Genetic diversity, Population Fitness and Environmental Change

Jeffrey Markert

D. Champlin, J. Grear, R. Gobell, A. Kuhn, A. Roth, T.J. McGreevy
M. Bagley & D. Nacci

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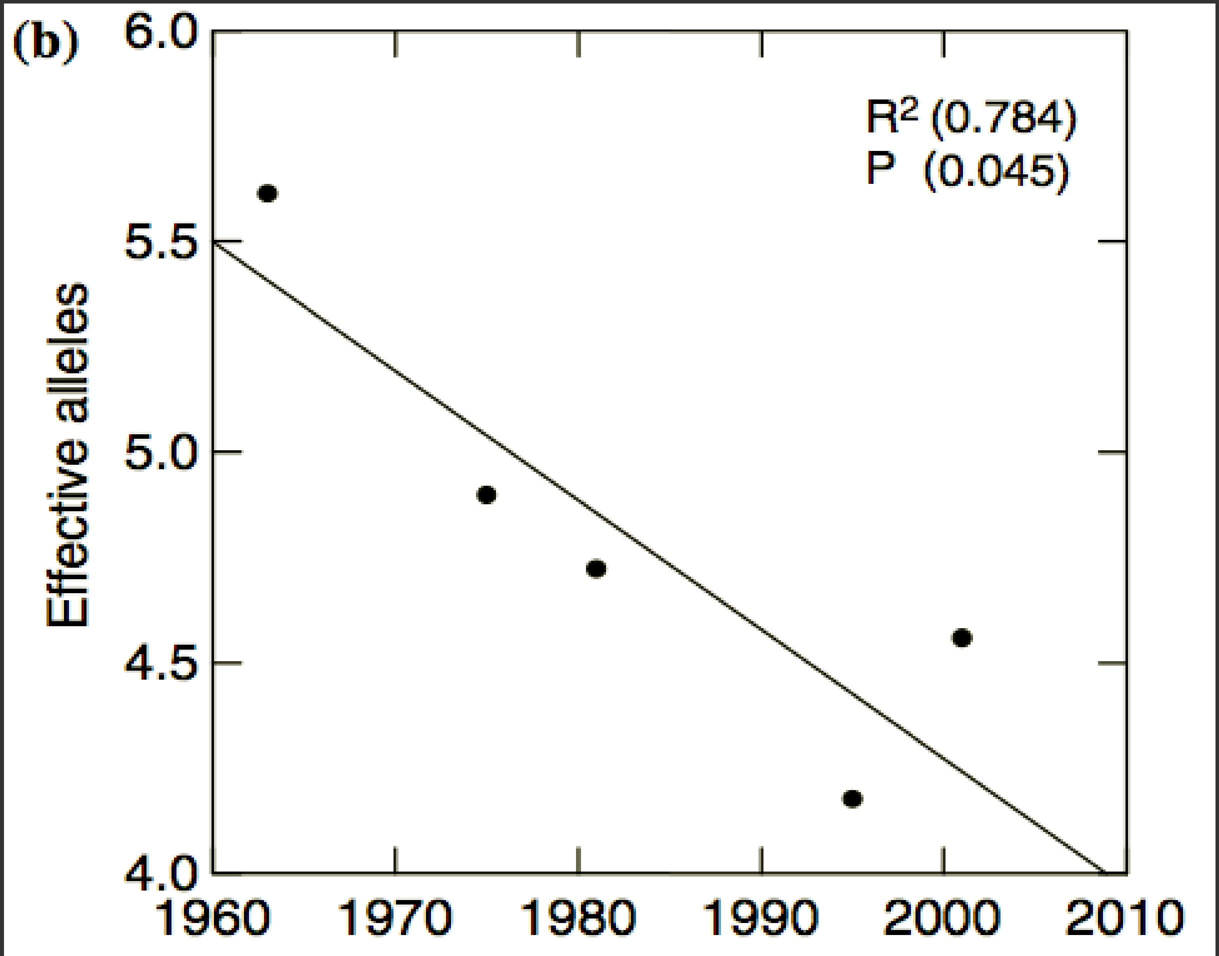
How do changes in
Genetic Diversity
influence
Population Fitness?

Microsatellite allele diversity in Atlantic Salmon

(Lage and Kornfield, 2006, Cons. Gen. 7: 91-104)



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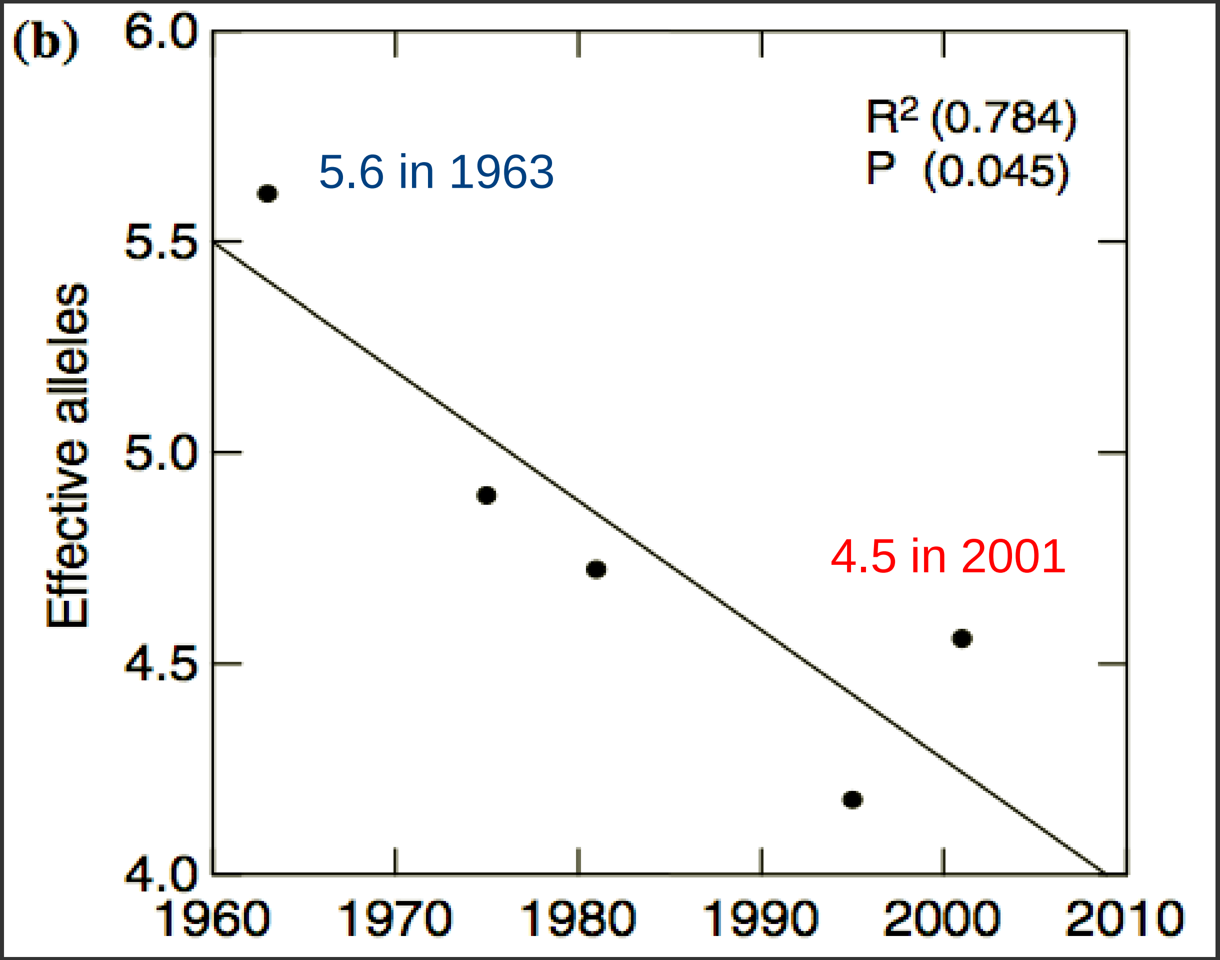

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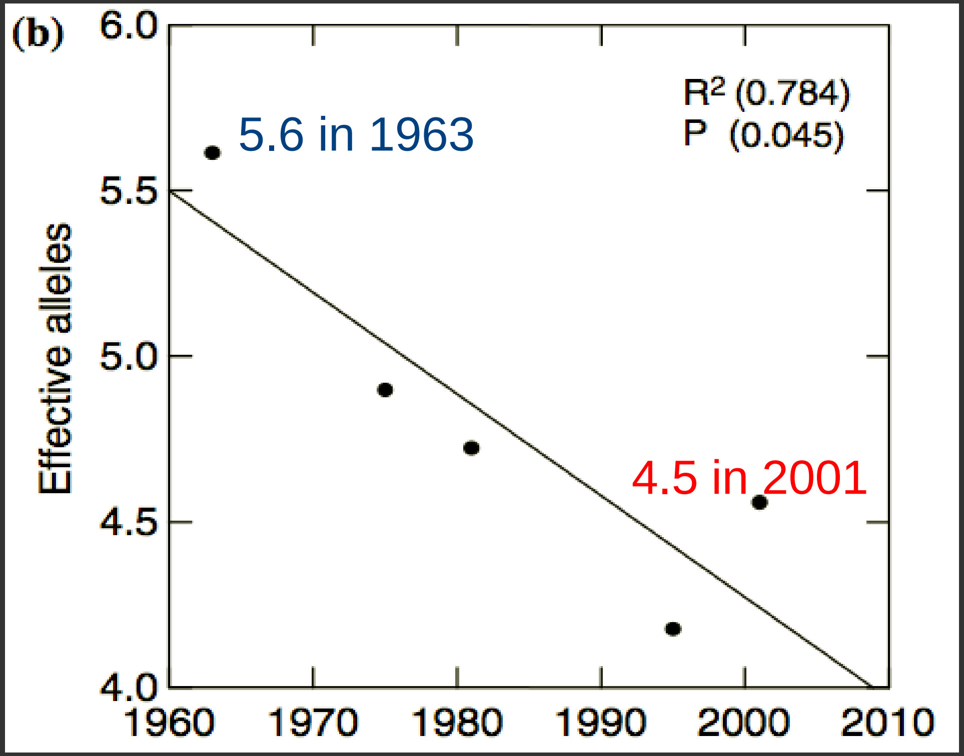


A 20 % loss in genetic diversity!! -

But is this bad???

How bad???

How much genetic diversity is ‘enough’?

