Genetic Rewilding :

how connectivity can rescue small populations

Sarah W. Fitzpatrick
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UNIVERSITY

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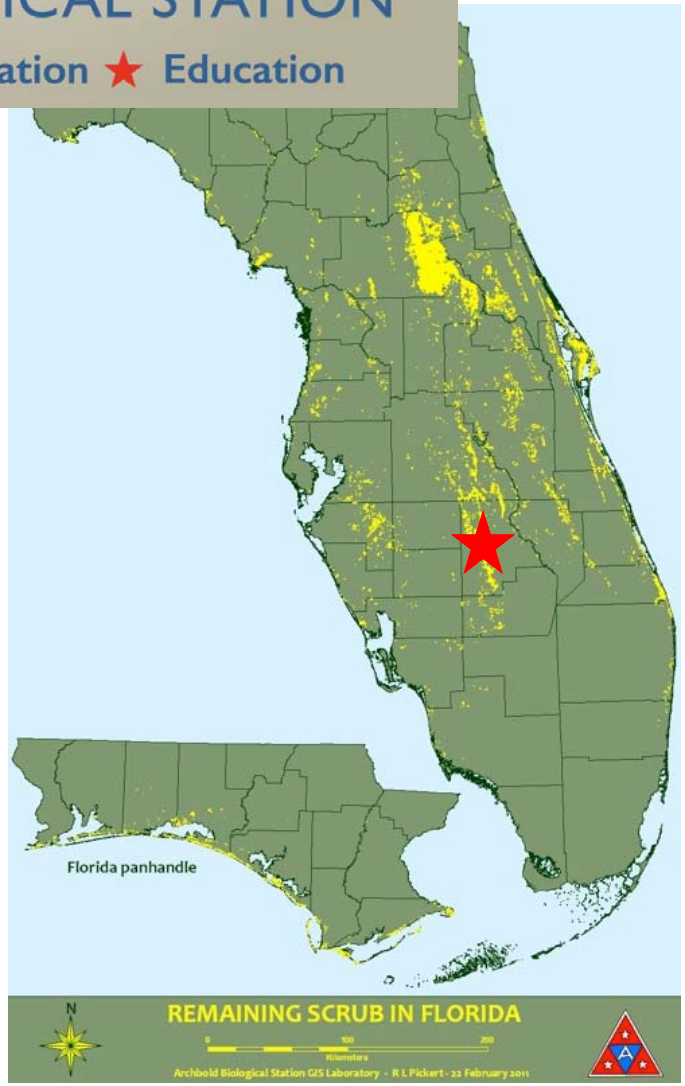

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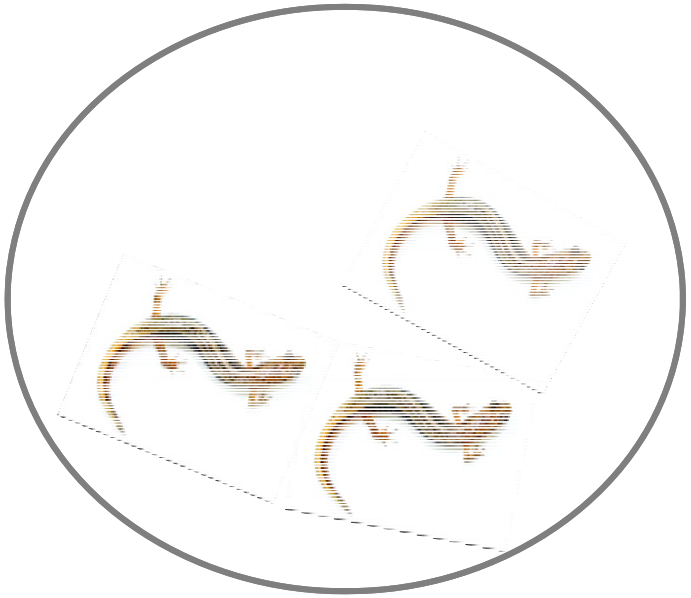
Why does connectivity matter?

- geographic distribution
- range size
- population dynamics
- evolutionary trajectory of species

Charley Harper

Connectivity shapes biodiversity patterns through gene flow

gene flow = genetic connectivity



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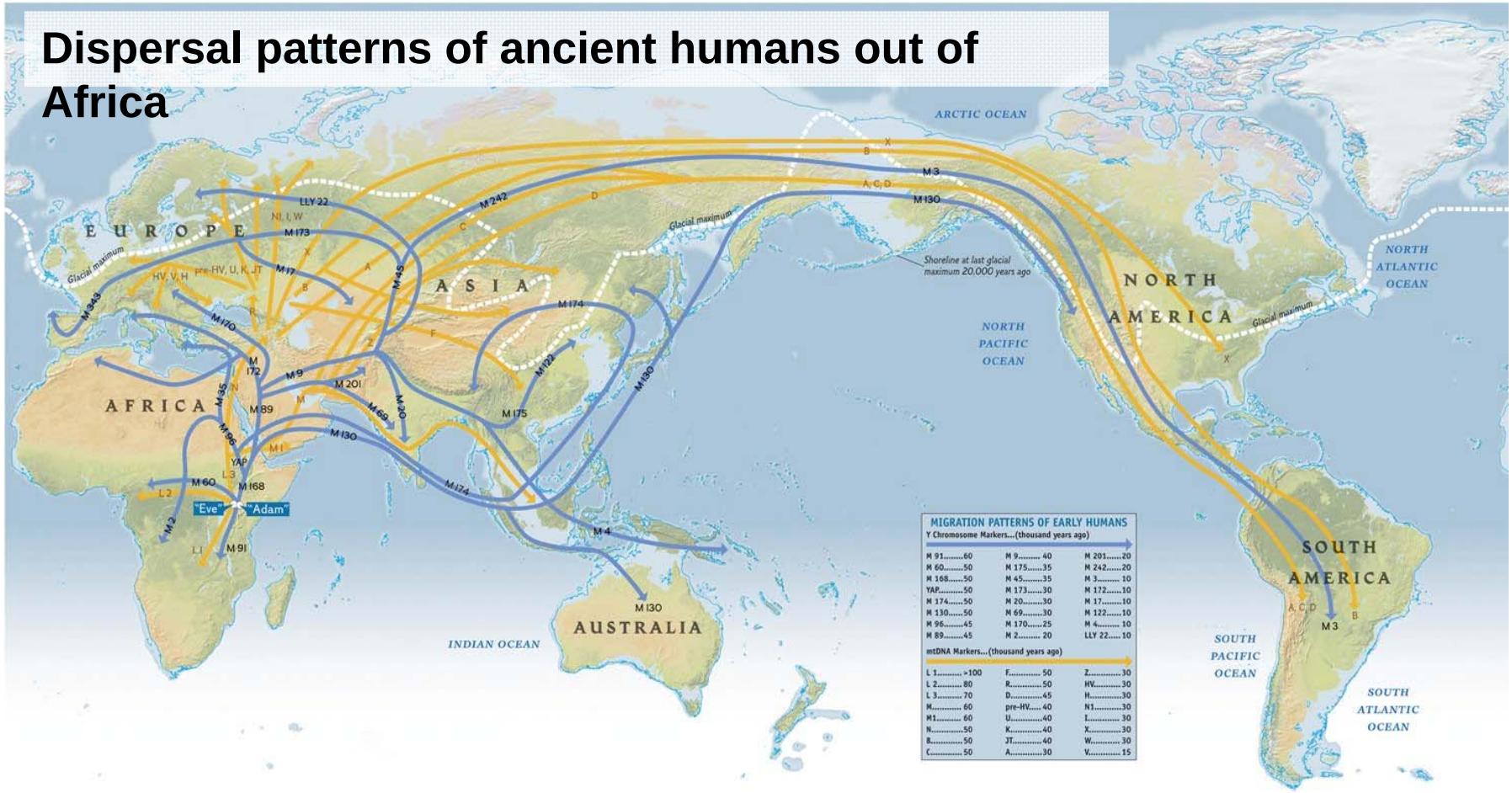

Why does gene flow matter for conservation?

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- Gene flow can decrease fitness
- Gene flow can increase fitness

fitness = a measure of reproductive success

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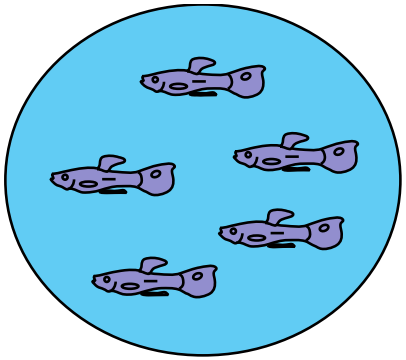

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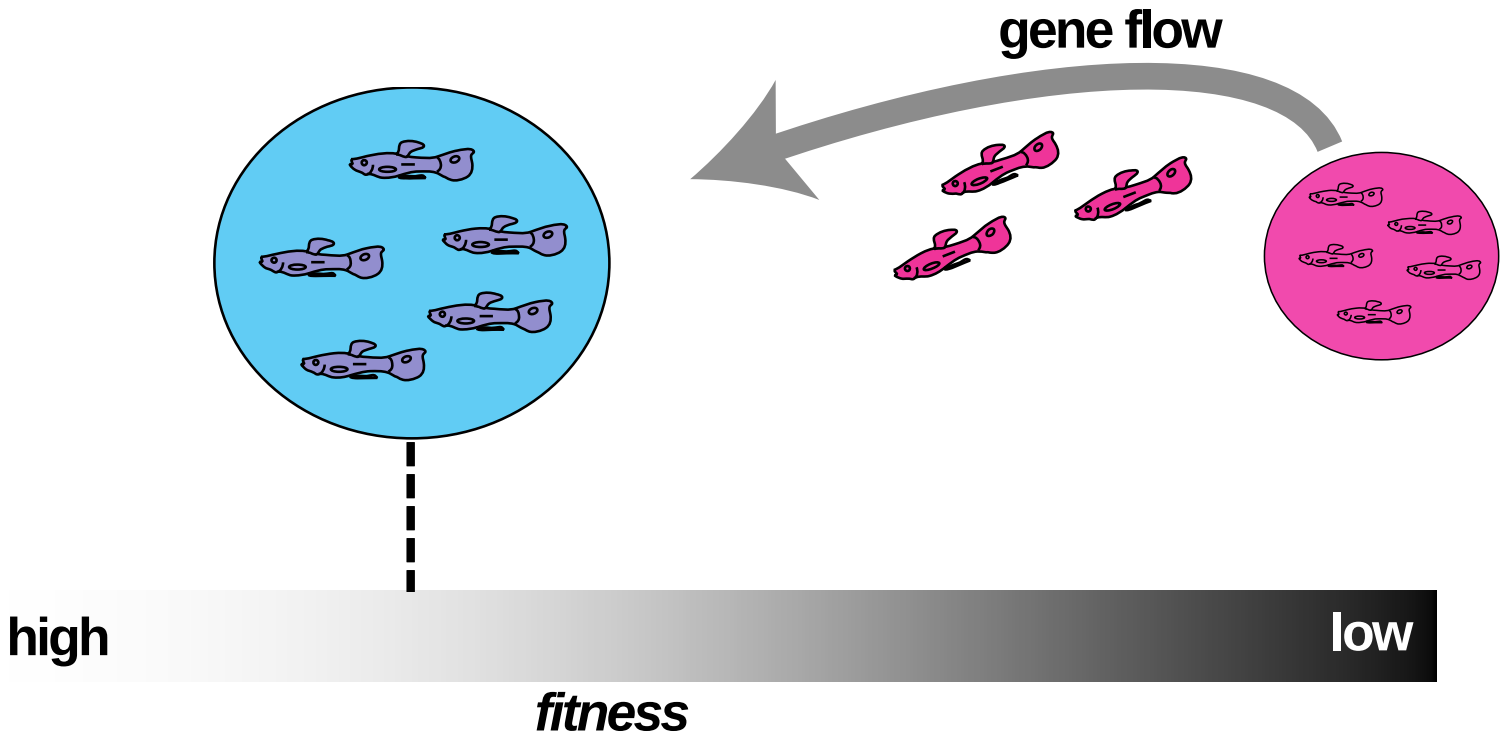

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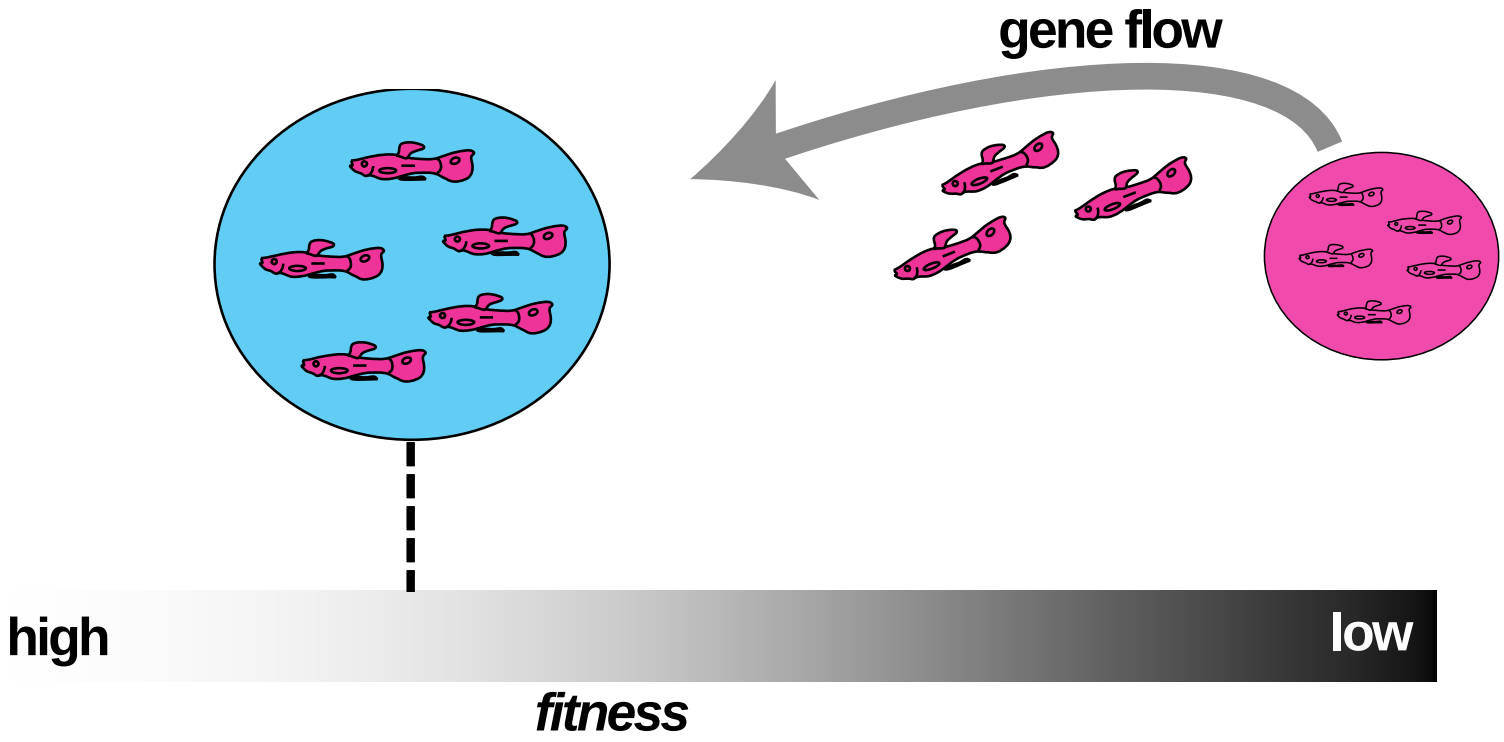

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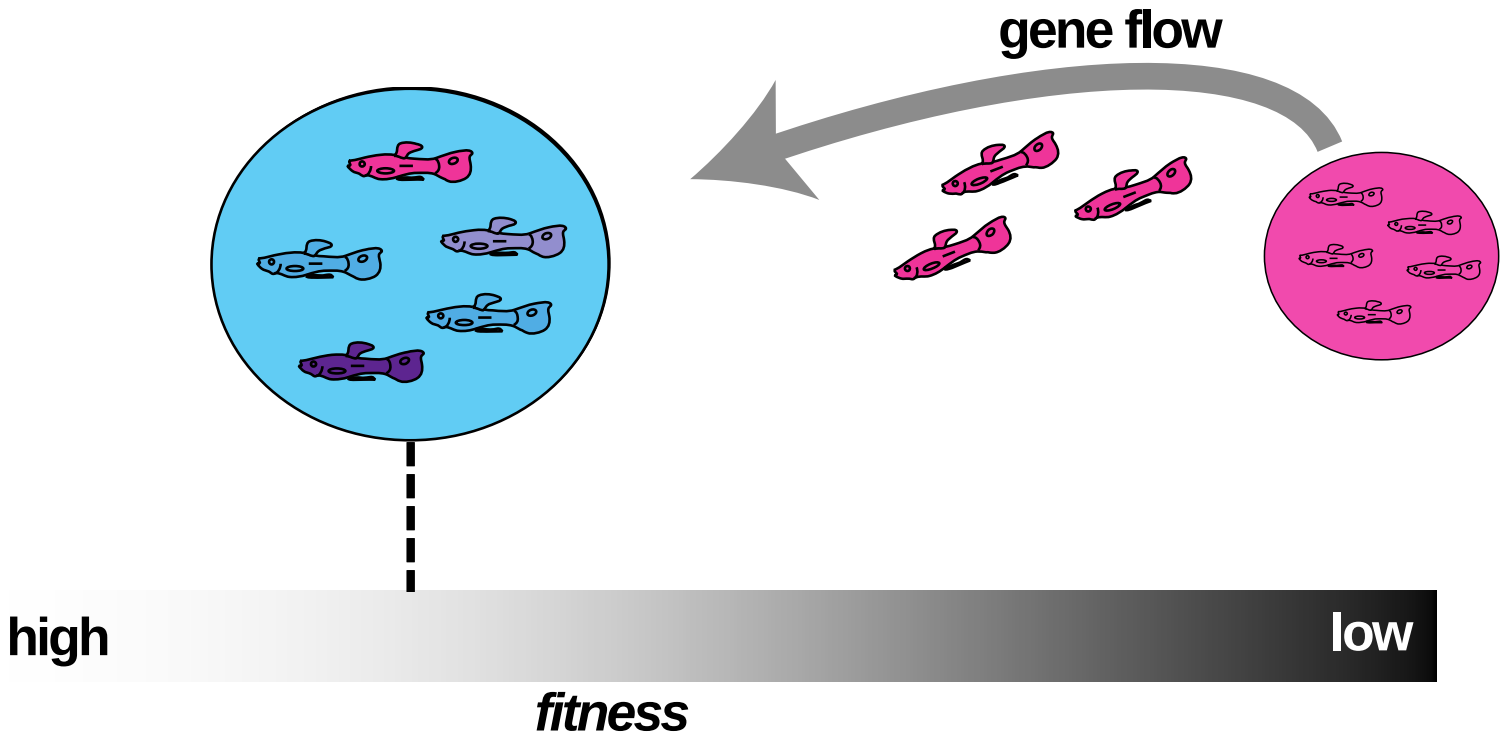

