Beyond REDD+

What management of land can and cannot do to help control atmospheric CO_2

R.A. Houghton
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Outline

- Introduction: Climate Change
- The Global Carbon Cycle
- What can we do?

Global Warming is a not a scientific controversy!

- There is a natural greenhouse effect; we know the gases responsible.
- The concentrations of these gases are increasing.
- Mean global temperature is increasing.

Recent weather disasters

In the 1990s

- 200 natural weather-related disasters per year

In the last decade

- 350 natural weather-related disasters per year

And all of these disasters happened with an average global warming of less than 1°C.

Recent AAAS report on climate

- Climate scientists agree: climate change is happening here and now.

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- Climate scientists agree: climate change is happening here and now.
- We are at risk of pushing our climate system toward abrupt, unpredictable, and potentially irreversible changes with highly damaging impacts.
- The sooner we act, the lower the risk and cost. And there is much we can do.

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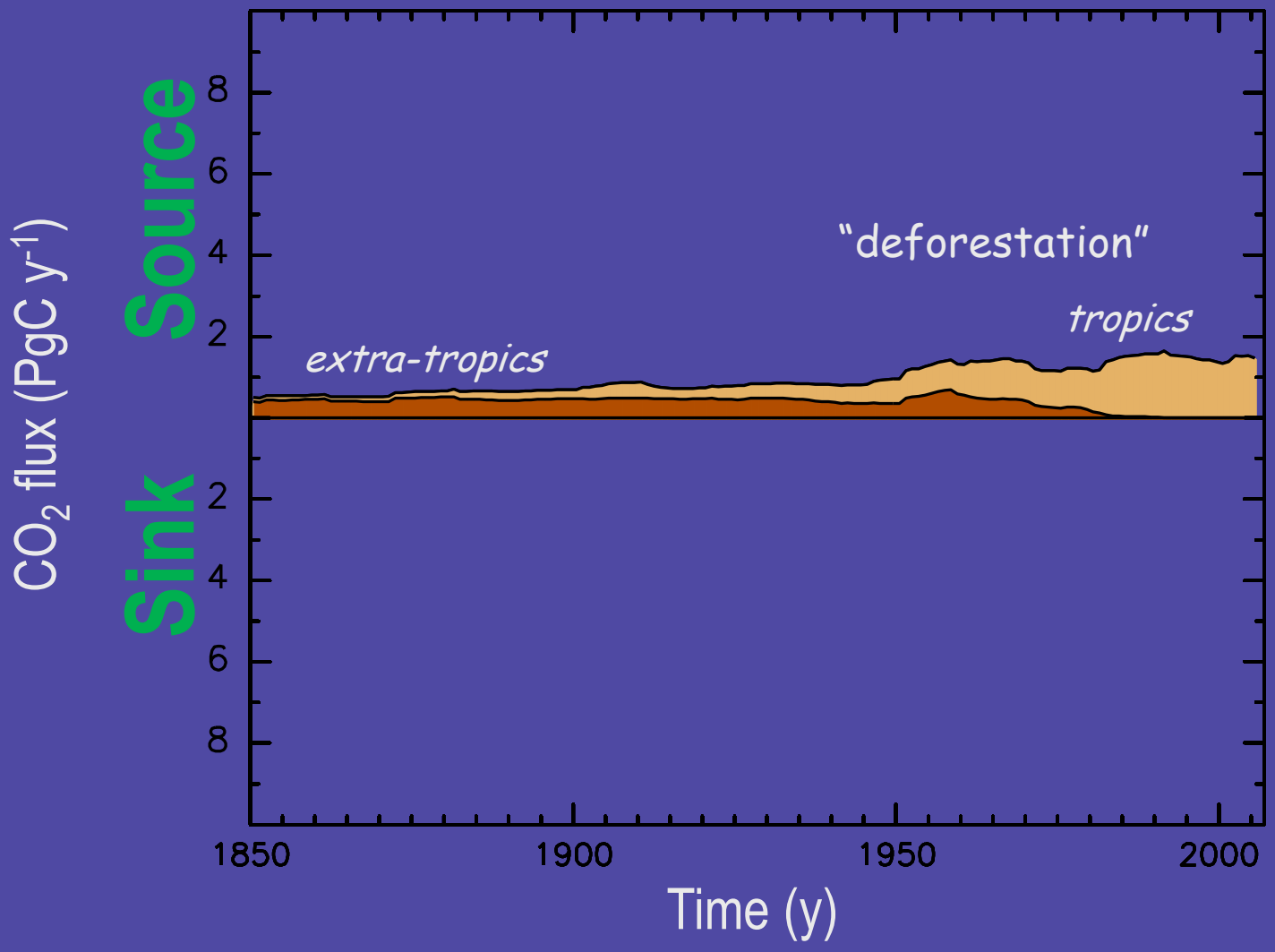
What is the global carbon cycle?

The exchanges of carbon within and among four reservoirs:

- Atmosphere
- Oceans
- Land (terrestrial ecosystems)
- Fossil fuels

Perturbation of Global Carbon Budget (1850-2006)



2000-2006

1.5 **PgC/yr**

Le Quéré, unpublished; Canadell et al. 2007, PNAS

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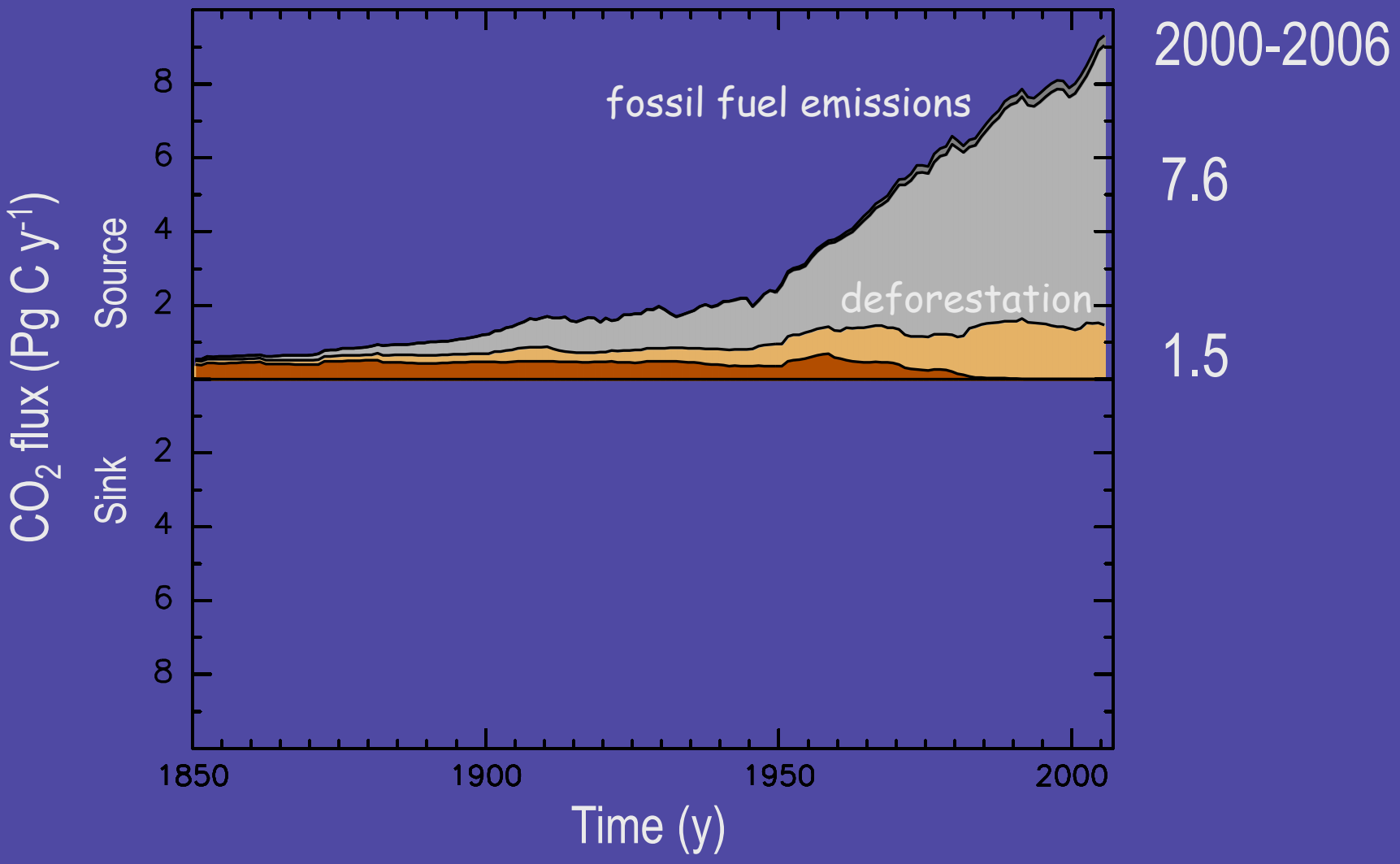

