Module 1.
The State of the World.

Human Population
Earth Capital - Natural Resources
Ecosystem Services - Processes
Redundancy & Biodiversity
Human Activity & Externalities
Biogeochemical Cycles
Society and Fossil Fuels

Solar & Earth Capital
Life-support systems provided by the Sun and Earth
**World Population Growth**

Real and predicted

<table>
<thead>
<tr>
<th>Date</th>
<th>Population (billions)</th>
<th>Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Revolution</td>
<td>7.3</td>
<td>unchecked population growth exhibits exponential properties</td>
</tr>
<tr>
<td>Bubonic Plague</td>
<td></td>
<td>technological innovations lead to unsustainable growth</td>
</tr>
<tr>
<td>Industrial Revolution</td>
<td></td>
<td>what are the limits to growth?</td>
</tr>
</tbody>
</table>

**Ecological Demand**

Consumptive pressures placed on the environment

<table>
<thead>
<tr>
<th>Date</th>
<th>Total ecological demand (1880 = 1)</th>
<th>Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1880</td>
<td>0</td>
<td>increased societal complexity requires increased resource use</td>
</tr>
<tr>
<td>1900</td>
<td>200</td>
<td>technological innovations lead to unsustainable growth</td>
</tr>
<tr>
<td>1920</td>
<td>400</td>
<td>what are the limits to consumption?</td>
</tr>
<tr>
<td>1940</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>800</td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>1200</td>
<td></td>
</tr>
</tbody>
</table>
Rapidly Growing Population Centers
1985 to 1990

Regions with growth rates > 2.5 times the National average

- migration significantly influences population densities
- population change occurs regardless of resource sustainability

Ecological Footprint
How much land area does the Earth need to support you?

Value of Earth’s Ecosystems
Balancing exploitation and longevity

- food
- recreation
- water purification
- pollination
- CO₂ regulation
- temperature modulation

$33$ Trillion

$18$ Trillion

concepts:
- we take for granted environmental services
- “externalities” are not considered in economic decisions
- as economic pressures continue, environmental services are lost

Fate of Resources
The flow Earth Capital through Society
Example: aluminum

source - ore
impacts - pollution

use - packaging

fate - landfill
impacts - pollution

concepts:
- resources cycle through the human environment
- extraction & refining of resources have high environmental impact
- resource use efficiency determines environmental impacts

Biology 105 Module 1
Resource Depletion
Influenced by use (stewardship & planning)

<table>
<thead>
<tr>
<th>Time</th>
<th>Resource extracted or harvested (unit/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>use &amp; discard</td>
</tr>
<tr>
<td></td>
<td>use &amp; reuse</td>
</tr>
</tbody>
</table>

Concepts:
- Resource depletion is driven by resource use efficiency
- Sustainable use leads to stability

Ecosystem Services
Processes in ecosystems that renew air, water, resources
Example: atmospheric CO$_2$

Concepts:
- All ecosystems function to sustain life on Earth
- Redundancy in organization builds resilience
Ecosystems Under Siege
How many connections dare we sever?

- rain forests
- hardwood forests
- conifer forests
- tundra

concepts:
- environmental degradation threatens ecosystem components
- loss of redundancy weakens system strength

Light & Heat
Solar radiation warms the atmosphere

- ultraviolet
- visible
- thermal

concepts:
- solar radiation interacts with the atmosphere & Earth’s surface
- ultraviolet radiation is absorbed, thermal radiation is retained
Earth’s Energy Budget

- photosynthesis 0.023%
- evaporation 23%
- reflected 34%
- heating surface & atmosphere 42%
- wind 1%
- degraded heat 66%

concepts:
- solar radiation is the primary source of energy on Earth
- this energy drives climate and ecosystem productivity

Carbon Cycle
Solar energy drives the transformation of carbon dioxide

- photosynthesis captures energy and “fixes” CO₂
- respiration liberates CO₂
- fixed carbon lost to soil & sediments
- heterotrophic organisms work - growth & maintenance
- autotrophic organisms

concepts:
- biogeochemical cycles transform matter
- there are many links to a cycle
- cycling maintains atmospheric CO₂ within limits
Industrial Age Carbon Cycle
Use of stored carbon augments the natural cycle

- Economic activity is altering basic biogeochemical cycles
- One thing cannot change without changing another
- Atmospheric CO₂ is rapidly changing