Forests and Carbon: Positive Feedback to Climate Change or Opportunities for Climate Mitigation?

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NoFC, Edmonton, AB
PFC, Victoria, BC

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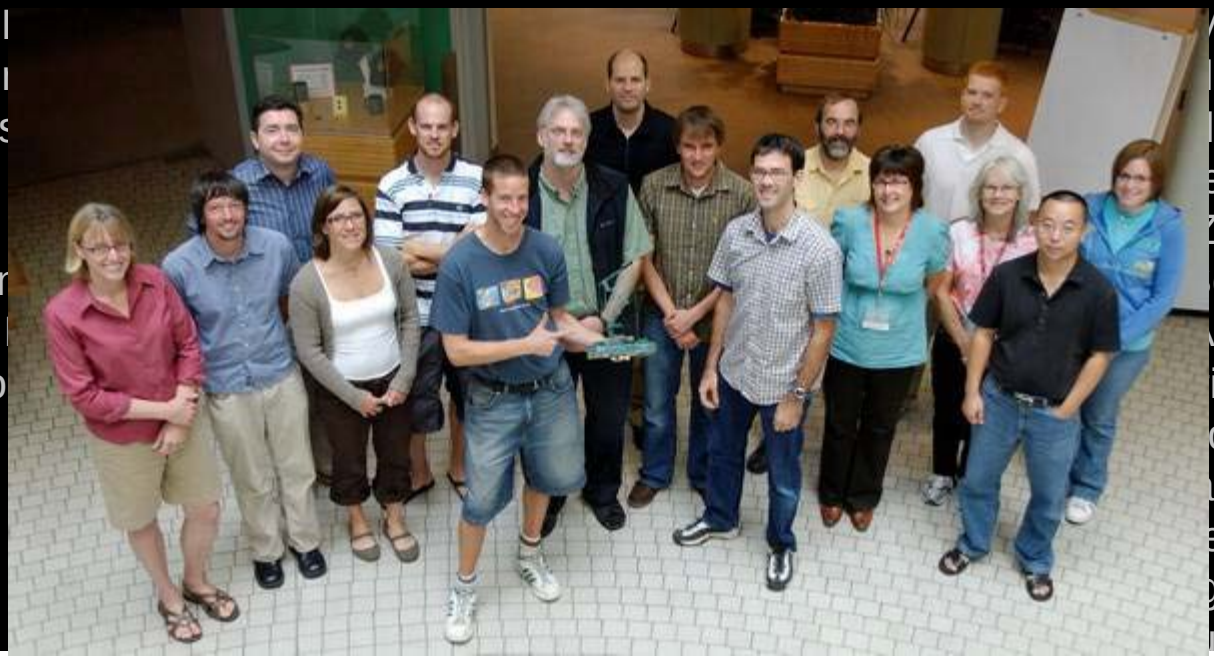
A Team Effort!

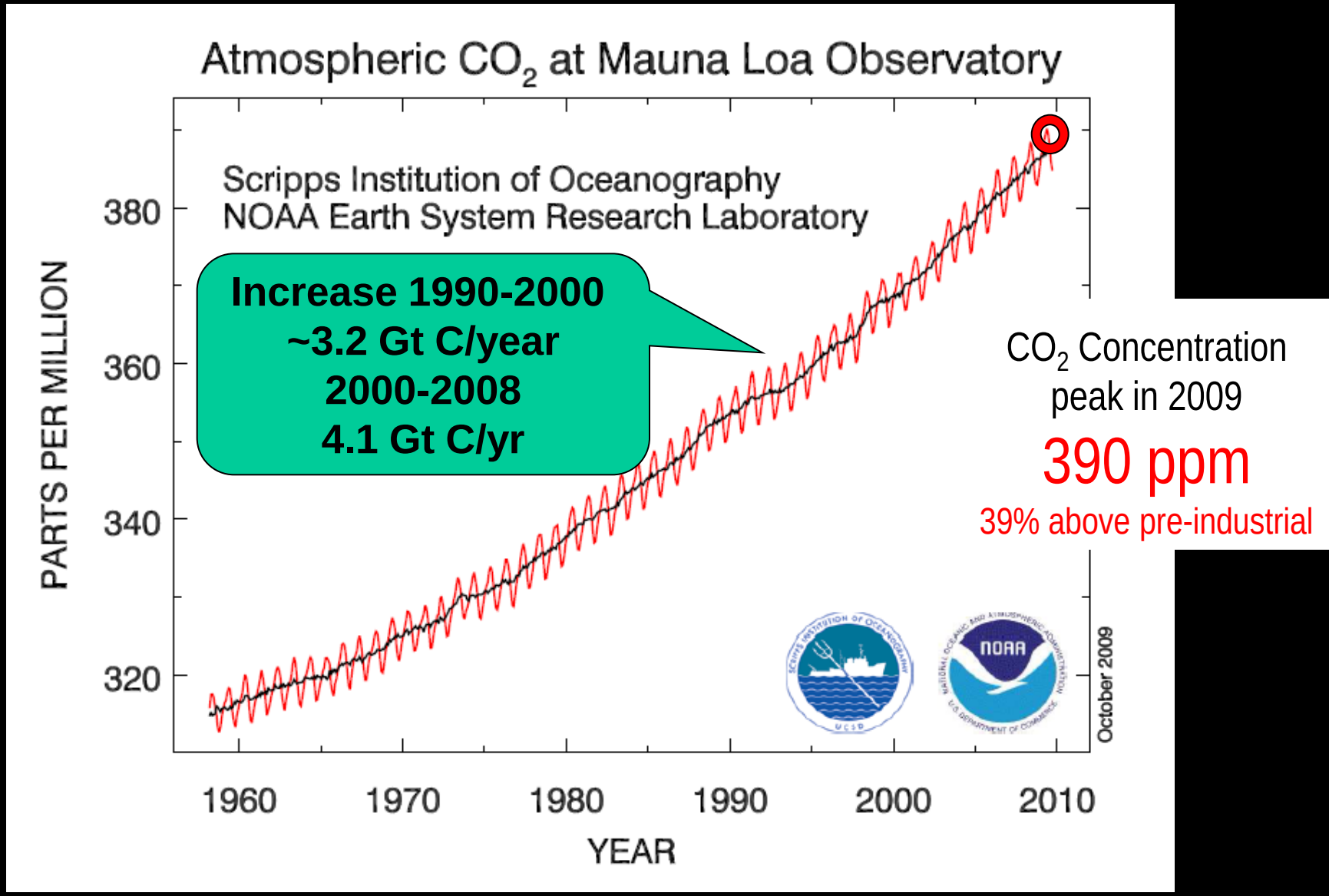


- CFS Carbon Accounting Team in Victoria and Edmonton in close cooperation with CFS policy community in Ottawa
- For national-scale analyses input from Resource Management Agencies in all Provinces and Territories
- Collaboration with scientists in CFS, universities in Canada and abroad, IPCC colleagues, and <u>many</u> others …

Outline

- Forests and the global carbon cycle
- Carbon balance in Canada's managed forest
  - Past
  - Future
- Mitigation options in the forest sector
- Conclusions

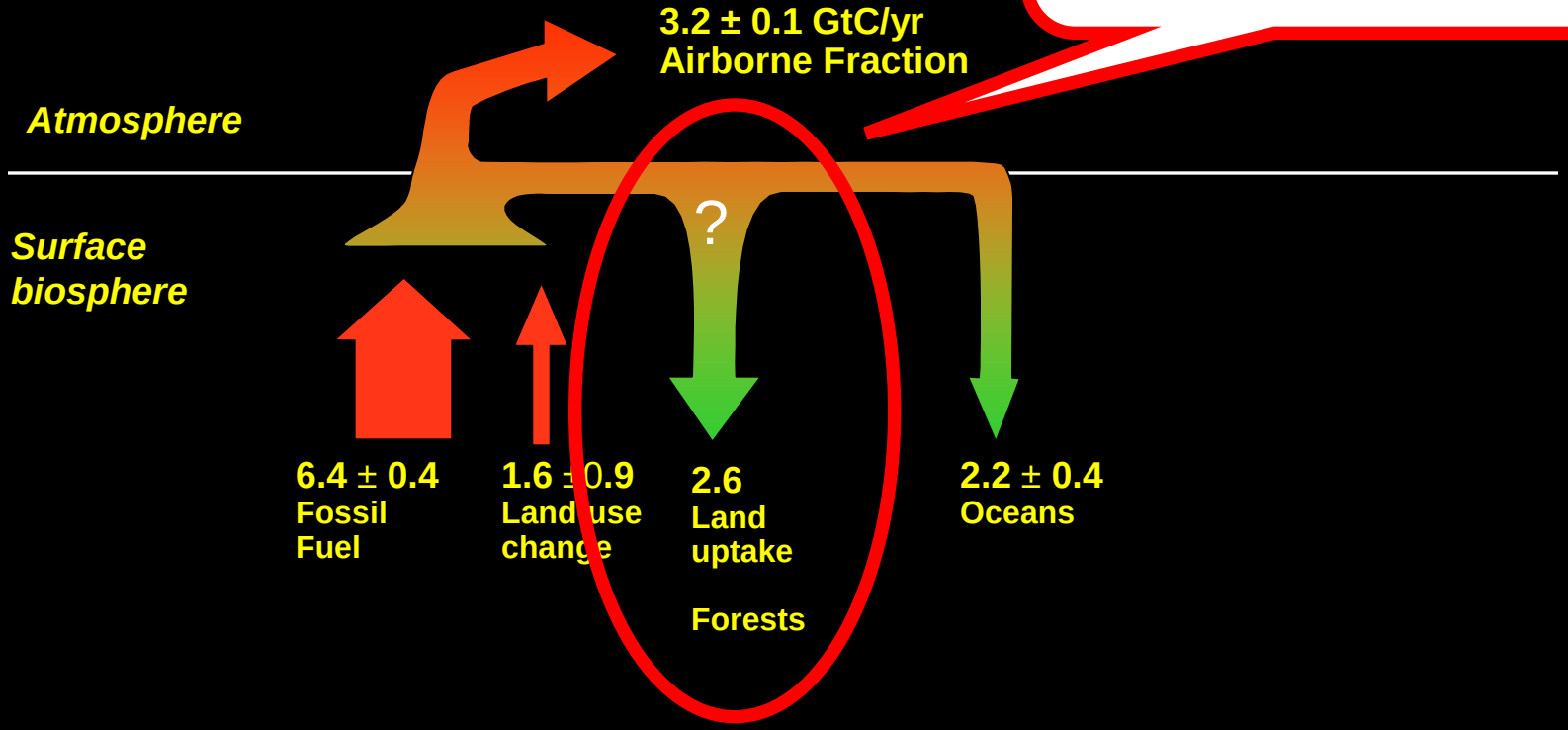
Increase in Atmospheric CO_2 Concentration