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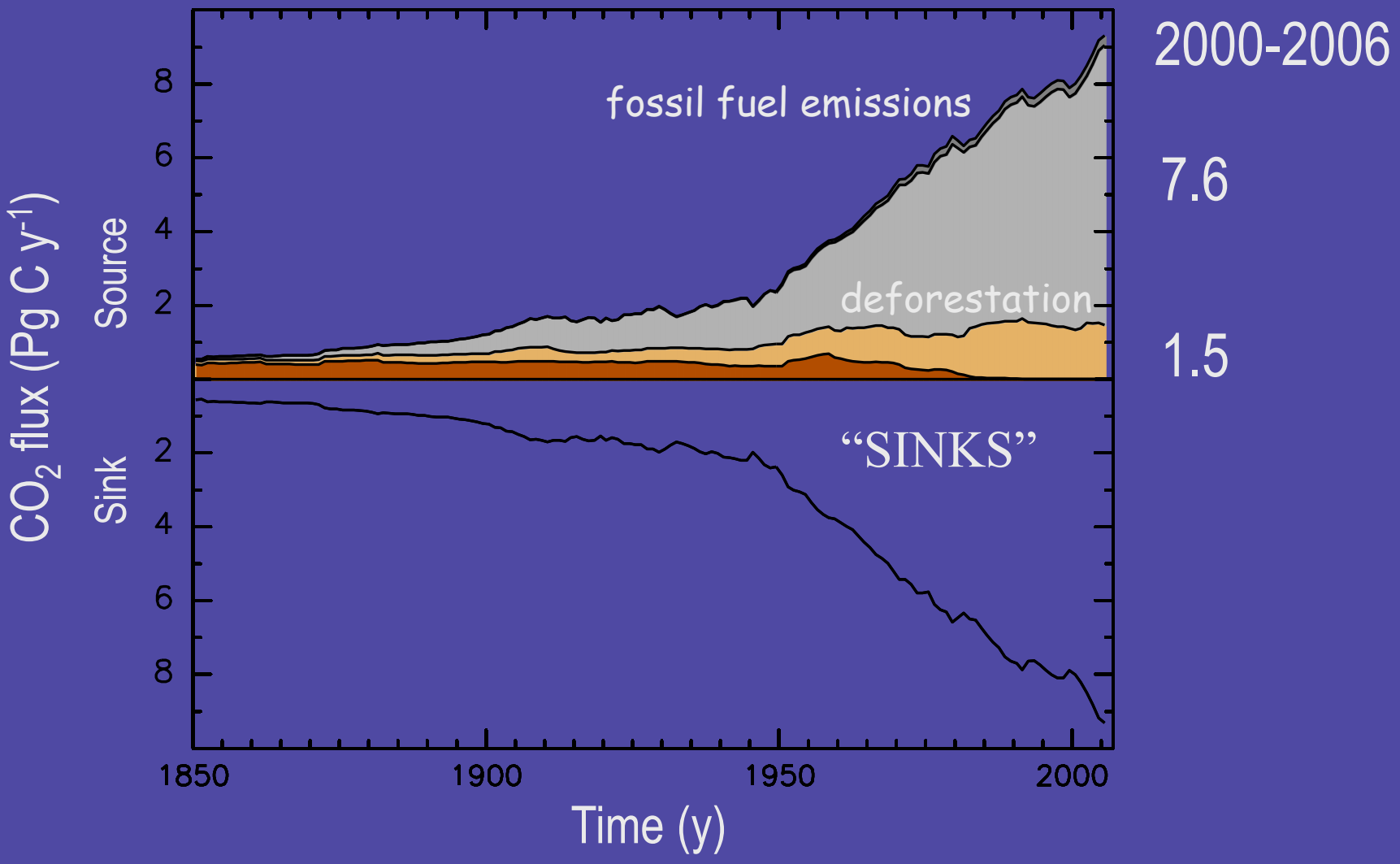

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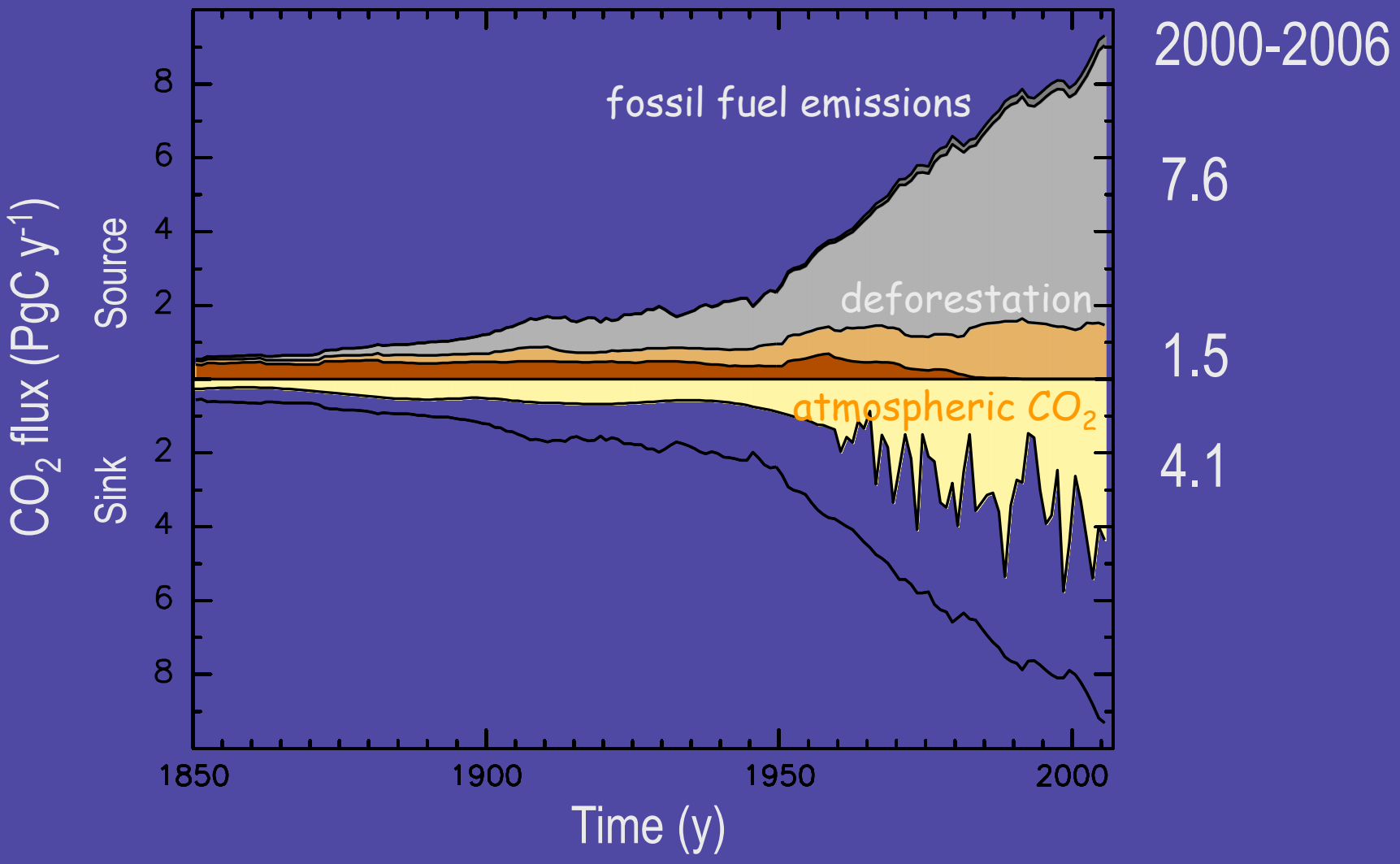

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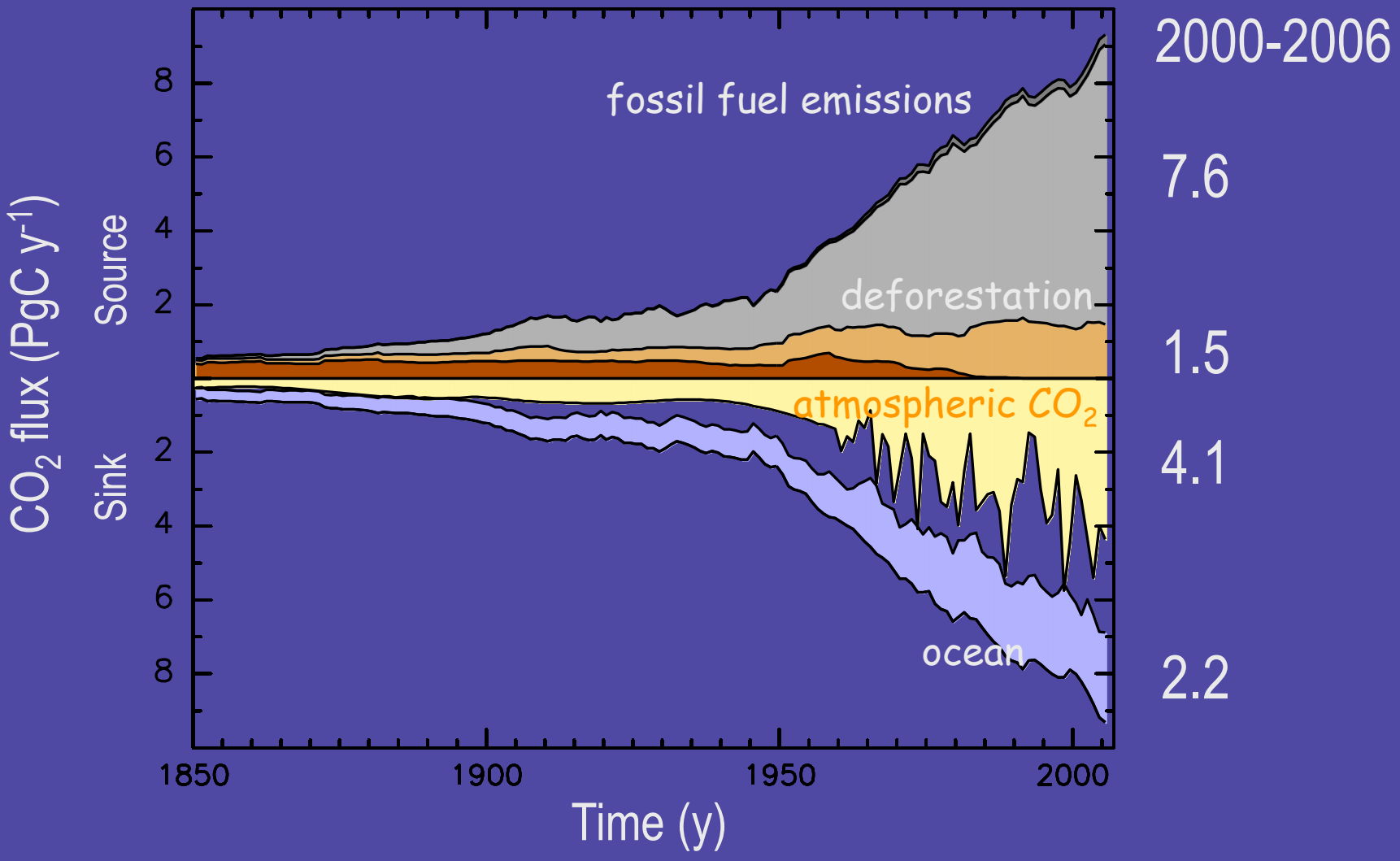

