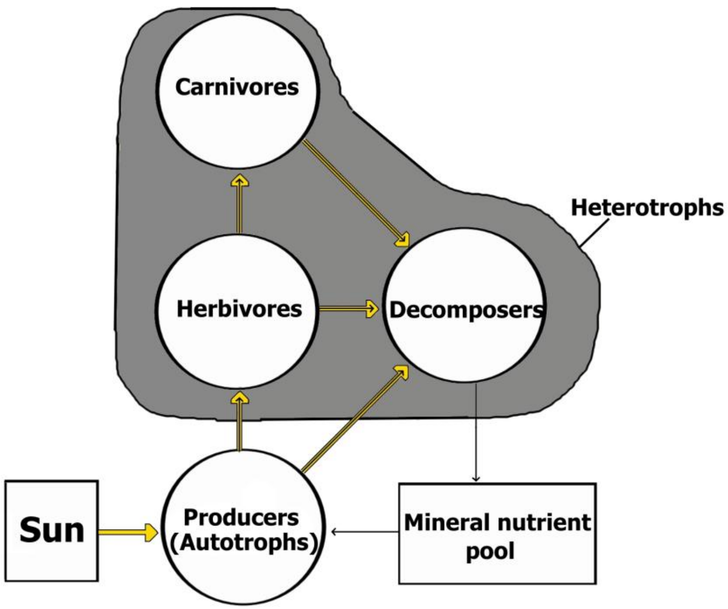
Jan 23 Conceptual models of ecological systems

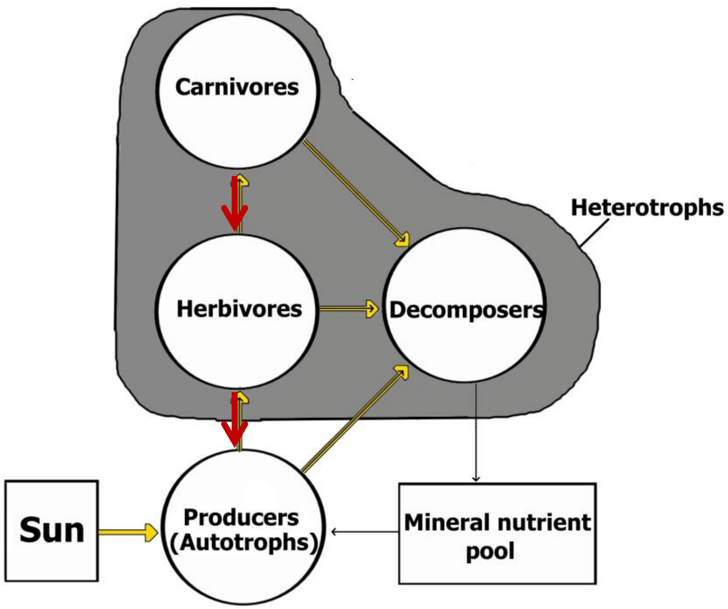
Example of drawing strong generalizations in ecology:

Trophic Cascades

Bottom-up



Top-down

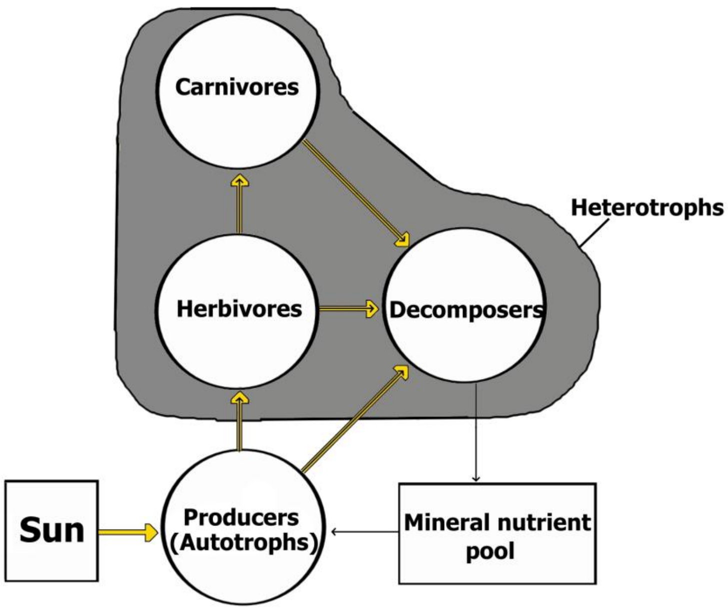


Arrows indicate controlling levels

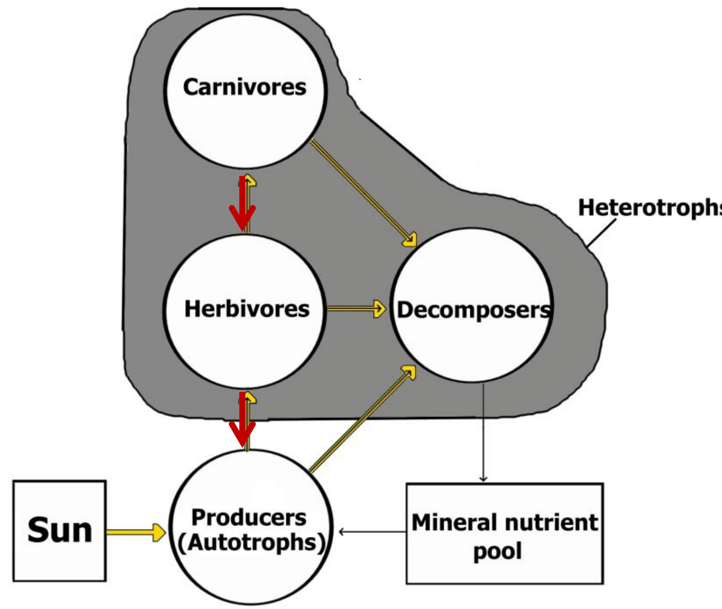
Example of drawing strong generalizations in ecology:

Trophic Cascades

Bottom-up



Top-down



Arrows indicate controlling levels

Are ecosystems controlled by bottom-up or top down trophic cascades?

