

Understanding forest fluxes And why it matters

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Paris Agreement goals cannot be met without a large contribution from forests and progress will be difficult to assess (the **Global Stocktake**) without understanding **why national estimates of forest fluxes differ from those in independent studies...**

...this report takes a first step in trying to explain the difference.

Paris Agreement Goals

Hold the **increase in global average temperature** to well **below 2°C** above pre-industrial levels and pursue efforts to limit the increase to 1.5°C

To achieve a **balance between anthropogenic emissions by sources and removals by sinks of GHGs in the second half of this century**

Global Stocktake

Assess the collective progress towards the Paris Agreement goals. **This will require comparing national reporting to independent studies**

Contents

- **Why does it matter?**

Why should we care about emissions and removals from forests?

- **What are forest fluxes?**

Understanding the component parts of emissions and removals from forests.

- **What's in and what's out?**

What forest-related fluxes, i.e. emissions and removals, are (and are not) included in national GHG inventories?

- **How do they compare?**

How do national estimates compare to independent sources of information (including those used in the IPCC's Assessment Reports)?

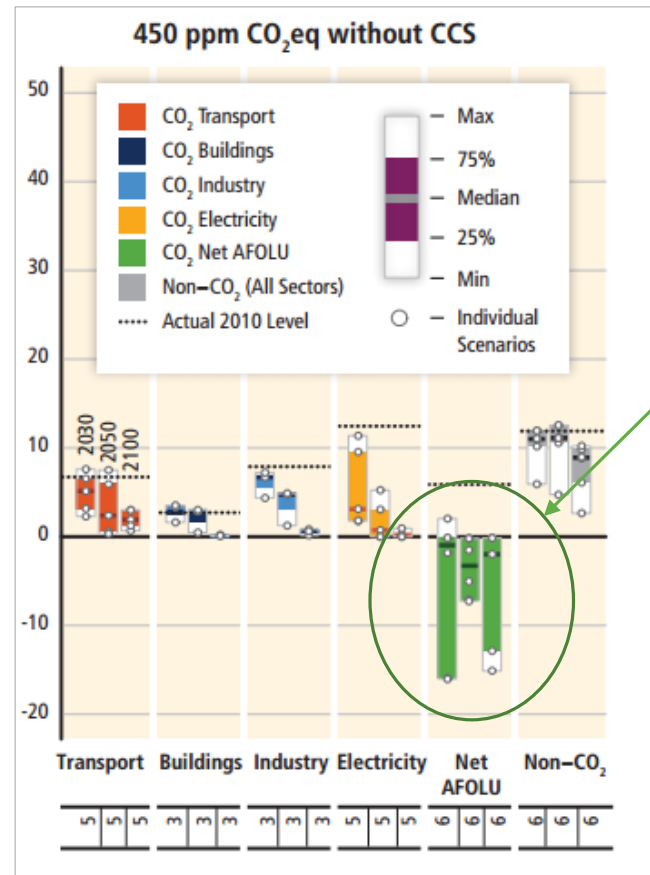
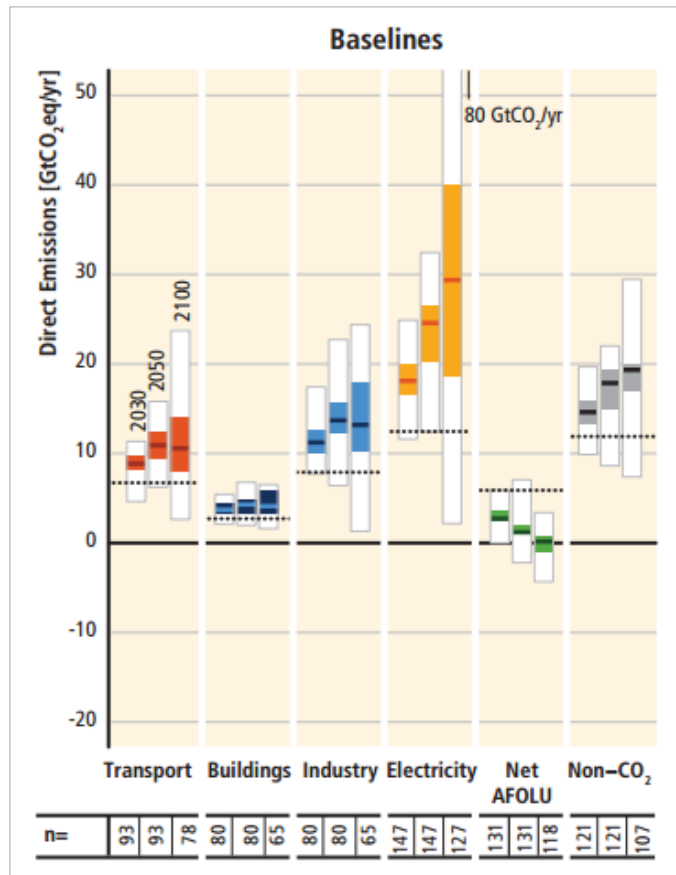
- **Recommendations.**

What should be done to better understand progress towards meeting Paris Agreement goals.

Why does it matter?

Forests are critical in a 2 degree scenario

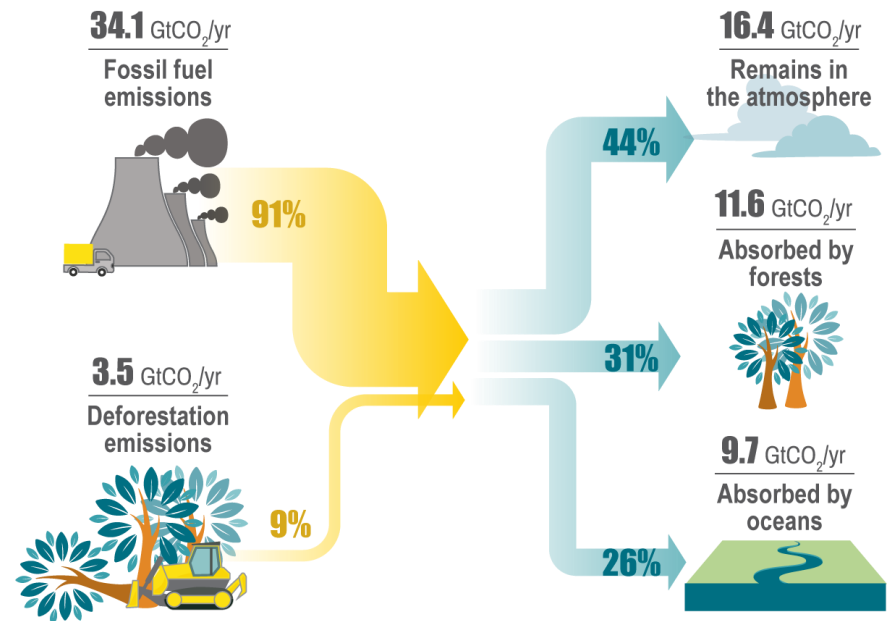
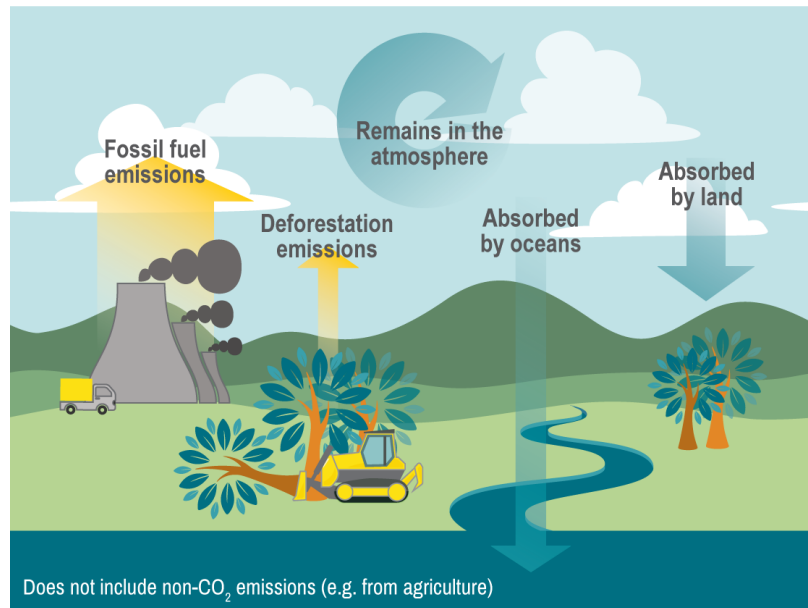
Terrestrial sequestration (mostly forests) is critical to keeping the temperature below a 2° increase, particularly if technologies for Carbon Capture & Storage (CCS) are not readily implementable or cost-effective.



Forests' role in a 2 degree scenario

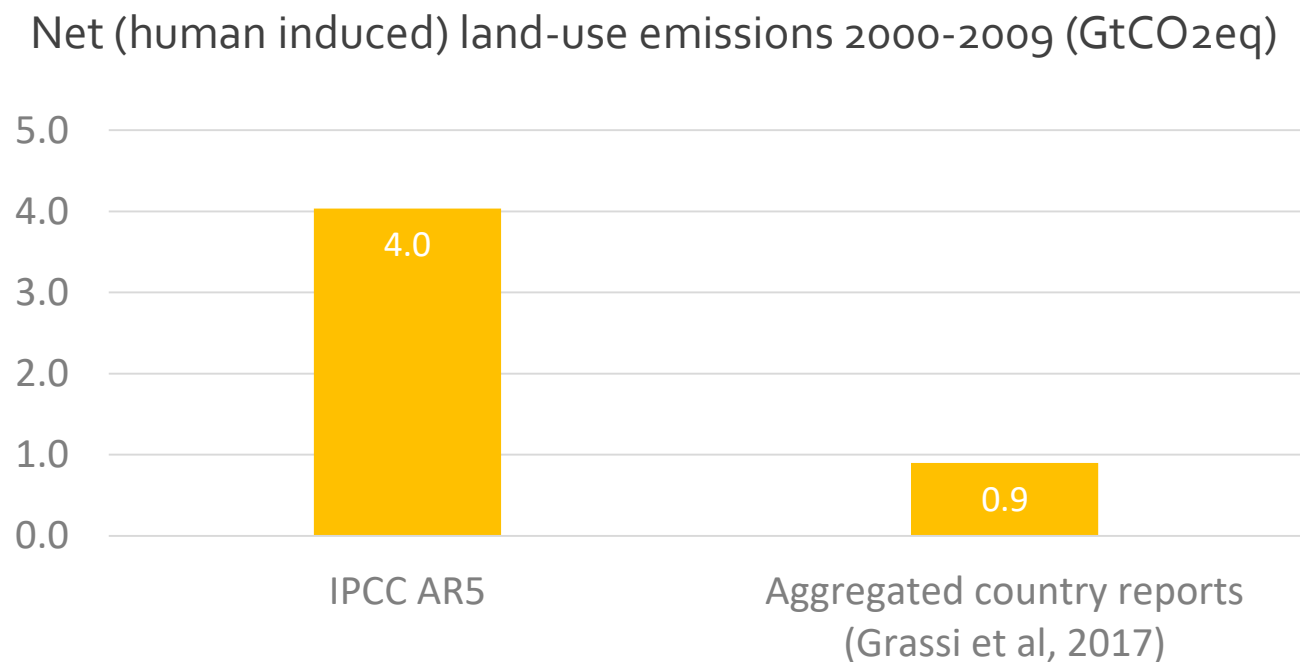
Forest are also critical for reaching a balance between emissions and removals

Forests currently emit ~10% of total CO₂ emissions, while also removing nearly one-third of the emissions from fossil fuels.