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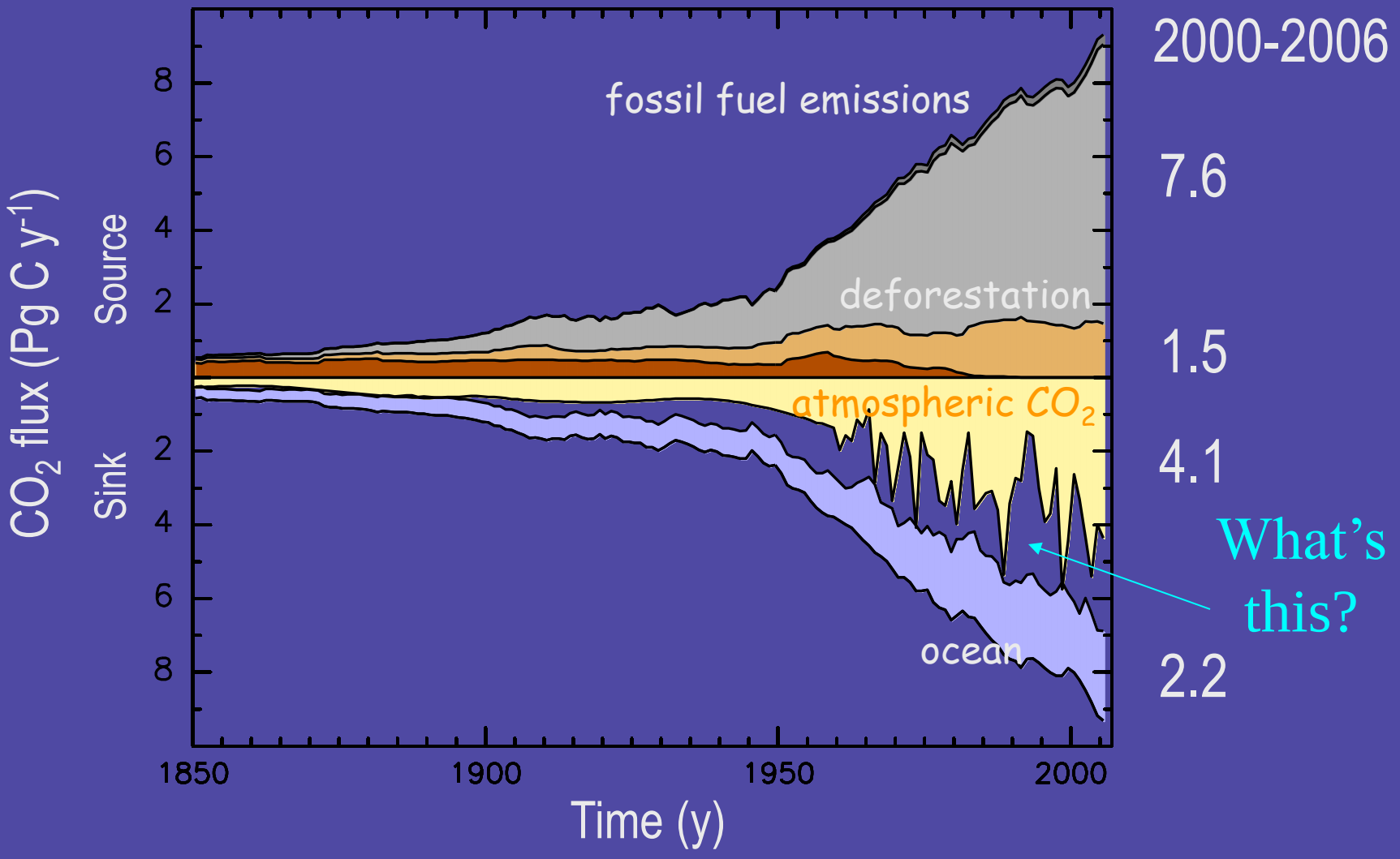

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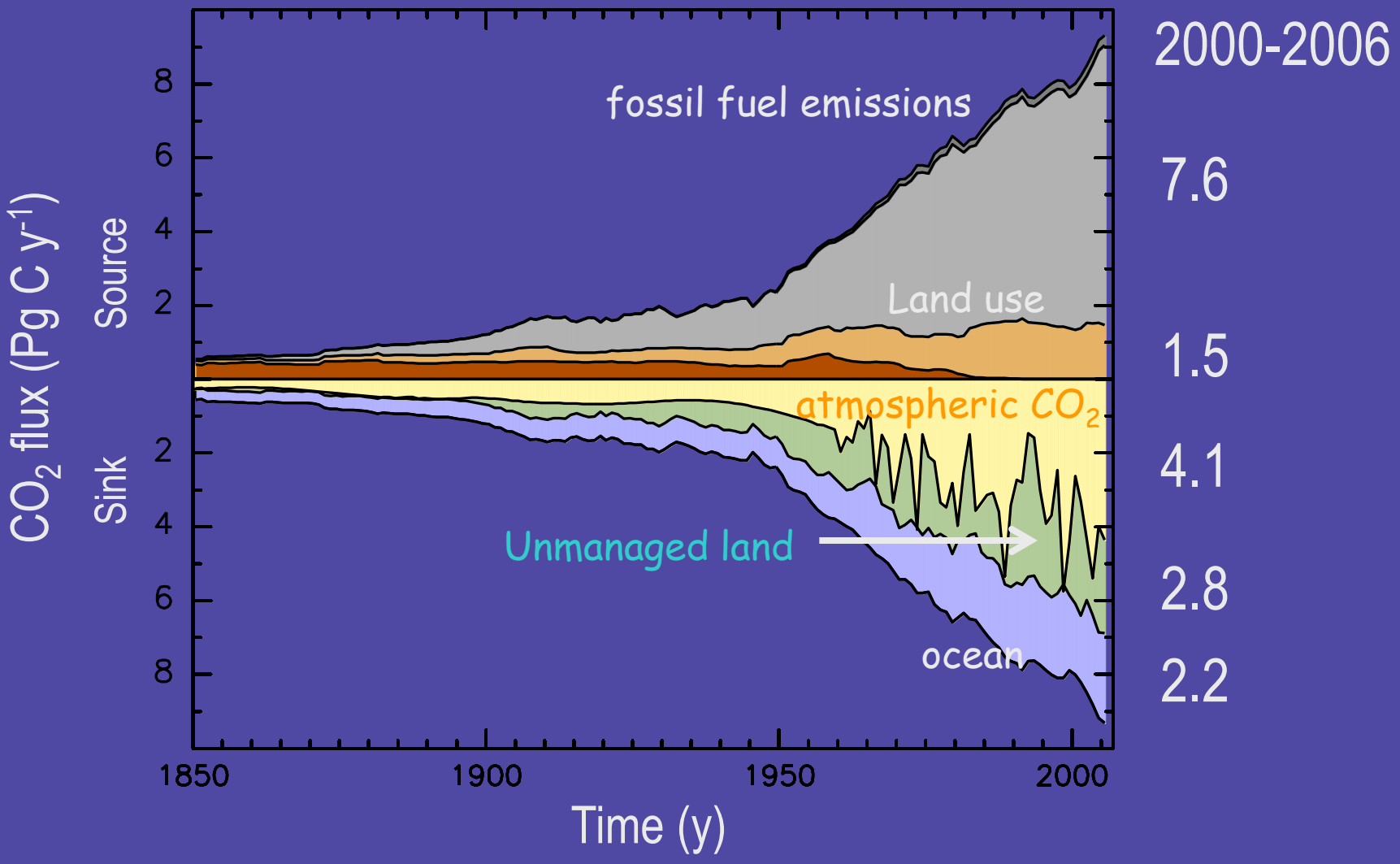

