THE FORAGE AND RANGE RESEARCH LABORATORY

Forage and Range Research Laboratory

Is genetic change a factor in the consideration of local is best?

Jack E. Staub

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PLANTS FOR THE WEST

Our Mission

Provide an array of improved plant materials and management alternatives for sustainable stewardship of rangelands and pastures in the western U.S.

Products provide materials and best management practices for improved client productivity.

What are you going to hear?

- ✓**The mechanisms of genetic change**
  - **Why? Because they affect how we do business**
- ✓**An example of genetic change**
  - **Why? Change can be monitored to allow us to act**
- ✓**What makes populations change**
  - **Why? If we understand change, then we can act**
- ✓**Simulation of genetic change**
  - **Why? To allow us to see the consequences of actions**

Genetic Shift vs. Genetic Drift

Genetic Shift (Selection)

Can be an abrupt, major change in a population

[Black Death (1348-1350) and Influenza Pandemic (1918-1919)]

1) 30-60% Europe/450 M
2) 675,000 USA/20-40 M
3)

Genetic Drift (Random)

Ongoing, often subtle changes in a population

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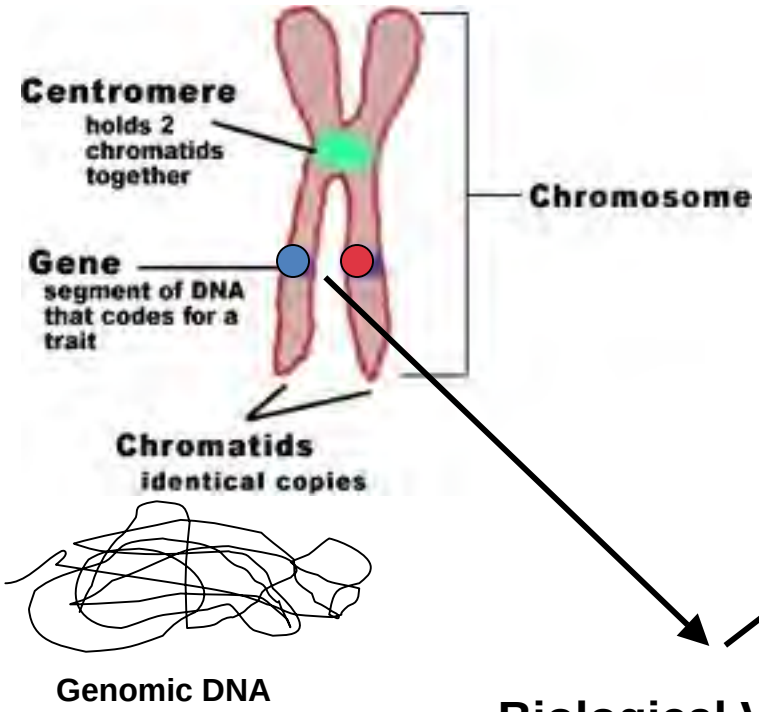
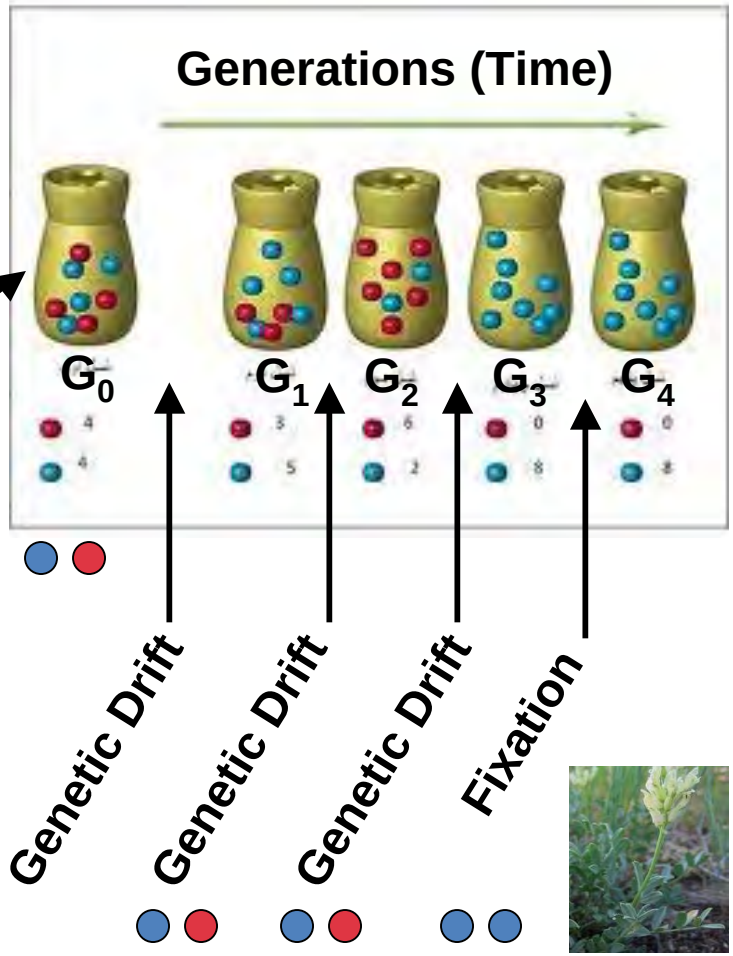
Utah Sweetvetch (*Hedysarum boreale*)

