Why Aim For Net Zero CO_2 Emissions by 2050? - Australia Has Achieved That Already!

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1. Australia has adopted the position that *"for the Paris Agreement all net emissions from all lands (in Australia) will be accounted for – without restriction - using the independent monitoring systems of the national inventory.* (So) *through the national inventory there is complete coverage of the land sector in the Government's target acquittal".* [Emphases added]. {See Appendix 1 and: https://www.aph.gov.au/Parliamentary_Business/Committees/House/Environment_and_Energy/ClimateBills2020/Submissions #588, p.13}. By way of contrast, for the Kyoto Protocol only c.1% of Australia's land mass was actually taken into account in determining net emissions from the LULUC&F sector {above link: p.12}.

2. France (host of the Paris Agreement (PA) negotiations) aims to accelerate the implementation of this Agreement by setting *"a national inventory target of achieving carbon neutrality by 2050 within French territories, this being understood as achieving a balance between anthropogenic emissions and anthropogenic absorption of greenhouse gas, i.e. that which is absorbed by the natural environment managed by man (forest land, grassland, agricultural soils, wetlands, etc.) and certain industrial procedures (carbon capture, storage and reuse)".* In a nutshell this means France, a major EU economy, will utilise sinks from its LULUC&F sector, as well as CCS, to balance emissions generated by consumption of those fossil fuels for which there are no alternative feedstocks. {See: https://unfccc.int/sites/default/files/resource/en_SNBC-2_summary_compl.pdf p.2; Fig.1 p.3}. Australia and several other countries have also specifically nominated land based sinks in their Nationally Determined Contributions (NDC).

3. The Department of Industry, Science, Energy and Resources (DISER) states that the Full Carbon Accounting Model (FullCAM) is used for carbon accounting in Australia's land sector of the national inventory. {See: https://www.aph.gov.au/Parliamentary_Business/Committees/House/Environment_and_Energy/ClimateBills2020/Submissions #588, p.9}.

4. Using a model (FullCAM) to estimate C fluxes over all lands in Australia (Point 1 above) – an area of c.769 M ha – is problematic to say the least. Especially so given the lack of appropriate validation of the accuracy and precision of the model's outputs over this huge area, combined with the complexity of the soils, vegetation, variable weather patterns and superimposed management – that all impact C flux and the utility of bottom-up biosphere models.

   Consider soil organic carbon (SOC). This is a dominant component of C stores and flows. It comprises >50% of all organic C contained within the rooting depth of vegetation, together with above + below ground organic matter in the LULUC&F sector. Yet SOC is not evenly distributed within soils, either vertically or horizontally. This means that intense sampling is required to obtain an accurate record of its pool size and flux over even small areas. As the target extent increases the sampling error for the estimated C flux commonly exceeds the flux that is claimed. Hence the result is not fit for purpose, certainly at a continental scale.

5. Alternatively, spectral sensors positioned on satellite based platforms (e.g. GOSAT and OCO-2) provide accurate data on the column averaged dry air mole fraction of CO_2 (XCO_2) measured from the top of the atmosphere to the earth's surface. The huge number of observations made integrate all sources and sinks contributing to the air column from the land beneath. They provide the robustness, spatial coverage and sampling intensity/frequency, as well as the accuracy and precision necessary to determine the Australia wide flux inversion of column averaged CO_2. They also make it possible to estimate the distribution and magnitude of CO_2 in regions that have sparse *in situ* surface atmospheric monitoring (https://doi.org/10.5194/acp-21-6663-2021).

   See: http://adsabs.harvard.edu/abs/2015EGUGA..1712580M for more insights. In particular it is notable that where satellite measurements are spatially filtered to include only data recorded near surface calibration sites, the resultant fluxes are found to converge to those based on surface measurements alone. [Despite this, confidence in the satellite inversion results would no doubt be further improved if more Total Carbon Column Observation Network (TCCON) stations were distributed over Australia – they are presently located at Darwin and Wollongong].

6. The developing methodology underlying this inversion procedure is reported *inter alia*, in Detmers et al. (2015 – updated 23 Jan 2017) {https://doi.org/10.1002/2015GL065161}, Chevallier et al. (2019) {https://doi.org/10.5194/acp-19-14233-2019 } and Yang et al. (2021) {https://doi.org/10.1007/s00376-021-1179-7}. The first two studies respectively reveal a natural ("managed land") flux over all of Australia of 770 ± 110 M t CO_2/yr (net sink c.366 Mt CO_2 after subtracting CO_2 derived from fossil fuel/cement sources in 2011); and a natural flux of c.697 Mt CO_2/yr (net sink c.282 Mt CO_2 after subtracting CO_2 derived from fossil fuel/cement sources in 2017). [The inferred natural flux for 2017 is scaled from the time series for the OCO-2 inversion in Chevallier et al. 2019 - Fig. 3. The latter paper (p. 14247) states that OCO-2 based calculations of annual fluxes are usually within 1σ of the Bayesian uncertainty of the surface based fluxes].

