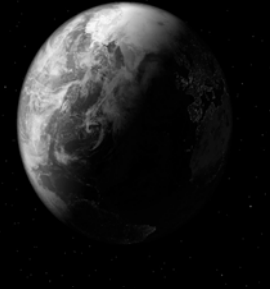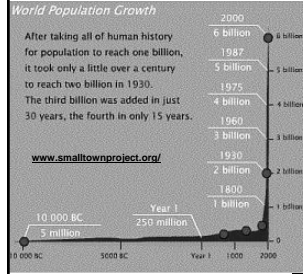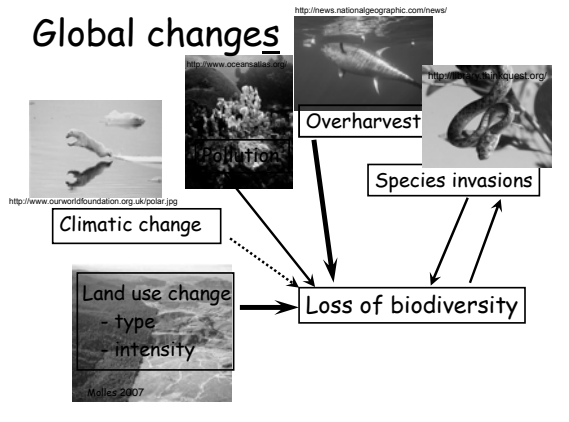## Biodiversity: what it is and why we're losing it

Chap. 23, Chap 16
- Drivers of biodiversity loss
- What is biodiversity?
- How much is there? Measuring diversity
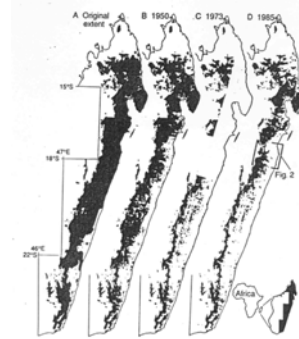- How is it organized? Community structure

This is our world

World Population Growth

After taking all of human history for population to reach one billion, it took only a little over a century to reach two billion in 1930. The third billion was added in just 30 years, the fourth in only 15 years.

www.smalltownproject.org/

Global changes

http://news.nationalgeographic.com/news/
http://www.oceansatlas.org
http://library.thinkquest.org
http://www.ourworldfoundation.org.uk/polar.jpg

Overharvest
Pollution
Species invasions
Climatic change
Land use change
- type
- intensity
Loss of biodiversity

Molles 2007

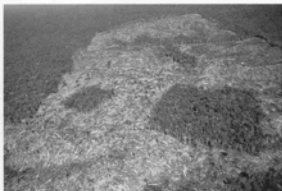## Land use change: Madagascar

Deforestation, there

FIGURE 23.18 Forest fragments left by clear-cutting forest from the surrounding landscape have very different physical environment.
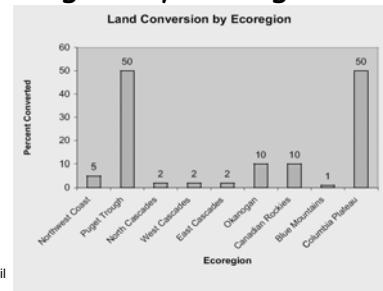
And here…

~50% of ice-free land transformed by humans. Much fragmented.

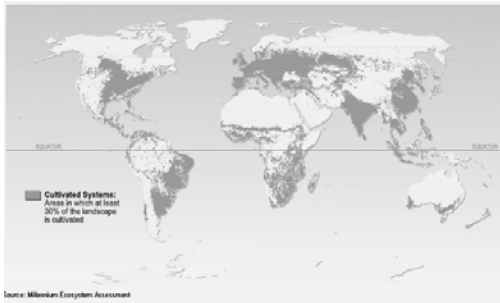FIGURE 23.20 Deforestation in the temperate forests of Washington.

