Course goals

1) Have you develop a firm understanding of the **concepts and mechanisms of ecosystem ecology**;
2) **Have you enhance your understanding** of how human society is altering ecosystems, some of the problems that entails, and some of the solutions that might be possible.

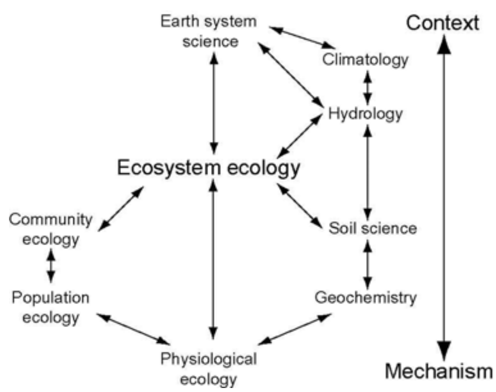
3) **Developing skills in critical thinking** by discussing the scientific literature;

4) **Improve your writing skills**;

5) **Introduce you to the primary literature** and some of the current "hot topics" being studied and debated in the field;

I. What is ecosystem ecology?

Definition: studies of <u>interactions</u> among <u>organisms</u> and their <u>physical environment</u> as an <u>integrated system</u>.

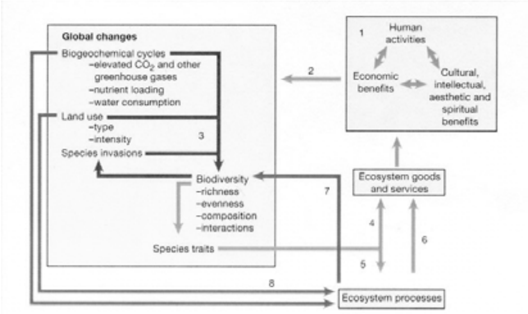


II. Why should we care about ecosystem ecology?

1. Ecosystem ecology provides a mechanistic basis for understanding the Earth System.

2. Ecosystems provide goods and services to humanity.

Ecosystem goods and services



Chapin et al. 2000

Ecosystem goods and services

Goods	Services
- Food	- Soil fertility
- Fuel	- Climate regulation
- Fiber	- Pollination, pest control
- Medicines	- Recreation
- Etc.	- Etc.

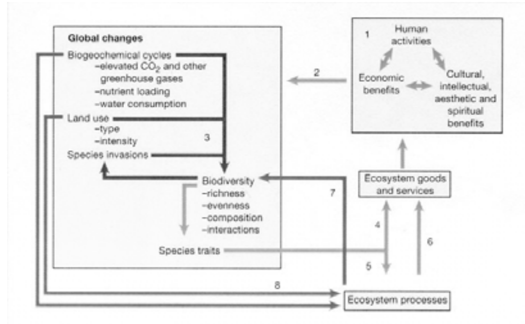
Why should we care about ecosystem ecology?

1. Ecosystem ecology provides a mechanistic basis for understanding the Earth System.

2. Ecosystems provide goods and services to humanity.

3. Humans are changing ecosystems world-wide.

Anthropogenic Global Changes



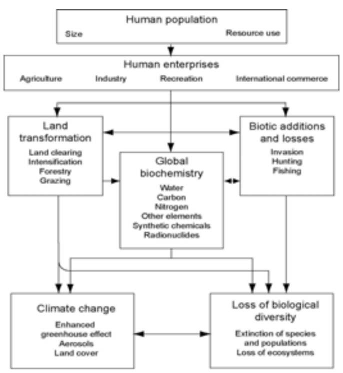
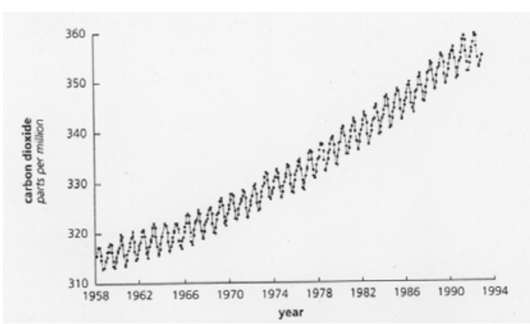


Fig. 1.5

Global changes

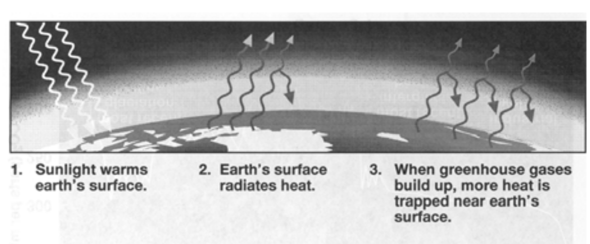
- Atmospheric Composition
  - direct effects
  - climatic change
- Nutrient cycles
- Species invasions
- Land use change
  - type
  - intensity
- Loss of biodiversity

