

WRAPPING UP THE SEMESTER:

Final Exam Review – Part 1

TOPIC #17

**Climate Change
Adaptations & Solutions**

FINAL EXAM REVIEW – Part 1

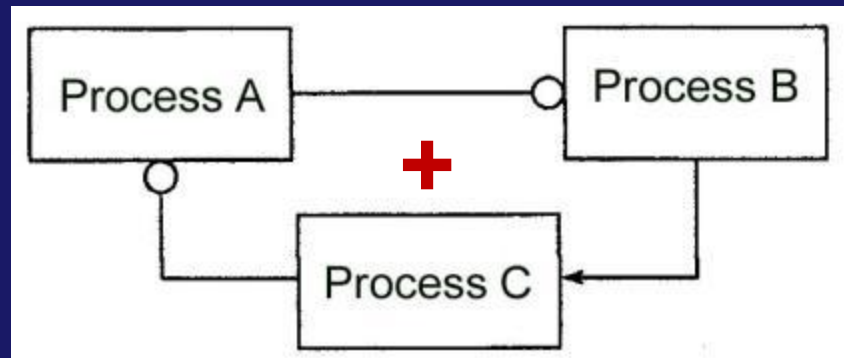
Remember The Energy Balance Symbols?

$$R_{NET} = \begin{array}{c} SW \\ \downarrow \end{array} + \begin{array}{c} SW \\ \downarrow \end{array} - \begin{array}{c} SW \\ \nearrow \end{array} - \begin{array}{c} \uparrow \\ \text{wavy} \\ LW \end{array} + \begin{array}{c} \downarrow \\ \text{wavy} \\ LW \end{array} = H + LE + G$$

&

Feedback Loops?

Is it a + or –
Feedback
Loop?



Is it self-
amplifying
or self-
regulating?

Self-Amplifying!




SAMPLE EXAM QUESTION:

You are designing a computer model to simulate the energy balance of the Earth & atmosphere under global change conditions

CHOOSE THE LETTER OF THE SYMBOL representing the **correct MODEL ADJUSTMENT** you will have to make in your model of the energy balance to simulate how the earth/atmosphere system will respond to the change indicated.

$$R_{NET} = \begin{array}{c} \text{SW} \\ \downarrow \\ \text{SW} \\ \downarrow \\ \text{SW} \\ \searrow \end{array} + \begin{array}{c} \text{SW} \\ \downarrow \\ \text{SW} \\ \downarrow \\ \text{SW} \\ \searrow \end{array} - \begin{array}{c} \text{SW} \\ \searrow \\ \text{SW} \\ \searrow \\ \text{SW} \\ \searrow \end{array} - \begin{array}{c} \uparrow \\ \uparrow \\ \uparrow \\ \uparrow \\ \text{LW} \end{array} + \begin{array}{c} \text{LW} \\ \downarrow \\ \text{LW} \\ \downarrow \\ \text{LW} \\ \downarrow \end{array} = H + LE + G$$

Q. After this change: **the increased burning of fossil fuels produces more and more CO₂ in the atmosphere. . . .** What will happen?

1. MORE  2. MORE  3. MORE  (to space)




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Q. After this change: **the increased burning of fossil fuels produces more and more CO₂ in the atmosphere. . . .** What will happen?

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FINAL EXAM REVIEW (cont.)

Applying these concepts to Biosphere Impacts & Issues . . .



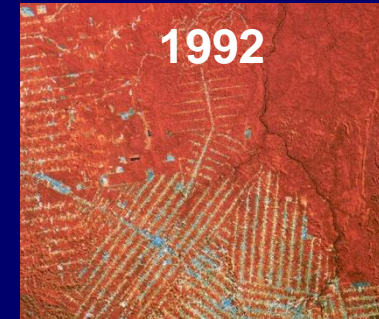
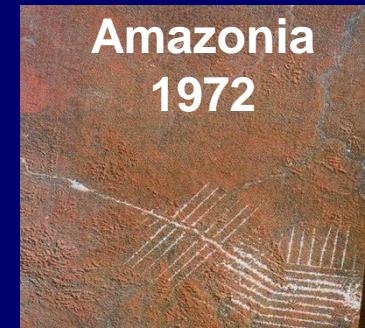
Biodiversity = The variety of life forms found in the natural world.

The greater the biodiversity within an ecosystem, the more **stable and resilient** it is, and the more productive it will be

DEFORESTATION

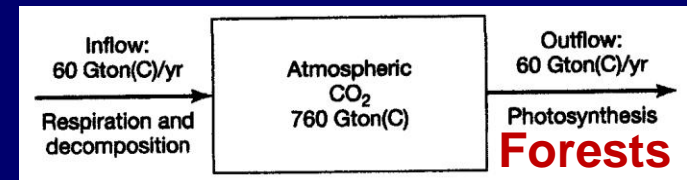
KEY CONCEPT #1 = LOSS OF BIODIVERSITY

- Tropics contain 3/4 of all the living things on Earth, but they cover only 6% of the land surface
- With such diversity, deforestation of the tropics could lead to immense species lost



