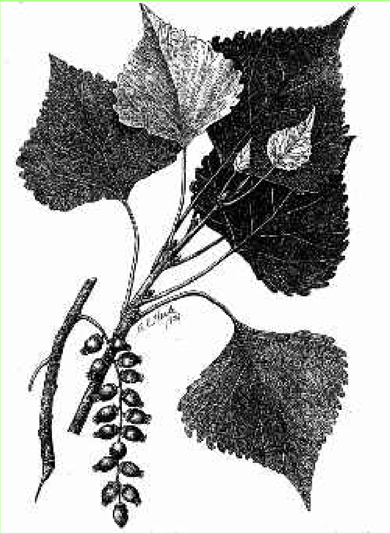
The Importance of Genetic Diversity in Riparian Restoration



Sharon Ferrier, Gery Allan, Laura Hagenauer, Karla Kennedy, Randy Bangert, & Tom Whitham

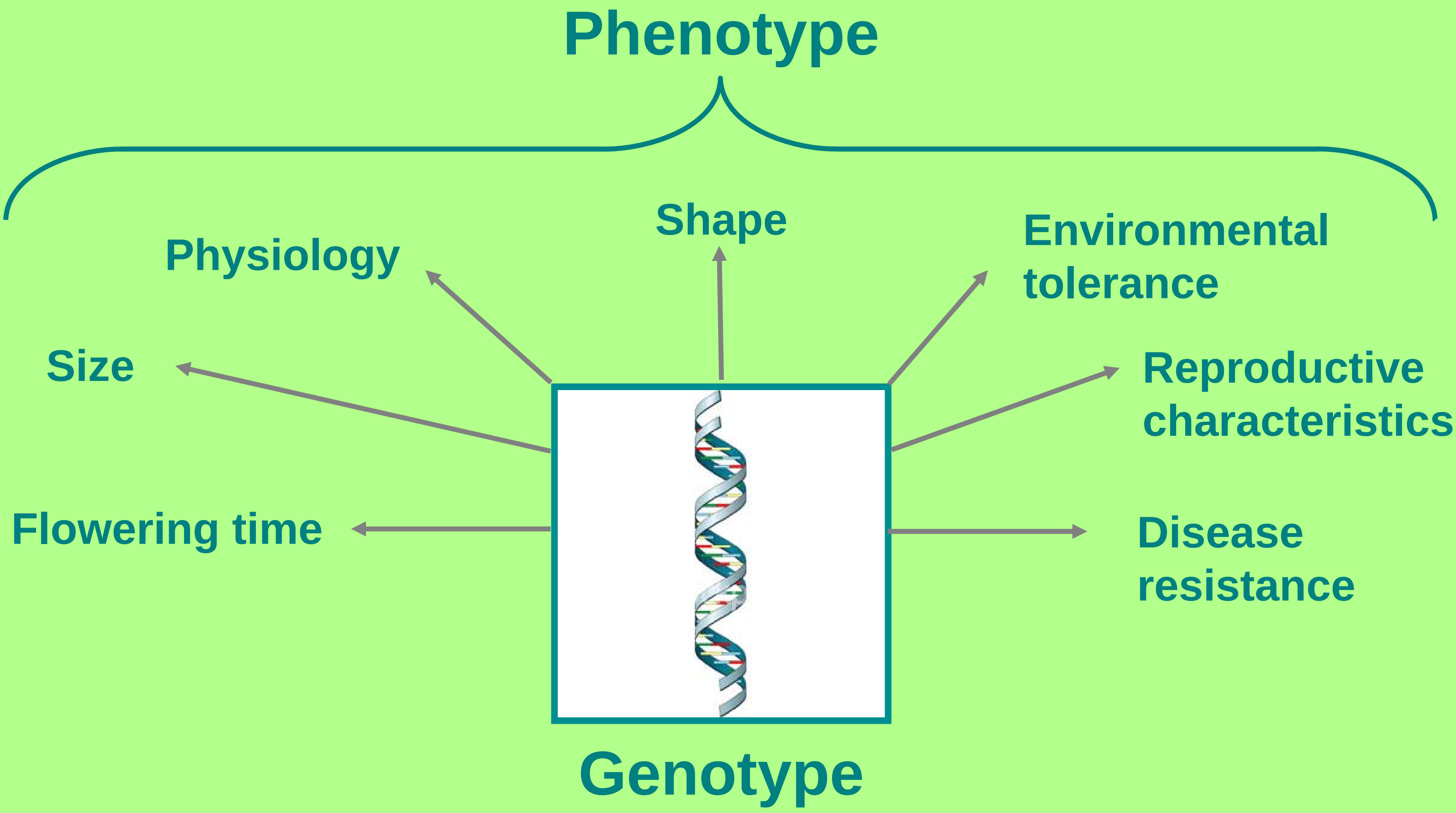
The Cottonwood Ecology Group: www.poplar.nau.edu

Northern Arizona University

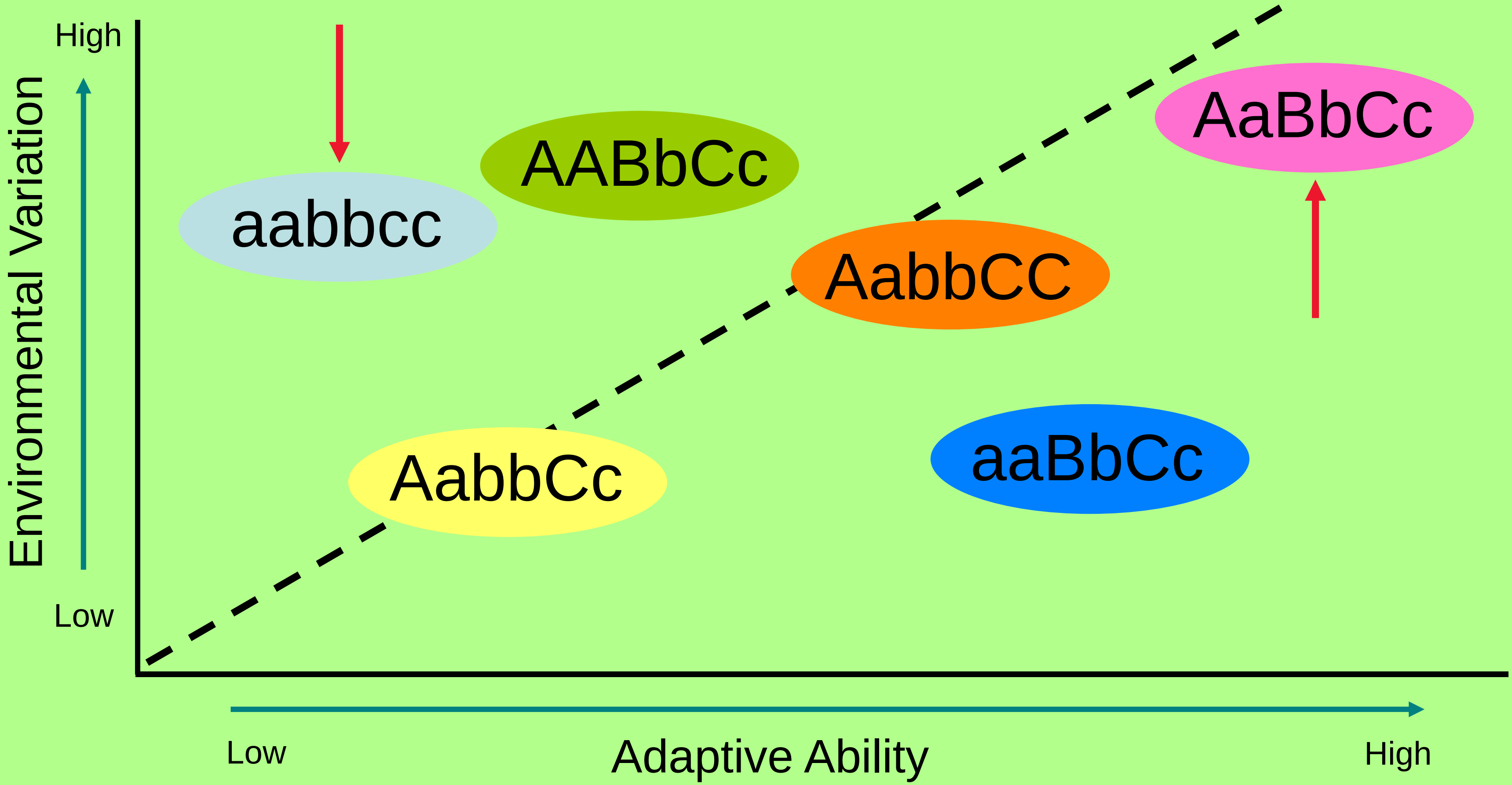
Flagstaff, AZ

Why use genetic tools?