Can we detect meaningful losses of diversity, before it’s too late?

beyond

Inbreeding Depression

towards

Adaptive Capacity

myfwc.com/panther/

www.whatbird.com

Part I: The Animal

Mysid or Opossum Shrimp

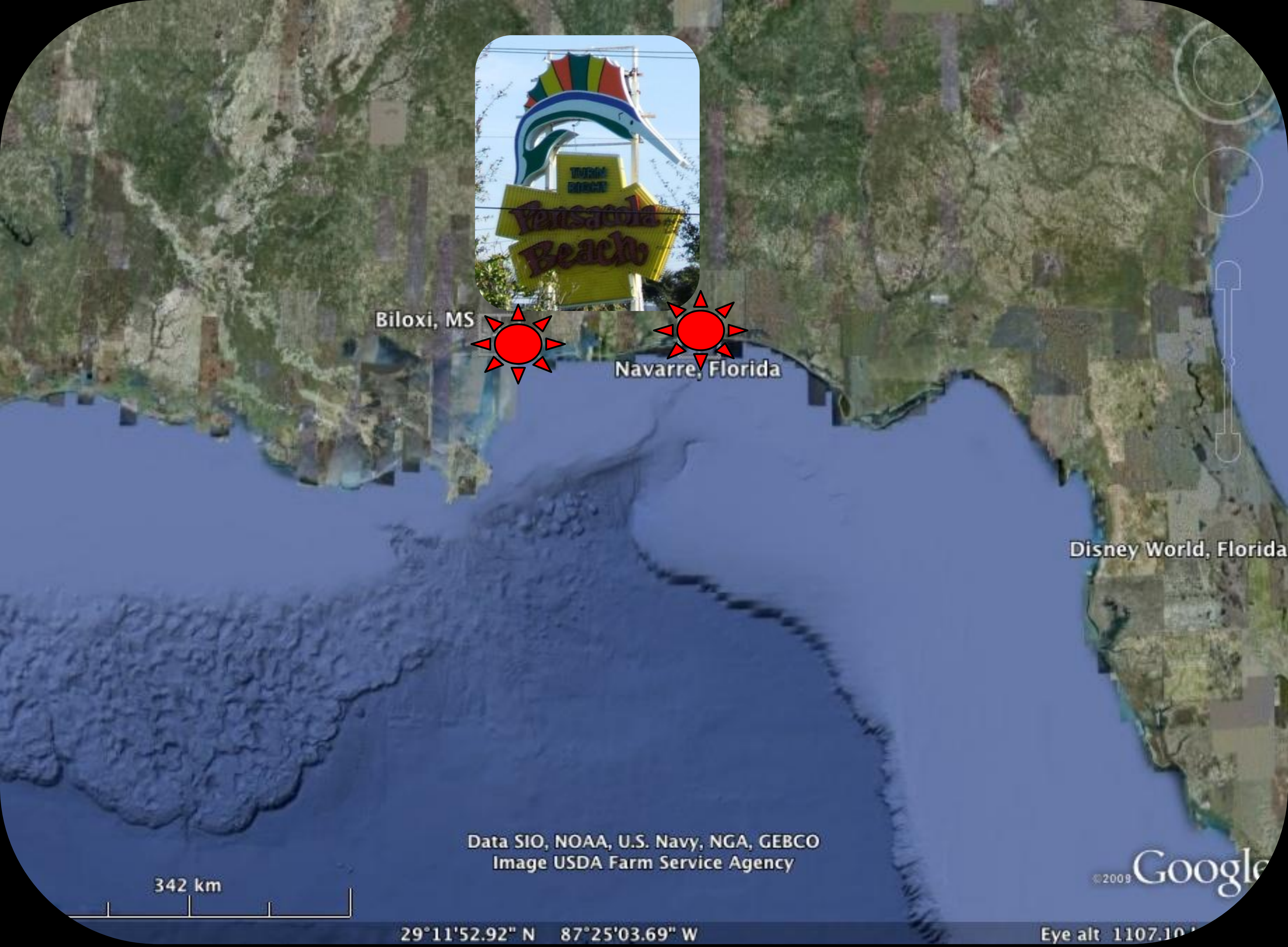
Americamysis bahia

Class Malacostraca

Order Mysida

Family Mysidae

Shrimp are in the order decapoda


TURN RIGHT
Pensacola Beach
Biloxi, MS
Navarre, Florida
Disney World, Florida
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image USDA Farm Service Agency
342 km
©2009 Google
29°11'52.92" N 87°25'03.69" W
Eye alt

Advantages

- short generation times
  ~ 3 weeks egg to egg

- live at high densities
  ~ 100 individuals in a 2.5 gallon (~ 10 l) aquarium

Advantages

Easy to establish *maternity* (Brood Care)

Tolerates multiple environments (esp. salinity)

Lower fecundity than *Drosophila* or *Tribolium* –
reproductive dynamics
more like a bird or mammal

Part II: The System

Goals

Manipulate levels of population GD

Replicate each level

Quantify fitness in multiple environments

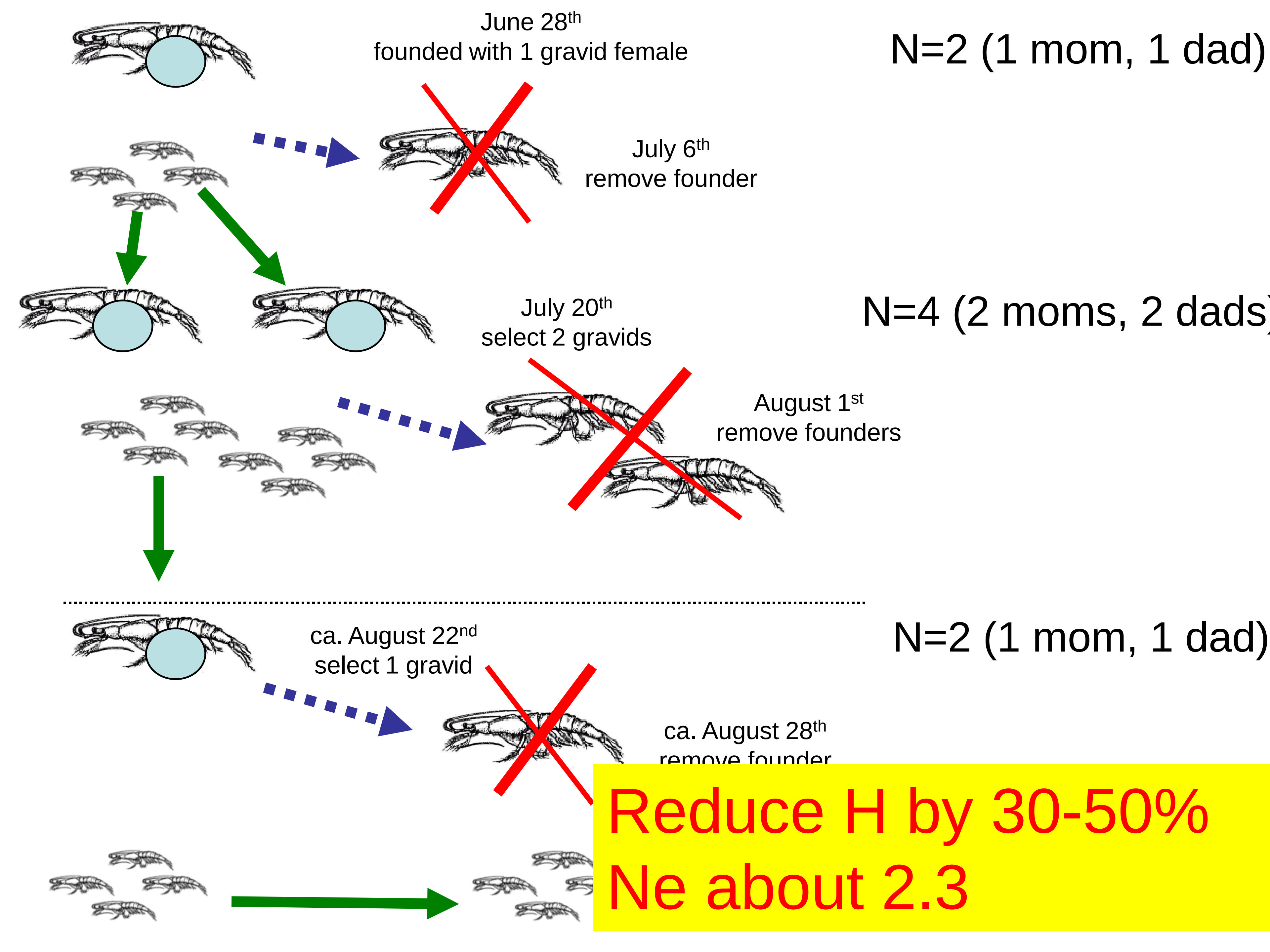
HOW?:

Partition - reduce genetic diversity through a series of bottlenecks

Reconstitute - combine different numbers of low diversity lines
(also included wild type ancestors - admixed)

Stress - Subject bottlenecked and reconstituted lines to environmental stress (*with controls*)

Census – count replicates weekly


June 28th
founded with 1 gravid female
N=2 (1 mom, 1 dad)
July 6th
remove founder
July 20th
select 2 gravids
N=4 (2 moms, 2 dads)
August 1st
remove founders
ca. August 22nd
select 1 gravid
N=2 (1 mom, 1 dad)
ca. August 28th
remove founder
Reduce H by 30-50%
Ne about 2.3

