Green Institute Working Paper 2

Forests: vital for climate protection

Margaret Blakers, Green Institute, September 2007[1]

Summary

1. Native forests have a vital role in Australia's greenhouse gas profile, as a very large store of CO_2 with considerable potential for additional sequestration, and as a source of greenhouse gas emissions, primarily resulting from logging.

2. Native forests (not including conservation forests) sequester at least 57 Mt CO_2 per annum, which reduces Australia's total emissions by 10% when full-carbon accounting is used. By comparison, total sequestration by Kyoto-compliant plantations (those established post-1990 on previously cleared land) was 19.6 Mt CO_2 in 2005.

3. Native forest logging results in greenhouse gas emissions estimated at 38 Mt CO_2 per annum, equivalent to 7% of Australia's total emissions. Depending on the age of the forest, it will take up to several centuries to recapture all the CO2 emitted.

4. Less than 5% of CO_2 generated by native forest logging is sequestered in durable wood products; 58% is lost on-site and as waste; 23% is exported as woodchips; and 11% is added to landfill.

5. Tasmania accounts for half Australia's emissions from native forest logging (19 Mt CO_2 per annum).

6. Full-carbon accounting (as distinct from the partial accounting required by the Kyoto Protocol) is likely to be used in global post-Kyoto arrangements which means that sequestration and emissions from native forests will be counted.

7. Protecting native forests is one of the quickest and easiest ways to reduce Australia's greenhouse gas emissions, with the added benefits of protecting biodiversity and conserving water.

8. Forest-related elements of Australia's greenhouse gas accounts need urgent upgrading to support policy development and action.

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Contents

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1. Introduction

Forests have a vital role in protecting the Earth's climate. Globally, emissions from deforestation and degradation, including from logging, account for at least 18% of greenhouse gas emissions.[2] In Australia, land use, land-use change and forestry appears, from the accounts, to be a small net sink (-3.2 $MtCO_2$ in 2005, UNFCCC accounting) with emissions from clearing of native vegetation counterbalanced by CO_2 uptake from native forests and plantations. Emissions from land clearing have reduced substantially since 1990 (enabling Australia to be within reach of its Kyoto target) but what of the other side of the ledger: emissions and uptake from Australia's native forests and plantations?

This information is not easy to obtain from Australia's national greenhouse gas accounts because the data are not reported separately. For example, the figure which appears under 'managed native forests' – an apparent sink of -43.5 Mt CO_2 in 2005 (UNFCCC accounts) -- is a composite. It includes CO_2 uptake from native forests and on-site emissions from logging; it does not include CO_2 in logs removed from the site or CO_2 uptake by conservation forests.

The significance of native forests in Australia's greenhouse profile is contentious. A more transparent accounting system would help clarify the issues for debate, policy development and action. It is also an essential pre-requisite for the use of carbon trading and other financial instruments. The point is underlined by the assessment of the Prime Minister's Task Group on Emissions Trading that forestry is 'not suitable for initial inclusion; improved and more cost-effective measurement methodologies to be developed'.[3]

This working paper examines the significance of native forests, plantations and wood products in Australia's greenhouse performance, using the methodologies of government's greenhouse gas accounts as far as they can be determined.[4] Australia's greenhouse gas accounts are prepared by the Australian Greenhouse Office (AGO) through the National Carbon Accounting System (NCAS). An NCAS technical report titled *Forest Management in Australia: Implications for Carbon Budgets* is in preparation but has not yet been published.

2. Australia's greenhouse gas accounts

Australia has two sets of greenhouse gas accounts: the Kyoto account, which reports only on those components of the land use, land-use change and forestry sector specified in the Kyoto Protocol;[5] and the comprehensive UNFCCC (United Nations Framework Convention on Climate Change) account. The Kyoto account is the one which measures Australia's progress towards meeting its Kyoto target for 2010-2012. But the UNFCCC account is likely to underpin the negotiations for post-Kyoto arrangements because it is a full-carbon accounting system. Both

[2] Stern 2006
[3] Australian Government 2007a
[4] For a more detailed commentary on the NCAS methodologies see Blakers 2007. Australia's greenhouse gas accounts are available on-line (AGEIS 2997)
[5] The Land Use, Land Use Change and Forestry (LULUCF) category includes greenhouse gas emissions associated with forests, crops and grasslands. Australia's Kyoto Protocol account reports only on specified activities in this category, specifically carbon uptake from the establishment of new forests and plantations post 1990; and carbon emissions from clearing of forests and woodlands post 1990 (Article 3.3 activities).

sets of accounts use methodologies recommended by the Intergovernmental Panel on Climate Change (IPCC).

