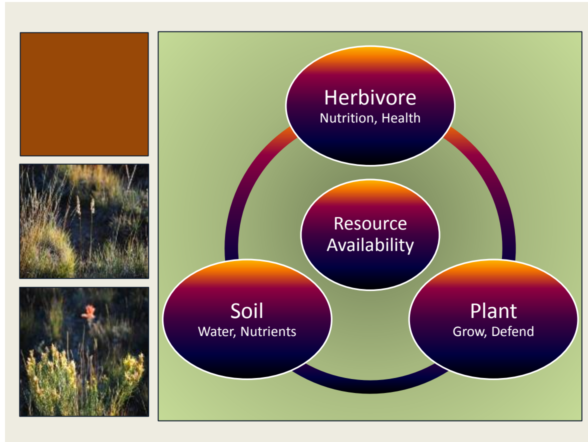
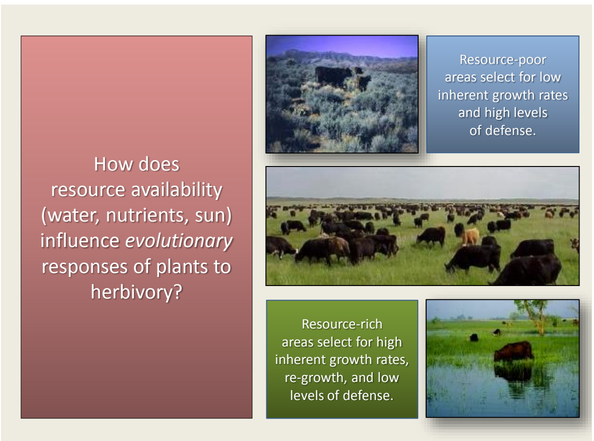
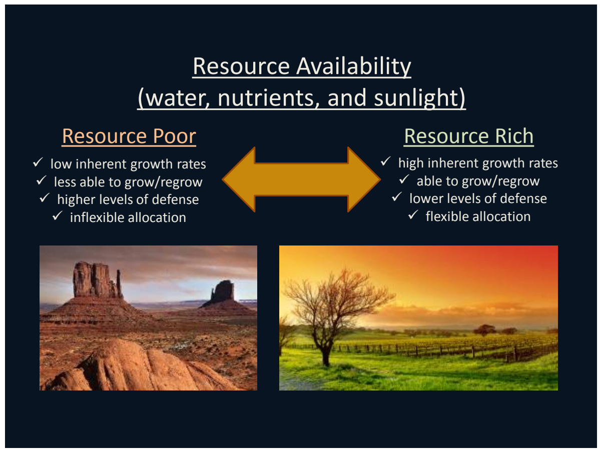
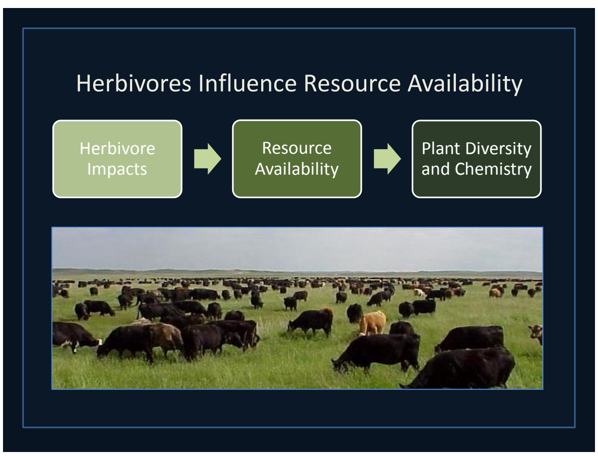
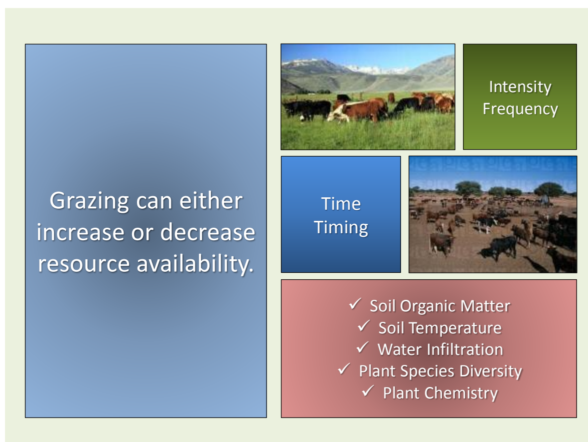
Plant Behavior