Yellowstone Case Study

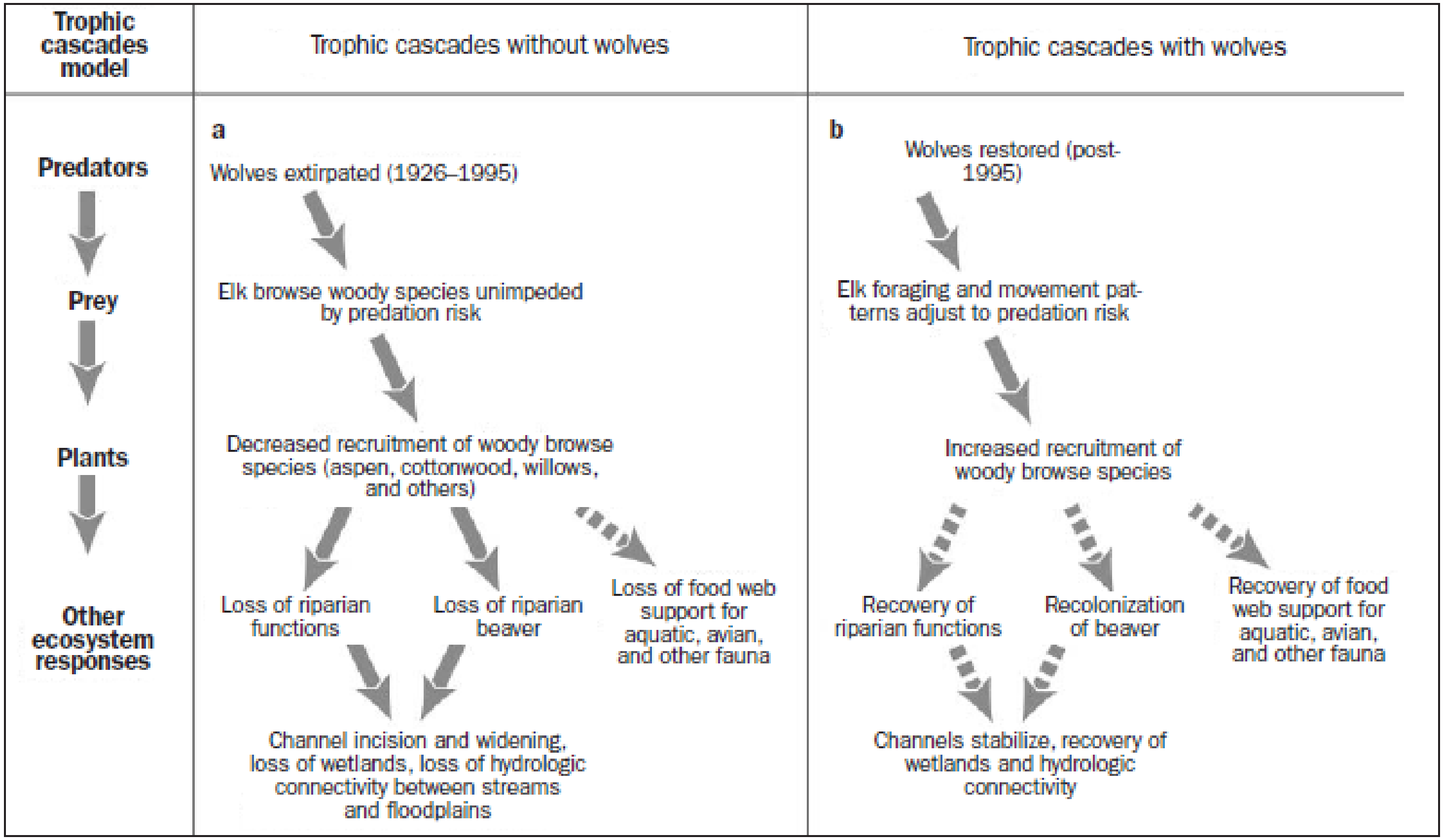


Figure 5. Trophic interactions due to predation risk and selected ecosystem responses to (a) wolf extirpation (1926–1995) and (b) wolf recovery (post-1995) for northern ecosystems of Yellowstone National Park. Solid arrows indicate documented responses; dashed arrows indicate predicted or inferred responses.



From Ripple and Beschta 2004

Yellowstone Case Study

Climate Change Hypothesis

Bottom-up Control

Increase in vegetation

↑

Improved growing conditions

↖

- **Longer periods of favorable conditions in the spring provide longer stems**
- **Longer periods of favorable conditions in the fall provide more defensive chemicals**

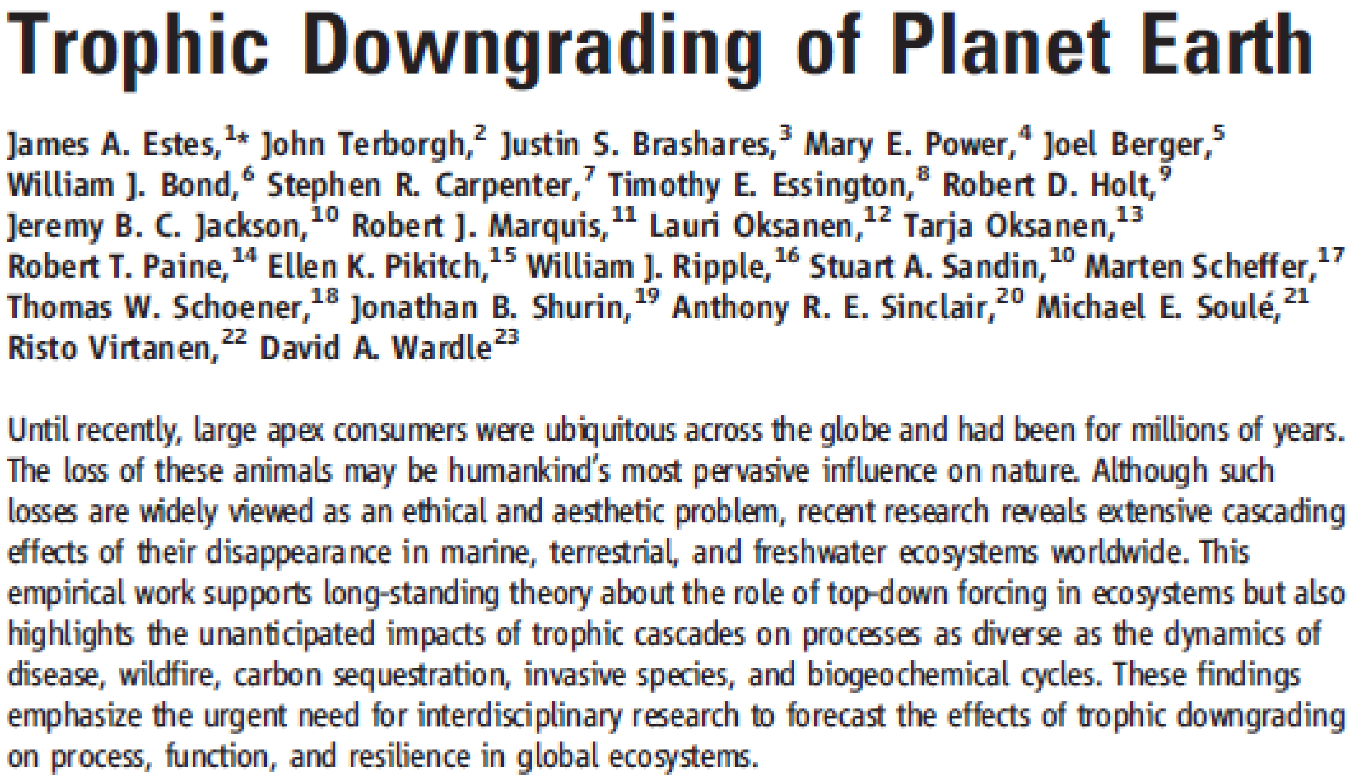
↑ **Growing degree days**

Yellowstone Case Study

?

Consensus is that predators contribute significantly to top-down trophic cascades on the Yellowstone Northern Range.