Genetic information determines form and function



Genotypic diversity influences individual responses to environmental variation and adaptability



Genotypic differences often affect survival and performance

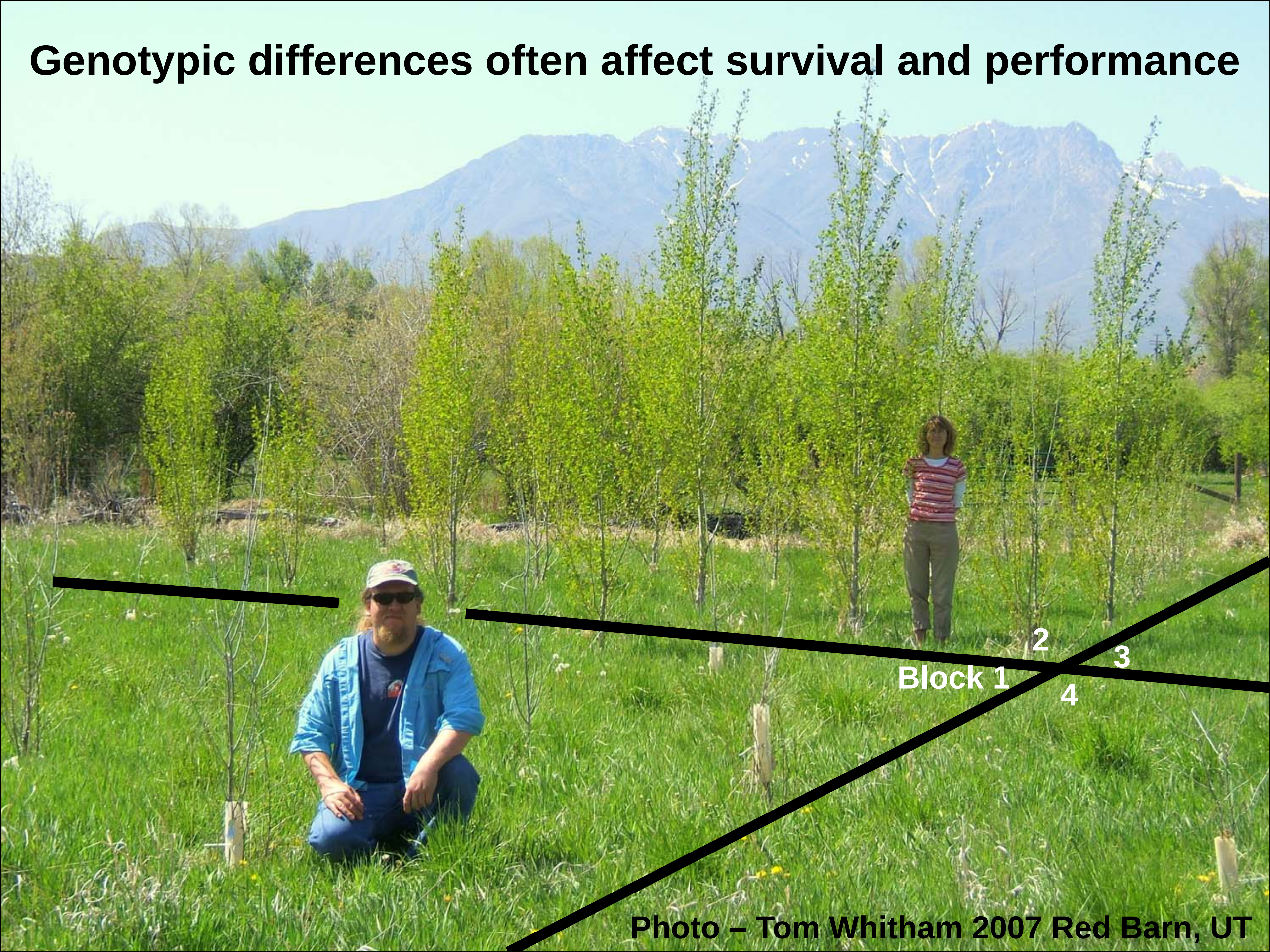
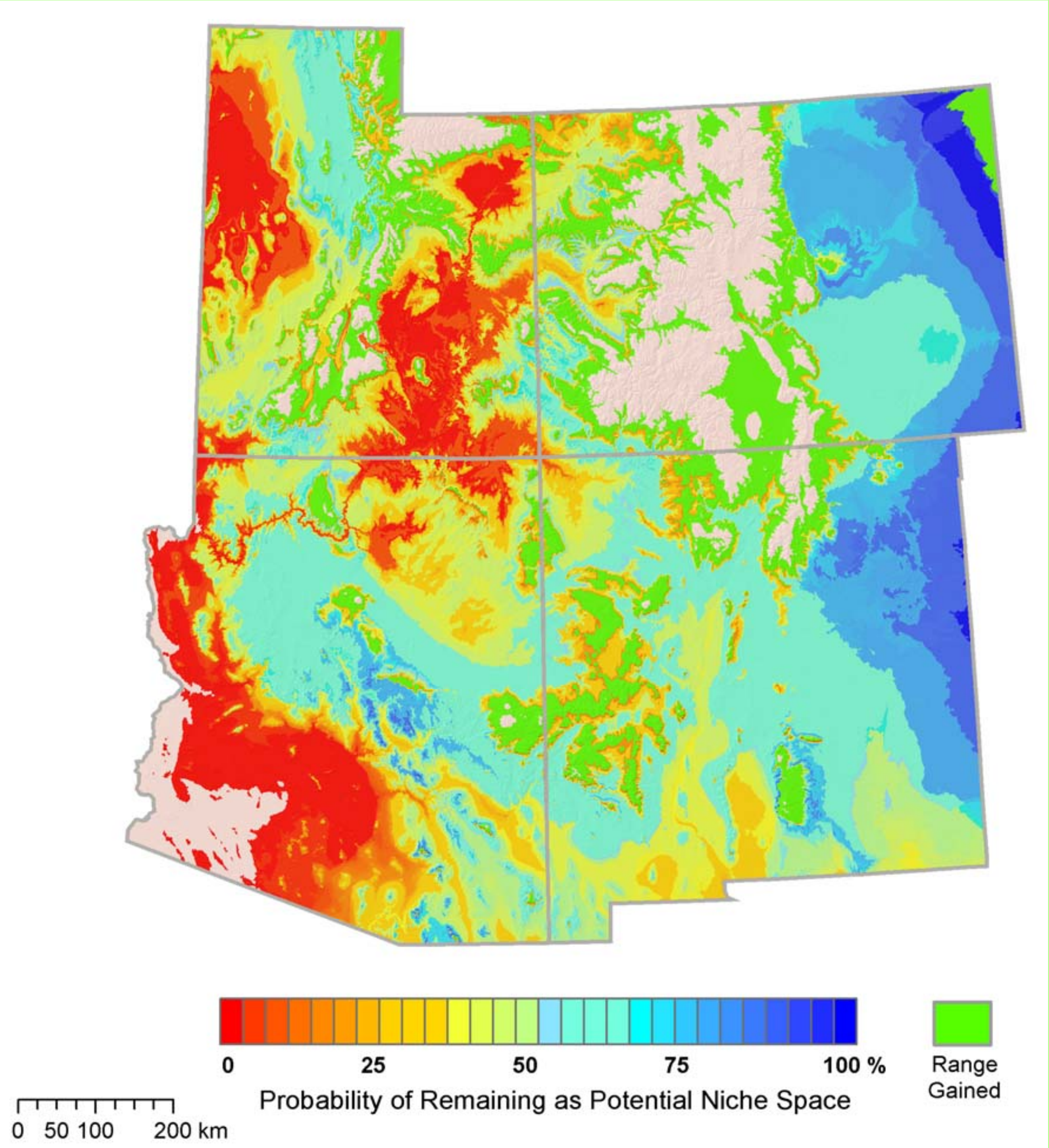


Photo – Tom Whitham 2007 Red Barn, UT

Cottonwood distributions based on GARP modeling of predicted climate change from IPCC



With predicted climate change locally adapted genotypes may no longer be locally adapted

Gitlin & Whitham, unpub. data
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Plant Genetic Factors Account for ~50% of the Variation in Ecosystem Services

Plant Growth Rate Constant 45%

(Productivity)
Lojewski et al. unpub. data

Community Stability 25%

Keith et al. unpub. data

Nutrient Cycles 34-65%

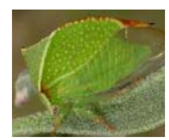
(Soil Fertility)
Schweitzer et al. 2004 Ecology Letters, 2005 Ecology, 2005 Oikos, LeRoy et al. 2006 Ecology

