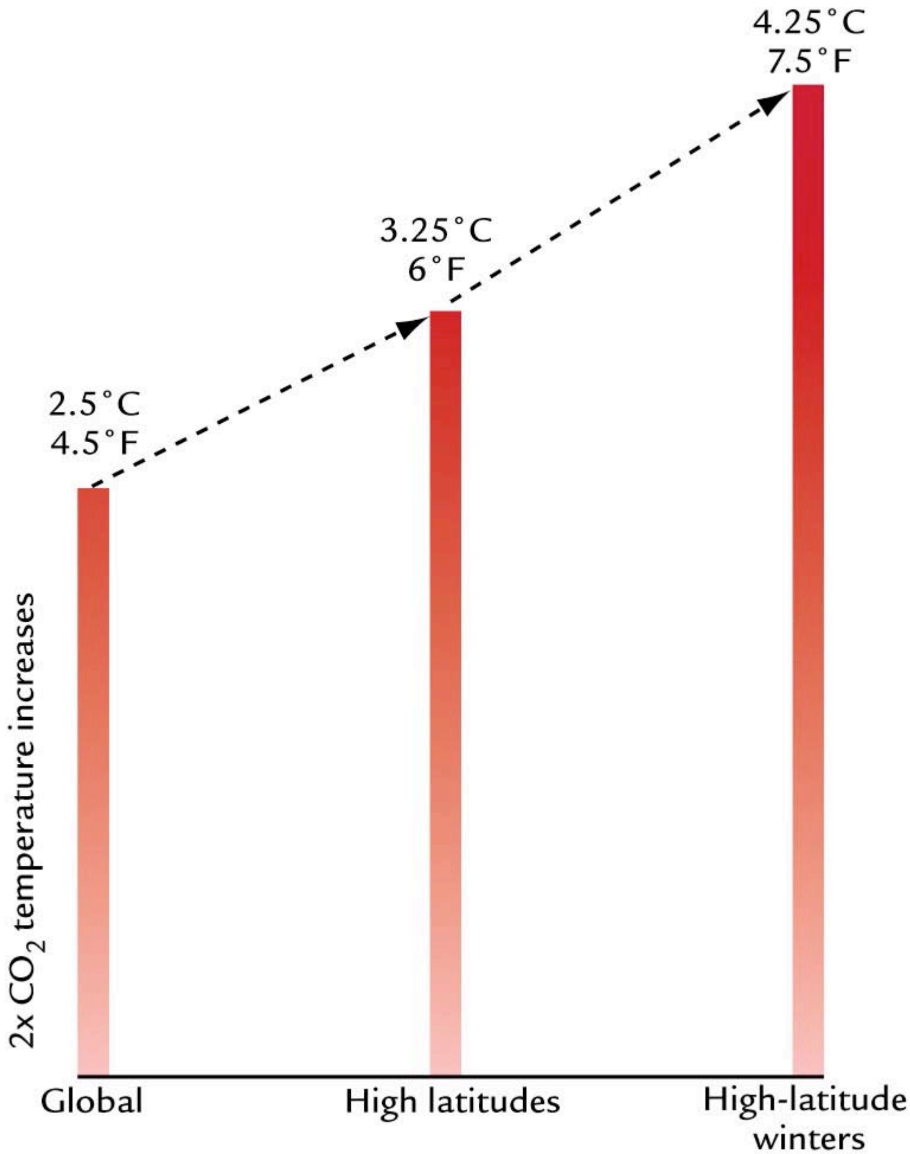
Lecture 35

Today: Biology impacts of global warming
(we'll skip p.335-336 textbook
on 'economic discounting')

Tomorrow: Policy solutions.

Thursday: Any questions?

