The Biosphere: Anthropogenic Impact

Biosphere: World's Ecosystems

not an object of study?

Ecosystem: Abiotic, Biotic Components

Energy, Nutrient Flux

Ecological Diversity, Genetic Information

The Biosphere: Anthropogenic Impact

Vitousek, PM, HA Mooney, J Lubchenco & JM Melillo. 1997. *Science* 277:494.

Kareiva, P, S Watts, R McDonald & T Boucher. 2007. *Science* 316:1866.

Halpern, BS *et al*. 2008. *Science* 319:948.

The Biosphere: Anthropogenic Impact

Human Activities Shape Landscapes,
Alter Ecosystem Structure and Function

~No Ecosystem Free of Human Influence

Does Not Invalidate Ecological Principles

The Biosphere: Anthropogenic Impact

Same Statistics, Two Perspectives

Human Domination;

Response: Protect/Conserve Nature

Domesticated Nature

Select Certain "Ecosystem" Traits;

Scientifically Monitor Tradeoffs;

Balance Conflicting Objectives

see J. Holdren's presentation

Human Domination of Landscapes, Ecosystems

Human Population Growth, Technology

Irreversible Transformations

"Planetary Stewardship;" (ESA 2011)

Protect Nature by Conserving

Challenge Economic, Sociopolitical Forces

Domesticated Nature

Species: Genetic (Artificial) Selection

Ecosystem: Select Productivity, Economic Convenience, Protection Abiotic/Biotic Loss

Understand the Tradeoffs From (say) Increased Food Production; Ecosystem Version of Quantitative Genetics, Pleiotropy

