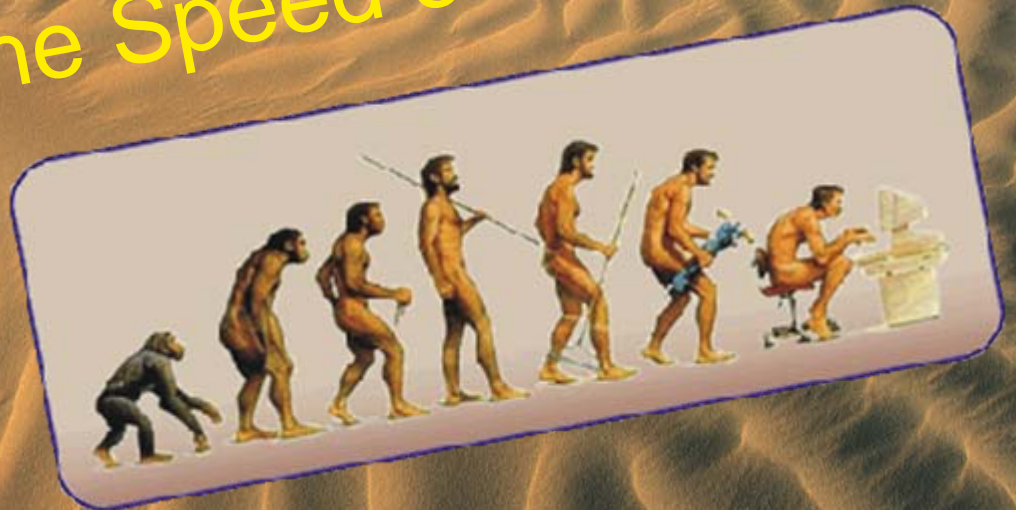
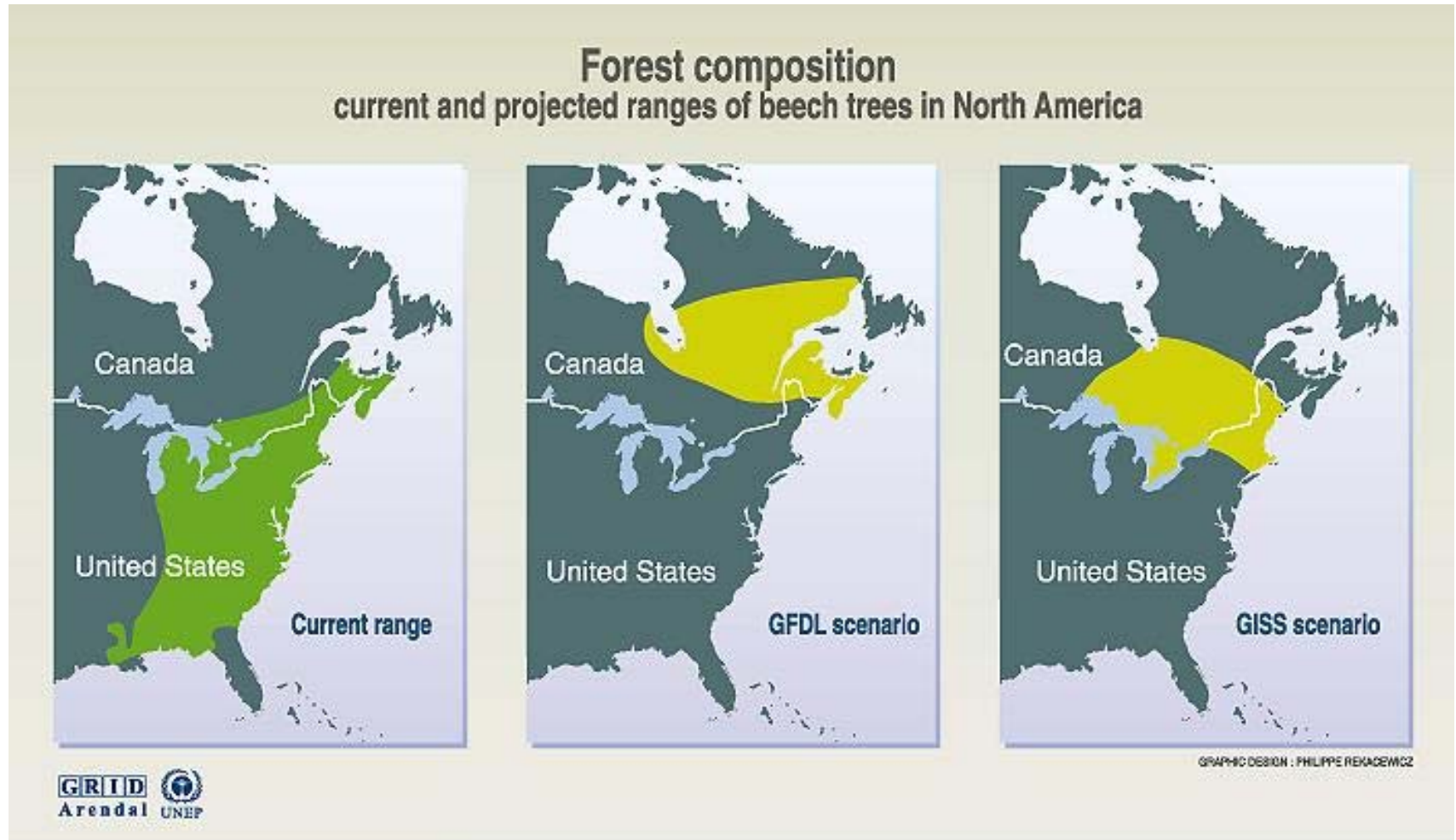


The Speed of Adaptation



Why should we care about the speed of adaptation?

