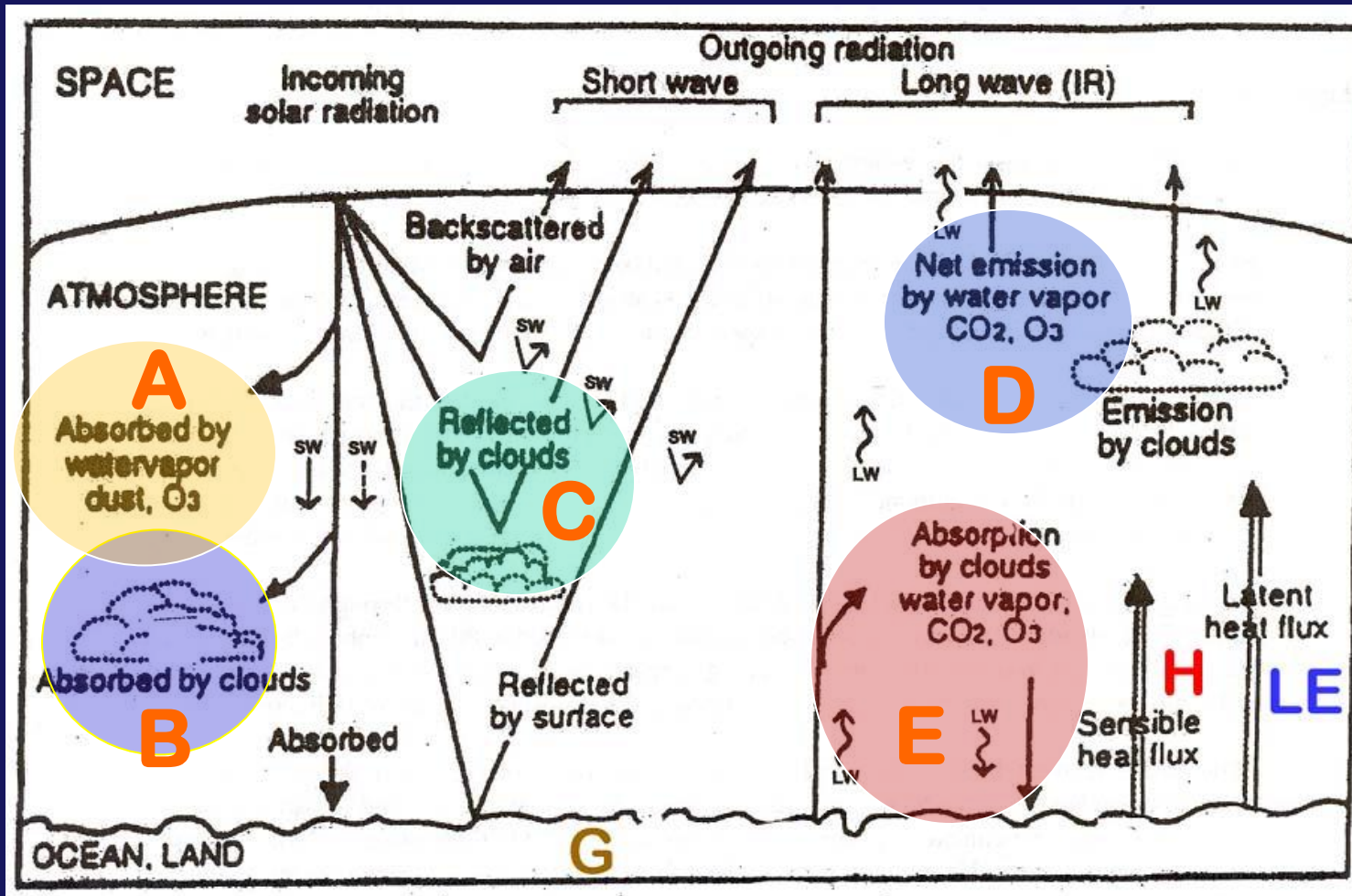


First . . . Some clicker
questions!

Q1. In which part of the energy balance does all the activity related to STRATOSPHERIC OZONE DEPLETION take place?

A B C D E G



HINT:
Examine
the Energy
Balance
yourself
on p 52 in
class
Notes

Q1. In which part of the energy balance does all the activity related to STRATOSPHERIC OZONE DEPLETION take place?

A

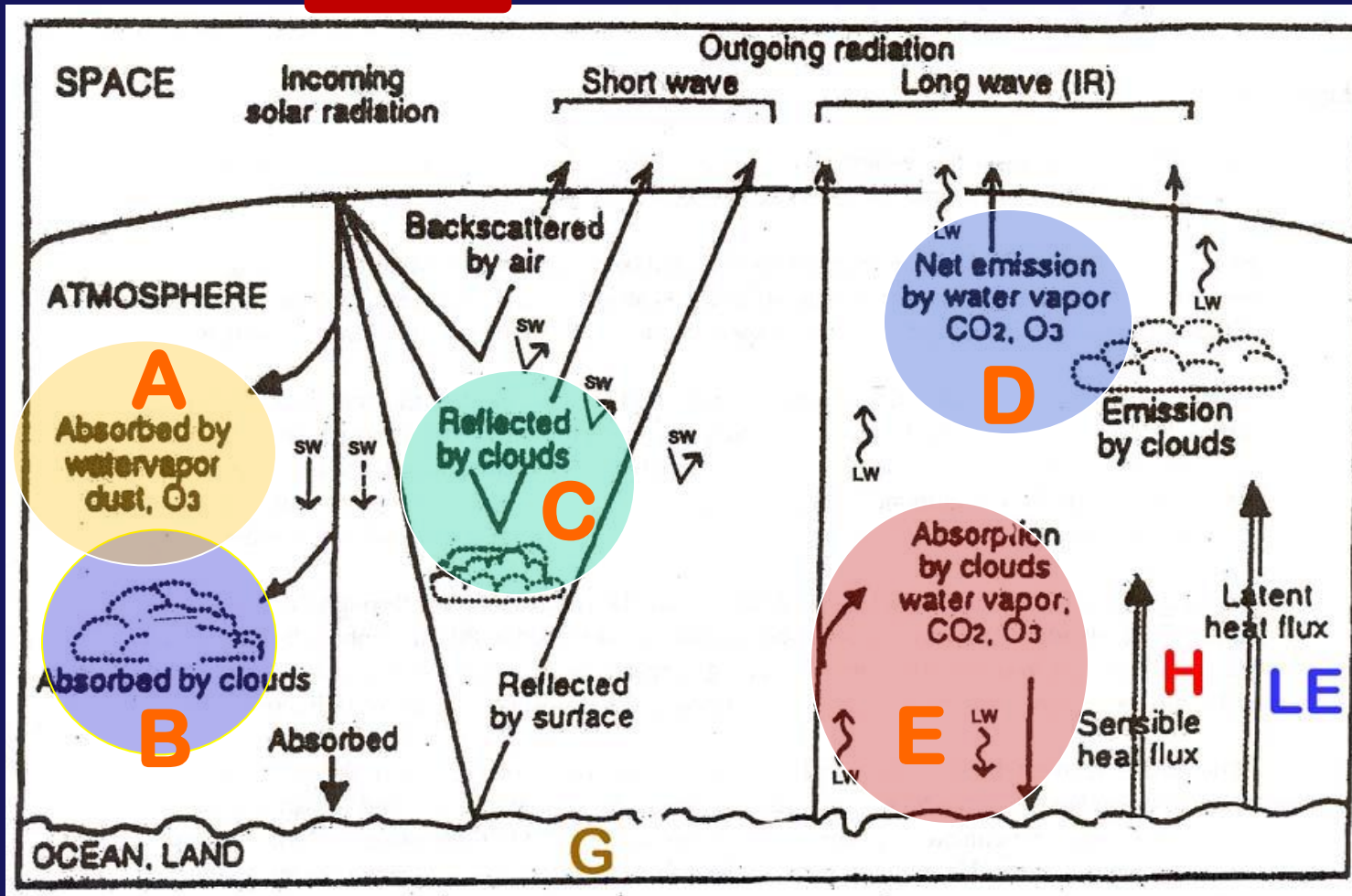
B

C

D

E

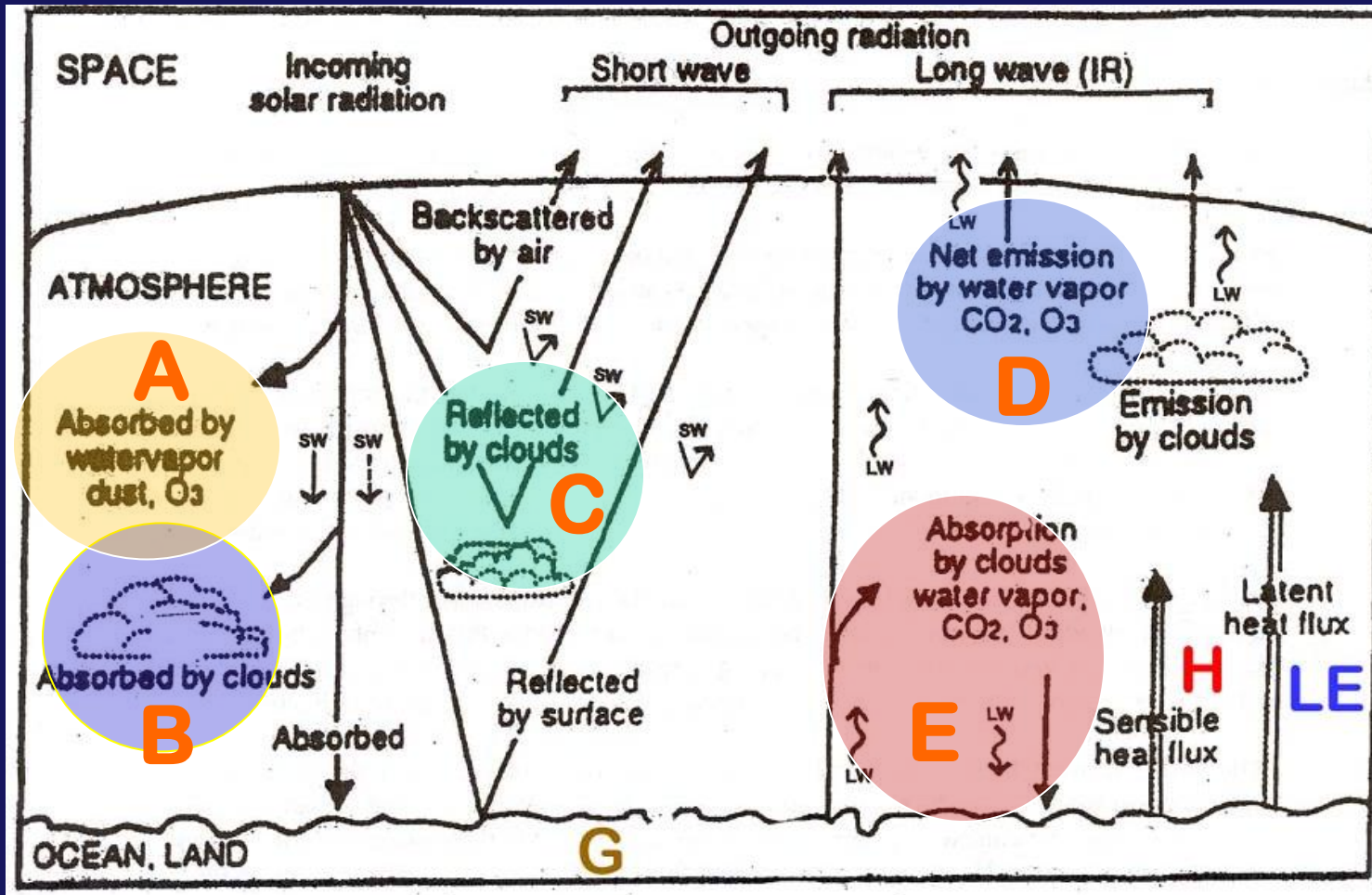
G



HINT:
Examine
the Energy
Balance
yourself
on p 52 in
class
Notes

Q2. In which part of the energy balance does the activity related to GLOBAL WARMING from the enhanced GHE take place?

