Ecosystems

29 January 2007
8th class meeting

Plate Tectonics →
Land Ethic →
Ecosystem Services

29 Jan READINGS:
Costanza et al. 1997, Leopold excerpt
Sky Islands, El Nino (on website)
Wednesday 31 Jan:
EO Wilson book chapter

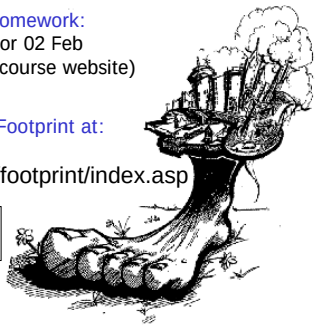
Lab 31 Jan/ 02 Feb:
Ecological Footprint (link and instructions on website)
Lab 07/09 Feb:
Meet in lab, then outside
See assignment on webpage

Environmental Biology (ECOL 206)
University of Arizona, spring 2007

Kevin Bonine, Ph.D.
Anna Tyler, Graduate TA

http://eebweb.arizona.edu/courses/Ecol206/206_Page2007.html

Ecological Footprint Homework:
for Lab 31 Jan or 02 Feb
(Links on your course website)



1. Calculate your Ecological Footprint at:

http://www.earthday.net/footprint/index.asp

Bring the calculated numbers (in hectares & acres) to lab.

(and bring your calculator to lab too!)

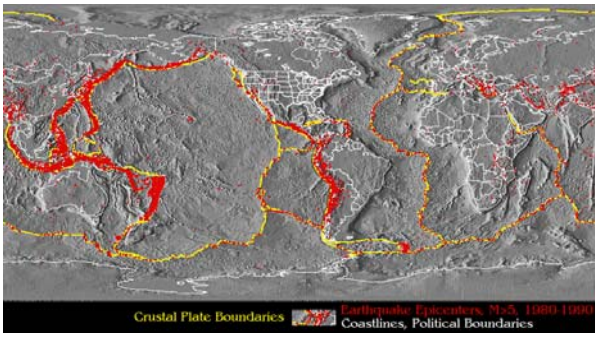
2. Calculate your Ecological Footprint a second time, but pretend you live in a different country (be creative about choosing your other country)

Upcoming Events of Interest

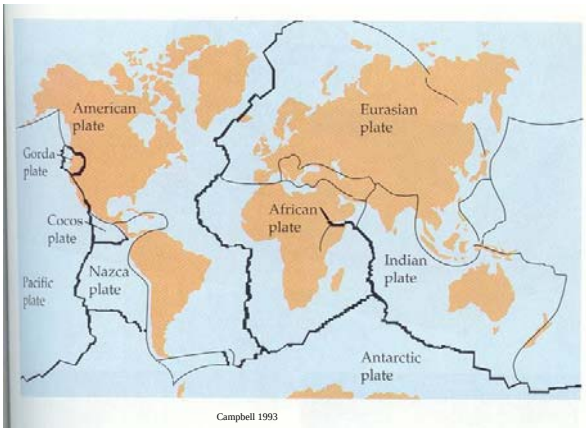
EEB Seminar: "Microbial enzymes and communities under environmental change: Implications for ecosystem processes"
Steven Allison, UC Irvine
Monday, January 29, 4:00 pm
Biosciences West 301

Free Screening of "An Inconvenient Truth" with a Panel Discussion by UA Climate Scientists (ISPE)
Wednesday, January 31, noon
Gallagher Theater, Student Union
Not eligible for Current Events assignment!

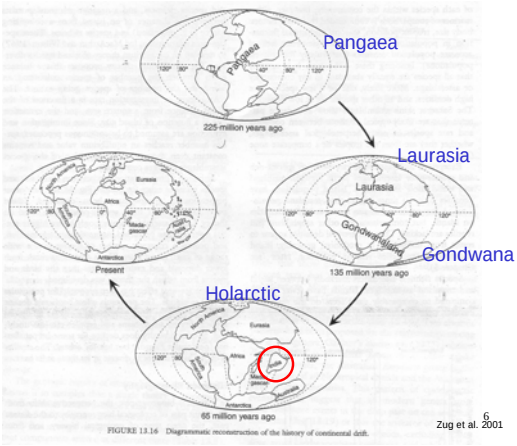
Plate Tectonics



Fat on Chicken Broth?



