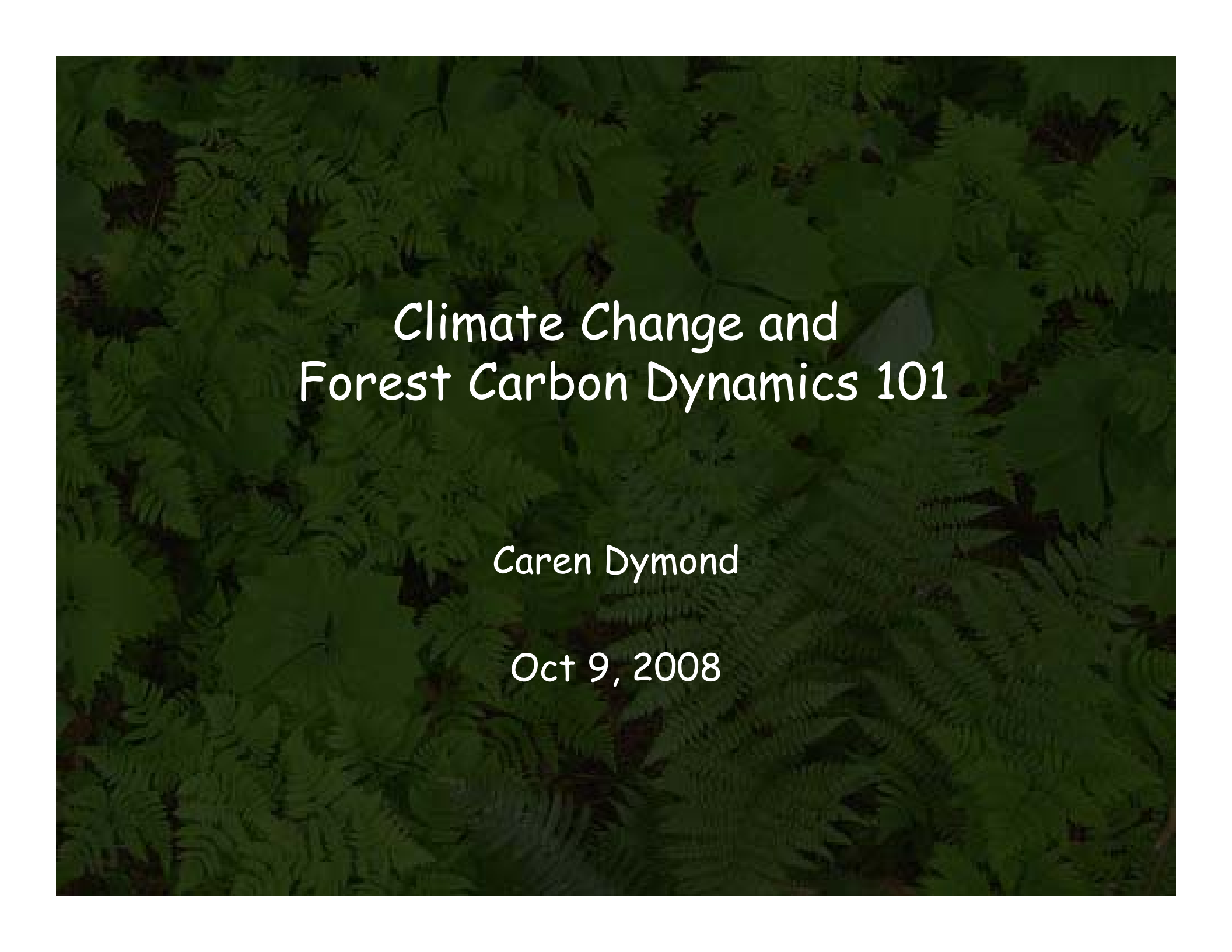




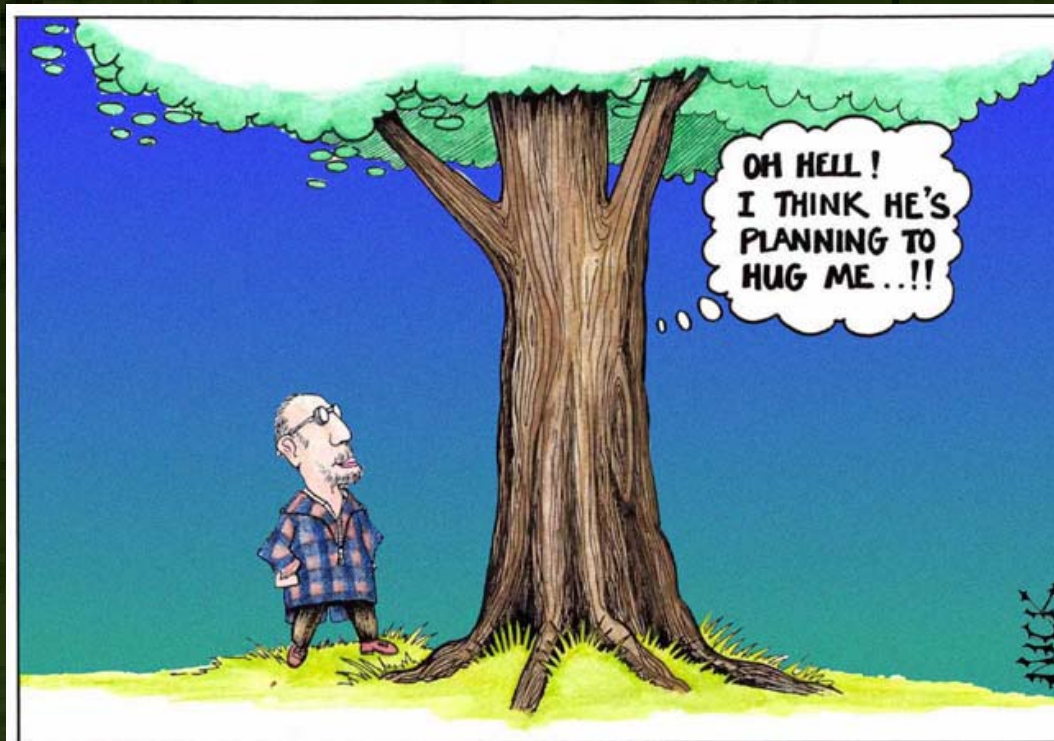
Climate Change and Forest Carbon Dynamics 101

Caren Dymond

Oct 9, 2008

Outline

- Climate change (the scientific basis)
- Impacts on forests
- Mitigation opportunities for the forest sector
- The role of forest carbon



Consider the trees. They have no legs to run with.

Global Change

- *Changes of importance for the forest sector:*
 - Atmospheric concentration of CO₂
 - Atmospheric N deposition
 - Atmospheric pollutants (e.g. O₃)
 - Climate change
- *Will affect:*
 - Water availability and water use efficiency
 - Nutrient availability
 - Species interactions (competition, pest dynamics, etc.)
 - Wildfire
 - Extreme weather (drought, wind, etc.)

Atmospheric CO₂

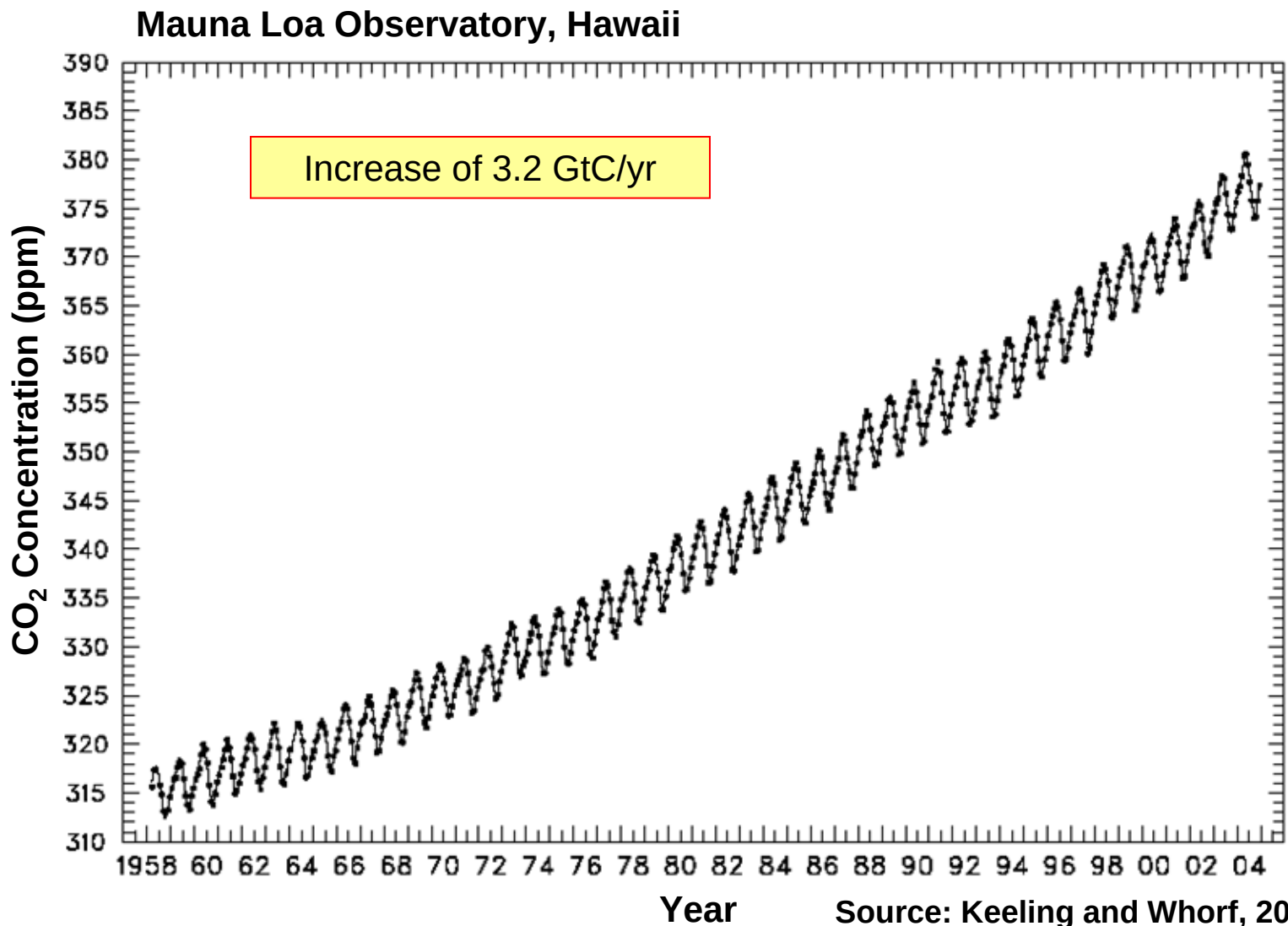
"On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground"

