Carbon storage in forests: motivations, risks and unknowns

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IEA Bioenergy Workshop: Forests and climate

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Canada

“In the long term,
a sustainable forest management strategy
aimed at maintaining or increasing forest carbon stocks,
while producing an annual sustained yield of timber,
fibre or energy from the forest,
will generate the largest sustained mitigation benefit.”

Nabuurs et al. 2007, IPCC AR4, WGIII, Forestry

Conclusions remain fundamentally correct – but the urgency has changed!

And this is raising some questions about sustainable forest management, and the timing of fast carbon emissions and slow carbon removals.

Some argue that, therefore, we should reduce or stop all logging.

Conclusions of mitigation analyses depend heavily on the baseline or counter-factual scenario assumptions.

We can demonstrate how changes in forest management practices and use of harvested wood products can reduce emissions and increase sinks – relative to current business-as-usual.

But if we stop all logging, we can – in the short term – increase sinks even more.

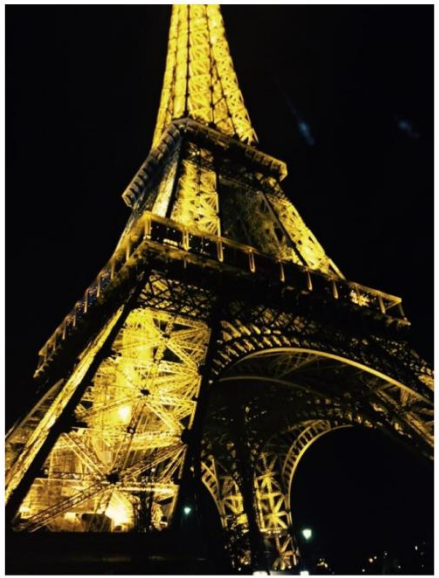
Aside from undesirable socio-economic outcomes, could this be a viable climate change mitigation strategy?

... it depends ...

United Nations

Framework Convention on Climate Change

2015 Paris Agreement



Source: K Simonson

- Goal: **limit temperature rise** to well below 2ºC
- All countries must establish **targets to limit emissions by 2030**
- Countries required to **further reduce emissions after 2030**
- Most countries plan to **include forests** in their efforts
- Aim to achieve **net-zero global emissions** in the second half of the century

ipcc
INTERGOVERNMENTAL PANEL ON climate change

GLOBAL WARMING OF 1.5 °C

- Limiting global warming to 1.5°C **requires rapid and far-reaching transformations in energy systems, land, industry, buildings, transport and cities.**
- **Net negative emissions** are required later this century:
  CO_2 removals from the atmosphere must be greater than emissions.
- **We cannot keep warming below 2º C without land sector contributions!**

Net zero emissions require sinks in the land sector

- Negative emissions can only be achieved with forest sinks.
- Globally, forests remove about 30% of fossil fuel emissions.
- But forest sinks are at risk from climate change.

- Nature-based solutions …. What is the real potential and over what time? What are the risks?

nature climate change

PERSPECTIVE

https://doi.org/10.1038/s41558-020-0738-8

Protecting irrecoverable carbon in Earth's ecosystems

Goldstein et al. April 2020 Nature Climate Change

Focus is entirely on carbon stocks.
Highlights important conservation needs, but no discussion of maintaining or enhancing sinks.

Fate of anthropogenic CO_2 emissions (2009–2018)

Sources = **Sinks**

34.7 $GtCO_2$/yr

86%

14%

5.5 $GtCO_2$/yr

17.9 $GtCO_2$/yr

44%

29%

11.5 $GtCO_2$/yr

23%

9.2 $GtCO_2$/yr

Can sink be sustained or enhanced?

Budget Imbalance:
(the difference between estimated sources & sinks)

4%

1.6 $GtCO_2$/yr

Source: CDIAC; NOAA-ESRL; Houghton and Nassikas 2017; Hansis et al 2015; Friedlingstein et al 2019; Global Carbon Budget 2019

IPCC SRCCL

Carbon removal through land and

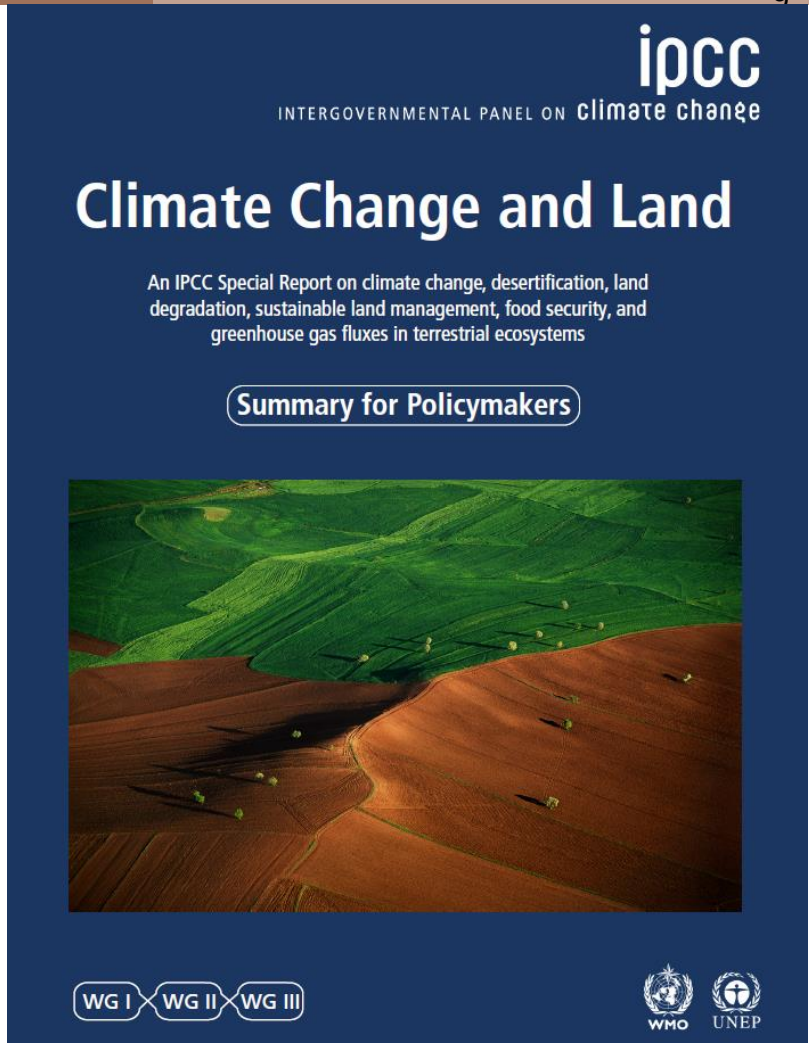
- Desertification
- Degradation
- Sustainable land management
- Food security

Identifies risks, opportunities and synergies

Not all activities require land

Expected future land sinks must not become an excuse to not reduce fossil fuel emissions!

https://www.ipcc.ch/report/srccl/



Things we can agree on:

Deforestation (i.e. land-use change) must be reduced

but this message needs to be communicated carefully because some interpret forest harvest as deforestation.

Afforestation, reforestation and land rehabilitation should be encouraged

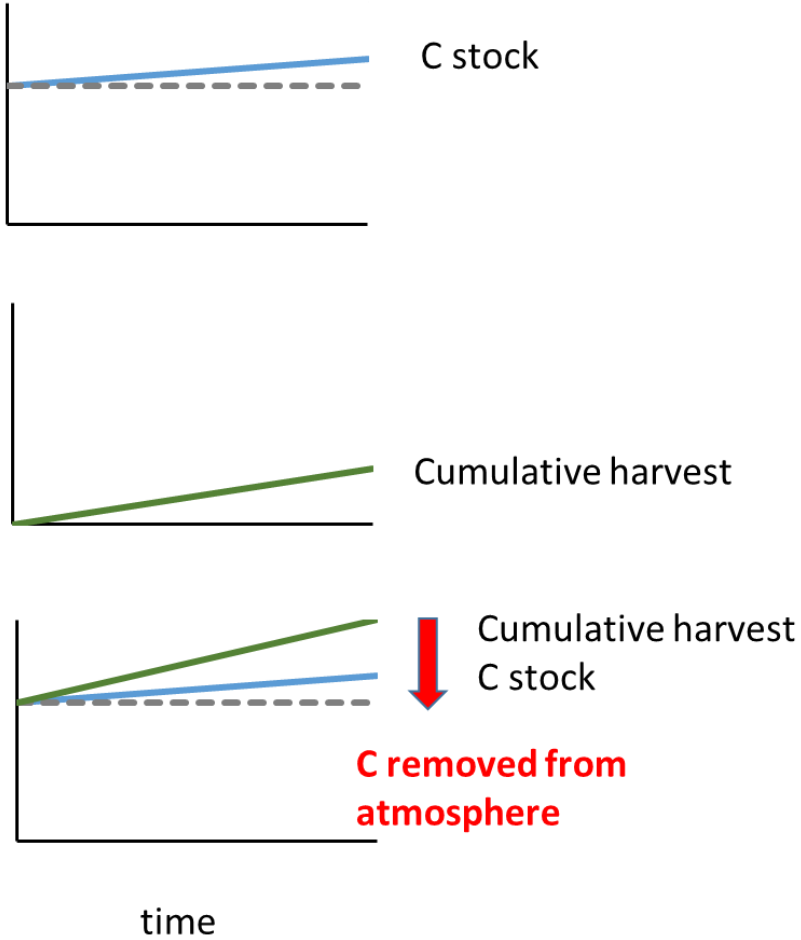
... with some caveats.

The debates focus on the role of forest management ...

The role of forest management depends on...

The system boundaries of the assessment (ecosystem, HWP, substitution),
The indicator(s) we are evaluating,
The time horizon of the assessment,
Initial forest conditions (old growth, managed, recovering from overuse), and
Risks from natural disturbances and climate change.

