognise that ecosystems have limited capacity to absorb carbon and that offsets are not a panacea that would neutralise all bushfire impacts⁵⁰.

Figure 3. Costs and benefit of restoring forest carbon lost to bushfires.



⁴⁶ <http://www.environment.gov.au/climate-change/publications/emissions-reduction-fund-update>. The total invested over the 10 years from 2011 was A\$2.29 billion, or an average of A\$290 million per annum.

⁴⁷ <https://www.theguardian.com/environment/2019/apr/02/coalition-climate-solutions-fund-must-last-further-five-years>. Based on total funding of A\$2 billion to be spent over 15 years, the average annual spend would be about A\$133 million.

⁴⁸ Roxburgh, S., Surawski, N., Raison, J., Luck, H. (2014) Native forest wildfire emissions background level and margin – review of methodological options and implications for emissions reporting, Report for the Department of the Environment (<https://publications.csiro.au/rpr/download?pid=csiro:EP146987&dsid=DS2>). See: <https://www.smh.com.au/politics/federal/bushfires-spew-two-thirds-of-national-carbon-emissions-in-one-season-20200102-p530ez.html>

⁴⁹ By the same token, a permanent reduction in carbon storage as a result of changes in Australia's land management, whether intended to reduce bushfire risk or for any other purpose, would impose A\$77/tCO_{2e} in climate change costs.

⁵⁰ The ecological limits of forest carbon storage also imply that we cannot rely on them to offset GHG emissions from burning fossil fuels. See: Mackay et al. (2013) 'Untangling the confusion around land carbon science and climate change mitigation policy' Nature Climate Change Vol. 3(June): 552-557 (<https://www.nature.com/articles/nclimate1804>)

VALUING NATURAL CAPITAL LOSSES FROM BUSHFIRES



8. Can We Rely On New Funding For Bushfire Recovery?

The preliminary analysis above suggests that the government's budget for emissions reduction is insufficient to replace the (net) carbon losses due to bushfires, even though doing so would be a good economic investment. But what about funding specifically earmarked for bushfire recovery?

To-date the Australian federal government has pledged A\$2 billion for this purpose⁵¹, including an initial investment of A\$50 million to protect and restore wildlife and habitat⁵². The government of NSW has committed A\$1 billion⁵³, while the government of Victoria has so far allocated at least A\$65 million, including A\$17.5 million for bushfire biodiversity response and recovery⁵⁴. Separately, private businesses and individuals have pledged over A\$200 million⁵⁵. In total, over A\$3.2 billion has been committed so far.

All of this funding for bushfire recovery is welcome and desperately needed to rescue, rebuild and restore what has been lost. At the same time, we must be realistic about the magnitude of bushfire damages and the level of reinvestment required.

This analysis suggests that the benefits of restoring forest carbon would far exceed the cost, while delivering many other values, notably habitat for wildlife. However, it is also clear that ***the cost of replacing forest carbon (at least A\$300M and perhaps A\$1 billion or more, as explained above) would absorb a very large share of the funding allocated or donated for bushfire recovery.***

In practice, it is difficult to imagine that a significant share of the funding available will be allocated to carbon offsets. People directly affected by bushfires will be first in line for compensation and support. This is as it should be. But who or what comes next? And how should funds be divided?

If history is any guide, the owners of assets with well-established market values – i.e. private land and private property – will be high on the list for support. People who have suffered indirectly, e.g. from smoke inhalation, will probably (unfortunately) come lower.

There is a real risk that the environment will come last and receive the least support, simply because property rights, public policies and markets do not fully reflect the fact that nature is an asset that generates significant economic value. Based on the analysis above, as a minimum starting point for natural capital restoration following bushfires, WWF believes that governments at all levels should increase their budgets for emissions reduction by at least A\$300 million, to replace the carbon stocks lost to bushfires, with additional funding for habitat restoration and wildlife recovery.