Water Cycles 35-40%

(Fluxes from Soil to Plant to Atmosphere) Fischer et al. 2004 Oecologia

Biodiversity 43-78%

(Microorganisms, Herbivores, Birds) Wimp et al. 2004 Ecology Letters, Bangert et al. 2004 Conservation Biology, Shuster et al. 2006 Evolution, Bailey et al. Ecology Letters 2006, LeRoy et al. 2006 Ecology, Schweitzer et al. 2007 Ecology

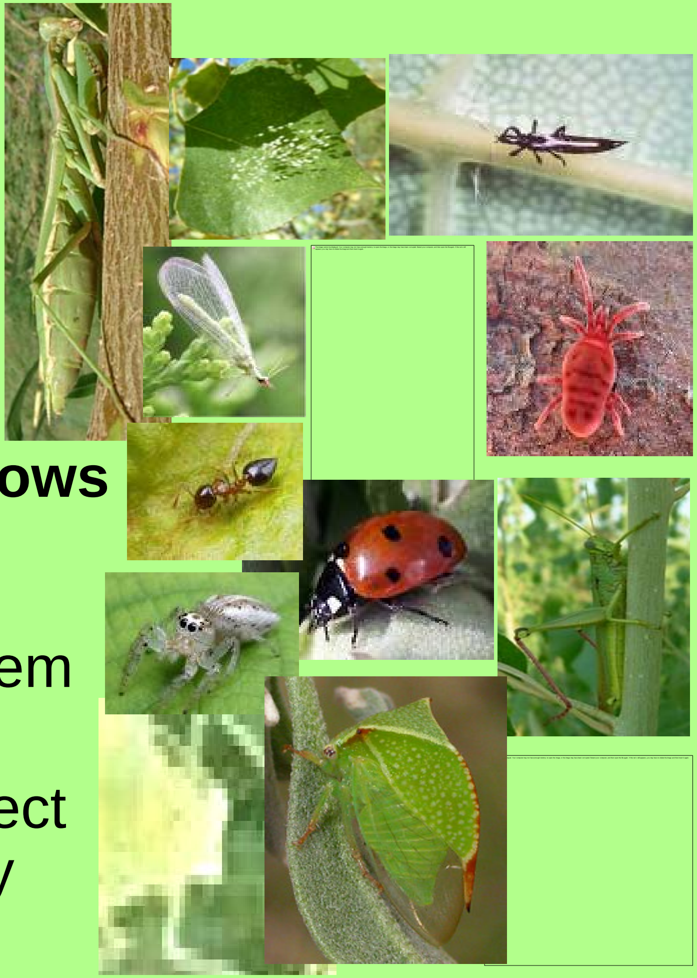


Belowground Carbon Storage & Root Production 77%

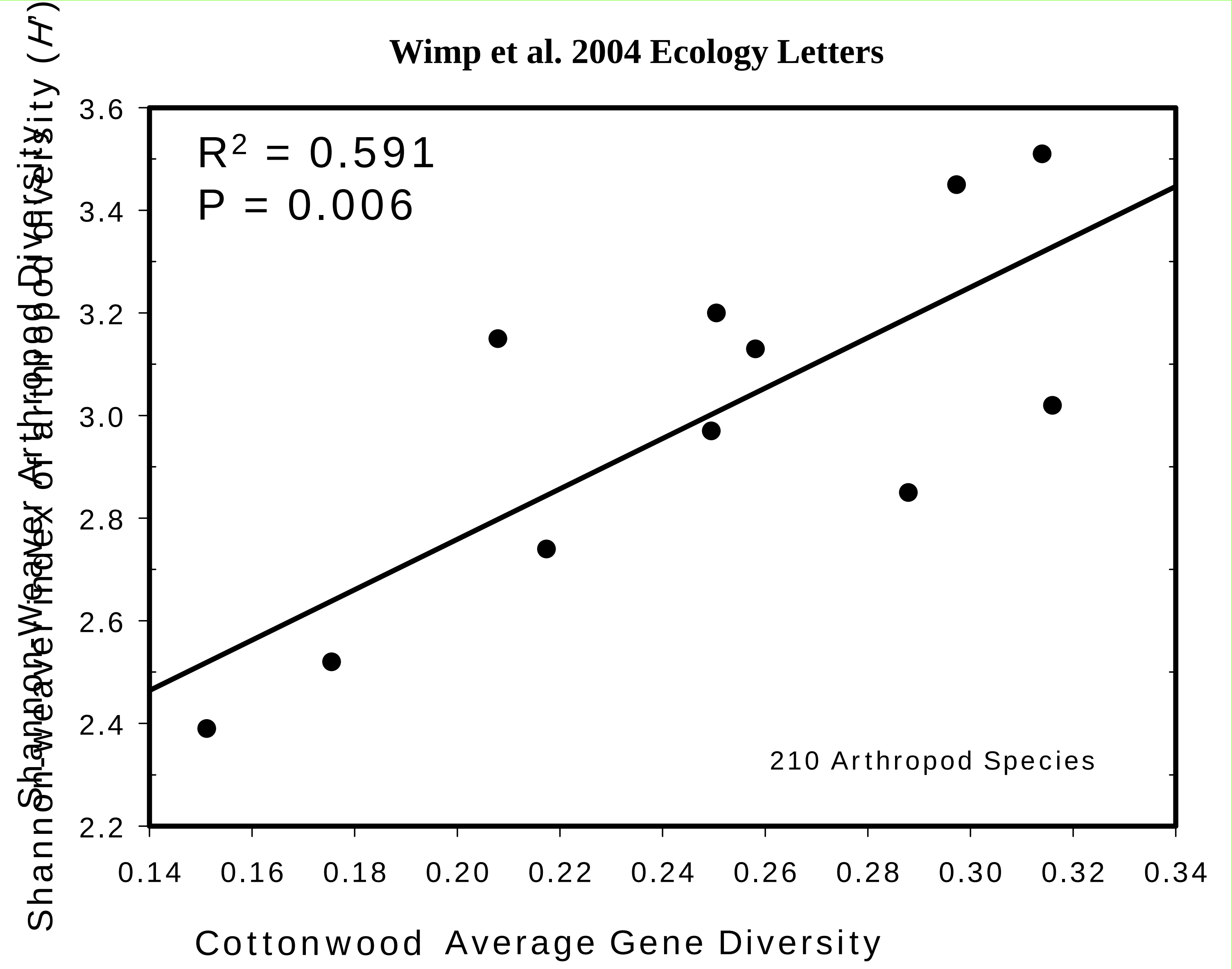
Fischer et al. 2006 Oecologia, Fischer et al. 2007 New Phytologist

