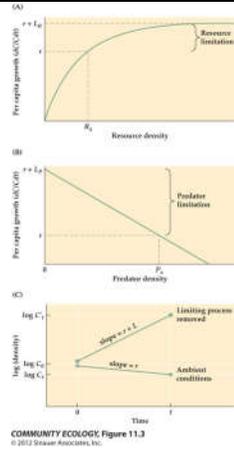


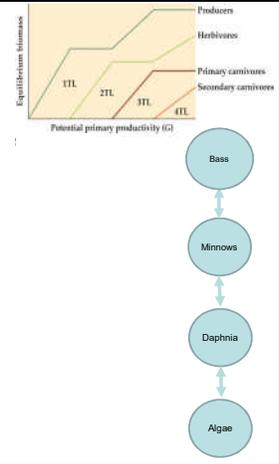
Abundance at Trophic Levels

- Resource limitation to growth rate
 - R_0 – ambient resources
 - r – ambient growth
 - L_R – growth limited by limited resources
- Predator limitation
 - P_a – ambient predator density
 - r – ambient population growth
 - L_P – growth not limited by predators
- Combined effects
 - Estimate predator control or resource limited through removal experiments
 - Slopes of lines indicate strength of control



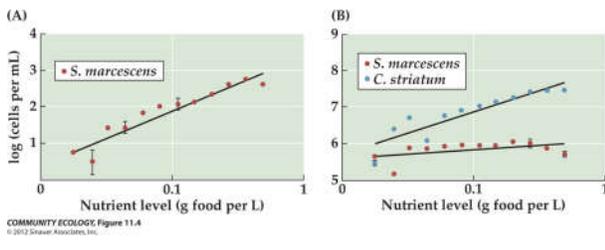
Predictions

- Increase in G increases abundance at the top, alternating no change and positive at lower levels.
- Reducing abundance at the top results in alternating + and – at lower levels (trophic cascade).
- Increase in G increases the length of the food chain.
- These are all testable hypotheses!**



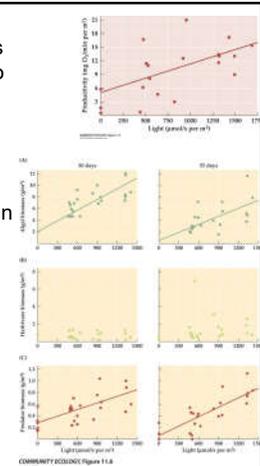
Predictions

- Prediction:** Increase in G increases abundance at the top
- Simple two trophic level system
- Increasing G (nutrient levels) should increase abundance at second level and not first.



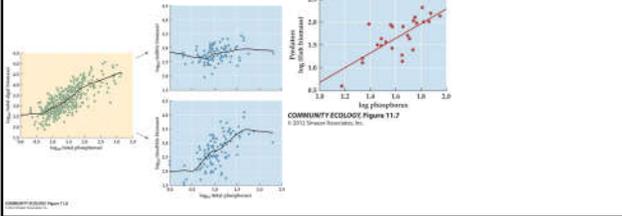
Predictions

- Prediction:** Increase in G increases abundance at the top, alternating no change and positive at lower levels.
- Light increase productivity...light levels = G
- Three level system (3TL), increase in G should:
 - Increase abundance at 3rd
 - No effect on 2nd
 - Increase abundance at 1st

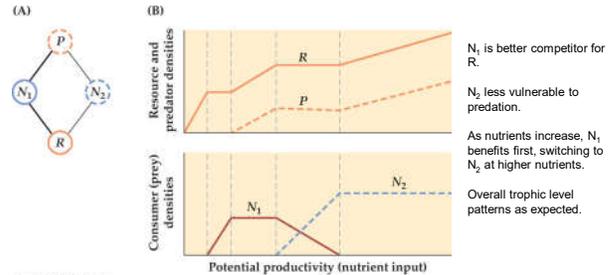


Predictions

- Not all patterns are as clear. Some experiments show a clear trend of increases at all levels with increased G.
- What is going on here? Key is likely specific predator-prey interactions.