Human Perturbations to the Global C Cycle

Airborne Fraction: ~45% of *human* emissions stay in the atmosphere:
8.0 Pg emitted but only 3.2 Pg remain.
AF stable despite increases in emissions.

Forests will affect the future CO_2 concentration.



Data for 1990s from IPCC 2007

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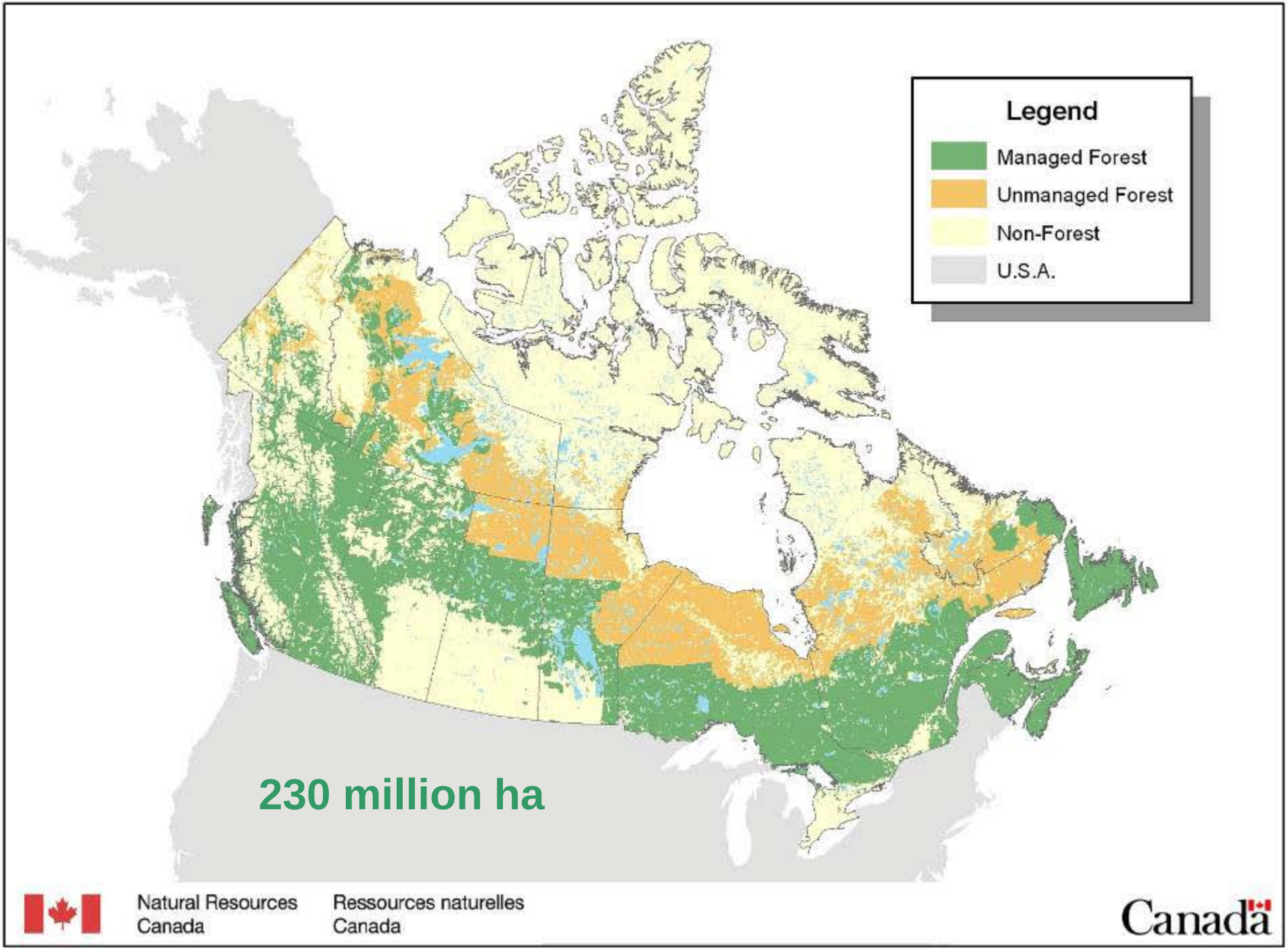
Canada's National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS)

Reporting of GHG balance to EC for National GHG Inventory Reporting.

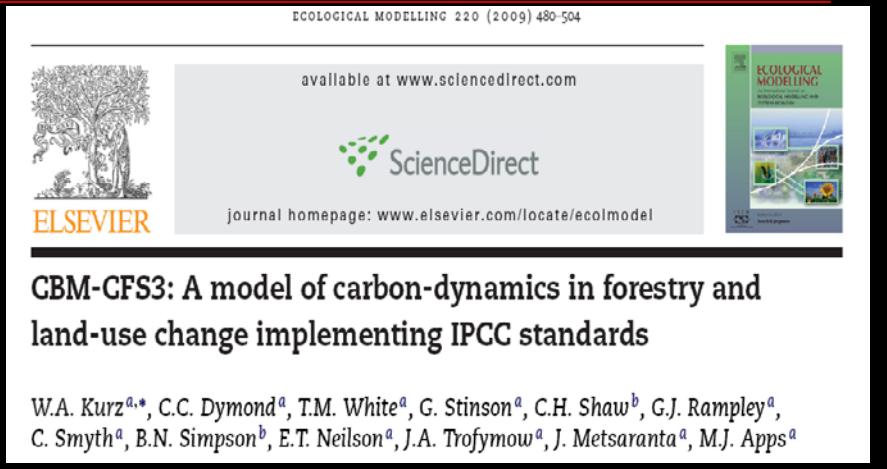
Analyses in support of policy development and negotiations.