Campbell 1993



Zug et al. 2001

Alfred Wegener,
winter 1912-1913

Crustal Plates moving
1-12 cm / year

1929 - Holmes, Magma Convection

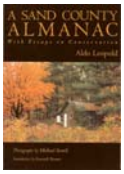
1960s - Harry Hess (1962) and R.Deitz (1961)

Theory of Plate Tectonics

"Scientists still do not appear to understand sufficiently that all earth sciences must contribute evidence toward unveiling the state of our planet in earlier times, and that the truth of the matter can only be reached by combing all this evidence. . . It is only by combing the information furnished by all the earth sciences that we can hope to determine 'truth' here, that is to say, to find the picture that sets out all the known facts in the best arrangement and that therefore has the highest degree of probability. Further, we have to be prepared always for the possibility that each new discovery, no matter what science furnishes it, may modify the conclusions we draw."

Alfred Wegener. *The Origins of Continents and Oceans* (4th edition)

1887 - 1948



http://www.aldoleopold.org/Biography/Biography.htm
Aldo Leopold Foundation

Leopold

Thinking like a mountain
" a mountain lives in mortal fear of its deer"

The planet will survive, will we?

Aldo Leopold Land Ethic

- land ethic enlarges the community
  to include biota

- processes
- evolutionary/ecological biology

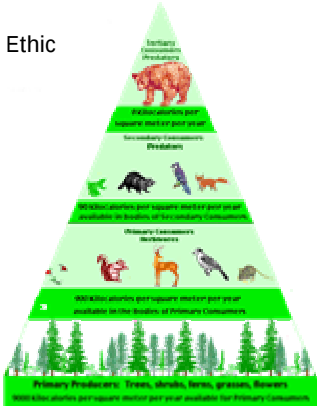
- scale of perturbation (temporal, spatial)

"a thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise"

Aldo Leopold

Aldo Leopold Land Ethic

- land pyramid



"Whether you will or not

You are a King, Tristram, for you are one

Of the time tested few that leave the world,

When they are gone, not the same place it was.

Mark what you leave."

As quoted in Leopold, 1949
p. 261 (The Land Ethic)

Costanza et al. 1997

The value of the world's ecosystem services and natural capital

Robert Costanza*†, Ralph d'Arge‡, Rudolf de Groot§, Stephen Farber‖, Monica Grasso†, Bruce Hannon¶, Karin Limburg#, Shahid Naeem, Robert V. O'Neill††, Jose Paruelo‡‡, Robert G. Raskin§§, Paul Sutton‖‖ & Marjan van den Belt¶¶**

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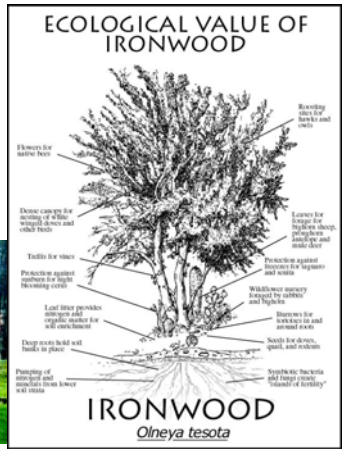
‡ *Economics Department (emeritus), University of Wyoming, Laramie, Wyoming 82070, USA*
§ *Center for Environment and Climate Studies, Wageningen Agricultural University, PO Box 9101, 6700 HB Wageningen, The Netherlands*
‖ *Graduate School of Public and International Affairs, University of Pittsburgh, Pittsburgh, Pennsylvania 15260, USA*
¶ *Geography Department and NCSA, University of Illinois, Urbana, Illinois 61801, USA*
# *Institute of Ecosystem Studies, Millbrook, New York, USA*
** *Department of Ecology, Evolution and Behavior, University of Minnesota, St Paul, Minnesota 55108, USA*
†† *Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA*
‡‡ *Department of Ecology, Faculty of Agronomy, University of Buenos Aires, Av. San Martin 4453, 1417 Buenos Aires, Argentina*
§§ *Jet Propulsion Laboratory, Pasadena, California 91109, USA*
‖‖ *National Center for Geographic Information and Analysis, Department of Geography, University of California at Santa Barbara, Santa Barbara, California 93106, USA*
¶¶ *Ecological Economics Research and Applications Inc., PO Box 1589, Solomons, Maryland 20688, USA*