GOVERNMENTS SHOULD
INCREASE BUDGETS FOR
EMISSIONS
REDUCTION

⁵¹ <https://www.smh.com.au/politics/federal/bushfire-recovery-fund-to-get-2-billion-over-two-years-20200106-p53p8j.html>

⁵² <https://www.smh.com.au/environment/conservation/ecological-tragedy-50m-federal-cash-to-aid-wildlife-after-fires-20200112-p53qtw.html>

⁵³ <https://www.smh.com.au/politics/nsw/berejiklian-government-to-spend-1b-rebuilding-fire-ravaged-nsw-20200109-p53q01.html>

⁵⁴ <https://www.theage.com.au/national/victoria/65-million-relief-package-for-fire-areas-20200126-p53uva.html>; <https://www.wildlife.vic.gov.au/home/biodiversity-bushfire-response-and-recovery>

⁵⁵ <https://www.msn.com/en-au/news/australia/australia-fires-where-your-donation-money-is-going/ar-BBYW9Fs>

VALUING NATURAL CAPITAL LOSSES FROM BUSHFIRES



9. What Other Environmental Impacts Should Be Considered?

ENVIRONMENTAL
BENEFITS
CAN AND SHOULD BE
MEASURED
AND VALUED

A complete environmental economic accounting of bushfire impacts and restoration options must consider not only carbon emissions but impacts on a range of other natural assets and ecosystem services as well. Recent reports on Australian bushfires have highlighted massive losses of wildlife⁵⁶ but also many other environmental damages⁵⁷. More generally, a recent global meta-analysis finds that wildfires typically have negative impacts on a wide range of ecosystem services⁵⁸.

Some environmental impacts are more easily valued than others. As noted above, for assets with well-established markets and prices, such as privately-owned farmland, livestock, fish farms or commercially valuable stands of timber, we might expect households, businesses and governments to make sure that any significant bushfire damages are accounted for (even if compensation is not always available).

Other environmental assets and bushfire impacts may be more difficult to value but are no less important socially and economically, including:

- Streams, lakes and reservoirs polluted by runoff from burned areas,
- Diminished appeal of affected areas for tourism and recreational uses,
- Loss or damage to sites of historical and cultural significance,
- Reduced amenity value of rural residential properties,
- Loss of natural pollination and pest control services,
- Loss of non-wood forest products (e.g. honey),
- Human health impacts from smoke, and
- Numbers of wildlife killed or injured.

These and other non-marketed (or partly marketed) environmental benefits can and should be measured and valued to assess the changes in natural wealth and ecosystem services resulting from the bushfires.

In many cases we can use the same general approach as for GHG emissions, namely: (i) estimate damages in physical terms, (ii) determine what portion of the damage is long-lasting or permanent, (iii) estimate the potential cost of rehabilitation or compensation if required, (iv) assess the benefits of restoration/compensation, and (v) compare costs and benefits to determine the return on investment. Ideally, we should also consider how different values vary in space and time, as well as how fire risk varies, to identify where values align and how much to invest in restoration.

For some environmental assets damaged by bushfires, it may be possible to build on existing data and reports⁵⁹. In practice, for many environmental assets affected by bushfires, we do not yet know the extent of the damage and recovery is uncertain. Moreover, for some environmental assets there are no liquid markets nor any obvious 'prices' with which to assess damages in monetary terms.

⁵⁶ <https://www.abc.net.au/news/2020-01-31/fact-check-have-bushfires-killed-more-than-a-billion-animals/11912538>. See also: <https://www.vox.com/energy-and-environment/2020/1/9/21057375/australia-fire-wildlife-extinctions-ecology>

⁵⁷ <https://www.theland.com.au/story/6596244/fire-sparks-massive-upper-murray-fish-kill/>; <https://www.unenvironment.org/news-and-stories/story/ten-impacts-australian-bushfires>

⁵⁸ Thom, D. and Seidl, R. (2016) 'Natural disturbance impacts on ecosystem services and biodiversity in temperate and boreal forests' *Biological Reviews*, 91: 760–781 (<https://onlinelibrary.wiley.com/doi/epdf/10.1111/brv.12193>)

⁵⁹ Useful data is provided in Australia's State of the Forests Report 2018, particularly sections on 'Values, quantities and use of non-wood forest products' and 'Value of forest-based services' (<https://www.agriculture.gov.au/abares/forestsaustralia/sofr/sofr-2018>). See also: Valuing Victoria's Parks – Accounting for ecosystems and valuing their benefits: Report of first phase findings, published by Parks Victoria (<https://www.parks.vic.gov.au/about-us/valuing-victorias-parks>)

Even where reliable estimates of physical damages, regrowth, restoration costs and benefits can be found, we may need to account for other differences. For example, if damages are large relative to local demand, it may be necessary to consider higher-priced substitutes (as we saw with carbon offsets). Other bushfire impacts may be irreversible – such as species extinctions – and therefore essentially ‘priceless’.

