Ecological Systems and Learning Progressions: applications of basic principles across multiple scales of organization

John Moore[1], Laurel Hartley[2], Jennifer Doherty[3], Cornelia Harris[4], Alan Berkowitz[4], Andy Anderson[3]

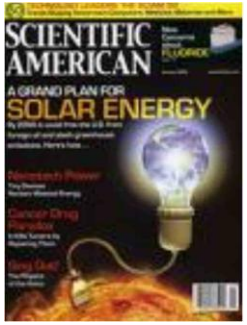
COLORADO STATE UNIVERSITY[1], UNIVERSITY OF COLORADO DENVER[2], MICHIGAN STATE UNIVERSITY[3], CARY INSTITUTE OF ECOSYSTEM STUDIES[4]

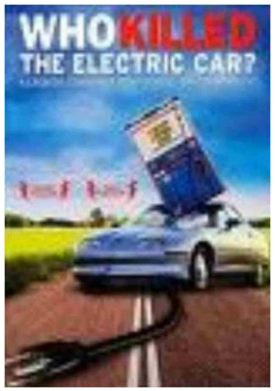
MSP – Pathways to Environmental Literacy

Colorado State University
Cary Institute
University of California, Santa Barbara
Michigan State University
Towson University
University of New Mexico
University of Northern Colorado
University of Wyoming
Montana State University
Arizona State University

Environmental Science Literacy

The capacity to understand and participate in evidence-based decision-making about socio-ecological systems.





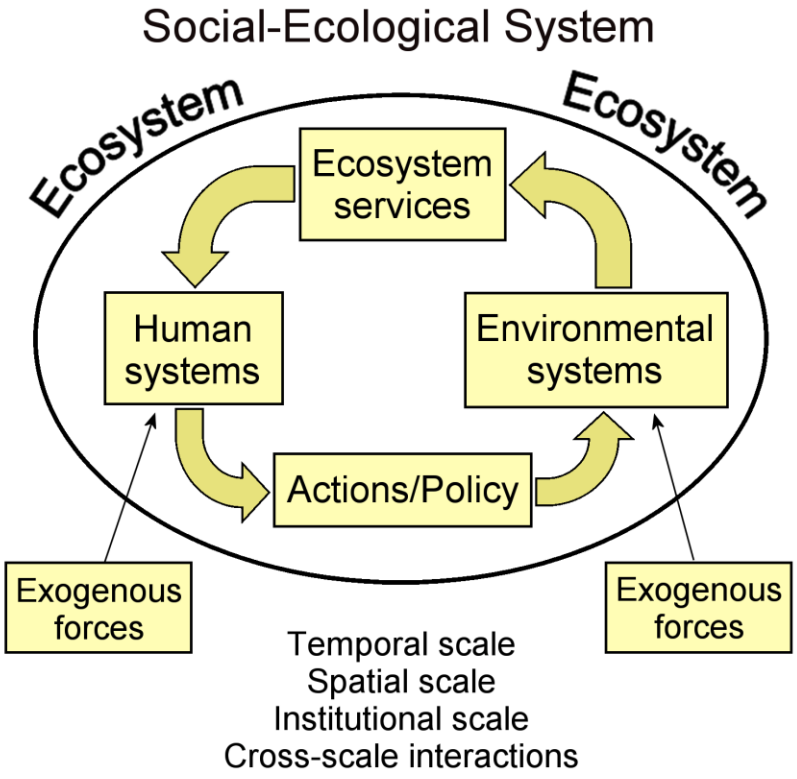
Natural Resource Ecology Laboratory

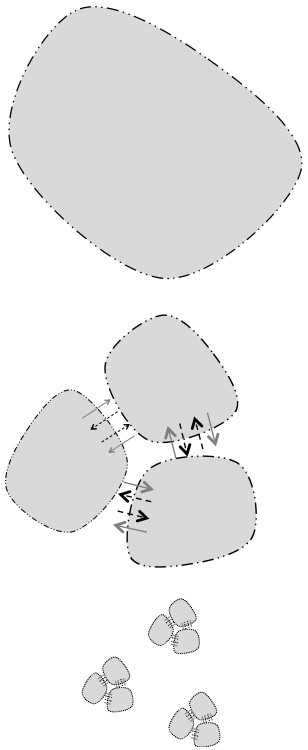
Colorado State University

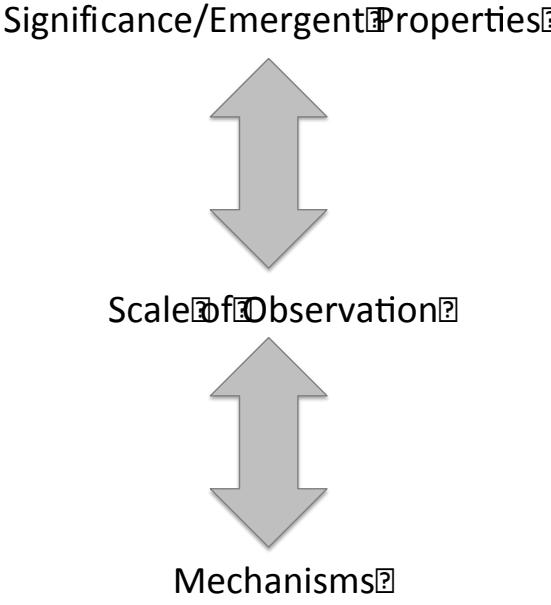
Department of Ecosystem Science and Sustainability

System Thinking

System Thinking is the process of understanding how components of a system interact and respond to disturbance, yet influence one another to act a whole.







Research
Learning Progressions

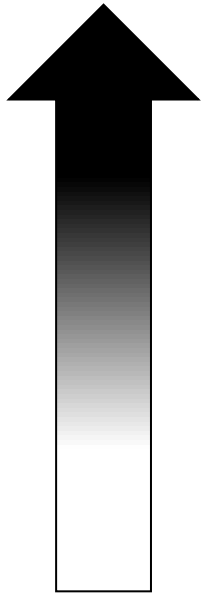
Learning progressions are descriptions of increasingly sophisticated ways of thinking about a subject

Anchored at the lower end by what we know about how younger students reason

Anchored at upper end by what experts in the field believe students should understand when they graduate

Level of achievement	Type of account (explanations & predictions)	Elements of accounts	
		Structure & systems	Scientific principles
Level 4: Model-based accounts	Scientific, model-based accounts of how and why events happen	Multiple, detailed connected systems	Driving forces & constraining factors
Level 3: School science accounts	Primarily descriptions of what happens	Connected systems, including visible and some hidden components	Puts events in order, names processes, uses "school rules"
Levels 1 & 2: Force-dynamic accounts	Force-dynamic perspectives of events	Visible, familiar components of systems	Force-dynamic reasoning