- Climate change: organisms must adapt or move.



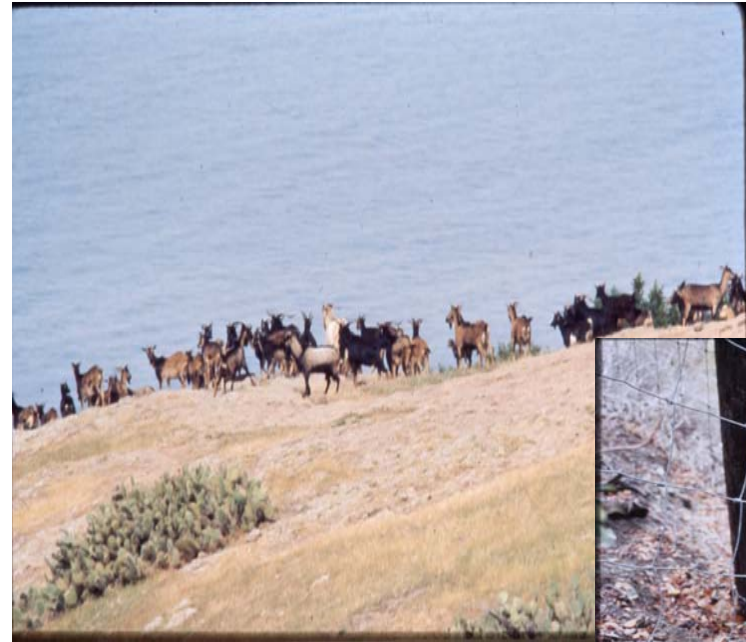
Why should we care about the speed of adaptation?

- Climate change: organisms must adapt or move.
- Habitat degradation: organisms must adapt.



http://maps.grida.no/go/graphic/human_impact_north_america

Human Impact - North America



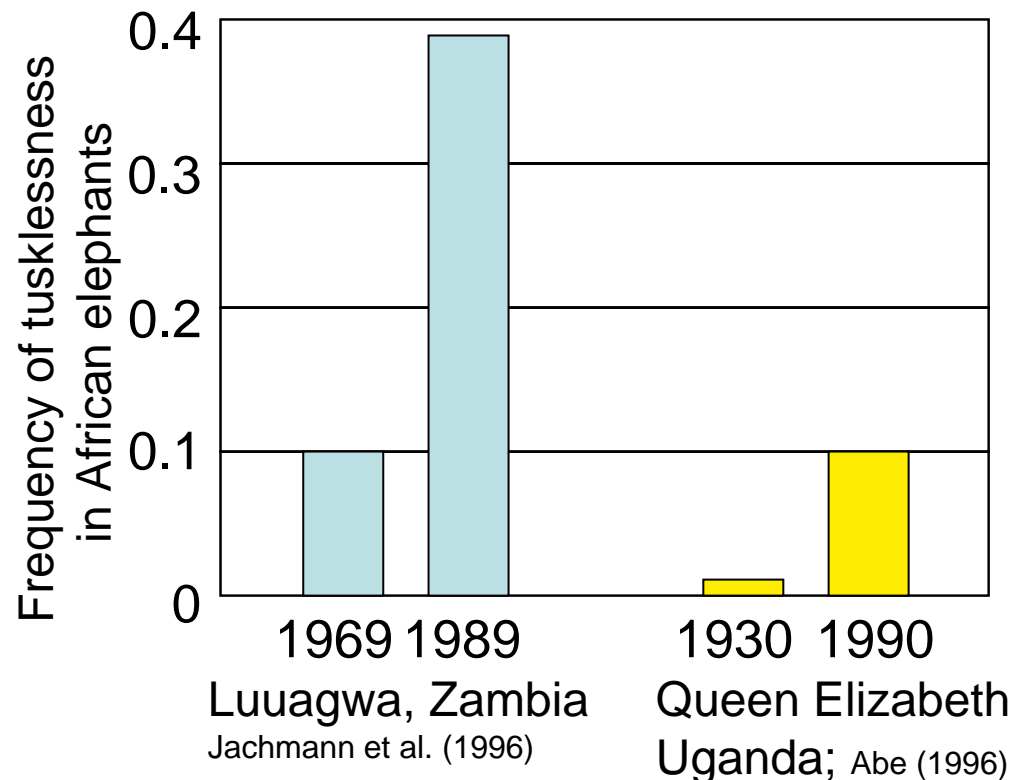
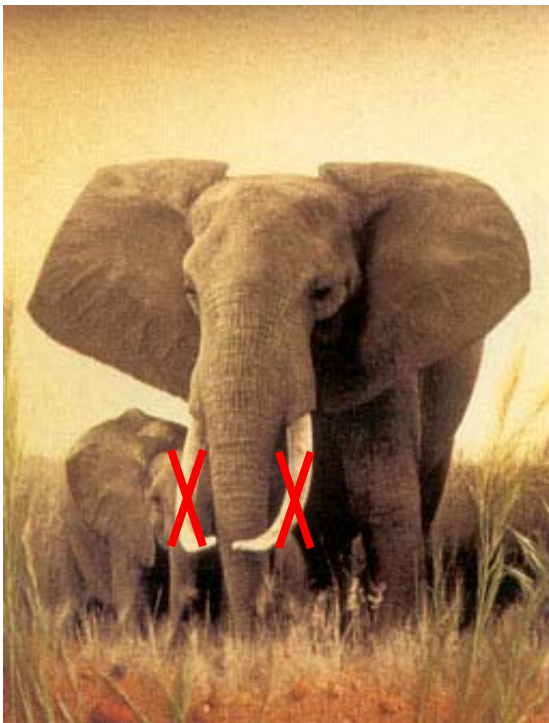
Feral Goats on
Santa Catalina Island



