Outcomes of Evolution: Species and Ecotypes

Reading Assignment:
Chapter 6 in GSF

9/2/09

Objectives – 9/2/2009

1. Observe, describe, and measure phenotypic variation among individuals in a population.
2. Characterize patterns of variation in response to environmental variation.
3. Apply your knowledge of species, ecotypes, and hybrids to a land management issue.

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At the end of today's lecture, see if you can answer these questions…

Why do we see variation in nature?

Why aren't all organisms of a given species identical?

What are some "ecological pressures" that generate variation?
What are some "ecological pressures" that reduce variation?

How have changes in the earth's environment influenced variation among organisms? How does ongoing environmental change influence the evolution of organisms?

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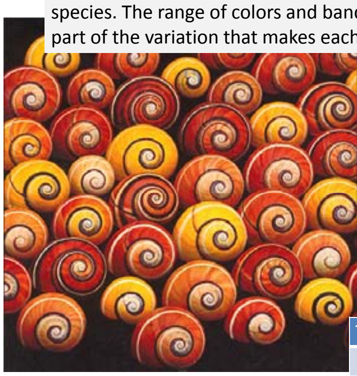
All the tropical tree snails in this image belong to a single species. The range of colors and banding patterns is only part of the variation that makes each of them unique.



With a partner, record some data about the variation that you see:

Trait	Versions

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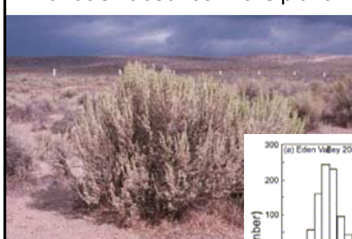
With a partner, write a response to the following:

Where did all this variation come from?

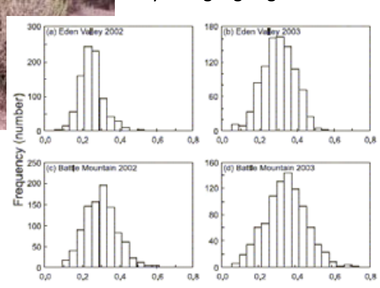
Is all this variation heritable?

Predict how variation will influence reproduction and survival.

Variation abounds in the plant world as well…



Wyoming Big Sagebrush



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Variation, natural selection and evolution

Natural selection occurs when individuals with differences in their traits leave different numbers of descendants because of that variation.

Speciation | phenotypic plasticity | ecotypes

Heritable traits of organisms

- **Phenotypic and genotypic variation are necessary for evolution.**
- **Evolution by natural selection is an ongoing process.**

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What is a species?

- A group of actually or potentially interbreeding organisms
- Reproductive isolation from other groups
- Taxonomic species are based on morphology
- Cryptic species are apparently similar except genetically (polyploidy)

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Plants, polyploidy, and subspecies

- Polyploidy is the duplication of the whole genome if an error produces gametes without meiosis, then hybridization occurs
- Polyploid individuals may be reproductively isolated unless they can self-fertilize
- Polyploid forms are usually considered members of the same taxonomic species if morphology is similar; however, they belong to different biological species

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Acclimation vs. Adaptation

- Acclimation
  - Not heritable
  - Organism level
  - Short term, reversible
  - Long-term, not immediately reversible
  - Morphological change
  - Examples?
- Adaptation
  - Heritable
  - Population level
  - Generational time scales
  - Confers some benefit
  - Improved reproduction or survival
  - Examples?