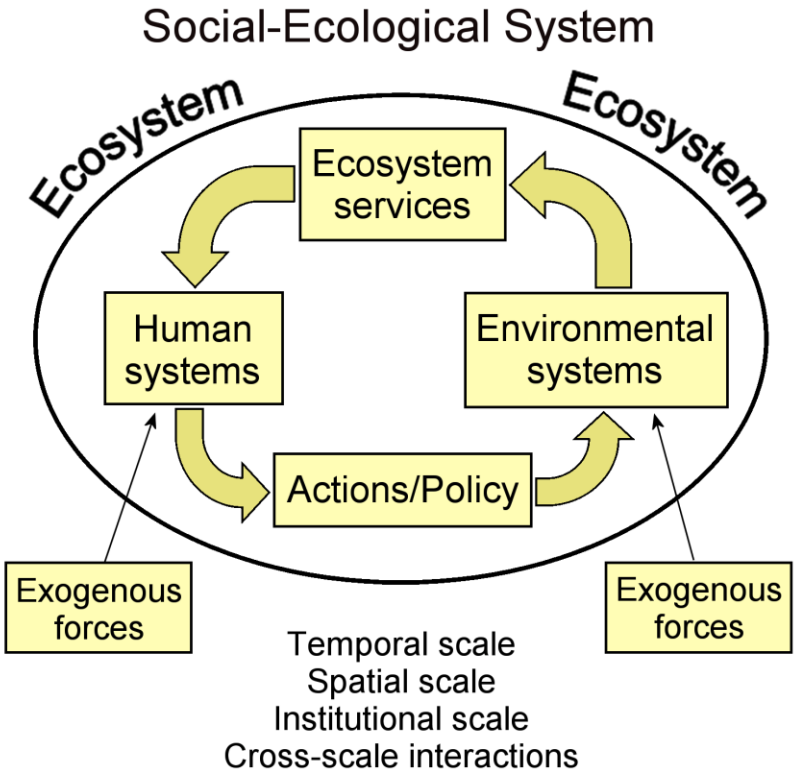
Scientific Reasoning
What high school students should know and be able to do

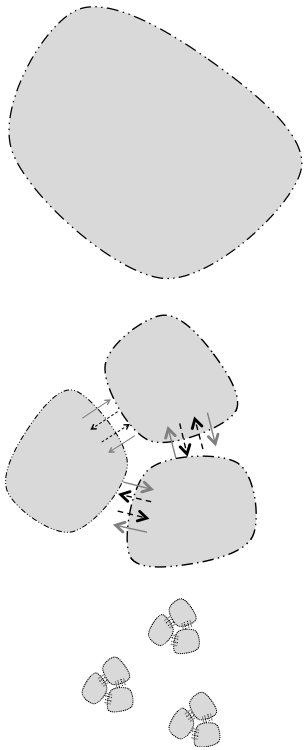


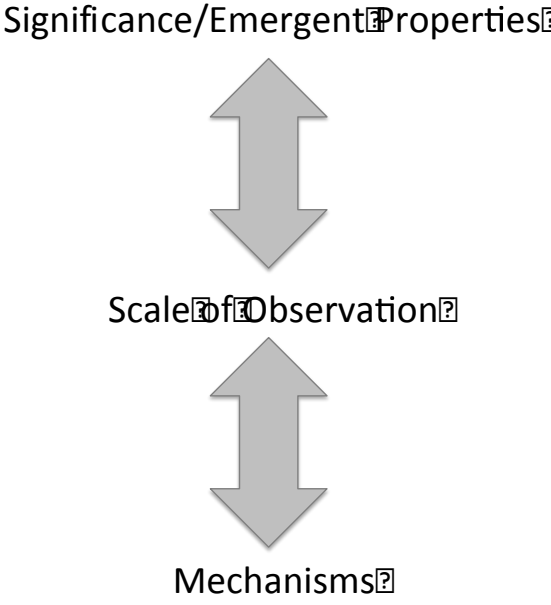
Informal Ideas
How children think about and make sense of the world

System Thinking

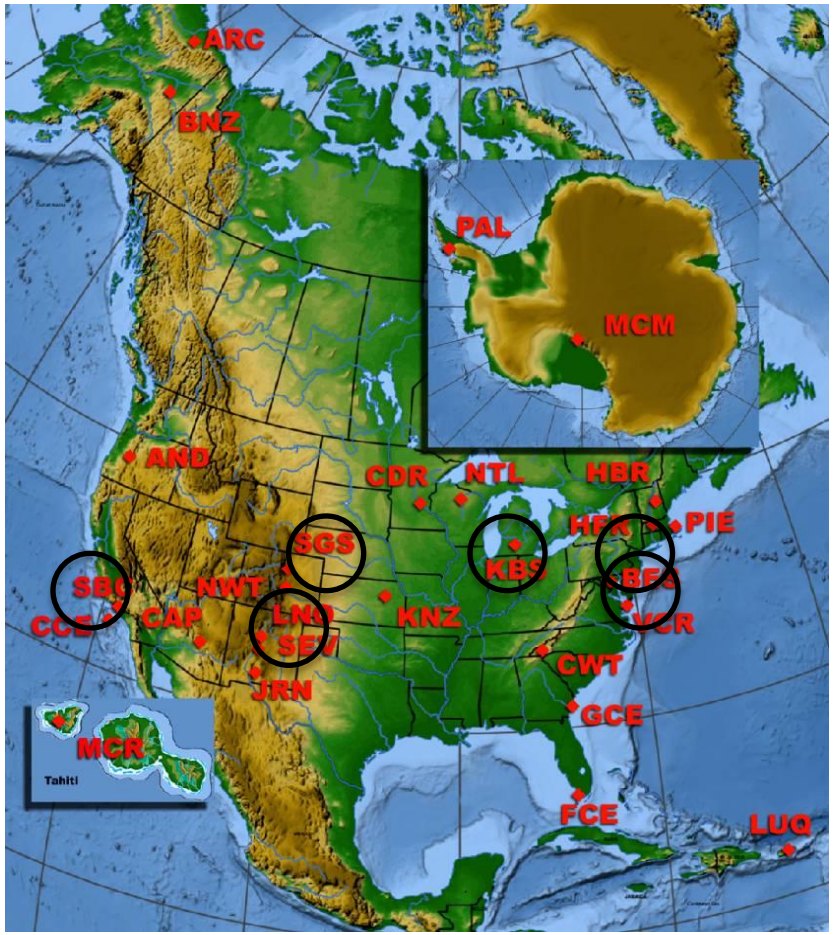
System Thinking is the process of understanding how components of a system interact and respond to disturbance, yet influence one another to act a whole.







MSP – Pathways to Environmental Literacy

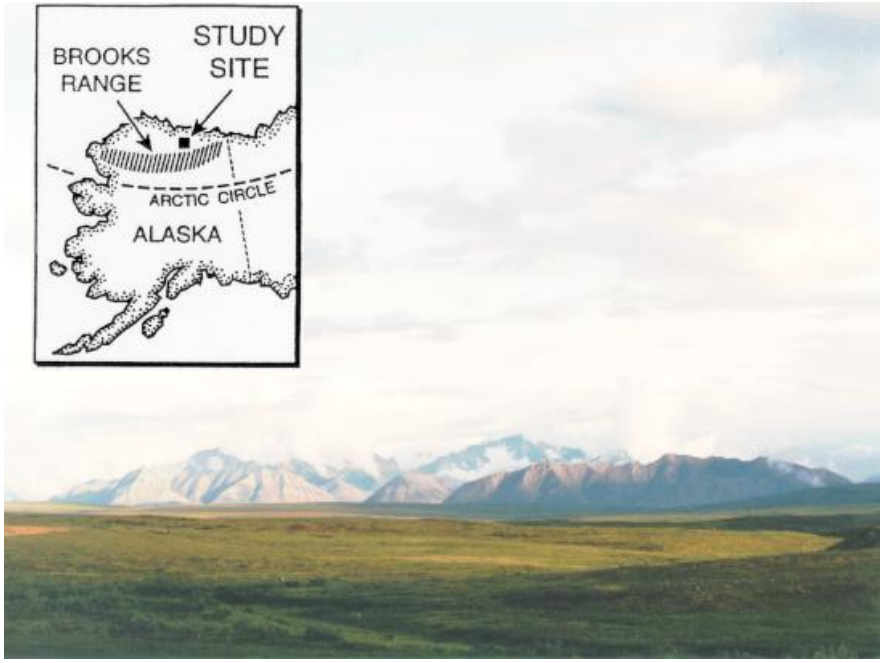


The topics we study are organized as dynamic hierarchical systems.