Land Transformation: Uncontested Levels

50% World's Land Surface Converted to Grazing or Crop Cultivation

~ ½ World's Forests Converted

17% of Land Area Not Human-Transformed

Primary Force Driving *Loss Biodiversity*

Habitat Loss, Fragmentation

Land Transformation

~ 20% Anthropogenic CO_2 Emissions

Runoff Affects Nearby Aquatic Systems, …

Purpose: *Food Production*

- Effective, Contra Malthus Globally
- Spatially Heterogeneous

Human Impact on Land

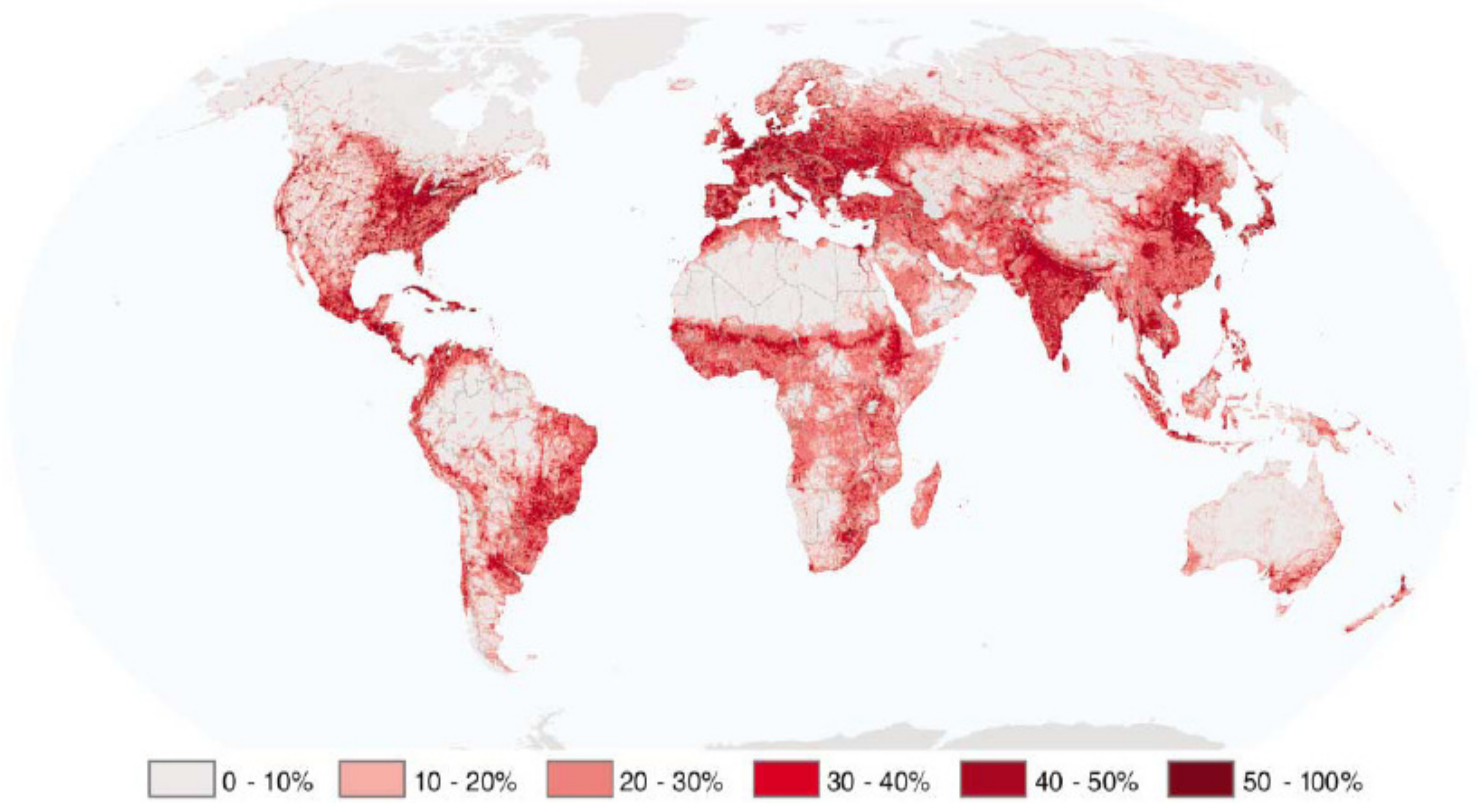


Fig. 1. The human footprint on Earth. Human impact is expressed as the percentage of human influence relative to the maximum influence recorded for each biome. Data include human population density, land transformation (including global landcover, roads, and cities), electrical power infrastructure (NOAA night-lights data), and access (via roads, navigable rivers, and coastline) to the land. Map created from data downloaded at www.ciesin.columbia.edu/wild_areas from the Human Footprint dataset generated by the Center for International Earth Science Information Network (CIESIN) at Columbia University and The Wildlife Conservation Society.

Ocean Transformation

~ 65% Human Population Within
100 km of Coastline

Large Impact, Productive Marine Ecosystems

66% Fisheries Overexploited, or at Equilibrium

Ocean Transformation

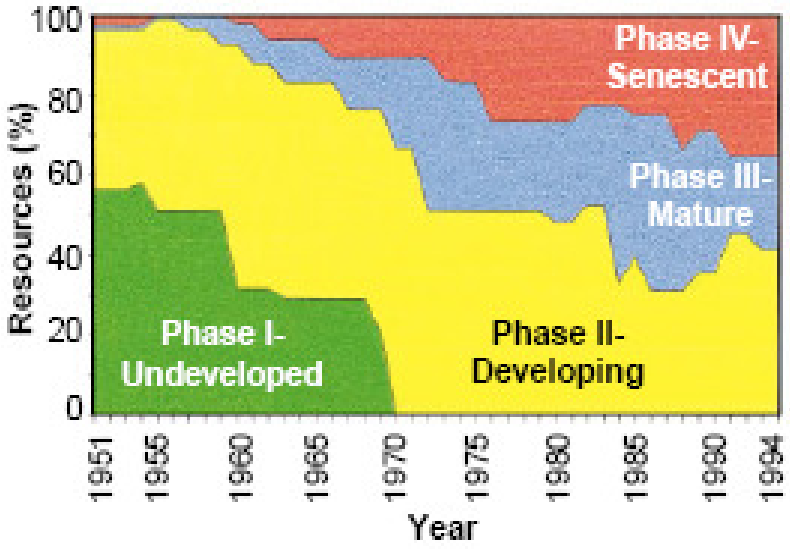
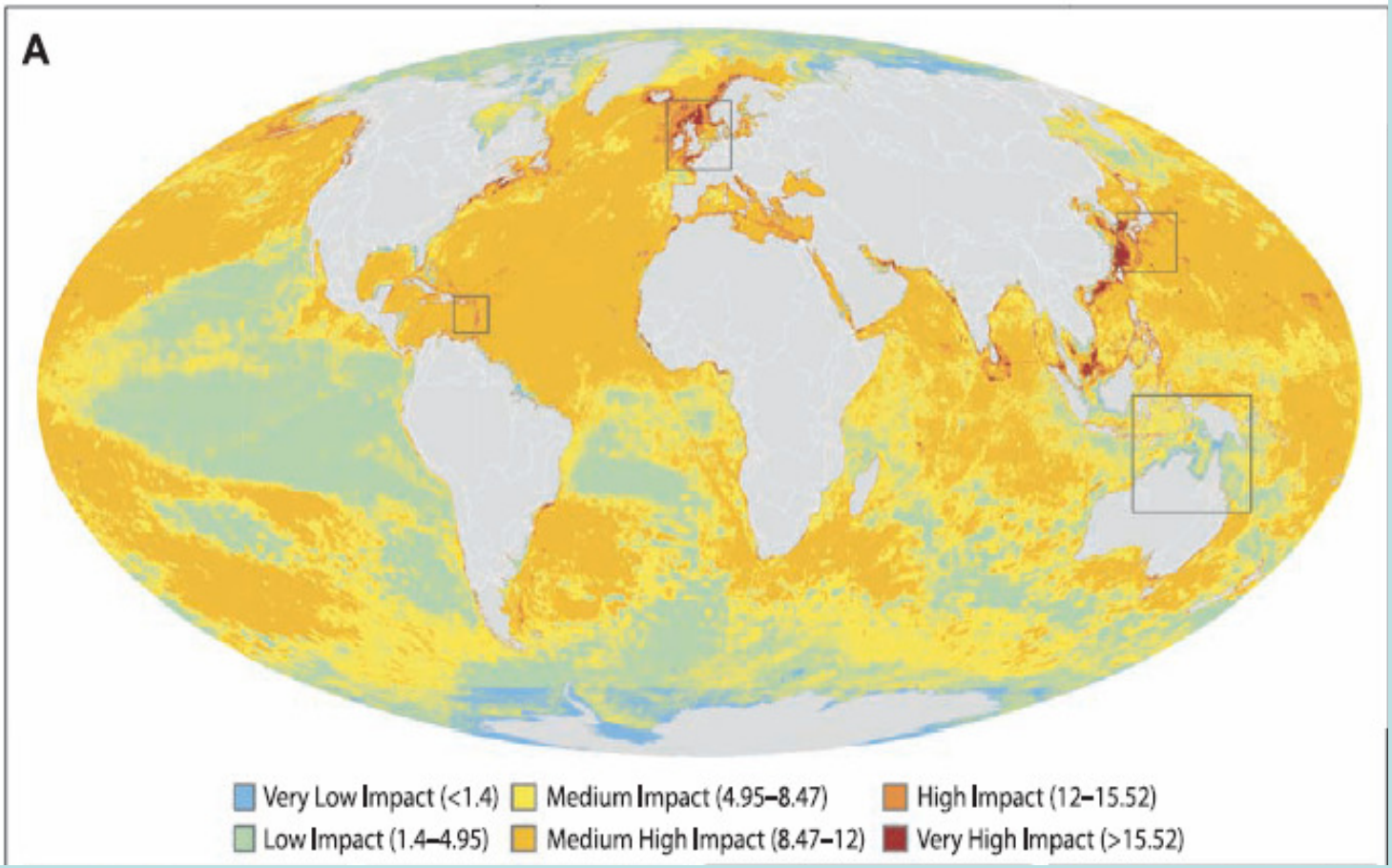