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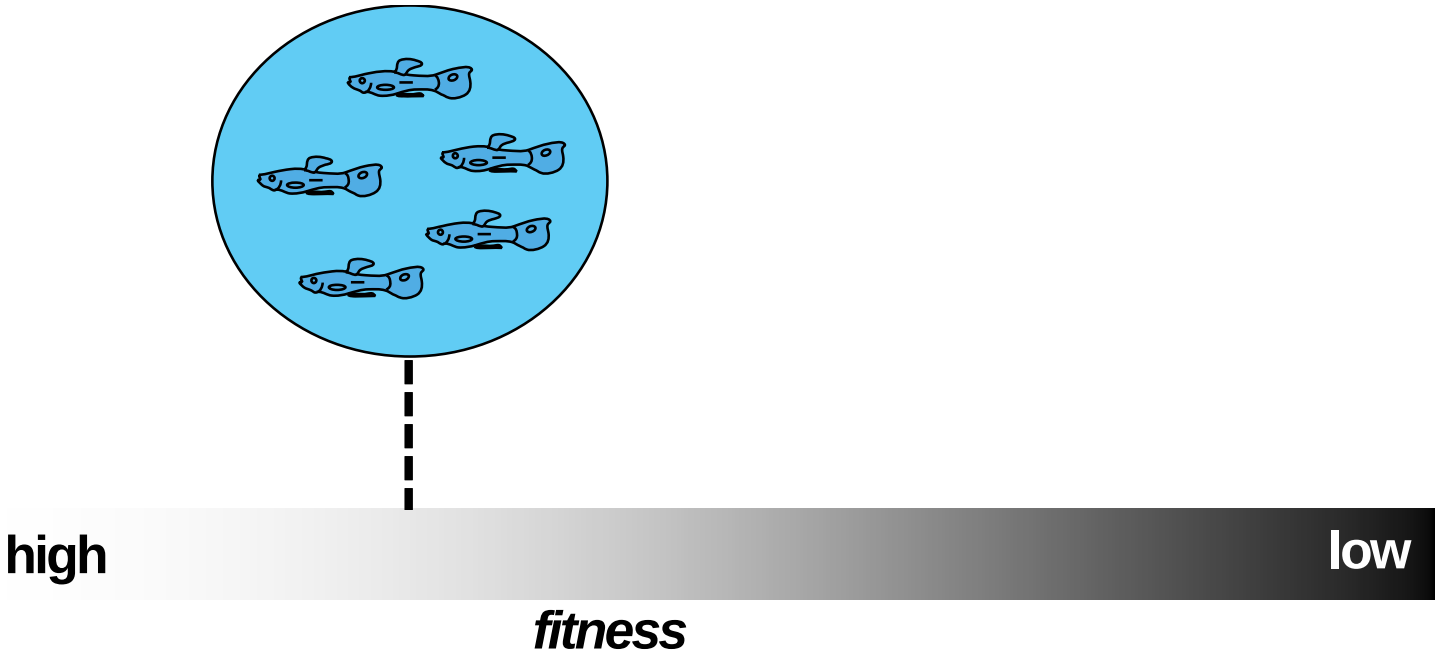

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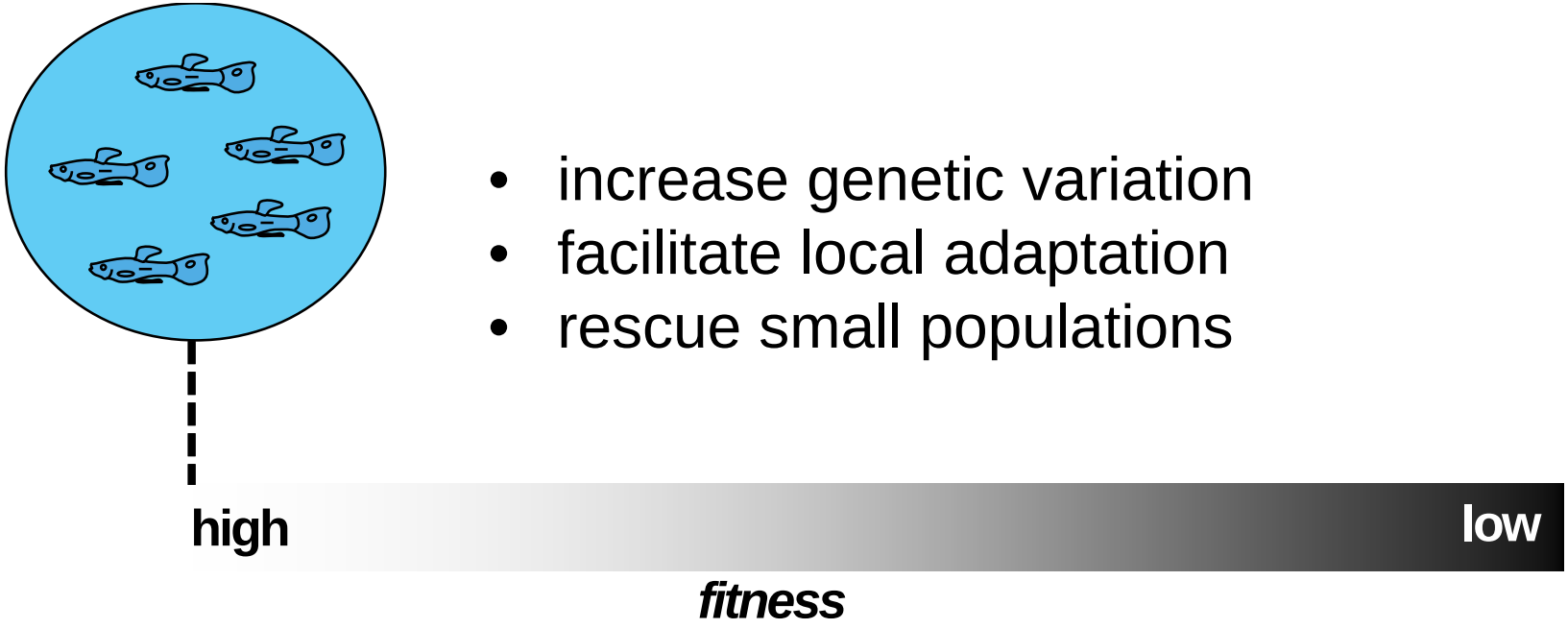


- increase genetic variation
- facilitate local adaptation
- rescue small populations

Problems with small populations

- risks of inbreeding depression
- reduced adaptive potential
- little buffer to withstand environmental disturbance

Cheetah

Scrub mint

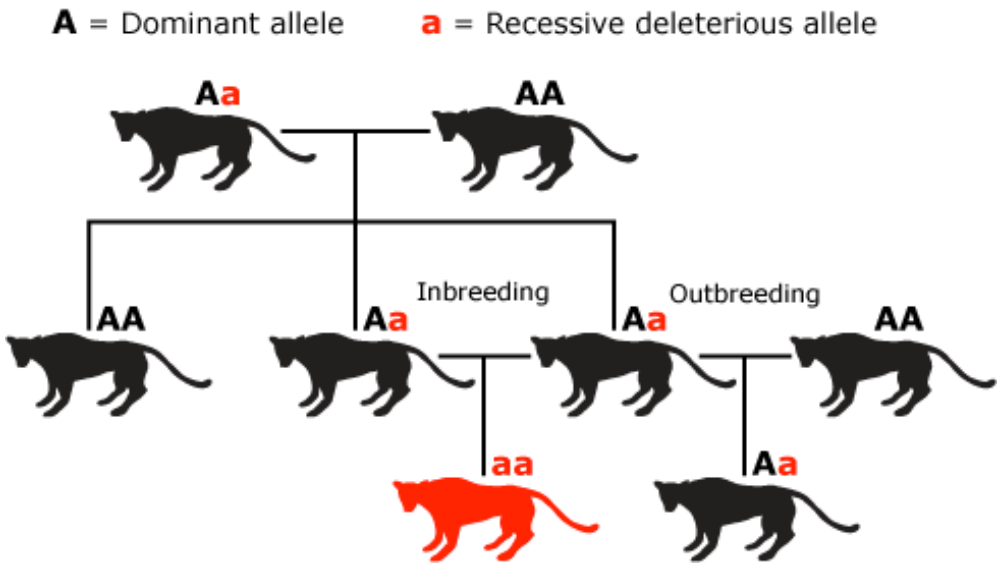
Devil's hole pupfish

Bighorn sheep

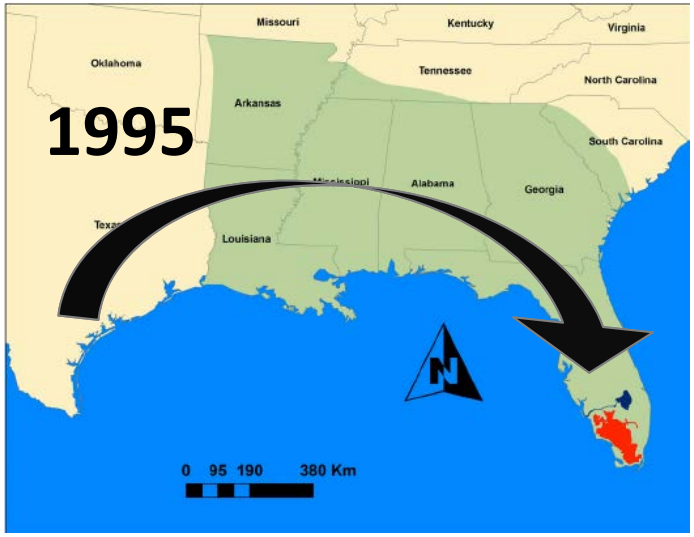
historical range (green)
current range (red)

- habitat loss
- severe population declines
- signs of inbreeding depression
  - 49 % of male panther's suffered from cryptorchidism (undescended testes)
  - kinked tail phenotype

Inbreeding exposes deleterious alleles



By 1994, only 20-30 adult panthers remained in Florida

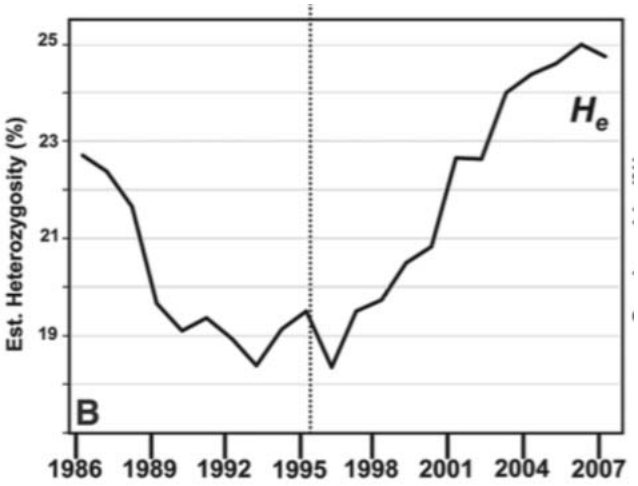


historical range (green)
current range (red)

- **8 female panthers from Texas introduced to Florida**

Great.
What about population size?

genetic diversity increased



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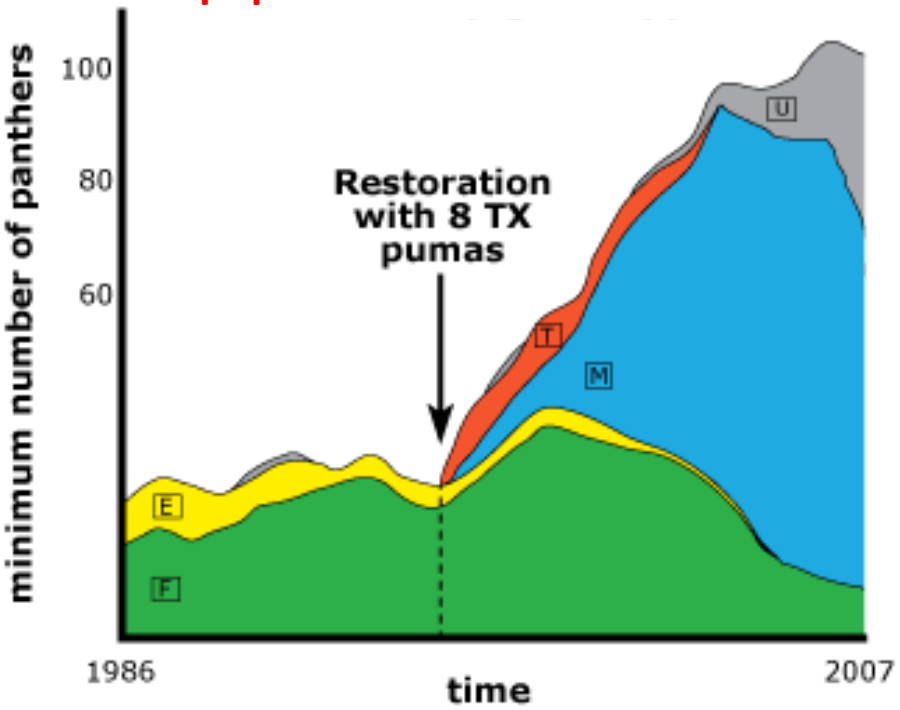
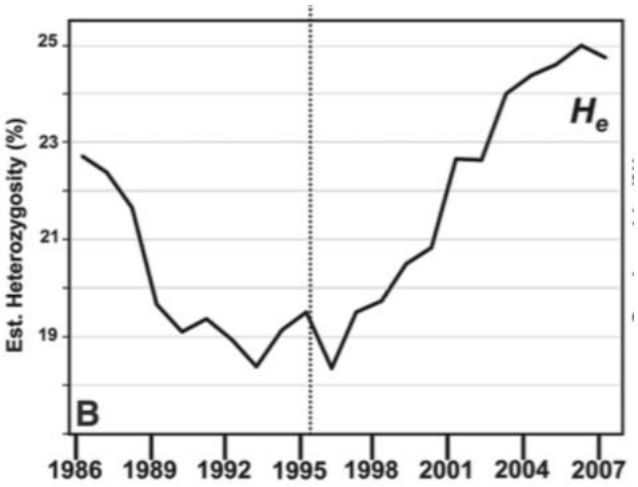
population size increased too!



E = pure Everglades panthers
F = pure Florida panthers
T = pure Texas pumas
M = panthers descended from crosses between locals and Texas pumas
U = panthers of unknown descent

genetic diversity increased



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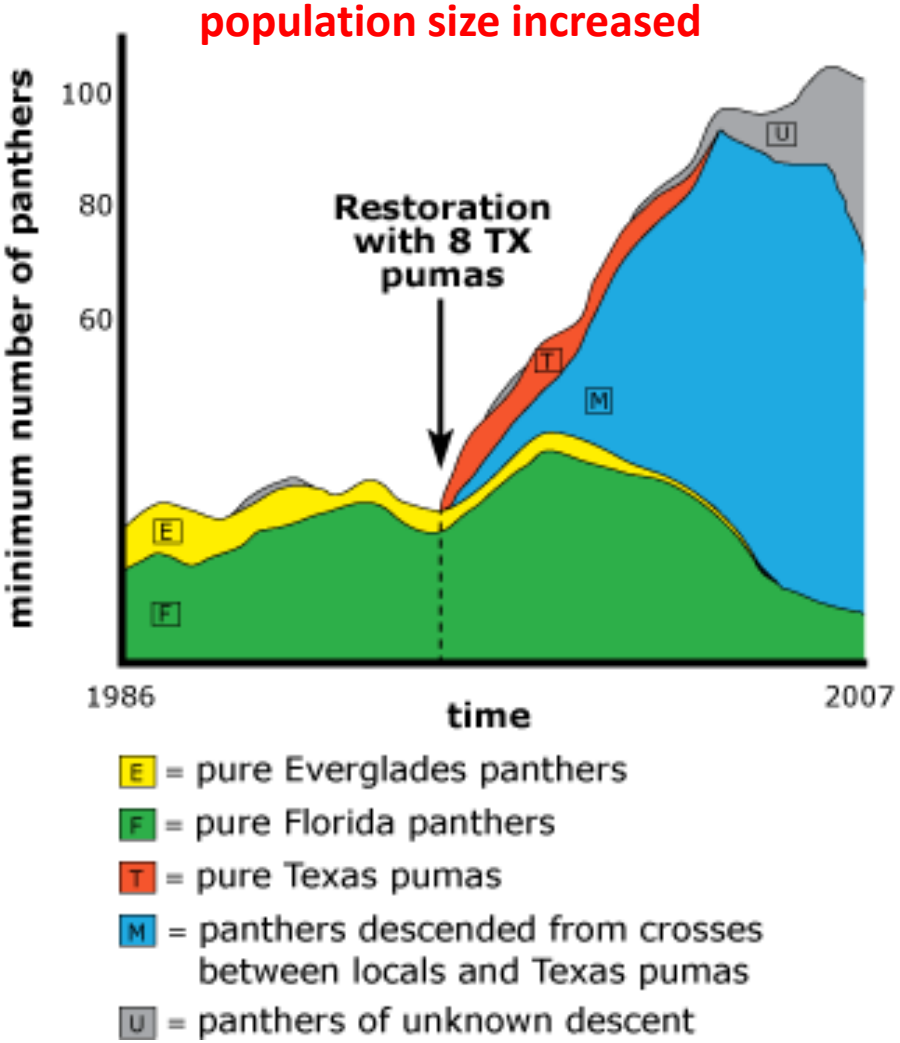
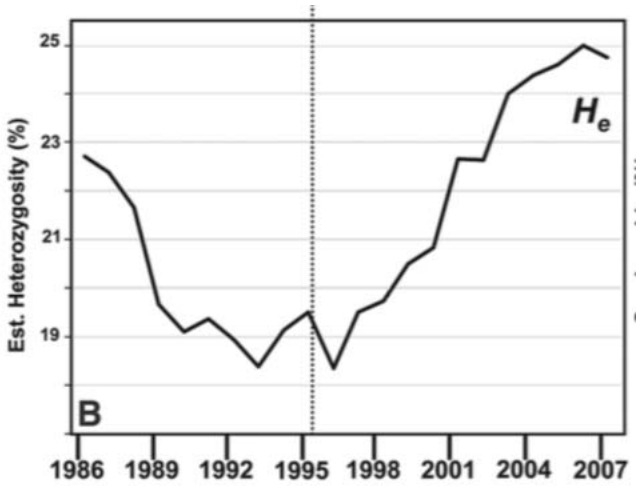
Genetic rescue: increase in population growth by more than the demographic contribution of immigrants

population size increased



genetic diversity increased



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How does connectivity, or lack thereof,
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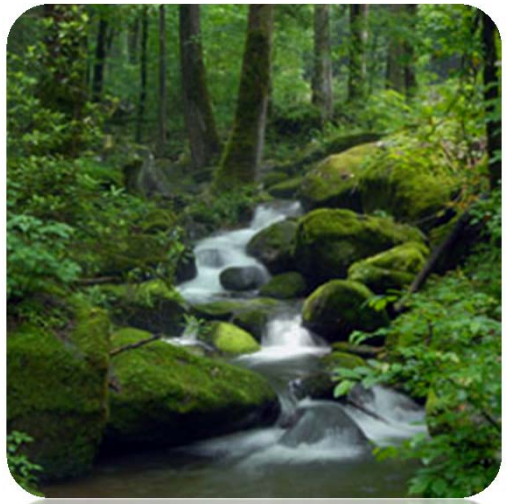