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Two terrestrial processes

Carbon sources and sinks on land result from two processes

1. Direct human effects (management)
   - Croplands, pasturelands
   - Forestry

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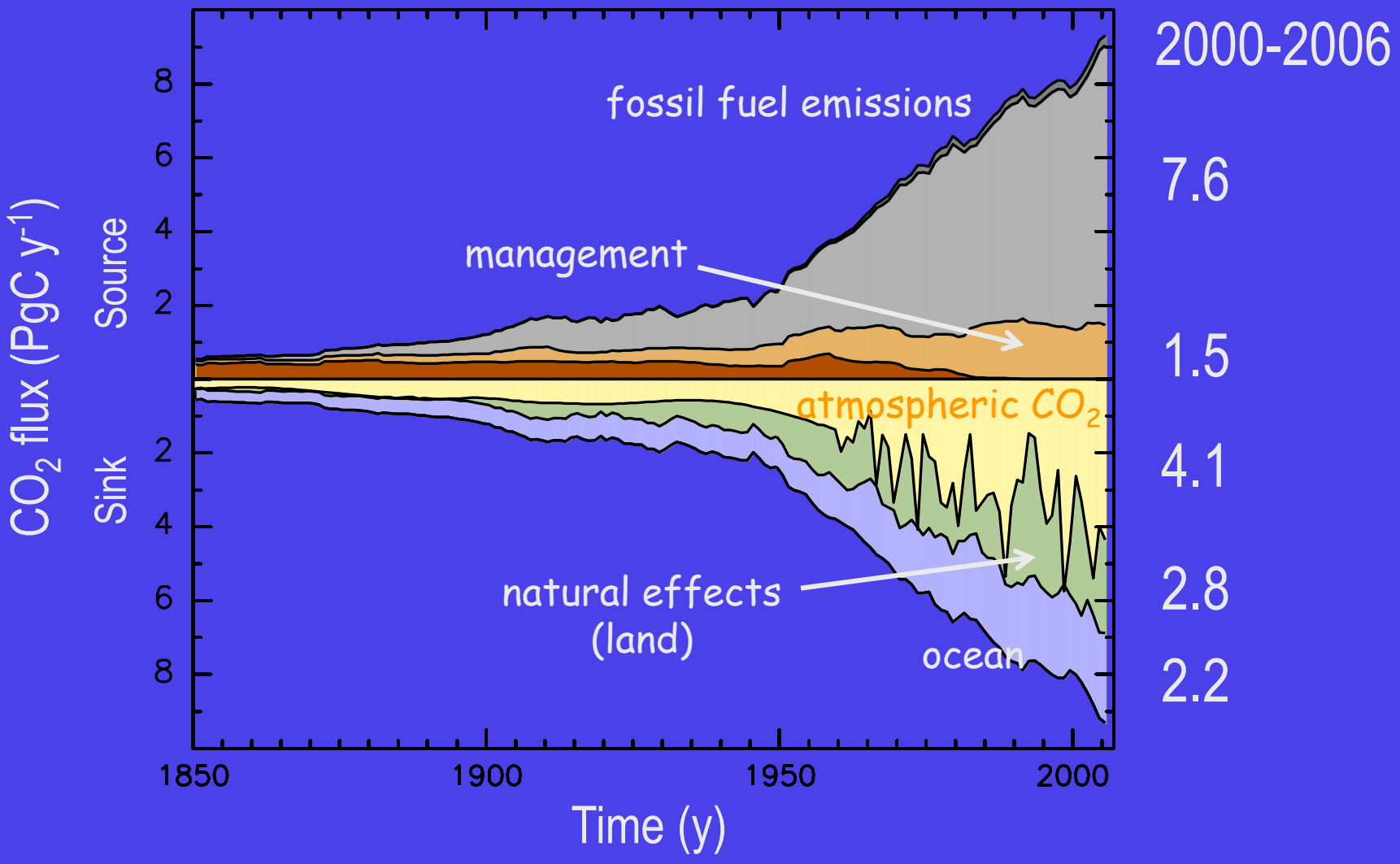

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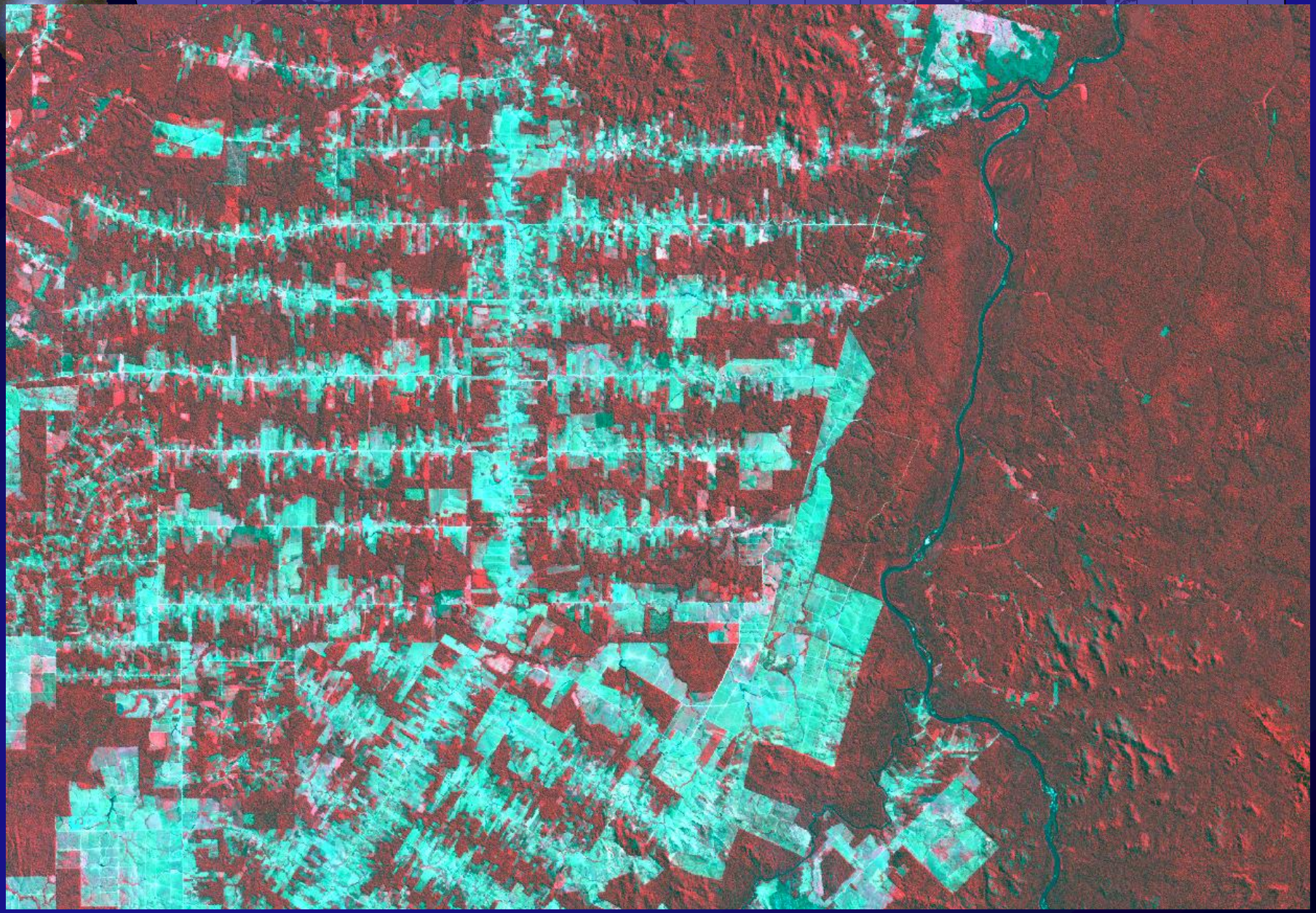
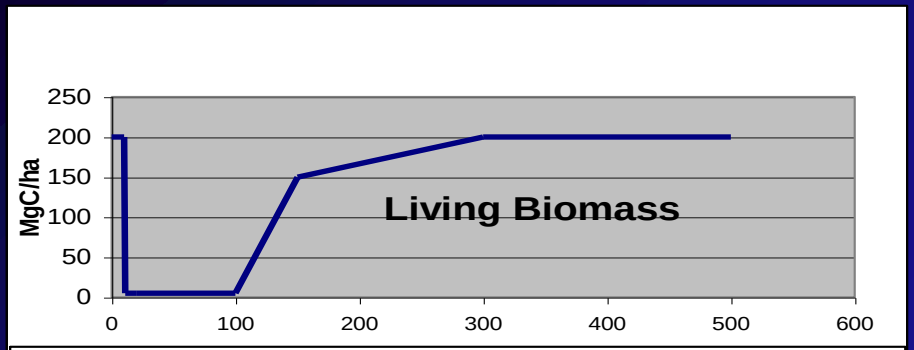
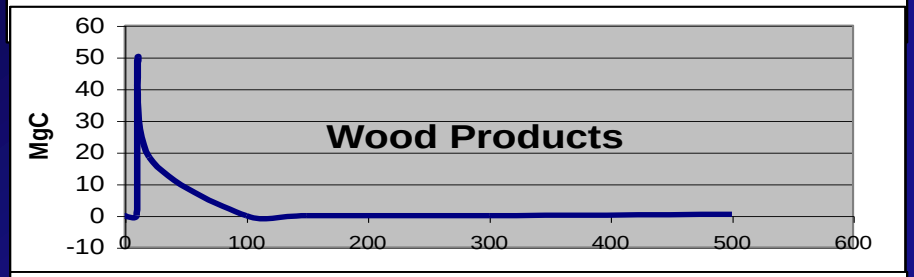
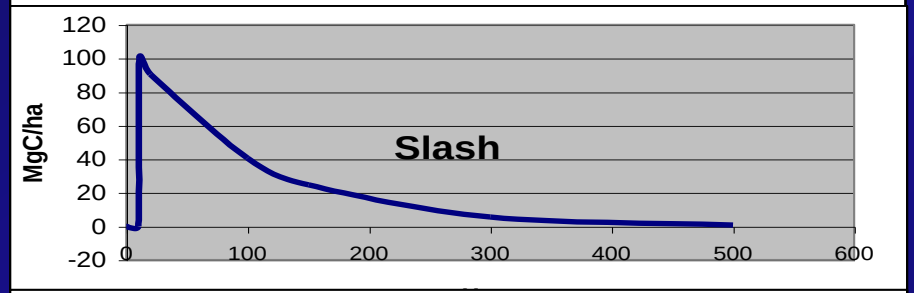
Changes in Land Use (management)