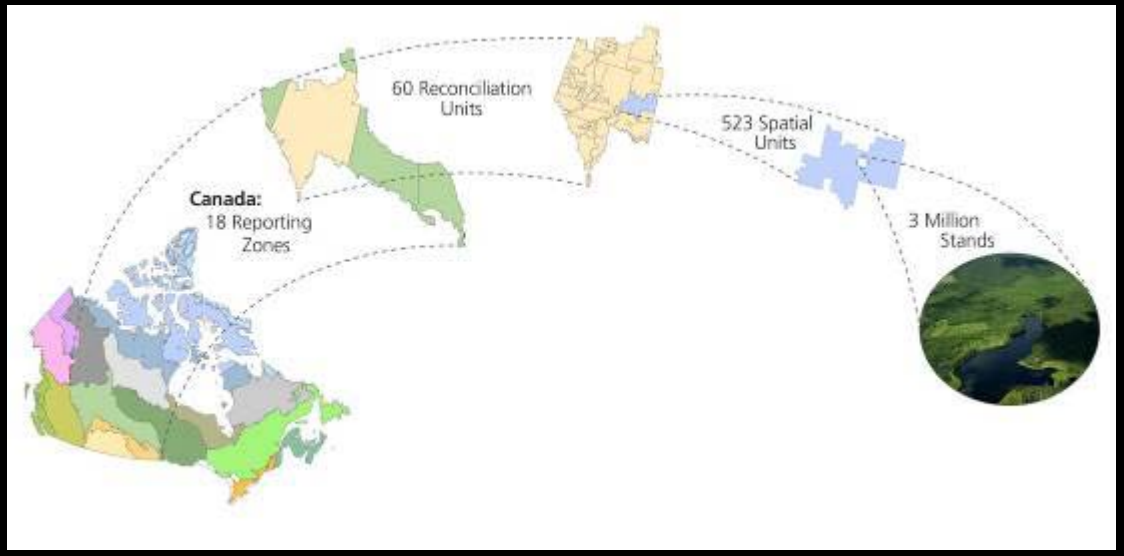


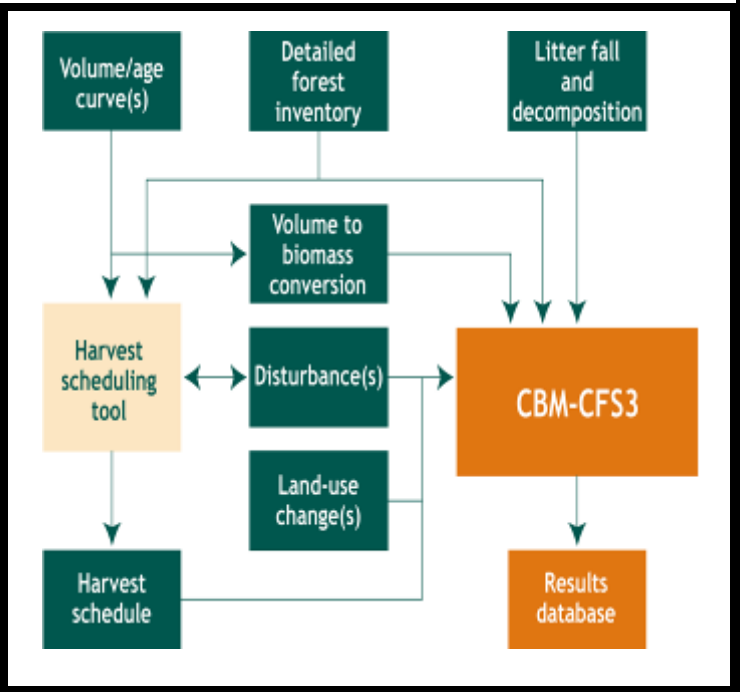
Natural Resources Canada
Ressources naturelles Canada
Canada

Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)

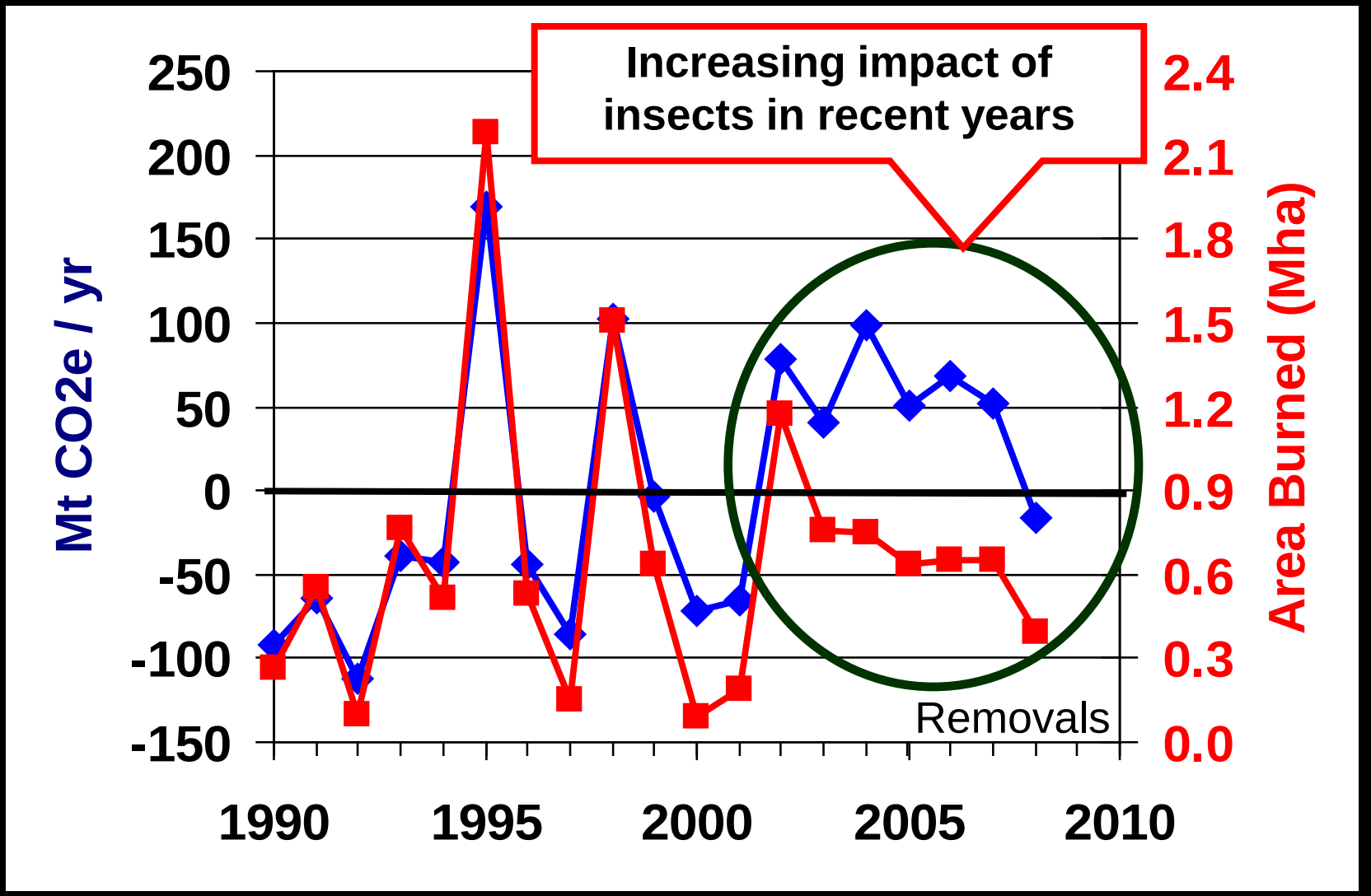
- Stand to landscape-scale model of forest ecosystem C dynamics developed to assess the past, present and future role of Canada's forests in the global C cycle.
- Uses empirical data from forest management planning
- http://carbon.cfs.nrcan.gc.ca







Large interannual variation in GHG balance resulting from wildfires



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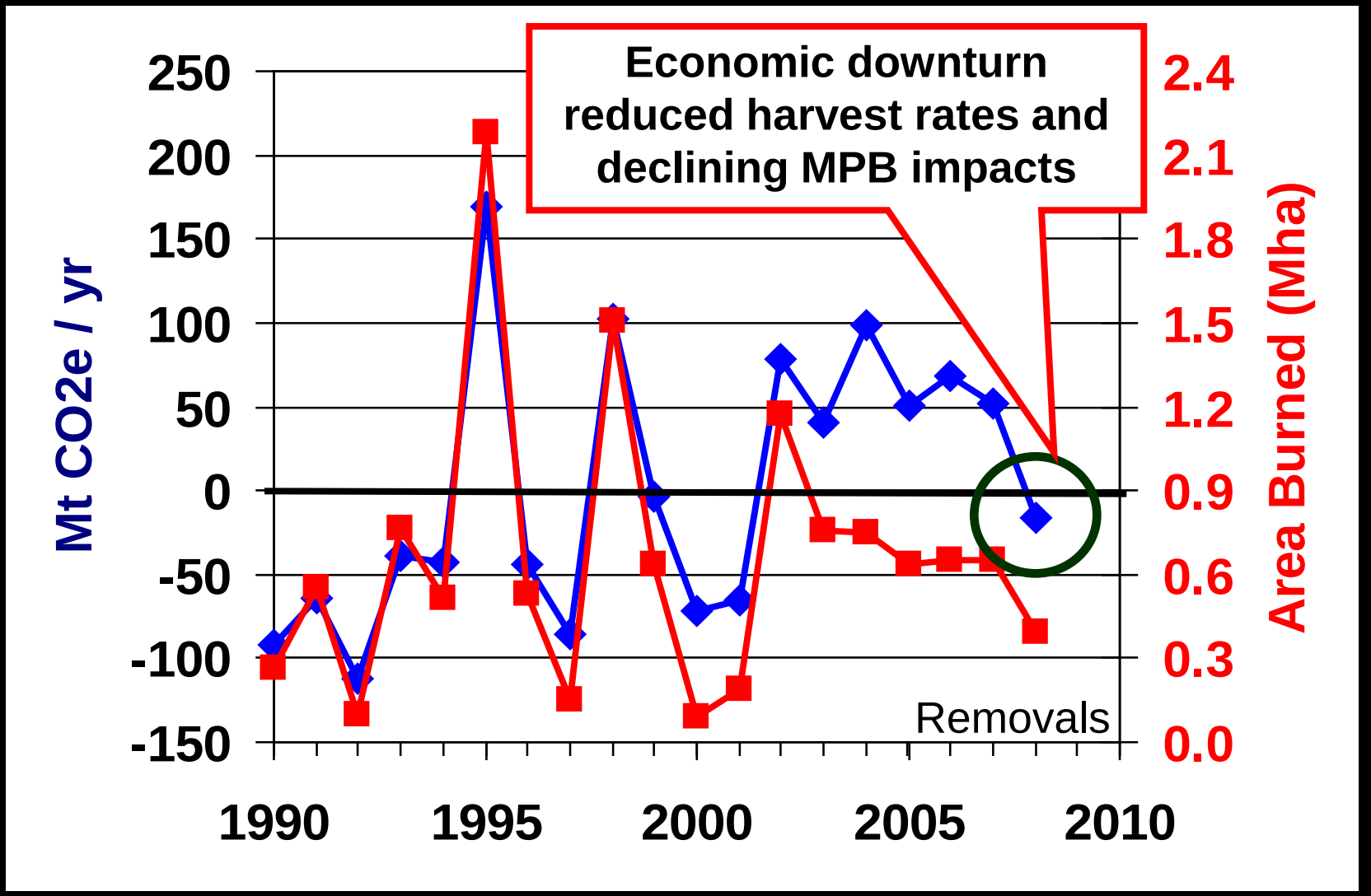