Call for Predator Restoration



Trophic Downgrading of Planet Earth

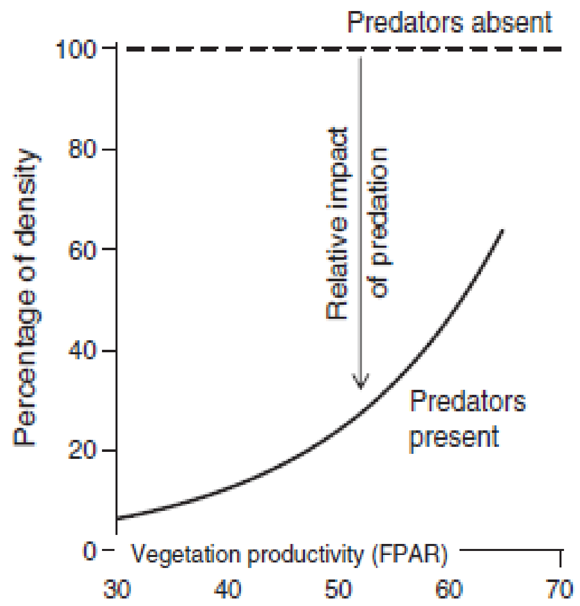
James A. Estes,[1*] John Terborgh,[2] Justin S. Brashares,[3] Mary E. Power,[4] Joel Berger,[5] William J. Bond,[6] Stephen R. Carpenter,[7] Timothy E. Essington,[8] Robert D. Holt,[9] Jeremy B. C. Jackson,[10] Robert J. Marquis,[11] Lauri Oksanen,[12] Tarja Oksanen,[13] Robert T. Paine,[14] Ellen K. Pikitch,[15] William J. Ripple,[16] Stuart A. Sandin,[10] Marten Scheffer,[17] Thomas W. Schoener,[18] Jonathan B. Shurin,[19] Anthony R. E. Sinclair,[20] Michael E. Soulé,[21] Risto Virtanen,[22] David A. Wardle[23]

Until recently, large apex consumers were ubiquitous across the globe and had been for millions of years. The loss of these animals may be humankind's most pervasive influence on nature. Although such losses are widely viewed as an ethical and aesthetic problem, recent research reveals extensive cascading effects of their disappearance in marine, terrestrial, and freshwater ecosystems worldwide. This empirical work supports long-standing theory about the role of top-down forcing in ecosystems but also highlights the unanticipated impacts of trophic cascades on processes as diverse as the dynamics of disease, wildfire, carbon sequestration, invasive species, and biogeochemical cycles. These findings emphasize the urgent need for interdisciplinary research to forecast the effects of trophic downgrading on process, function, and resilience in global ecosystems.

2011. Science. 333:301-306.

Trophic Cascades are Context Dependent?

Top-down effects vary with Primary Productivity

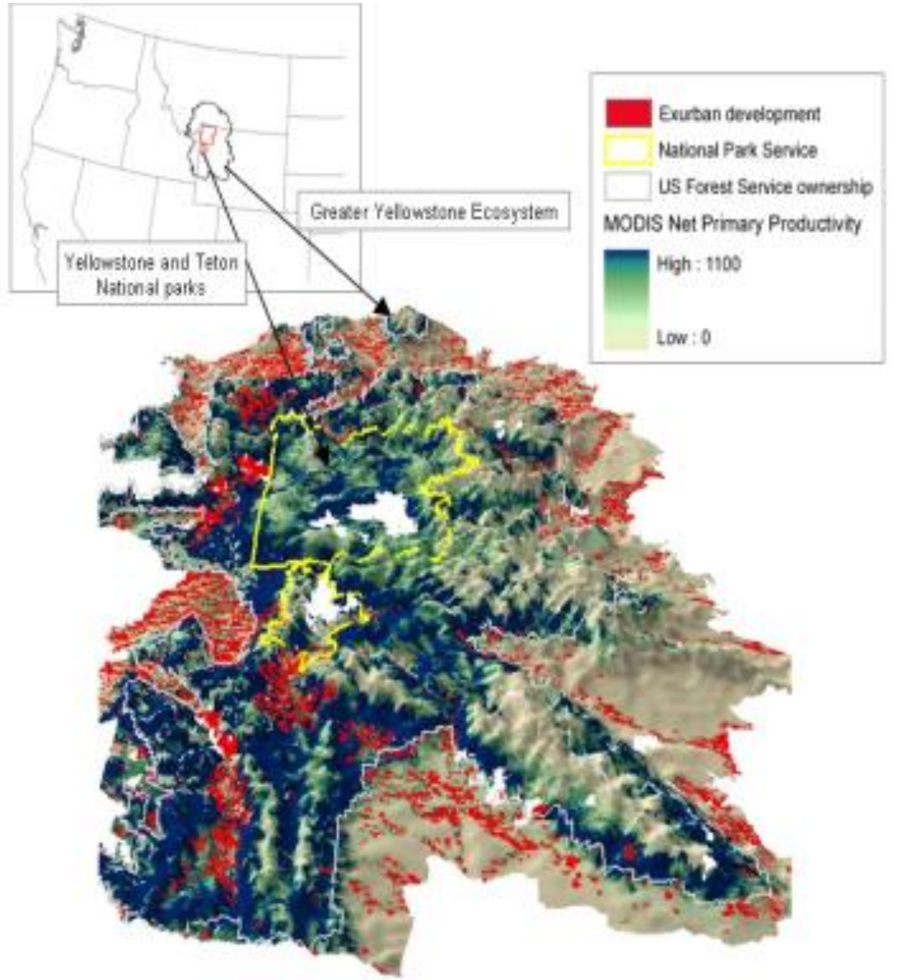


Generalized role of predation in limiting roe deer abundance below the habitat carrying capacity along the productivity gradient. In the most productive regions, deer populations with predators present attained 60-80% of the predator-free population density. In the least productive regions, populations with predation had densities less that 10% of those without predators. From Melis et al. 2009.

Trophic Cascades are Context Dependent?

Implications

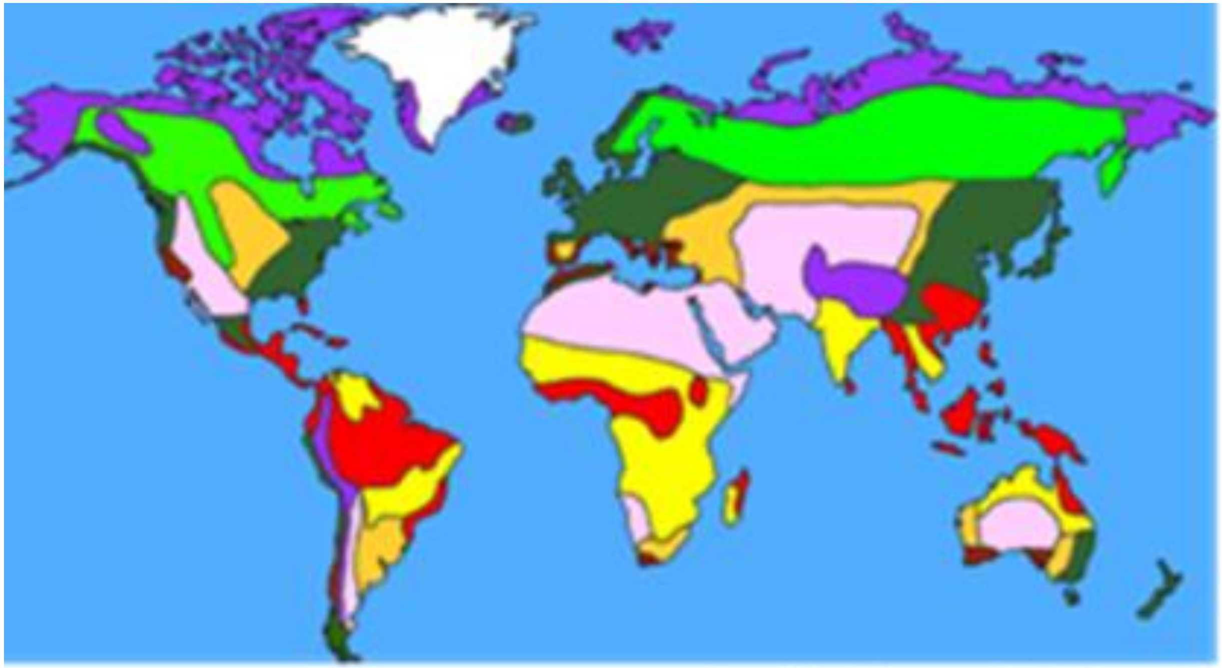
- **Does wolf effect vary across the productivity gradient of the Northern Rockies?**



Trophic Cascades are Context Dependent?