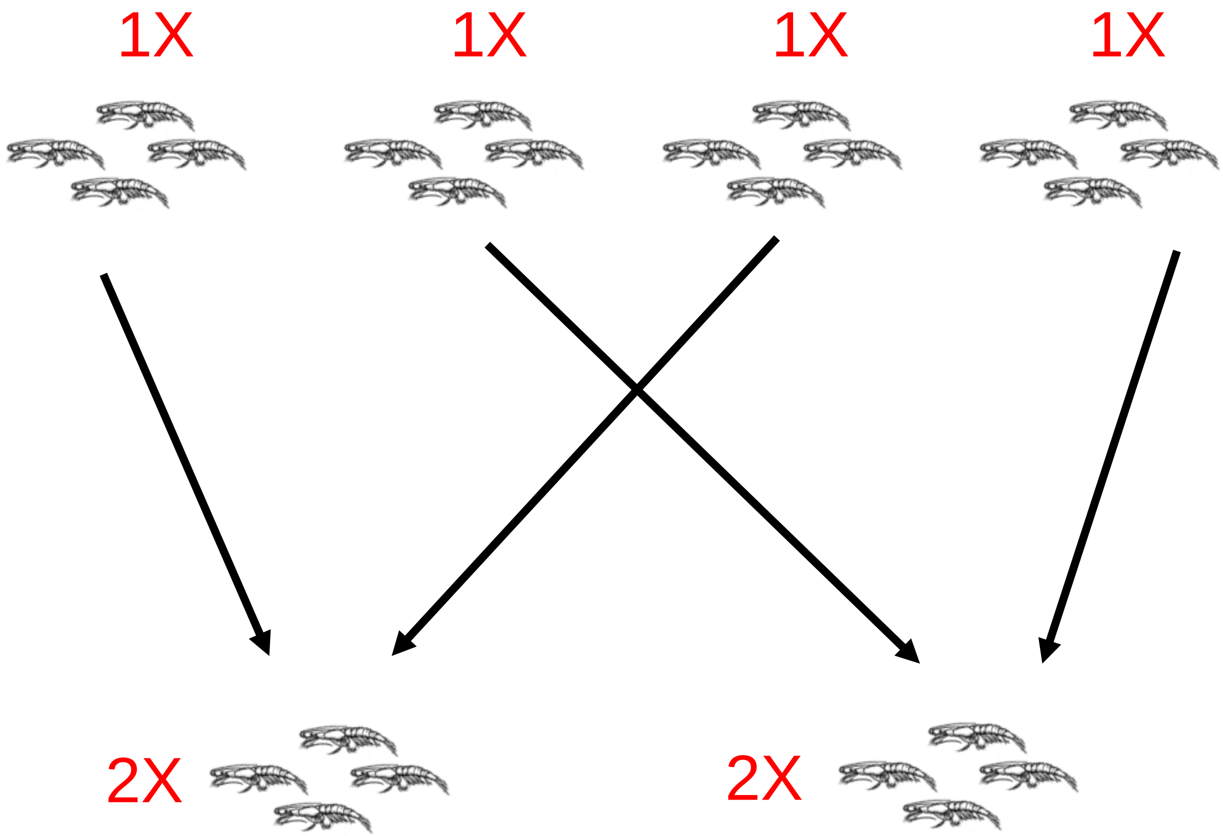
Methods:

Partition - reduce genetic diversity through a series of bottlenecks

Reconstitute - combine different numbers of low diversity lines
(also included wild type ancestors - admixed)

Stress - Subject bottlenecked and reconstituted lines to environmental stress (*with controls*)

Census – count replicates weekly



…15 <u>1X lines</u>

…15 <u>2X lines</u>

<u>…..6X lines, 8X, Admixed (wild type)</u>

Methods:

Partition - reduce genetic diversity through a series of bottlenecks

Reconstitute - combine different numbers of low diversity lines
(also included wild type ancestors - admixed)

Stress - Subject bottlenecked and reconstituted lines to environmental stress (*with controls*)

Census – count replicates weekly

Reduced Salinity (with controls)

Methods:

Partition - reduce genetic diversity through a series of bottlenecks

Reconstitute - combine different numbers of low diversity lines
(also included wild type ancestors - admixed)

Stress - Subject bottlenecked and reconstituted lines to environmental stress (*with controls*)

Census – count replicates weekly


DON'T PANIC

Part III: The Experiment

Design Summary

Environmental Stress
9 ppt salt

Diversity Level	# Replicates	Environment
1X	15	Low Salinity
	15	Normal Salinity
2X	15	Low Salinity
	15	Normal Salinity
6X	10	Low Salinity
	10	Normal Salinity
8X	10	Low Salinity
	10	Normal Salinity
Admixed	10	Low Salinity
	10	Normal Salinity
	=120	

Good Environment
30 ppt salt

Some Details….

All tanks founded under permissive conditions (normal salinity)

Allowed 3 weeks to settle, then counted

Salinity lowered in half the tanks

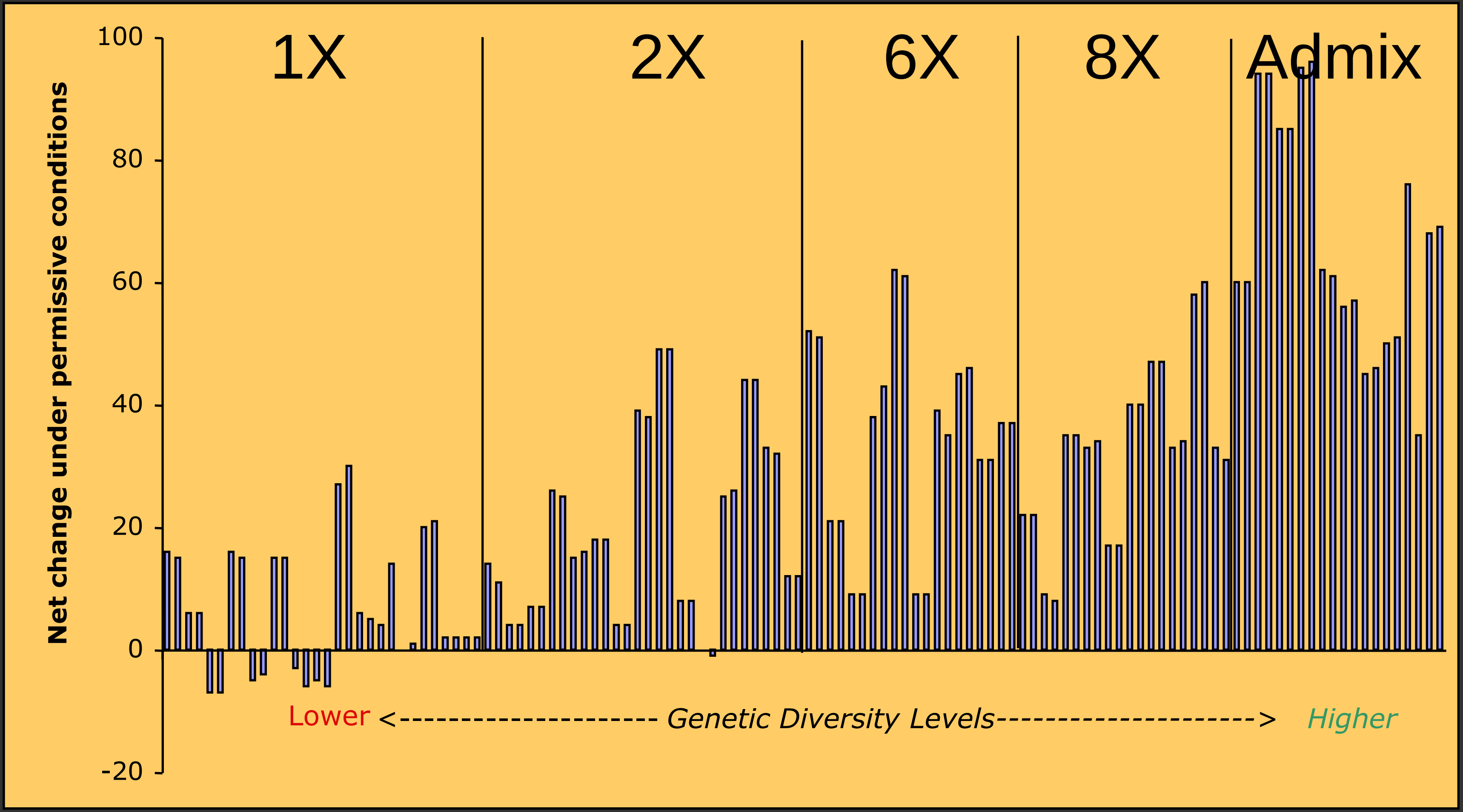
Counted every week for 3 months

91,519 mysids counted!