Genetic Diversity affects Biodiversity

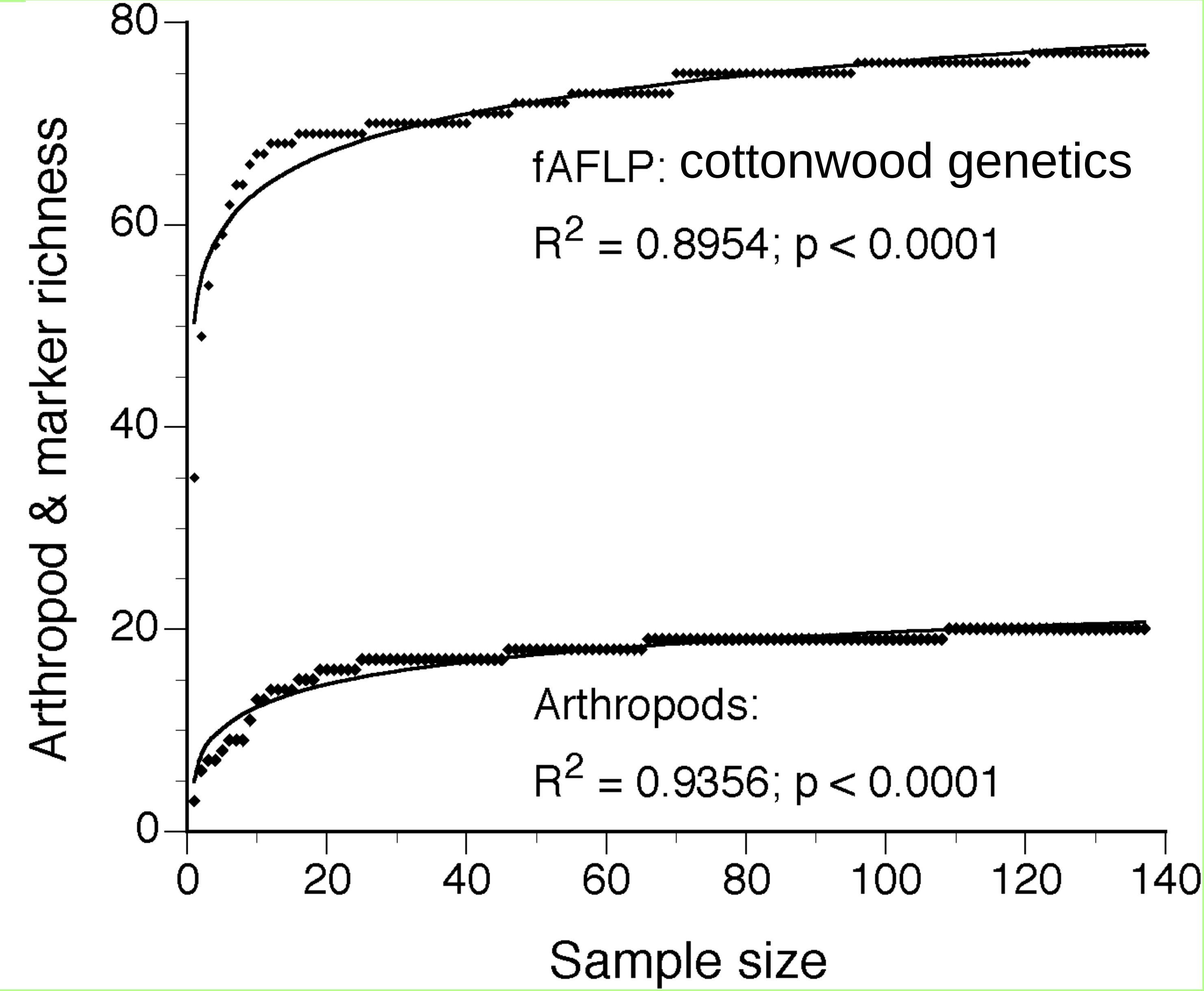
- **Biodiversity** is a key feature of riparian ecosystems, and is driven, in part, by species that dominate riparian landscapes.
- **Cottonwoods and Willows** are foundation riparian species that drive community and ecosystem diversity.
- **Our studies** show a direct link between biodiversity and cottonwood genetic diversity.



Plant genetic diversity determines arthropod diversity at a landscape level

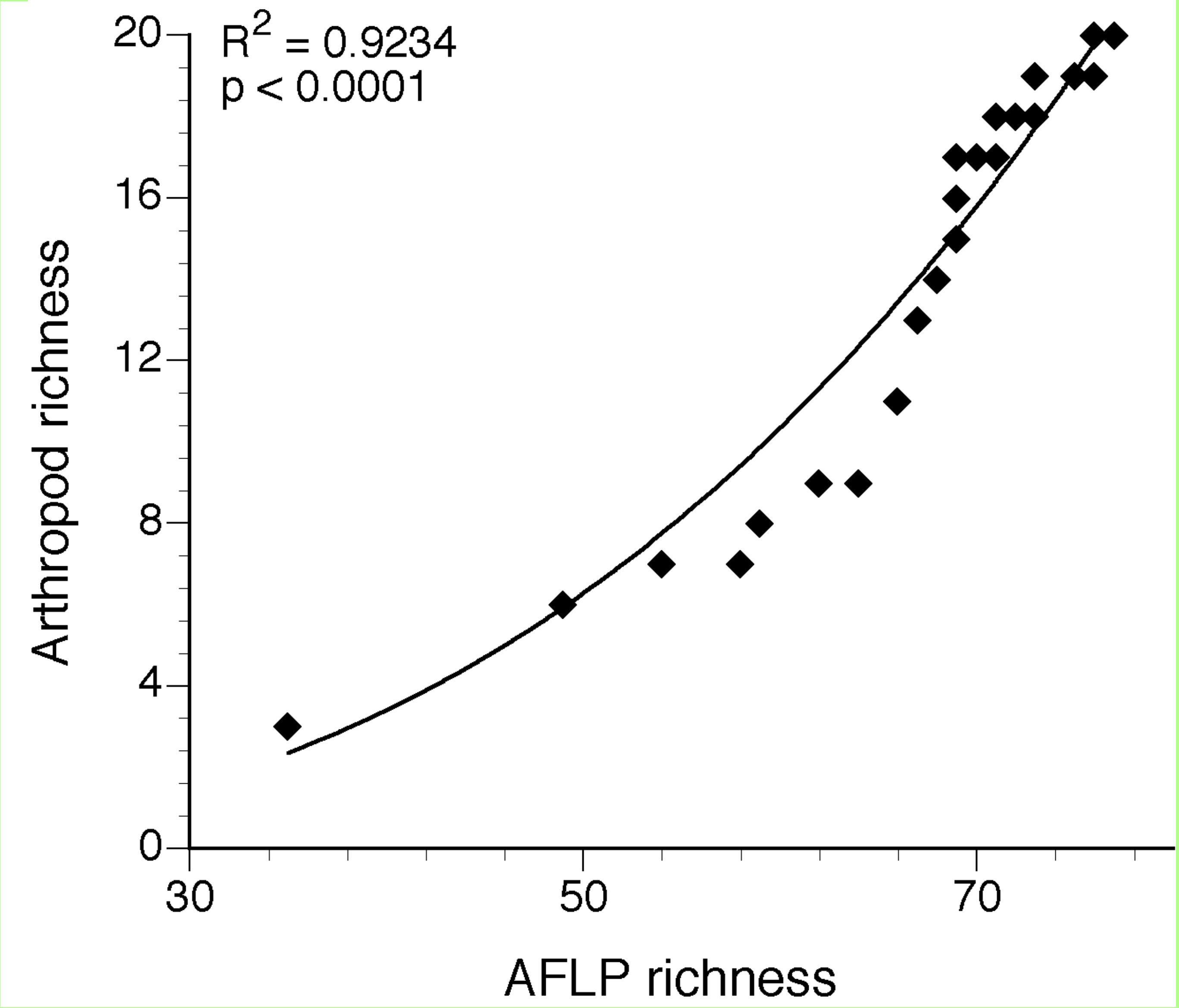


Species-area and genetic diversity-area curves are nearly identical
Is area important and/or is it genetic diversity?



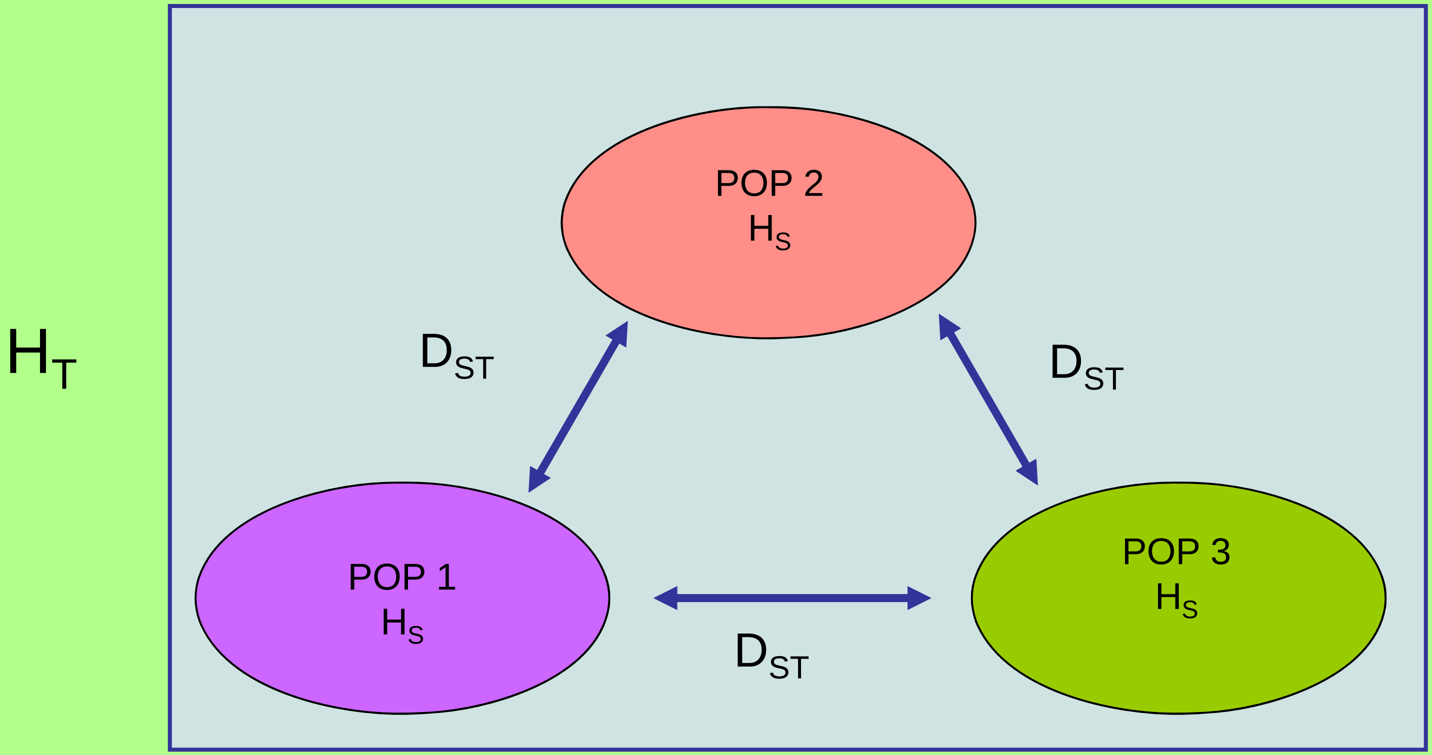
Bangert et al. 2007 Heredity

Genetic variation in a foundation tree is highly correlated with species richness