Note: Quantified figures from the Global Carbon Project. (<http://www.globalcarbonproject.org>).

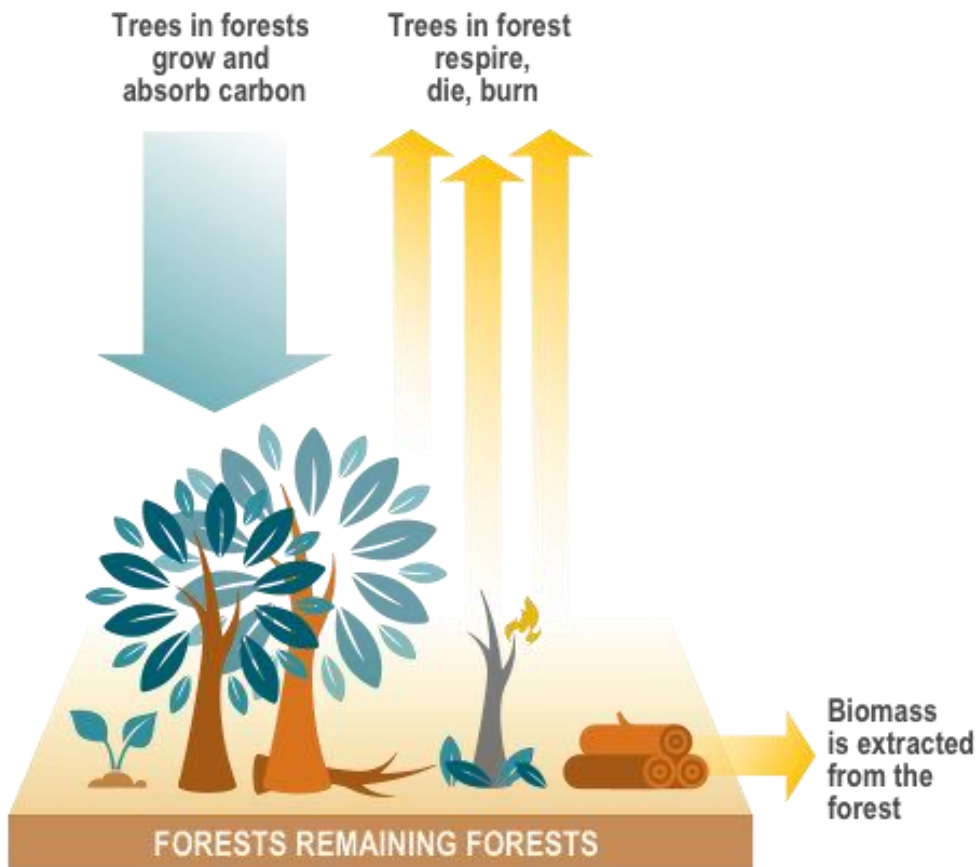
However, there is a difference in what **independent studies** estimate as the human-induced contribution of land-use emissions to the atmosphere compared to **national GHG reports**.



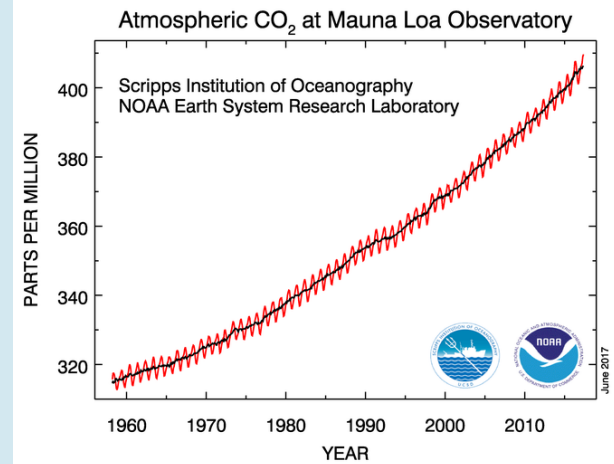
If the Global Stocktake uses both IPCC Assessment Reports (i.e. independent estimates) and national reporting to assess progress towards Paris Agreement goals, we need to understand why there are such differences.

What are forest fluxes?

Today, there are 4 billion hectares of forests in the world...



Trees are constantly absorbing and respiring carbon, collectively generating huge daily and seasonal fluxes. These annual cycles are why there is fluctuation around the overall (rising) CO₂ concentrations in the atmosphere.



...which *remove* more carbon than they emit...

One important reason is that many temperate and boreal forests were disturbed in the past and their biomass is now growing back to its original carbon stock... this is called a “**legacy**” effect



Another important reason is that several **environmental conditions** that impact forest fluxes are changing, for example:

- CO₂ fertilization
- Nitrogen deposition
- Temperature variation, changes in precipitation
- Permafrost thaw



These changes can be seen as “**indirect human induced**” effects

...although forests are also subject to natural disturbances that result in emissions.

Over time, there may be more mortality due to climate change-induced fire, pest or other impacts, such as temperature changes that result in drought or permafrost thaw.



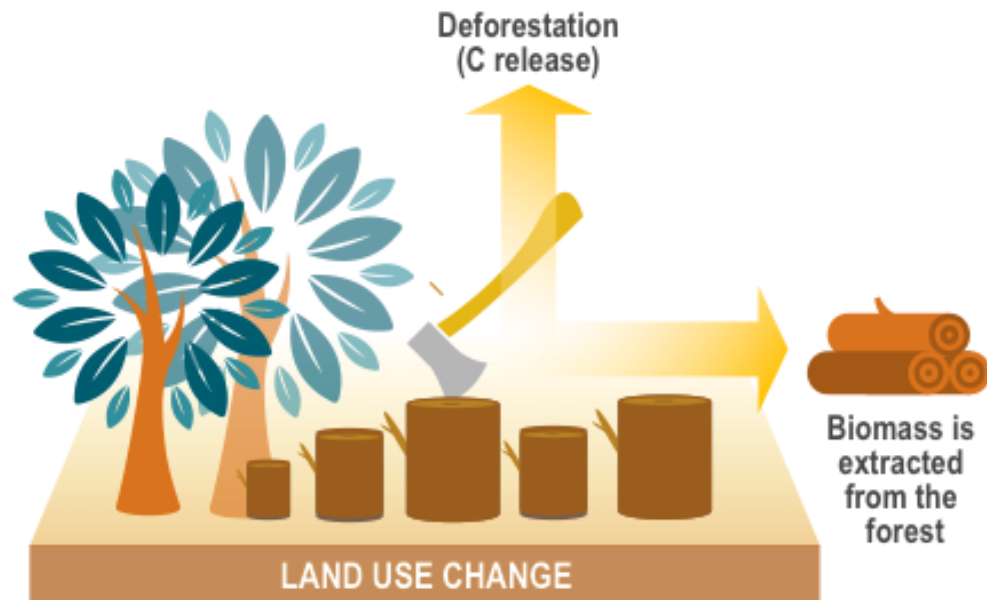
Forest fires are a source of two other GHGs: nitrous oxide (N_2O) and methane (CH_4).

In developed countries, N_2O and CH_4 from forest fires represent less than 5% of total forest-related net emissions.

In developing countries, where slash and burn practices are common as well as peat fires, non- CO_2 forest emissions are expected to be more significant.

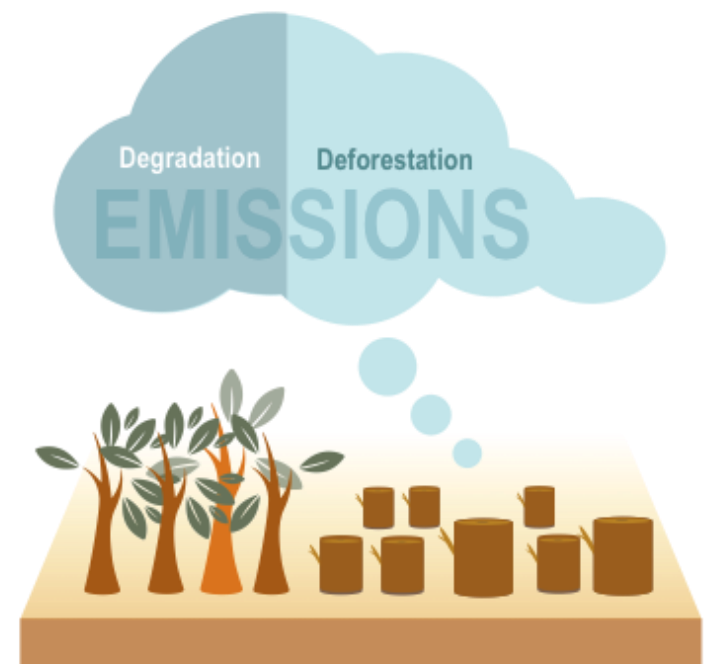
Forest loss (deforestation) is around 10% of total global emissions

Deforestation largely occurs in the tropics, mostly due to agricultural expansion. The world loses around 6.5 million ha per year, or the area of a football (soccer) field every 3 seconds.



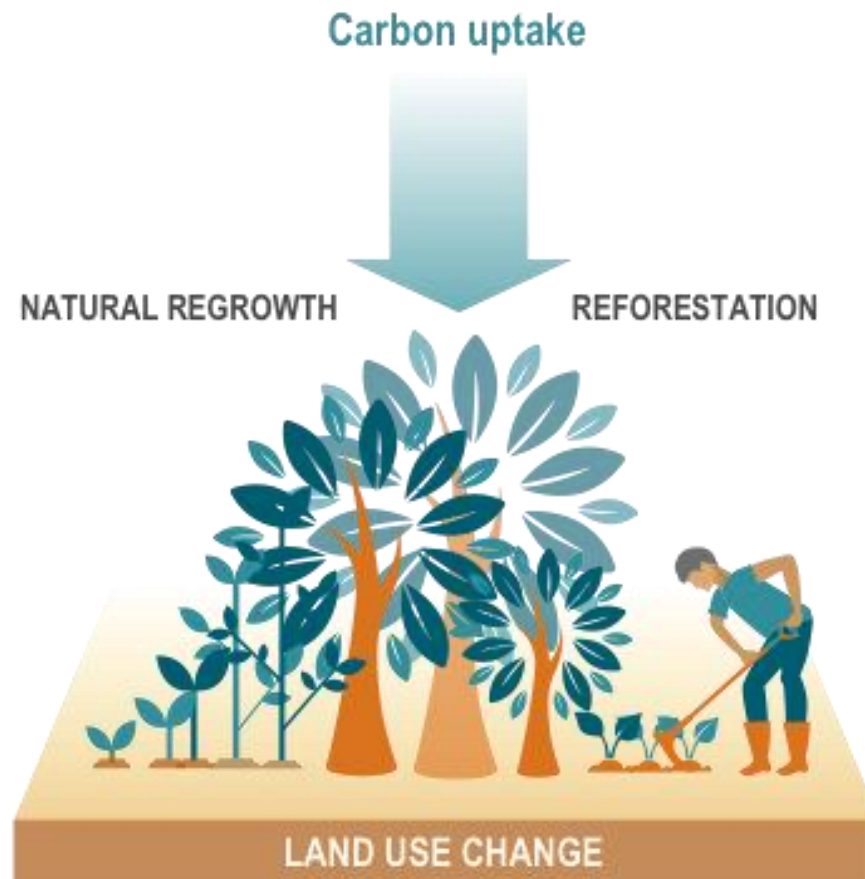
Forest degradation is also a significant source of emissions

Forests are also being degraded by over-harvesting and (man-made) fire. A recent study suggests emissions from forest degradation are equivalent to around one-third of deforestation emissions.