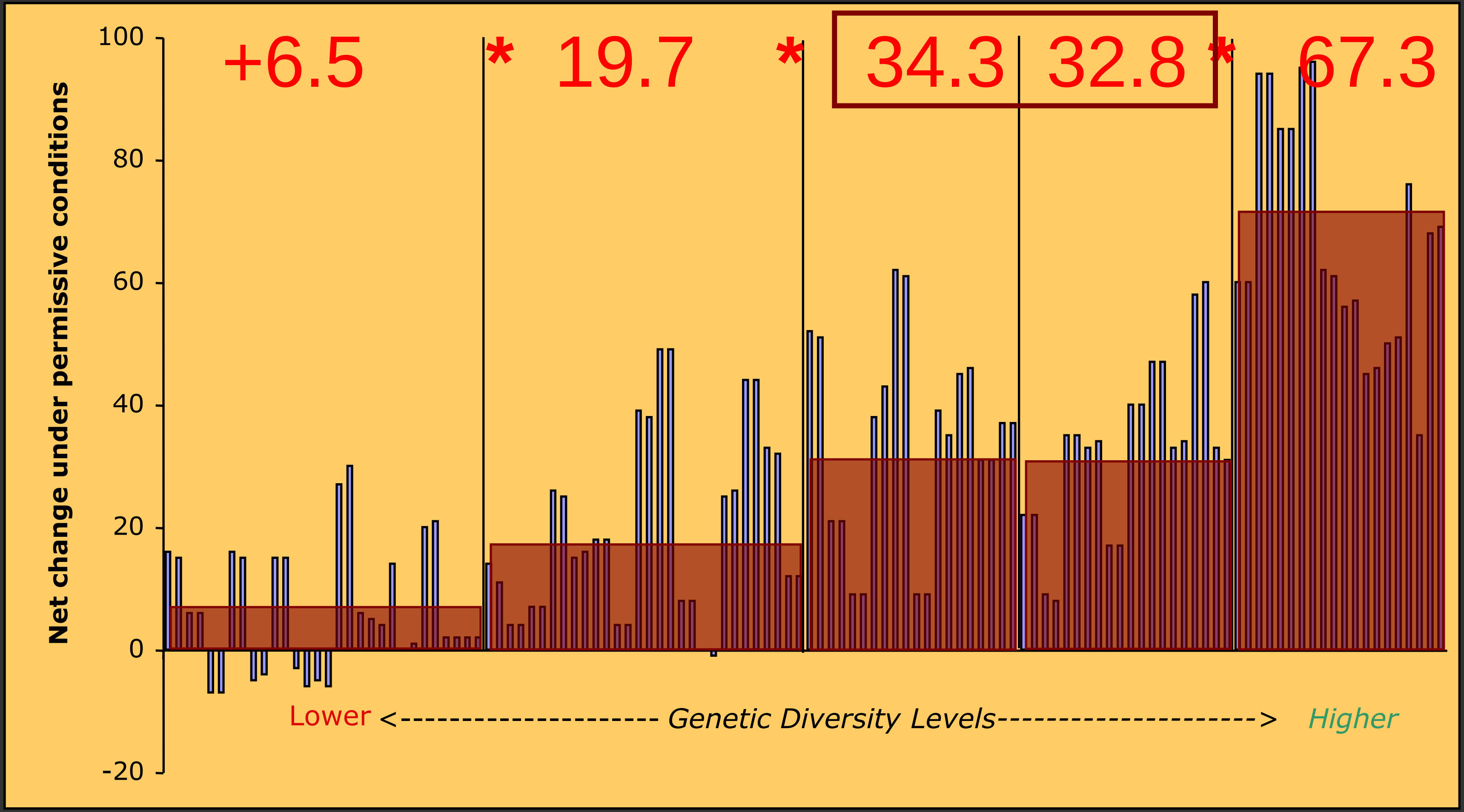
Part IV: Results

Week Zero

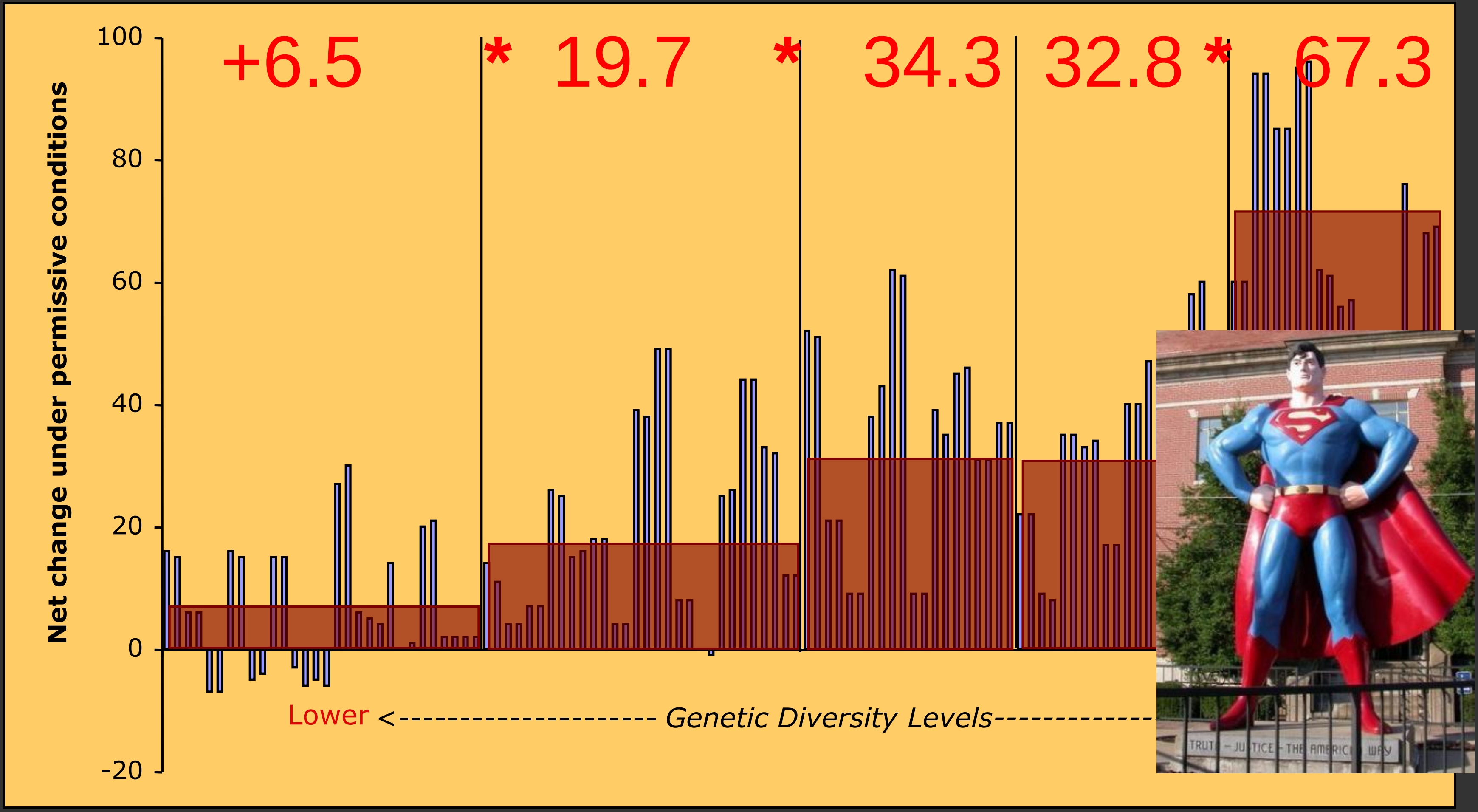
(net increase after 3 weeks in permissive conditions)



Hybrid Vigor



Hybrid Rescue



Long-term fitness and environmental stress

Several fitness proxies available --

Median Population Size

Actual Population Extinction

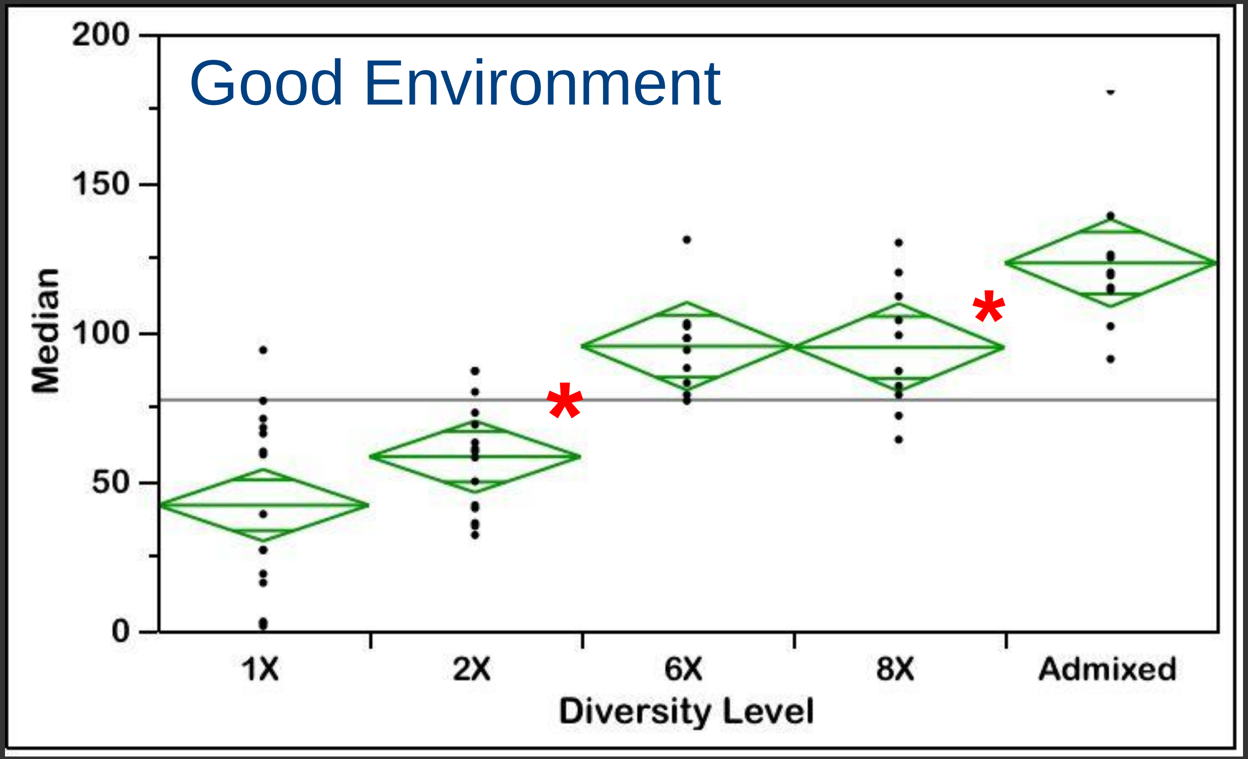
Observed Extinction

High---*Diversity*---Low

Diversity	Environment	% Extinct
1X	Permissive	20
	Stressful	73
2X	Permissive	-
	Stressful	7
6X	Permissive	-
	Stressful	-
8X	Permissive	-
	Stressful	-
Admixed	Permissive	-
	Stressful	-

Long-Term Fitness

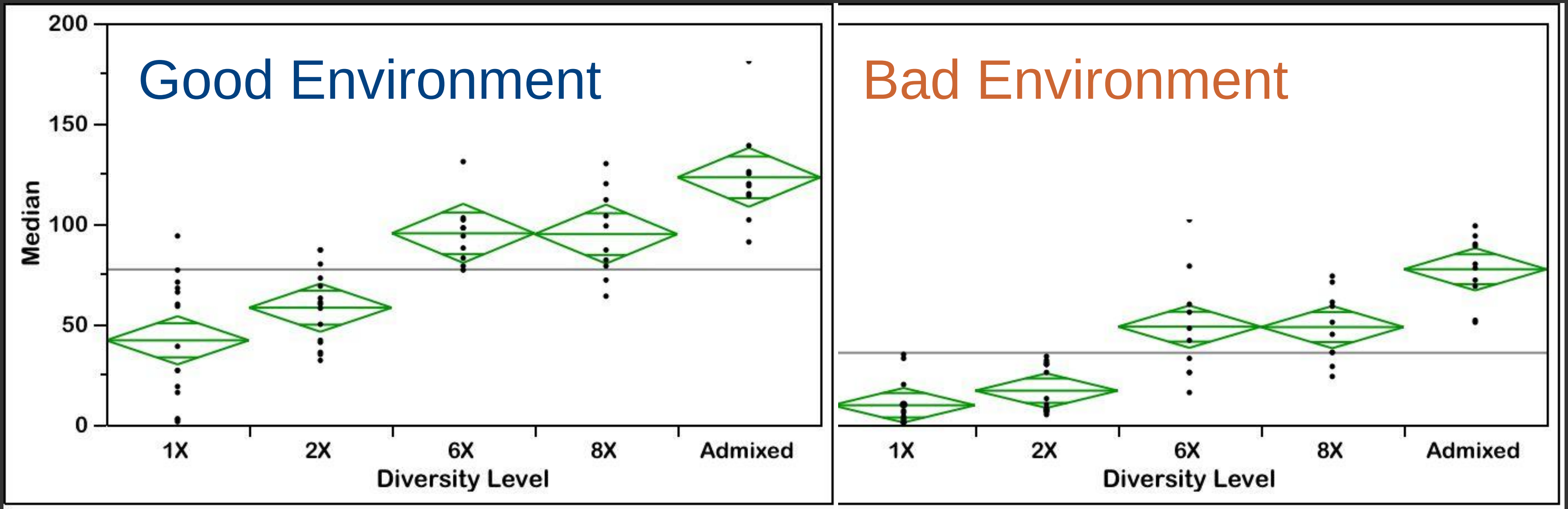
(13 wk median population size)