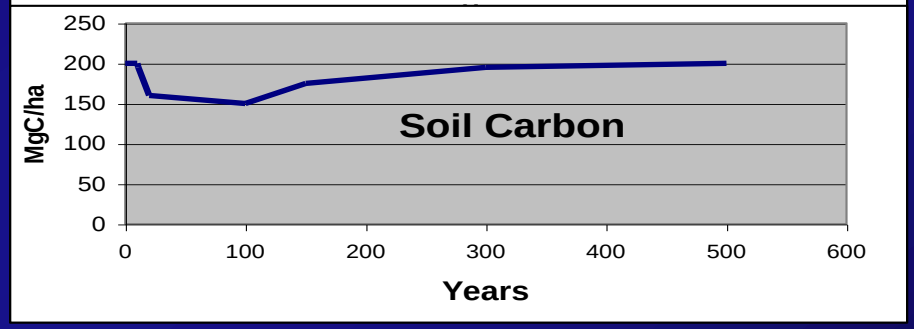


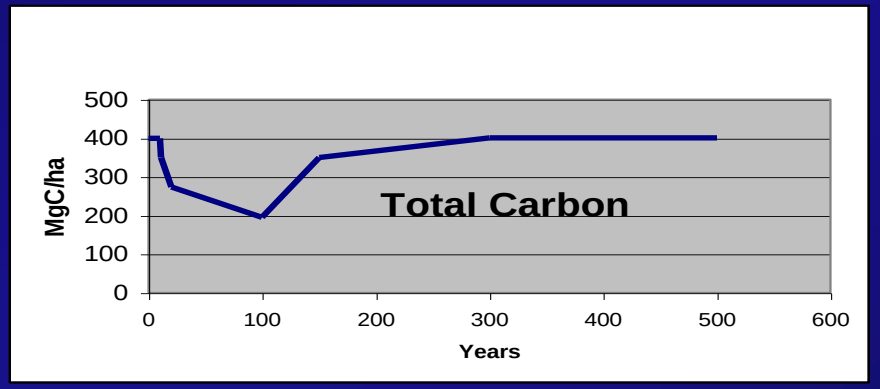
Changes in carbon from management

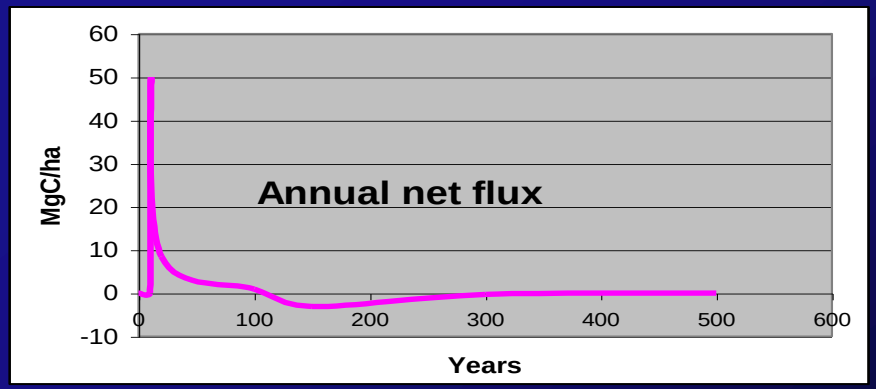






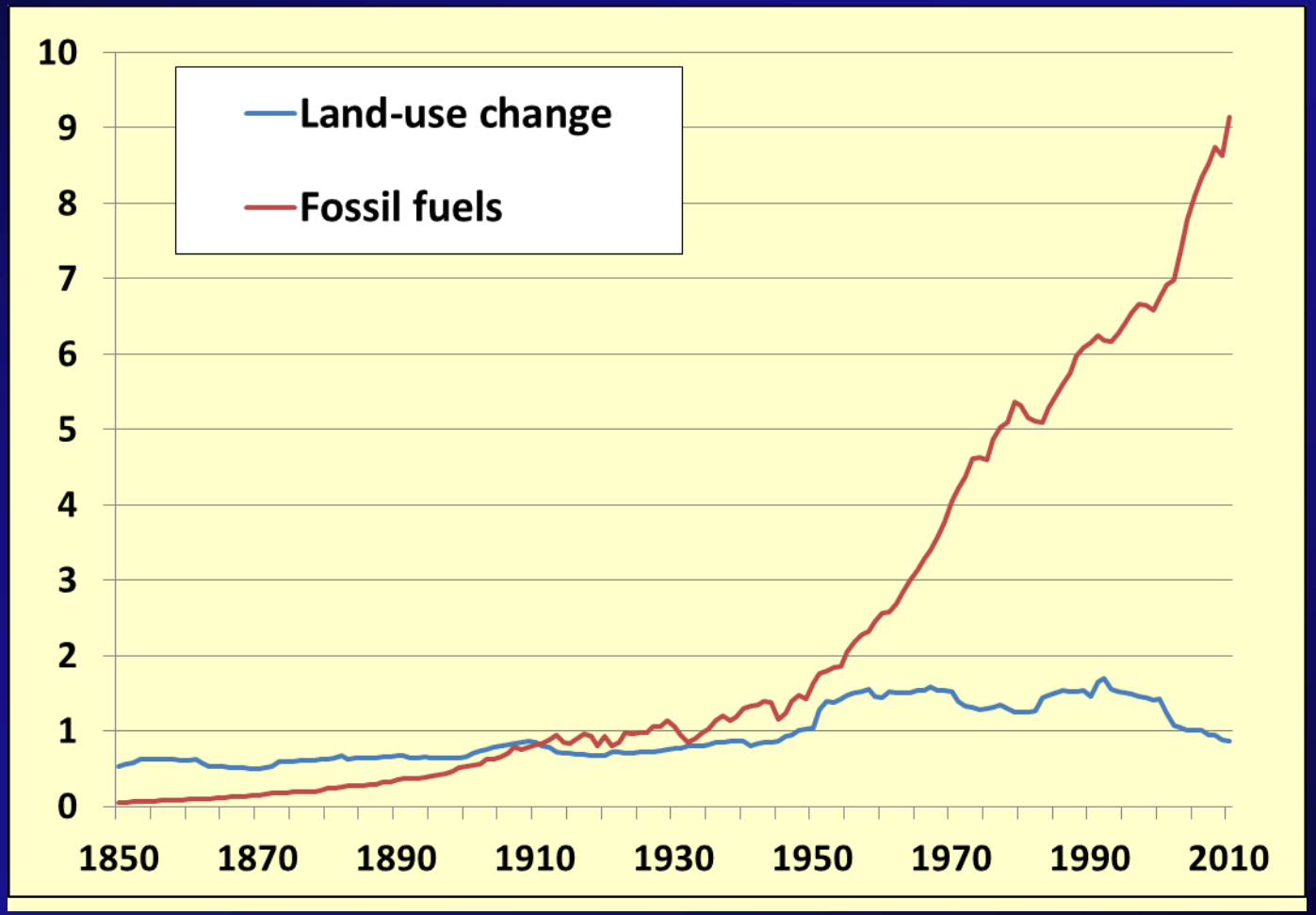




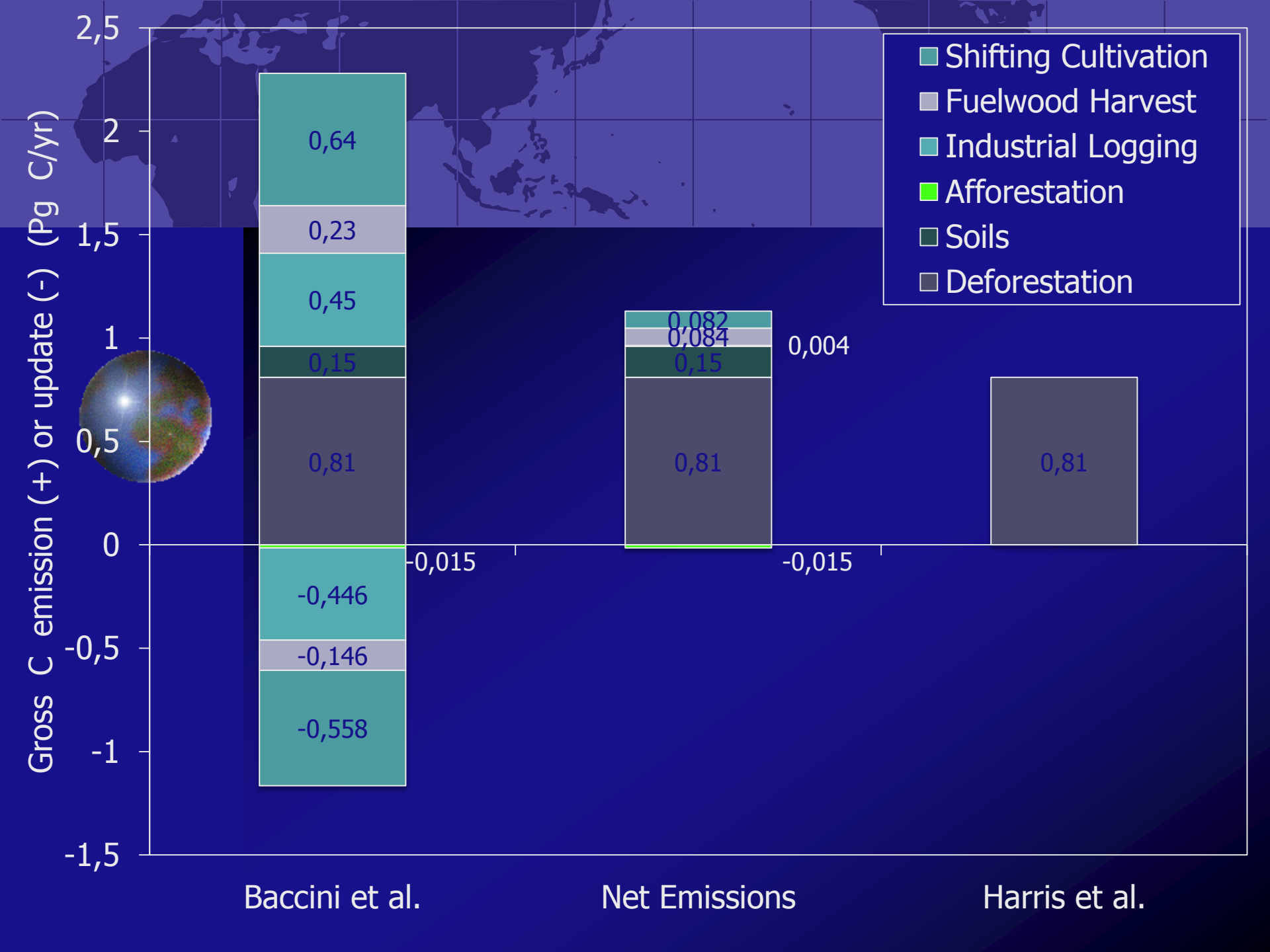


A bookkeeping model

10% - 15% of the problem.