- Increased CO₂ in the air will increase ground temperatures.
- Stronger influence near the poles than near the equator.
- Stronger impact in the northern hemisphere.
- Diminished difference in temperature between day and night.

Svante Arrhenius (1859-1927), Stockholm University

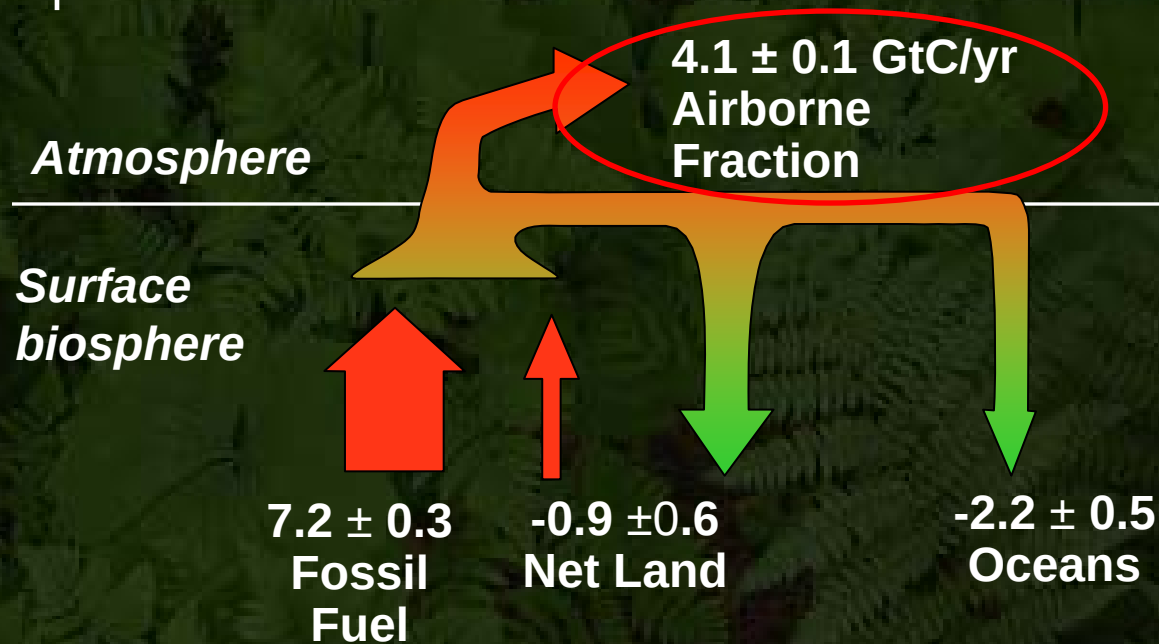
Philosophical Magazine 41, 237 (1896)

Atmospheric CO₂



Human Perturbations to the Global C Cycle

Land and ocean compensate somewhat for *human* emissions:
>8 up but only 4.1 remains in atmosphere



Atmospheric CO₂ Growth Rate Higher than Expected

Four main factors:

1. High economic growth rates
2. Increased energy intensity (energy used per GDP)
3. Reduced uptake by oceans
4. Reduced uptake by terrestrial sink

2007 Lowest Recorded Level of Arctic Sea Ice

Positive Feedback:

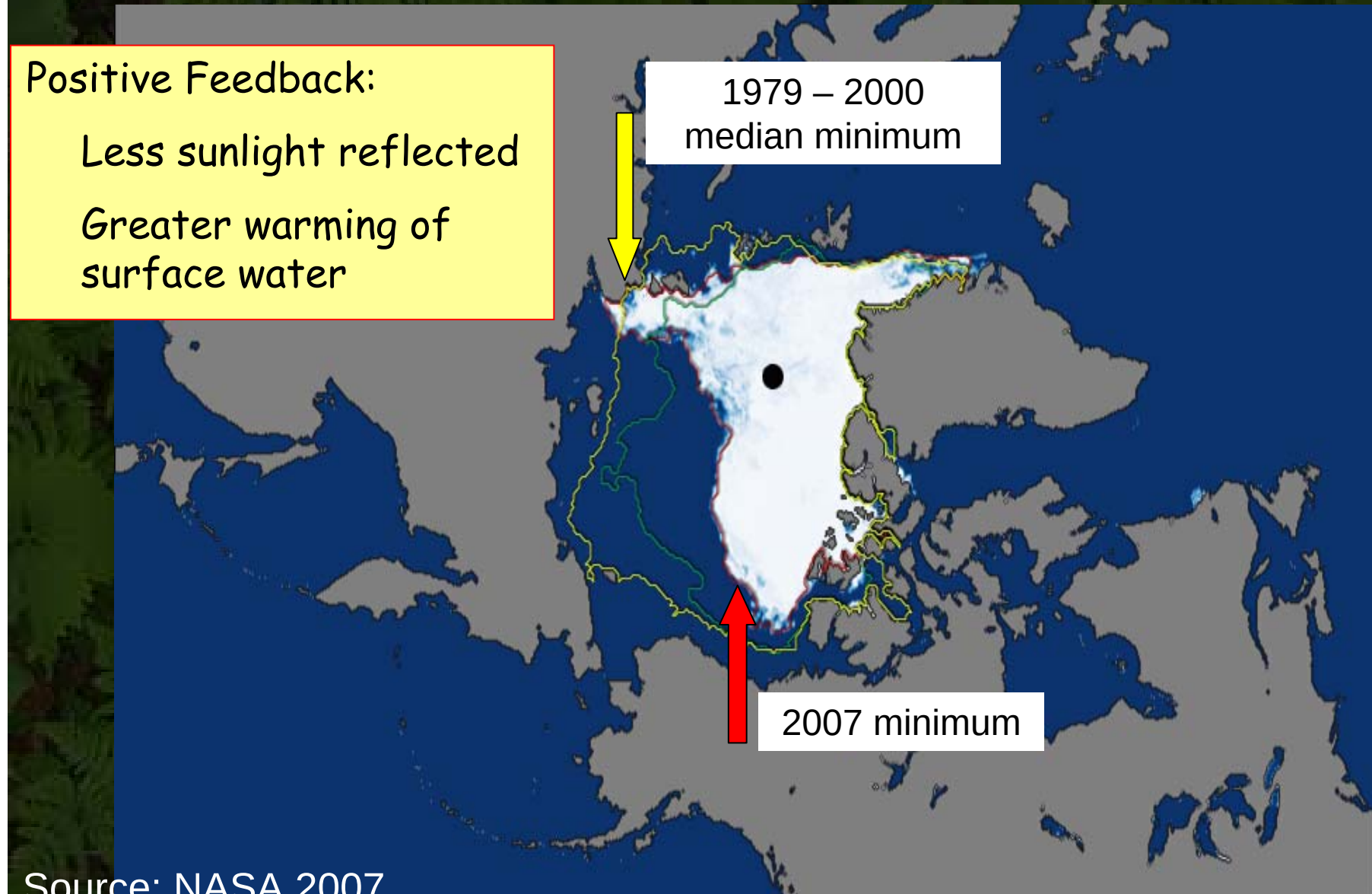
Less sunlight reflected

Greater warming of
surface water

1979 – 2000
median minimum

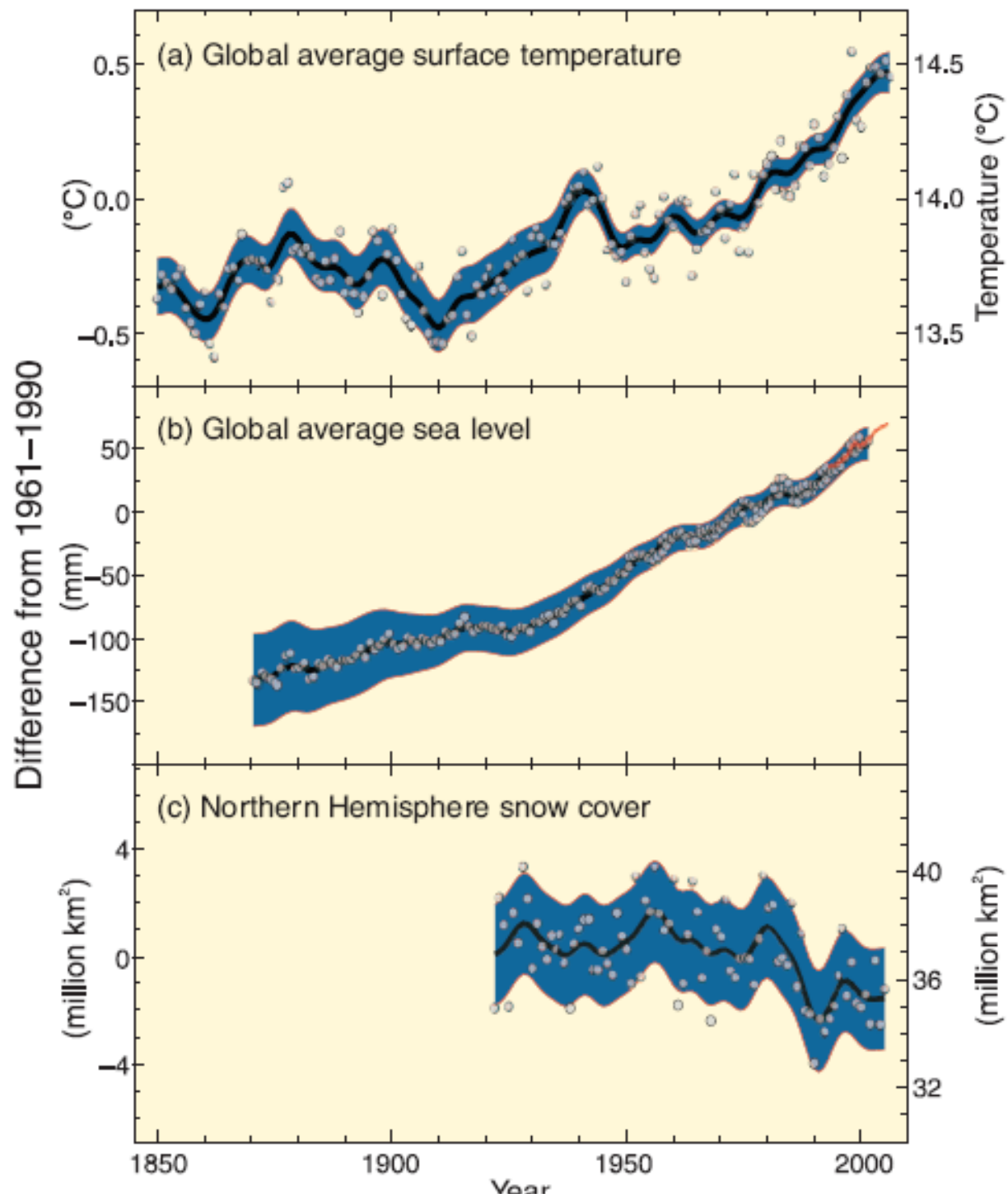
2007 minimum

Source: NASA 2007



IPCC Fourth Assessment Report 2007

- The understanding of anthropogenic warming and cooling influences on climate leads to *very high confidence* that the net effect of human activities since 1750 has been one of warming.
- Eleven of the last twelve years (1995 - 2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850).
- Human influences will continue to change atmospheric composition throughout the 21st century.



Bottom Line

- Balance of evidence points to a need to consider the forecasts seriously
 - Mitigation + adaptation
- Society's views of the situation are changing
 - Increased willingness to change behaviour
 - Changing social license for the forestry sector
 - New policies and new economics

Examples:

- 1) BC's involvement in the Western Climate Initiative*
- 2) Recently announced Federal GHG Regulatory Framework*
- 3) Future Forest Ecosystem Initiative*

Climate Change Impacts on Forest Carbon



Source: <http://ksjtracker.mit.edu/>

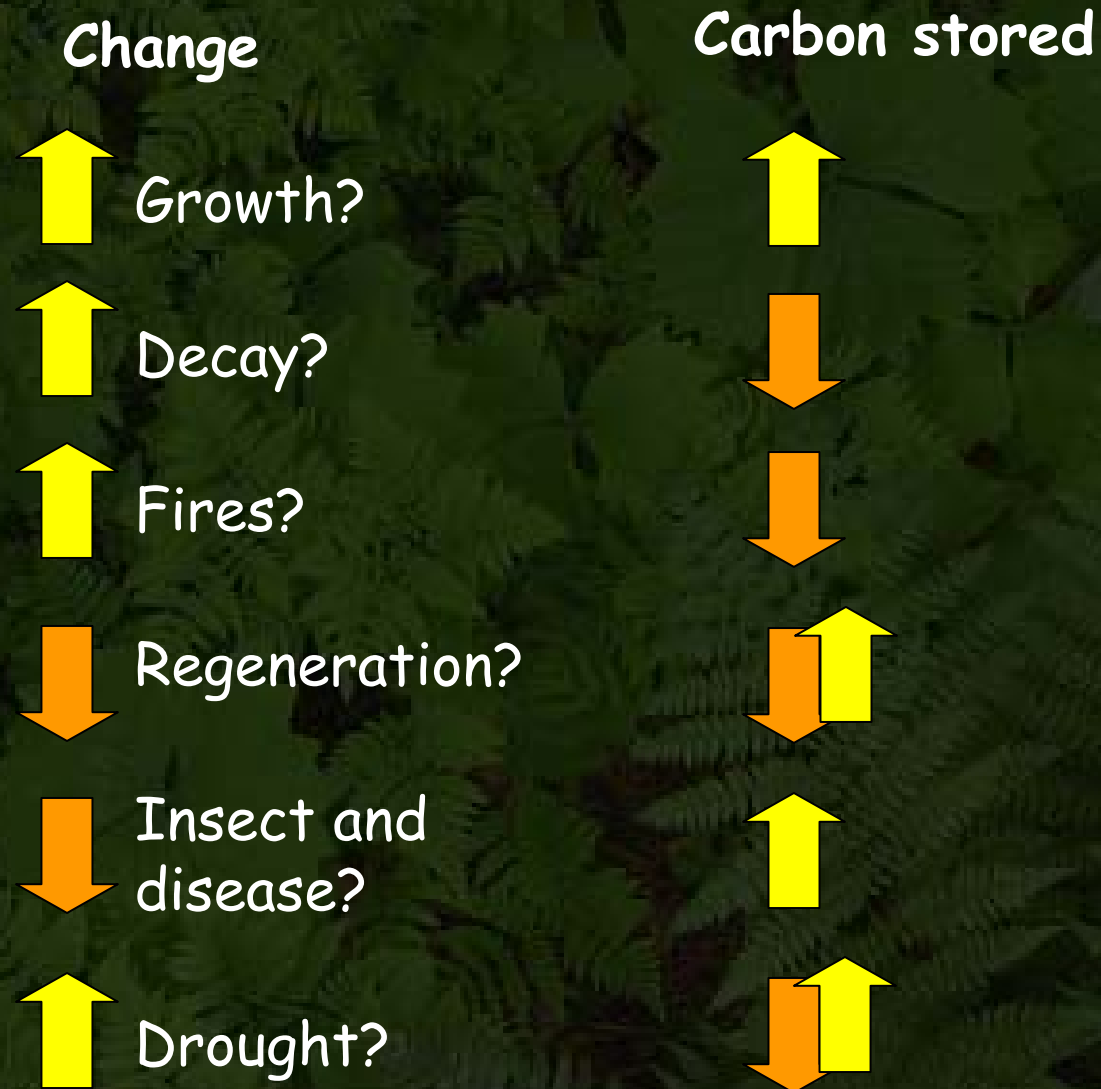
Impacts on Forests

Global Change will have multiple interacting impacts:

- Changes in productivity
 - CO₂ fertilization
 - Higher temperature
 - N mineralization
 - Longer growing seasons
 - Changes in water balance
- Changes in decomposition
- Regeneration and succession
- Migration of plant species (north and up)
- Changed species ensembles
- Increased area burned by forest fires
- Changes in insect dynamics