Implications

- Will reintroduction be effective in restoring ecosystem function in all biomes?



Other Context Dependent Ecological Interactions??

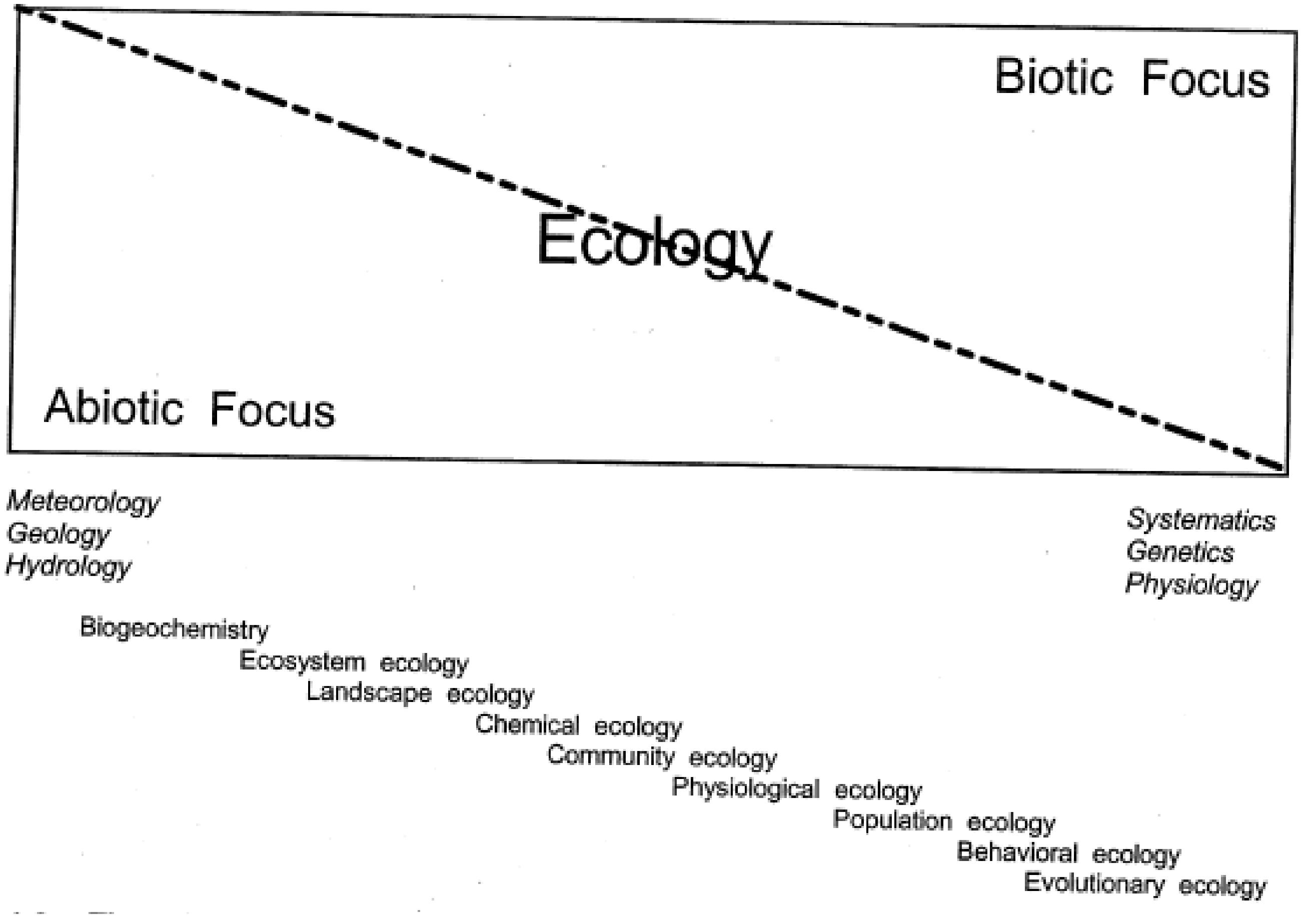
- **Invasive species effects?**
- **Grazing effects on plant diversity?**
- **Habitat fragmentation effects?**
- **Human land use effects on biodiversity?**
- **Climate change effects?**