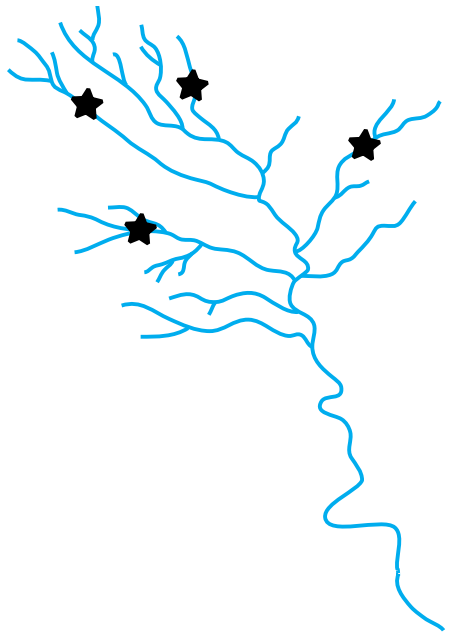

How does connectivity, or lack thereof,
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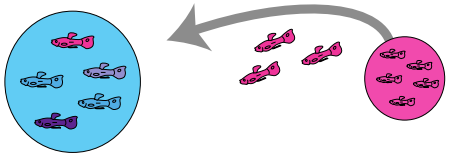
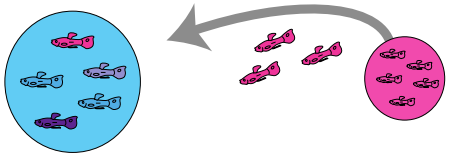
Rest of talk



1. Effects of a rapidly changing landscape on natural patterns of connectivity in a threatened fish

Rest of talk



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2. Genetic rescue in guppies: a model system for evolution, conservation, and education

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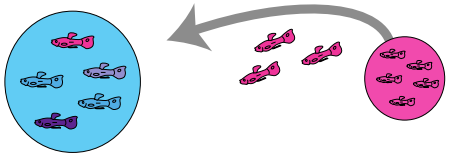

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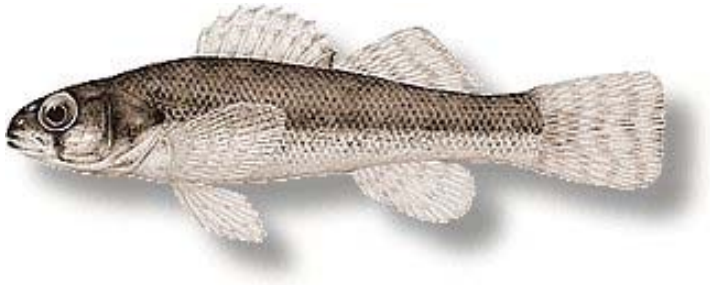
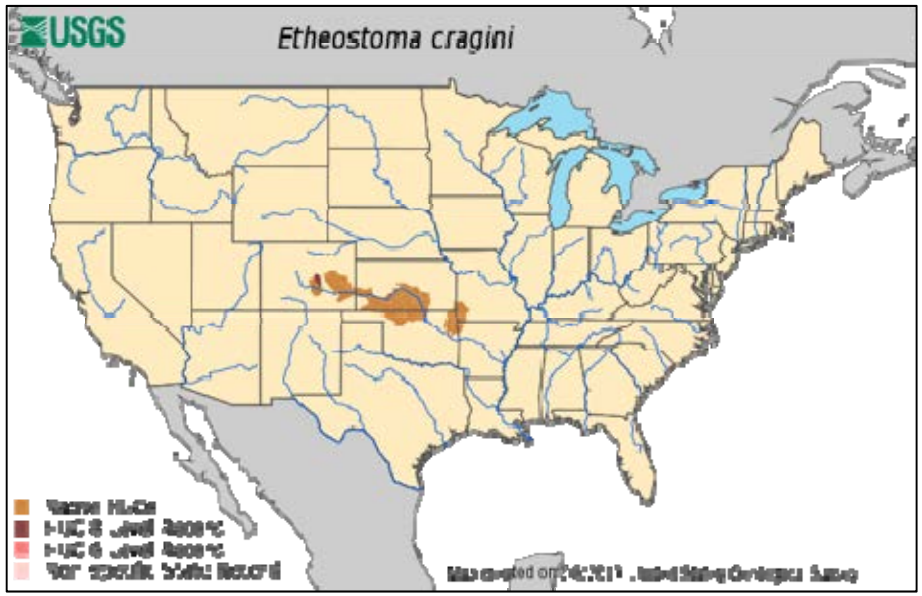
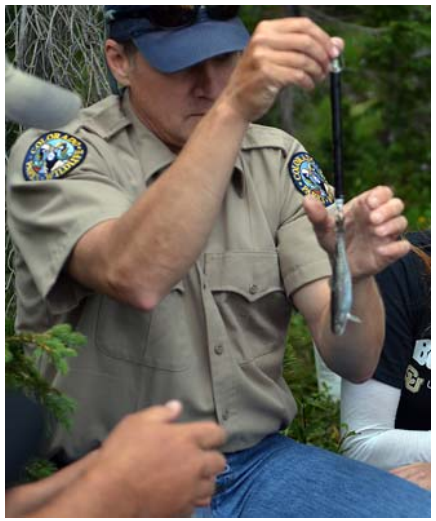
Characterizing gene flow in an imperiled species



Arkansas darter (*Etheostoma cragini*)





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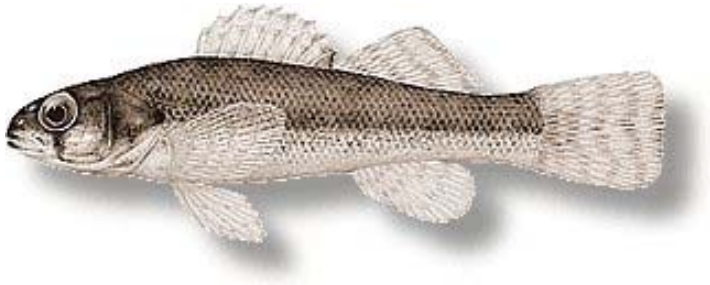

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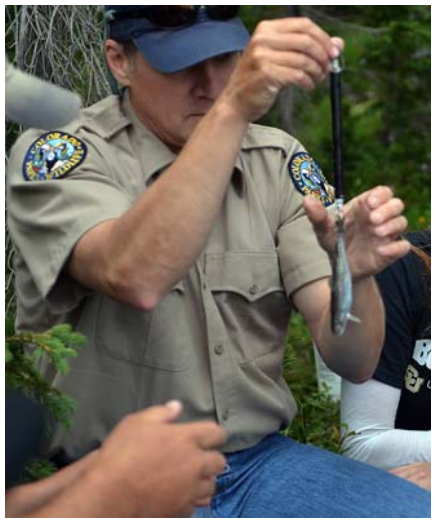

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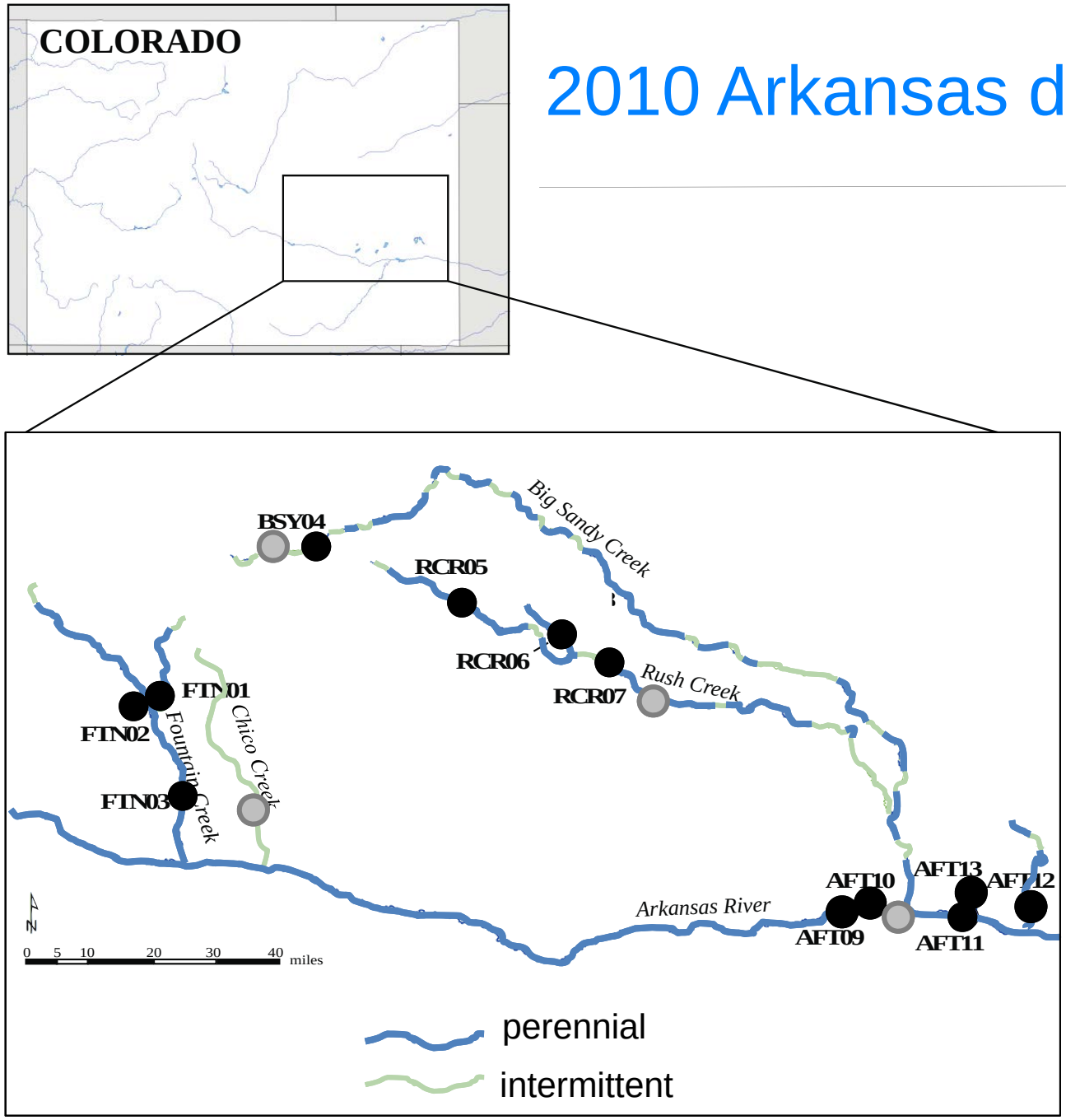
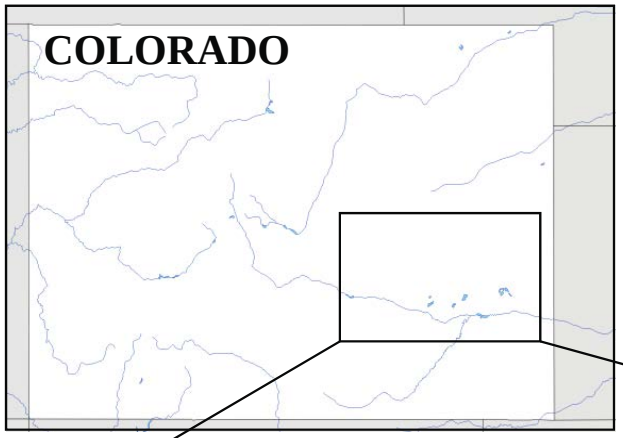
Big Sandy Creek
lives up to its name

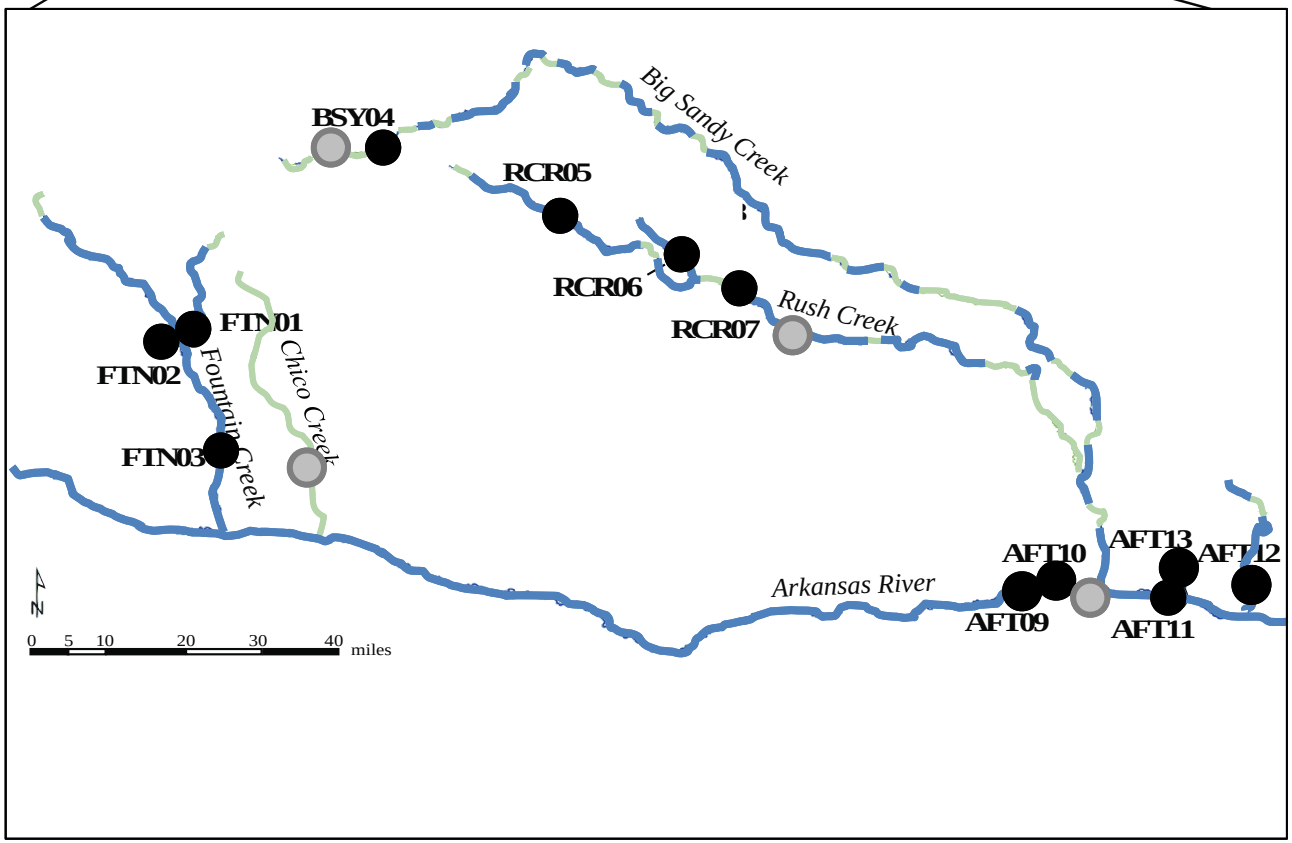
2010 Arkansas darter sampling



- more than 5 darters
- 5 darters or less

2010 Arkansas darter sampling





- more than 5 darters
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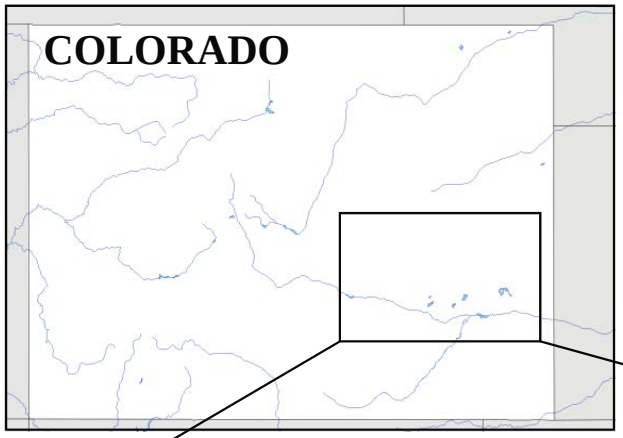
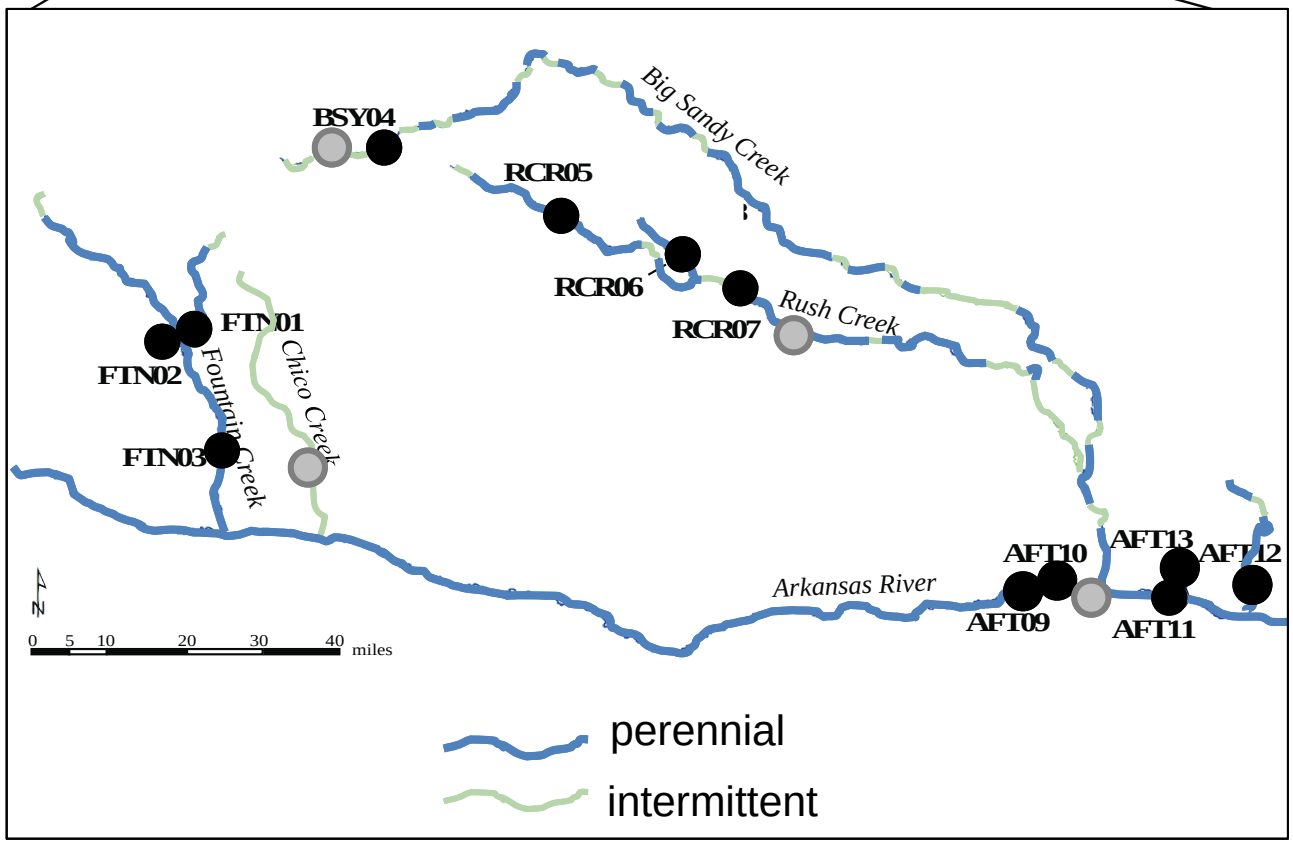
Totals