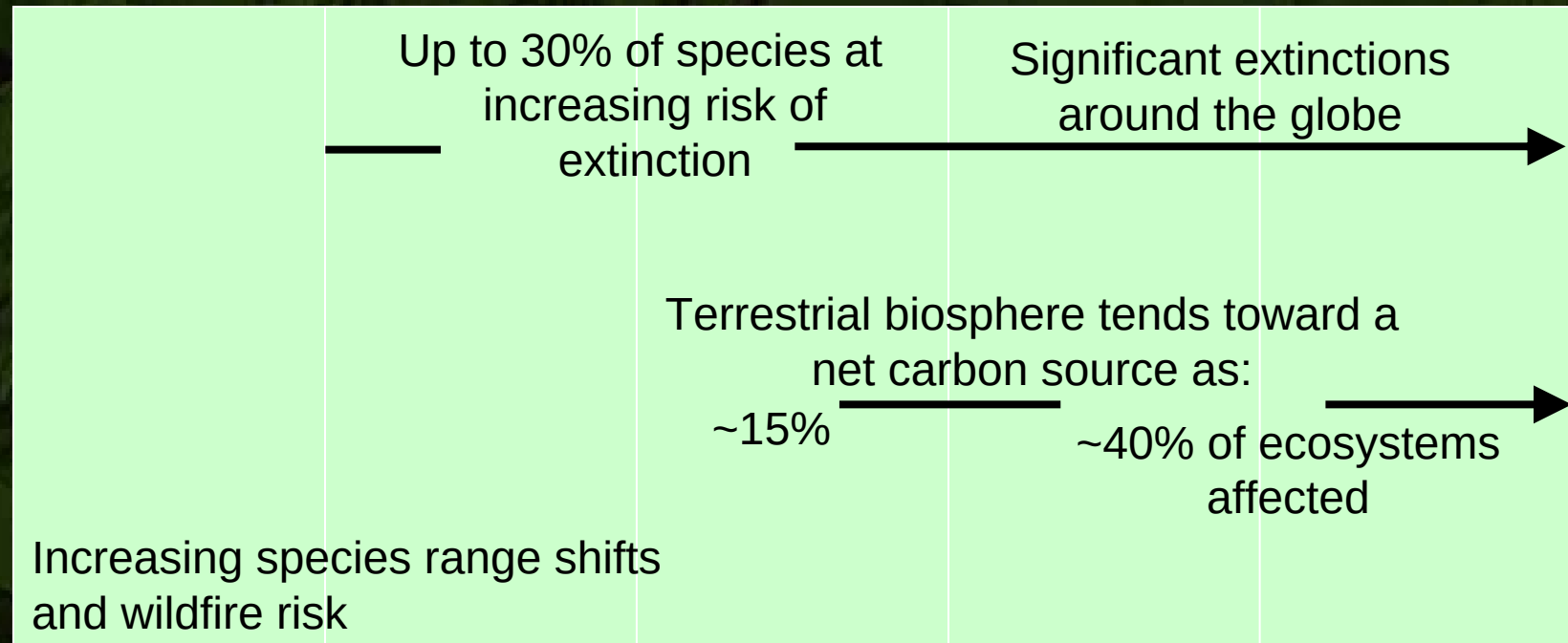
Climate Impacts on Forest Carbon



IPCC Future Impacts

Global mean annual temperature change relative to 1980-1999 (°C)

0 1 2 3 4 5 °C



Mitigation...



~ 1 million cubic meters of wood
~ 0.25 Mt C



Global Fossil Carbon Emissions

- Global Fossil Carbon Emissions $\sim 7 \text{ Gt C / yr}$
- about the biomass C in all of BC's forest



X 28,000

- Enough wood to produce a 2 x 4 that wraps around the earth at equator ...
.... over 200,000 times.

Forest Sector Carbon Flows

The diagram illustrates the carbon flows within the forest sector, showing the exchange between the atmosphere, land, and fossil fuels. Key components include:

- Atmosphere:** The top light blue area where carbon is exchanged.
- Land:** The brown area representing the forest floor and soil.
- Forest:** Green trees with roots in the soil. A fire is shown burning in the center.
- Carbon Flows:**
 - Growth:** A green arrow pointing from the atmosphere to the trees.
 - Respiration:** A blue arrow pointing from the trees to the atmosphere.
 - Decay:** Blue arrows pointing from dead wood and the soil to the atmosphere.
 - Burning:** A blue arrow pointing from the fire to the atmosphere.
 - Landfill:** A yellow arrow pointing from wood to a landfill area.
 - Fossil Fuels:** A black arrow pointing from the fossil fuel layer to the land.

4 m³ wood ~ 1 tonne of C, if emitted = 3.67 t CO₂

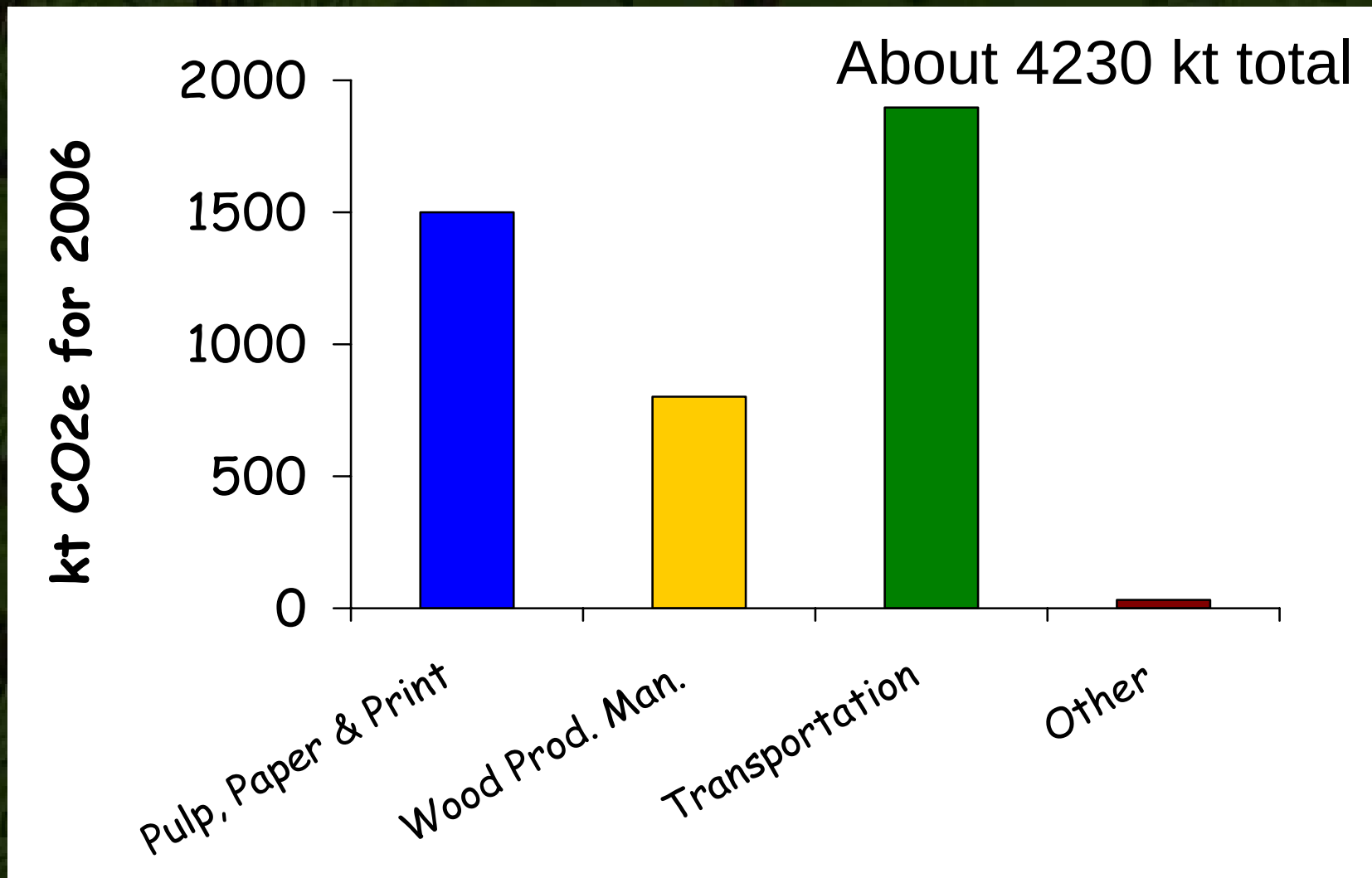
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Forest Sector Mitigation Opportunities