In some areas, forests are also expanding...

Forest areas can increase, either through natural regeneration, afforestation, or reforestation, resulting in carbon removals from the atmosphere.



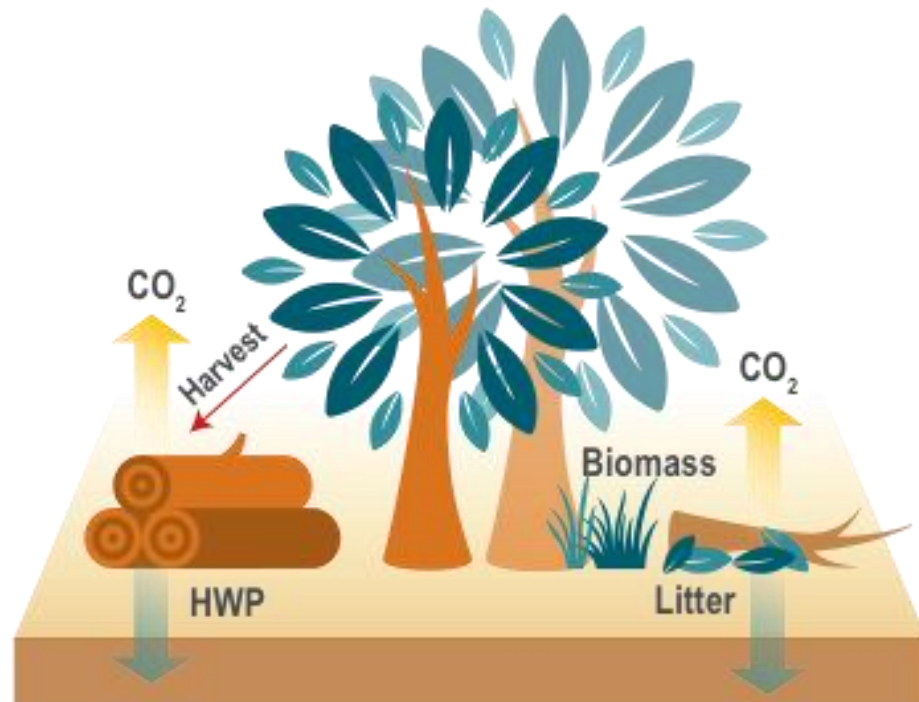
There are also carbon stock exchanges in forest carbon pools

Harvested wood products can store carbon for periods of time depending on what they are used for.

HWP	Half life
Paper	2 years
Wood panels	25 years
Sawn wood	35 years

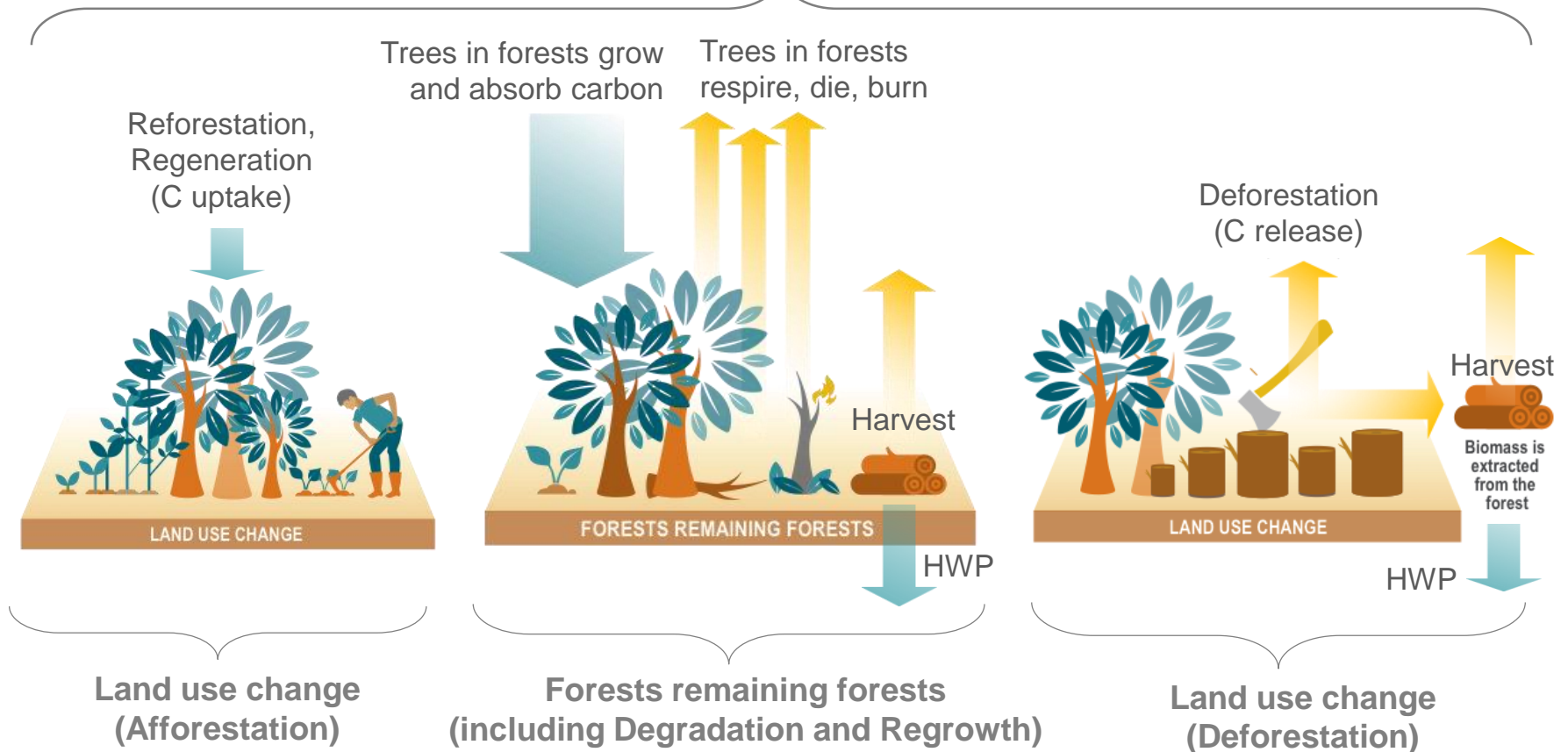
In most developed countries, managed forests and their corresponding wood products are a net sink.

Dead wood and litter (on forest floors) either decompose releasing CO_2 to the atmosphere, or the residual organic carbon accumulates in the soil resulting in a long-term net carbon transfer.



To sum up: Forest fluxes are a result of...

Changes to environmental conditions*

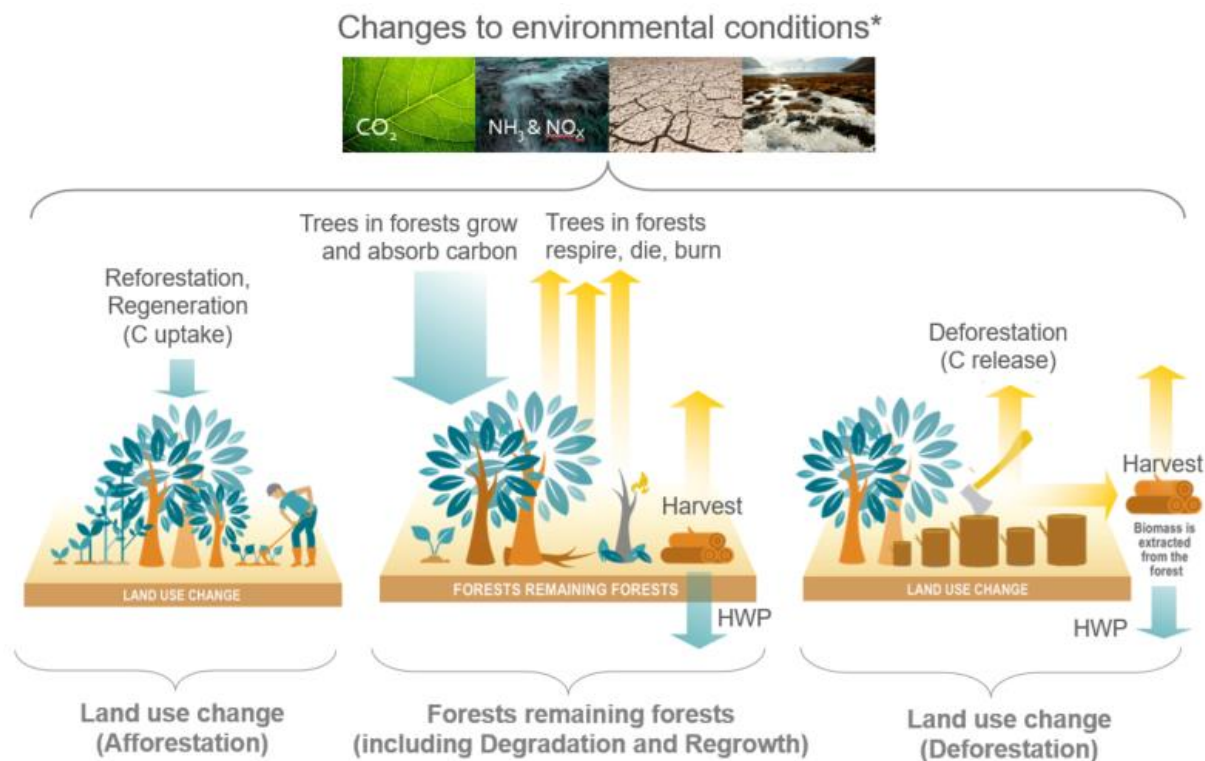


*Environmental conditions mostly impact "forests remaining forests" since this accounts for most of the forest area (95-99%) in the world.

What forest fluxes are
(and are not) included in national
GHG inventories?

What's in?

All **anthropogenic** emissions and removals from forests should be “in” national GHG inventories...