- 12 sites
- 614 darters sampled
- genotyped at 10 microsatellite loci

2010 Arkansas darter sampling





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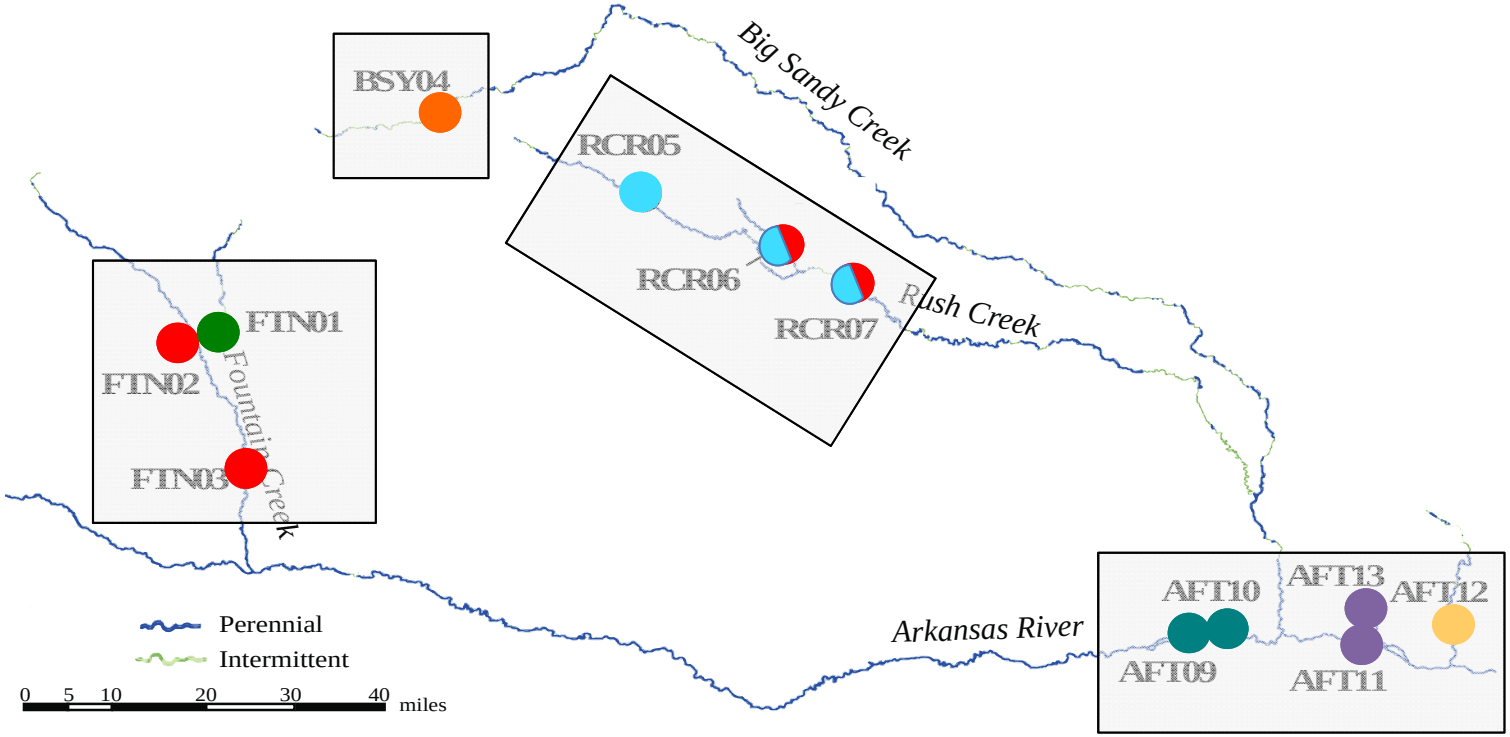
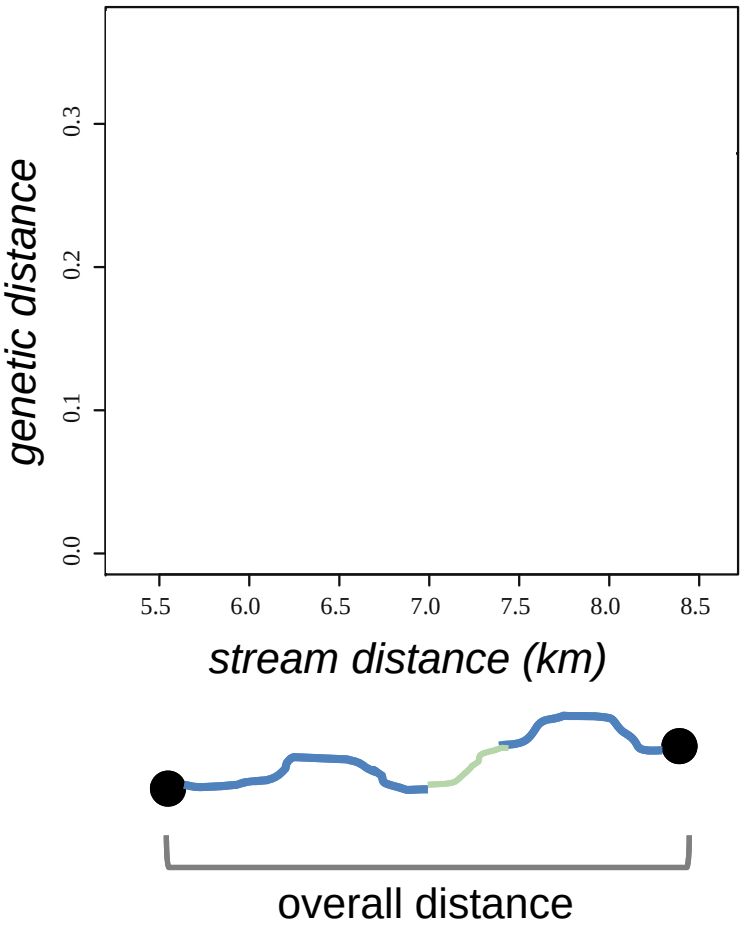
Low genetic diversity within sites & connectivity among sites



Fitzpatrick, S.W., H. Crockett, W.C. Funk (2014) *Conservation Genetics.*

How does the landscape affect connectivity?



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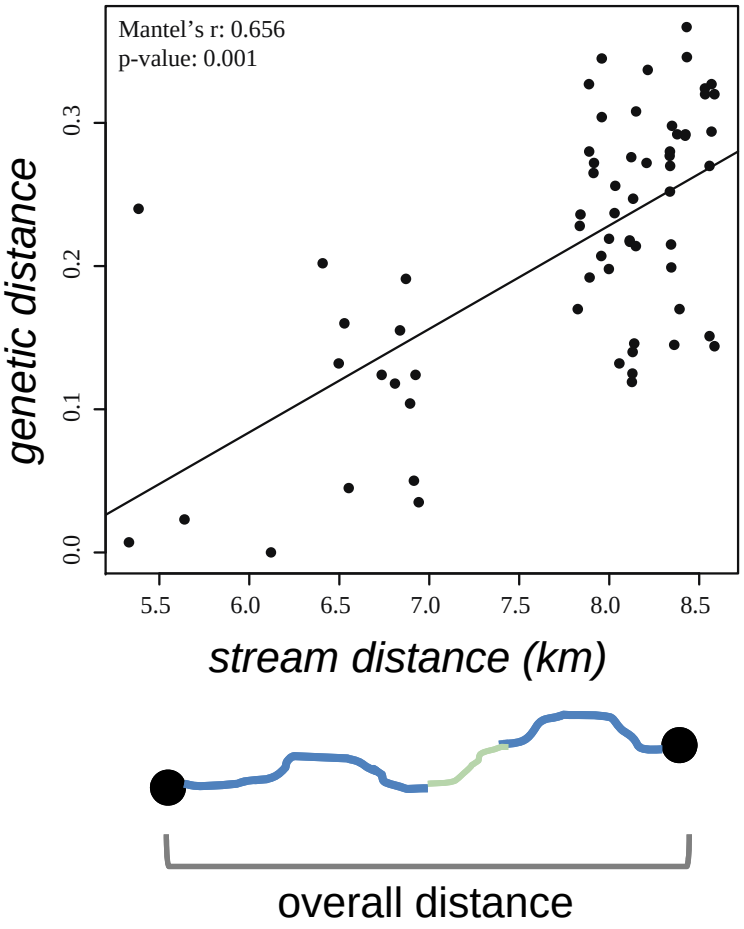
Stream distance lowers connectivity



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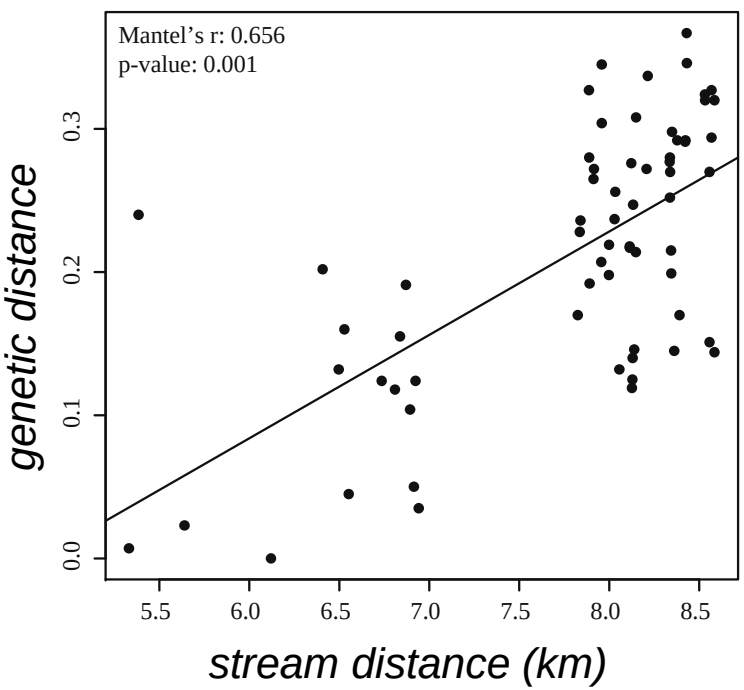
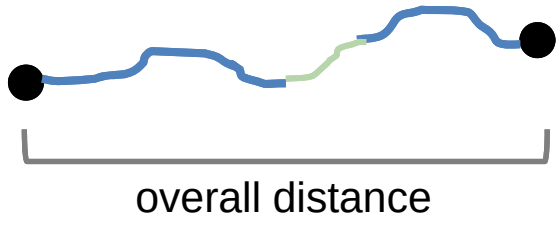
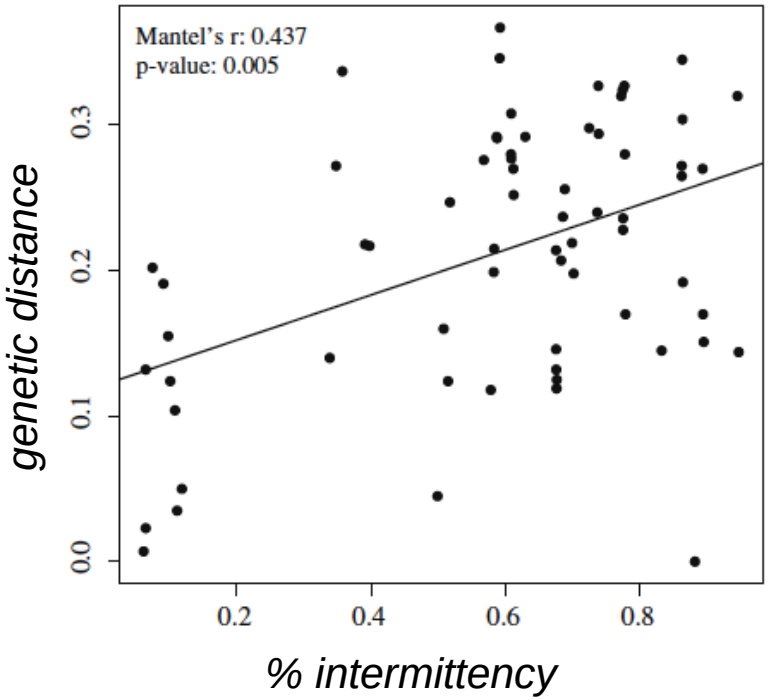
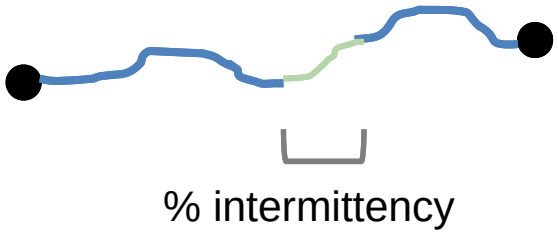
Intermittency acts as a barrier to gene flow









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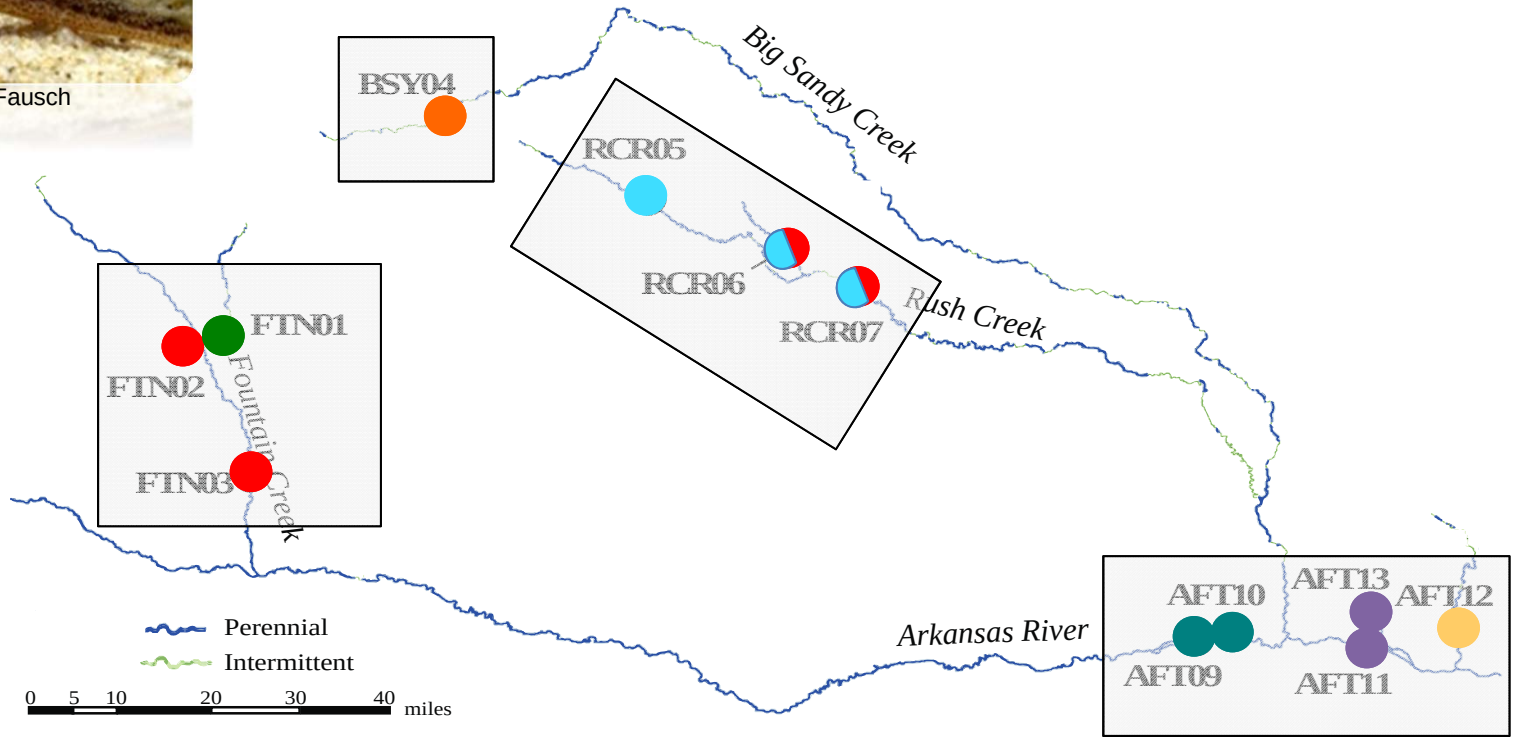
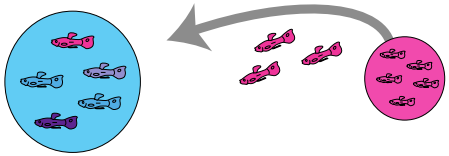
How should isolated, threatened populations be managed?

photo credit: Kurt Fausch



Rest of talk



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“The island of Trinidad formed
the natural laboratory for
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- Caryl Haskins
Venezuela


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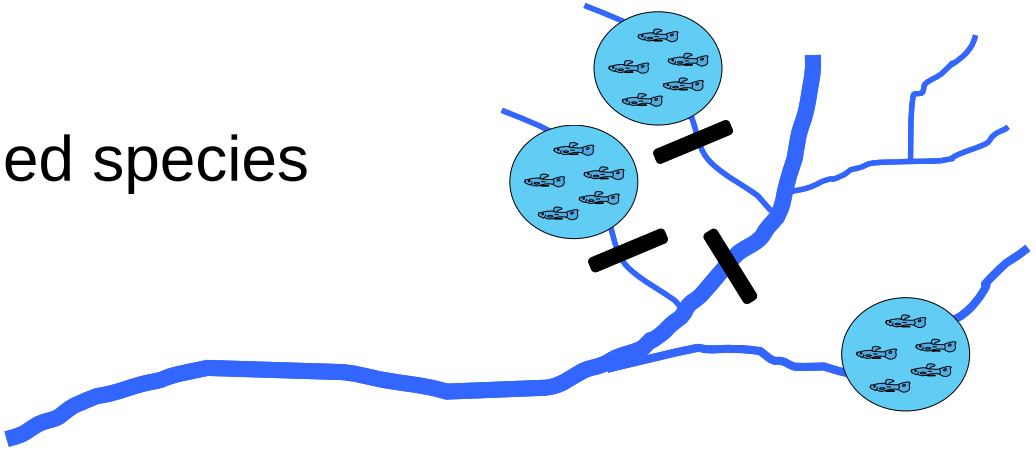
High
Low
Low
Mid
High
Venezuela