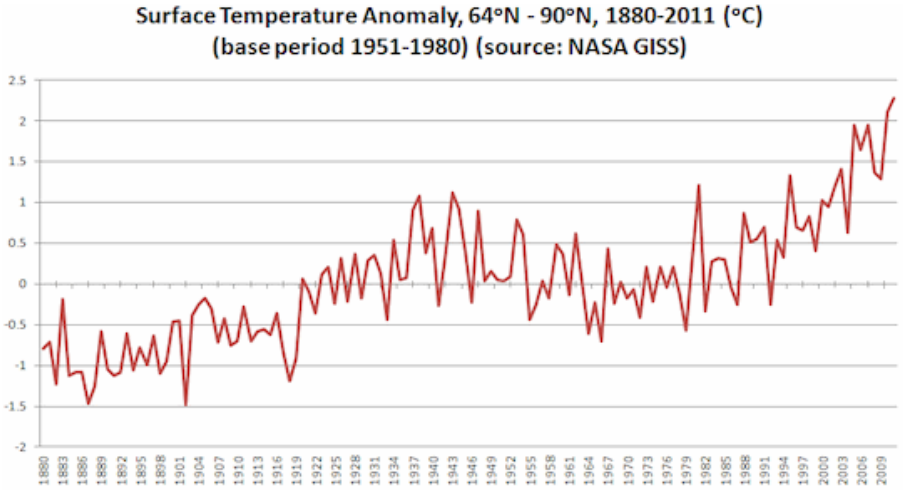
The topics may include multiple principles operating simultaneously.

The relationships among the principles in terms of their relative importance to the topic change as one moves up and down the hierarchy.

The questions we ask when developing learning progression define a pivotal node, level, or scale within the hierarchy that serves as an entry point for the student.