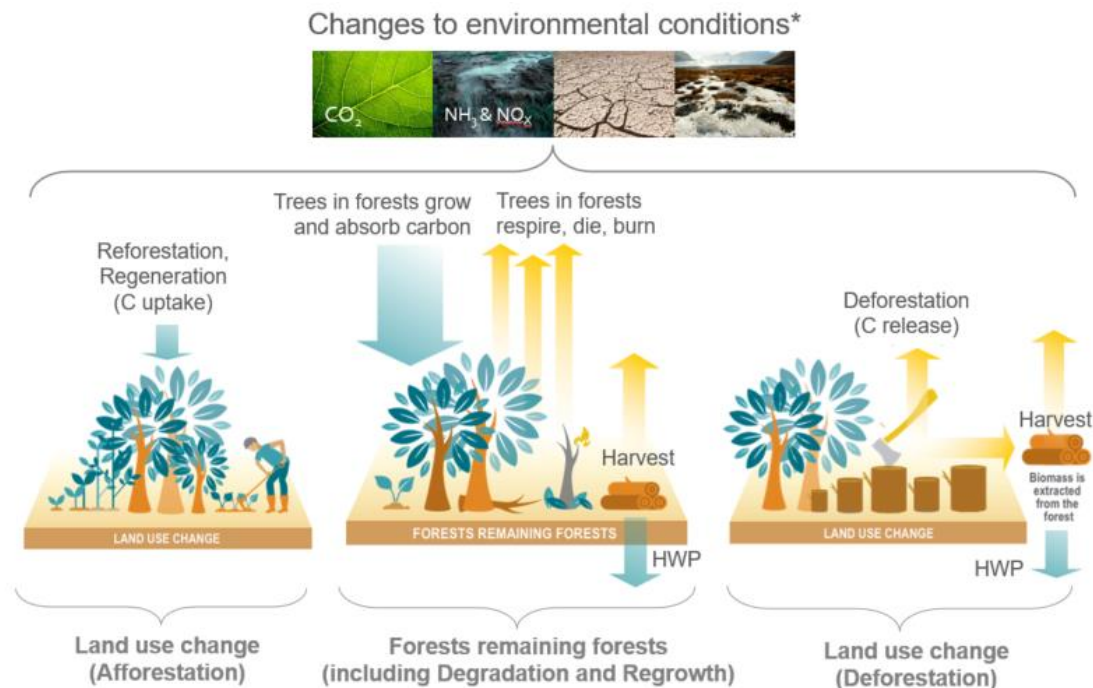
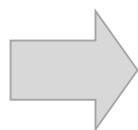
... but what is **anthropogenic**?

What's in?

Since 2003, the IPCC has provided guidance to countries to estimate fluxes on **managed land**, as a proxy for **anthropogenic** emissions and removals.

Managed land is defined by the IPCC as “land where human interventions and practices have been applied to perform production, ecological or social functions”.

Therefore **all forest fluxes on managed lands** should be reported in national GHGIs (including both direct and indirect effects)



What's out?

Fluxes on unmanaged land

Fluxes that occur on “**unmanaged**” lands are therefore not estimated or included in national GHGI reports

For example, Canada identifies around one-third of its forests as “unmanaged” based on whether management activities (e.g. timber and fire) are in place

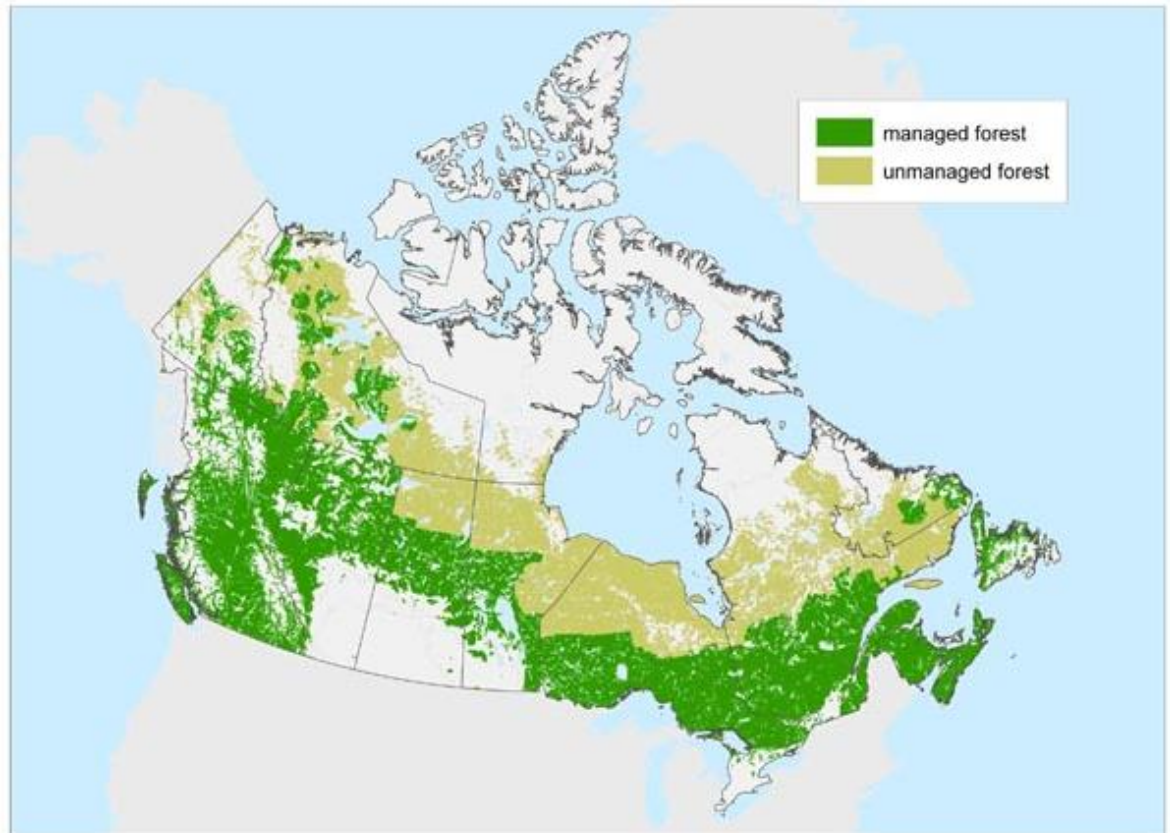
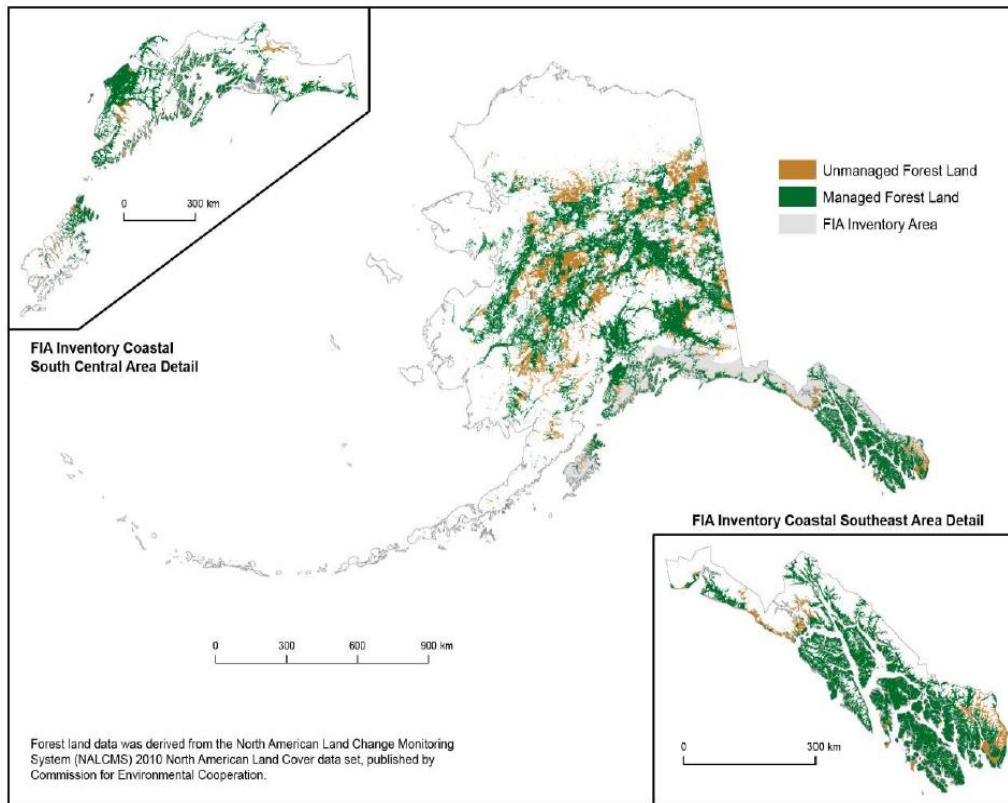


Figure: Natural Resources Canada,
<http://www.nrcan.gc.ca/forests/climate-change/carbon-accounting/13111>

What's out? Fluxes on unmanaged land

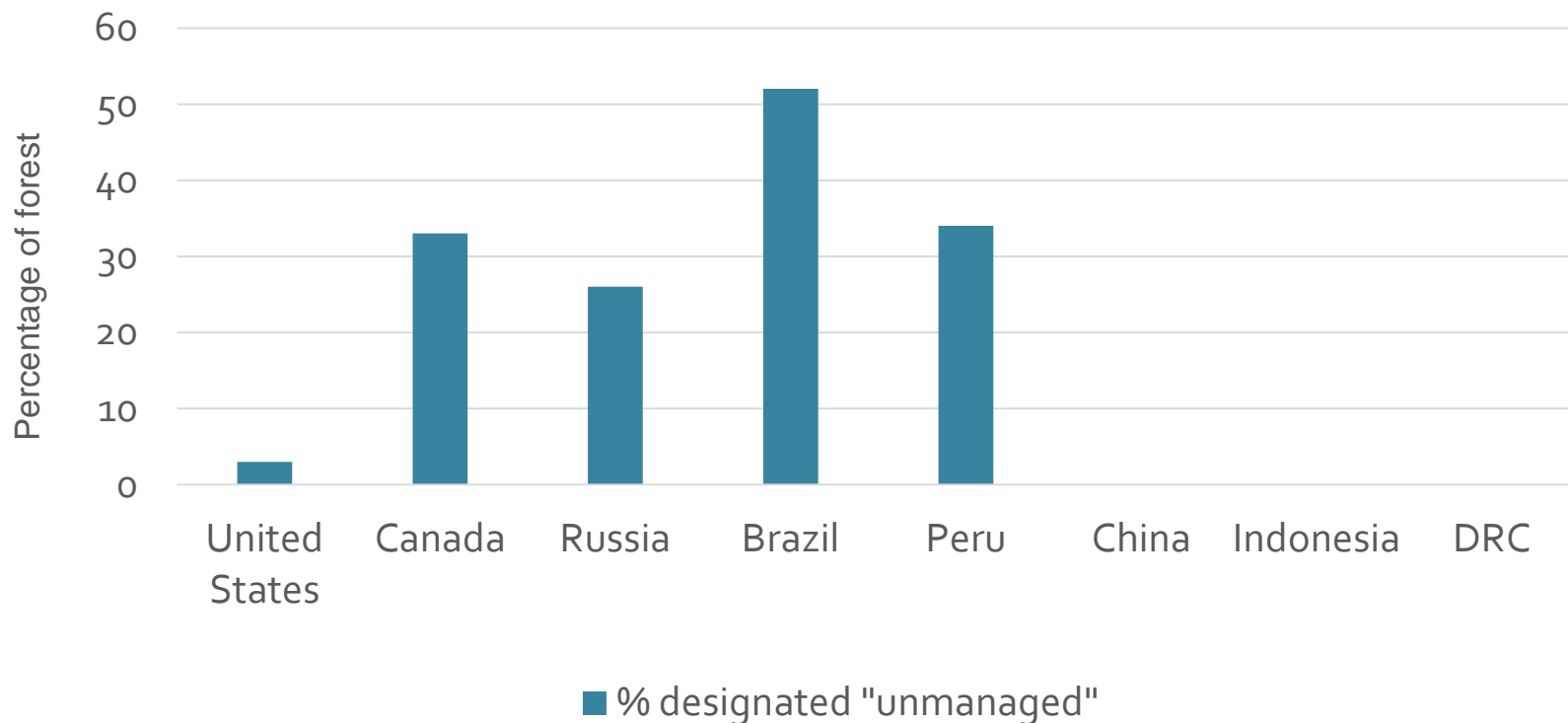
Countries vary on how they apply the Managed Land Proxy



The United States defines “managed” areas in Alaska by creating buffer areas around settlements, transportation corridors, oil wells and mines as well as lands with active fire management and protection (e.g. for recreation). The rest of the US is considered managed.