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Evidence of adaptation

Convergent evolution in unrelated species suggests that those traits did not appear just by chance

Leafless, succulent stems; spines; CAM photosynthesis

- Cactaceae in N. America, Euphorbiaceae in Africa are distantly related
- Spines on cactus evolved from leaves; spines on euphorbs evolved from stipules
- Spines and thorns reduce herbivory and lower plant temperature

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Convergent evolution as evidence for adaptation by natural selection

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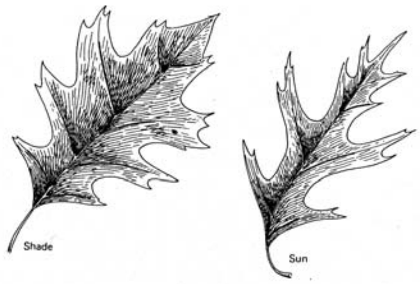
- Acclimation may result from **phenotypic plasticity** when morphological differences occur due to differences in environment
  - Classic example: sun and shade leaves in *Quercus* leaves



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Example: Krummholtz growth form

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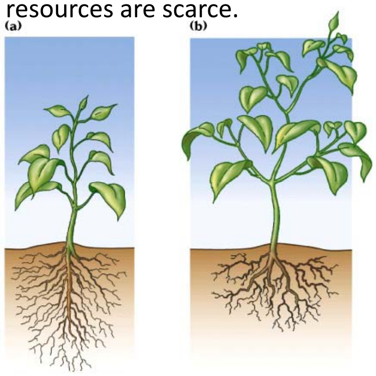
Example: Adjustment of root to shoot ratio when soil resources are scarce.



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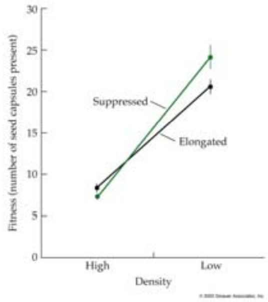
Plants cannot move. Phenotypic plasticity enables the plant to perform better when environmental conditions change.

- Degree of phenotypic plasticity in individual plants may be a heritable trait

Jewelweed in sun vs. shade plants



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Ecotypes belong to one species

- Groups may look different and come from disparate locations, yet still interbreed; these are ecotypes of a single species
- Given enough time, ecotypes may segregate into different species
- Genetic differences may arise from genetic drift, somatic mutations, or hybridization

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Ecotypes and common garden experiments

Turesson (1922) collected seeds from several species growing in different habitats all over Europe, and planted them in experimental common gardens

- differences in physical and functional attributes in a species were retained even when the plants from different habitats were grown under uniform conditions
- Turesson coined the term "**ecotypes**" to describe populations of a species from different locations that had genetically based differences in appearance or function.

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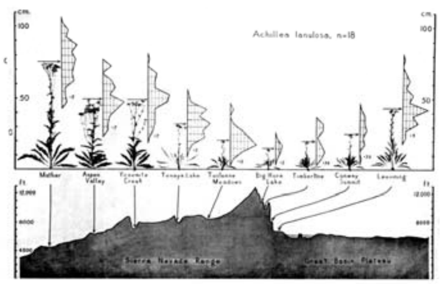
Clausen, Keck and Hiesey (1940) collected clones of yarrow from a transect across California, and propagated many genetically identical individuals.



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Later experiments on yarrow demonstrated physiological adaptations

- Photosynthetic rates varied among the ecotypes
- Leaf shape, degree of dissection, and pubescence were related to leaf temperature regulation:
  - alpine leaves were densely hairy with lower heat conductance, and stayed warmer
  - low elevation leaves were highly dissected, which promoted heat conductance and cooling (Gurevitch, 1988).

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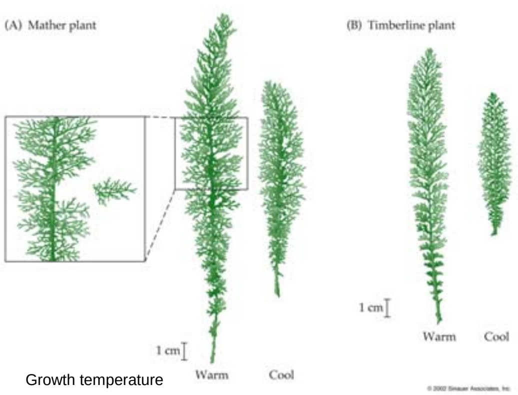
Fig. 6.17



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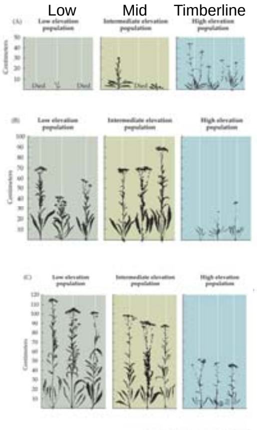
From Low | From Mid | From Timberline

Grown at Timberline

Grown at Intermediate Elevation

Grown at Low Elevation



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What is a hybrid?