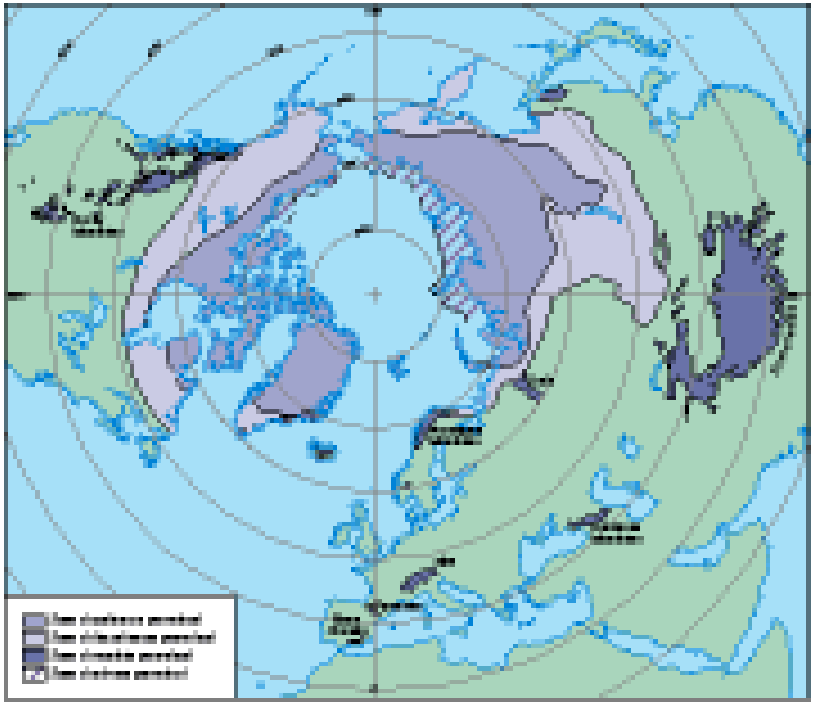


Climate Change in the Arctic

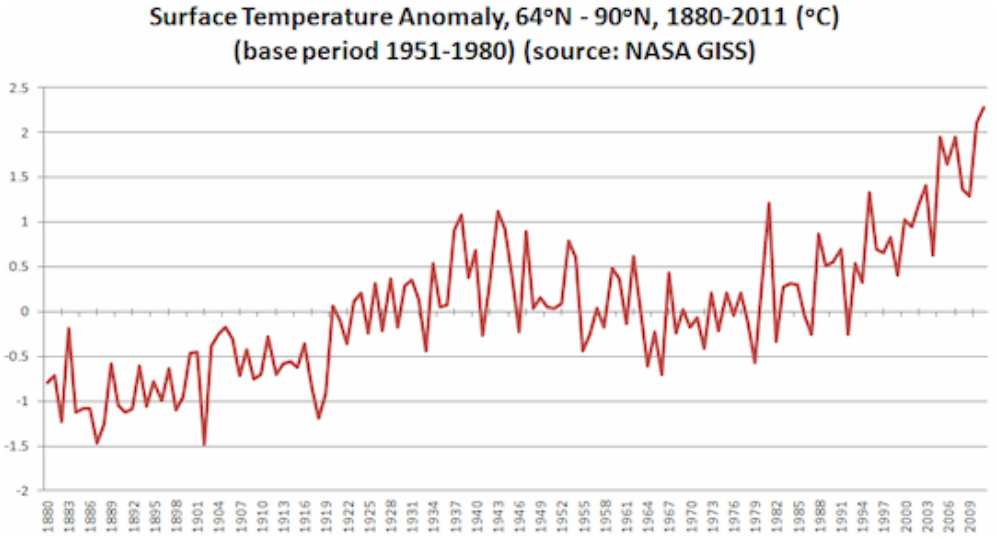


Control

Fertilized



Permafrost

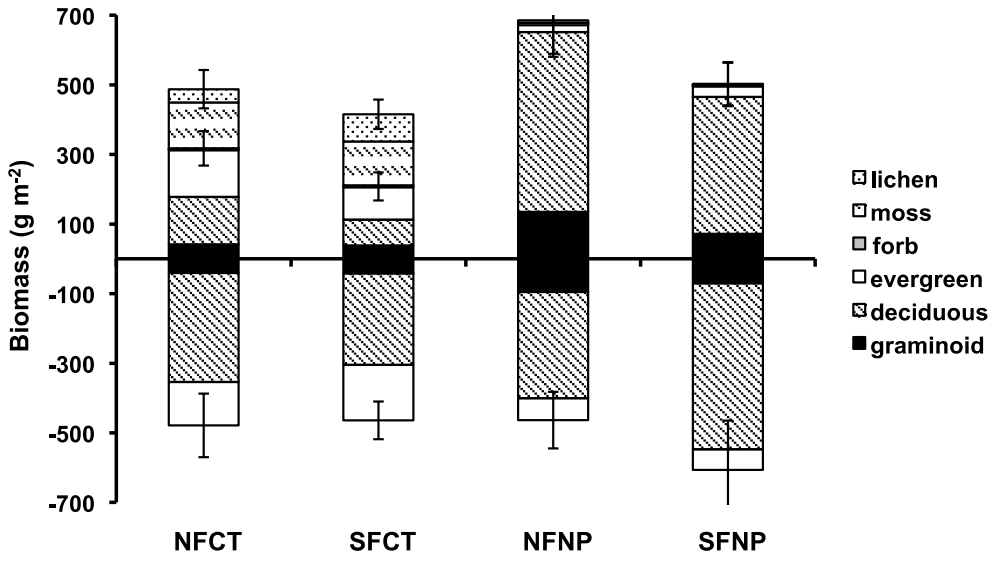


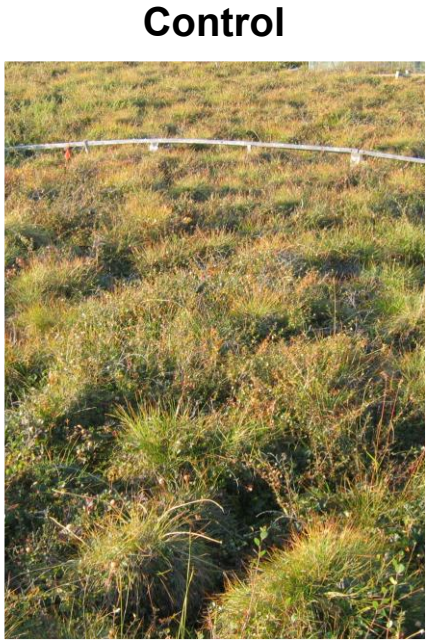
Increase in the active layer

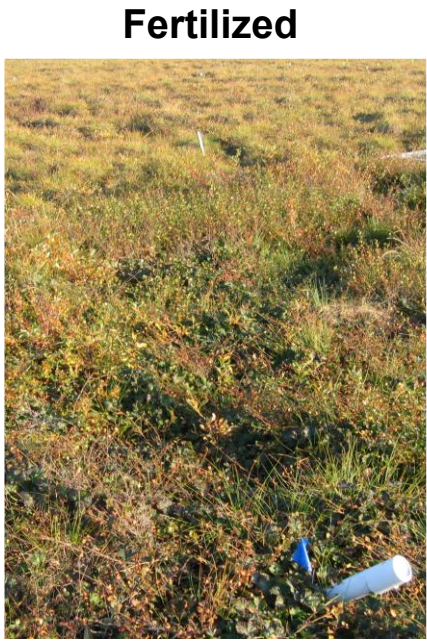
Increase in available N

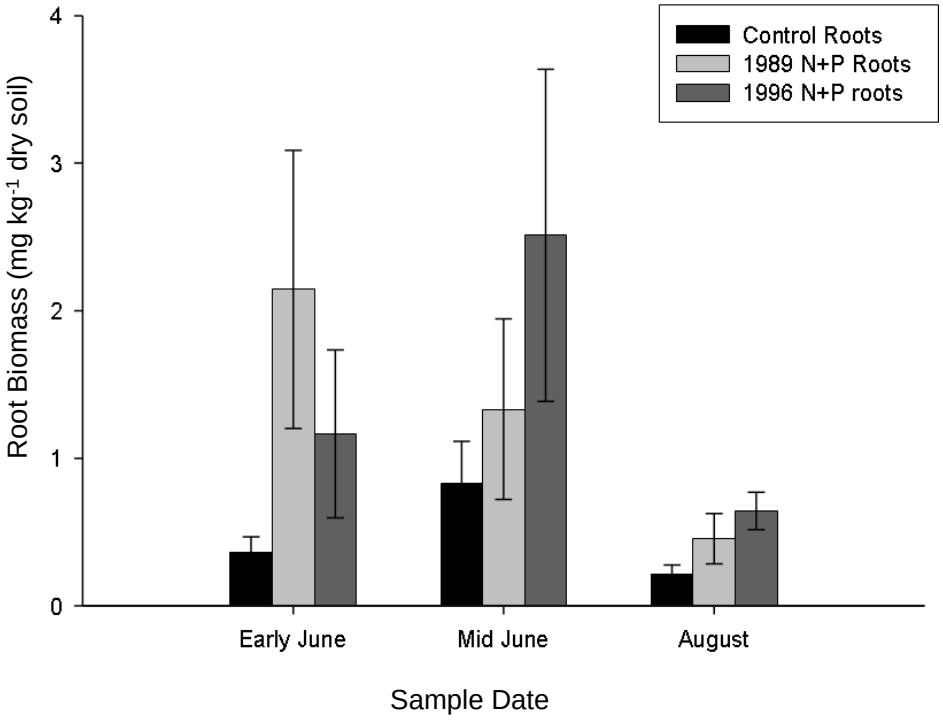
Alterations in the plant community

Increase in decomposition rates (?)