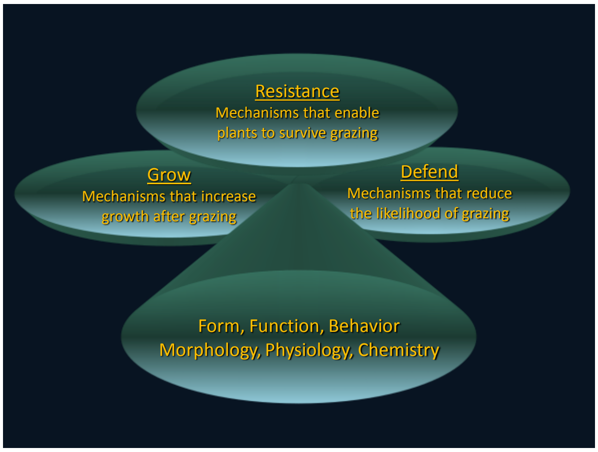


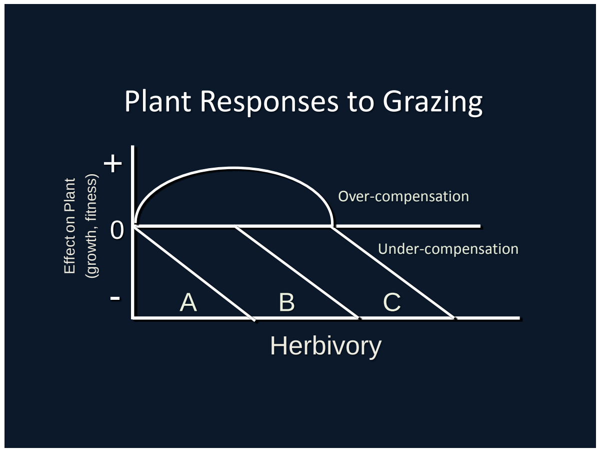


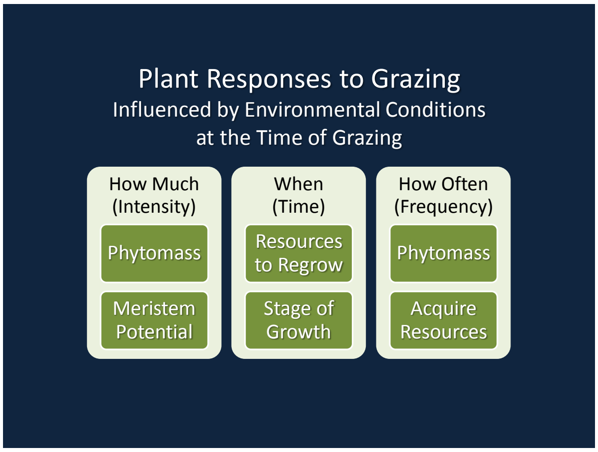


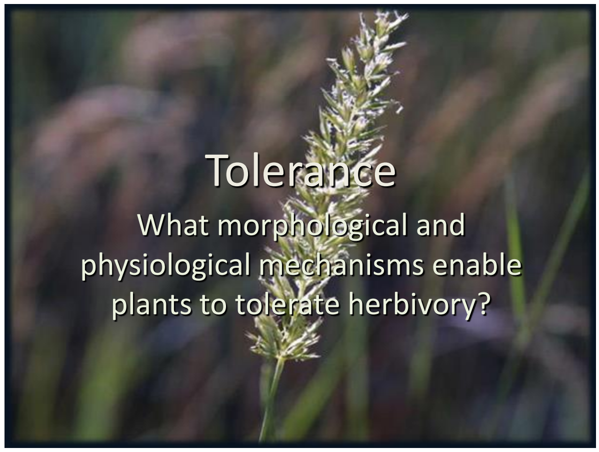


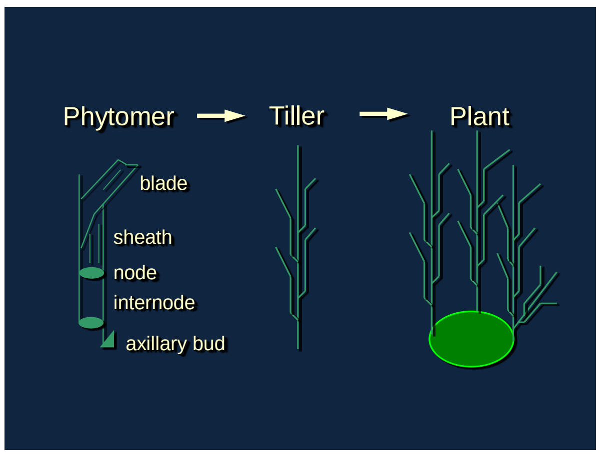
Plant Behavior

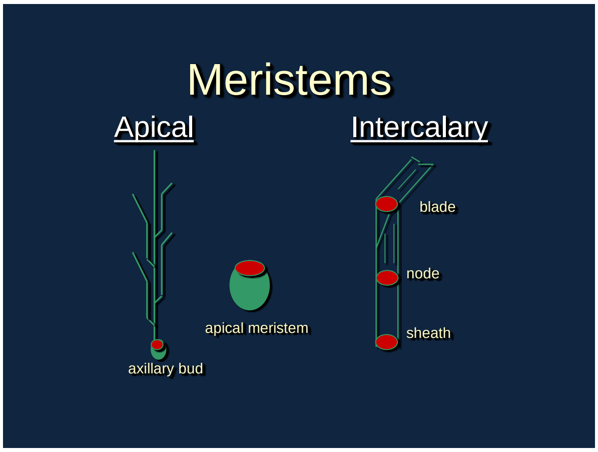


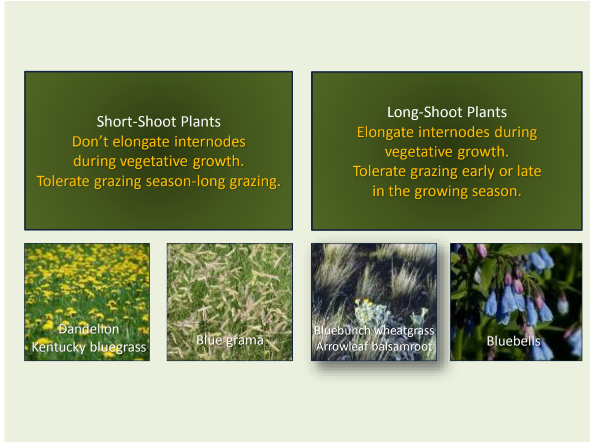


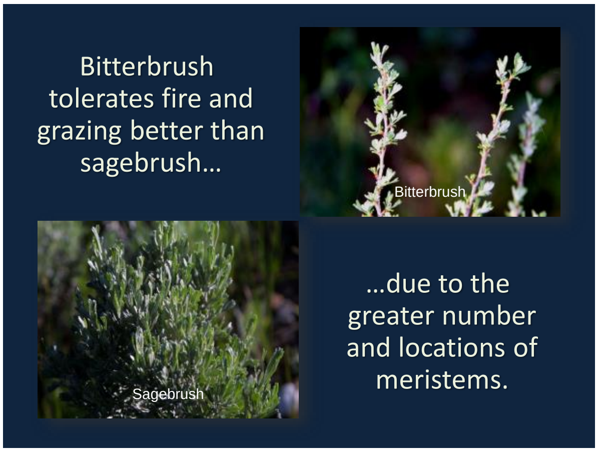






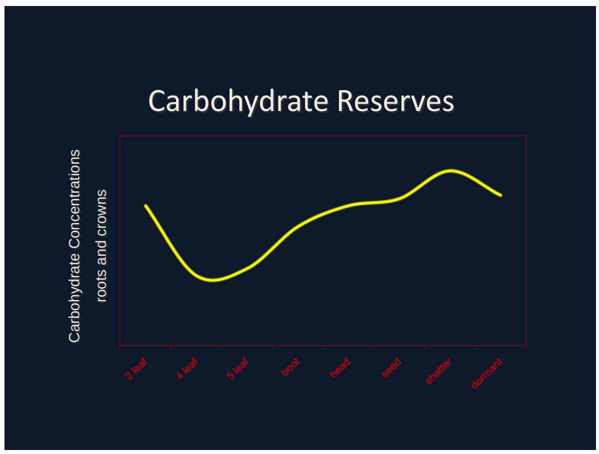

Meristems
Apical
Intercalary
blade
node
sheath
apical meristem
axillary bud

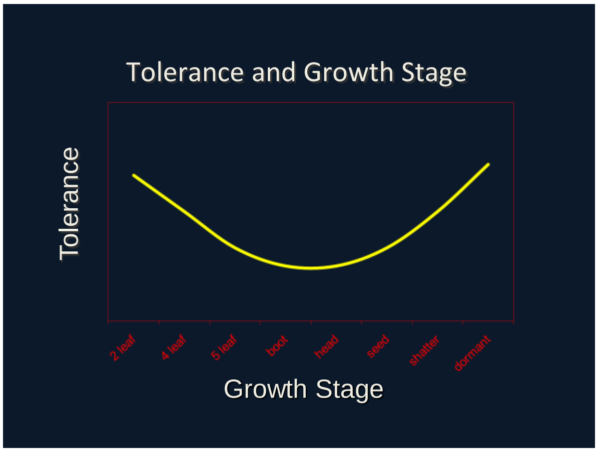

Short-Shoot Plants
Don't elongate internodes
during vegetative growth.
Tolerate grazing season-long grazing.
Long-Shoot Plants
Elongate internodes during
vegetative growth.
Tolerate grazing early or late
in the growing season.
Dandelion
Kentucky bluegrass
Blue grama
Bluebunch wheatgrass
Arrowleaf balsamroot
Bluebells


Bitterbrush
tolerates fire and
grazing better than
sagebrush…
Bitterbrush
Sagebrush
…due to the
greater number
and locations of
meristems.

