TOPIC # 15
GLOBAL WARMING & ANTHROPOGENIC FORCING

Part A
CARBON RESERVOIRS & FLUXES:
Natural vs. Anthropogenically Enhanced

(or How does all that "C" get into the atmosphere??)

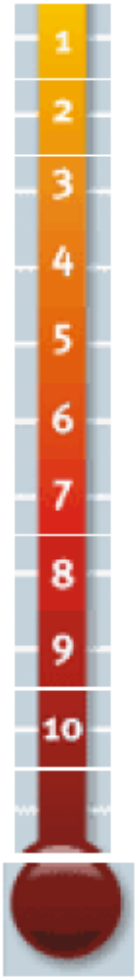
Class Notes pp 81

CLIMATE CHANGE: GLOBAL WARMING

WHAT'S CAUSING IT?

The most used "denier" arguments about the causes and effects of climate change

From: http://www.skepticalscience.com/



1. Climate's changed before
2. It's the sun
3. It's not bad
4. There is no consensus
5. It's cooling
6. Models are unreliable
7. Temp record is unreliable
8. Animals and plants can adapt
9. It hasn't warmed since 1998
10. And so forth . . . . .

This semester we will critically examine and evaluate the most used arguments and myths about climate change!

"We are playing Russian roulette with our climate . . . The Earth's climate system is an angry beast subject to unpredictable responses, and **by adding carbon dioxide to the atmosphere we may be provoking the beast.**"

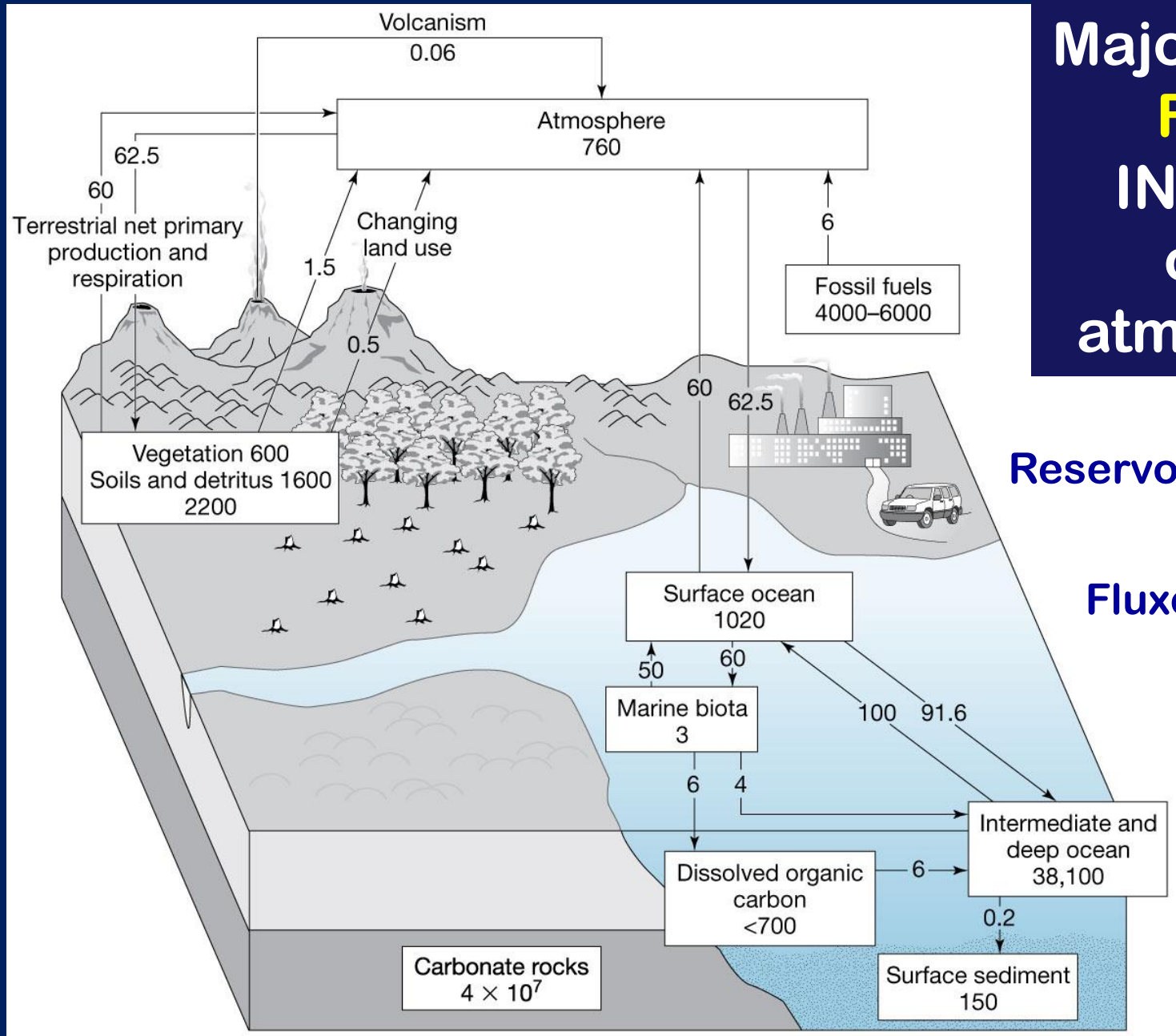
~Wally Broecker , Paleoclimatologist

CO_2 & CARBON RESERVOIRS

CO_2 in the atmosphere is one place CARBON resides in the Earth-Atmosphere system.

Where else is carbon located and how does it move (flux) from one reservoir to another?

Major Carbon Fluxes IN & OUT of the atmosphere



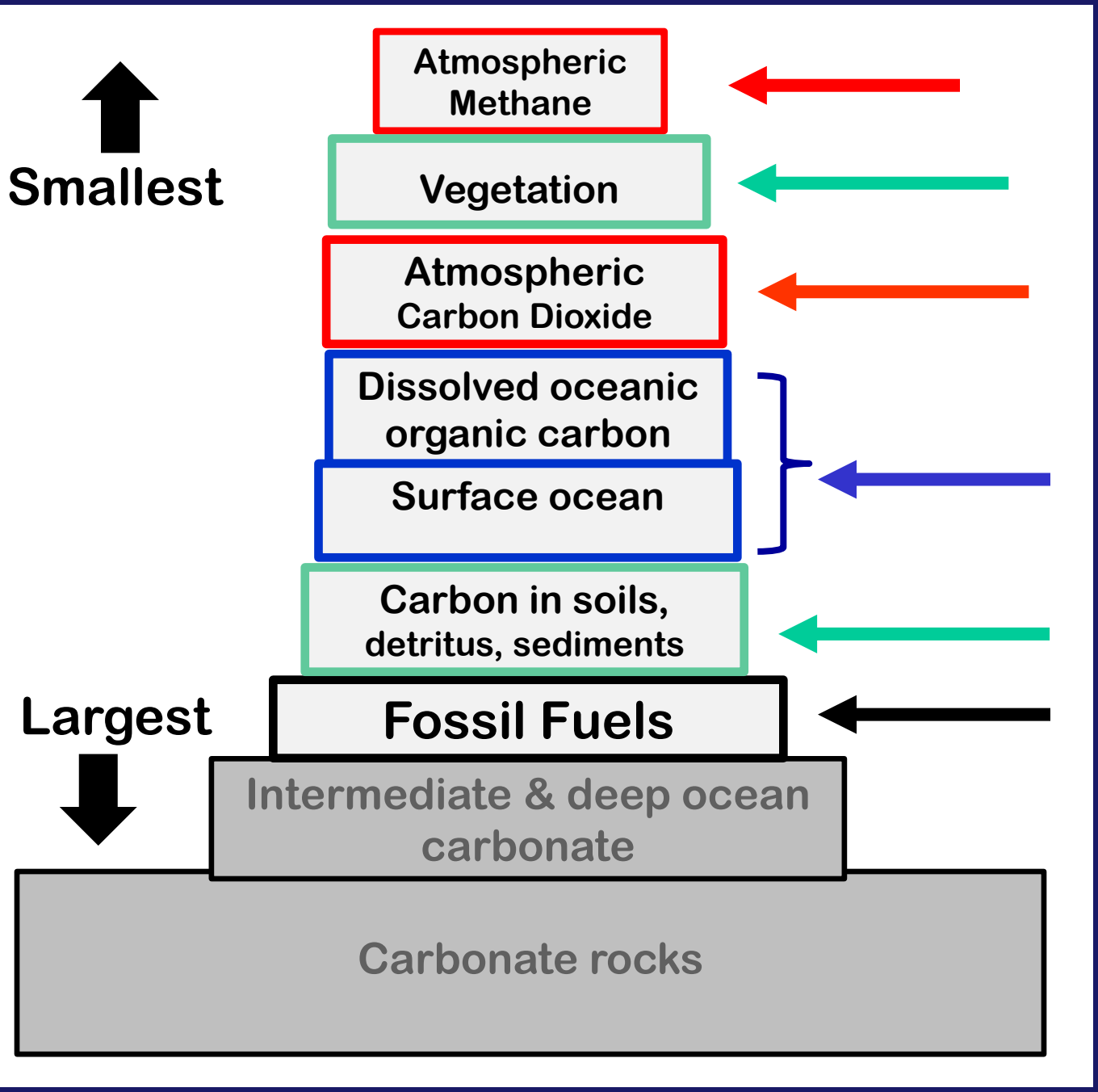
Reservoirs =

Fluxes =

RESERVOIR (def)

a place where anything is collected or accumulated in great amount.

