Genetic Considerations for Restoring Chaparral

Arlee M. Montalvo

Riverside-Corona Resource Conservation District

Native Plant Materials are Used in Many Types of Planting Projects

Consideration of genetics is a cornerstone to managing biodiversity

- Preserving migration corridors and restoring dispersal linkages among fragmented populations
- Providing raw material (genetic variation) and potential for tracking environmental changes
- Preserving essential species interactions (pollinators, seed dispersers, soil microorganisms)
- Preserving natural processes at all levels

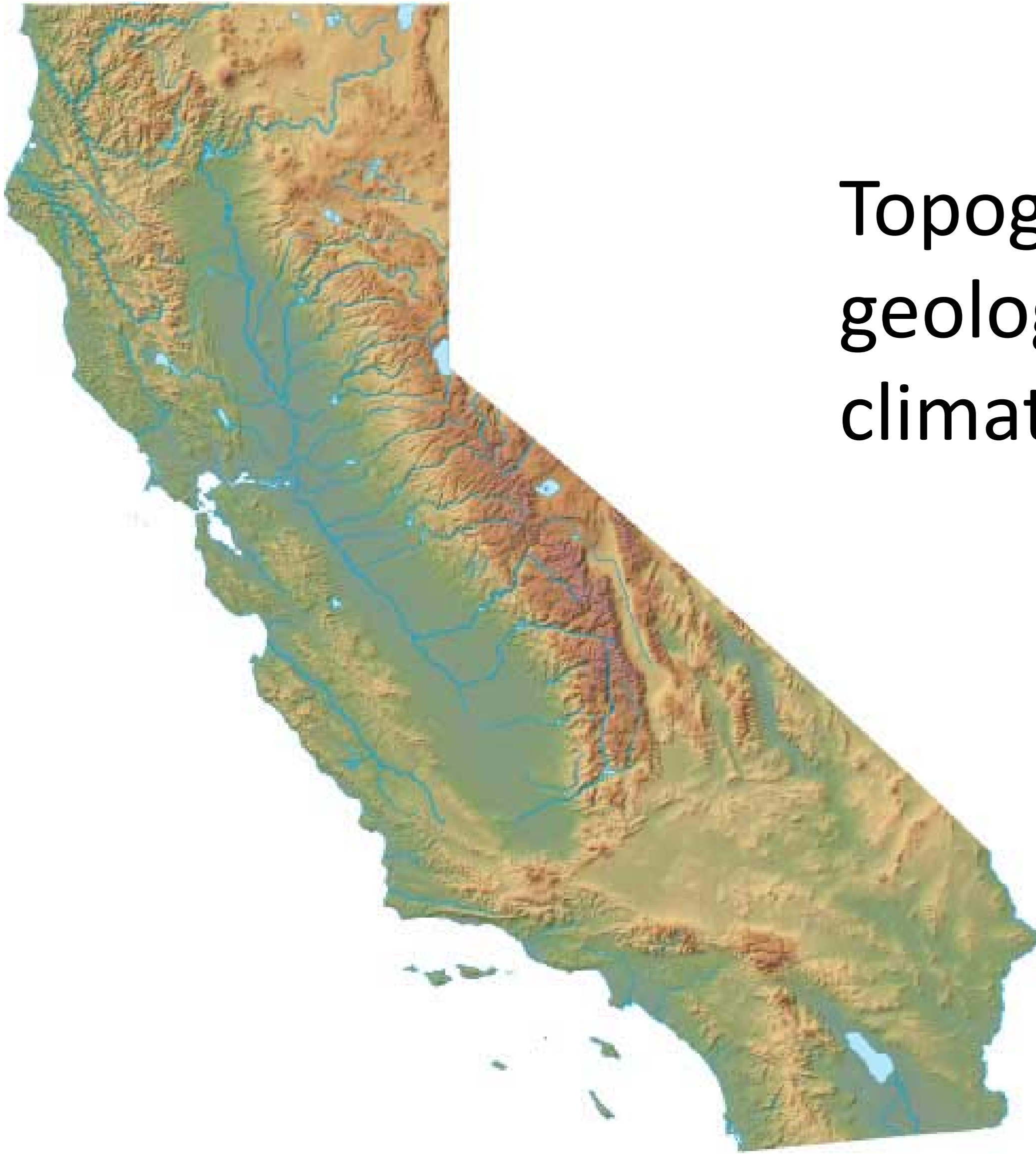
Careful Choice of Species and Seed Sources for Projects Can:

- Provide appropriate genetic variation
- Help species track environmental changes
- Reduce adverse effects of inbreeding
- Minimize detrimental introductions
- Preserve critical interactions
- Protect genetic reserves
- Increase long-term success of projects