In effect, the greenhouse gas accounts are like a cash-flow account, tracking the amounts of CO_2 flowing into and out of the atmosphere each year. In the case of land use, land-use change and forestry, CO_2 emissions result from activities such as logging, clearing, burning and soil disturbance. CO_2 uptake results from the growth of native vegetation and plantations. The Australian accounts differentiate between native forests (natural vegetation) and plantations (tree crops), so their respective uptake and emissions can be compared.

Australia's National Carbon Accounting System (NCAS) is still under development. Most effort has gone into accounting for sectors which form part of the Kyoto account. The interim methodologies used for other sectors have major shortcomings, for example by not reporting on emissions of soil carbon which can be significant.[6] Nevertheless, they represent the best available information and are relied on by the Australian government in its annual report to the UNFCCC. They are used in this paper to estimate emissions from native forest logging and review the contribution of plantations and wood products.

Australia defines forests as vegetation (trees) greater than 2m in height, with a crown canopy cover of greater than 20% and covering a minimum area of 0.2ha.

In this discussion, all figures are standardised as CO_2-e (carbon dioxide equivalent) and relate to the 2005 UNFCCC inventory[7] unless otherwise specified. Carbon is converted to carbon dioxide by multiplying by 3.667.

3. Native forests: CO_2 emissions

2.1 Methodology for estimating emissions

Native forest logging results in CO_2 emissions because the carbon locked up in wood, branches, leaves, litter, roots and soil is released to the atmosphere. Logging emissions are included in Australia's UNFCCC inventory, but only as a net figure which combines emissions from logging with uptake from annual forest growth.

Logging emissions are estimated by applying standard ratios to the commercial log volume to account for 'slash' (branches, leaves and understorey vegetation) and roots. These on-site amounts are added to the log volume itself to give total emissions.[8] It is likely that this significantly understates CO_2 releases from native forest logging because:

- It does not include the carbon stored in dead wood, soils and litter.
- Log volume is not a good proxy for CO_2 emissions in native forests. The log volume actually harvested from a coupe may be considerably less than the merchantable volume because, unlike plantations, there may be no commercial imperative to remove all the

[6] See Blakers 2007
[7] Australian Government 2007b
[8] The ratios are:
- carbon density of eucalypt wood 0.325 t C/ m^3
- 'expansion factor' to estimate carbon in above ground biomass (slash): 1.9 x volume
- proportion of carbon in roots: 0.25 x weight of above ground biomass

merchantable wood. A post-logging survey of one Tasmanian coupe found that only 26% of the timber volume had been removed, which means the estimated CO_2 emissions would be barely a quarter of what they actually were.[9] This issue applies particularly to old growth forests with thick understoreys of 'special species' such as myrtle, celery-top pine, sassafras and leatherwood and to very old eucalypts which may be blown up rather than felled.

The only way to overcome these deficiencies, is to obtain measures on an area basis of the amount of CO_2 in forests of different types and ages.

There is also a data problem with Australia's 2005 native forest account which appears to combine log volumes from native forest and hardwood plantations. The correct figures for native forest log volumes can be obtained from ABARE and are used here.[10]

2.2 Estimated emissions

In 2005, the harvested volume of native forest logs was 9.8 million m^3. Using the NCAS methodology,[11] this corresponds to potential national emissions of 27.7 Mt CO_2 comprising:

Logs removed from the site: 11.7 Mt CO_2

On site slash: 10.5 Mt CO_2

On site roots: 5.5 Mt CO_2

Some of this CO_2 reaches the atmosphere almost immediately when logged coupes are burnt. The balance is released over the following years depending on decay times for processing waste and the use to which the wood is put. The Australian accounts assume that slash decays linearly over seven years. The fate of the carbon in logs removed from the site is discussed in section 6.

The reference year for greenhouse gas accounts is 1990. In the 16 years since, native forest logging has averaged 10 million m^3 pa. This equates to CO_2 emissions of 28.3 Mt CO_2 per annum, which compares with Australia's total emissions in 2005 of 522 Mt CO_2 (UNFCCC account).