This terrestrial source from management (or land-use change) is a net source, composed of both sources and sinks, for example, logging and forest regrowth


2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
Gross C emission (+) or update (-) (Pg C/yr)
Shifting Cultivation
Fuelwood Harvest
Industrial Logging
Afforestation
Soils
Deforestation
0,64
0,23
0,45
0,15
0,81
-0,446
-0,146
-0,558
-0,015
0,082
0,084
0,15
0,81
0,004
-0,015
0,81
Baccini et al.
Net Emissions
Harris et al.

Carbon sources and sinks on land result from two processes

1. Direct human effects (management)
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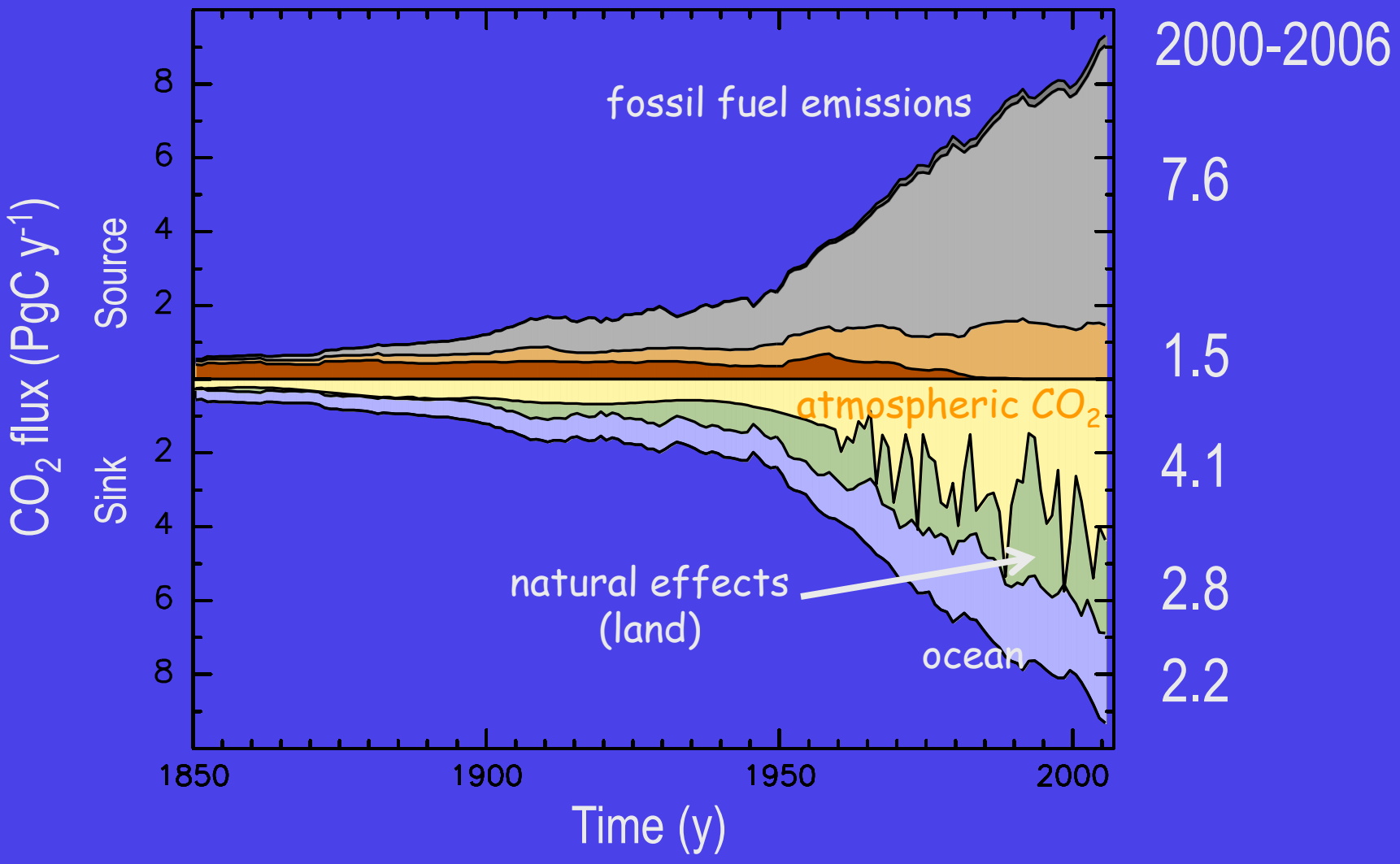
Perturbation of Global Carbon Budget (1850-2006)



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Over the last 5 decades the land and ocean sinks have increased in proportion to emissions.

It's remarkable.

Nature's been on our side.

Today the terrestrial sink (nature)
is 3 times larger than
the terrestrial source (management).

2.8 PgC/yr versus 0.9 PgC/yr

And this natural terrestrial sink
is composed of
both sources and sinks.

What's causing the natural sink?

Hypotheses:

- CO_2 fertilization
- Nitrogen deposition
- Changes in climate

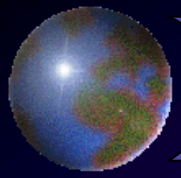
Will the carbon sinks on land and in the ocean continue?

Will they keep up with emissions?

Tipping Points in the Carbon-Climate System?

If the natural sinks on land and ocean are beginning to decline:

1. more of the carbon emitted stays in the atmosphere,



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Tipping Points in the Carbon-Climate System?

If the natural sinks on land and ocean are beginning to decline:

1. more of the carbon emitted stays in the atmosphere,
2. the rate of climatic disruption increases,
3. it is more difficult to manage the carbon cycle,
4. the carbon cycle is not behaving as the projections assumed.

Tipping Points in the Carbon-Climate System?

Perhaps the only way to avoid declining natural sinks is to limit the rate and extent of global warming.

Outline

- Climate Change
- The Global Carbon Cycle
- What can we do?

To stop the warming, we need to stabilize the CO_2 concentration in the atmosphere…

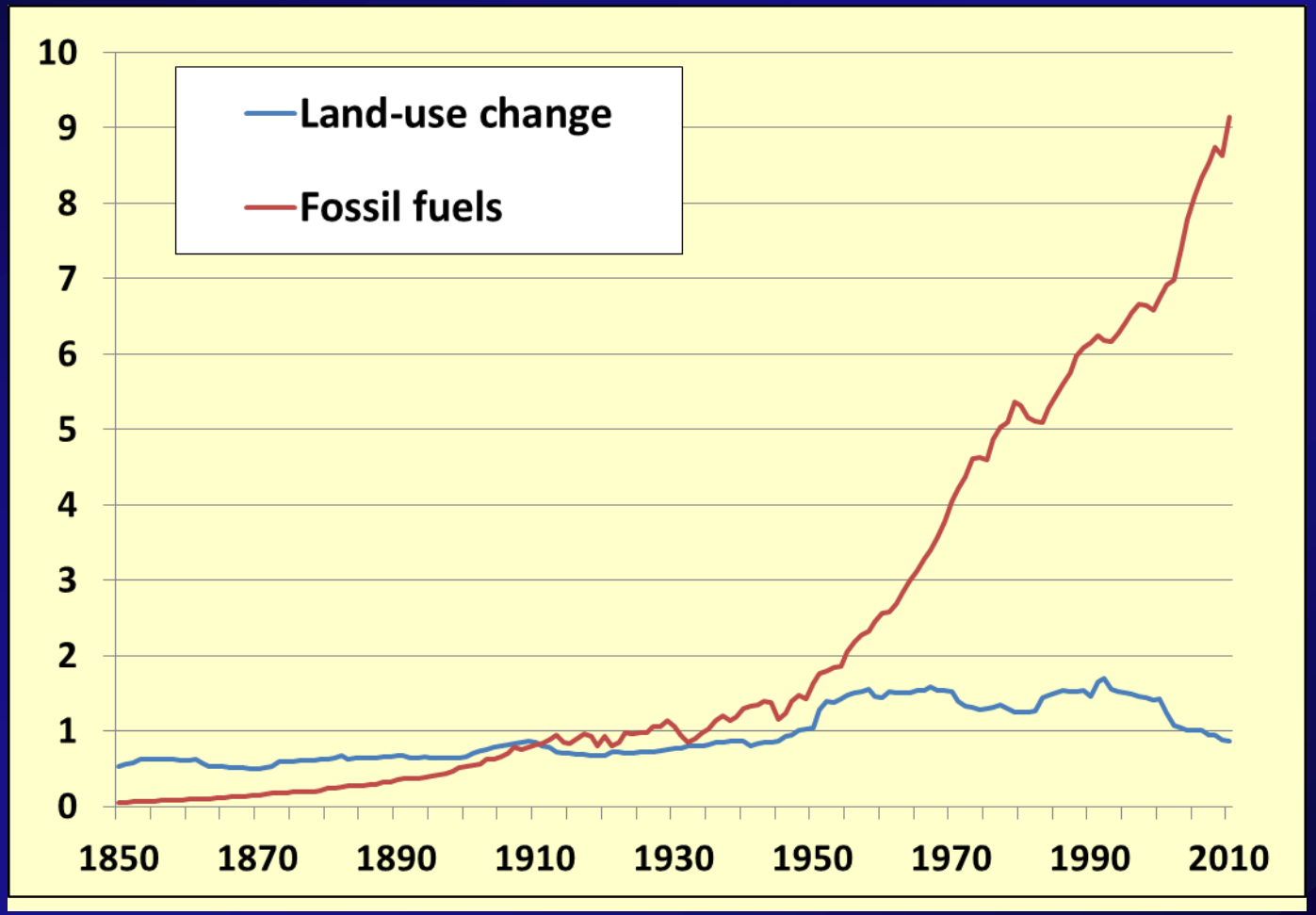
…and there are two ways to do that:

- Reduce emissions
- Increase uptake by land, oceans

First, management…

1. Direct human effects (management)
   - Deforestation
   - Croplands, pasturelands
   - Forestry: harvests and use of products

Can we reduce emissions?