Lower----------------------------------Higher

Genetic Diversity

Long-Term Fitness

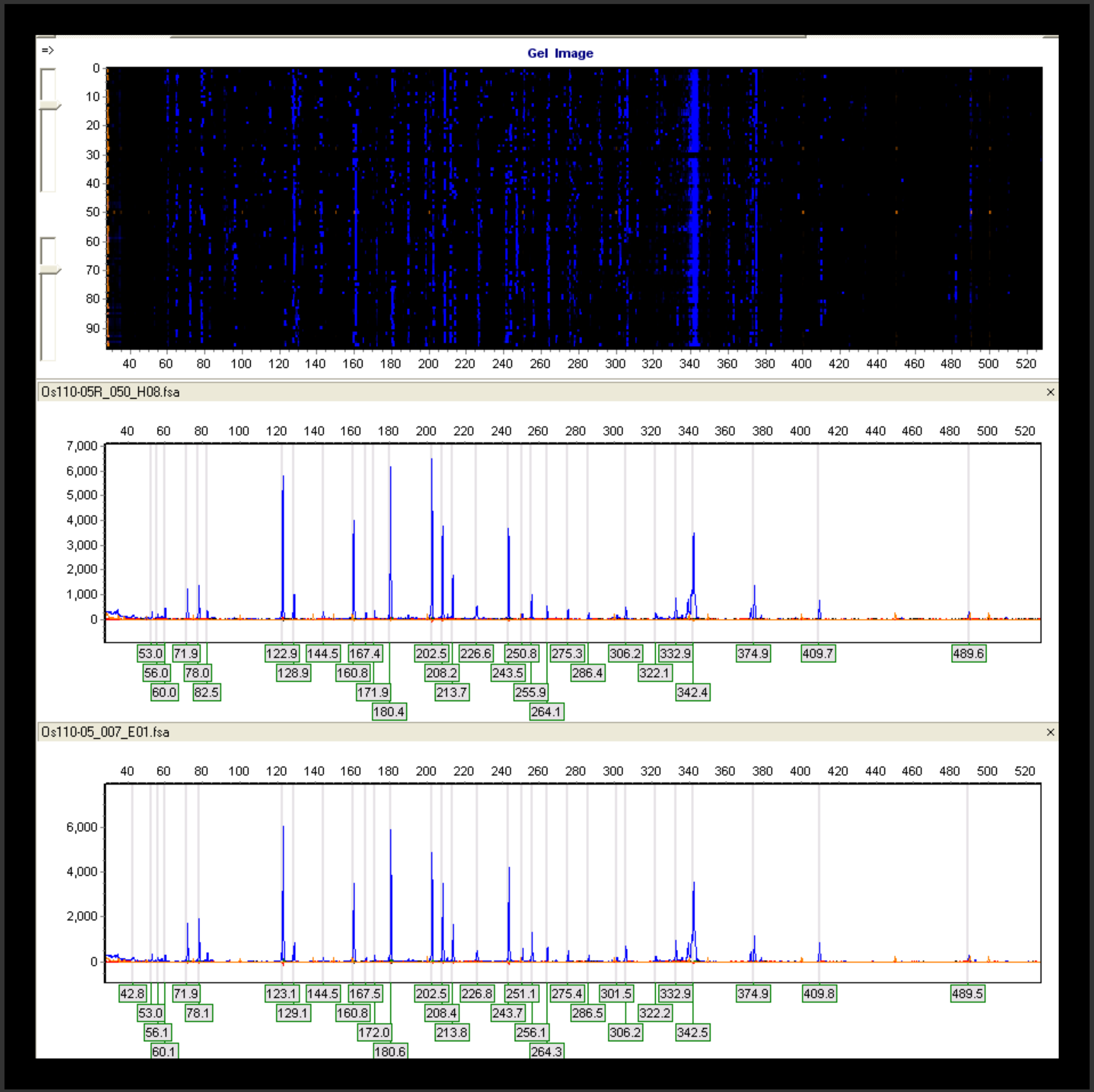


Lower---------------------Higher Lower------------------Higher

Genetic Diversity

13 week median population size

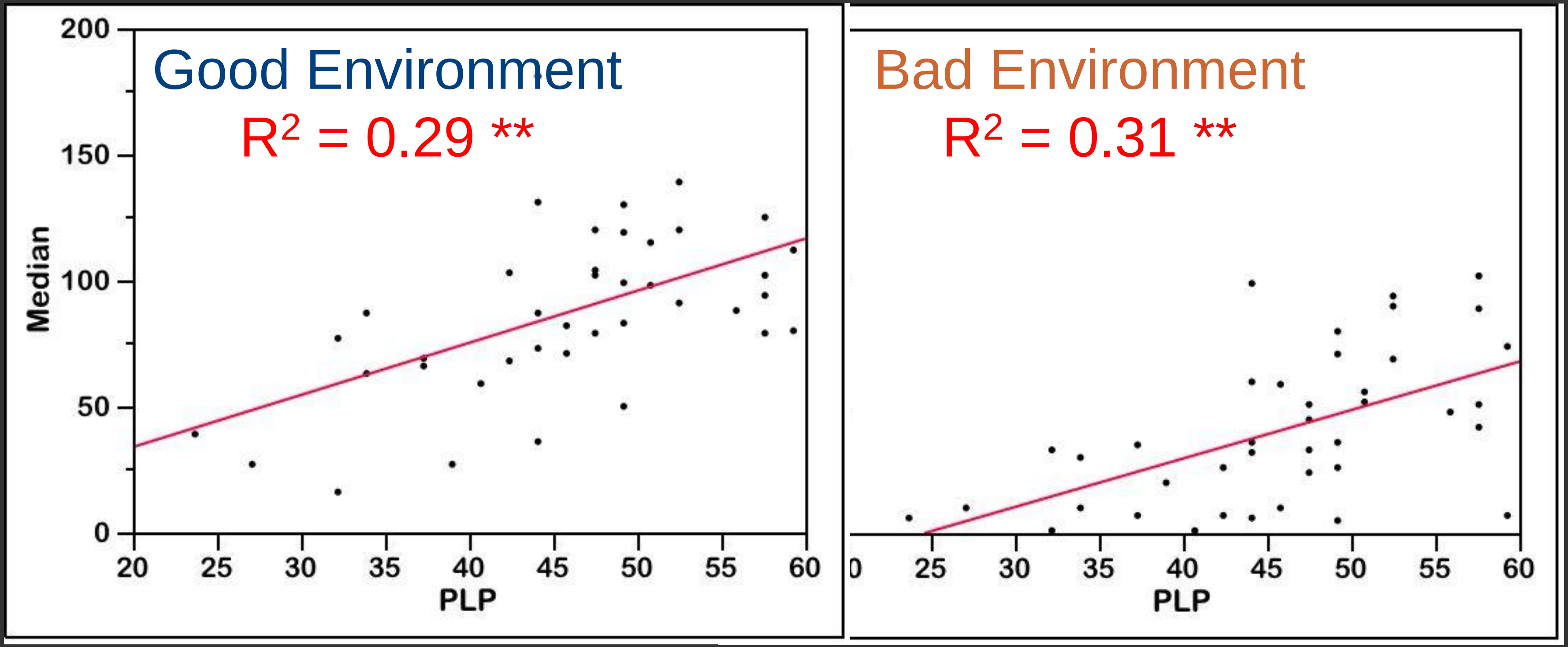
AFLP Diversity and Fitness



Why not SSR's?