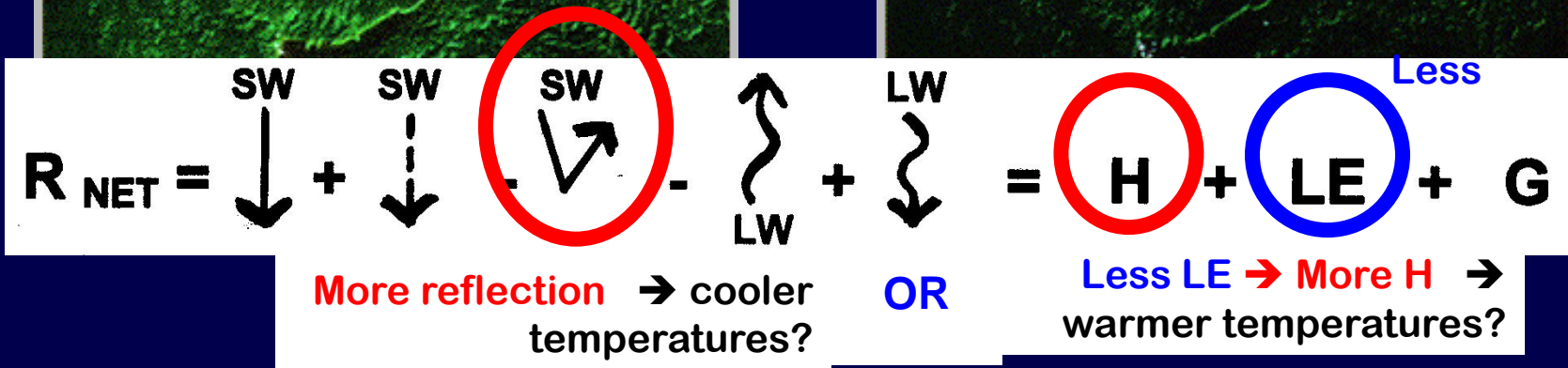
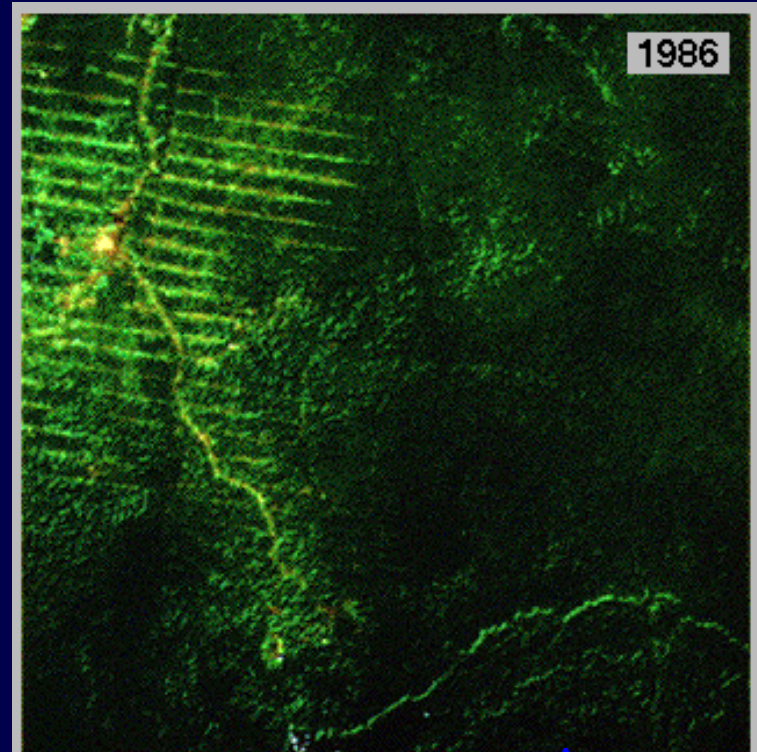
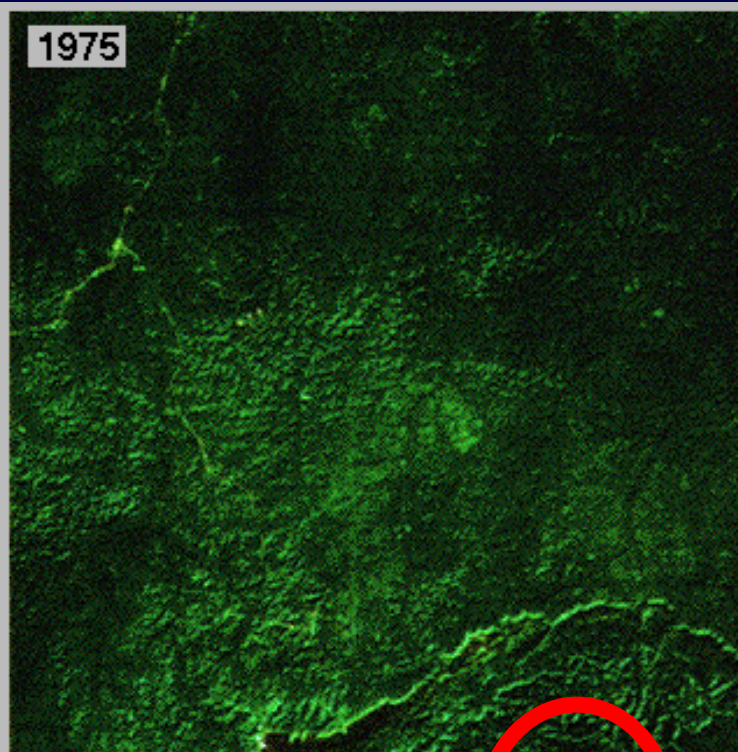
KEY CONCEPT #2 = LOSS OF LARGE PORTIONS OF NATURAL CARBON SINK

- Forests are a **major SINK** for atmospheric CO₂



- Deforestation → an increase of CO₂ in the atmosphere → **will it lead to warming both Globally and Locally?**

REVIEW: **BUT It's COMPLEX!** We have to look at all parts of the ENERGY BALANCE, including the local energy balance !!!