Catalina Island
Mahogany

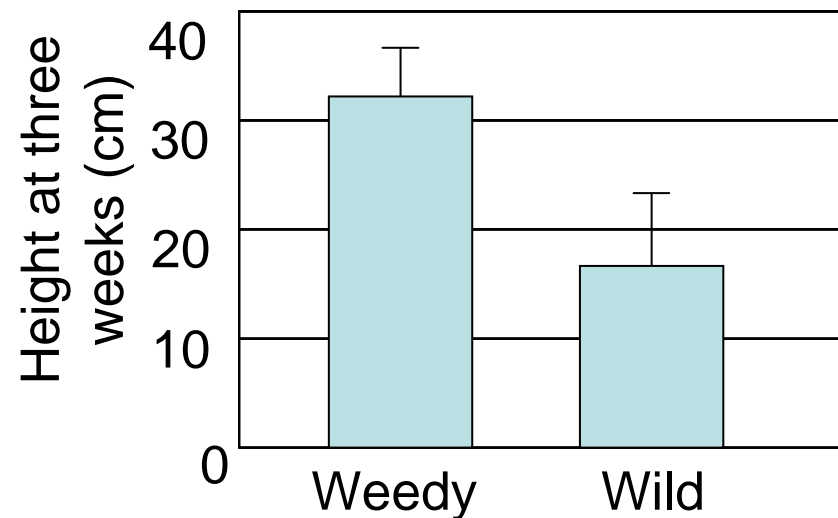
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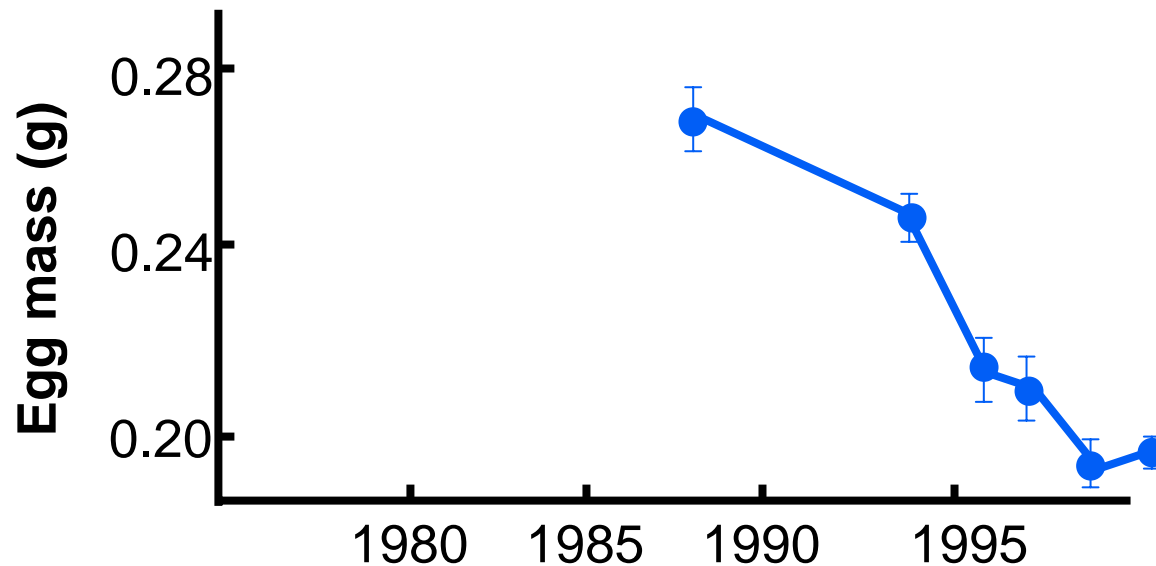


Microarray Comparisons:

- 5% of genes show differential expression in weeds
- Genes that respond to stress or to abiotic and biotic stimulus are over-represented.

Why should we care about the speed of adaptation?