Low predation

- small headwater populations
- isolated from gene flow
- good proxy for threatened species



low predation

Caigual River

Taylor River

Caigual & Taylor FOCAL SITES

waterfall barrier to upstream gene flow

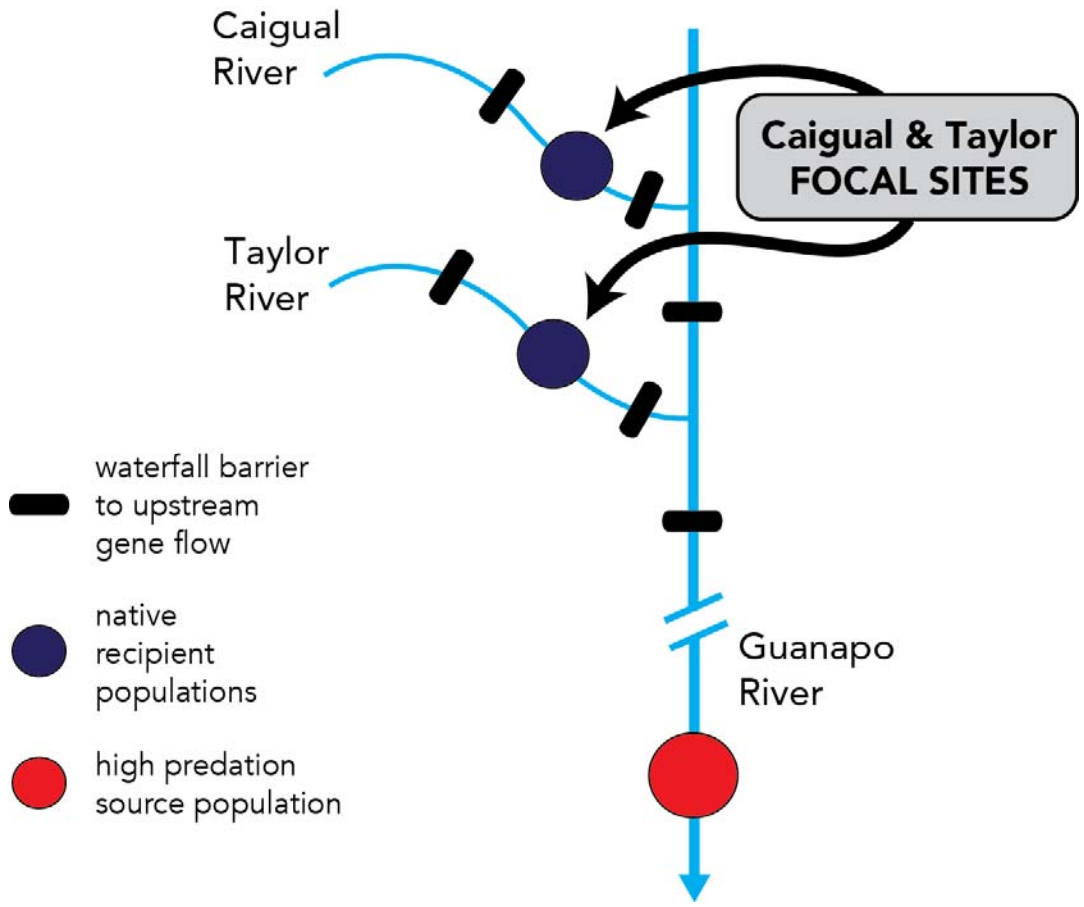
native recipient populations

high predation source population

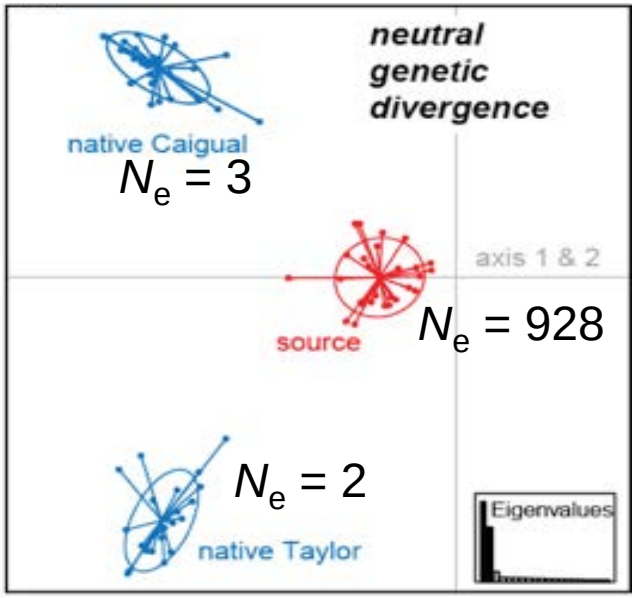
Guanapo River

high predation

Initial divergence between native and source populations



12 microsatellite loci



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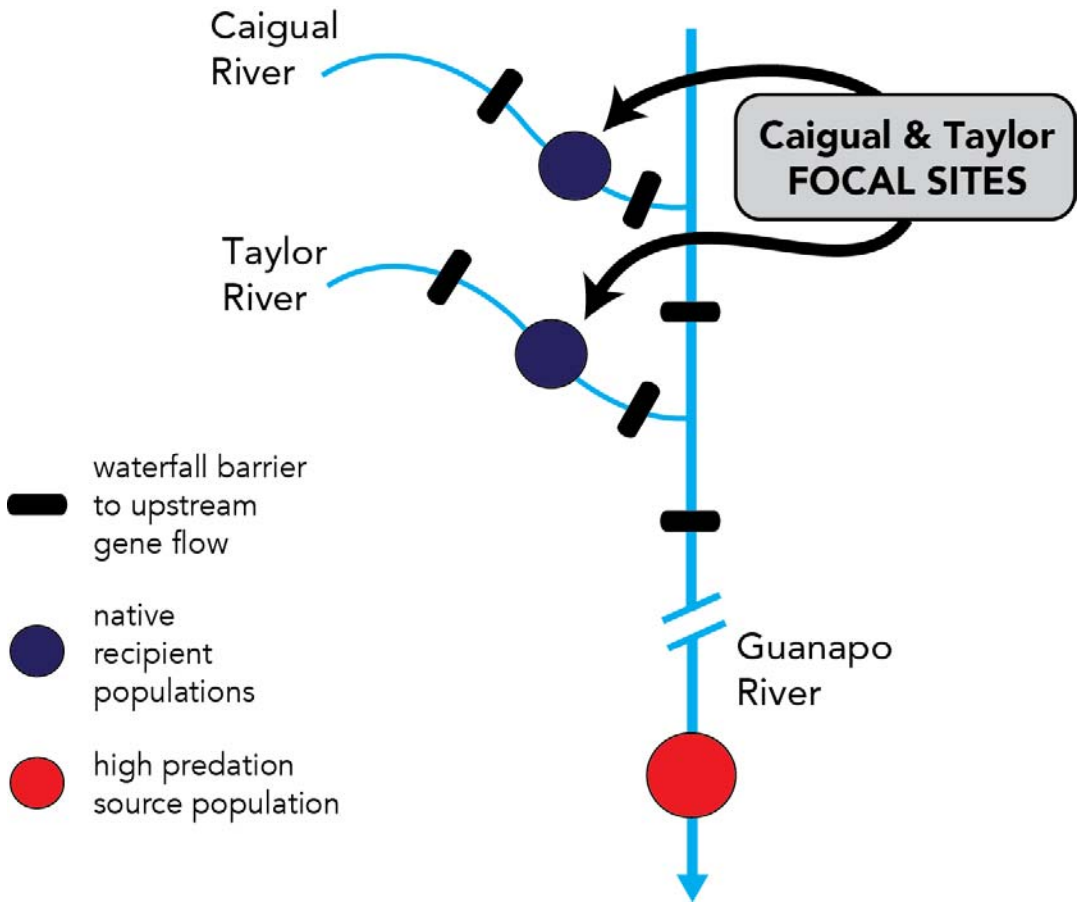

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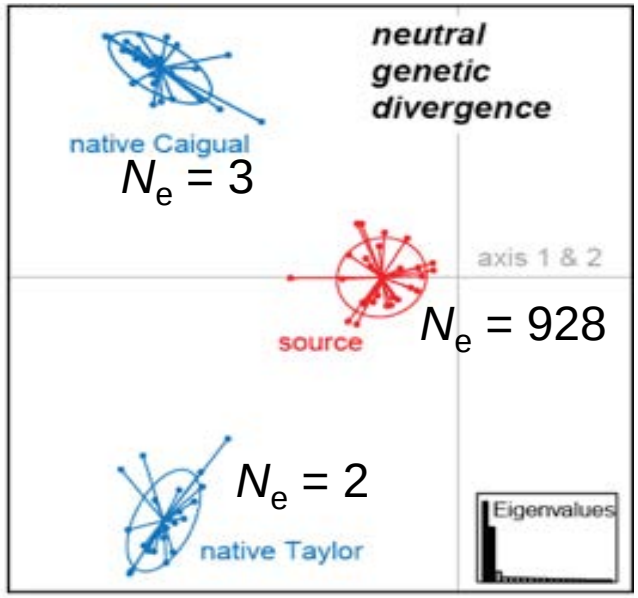
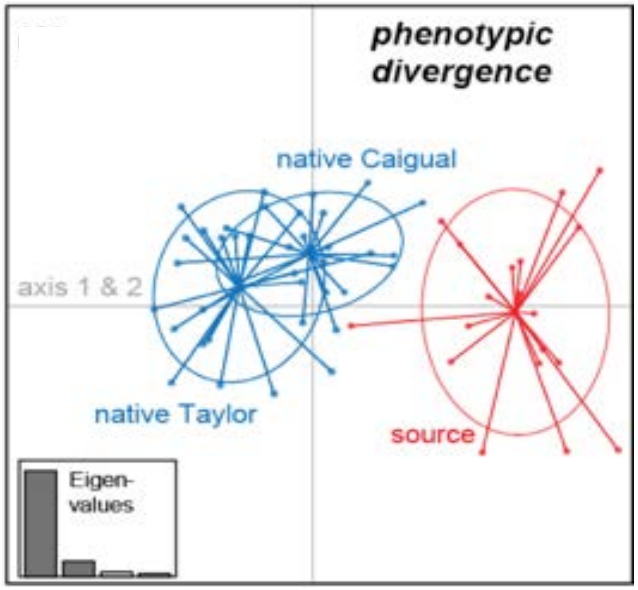
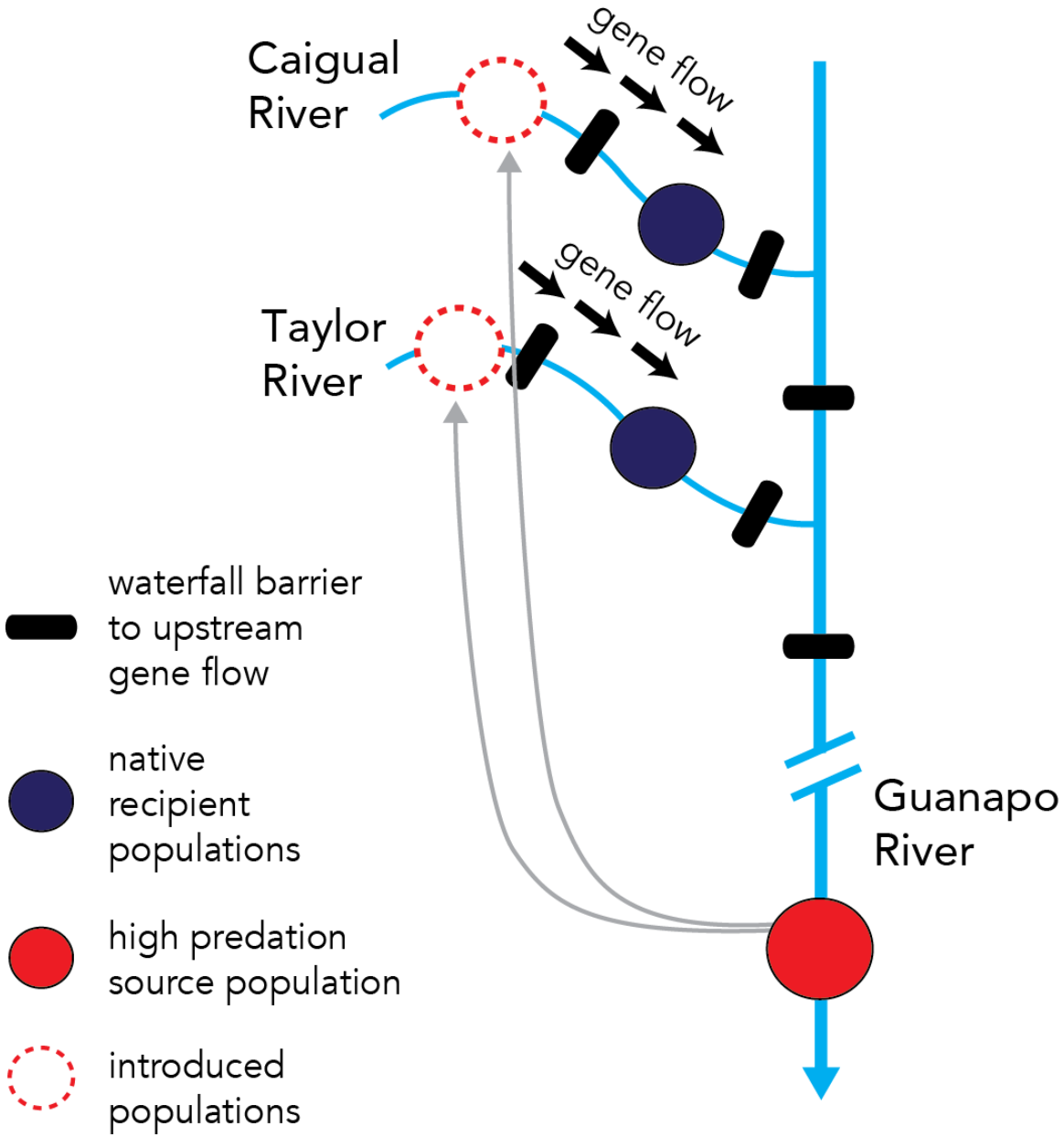
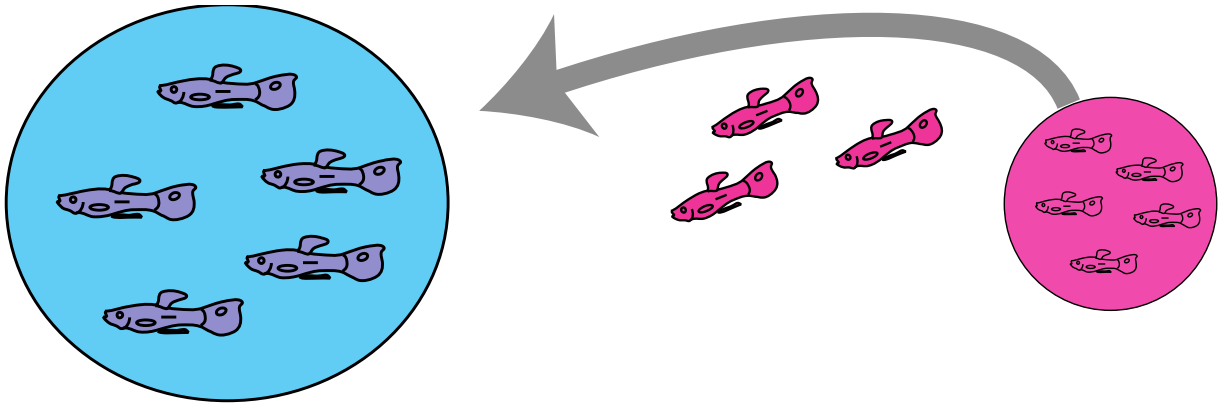


male body shape & size traits




Caigual River
gene flow
Taylor River
gene flow
Guanapo River
waterfall barrier to upstream gene flow
native recipient populations
high predation source population
introduced populations

- Gene flow can <u>decrease</u> fitness
- Gene flow can <u>increase</u> fitness




“Counting fish is like counting trees…
except they are invisible and they keep moving.”
-John Shepard
2 streams
29 months
9,590 guppies
25,581 captures
photo: Andrés Lopez-Sepulcre