Carbon Reservoirs ranked by size :



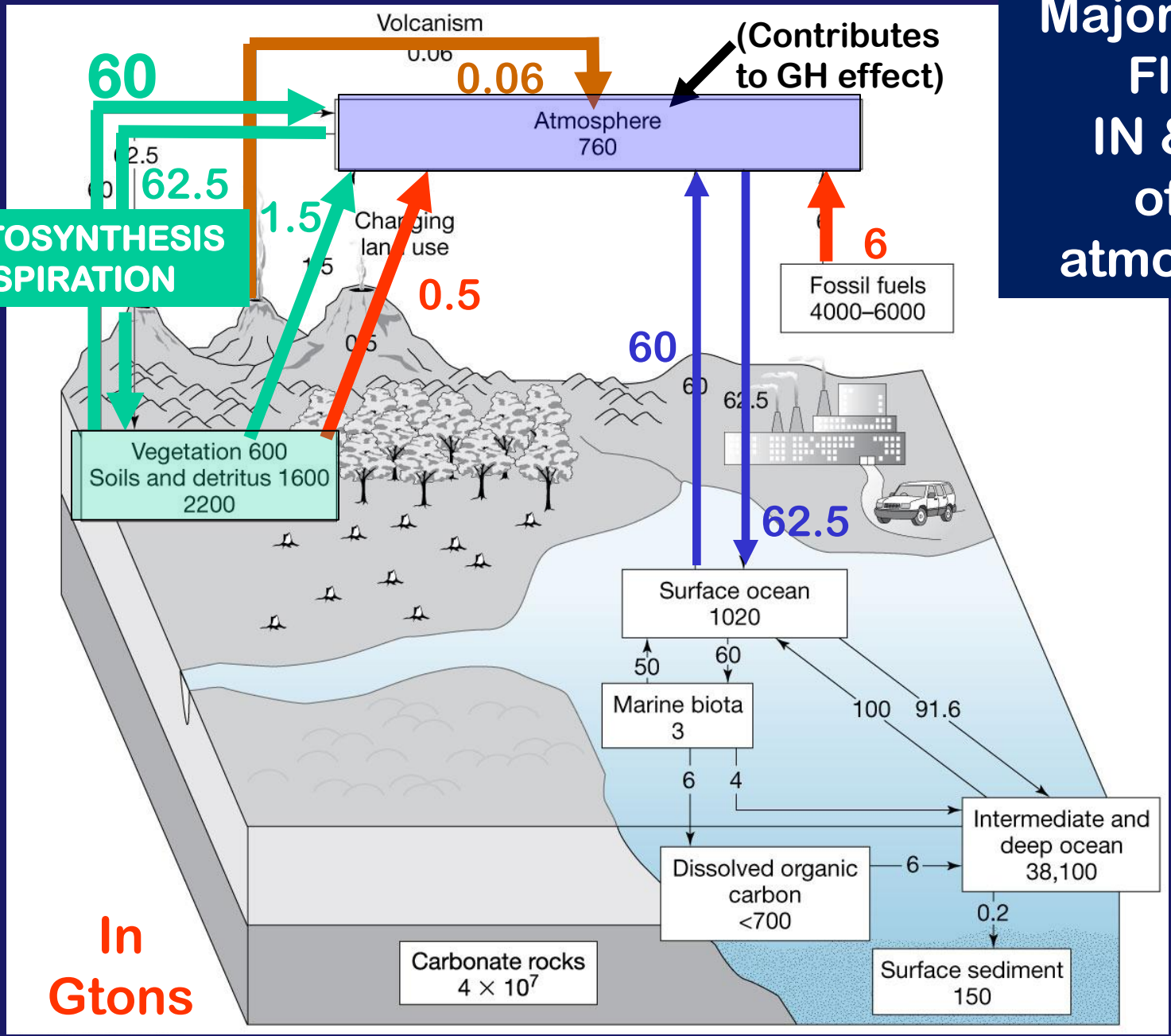
Amount of carbon is expressed in units of Gtons (gigatons) of carbon: GT(C)

Amounts represent the **MASS OF CARBON ATOMS ONLY**, not other atoms to which C is attached (e.g. CO_2)

One gigaton is . . .

Greater than the mass of all the humans on the planet

Major Carbon Fluxes IN & OUT of the atmosphere



Q5.How does CARBON "flux" FROM the biosphere INTO the atmosphere?

1. Trees take in carbon dioxide during photosynthesis.

2. Trees release carbon dioxide during photosynthesis.

3. Trees release carbon dioxide into the atmosphere during respiration.

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NATURAL FLUXES INTO & OUT OF THE ATMOSPHERIC CARBON RESERVOIR related to **BIOMASS** = respiration & photosynthesis

FLUX from PLANT INTO ATMOSPHERE:

Respiration: CH_2O + O_2 ⟶ CO_2 + H_2O.

carbohydrate | oxygen gas | carbon dioxide | water

FLUX <u>OUT OF ATMOSPHERE</u> into PLANT:

Photosynthesis: CO_2 + H_2O ⟶ CH_2O + O_2.

(Primary Production) | carbon dioxide | water | carbohydrate | oxygen gas

SOME DEFINITIONS:

Respiration =

biochemical process
living organisms take up O_2,
consume organic matter,
RELEASE CO_2, heat, & H_2O

Decomposition =

breakdown of organic matter
by bacteria and fungi,
RELEASES CO_2 to the atmosphere

Photosynthesis =

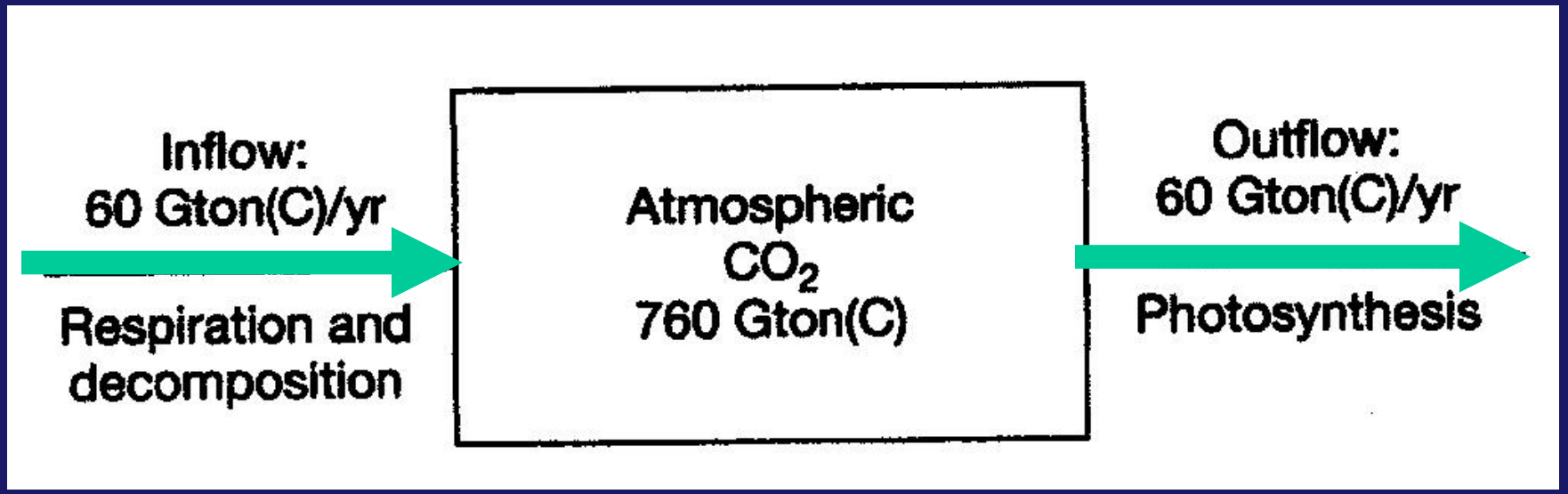
manufacture of carbohydrates & O_2
from CO_2 and H_2O
in the presence of chlorophyll
sunlight as the energy source.

Oxygen is *released* in the process.

Solar energy → chemical energy

(Part of chemical energy is stored in living tissues & used by other organisms (consumers) that cannot use solar energy directly.)

The Atmospheric Carbon Reservoir

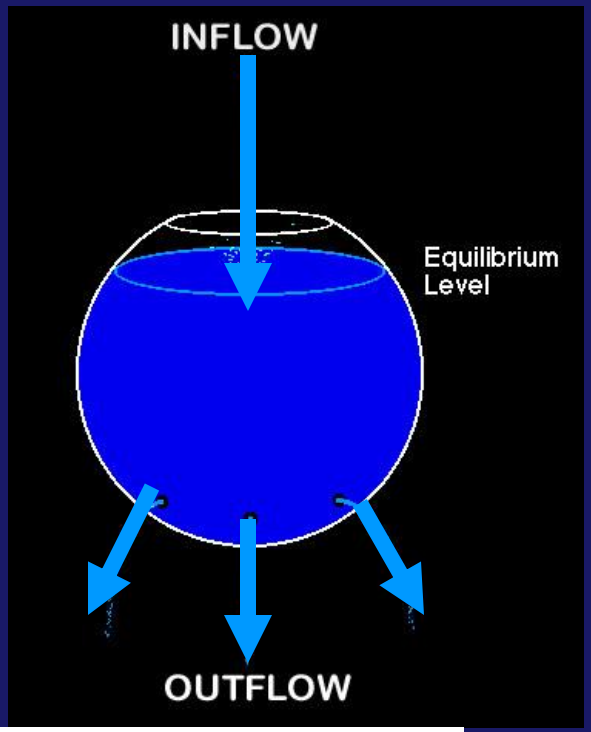


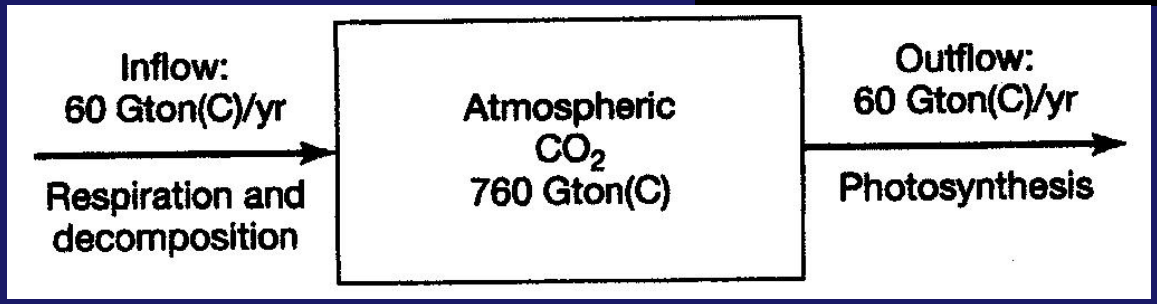
showing inflows and outflows (fluxes)

. . . leads to a

STEADY STATE

In the atmospheric CO_2 "reservoir"