Managed forests can be C sinks even if C stocks do not increase



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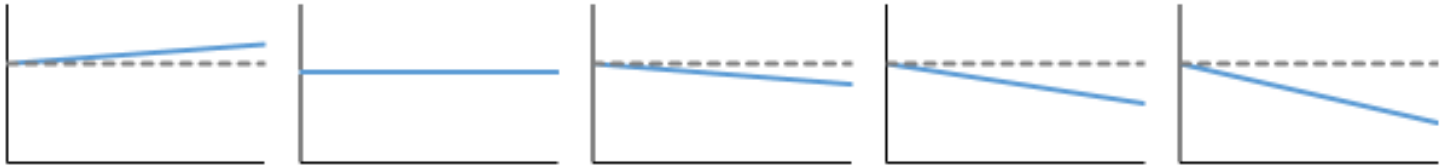
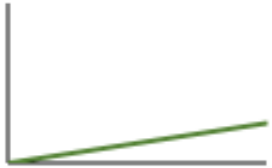
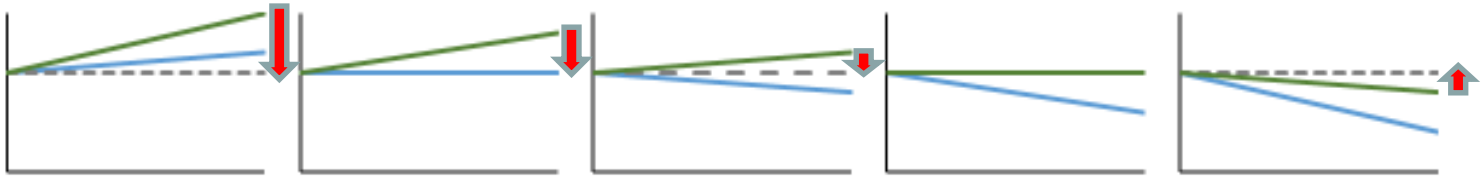


C stock



Cumulative harvest

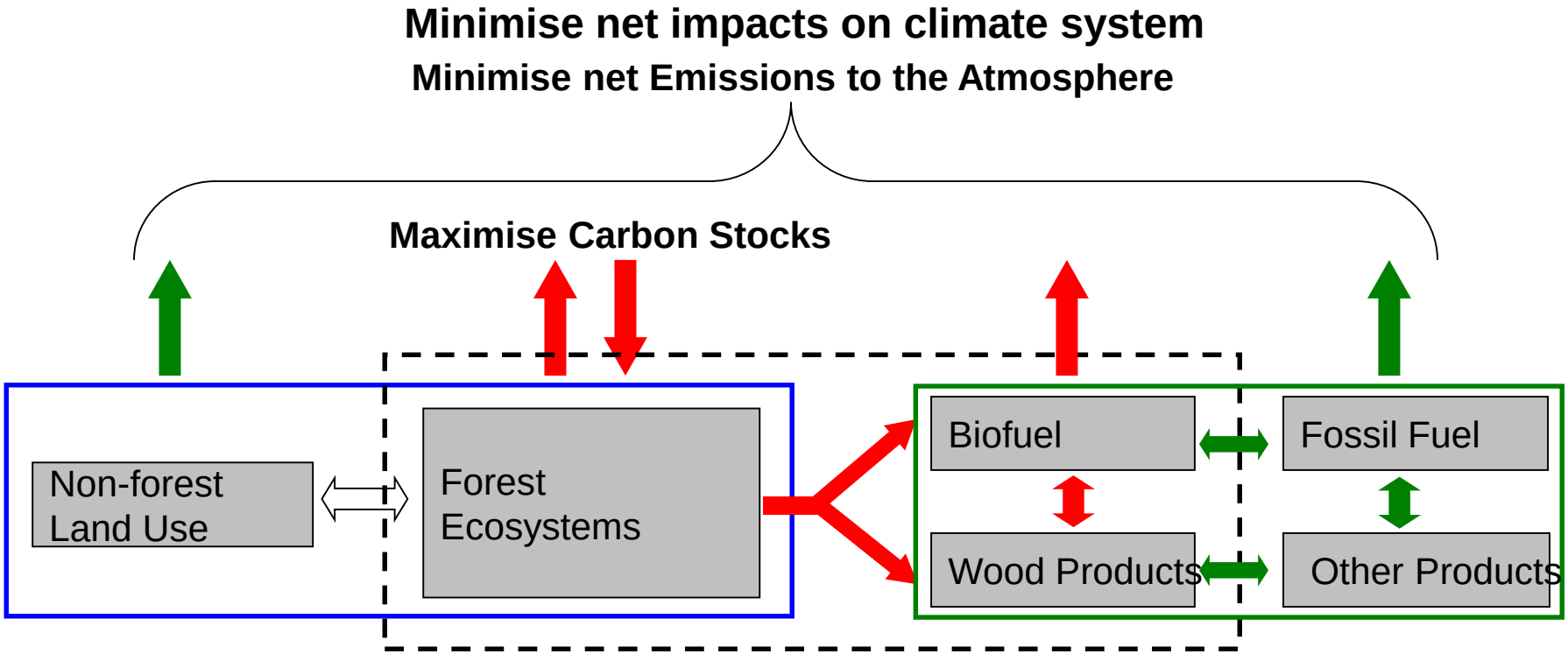
Sink



Source

But how the harvested wood is used also needs to be quantified.

Mitigation Strategies: Need for Systems Perspective



Source: IPCC 2007, AR4 WG III, Forestry

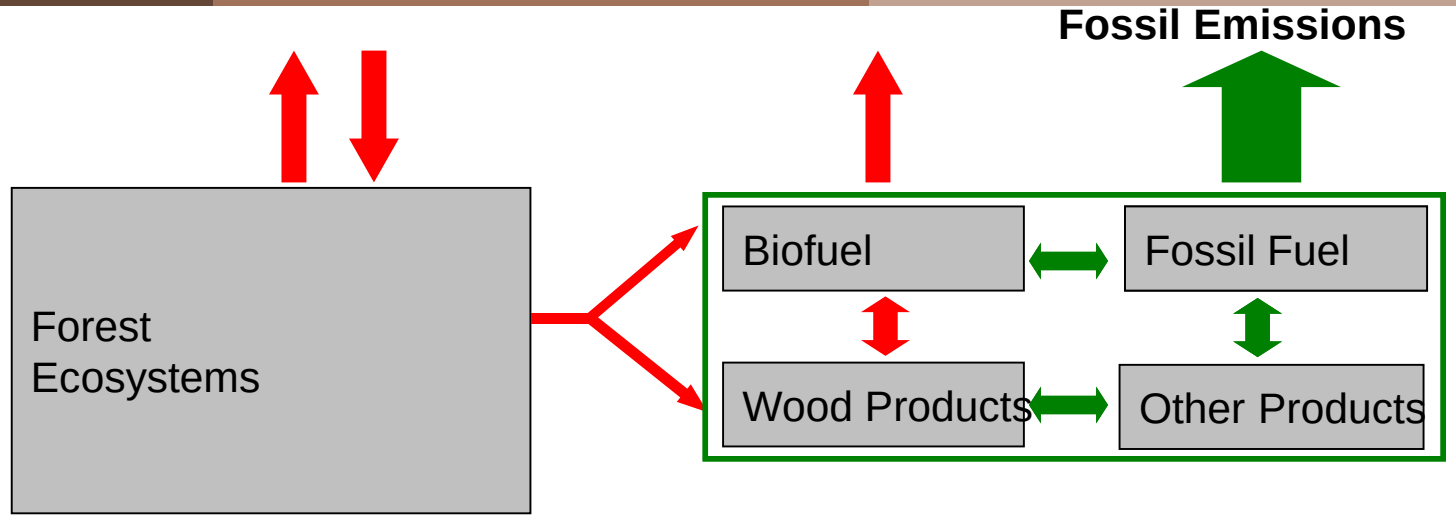
Mitigation analyses require systems perspective

Design of portfolios aimed at climate change mitigation through GHG management in the forest sector should account for changes in

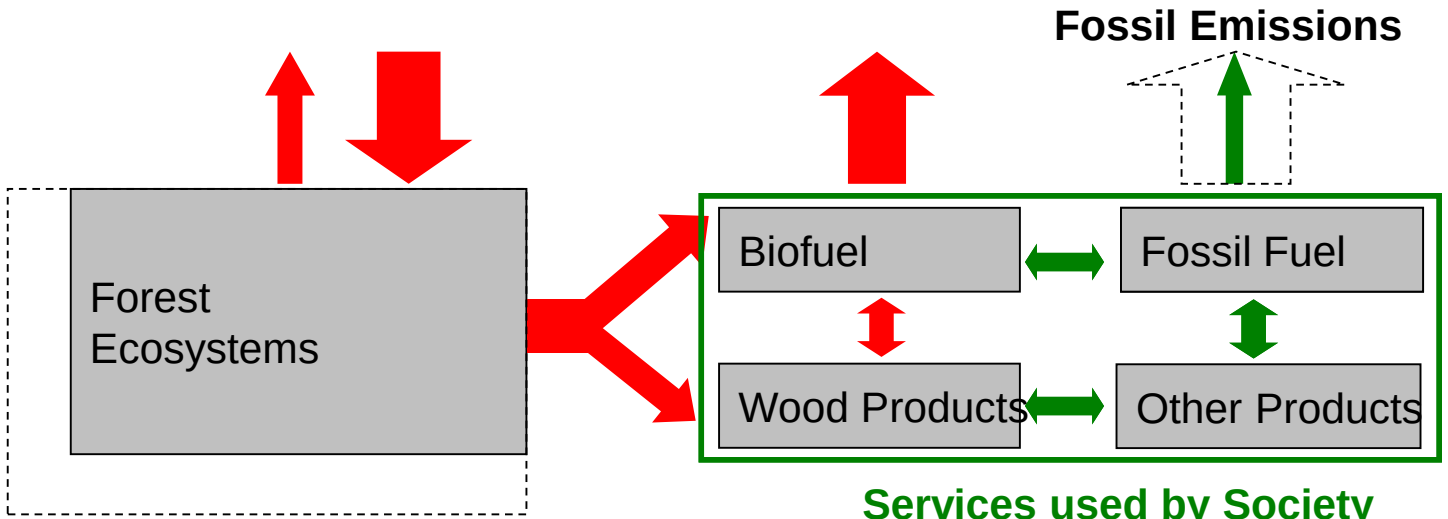
- **forest ecosystem carbon,**
- **harvested wood product carbon**, and
- for changes in emission from **substitution benefits**

relative to a base case (business-as-usual).