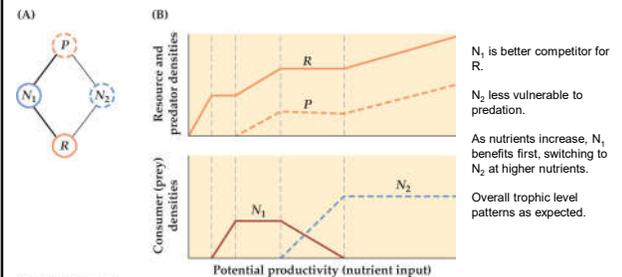


Productivity and Species Interactions



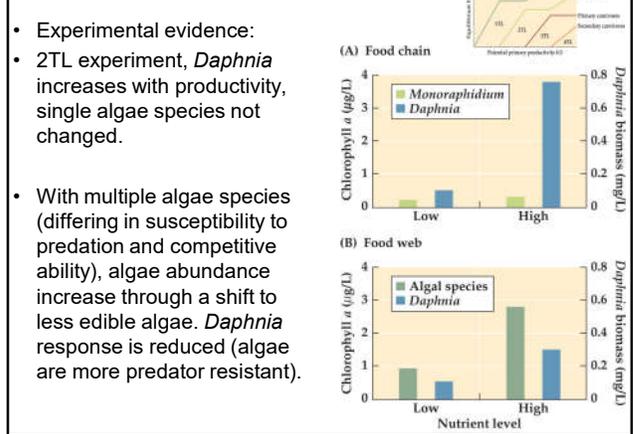
- Keystone predation and species interactions within or between trophic levels will alter patterns
 - Differences in species traits (tradeoffs between competitive ability and susceptibility to predation)

Productivity and Species Interactions



- Evidence of this mechanism
 - High rates of species turnover over productivity gradients (i.e. N_2 replacing N_1 as productivity increases).
 - Higher productivity systems feature species less prone to predation, low productivity systems have better competitors.

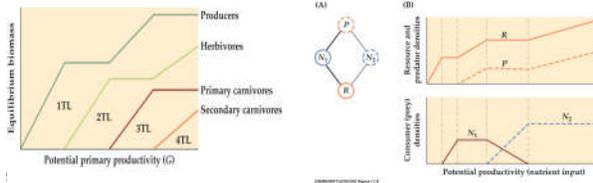
Productivity and Species Interactions



- Experimental evidence:
 - 2TL experiment, *Daphnia* increases with productivity, single algae species not changed.
 - With multiple algae species (differing in susceptibility to predation and competitive ability), algae abundance increase through a shift to less edible algae. *Daphnia* response is reduced (algae are more predator resistant).

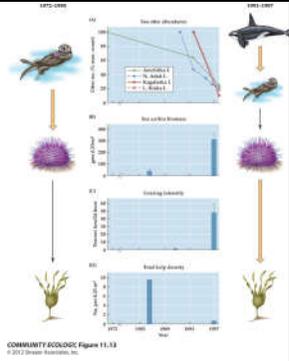
Synthesis of Productivity Effects

- Oksanen et al. and HSS model provided good insight into how trophic levels may respond to **productivity**.
- Categorizing food webs as simply top-down or bottom-up is problematic, over simplified.
- Clear that species tradeoffs (competitive ability, predation etc.) play a role and we expect shifts in species abundance based on **productivity**.



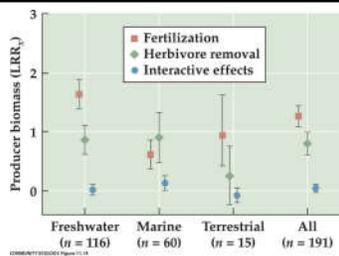
Trophic Cascade

- Many of the previous examples viewed productivity as the driving force of change in trophic structure. What about forces from above (trophic cascade)?
- Classic example of trophic cascade seen in coastal ecosystem. Orca shifts in diet (targeting otters) cascaded through to increase urchin and decrease kelp abundance.
- Are trophic cascades “all wet”?
 - Terrestrial producers (plants) are generally larger and better protected from herbivory than aquatic produces (algae).



Trophic Cascade

- Overall, top-down driven trophic cascades may be more pronounced in aquatic systems, but are present in both.
- Both fertilization and herbivore removal seem to have similar effects. Thus, both top-down and bottom-up forces are important in trophic level biomass.



Food Chain Length

- Prediction that food chain length should increase with G . However, ecosystem vary in food chain length.
- Hypotheses
 - **Energy limitation** – low transfer efficiency
 - **Dynamic stability** – longer food chains may be less stable, prone to disturbance
 - **Ecosystem size** – species-area relationship increases diversity and the opportunity for greater food chain length.
 - **Productive space** – ecosystem size and productivity interact to determine length.