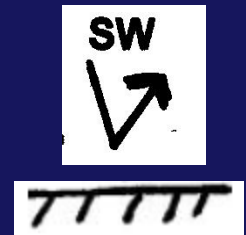


SAMPLE FINAL EXAM QUESTION:

$$R_{NET} = \begin{array}{c} SW \\ \downarrow \end{array} + \begin{array}{c} SW \\ \downarrow \end{array} - \begin{array}{c} SW \\ \swarrow \end{array} - \begin{array}{c} \uparrow \\ \text{wavy} \\ LW \end{array} + \begin{array}{c} LW \\ \downarrow \end{array} = H + LE + G$$

Q. SCENARIO: Deforestation occurs in the Amazon rain forest occurs, changing the land from lush forest to bare grazing and crop land. MODEL ADJUSTMENT:

- (a) more **LE** (b) less **H** (c) more



Same idea in another question format:

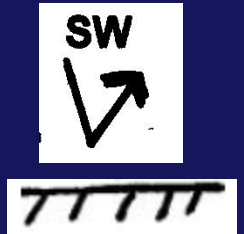
$$R_{NET} = \begin{array}{c} SW \\ \downarrow \end{array} + \begin{array}{c} SW \\ \downarrow \end{array} - \begin{array}{c} SW \\ \nearrow \end{array} - \begin{array}{c} \uparrow \\ \text{wavy} \\ LW \end{array} + \begin{array}{c} LW \\ \downarrow \end{array} = H + LE + G$$

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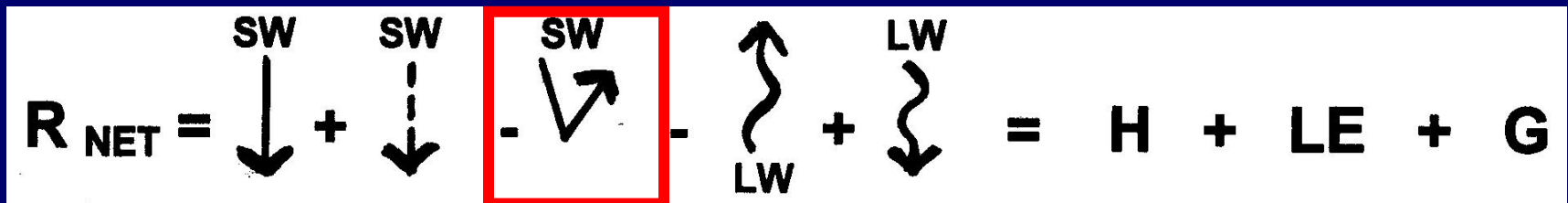
(c) more



KEY CONCEPT # 3 + 4 = Change in the ALBEDO

(of the Earth's Surface)

→ affects Energy Balance (on the left side)


$$R_{NET} = \downarrow_{SW} + \downarrow_{SW} - \swarrow_{SW} - \updownarrow_{LW} + \downarrow_{LW} = H + LE + G$$

Will albedo [INCREASE / DECREASE]
with deforestation?

Q. Would this lead to local COOLING or Warming?

- 1) Cooling 2) Warming

KEY CONCEPT # 3 & 4 = Change in the ALBEDO

(of the Earth's Surface)

→ affects Energy Balance (on the left side)

$$R_{NET} = \begin{matrix} \text{SW} \\ \downarrow \end{matrix} + \begin{matrix} \text{SW} \\ \downarrow \end{matrix} - \boxed{\begin{matrix} \text{SW} \\ \nearrow \end{matrix}} - \begin{matrix} \updownarrow \\ \text{LW} \end{matrix} + \begin{matrix} \text{LW} \\ \downarrow \end{matrix} = H + LE + G$$

Will albedo [**INCREASE** / DECREASE]
with deforestation?

Q. Would this lead to local COOLING or Warming?

1) Cooling

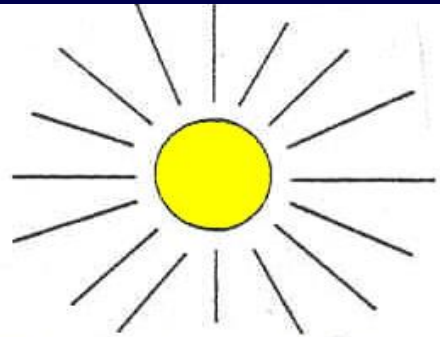
2) Warming

KEY CONCEPT #3 & 4 = Change in
Local HYDROLOGY & Energy Balance

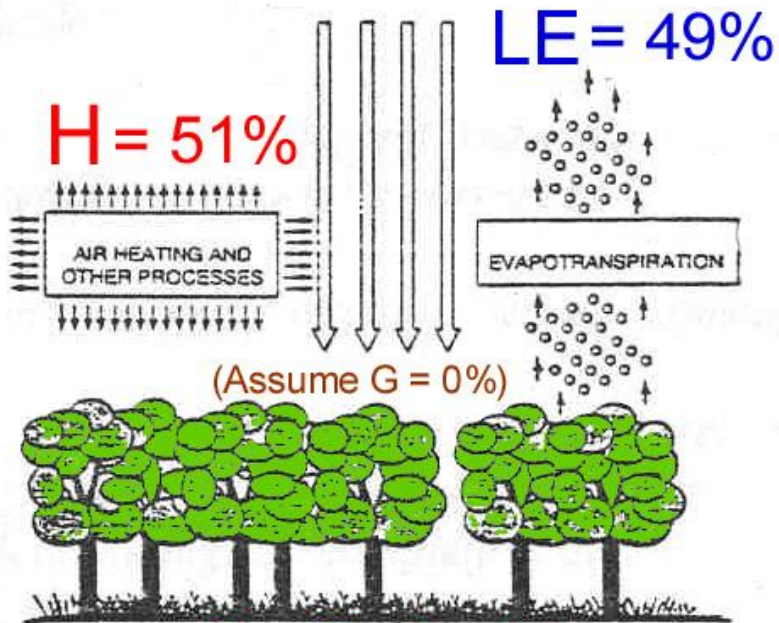
$$R_{NET} = \begin{matrix} SW \\ \downarrow \end{matrix} + \begin{matrix} SW \\ \vdots \downarrow \end{matrix} - \begin{matrix} SW \\ \swarrow \end{matrix} - \begin{matrix} \uparrow \\ \text{LW} \end{matrix} + \begin{matrix} \downarrow \\ \text{LW} \end{matrix} = H + \boxed{LE} + G$$

