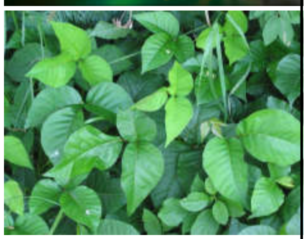
Energy Transfer → herbivore inefficiency

- Selective pressures:
  - On plants to decrease efficiency of transfer
  - On herbivores to increase efficiency
- Plant defenses
  - Physical (spines, silica)
  - Chemical (alkaloids, terpenoids, tannins, nicotine, caffeine)
  - Low food quality



Food Web Energetics

- Some trends in energy conversion, estimates for 1st to 2nd trophic level:
  - Invertebrate ectotherms 23%
  - Vertebrate ectotherms 9%
  - Vertebrate endotherms 6%

ARTICLE

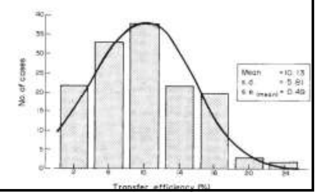
Large mesopelagic fishes biomass and trophic efficiency in the open ocean

Estimated Fish at 3rd trophic level may be respiring as much as 10% of productivity.

Primary production required to sustain global fisheries

D. Pauly* & V. Christensen

FIG. 2 Frequency distribution of energy transfer efficiencies (TE, in %) in 48 trophic models of aquatic ecosystems. The estimates of TE (*N* = 140) express, for TL 2 (=herbivores and detritivores) to 4 (=third-order consumers), the fraction of production passing from one TL to the next, and account for consumers feeding on the different TL of an ecosystem[11,19] (no trend of TE with TL was apparent[20]). All 48 trophic models used as sources of TE are fully documented[11,18,21-23]; they jointly show that the 10% TE value commonly used for aquatic organisms[24] is extremely close to the mean of the 140 estimates available for this study.



- Assuming fairly constant transfer efficiencies, greater productivity is expected to support longer food chains.

Productivity, disturbance and food web structure at a local spatial scale in experimental container habitats

B. Jenkins, R. L. Kitching and S. L. Pimm

- Manipulative mesocosm experiment.
- Detritus (leaves) → mosquito larvae → predators
- Low, medium and high energy treatments.
- High energy yielded larger S, longer food webs.

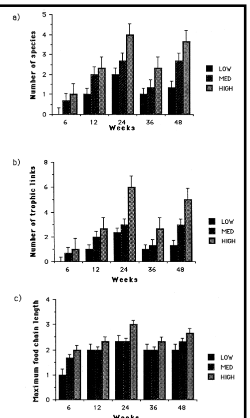
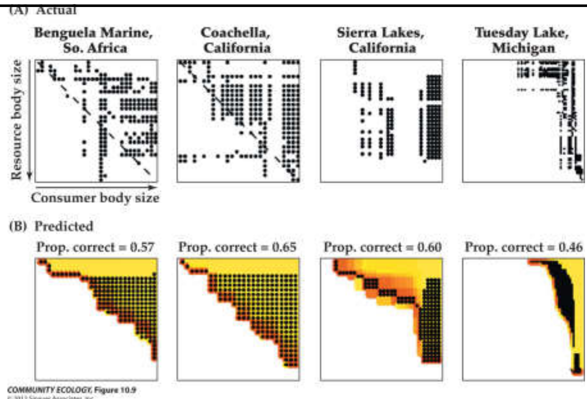


Fig. 1. Changes that took place over assembly time for three food web characteristics at three levels of productivity (LOW, MED, HIGH). The error bars represent standard errors for all data at each level of productivity.

Interaction Strength and Body Size

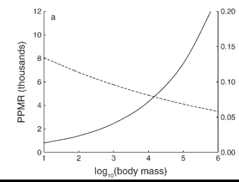
- Energy and biomass based food webs have been poor predictors of **interaction strength**.
- Elton noted that body size, as a basic species attribute, may be both **predictable** and a good **predictor**.
  - Consumers must be the appropriate size to consume prey at maximum efficiency (relative energy gain and T_h).
  - We predict consistent body size structure among trophic levels.
  - Body size is correlated with a variety of other fundamental properties (metabolism, movement rate, energy demands).
  - Thus, ratio of **predator-prey body** size may predict the strength of interactions.

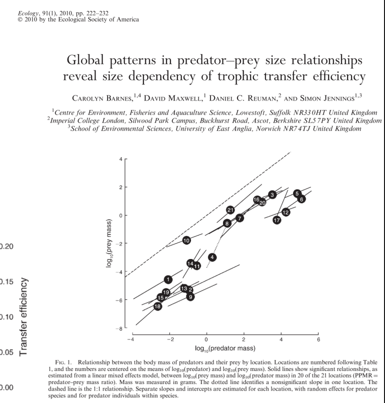


- Predicted (based on body size differences and optimal foraging, colors indicating profitability) and actual relationships four food webs.