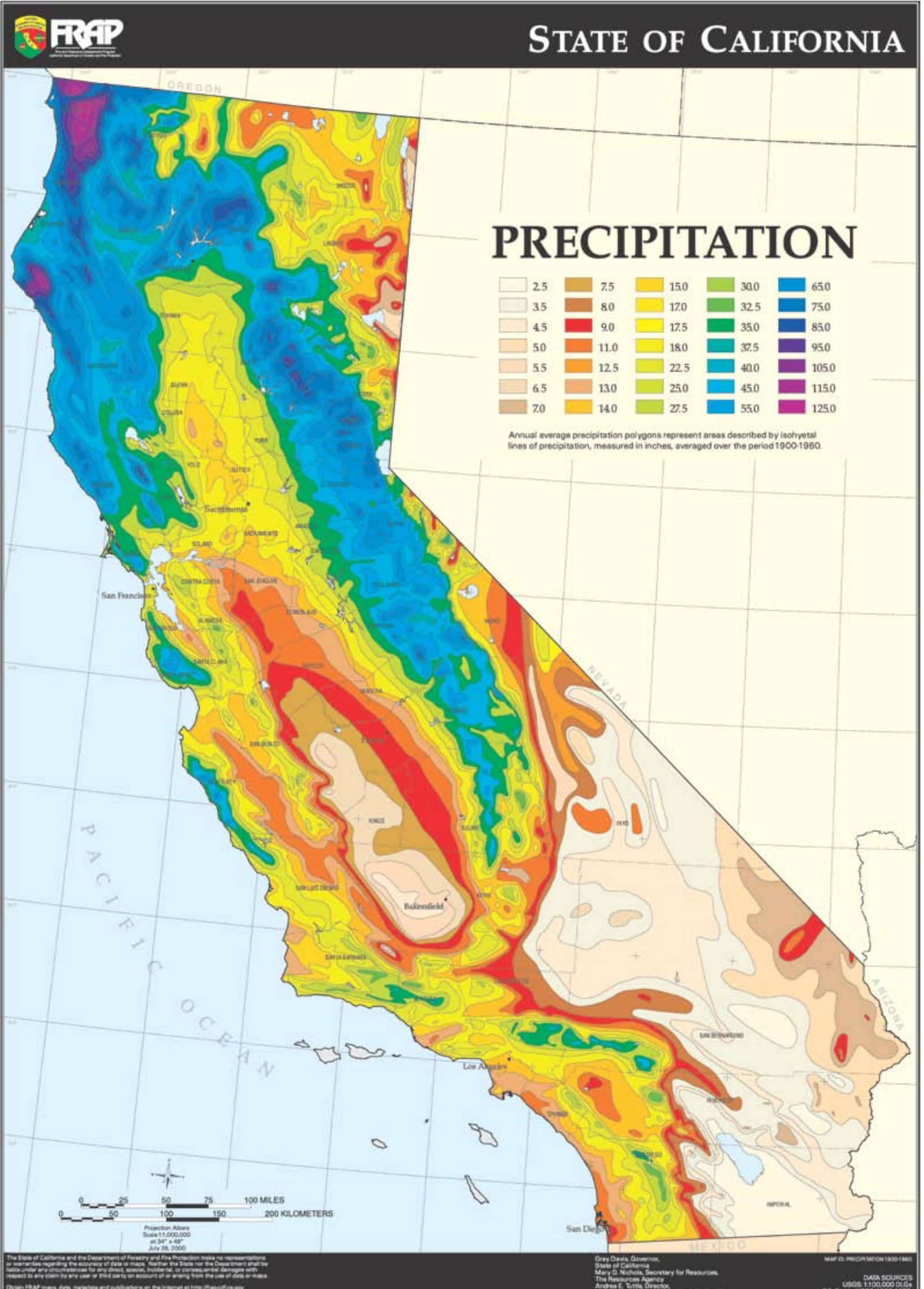
Why Genetics Matters

1. **Physical and biotic environments influence plant variation and distribution**
2. Experiments reveal that adaptive differences affect success of translocation
3. Translocated species interact
4. Methods to guide choice of seed source

California



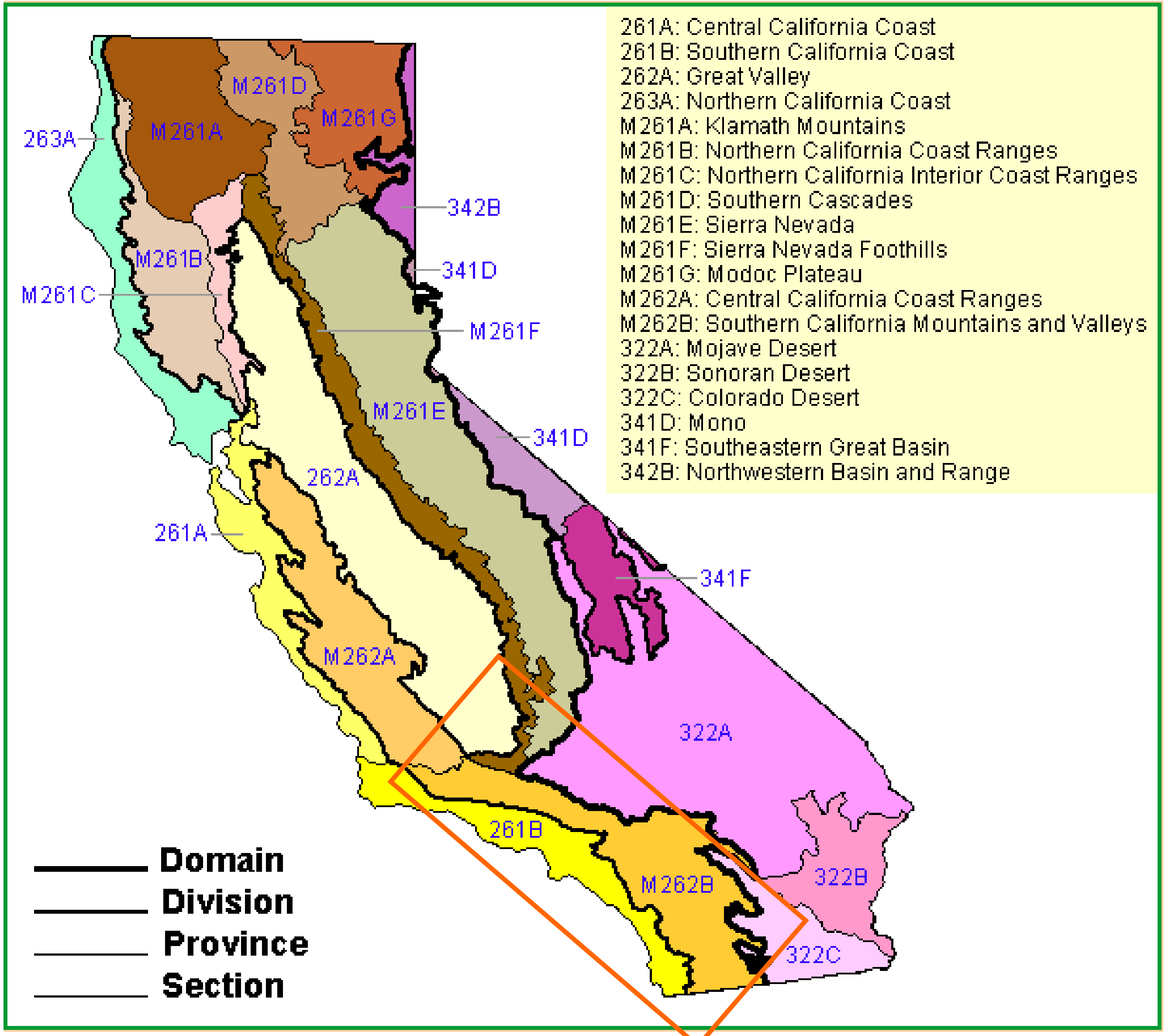
Topographically, geologically, and climatically diverse