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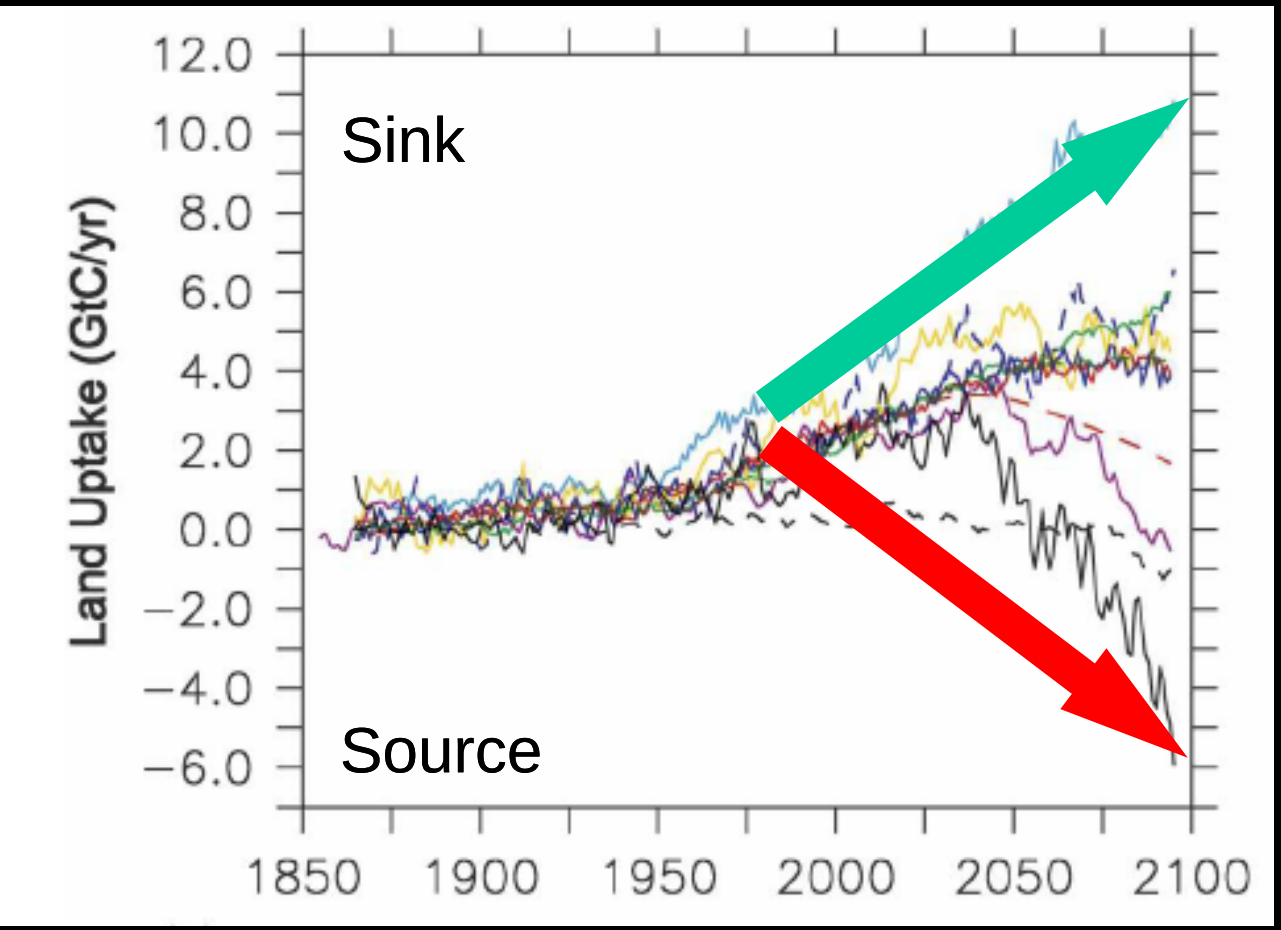
Climate Change impacts on forest carbon balance will affect the required level of mitigation efforts



Negative Feedback

Sink increases with climate change

Positive Feedback

Sink decreases with climate change

Source: Friedlingstein et al., 2006

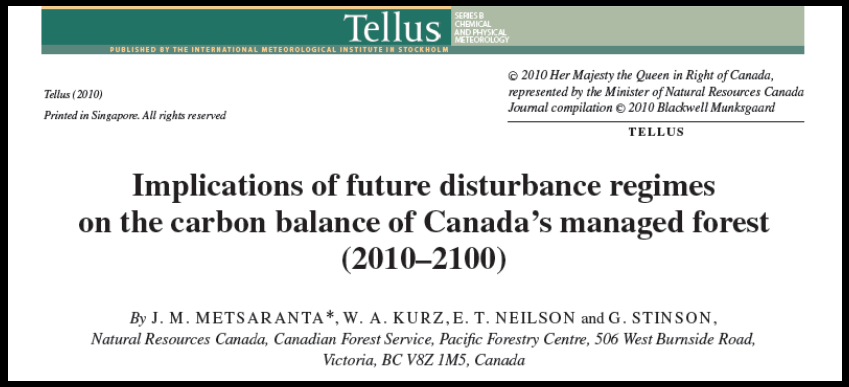
Climate Change and Forests: Multiple Interacting Effects

Changes in Fire Regime
- Future fire weather may be more severe
- Increase in annual area burned?

Changes in soil C decay rates
- Increase due to warmer temperatures?

Changes in productivity
- Increase due to, e.g. CO2 fertilization?
- Decrease due to, e.g., drought?

1. Effect of Increasing Area Burned Nationally



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TELLUS

Implications of future disturbance regimes on the carbon balance of Canada's managed forest (2010–2100)

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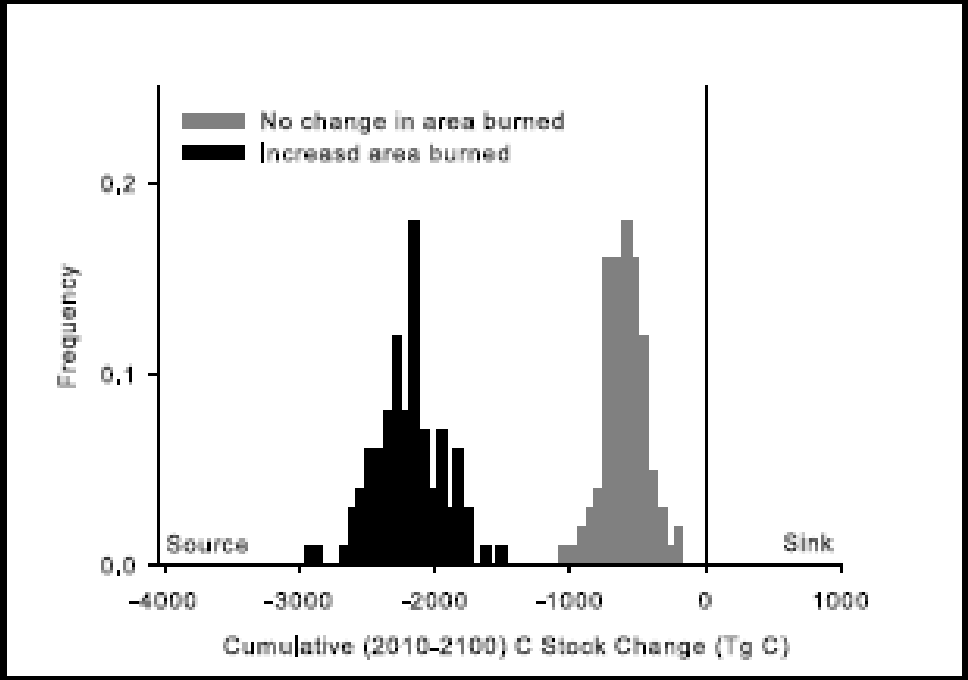
- Scenario 1: Annual area burned in the 21st century is similar to late 20th century observations (1959-1999)
- Scenario 2: Area burned increases between 2010 and 2100 by
  - factor 2 eastern Canada & BC (Flannigan et al. 2001)
  - factor 4 in western Canada (Balshi et al. 2008)

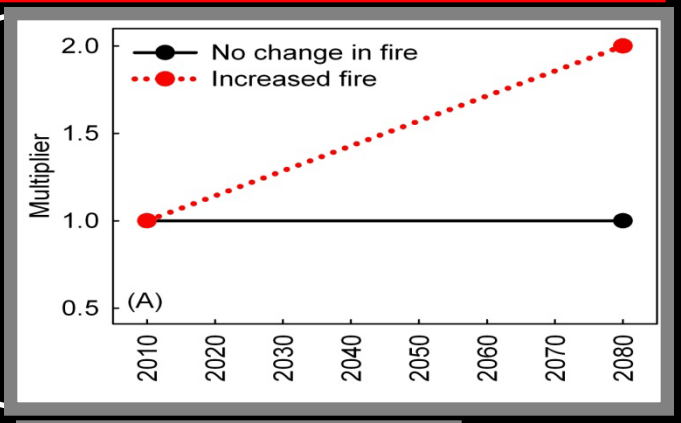
Cumulative C Stock Change (2010 to 2100)

- All runs under both scenarios are large cumulative sources
- Managed forest will have declining C stocks over the 21st century, whether area burned increases or not.