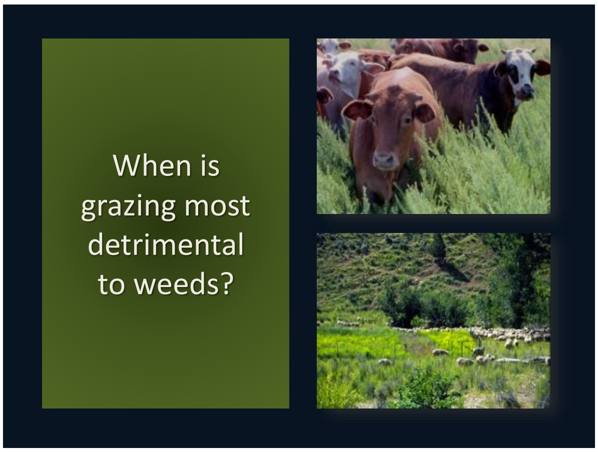

Physiological Characteristics
Carbohydrate Reserves
Competitive Ability

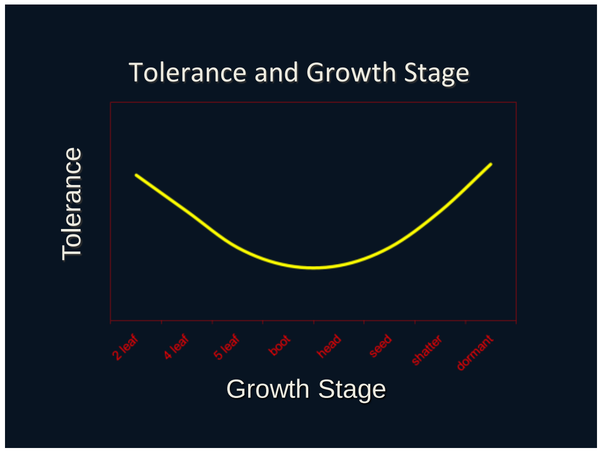

Bluebunch wheatgrass
and crested wheatgrass are
similar in many characteristics,
Bluebunch Wheatgrass
Crested Wheatgrass
…but crested wheatgrass tolerates
grazing much better than does
bluebunch, even though they have
similar carbohydrate reserves. Why?

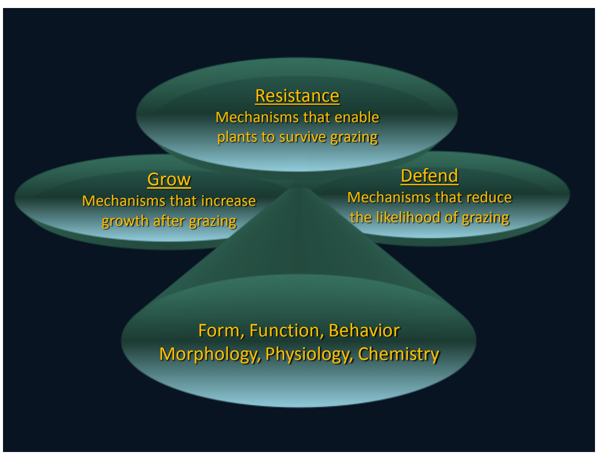

Carbohydrate Reserves
Carbohydrate Concentrations
roots and crowns
2 leaf
4 leaf
5 leaf
boot
head
seed
shatter
dormant

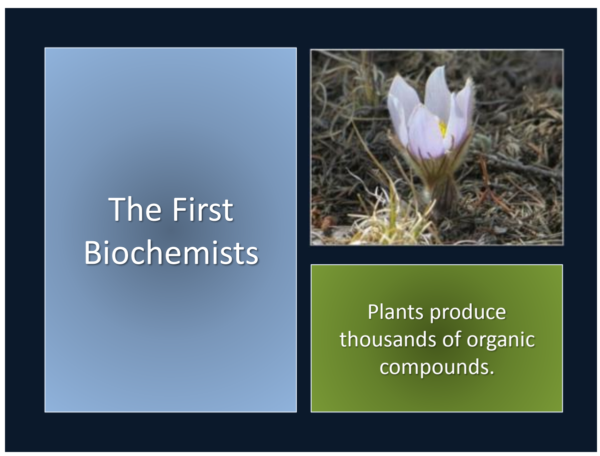

Tolerance and Growth Stage
Tolerance
2 leaf
4 leaf
5 leaf
boot
head
seed
shatter
dormant
Growth Stage


Crested wheatgrass competes better than bluebunch wheatgrass for resources.
Crested wheatgrass regrows much more quickly after grazing.
Crested Wheatgrass-Sagebrush
Bluebunch Wheatgrass-Sagebrush

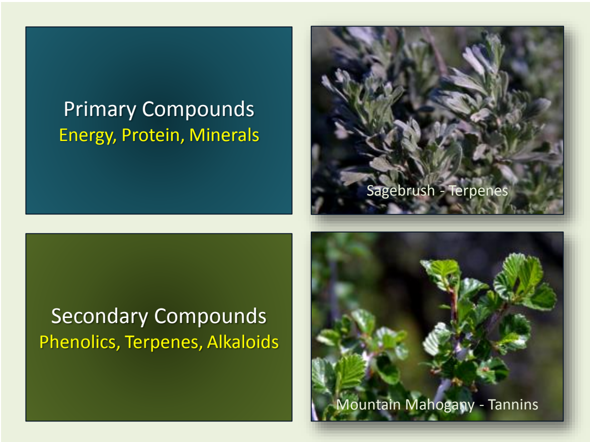

When is grazing most detrimental to weeds?