Notwithstanding these and other complications, reliable methods are available to estimate the values of many non-marketed environmental goods and services⁶⁰. For example, public surveys can be used to measure consumers’ willingness-to-pay for outdoor recreation or wildlife conservation⁶¹. Econometric models can discern how much of the value of housing is attributable to views of natural areas, or the extent to which agricultural productivity is influenced by proximity to wild nature⁶². Epidemiological studies can clarify the impacts of bushfire smoke on labour productivity and human health outcomes⁶³. Emerging markets for biodiversity offsets⁶⁴ and native vegetation credits⁶⁵ can provide rough estimates of the costs of restoring damaged habitat. Such analysis is beyond the scope of this report but should be a priority for future research, not only to assess the economic impacts of bushfires but also the potential benefits of bushfire prevention and forest restoration.

⁶⁰ Baker, R. and Ruting, B. (2014) Environmental Policy Analysis: A Guide to Non-Market Valuation, Productivity Commission Staff Working Paper (<https://www.pc.gov.au/research/supporting/non-market-valuation/non-market-valuation.pdf>)

⁶¹ Bateman, I.J. et al (2002) *Economic valuation with stated preference techniques: a manual*, Edward Elgar: Cheltenham, UK (<https://www.cabdirect.org/cabdirect/abstract/20043091507>)

⁶² See: ‘Appendix C: Production Function Models’ in <https://www.nap.edu/catalog/11139/valuing-ecosystem-services-toward-better-environmental-decision-making>

⁶³ See for example: <https://ec.europa.eu/jrc/en/publication/assessment-and-economic-valuation-air-pollution-impacts-human-health-over-europe-and-united-states>; <https://www.epa.nsw.gov.au/~media/EPA/Corporate%20Site/resources/air/HealthPartEmiss.ashx>; <https://www.sciencedirect.com/science/article/abs/pii/S030421596000511>; <https://www.sciencedirect.com/science/article/abs/pii/S0921800905004179>

⁶⁴ <https://www.bct.nsw.gov.au/biodiversity-offsets-program>; <https://www.qld.gov.au/environment/pollution/management/offsets>

⁶⁵ <https://www.environment.vic.gov.au/native-vegetation/native-vegetation/offsets-for-the-removal-of-native-vegetation>





VALUING NATURAL CAPITAL LOSSES FROM BUSHFIRES



10. Where Do We Go From Here?

This analysis has sought to shed light on the economic significance of natural capital losses due to recent bushfires in Australia, using forest carbon stocks to illustrate the magnitude of the values at stake. We also highlight the economic values that may be gained by re-investing in nature and assess the (in)adequacy of existing budget allocations for emissions reductions and bushfire recovery.

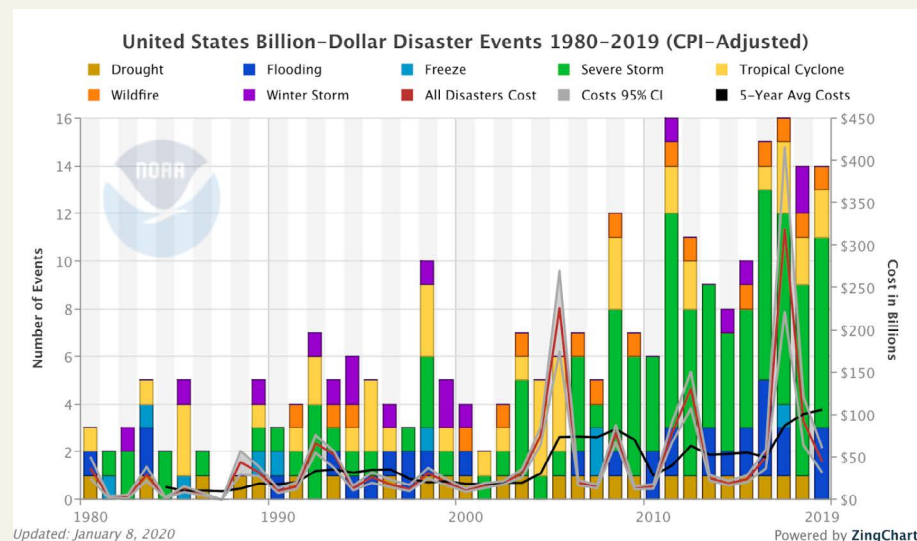
The next steps are still being worked out at national, state and local levels. Humanitarian responses come first, especially while bushfires are still burning. As the fires increasingly come under control, attention and effort will turn to evaluating the extent of the damages and starting to rebuild. At this stage it will be vitally important to assess not only the impacts of bushfires on people's livelihoods and tangible assets, but also the impacts on less visible natural assets and ecosystem services. A comprehensive analysis of bushfire impacts is necessary to ensure that we allocate sufficient resources and make informed investments when rebuilding our national and *natural* wealth.