Bangert et al. 2007 Heredity

Knowledge of population genetic diversity is critical for restoration and can be readily characterized



D_{ST} = Among population diversity

H_S = Within population diversity

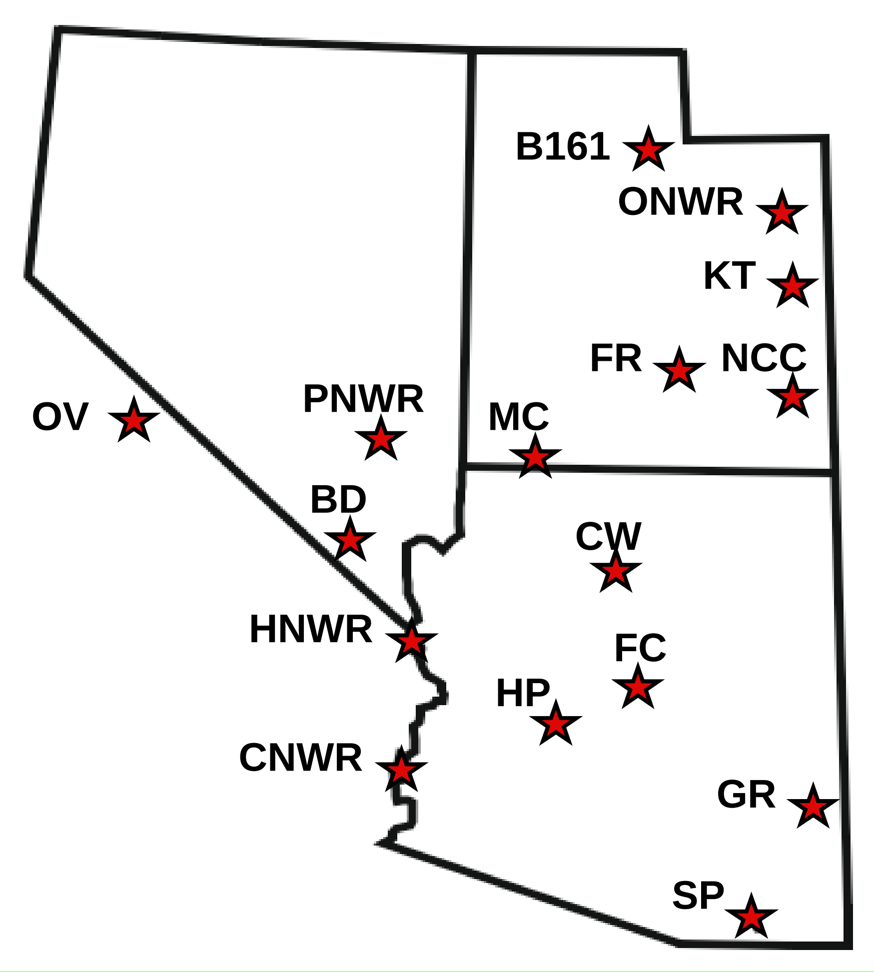
H_T = Total population diversity

Restoration and Landscape Level Experiments

- Key Partnerships
- Two restoration projects on the Lower Colorado River (LCR)
  - Cibola National Wildlife Refuge (CNWR)
  - Palo Verde Ecological Reserve (PVER)
- The goal of these projects is to combine riparian habitat restoration with scientific investigation

Collections: Cibola National Wildlife Refuge

- 16 different Fremont genotypes were collected from NV, AZ, UT, and CA
- Trees propagated at NAU greenhouses
- Experimental Question: What effect does tree genetic diversity have on community diversity?



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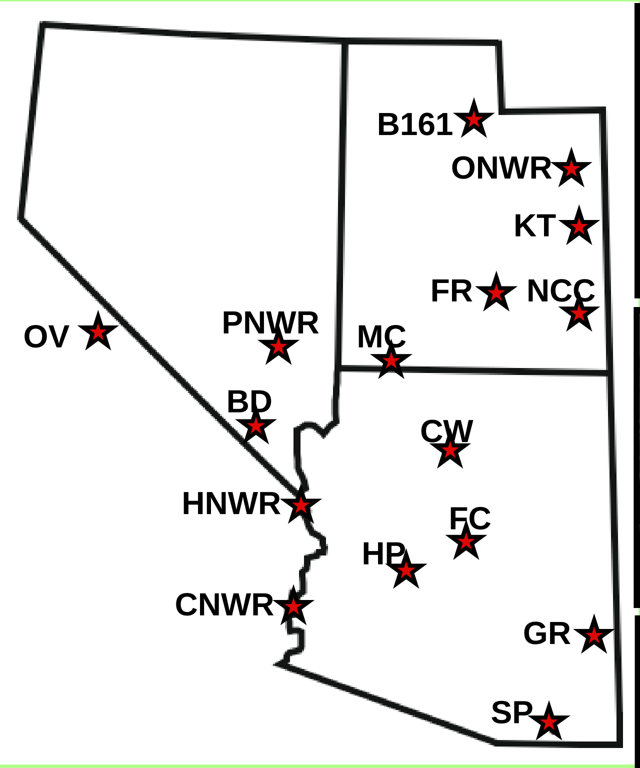

Planting at Cibola NWR

6,400 Fremont Cottonwoods were planted on 4m centers in March 2007 in an ag. land conversion at Cibola NWR where they are flood irrigated.

4 months later the trees are averaging 2 meters in height

Experimental Design : CNWR

- 16 different genotypes in pure and mixed stands of 16 trees each
  - Numbers represent different genotypes (e.g., genotype #8)
  - Letters represent different mixes of genotypes
    - **A** mix: **16** genotypes (1 tree/ea)
    - **B** mix: **8** genotypes (2 trees/ea)
    - **C** mix: **4** genotypes (4 trees/ea)
    - **D** mix: **2** genotypes (8 trees/ea)