Affects RIGHT side of ENERGY BALANCE EQUATION
through LE (evapotranspiration)

Less energy in LE → more in H → WARMING



$R_{net} = 100\%$



Energy Transfer each day
above forest in Amazon Basin

AMAZON FOREST

REVIEW:

Deforestation will lead to a **DECREASE** in the amount of energy stored in

H or LE *[circle one]*

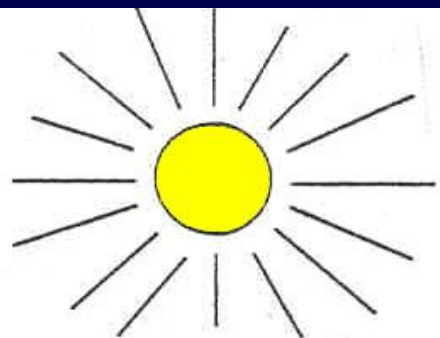
and an **INCREASE** in the amount of energy stored in

H or LE *[circle one]*

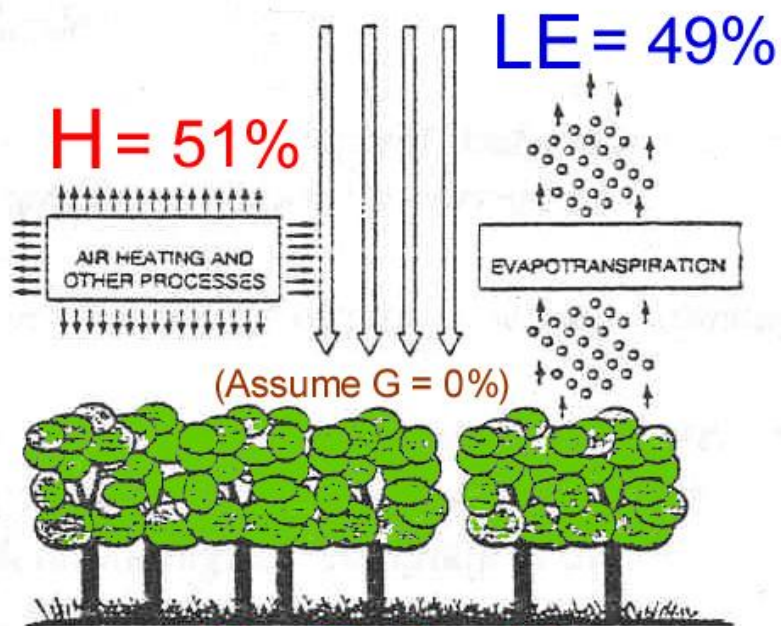
Q1. Would this lead to local COOLING or WARMING in the region?

1) Cooling

2) Warming



R net = 100 %



Energy Transfer each day
above forest in Amazon Basin

AMAZON FOREST

REVIEW:

Deforestation will lead to a **DECREASE** in the amount of energy stored in

H or **LE** [circle one]