7. The proximity in value of these two annual net sinks for Australia is somewhat surprising given 2010-11 experienced a strong La Niña, and 2015-16 was a strong El Niño weather pattern. It is posited that the former led to massive regeneration of perennial vegetation with surviving recruits entering the steeper slope of sigmoid growth by 2017.

   Rising CO_2 levels in the earth's atmosphere – from Jan 2011 to Jan 2017 CO_2 at Cape Grim rose by 3.6% (3.8% at Mauna Loa) - also improve growth and water use efficiency within vegetation. Further, northern wet season (October–April) rainfall deciles for the 20 years (1998–99 to 2017–18) show wet season rainfall was very much above average for the 20 year period 1998-99 to 2017-18. {See: https://www.csiro.au/en/research/environmental-impacts/climate-change/state-of-the-climate/previous/state-of-the-climate-2018/australias-changing-climate }. Most woody vegetation is located in the northern half of the continent.

8. To understand why Australia has already achieved net zero CO_2 emissions (in terms of the Paris Agreement) the following key points are relevant:
   - in future we will be accounting for all net emissions from all lands in the LULUC&F sector – without restriction - (cf. only c.1% of the land mass included in accounts for the Kyoto Protocol)
   - the only practical way to accurately sample all net emissions at a continental scale (769 M ha) is via inversions, based on satellite retrievals of the column averaged dry air mole fraction of CO_2 (XCO2) measured from the top of the atmosphere to the land surface
   - inversion studies cited in Point 6 above suggest we are currently a net sink of c.320 Mt CO_2 per year – after averaging La Niña and El Niño year results, and deducting fossil fuel/cement generated emissions for each respective year from the total. All things being equal it is likely that net sinks of this order will be maintained through 2050 – as vegetation continues to respond and adapt to the fire regimes which replaced the regular/frequent burning of previous millennia, under now displaced (pre-European) indigenous management.
   - Australia is the 6th largest nation in area in the world (and in the main has a land mass covered by CO_2 absorbing perennial vegetation), yet it has far fewer people living in it than live in a single world mega city (e.g. Tokyo). Yearly fossil fuel emissions from anthropogenic sources in this country, either in terms of CO_2 or CO_2-e – see: https://ourworldindata.org/co2/country/australia - are thus more than offset by the ongoing capacity of our LULUC&F sector (≡ "all lands" in Point 1) to absorb them. For example, the Australian natural land sink (averaged over La Niña and El Niño years) is c. 140% of all its anthropogenic emissions . By way of contrast the equivalent managed land sink in the USA (890 M ha) only equates with c. 12% of that nation's fossil fuel emissions.

9. Australia has had a chequered history with its accounting of CO_2 fluxes in the LULUC&F sector ever since the Articles of the KP were first compiled (see Appendix 2). That history will make it very difficult for this country and the World to now accept that our land mass is actually a significant net CO_2 sink cf. with the information provided for our KP First Commitment Period accounts. Yet the facts must prevail and as a nation and people we can no longer 'cancel' or ignore them (Appendix 2 & 3). To paraphrase John.Maynard.Keynes: "When the facts change, I change my mind – so what will Australia do?"

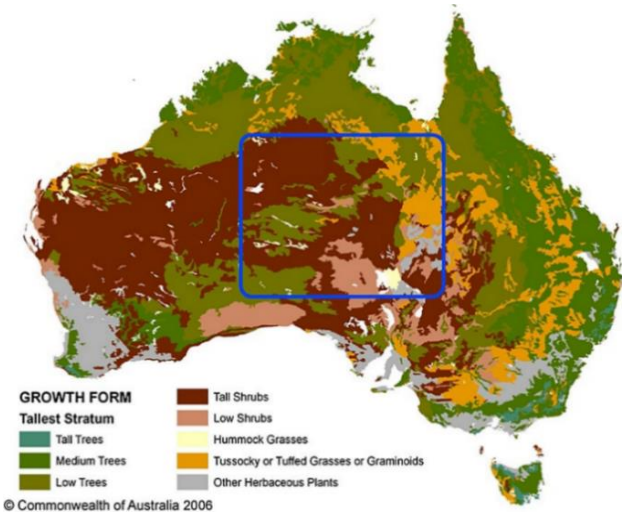
10. All Web links in this document were accessible on a Firefox browser on 24.8.21.