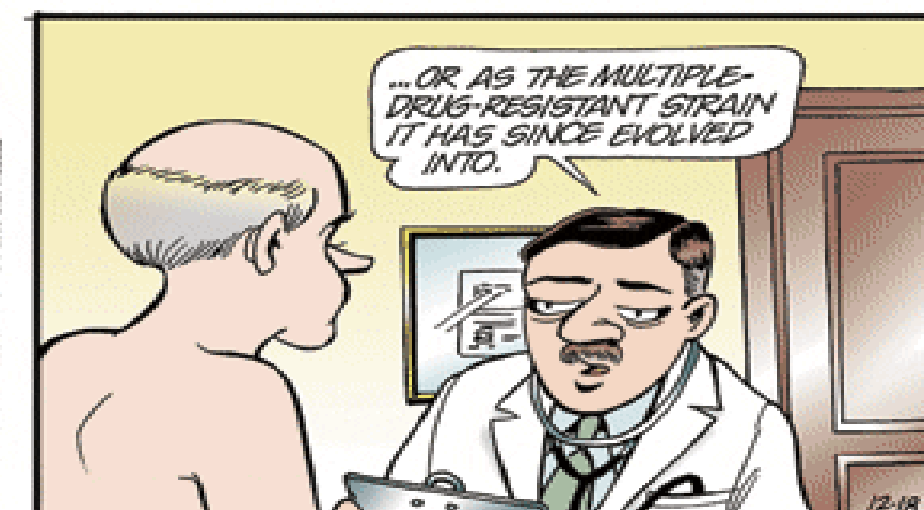
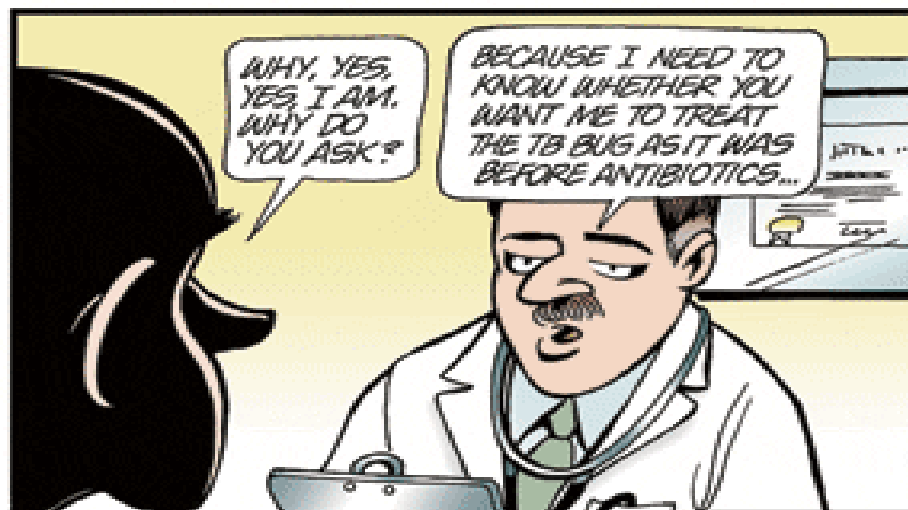
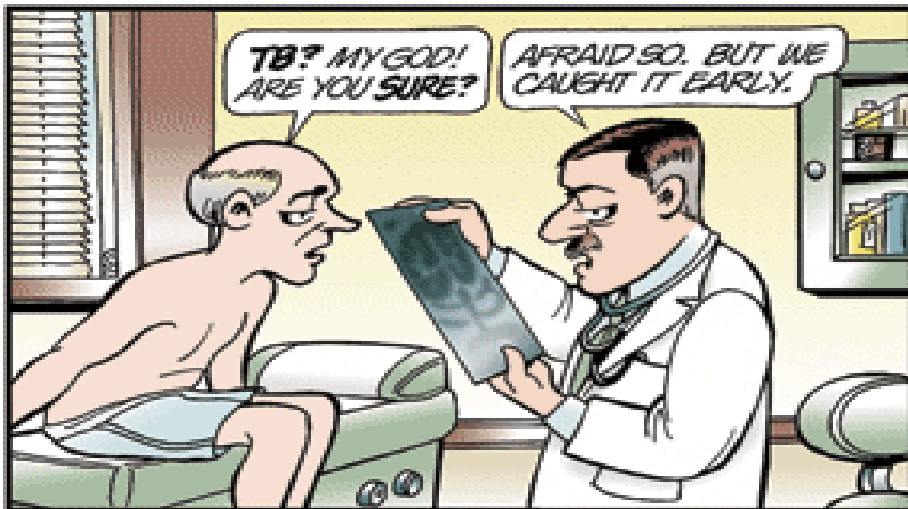
- Climate change: organisms must adapt or move.
- Habitat degradation: organisms must adapt or move.
- Selective harvesting: decline in freq. of selected traits.
- Invasive species: rapid adaptation may facilitate spread.
- *Ex situ* conservation: captive organisms may become domesticated.