- Speciation by hybridization occurs when different species mate and produce viable offspring
  - Common among plants such as saltbush, oaks and sagebrush
  - Difficult to define species in hybrid swarms

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Hybridization of Big Sagebrush
Artemisia tridentata

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Big Sagebrush
Artemisia tridentata

Subspecies differ in:

- Habitat
- Growth habitat
- Chemical constituents
- Palatability to various animals
- Leaf shape and anatomy
- Inflorescence form
- Seed germination characteristics
- Phenology

Moisture and elevational gradients explain distribution patterns.

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Hybridization

- Three possible outcomes:
  - **Lower fitness** – differentiation between parental populations increases (reinforcement)
  - **Equal fitness** – differentiation between parental populations decreases (coalescence)
  - **Higher fitness** – stable hybrid zone or formation of a new species

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Big Sagebrush Hybrids

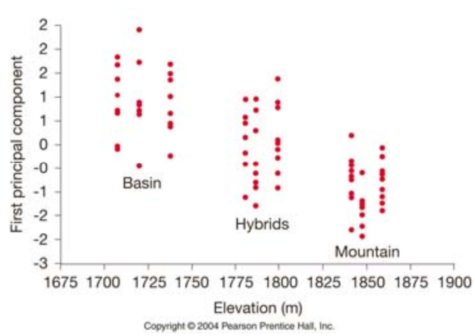


Figure 15.14 Hybrid sagebrush are intermediate in form between parental subspecies. Measurements included morphological traits such as height, circumference, crown diameter, and branch length.

Relative Fitness of Big Sagebrush

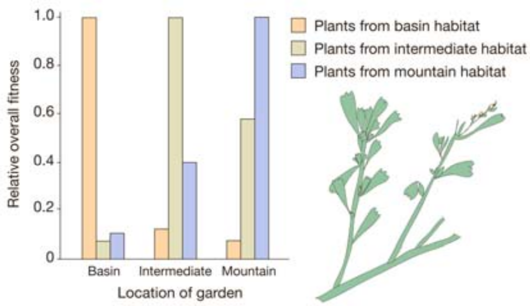
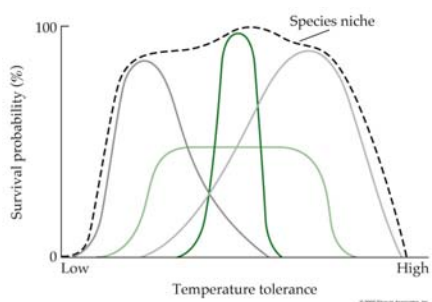


Figure 15.15 Plots an overall measure of fitness that combines data on survivorship, flowering, seed production, and seed germination rate. A value of 1.0 is assigned to the group with the highest fitness in each of three experimental gardens and the other groups as a percentage of that group's fitness.

The niche concept

- Each species has a range of ecological conditions in which it can grow, called the species' **niche** (Grinnel, 1917).
- The species' niche is determined by the sum of the individuals' niches, which may be wide or narrow.
  - Would these niches have high or low phenotypic plasticity?

Overlapping ranges of individuals make up species niche



Fundamental vs. realized niche

- **Fundamental niche** is the range of conditions the species is capable of growing in physiologically
- **Realized niche** is the range of conditions it is actually found in, as competition, herbivory, pollinators and seed dispersers factor in

You are working on a mine reclamation project for the Bureau of Land Management. Your task is to restore the site to a habitat that can support large/small mammals and birds. What information do you need to know in order to decide on which plant species to plant? How will you go about restoring this habitat?

**Use your knowledge about ecotypes, hybrids, and phenotypic plasticity in developing your plan.