Typical Approach to Studying Ecology

Biology 303 Principles of Ecology

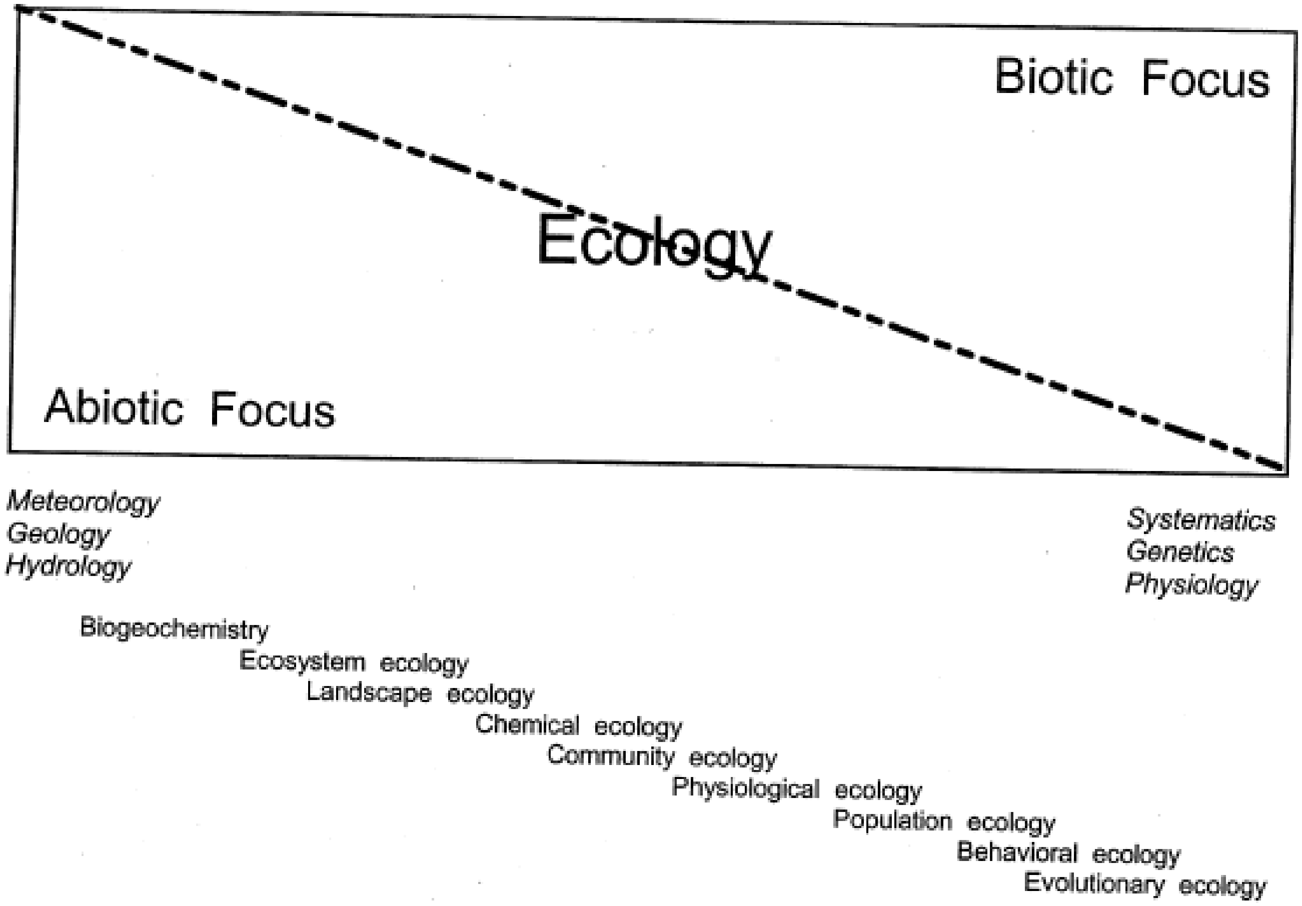
Jan 16	**Introduction to Ecology**
Jan 18	**Overview of Class, Scientific Method**
Jan 23	**Climate Processes**
Jan 25	**Geography of Biomes**
Jan 28	**Aquatic Environments**
<u>Individual Organisms</u>	
Jan 30	**Organisms and Limiting Factors**
Feb 1	**Niche Concept**
Feb 4	**Temperature Relations**
Feb 6	**Water relations**
Feb 8	**Energy and Nutrient Relations**
<u>Populations</u>	
Feb 13	**Evolution and Natural Selection**
Feb 15	**Evolution and Natural Selection**
Feb 22	**Population Distribution and Abundance**
Feb 27	**Movements: Dispersal and Migration**
Feb. 29	**Population Dynamics: Survival and Age Distribution**
Mar 3	**Population Dynamics Continued**
Mar 5	**Exponential Population Growth**
Mar 17	**Logistic Population Growth**
Mar 19	**Population Regulation**
<u>Communities and Ecosystems</u>	
Mar 24	**Interspecific Competition**
Mar 26	**Predation**
Mar 28	**Predation Case Study**
Apr 2	**Herbivory: Animals in Ecosystems**
Arpil 9	**Community Diversity**
Apr 11	**Ecosystem Energy Flow**
Apr 14	**Ecosystem Nutrient Cycling**
<u>Large-scale Ecology</u>	
Apr 16	**Ecological Succession**
Apr 18	**Natural and Human Disturbance**
Apr 21	**Landscape Ecology**
Apr 23	**Landscape Ecology: Fire and Biodiversity**
Apr 25	**Island Biogeography and Conservation**
Apr 28	**Human Population Change**
Apr 30	**Human Effects on Climate**

Typical Approach to Studying Ecology



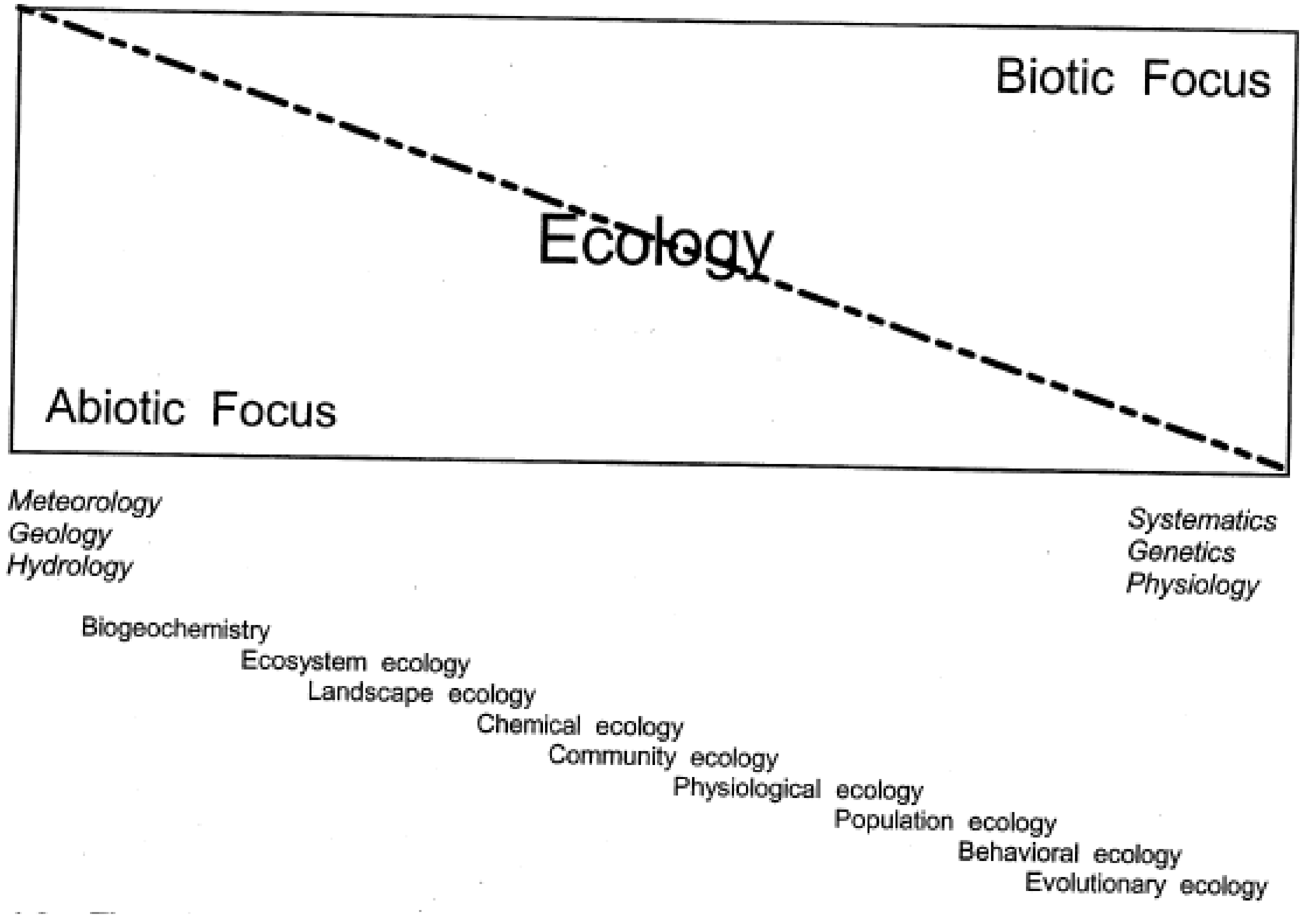
Pickett et al. 2007

Typical Approach to Studying Ecology



Which sub-disciplines are needed to deal with geographic variation in trophic cascades?

Typical Approach to Studying Ecology



How would we put the pieces back together to study integrated ecological systems?

Why is Integration Needed in Ecology?

Great advances have been made by dividing ecology into subdisciplines.

But too much focus on subdisciplines has also hindered ecology

- too little study of the interface between disciplines
- tended to narrow focus to particular scales and levels of organization when in fact may problems are best understood at multiple scales/levels
- subdisciplines loose the ability to understand and to appreciate each other.

