Ecosystem productivity

The complete picture

Lecture outline
- Description of ecosystems
- Primary production (vs. biomass)
  - Controls on primary productivity
  - Food webs
- Secondary productivity
  - Energetic efficiencies
- Energy flow through ecosystems

What's an ecosystem?
- Coined by Tansley in 1935
- Focuses on energy flow and nutrient cycling
  - What's energy flow?
  - Can you be considered an ecosystem?

Arthur Tansley

A forest ecosystem

Energy and thermodynamics
- What is energy?
- 1\textsuperscript{st} law: energy cannot be created or destroyed; it is transformed or moved
  - Eco. example?
- 2\textsuperscript{nd} law: transfer of energy is accompanied by a loss of energy as waste; entropy, or disorder, is increased
  - Eco. example?
- Because of these laws, we have a powerful tool to understand how biological systems work

Productivity vs. biomass
- Productivity (g mass/m\textsuperscript{2}/yr)
- Standing stock biomass (g mass/m\textsuperscript{2})
Primary production
- Energy produced by ?? (mostly)
  - = autotrophic production
  - = carbon fixation
- Gross primary production (GPP) = ?
- Net primary production (NPP) = ?
- Is GPP or NPP a good measure of what is available to consumers (i.e., heterotrophs)?

What controls primary production?

Environmental controls of 1º production (1)
- Primary production in grassland increases with greater annual precipitation.

Environmental controls of 1º production (2)
- Figure 18.2

Environmental controls of 1º production (3)
- Figure 18.6

NPP by ecosystem
- Figure 18.3

Lake phytoplankton
- Figure 18.6
Environmental controls of 1° production (4)

FACE experiments

Environmental controls of 1° production (5)

Human Appropriation of the Products of Photosynthesis

Nearly 40% of potential terrestrial net primary productivity is used directly, co-opted, or foregone because of human activities

Table 4. High calculation of net primary productivity. Data grouped in human appropriation denoted by shaded area. Human appropriation is a portion of the total productivity that is converted into human food products.

BioScience 1986

Whole-lake experiments show...

Fig. 18.11, Fig. 18.13

A complementary approach

What if abundance, biomass, and trophic levels are not enough to describe the importance of a species to a community or an ecosystem?

Food web with Pisaster

Fig. 17.9, top
Is *Pisaster* a keystone species?

- Rocky coast of WA
- Robert Paine
- Explain these results

![Graph showing removal of sea stars and species loss]

Control plot still had 15 spp.

**Fig. 17.10, top**

Food web withOUT *Pisaster*

Limiting resource?

**Fig. 17.9, top**

Bridging trophic cascades & food webs

- If we combine our understanding of food webs and the existence of trophic cascades, what do we learn?
- Two predictions:
  - *Even* number of trophic levels emphasizes roles of consumers
  - *Odd* number of trophic levels encourage “the world to be green.”
- Bottom-up vs. top-down regulation

Secondary production

- Production by ?
- Practically speaking, it’s all ‘net’ secondary production
- Units: g mass/m²/yr
- In one measurement, provides two important pieces of information:
  - individual growth
  - population survivorship

Secondary production (2)

- So, how do you make 2° production?
- \( P = C - R - (F + U) \)

Asian palm civet

Energy flow

![Energy flow diagram]

Aziuthal: Ingestion → Assimilation → Production → Growth → Respiration → Biomass → Regeneration

Robert Paine observed that a relatively simple trophic food web contained a relatively low proportion of predatory species...
How efficient are these processes? (1)

- Assimilation efficiency = Food assimilated / food consumed
  - Measures how effective the ingested food is made available for different bodily needs
  - Differs by type of food:
    - Leaf-eating insects: AE may be 10 – 20%
    - Predatory insects: AE may be 70% or more
  - Differs by organism:
    - Broad averages
      - Endotherms: AE = 78%
      - Ectotherms: AE = 42%

How efficient are these processes (2)?

- Net production efficiency = Production / food assimilated
  - Measures how effective the assimilated food is converted to new tissue and reproduction
  - Differs less by type of food:
    - Stream insects: NPE = 50%
  - Differs by organism:
    - Broad averages
      - Endotherms: NPE = 2.5%
      - Ectotherms: NPE = 45%

Why so different?

Energy flow

Environmental controls of secondary production

Trophic dynamics

- Feeding relationships
  - From an ecosystem perspective, you can lump all autotrophs, all herbivores, and all carnivores into trophic levels; species are not identified
Trophic or Ecological pyramids

● 10% ‘rule’

Raymond Lindeman (1942)