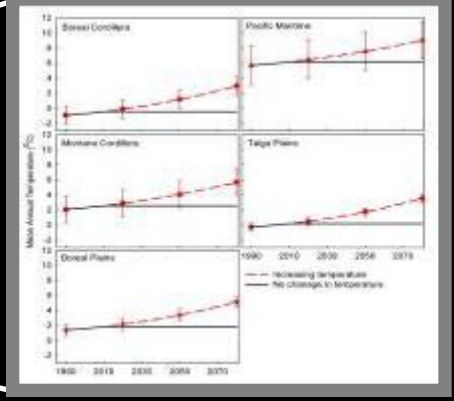


2. Interactive Effects Regionally (British Columbia)

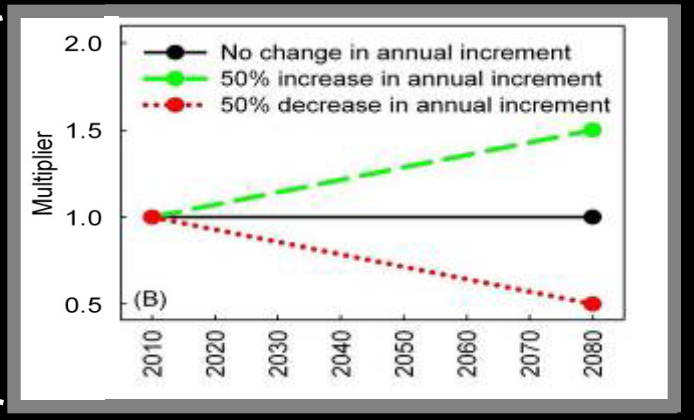
Forest Fire
(Gradual doubling 2010 to 2080)



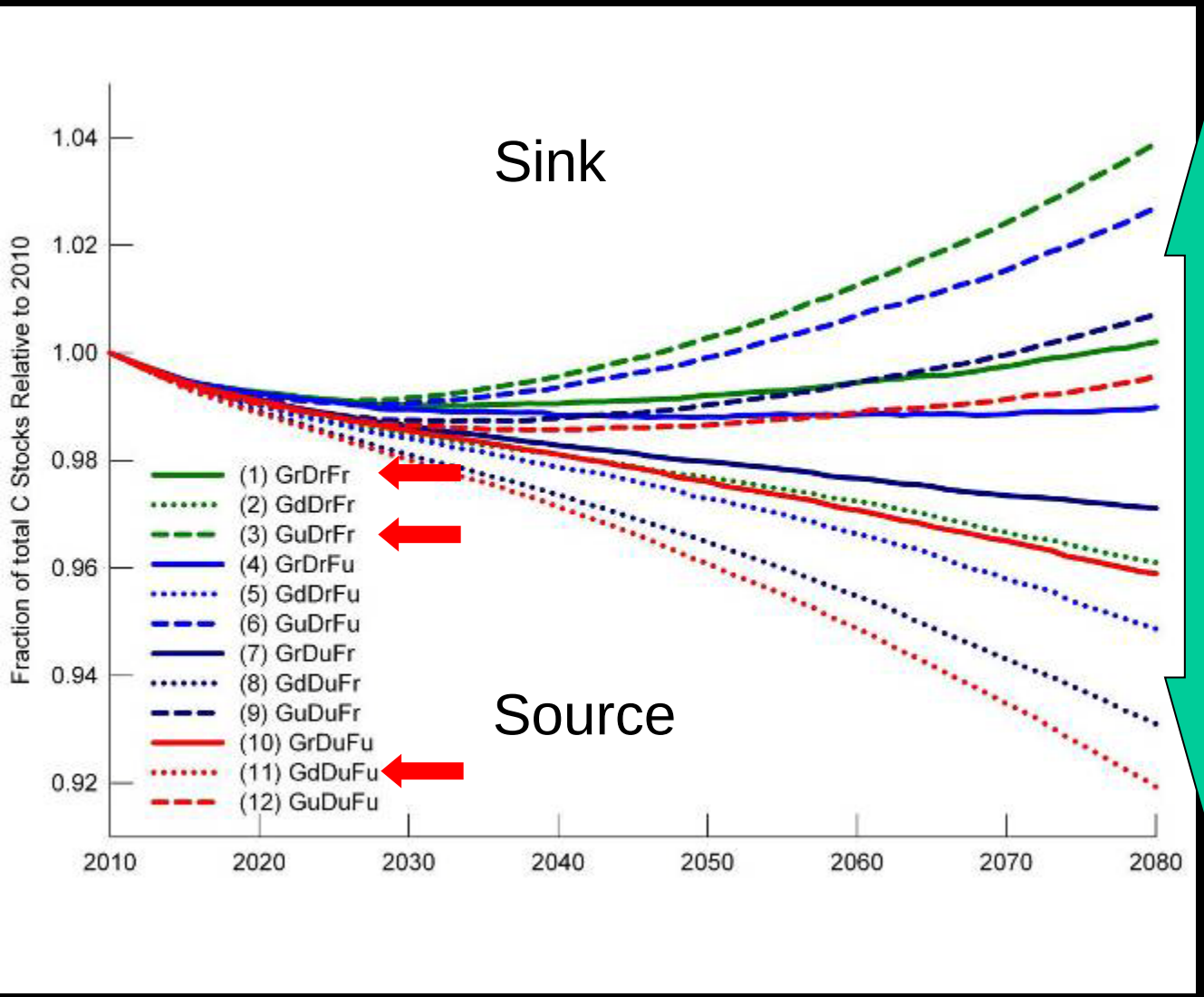
Decay
(CGCM A2 = warmer temperatures)



Productivity
(Up or Down)



Uncertainty in response of BC Forests: twice the annual emissions from all other sectors



Difference between endpoints of 12 realistic scenarios:

2.4 Pg C or

126 Mt CO_2e yr^{-1} over 70-yr period

BC emissions in 2007: **~65 Mt CO_2e**

Metsaranta JM, Dymond CC, Kurz WA, Spittlehouse D. in review

Feedback to Climate Change

- Climate changes will affect many processes (growth, decay, disturbances) with large differences between ecosystems and regions.
- Currently not able to predict net impacts, but …
- **Asymmetry of risks:** unlikely that productivity increases can off-set increased disturbance losses (Kurz et al. 2008).
- **Monitoring and modelling** required to quantify direction and magnitude of feedback.

Feedback to Climate Change

- Forests' response to climate change has the potential to provide positive feedback to future climate change through increased emissions that **could completely negate the benefits of mitigation efforts in all other sectors.**

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Does the Forest Sector have a Role in a Climate Change Mitigation Portfolio?

- Despite potential impacts of climate change, human activities in forest sector can contribute to mitigation objectives by reducing sources & increasing sinks, relative to a baseline.
- Future forest C budgets are affected by many processes and factors – age-class legacy, recovery from past land-use, climate change impacts, etc.
- Need to evaluate mitigation benefits relative to a **"forward looking baseline"** and seek to improve C balance relative to this baseline through directed mitigation efforts.
- Merely claiming credit for existing sinks does not contribute mitigation benefits.
- Reducing a source does contribute to mitigation objectives.