North. Hem. Latitudinal Effect



Temperature increases are expected to be about 2 times greater in polar regions

More responsive than tropics because of

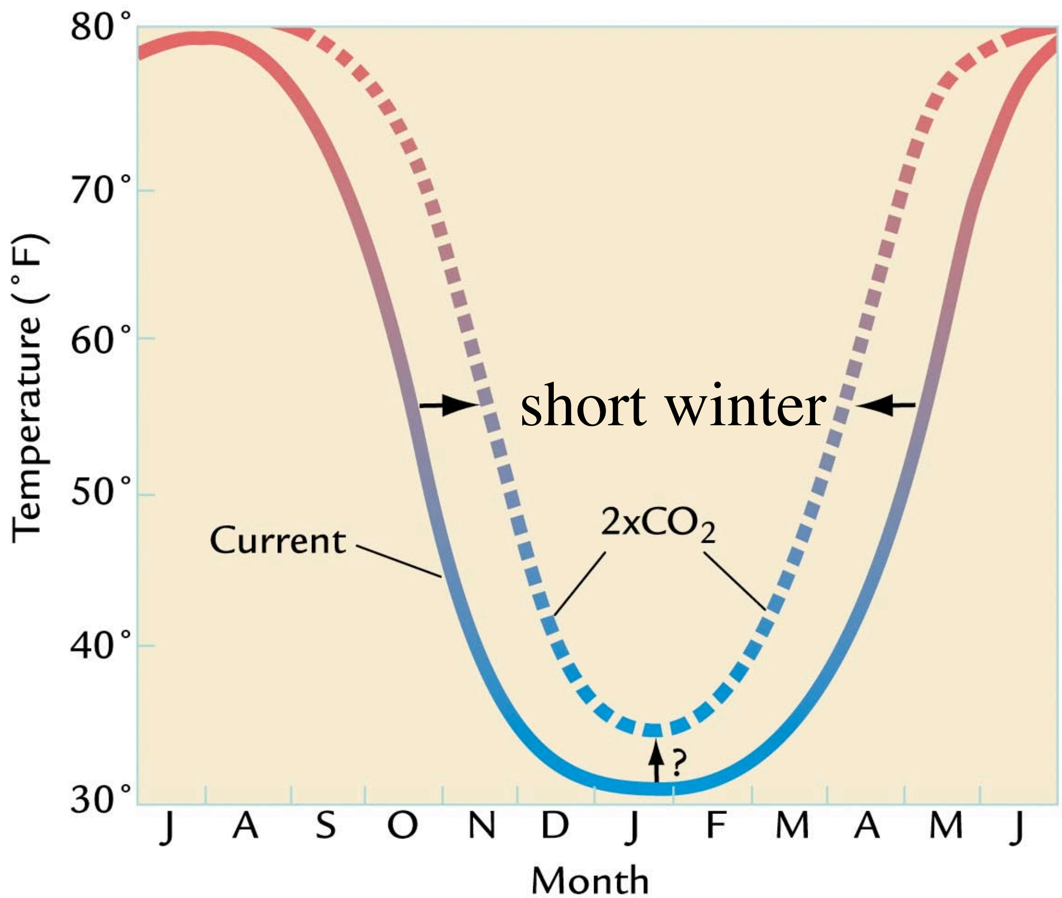
- ice-albedo feedback
- more land-mass

e.g. global mean increases +2.5 C

mid-latitude increases 3-3.5 C

Midlatitude Seasonal Change

2 x CO_2 means:
Future Aprils like modern Mays
Future Novembers like modern Octobers
i.e. two extra months of summer.



Seasons
50-100 years
in the future

Spring Earlier, Fall Later

OBSERVATIONS:

Mediterranean deciduous plants now leaf 16 days earlier and fall 13 days later than 50 years ago

Europe and North America, biological spring is 1-2 weeks earlier than 100 years ago

Growing season is 18 days longer in Eurasia, 12 days longer in N. America over past 20 years

Effects on Biology

Can divide climate change impacts into:

1. Marine environments

2. Terrestrial ecosystems

Marine Biology & Global Warming

We have already discussed sea-level rise.

A potential long-term (22nd century?) catastrophe is a shut-down of the thermohaline circulation due to freshwater input in the N. Atlantic from precipitation and icesheet disintegration. (see p.332, Kump)

Qu.) Suppose CO_2 is increased? What happens to the pH of the ocean?

Answer) CO_2 dissolves to form carbonic acid. So we should expect the ocean to become a bit more acidic.