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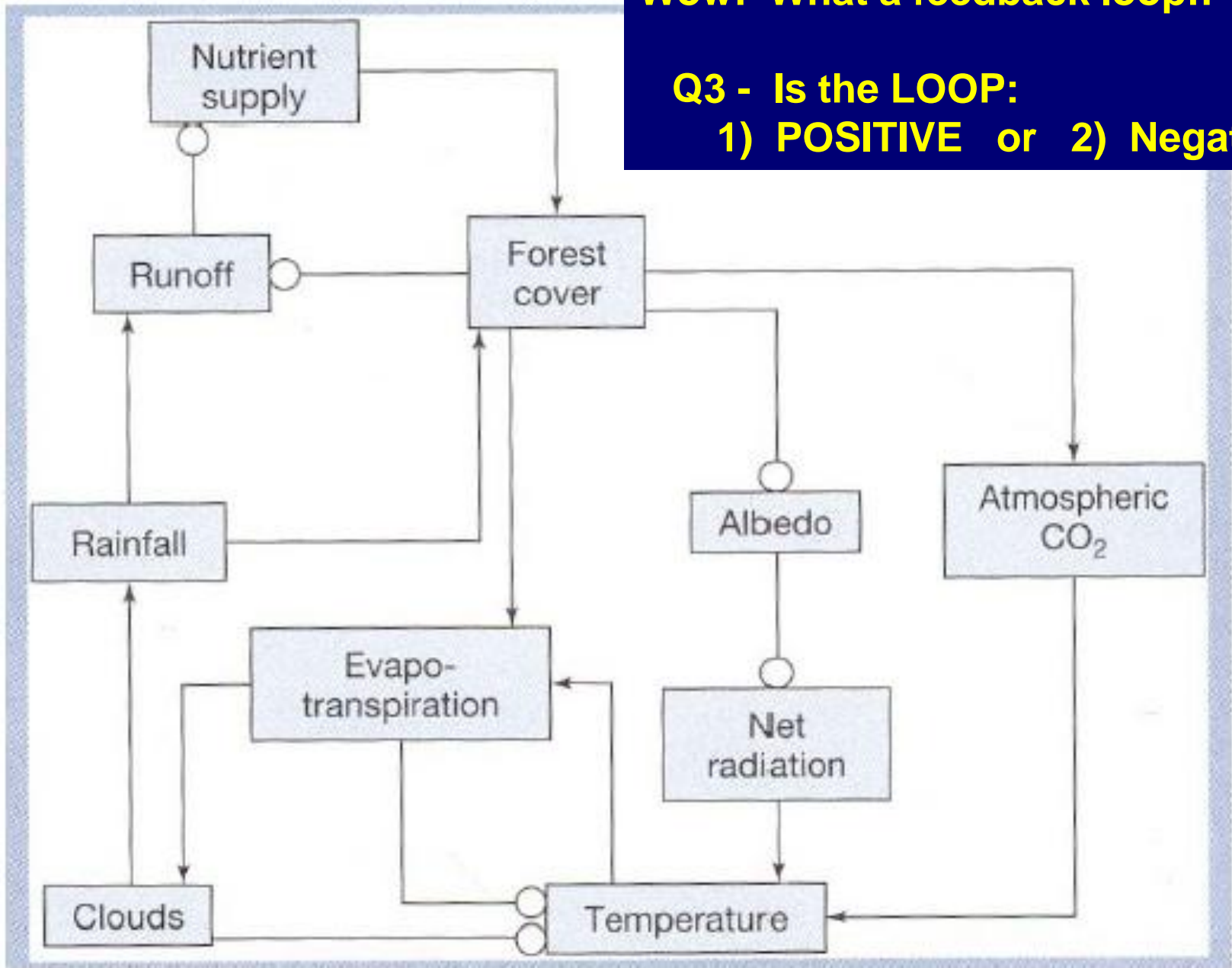
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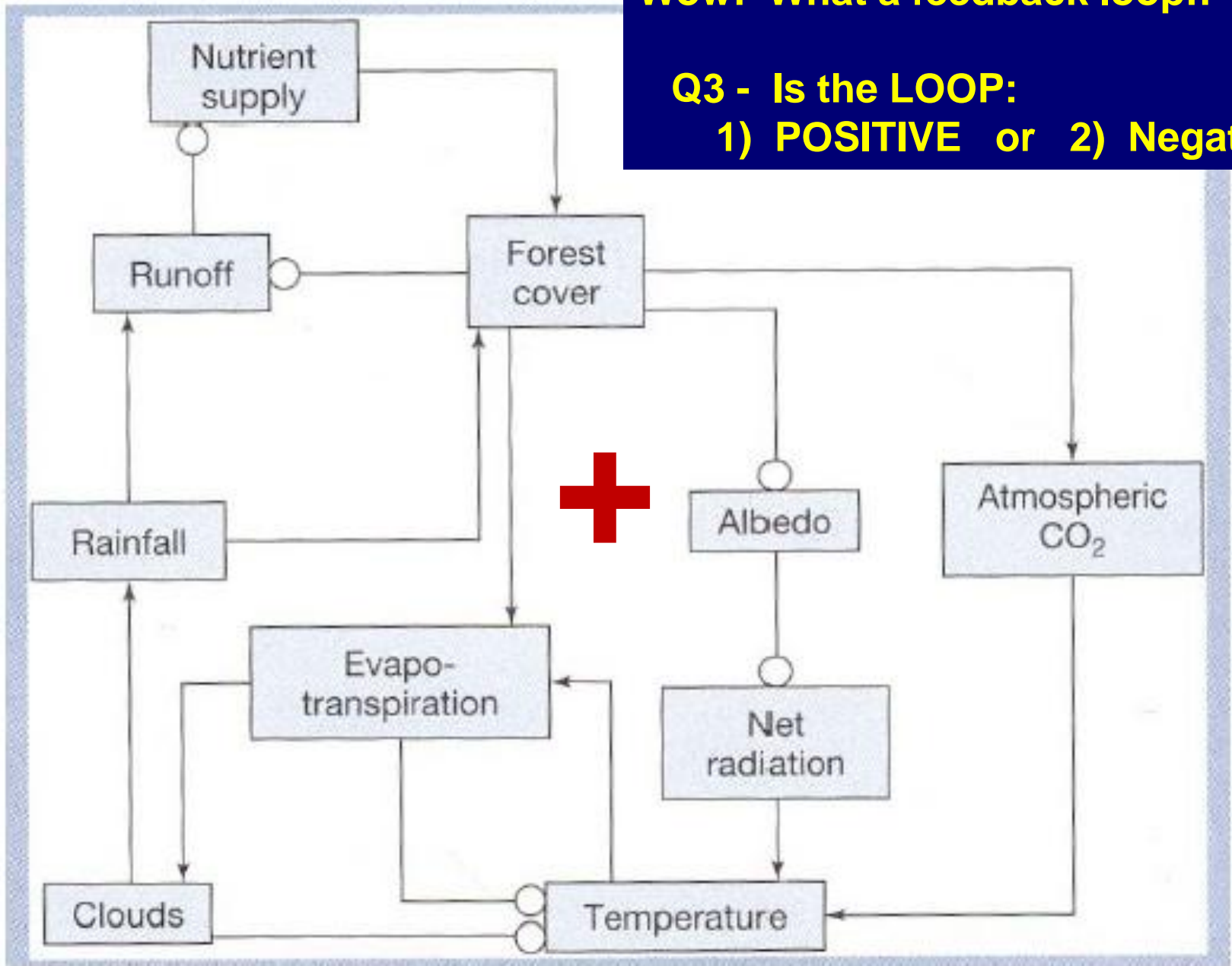
Wow! What a feedback loop!!

Q3 - Is the LOOP:
1) POSITIVE or 2) Negative?



Wow! What a feedback loop!!

Q3 - Is the LOOP:
1) POSITIVE or 2) Negative?



So does deforestation => warming or cooling in the LOCAL Climate?

Results of one study based on a climate model:

Impacts of Deforestation on Local Climate			
<i>Surface Variable</i>	<i>Observed Control*</i>		<i>Deforested*</i>
Evaporation (mm/d)	3.34	3.12	2.27 (-27.2%)
Precipitation (mm/d)	5.26	6.60	5.26 (-20.3%)
Soil moisture (cm)		16.13	6.66 (-58.7%)
Runoff (mm/d)	2.76	3.40	3.00 (-11.9%)
Net radiation (W/m ²)		147.3	126.0 (-14.5%)
Temperature (°C)	24.0	23.6	26.0 (+2.4°C)

This model's results indicated a slight **Temperature INCREASE**

TO THINK ABOUT FOR THE FINAL EXAM



**AMAZON RAIN
FOREST**

VS.