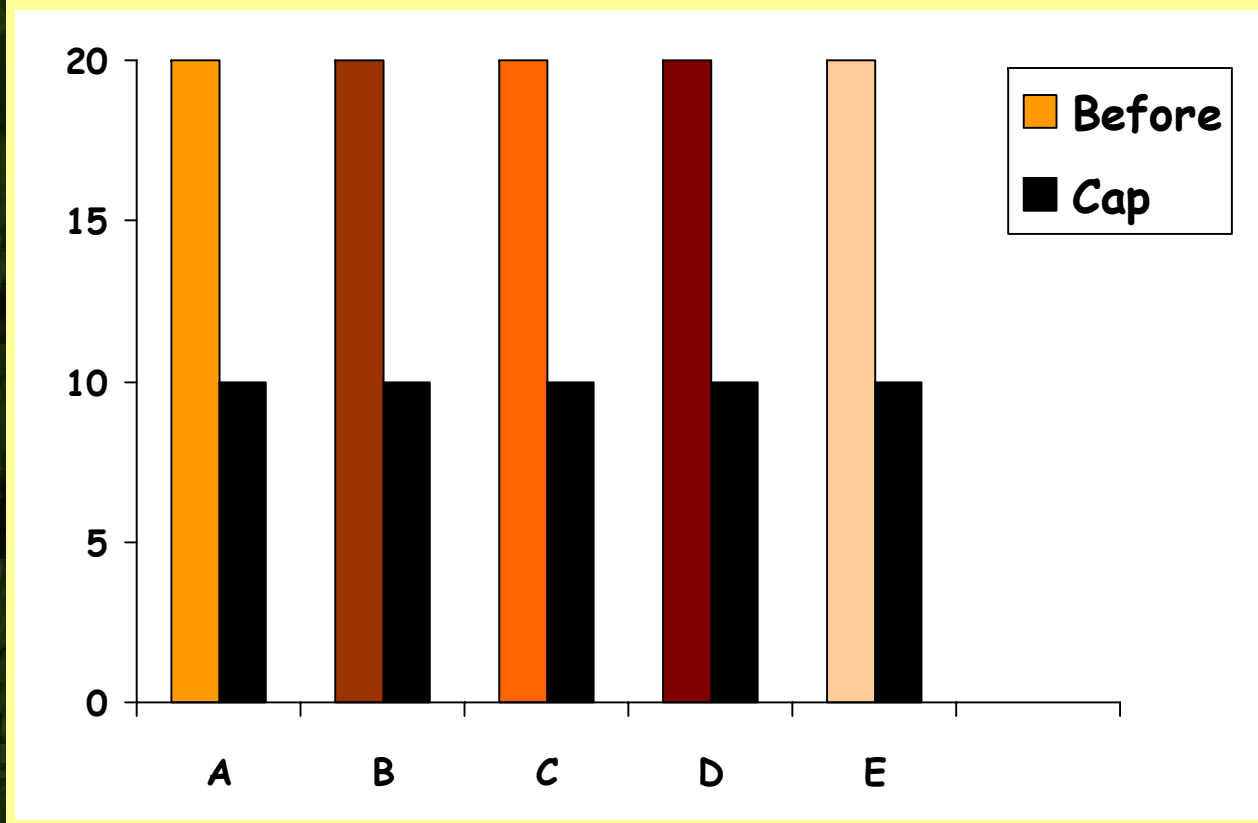
1. Reduce fossil emissions
 - More efficient operations
 - Bioenergy use of waste wood and,
 - Product substitution
2. Increase (or maintain) forest area
3. Increase stand-level carbon density
4. Increase landscape-level carbon density
5. Increase C stored in wood products.

Forest Industry Emissions



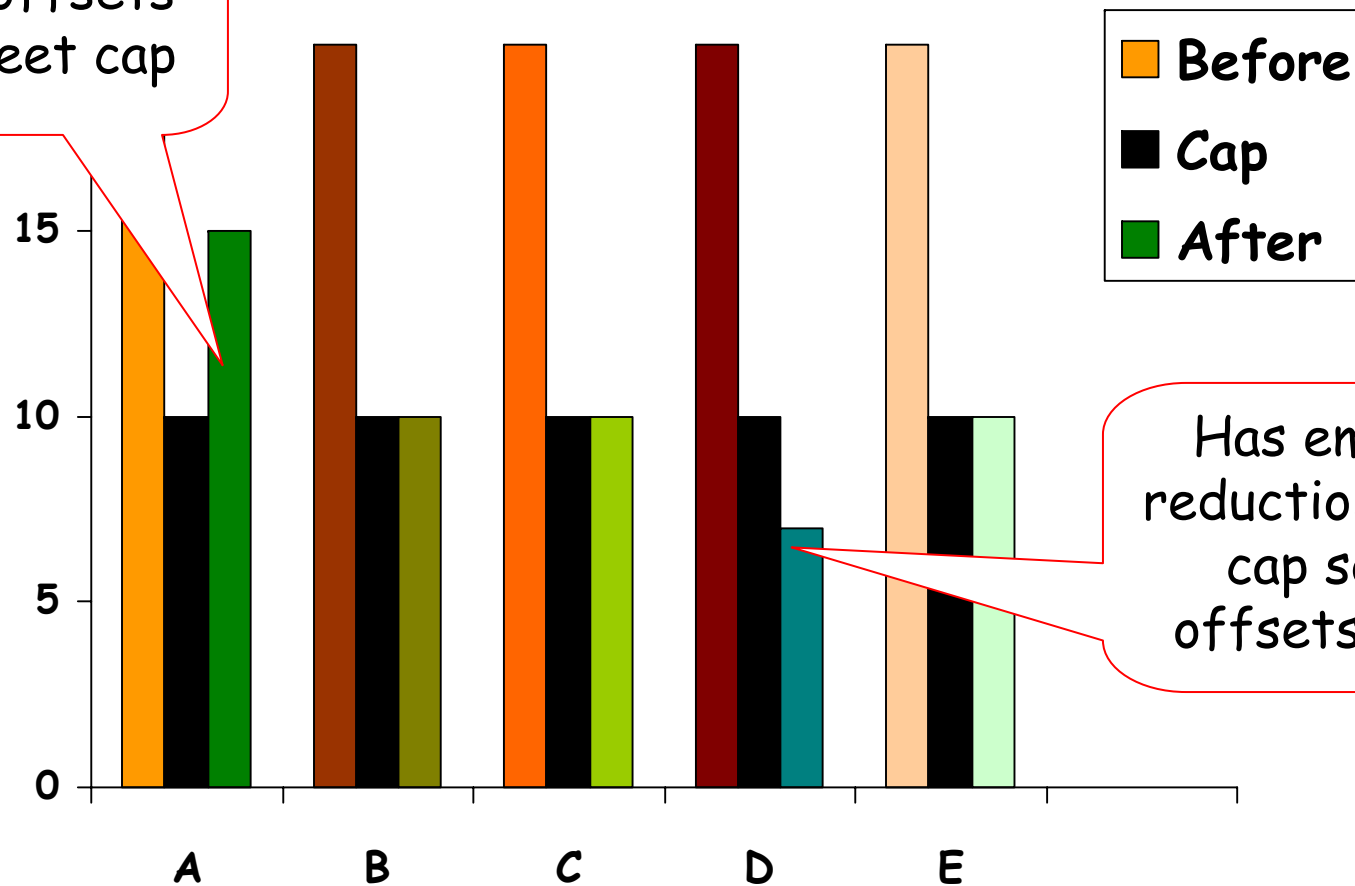
Cap and Trade

- An offset is a greenhouse gas emissions reduction or increase in carbon-storage
- Helps you meet your target for mitigating climate change.
- It's supposed to be a last-hope mechanism.



Offset Trading

Needs to
buy offsets
to meet cap



Has emission
reductions below
cap so has
offsets to sell

Key Criterion

- The greenhouse gas reduction would not have happened anyway i.e. is "additional" or "incremental" to business-as-usual activity.

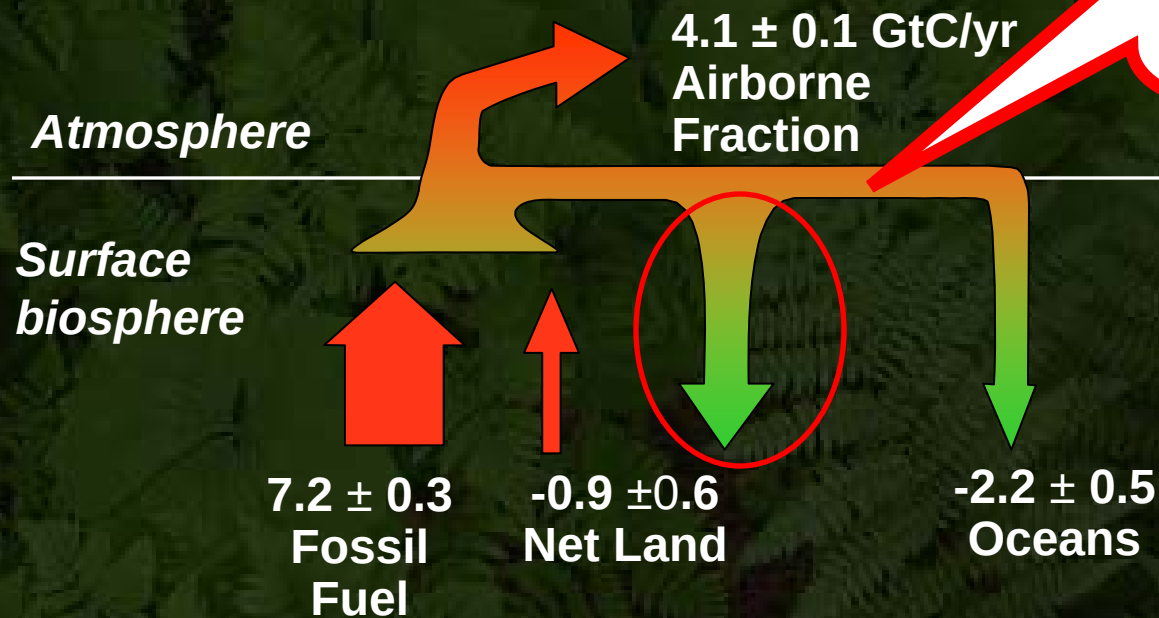


Forest Sector Mitigation Opportunities

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Human Perturbations to the Global C Cycle

Land and ocean compensate somewhat for *human* emissions: >8 up but only 4.1 remains in atmosphere



Forests play a key offset role (natural sinks)

Forest Sector Carbon Flows

The diagram illustrates the carbon flows within the forest sector, showing the exchange between the atmosphere, land, and fossil fuels. Key components include:

- Atmosphere:** The top light blue region where carbon is exchanged.
- Land:** The brown ground area containing forests, a fire, a factory, wood stacks, and a stove.
- SOIL:** The bottom brown layer where carbon is stored and exchanged with the atmosphere.
- FOSSIL FUELS:** A black bar at the bottom representing the source of carbon for the factory and stove.