2.3 Other estimates

The Wilderness Society (TWS) calculates that 52 603 ha of native forest is logged annually in Tasmania, Victoria and southern NSW, and that the amount of CO_2 released ranges from a minimum 550 tonnes per hectare rising to over 4400 tonnes per hectare in tall wet old growth forest (including carbon lost from deadwood, soil and litter). They estimate CO_2 emissions from native forest logging in these states to be 33.5 Mt CO_2 per annum.[12] Native forests are also logged in other states (Table 1). To account for this, comparison of log volumes suggests that the TWS estimate should be increased by at least 5 Mt CO_2. This would give a national total of 38 Mt CO_2 per annum of potential emissions from native forest logging.

Taken together, the two sets of estimates suggest that emissions from native forest logging are in the order of 28--38 Mt CO_2 per annum. The lower estimate does not include carbon stored in

[9] Green 2002
[10] ABARE 2007
[11] Australian Government 2007b, pp.23-27
[12] TWS 2006

dead wood, litter and soil and depends on harvested log volume rather than actual on-site biomass. Pending a more comprehensive analysis, 38 Mt CO_2 per annum is the current best estimate.[13] State by state, Tasmania is by far the largest contributor with the largest log volumes and the greatest extent of logging. It is responsible for 50% of total emissions from native forest logging, an estimated 19 Mt CO_2 per annum.

Table 1. CO_2 emissions, comparing estimates from log volumes with estimates from logged areas

State	Harvested log volume (2005) m^3	Emissions estimated from log volume Mt CO2	Logged area ha	Emissions estimated from logged area (TWS 2006) Mt CO2
Tasmania – public forests (04/05)	3 100 569	8.8		
Tasmania – private forests (04/05)	1 570 661	4.4		
Tasmania – total	4 671 230	13.2	34 328	18.9 Mt
Victoria – public forests (04/05)	1 833 922	5.2		
Victoria – total			8995	9.5 Mt
NSW – public forests (04/05)	1 097 270	3.1		
SE NSW			9280	5.1 Mt
Western Australia -- total (04/05)	510 000	1.4		
Balance (NSW and Vic private forests, Qld: by subtraction from total)	1 660 578	4.7		
Total (southern NSW, Vic, Tas)				33.5
Total (all states)	9 772 000	27.7		

Sources: Forestry Tasmania, Annual Report 2005/06; Private Forests Tasmania, Annual Report 2005/06; VicForests Annual Report 2006; Forests NSW Social, Environmental and Economic (Seeing) Report 2005/06; WA State of the Environment Report 2007.

2.4 Significance

Emissions of 38 million tonnes of CO_2 per annum are highly significant in Australia's overall greenhouse profile. If it is assumed that all emissions occur at the time of harvest (the IPCC default), native forest logging results in greenhouse gas emissions equivalent to 7% of Australia's total net emissions for 2005 (UNFCCC account).

In scale, emissions from native forest logging approach those for deforestation, which in 2005 were 53 Mt CO_2. They are close to half Australia's transport emissions (80 Mt CO_2 in 2005). They have not received nearly the same level of attention as these categories because they do not form part of the Kyoto account or contribute towards Australia's Kyoto target. They are

[13] This estimate is consistent with the IPCC default methodology which accounts for all logging emissions at harvest. Australia's accounts adopt alternative methodologies: on-site emissions are reported in the appropriate category (native forests or plantations); logs removed off site are accounted for according to where they end up (landfill, domestic wood products, waste); exported wood products are not accounted for in Australia but in the country where the wood is processed. This is particularly significant for native forest wood: the majority is exported as woodchips and so does not appear as an emission in the Australian accounts.

nevertheless real with respect to the atmosphere and offer an important option for reducing greenhouse gas emissions.

4. Plantations and CO_2

The reference year for the Kyoto Protocol target is 1990; this is also the baseline for measurement of clearing and reforestation that counts towards achieving the target. Conveniently Australia's 'plantation estate' (total plantation area) can be separated into plantations established before 1990, the majority of which are softwood to supply sawntimber, and those established since, most of which are hardwood to produce pulplogs.

4.1 Pre-1990 plantation estate

Plantations established prior to 1990 are reported in the UNFCCC account to produce net emissions of 2.3 Mt CO_2. This figure is effectively the on-site emissions resulting from logging. Soil carbon is assumed to be in equilibrium and the carbon content of logs removed from the site is accounted for elsewhere, as wood products or waste.