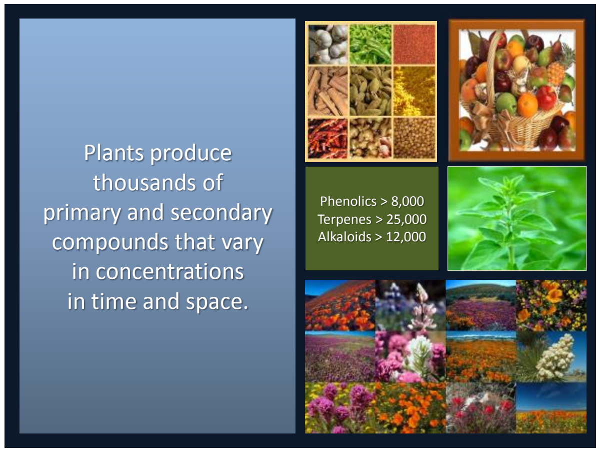

Tolerance and Growth Stage
Tolerance
2 leaf
4 leaf
5 leaf
boot
head
seed
shatter
dormant
Growth Stage

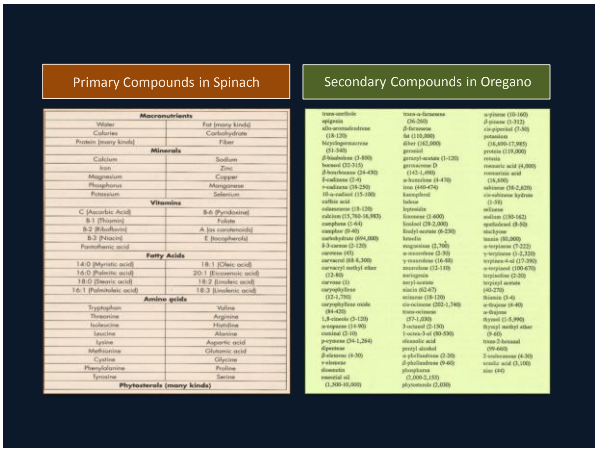

Resistance
Mechanisms that enable plants to survive grazing
Grow
Mechanisms that increase growth after grazing
Defend
Mechanisms that reduce the likelihood of grazing
Form, Function, Behavior
Morphology, Physiology, Chemistry

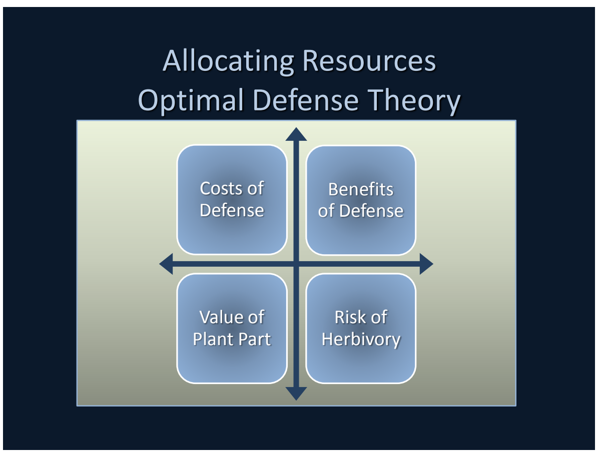

The First Biochemists
Plants produce thousands of organic compounds.

Plant Behavior









Defenses are costly.
The cost of defense is due to diversion of energy and nutrients from other needs.

Costs of Defense

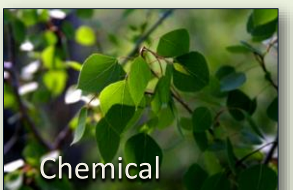
Synthesis
raw materials, biosynthetic machinery
Storage
storage sites, enzymes to degrade secondary compounds
Transport
extra and intracellular movement
Maintenance
volatilization, leaching, exudation

Commitment to defense is a positive function of the energy and nutrient budget of a plant and is negatively related to growth and reproduction.

Wild tobacco allocates fewer resources to growth and reproduction when it is allocating resources to defense.

Commitment to defense is decreased when enemies are absent and increased when plants are subjected to attack.

Induced defenses are produced when plants are attacked



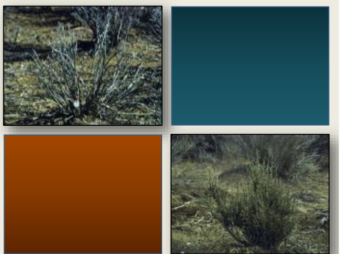
Less well defended individuals have higher fitness than more highly defended individuals when herbivores are absent.

Plant Behavior

Within species, individuals with low levels of defense outcompete those with high levels of defense in the absence of herbivores.

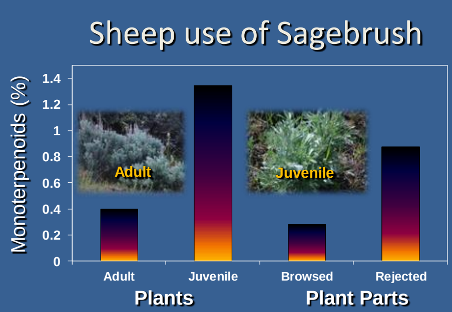
More valuable plants and plant parts (young vs. mature) are more highly defended than less valuable plants and plant parts.

Young plants and plant parts are more highly defended than older plants and plant parts.

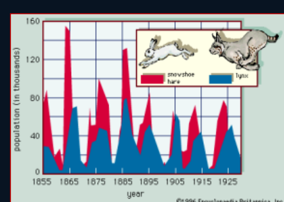


Heavy browsing by goats during winter stimulates production of new twigs that are much higher in tannins.