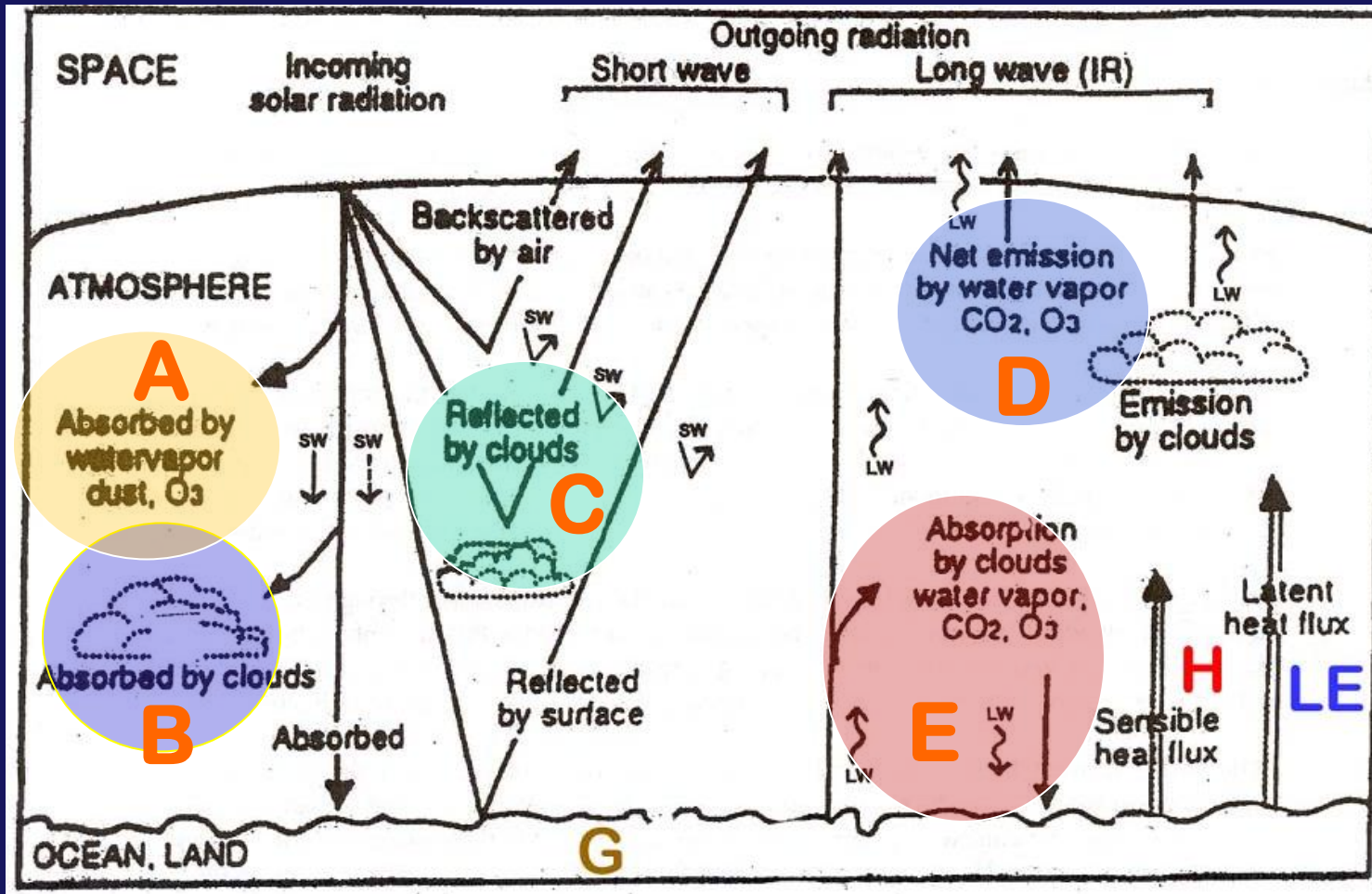
A B C D E G H



HINT:
Examine
the Energy
Balance
yourself
on p 52 in
class
Notes

Q2. In which part of the energy balance does the activity related to GLOBAL WARMING from the enhanced GHE take place?

A B C D **E** G H



HINT:
Examine
the Energy
Balance
yourself
on p 52 in
class
Notes

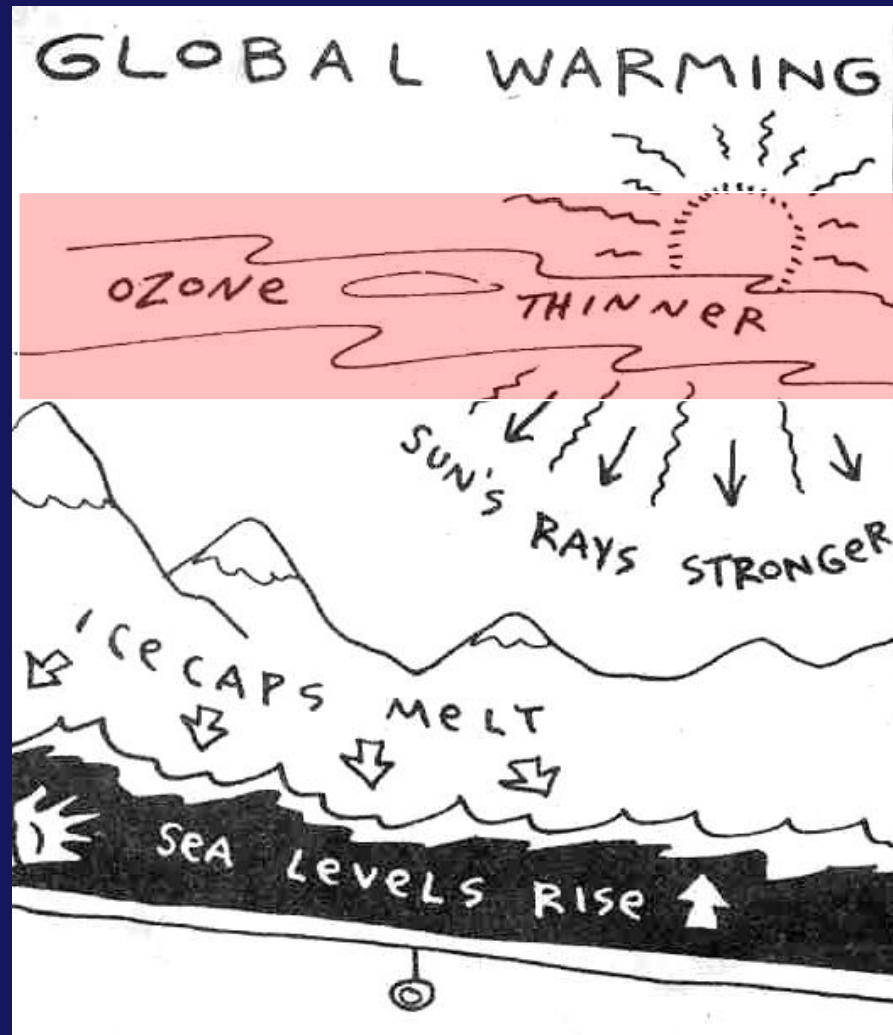
Q3 – Which is the correct statement:

- 1 The depletion of STRATOSPHERIC OZONE in the Ozone Hole is a critically important CAUSE of increased GLOBAL WARMING in the troposphere.
- 2 Increased GLOBAL WARMING in the troposphere is a critically important CAUSE of STRATOSPHERIC COOLING which could prolong or worsen the OZONE HOLE
- 3 Neither

Q3 – Which is the correct statement:

- ~~1 The depletion of STRATOSPHERIC OZONE in the Ozone Hole is a critically important CAUSE of increased GLOBAL WARMING in the troposphere.~~
- 2 Increased GLOBAL WARMING in the troposphere is a critically important CAUSE of STRATOSPHERIC COOLING which could prolong or worsen the OZONE HOLE
- 3 Neither

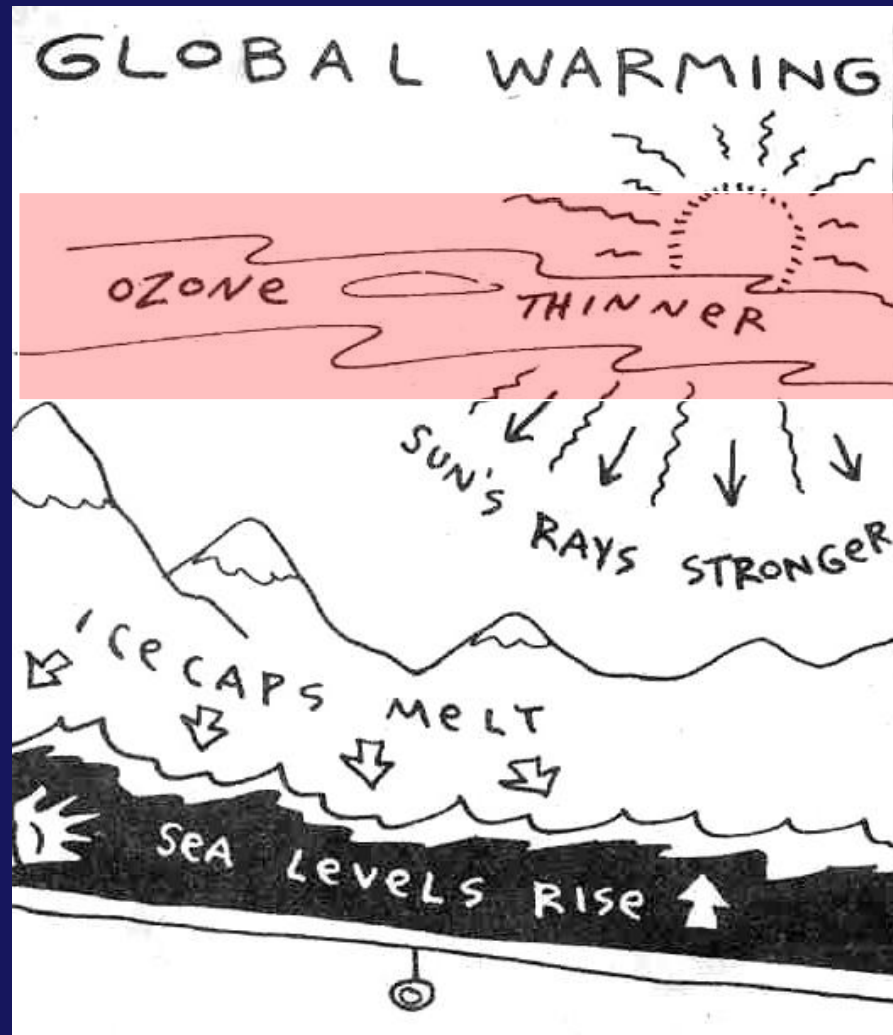
Q4. Is this explanation of the main CAUSE of GLOBAL WARMING correct?



1- YES

2- NO

Q4. Is this explanation of the main CAUSE of GLOBAL WARMING correct?



1- YES

2- NO

TOPIC # 14

GLOBAL WARMING & ANTHROPOGENIC FORCING

Part A

CARBON RESERVOIRS & FLUXES: Natural vs. Anthropogenically Enhanced

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

“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.**”