Because the area of the pre-1990 plantation estate is static, this result suggests that annual tree growth in the unlogged portions of the estate is not great enough to offset the on-site emissions from logging.

4.2 Post-1990 plantation estate ('Kyoto forests')

CO_2 uptake by plantations established since 1990 on previously cleared land can be counted against Australia's Kyoto target. In 2005 the reported size of this sink was -19.6 Mt CO_2 (Kyoto Account) or -21.9 Mt CO_2 (UNFCCC account). The reason for the discrepancy is unclear.

Pulpwood trees take about 15 years to grow, so hardwood plantations established in the 1990s are just reaching maturity. As they are logged, emissions will offset tree growth in the younger parts of the estate. The growth in carbon uptake reported in the accounts (from zero in 1990 to –19.6 Mt CO_2 in 2005) would only continue to increase if the area of new plantations continued to expand in the future at a similar rate to the last decade. In fact, projections show that CO_2 uptake by Kyoto plantations is expected to plateau at the current level then decrease as the rate of new plantation establishment slows.[14]

Table 2. Carbon uptake by plantations established since 1990 (Mt CO2 in 2005). A state by state breakdown is not available for the UNFCCC accounts.

State	Tas	Vic	NSW	Qld	SA	WA	ACT	NT	Total Kyoto	Total UNFCCC
Afforestation/ reforestation Uptake Mt CO_2	-2.128	-6.726	-1.557	-0.241	-3.621	-6.061	-0.113	-0.113	-19.609	-21.933

[14] AGO 2005

5. Recapture time: CO_2 uptake by forests and plantations

Ecosystems act as a 'sink' by removing CO_2 from the atmosphere and storing it in the branches leaves and roots of plants, and in dead wood, litter and soil organic matter. Following a disturbance such as logging, the CO_2 emitted to the atmosphere will, over time, be recaptured as the vegetation regrows. The extent to which the greenhouse impact is ameliorated depends on the time taken to recapture the CO_2. For a plantation, the recapture time may one to several decades depending on the age of the plantation when logged; and for a native forest the recapture time may be up to several centuries, again depending on the age when logged. The concept of 'recapture time' is a useful way of comparing the greenhouse impact of logging plantations compared with native forests, especially old growth. The longer the recapture time, the greater the greenhouse impact because part of the CO_2 remains in the atmosphere.[15]

Most native forests in Australia have suffered past disturbance. As a result, the UNFCCC account reports that Australian 'forest lands' (native forests and plantations) are a large sink with a CO_2 uptake of –51.495 Mt CO_2 in 2005. The effect of this is to reduce Australia's current net greenhouse gas emissions by 10%. Breaking the figure down into its components (table 3), shows that:

- CO_2 uptake from the growth or regrowth of existing native forests is by far the largest component of the 'forest lands' sink (-43.476 Mt CO_2).
- Without logging, native forests would be an even bigger sink (-57.3 Mt CO_2).
- If forests in conservation reserves were included, the native forest sink would be bigger again.
- Net CO_2 uptake by plantations is less than half that from native forests (-19.6 Mt CO_2 comprising uptake of -21.9 Mt CO_2 by post-1990 plantations and emissions of 2.3 Mt CO_2 from pre-1990 plantations).
- Biomass burning, which includes wildfire and prescribed burning (but not post-logging regeneration burns), is not, relatively, a large souce of emissions (the average has been 2.2 Mt CO_2 per annum since 1990).

The actual sink capacity of Australia's native forests on an annual basis is likely to be significantly greater than reported, because the estimate in the accounts is outdated and may not include soil carbon. The native forest accounts are not spatially explicit and nor would they presently allow recapture times to be estimated (in effect modelling future CO_2 uptake). There is an urgent need for improved methodologies.

[15] The rate at which CO_2 is recaptured is also important. It should be possible to measure CO_2 recapture curves for different sites and convert them to an index for comparison of the actual greenhouse impact of logging or other disturbances. The index could be weighted, for example to give additional significance to near-term emissions, recognising that the next decade is crucial in avoiding dangerous climate change.

Table 3. CO2 uptake and emissions by native forests and plantations in 2005 (MT CO_2 UNFCCC accounts). These figures do not include the log volume removed from the site which is accounted for in the wood products and waste categories. Emissions are represented by positive numbers and uptake by negative numbers.