With "business as usual" emissions, pH decreases by 0.35 units by 2100.

Qu.) How does acid affect organisms that make $CaCO_3$ shells?

It will decrease the ability of the organisms to make their shells. This is exacerbated by an increase in surface water temperature.

Coral Reefs

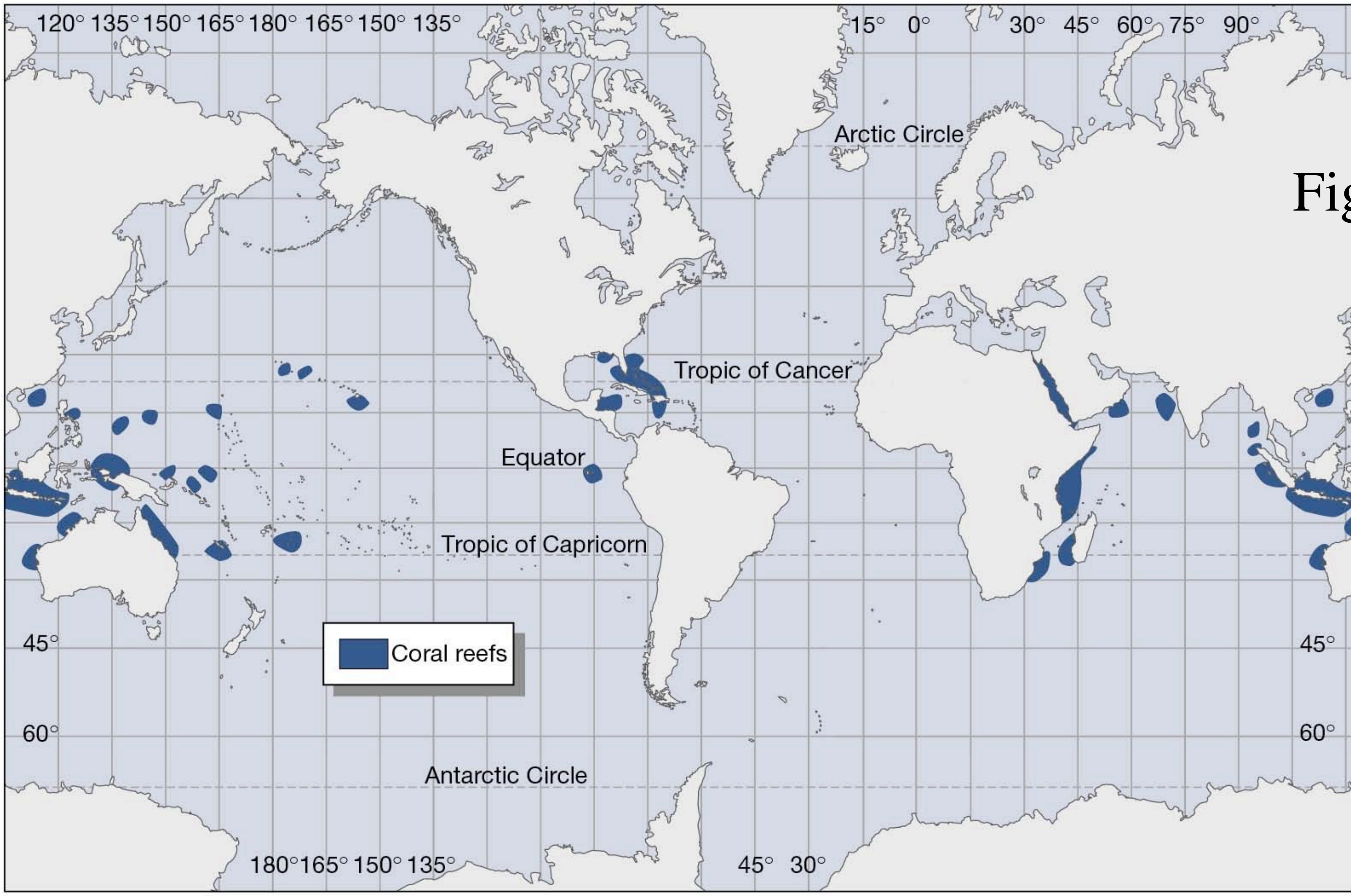


Fig 18-5

Colonies of animals that contain symbiotic algae and deposit $CaCO_3$

-habitat for 25% of marine species, protect shorelines, provide fisheries

-contain ~4000 species of fish

Coral Reefs under pressure

Range of temperature for growth is narrow: 21 to 29°C

Algae give color to the naturally transparent coral animals
and provide them with food. In return…
Corals protect the algae and provide algae with CO_2 and ammonia