8	2	15	**A**
12	**D**	9	16
B	6	4	10
3	1	**C**	5
14	13	7	11

1 Block = 20 stands x 20 reps = 6400 trees

Experimental Design : CNWR

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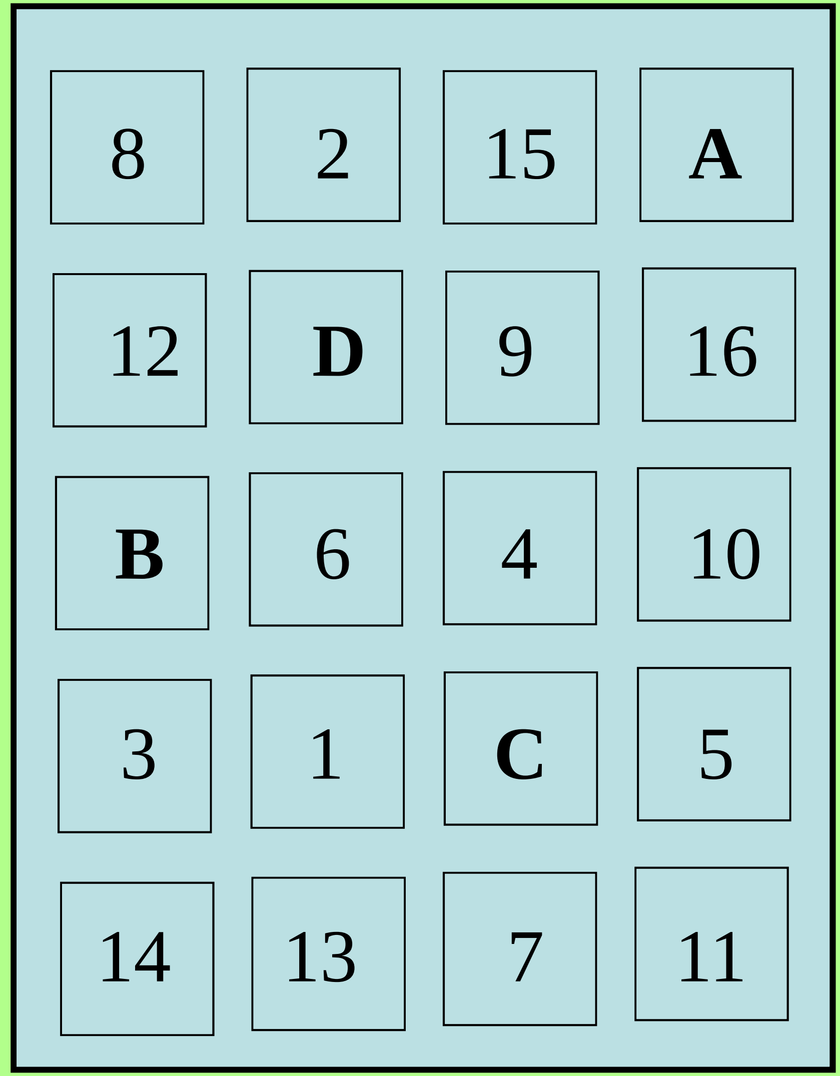
  - Letters represent different mixes of genotypes
    - **A** mix: 16 genotypes (1 tree/ea)
    - **B** mix: 8 genotypes (2 trees/ea)
    - **C** mix: 4 genotypes (4 trees/ea)
    - **D** mix: 2 genotypes (8 trees/ea)

Experimental Question: What effect does tree genetic diversity have on community diversity?



1 Block = 20 stands x 20 reps = 6400 trees

Research at Cibola NWR

7 years old

5 years old

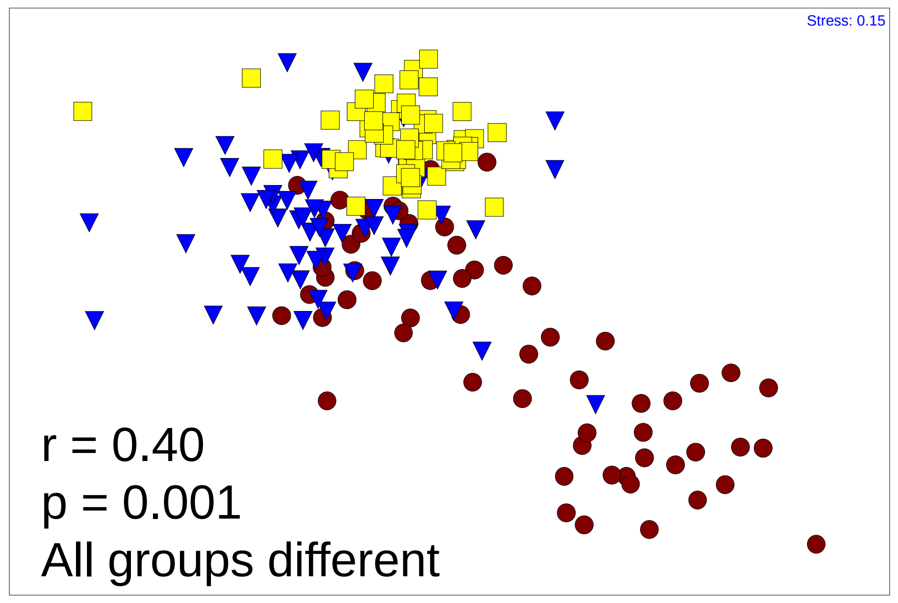
2 years old

Do different aged stands support different arthropod communities and increased biodiversity?

Laura Hagenauer
Ph.D. Student
Northern Arizona University

Research at Cibola NWR

7 years old ▼ | 5 years old ● | 2 years old ■

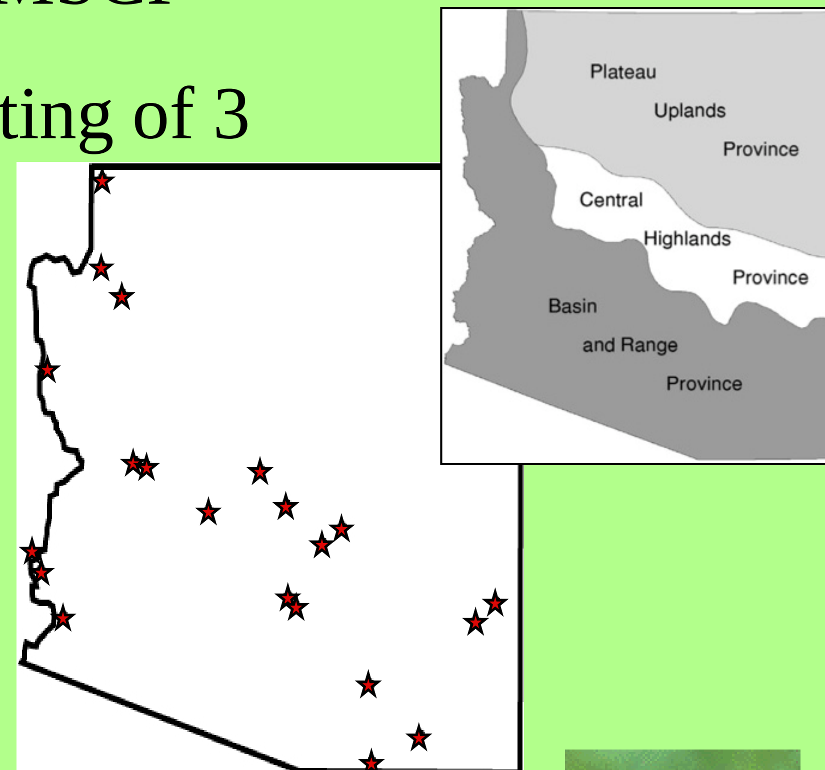


Different aged stands DO support different arthropod communities

Laura Hagenauer
Ph.D. Student
Northern Arizona University

Palo Verde Ecological Reserve

- Restoration of approximately 5, 940 acres of riparian habitat along the LCR: MSCP
- Collection, propagation and planting of 3 riparian species:
  - Fremont cottonwood, Goodding's willow, and Coyote willow
  - 20 collection locations
  - 10 genotypes/ species/ location
  - 200 genotypes/ species
  - 600 total genotypes



- Examine how differences in vegetation density and genetic diversity affect recovery of the southwestern willow flycatcher

Planting at PVER

16,896 individuals were planted on 2m centers in March 2007 in an ag. land conversion at PVER where they are flood irrigated.


March 2007


March 2007


May 2007 - 2 months


August 2007 - 5 months

Experimental Design: PVER

4	1	3	1	2	6
6	2	6	3	3	6
2	4	6	5	6	5
5	3	4	5	5	2
3	1	1	5	4	6
2	4	5	6	6	5
2	4	5	6	5	6
2	5	5	3	3	3
1	6	5	6	6	6
2	4	3	1	1	4
6	1	5	5	6	5

20 acre ag land conversion

66 blocks

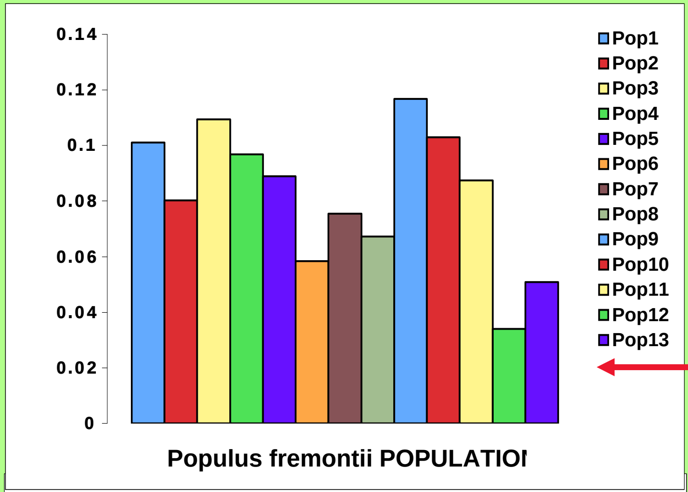
Different genotypes planted in different proportions

Treatment	Density Treatment Pf / Sg	Raw Numbers Pf / Sg / Se	Proportion Pf / Sg / Se
1	L / L	22/22/212	.087/.087/.83
2	H / L	43/22/189	.17/.087/.74
3	L / H	22/43/189	.087/.17/.74
4	H / H	43/43/169	.17/.17/.66
5	M / M	33/33/189	.13/.13/.74
6	M / M	33/33/189	.13/.13/.74