Maximise Carbon stocks

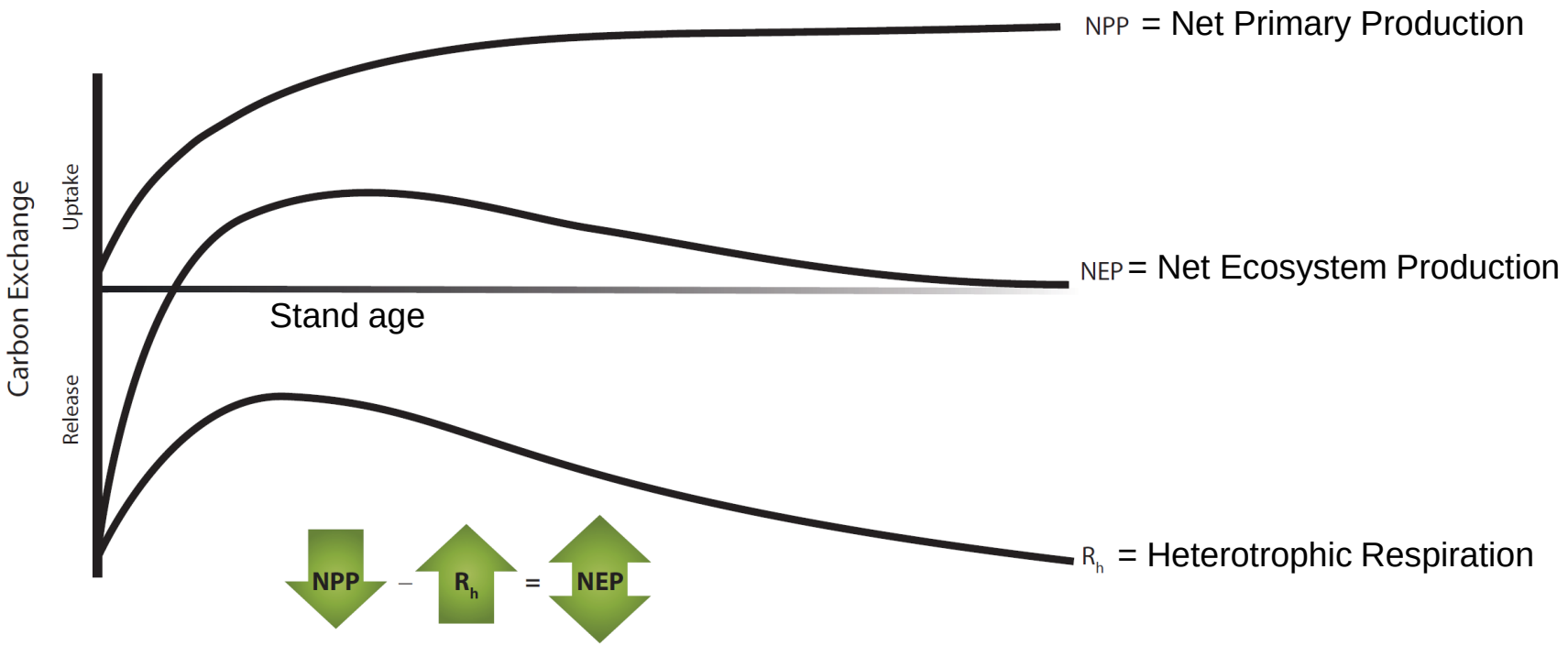


or maximise Carbon uptake?



Services used by Society

Max. C uptake (NEP) and max. C stocks occur at different stand ages: we cannot “maximise” both at the same time



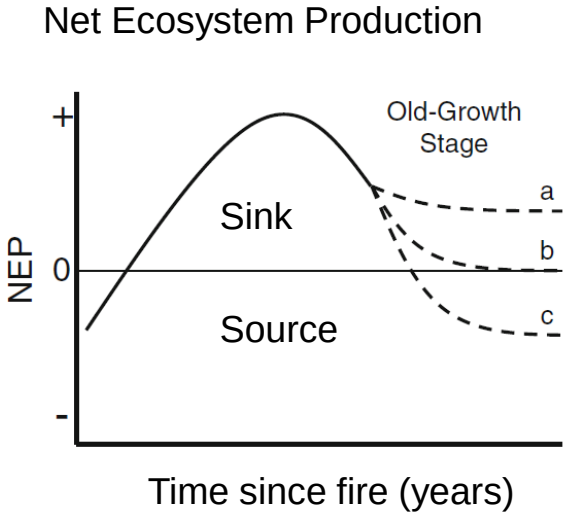
Source: Kurz et al. 2013

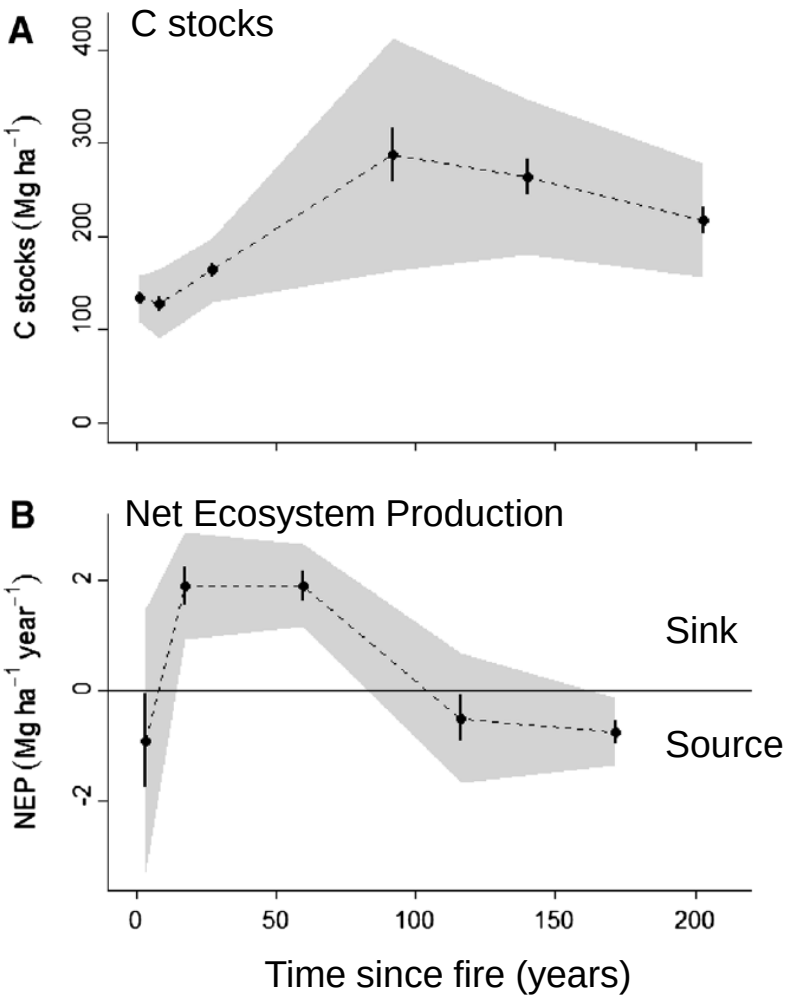
Net forest carbon balance is a small difference between two large fluxes.

Forest as carbon sources and sinks

- There is ample evidence from both inventory and flux measurements that old growth forests can be small sinks, C neutral or C sources.
- Even if **biomass** stocks are decreasing, total **ecosystem** C stocks can be increasing.
- With small scale disturbances such as individual tree death, windthrow, insects and pathogens, old forests can be C sources.

Carbon sinks decrease in older forests and they can become sources





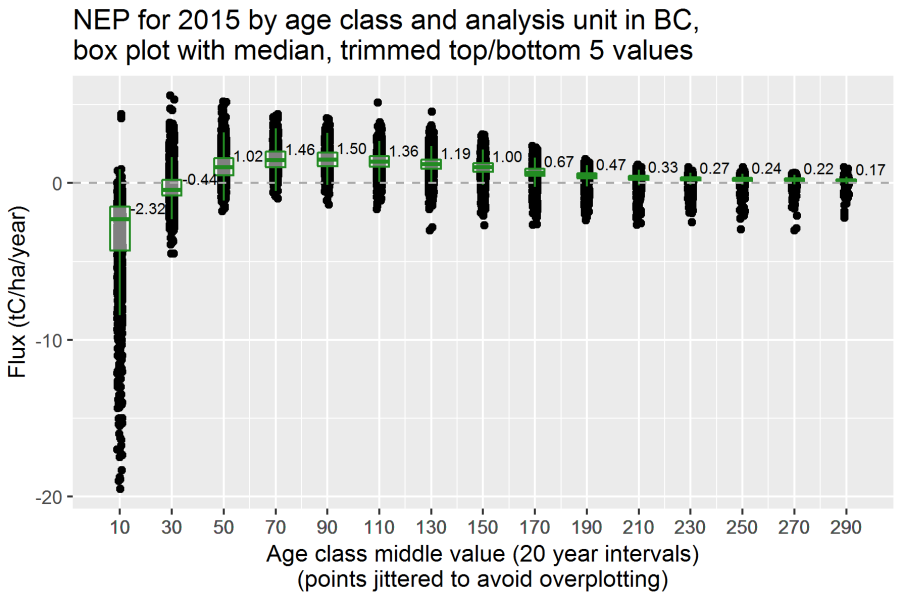
Study sites from Eastern Canada

Note wide range in values depending on ecosystem type.

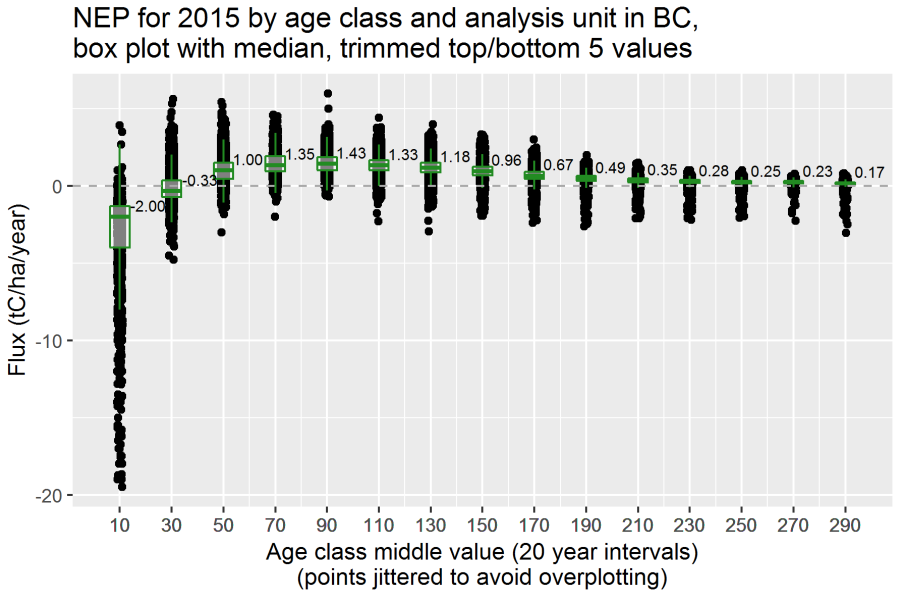
Source: Taylor et al. 2014

Net Ecosystem Productivity Estimates by age class for BC

Timber Harvest Land Base (20 Mha)