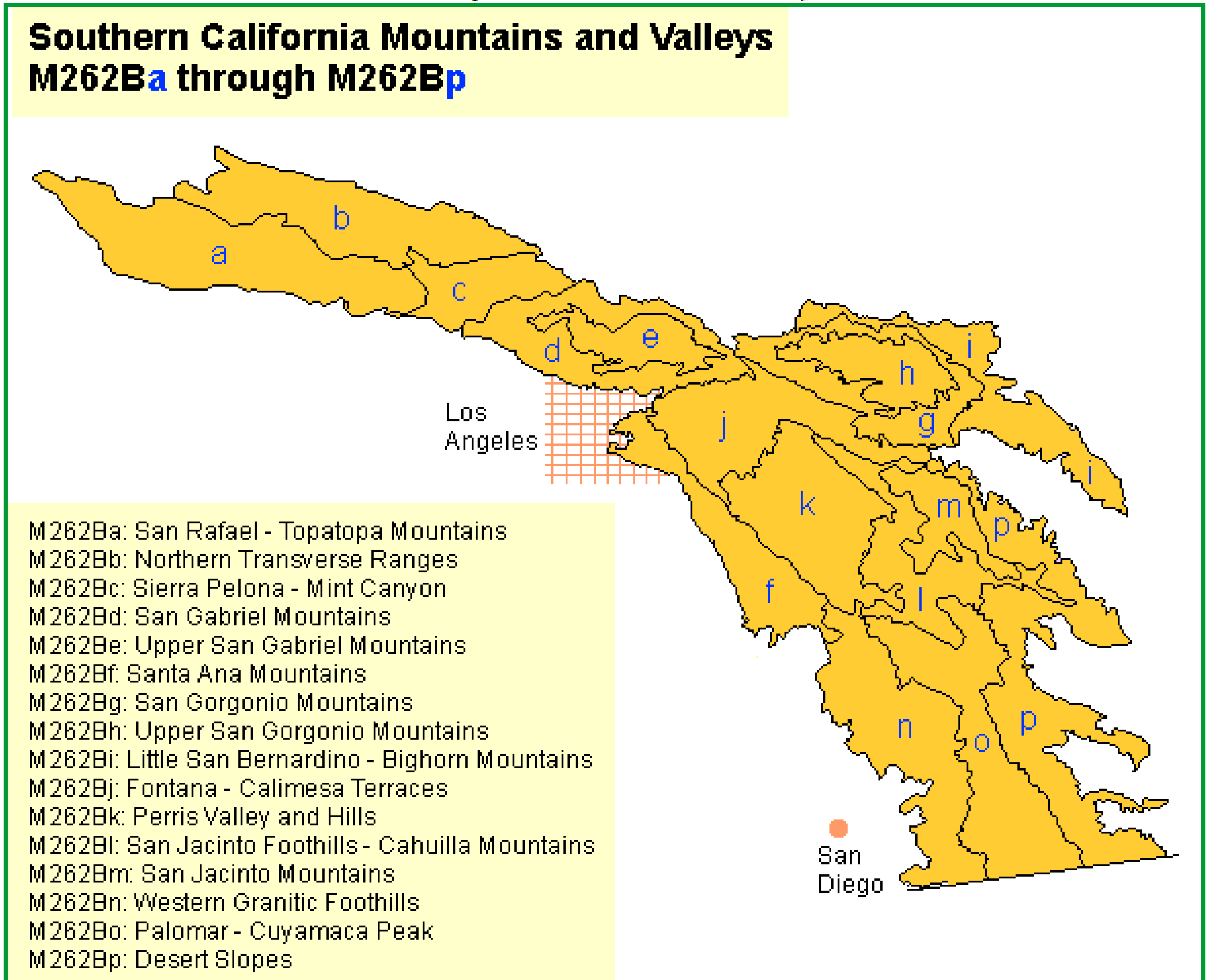
Precipitation
2.5 – 125 inches

varies with latitude, elevation, distance from coast

Ecological Regions of California



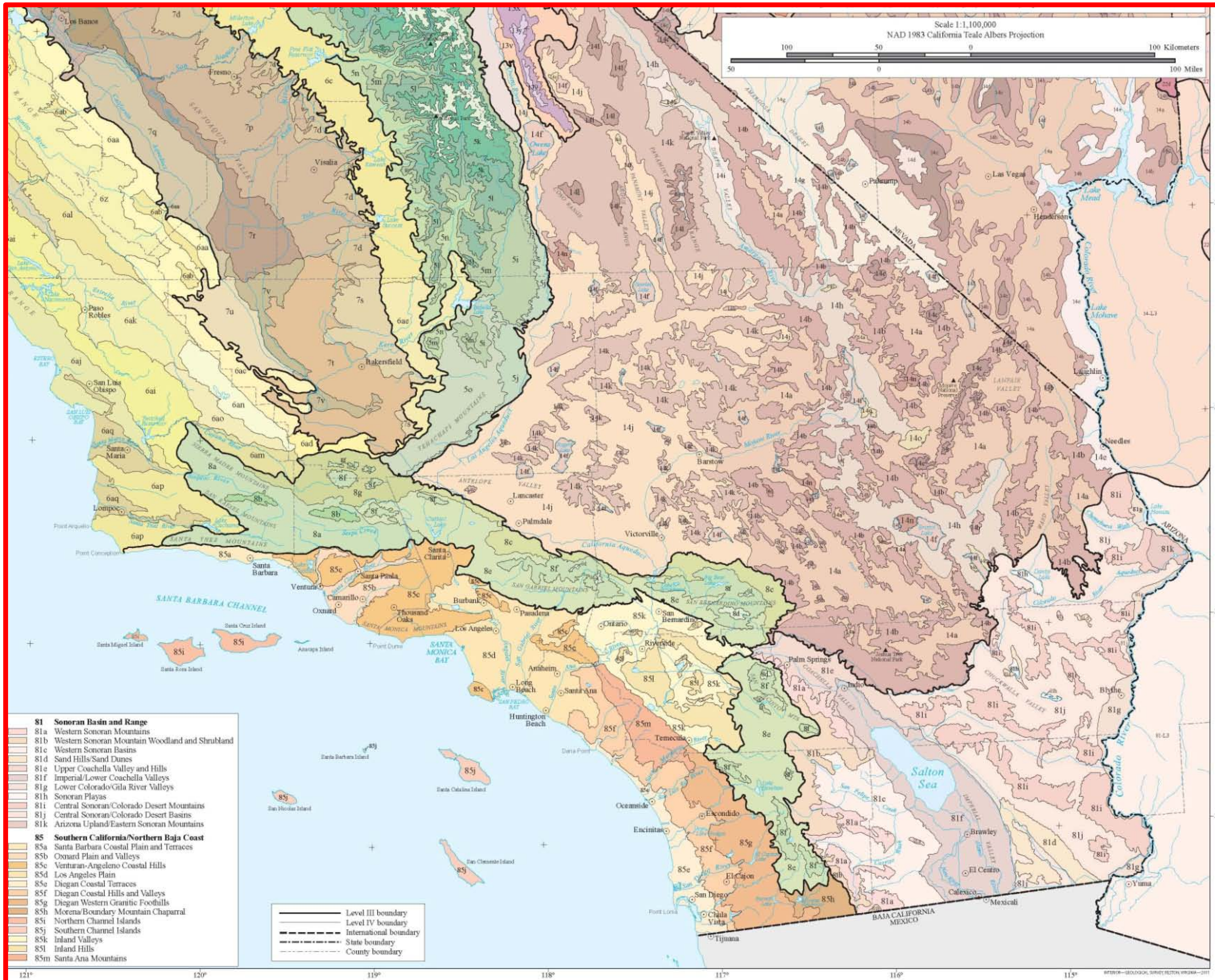
http://www.fs.fed.us/r5/projects/ecoregions/ca_sections.htm



- **Elevation.** 300 to 11,500 ft.
- **Precipitation.** 6 to 40 inches
- **Temperature.** 40° to 70°F.
- **Growing Season.** 150 to 300 days

