Conservation Biology 406R/506R

1. Global Climate Change  
   Implications for Conservation Biology

2. Thank Bill Mannan

Exam two on Thursday in lecture  
same format as before
Focus: Consequences of Ecosystem Change for Human Well-being

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**Focus:** Consequences of Ecosystem Change for Human Well-being

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**Constituents of Well-Being**

- **Security**
  - Personal safety
  - Biodiversity preservation
  - Security from disasters

- **Basic Material for Good Life**
  - Adequate food
  - Access to clean water
  - Shelter

- **Freedom of Choice and Action**
  - Opportunity to achieve what is individually valued and being

- **Health**
  - Good health
  - Access to clean air and water

- **Good Social Relations**
  - Social cohesion
  - Human respect
  - Ability to help others

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**Environment**

**States Sue Over Global Warming**

In a legal gambit aimed against global warming, the attorney general of eight states last week sued the five largest emitters of carbon dioxide in the United States for creating a public nuisance. The states are arguing that the electric utility companies cut emissions by 3% each year for a decade. Legal experts predict the states’ case will be a key test battle.

Carbon dioxide litigation is heating up. In 2002, environmental groups sued the Overseas Private Investment Corp. and the Export-Import Bank of the United States for not conducting environmental reviews on the power plants they financed. And last year, Maine, Massachusetts, and Connecticut sued the Environmental Protection Agency for not regulating CO₂ as a pollutant under the Clean Air Act. Now, the states have taken the first legal action directly against CO₂ emitters.

The plaintiffs—California, Connecticut, Iowa, New Jersey, New York, Rhode Island, Vermont, and Wisconsin, along with the City of New York—claim that the CO₂ that utility companies release contributes to global warming, which will harm state residents. The alleged ill effects include increased numbers of deaths from heat waves, more asthma from smog, beach erosion, contamination of groundwater, rising sea levels, and more drought and floods. “The harm to our states is increasing daily,” Ellen Spitzer, the attorney general of New York state, said at a press conference.

The defendants together spew about 135 million tons of CO₂ a year. Their 174 fossil fuel-burning plants contribute roughly 10% of the anthropogenic CO₂ in the United States. The suit maintains that annual cuts of 3% are feasible through making plants more efficient, promoting conservation, and using wind and solar power—without substantially raising electric bills. “All that is now lacking is action,” Spitzer said.

That claim from American Electric Power of Columbus, Ohio, a defendant. Spokesperson Melissa McInerney says that the company had already committed to reducing its emissions by 15% by 2005. “Filing lawsuits is not constructive,” she says. “It’s a global issue that can’t be addressed by a small group of companies.”

It will also be a tough suit to win, says Richard Brooks of Vermont Law School in South Royalton, who studies the legal issues of air pollution. The fact that global warming is a planetary phenomenon will make it difficult to establish how much those companies are contributing to the claimed harm. And under public nuisance law, the plaintiffs must show that those citizens are suffering significantly more than the nation as a whole. “I would be totally amazed if the court gave this a serious response,” Brooks says. “This makes me imagine that this is more of a symbolic suit.”

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*Environment* 30 July 2004 VOL 305 SCIENCE www.sciencemag.org
http://www.acia.uaf.edu/
Global Climate Change

**GeoSigns, EcoSigns, Time Signs**
National Geographic September 2004

We are changing our planet's climate and the evidence is to be found in the *geological, biological, and climatological* records available for study.

- Carbon Dioxide, Methane, Nitrous Oxide
- Deforestation, etc.
Selected Greenhouse Gases

- **Carbon Dioxide (CO₂)**
  - Source: Fossil fuel burning, deforestation
  - Anthropogenic increase: **30%**
  - Average atmospheric residence time: **500 years**

- **Methane (CH₄)**
  - Source: Rice cultivation, cattle & sheep ranching, decay from landfills, mining
  - Anthropogenic increase: **145%**
  - Average atmospheric residence time: **7-10 years**

- **Nitrous oxide (N₂O)**
  - Source: Industry and agriculture (fertilizers)
  - Anthropogenic increase: **15%**
  - Average atmospheric residence time: **140-190 years**
GeoSigns

Glaciers
(disappearing; water and electricity for humans)

Sea Level
(>100 million people live within 3’ mean sea level)
(1” sea level $\rightarrow$ 8’ beach loss)