Pickett et al. 2007

Why is Integration Needed in Ecology?

All of these examples show that debate is often problematic in ecology, and it often arises from poorly articulated concepts or contrasts. The limitations of dichotomous debate make it reasonable to suppose that advances in understanding may be made by asking questions such as when, where, and why some processes are more important than others, rather than asking whether process A or B is the right solution. What determines the mix of forces in particular cases? Such questions require synthesis of existing data, as well as new types of studies. Ultimately, the process of integration should help resolve the dichotomies; afford greater powers of explanation, prediction, comparison, and generalization; and eventually lead to the disappearance of current rival "schools of thought" and their replacement by a unified approach. Of course, any new resolution may lead to a new generation of controversies that could, in their turn, also benefit from integration. Cycles of debate and integration may well run through in the history of ecology.

Pickett et al. 2007

Why is Integration Needed in Ecology?

subdisciplines. However, in the broadest sense, ecology is "the scientific study of the processes influencing the distribution and abundance of organisms, the interaction among organisms, and the interaction between organisms and the transformation and flux of energy and matter" (Likens 1992). From the perspective of this broad definition emphasizing both organismal and systems properties, it is clear that integration of the population and ecosystem subdisciplines is a goal for advancing ecological understanding. Such a goal can be achieved by forging links across these subdisciplines and by focusing on ecological issues and critical questions that lie at the intersection of the subdisciplines (Jones and Lawton 1994) and, therefore, cannot be addressed by either of the two paradigms alone but require input from both paradigms.

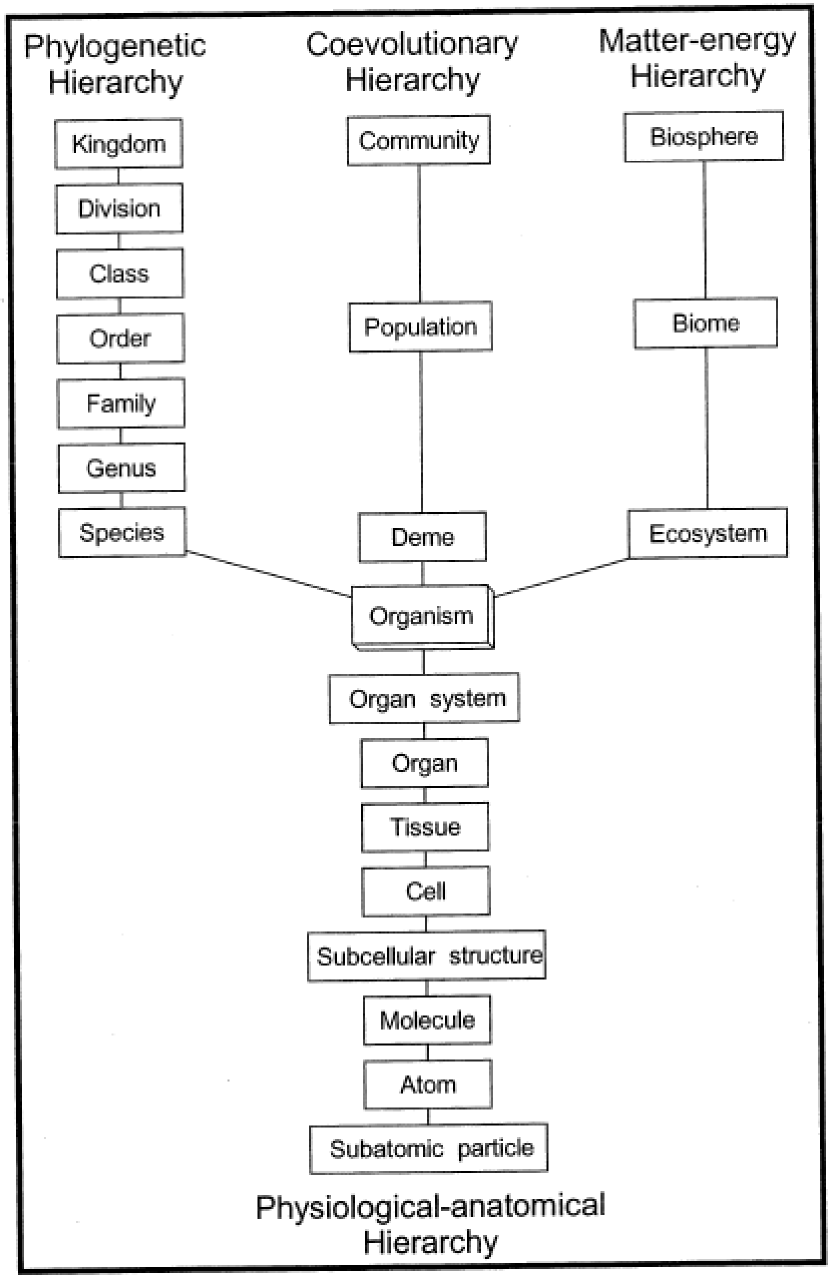
Pickett et al. 2007

Conceptual Models of Ecological Systems and Integration

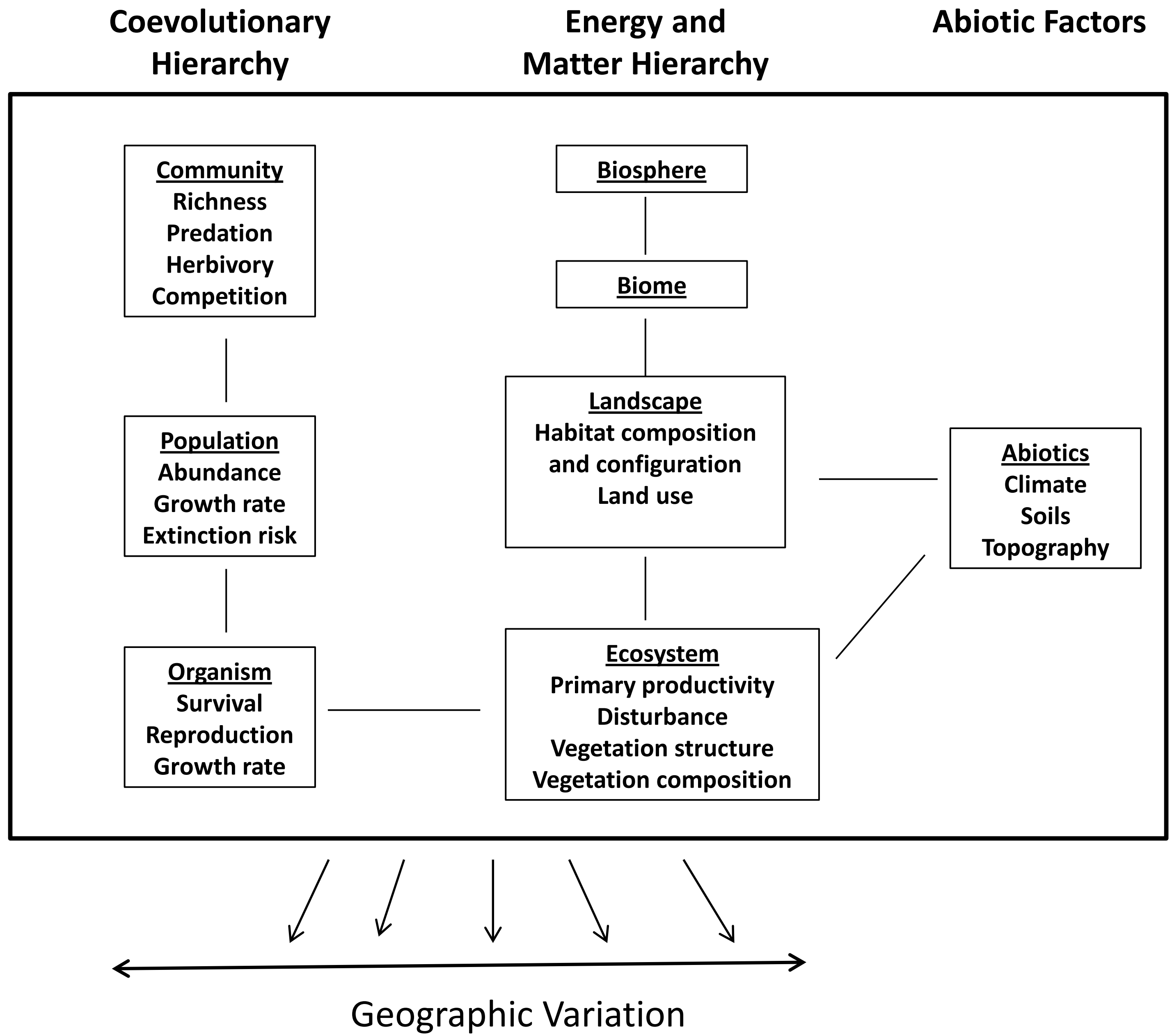
BOX 1.5 Traditional Levels of Organization for Ecology