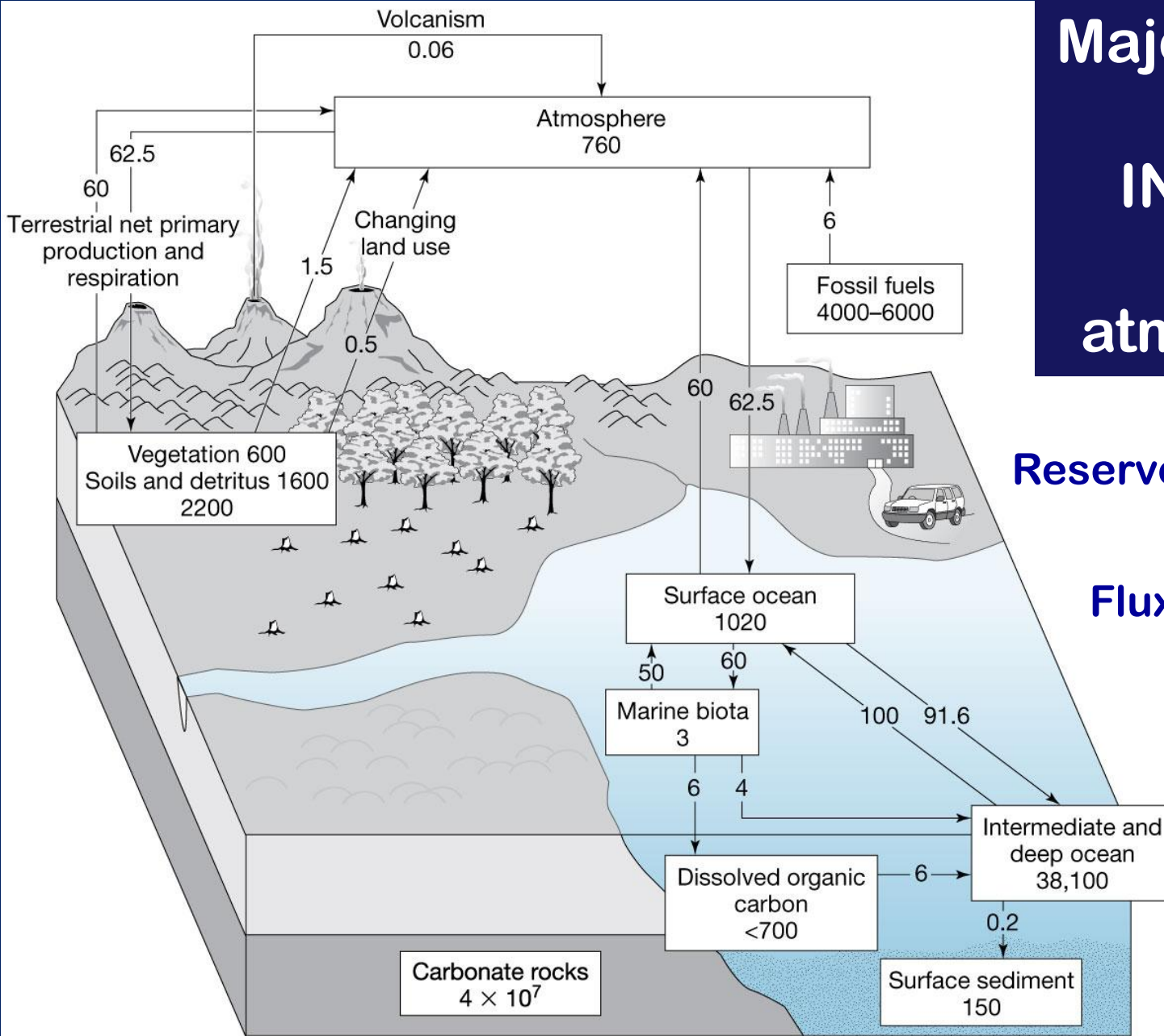
~Wally Broecker , Paleoclimatologist

CO₂ & CARBON RESERVOIRS

CO₂ 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



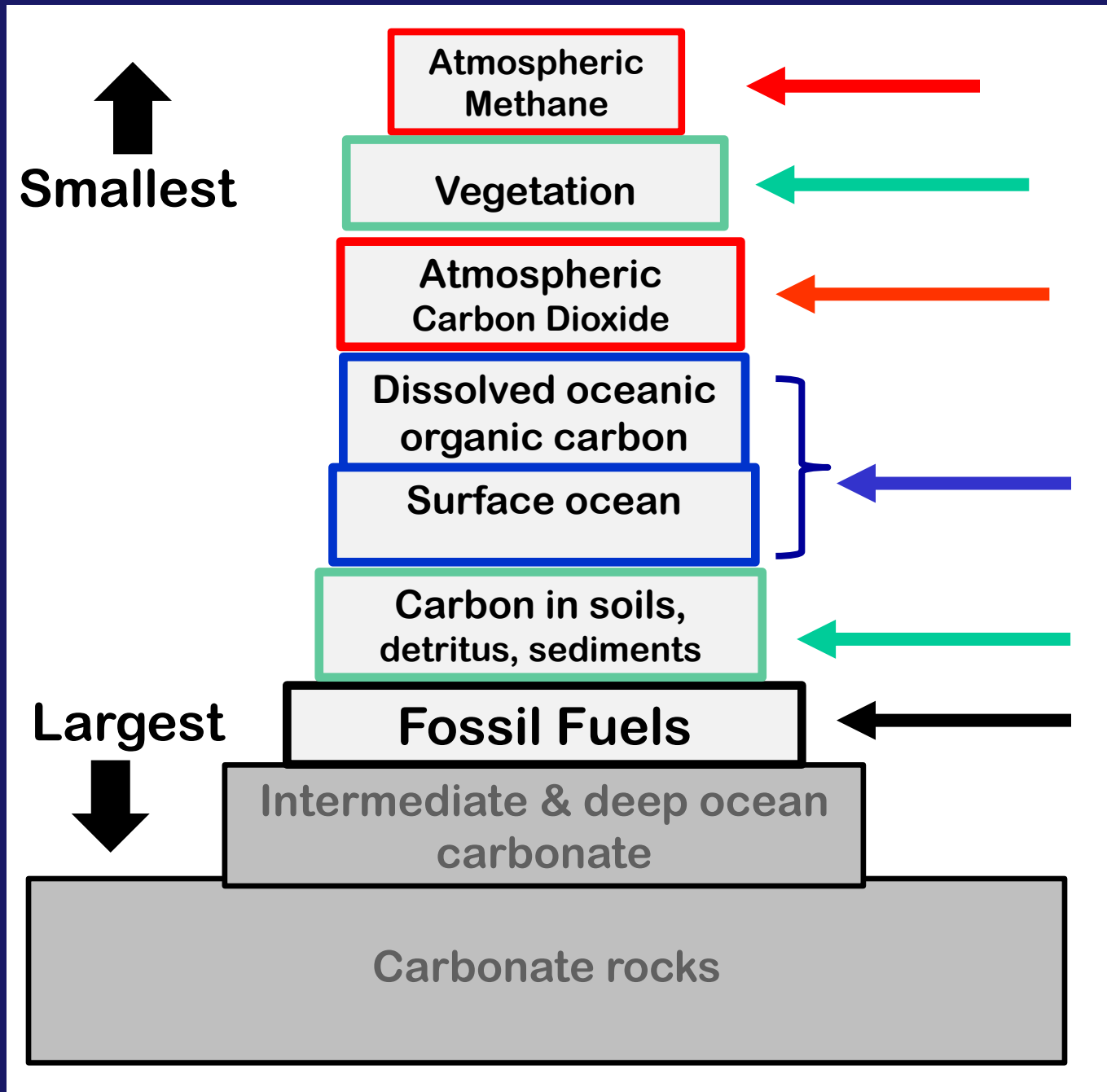
Reservoirs =

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. CO₂)

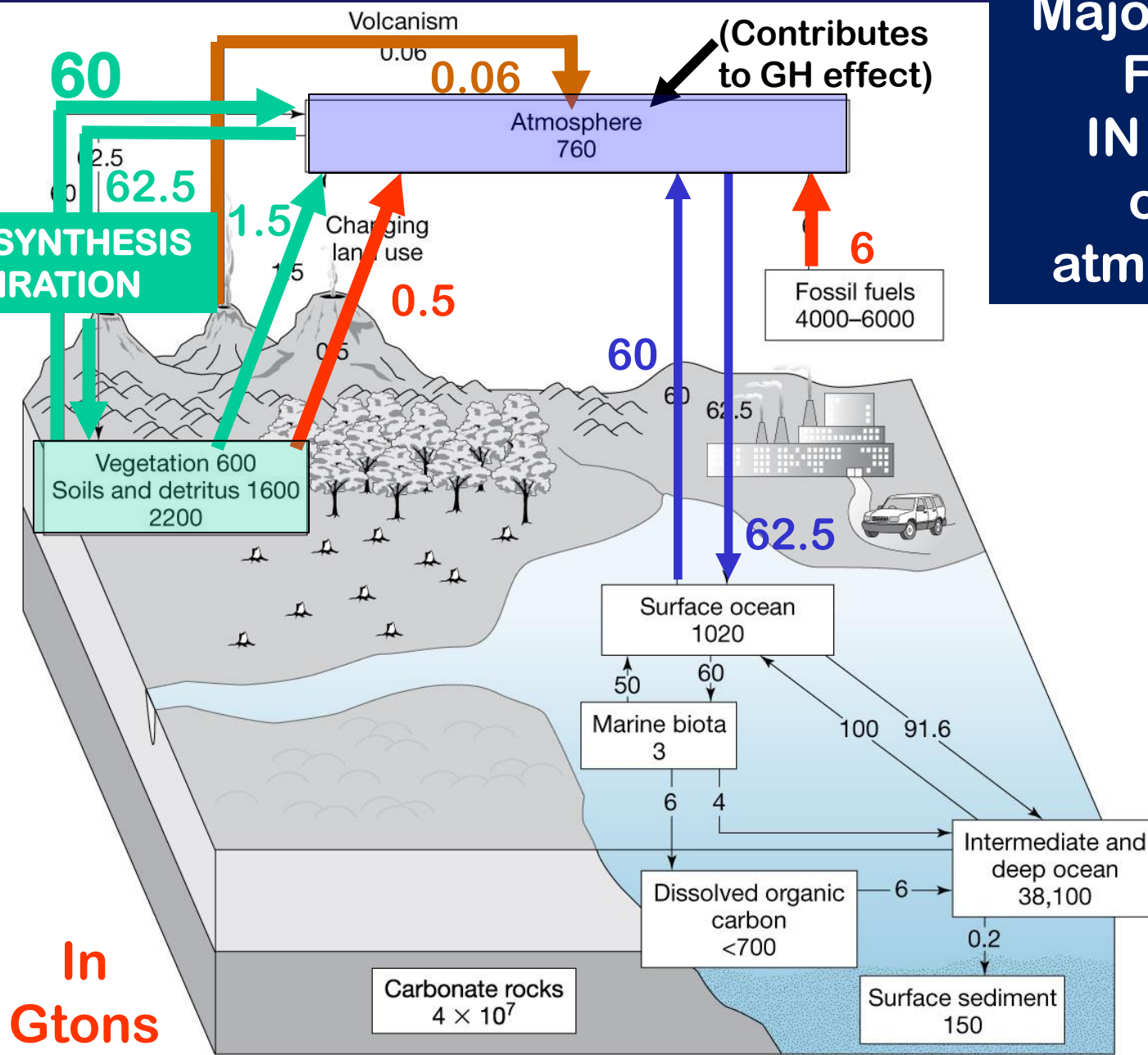
One gigaton is . . .



Greater than the mass
of all the humans on the planet

Major Carbon Fluxes IN & OUT of the atmosphere

PHOTOSYNTHESIS & RESPIRATION



**In
Gtons**

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

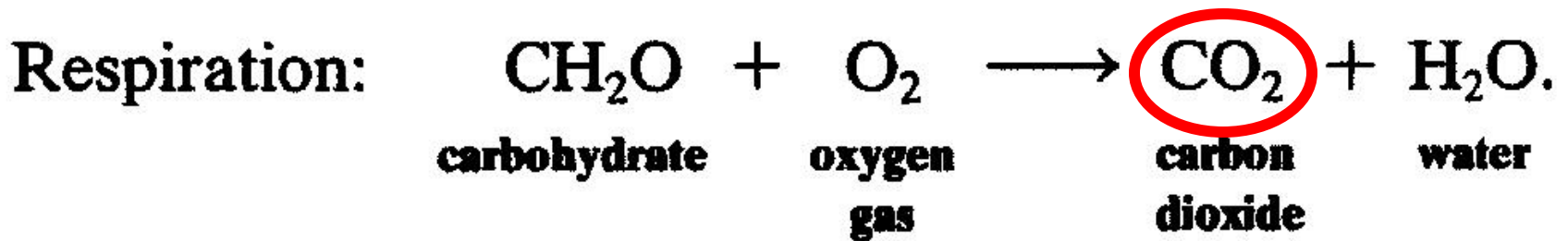
1. Trees take in carbon dioxide during photosynthesis.
2. Trees release carbon dioxide during photosynthesis.
3. Trees release carbon dioxide into the atmosphere during respiration.

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

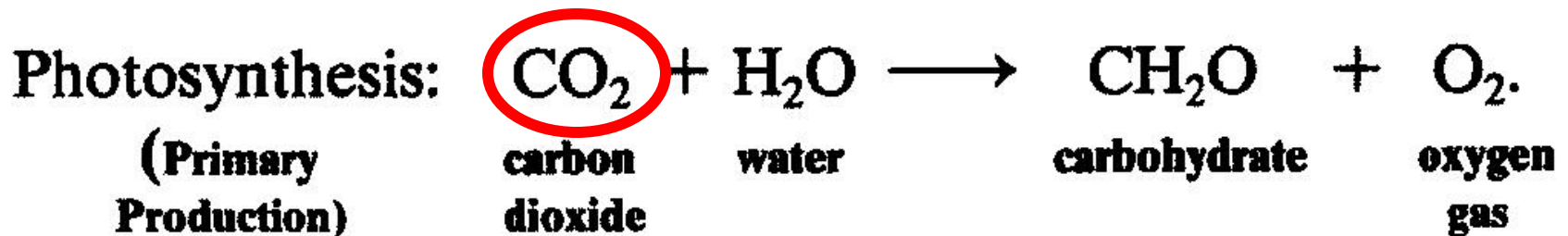
1. Trees take in carbon dioxide during photosynthesis.
2. Trees release carbon dioxide during photosynthesis.
3. Trees release carbon dioxide into the atmosphere during respiration.