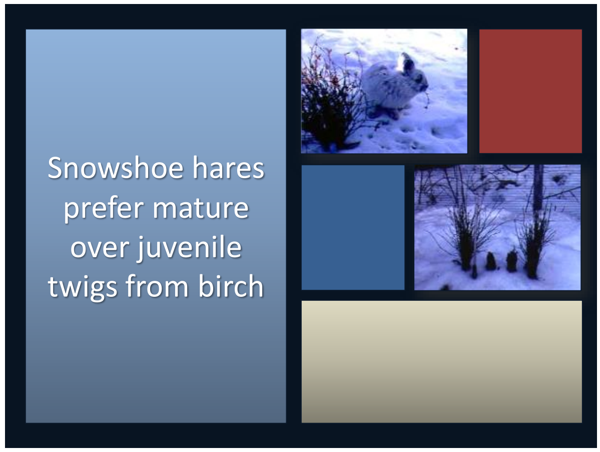
Juvenile vs. Mature Growth Stages Woody of Plants

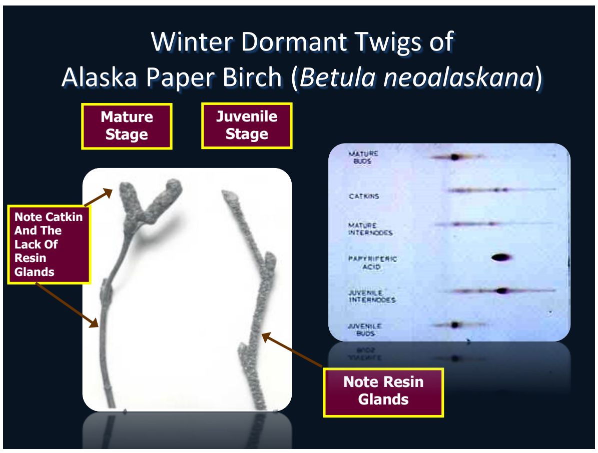


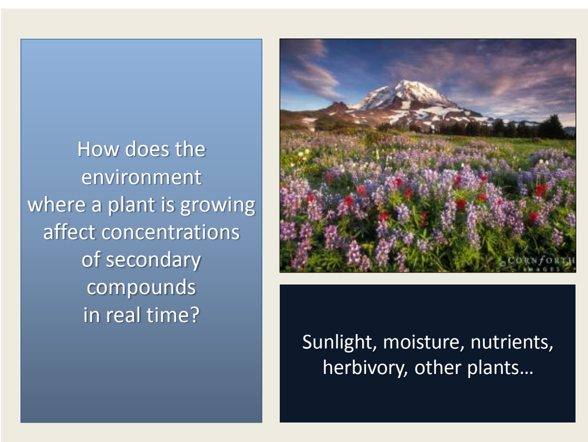
Snowshoe hares and lynx cycle at 10-year intervals in Canada and Alaska.

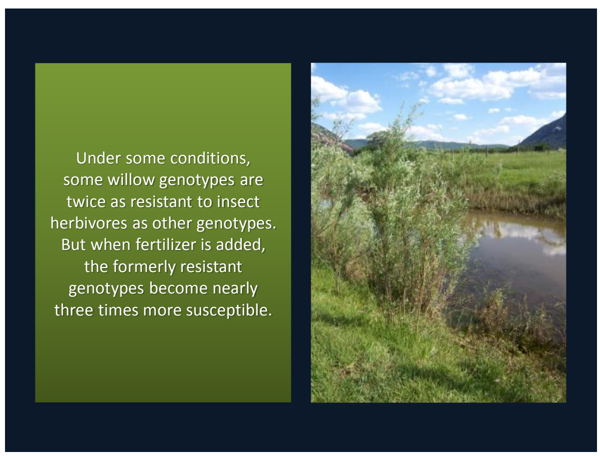



Fire → Alaska Paper Birch → Hares →
Highly Defended (papyriferic acid) Juvenile
Growth Stage in Birch → Hares Crash

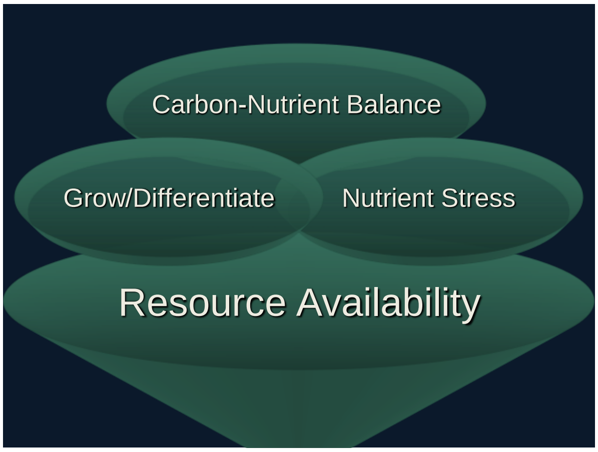

Snowshoe hares prefer mature over juvenile twigs from birch

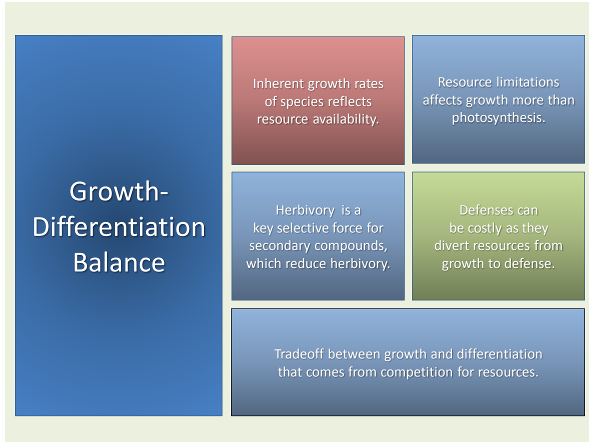

Winter Dormant Twigs of
Alaska Paper Birch (*Betula neoalaskana*)
Mature Stage
Juvenile Stage
Note Catkin And The Lack Of Resin Glands
MATURE BUDS
CATKINS
MATURE INTERNODES
PAPYRIFERIC ACID
JUVENILE INTERNODES
JUVENILE BUDS
Note Resin Glands