Fig. 3. Percentage of major world marine fish resources in different phases of development, 1951 to 1994 [from (*57*)]. Undeveloped = a low and relatively constant level of catches; developing = rapidly increasing catches; mature = a high and plateauing level of catches; senescent = catches declining from higher levels.

Oceanic Impact

Fig. 1. Global map (**A**) of cumulative human impact across 20 ocean ecosystem types. (Insets) Highly impacted regions in the Eastern Caribbean (**B**), the North Sea (**C**), and the Japanese waters (**D**) and one of the least impacted regions, in northern Australia and the Torres Strait (**E**).



Biotic Changes: Species Loss

Humans Protect Themselves and Livestock

Most Large, Terrestrial Carnivores Extinct

Rate of Species Extinctions: 100 – 1000 Times Background

Humans: 33% Bird Species Extinct Last 2000 yrs

Endangered: 18% Mammal, 11% Bird, 8% Plant Species

Biotic Changes: Genetic Variation Loss

Within Species: Locally Adapted Populations
(*Ecotypes*)

Within Populations: Loss of Genetic Diversity

Artificial Selection for Productivity

Loss of Potentially Useful Genotypes;
Reduced Capacity to Adapt?

Biotic Homogenization: Invasive Exotics

Humans, Purpose/Accident, Mix Plants/Animals
Long Isolated Geographically

Local Diversity: Decline or Increase

Global Diversity: Decline

Cosmopolitan Spp: Larger Range; Rare Spp Gone

Islands: ½ Plant Species Non-indigenous

Biotic Homogenization: Invasive Exotics

San Francisco Bay:

1875: 1 New Species/36 Weeks

1970: 1 New Species/24 Weeks

2000: 1 New Species/12 Weeks

Acceleration of Exotic Invasions

Shaping the Path of Ecosystem Domestication

Objective To Be Advanced: Cost(s)

Greater Food Production:

- Perturbed Nitrogen Cycle, Eutrophication
- Reliance on Monoculture (Not Resilient to Disease)
- Climate Resilient?

Shaping the Path of Ecosystem Domestication

Greater Cattle Production:

- Overgrazing, Excess Antibiotic Support
- Selection for Growth, Reproduction, Milk Production
  - May Invites Pleiotropic Cost

Greater Fisheries Yield:

- Loss of Higher Trophic Level
- Increase in Undesirable Species

Shaping the Path of Ecosystem Domestication

Predator Removal:

Herbivore Overpopulation, Grazing Land Degradation

Enhanced Trade:

Spread of Disease and Invasive, Exotic Species

Addressing Trade-offs

Map Domestication Effects onto Holdren's "3 Pillars"

Economic Conditions: Mean and Distribution
Sociopolitical Conditions: Environmental Justice
Environmental Conditions: Sustainability

Interdependent, Non-trivial; Address at Different Scales

Quantify "Condition:" Multi-attribute;

Then Integrate Three: "Preference Axioms"

Addressing Trade-offs

Integrate Three Pillars:

- Energy Demands
- Human Competition for Water, Land, Food
- Unpredictable (Changing) Climate

Immense Challenges