AFLPs realistic for many at risk taxa

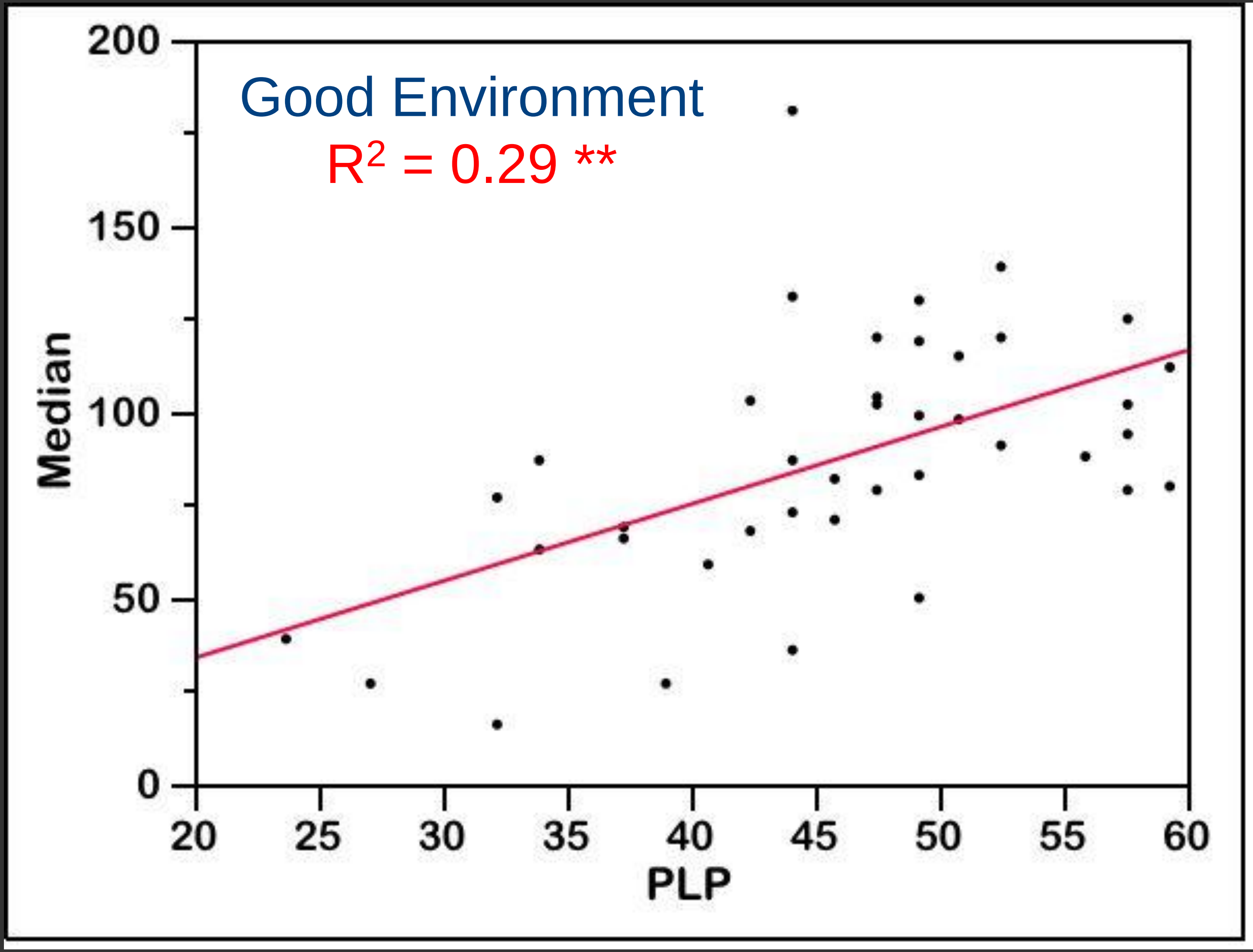
AFLP Diversity and Fitness



Lower--------------------Higher Lower-----------------Higher

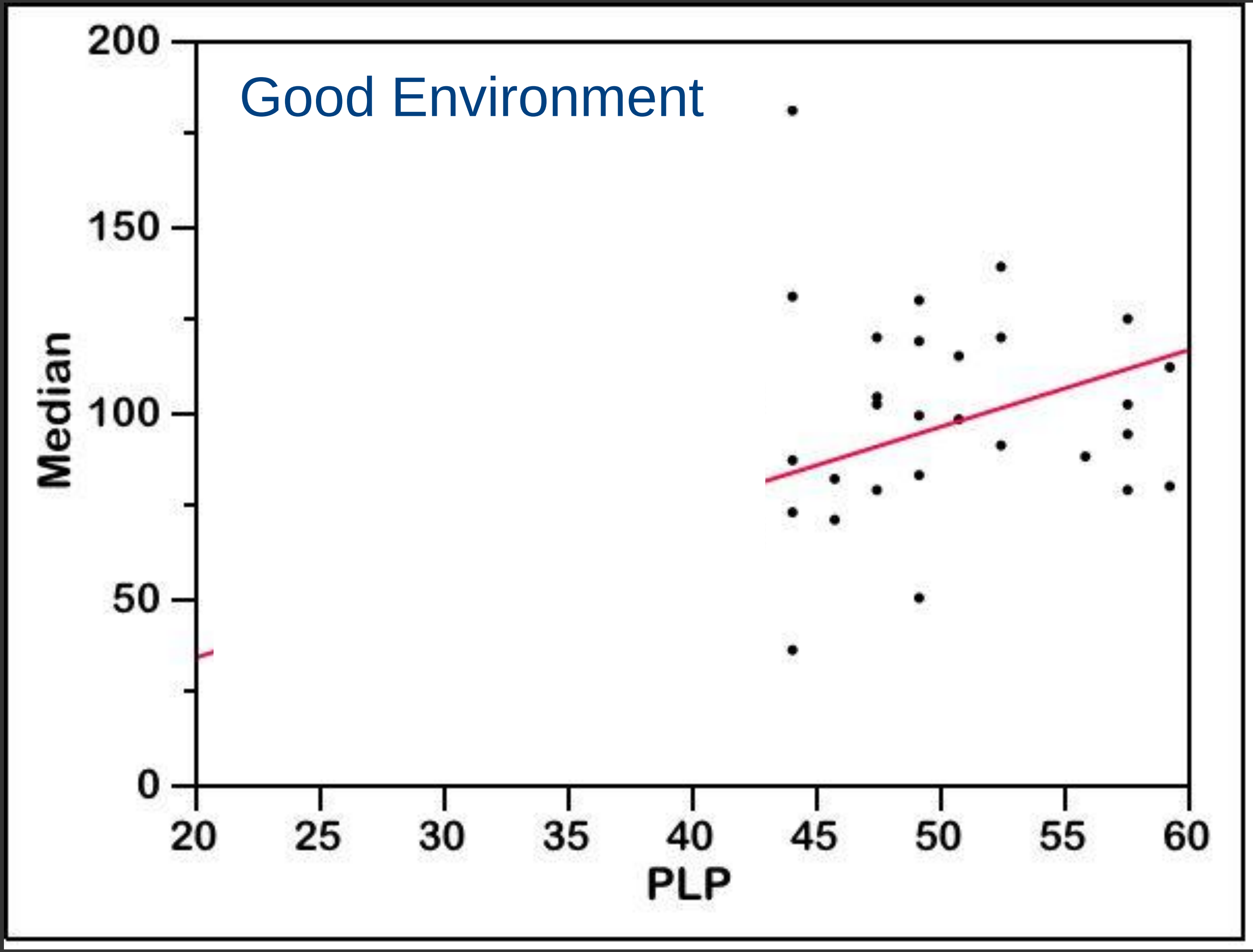
Genetic Diversity (% polymorphic bands)