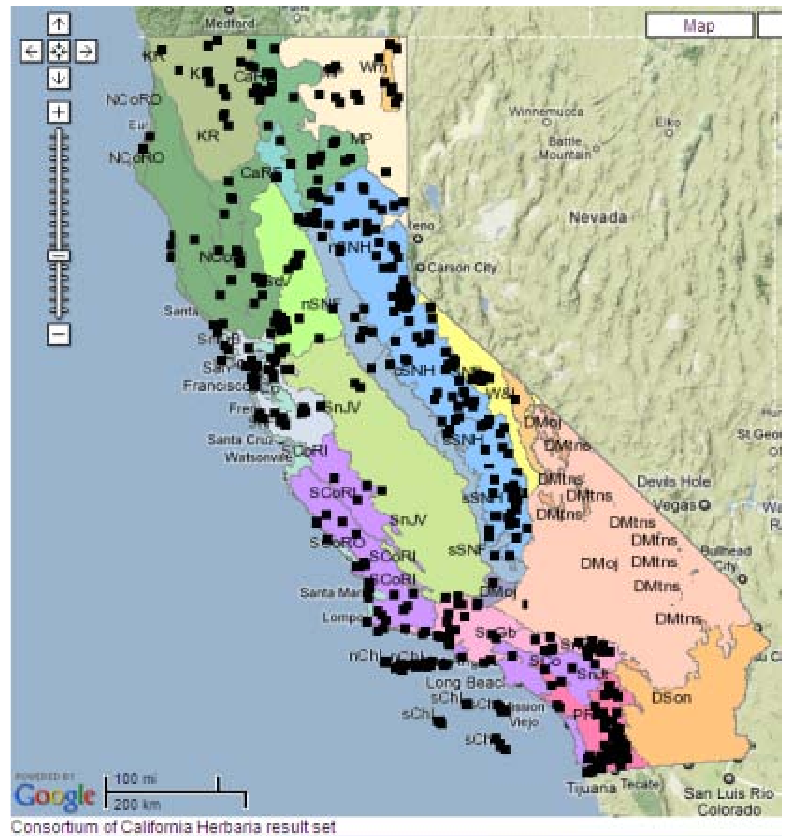
Level IV Ecoregion Map

Griffith, G.E., Omernik, J.M., Smith, D.W., Cook, T.D., Tallyn, E., Moseley, K., and Johnson, C.B., 2011(draft)



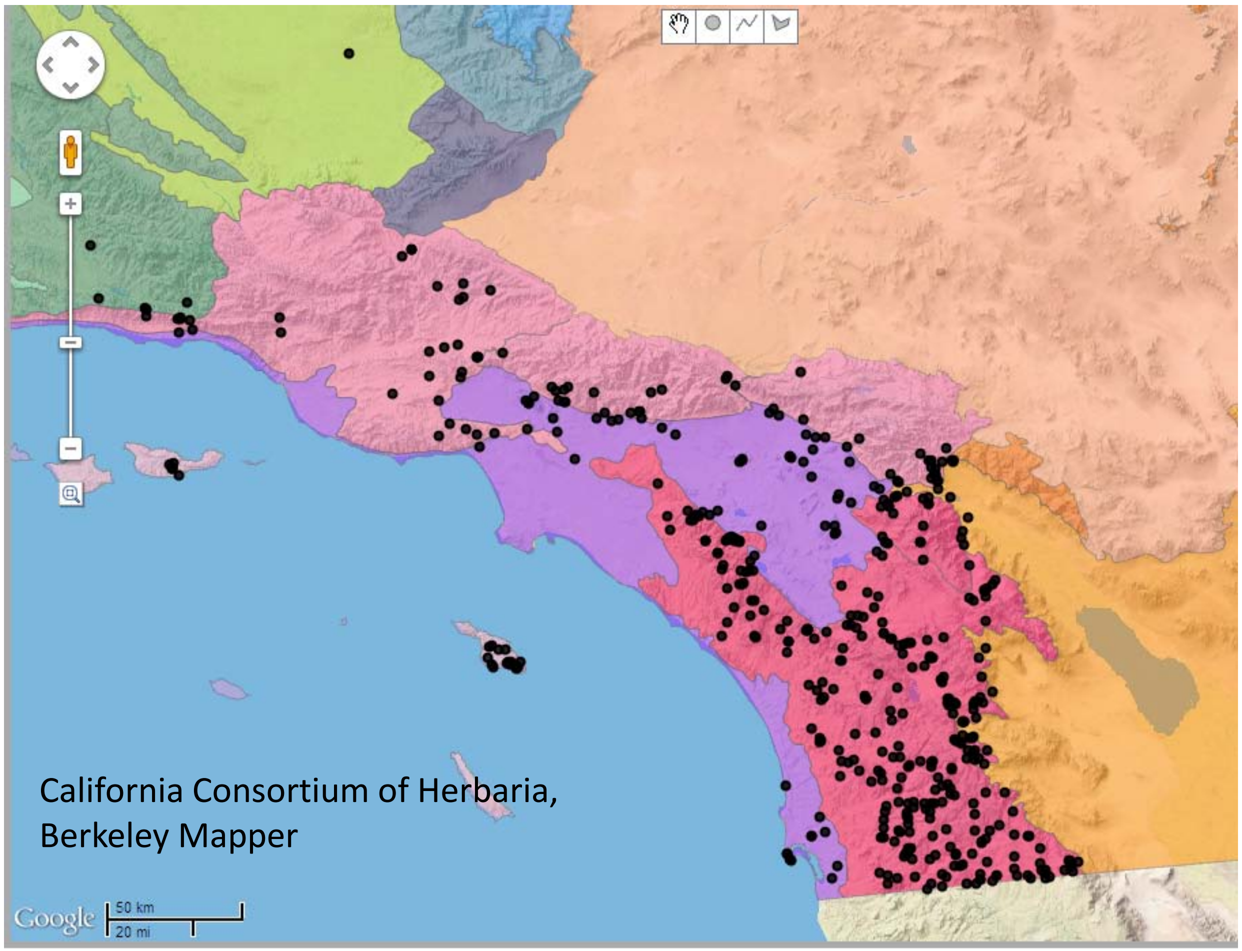
Many species wide-ranging

California Consortium of Herbaria, Berkeley Mapper: http://ucjeps.berkeley.edu/consortium



common yarrow, *Achillea millefolium* L. (all varieties on map)