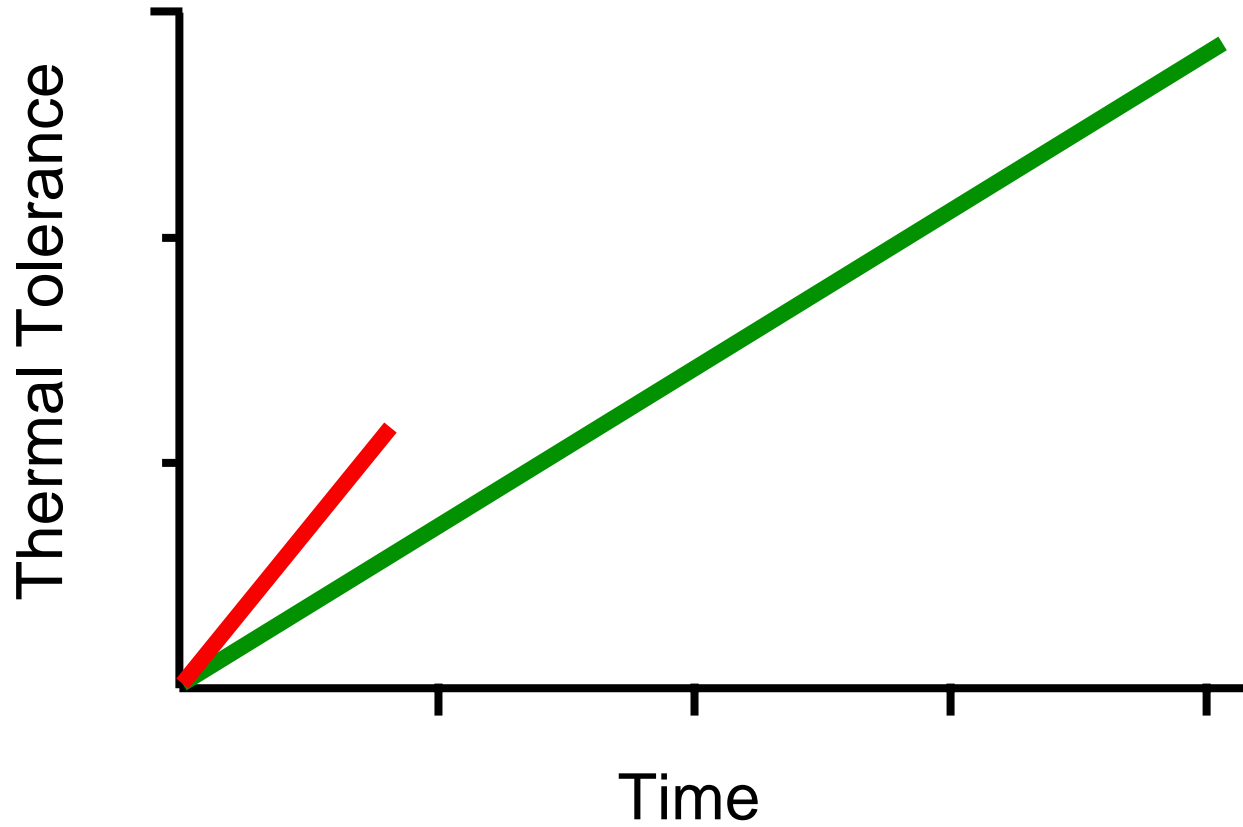
Reduction in egg size in captive chinook salmon (Heath et al., 2003)

Why should we care about the speed of adaptation?

- Resistance evolution: pests may evolve resistance to antibiotics, herbicides, and pesticides



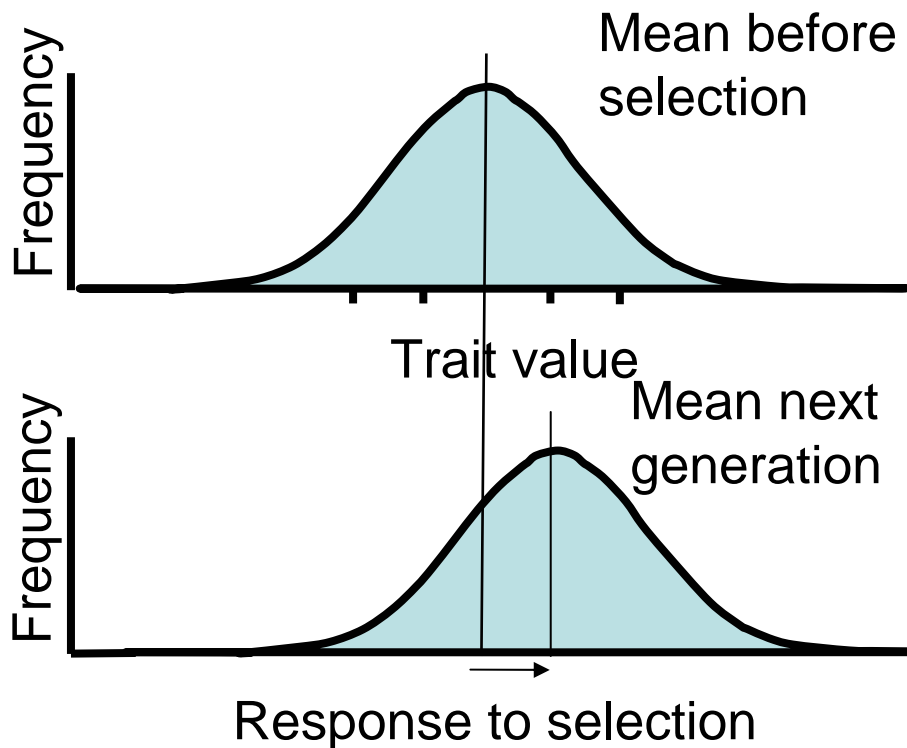
What is the sustainable rate of adaptation?