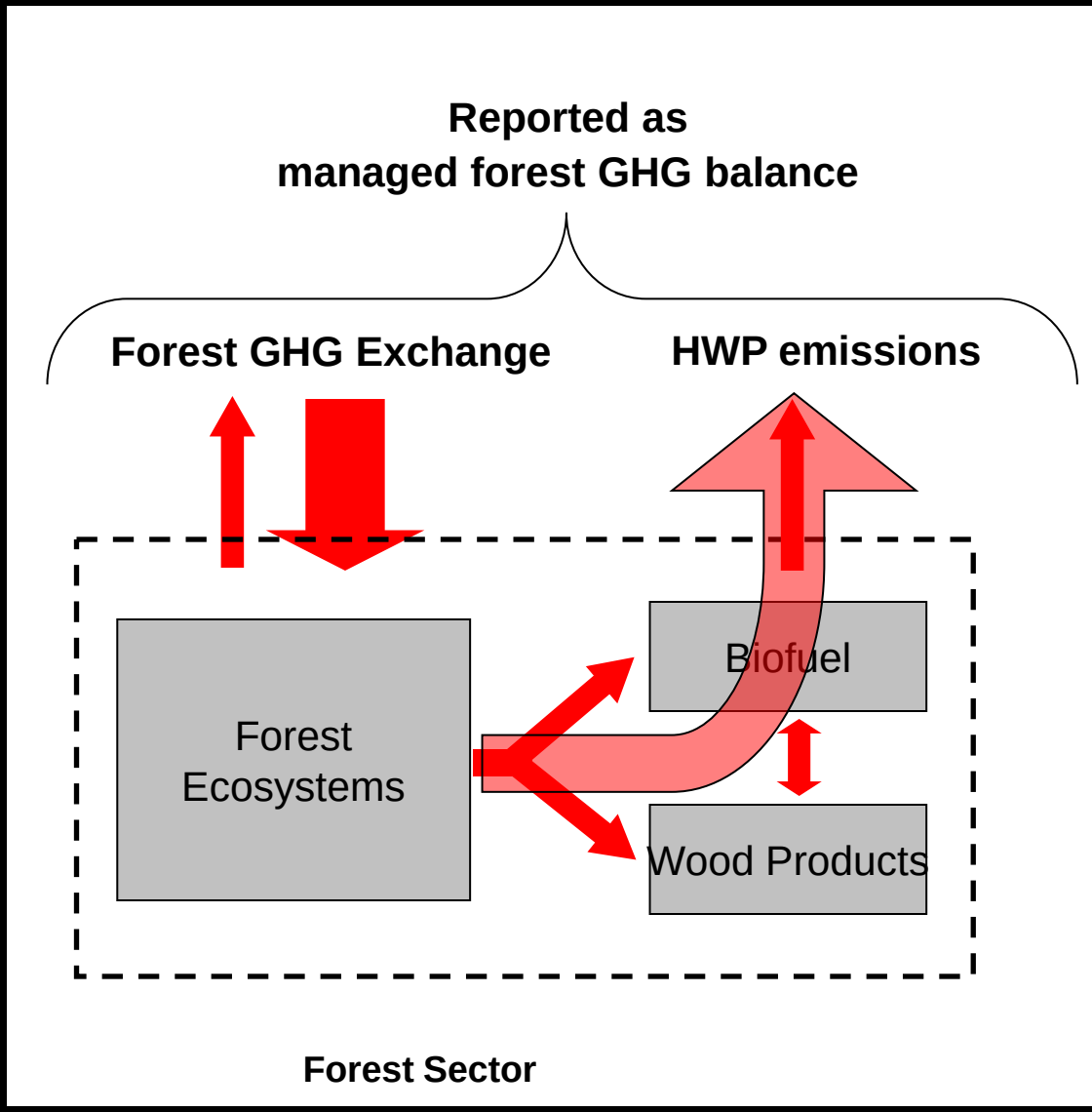
Mitigation Options in the Forest Sector

1. Increase (or maintain) forest area
   - Reduce deforestation (REDD), increase afforestation
2. Increase stand-level carbon density
   - Silviculture, avoid slashburning, reduced regeneration delays, species selection, fertilization, tree improvement programs
3. Increase landscape-level carbon density
   - Longer rotations, conservation areas, protection against fire
4. Increase C stored in products, reduce fossil emissions through product substitution and through bioenergy use

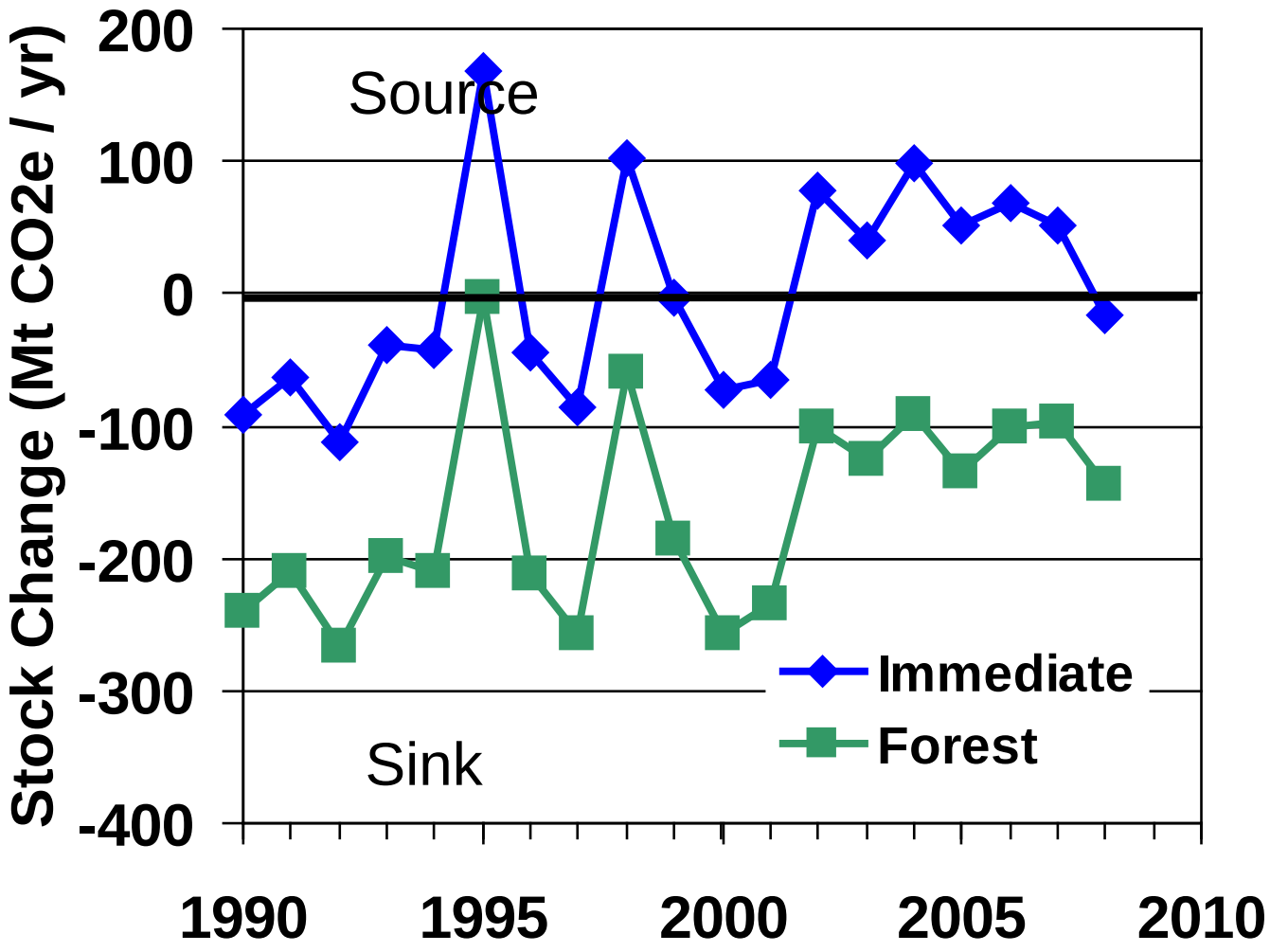
Source: Nabuurs et al. 2007, IPCC AR4

Accounting of Harvested Wood Products (HWP)

- Default assumption of 1996 IPCC reporting guidelines is that C added to HWP stocks this year replaces C lost through decay and burning of C harvested in prior years.
- Thus all harvested wood C is reported as immediately emitted to the atmosphere.
- HWP C stocks are assumed constant
- Data indicate that HWP in use and in landfills are increasing (e.g. Apps et al. 1999).



GHG Fluxes with and without immediate emissions of harvested carbon



Cumulative Sink:
Immediate emissions: 24 Mt CO_2e

Forest only: 3125 Mt CO_2e

3149 Mt CO_2e exported to HWP. 25 to 50% remaining in HWP and landfills?

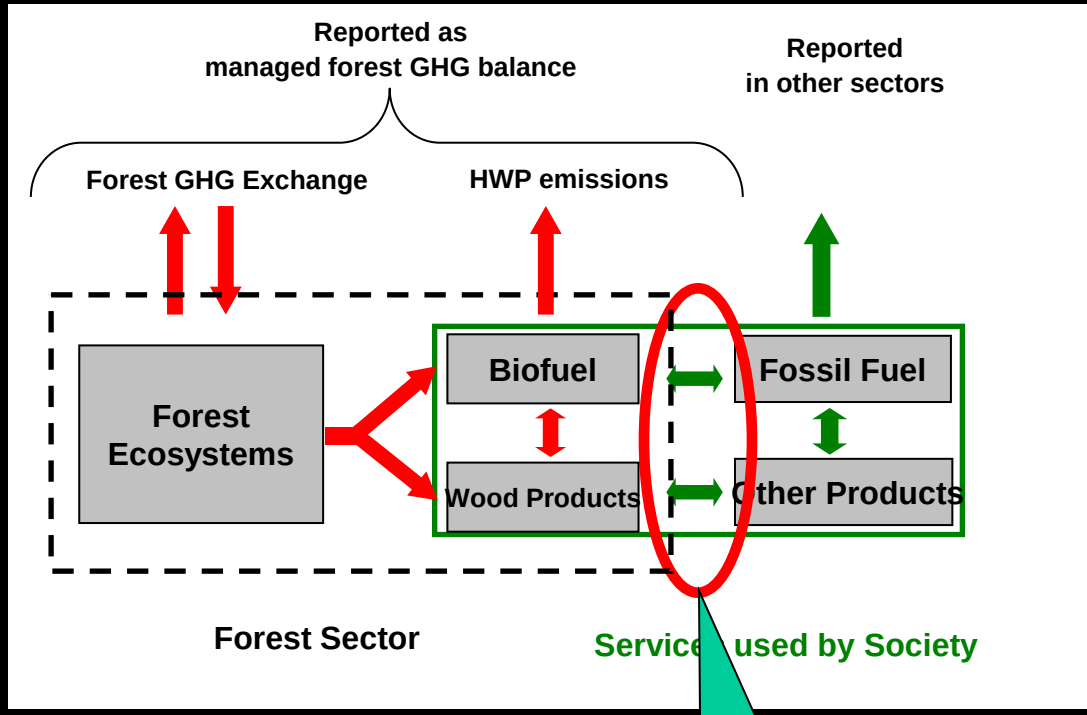
Stinson et al. In Review

Impact of UNFCCC reporting guidelines

- In Canada (1990 – 2008) ~3,150 Mt CO_2e are reported as emitted – but 25-50% of this remains stored in HWP
- Default assumption doesn't capture the timing or the location of actual emissions.
  - Many of the emissions occur outside Canada.
  - Same issue for all (net) wood exporting countries.
- Not reporting C stocks retained in HWP
  - creates **public misunderstanding** of forest management contribution to C cycle.
  - decreases incentives to manage C in HWP.