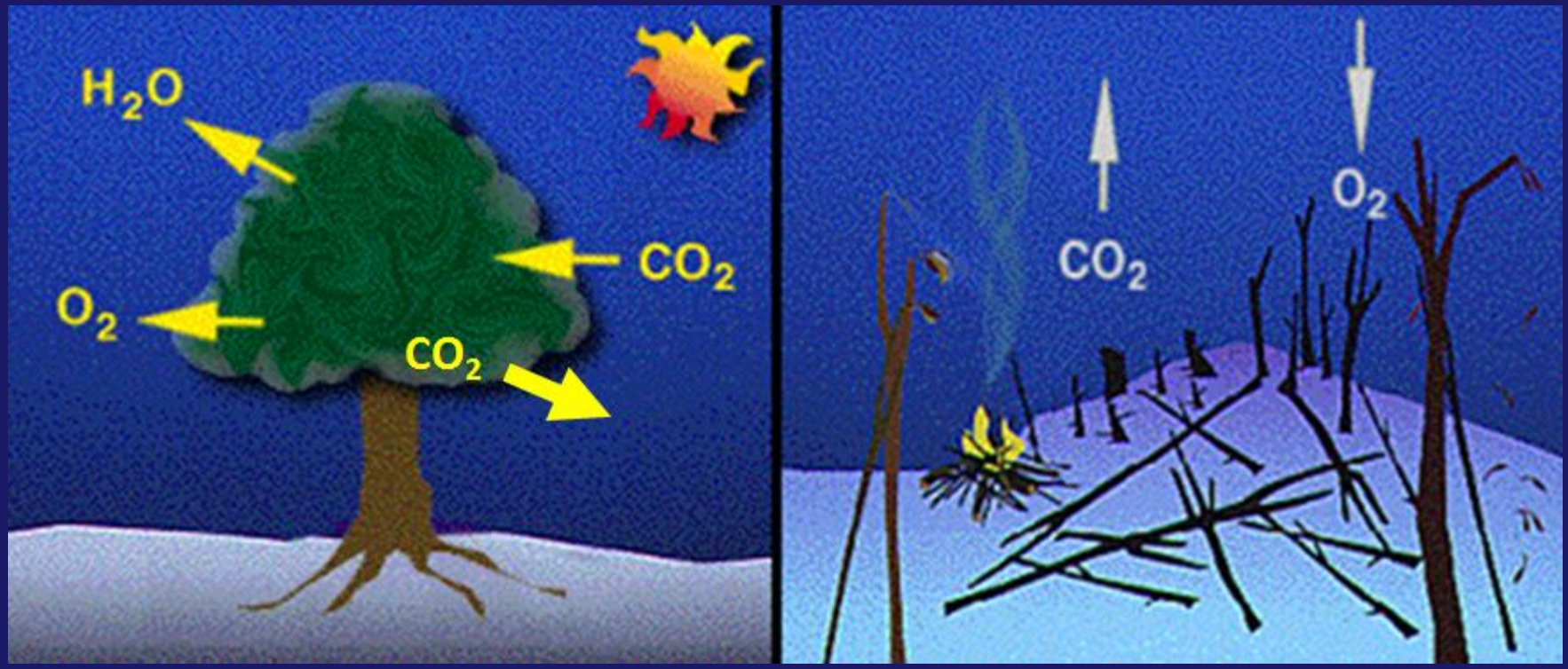




Where have we seen a STEADY STATE before?

Photosynthesis & Respiration

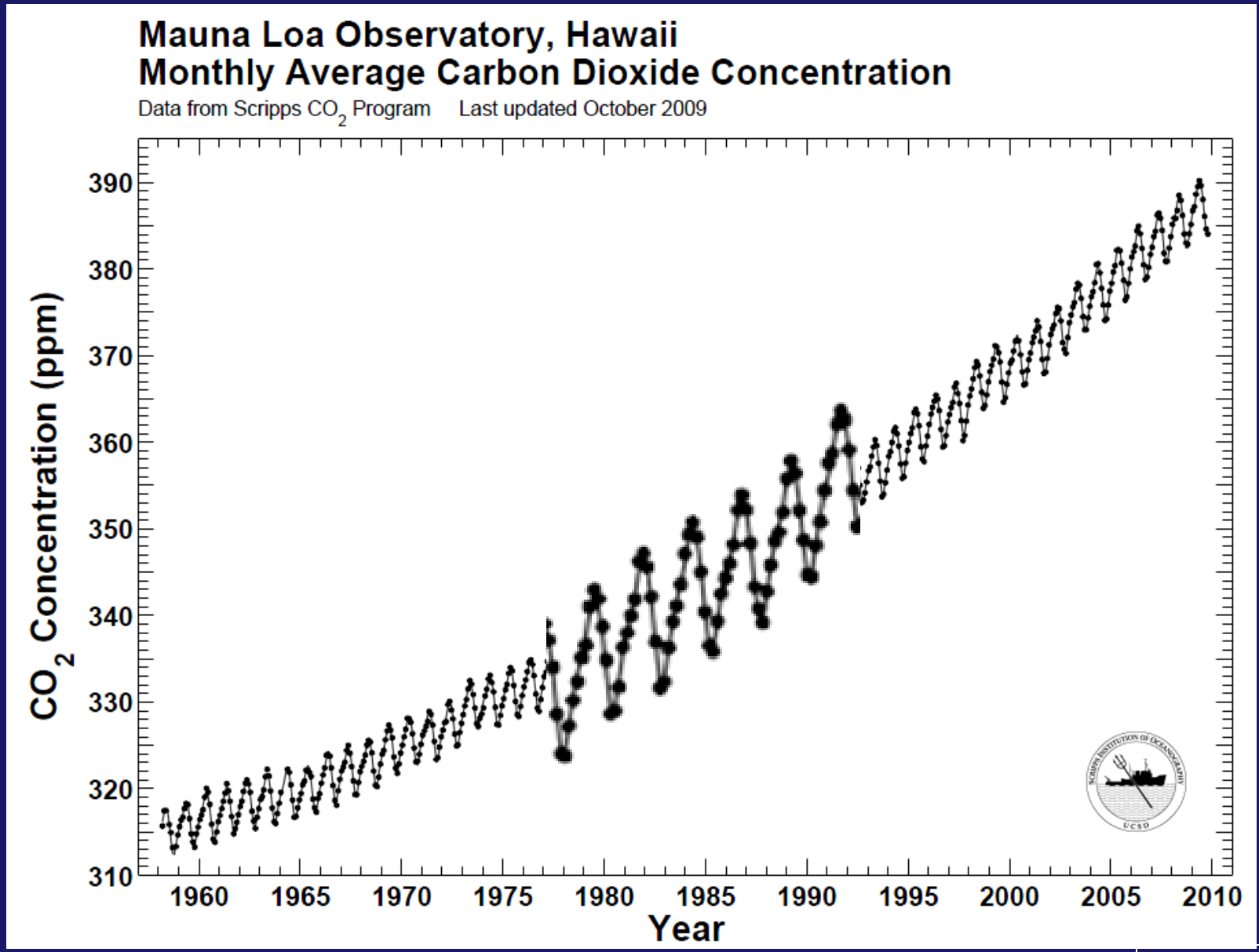
Respiration, Burning of Biomass, & Decomposition