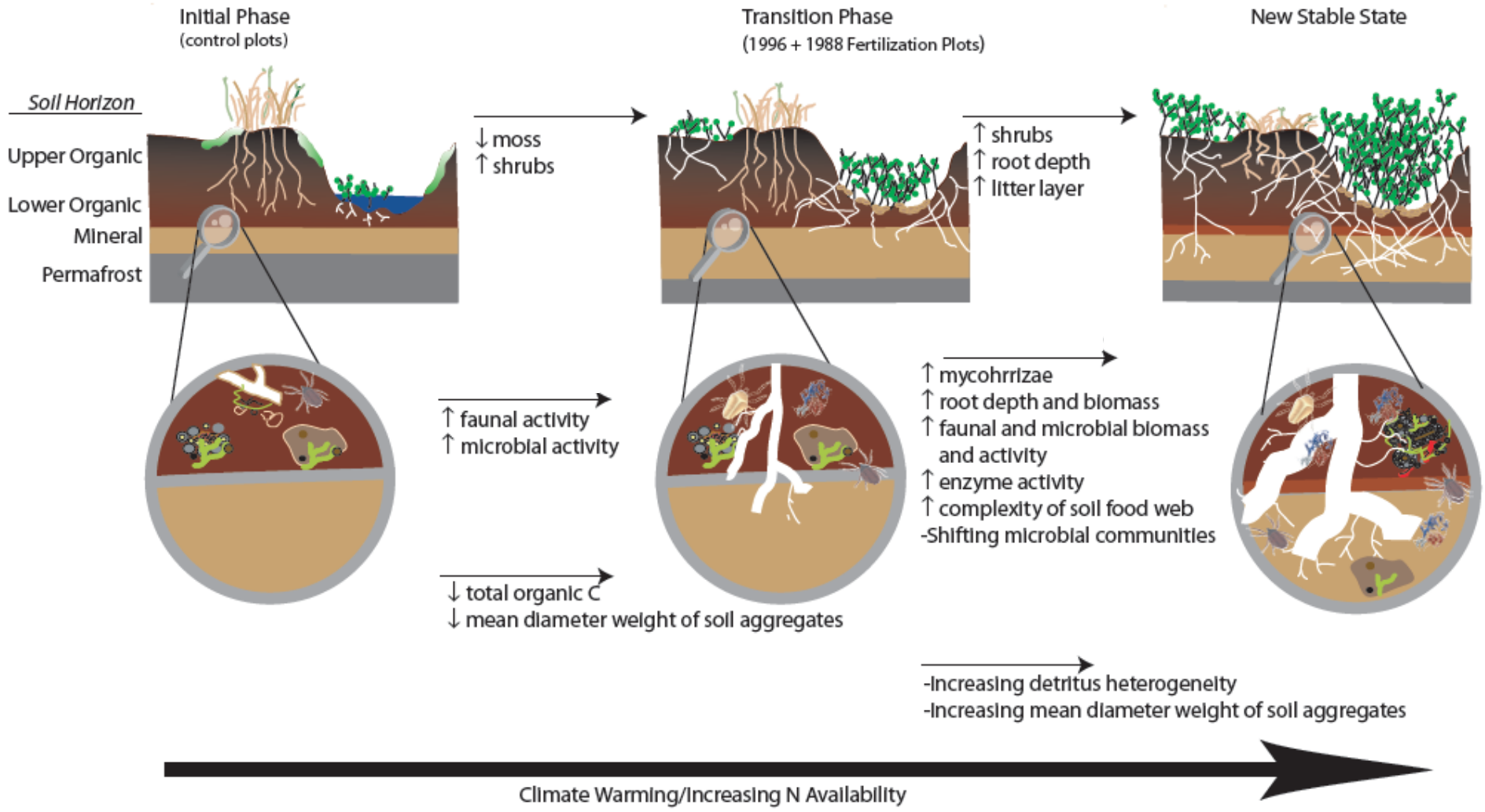


Aboveground

- Increase in shrub
- Decrease in mosses and lichens

Belowground

- Increase in roots


Initial Phase
(control plots)
Transition Phase
(1996 + 1988 Fertilization Plots)
New Stable State
Soil Horizon
Upper Organic
Lower Organic
Mineral
Permafrost
↓ moss
↑ shrubs
↑ shrubs
↑ root depth
↑ litter layer
↑ faunal activity
↑ microbial activity
↑ mycohrrizae
↑ root depth and biomass
↑ faunal and microbial biomass
and activity
↑ enzyme activity
↑ complexity of soil food web
-Shifting microbial communities
↓ total organic C
↓ mean diameter weight of soil aggregates
-Increasing detritus heterogeneity
-Increasing mean diameter weight of soil aggregates
Climate Warming/Increasing N Availability

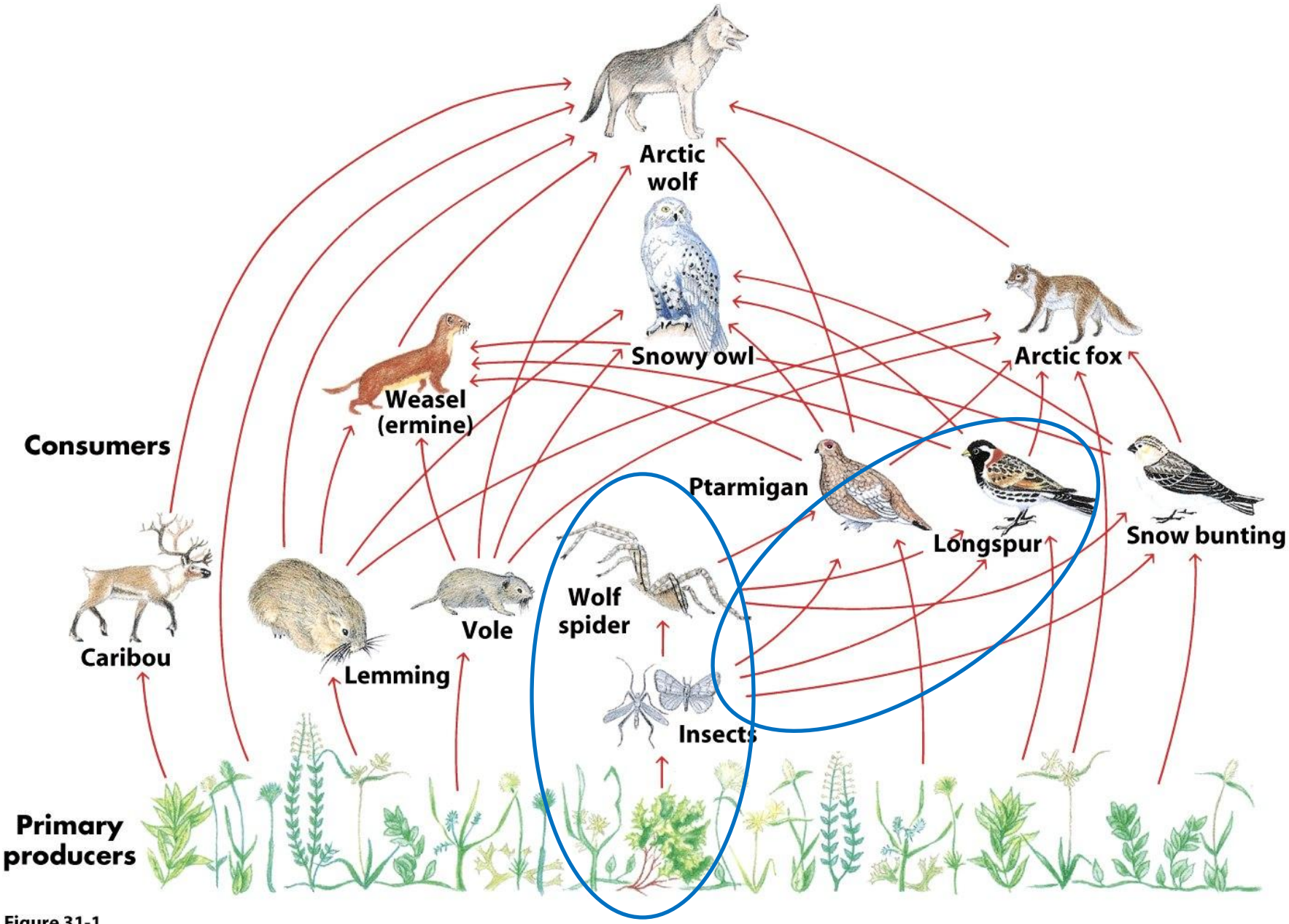
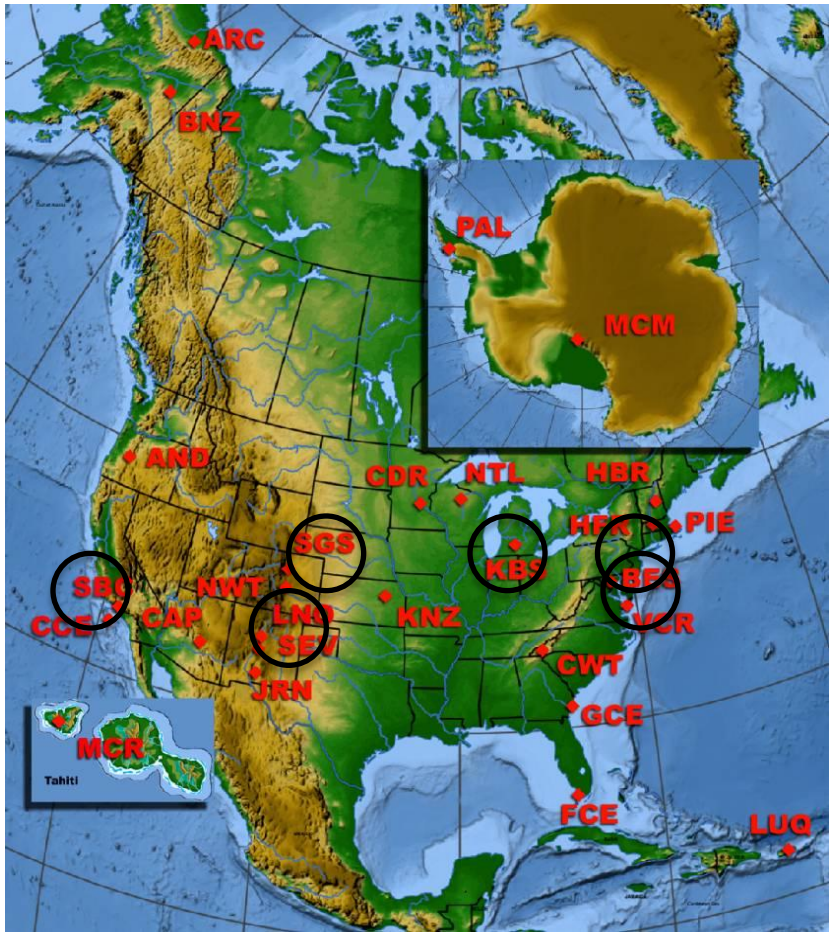