What is the sustainable rate of adaptation (theory)?

Two approaches:

- Rate beneficial mutations become established
- Rate of adaptive phenotypic change



- Large populations: “a few percent” of a phenotypic standard deviation per generation (Lynch, 1996).

- Small populations: $< 1\%$ of a phenotypic standard deviation per generation (Burger and Lynch, 1995).

Factors that affect speed of adaptation

Speed of adaptation



- Large Populations: \uparrow beneficial mutations
- Large Number of Genes : \uparrow beneficial mutations
- High Rate of Recombination (in large populations)
- Strong Selection: \uparrow initial rate of adaptation
- Constant Selection



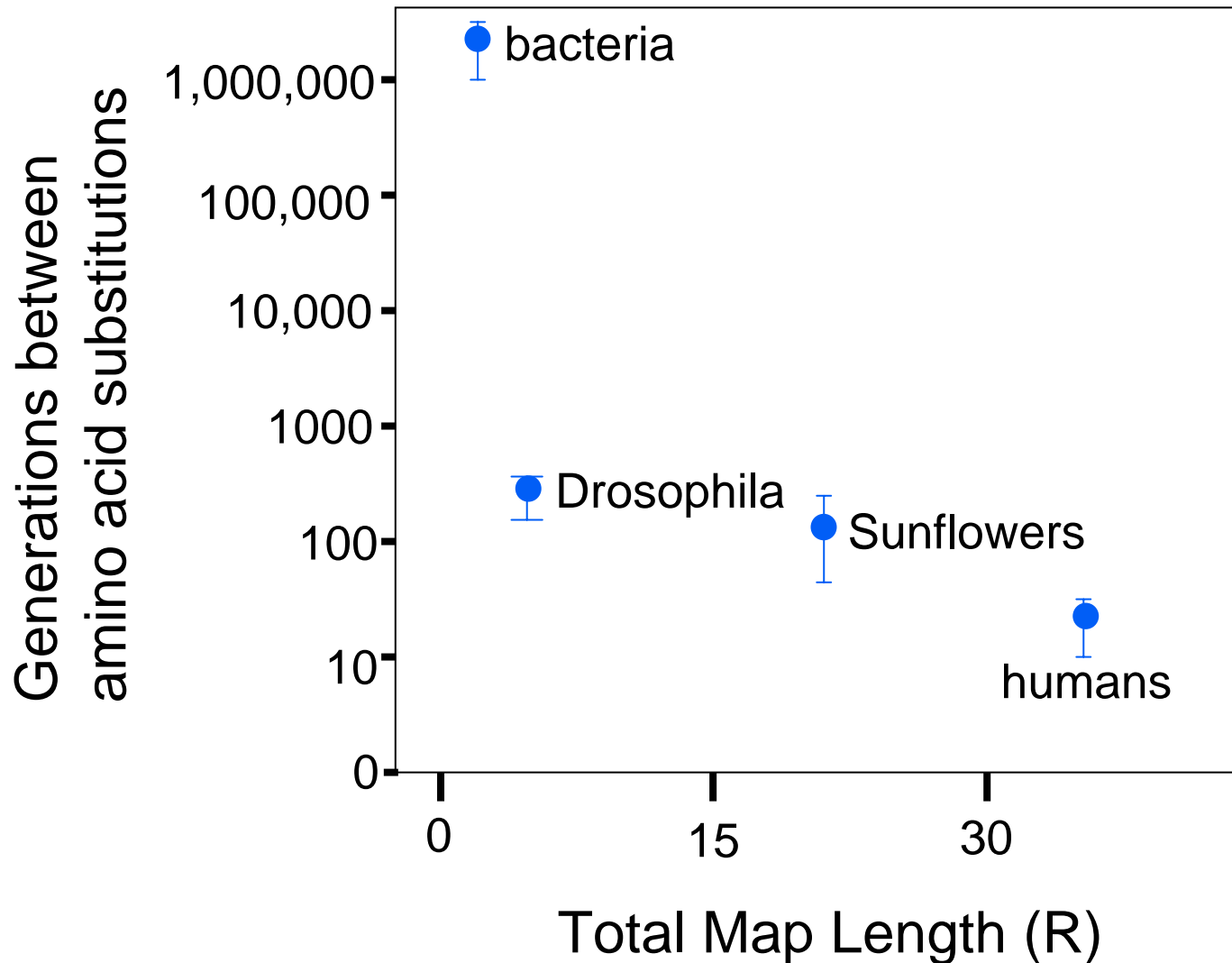
- Small Populations: \downarrow beneficial mutations, drift, inbreeding depression
- Fluctuating selection
- Low trait heritability



- Gene flow: increases variability, but reduces efficiency of selection
- Genetic correlations

The speed of adaptation (empirical data)