	Land use category	Land use subcategory	Activity*
Forest land (native forests and plantations)	-51.5		
Managed native forests (net)		-43.5	
Managed native forests -- logging			13.8
Managed native forests -- growth			-57.3
Pre-1990 plantations (net)		2.3	
Fuelwood consumption		10.4	
Biomass burning		1.3	
Post-1990 plantations (land converted to forest land)		-21.93	

*Calculated, see Blakers 2007

6. Where does the wood end up

5.1 Wood grown in Australia

The carbon in native forest or plantation logs removed for processing ends up as CO_2 in the atmosphere at different times depending on what happens to the wood. Some is emitted almost immediately when processing waste is burnt or decays. Some is made into products which have a short life, such as paper; and some into longer-lived goods such as wood-based panels and house framing. The carbon in these products eventually makes its way into the atmosphere directly or into landfill and thence into the atmosphere. The longest residence time assumed for any wood product in the NCAS model is 90 years.

Analysis by the AGO allows the ulimate destination of the carbon in all wood grown in Australia to be estimated.[16] In round terms, this shows that, for a given volume of logs (native forest and plantation combined), 20% of the CO_2 is quickly lost through burning and decay; 55% contributes to a net increase in landfill; and only 25% contributes to an increase in carbon stored as wood products (the 'wood products' pool).

According to the NCAS model, the amount of CO_2 stored in the wood products pool grew by an average of 5.0 Mt CO_2 per annum since 1990. Over the same period, the amount in wood products disposed of in landfill grew by an average 10.7 Mt per annum.[17]

Comparing native forests and plantations: relatively more plantation softwood will end up in the wood products pool because this supplies most of Australia's sawntimber; relatively more native forest wood and almost all hardwood plantation wood will end up in landfill or very short term products because these are predominantly used for woodchips.

[16] Richards et al 2007. Wood 'stored' in Australia is domestic production plus imports minus exports. Native forest and plantations are not differentiated.
[17] Richards et al 2007

5.2 Native forest wood

Australia's accounts for wood products do not distinguish between native forest and plantation logs. They also exclude wood which is exported (which is to be accounted for in the receiving country).

A reasonably comprehensive account for native forest logs can be estimated by breaking down the total log volume into export woodchips and domestically processed logs, then applying the ratios from s. 5.1 above (see table 4). This shows that over 60% of potential CO_2 emissions from native forest logging occurs in the forest or from burning or decay, 23% of the CO_2 is in exported woodchips (with a maximum life of three years), 11% adds to landfill, and only 4% adds to the store in longer lived wood products.

In other words, the argument that wood products store significant amounts of CO_2 relative to native forests has no validity. Almost all CO_2 from wood processing is released within a few years, and the absolute maximum residence time of carbon in wood products is estimated at 90 years. Old growth forests contain trees aged 200-300 years plus.

Table 4. Native forest logging emissions produced by 10 million m^3 annual harvested volume (the average for the last 15 years)

	Logs only Mt CO_2 (% total)	Total emissions Mt CO_2 (% total)
Total CO_2	11.9	28.3
Forest slash and roots		16.4 (58%)
Exported as woodchips (5.4 million m^3)	6.5 (55%)	6.5 (23%)
Emissions from burning and decay	1.2 (10%)	1.2 (4%)
Net additions to landfill	3.0 (25%)	3.0 (11%)
Net addition to wood products pool	1.2 (10%)	1.2 (4%)

7. Responding to NAFI

NAFI and other forestry interests argue that the carbon storage benefits of forests and wood products should be better recognised.[18] They make several arguments, some of which are correct, but others very misleading.

Argument 1. Australia's plantations and 'commercial forests' (i.e. native forests available for logging) act as a carbon sink, removing a net –43.7 Mt CO_2 from the atmosphere in 2004.

Comment. This is true. But the majority of the carbon uptake is from the growth of native forests and without logging the size of the sink would be even bigger.

Argument 2. The accumulated stock of carbon in 'wood products' is more than 230 Mt C.

Comment. The 230 Mt C comprises 96 Mt C in 'wood products' and 136 Mt C in landfill.

[18] For example, NAFI 2007

Argument 3. Solid wood products have greenhouse benefits compared with substitutes such as cement and steel.

Comment. This is probably correct for plantation wood but requires a full life cycle analysis to be certain, including emissions from plantation management, processing and transport.