1. More CO_2-rich waters prevent secretion of $CaCO_3$ skeleton
2. Warmer water stress the corals and they expel the algae
    - coral bleaching

RESPONSE TO WARMING:
Since 1980s: Coral bleaching outbreaks are more common
1991-2: Mt. Pinatubo cool years saw a decline of coral bleaching
1997-98, El Niño ocean temperatures wiped out 16% of the world's reefs

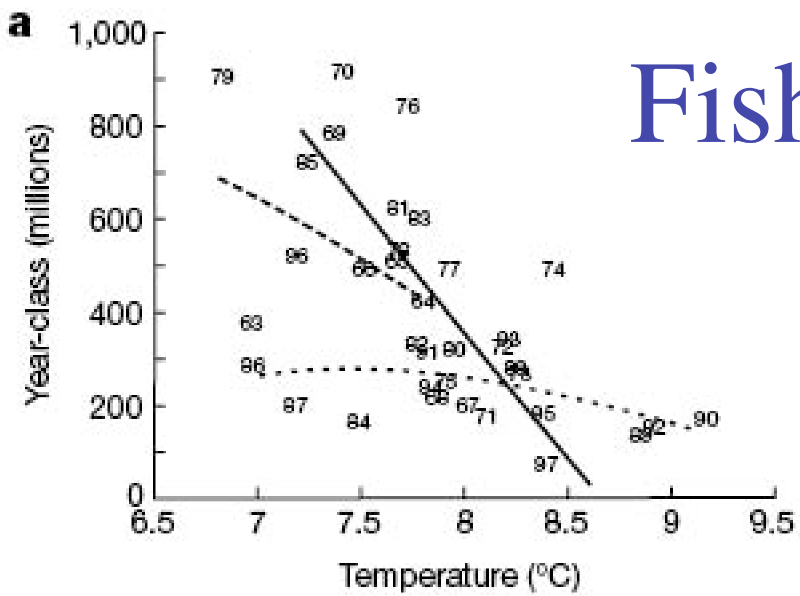
Today: 30% of coral reefs damaged from warming (and pollution)
2030: 60% prediced loss (Hughes et al. (2003) *Science*, 301, 930-933)