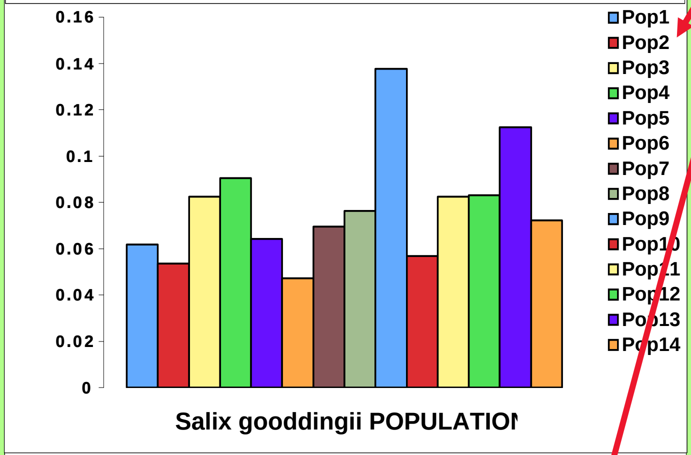
Pf = *Populus fremontii* **Sg** = *Salix gooddingii*

Se = *Salix exigua*

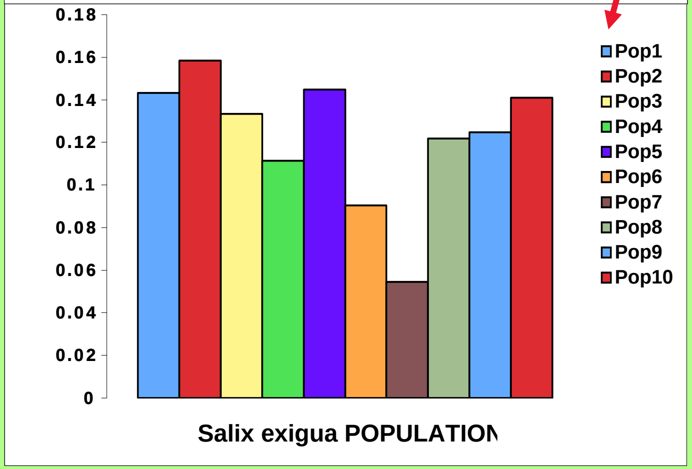
Using genetic diversity as a tool for restoration

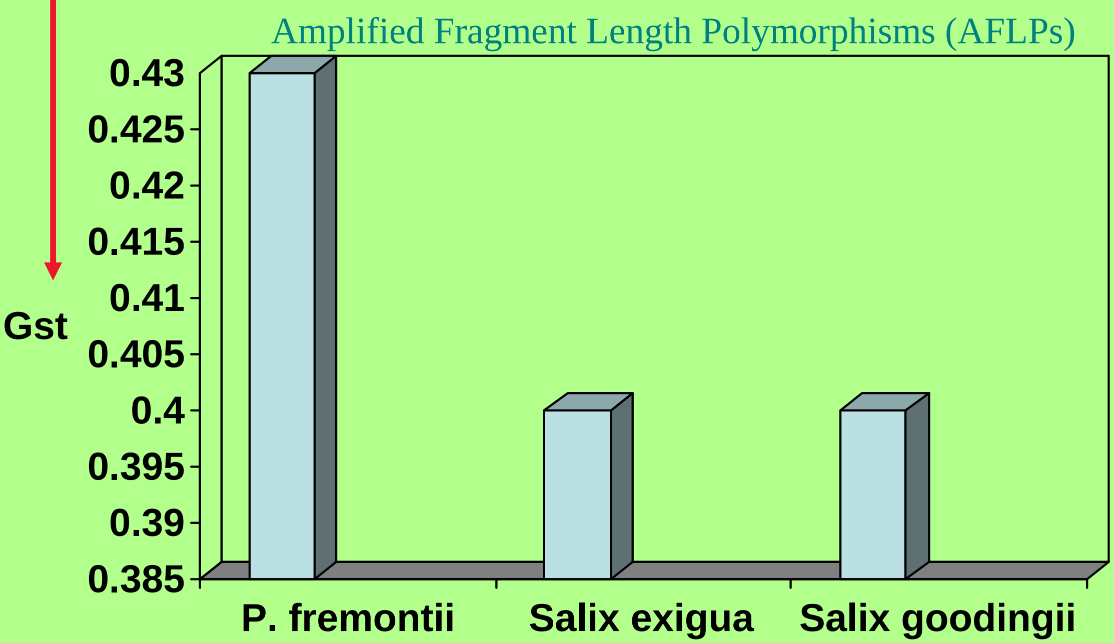


H_s : Within population diversity

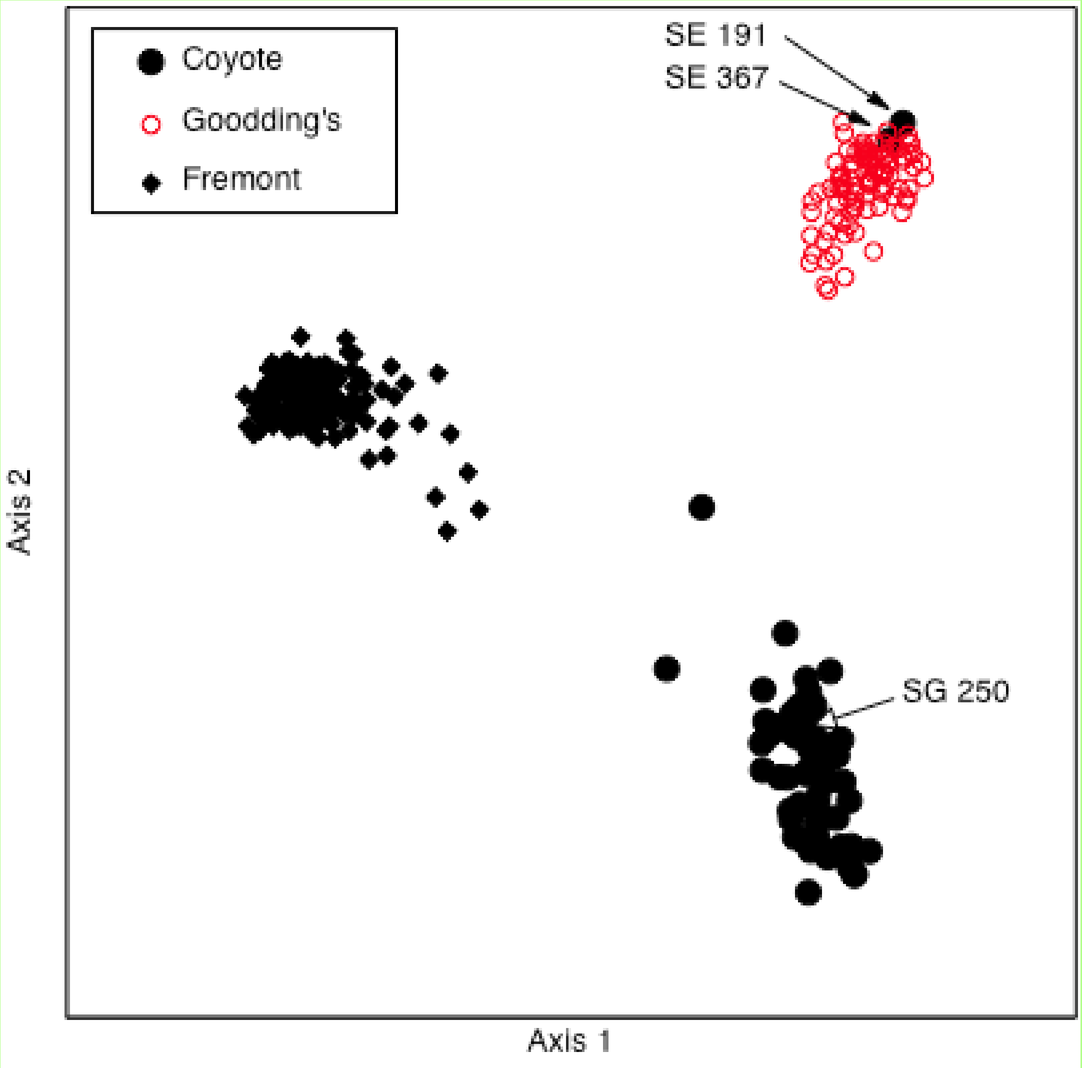


G_{ST}: Among population diversity





Genetic differentiation of 3 riparian species used in the PVER garden

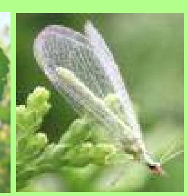


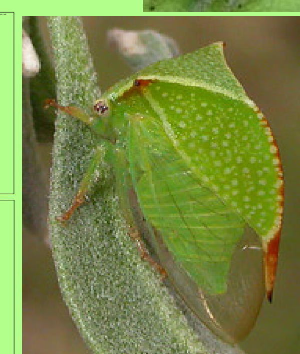
Mis-labeled samples are easily identified using the AFLP method