Carbon flows are indicated by arrows:

- Growth:** A green arrow pointing from the atmosphere to the forest trees.
- Respiration:** A blue arrow pointing from the forest trees to the atmosphere.
- Decay:** Blue arrows pointing from dead wood and the soil to the atmosphere.
- Fire:** A red arrow pointing from the forest trees to the atmosphere.
- Burning:** A blue arrow pointing from the factory and the stove to the atmosphere.
- Landfill:** A yellow arrow pointing from wood stacks to the landfill.

4 m³ wood ~ 1 tonne of C, if emitted = 3.67 t CO₂

27

4 m³ wood ~ 1 tonne of C, if emitted = 3.67 t CO₂

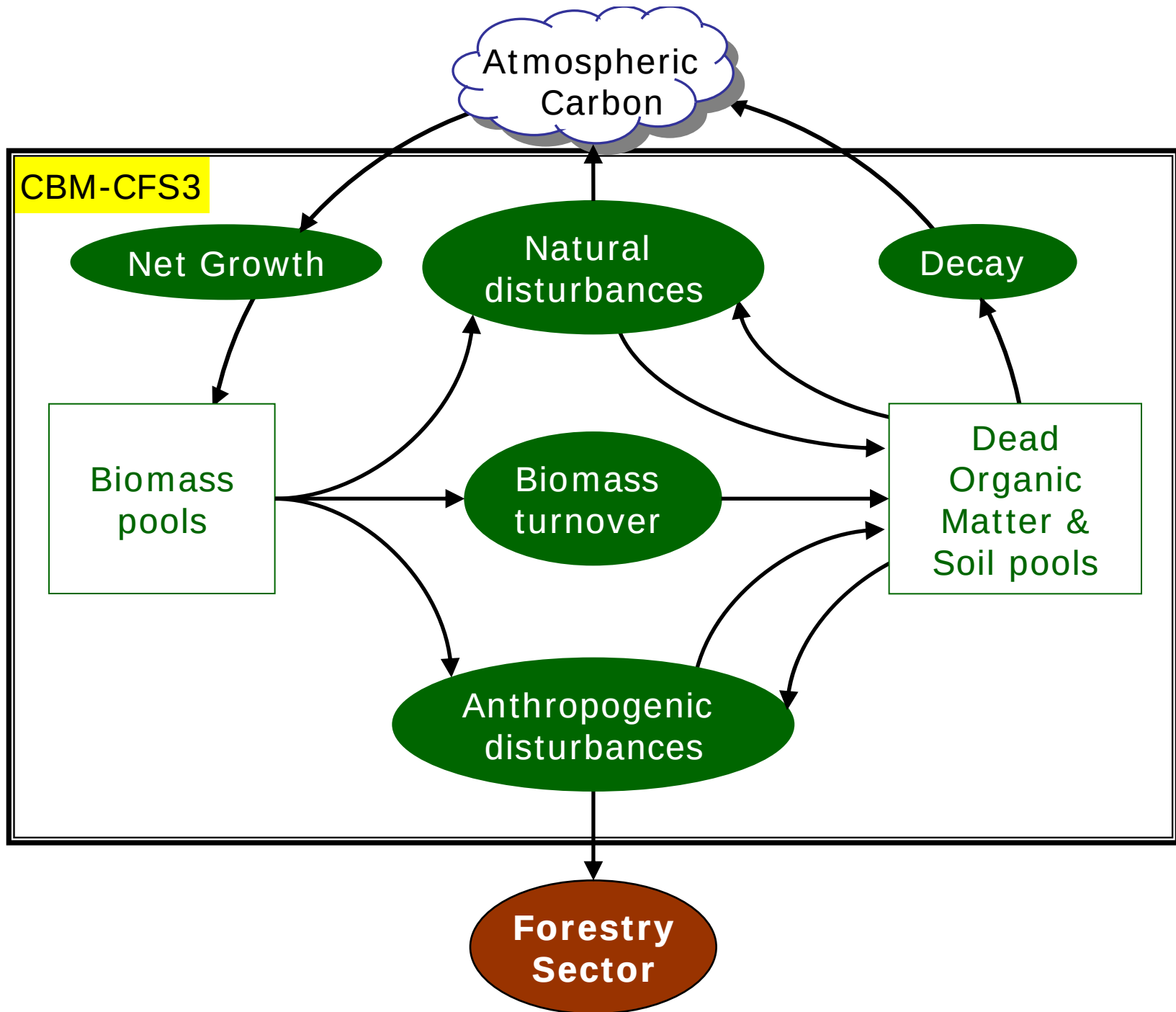
Forests can act as sinks or sources

- When times are good...

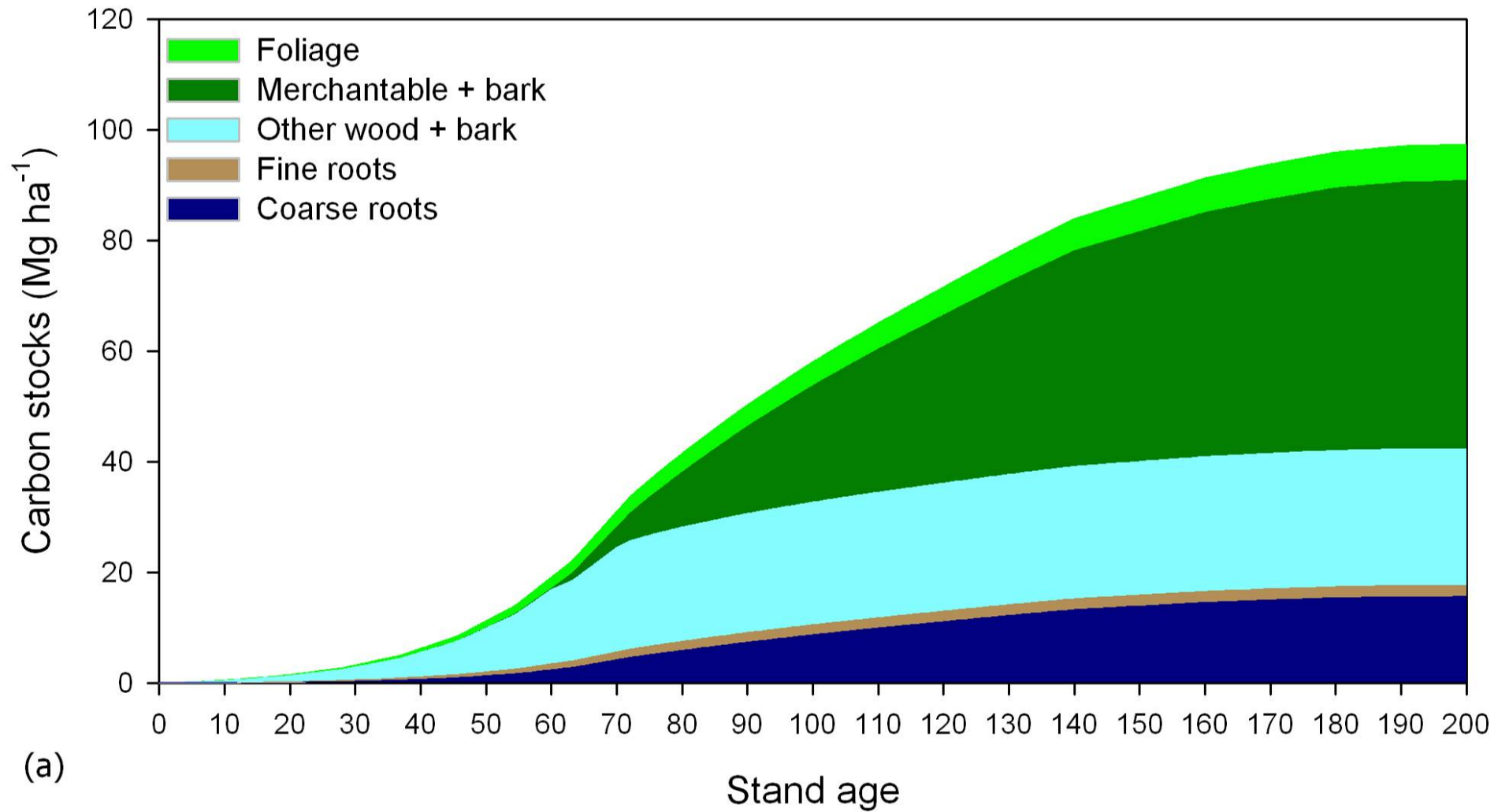


- When times are not so good...