Plants with limited distributions may also occupy variable habitats



sugar bush, *Rhus ovata*

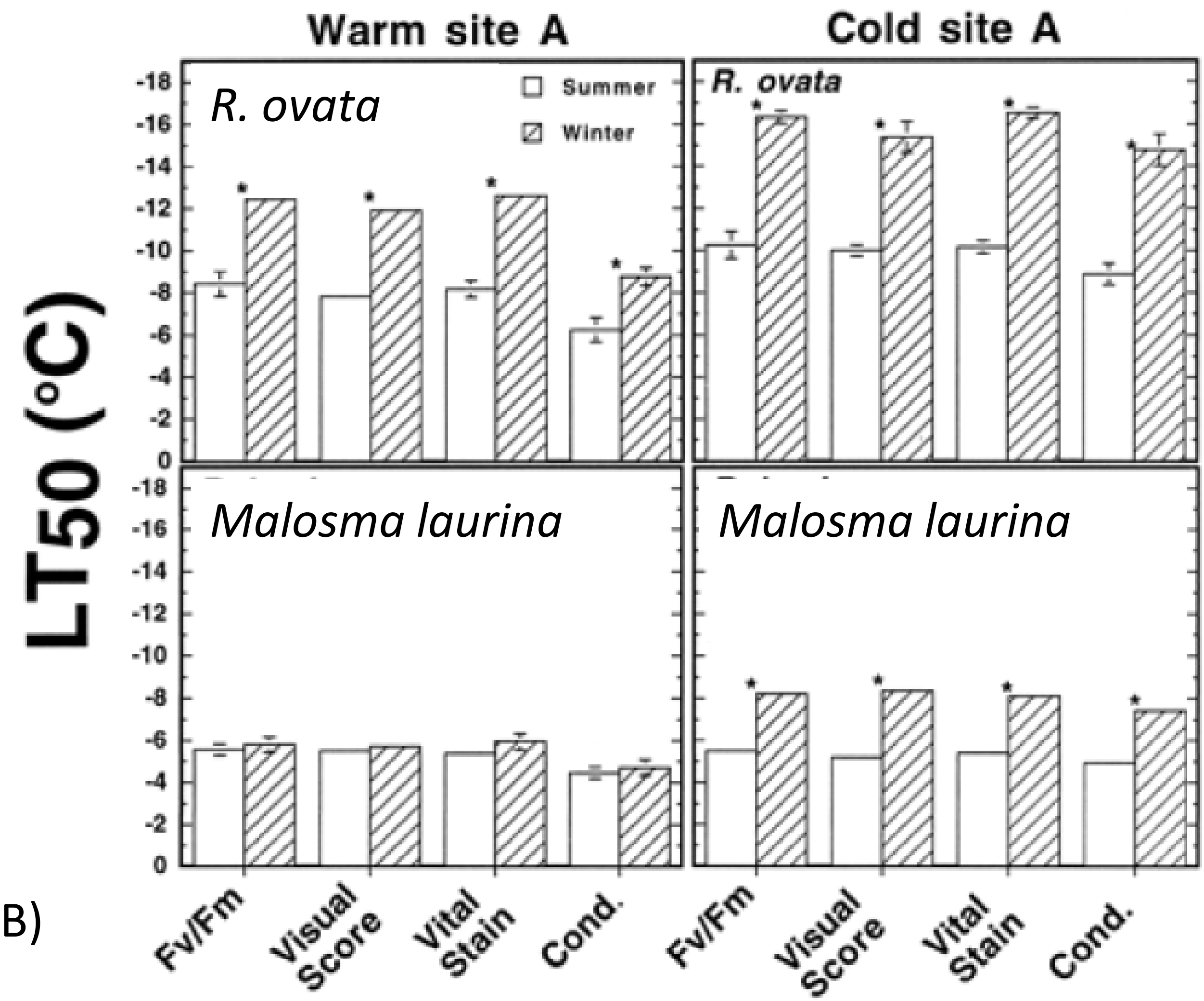
Elevation: 6 m to 1,700 m

Variable environment → differences among populations.

Studies of leaf temperature at 50% cell death showed susceptibility to freezing varies among species and populations.

Plasticity vs. heritable differences?

(Boorse et al. 1998. AJB)



Traits often vary with elevation

Mimulus cardinalis, scarlet monkeyflower

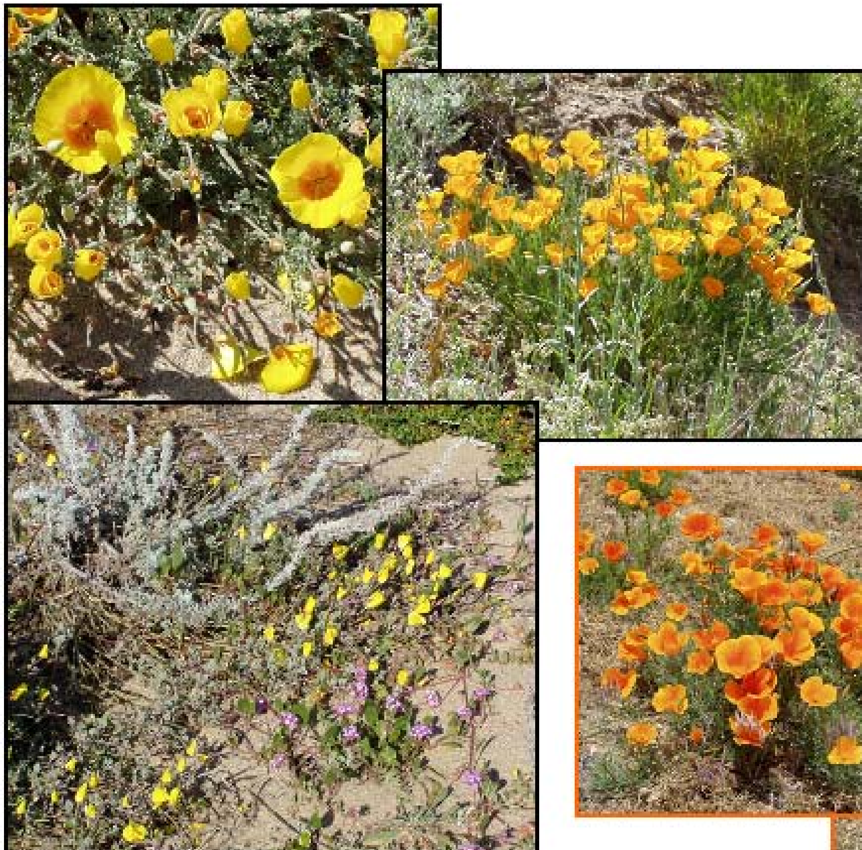
large variation in flowering time from sea level to 8000 ft

Traits also vary with moisture and soil

Eschscholzia californica varies in flower color, size, annual vs. perennial life history, seed dormancy

ANNUALS

coastal



inland

PERENNIALS

(Cook 1972; Montalvo, Feist-Alvey & Koehler 2002)

Ecological and Genetic Experiments

1. Physical and biotic environments influence plant variation and distribution
2. **Experiments reveal adaptive differences affect success of translocations**
3. Translocated species also interact
4. Methods to guide choice of seed source

Traditional Common Garden Studies Detect Genetic Differences

Basic model:

$$V_P = V_{Gen} + V_{Env}$$

in common garden:

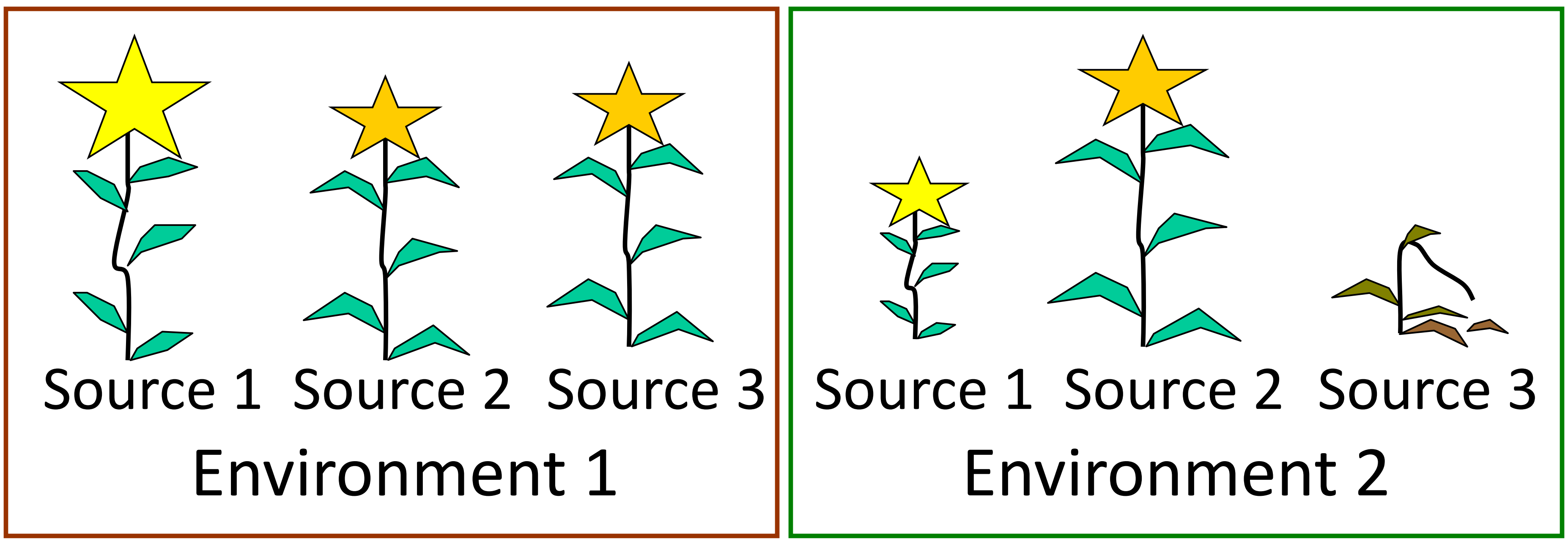
$$V_P \sim= V_{Gen}$$

Nassella pulchra, purple needlegrass

Plants from several source populations grown together in random design (Knapp & Rice)

Common Gardens Can be Placed in Multiple Locations

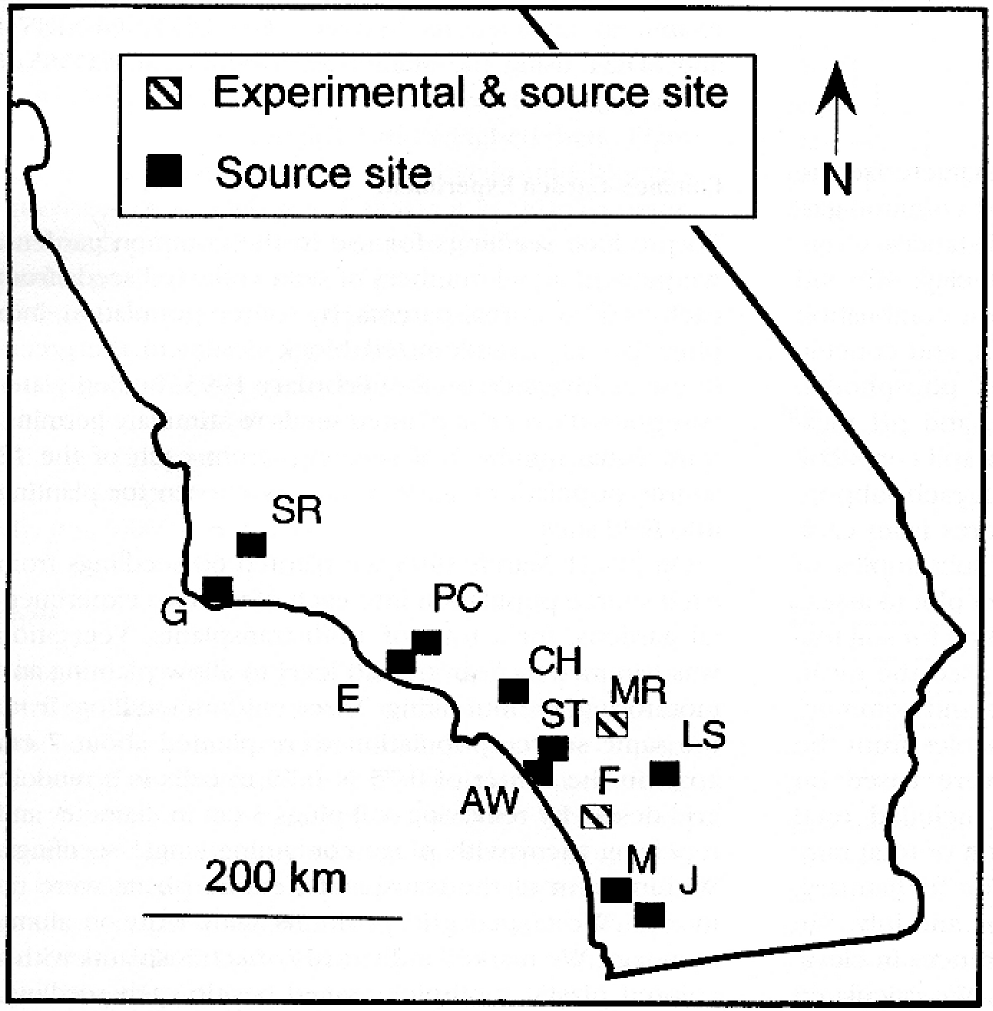
- Reveal plastic response to environment
- Reveal existence & scale of adaptive differences



Study of *Lotus scoparius,* California broom

- common self-compatible subshrub
- variable morphology and habitats
- two named varieties
- distributed widely in California
- used for erosion control, restoration

Lotus scoparius source sites and common gardens



Montalvo & Ellstrand 2000 Con. Bio.

Study Showed Local Adaptation

- Evidence for significant home-site advantage
  - fitness decreased with an increase in genetic or environmental distance to planting site
  - fitness not associated with "geographic distance"

Prediction: long-distance outcrossing will disrupt local adaptation and may result in outbreeding depression

Next: Species Interactions!