Fine scale
Molecule
Subcellular structure
Cell
Tissue
Organ
Organism
Population
Community
Ecosystem
Biosphere
Coarse scale

Conceptual Models of Ecological Systems and Integration

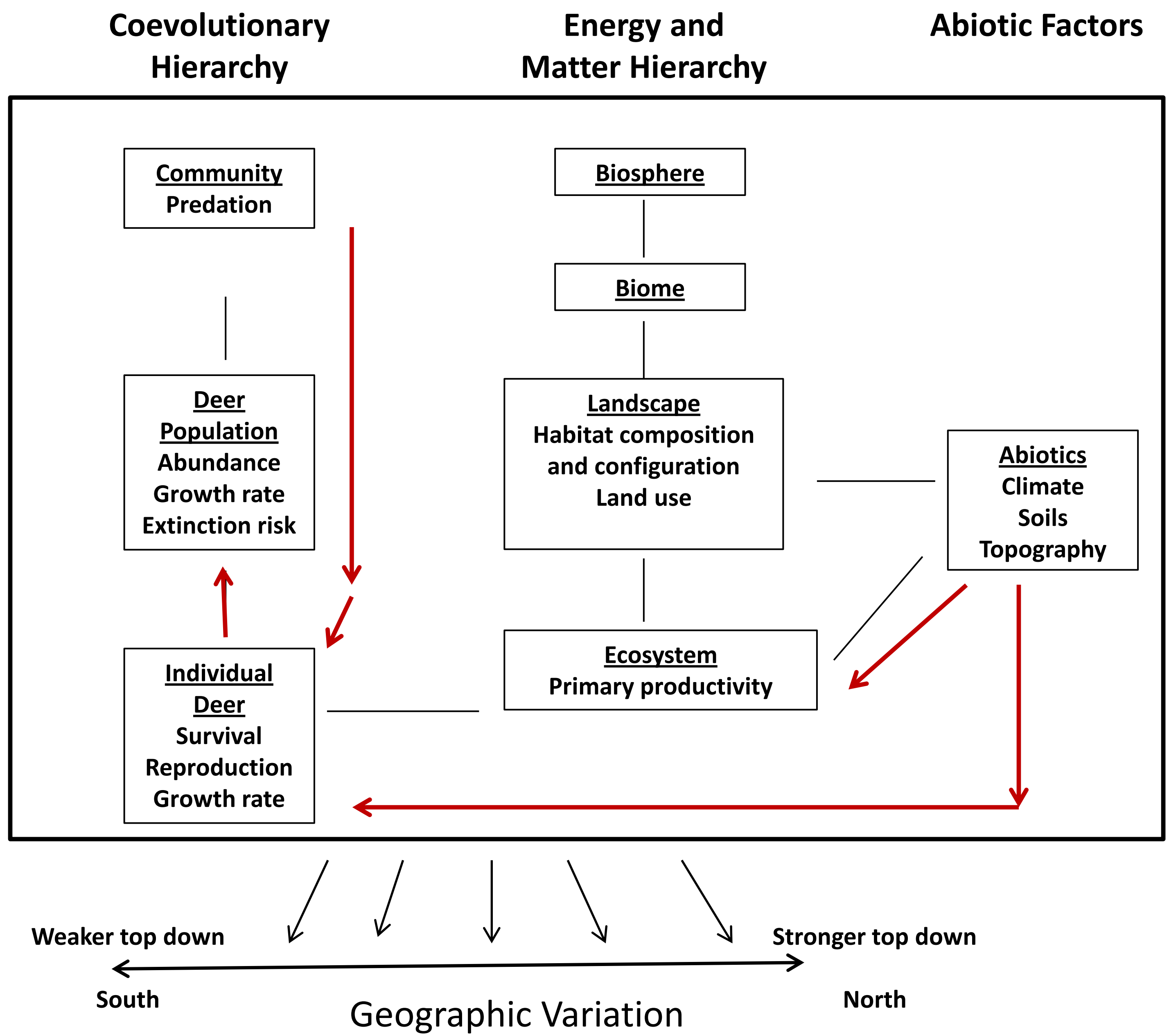


Conceptual Models of Ecological Systems and Integration



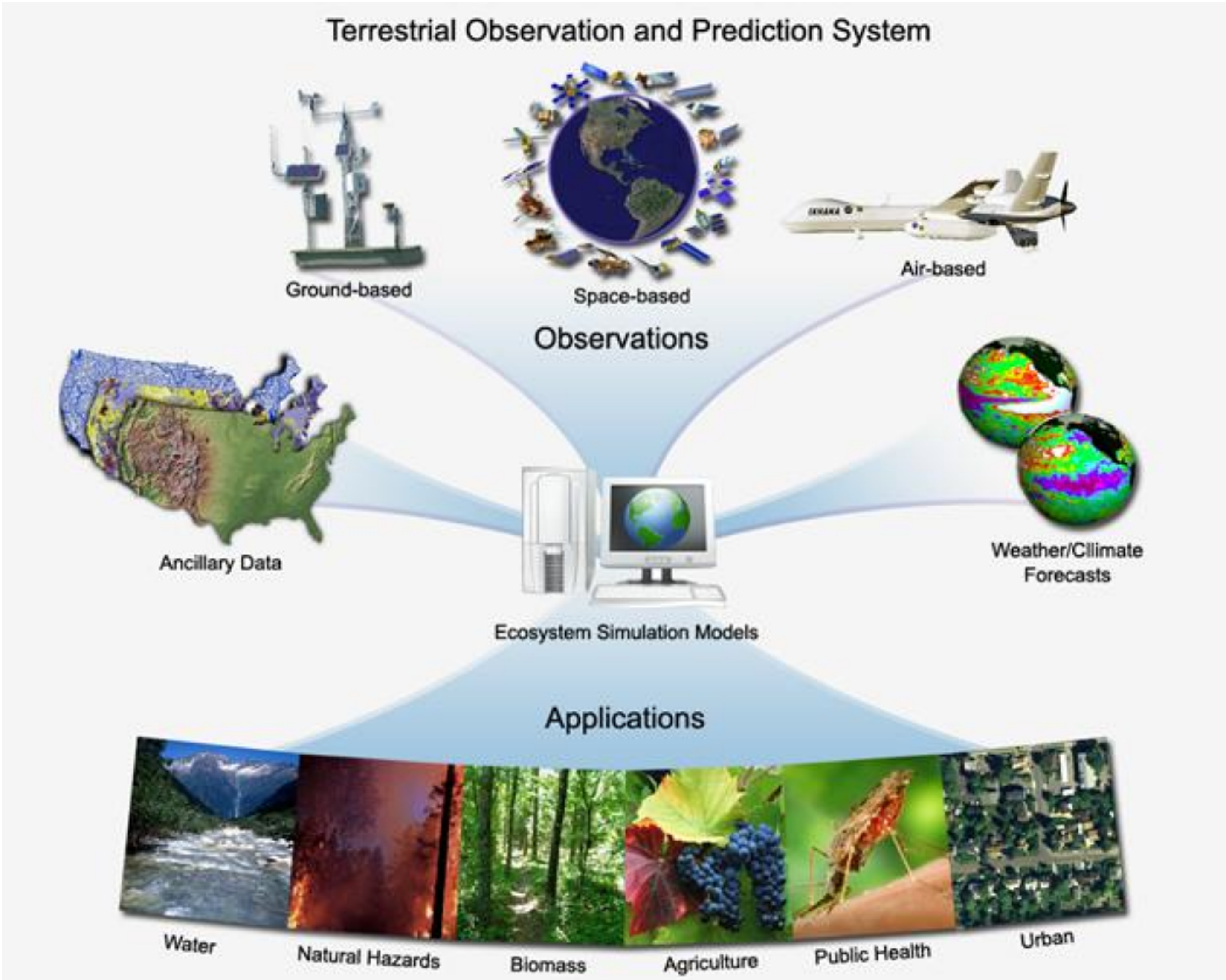
Implication for management?

Conceptual Models of Trophic Cascades as Suggested by Melis et al 2009



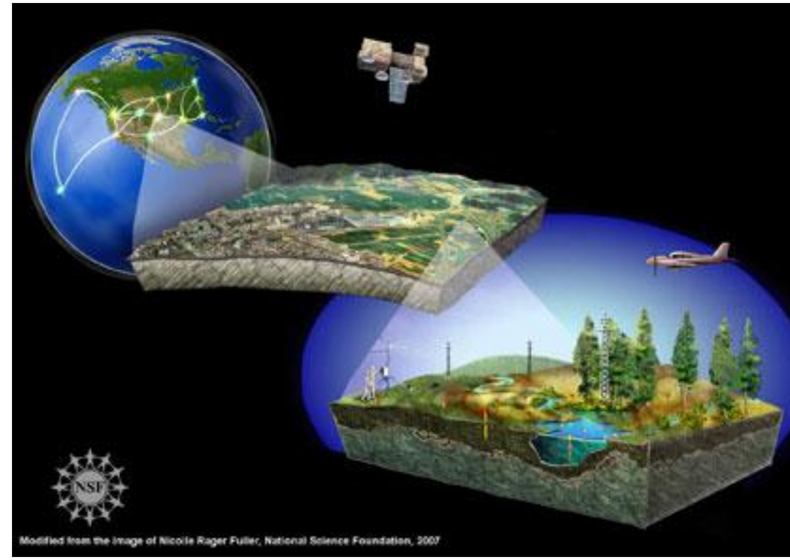
Implication for management?

Continental to Global Scale Ecology Programs



Continental to Global Scale Ecology Programs

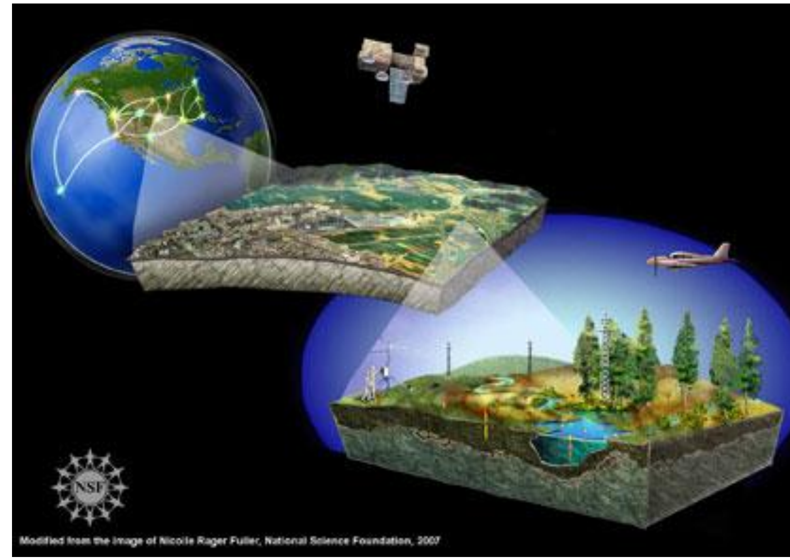
Long-term Ecological Research Program (LTER)



National Ecological Observatory Network (NEON)

Continental to Global Scale Ecology Programs

Long-term Ecological Research Program (LTER)



National Ecological Observatory Network (NEON)

How could LTER and NEON data be used to examine how ecological interactions (e.g., trophic cascades) vary geographically and the general principles that underlie these patterns?

Course Topics

Jan 23	**Conceptual models of ecological systems, Class orientation**
Jan 30	**Terrestrial forest biomes of the world**
Feb 6	**Primary productivity: controls, patterns, consequences**
Feb 13	**Primary productivity: comparison among biomes**
Feb 27	**Habitat complexity: controls, patterns, consequences**