[WHB - 9.9.2021]

Appendix 1: **Vegetation Map of Australia** [Source: ABARES]

Australia

Total land area = 769 M ha
Av. Total natural land sink = 733 Mt CO_2 per yr.
(After Points 6 & 8 in text. Net sink is inclusive of all gains & losses in Vegetation + SOC ecosystem components)
∴ Av. Sink = 733/769 = 0.95 t CO_2 /ha/yr - **OR** c. 0.26 t C/ha/yr sequestered in veg + the SOC within rooting depth of the veg.
This result is in line with past Australian studies where partial C budget data included both La Niña and El Niño year sampling sequences e.g. (i) ground based sampling - https://onlinelibrary.wiley.com/doi/abs/10.1046/j.1365-2486.2002.00515.x
(ii) satellite-based passive microwave data - https://www.researchgate.net/publication/281887147_Recent_reversal_in_loss_of_global_terrestrial_biomass



Appendix 2: **In search of a credible accounting of net CO_2 emissions in Australia's landscape**

Carbon fluxes in the LULUC&F sector have been integral components of many countries NGGIs from the initial signing of the Kyoto Protocol (KP). However, unlike fossil fuels (of known C content) which pass through accurately calibrated weigh bridges or flow meters before consumption, measuring the C flux in the LULUC&F sector is much more problematic. This enabled countries to be selective in what was included or excluded from their KP accounts – which consequently have mostly been a misleading record of their real C fluxes. This problem has been further compounded by Australia's inability to so far monitor C fluxes in its landscape at a continental level – either through ground based sampling or via models whose output can't be validated in practice at such scale.

Before the KP was signed in 1997 a DEST 'expert panel' recommended that sinks resulting from vegetation thickening should be included in Australia's NGGI, but this recommendation was ignored – [See: the Noble Report https://www.keepandshare.com/doc22/112099/ian-noble-tree-thickening-report-for-dest-1997-pdf-1-5-meg?da=y]. If Prof Noble's recommendation had been followed Australia would not have been able to take advantage of the Article 3.7 (2nd sentence) provision of the KP. This Clause allowed Parties for whom land-use change and forestry constituted a net source of GHG emissions in 1990 to include in their 1990 emissions base year or period the aggregate anthropogenic CO_2 equivalent emissions by sources, minus removals by sinks in 1990 from land-use change for the purposes of calculating their assigned amount. So by ignoring the sinks identified in the Noble Report Australia could avail itself of KP Article 3.7 – 2nd sentence (the 'Australia Clause') as its LUC&F sector was depicted as a large source of emissions [See: https://www.keepandshare.com/doc22/112524/carruthers-link-pdf-684k?da=y **(***Negotiation of the second sentence of Article 3.7* pp.1-2)].

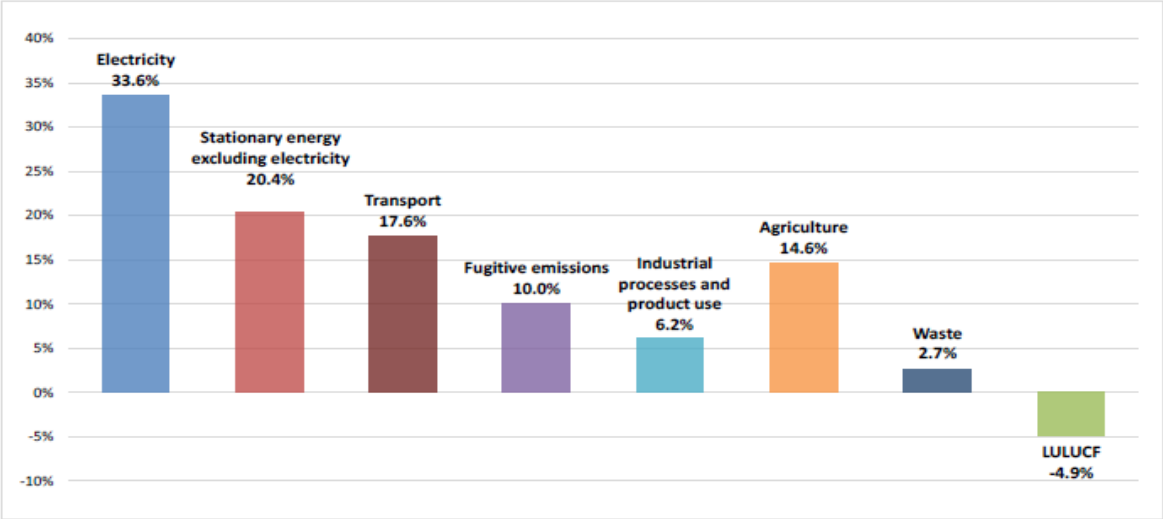
As a consequence of these machinations Australia could then largely meet emissions reduction targets for the KP's First Commitment Period by simply banning tree clearing. Hence on the 29th September 2000 Senator Robert Hill, Leader of the Australian negotiating team for the Kyoto Protocol was quoted in the "Rural Weekly" as saying – "*Reducing land clearance in Queensland would be one of the cheapest ways for Australia to lower its overall greenhouse (gas) emissions*" – [but only by presenting a partial C budget for the LULUC&F sector and by allowing trees and shrubs to grow unchecked on land previously assigned by government for the prime purpose of agricultural production! – WHB].