Land conversion in Washington by ecoregion

Land Conversion by Ecoregion

Washington Biodiversity Council 2007

Figure 3.3 Land conversion by ecoregion. See footnote 17.

Areas in cultivation

Cultivated Systems:
Areas in which at least 30% of the landscape is cultivated

Source: Millennium Ecosystem Assessment

Total Plant Production on land

g C*m^{-2}*yr^{-1}

http://www.ntsg.umt.edu/ecosystem_modeling/spatial/pik-npp/

Current extinction rates are 10-100 fold higher than past

Source: Millennium Ecosystem Assessment

The "Sixth Extinction"?

National Geographic 1999
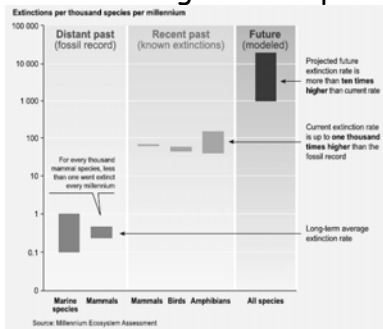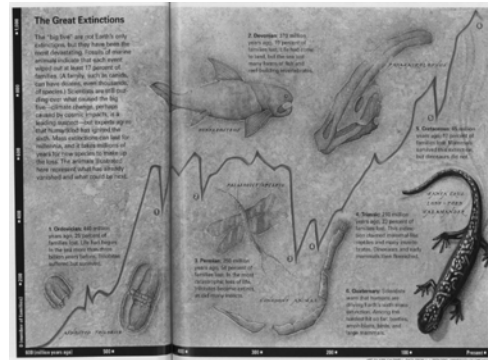
Loss of Biodiversity: Reasons for concern

- Extinctions are irrevocable
- Ethical/moral/religious
- Benefits to humanity
  - Goods: food, fuel, building, medicines, etc.
  - Services:
    - Regulating (climate, disturbance, water)
    - Cultural (Recreation/Education/Aesthetic/Spiritual)

Biodiversity affects human well-being

Global changes

Human activities

Ecosystem services

Biodiversity

Ecosystem processes

Ecosystem Services

MEA 2005

Problems can occur long before species go extinct.

© National Geographic Magazine 2007

Shifts in species can be difficult, expensive, or impossible to reverse.

Reed canary grass, Whatcom County

Buffelgrass invasion – Sonoran desert

(*Pennisetum ciliare*)

http://www.buffelgrass.org/stories.php

http://www.desertmuseum.org/invaders/invaders_buffelgrass.htm

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Invasive species in the U.S.
(a partial list)

PLANTS
Autumn Olive (*Elaeagnus umbellata*)
Beach Vitex (*Vitex rotundifolia*)
Canada Thistle (*Cirsium arvense*)
Chinese Tallow (*Triadica sebifera*)
Cogongrass (*Imperata cylindrica*) (Aug 29, 2008)
Common Teasel (*Dipsacus fullonum*)
Dalmation Toadflax (*Linaria dalmatica*)
Diffuse Knapweed (*Centaurea diffusa*)
Downy Brome (*Bromus tectorum*)
Garlic Mustard (*Alliaria petiolata*)
Giant Hogweed (*Heracleum mantegazzianum*)
Hairy Whitetop (*Lepidium appelianum*)
Houndstongue (*Cynoglossum officinale*)
Japanese Honeysuckle (*Lonicera japonica*)
Japanese Knotweed (*Fallopia japonica*)
Johnsongrass (*Sorghum halepense*)
Kudzu (*Pueraria montana var. lobata*)
Leafy Spurge (*Euphorbia esula*)
Medusahead (*Taeniatherum caput-medusae*)
Mile-A-Minute Weed (*Persicaria perfoliata*)
Multiflora Rose (*Rosa multiflora*)
Musk Thistle (*Carduus nutans*)
Old World Climbing Fern (*Lygodium microphyllum*) (Jan 23, 2008)
Oriental Bittersweet (*Celastrus orbiculatus*) (Dec 29, 2008)
Princess Tree (*Paulownia tomentosa*) (Mar 18, 2009)
Purple Star Thistle (*Centaurea calcitrapa*)
Quackgrass (*Elymus repens*)
Russian Knapweed (*Rhaponticum repens*)
Russian Olive (*Elaeagnus angustifolia*)
Saltcedar (*Tamarix spp.*)
St. Johnswort (*Hypericum perforatum*)
Scotch Broom (*Cytisus scoparius*)
Scotch Thistle (*Onopordum acanthium*)
Spotted Knapweed (*Centaurea stoebe*)
Tree-of-Heaven (*Ailanthus altissima*)
Tropical Soda Apple (*Solanum viarum*)
Whitetop (*Lepidium draba*)
Witchweed (*Striga asiatica*) (Apr 9, 2009)
Yellow Star Thistle (*Centaurea solstitialis*)
Yellow Toadflax (*Linaria vulgaris*)