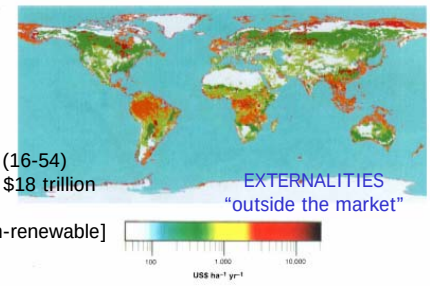
The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$16–54 trillion ($10^{12}$) per year, with an average of US$33 trillion per year. Because of the nature of the uncertainties, this must be considered a minimum estimate. Global gross national product total is around US$18 trillion per year.

Lesser long-nosed bat (*Leptonycteris curasoae*) pollinating saguaro flower (*Carnegia gigantea*)



Costanza et al. 1997

Figure 2 Global map of the value of ecosystem services. See Supplementary Information and Table 2 for details.



$33 trillion/yr (16-54)
Global GNP = $18 trillion

EXTERNALITIES
"outside the market"

[excluded non-renewable]

Gas regulation $1.3 trillion
Disturbance reg. $1.8 trillion
Waste treatment $2.3 trillion
Nutrient cycling $17 trillion

Marine Services $20.9 trillion
(coastal $10.6 trillion)
Forests $4.7 trillion
Wetlands $4.9 trillion

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Costanza et al. 1997
Table 1

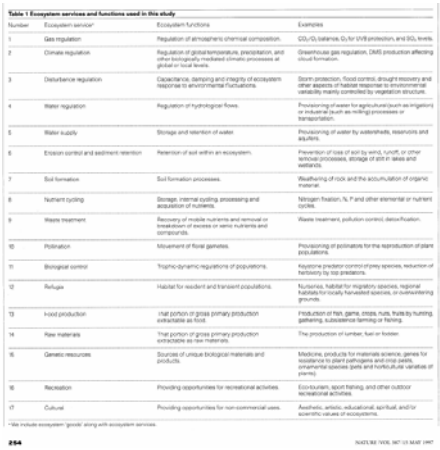

Table 1 Ecosystem services and functions used in this study

Number	Ecosystem service*	Ecosystem functions	Examples
1	Gas regulation	Regulation of atmospheric chemical composition.	CO_2/O_2 balance, O_3 for UVB protection, and SO_x levels.
2	Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local levels.	Greenhouse gas regulation, DMS production affecting cloud formation.
3	Disturbance regulation	Capacitance, damping and integrity of ecosystem response to environmental fluctuations.	Storm protection, flood control, drought recovery and other aspects of habitat response to environmental variability mainly controlled by vegetation structure.
4	Water regulation	Regulation of hydrological flows.	Provisioning of water for agriculture (such as irrigation) or industrial (such as milling) processes or transportation.
5	Water supply	Storage and retention of water.	Provisioning of water by watersheds, reservoirs and aquifers.
6	Erosion control and sediment retention	Retention of soil within an ecosystem.	Prevention of loss of soil by wind, runoff, or other removal processes, storage of silt in lakes and wetlands.
7	Soil formation	Soil formation processes.	Weathering of rock and the accumulation of organic material.
8	Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients.	Nitrogen fixation, N, P and other elemental or nutrient cycles.
9	Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds.	Waste treatment, pollution control, detoxification.
10	Pollination	Movement of floral gametes.	Provisioning of pollinators for the reproduction of plant populations.
11	Biological control	Trophic-dynamic regulations of populations.	Keystone predator control of prey species, reduction of herbivory by top predators.
12	Refugia	Habitat for resident and transient populations.	Nurseries, habitat for migratory species, regional habitats for locally harvested species, or overwintering grounds.
13	Food production	That portion of gross primary production extractable as food.	Production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming or fishing.
14	Raw materials	That portion of gross primary production extractable as raw materials.	The production of lumber, fuel or fodder.
15	Genetic resources	Sources of unique biological materials and products.	Medicine, products for materials science, genes for resistance to plant pathogens and crop pests, ornamental species (pets and horticultural varieties of plants).
16	Recreation	Providing opportunities for recreational activities.	Eco-tourism, sport fishing, and other outdoor recreational activities.
17	Cultural	Providing opportunities for non-commercial uses.	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems.