**SONORAN
DESERT**



**How will their local
energy balances
differ??**



So what do we do about all of these impacts???

TOPIC #17 CLIMATE CHANGE ADAPTATION & MITIGATION SOLUTIONS

**POLICIES & POSSIBLE ACTIONS
to SLOW
GLOBAL WARMING . . .
& ADAPT to the warming we
can't prevent!**

READ: the rest of CHAPTER 16 in SGC E-TEXT

**“ A world civilization able
to envision God and the afterlife,
to embark on the colonization of space,
will surely find the way
to save the integrity of this magnificent planet
and the life it harbors because quite simply
it's the right thing to do,
and ennobling to our species.”**

-E. O. Wilson



**MITIGATION
VS
ADAPTATION ?**

We need BOTH!

MITIGATION

Mitigation: intervention to reduce anthropogenic
Forcing on the climate system through:

(a) strategies to
reduce GHG **emissions**



(b) strategies to
enhance GHG **sinks**



planting trees

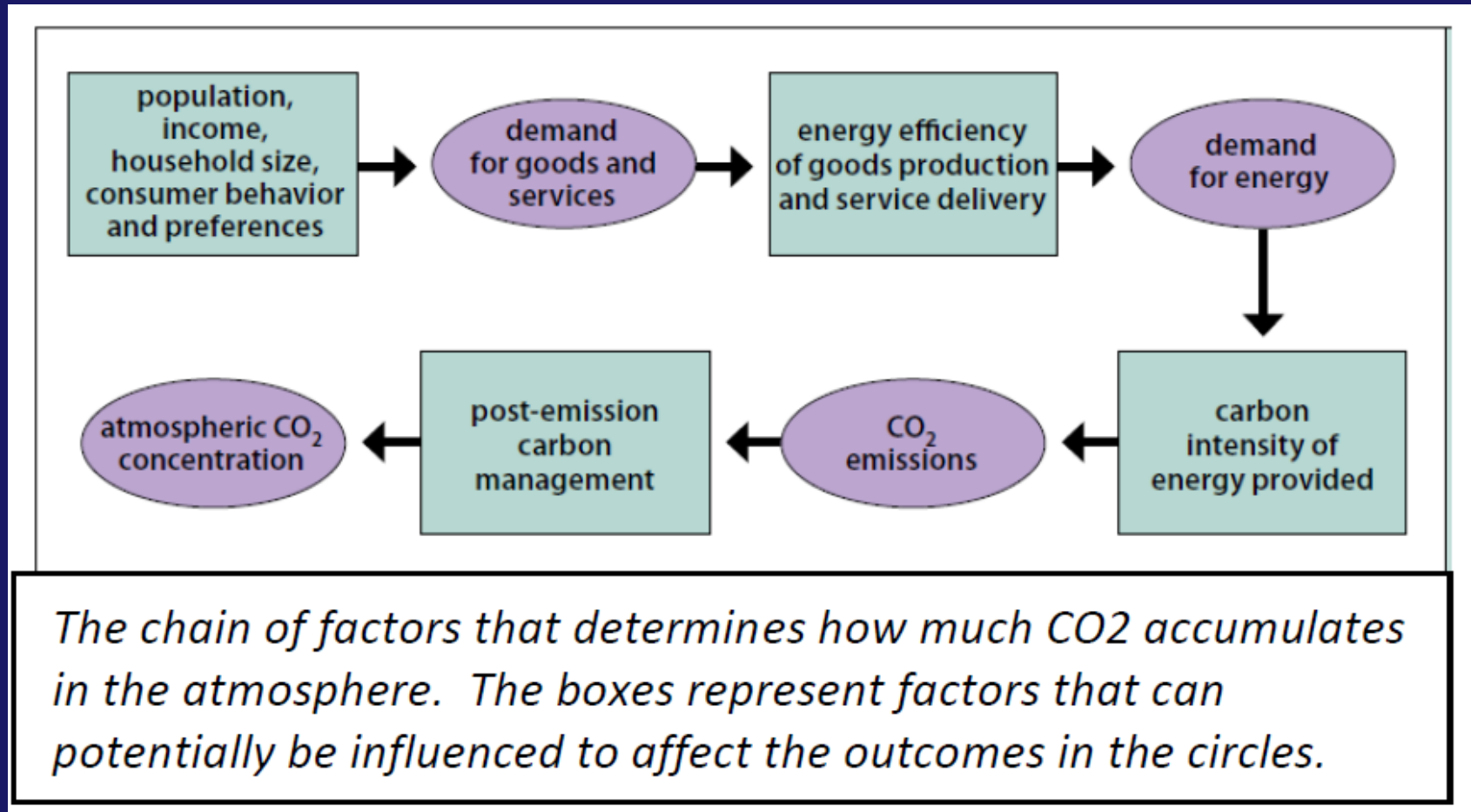
EXAMPLE OF MITIGATION PROCESS

PROBLEM FACTORS!