We can imagine an optimistic scenario, in which the bushfires help create national consensus to address climate change and trigger the investments needed to restore Australia's frayed natural capital. There is no reason we cannot have larger natural carbon stocks, more wildlife, cleaner air and a healthier environment than before the bushfires. Realising such a vision will not come cheap and requires major policy reform, but the economic evidence suggests it is worth pursuing. As a starting point, **WWF believes that governments should increase their budgets for GHG emissions reduction by at least A\$300 million, in the aftermath of bushfires, plus additional support for habitat restoration and wildlife recovery.**

Investment in data collection and analysis is also essential. Like most countries around the world, Australia is likely to experience more climate and weather-related destruction over the coming years (Figure 4). To help prepare for a riskier future, we will need better understanding of bushfire trends, drivers and impacts, as well as cost-effective mitigation measures. An important area for innovation is to improve land management to reduce bushfire risk, including the use of hazard reduction or 'cultural' burning, while at the same time protecting or enhancing other values⁶⁶.

Figure 4. Trends in weather and climate disasters in the United States


(Source: <https://www.ncdc.noaa.gov/billions/time-series>)⁶⁷



⁶⁶ <https://theconversation.com/burn-bush-reduce-emissions-evaluating-costs-and-benefits-of-prescribed-burning-1098>; <https://www.theguardian.com/commentisfree/2020/jan/11/how-first-australians-ancient-knowledge-can-help-us-survive-the-bushfires-of-the-future>; <https://volunteerfirefighters.org.au/bushfire-greenhouse-gas-emissions-from-mild-to-wild>

⁶⁷ For details see: <https://www.climate.gov/news-features/blogs/beyond-data/2010-2019-landmark-decade-us-billion-dollar-weather-and-climate>; <https://www.ncdc.noaa.gov/monitoring-references/dyk/billions-calculations>





We need to *institutionalise* environmental economic monitoring and analysis, to ensure ongoing accountability for environmental expenditures and interventions. The risk is that these kind of measurements are only undertaken in response to disasters, when they should be seen as part of building an ongoing evidence base to inform public and private decision making. Fortunately, there are proven frameworks, standards and methods already available to support robust environmental economic monitoring and accounting⁶⁸. The bushfires are a timely reminder that governments and other institutions need to adopt and apply these tools, as an essential part of ensuring that our precious natural capital is not simply taken for granted until the next natural disaster occurs.

⁶⁸ At a national level, see: <https://sea.un.org> and <https://www.worldbank.org/en/topic/natural-capital>. For company-level natural capital accounting, see for example: <https://naturalcapitalcoalition.org/natural-capital-protocol/>

WHAT WE'RE DOING

WILDLIFE CARE

WWF-Australia is deploying emergency care for wildlife.

IMPACT ASSESSMENT

Assessing the scale of the damage to species and habitat.

WILDLIFE REHABILITATION

Rehabilitating wildlife through food drops, water stations, and supporting care facilities.



SEARCHING FOR KOALAS IN NEED


In partnership with OWAD, we've deployed koala detection dogs who have located surviving koalas.

RESTORING HABITAT

When the fires clear we will help restore homes for wildlife through WWF-Australia's Two Billion Trees plan.

FUTURE-PROOFING AUSTRALIA

WWF-Australia's work will include driving innovative solutions to help mitigate climate change, driving climate preparedness, species adaptation and long-term wildlife and nature conservation efforts towards securing Australia's natural resources for people and nature.

	<p>Why we are here To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.</p> <p>wwf.org.au</p>
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