Simple Genetic Drift





Biological Variation

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Genetic Drift and Seed Production

Plant Collection

Seed Production

Seed Warehousing

Biological Variation

Plant Breeding

Planting

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Genetic Drift and Change: An Example

Known Sources of Drift

Plant Collection

Seed Production

Plant Breeding

Seed Warehousing

Planting

Bushman et al. 2009

Location ID	N
Orem Water Tank	20
Dry Fork	20
south of Payson, Utah Co.	20
San Rafael Swell	20
Rabbit Gulch Starvation	20
12 mile canyon above Mayfield.	20
Nine Mile Lower	20
Echo Reservoir	20
Cutoff	20
Willow Creek	20
Escalante	19
Antelope Butte	20
Collected in Jefferson Co. CO.	6
Wasatch Front, Rita Jo Anthony, Wild Seed Inc.	13
Collected July 2000, Alaska. Ssp. mackenziei	19
Moose Lake, Custer Co., ID	20
0.5 mi N of Provo Canyon mouth, E of Orem.	19
variety non-specified	19
Nine Mile Lower H. occidentalis	20
Joes Valley Dam 2 of 4 H. occidentalis	4
Joes Valley H. occidentalis	20

18 *boreale*

3 *occidentalis*

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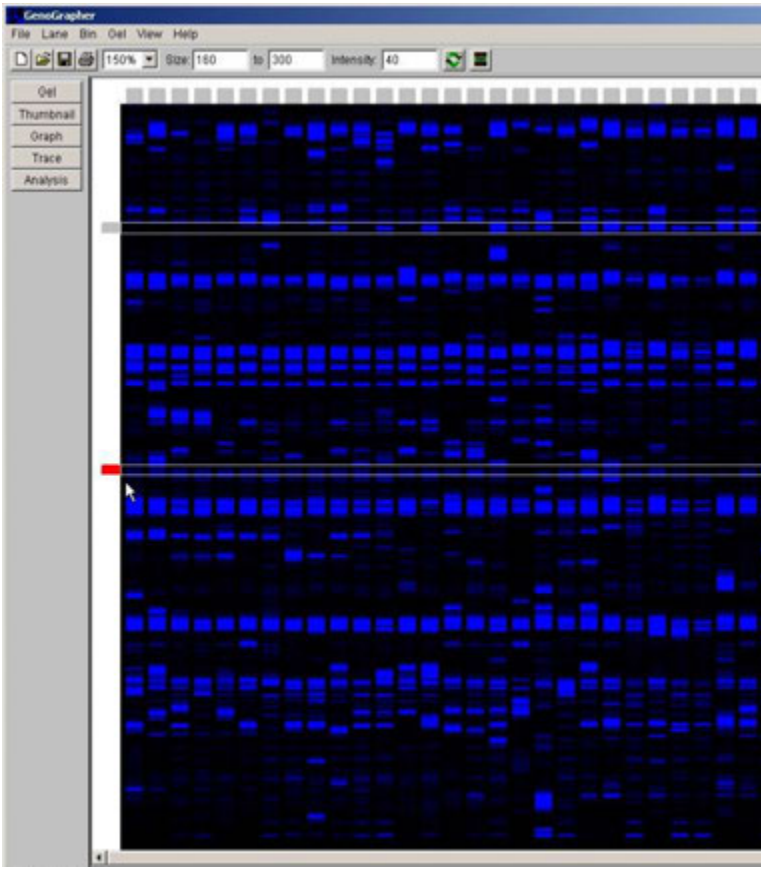
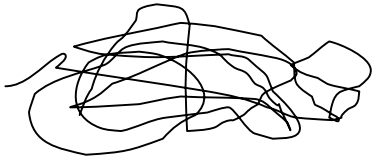
Genotyping of Collections