1. Physical and biotic environments influence plant variation and distribution
2. Experiments reveal that adaptive differences affect the success of translocation
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Thinking Beyond Initial Transfers: Mixing Populations Can Result in Hybridization

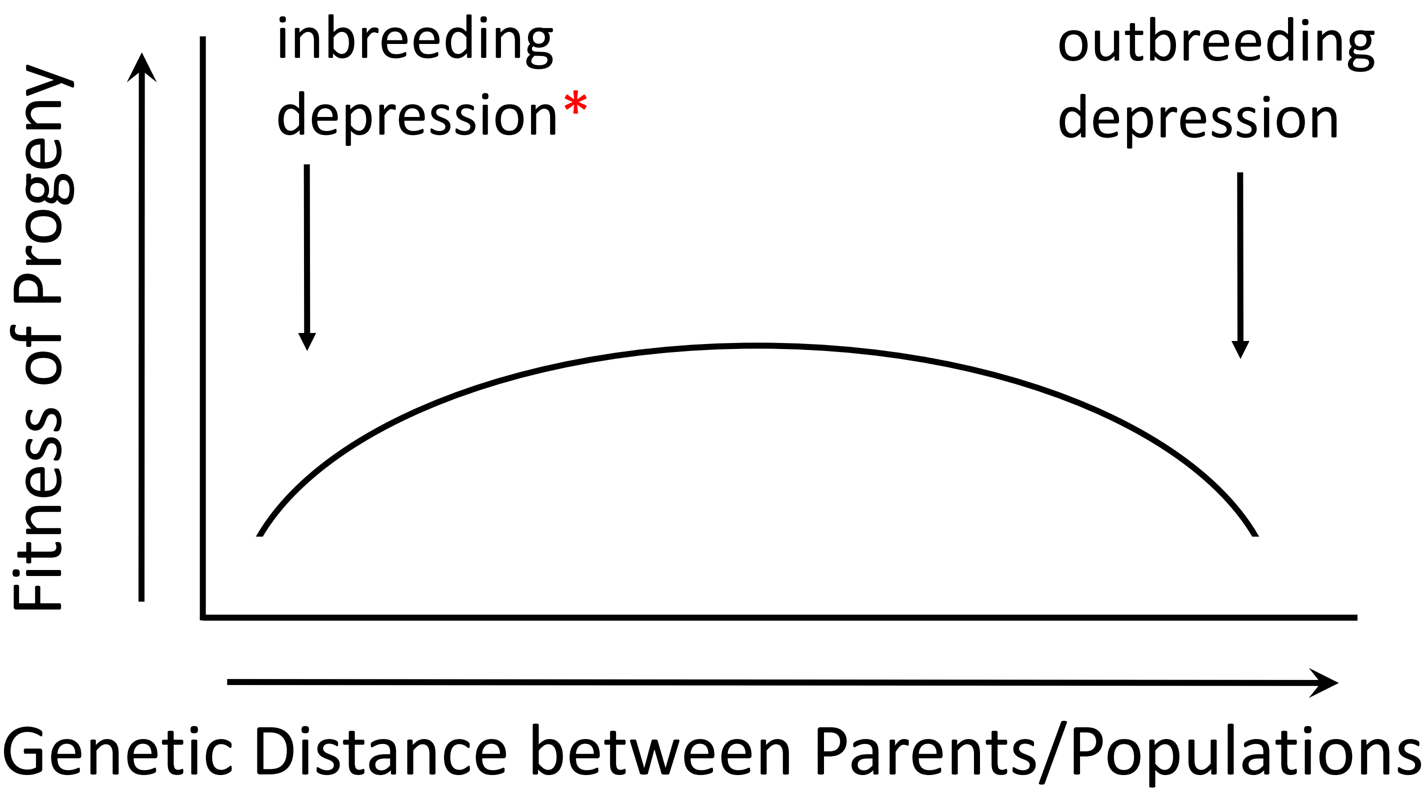
Beneficial Effects

- Genetic rescue from inbreeding effects
- Introgression of new beneficial genetic combinations
- Possible hybrid vigor

Adverse Effects

- Mating incompatibilities
- Dilution of adaptation
- Hybrid breakdown and lower fitness for multiple generations
- Swamping rare species

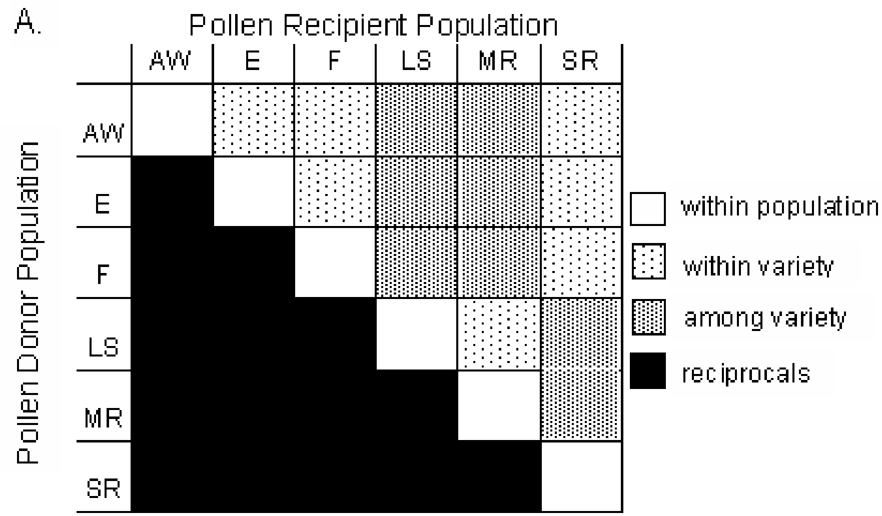
Inbreeding and Outbreeding Depression as a Function of Distance