Substitution Benefits

- HWPs also meet societal demands that would otherwise be met with steel, concrete or plastics – all of which are energy-intensive to produce.
- Substitution benefits – where they do occur – cannot be accounted for in the forest sector
- They do result in real emission reductions observed in energy or production sectors.
- Therefore substitution benefits should be considered when developing mitigation policies in the forest sector.



How big are substitution benefits?

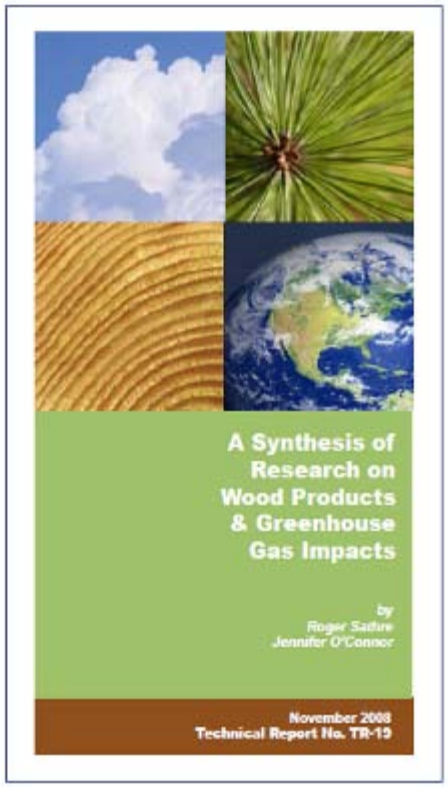
Meta-analysis of Displacement Factors

- Displacement factor (DF) quantifies the amount of emission reduction achieved per unit of wood used in products (i.e. substitution)
- DF includes all emissions of processing steps and substitution benefits and bioenergy.
- **Average DF was 2.0** in 48 studies.

But note that study did not include bioenergy systems:

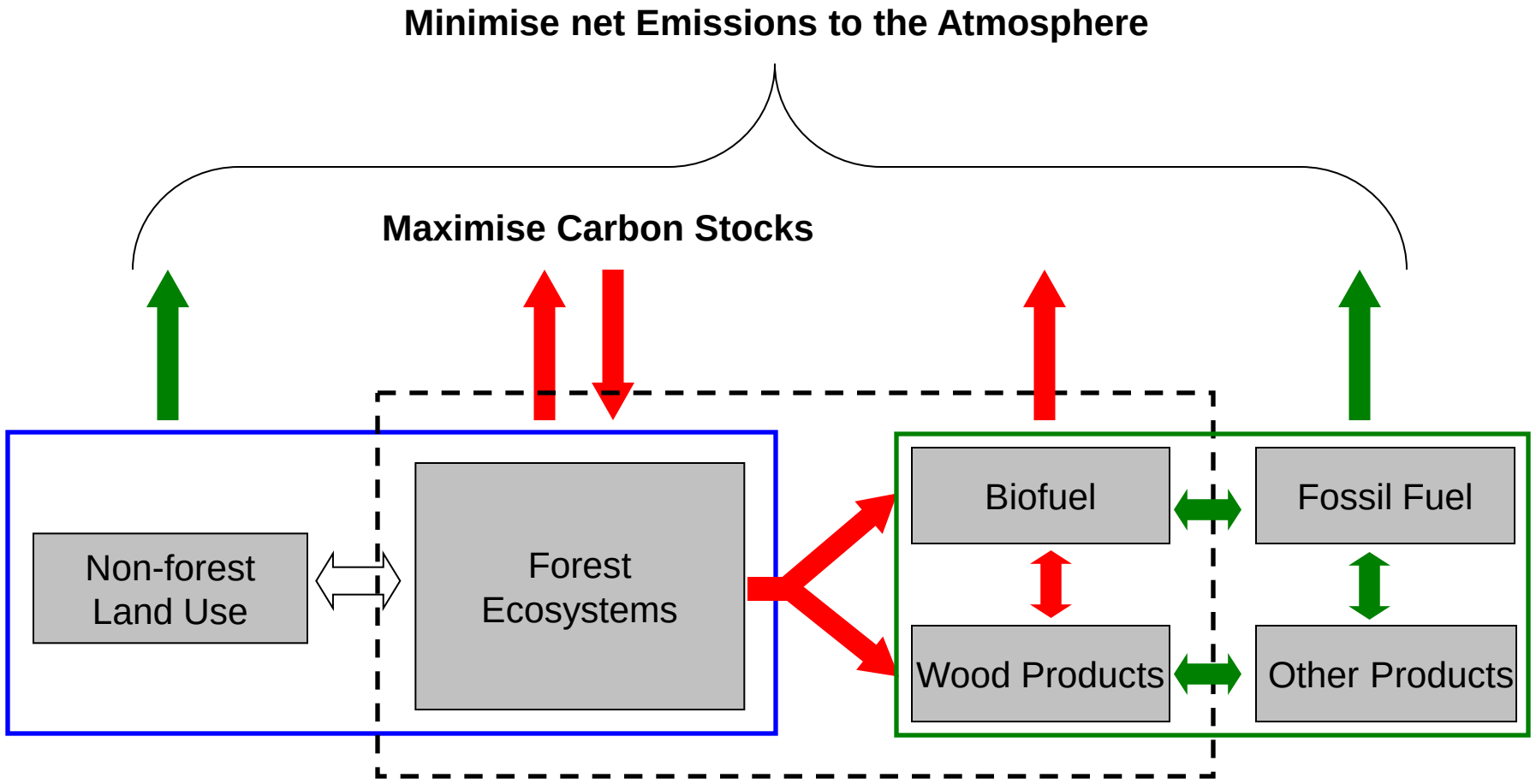
- DF of bioenergy is well below 1

… a consideration when designing mitigation portfolios?



Source: Sathre, R. and J. O'Connor 2008 and 2010

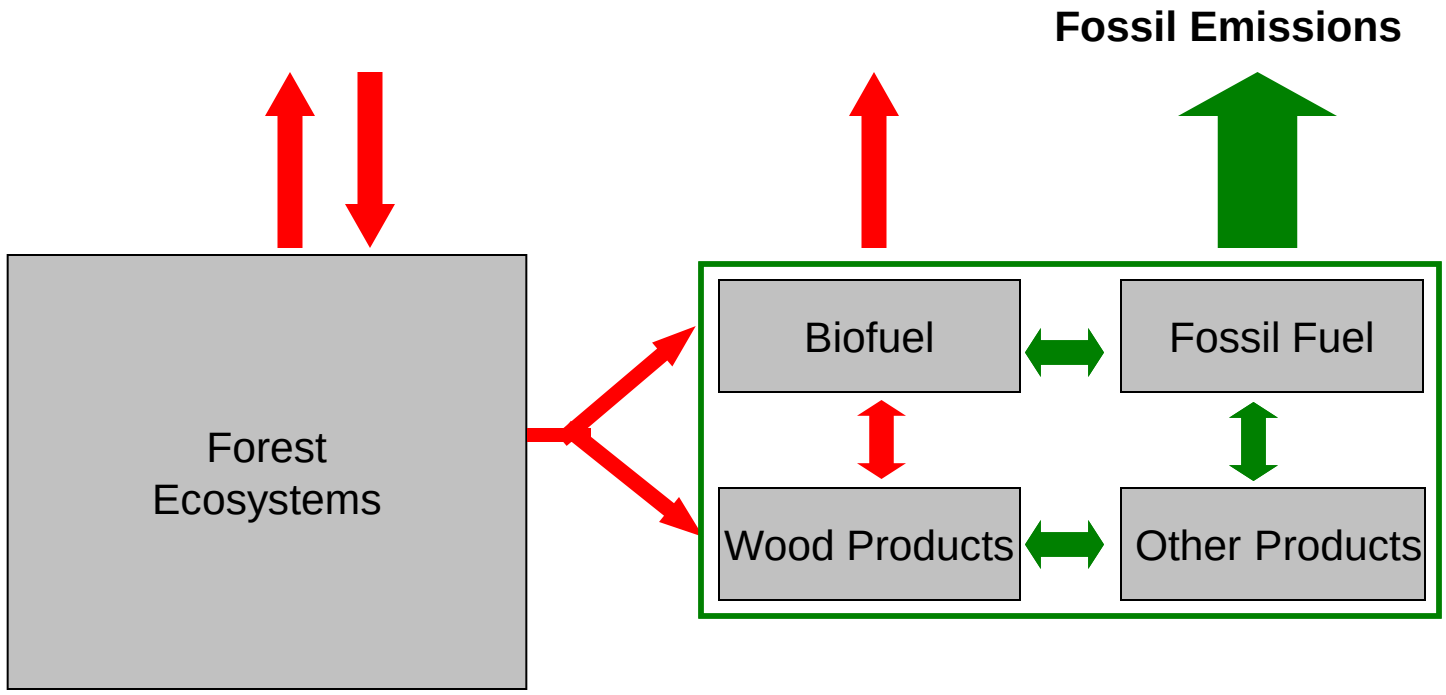
Forest Mitigation Strategies: What to Optimise?