= factors that lead to increasing accumulation of CO₂ in atmosphere

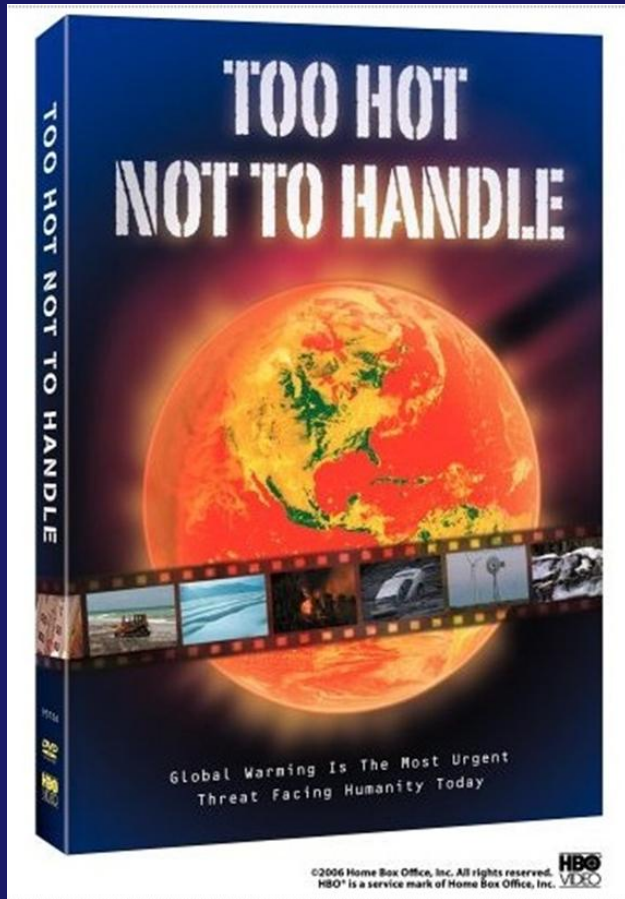
SOLUTION FACTORS!

= factors that HUMANS can adjust to influence the :  factors



Several **MITIGATION SOLUTIONS** were described in:

“Let a thousand flowers bloom”.



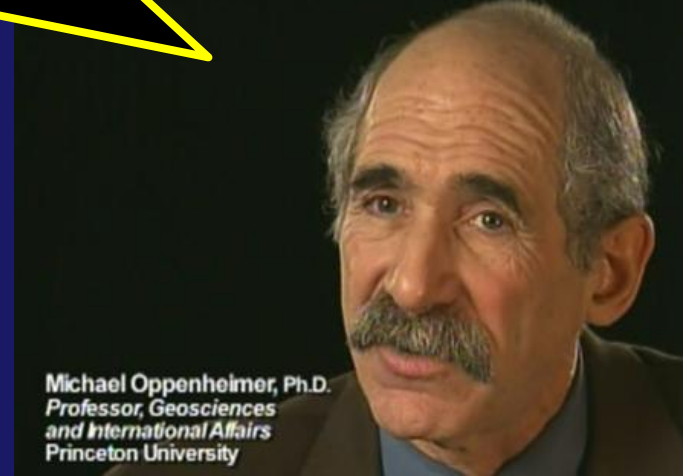
SOLAR

BIOFUELS WIND

SUSTAINABLE COMMUNITIES

(Portland, Oregon example)

Michael Oppenheimer, Ph.D.
Professor, Geosciences
and International Affairs
Princeton University



FILM FOLLOW UP. . . . Tucson's answer to Portland's "Hot Lips Pizza:



Welcome to Brooklyn Pizza Company

Brooklyn has gone Solar! The new panels generate 160,000 kWh of electricity per year. Find out how Brooklyn does its part to mitigate environmental impact.

See the PDF.

NOW 100% SOLAR POWERED!

-80,000 gal of water saved each year

-29,700 lbs of CO2 - the biggest contributor to global warming - saved each month

-160,000 lbs of coal saved each year



Your favorite pizzeria goes solar!

In
TUCSON,
on 4th
Avenue

**MITIGATION
VS
ADAPTATION ?**

We need BOTH!

ADAPTATION

ADAPTATION: Adjustments made in response to (or anticipation of) **CLIMATIC IMPACTS** in order to:

(a) Lessen or reduce harm

(b) take advantage of beneficial opportunities



Should this house be rebuilt?





The IPCC Special Report on Managing the Risks
of Extreme Events and Disasters to Advance
Climate Change Adaptation

November 2011

ipcc
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

IPCC Special Report



- **Changes in climate vary across regions**
- **Each region has unique vulnerabilities & exposure to hazards**
- **Effective adaptation & risk management must address BOTH exposure & vulnerability of a region**

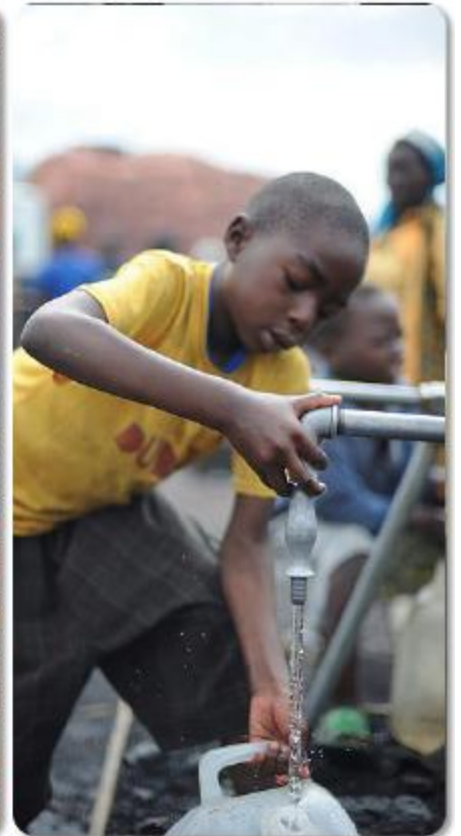
“ADAPTIVE MANAGEMENT”

Managing **risks of disasters** in a changing climate benefits from an **iterative** process



... and also depends on the CAPACITY of a region (or a system) to adjust to climate change (e.g., rich vs poor nations or communities / ecosystem migration)

There are strategies that can help **manage disaster risk now** and also help improve people's livelihoods and well-being



The most effective strategies offer **development benefits** in the relatively near term and **reduce vulnerability** over the longer term

Managing the risks: heat waves in Europe

Risk Factors

- lack of access to cooling
- age
- pre-existing health problems
- poverty and isolation
- infrastructure



Risk Management/Adaptation

- cooling in public facilities
- warning systems
- social care networks
- urban green space
- changes in urban infrastructure

Projected: *likely* increase heat wave frequency and *very likely* increase in warm days and nights across Europe

