Managing for the New Normal: using novel ecosystems to achieve conservation and restoration objectives – A population genetic perspective

Deborah Rogers

Center for Natural Lands Management

Cal-IPC
October 4, 2013

1. Focus on genetic diversity
2. The “new normal” – Reconsider our approaches and conceptual frames for understanding and serving adaptation

Rapid Climate Change:

Normal or new selective pressure?

- Rate of change
- Magnitude of change
- New vegetative communities, genetic relationships, and abiotic/biotic relationships

Potential for responses to climate change

Response	Time-scale
• Phenotypic plasticity	• Individual life-time
• Adaptation	• Generations
• Migration	• Generations

Limits of Adaptation

‘Gain’ or response to selection varies according to three values:

$$G = I\ h^2\ \sigma_P{}^2$$

- Genetic basis for trait(s) of interest (heritability)
- Genetic diversity (in population) in trait(s) of interest
- Reproduction (generations)
- Demographic cost

Limits of Migration

- Reproductive rate and distance
- Species competition
- Fragmentation, edge effects
- Availability of suitable habitat
- Barriers
- Loss of essential pollinators, seed dispersers
- Contradictory influences (latitude/elevation, day length/temperature)

Avoiding cascading effects throughout the ecological community

- "Conserving genetic diversity is more than a species issue … it is an important community issue … nearly 60% of arthropod diversity could be accounted for by genetic diversity in cottonwood stands … MVP concept may be inadequate for describing the genetic diversity needed in a producer to maintain species diversity in the dependent community … conserving genetic diversity in dominant plant species may be just as important as conserving genetic diversity in rare and endangered species."
- Whitham et al. 2003, Wimp et al. 2005.

(Photo from G. Allan)

Can Adaptation Occur Quickly Enough?

"Human activities are impacting evolutionary process and the scientific community has not adequately incorporated this into conservation planning. Evolution precipitated by human activities is occurring in years and decades rather than centuries and has "disrupted" evolutionary processes in recent times. Adaptation of species through evolution cannot keep pace with the rate of change."

