The Ecological Approach

- Ecosystems consist of interconnected and integrated biotic and abiotic (climate, soil, etc) components
- A human ecologist measures the impact of each component on all other components and the species (human) under consideration
- Interaction between components is often measured in terms of energy flow
Ecosystems as integrated wholes: the Aswan Dam

Goals of the Aswan Dam:

• Increase hydroelectric power for rural electrification and heavy industry
• Provide water for irrigation
• Flood control

• All of these goals were achieved. Unfortunately, there were a number of negative consequences that demonstrate how ecosystem components are interconnected in surprising ways
Egypt and the Aswan
Unanticipated Consequences of the Aswan Dam

- Lack of silt for farmers
- Coastal erosion at the mouth of the Nile
- Reservoir (Lake Nasser) behind dam becomes filled with silt
- Parasitic diseases of bilharzia, trachoma, and malaria increase
- Increase in salinity levels around the mouth of the Nile which lowers sardine catch
High DDT levels accumulated in cockroaches
DDT transferred to cockroach eating lizards at even higher levels
Cats who ate lizards die of DDT poisoning which led to:
  • rat increase which consumed stored rice
  • humans get lice, fleas, and sylvatic plague from rats
Caterpillar population explodes because they are no longer preyed upon by lizards and they eat roof thatch
Energy Flow Trends

1% of sun’s energy that reaches earth is used by plants

Food Pyramid
- Decreases in Biomass
- Numbers
- Energy

Only 10% of energy produced at each level available to the next
Energy Flow Model of an Inuit Ecosystem

Inputs to the System

- Climate
- Sun
- Upwelling

Nutrient Cycling

- Tundra
- Lemming population
- Caribou population

Carnivores

- Fish
- Sea Mammals

INUIT

Aquatic Plants

Upwelling
Inuit Energy Flow Generalizations:

- Inuit are top predators in the system.
- As a consequence, they have a low population density.
- Terrestrial and aquatic resources are two independent sources of food.
- Inuit are immediately limited by availability of fish and game animals.
- Inuit are ultimately limited by productivity of terrestrial and marine plant resources.
Netsilik Territory Relative to Nebraska

Nebraska: 76,000 square miles or 22.3 (US=80) people per square mile
Netsilik: 9,000 square miles at 0.016 people per square mile
San Bushmen of Botswana 0.10 people per square mile
Yanomamö of Venezuela and Brazil about 0.5 people per square mile
Hiwi: A tropical energy flow model

Figure 14-5 The flow of energy through the Venezuelan Hiwi foraging system. Numbers represent kcal/person/day. (Data from A. M. Hurtado and K. R. Hill. 1990. *Journal of Anthropological Research* 46:293–346.)
Seal hunting at a breathing hole
## Technoenvironmental Efficiency in Basic Economic Formations

<table>
<thead>
<tr>
<th>Economic Formation</th>
<th><em>Ea/Ee</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Foragers (!Kung, Kalahari Desert, Botswana, Africa)</td>
<td>9.6</td>
</tr>
<tr>
<td>Dryland horticulturalists (Genieri, Gambia, West Africa)</td>
<td>11.2</td>
</tr>
<tr>
<td>Tropical horticulturalists (Tsembaga, Highland New Guinea)</td>
<td>18.0</td>
</tr>
<tr>
<td>Agriculturalists (irrigated rice Yunnan Province, China)</td>
<td>53.5</td>
</tr>
<tr>
<td>Modern grain cultivation (human labor input only)</td>
<td>6,000.0</td>
</tr>
<tr>
<td>Modern grain cultivation if all caloric inputs (e.g., petrochemicals) are included.</td>
<td>0.125</td>
</tr>
</tbody>
</table>

*Energy acquired divided by energy expended*
Energy Consumption in Various Economic Formations


(In 1,000's of calories per capita)
Lotka-Volterra Model of population growth

\[
d\frac{N}{dt} = rN \left( \frac{K-N}{K} \right)
\]

K, or carrying capacity

Growth slows from environmental resistance or limiting factors

r, or intrinsic rate of growth
Consequences of population growth

- Through time the population meets increasing “environmental resistance” which means that growth slows as resources diminish or other factors (e.g. disease) that reduce growth increase in force.

- Three Malthusian forces that down regulate growth
  - Disease
  - Warfare
  - Starvation

- Malthus argued that the above problems were inevitable because of the “passion between the sexes”
Negative Responses to Limiting Factors and Environmental Resistance

A. Work more  
   B. Lower quality food intake  
   C. Lower quantity food intake

Demographic consequences of above:

• Higher mortality rate  
• Lower fertility rate

Positive Responses to Limiting Factors and Environmental Resistance

A. Move to new environment  
   B. Innovate a more efficient means of energy capture

Demographic consequences of above:

• Lower mortality rate  
• Higher fertility rate
Cultural responses to resource shortages

- **Increasing mortality**
  - infanticide and abortion
  - invalidicide
  - offspring neglect
  - senilicide or gerontocide

- **Decreasing fertility**
  - Post partum sex taboos
  - Abstinence

- **Increasing resources**
  - movement to new areas
  - warfare – taking land possessed by neighbors
  - reliance on secondary food resources
Natural Mechanisms of Population Regulation

**Density Dependent**
- Events that occur as population density increases
  - Starvation and poor nutrition (dietary deficiencies)
  - Disease
  - Starvation amenorrhea (suppression of ovulation because of low caloric intake)

**Density Independent**
- Any catastrophic natural phenomenon that has a negative effect on a population regardless of its density
  - Drought
  - Hurricanes
  - Flooding
  - Volcanic eruptions
The Myth of the Ecologically Noble “Savage”

How can you buy or sell the sky? The land? The idea is strange to us. Every part of this earth is sacred to my people. Every shining pine needle, every sandy shore, every mist in the dark woods, every meadow, every humming insect. All are holy in the memory and experience of my people.

Will you teach your children what we have taught our children? That the earth is our mother? What befalls the earth befalls all the sons of earth. This we know: the earth does not belong to man, man belongs to the earth. All things are connected like the blood that unites us all. Man does not weave the web of life, he is merely a strand in it. Whatever he does to the web, he does to himself.

Attributed to Chief Seattle, the leader of the Duwamish, when the US government offered to buy his land in 1854. In reality, it was written by Ted Perry, a professional screen writer, in 1971 for a television movie.
Key Ecological Concepts

- **Carrying capacity**: mortality and fertility rates balanced
- **Liegib's Law of the Minimum**: organisms adapted to minimum and not mean conditions
- **Sheldon's Law of Tolerance**: organisms are adapted to extremes and not means
- **Niche**: an organism's role (job) in an ecosystem or how it gains its energy
- **Habitat**: the spatial and structural characteristics of an organism’s home
- **Competitive Exclusion**: two organisms cannot occupy the same niche indefinitely
- **Technoenvironmental efficiency**: output:input ratio of energy capture
- **Limiting factor**: requirement that if not gained in sufficient quantity decreases survival or fertility
Two-way energy flow as viewed by Gary Larson
...as viewed by Gary Larson

Energy Flow Model

“I lift, you grab ... was that concept just a little too complex, Carl?”
Caribou: most important terrestrial resource