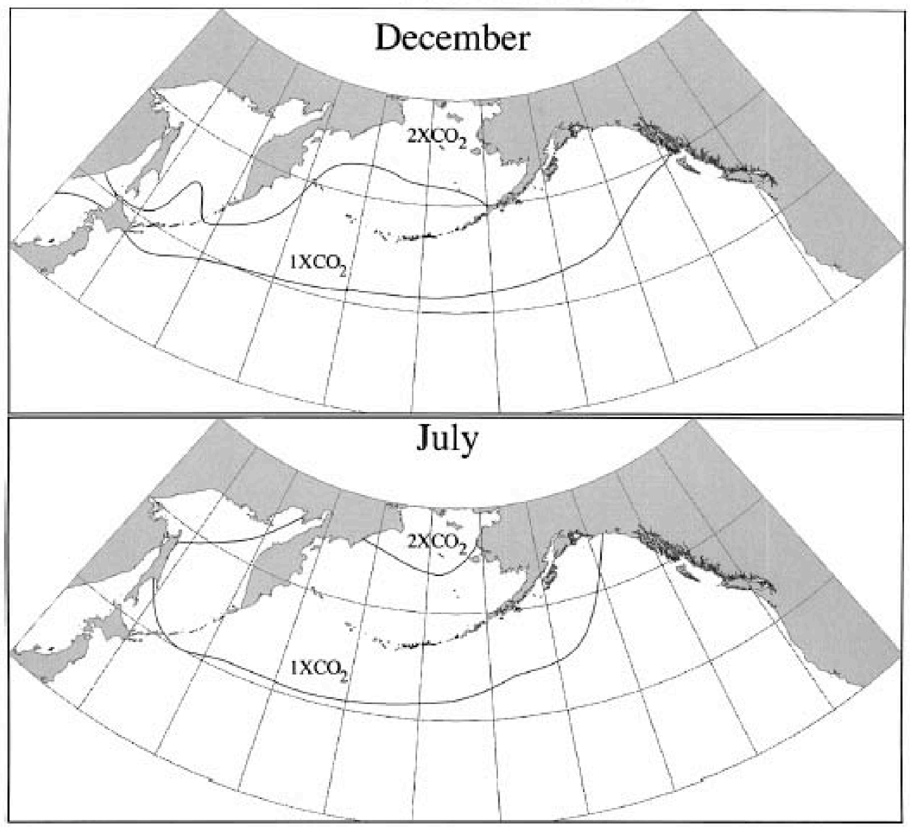
Coral bleaching in the Red Sea

Before

After

Fish





North Sea cod: year-class (millions of 1-yr-old fish) empirically decreases with water temperature.

(O'Brien et al (2000) Nature 409, 142)

Over-fishing + global warming are causing collapse of this fish stock.

Sockeye salmon: with 2 x CO_2 temperatures, Pacific marine habitat shrinks to the Bering Sea (Welch et al. (1998) *Can. J. Fisheries Aquatic Sciences*, 55, 937-948.)

(thermal regime restricted by T-dependent metabolic rate vs. food intake)

Marine disease

Example:

25 years of increasing temperatrure on E. Coast of US:

Increased spread of Dermo (parasite) and MSX (bacteria) diseases in oysters by decreasing parasite mortality in winter

1980s: MSX & Dermo spread throughout Cheasapeake Bay
1990s: Dermo spread to Maine
1998 (hot year): MSX spread to New York
2000-2100: ???

Terrestrial ecosystems

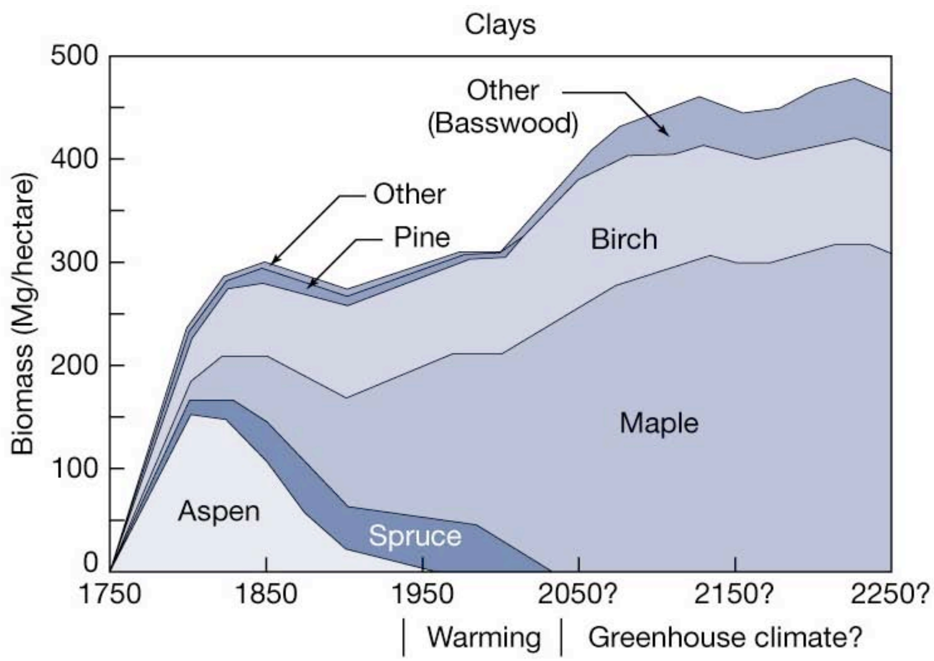
C3 photosynthesizers: cyanobacteria and most plants

C4 plants: (CO_2-concentrating): corn, sugarcane, tropical grasses

(corn, sugarcane: actually grasses)

C3 and C4 are different types of photosynthetic metabolism.
C4 plants evolved 7-8 m.y. ago and are insensitive to CO_2 levels because they can concentrate CO_2 within inner cells in their leaves.