Figure 31-1
Biology of Plants, Seventh Edition

MSP – Pathways to Environmental Literacy



The topics we study are organized as dynamic hierarchical systems.

The topics may include multiple principles operating simultaneously.

The relationships among the principles in terms of their relative importance to the topic change as one moves up and down the hierarchy.

The questions we ask when developing learning progression define a pivotal node, level, or scale within the hierarchy that serves as an entry point for the student.

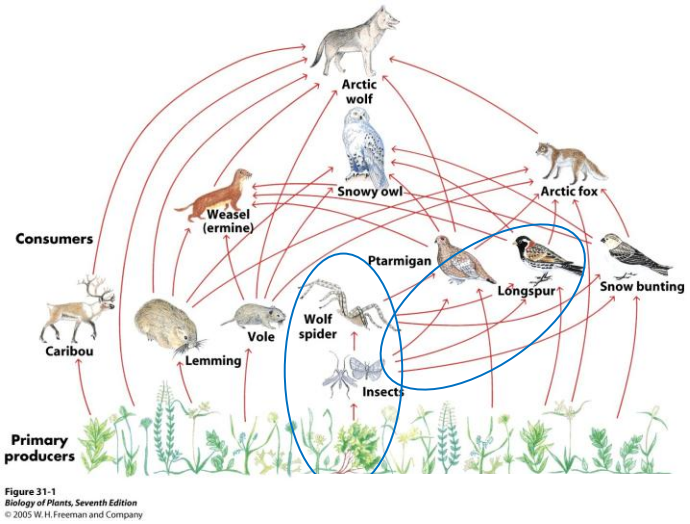
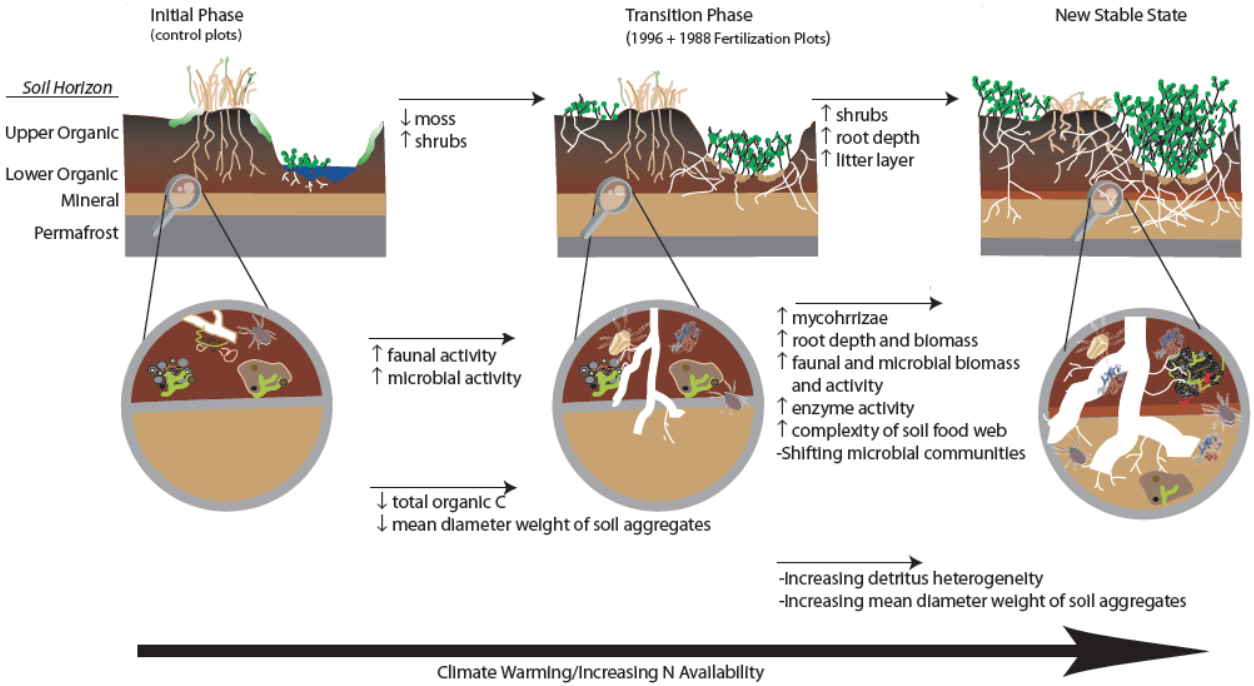


Figure 31-1
Biology of Plants, Seventh Edition

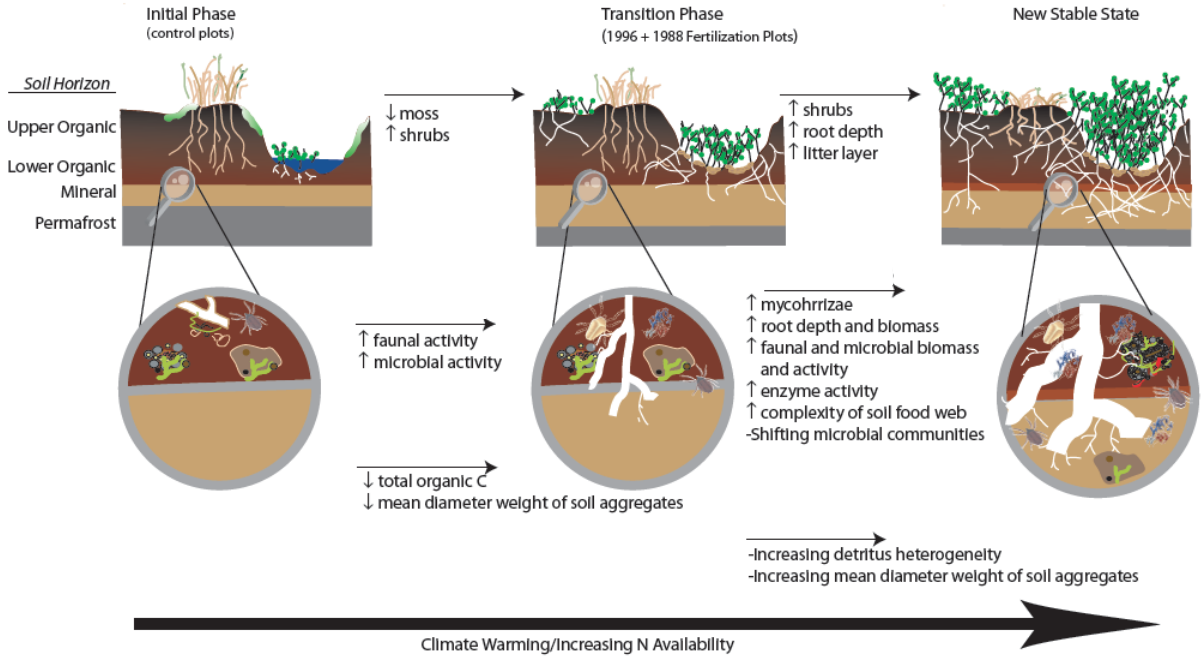
The topics we study are organized as dynamic hierarchical systems.