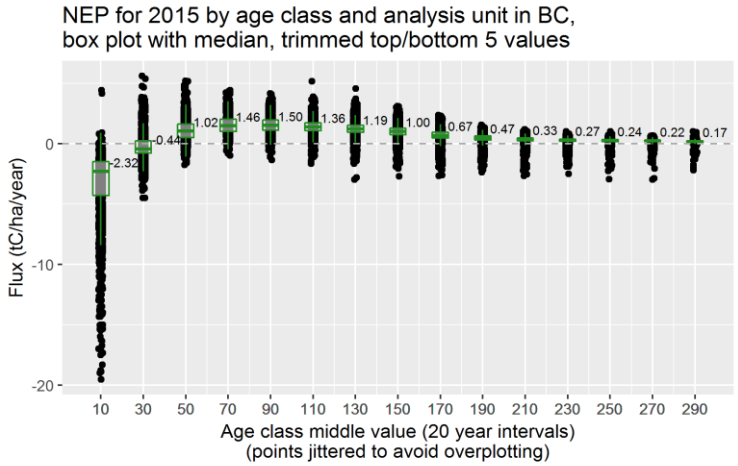


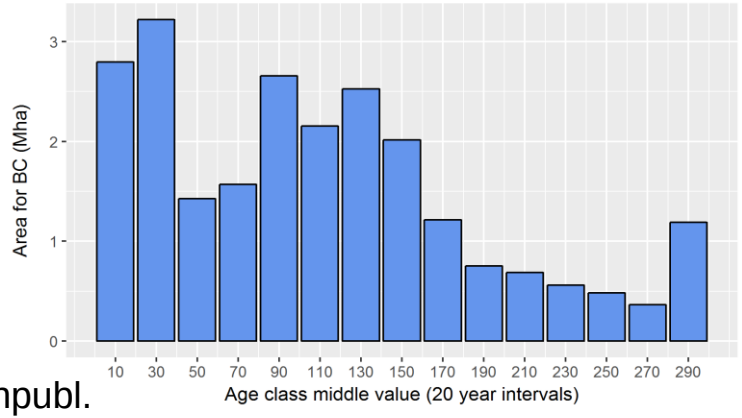
Non-THLB (40 Mha)



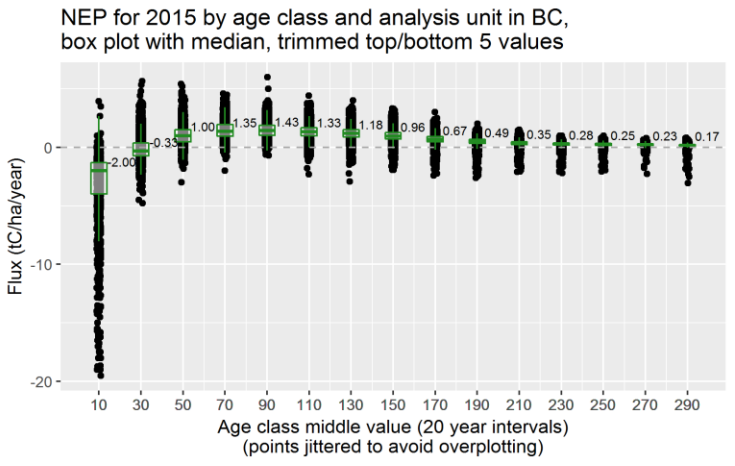
Source: CFS, unpublished data

THLB in 2015 (20 Mha)

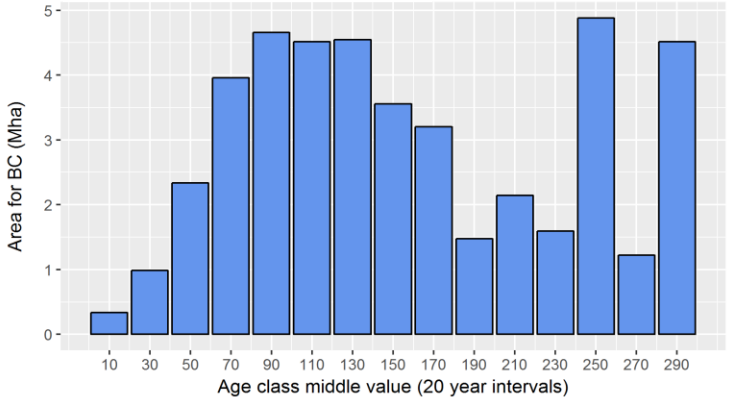




Non-THLB in 2015 (40 Mha)



Note non-sustainable age-class structure



Source:

CFS, unpubl.

Can forest sinks be sustained in the absence of disturbances?

Most of Canada’s National Parks (by area) were established over 100 years ago (1885 onwards).

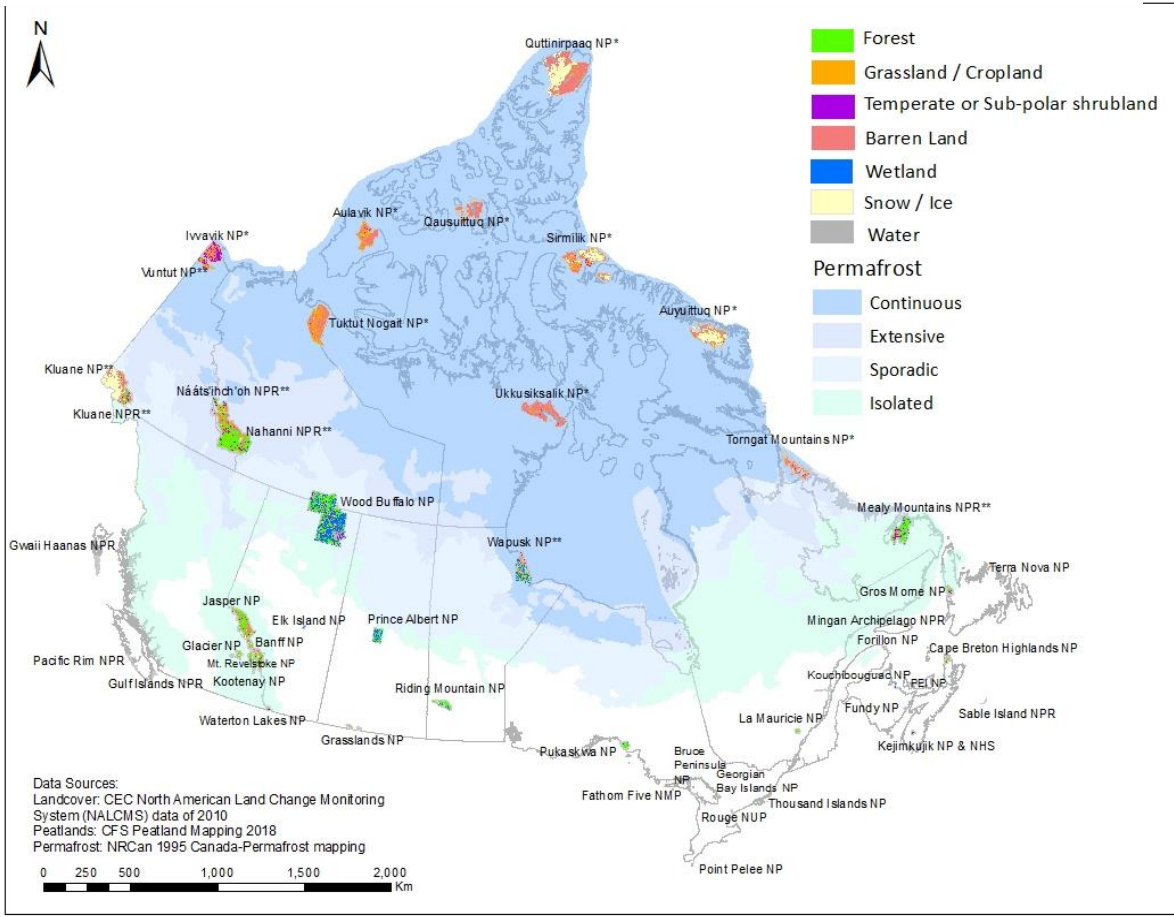
There is no commercial timber harvest.

Parks Canada Carbon Atlas

- Collaboration PC and CFS
- Forests in 31 National Parks
- 1990 – 2017
- 5.6 Mha
- 30 m resolution
- GCBM
- C stocks
- Net C balance

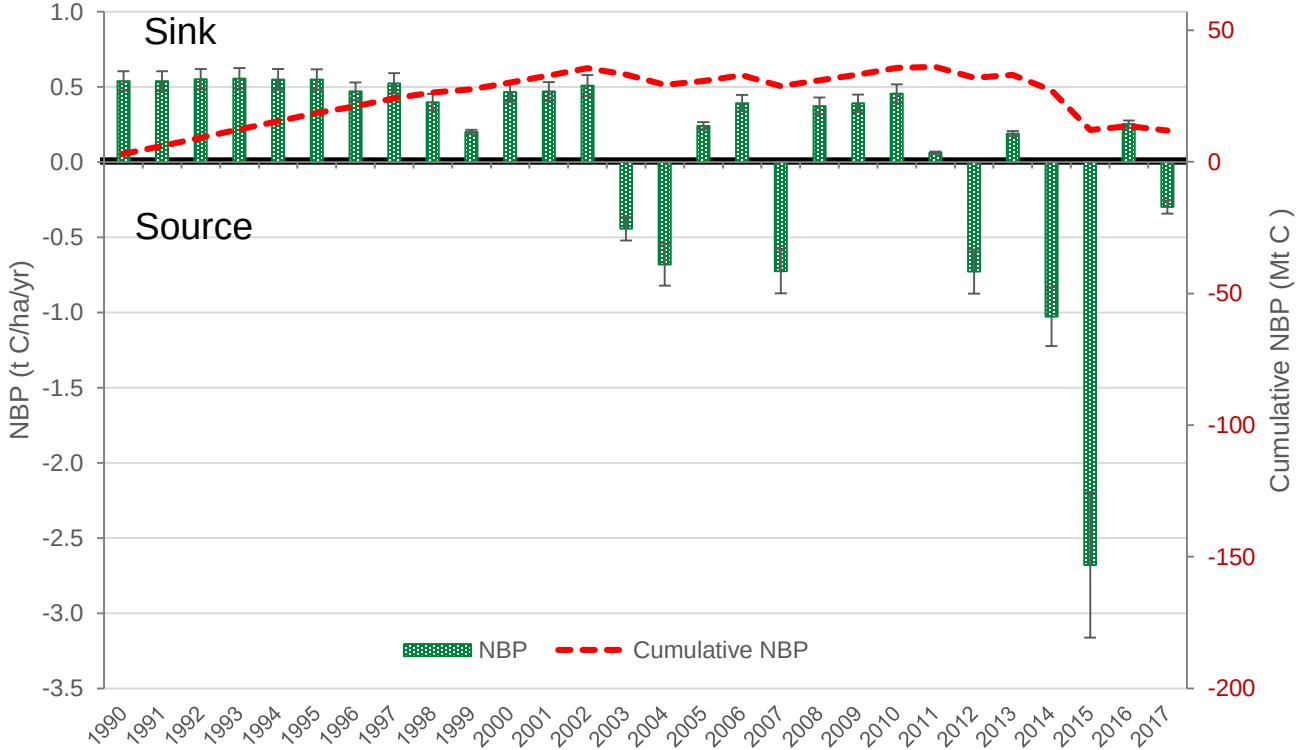
Source:

Sharma et al. 2020, in press



Annual and cumulative Net Biome Production (Mt C) in 31 National Parks

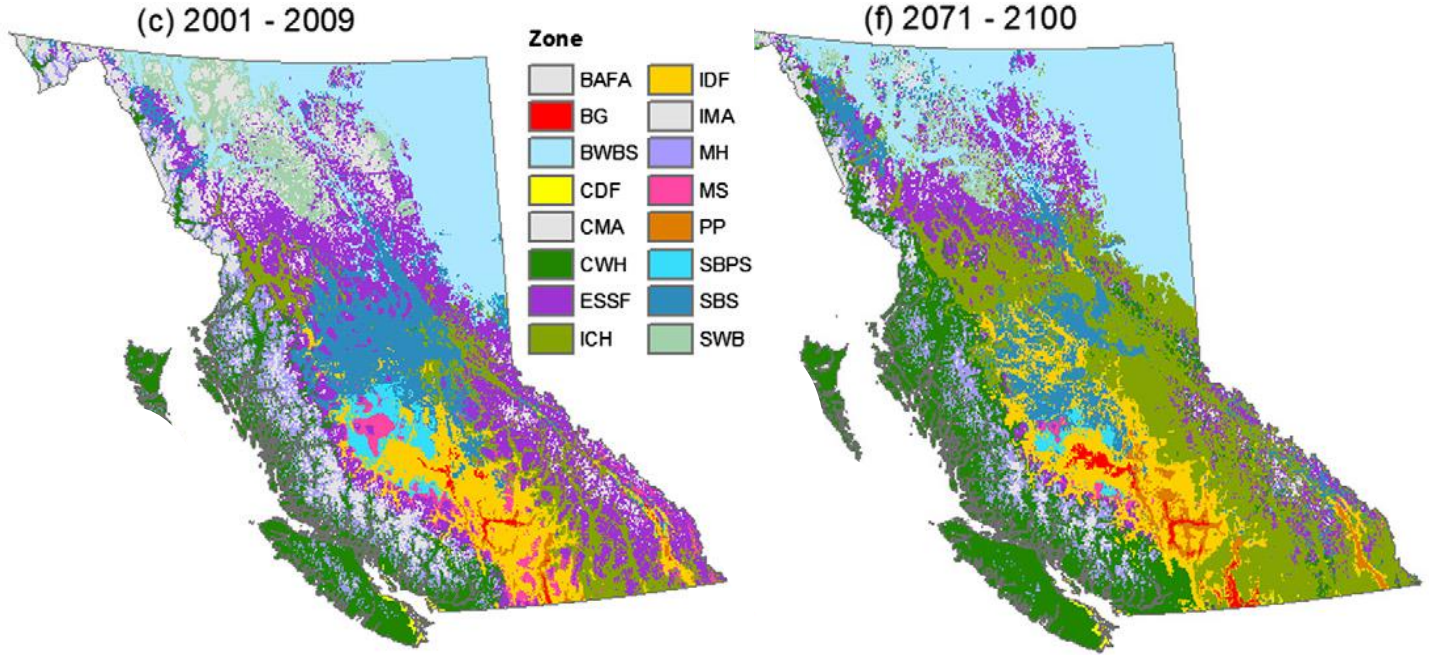
- Small net sink
- Dominated by Wood Buffalo National Park



Source: Sharma et al. 2020, in press

Climate change will alter distribution and area of ecosystems – including transition from forest to non-forest

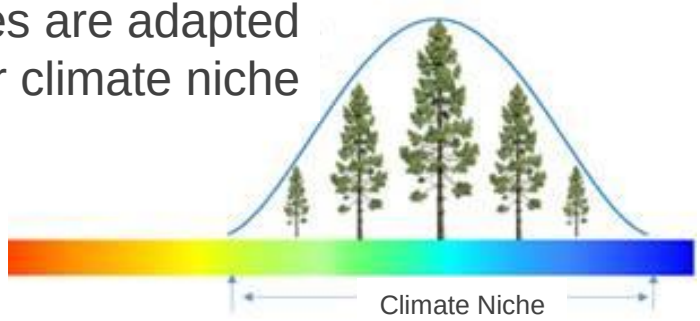
What will our responses be when millions of hectares of forest are stressed or dying?

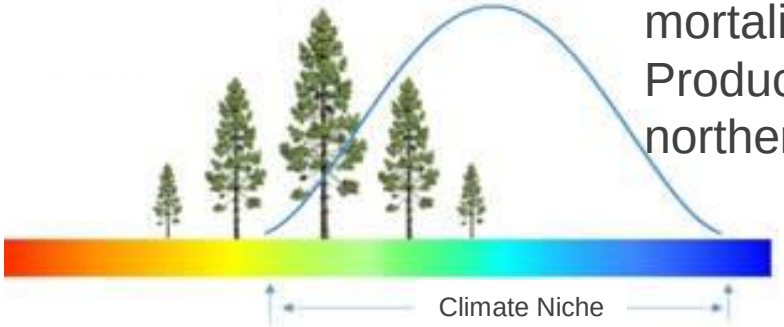


Source: Wang et al. 2012

Shifting climate niches (latitude or elevation) contribute to species maladaptation, stress and tree mortality

Tree species are adapted to their climate niche

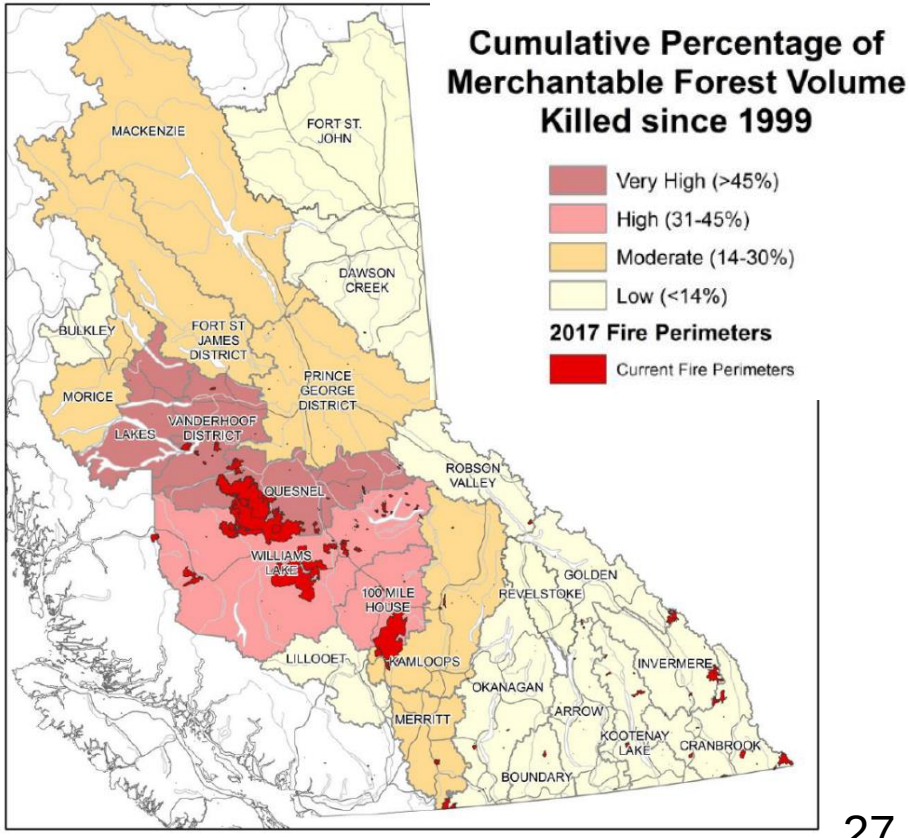




Climate change shifts niches causing maladaptation, stress and mortality.
Productivity may increase at the northern (high elevation) boundary.