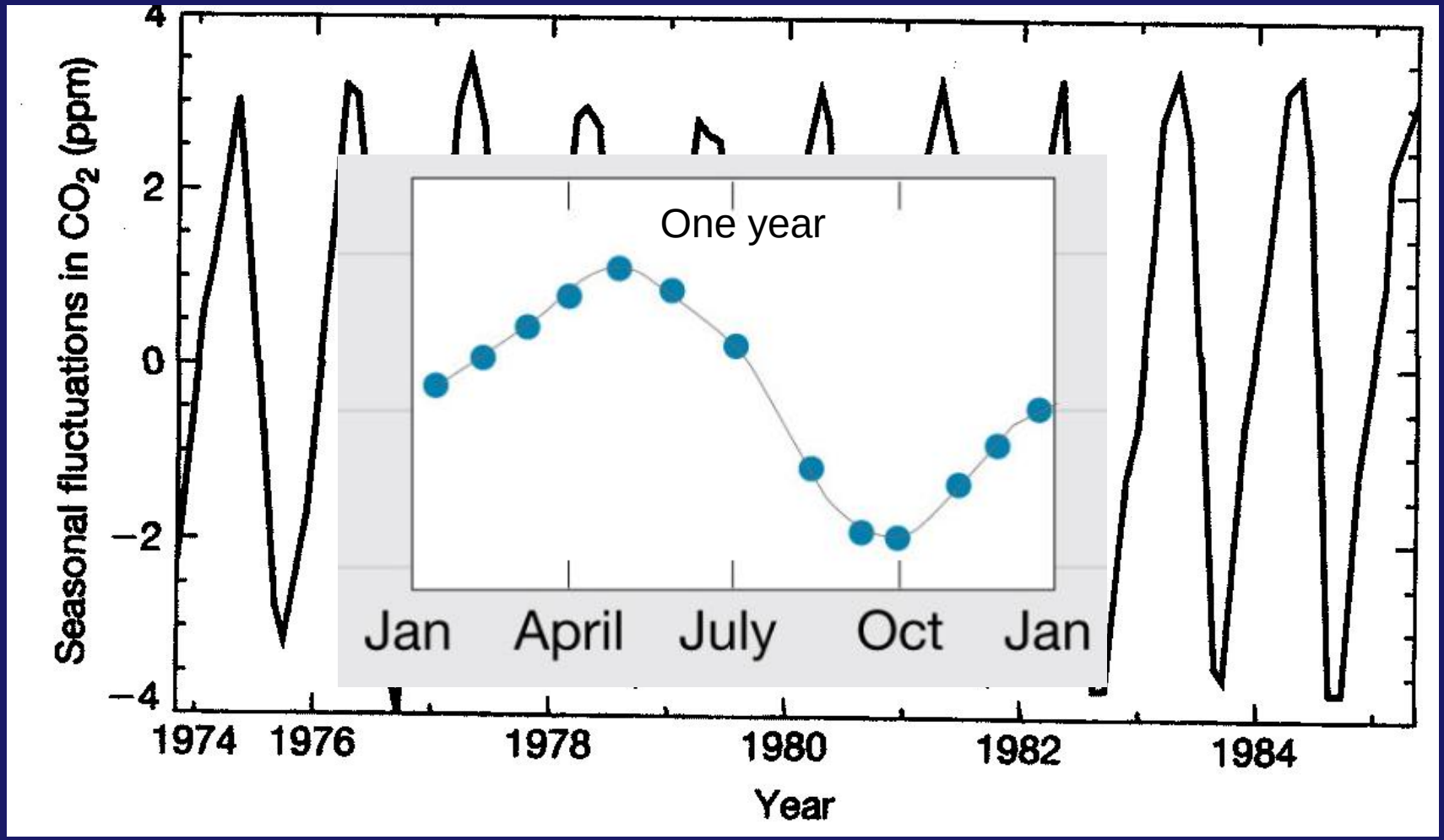
Steady State

Disruption of Steady State

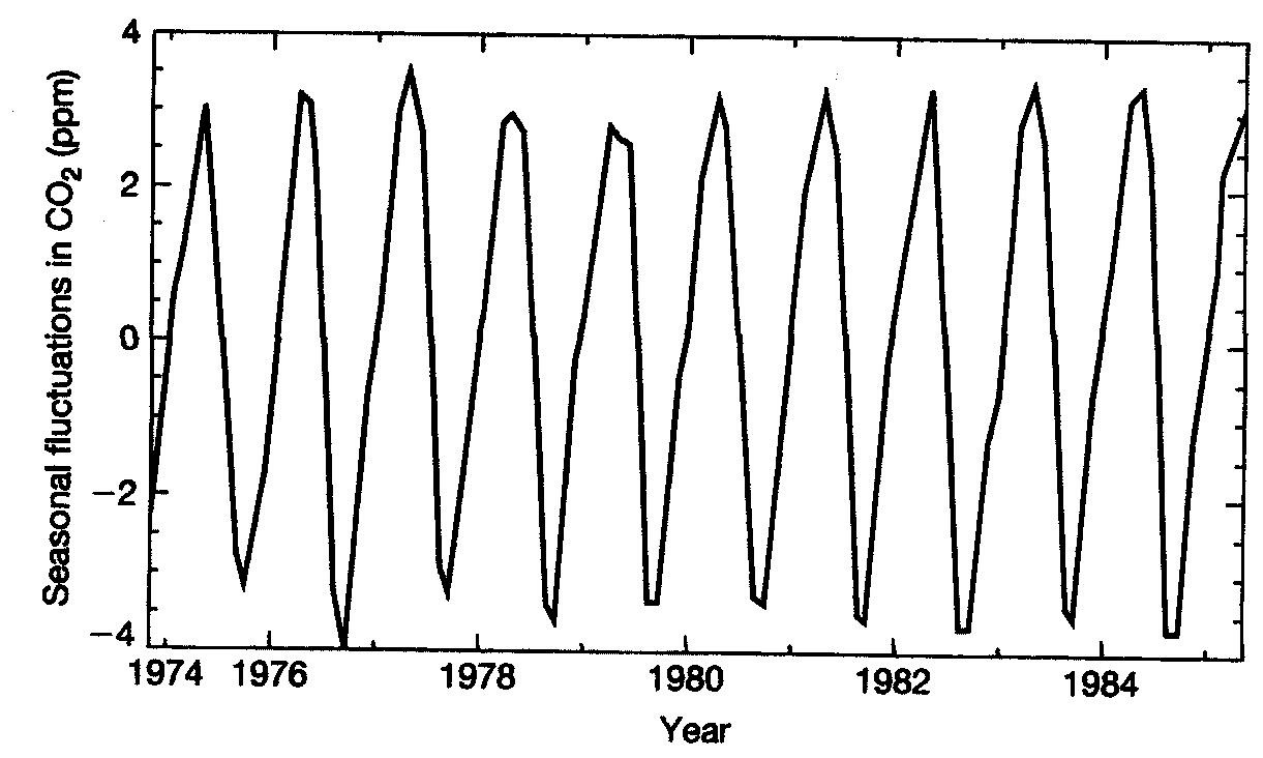
WHAT ABOUT THOSE ZIG-ZAGS IN THE KEELING CURVE?



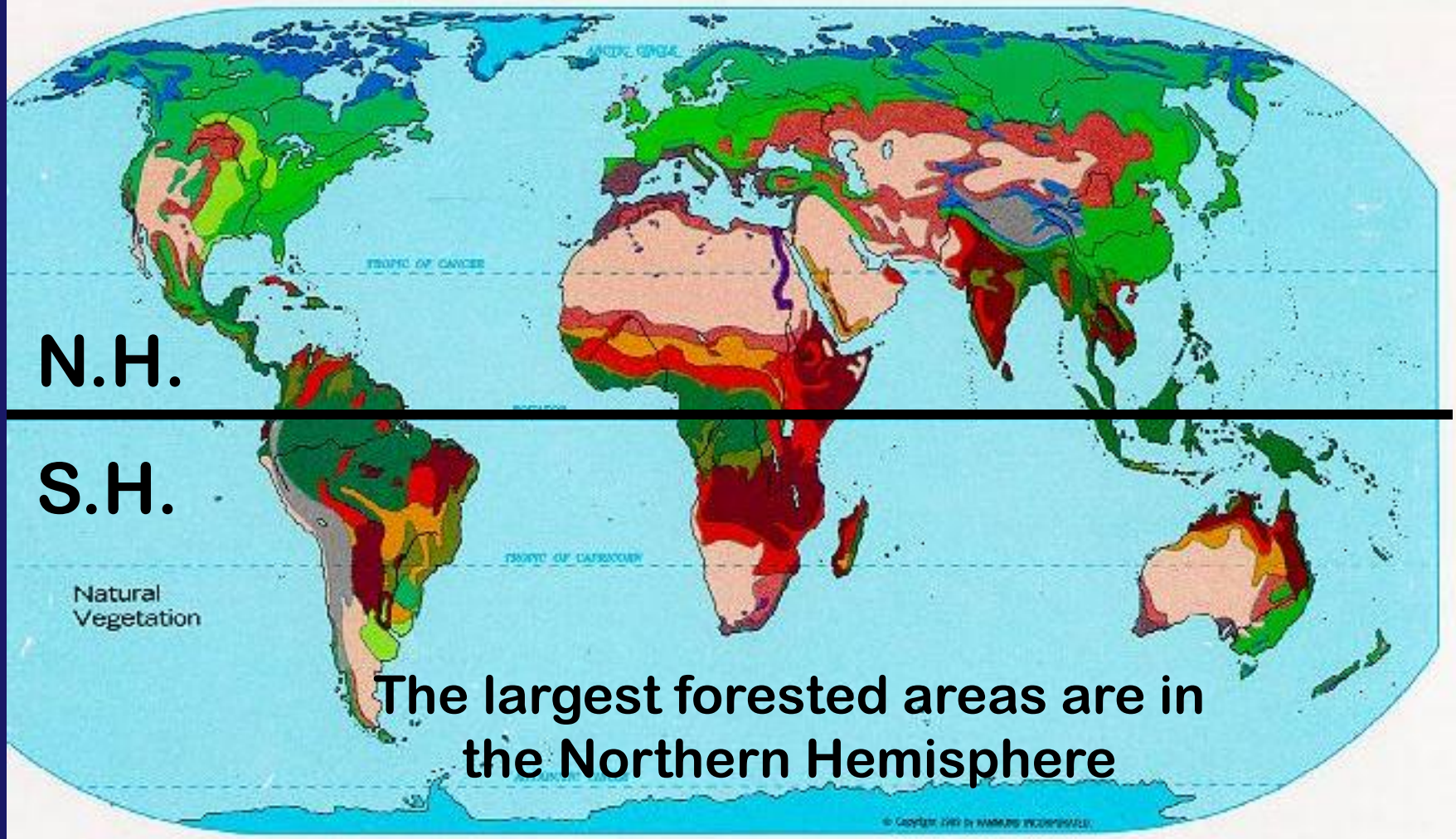
CLOSE-UP VIEW:



Trend due to anthropogenic increases has been removed.



Oscillations represent seasonal fluctuations driven by the balance between respiration & photosynthesis (dominated by Northern Hemisphere forests)