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

FLUX from PLANT INTO ATMOSPHERE:



FLUX OUT OF ATMOSPHERE into PLANT:



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 =

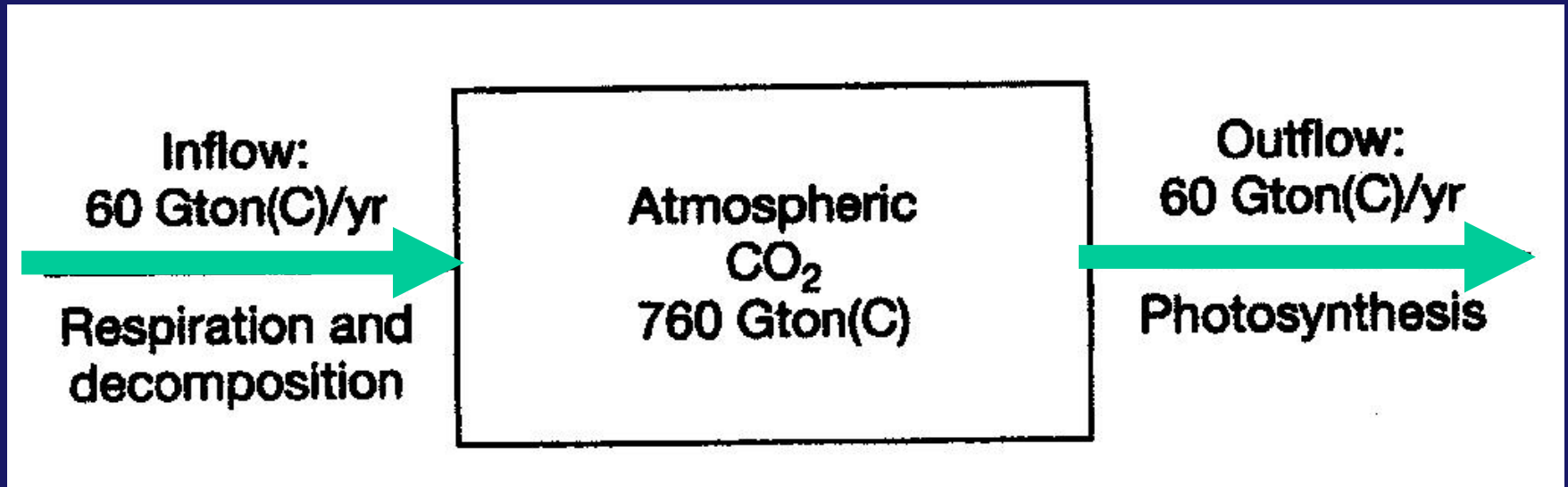
manufacture of carbohydrates & O_2
from CO_2 and H_2O
in the presence of chlorophyll
sunlight as the energy source.

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.)

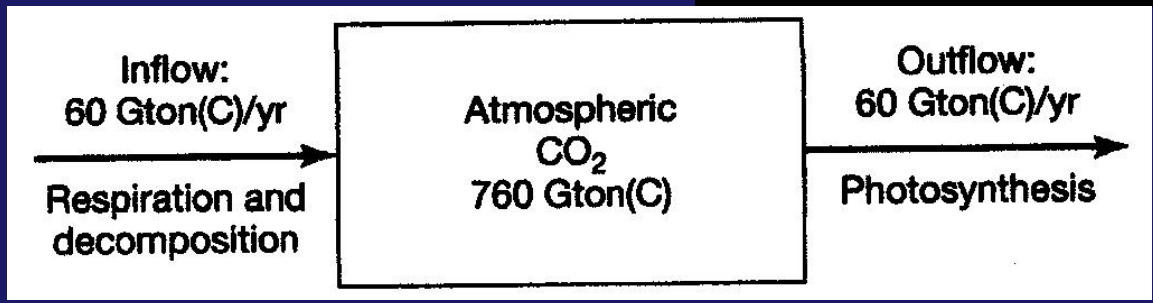
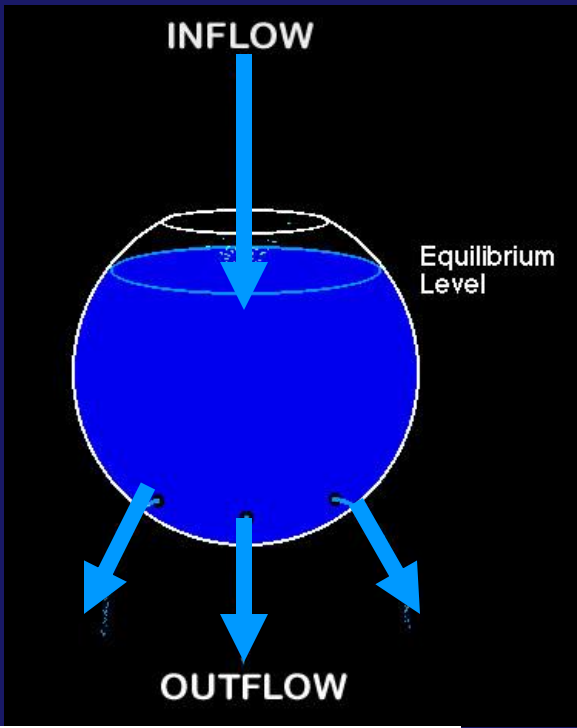
The Atmospheric Carbon Reservoir



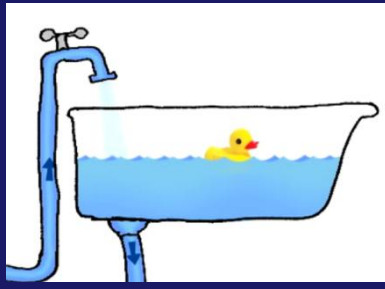
showing inflows and outflows (fluxes)

... leads to a
STEADY STATE

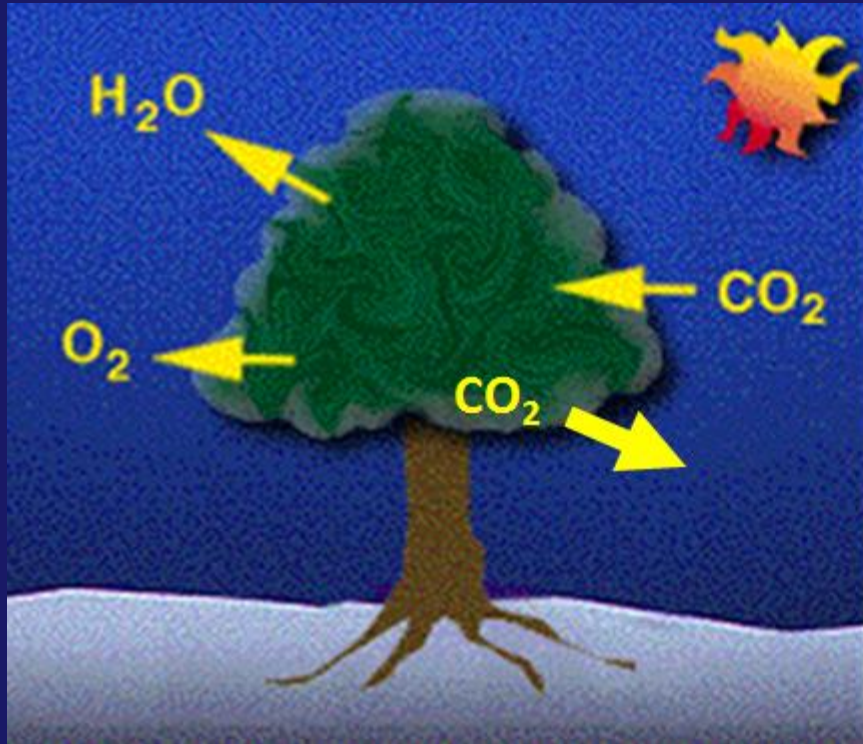
In the atmospheric
CO₂ "reservoir"