Rising atmospheric CO_2



Schlesinger 1997

Enhanced Greenhouse Effect



Starr and Taggart 1997

Global changes

Atmospheric Composition
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Nutrient cycles

Species invasions

Land use change
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Loss of biodiversity

Land Use Change

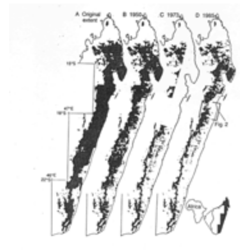
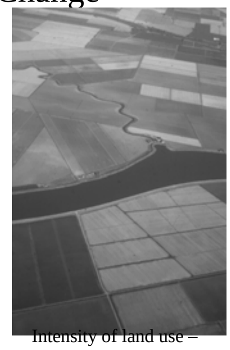


Figure 1b. Aerial photography showing rainforest distribution in eastern Madagascar over 35 years. Map A represents the supposed rainforest coverage before human colonization. Extensive cloud cover disrupted mapping of the northeastern region in 1973 (modified from Green and Sussman, 1990).

Land Cover Change in Madagascar



Intensity of land use – Sacramento Valley, CA

Global changes

Atmospheric Composition
- direct effects
- climatic change

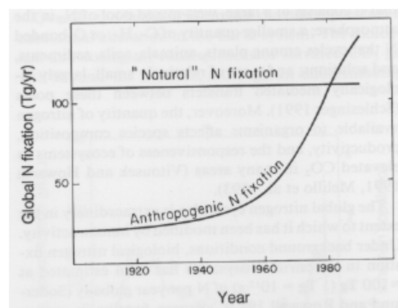
Nutrient cycles

Species invasions

Land use change
- type
- intensity

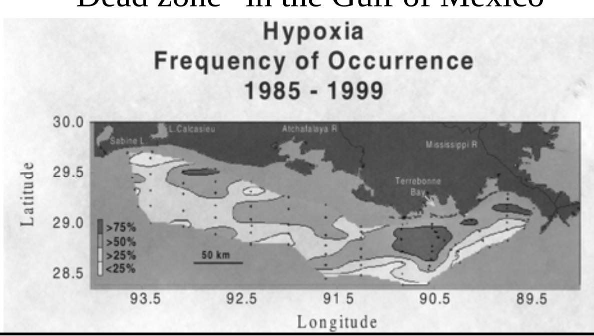
Loss of biodiversity

Global Nitrogen-fixation



Vitousek 1994

Eutrophication of aquatic ecosystems – "Dead zone" in the Gulf of Mexico



Global changes

Atmospheric Composition
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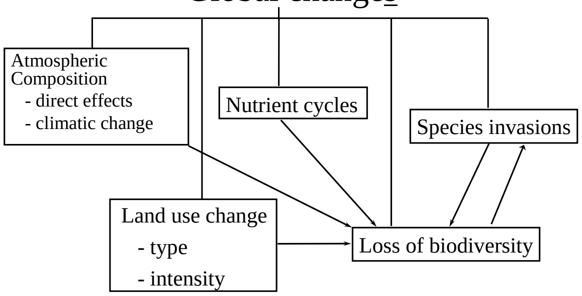
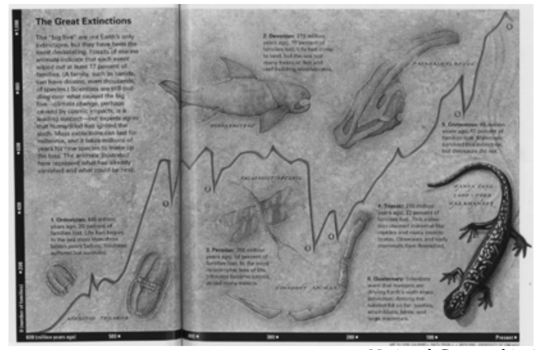
Global changes

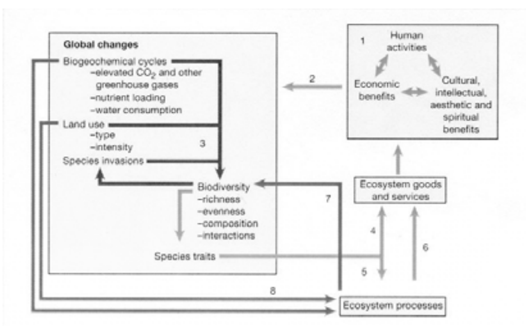


The "Sixth Extinction"?