Argument 4. Storing carbon from native forests in harvested wood products represents a 'more secure' way of locking up carbon than leaving it in the forest, because forests are subject to wildfire, disease and mortality.

Comment. This is untrue. Less than 5% of the carbon from native forest logging ends up in relatively long-lived wood products. Fire is not a large source of emissions (between 1.0 and 5.5 Mt CO_2 per annum over the last 15 years) and 'mortality' applies to individual trees, not to forests.

Argument 5. Waste wood can be used to generate electricity and eliminate emissions from fossil fuels.

Comment. This is untrue for native forests where every tonne of carbon burnt would release two to three times as much carbon from logging, with a recapture time of up to several centuries, depending on the age of the forest. An assessment for plantations would require a full life cycle analysis.

8. Discussion

Forests deserve serious attention for their contribution to reducing greenhouse gas emissions, not just in developing countries but also in Australia. Native forests are already the single largest CO_2 sink in Australia, absorbing annually at least 57 Mt CO_2 per annum (more if conservation forests are included). Per hectare, they are a considerably more concentrated carbon store than plantations because the trees are much older and carbon builds up in the soil as well as the vegetation. Also, eucalypt wood is denser than softwood (contains more carbon per cubic meter). Old forests are especially large carbon stores: old growth *Eucalyptus regnans* forest with an undisturbed rainforest understorey can sequester up to 5500 t CO_2 per hectare (that is, 1000 hectares of such forest would store 5.5 Mt CO_2).

Because forest landscapes contain the highest densities of terrestrial carbon, logging results in correspondingly significant greenhouse gas emissions of 38 Mt CO_2 per annum, equivalent to 7% of Australia's total emissions in 2005. Plantations or forest regrowth take decades to recapture the carbon which is lost almost immediately through logging. Between 1990 and 2005, logging resulted in the release of between 450 and 600 Mt CO_2 to the atmosphere, equivalent to one year's worth of emissions from all sources in Australia. In the same period, carbon uptake by Australia's entire stock of Kyoto compliant plantations was 120 Mt CO_2, less than one-fifth of that lost through native forest logging.[19]

Long term storage in wood products accounts for a minimal proportion of the CO_2 released by logging native forests (less than 5%). By comparison, 15% ends up in landfill where it may be

[19] Regrowing forest will also have sequestered some carbon lost through logging but a study of temperate forest in south-eastern Australia predicts that an average forest plot would take 152 years to exceed 90% of its former carbon carrying capacity (Roxburgh et al 2006).

released in the form of the far more potent greenhouse gas, methane. Fires are also a relatively small source of emissions compared with native forest logging.

Great effort has been put into modelling wood flows to estimate the amount of carbon stored in wood products, a process which will always be complex and uncertain. Meanwhile the methods for estimating CO_2 uptake and emissions in native forests remain relatively rudimentary. It would be much more efficient to adopt the IPCC default methodology of accounting for all emissions at the time of harvest and transfer the resources to improving the native forest accounts.

This analysis makes it clear that native forests have a vital role in carbon sequestration. Avoiding the logging of native forests is without doubt one of the cheapest, quickest and easiest ways to reduce Australia's greenhouse gas emissions in actuality (as distinct from the subset measured by the Kyoto Protocol). If Australia's burgeoning supply of plantation hardwood was used to substitute for native forest woodchip exports, the greenhouse impacts would be strongly positive. Protecting the forests would have the added benefit of contributing substantially to biodiversity conservation and water management.

Arrangements post-Kyoto are highly likely to reflect the full carbon accounting methodology now available, which means emissions from native forest logging will be counted in the future. If they are not reduced, other sectors of the economy will have to work harder to rein in Australia's emissions.

Australia is already proposing that deforestation and forest degradation in developing countries be taken into account. It is improbable that developed countries will be permitted to avoid doing the same.

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Acronyms

ABARE. Australian Bureau of Agricultural and Resource Economics
AGO. Australian Greenhouse Office
IPCC. Intergovernmental Panel on Climate Change
LULUCF. Land use, land-use change and forestry
Mt CO_2. Million (mega) tonnes of carbon dioxide
NAFI. National Association of Forest Industries
NCAS. National Carbon Accounting System
TWS. The Wilderness Society
UNFCCC. United Nations Framework Convention on Climate Change

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