AFLP Diversity and Fitness



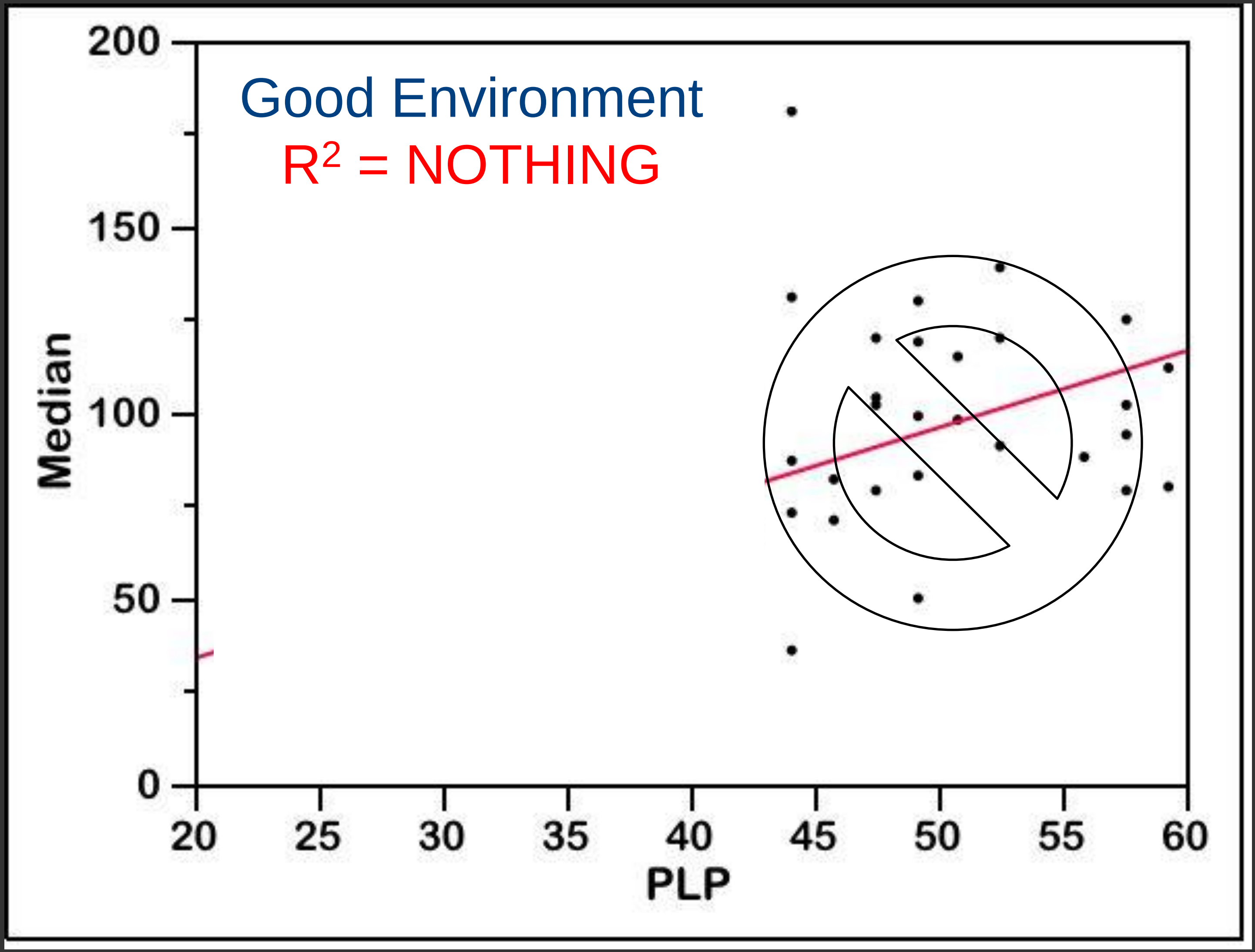
Lower---------------------Higher

AFLP Diversity and Fitness



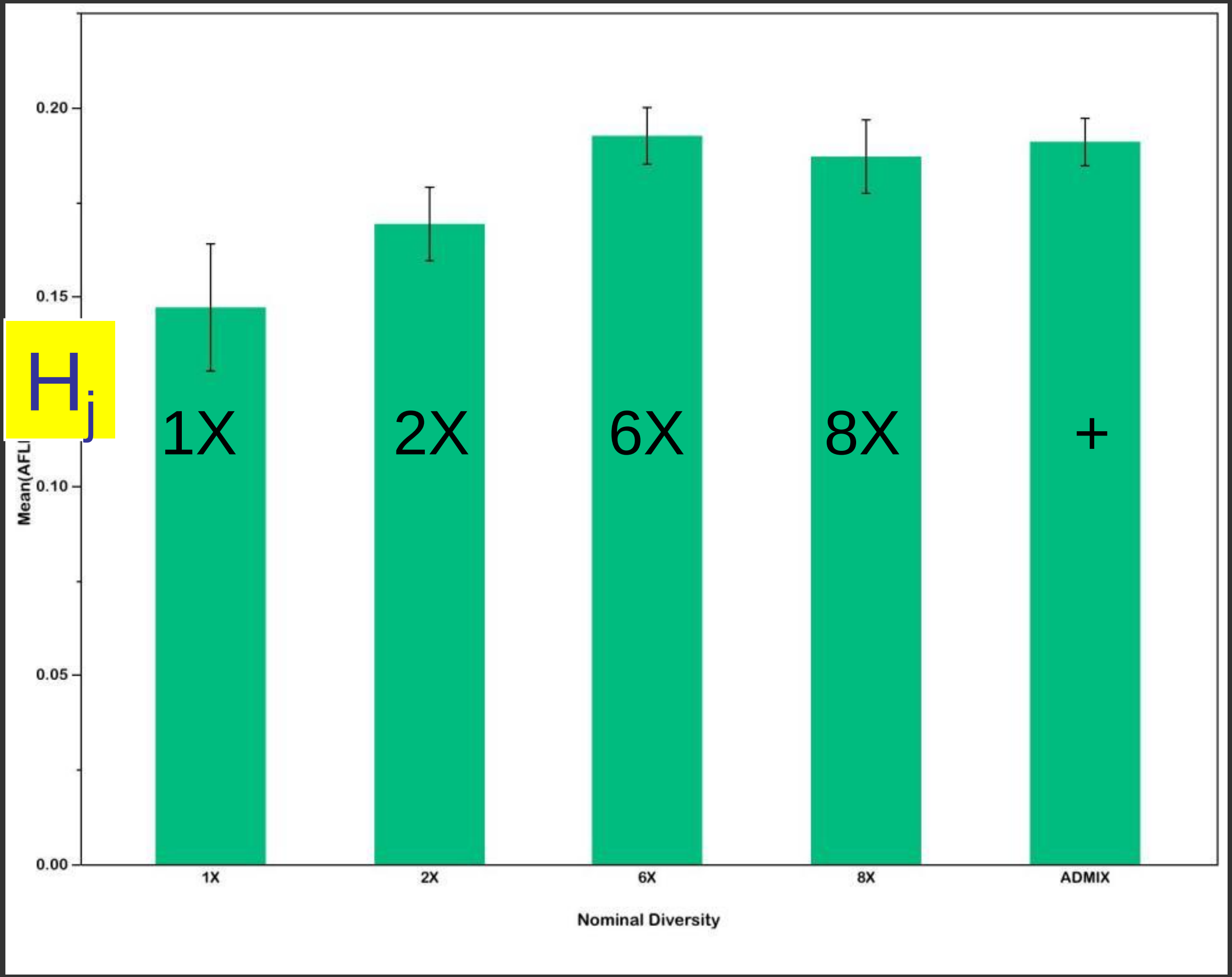
Lower---------------------Higher

AFLP Diversity and Fitness



Lower---------------------Higher

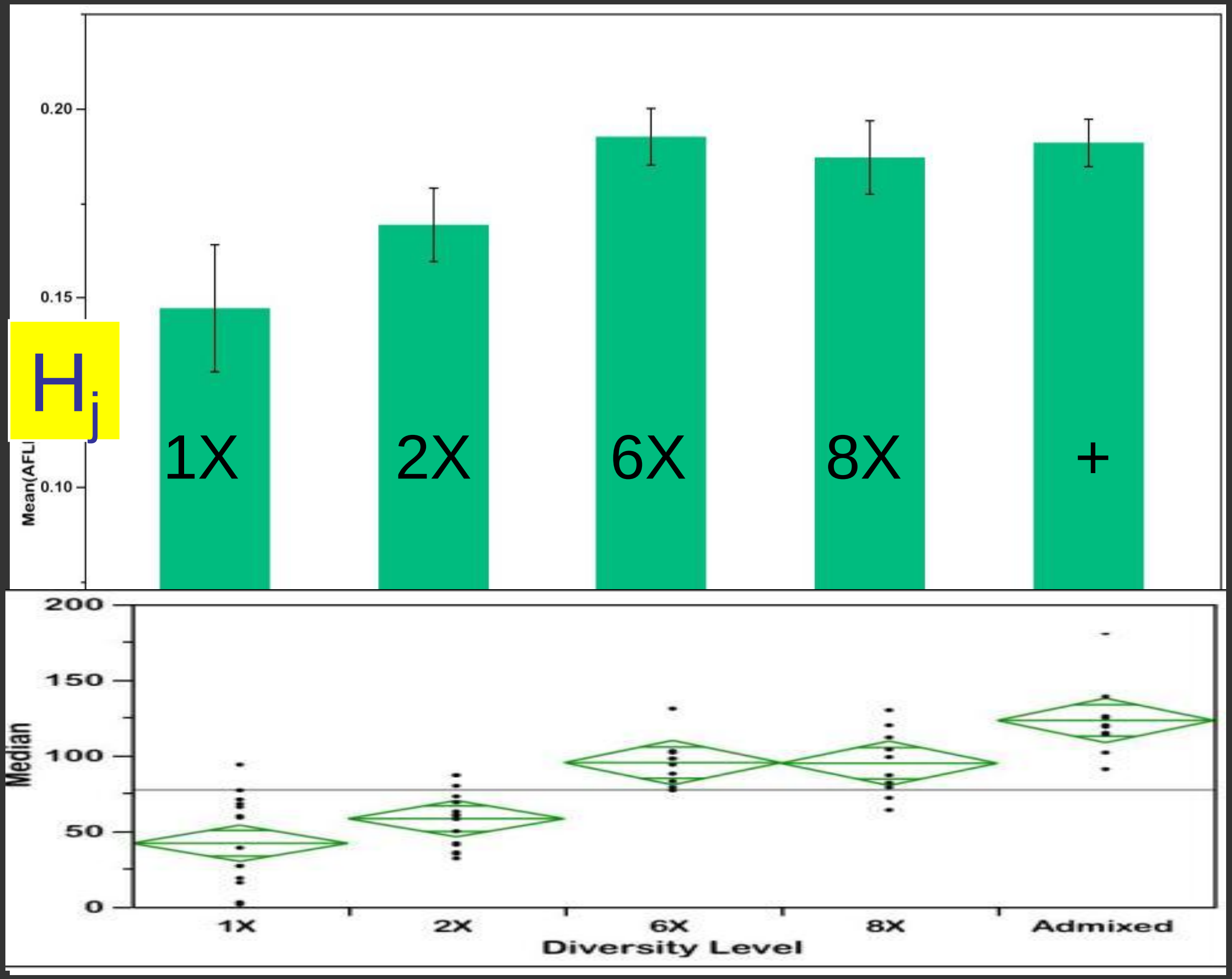
AFLP Diversity



Lower-----------------------------------Higher

Genetic Diversity

AFLP Diversity



Lower-----------------------------------Higher

Genetic Diversity

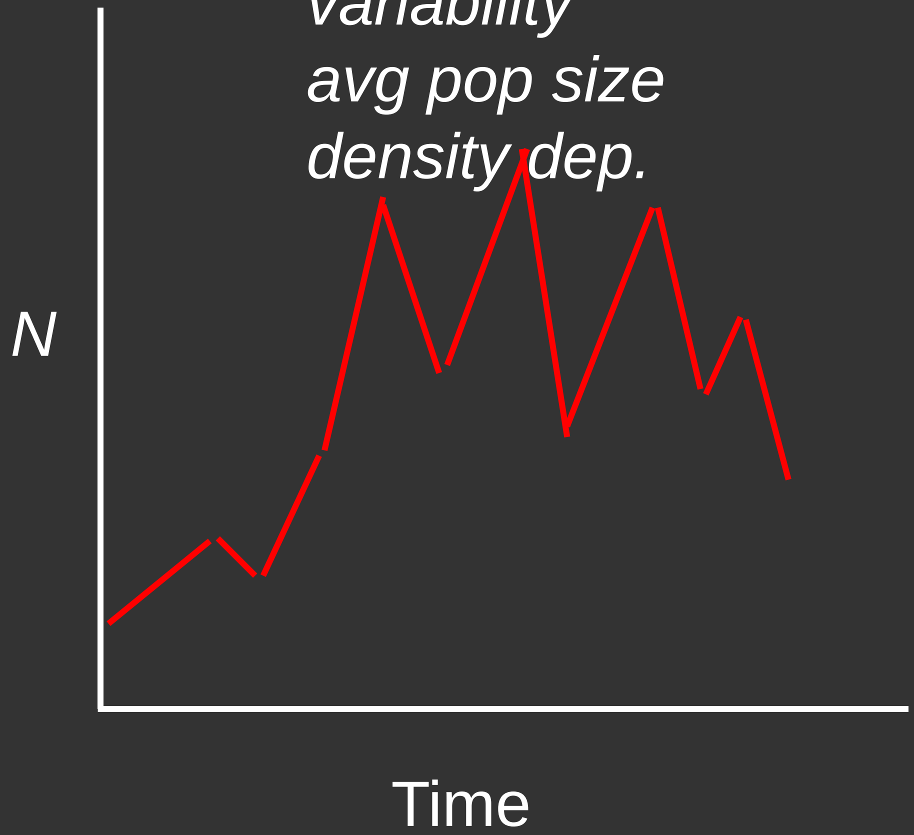
Part V: The Future

What about Extinction Risk??

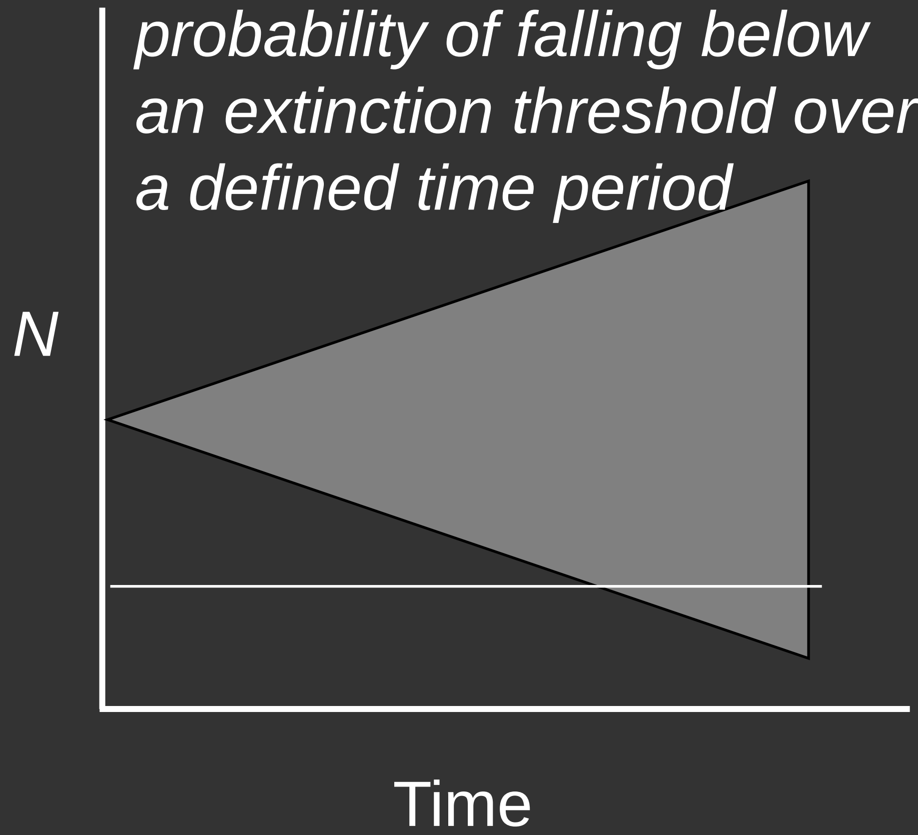
Diversity	Environment	% Extinct
1X	Permissive	20
	Stressful	73
2X	Permissive	-
	Stressful	7
6X	Permissive	-
	Stressful	-
8X	Permissive	-
	Stressful	-
Admixed	Permissive	-
	Stressful	-

Population Viability Analysis

Within one tank…….
variability
avg pop size
density dep.