We could stabilize the concentration of CO_2 in the atmosphere quickly by:

- reducing emissions by 4 PgC/yr (about 50%)

Global Carbon Budget 2000-2010

	(PgC/yr)
Sources	
Fossil fuels	7.9 ±0.5
Land-use change	1.0 ±0.7
Sinks	
Atmosphere	**4.1 ±0.2**
Oceans	2.4 ±0.5
Residual terrestrial	2.4 ±1.0

We could stabilize the concentration of CO_2 in the atmosphere quickly by:

- reducing emissions by 4 PgC/yr (about 50%)

And we could do that by:

- managing forests

Three land management mechanisms for the near term

- Stop deforestation (1 PgC/yr)
- Allow existing forests to grow (1-3 PgC/yr)
- Expand the area of forests (1 PgC/yr)
- Total CO_2 reduction: 3-5 BMT C yr^{-1}

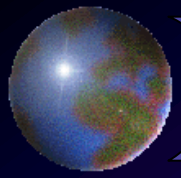
Global Carbon Budget 2000-2010

(PgC/yr)

	2000-2010	With management
Sources		
Fossil fuels	7.9 ±0.5	7.9
Land-use change	1.0 ±0.7	-2 to -4
	8.9	**4 to 6**
Sinks		
Atmosphere	**4.1** ±0.2	**0.0**
Oceans	2.4 ±0.5	2.4
Residual terrestrial	2.4 ±1.0	2.4

Managing land will not be simple

- Forests don’t accumulate carbon indefinitely
- Fossil fuel emissions must decline
- Natural land and ocean sinks must continue
- Carbon in forests is vulnerable
- Suitable land areas must be identified
- Much will depend on the price of carbon
- There will be intense competition for land
- Rights and equity must be protected



Second, natural processes…

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Review

Direct human effects (management)

versus

Natural effects

Review

Direct human effects (management)

and

Natural effects

Today	Tomorrow's Potential
0.9 PgC/yr source	2-4 PgC/yr sink

Review

Direct human effects (management)

and

Natural effects

Today	Tomorrow's Potential
0.9 PgC/yr source and 2.8 PgC/yr sink	2-4 PgC/yr sink and ???

Review - climate governance

Direct human effects (management)

versus

Natural effects

How do we account for these sources and sinks?

(debits and credits)

Climate governance

Direct human effects (management)

- REDD+
- Kyoto Protocol

Natural effects

- No credits or debits

Climate governance

Direct human effects (management)

- REDD+
- Kyoto Protocol

} Private, National

Natural effects

- No credits or debits

} Public, Common property, Global

Climate governance

We need a global agreement
for dealing with the common property
of natural sources and sinks of carbon.

For example, reducing sources even more in response to large atmospheric CO_2 increases; and allowing greater sources in response to small atmospheric CO_2 increases (i.e., more management).

In conclusion…

Conclusions

Highest priority is reducing fossil fuel use.

…but that's only part of the solution.

Conclusions

Highest priority is reducing fossil fuel use.

…and it will take some decades.

In the meantime…

- Forest and land management could reduce emissions of carbon by 3-5 PgC/yr,
- and stabilize the CO_2 concentration.

Conclusions

Highest priority is reducing fossil fuel use.

Forest and land management could change from 10-15% of the problem

to 50% of the solution.

Conclusions (continued)

Highest priority is reducing fossil fuel use.

The urgency:

Global warming could increase sources of carbon (the natural terrestrial sink could disappear)… and make carbon management insignificant.

Conclusions (continued)

Highest priority is reducing fossil fuel use.

The urgency:

Global warming could increase sources of carbon (the natural terrestrial sink could disappear)… and make carbon management insignificant… with harsh consequences:

- extreme weather: floods, droughts, fires
- crop failures
- sea level rise
- forest die-off

To stop further climatic disruption…

…we must

stabilize the concentrations

of greenhouse gases in the atmosphere

(CO_2 especially).

But when?

At what concentration?

How much warming is safe?

A 2°C warming has been set as a limit or goal.

-- the cut-off between safe and dangerous.

-- a compromise between what's needed (science) and what was seen as possible (politics). But it may be too much.

A limit of 2°C ??

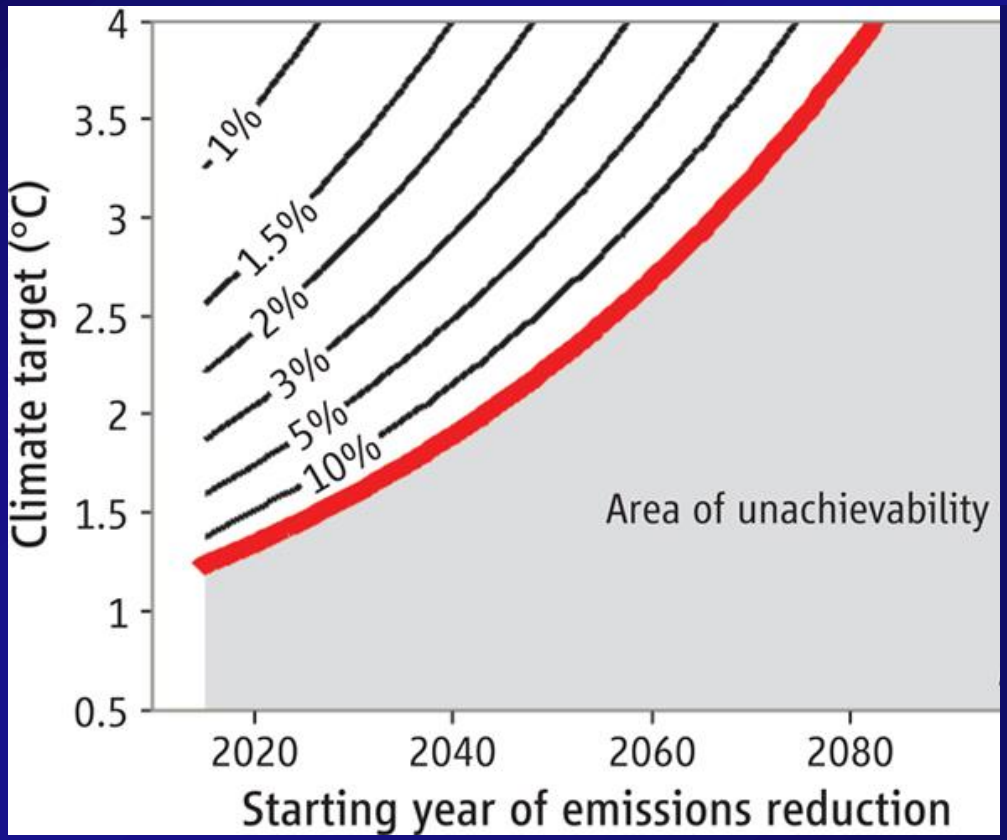
The average global warming so far has been ~ 0.75°C.

We are committed to a warming of almost another 0.75°C **if all emissions stopped now**.

(That's almost 1.5°C)

2°C ??

A closing window

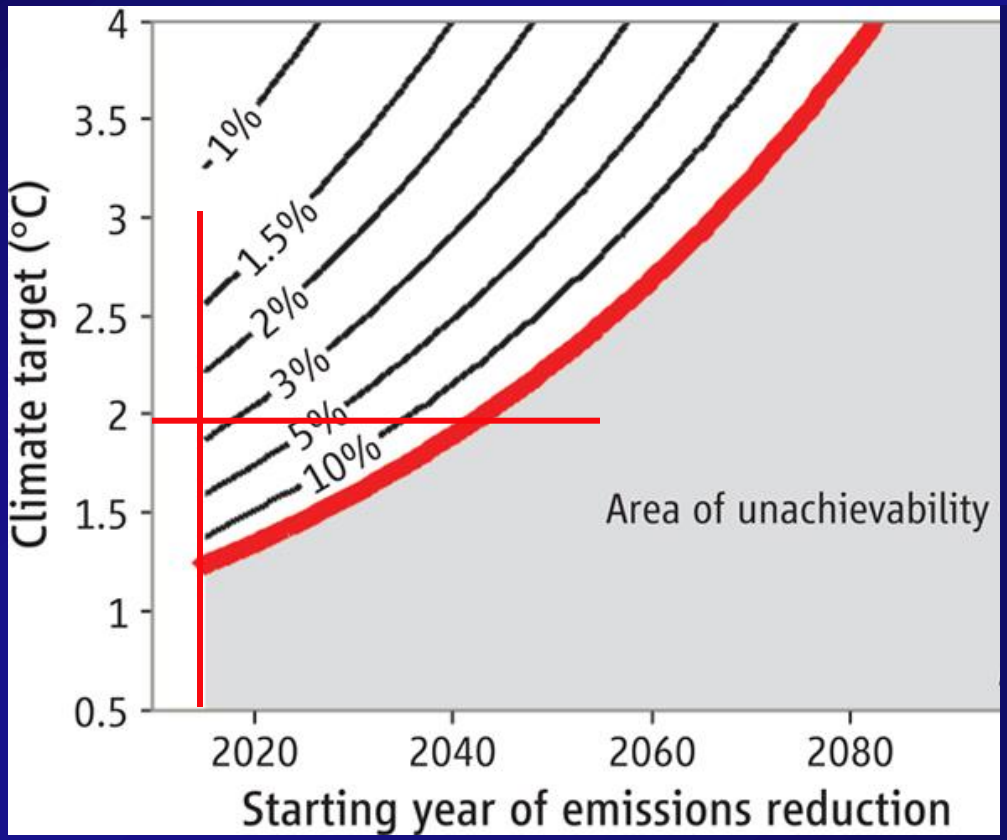


T F Stocker Science 2013;339:280-282

Science
AAAS

2°C ??