ANIMALS
Invertebrate Species
Africanized Honeybee (*Apis mellifera scutellata*)
Asian Citrus Psyllid (*Diaphorina citri*) (Nov 11, 2008)
Asian Long-Horned Beetle (*Anoplophora glabripennis*)
Asian Tiger Mosquito (*Aedes albopictus*)
Cactus Moth (*Cactoblastis cactorum*)
Citrus Longhorned Beetle (*Anoplophora chinensis*) (Mar 10, 2009)
Emerald Ash Borer (*Agrilus planipennis*)
European Gypsy Moth (*Lymantria dispar*)
European Spruce Bark Beetle (*Ips typographus*) (Dec 29, 2008)
Formosan Subterranean Termite (*Coptotermes formosanus*)
Giant African Snail (*Achatina fulica*)
Glassy-Winged Sharpshooter (*Homalodisca coagulata*)
Hemlock Woolly Adelgid (*Adelges tsugae*)
Light Brown Apple Moth (*Epiphyas postvittana*) (Aug 19, 2008)
Mediterranean Fruit Fly (*Ceratitis capitata*) (Dec 30, 2008)
Mexican Fruit Fly (*Anastrepha ludens*) (Feb 10, 2008)
Pink Hibiscus Mealybug (*Maconellicoccus hirsutus*)
Red Imported Fire Ant (*Solenopsis invicta*)
Russian Wheat Aphid (*Diuraphis noxia*)
Silverleaf Whitefly (*Bemisia argentifolii*)
Sirex Woodwasp (*Sirex noctilio*) (Aug 14, 2008)
Soybean Cyst Nematode (*Heterodera glycines*) (Dec 3, 2008)
Vertebrate Species
Brown Tree Snake (*Boiga irregularis*)
Cane Toad (*Bufo marinus*)
European Starling (*Sturnus vulgaris*)
Wild Boar (*Sus scrofa*)

http://www.invasivespeciesinfo.gov/unitedstates/wa.shtml
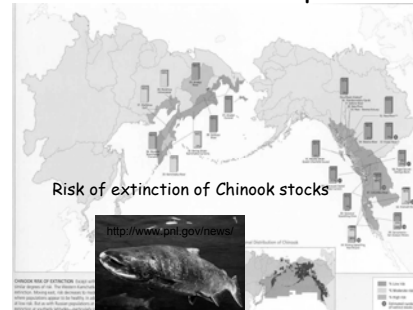

Questions?

2. What is biodiversity?
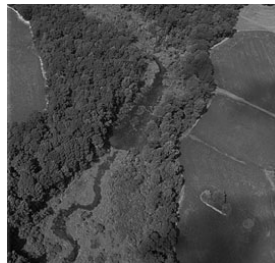
The spectrum of life on earth, in terms of variation in

- genes,
- populations,
- species,
- ecosystems,
- interactions among them.