Body Size and Transfer Efficiency

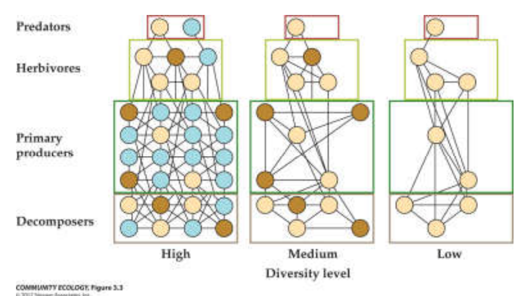
- Consistent predator-prey body size ratios.
- Higher productivity needed to support larger body sizes.
- Trophic transfer efficiency (---) decreases with increasing body size.





Diversity, Stability and Web Structure Revisited

- Diversity itself may not be as important as the number of species interactions.

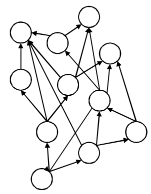


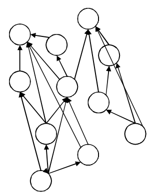
Diversity, Stability and Web Structure Revisited

- Observation: Low diversity systems tend to have more variable population sizes (reduced stability).
- May (1972) – models indicated greater diversity may destabilize communities. However, May randomly assigned interaction strengths to food webs.
- In nature, interaction strengths are skewed. Evidence that a large number of weak interactions dampens population sizes, having a stabilizing effect. In this view, diversity increases stability.

Modularity and Stability

- Food web (network) topology may be **modular**: tendency for groups of species to interact more with themselves than species in other groups.
- Similar to **portfolio effect,** extinctions in one module less likely to impact species in other modules.
- Modules may provide functional redundancy.
- Large complex networks often stabilized by having modular structure (e.g. power grid).





Assemblage Rules and Priority Effects

- If species interactions are important (e.g. facilitation) and different species play different roles then one might expect “rules” to govern how communities are formed.
- Alternatively, if communities are stochastic, formation of communities might be essentially random.
- Diamond (1975) **Assembly Rules**

Oecologia (2009) 161:139–148
DOI 10.1007/s00442-009-1350-9

COMMUNITY ECOLOGY - ORIGINAL PAPER

Experimental confirmation of multiple community states in a marine ecosystem

Peter S. Petraitis · Elizabeth T. Methratta · Erika C. Rhile · Nicholas A. Vidargas · Steve R. Dudgeon

Petraits et al (2009) – open patches converge on final community type based on what arrived first. Final community type was stable, not invaded by other.

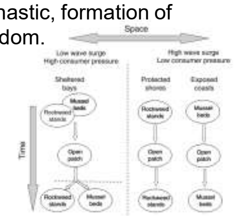


Fig. 3 Development of rockweed stands and mussel beds over time and space. On open coastal shores there is a gradient in wave surge from protected to exposed shores with predators of mussels showing an increase in activity as wave surge diminishes. Work by Lubchenco and Menge (1978) suggested that rockweeds are confined to protected shores where predators are active enough to eliminate mussels. In sheltered bays, both mussels and rockweeds occur as a mosaic of patches and our work suggests that development depends on which species becomes established first. The *horizontal dotted line* shows where a developing patch is “committed” to becoming a mussel bed or rockweed stand. The *vertical dotted line* shows the hypothetical boundary between the two kinds of development, but the transition could also be gradual or not linked to wave exposure alone

Reading for Monday – Assembly Rules

COMMUNITY-ASSEMBLY MECHANICS AND THE STRUCTURE OF AN EXPERIMENTAL SPECIES ENSEMBLE

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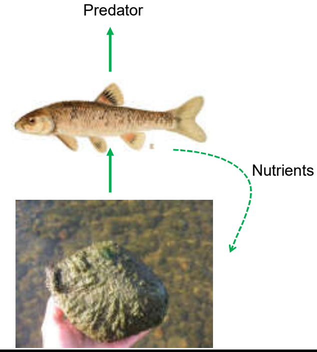
Submitted August 9, 1988; Revised May 23, 1989; Accepted October 29, 1989