*Where have we seen a
STEADY STATE before?*

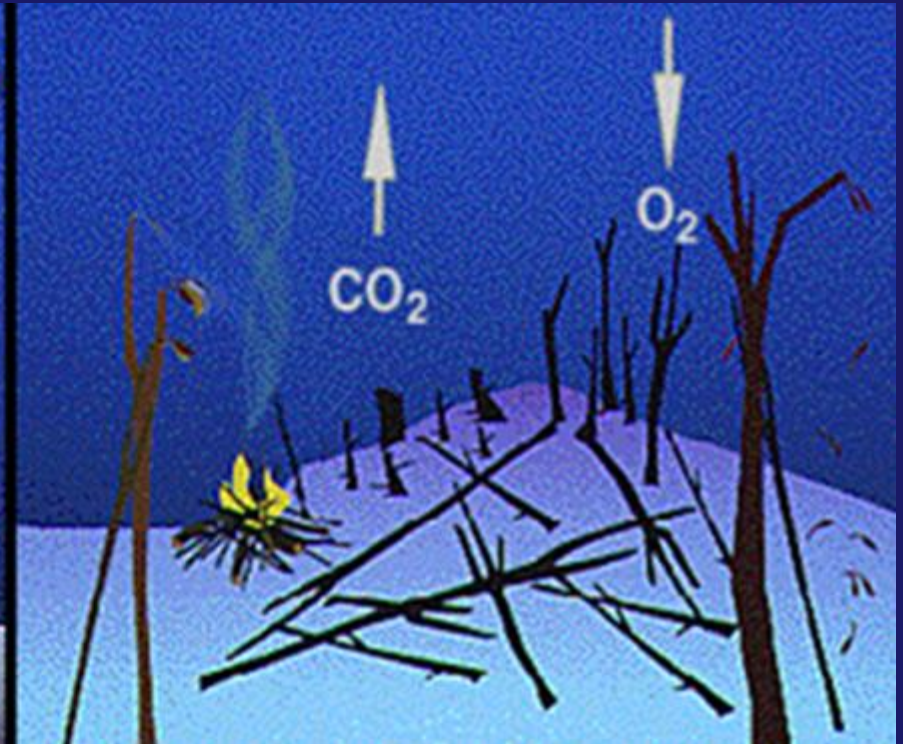


Photosynthesis & Respiration



Steady State

Respiration, Burning of Biomass, & Decomposition

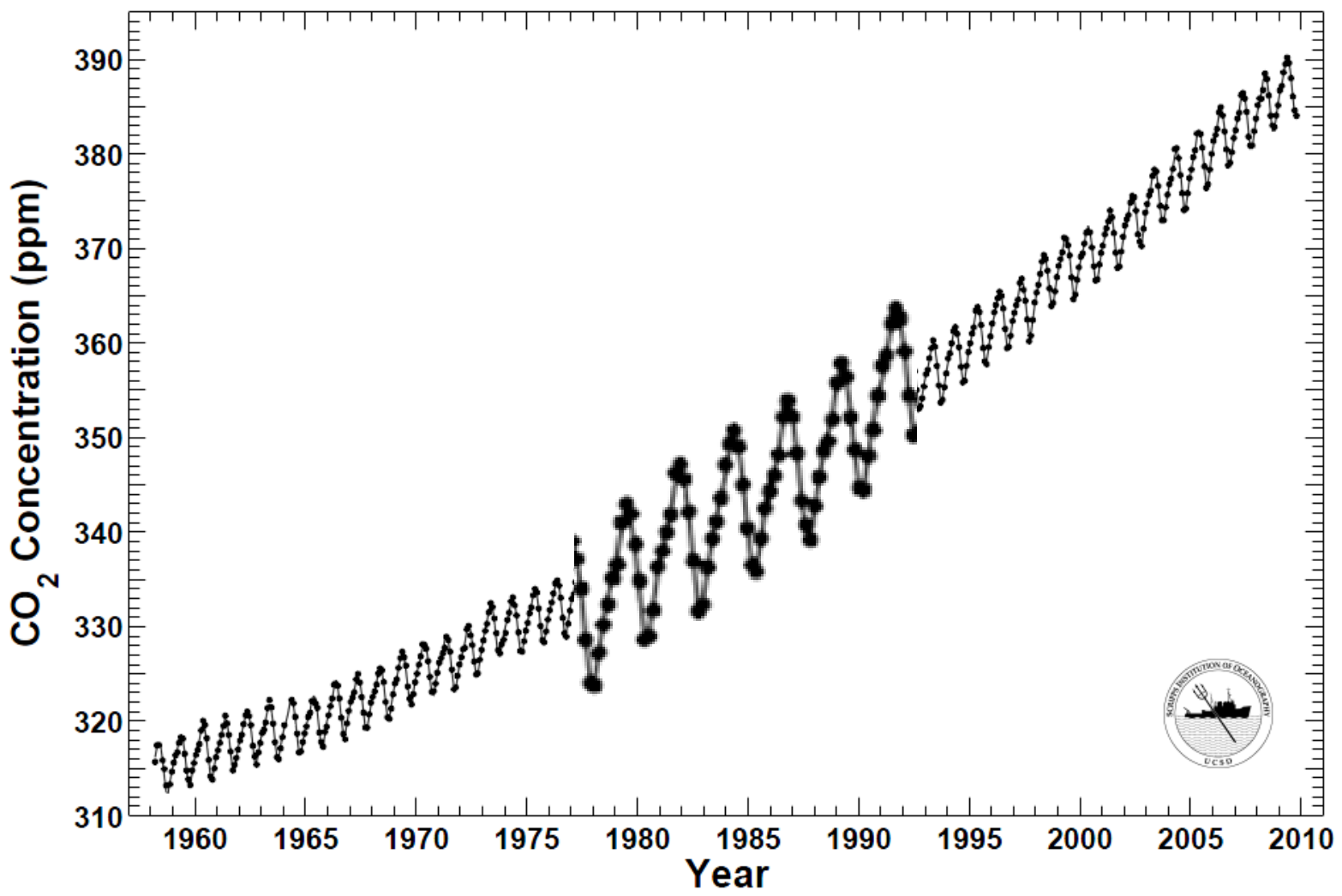


Disruption of Steady State

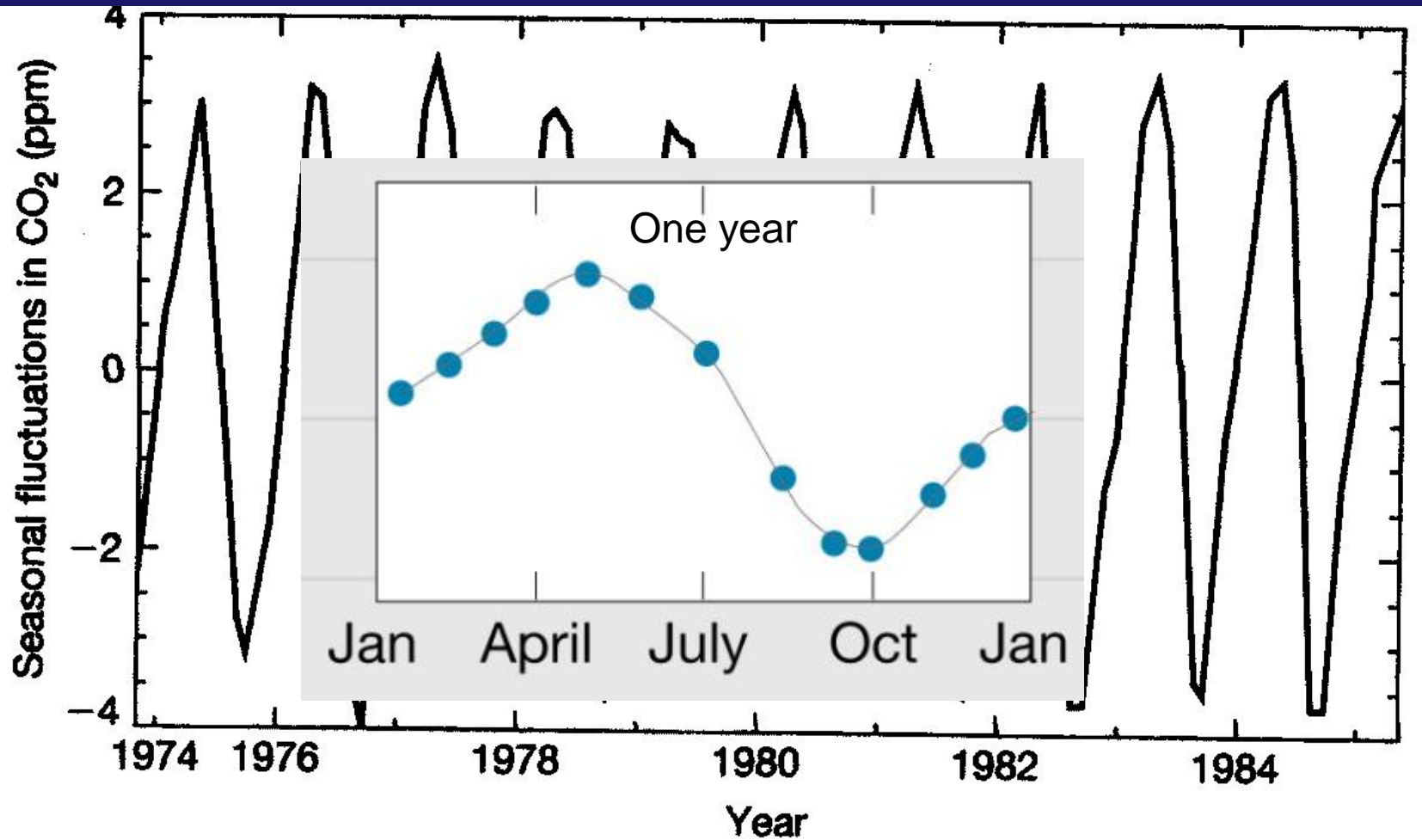
WHAT ABOUT THOSE ZIG-ZAGS IN THE KEELING CURVE?

Mauna Loa Observatory, Hawaii Monthly Average Carbon Dioxide Concentration

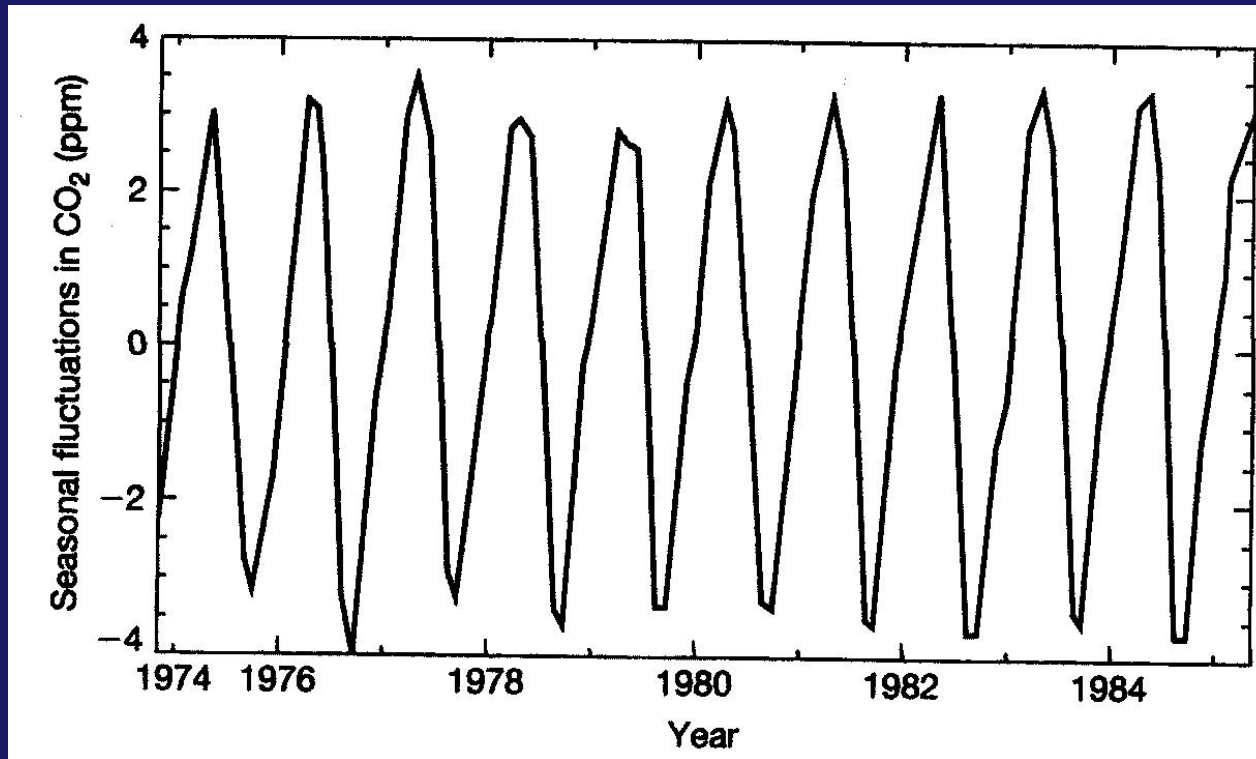
Data from Scripps CO₂ Program Last updated October 2009



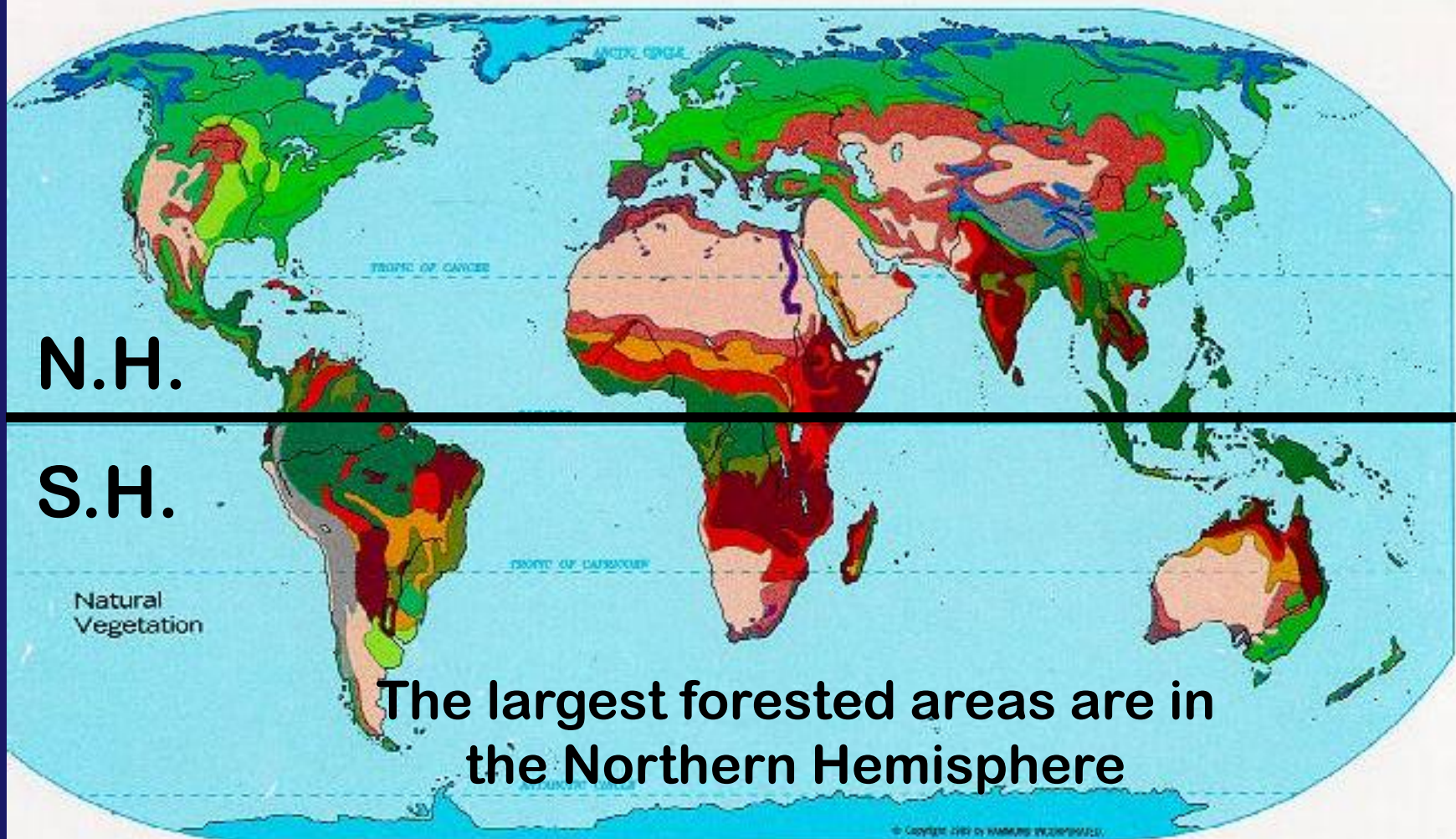
CLOSE-UP VIEW:



*Trend due to anthropogenic increases
has been removed.*



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



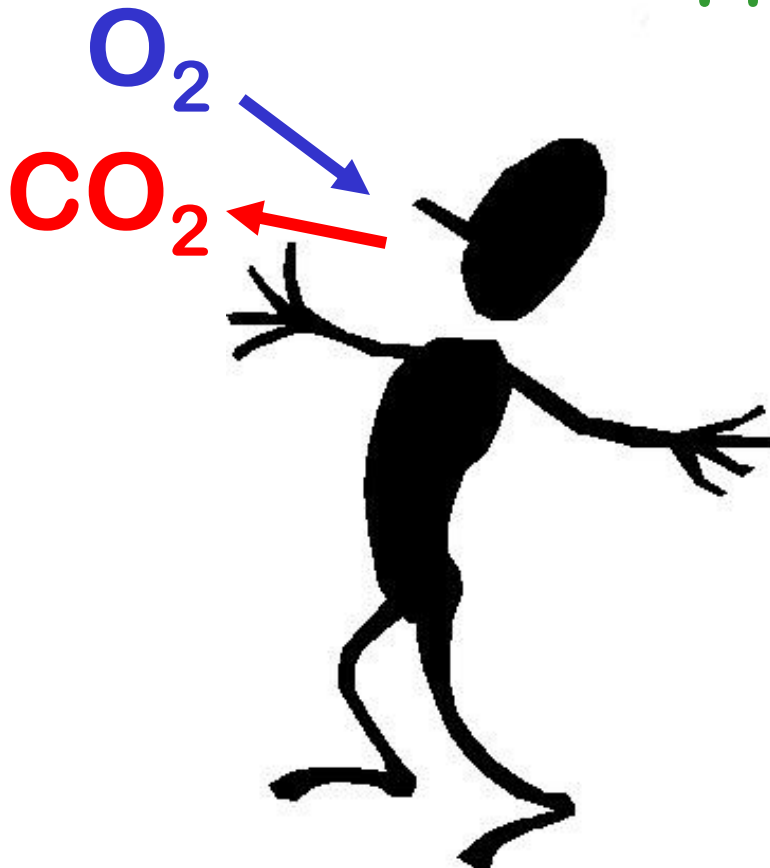
GLOBAL VEGETATION PATTERNS

Needleleaf Forest	Woodland and Shrub (Mediterranean)	River Valley and Oasis	Tropical Grassland and Shrub (Savanna)	Tropical Rain Forest
Broadleaf Forest	Short Grass (Steppe)	Desert and Desert Shrub	Tropical Woodland and Shrub	Heath and Moor
Mixed Needleleaf and Broadleaf Forest	Tall Grass (Prairie)	Wooded Savanna	Light Tropical Forest	Tundra and Alpine
Unclassified Highlands			Permanent Ice Cover	