Biological Variation



Genomic DNA



AFLP data is recorded as the presence or absence of a band

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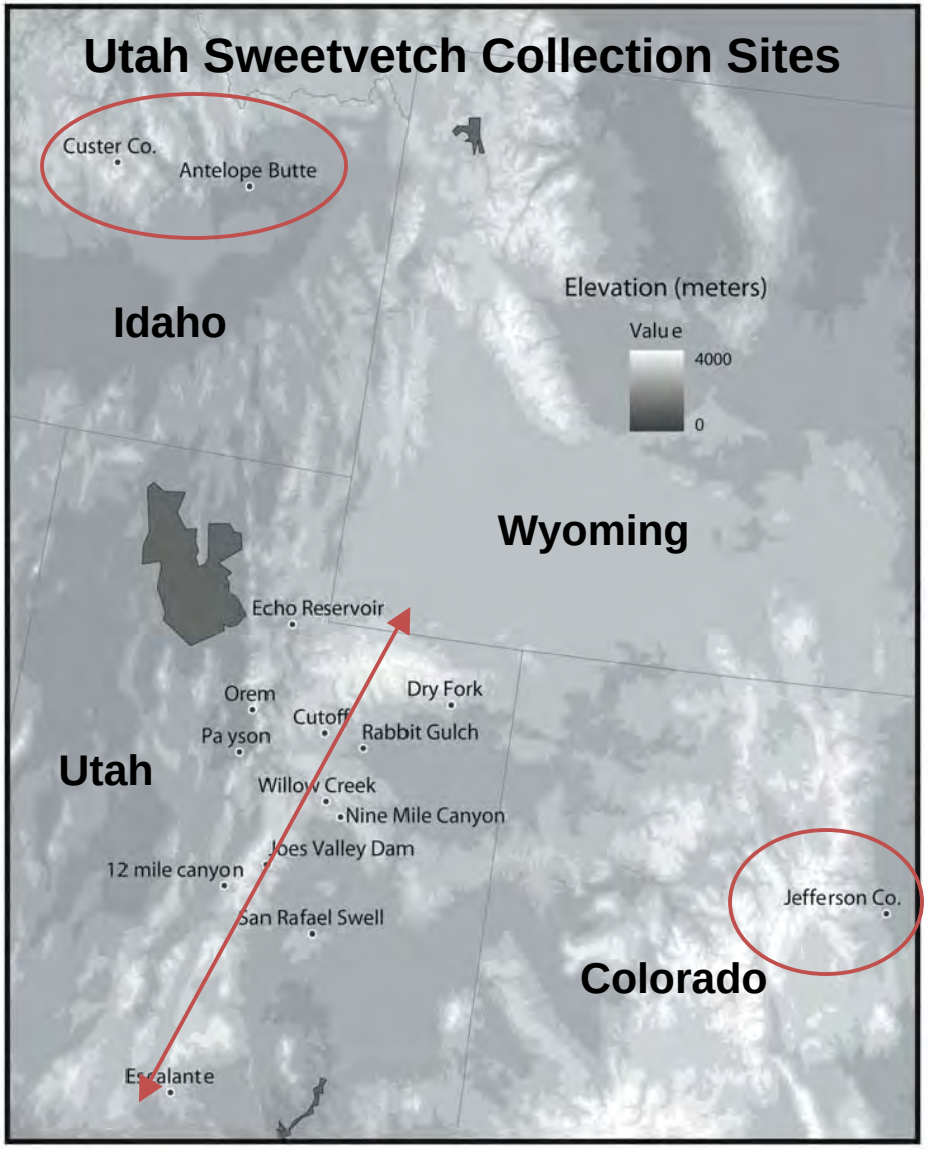
What can DNA bands tell you?