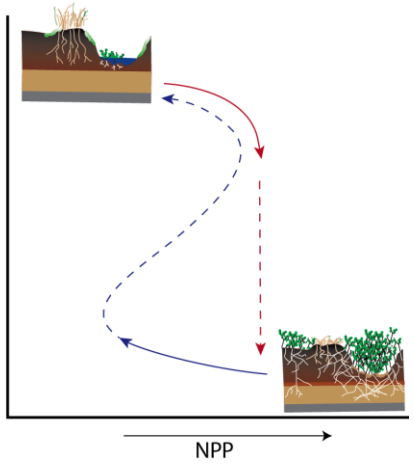
Level	*Dominant Principle(s)*
Molecular/Cellular	Genetics and Evolution
Individual/Species	Genetics and Evolution/Thermodynamics
Population/Species	Genetics and Evolution/Thermodynamics
Community/Multiple Species	Thermodynamics/Systems Theory
Ecosystem	Thermodynamics/Systems Theory

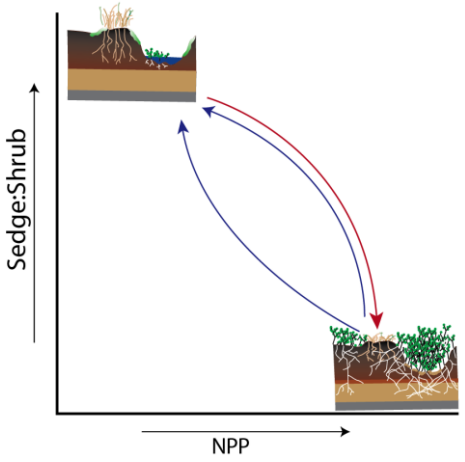


The topics may include multiple principles operating simultaneously.

Level	*Dominant Principle(s)*
Molecular/Cellular	Genetics and Evolution
Individual/Species	Genetics and Evolution/Thermodynamics
Population/Species	Genetics and Evolution/Thermodynamics
Community/Multiple Species	Thermodynamics/Systems Theory
Ecosystem	Thermodynamics/Systems Theory

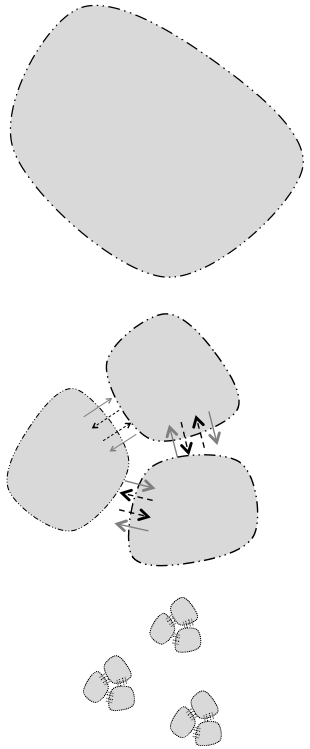






The relationships among the principles in terms of their relative importance to the topic change as one moves up and down the hierarchy.

Level	*Dominant Principle(s)*
Molecular/Cellular	Genetics and Evolution
Individual/Species	Genetics and Evolution/Thermodynamics
Population/Species	Genetics and Evolution/Thermodynamics
Community/Multiple Species	Thermodynamics/Systems Theory
Ecosystem	Thermodynamics/Systems Theory



Significance/Emergent Properties

Scale of Observation

Mechanisms

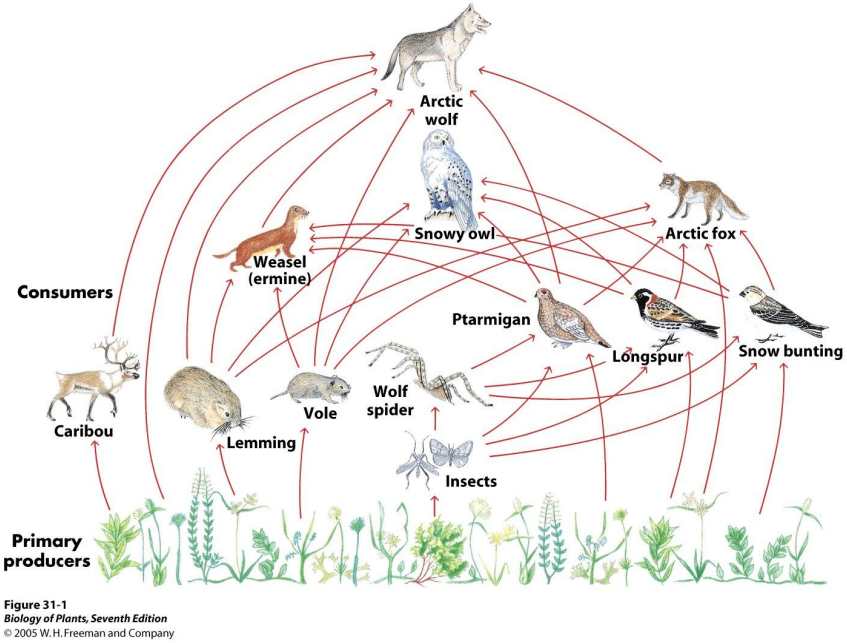


Figure 31-1
Biology of Plants, Seventh Edition

MSP – Pathways to Environmental Literacy

The questions we ask when developing learning progression define a pivotal node, level, or scale within the hierarchy that serves as an entry point for the student.