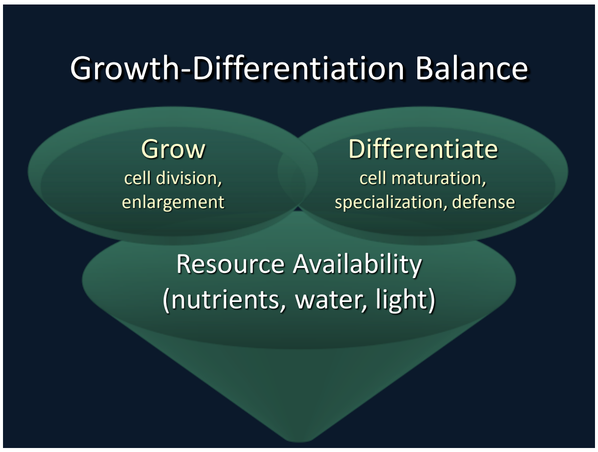

How does the environment where a plant is growing affect concentrations of secondary compounds in real time?
Sunlight, moisture, nutrients, herbivory, other plants…

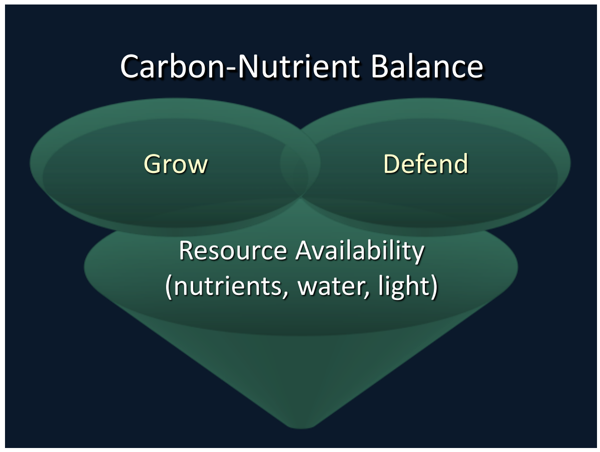

Under some conditions, some willow genotypes are twice as resistant to insect herbivores as other genotypes. But when fertilizer is added, the formerly resistant genotypes become nearly three times more susceptible.