catching guppies

catching guppies

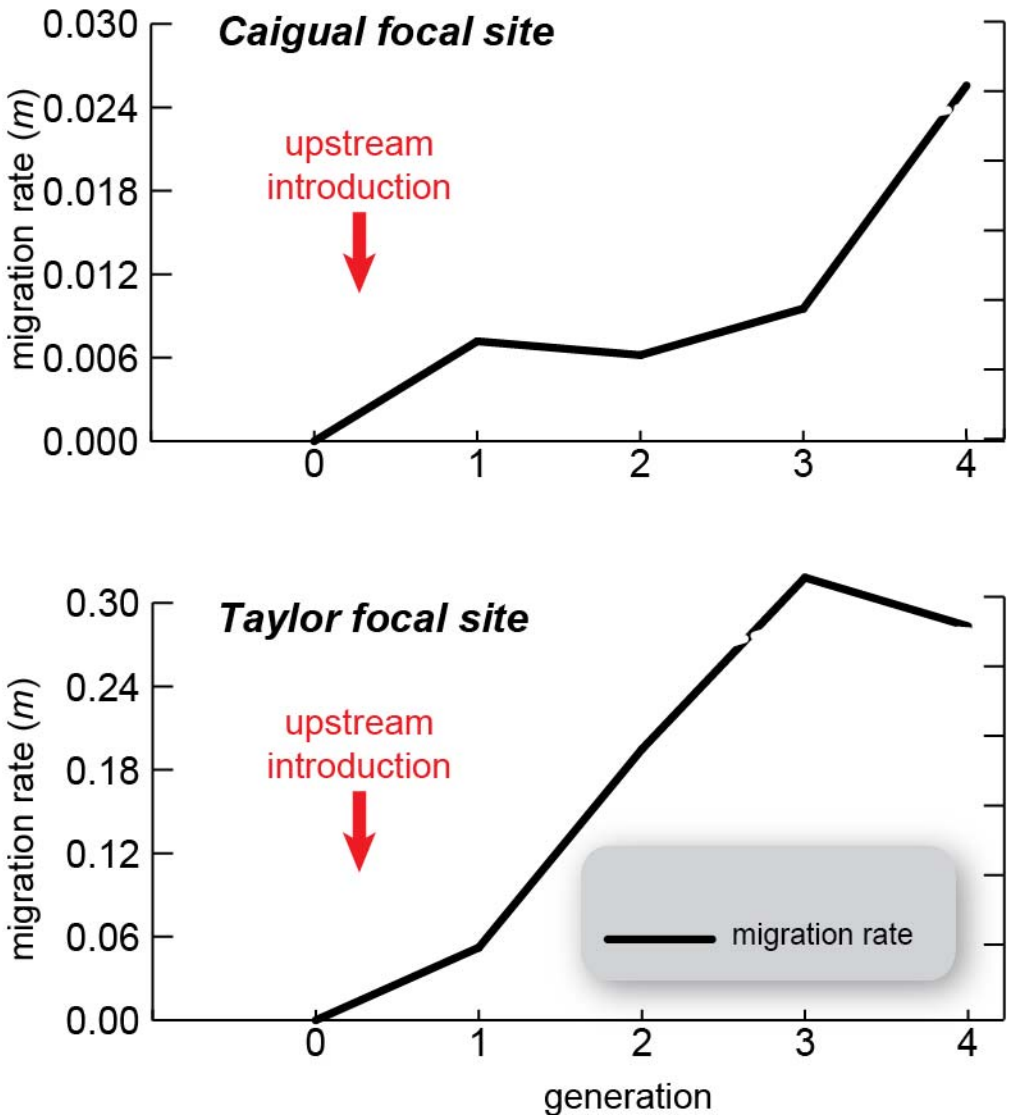
lab processing

catching guppies

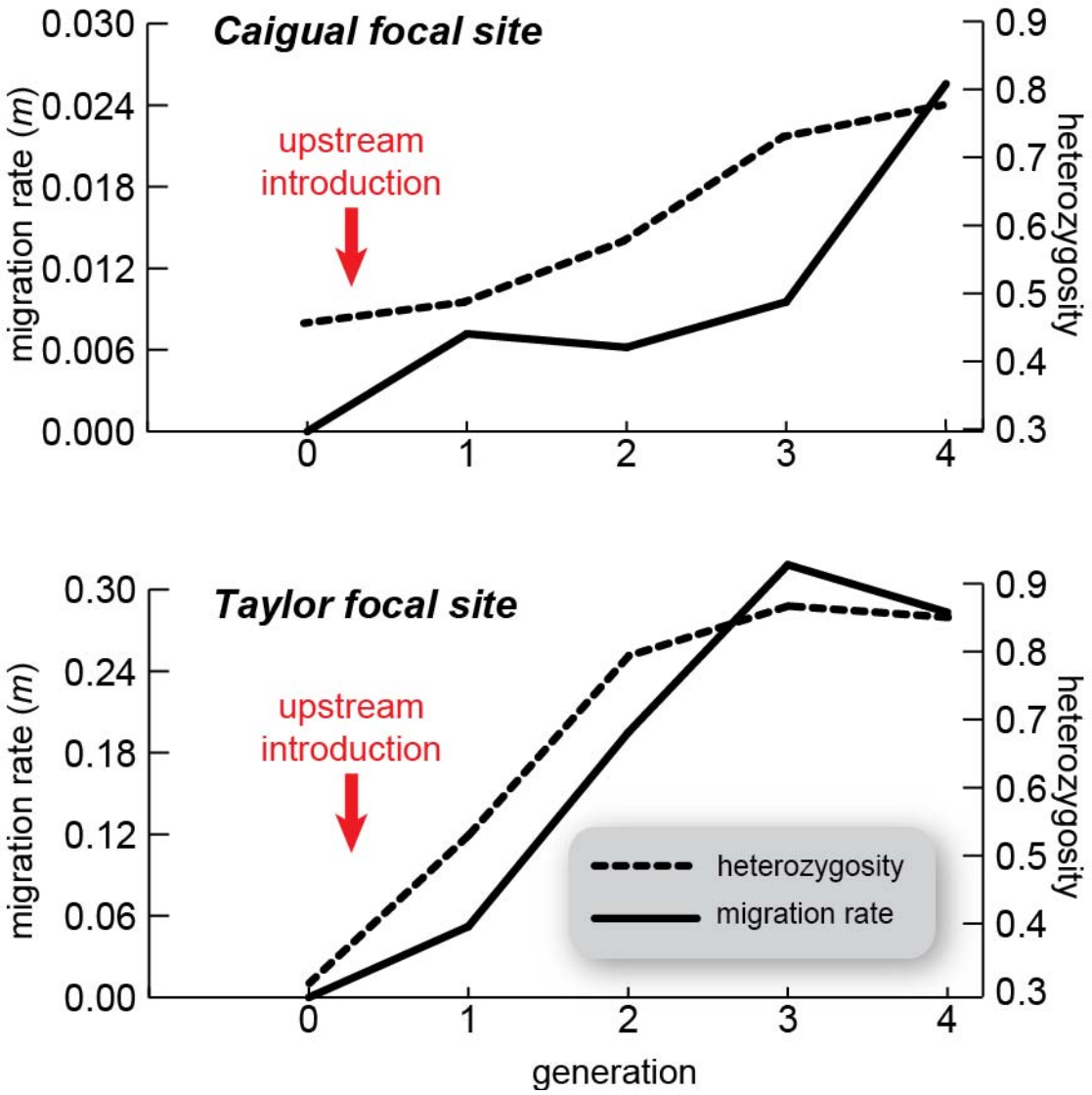
release!

lab processing

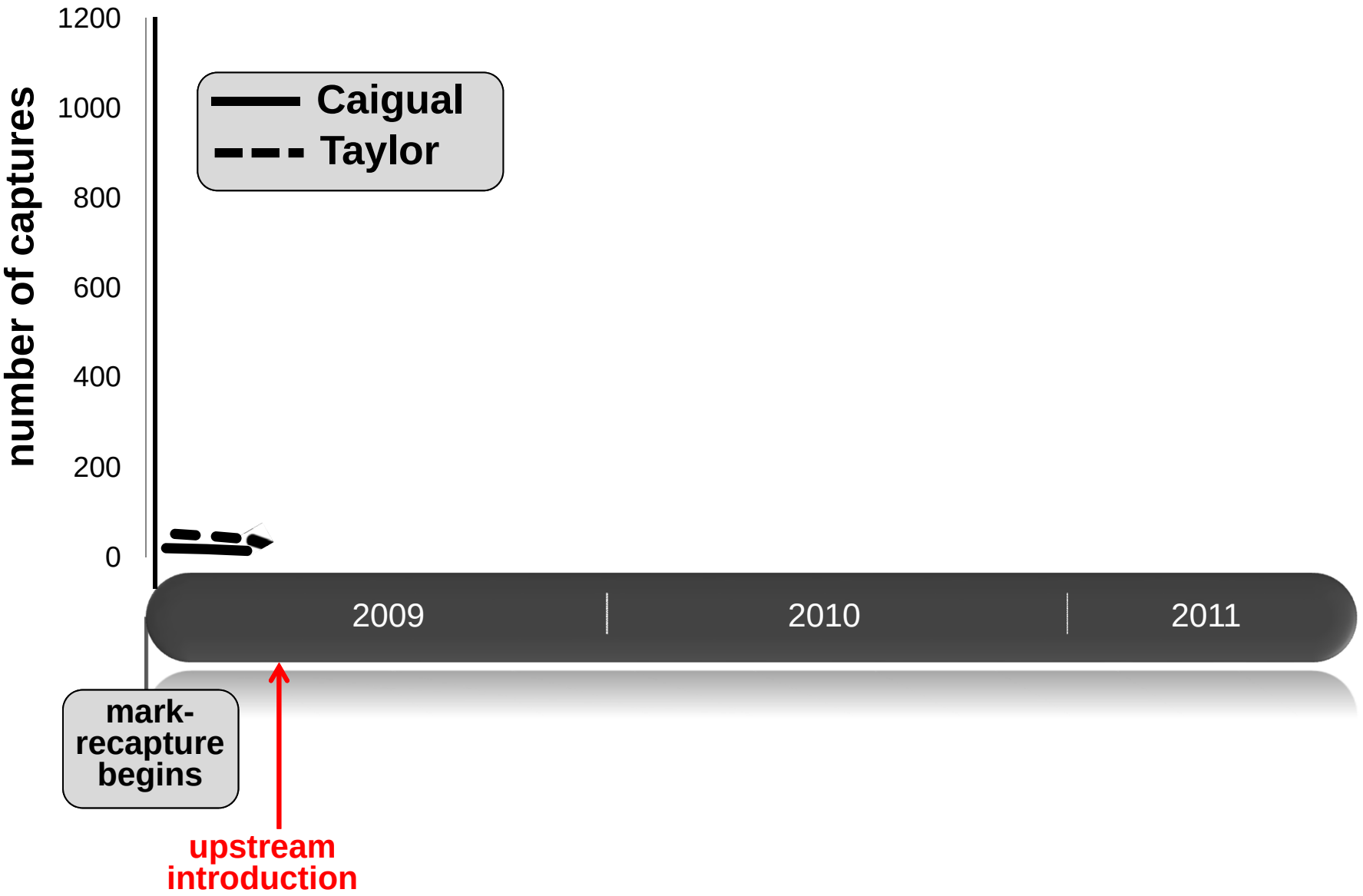
Increase in migration rate



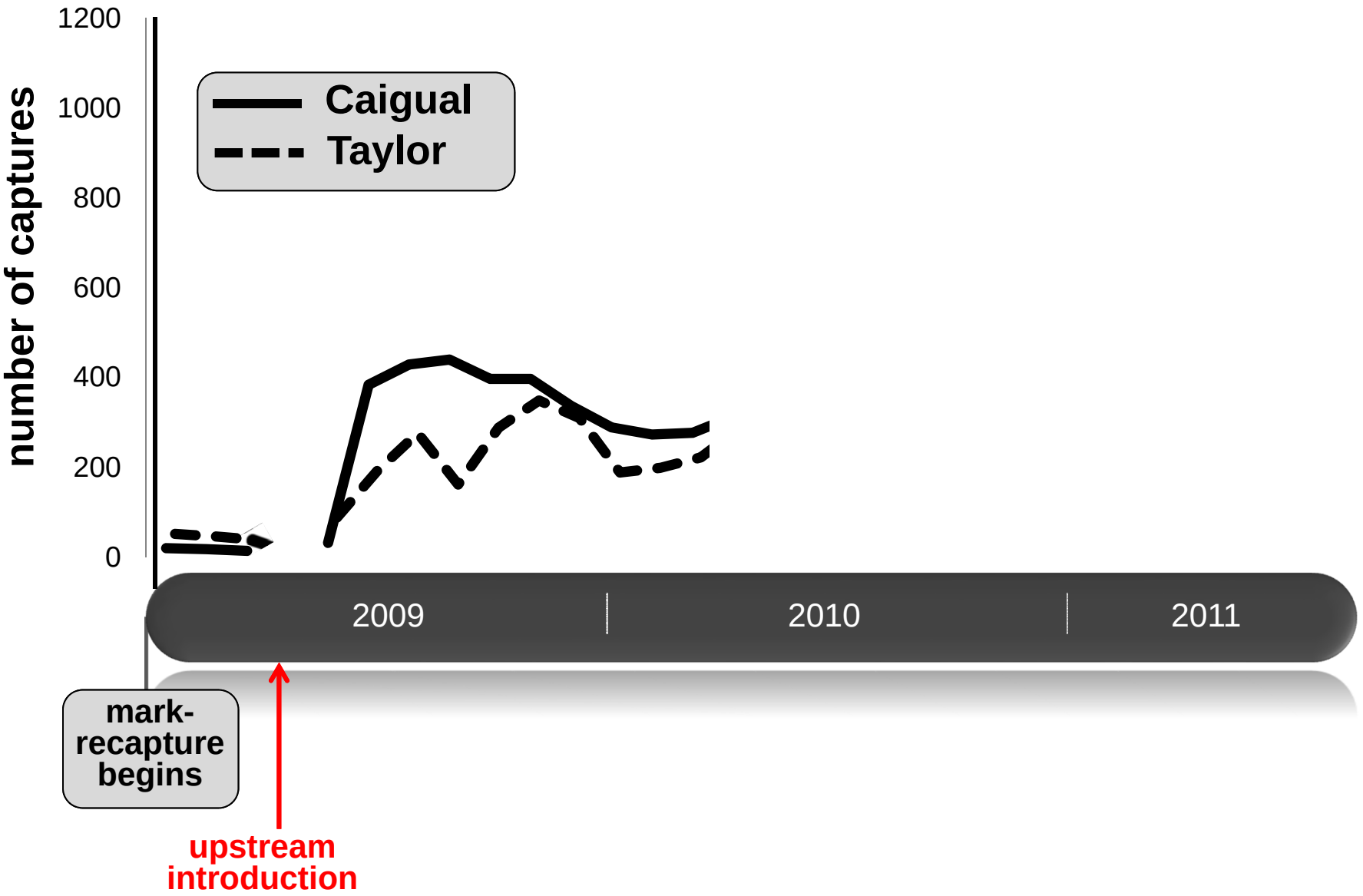
Increase in migration rate and genetic diversity



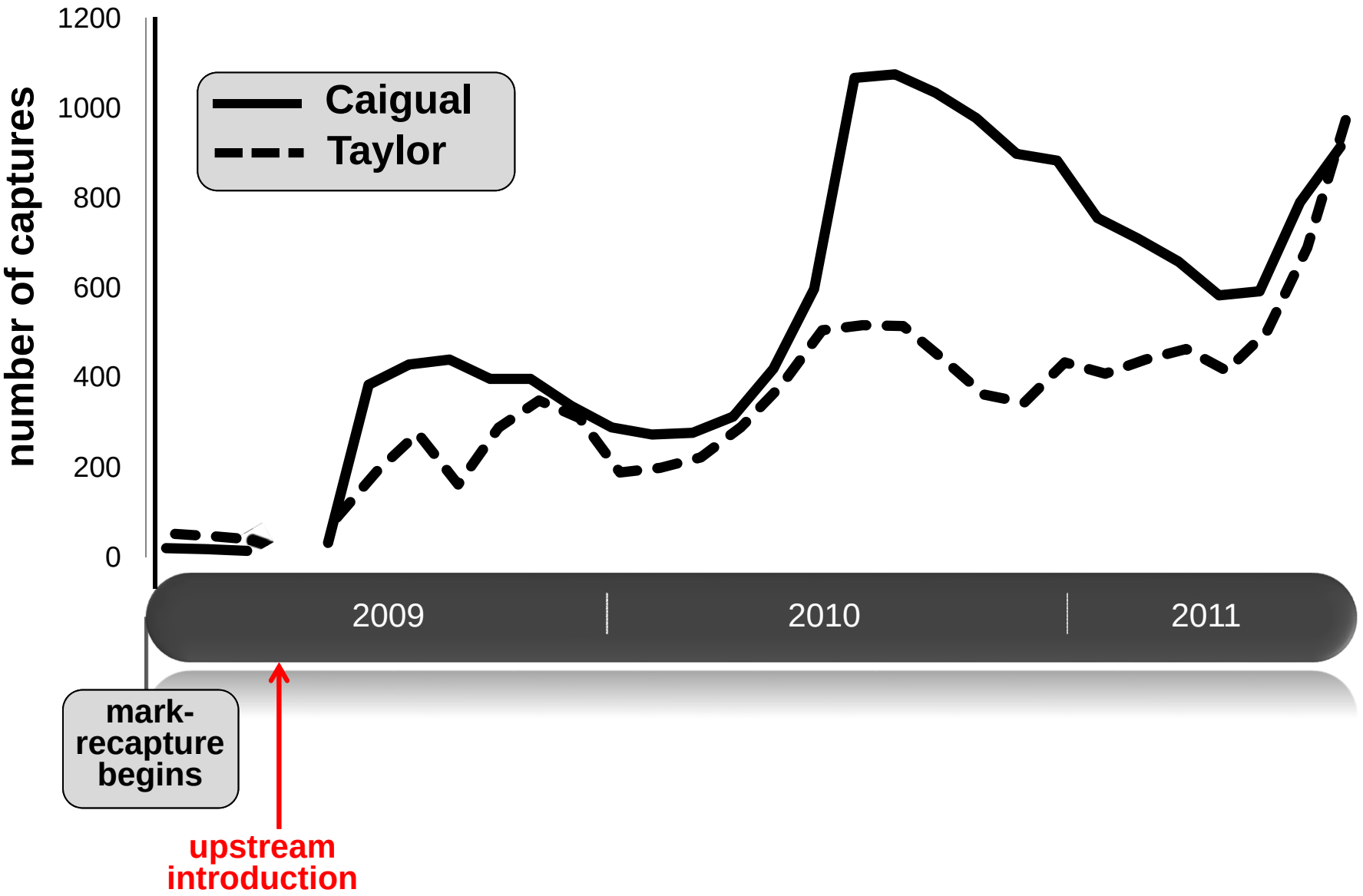
Changes in population size following gene flow



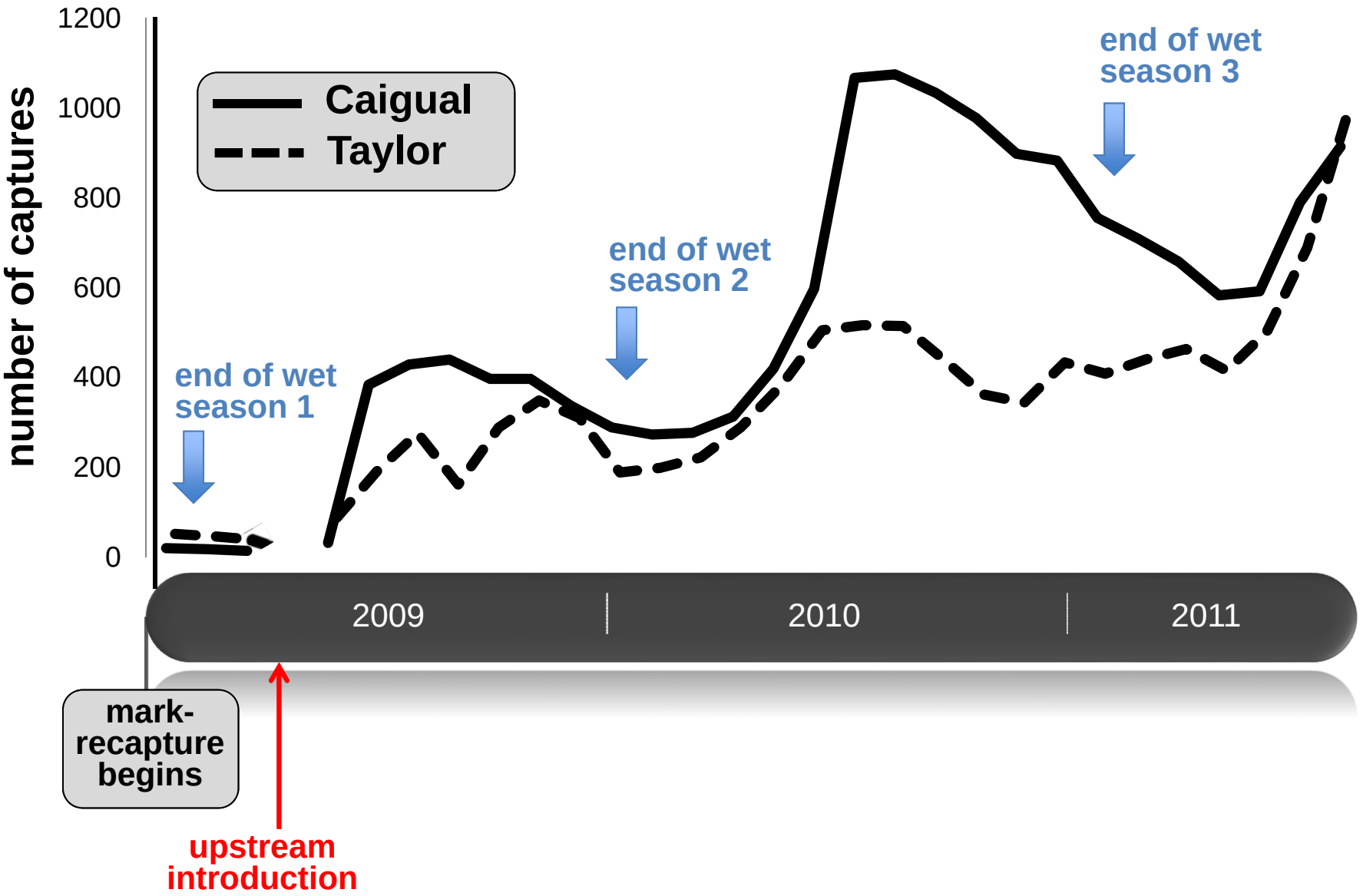
Changes in population size following gene flow