Mar 5	**Habitat complexity: comparison among biomes**
Mar 19	**Trophic cascades: controls, patterns, consequences**
Mar 26	**Tropic cascades: comparison among biomes**
Apr 2	**Community diversity: controls, patterns, consequences**
Apr 9	**Community diversity: comparison among biomes**
Apr 16	**Synthesis: Interactions among state variables across biomes**
Apr 23	**Synthesis: Grouping Biomes based on ecological properties**
Apr 30	**Student presentations**

References

Estes, J. A., J. Terborgh, J. S. Brashares, M. E. Power, J. Berger, et al. 2011. Trophic downgrading of planet earth. Science 333:301-306.

Melis, C., B. Jedrzejewska, M.Apollonio, K. A. Barton, W. Jedrzejewski, J. D. C. Linnell, I. Kojola, J. Kusak, M. Adamic, S. Ciuti, I. Delehan, I. Dykyy, K.Krapinec, L. Mattioli, A. Sagaydak, N. Samchuk, K. Schmidt, M. Shkvyrya, V. E. Sidorovich, B. Zawadzka, and S. Zhyla. 2009. Predation has a greater impact in less productive environments: variation in roe deer, Capreolus capreolus, population density across Europe. Global Ecology and Biogeography 18:724–734.

Pickett, S.T.A., J. Kolasa, C.G. Jones. 2007. Ecological Understanding: The Nature of Theory and the Theory of Nature. Elsevier, Boston. Chapter 1 Integration in Ecology

Ripple, W.J., R.L. Beshta 2004. Wolves and the Ecology of Fear: Can Predation Risk Structure Ecosystems? BioScience 54:755-766.