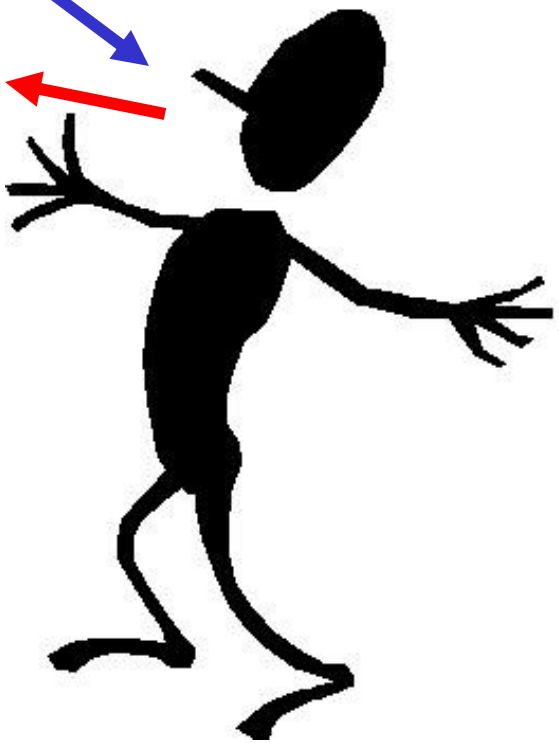
GLOBAL VEGETATION PATTERNS

"Breathing" -- ANIMALS vs. PLANTS

Respiration

O_2

CO_2

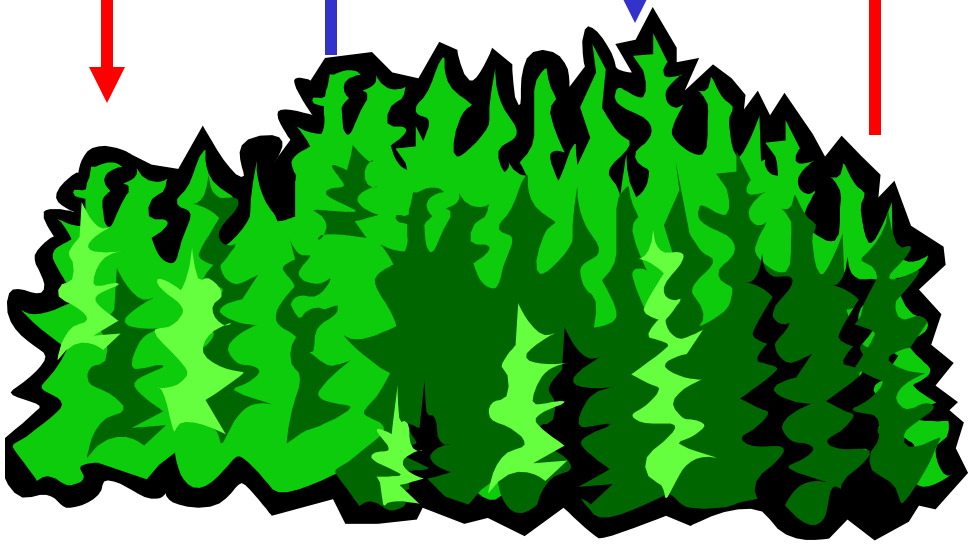


Photosynthesis

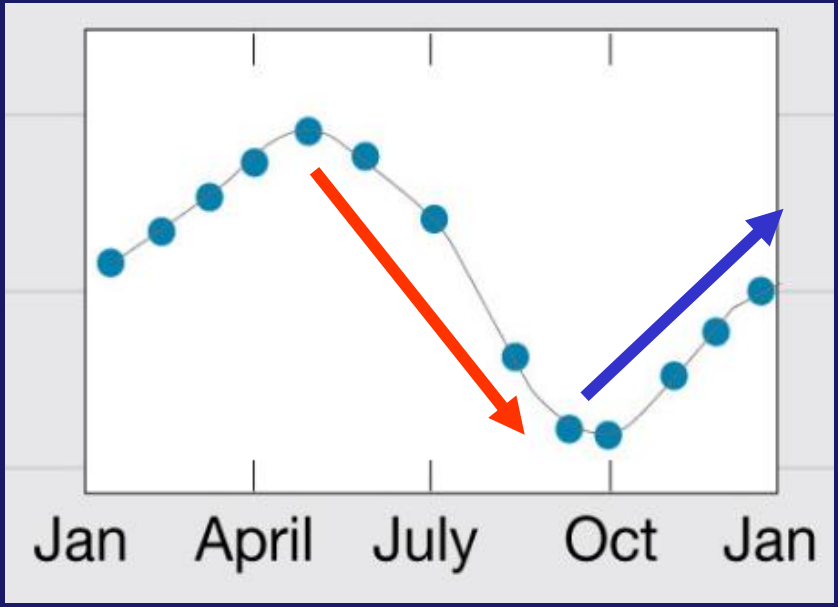
CO_2 O_2

Respiration & Decomposition

O_2 CO_2



Photosynthesis > Respiration
(CO_2 goes down in SUMMER as forests "breathe in" more CO_2)



Respiration > Photosynthesis
(CO_2 levels rise in FALL/WINTER as forests "breathe out" more CO_2)

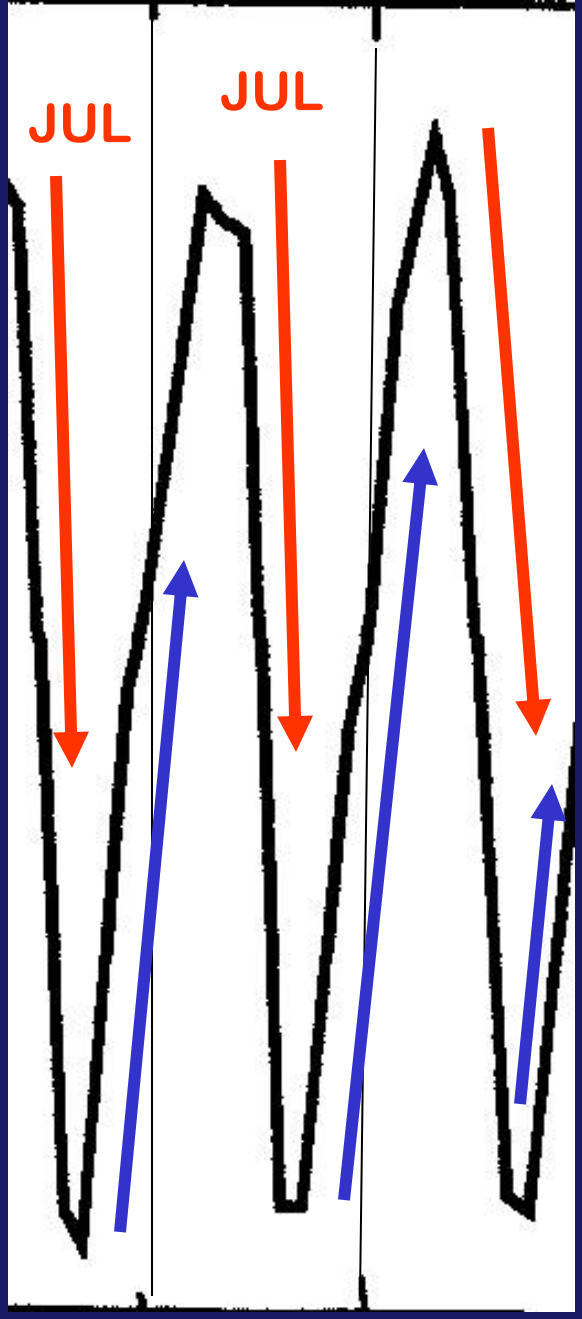
Tick marks are at January of each year:

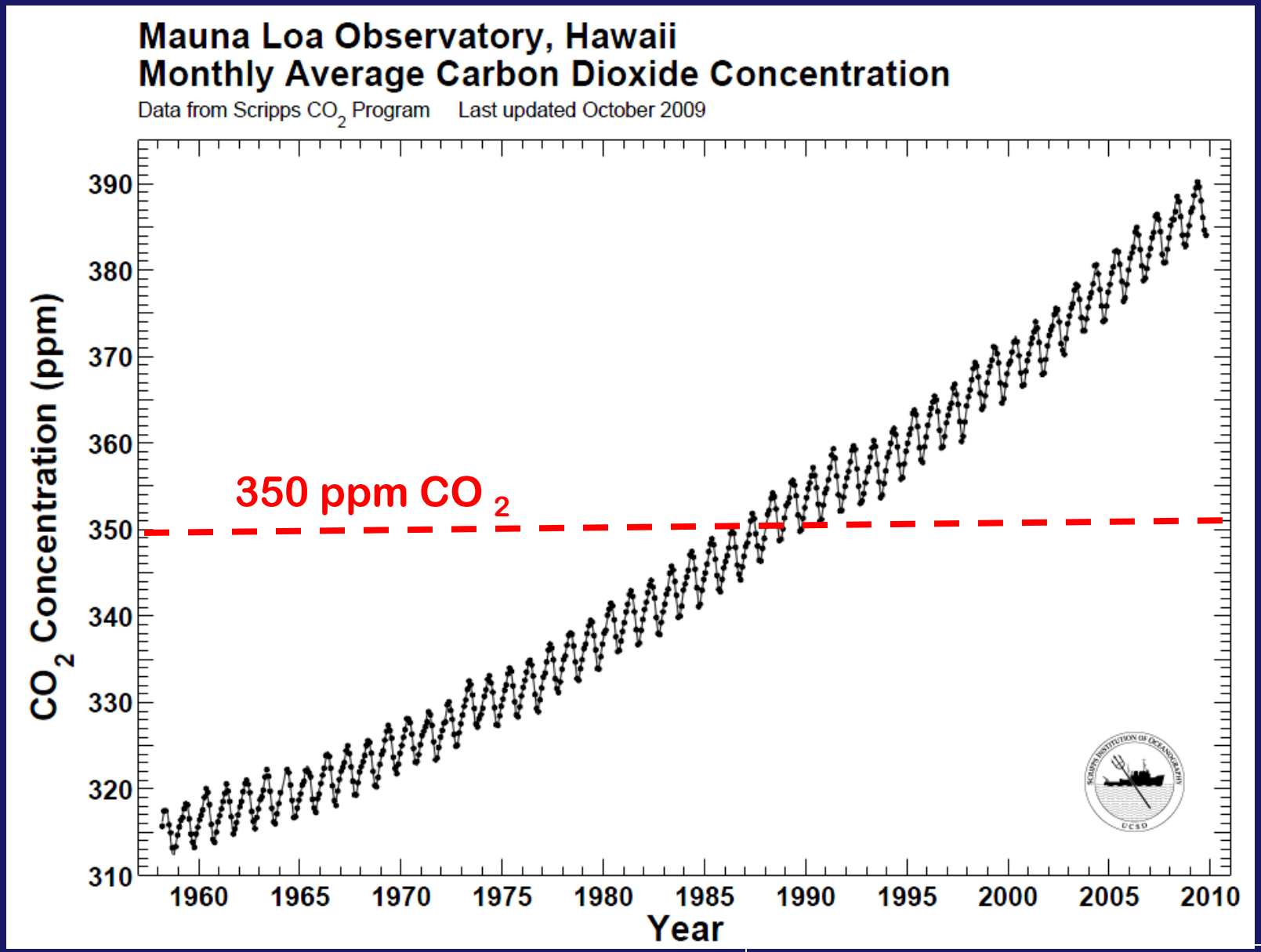
Photosynthesis > Respiration
(CO_2 goes down in SUMMER as forests "breathe in" more CO_2)

Respiration > Photosynthesis
(CO_2 levels rise in FALL/WINTER as forests "breathe out" more CO_2)

Photosynthesis > Respiration
(CO_2 goes down in summer)

Respiration > Photosynthesis
(CO_2 levels rise in fall/winter)

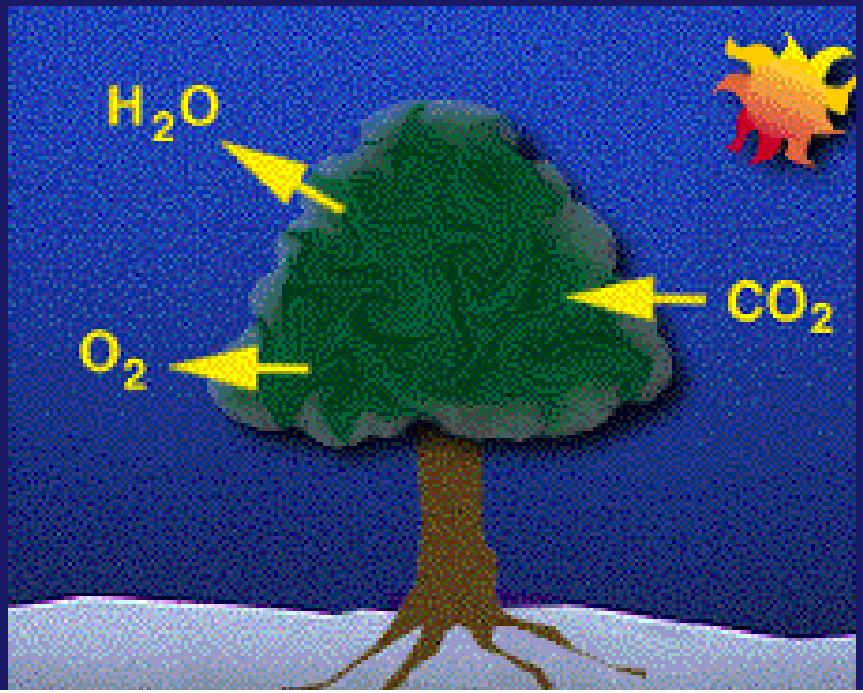



Mauna Loa Observatory, Hawaii
Monthly Average Carbon Dioxide Concentration
Data from Scripps CO2 Program Last updated October 2009
CO2 Concentration (ppm)
390
380
370
360
350
340
330
320
310
350 ppm CO 2
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

review

BUT IS ALL THE EXTRA CO_2 A BAD THING???