Result: C3 weeds could do well,
whereas C4 corn will do poorly in high CO_2.

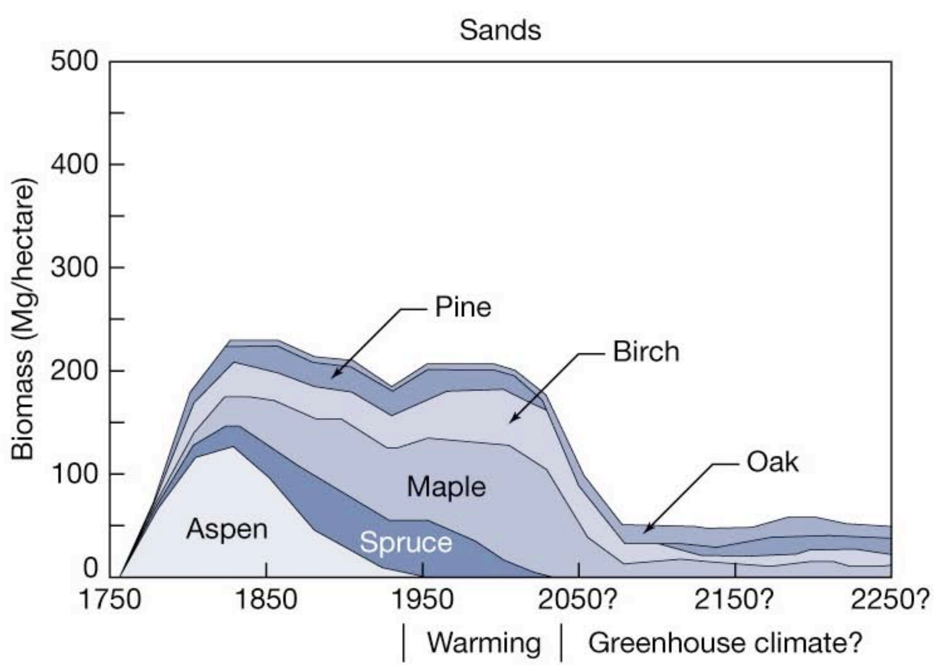


(a)

Trees

High water capacity soil (clay)

Move from cold-adapted
Aspen/Spruce to Maple/Birch



(b)

Low water capacity soil (sand)
All species do poorly after 2050
due to dry soil.

□ conclusion: species
distribution is highly likely
to change in all scenarios.

Fig 16-11: Minnesota trees.

Can trees keep pace with climate? No.

500 km migration is needed from 2000-2100 for trees

This is about 25 times faster than the latitude shift
of forest ecosystems from the last glacial
and considered too fast by tree botanists.
(Roberts (1988) Is there life after climate change? *Science*, 242, 1010-1012)

Another problem is break-up of forests by other human activity.

Conclusion: Warming is likely to eliminate sedentary species.

Extinction rates

The modern (human-induced) extinction rate is
about 3000 times faster than the natural rate of species loss.

This is mainly caused by tropical forest deforestation.
Tropical forests contain ~50% of world's animal/plant species.
Global extinction rate: made worse by global warming. (Floods, droughts).

Why care?

<u>Practical reasons:</u> Medicinal use of plants

e.g. rosy periwinkle, used against Hodgkins disease & child leukemia
e.g. 1987: discovered that the *Calophyllum* tree of Borneo prevents HIV replication, but the tree has been eliminated by deforestation
Currently 42m people are infected with AIDS (www.unaids.org).

<u>Aesthetic reasons:</u> nature is beautiful; loss of animals and plants diminishes our natural heritage and culture.