The KP rules were subsequently modified so that "The Kyoto Protocol allows parties to offset emissions from other sectors with removal credits generated through afforestation and reforestation, cropland management (CM), grazing land management (GM), forest management and revegetation (RV). Significantly, parties were able to choose whether or not they included C stock changes on grazing land, cropland and existing forests. **Australia chose not to include these 'Article 3.4' activities, due to the *perceived risk* that they may be a net source rather than net sink"**! (Emphases added - See p.285 on *Climate Change Policy* in Cowie et al. (2012)). ["Oh what a tangled web we weave --------"…. When we arbitrarily include or exclude data! – WHB].

Now for the PA, Australia can finally present a true and comprehensive report on net CO_2 emissions for all of the Australian continent. But as outlined in this article and above, if this is done by applying the current methodology for LULUC&F accounting (notably FullCAM modelling) over c. 769 M ha, the result is fraught. Fortunately, the timely development of inverse procedures utilizing satellite based spectral scanners not only increases the intensity, frequency and completeness of sampling; it also integrates **all** sources and sinks in the landscape (including some not likely to have been identified) that could never be achieved using ground based methods. Confidence in inverse procedures (as referenced herein) is rapidly improving and results already available for Australia suggest the methodology deserves major government funding support (e,g, by expanding TCCON ground calibration coverage). This could well be the most efficient and cost effective approach that will convince the world (and Australia itself) that this nation is well on its way to achieving 'Net zero CO_2 emissions by 2050', and indeed has seemingly reached that goal already. Yet given our past history of data rejection and creative carbon accounting the truth may never be told. Meanwhile the implications in pursuing 'net zero' via a prime and narrow focus on the energy sector could be doing great economic harm. And in the face of information presented here, it all seems so unnecessary. Wake up Australia!

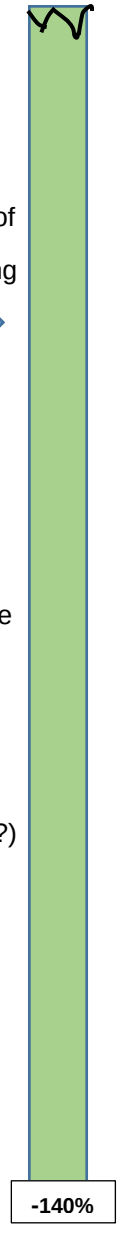
Appendix 3: **A pro forma chart of total anthropogenic emissions share across sectors based on DISER published data for the year to December 2020. The chart (copied from DISER's Fig. 4) is superimposed with likely LULUC&F emissions (extended green shaded column) under the Australian Government's proposal to include 'complete coverage of the land sector' in Paris Agreement target acquittals.** [As per convention positive values are sources, negative values are atmospheric withdrawals (sinks)].

Figure 4: Share of total emissions, by sector, for the year to December 2020



Source: Department of Industry, Science, Energy and Resources

What the above chart could look like by adding "net withdrawal of CO_2 from the atmosphere – in line with a ***'complete coverage of the land sector in the Government's PA target acquittal'***. Data (Point 6 - main text) indicates a mean sink of c.733 Mt CO_2 per year or c.140% of total 2020 anthropogenic sources (bar chart scaling for the this sink is only approximate).



∴ **The putative annual LULUC&F sink >> the Grand Total of all annual anthropogenic sources to the atmosphere above Australia.** So the goal of 'Net Zero CO_2 Emissions by 2050' has already been attained (and well exceeded) by 2021 – given the total land area will now be included in Australia's NDC for the PA. The current level of exceedance also indicates a comfortable buffer exists should future net emissions targets tighten.

[Note: This is not an argument against the improvement of technology to attain the same goal. However it does suggest this nation can adopt a more measured (relaxed?) stance if all signatories to the PA are to be judged on whether they have achieved their NDC by 2050 or not.]