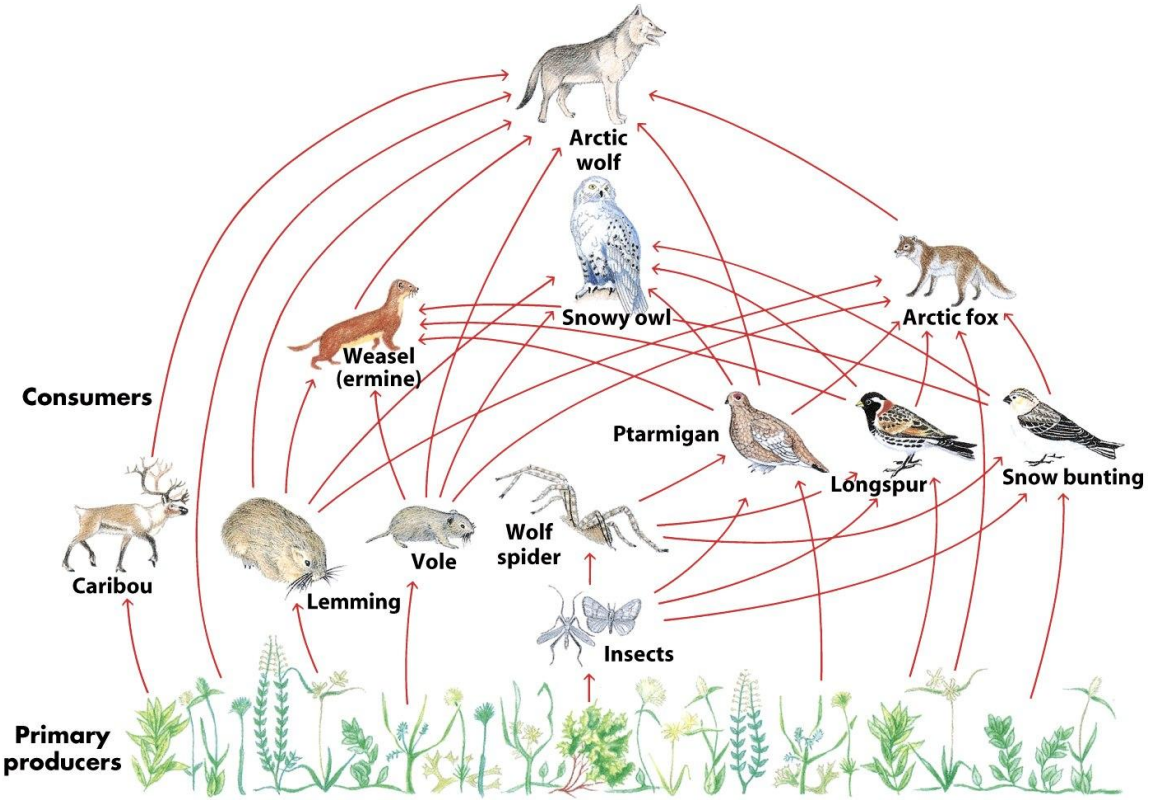
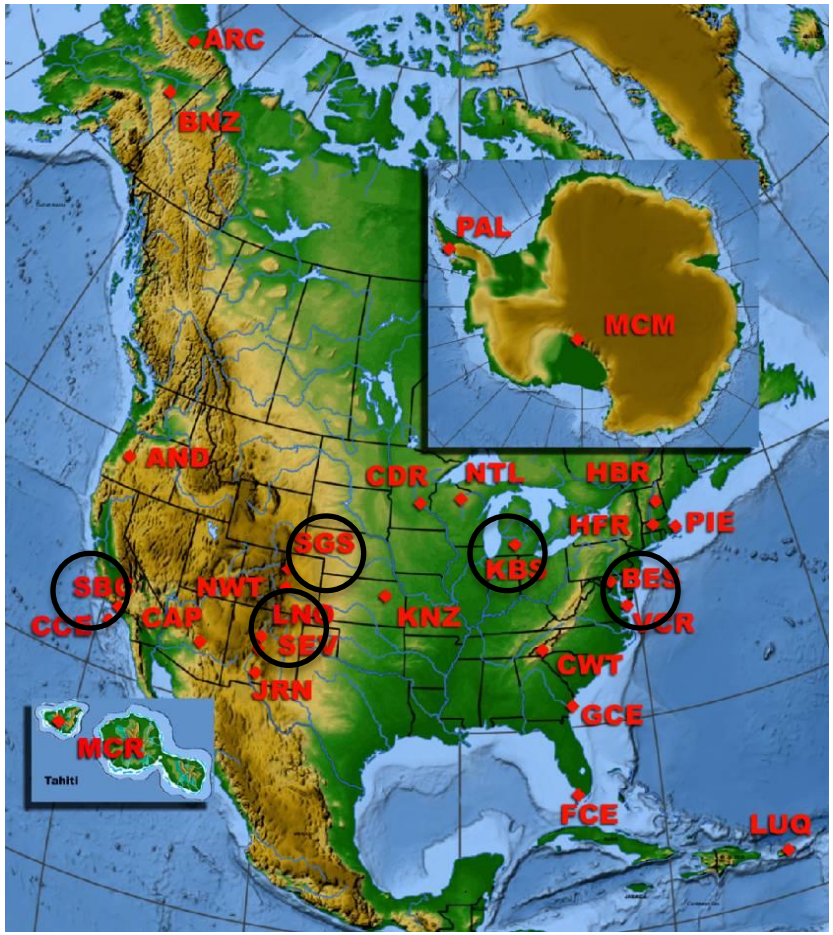


Figure 31-1
Biology of Plants, Seventh Edition

MSP – Pathways to Environmental Literacy



Hartley et al. – Disturbance and communities

Doherty et al. – Disturbance and Evolution

Wyner and Doherty – Pivotal nodes and entry points

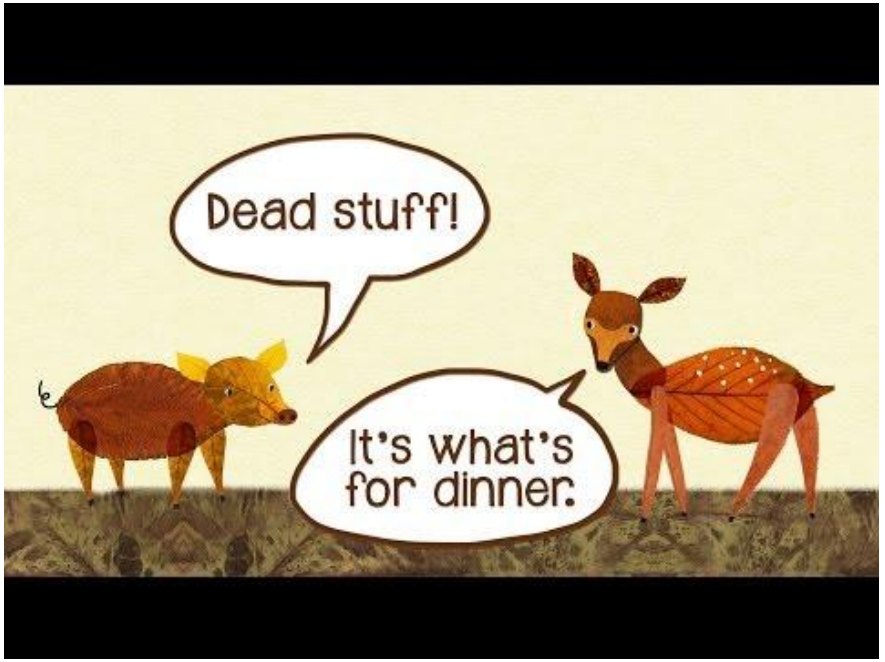
Energetic Food Webs

An Analysis of Real and Model Ecosystems

John C. Moore
Peter C. de Ruiter

Oxford Series in Ecology and Evolution

TED Ed



http://ed.ted.com/lessons/dead-stuff-the-secret-ingredient-in-our-food-chain-john-c-moore