The managed land proxy

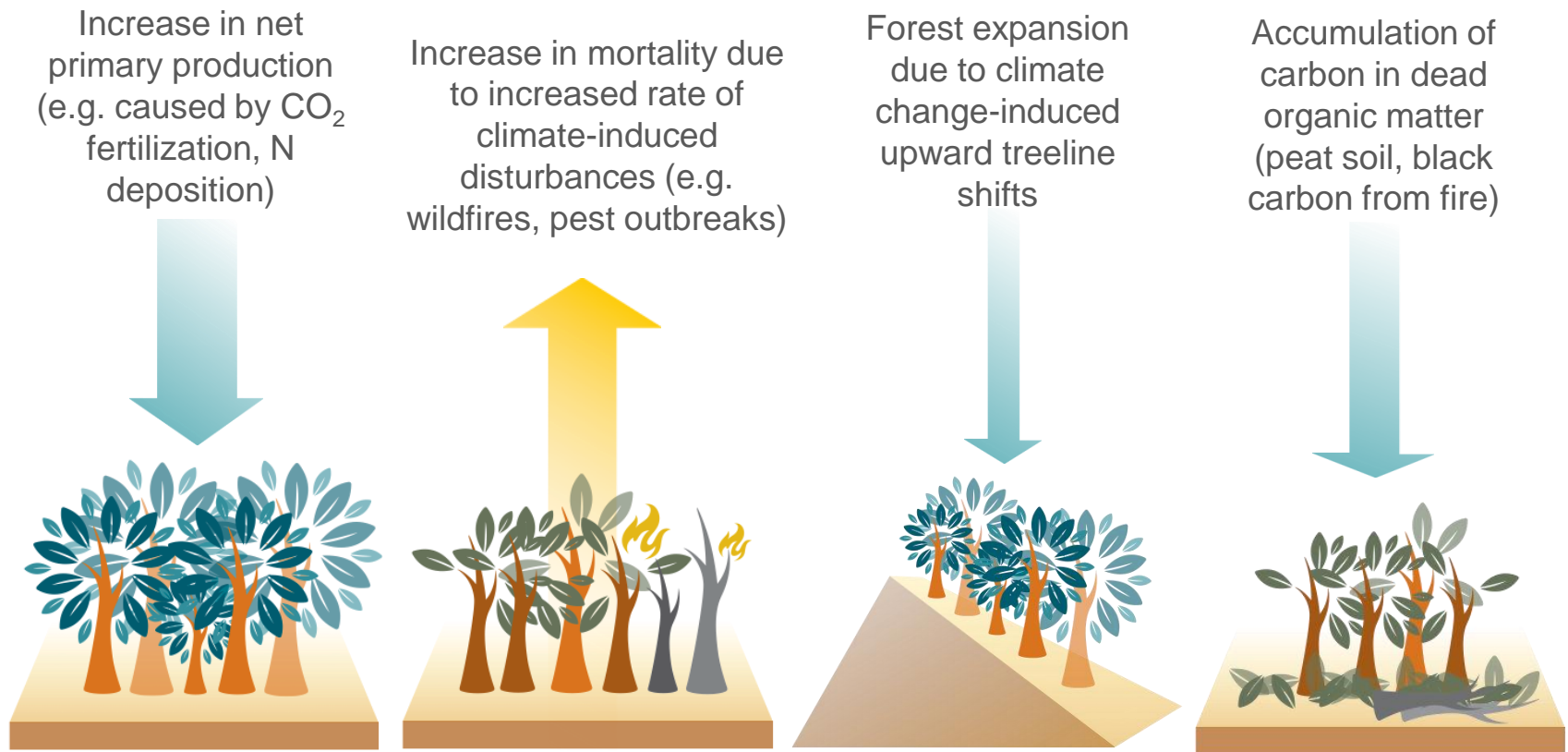
It is more common for developed countries to use the **Managed Land Proxy**.



Reasons why developing countries do not identify unmanaged lands may be due to use of older IPCC Guidelines (1996), which do not include the proxy, capacity gaps to apply the proxy, or because all land is considered managed.

What important fluxes occur on unmanaged land?

The following forest fluxes occur on unmanaged lands and therefore are not reported in GHGs



Note: Arrows are the likely direction of current net global fluxes although for all processes there are likely both emissions and removals (that are locally dependent); the net directions may also change over time with increasing climate change.

How significant are these fluxes?

It is difficult to know, since they are not specifically quantified by countries or independent research, however...



Canada's unmanaged areas account for two-thirds of total area affected by fires, which could be up to **~350 MtCO₂e/yr**



Expansion of unmanaged forests on abandoned agricultural land in Russia may remove up to **~400 MtCO₂/yr** in the soil organic matter pool; Brazil's unmanaged forests may be removing **~288 MtCO₂/yr**.



There are **no estimates** for unmanaged peatlands; however, they may be a significant net sink, although this may reverse if water levels decrease or permafrost thaws.

What's out? (but should be in!)

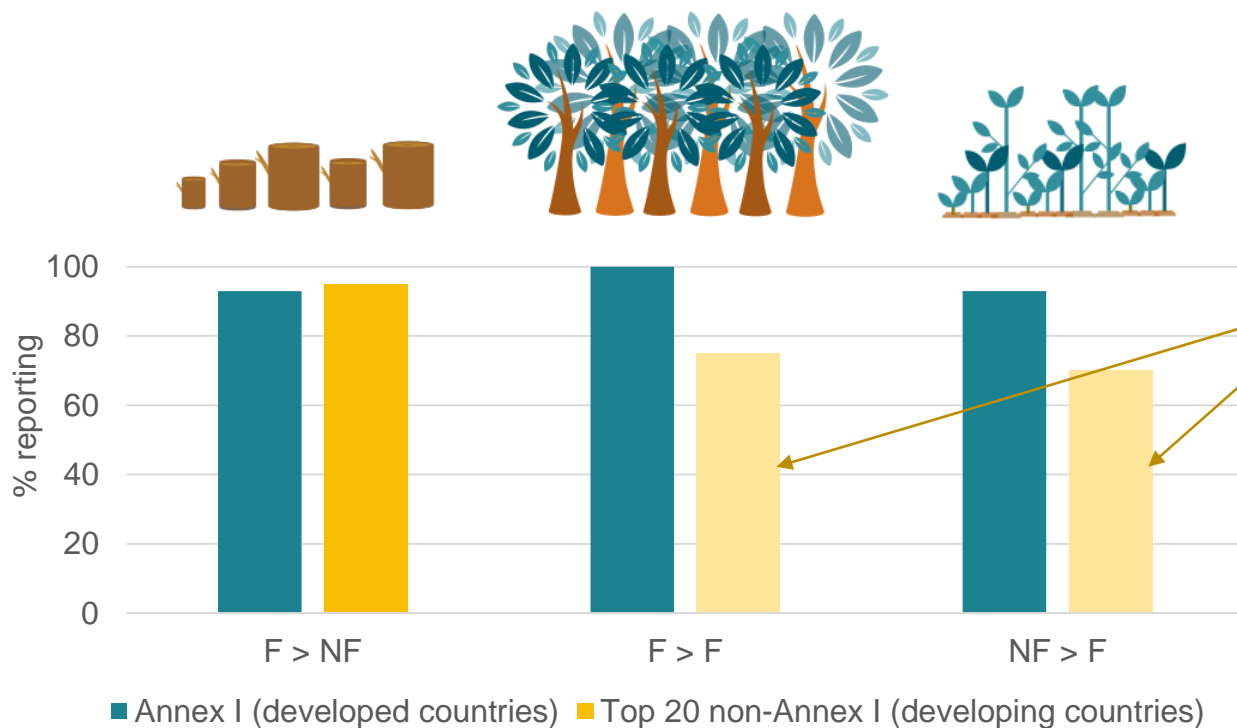
While national GHG inventory reports *should* include all significant fluxes on managed land, *in practice* many are **incomplete**, particularly those of developing countries, due to a lack of capacity to measure all forest-related fluxes.

A complete GHG inventory contains...

Categories	Pools	Gases
<ul style="list-style-type: none">• Forests converted to non-forest (F > NF)• Forests remaining forests (F > F)• Non-forest converted to forest (NF > F)	<ul style="list-style-type: none">• Aboveground biomass (AGB)• Belowground biomass (BGB)• Dead organic matter (DOM), including Deadwood (DW) and Litter (L)• Soil organic matter (SOM)• Harvested Wood Products (HWP)	<ul style="list-style-type: none">• Carbon dioxide (CO₂) from biomass loss• Nitrous Oxide (N₂O) and Methane (CH₄) mostly from fire