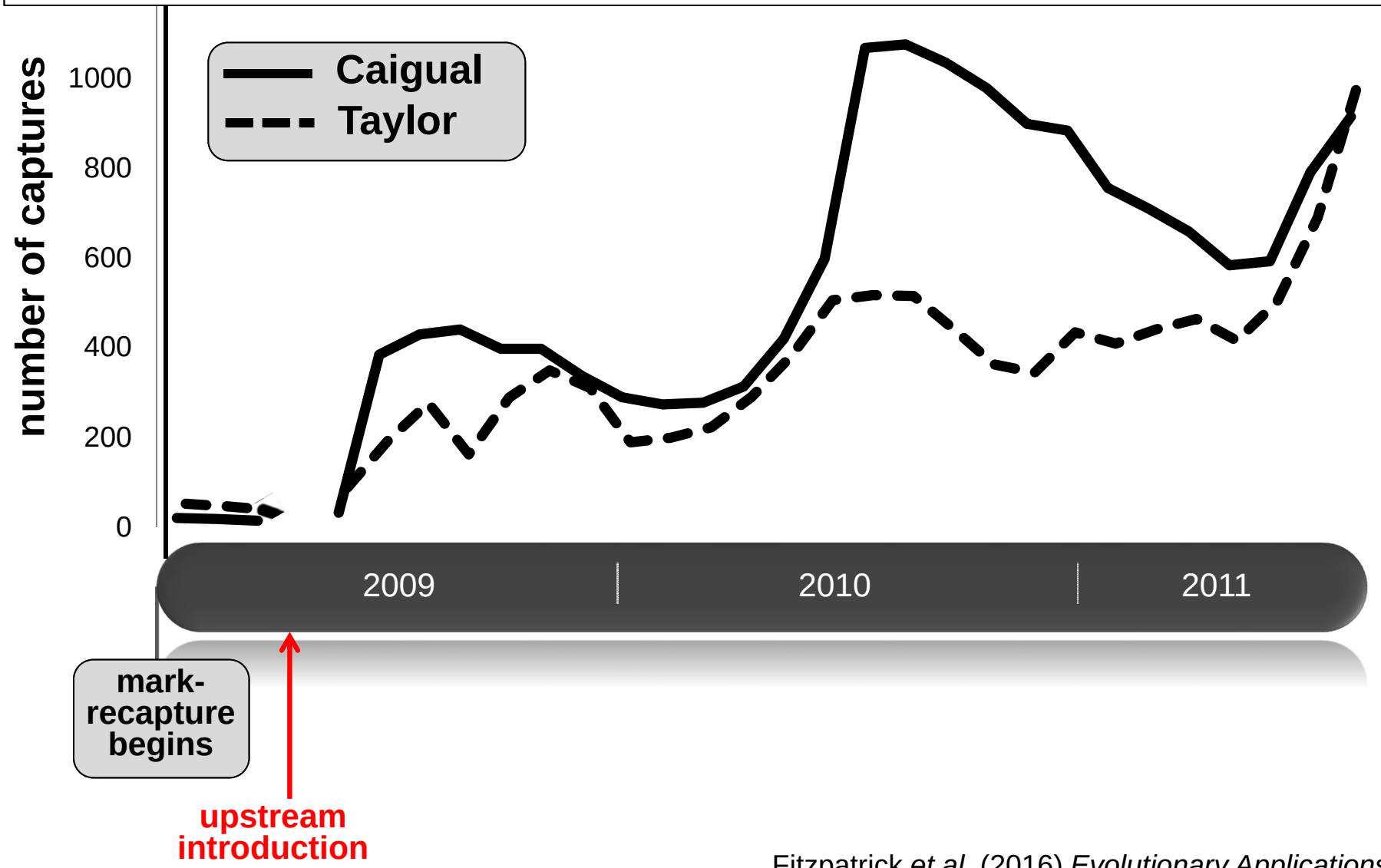
Changes in population size following gene flow



Changes in population size following gene flow

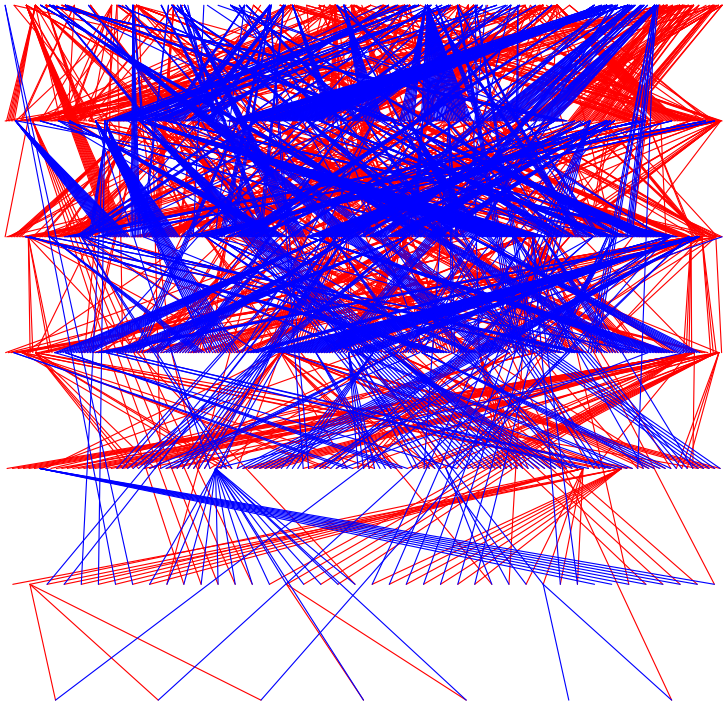


Genetic rescue: increase in population growth by more than the demographic contribution of immigrants

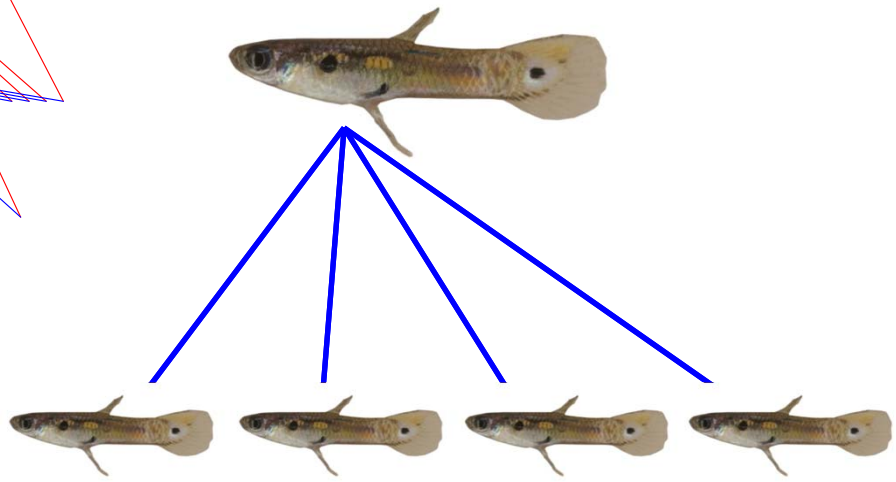


Fitzpatrick *et al*. (2016) *Evolutionary Applications*

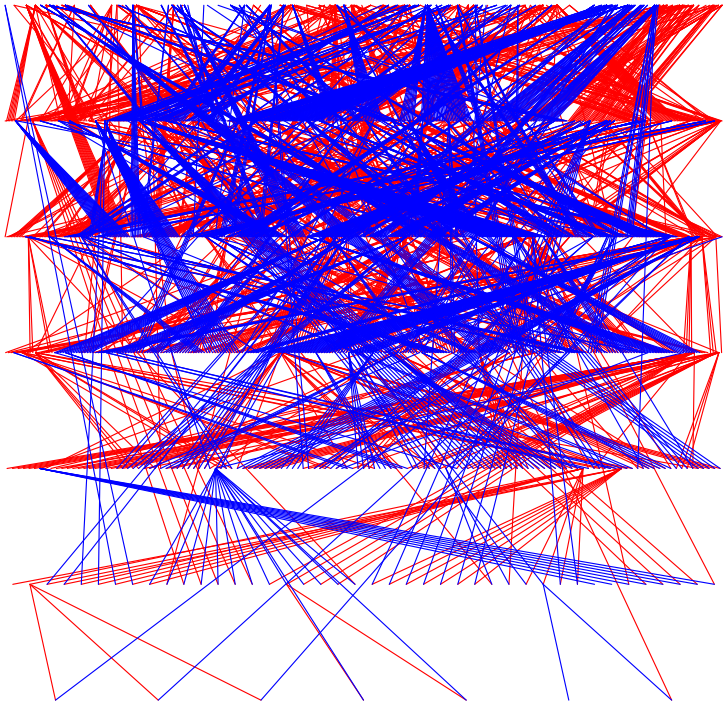
Estimating individual fitness with wild pedigrees



Lifetime reproductive success = 4

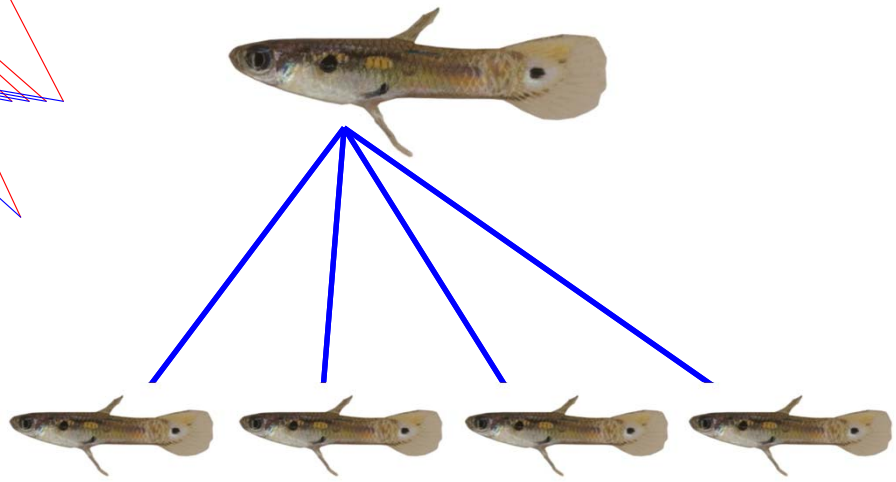


Estimating individual fitness with wild pedigrees

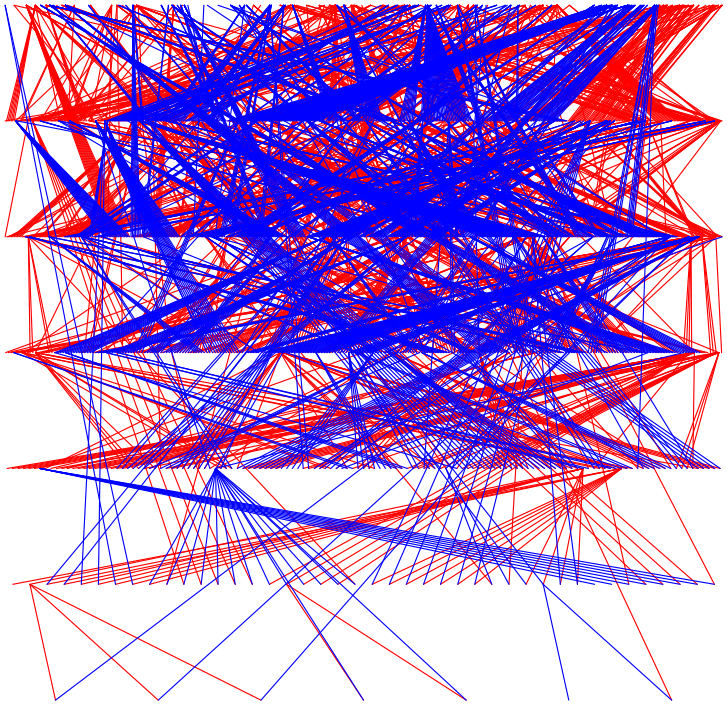


fitness = a measure of reproductive success

Lifetime reproductive success = 4

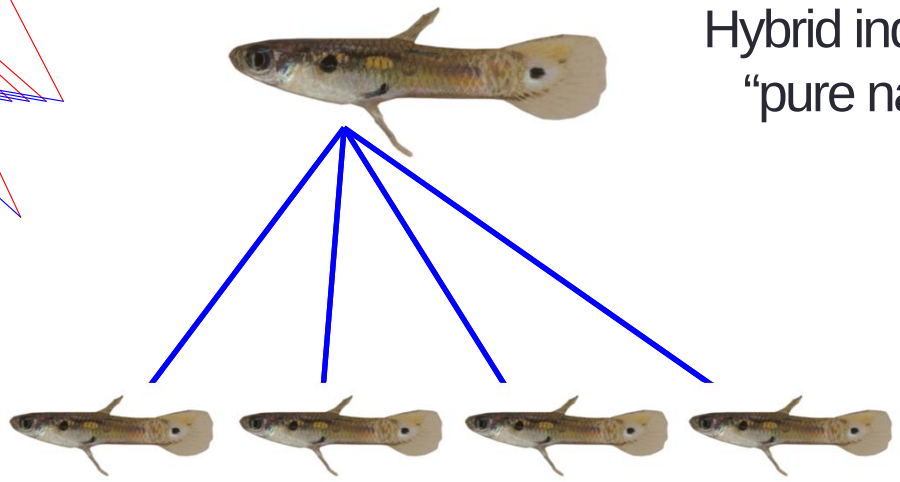


Estimating individual fitness with wild pedigrees

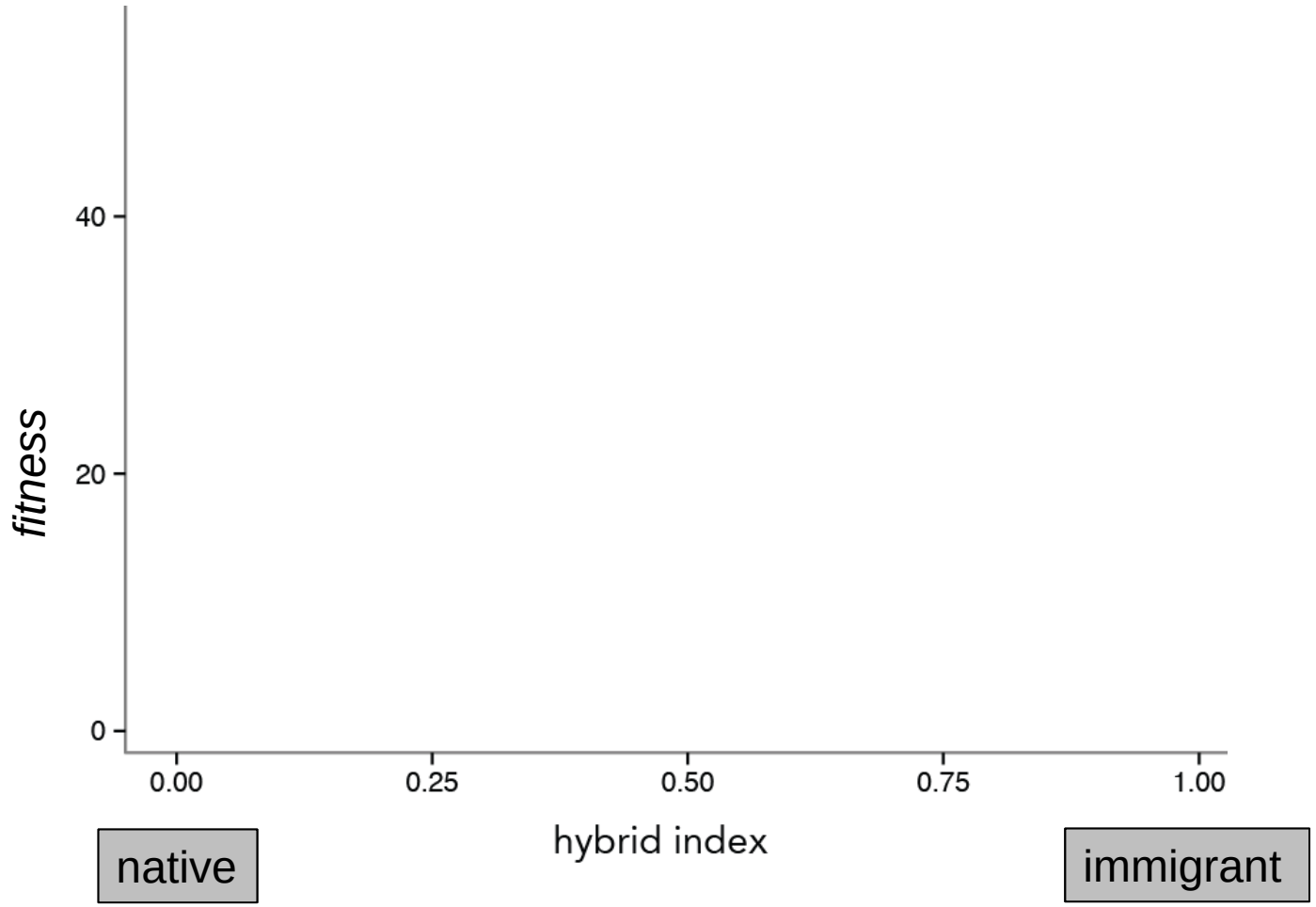


Lifetime reproductive success = 4

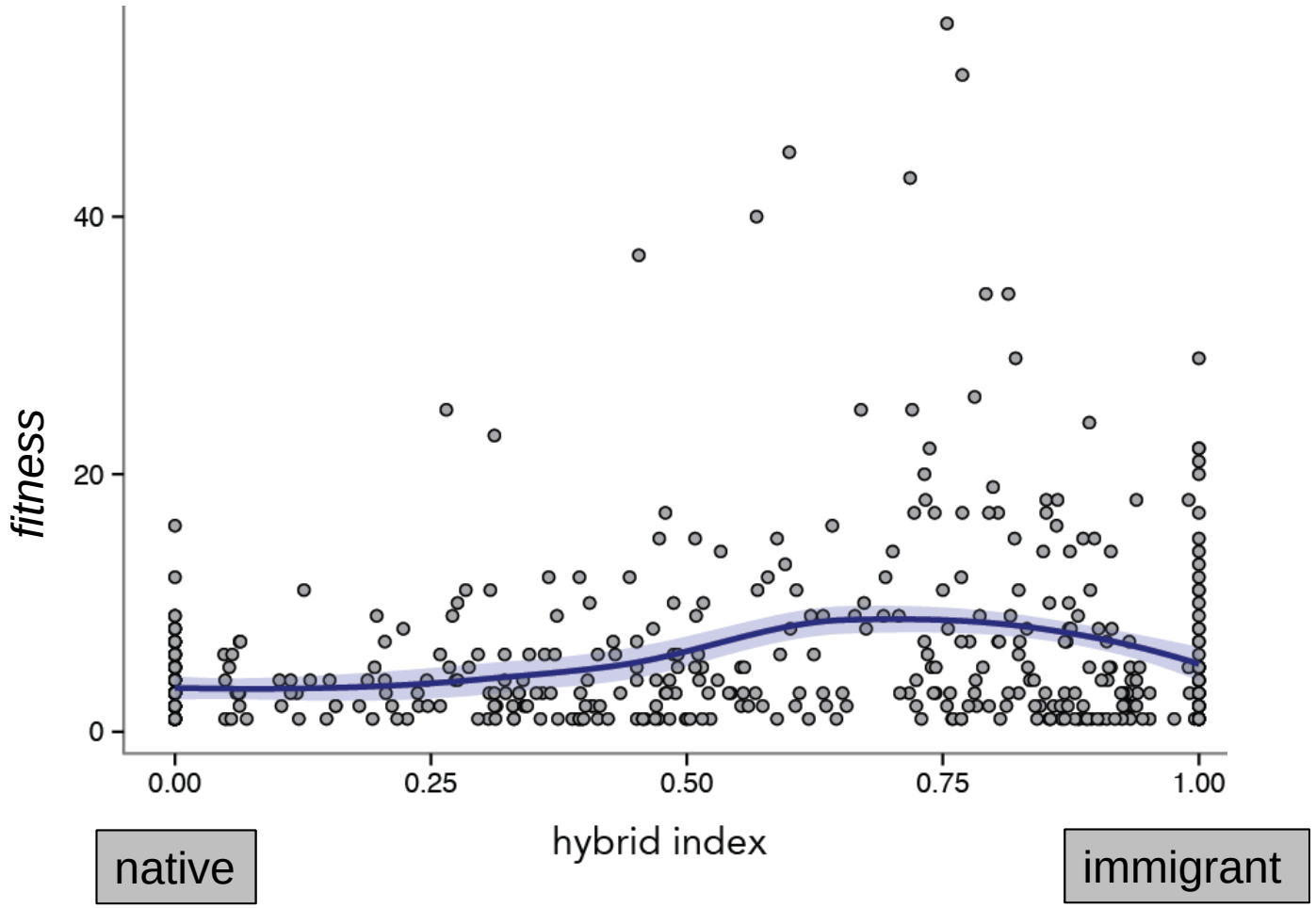
Hybrid index = 0
"pure native"