Managing the risks: hurricanes in the USA and Caribbean

Risk Factors

- population growth
- increasing property value
- higher storm surge with sea level rise



Risk Management/Adaptation

- better forecasting
- warning systems
- stricter building codes
- regional risk pooling

Projected globally: *likely* increase in average maximum wind speed and associated heavy rainfall (although not in all regions)

Managing the risks: flash floods in Nairobi, Kenya

Risk Factors

- rapid growth of informal settlements
- weak building construction
- settlements built near rivers and blocked drainage areas



Risk Management/Adaptation

- reduce poverty
- strengthen buildings
- improve drainage and sewage
- early warning systems

Projected: *likely* increase in heavy precipitation in East Africa

Managing the risks: sea level rise in tropical Small Island Developing States

Risk Factors

- shore erosion
- saltwater intrusion
- coastal populations
- tourism economies



Risk Management/Adaptation

- early warning systems
- maintenance of drainage
- regional risk pooling
- relocation

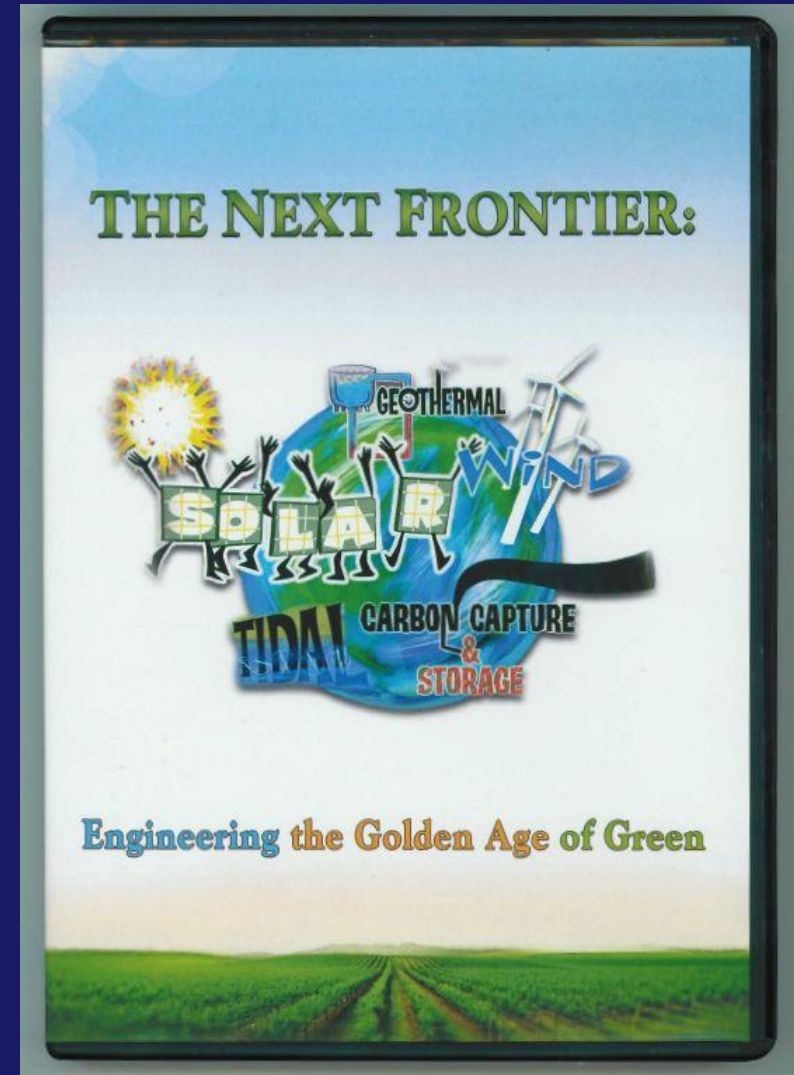
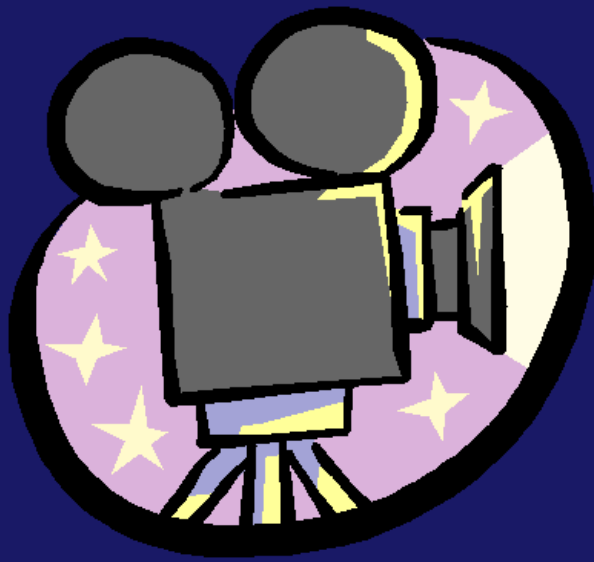
Projected globally: *very likely* contribution of sea level rise to extreme coastal high water levels (such as storm surges)

**MITIGATION
VS
ADAPTATION ?**

We need BOTH!

So what other possible
**MITIGATION
SOLUTIONS**
are out there?

A brand new
“Sustainability Segment”
film



See you on WEDNESDAY for:
MORE SOLUTIONS FOR YOU
And MORE
FINAL EXAM REVIEW!

Atmospheric Structure and Composition	Radiation Laws	Matter & Thermo- dynamics	Laws of Motion	Odds & Ends
<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>
<u>200</u>	<u>200</u>	<u>200</u>	<u>200</u>	<u>200</u>
<u>300</u>	<u>300</u>	<u>300</u>	<u>300</u>	<u>300</u>
<u>400</u>	<u>400</u>	<u>400</u>	<u>400</u>	<u>400</u>
<u>500</u>	<u>500</u>	<u>500</u>	<u>500</u>	<u>500</u>