Incomplete GHGs: Forest categories

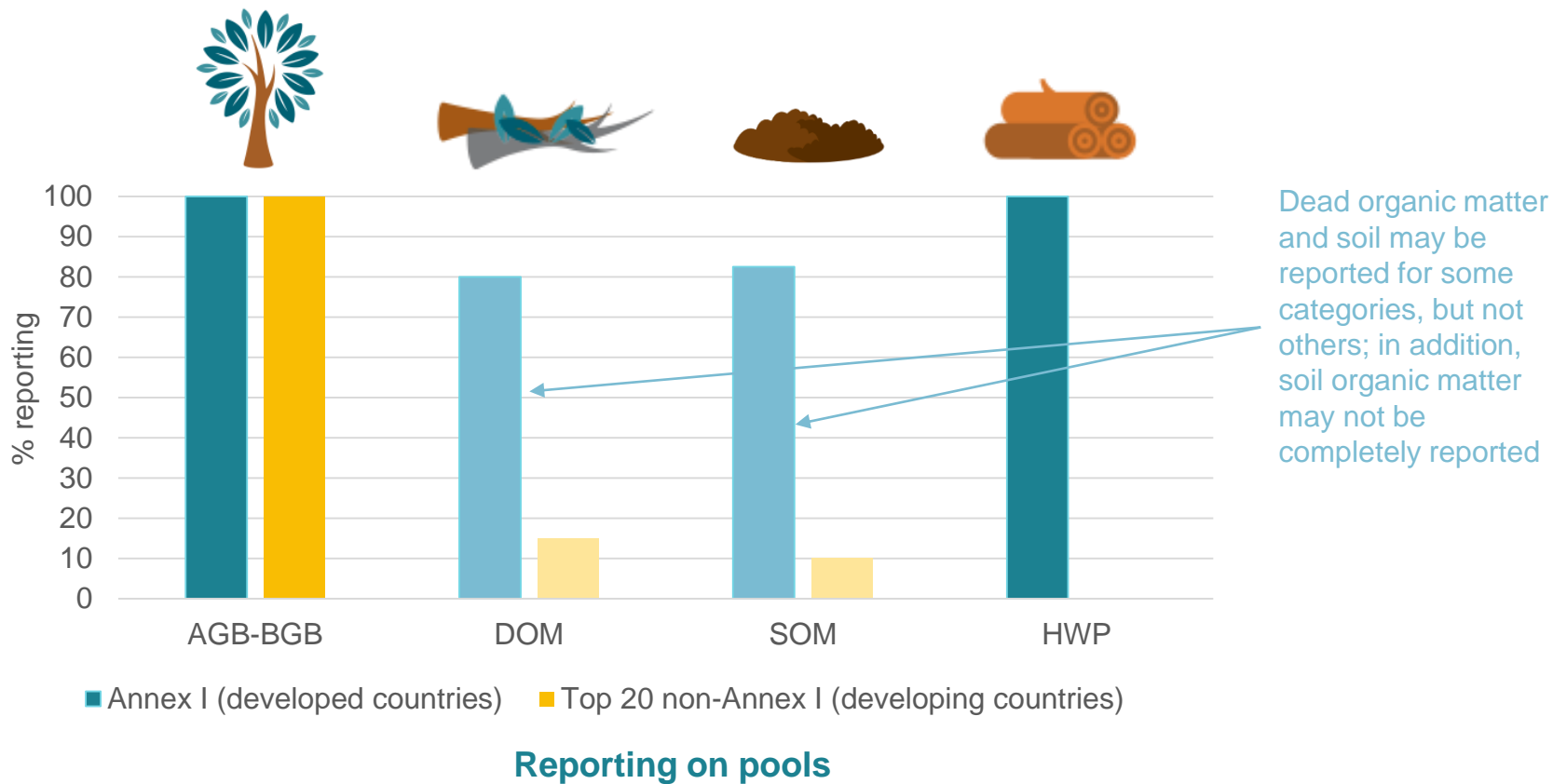
Developed countries tend to report on all forest categories. Developing countries generally report on deforestation, but less often on forest degradation, forest expansion and regrowth.



Reporting of forest categories

Incomplete GHGs: Pools

Developed countries tend to report more completely on carbon pools, including harvested wood products. Omitting pools can significantly change flux estimates—by up to two or three times the amount.

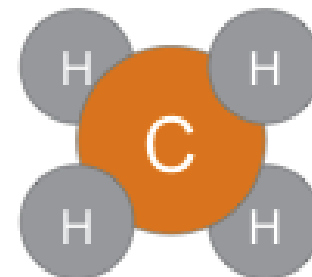


Incomplete GHGs: Gases

Reporting on non-CO₂ gases is also incomplete, particularly in developing country reports

The vast majority of developed countries report on non-CO₂ gases (N₂O and CH₄), which are mainly from forest fires. These represent around 10% of total CO₂-equivalent fire emissions (i.e. from loss of biomass).

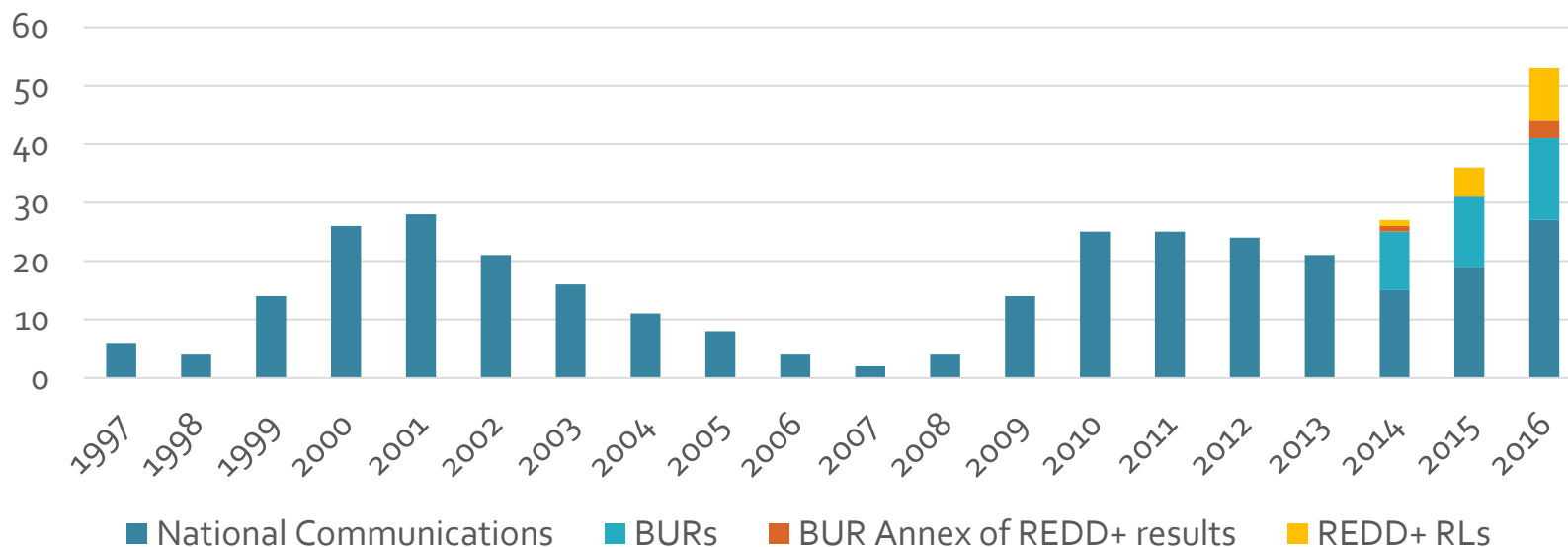
The situation regarding forest-related non-CO₂ gases in developing countries is less clear. Most countries do not report on them (due to insufficient data). The relative importance of non-CO₂ gases may differ in developing countries, particularly those that experience peatland fires or where slash-and-burn agriculture is common.



Developing country reporting

With the new requirement (since 2014) for developing countries to submit **Biennial Update Reports** (including a GHGI), voluntary submissions of **REDD+ reference levels** and **BUR Annexes of REDD+ Results**, reporting by developing countries of forest-related fluxes is increasing along with their capacity to measure forest-related fluxes.

Number of developing countries reporting GHG estimates to the UNFCCC



Summary of “What’s Out” (of GHGs)?

National GHG inventories do not include:

- **Fluxes on “unmanaged” lands, such as:**
 - GHGs from disturbances such as fires
 - Natural sink in unmanaged forest and peatlands

Out
(not required in GHGs)
- **Fluxes that some countries lack capacity to estimate, such as:**
 - Forest degradation
 - Forest growth and regrowth
 - Certain pools, e.g. dead organic matter and soil
 - Some “indirect” processes, such as CO₂ and N fertilization, that occur on managed land*

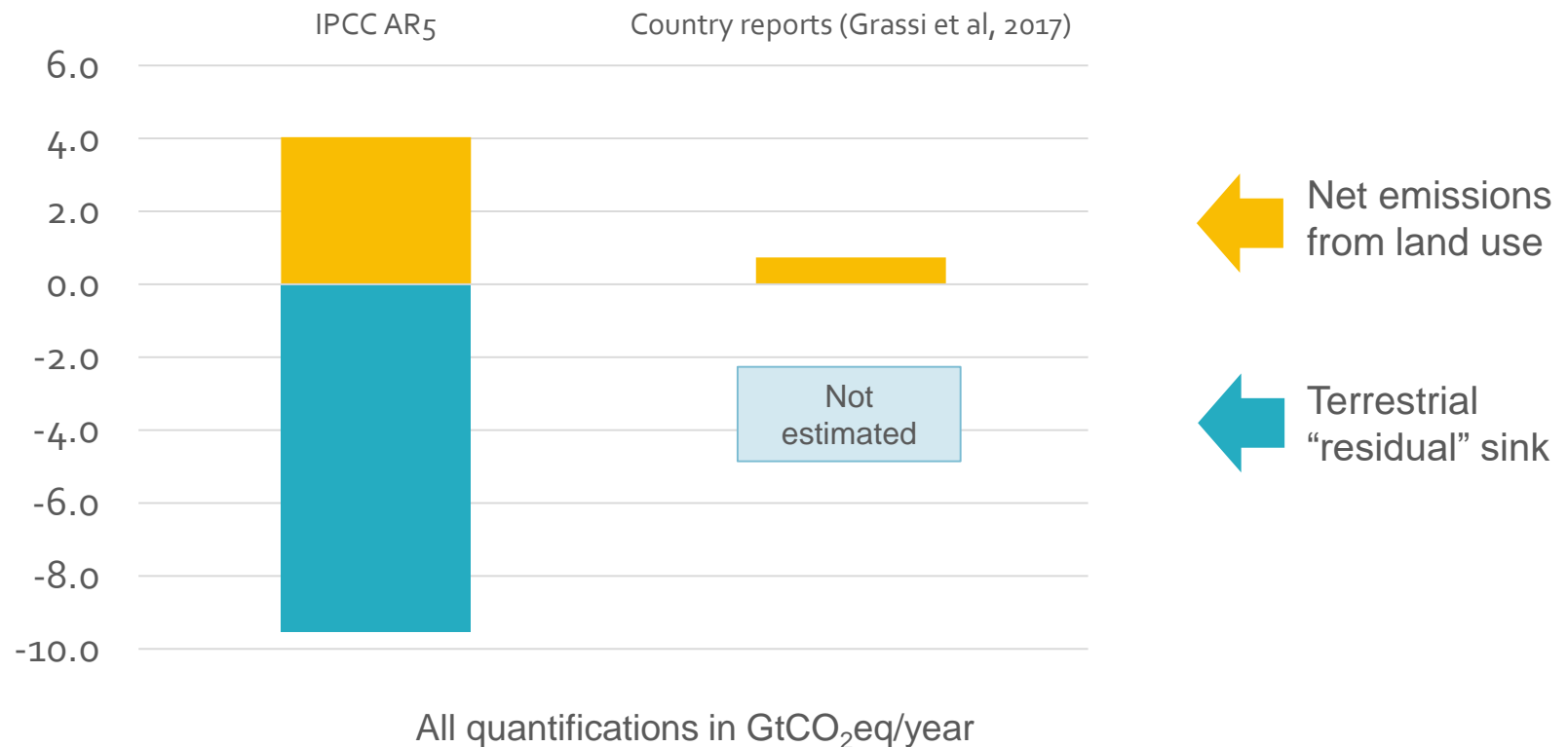
In
(required in GHGs)

*Note: Depending on the IPCC method used to calculate fluxes, some indirect processes could be omitted

How do national GHGI reports
compare to
independent research?