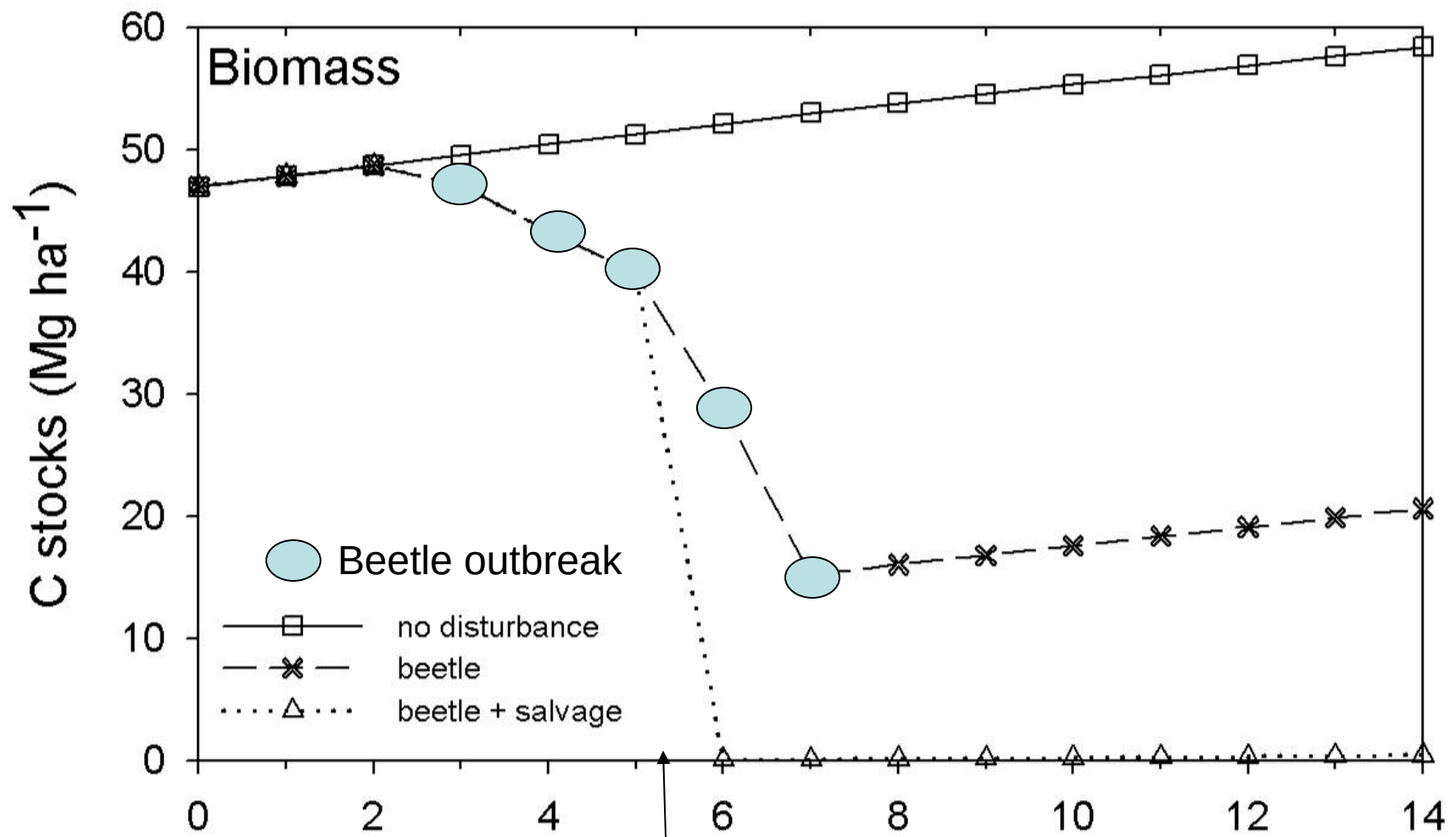




Growth

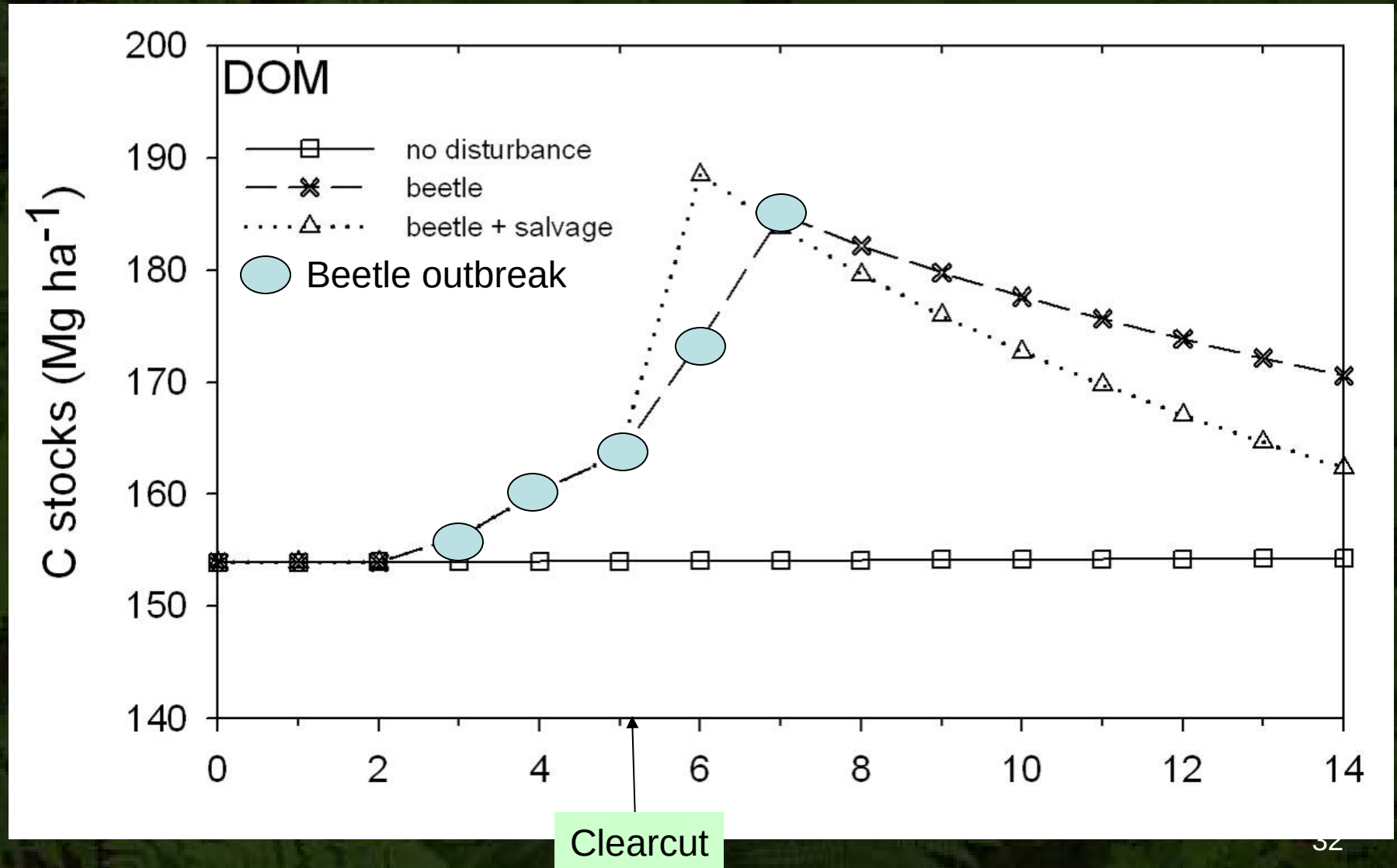


Beetle + Salvage - Biomass

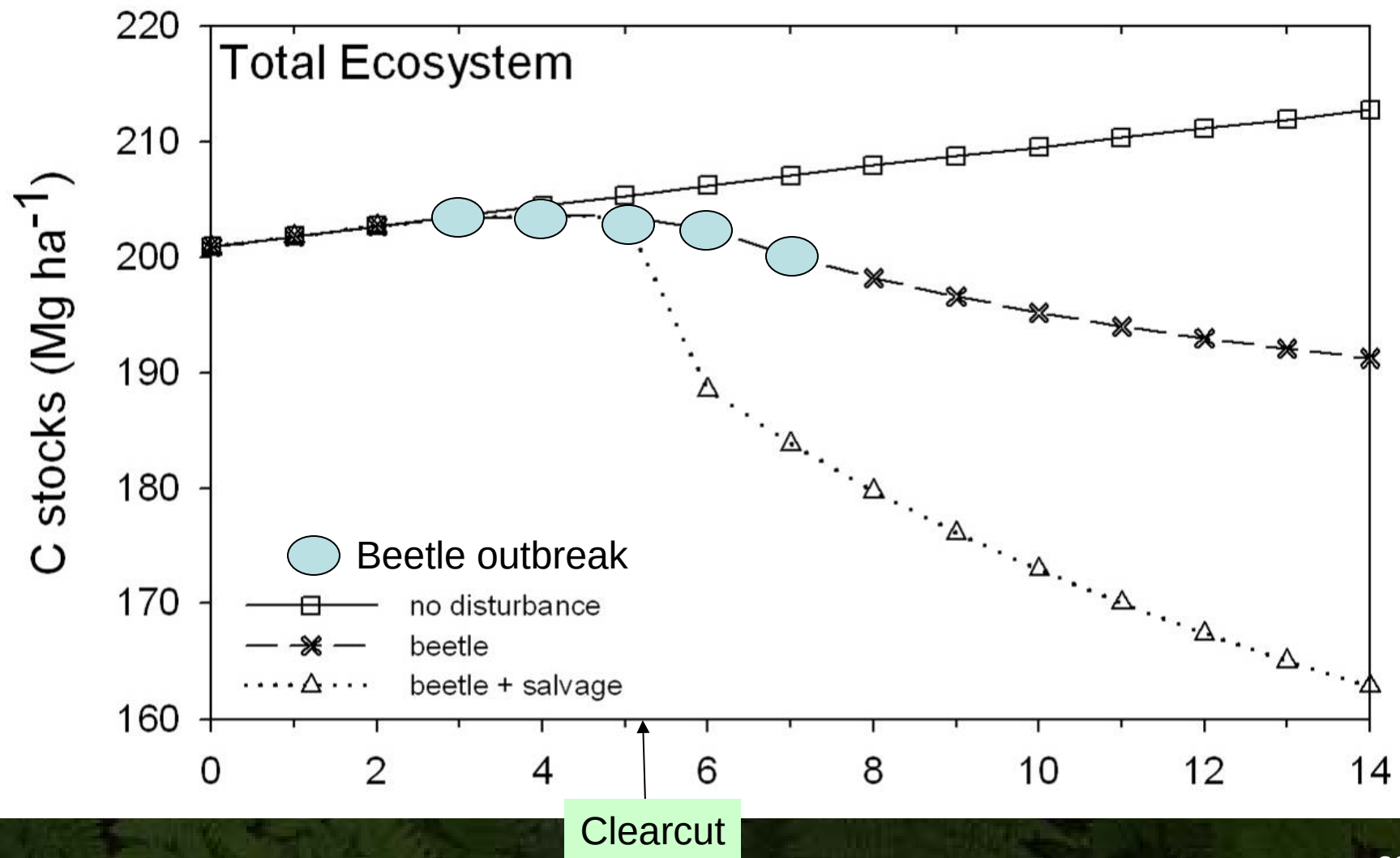


Clearcut

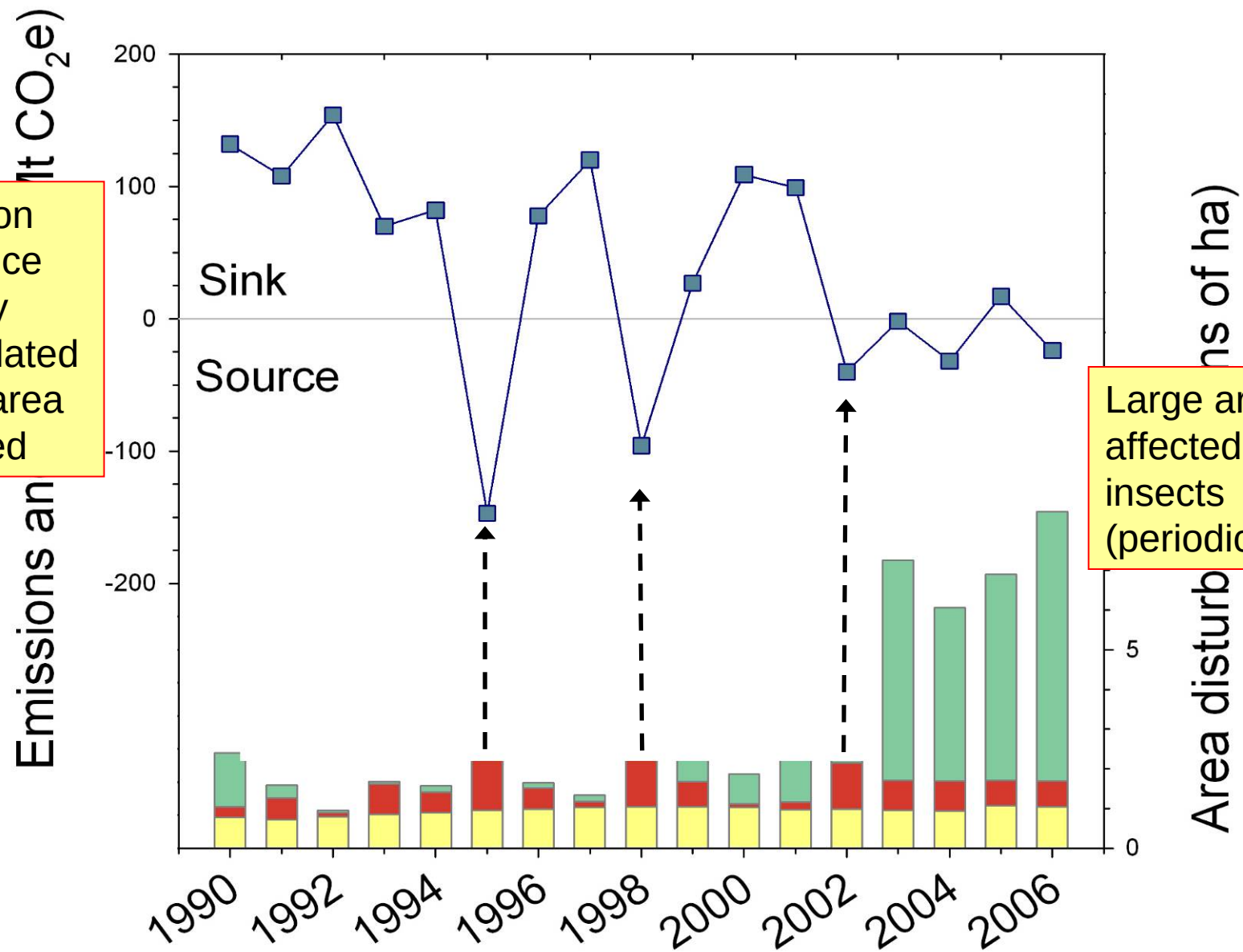
Beetle + Salvage - Dead wood & Soil



Beetle + Salvage - Ecosystem



National Scale Forest GHG Balance



Carbon balance highly correlated with area burned

Large areas affected by insects (periodic)

Contribution of BC's forests

- Non-THLB is generally a carbon sink
 - Suppression of natural disturbances, but no harvesting
- Coastal BC forests have generally been carbon sources
 - Conversion of old, high carbon forests to younger forests managed on shorter rotations
 - Conversion to condos and farms
- Interior BC forests have generally been a carbon sink, but...
 - Bad fire years in 2003 and 2004