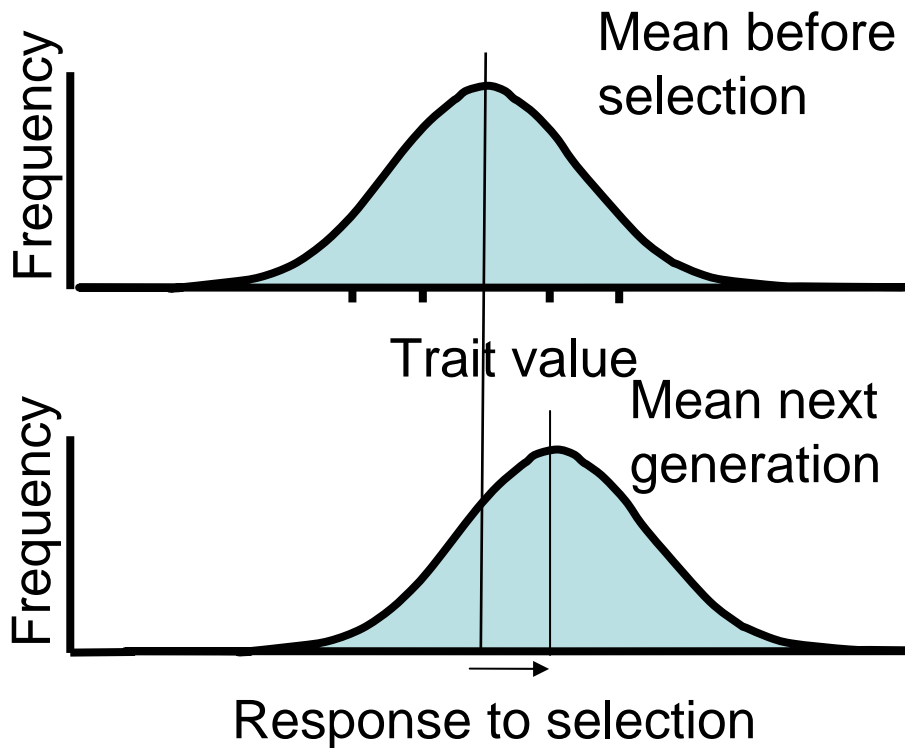
1) Rate of beneficial amino acid substitutions



The speed of adaptation (empirical data)