Permafrost
(melting and causing subsidence; drunken forests)

Rate of Change

Hottest Years on Record
1. 1998
2. 2002
3. 2003
4. 2001
5. 1997

Albedo Feedback
(poles changing more rapidly [7-9 F]; 1 F globally)

North Atlantic Thermohaline Circulation
(transfers heat around planet, keeps Europe warm)
Global Warming

[CO2] higher than in past 420,000 years

20th Century hottest in last 10

Temperature has increased 0.5 C since 1950

Since 1861, 9 of the 10 warmest years occurred since 1990

EcoSigns

Adelie Penguins, Polar Bears
(ice shelves for nesting and foraging on krill)
(thinner bears b/c feeding season shortened)

Timing of Migration, Reproduction (incl. TSD)

Shifting Ranges
(sky islands, invasives, decoupled food webs)

Anthropogenic Barriers
(restrict movements)

Coral Bleaching
(1998, 16% corals killed or bleached)
**Report: Warming dooms Great Barrier Reef’s coral**

SYDNEY — Australia’s Great Barrier Reef will lose most of its coral cover by 2050 and, at worst, the world’s largest coral system could collapse by 2100 because of global warming, a study released on Saturday said.

The study by Queensland University’s Centre for Marine Studies, commissioned by the Worldwide Fund for Nature, said the destruction of coral on the Great Barrier Reef is inevitable due to global warming.

Under the worst-case scenario, coral populations will collapse by 2050 and the resuscitation of coral reefs will be highly unlikely over the following 300,000 years, said the report titled “Implications of Climate Change for Australia’s Great Barrier Reef.”

The Great Barrier Reef is the world’s largest living reef formation, stretching 1,000 miles north to south along Australia’s northeast coast.

“Only if global average temperature change is kept to below 2 degrees Celsius can the reef have any chance of recovering from the predicted damage,” the report said.

Coral has a narrow comfort zone and is highly stressed by a temperature rise of less than 1 degree Celsius.

Water temperature increases of less than 1 degree coincided with the world’s worst recorded coral bleaching episode in 1998. With bleaching, the warmer water forces out the algae that give coral its color and, if all are lost, the coral dies and the reef will crumble.

In 1998, 90 percent of the world’s coral died, with 30 percent of the 850-kilometer (five-degrees Celsius) destroyed.

Scientists project water temperatures to rise this century by 1 and 6 degrees Celsius.

The Australian report said that by 2050 the Great Barrier Reef would annually experience stress levels higher than those of 1998 and by 2099, stress levels globally for coral would be several times higher than 1998.

“Coral reefs will decrease in less than 3 percent of most reefs (in the Great Barrier Reef) by the middle of the century and, even the most threatened ecosystems,” said the report.

Reef will not disappear but they will be devoid of coral and dominated by other less appealing species, such as seagrass.

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**TimeSigns**

Stalagmites, Coral Rings  
(evidence of cave flooding; annual variability)

Tree Rings  
(sophisticated recorders of environmental fluctuations)

Ice Cores  
(data going back >100,000 years)  
(ice cores as conservation tools?)

Sediment Cores  
(mud, pollen)

Pack Rat Middens  
(hoarders, urinaters, climate fluctuation)
“Some of the ice we have here is already gone from the mountains.”

Carbon Dioxide at Mauna Loa, Hawaii

http://www gsfc.nasa.gov/gsfc/service/gallery/fact_sheets/earthsci/green.htm

atmospheric CO₂ up 25% since 1800
GLOBAL SURFACE AIR TEMPERATURE

Temperature anomaly, °F

Year
1860 1880 1900 1920 1940 1960 1980 2000

Annual mean
5-year mean

Source: NASA/GISS

Why Does the Arctic Warm Faster than Lower Latitudes?

1. As snow and ice melt, darker land and ocean surfaces absorb more solar energy.
2. More of the extra trapped energy goes directly into warming rather than into evaporation.
3. The atmosphere layer that lies far away is still to warm the surface in summer, shallows in the Arctic.
4. As snow and ice melt, solar heat absorbed by the ocean in summer is more easily transferred to the atmosphere in winter.
5. Alterations in atmospheric and oceanic circulation can increase melting.
What happens to the solar radiation that reaches the earth?