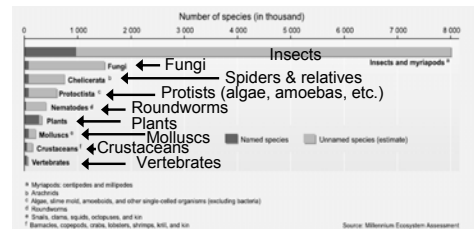## Salmon - Genetic diversity maintains local adaptation

Risk of extinction of Chinook stocks

http://www.pnl.gov/news/

Augerot 2005

Ecosystem type and distribution on the landscape

Wetlands & riparian buffers:
Flood control,
Nutrient filtration

http://extension.umd.edu/environment/index.cfm

---

3. How much is there?
#'s of species for major taxa globally

Fungi
Spiders & relatives
Protists (algae, amoebas, etc.)
Roundworms
Plants
Molluscs
Crustaceans
Vertebrates
Insects

Scales of diversity: Global – total number of species of different taxa in the whole world. About 1.65 million identified. Estimates range up to about 30 million species.

Scales of diversity
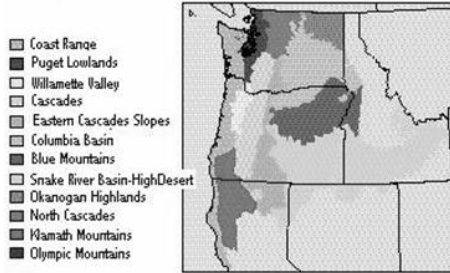
Alpha – number of species in a given plot or area

a d a b
a   b a
    b   b
  c a
     a
a c   b   c
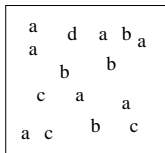
Scales of diversity

Beta – species turnover across an environmental gradient
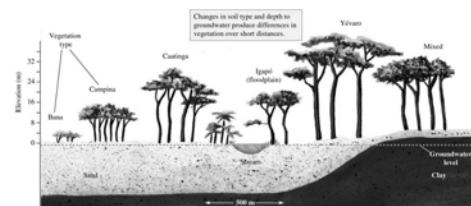
16.14

Scales of diversity

Gamma – regional species richness

Coast Range
Puget Lowlands
Willamette Valley
Cascades
Eastern Cascades Slopes
Columbia Basin
Blue Mountains
Snake River Basin-HighDesert
Okanogan Highlands
North Cascades
Klamath Mountains
Olympic Mountains

Ecoregions of the Pacific Northwest

4. Community structure

Community: Association of interacting species inhabiting some defined area.

Community Structure: Includes attributes such as # of species, relative species abundance, and kinds of species present.

Guild: Group of organisms that all make their living in the same fashion.

Ex.: Seed eating animals in the desert.

Life Form: combination of structure and growth dynamics.

Questions to focus on:

1. How do species richness and species evenness influence community diversity? How are they combined in the Shannon Index of diversity?

2. What does the lognormal abundance distribution tell us about the relative abundances of species in communities? Why is it sometimes difficult to see this pattern in real communities?
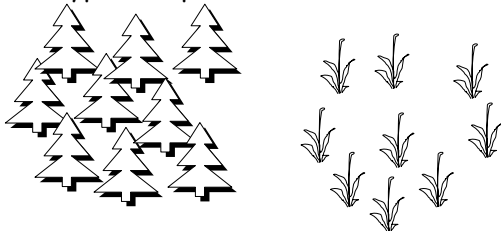
Community structure