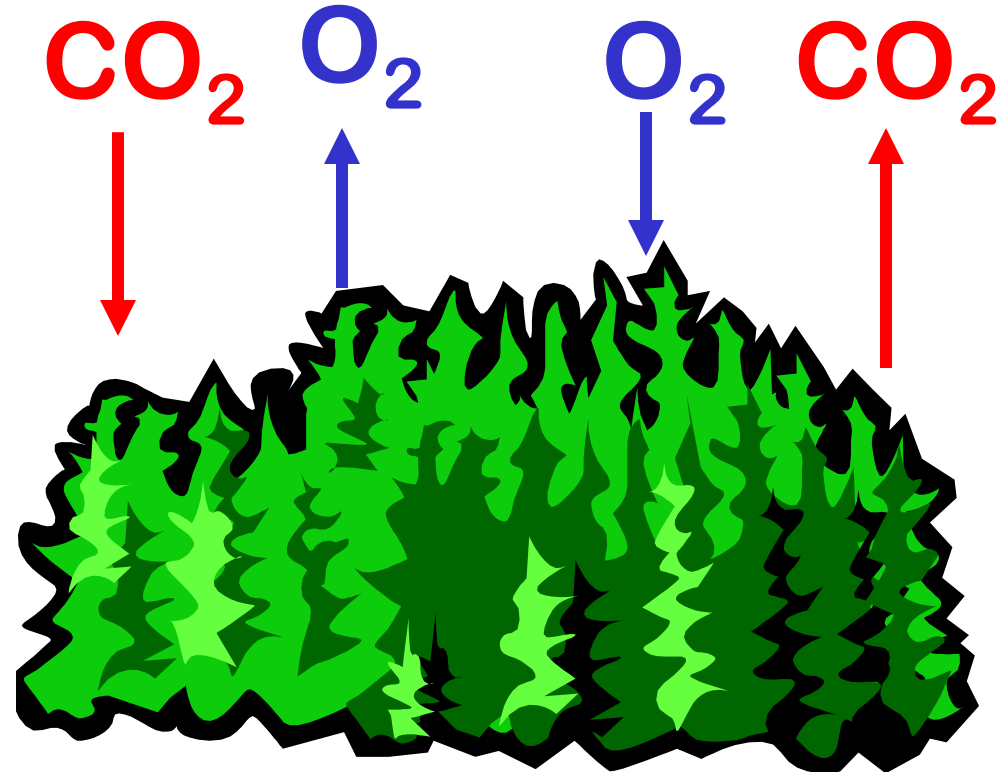


“Breathing” -- ANIMALS vs. PLANTS

Respiration



Photosynthesis



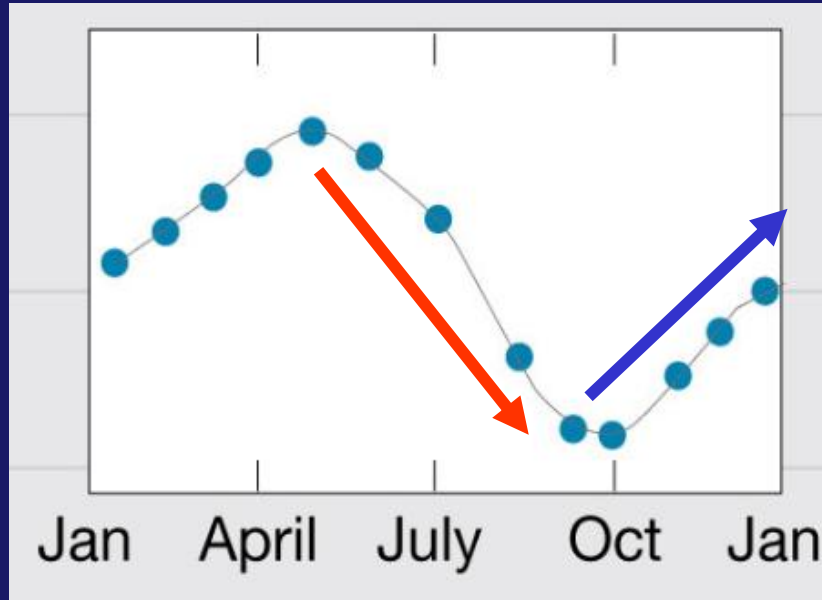
Respiration & Decomposition





Photosynthesis > Respiration

(CO₂ goes down in SUMMER as forests “breathe in” more CO₂)



Respiration > Photosynthesis

(CO₂ levels rise in FALL/WINTER as forests “breathe out” more CO₂)

Tick marks are at January of each year:

Photosynthesis > Respiration

(CO₂ goes down in SUMMER as forests “breathe in” more CO₂)

Respiration > Photosynthesis

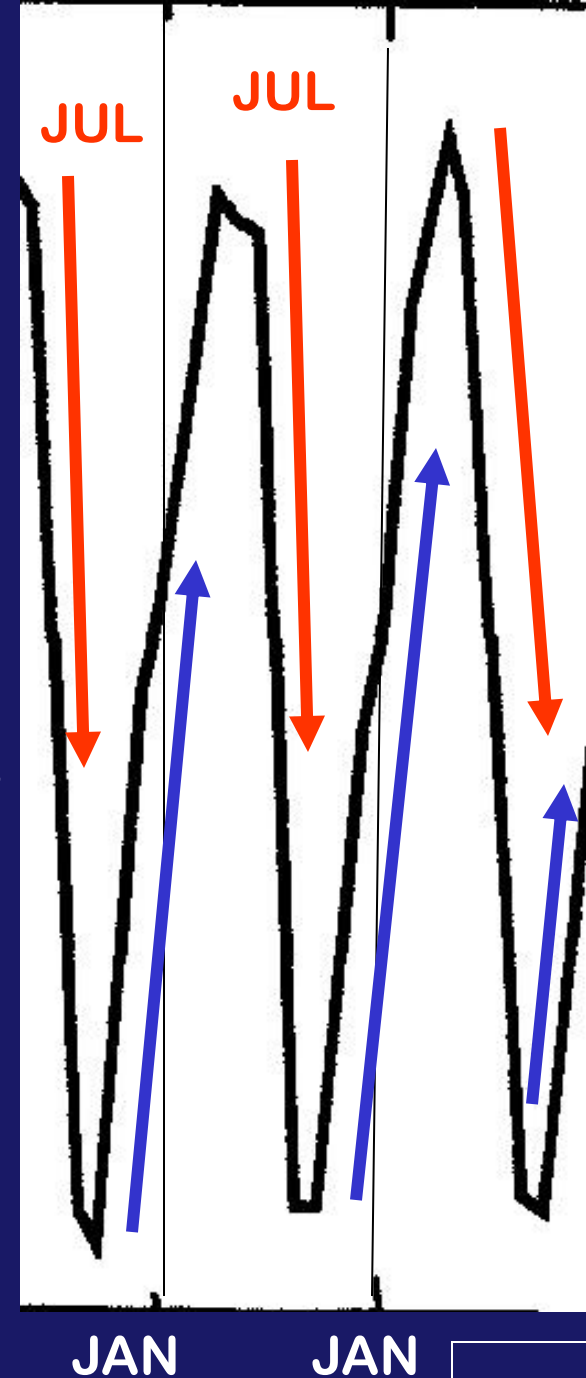
(CO₂ levels rise in FALL/WINTER as forests “breathe out” more CO₂)

Photosynthesis > Respiration

(CO₂ goes down in summer)

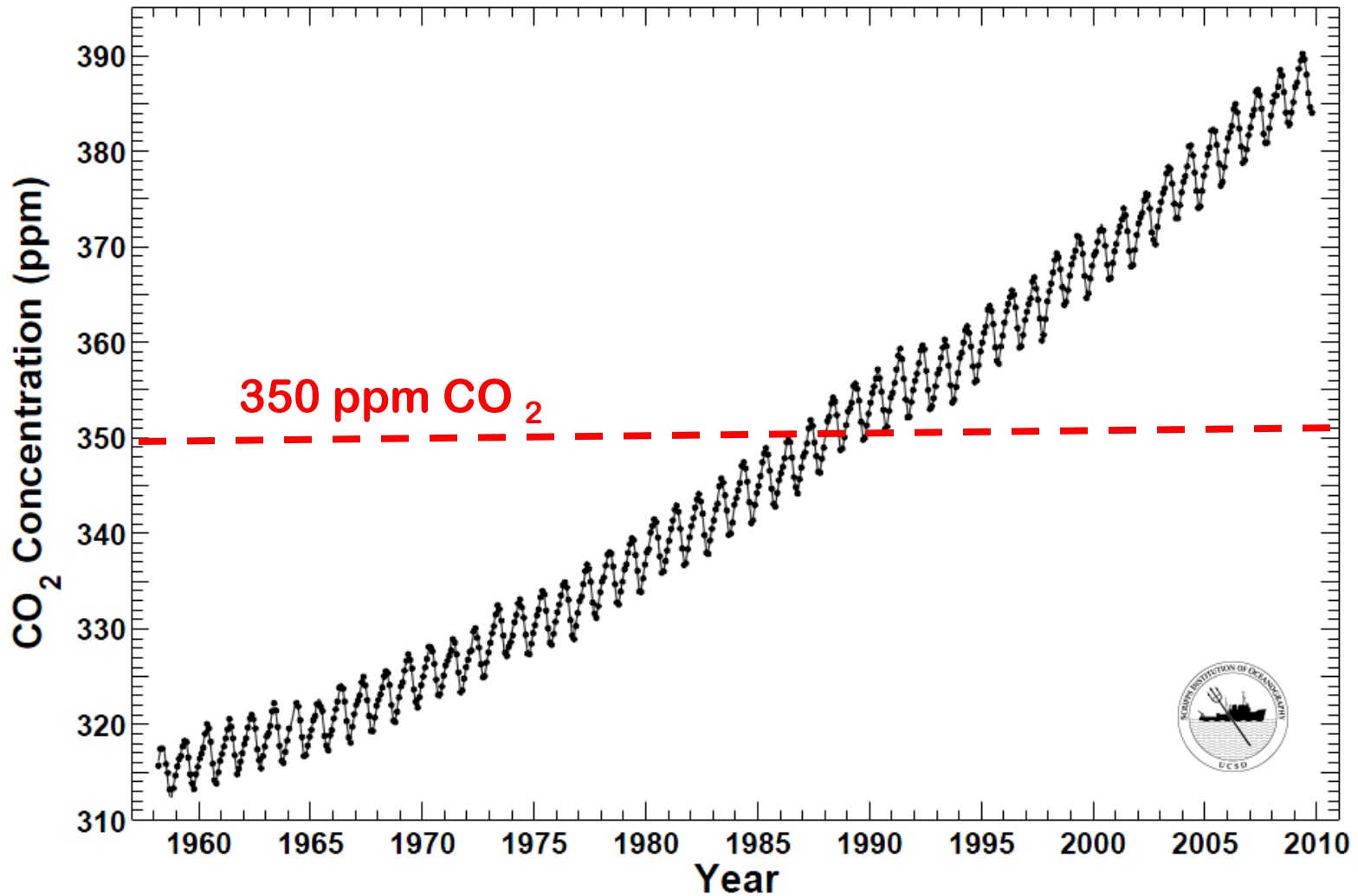
Respiration > Photosynthesis

(CO₂ levels rise in fall/winter)



Mauna Loa Observatory, Hawaii Monthly Average Carbon Dioxide Concentration

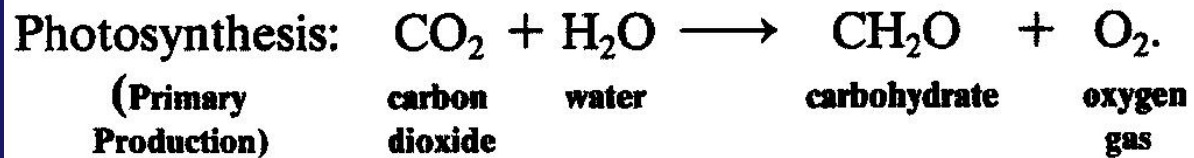
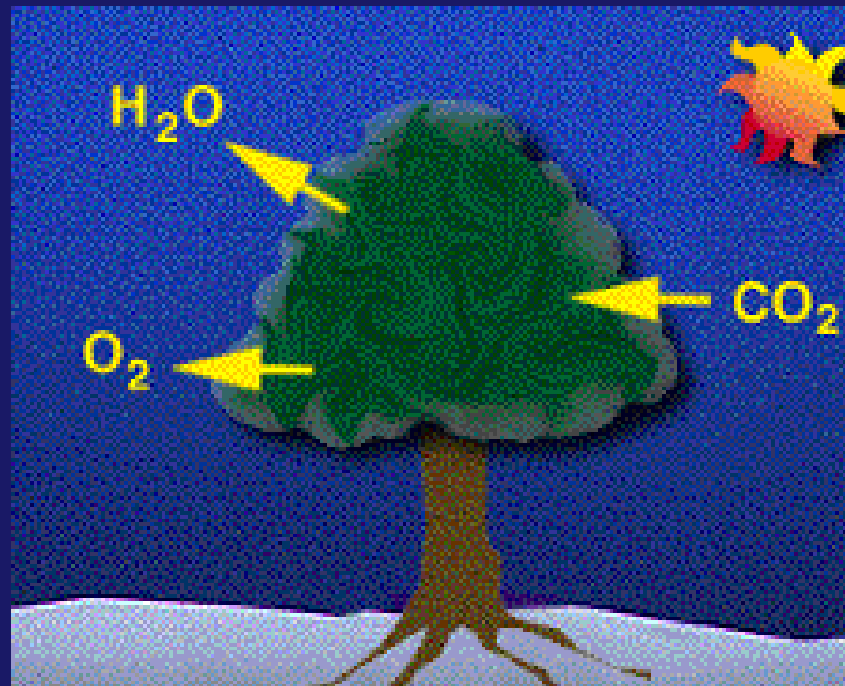
Data from Scripps CO₂ Program Last updated October 2009



review

BUT IS ALL THE EXTRA CO₂
A BAD THING???