PLANTS DEPEND ON CO_2!!!



Photosynthesis: $CO_2 + H_2O \longrightarrow CH_2O + O_2$.

(Primary Production) — carbon dioxide — water — carbohydrate — oxygen gas

Mini- Break:

YOU TUBE!

http://www.youtube.com/watch?v=0_VmMIbWKoo

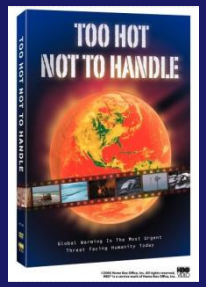
With rising CO2 levels:

- Some plant species continue to increase photosynthesis (C3) ⟷ • others do NOT (C4)

- Some plants can respond readily to higher CO2 levels ⟷ • Other plants can make only limited responses

Hence with Increased CO2 :

- some plant species will be stronger, more prolific, and may overwhelm those less able to benefit



"WE ARE ALREADY SEEING POLLEN INCREASES FROM RAGWEED & OTHER PLANTS"

And . . . there may be consequences we don't yet know !!

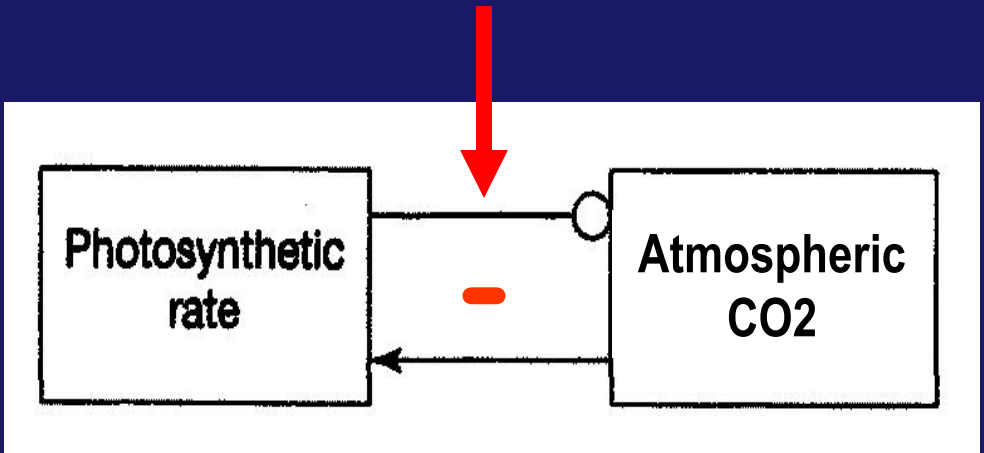
Greater atmospheric CO_2 concentration

➔ enhanced photosynthesis (due to "CO_2 Fertilization")

➔ more CO_2 being assimilated by plant from the atmosphere

➔ less atmospheric CO_2

What kind of FEEDBACK LOOP?



Negative & self-regulating!

. . . but the jury is still out on how well this negative feedback loop can counteract HUGE anthropogenic influxes of CO2

The New York Times

OP-ED COLUMNIST

Trucks, Trains and Trees

By THOMAS L. FRIEDMAN

November 11, 2009

"Imagine if you took all the cars, trucks, planes, trains and ships in the world and added up their exhaust every year. . . .

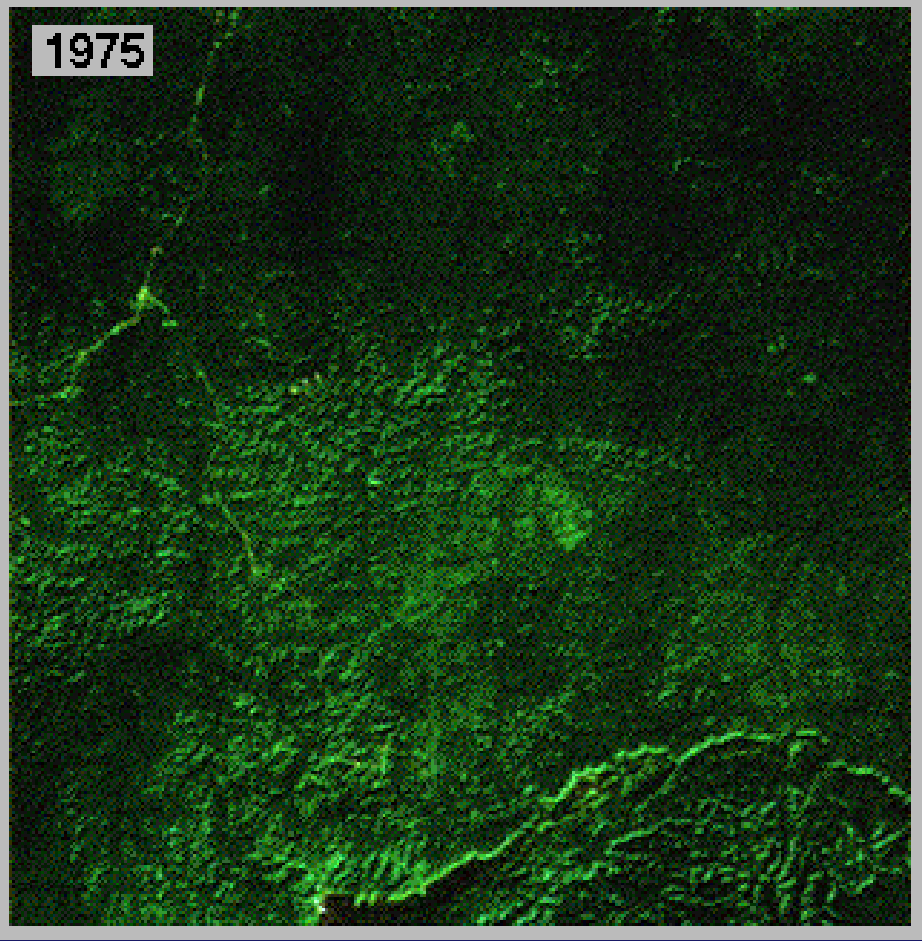
[it is] actually LESS than the carbon emissions every year that result from the chopping down and clearing of tropical forests in places like Brazil, Indonesia and the Congo. "

"We are now losing a tropical forest the size of New York State every year, and the carbon that releases into the atmosphere now accounts for roughly 17 percent of all global emissions contributing to climate change. "

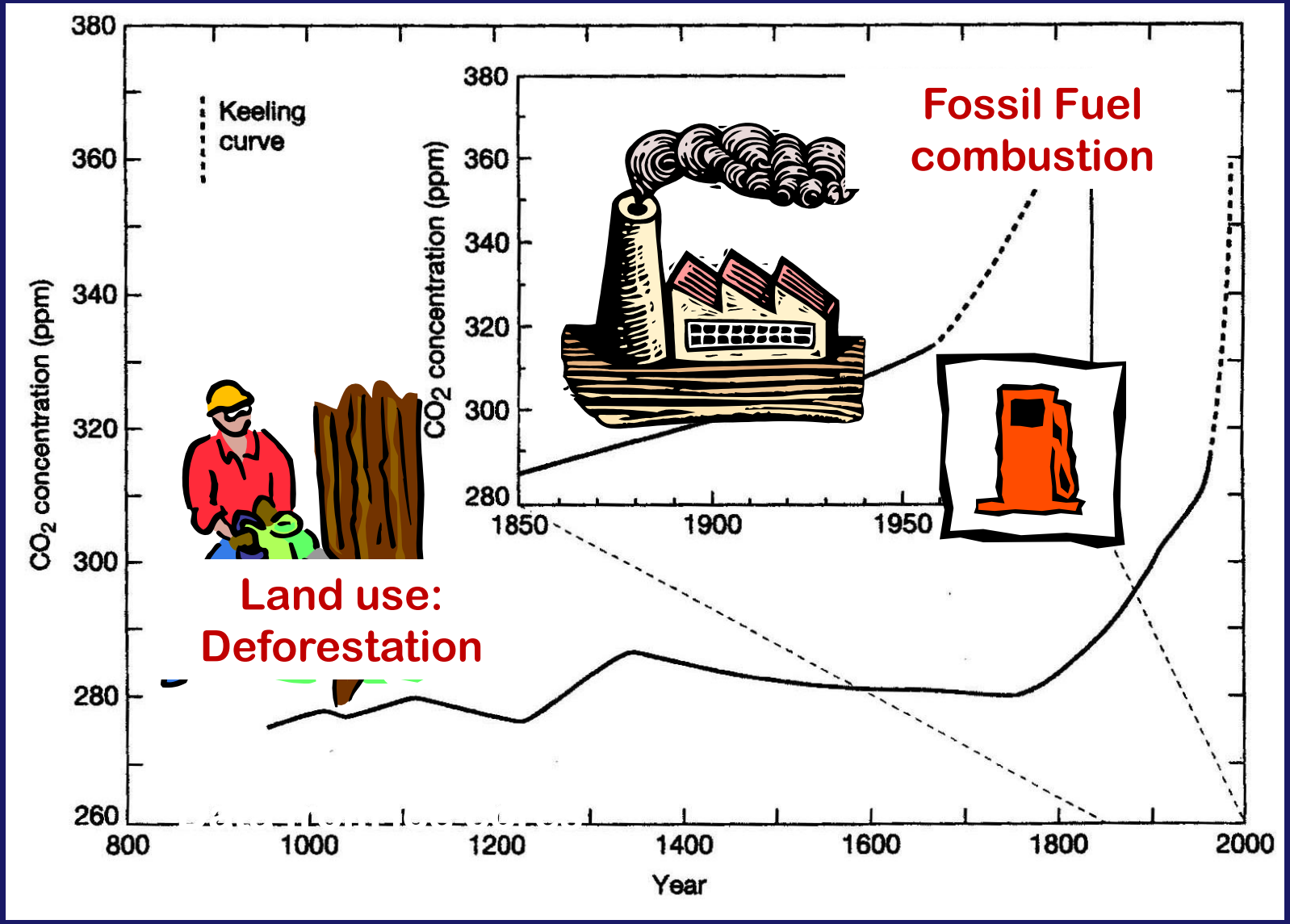
http://www.nytimes.com/2009/11/11/opinion/11friedman.html