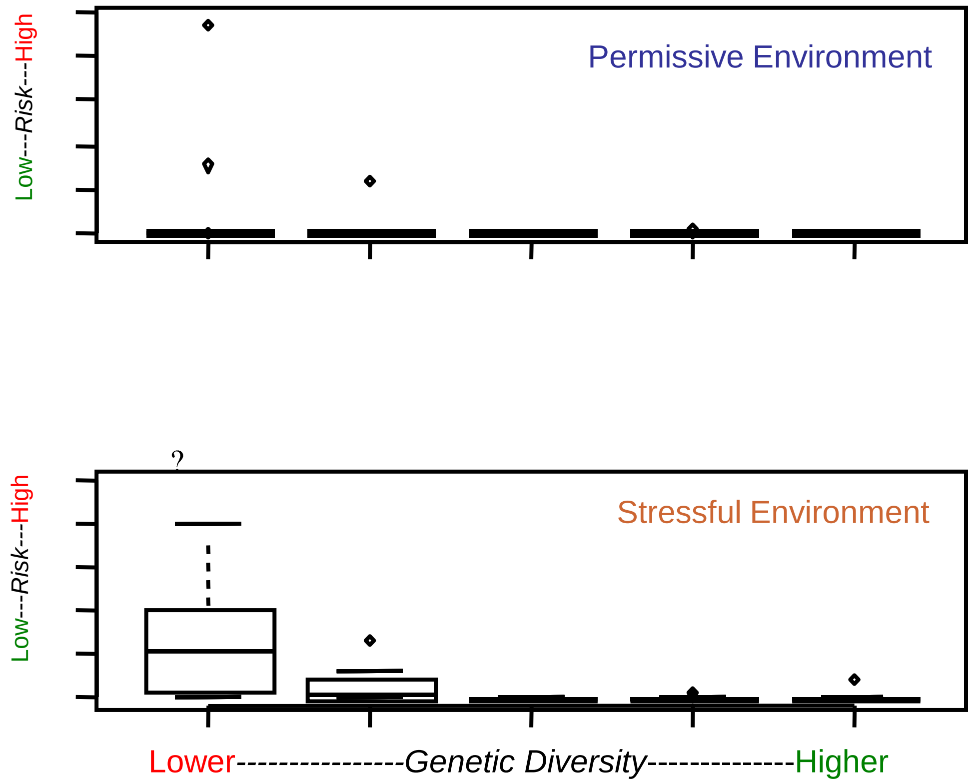


Used to parameterize a stochastic model - predicts probability of falling below an extinction threshold over a defined time period



‘Long-term’ Extinction Risk

13 week projection



Actual Extinction

Diversity	Environment	% Extinct
1X	Permissive	20
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Box-whisker plots of the probability of Nt passing below N0/100

Probabilities are separately estimated by simulation for each

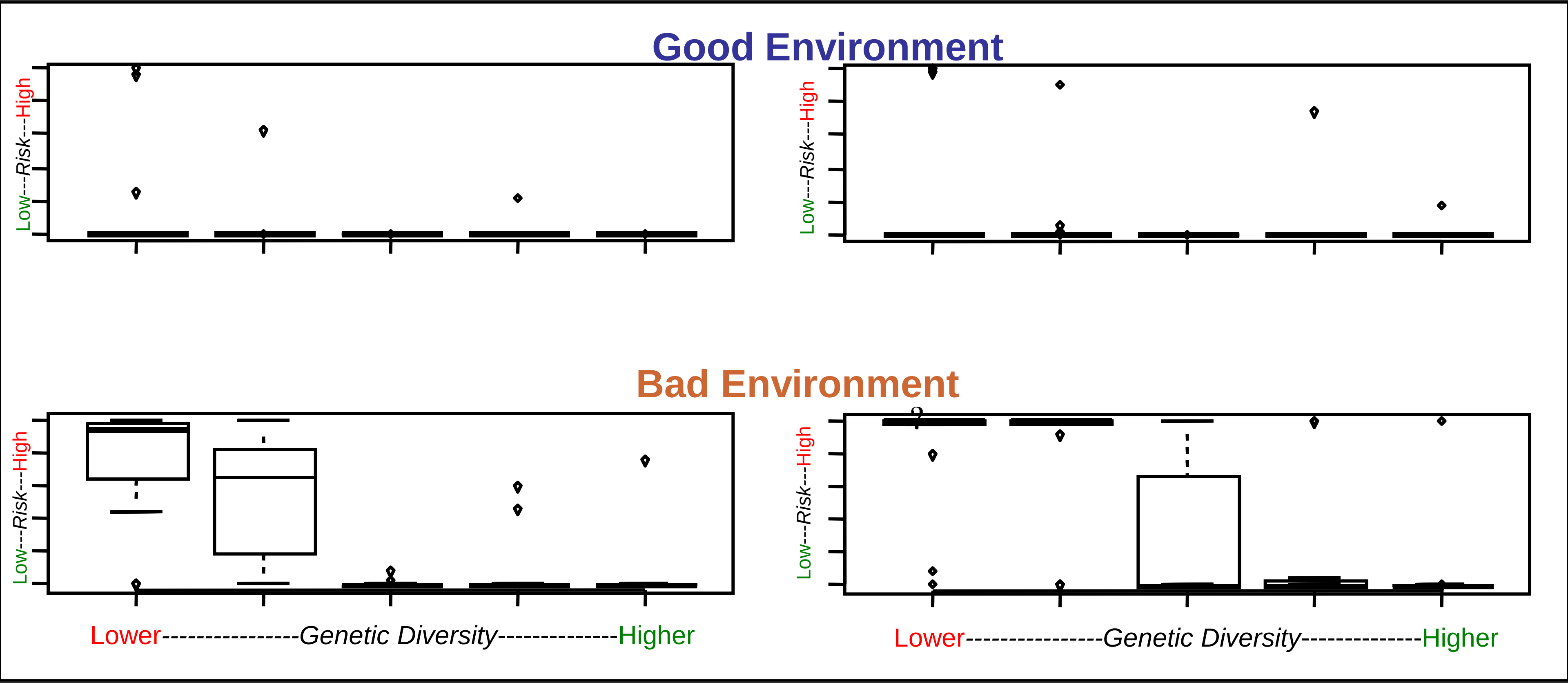
population from separately estimated parameters of the discrete-time stochastic-

logistic model of Dennis and Taper (1994).

‘Long-term’ Extinction Risk

26 week projection

56 week projection



Part VI: What have we learned?

General Conclusions

As expected, long-term extinction risk is associated with genetic diversity in harsh environments - even with modest losses of GD

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BUT

Permissive environments may mask the harmful effects of reduced genetic diversity in the short term

General Conclusions

As expected, long-term extinction risk is associated with genetic diversity in harsh environments - even with modest losses of GD

BUT

Permissive environments may mask the harmful effects of reduced genetic diversity in the short term

AND

AFLP markers do a poor job detecting small, but potentially critical losses of genetic diversity under very tightly controlled conditions

How much genetic diversity is 'enough'?

- minor losses can be important in especially in suboptimal environments

Can we detect meaningful losses of diversity, before it's too late?

- perhaps not with AFLP

Acknowledgements

Coauthors:

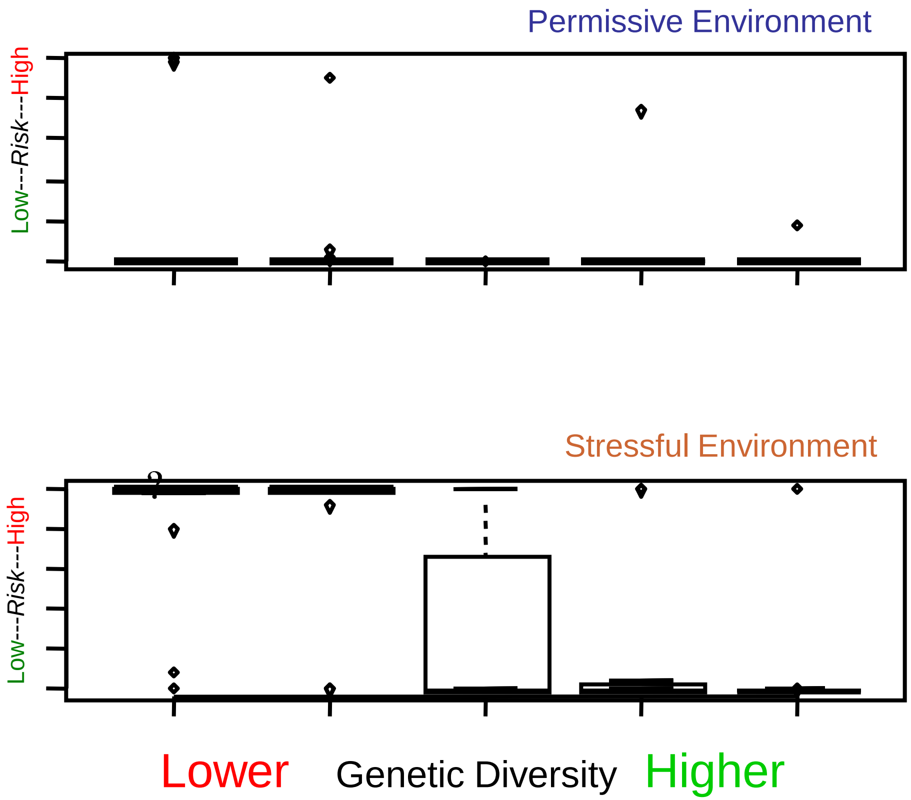
M. Bagley, D. Nacci,
D. Champlin, J. Grear, R. Gobell, A. Kuhn, A. Roth,
T.J. McGreevy

US-EPA Atlantic Ecology Division, Gulf Ecology Division and Ecological Exposure Research Division

Volunteers:

L. Coiro, K. Ho, L. Mills, B. Minor, P. Pelletier, M. Perron,
S. Rego, M. Tagliabue, G. Thursby, M. Smith, H. Haring, A. Collins,
S. Winnicki,, M. Schroeder, D. Duquette, Z. Schuyler, J. Darling,
D. Proestou, R. Brown, BHS, POS

More at www.markert.fastmail.fm



In this controlled system AFLP’s are poor predictors of population genetic health