* We include ecosystem 'goods' along with ecosystem services.

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Costanza et al. 1997 Table 2

Ecosystem Services…

Table 2.1 Ecosystem Services and Functions

Ecosystem service*	Examples
Gas regulation	Carbon dioxide/oxygen balance, ozone for protection against ultraviolet light
Climate regulation	Greenhouse gas regulation, dimethyl sulphide production affecting cloud formation
Disturbance regulation	Storm protection, flood control, drought recovery, and other aspects controlled by vegetation structure
Water regulation	Provisioning of water for agricultural (such as irrigation) or industrial (such as milling) processes or transportation
Water supply	Provisioning of water by watersheds, reservoirs, and aquifers
Erosion control and sediment retention	Prevention of loss of soil by wind, runoff, or other removal processes; storage of silt in lakes and wetlands
Soil formation	Weathering of rock and the accumulation of organic material
Nutrient cycling	Nitrogen fixation, nitrogen, phosphorus, and other elemental or nutrient cycles
Waste treatment	Waste treatment, pollution control, detoxification
Pollination	Provisioning of pollinators for the reproduction of plant populations
Biological control	Keystone predator control of prey species; reduction of herbivory by top predators
Refugia	Nurseries, habitat for migratory species, regional habitats for locally harvested species, or overwintering grounds
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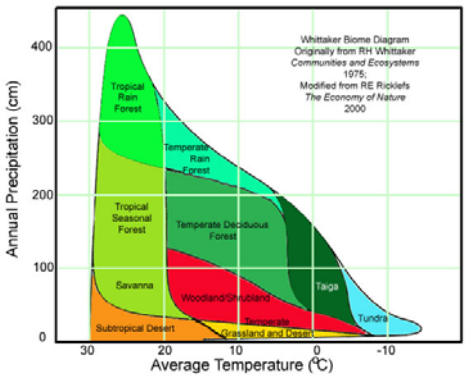
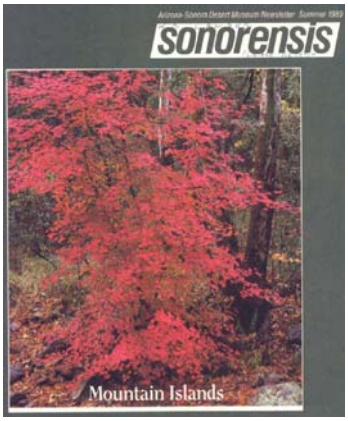
Recreation	Ecotourism, sport fishing, and other outdoor recreational activities
Cultural	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems

*Ecosystem "goods" included in ecosystem services.
Source: Adapted with permission from Robert Costanza et al., "The value of the world's ecosystem services and natural capital," Nature, May 1997.

Brennan and Withgott 2005

"To my mind these live oak-dotted hills fat with side oats grama, these pine-clad mesas spangled with flowers, these lazy trout streams burbling along under great sycamores and cottonwoods, come near to being the cream of creation."
-So wrote Aldo Leopold in 1937.





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Rocky Mountains
Sierra Madres

http://www.skyislandalliance.org/index.htm

Basin and Range

Biomes

Sky "Islands", within Desert or Grassland "Seas"

1000 feet elevation →
3 F drop in temperature →
300 miles toward Canada

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http://www.twp.org/cms/page1111.cfm

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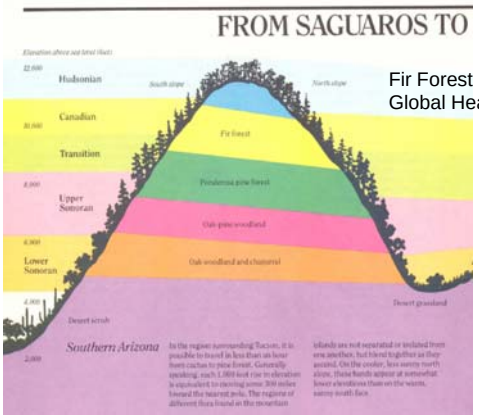

Fir Forest in age of Global Heating?

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Thick-billed parrots in Arizona?

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