National Geographic 1999

Sustainability?



III. What is an ecosystem?

bounded <u>ecological system</u> consisting of all the <u>organisms</u> in an area and the <u>physical environment</u> with which they interact

- **Biotic and abiotic processes**
- **Pools and fluxes**

Ecosystem components

Autotrophs – photosynthetic, chemosynthetic

Heterotrophs – herbivores, predators, decomposers

Abiotic – soil minerals
- water
- atmosphere

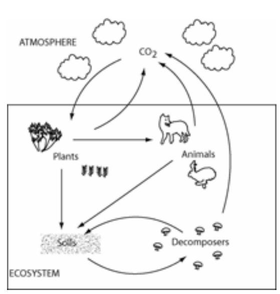
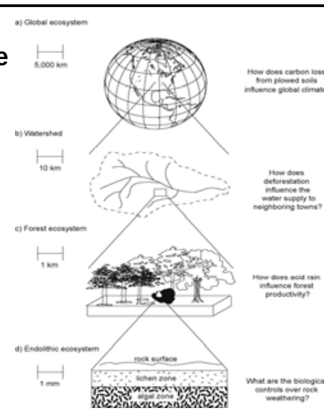


Fig. 1.1 - Spatial scale



Temporal scales

For example, photosynthesis:
- Instantaneous
- Daily
- Seasonal
- Yearly
- Successional
- Species migrations
- Evolutionary history
- Geological history

IV. Controls on Ecosystem Processes

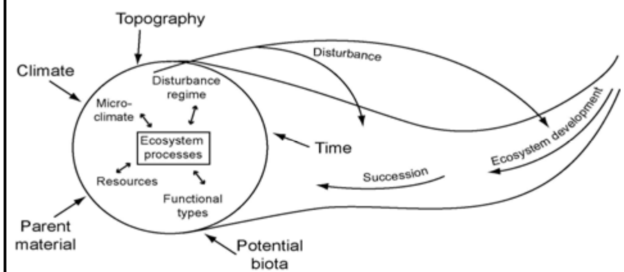
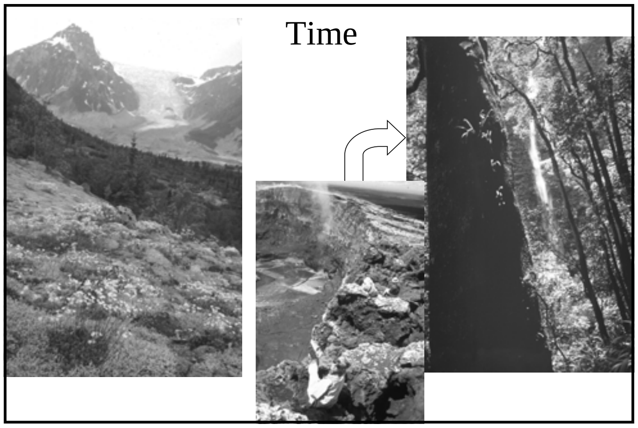
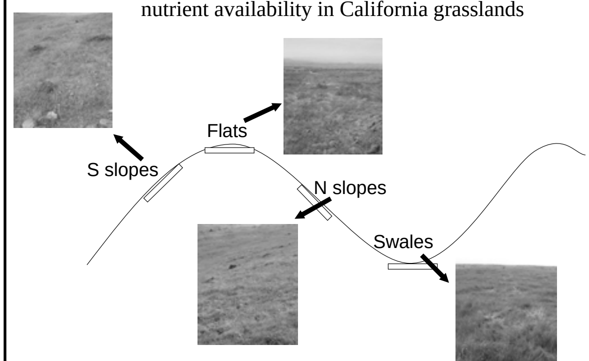


Fig. 1.3 – Controls on processes
A. State factors
B. Interactive controls

Time

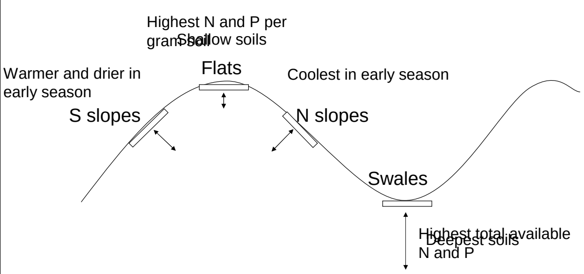


Topographic differences in plant production and nutrient availability in California grasslands



Taken on the same date

Correlated changes in environment drive ecosystem differences across topographic gradients.