A closing window



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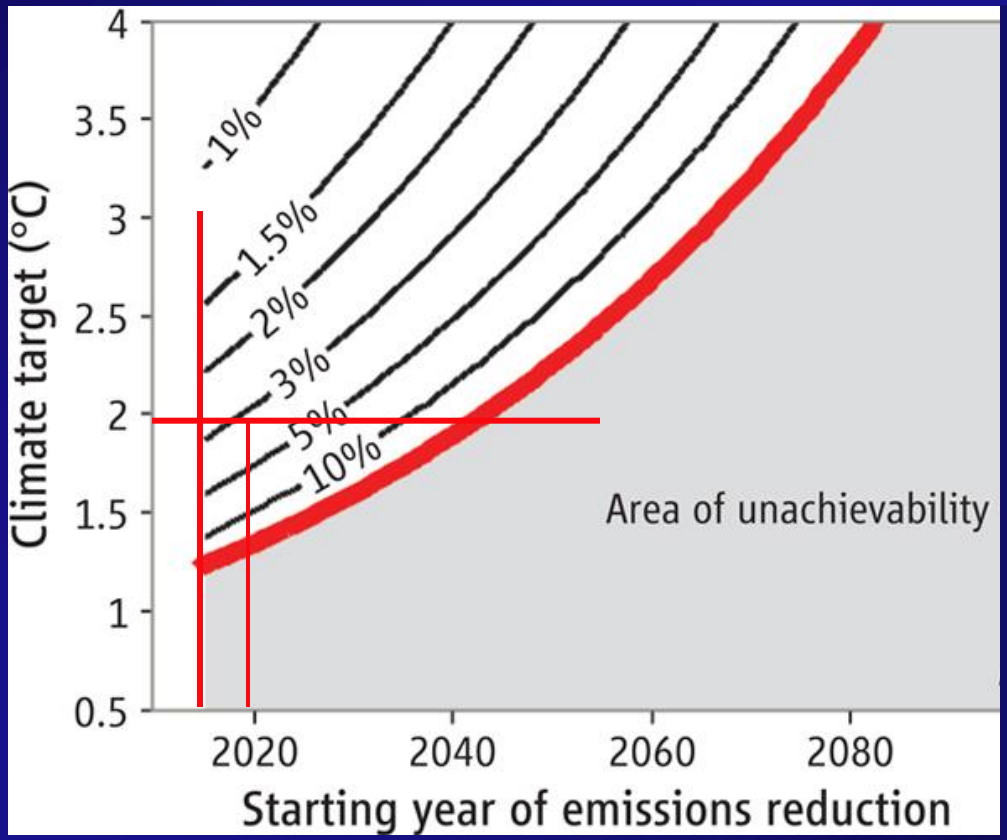

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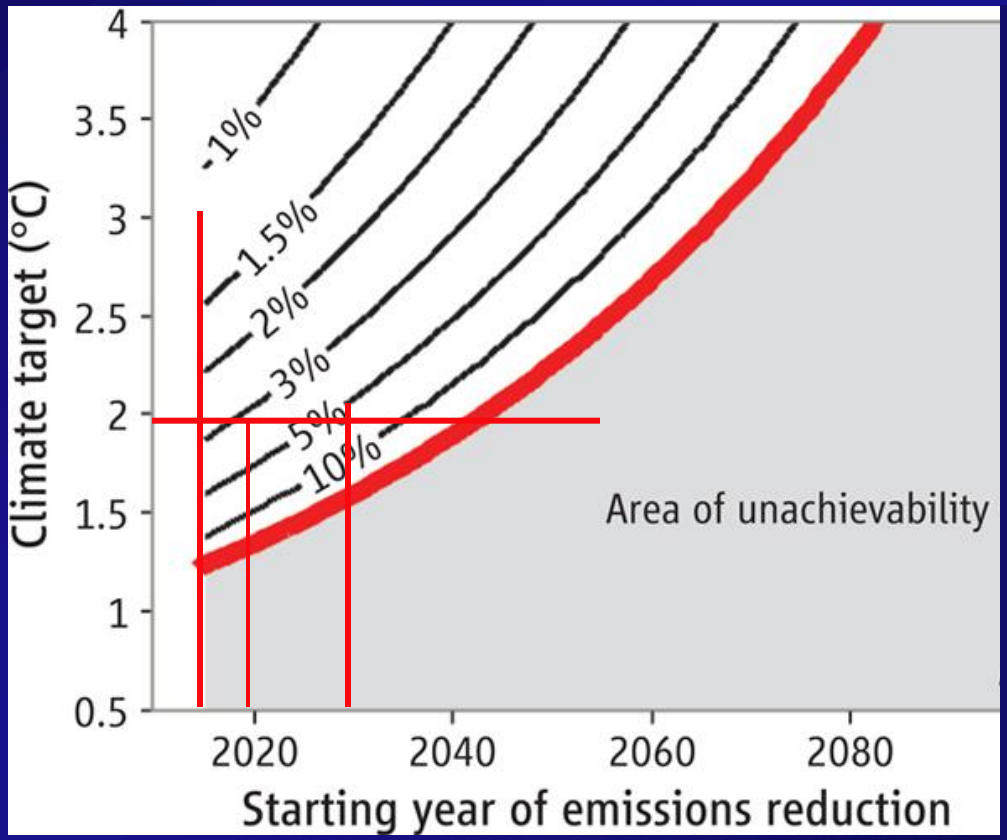

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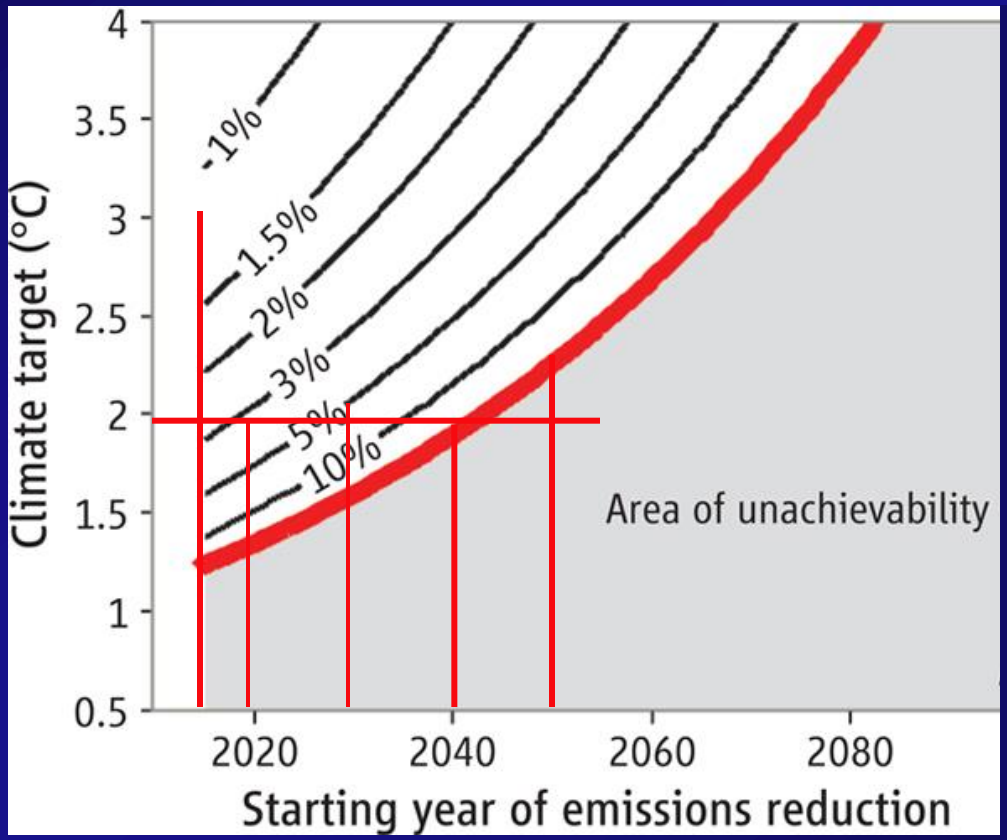

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Therefore …

…if we want to limit the warming to 2°C, we have about 25 years to do it …

…if we start now.

We are almost certainly going to exceed a warming of 2°C, safe or not.

We'll have to take carbon out of the atmosphere.

And we can do that at the same time we restore the biosphere.

Must stabilize concentration

(PgC/yr)

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Sources		
Fossil fuels	7.9 ±0.5	7.9
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…and start taking CO_2 out of the atmosphere

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Thank you

Using land to transition from fossil to renewable fuels

R.A. Houghton
Woods Hole Research Center

Gross sources are ~3x greater than net sources