 - Mountain pine beetle

Potential Changes to Forest Management...

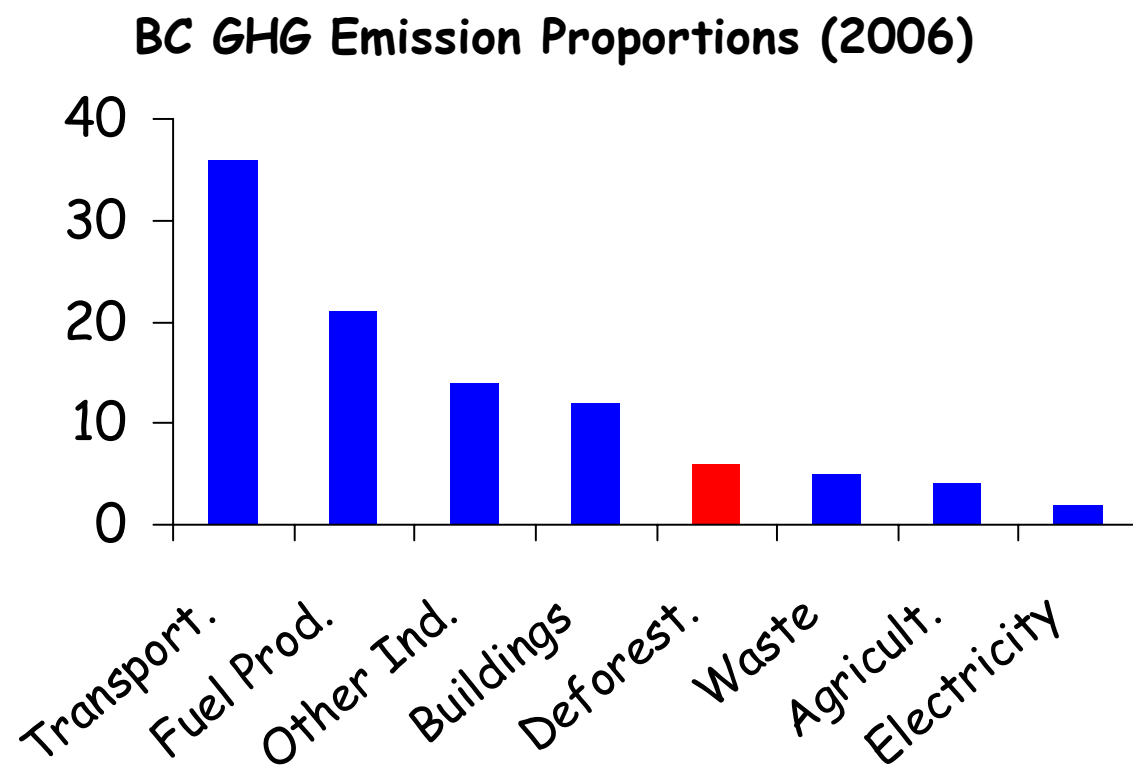
- Longer rotation age
- More intensive silviculture to increase carbon uptake and storage
- Shifting harvest methods and target stands
- Mixed species plantings

and Forest Products...

- Longer-lived forest products
- Substitution of wood products for C-intensive products
 - e.g. concrete

Reducing Emissions from Deforestation

- Global emissions from deforestation are larger than global emissions from the transportation sector (Stern Review, 2006).
- 10 to 30% of human emissions globally
- About 6% of BC's emissions



Source: BC Climate Action Plan

More Information

sharepoint.forests.gov.bc.ca/Climate_Change

www.IPCC.ch

Carbon.cfs.nrcan.gc.ca

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