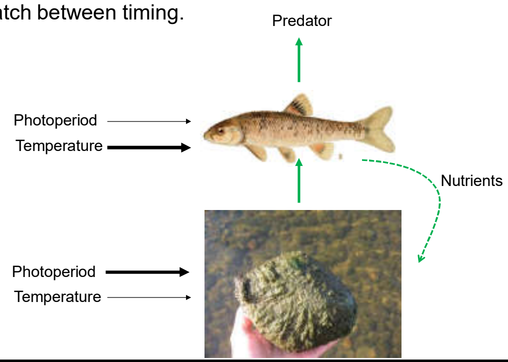
Food Web Research Example

- Stream ecosystems often dominated by single producer and consumer.
- Producers and consumers need to be in synch (consumer growth and reproduction should coincide with maximum primary productivity)



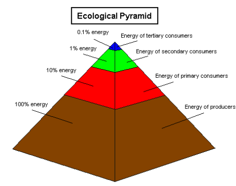
Food Web Research Example

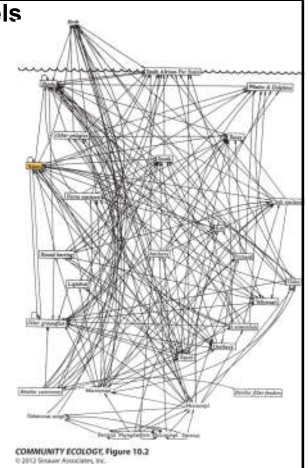
- **Match-mismatch hypothesis** – producer and consumer seasonal cues differ. If temperature changes more rapidly than consumers can adapt, there may be a mismatch between timing.



Abundance at Trophic Levels

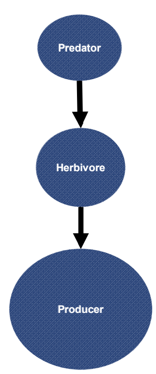
- Clearly food webs and assemblages are complex with multiple interactions.
- Are there patterns apparent when looking at abundance among trophic levels?





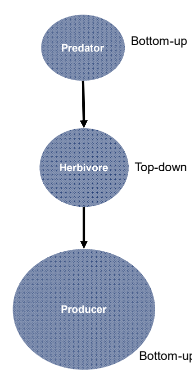
Top-Down vs. Bottom-Up

- Top-down control - consumers control abundance of their prey.
- Bottom-Up (donor) control – consumer abundance controlled by resource availability.
- Are communities dominated by top-down or bottom-up forces?
- Are herbivores controlled by predators or availability of resources?



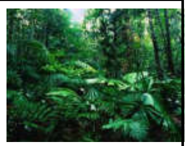
Abundance at Trophic Levels

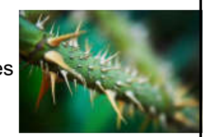
- Hairston, Smith and Slobodkin (HSS) (1960)
  - Predators should be limited by competition for food (herbivores)
  - Herbivores should be below K due to predation (predator suppression).
  - Producers should be limited by competition due to reduced herbivory.



Top down vs. Bottom up control

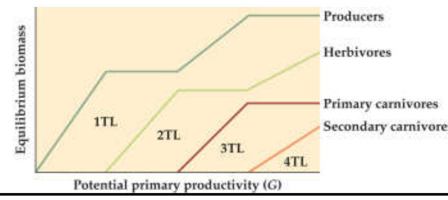
- HSS – "The world is green"
  - Evidence
    - Green plant depletion by herbivores is rare
    - Green plants may be depleted when herbivores are artificially protected (by man)
    - Thus…consumers are most often controlled by predators and not resource availability
  - Problem: If plants are not controlled by herbivores, why do plants have defenses against herbivory?

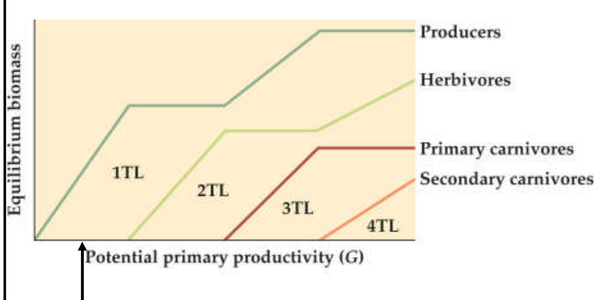




Abundance at Trophic Levels

- HSS ideas further developed by Oksanen et al. (1981)
  - Developed theory based on productivity, consumer, resource approach.
  - Number of trophic levels (food chain length) should be based on **potential primary productivity** (**G**: typically linked to a single limiting factor that changes from system to system).
  - Biomass at various levels expected to change with productivity. Productivity interacts with food chain length to shift top-down vs. bottom-up forces among levels.





- 1TL – productivity only supports one trophic level
- 2TL – productivity supports herbivores, producer biomass controlled by herbivory
- 3TL – productivity supports 3rd level, herbivores controlled from above, producers increase with G
- 4TL – productivity supports 4th level, 4th and 2nd increase with G, 3rd and 1st controlled from above