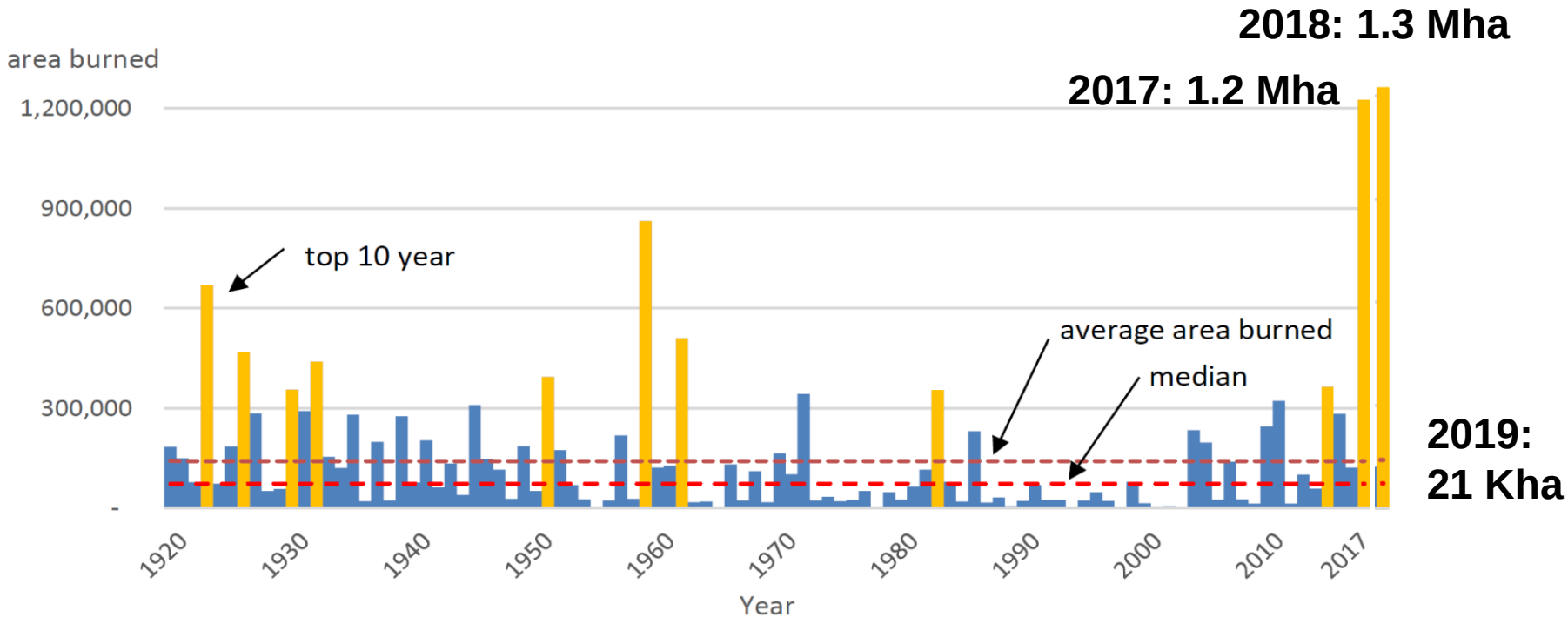
Source: Modified from Tongli Wang, UBC

Climate change impact spiral: Drought/heat, stress, insects/diseases, fires, … ?



Source: BC Ministry FLNRORD 2018

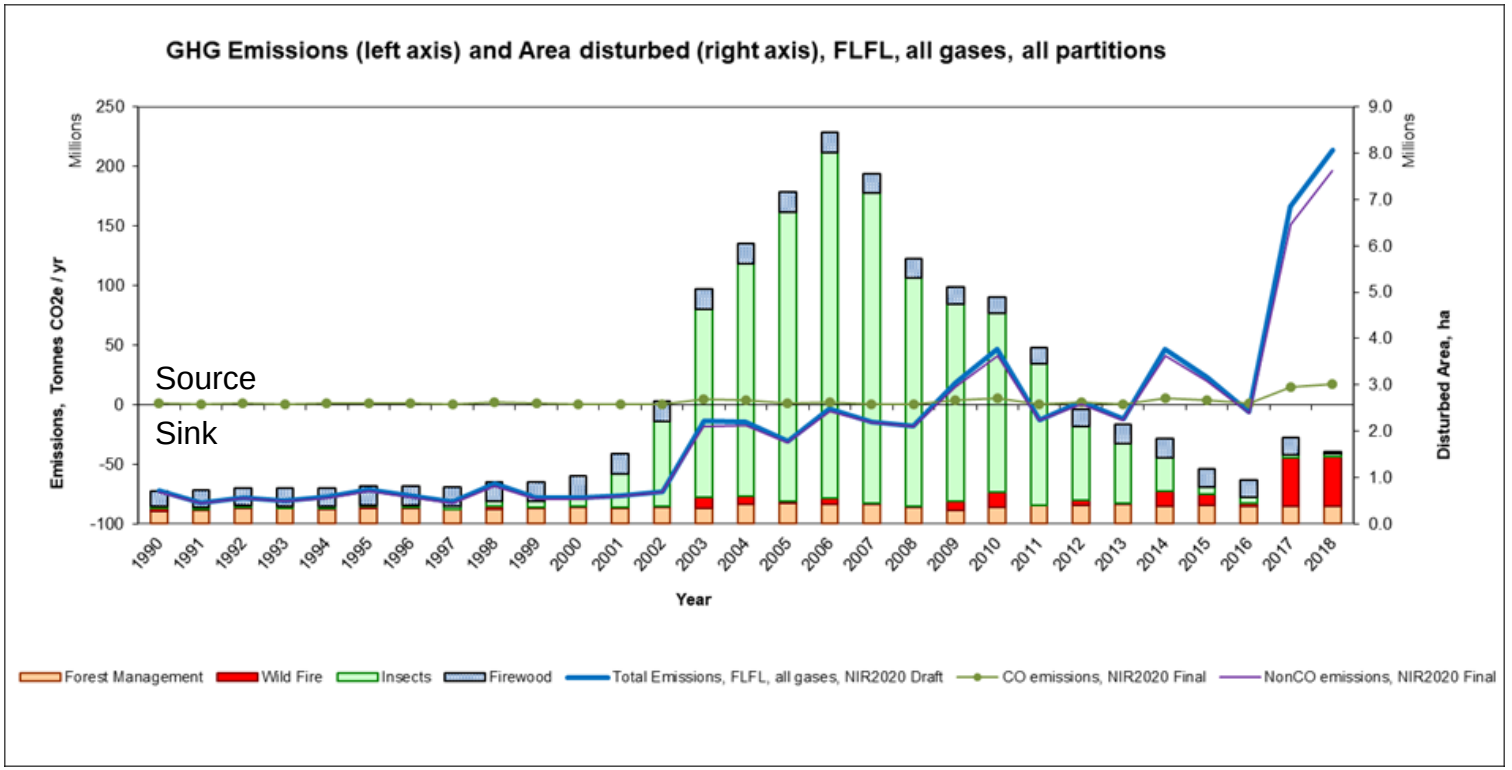
Area annually burned in British Columbia



Source: BC Ministry FLNRORD 2018

Annual BC Forest GHG Balance and its drivers 1990 - 2018

FL-FL only: HWP emissions not included



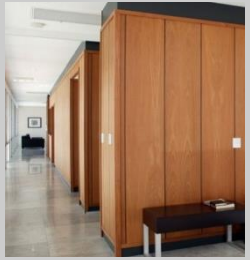
Source: NIR2020 (National GHG Inventory) – which does not report by Province

2017 and 2018 wildfire emissions estimated at ~3 times the emissions from all other sectors in BC

Options for forest sector mitigation activities:







Increase sinks through forest management: fertilization, stand tending, tree selection, etc.

Rehabilitation after natural disturbances (wild fire and insects).

Reduce harvest residue burning.

Harvest less / more depending on conditions.

Increase afforestation and avoid deforestation.

Maximize carbon retention in long-lived products.

Cascading wood use.

Reduce wood waste at every stage.

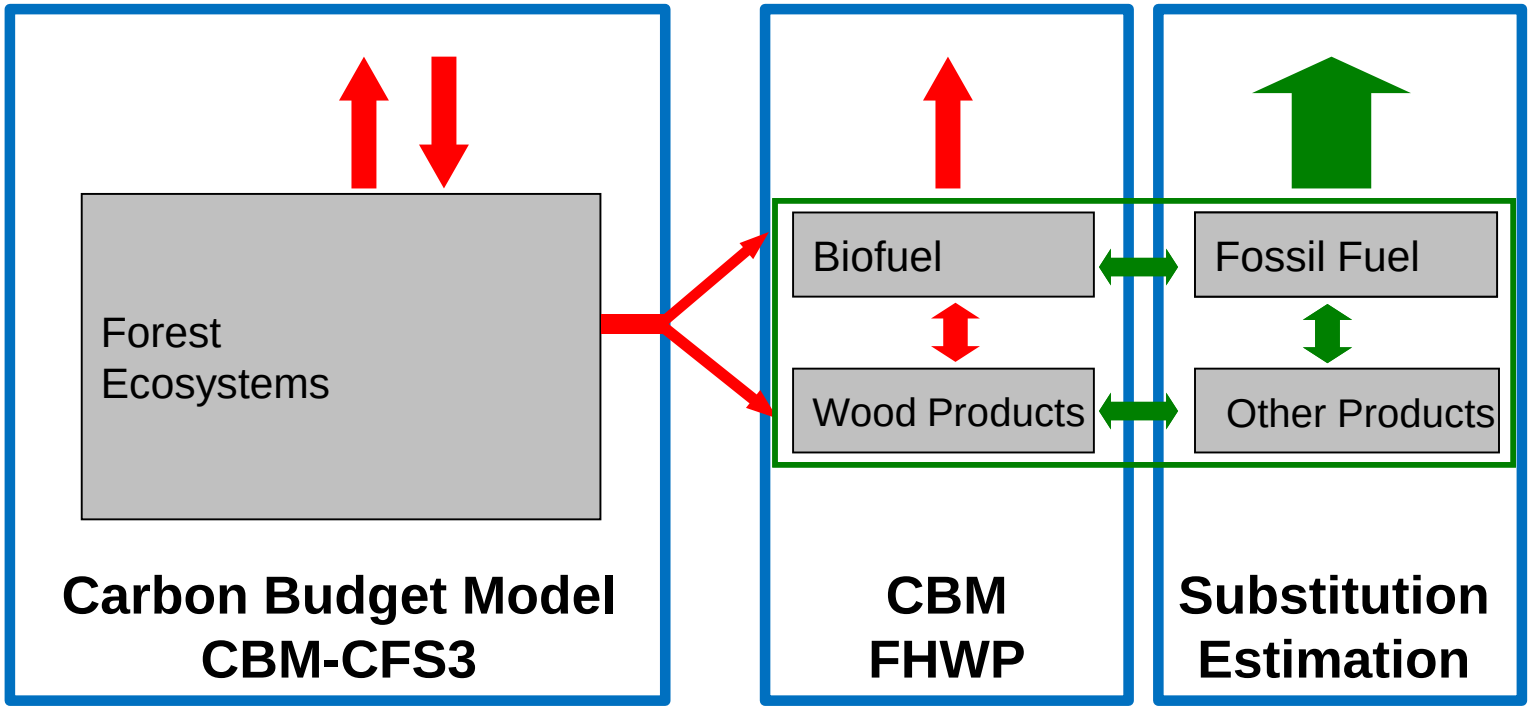
Divert wood products from landfills.

Replace emissions-intensive products such as steel and concrete with wood products.

Replace fossil fuels with bioenergy from wood waste, where appropriate.