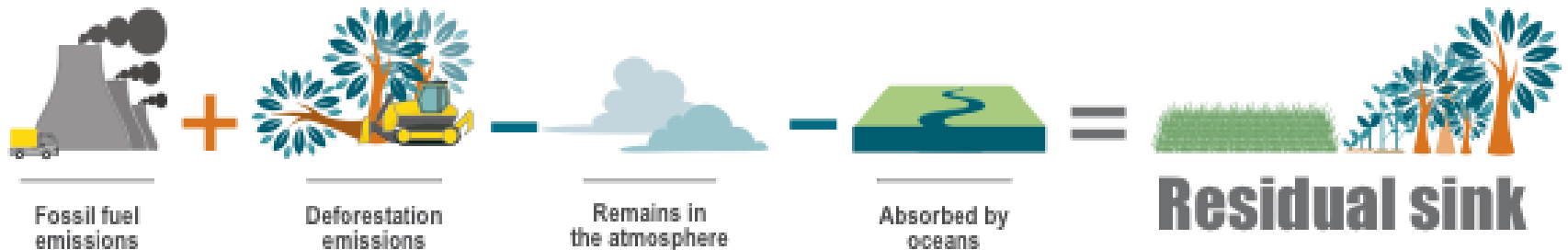
Comparison of global aggregates

There is an important discrepancy between country reporting of *net emissions from land use* and independent studies. In addition, independent studies suggest the presence of a “residual sink”.



The residual sink

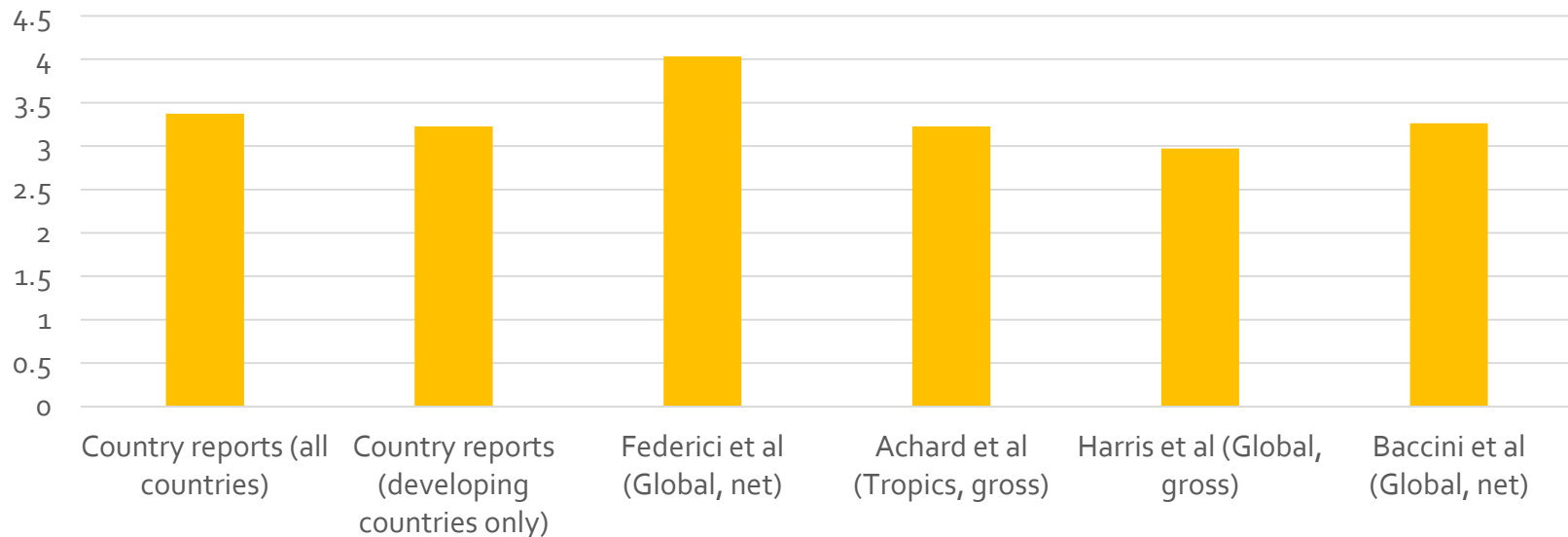
The “**residual sink**” is the difference between the portions of the carbon budget that are estimated (fossil fuel and land use emissions), minus atmospheric concentration and CO₂ absorbed by the ocean.



Deforestation emissions compare well...

Further investigation shows that various estimates of **emissions** from land use change, or deforestation (F→NF), are not that different at the global scale (close to 1 Gt/year) and mostly occurring in the tropics

Estimated emissions from land-use change or deforestation

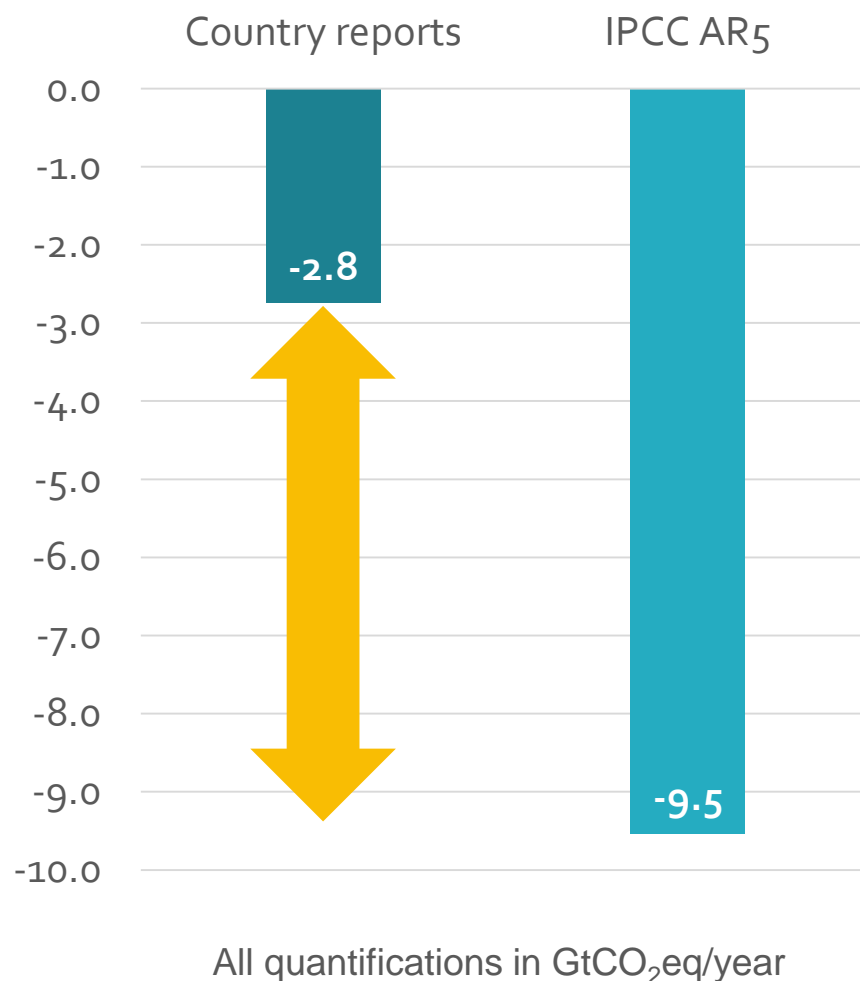


All quantifications in GtCO₂eq/yr

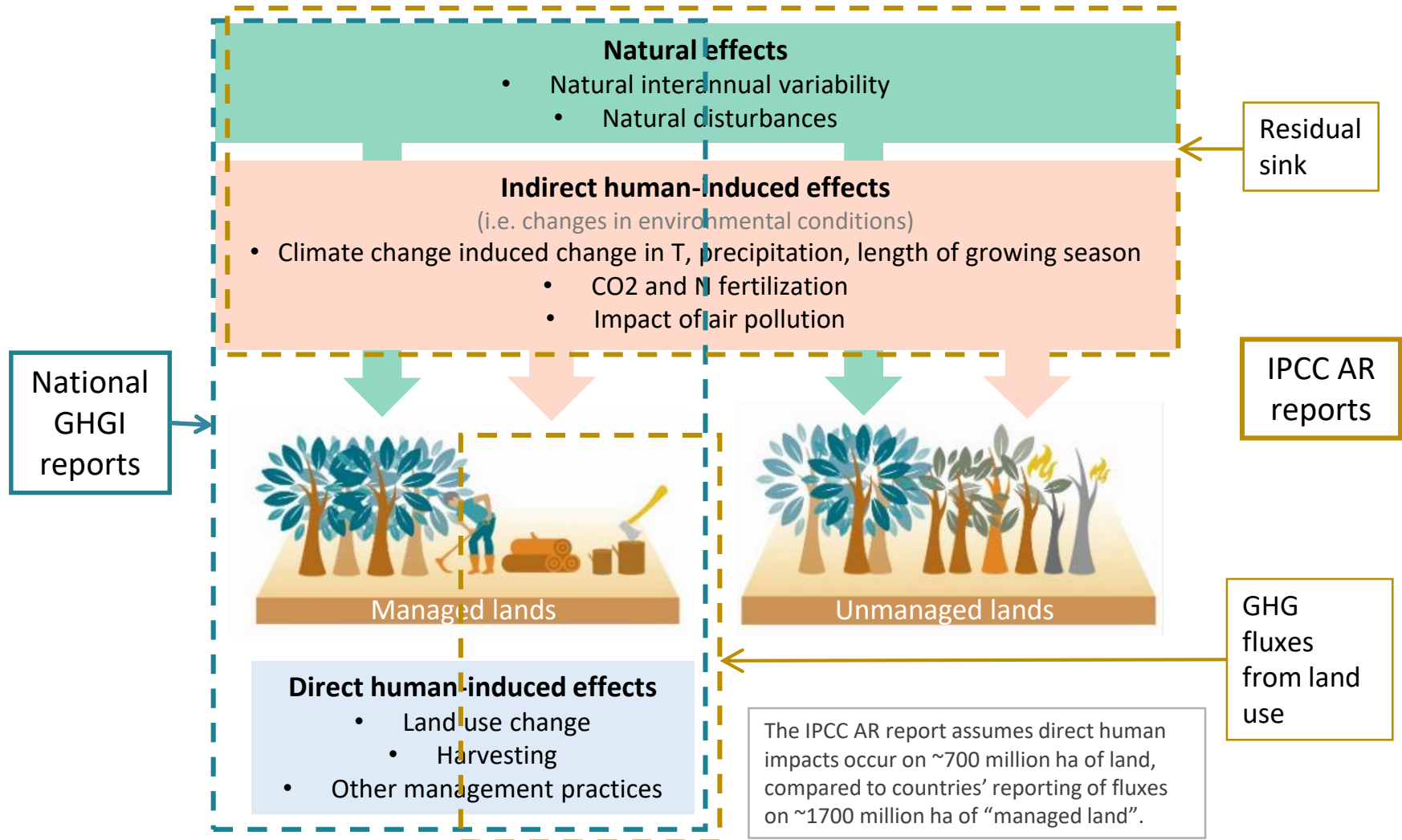
... but estimates of the forest sink do not compare well