Hawai’i as a model ecosystem: Non-correlated gradients help understand effects of different state factors

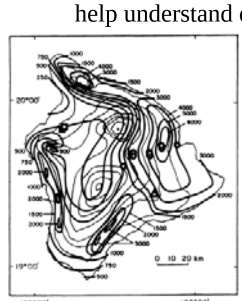


FIG. 1. Locations of the study sites on the Island of Hawai'i. The fine lines are elevational contours (500 m intervals), and the coarse lines are mean annual precipitation (in millimetres, redrawn from Giambelluca et al. 1986). The circles represent sites on the wet east flank of Mauna Loa, the squares sites on the dry northwest flank, and the triangle the Kilauea rainforest site.

TABLE 1. Characteristics of the sites on the Mauna Loa environmental matrix, and of the Kilauea rainforest site where litter from all of the sites was decomposed.*

Area	Elevation (m)	Flow age (yr)	Mean annual temperature (°C)	Mean annual precipitation (mm/yr)	AET (mm/yr)
East flank, Mauna Loa	70	109	24	3800	1640
	760	135	20	6000	1400
	1220	135	17	4200	1270
	1720	135	14	2500	1180
	760	≈3400	20	6000	1400
	1220	≈3400	17	4200	1270
	1720	≈3400	14	2500	1180
	2410	>3400	10	1200	930
Northwest flank, Mauna Loa	700	131	20	500	500
	700	≈2800	20	500	500
Kilauea Volcano	1160	>200	17	2400	1280

* Lava flow ages (as of 1990) are from Lockwood et al. (1988 and *personal communication*), mean annual temperatures are calculated from Atlas of Hawaii (1983), mean annual precipitation is interpolated from Giambelluca et al. (1986), and Thornthwaite's calculated actual evapotranspiration (AET) is interpolated from Juvik et al. (1978).

Vitousek et al. 1994

Reciprocal transplant experiments test effects of site vs. substrate

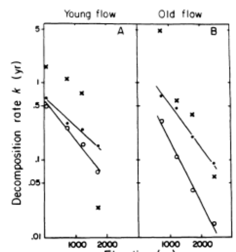


FIG. 5. Decomposition rate constants (log scale) as a function on elevation on lava flows on the wet east flank of Mauna Loa. ●, common *Metrosideros* leaves; ○, wood dowels; ×, cellulose filter paper. (A) Young lava flow. (B) Old lava flow.

TABLE 2. Decomposition rate constants (mean ± SE) for senescent *Metrosideros polymorpha* leaves from the Mauna Loa matrix (based on three replicate strings at each of 5 or 6 times).

Site	Elevation (m)	Decomposition rate, k (yr)* Common leaves in sites	Leaves in common site	Leaves in situ
Young flow, wet side	70	.64 ± .07	.49 ± .04	.62 ± .03
	760	.30 ± .02	.31 ± .01	.30 ± .02
	1220	.25 ± .02	.35 ± .02	.23 ± .12
	1720	.15 ± .01	.24 ± .01	.18 ± .01
Old flow, wet side	760	.68 ± .13	.41 ± .04	.92 ± .20
	1220	.47 ± .05	.42 ± .04	.37 ± .01
	1720	.20 ± .01	.32 ± .04	.12 ± .02
	2410	.09 ± .01	.81 ± .05	.18 ± .02
Young flow, dry side	700	.16 ± .02	.64 ± .05	.18 ± .03
Old flow, dry side	700	.07 ± .01	.93 ± .05	.31 ± .04

* "Common leaves in sites" represents senescent leaves from a single site whose decomposition rates were measured in all of the sites, "Leaves in common site" represents leaves from each of the sites measured in a single site (Kilauea rainforest), and "Leaves in situ" represents leaves measured in their own sites.

Vitousek et al. 1994

C. Feedbacks – negative and positive

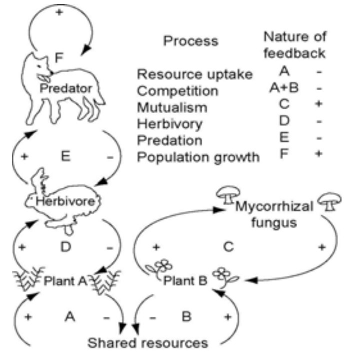


Fig. 1.4