We have modeled some of these …

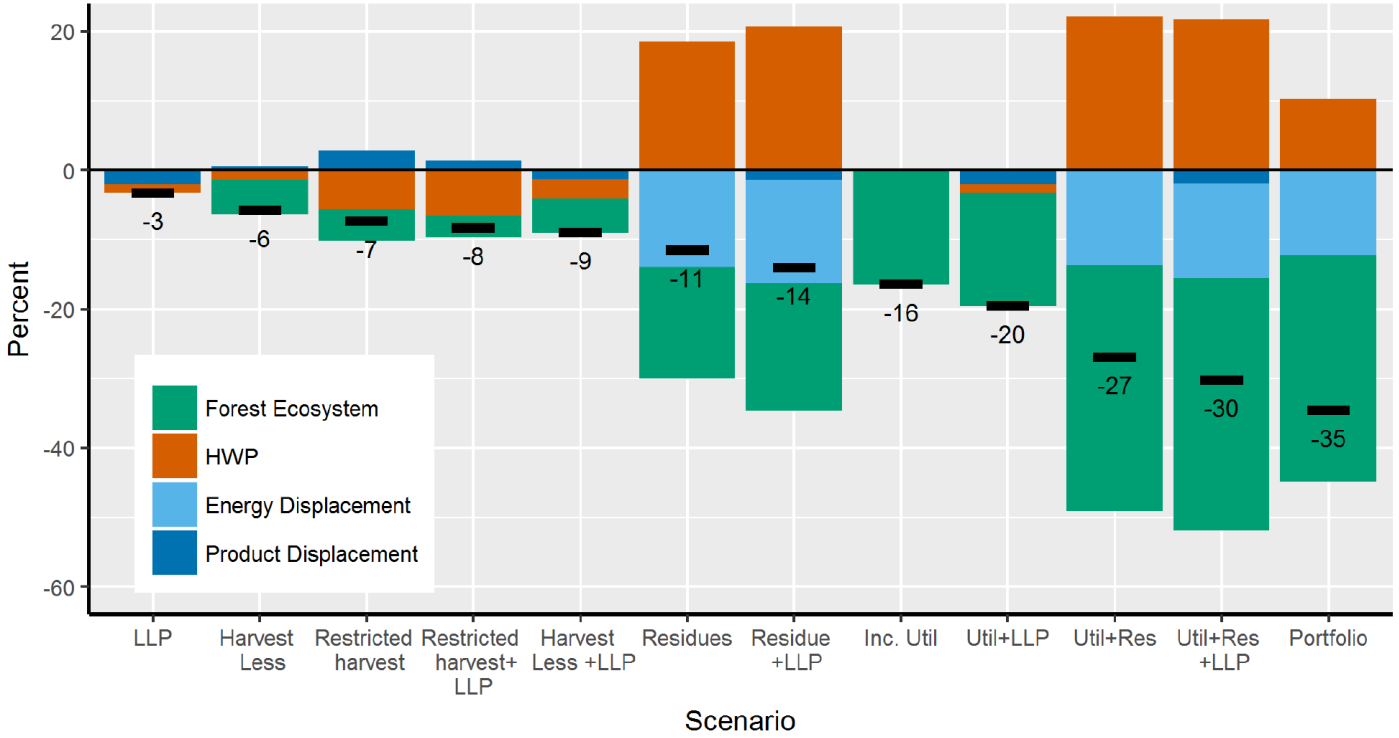
Mitigation analyses: analytical framework



CBM-CFS3 and CBM-FHWP used for Canada's National GHG inventory reporting.

Results (Xu et al. 2017)

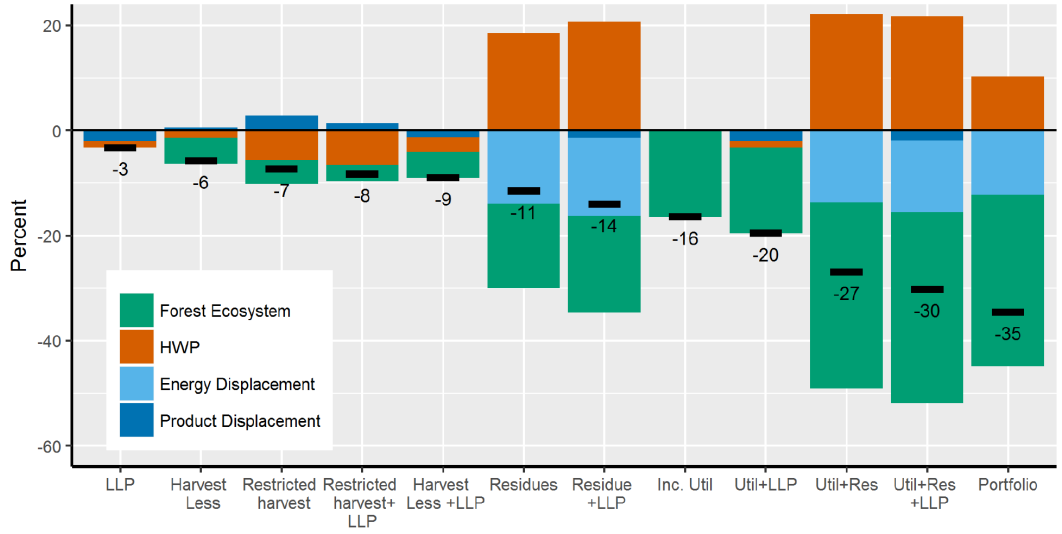
Best mitigation activities vary by region in BC: a portfolio of regionally-differentiated forest management and wood-use strategies can achieve 35% of emission reductions in BC by 2050.



Increased wood product emissions,

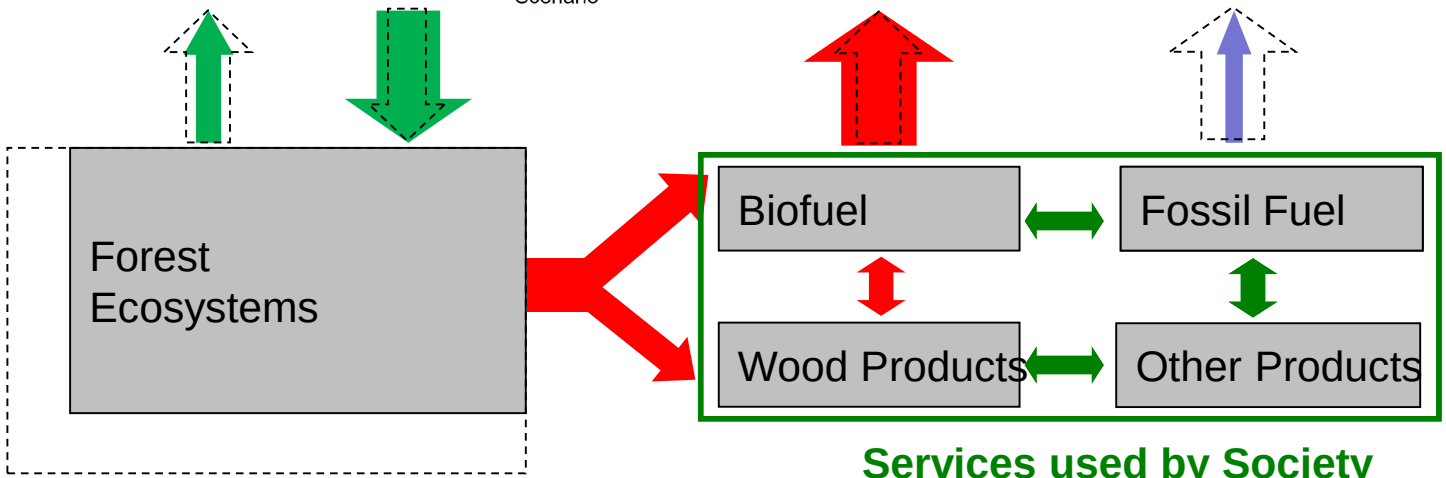
but these reduced emissions from non-wood sources,

and reduced emissions or enhanced sink in the forest.