LAND USE CHANGES:

Deforestation practices increase burning & decomposition of large areas of forest

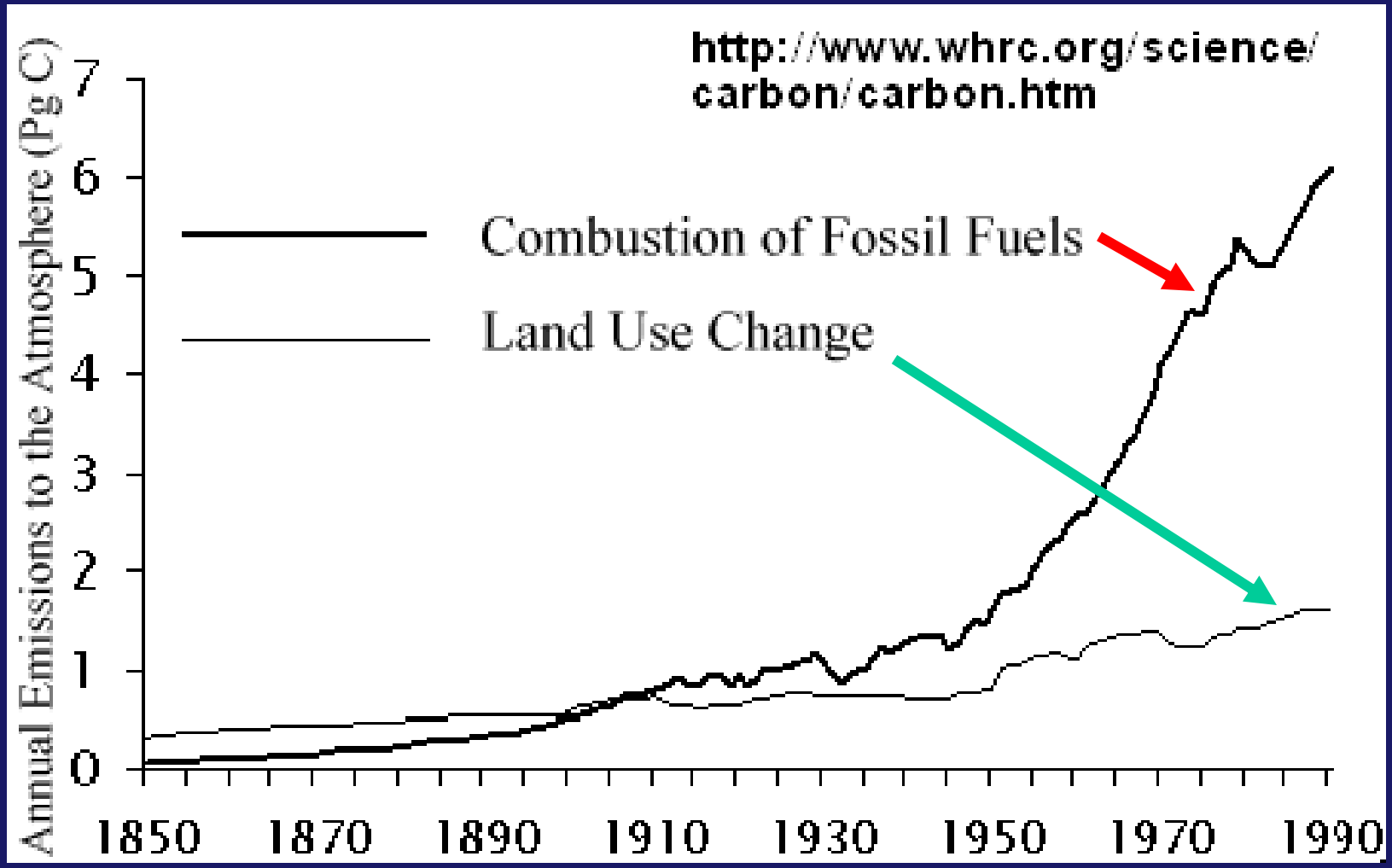


CARBON DIOXIDE: Two big sources



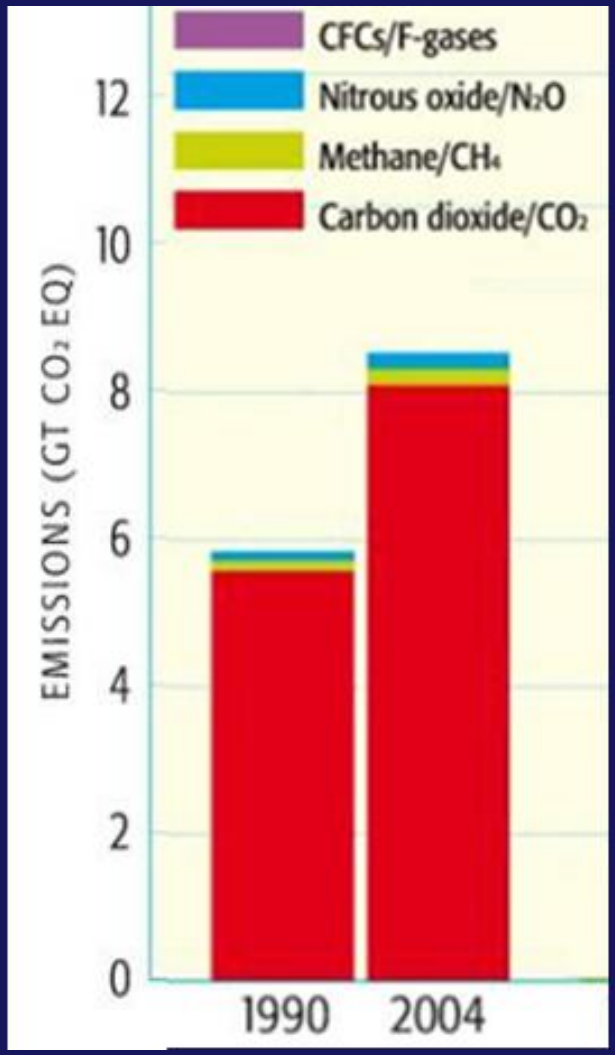
Review

Time Series Graph comparison of two ways CARBON gets into atmosphere:



Greenhouse Gas emissions from Forestry:

(1990 – 2004)



from p 159 in *Dire Predictions*

RATE OF CHANGE IN FORESTED AREA

Much of increase in China due to **AFFORESTATION** = planting new forests in places where preceding vegetation or land use was NOT a forest

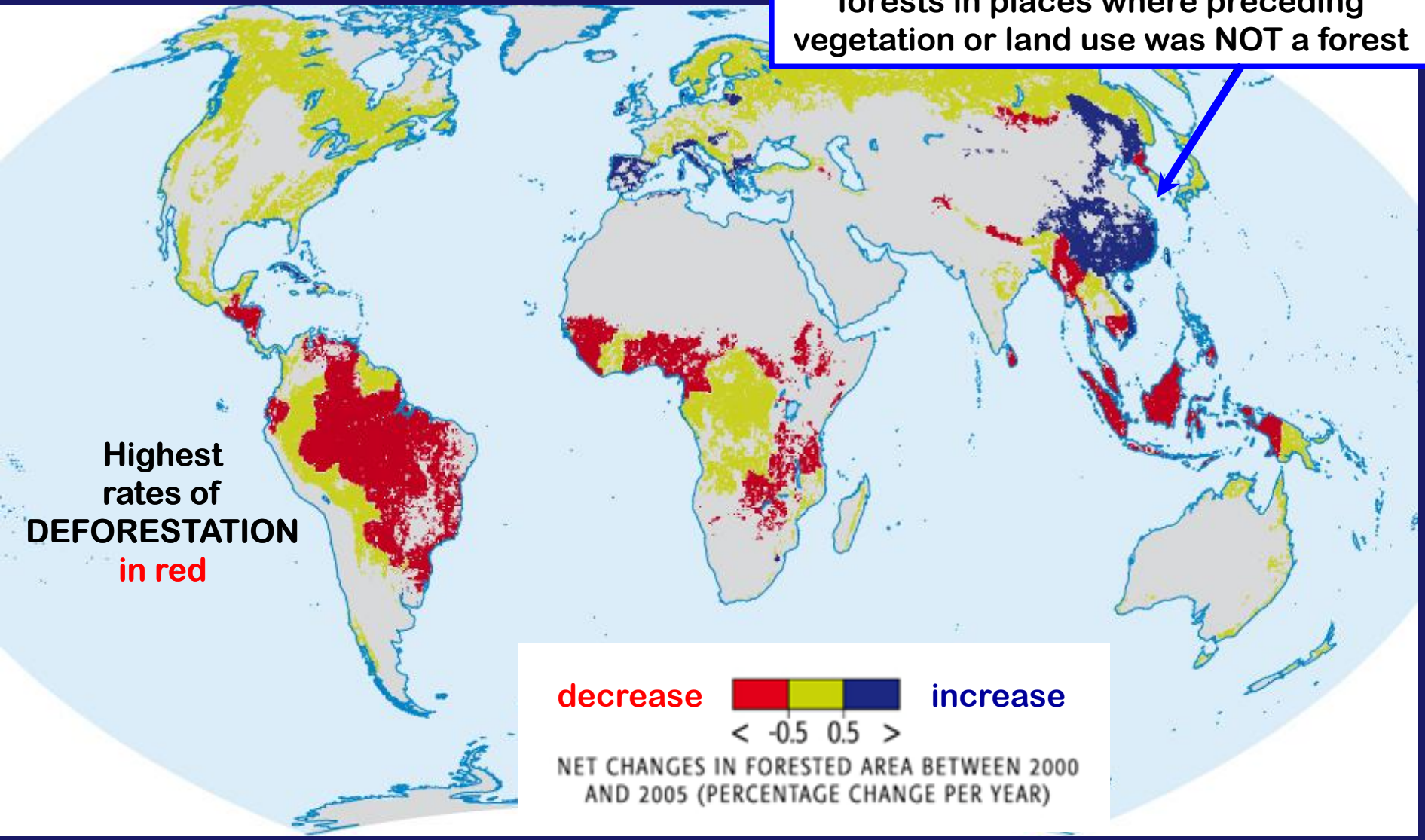
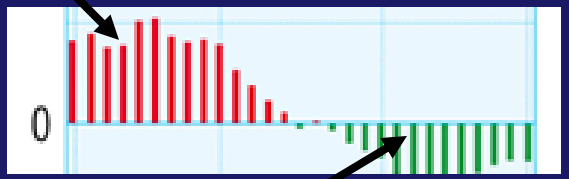