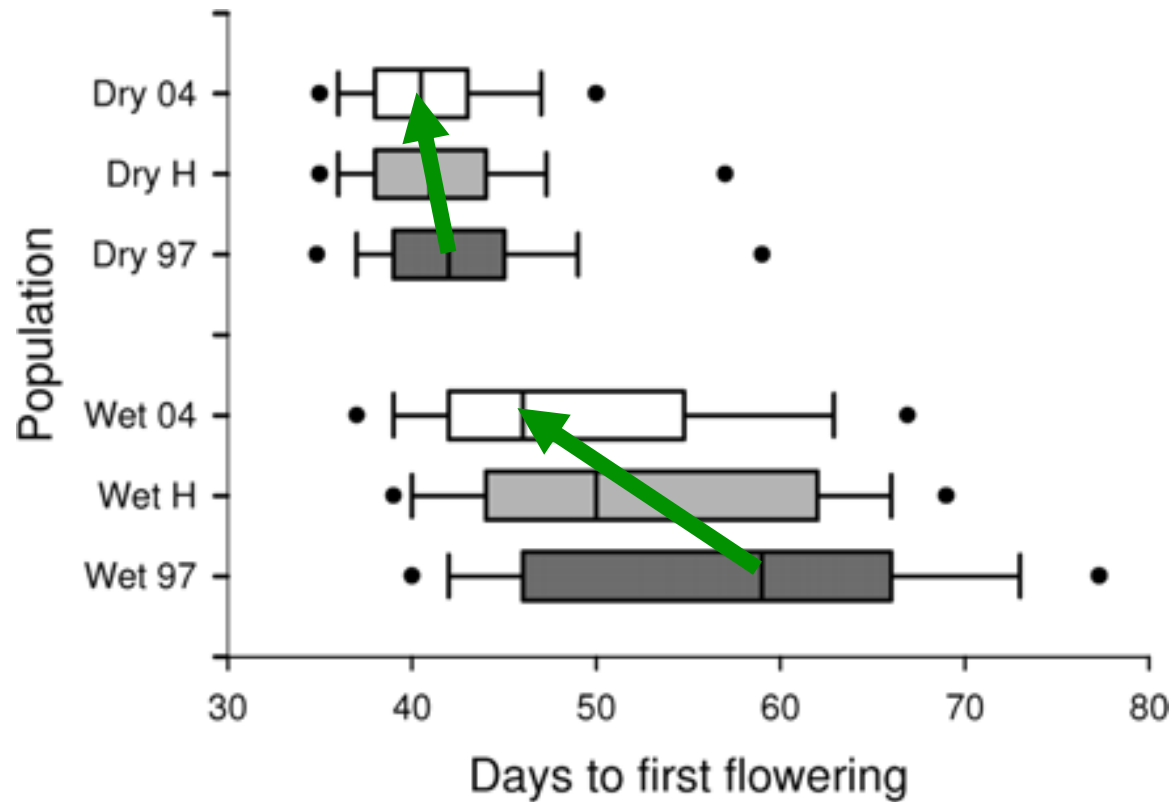
2) Rate of adaptive phenotypic change

- per year = Darwins
- per generation = Haldanes



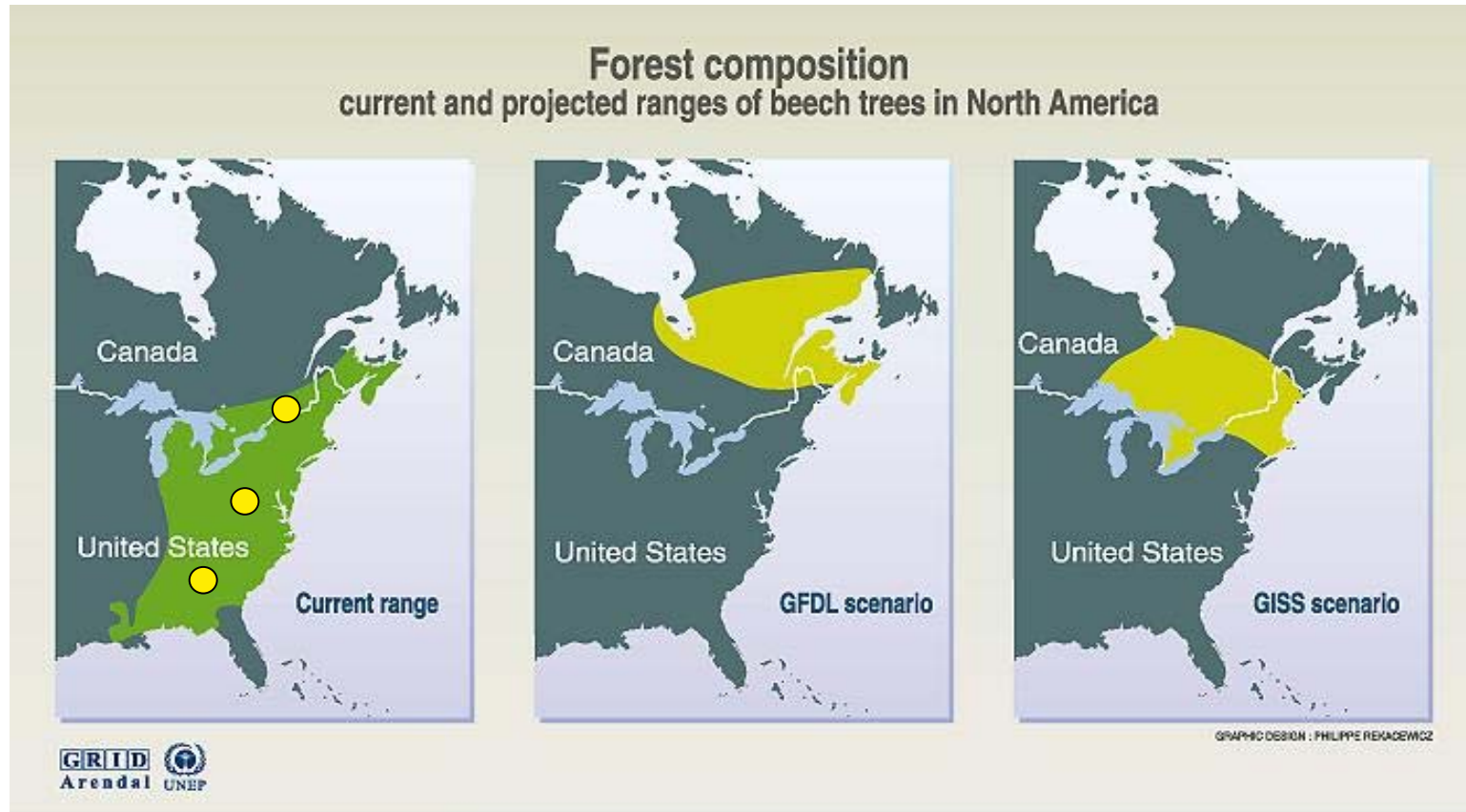
Haldane = one phenotypic standard deviation per generation

Example



Time to first flowering in *Brassica rapa*. Haldanes = 0.039 for Dry site and 0.101 for Wet site (Franks et al., 2007).

Can Organisms Adapt Fast Enough to Cope with Predicted Climate Change?



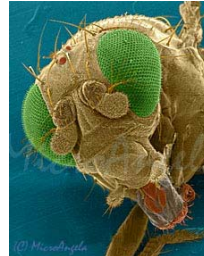
Source : US Environmental Protection Agency (EPA), 1998.

Approach: Analyze phenotypic differences along latitudinal clines

- 133 clines
- Calculated phenotypic standard deviations per degree of latitude

Conclusions

- The good: adaptation will ameliorate effects of climate change, at least for organisms with short generation times.



- The bad: adaptation will not provide much help for organisms with long generation times.

- The ugly:
 - elephants may lose their tusks
 - harvested fish will get smaller
 - weeds will get weedier
 - captive populations will be domesticated
 - pathogens may win the arms race