Reasons for the difference between the removals in F→F reported by countries and the “residual sink” include:

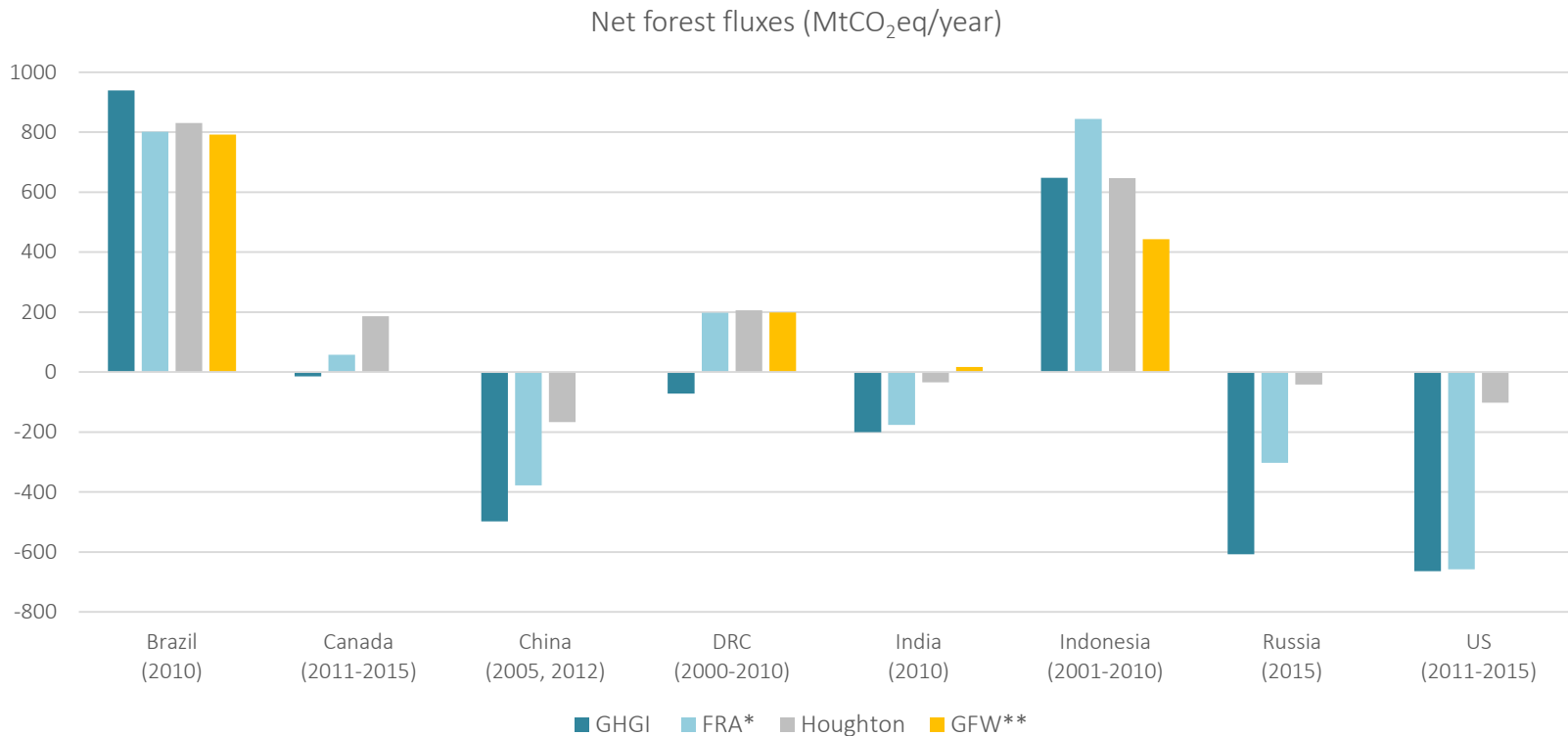
- Uptake on unmanaged lands, for example in Brazil (254M ha), Canada (116M ha), Russia (212M ha)
- Unreported removals by developing countries (e.g. growth in managed forests)
- Other impacts, such as CO₂ and N fertilization effects, that may not be well understood or estimated



In other words... the reason why there are differences in estimates relates to what is being measured.



Comparisons at the country level of net forest fluxes illustrate further the differences between independent estimates and country reports



* Derived from country reports to the FAO Forest Resources Assessment. Ostensibly, FRA data should be consistent with the national report to the UNFCCC (GHGIs); but this is often not the case.

Country comparison of deforestation emissions

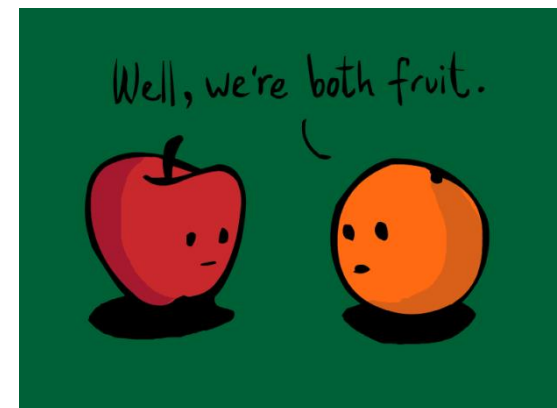
Country level comparisons also show that while it may appear that global estimates of emissions from deforestation from independent studies match well with aggregated forest emissions from national GHGI reporting—this may not indicate accuracy by either source of information. It is possible that global or pan-tropical aggregates are averaging out actual differences in estimations.

Country	FREL	GFW-Climate	% difference
Brazil (2006-2010)	725.3	523	28%
Cambodia (2006-2014)	79.2	55	31%
Colombia (2010-2012)	46.9	22	53%
DRC (2000-2010, 3 rd NC)	77.6	198	-155%
Ecuador (2000-2008)	43.4	13	70%
Indonesia (2000-2012)	93.0	215	-131%
Paraguay (2000-2015)	58.8	44	25%
Peru (2010-2014)	53.4	56	-5%
Tanzania (2002-2013)	58.5	26	56%
Uganda (2000-2015)	8.2	10	-22%
TOTAL	1,224.3	1,162	7%

There can be other reasons that account for differences in estimates...

- Forest definition used
- Carbon pools included
- Whether non-CO₂ fire emissions are included
- Input data (and how its measured):
 - Land cover change
 - Carbon stocks

**Important to compare
apples to apples!**



Conclusions and Recommendations

Independent research and national GHGI reporting often have different goals...



Independent research

- Aims to measure all fluxes (sometimes separating out the direct man-made component)
- Seeks to develop new and innovative methods and results



National reporting

- Estimates only man-made fluxes (no distinction between direct and indirect effects)
- Aims to maintain consistency in data and methods over time
- Uses internationally agreed methodologies and national definitions (e.g. of forest)

Conclusion

Independent studies and national reporting of forest fluxes are not easily comparable

- Likely, the most significant reason independent studies differ from national reports (at the global scale) is the different treatment of removals
- Varying flux estimation methods may also explain differences

The international review process has been critical to improving national estimates.

- Developed countries have undergone multiple reviews over the past two decades, resulting in continuous improvement and higher capacity to estimate GHGs.

Different results among independent studies and national reports do not necessarily mean the data is unreliable

- The differences may be reconciled if the underlying differences are understood

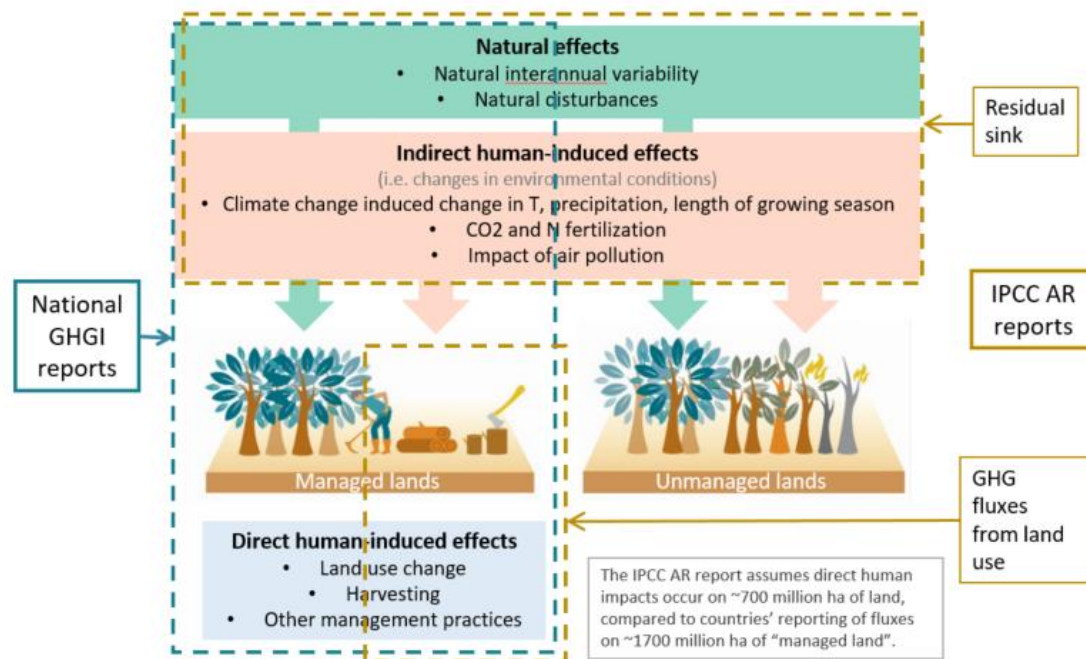
Global comparisons are useful for the global stocktake, but country comparisons are equally critical as they form the basis for mitigation action

- Comparative analyses at the country scale can increase the credibility of estimates and build capacity, in particular of developing countries.

Recommendations

- The outcome of the **Global Stocktake** should include the current “gap” between existing pledges and the net emission reductions required to achieve the Paris Agreement’s long term mitigation goals.

This will require recognizing the differences between independent estimates of forest-related fluxes and national GHG reports.



Recommendations

- Future **IPCC reports** should seek to describe differences between independent studies and national GHG estimates.
- To understand why estimates may differ, sources of information (including both independent research and national reports) should provide **transparent documentation** on how estimates were derived.
- **Improving the capacity** of developing countries to estimate and submit more complete GHGs should be a priority.

Recommendations

- **Awareness in the scientific community of information contained in national GHGIs** should be increased to enhance the policy relevance of independent research.
 - Independent research could disaggregate their estimates in way to make them comparable with country reports and provide estimates at the national level.
 - If this is done, national GHGI compilers can use independent scientific studies for independent verification—which can build national capacity and encourage more cooperation between the two communities.

Implementing these recommendations can ensure that reporting on forest sector emissions and removals will be seen as credible and that the mitigation potential of forests—critical for reaching carbon balance by the second half of the century—will be achieved.

To see the full report: www.GHGforestfluxes.com
Comments or questions? Contact: forestfluxes@clua.net