Portfolio impacts on changes in carbon fluxes

Other Emissions



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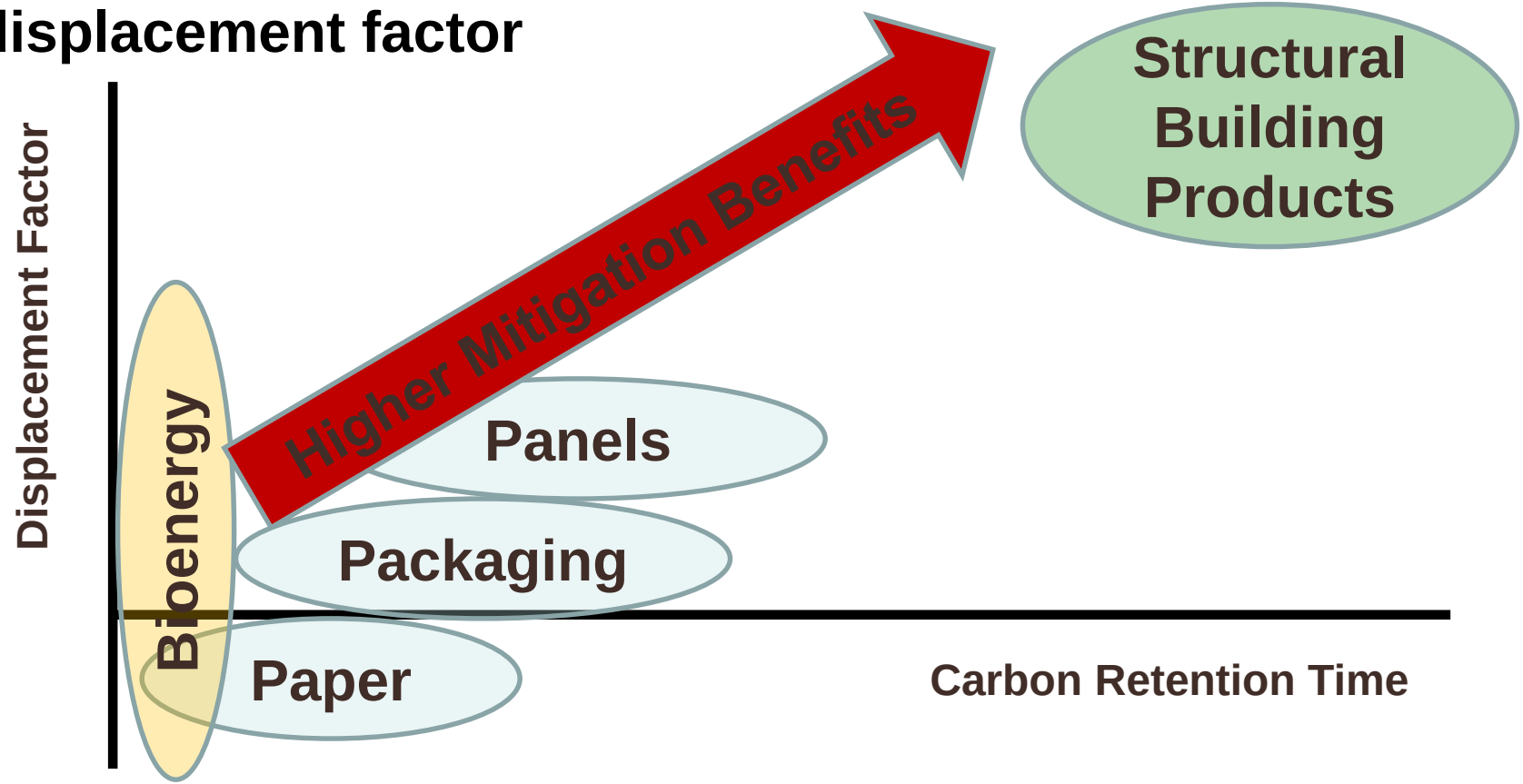
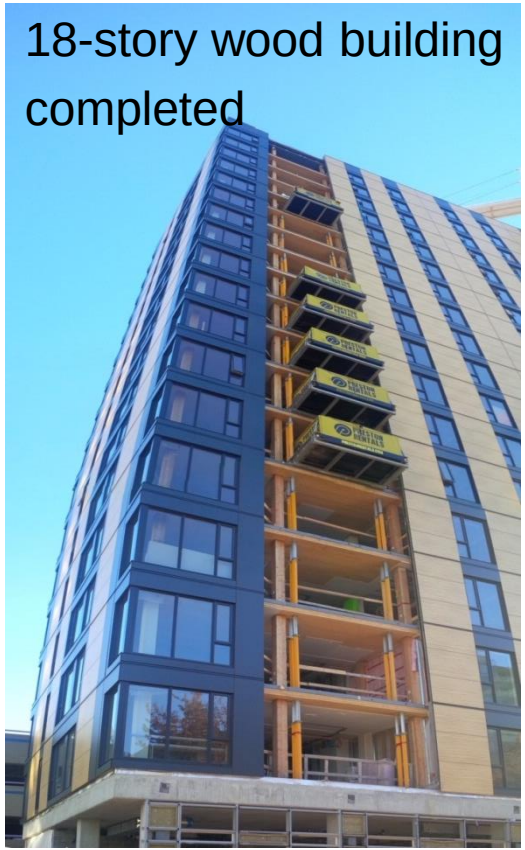
Mitigation benefit increases with carbon retention and displacement factor



Mitigation benefits by displacing emissions from concrete and steel through the use of wood products

Art Gallery of Ontario
Toronto, Ontario



18-story wood building completed

35-story wood building planned

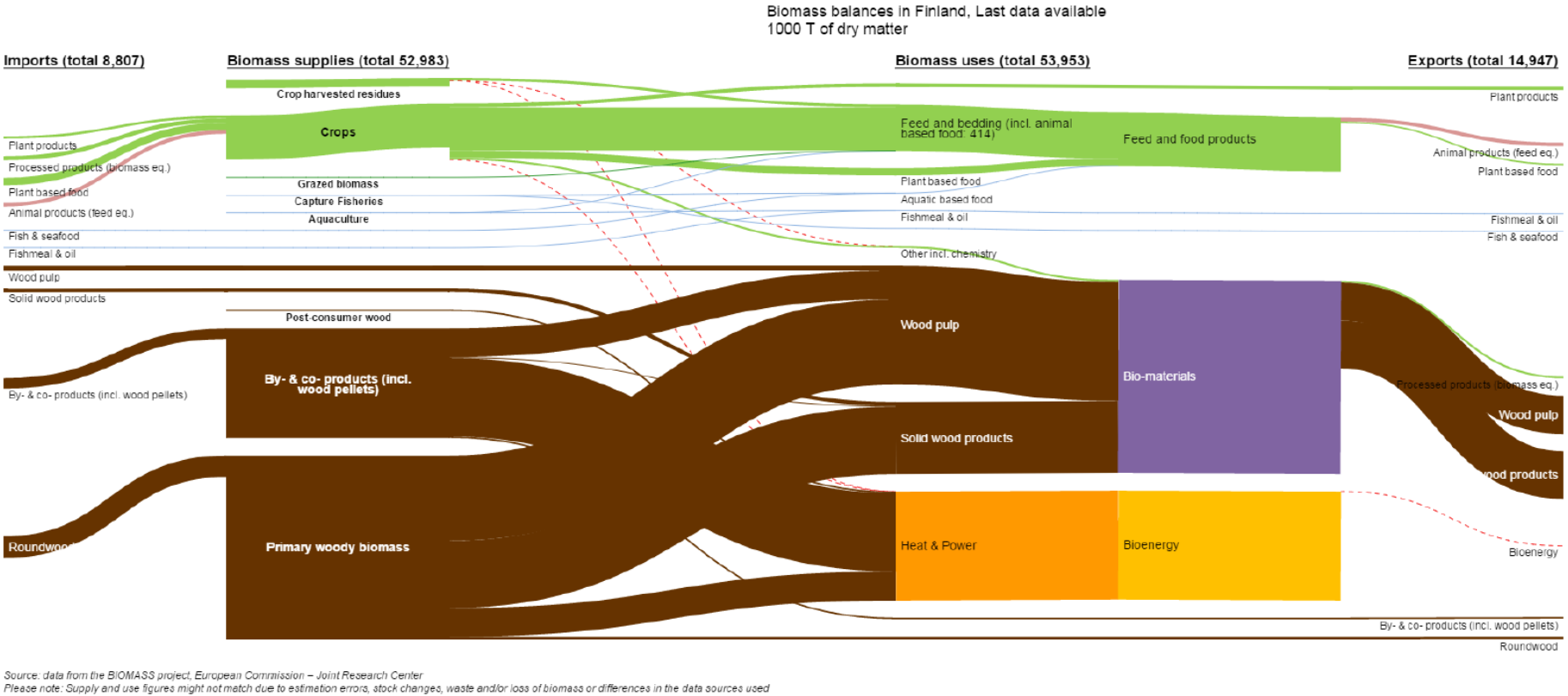
Source: Perkins and Will

Required Displacement Factors

- Required Displacement Factors (Seppälä et al. 2019) to evaluate the impacts of increased harvest on net GHG balance.
- The RDF quantifies the required displacement for all wood products and bioenergy manufactured and harvested in a certain country in order to achieve zero CO_2 equivalent emissions from increased forest utilization in comparison with a baseline harvesting scenario.
- Opportunities exist to increase the DF through forest management and through wood uses (e.g. more long-lived products) but in the Seppälä et al. study – the RDF was about twice the current DF.
- They argue that increasing harvest does not contribute to climate change mitigation.

A large proportion of all harvested wood is used for short-lived products and bioenergy

Finland, Full trade



Source: data from the BIOMASS project, European Commission – Joint Research Center
Please note: Supply and use figures might not match due to estimation errors, stock changes, waste and/or loss of biomass or differences in the data sources used

Source: Guirra et al 2017, JRC.

10 steps towards forest sector mitigation

- Improve GHG balance: increase sinks (grow more trees, faster) and reduce sources (thinning to capture mortality and fuel management)
- Avoid land-use change (deforestation)
- Use harvested trees first for long-lived harvested wood products (HWPs)
- Maximize carbon retention in HWPs and reduce wood waste at every stage
- Maximize avoided emissions through wood use
- Do not burn residues or waste unless energy is captured
- Conserve forests in areas of high conservation value and at low risk of natural disturbances
- Anticipate climate change impacts and align mitigation and adaptation objectives
- Monitor consequences of carbon management actions
- Obtain public support to use forest sector in climate change mitigation strategies

Research needs

- Develop and assess forest sector climate change mitigation strategies, including interactions with, and risks from climate change impacts.
- Quantify interactions between land management and non-GHG impacts on the earth system (albedo, VOCs, etc.).
- Evaluate the potential, costs, and impacts of strategies aimed at protecting forests and enhancing their productivity through active forest management.
- Design bioeconomies that are based on principles of sustainable land management, cascading wood uses, and high substitution benefits while also meeting other socio-economic goals.
- Quantify substitution benefits through wood use by improving life cycle analyses and the understanding of consumer responses to changes in product availability.
- Develop monitoring programs that determine the GHG benefits of mitigation actions relative to the business-as-usual baseline
- Quantify cost of mitigation to inform the public about the investment outcomes.

Conclusions

- Keeping temperature increase to below 2 ^{o}C requires **net negative emissions** before 2100, within the **lifetime** of children born today!
- Requires **drastic reductions of emissions** in all sectors.
- Not achievable without also greatly increasing **forest sinks**.
- But forests are also at **risk from climate change**.
- **We still have options** – but the longer we delay action, the more severe the consequences will be.
- Forest sector can make a significant contribution – but must also address vulnerabilities to climate change impacts.

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Publications at:

http://cfs.nrcan.gc.ca/publications/search?query=Kurz

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Recent Publications

Kurz et al. 2016. **Climate change mitigation through forest sector activities: principles, potential and priorities**. Unasylva 246 (67): 61-67. www.fao.org/3/a-i6419e.pdf

Lemprière et al. 2017. **Cost of climate change mitigation involving's Canada's forest sector.** Canadian Journal of Forest Research. DOI: 10.1139/cjfr-2016-0348 http://www.nrcresearchpress.com/doi/pdfplus/10.1139/cjfr-2016-0348

Smyth et al. 2016. **Climate change mitigation potential of local use of harvest residues for bioenergy in Canada**. Glob. Chg. Biol. Bioenergy. DOI: 10.1111/gcbb.12387 http://onlinelibrary.wiley.com/doi/10.1111/gcbb.12387/abstract

Smyth et al. 2016. **Estimating product and energy substitution benefits in national-scale mitigation analyses for Canada**. Glob. Chg. Biol. Bioenergy. DOI: 10.1111/gcbb.12389 http://onlinelibrary.wiley.com/doi/10.1111/gcbb.12389/abstract

Xu et al. 2017. **Climate change mitigation strategies in the forest sector: biophysical impacts and economic implications in British Columbia, Canada**. Mitigation and Adaptation Strategies for Global Change. DOI: 10.1007/s11027-016-9730-z http://link.springer.com/article/10.1007/s11027-016-9735-7.