UCLA Evolutionary Change Conference 2007

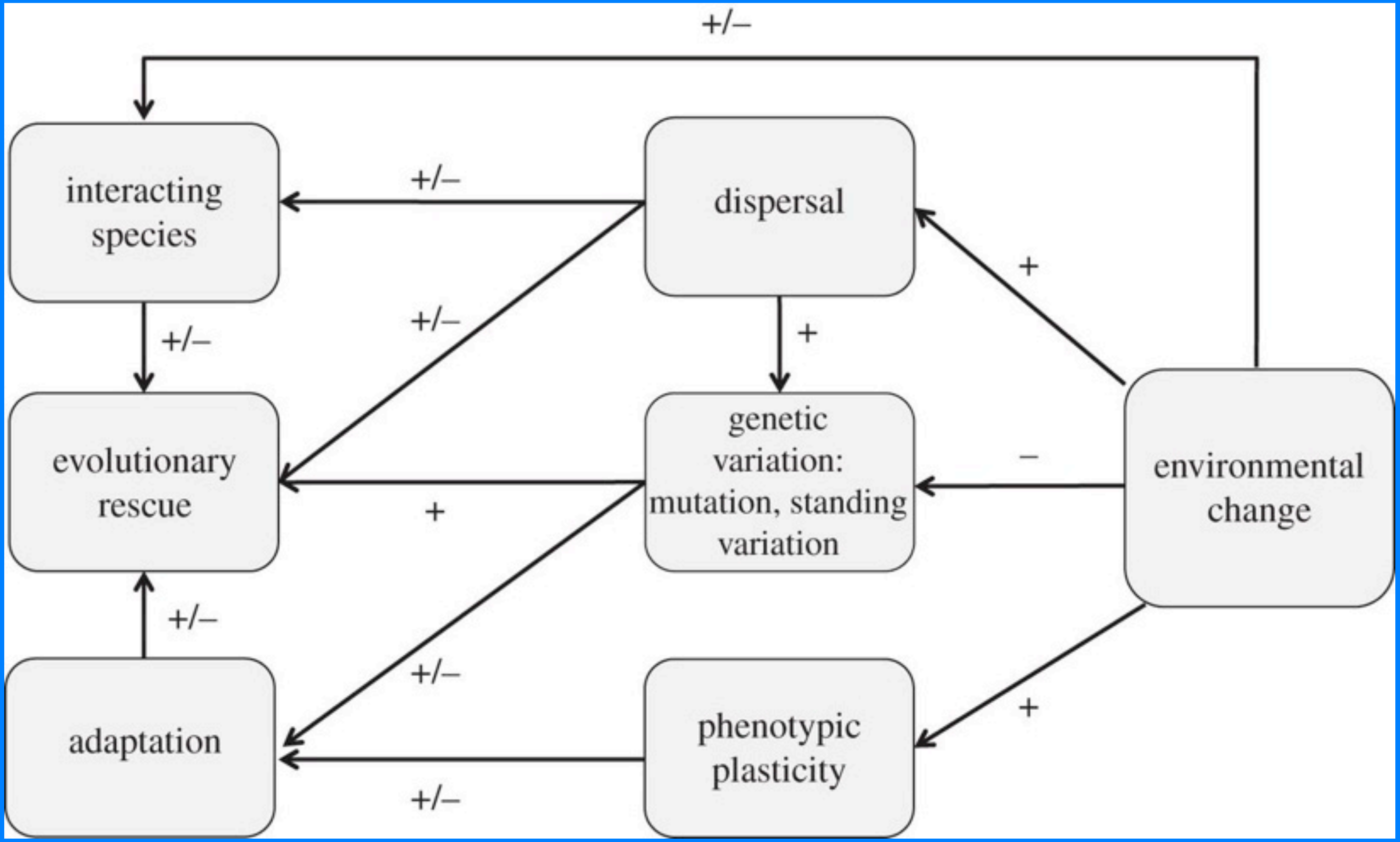
Joshua Tree NP May 2006

Evolutionary Rescue (ER)

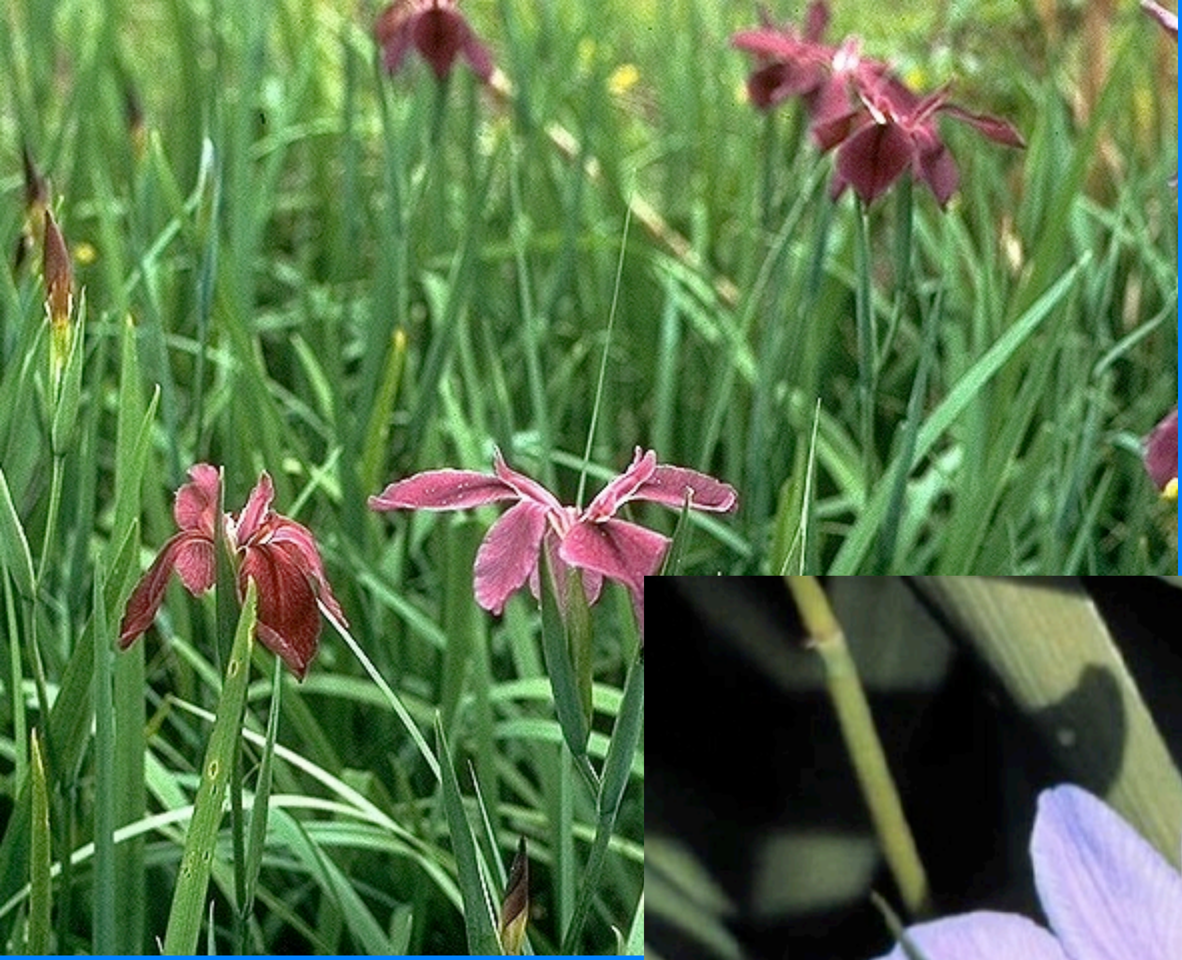
- ER occurs when genetic adaptation allows a population to recover from demographic effects initiated by environmental change that would otherwise cause extirpation
- Broader concept than genetic rescue; emphasizes demographic effects of genetic variation
- Combines population genetics, population dynamics, and ecology
- ER most likely to depend on the presence of rare rescue genotypes that can tolerate extreme conditions (extremes of the fitness distribution rather than the mean)
- Initial population size is critical determinant of ER