(figure After Kaye 2001)   This may be especially important for rare species

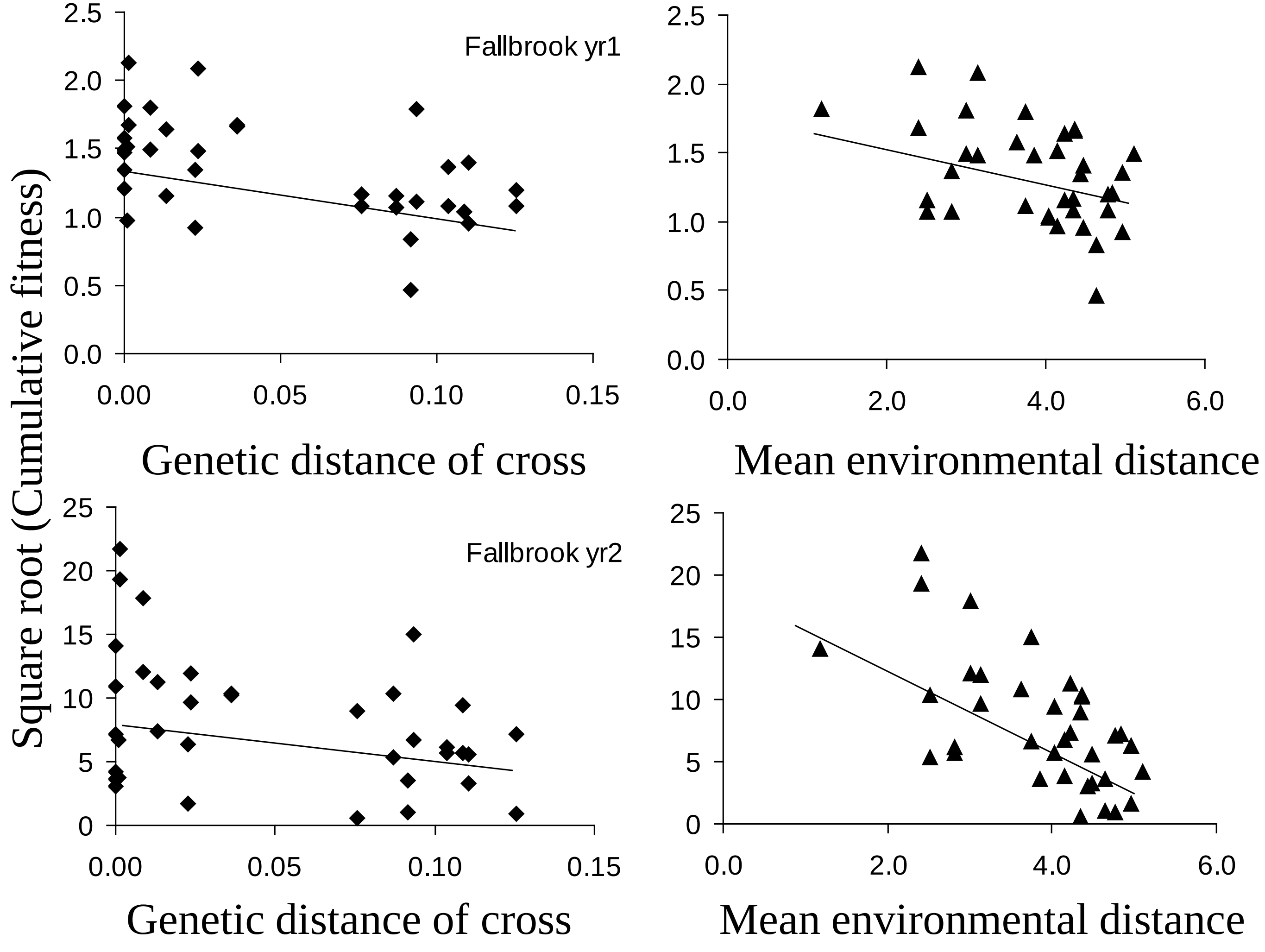
13,000 pollinations → parents and F1 hybrids

Lotus scoparius study



Seedlings of parents and hybrids planted into common gardens at two contrasting sites

Cumulative fitness of populations
(seeds * seedlings * survival * flower production)



Montalvo & Ellstrand 2001 AJB

Translocation Can be Detrimental *Depending* on Scale of Differences

- Outbreeding depression increased with:
  - genetic distance between parents
  - environmental distance of parental sites to transplant site

Environmental similarity most influential

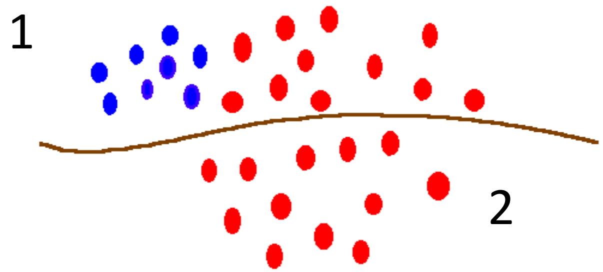
Consider Community Interactions

- Is there local adaptation to soil organisms?
- Is there local adaptation for pollinator service?
- Have populations adapted to local herbivores?
- Do populations differ in competitive ability?
- Can species hybridize with others in new place?
- Could species be invasive in its new location?

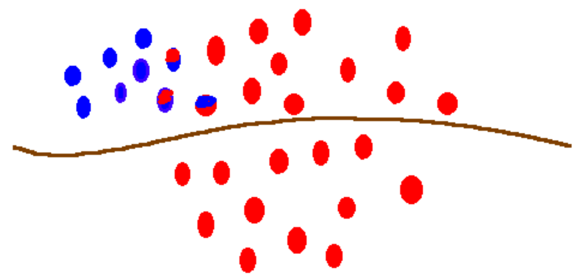
Reciprocal Transplant Study with blue wild rye (*Elymus glaucus*) and purple needle grass (*Nassella pulchra*) (Rice & Knapp 2008)

- Source populations differed in response to competition
- Increased interspecific competition amplified expression of local adaptation

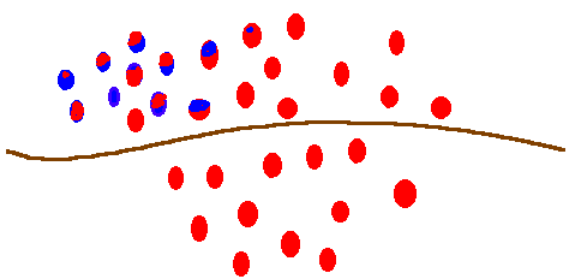
Genetic Assimilation -- the "Borg" Factor



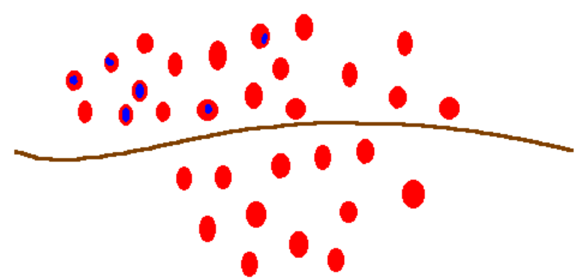
A. Populations come into contact



B. First generation hybridization



C. Continued backcrossing



D. Species 1 locally extinct

Potential Genetic Assimilation?

Abronia latifolia

A. maritima x A. latifolia

A. maritima x A. umbellata

Abronia maritima

Abronia umbellata

- The rare *Abronia maritima* hybridizes with *A. latifolia* and *A. umbellata*
- 14 of 40 sample populations had hybrids, including several thought to be single species populations (Blancas 2001) .

Photos by Lesley Blancas

Hybridization and New Invasive Species

Spartina alterniflora introduced from east coast of USA to San Francisco Bay. Grows in lower, deeper zones.

Hybridized with the native *Spartina foliosa* which doesn't collect sediments.

Using Ecological and Genetic Principles to Maintain Biodiversity – A Challenge

When in doubt, play it safe……….

- Reduce risk by making informed choices
- Collect in local area and elevation for lower risk
- Stay within Ecological Subregions, reserves, as needed
- Source seeds more widely for severely altered sites
- To adjust for fragmentation and climate change, consider historical patterns and future projections

You can maintain multiple levels of genetic diversity from genes to populations to communities and ecosystems.

END