Arthropod Surveys at PVER

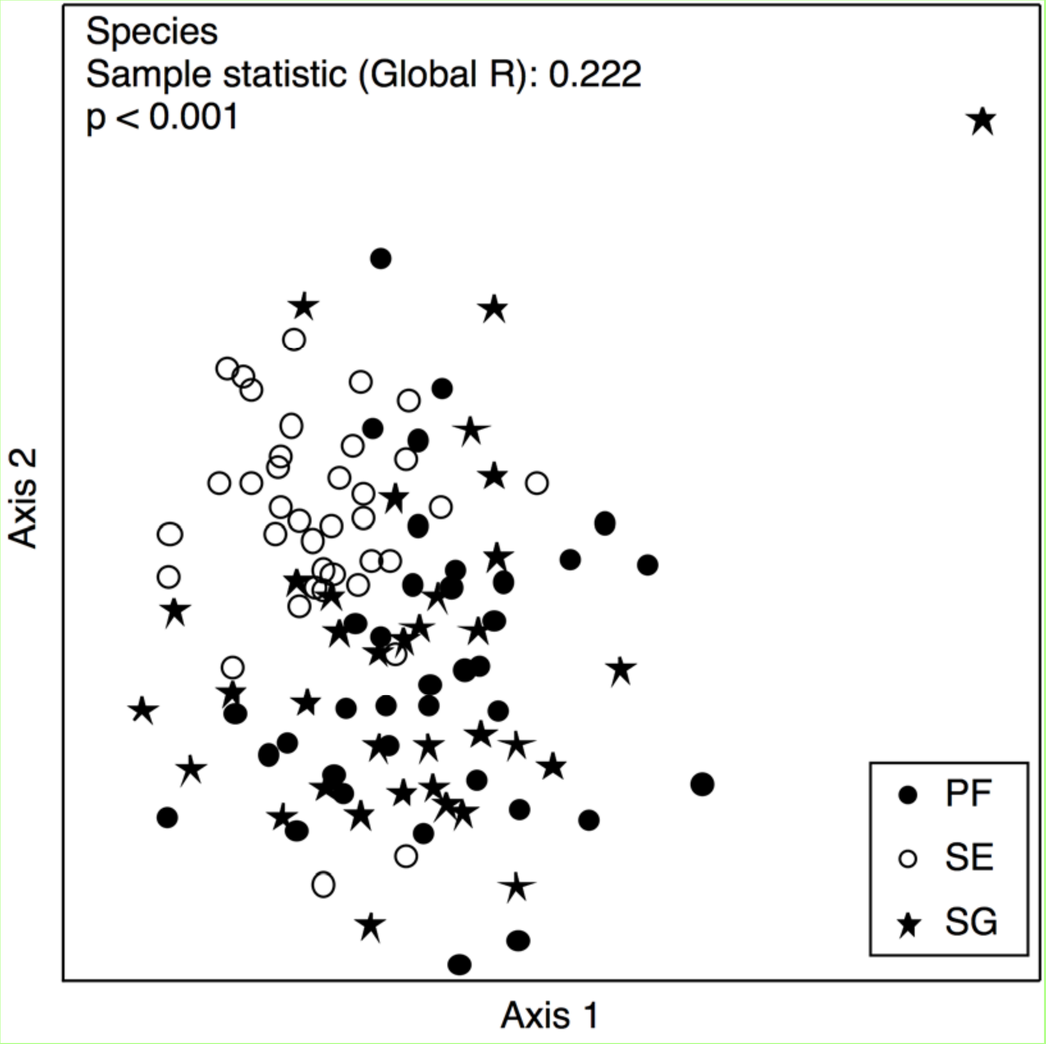
Timed Visual Census Sampling: Sampling the specific arthropods associated with individual genotypes of each of the three plant species in all density treatments.

Malaise Sampling: Sampling the general arthropod prey base available in each of the density treatments

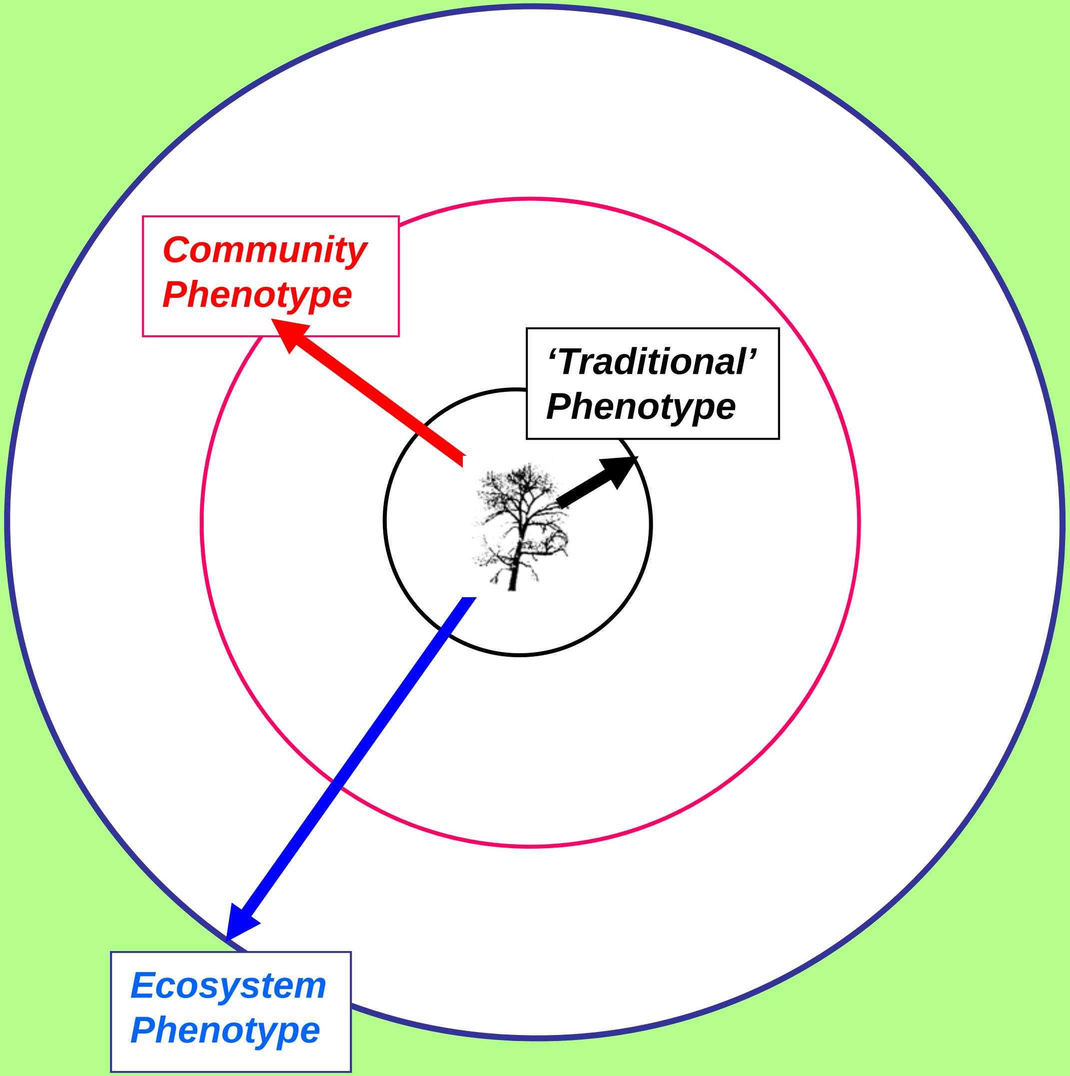




Arthropod communities are statistically different among plant species



Ecological Genetic Considerations for Riparian Habitat Restoration



1. Host **plant genetics** directly **influences** the structure and diversification of **ecological communities**.

2. Foundation tree species can have a profound **impact** on **dependent communities and ecosystem processes** (Whitham et al. 2006 Nature Reviews Genetics).

3. Genetic variation and its extended effects should be a **major consideration** when considering management strategies **for habitat restoration**


Science
meets
Restoration
NSF
NATIONAL
WILDLIFE
REFUGE
SYSTEM
RECLAMATION
Managing Water in the West

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