(E.g., Gonzalez et al. Evolutionary rescue: an emerging focus at the intersection between ecology and evolution. Phil. Trans. R. Soc. B. 2013, 368: 20120404. http://dx.doi.org/10.1098/rstb.2012.0404)

A simplified diagram of the factors influencing ER .



Gonzalez A et al. Phil. Trans. R. Soc. B 2013;368:20120404



Mechanisms?

Adaptive introgression in Louisiana iris

Iris brevicaulis, Zigag iris
Larry Allain @ USDA-NRCS PLANTS Database

Iris fulva, Copper iris
Clarence A. Rechenthin @
USDA-NRCS PLANTS Database

Martin et al.
Genetics 172: 2481–2489

Adaptive trait introgression between these two species

CROSS	ALIVE	DEAD	Fraction Survival
I. Fulva	3	8	0.272727
I. Brevicaulis	0	13	0
BCIB	23	393	0.055288
BCIF	33	325	0.092179

Adaptive introgression for multiple traits

• Introgression of abiotic tolerance traits between two hybridizing North American sunflower species, *Helianthus annuus* and *H. debilis*

• Examined 10 ecophysiological, phenological, and architectural traits in parents, hybrids, backcrosses in two common environments

• Introgression has altered multiple aspects of the *H. annuus* phenotype in an adaptive manner, has affected traits relevant to both biotic and abiotic environments, and may have aided expansion of the *H. annuus* range into central Texas

Whitney, Randell, and Rieseberg. New Phytologist (2010) 187: 230-239

When does a native cease to be a native?

Introduced

Spartina alterniflora/hybrids (smooth cordgrass)

Above: Taller, more robust clone of introduced *S. alterniflora* surrounded by native cordgrass, *S. foliosa*.

Above: Red/maroon leaf sheaths around culm (bottom) of *S. alterniflora*. Native *S. foliosa* are white/green.

Above: Inflorescence of native *S. foliosa (left)* compared to the large *S. alterniflora*/hybrid.

San Francisco Estuary Invasive Spartina Project

Preserving native wetlands

www.spartina.org

“Toxic water favors genetic invasion: Hybrid tiger salamanders survive water conditions that are lethal for California tiger salamanders”

“Hybridization with non-native increases tolerance of native California tiger to polluted water conditions”

Camissonia cheiranthifolia in GGNRA

- Two distinct subspecies in California
- The non-local subspecies – *C.c. suffruticosa* – accidentally introduced in 1982
- Cross-breeding with native subspecies – *C.c. cheiranthifolia* – is evident

Photo source: USDA/NRCS Native Plants Database

Successful restoration, (somewhat premature) assisted migration, *or* exotic invasion ?

- Cross-breeding with native subspecies – *C.c. cheiranthifolia* – is evident
- Hybrids are spreading, and are difficult to identify
- Unknown threat to local subspecies and dune restoration efforts
- 'Volunteer fatigue'
- Seeds collected from initial plantings have been widely used in other coastal dune areas of San Francisco County

Photo: Courtesy: S. Fritzke , NPS, 2005

Management Implications

I. Begin with the objectives:
   “Natives only” or …
   Diversity?
   Long-established relationships?
   Well adapted?
   Well buffered?

II. Manage within an experimental frame

III. Monitor

Managing for the new normal: using novel ecosystems to achieve conservation and restoration objectives – A population genetic perspective

Deborah Rogers

Center for Natural Lands Management

"I love how you've introgressed adaptive genes into your largely native plants to complement your novel garden environment"

Cal-IPC
October 4, 2013