PLANTS DEPEND ON CO₂!!!



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

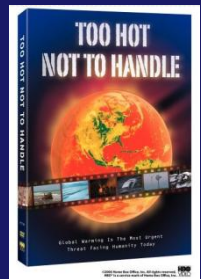


Hence with Increased CO2 :

- 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 !!



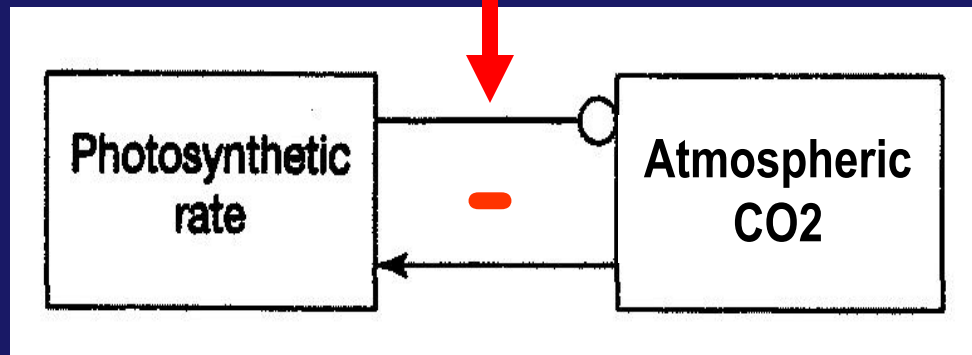
Greater atmospheric CO₂ concentration

→ **enhanced photosynthesis** (due to “CO₂ Fertilization”)

→ **more CO₂ being assimilated by plant**
from the atmosphere

→ **less atmospheric CO₂**

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

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

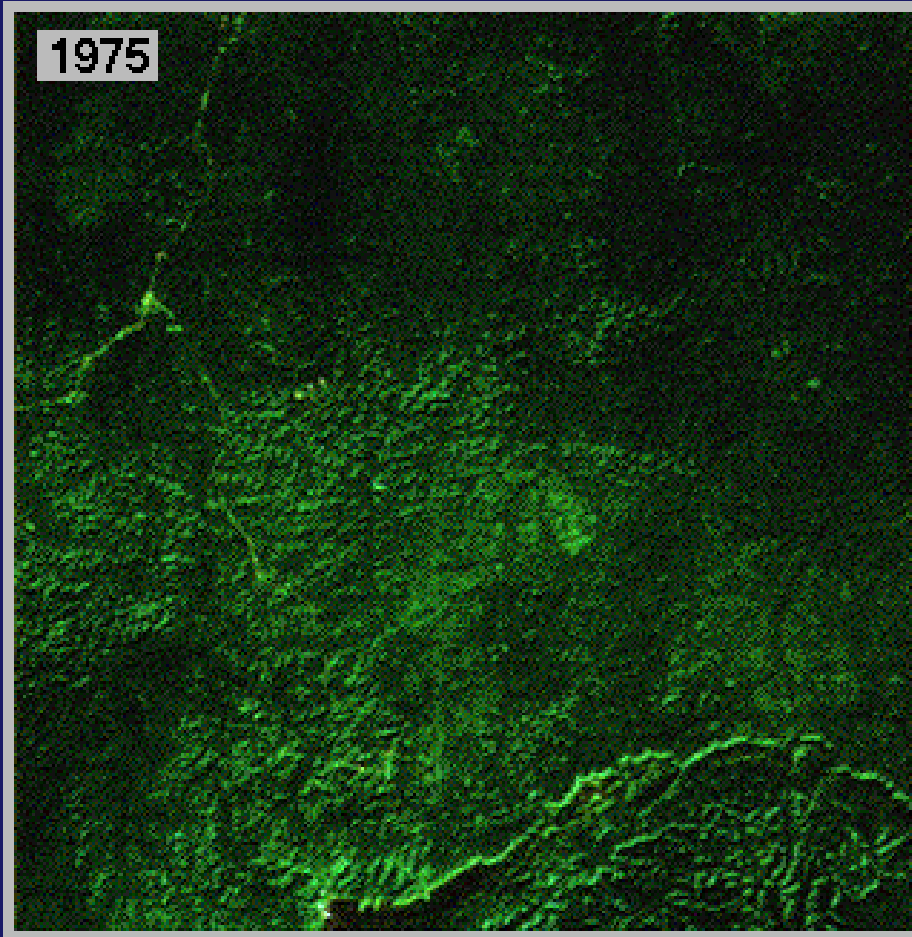
The amount of carbon dioxide, or CO₂, all those cars, trucks, planes, trains and ships collectively emit into the atmosphere is **actually LESS than the carbon emissions every year** that result from the **chopping down and clearing of tropical forests** in places like Brazil, Indonesia and the Congo. “

“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.** “

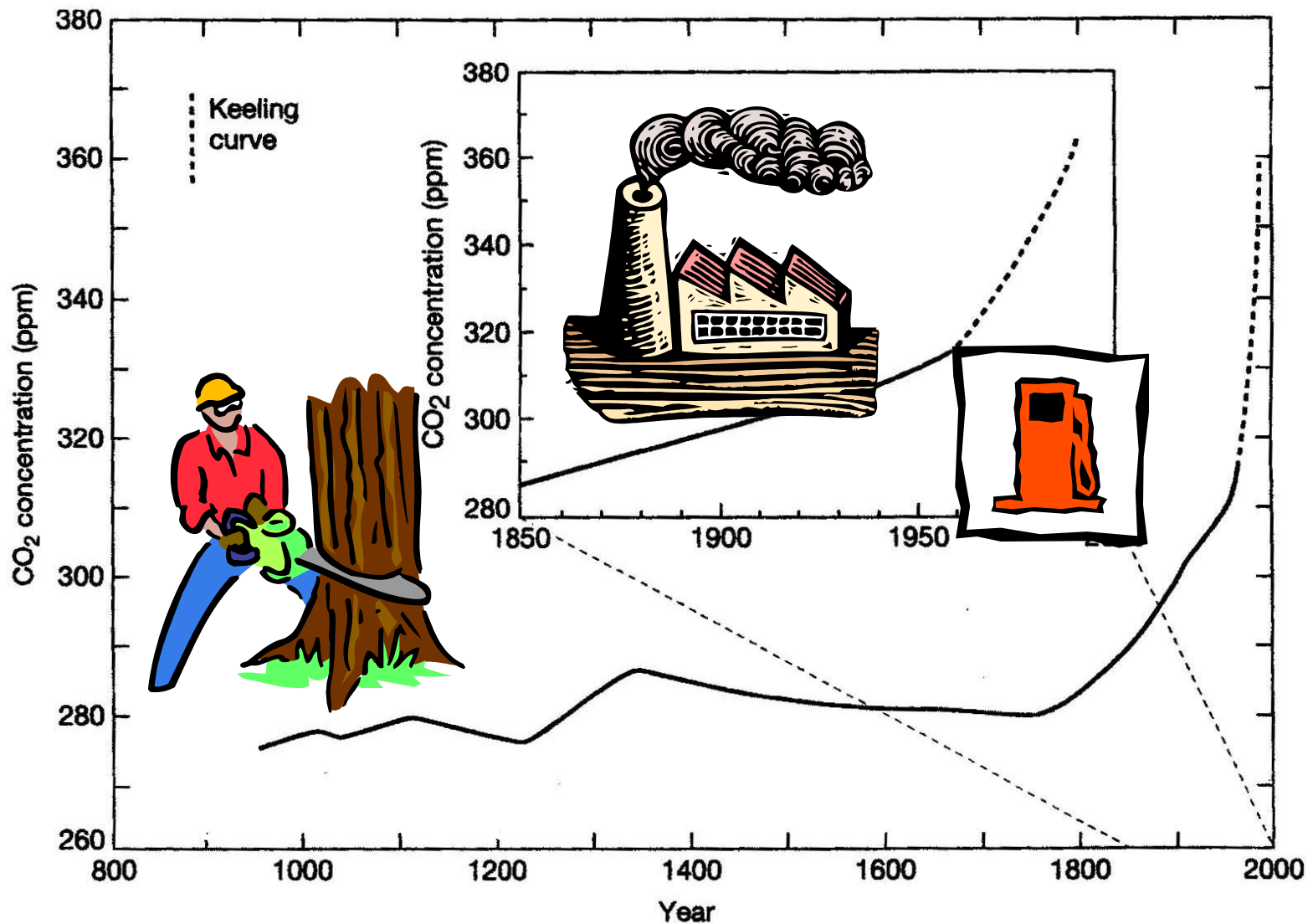


LAND USE CHANGES:

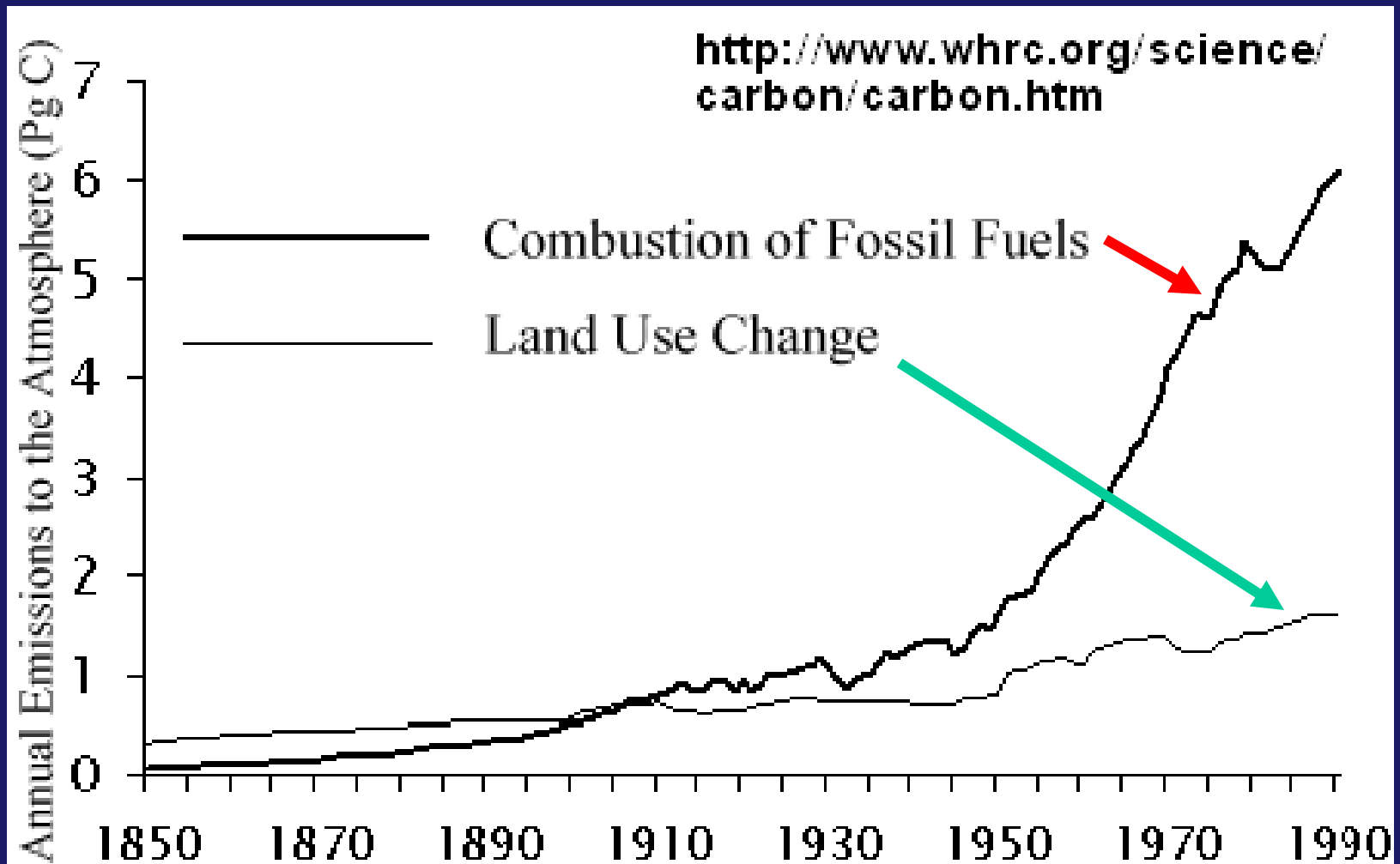
Deforestation practices increase burning & decomposition of large areas of forest