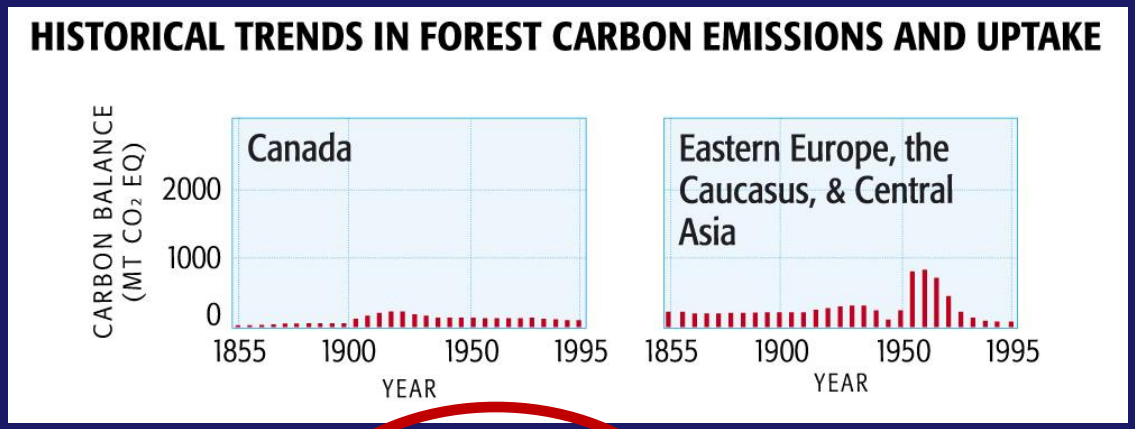
Figure on p 175 in *Dire Predictions*

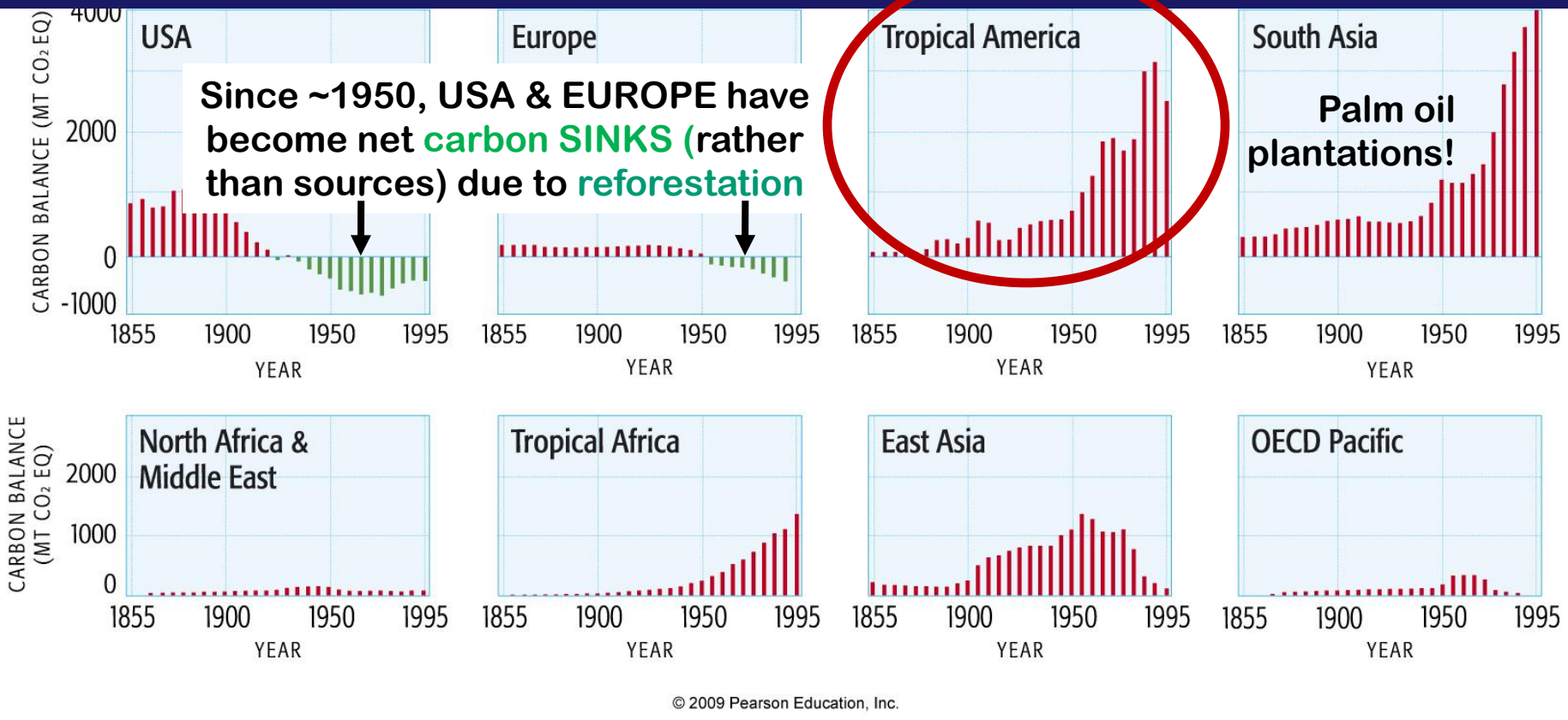
Data Source: UN / FAO Global Forest Assessment Report
http://www.fao.org/forestry/fra/41555/en/

Forest carbon emissions INTO the atmosphere (+)



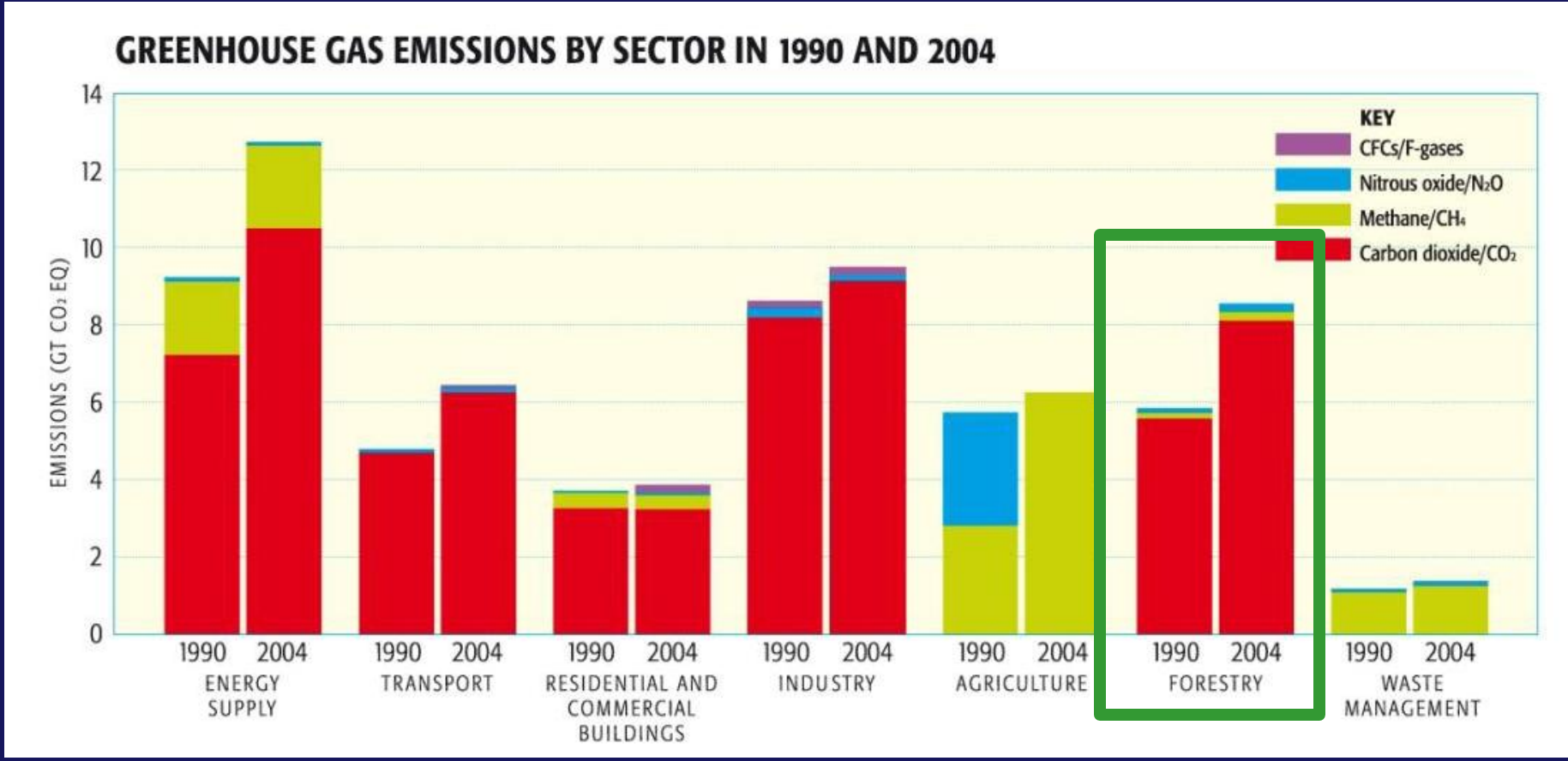
- Forest uptake of carbon OUT OF the atmosphere (-)





from pp 174-175 in *Dire Predictions*

Where do all those OTHER Greenhouse Gas emissions come from?



from p 159 in *Dire Predictions*

TO BE CONTINUED . . . .