-1 billionth solar output

-visible and ultraviolet (UV)

-greenhouse gases (water vapor, CO₂, methane, nitrous oxide, ozone)

-autotrophs/primary productivity
Greenhouse Effect
- earth’s surface absorbs or reflects
- reflected either into space or absorbed by gases
- greenhouse gases heat up and emit infrared radiation

![Greenhouse Effect Diagram](image)

*Figure 2-12: The greenhouse effect. Without the atmospheric warming provided by this natural effect, the earth would be a cold and mostly lifeless planet. According to the widely accepted greenhouse theory, when concentrations of greenhouse gases in the atmosphere rise, the average temperature of the troposphere also rises. (Modified by permission from photo by Beck, Biology: Concepts and Principles. 4th ed. Pacific Grove, Calif.: Brooks/Cole, 2000)*

Ice caps
- Glaciers
- Migrations
- Floods
- Droughts

*(rate of change)*

<table>
<thead>
<tr>
<th>Agriculture</th>
<th>Water Resources</th>
<th>Forests</th>
<th>Sea Level and Coastal Areas</th>
<th>Biodiversity</th>
<th>Weather Extremes</th>
<th>Human Population</th>
<th>Human Health</th>
</tr>
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<tbody>
<tr>
<td>- Shifts in food-growing areas&lt;br&gt;- Changes in crop yields&lt;br&gt;- Increased irrigation demands&lt;br&gt;- Increased pests, crop diseases, and weeds in warmer areas</td>
<td>- Changes in water supply&lt;br&gt;- Decreased water quality&lt;br&gt;- Increased drought&lt;br&gt;- Increased flooding</td>
<td>- Changes in forest composition and locations&lt;br&gt;- Disappearance of some forests&lt;br&gt;- Increased fires from drying&lt;br&gt;- Loss of wildlife habitat and species</td>
<td>- Rising sea levels&lt;br&gt;- Flooding of low-lying islands and coastal cities&lt;br&gt;- Flooding of coastal estuaries, wetlands, and coral reefs&lt;br&gt;- Beach erosion&lt;br&gt;- Disruption of coastal fisheries&lt;br&gt;- Contamination of coastal aquifers with saltwater</td>
<td>- Extinction of some plant and animal species&lt;br&gt;- Loss of habitats&lt;br&gt;- Disruption of aquatic life</td>
<td>- Prolonged heat waves and droughts&lt;br&gt;- Increased flooding from more frequent, intense, and heavy rainfall in some areas</td>
<td>- Increased deaths&lt;br&gt;- More environmental refugees&lt;br&gt;- Increased migration</td>
<td>- Increased deaths from heat and disease&lt;br&gt;- Depletion of food and water supplies&lt;br&gt;- Spread of vector-borne diseases to temperate zones&lt;br&gt;- Increased respiratory, digestive, and pollen allergies&lt;br&gt;- Increased water pollution from coastal flooding</td>
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*Figure 11-14: Some possible effects of a warmer atmosphere. Most of these effects could be harmful or beneficial depending on where we live. Current models of the earth’s climate cannot make reliable predictions about where such effects might take place and how long they might last.*

*Miller, 2003*
Walther et al. 2002
Ecological Responses to Recent Climate Change

Spatial Heterogeneity

Phenology
- timing
- frost-free days
- variability

Range Shifts
1. temperature
2. precipitation
- latitude and altitude

Beech Tree Range
- poles will heat up relatively faster

For each 1 degree C change:
- climate belts will shift toward the poles by 100-150 km
**Walther et al. 2002**

**Ecological Responses to Recent Climate Change**

**Community Changes**
- Plant structure
- Animal community
- Bleaching
- Antarctic

**Ecosystem Changes**
- Recruitment
- Trophic interactions

**Synergistic Effects**
(cod, coral)
Hayhoe et al. 2004
Emissions and climate change in California

- Two models
  sensitive (PCM), less sensitive (HadCM3)

- Two CO₂ values
  550ppm, 970ppm

Dismissed by one expert as “another piece of climate alarmism”
(NYTimes 17 Aug 2004)
Hayhoe et al. 2004
Emissions and climate change in California

1. Temperature (increase 1.5 – 9.0 C)
2. Precipitation (mostly decrease)
3. Heat Index (Hot in L.A. = more deaths)
4. Snowpack, Runoff, Water Reserves (trade-off)
5. Agriculture (wine grapes, milk)