Source: IPCC 2007, AR4 WG III, Forestry

Forest Mitigation Strategies: Two competing positions

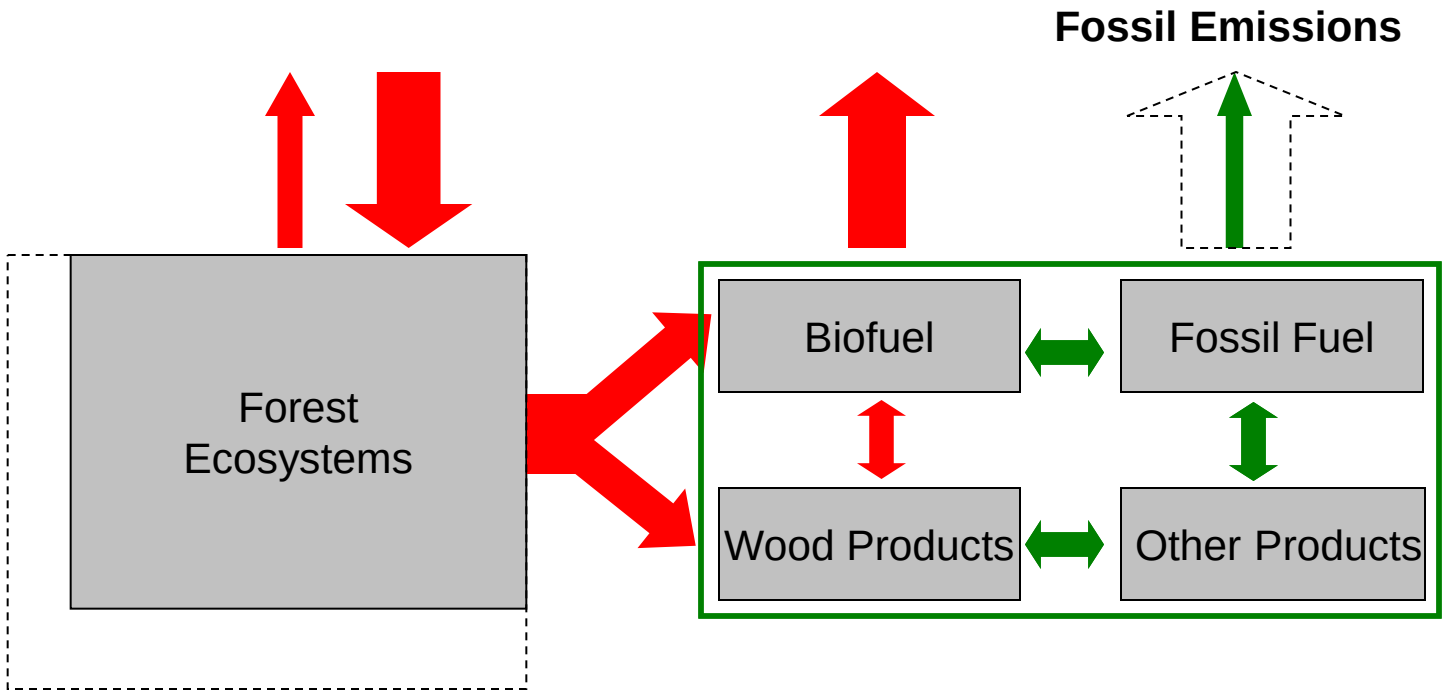
Maximise Carbon stocks ….



Services used by Society

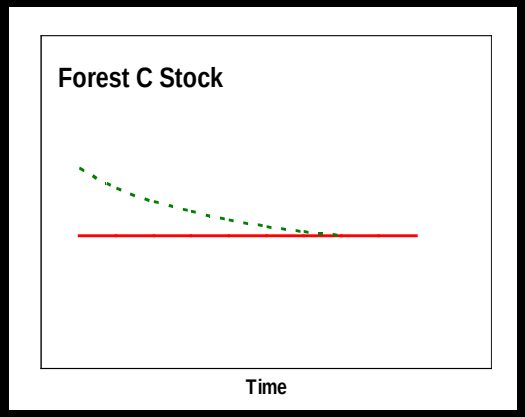
Forest Mitigation Strategies: Two competing positions

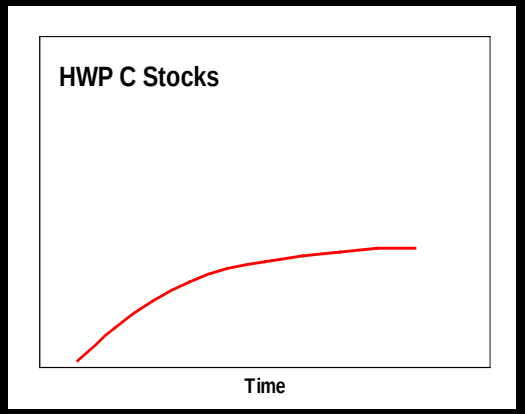
… or maximise Carbon uptake?

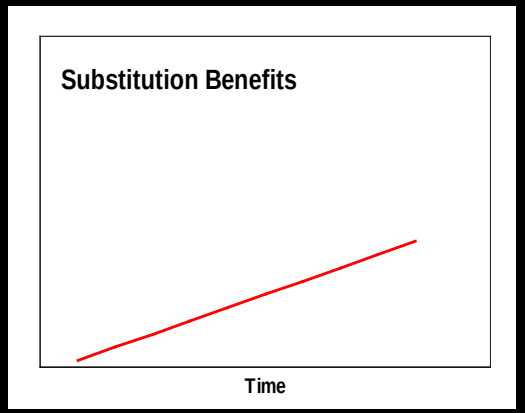


Forest Sector Carbon with SFM

- With SFM C stocks can be maintained
  - once transition from natural to managed landscape completed
- Harvested Wood Product C stocks eventually saturate
  - continuous increases in landfills possible – but because of CH_4 emissions not desirable
- Substitution benefits accumulate over time
  - a longer analysis period increases substitution benefits

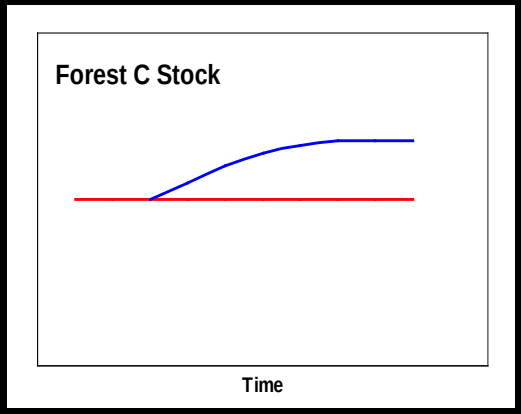


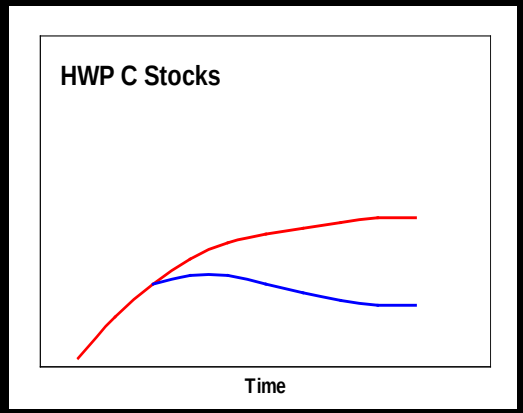


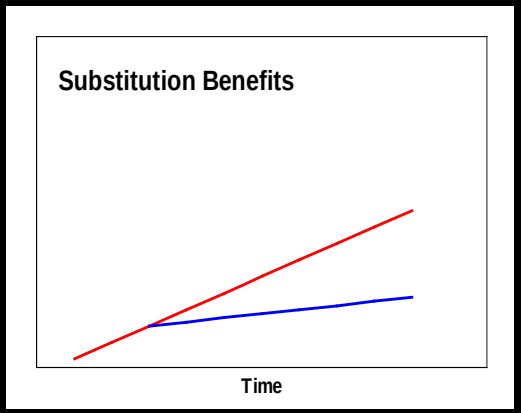


Forest Sector Carbon with Conservation Strategy

- With conservation strategy forest C stocks can increase
- Harvested Wood Product C stocks decrease to lower level
- Substitution benefits accumulate at slower rate.







Forest Sector C Mitigation Strategies

- **Relative advantage of each strategy depends on MANY factors and is not decided by C criteria alone.**
- Increasing C in forests, harvested wood products or bioenergy reduces C in one or both of the other pools.
- The magnitude of the trade-offs and the factors that affect these trade-offs need to be better quantified – as this is one area where mitigation opportunities exist
- Preliminary assessment of national forest sector mitigation potential by 2020 suggests that expectations have to be very modest.
- Increased potential in the longer term but to achieve this requires investment now.

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- Mitigation opportunities – i.e. reducing sources and increasing sinks relative to a baseline – exist in both forest management and the forest product sector.
- BUT - Limiting the impacts of climate change is one important step towards maintaining the mitigation potential of forests.
- Contributions to climate mitigation are achieved by:
  - Retaining carbon in wood products,
  - Using wood products to achieve substitution benefits,
  - avoiding disposal of wood products in landfills,
  - extracting energy from wood waste.
- Forest managers do not control end-use of products but that has a large impact on mitigation benefits.
- Designing effective climate mitigation portfolios requires quantification of GHG implications of alternative options.

Conclusions

- Scientific evidence continues to increase and support the IPCC conclusions that:

  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 (IPCC AR4, Nabuurs et al. 2007).

Conclusions

- Forests and forestry cannot solve the problem of fossil C emissions, but they can contribute to the solution.

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