Hybrids have highest individual fitness

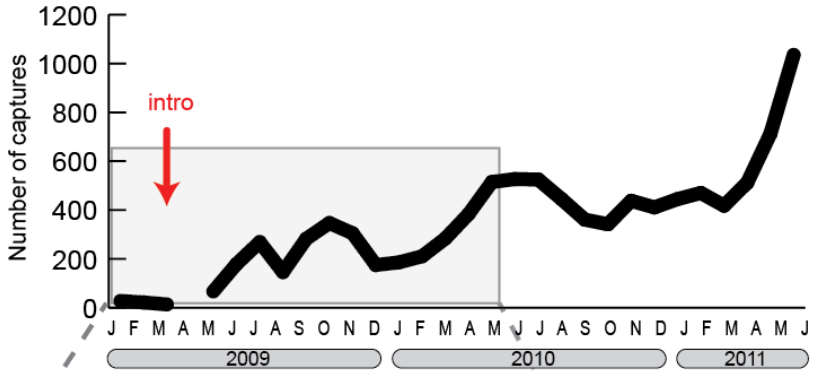


Hybrids have highest individual fitness

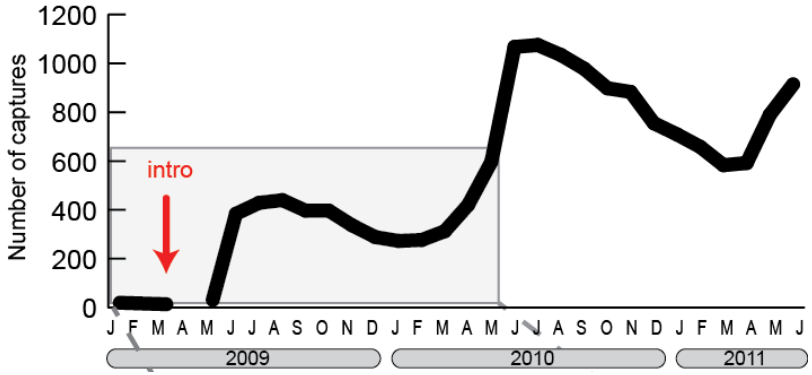


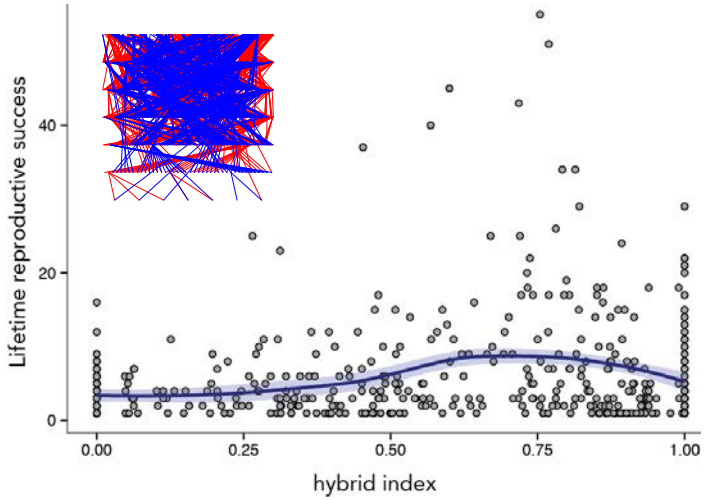
<u>TAKE HOME:</u> gene flow from a divergent source caused genetic rescue in two wild populations of guppies

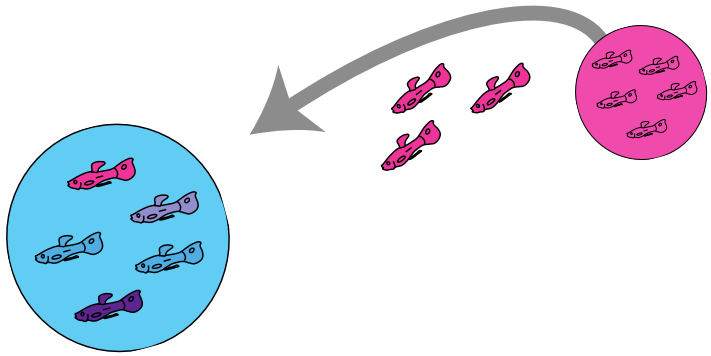
Taylor



Caigual

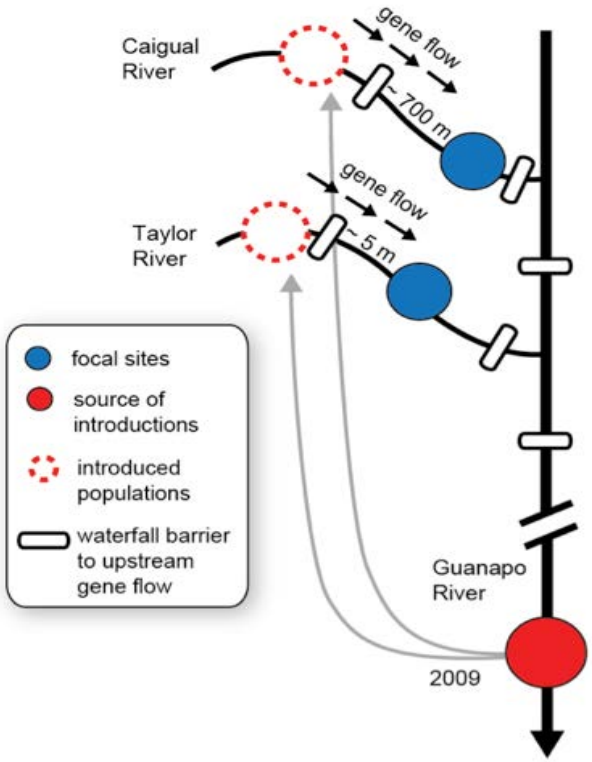






Important considerations

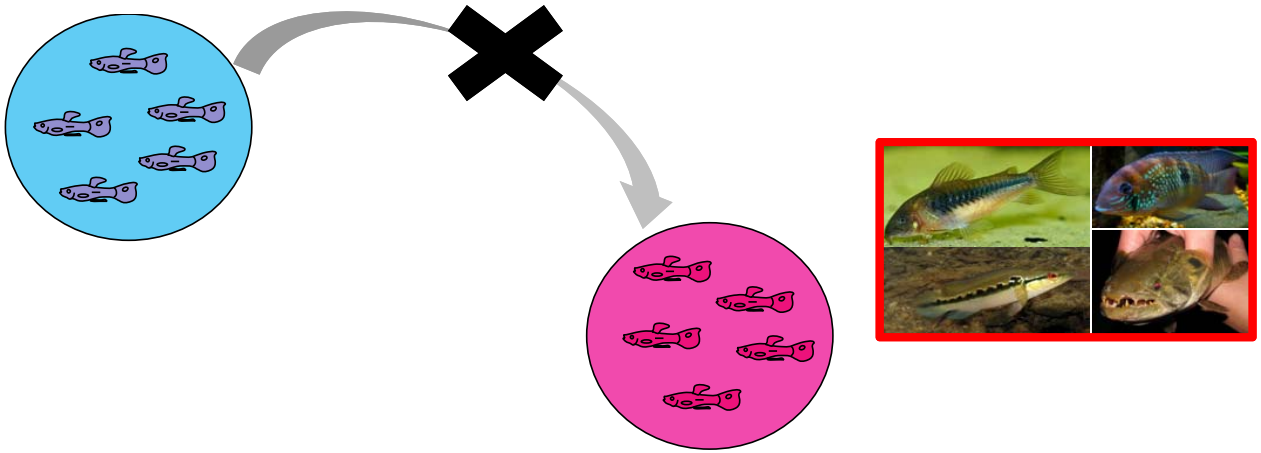
- introduced population came from the same drainage



reduced chance of
negative impacts of gene flow!

Important considerations

- environment matters



Weese *et al*. (2011) *Evolutionary Applications*

What can we learn from the guppy?

Genetic rescue to the rescue

Andrew R. Whiteley[1*], Sarah W. Fitzpatrick[2*], W. Chris Funk[2,3*], a
David A. Tallmon[4*]

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[2]Department of Biology, Colorado State University, Fort Collins, CO 80523, USA
[3]Graduate Degree Program in Ecology, Colorado State University, Fort Collins, CO 80523, USA
[4]Department of Biology and Marine Biology, University of Alaska Southeast, Juneau, AK 99801, USA

Forum

Sex, Mitochondria, and Genetic Rescue

Justin C. Havird,[1,*]
Sarah W. Fitzpatrick,[1,2]
John Kronenberger,[1,3]
W. Chris Funk,[1,3]
Lisa M. Angeloni,[1,3] and
Daniel B. Sloan[1,3]

(not to scale)

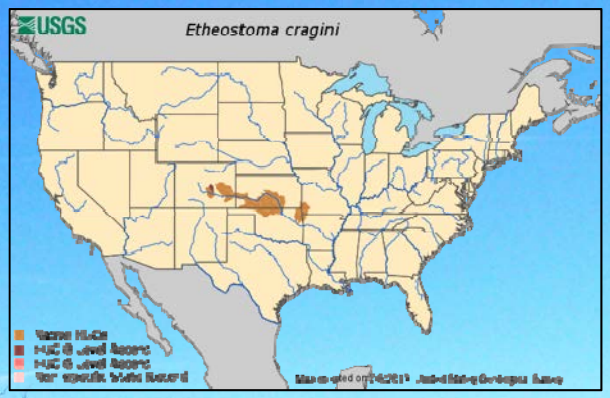
Genetic rescue of small inbred populations: meta-analysis reveals large and consistent benefits of gene flow

RICHARD FRANKHAM*†
*Department of Biological Sciences, Macquarie University, Sydney, NSW 2109, Australia, †Australian Museum, 6 College St, Sydney, NSW 2010, Australia

Three types of rescue can avert extinction in a changing environment

Ruth A. Hufbauer[a,b,1], Marianna Szűcs[a], Emily Kasyon[a], Courtney Youngberg[a], Michael J. Koontz[a,b,c], Christopher Richards[d], Ty Tuff[e], and Brett A. Melbourne[e]


Etheostoma cragini
USGS
U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR
COLORADO
PARKS • WILDLIFE
AD ASTRA PER ASPERA
Kansas
Department of Wildlife, Parks and Tourism



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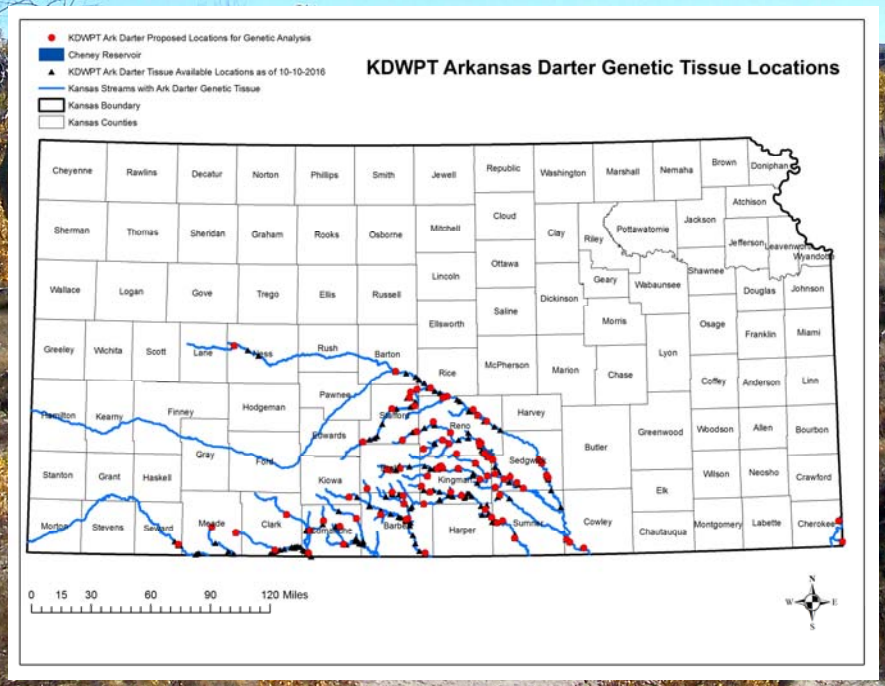
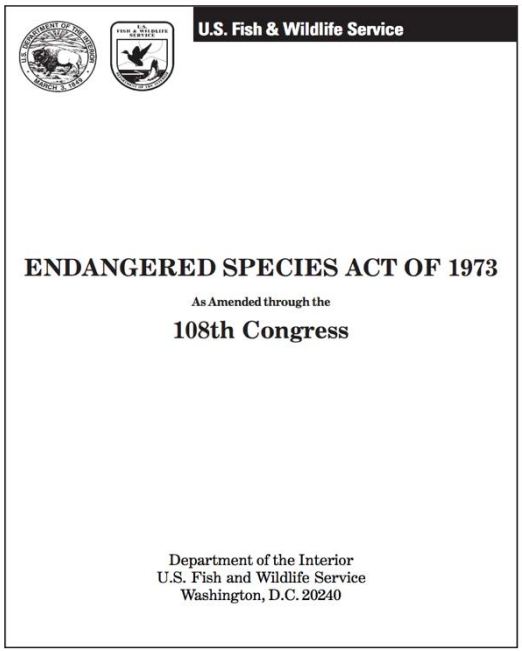


When will genetic rescue be useful in conservation?

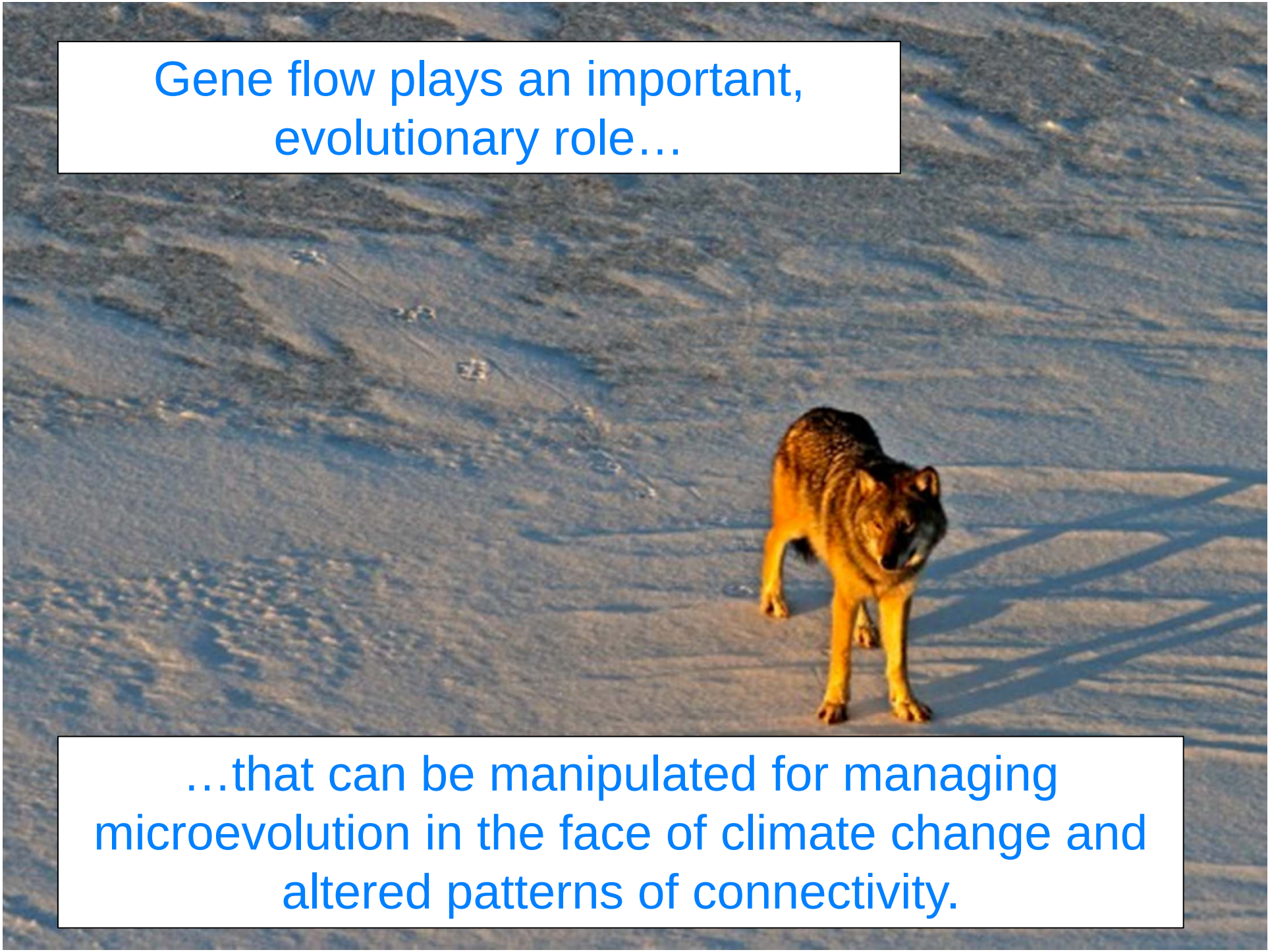


Ozark Hellbender

Channel Island fox

Blue shiner

FL Scrub Jay


Gene flow plays an important, evolutionary role…
…that can be manipulated for managing microevolution in the face of climate change and altered patterns of connectivity.




Collaborators

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David Reznick
Julian Torres-Dowdall

Funk-Hoke Lab Undergraduate assistants

Jill Gerberich
Brie Nixon
Samantha Coisman

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Colorado State University
Kellogg Biological Station
Michigan State University
National Science Foundation
National Geographic
Society for the Study of Evolution

Thank you!

MICHIGAN STATE UNIVERSITY | W.K. Kellogg Biological Station

Questions?

photo credit: John Fitzpatrick

http://www.sii-inc.org/guppy-trailer-3/