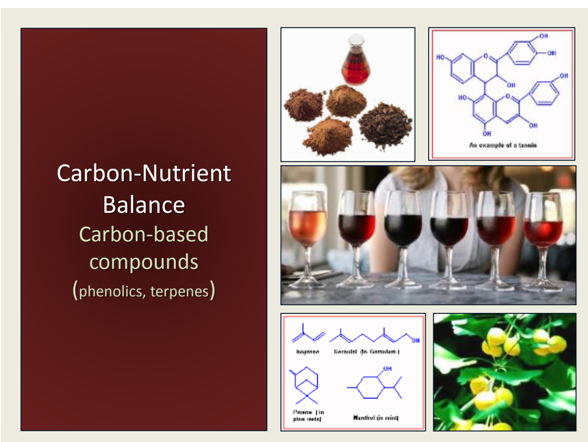
Plant Behavior

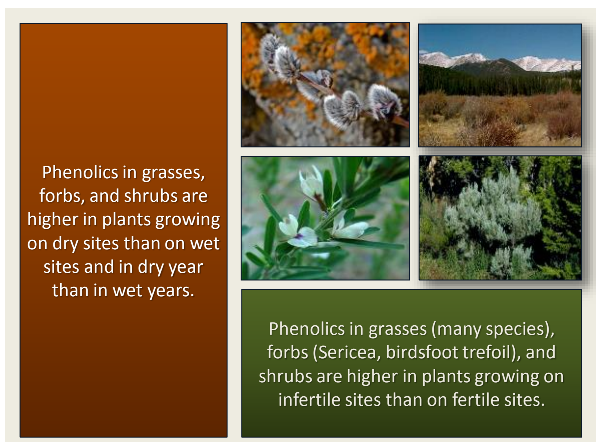




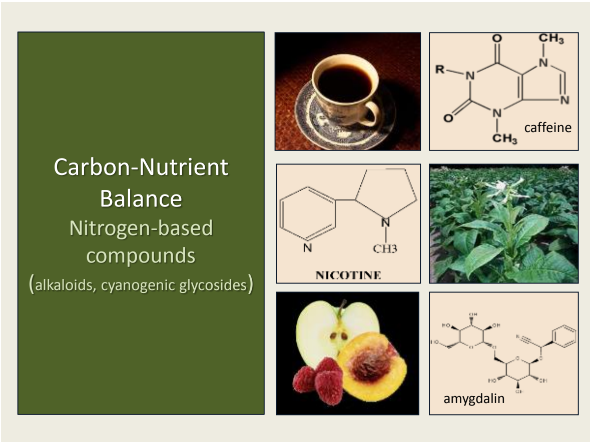


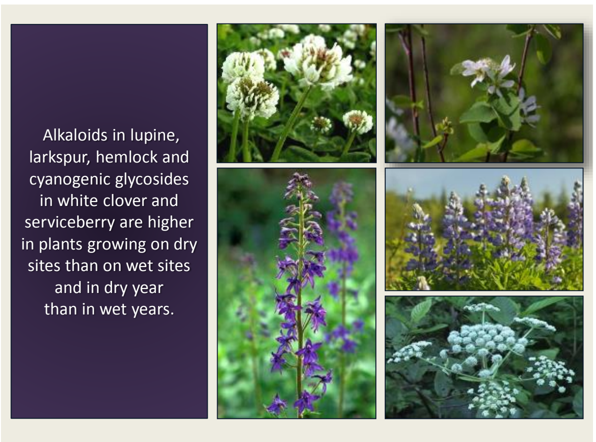


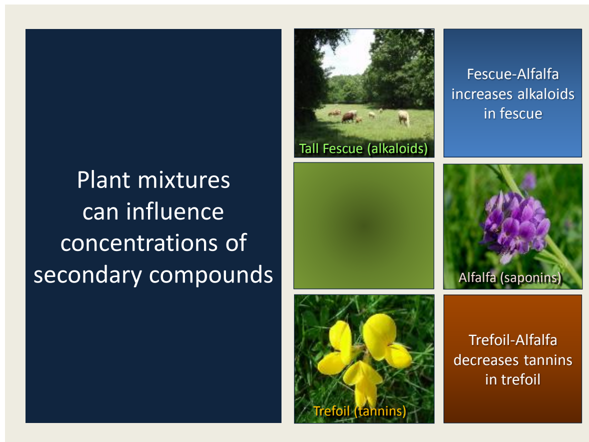


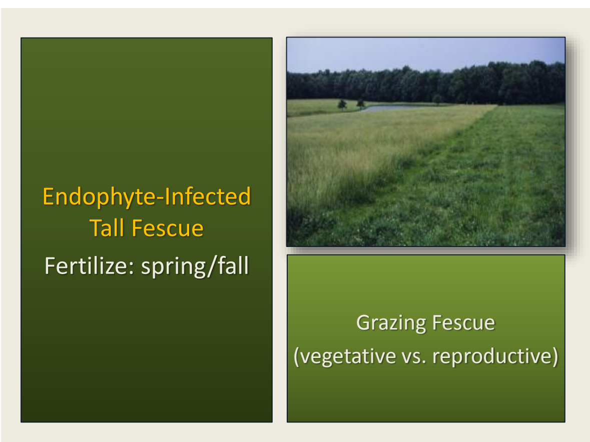


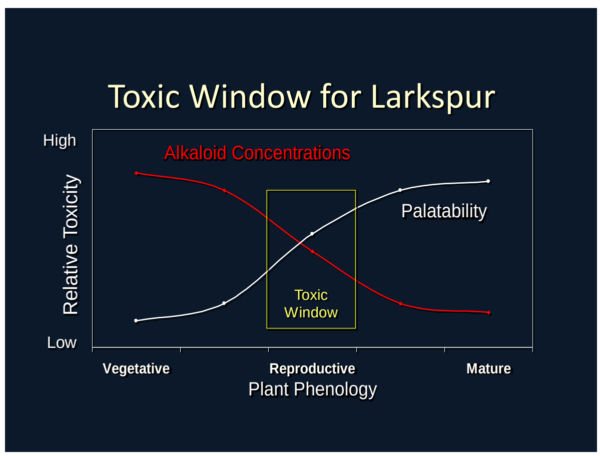
Plant Behavior





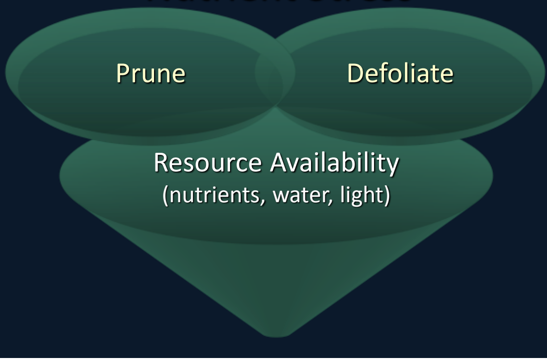




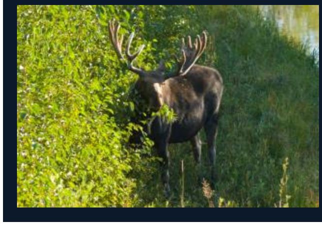


Plant Behavior

Nutrient Stress



By removing leaves, *defoliation* can increase nutrient stress

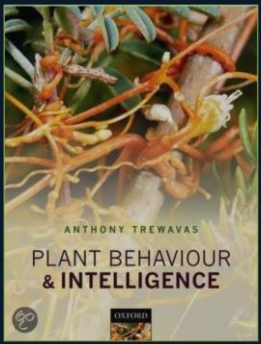


By removing twigs, pruning can decrease nutrient stress

Topping tobacco increases concentrations of alkaloids (nicotine) in leaves.

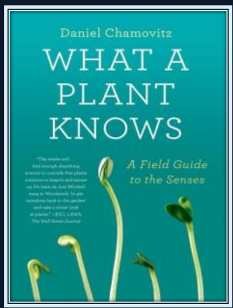
The First Biochemists

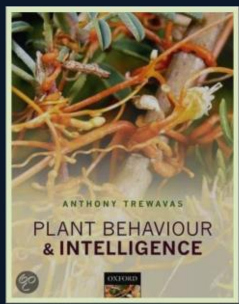
Plants produce thousands of organic compounds.



A goal for the future would be to determine the extent of knowledge the cell has of itself and how it uses that knowledge in a thoughtful manner when challenged.
Barbara McClintock

Plant Behavior





Plants communicate via chemical signals.

Plants can 'smell' volatile compounds in the air and they can 'taste' compounds on their bodies.

Plants respond to tactile cues: vines and roots know when they encounter various objects including, for instance, their own shoots and roots or those of other plants.

Plants 'see' different wavelengths of light; they 'breathe' through stomata on the surface of leaves and stems.

Cells and the plants they make up have knowledge of themselves.

Cells receive environmental challenges that lead to changes in form, function, and behavior of cells and plants.

Learning and memory are vital as cells and organ systems interact with one another and the plants they create to address environmental challenges and solve problem.

Plants behave in ways that imply assessment and intelligent behavior.

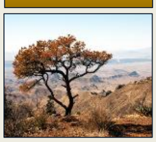
The game plans of organisms in nature are complex, honed by playing offence and defense with friends and foes alike for eons.

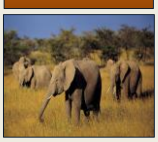
People have been playing these games for decades and the simple game plans we've devised enable our 'foes' to easily resist our attempts to thwart them.

Primary Roles for Secondary Compounds

Sun Screen
Antioxidants
Adaptive Coloration
Attract Pollinators
Fruit Eaters

Allelopathy
Drought Resistance
Persistence

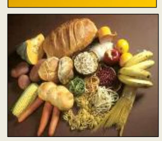




Recovery Injury
Regrowth Grazing
Defense Grazing

While some were learning of the values of secondary compounds, others were reducing their concentrations…