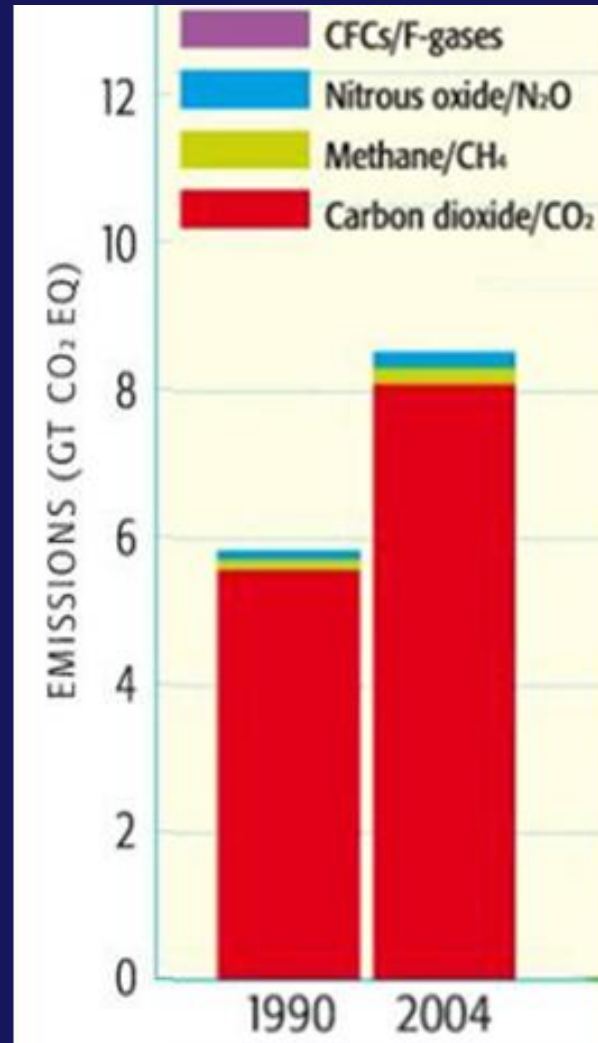
CARBON DIOXIDE: Trends



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

Highest rates of **DEFORESTATION** in red

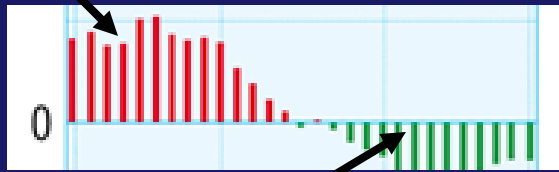
decrease  increase
< -0.5 0.5 >

NET CHANGES IN FORESTED AREA BETWEEN 2000 AND 2005 (PERCENTAGE CHANGE PER YEAR)

Figure on p 175
in *Dire Predictions*

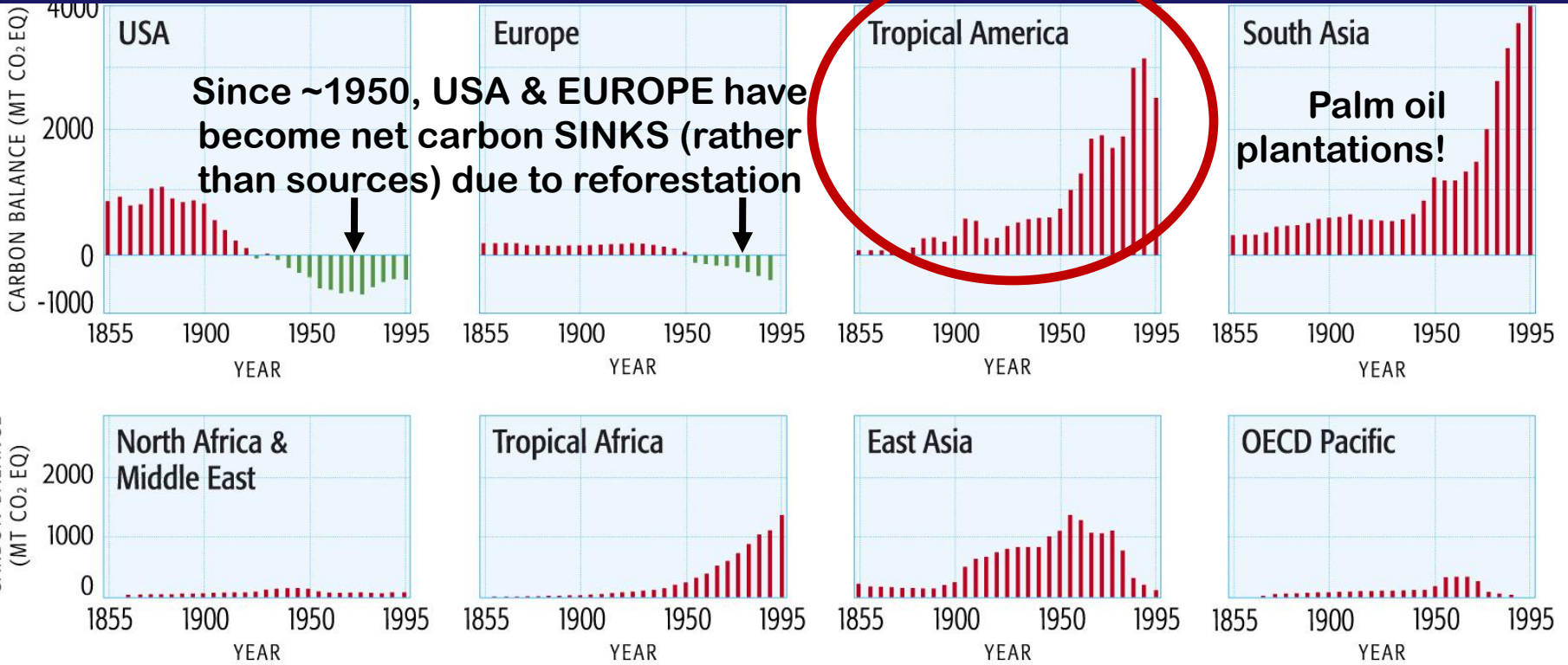
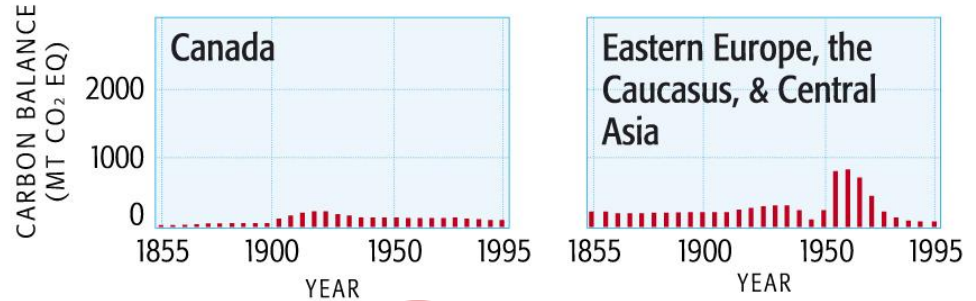
Data Source: **UN / FAO Global Forest Assessment Report**
<http://www.fao.org/forestry/fra/41555/en/>

Forest carbon emissions INTO the atmosphere (+)



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

HISTORICAL TRENDS IN FOREST CARBON EMISSIONS AND UPTAKE



© 2009 Pearson Education, Inc.

Some good news? . . .

Amazon deforestation at record low



By Richard Reynolds

Posted Fri Nov 13, 2009 2:35pm AEDT

Brazil has announced that deforestation in the Amazon basin has fallen to its lowest level since records began 21 years ago.

The report comes from Brazil's space agency, which monitors deforestation with satellites.

The organisation is considered credible and often contradicts the Brazilian Government when it makes outlandish claims about deforestation.

The agency claims that in the year to August, only 7,000 square kilometres of forest has been cut down.

That level is a 45 per cent reduction on the previous year.

Brazilian President Lula da Silva has promised a reduction in deforestation and is using that to pressure the leaders of major nations to reduce greenhouse gas emissions.

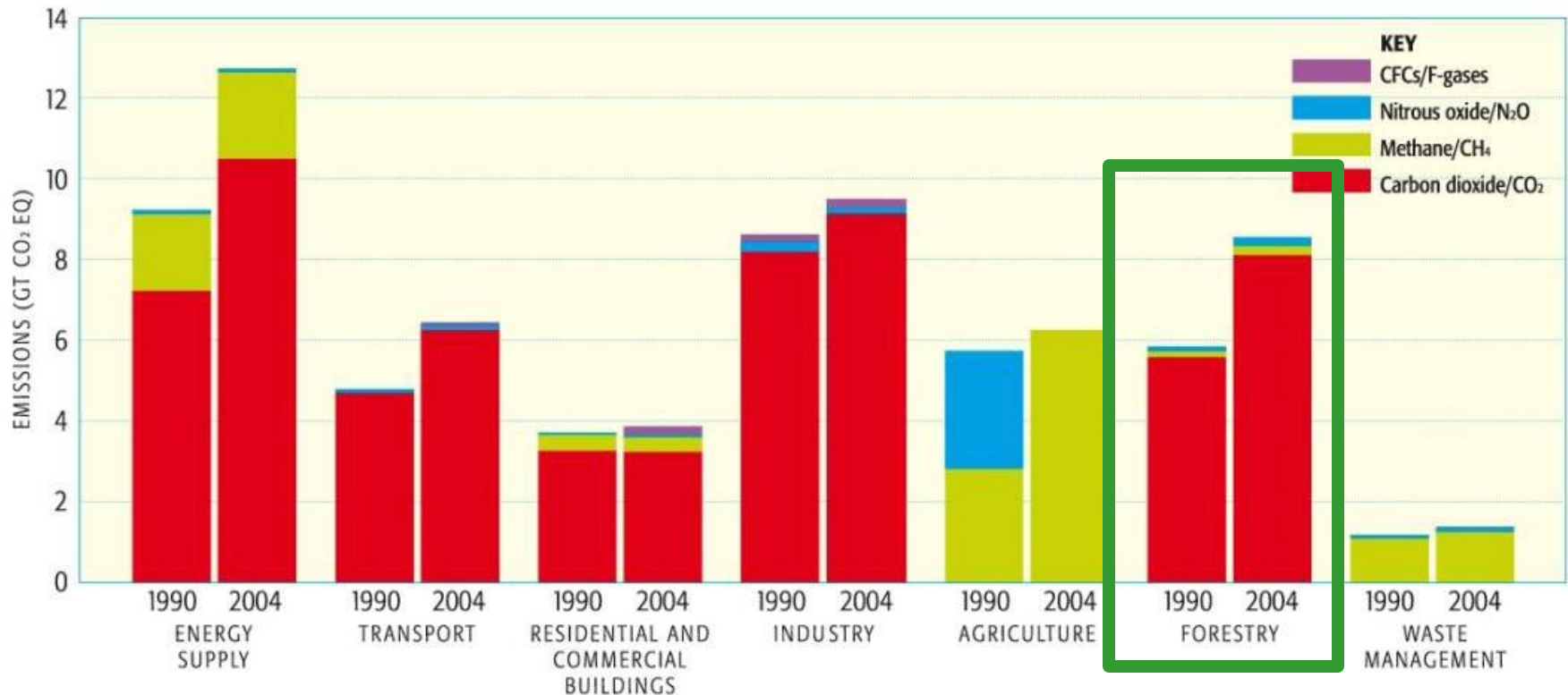
This comes ahead of the UN conference on climate change next month in Copenhagen.

<http://www.abc.net.au/news/stories/2009/11/13/2742229.htm>



Where do all those OTHER Greenhouse Gas emissions come from?

GREENHOUSE GAS EMISSIONS BY SECTOR IN 1990 AND 2004



from p 159 in *Dire Predictions*

TO BE CONTINUED

HAVE A GREAT WEEKEND . . .

. . . but **DON'T FORGET I-3 FILM
REVIEWS DUE MONDAY!**