Richness – number of species
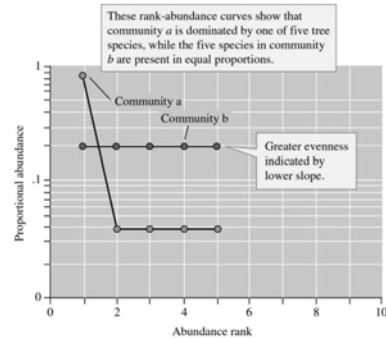
Evenness – relative abundance
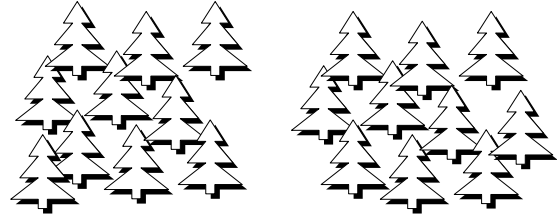
Community structure
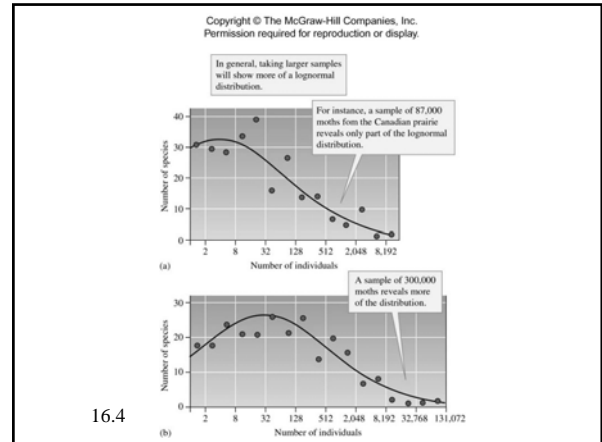
Composition – who are they? which types of species?

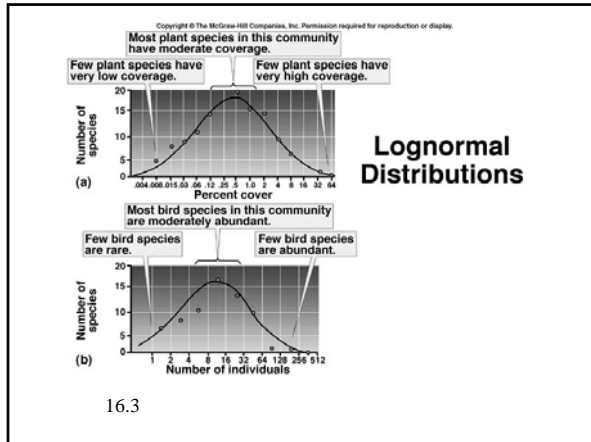## Rank Abundance Curves

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These rank-abundance curves show that community *a* is dominated by one of five tree species, while the five species in community *b* are present in equal proportions.

Community a
Community b

Greater evenness indicated by lower slope.

Proportional abundance

Abundance rank

16.6

Most plant species in this community have moderate coverage.

Few plant species have very low coverage.

Few plant species have very high coverage.

Lognormal Distributions

(a) Number of species — Percent cover

Most bird species in this community are moderately abundant.

Few bird species are rare.

Few bird species are abundant.

(b) Number of species — Number of individuals

16.3

In general, taking larger samples will show more of a lognormal distribution.

For instance, a sample of 87,000 moths fom the Canadian prairie reveals only part of the lognormal distribution.

(a) Number of species — Number of individuals

A sample of 300,000 moths reveals more of the distribution.

(b) Number of species — Number of individuals

16.4

Quantitative Index of Species Diversity

Shannon Wiener Index:

$$H' = -\sum_{i=I}^{s} p_i \log_e p_i$$

H'   = Value of Shannon-Wiener diversity index.

P_i = proportion of the ith species.

$\log_e$ = natural logarithm of p_i.

S   = number of species in the community.

Major Concepts

Human activities are causing dramatic changes in species' abundances and distributions.

These changes can have strong effects on human well-being.

"Biodiversity" refers to the breadth of biological organization from genes to ecosystems.

Most species are moderately abundant; few are very abundant or extremely rare.

A combination of the number of species and their relative abundance defines species diversity.

End