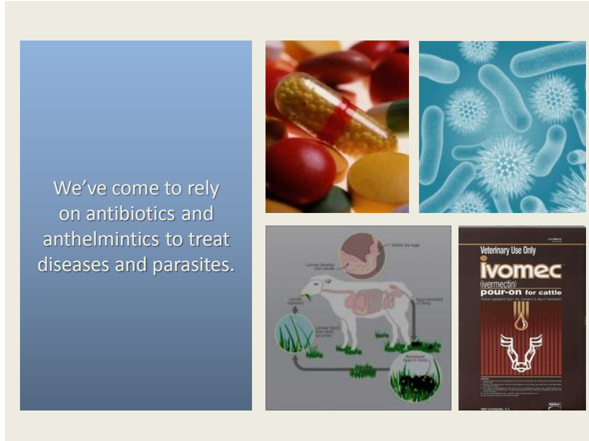
…increase yields of crops and forages

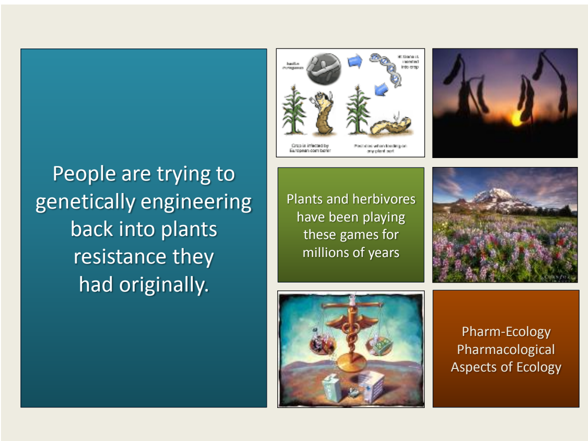


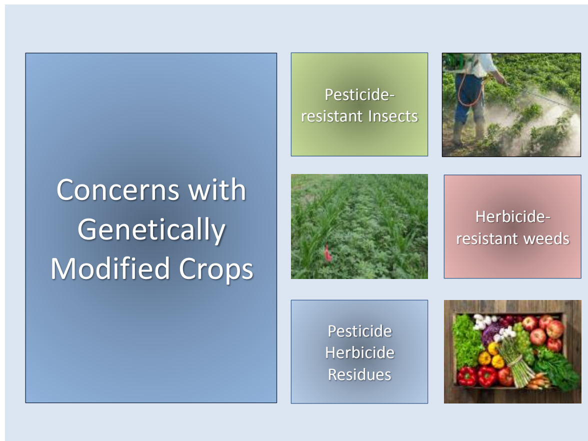
…maximize energy/protein as opposed to total phytochemical richness

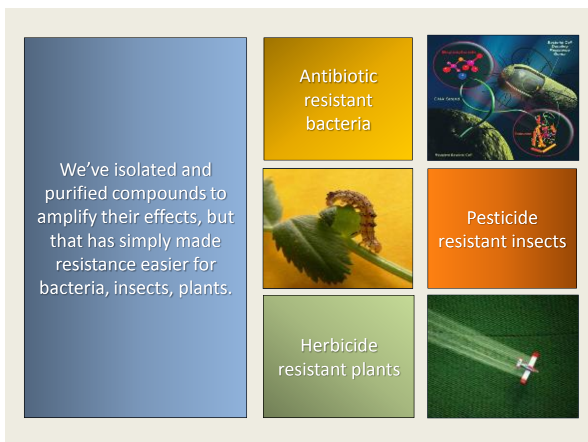
…make plants more susceptible to environmental hardships

Plant Behavior









Plant Behavior

Pesticide-Resistant Insects

Bollworm resistance to first-generation Bt cotton has been confirmed in India, Australia, China, Spain, and the U.S. Monsanto responded by introducing a second-generation cotton with multiple Bt proteins.

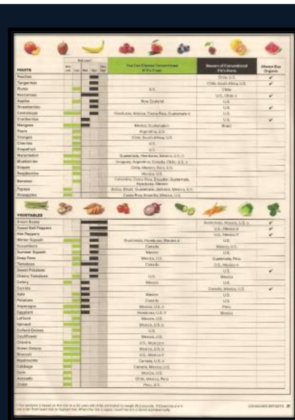
Herbicide-Resistant Weeds

The number and extent of weed species resistant to glyphosate has increased quickly since 1996, with 21 species now confirmed globally (Heap, 2011). There are now 245 species of herbicide-resistant weeds globally (449 unique cases: species x site of action. Weeds have evolved resistance to 22 of the 25 known herbicide sites of action and to 156 different herbicides. Herbicide resistant weeds have been reported in 86 crops in 66 countries.

Herbicide-Pesticide Residues

The Lancet Oncology, the foremost scientific journal for cancer studies, recently published a review paper by the World Health Organization's International Agency for Research on Cancer (IARC) that has classified glyphosate (the active ingredient in Roundup) as a 'probable carcinogenic,' reviewing studies that show glyphosate causes a range of cancers…

…including non-Hodgkin's lymphoma, renal cancer, skin cancer, and pancreatic cancer.

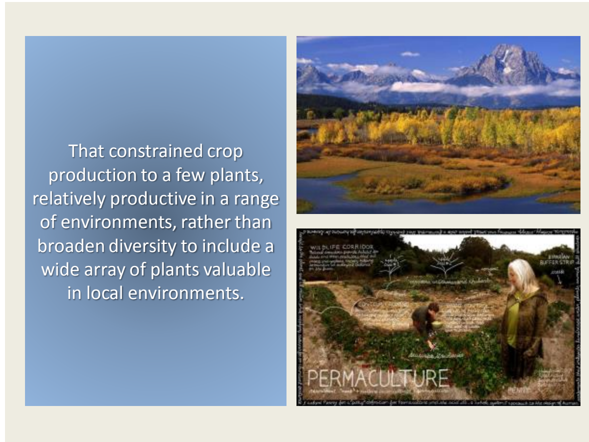


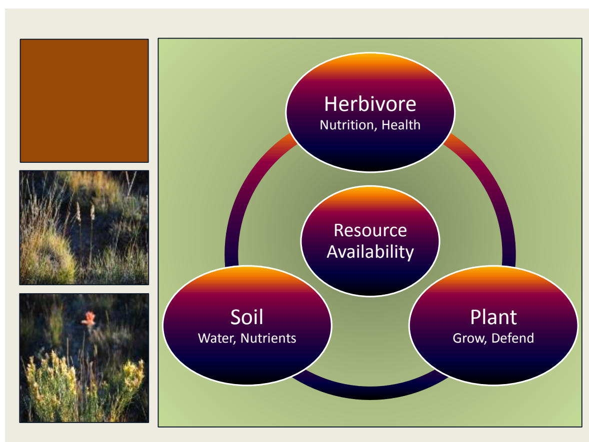
Historically, people used cultural practices like washing and cooking to reduce concentrations of secondary compounds in plants. That had multiple ecological benefits.

Plants resistant to environmental hardships, which contributed to our health, and that of the animals in our care.

'Primitive' Foodscapes → morphed into → 'Modern' Foodscapes
(flavor/phytochemical richness trump yield) (yield trumps flavor/phytochemical richness)

Plant Behavior





Plant Behavior