Total number of markers (bands available) = 1629

Location ID	N	Average Number of Bands / Population	Average Within-population similarity
Orem	20	387.00	0.825
Timpanogas	19	386.42	0.809
Dry Fork	20	381.70	0.789
Payson	20	374.90	0.839
San Rafael Swell	20	377.25	0.816
Rabbit Gulch	20	382.95	0.807
12 Mile Canyon	20	378.15	0.802
9 Mile Canyon	20	379.80	0.808
Echo Reservoir	20	386.95	0.819
Cutoff	20	378.85	0.791
Willow Creek	20	376.35	0.797
Escalante	18	374.67	0.838
Antelope Butte	19	360.58	0.871
Custer Co., ID	20	364.05	0.848
Jefferson Co., CO	6	362.67	0.828
Alaska	19	366.11	0.859
Wasatch Front	13	369.85	0.802
Variety not specified	19	374.89	0.814

Average number of bands per population = 375 (23% of total). Average within population similarity = 82%.



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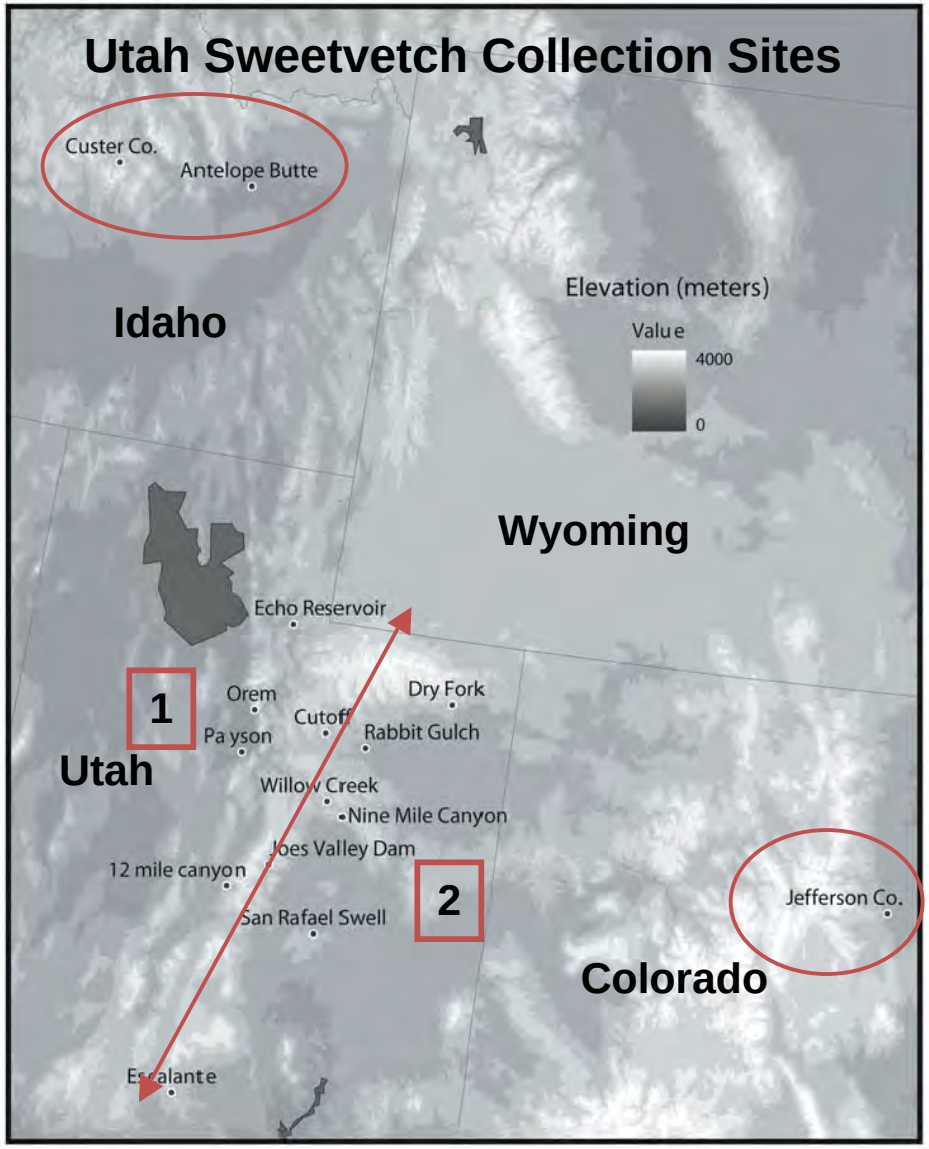
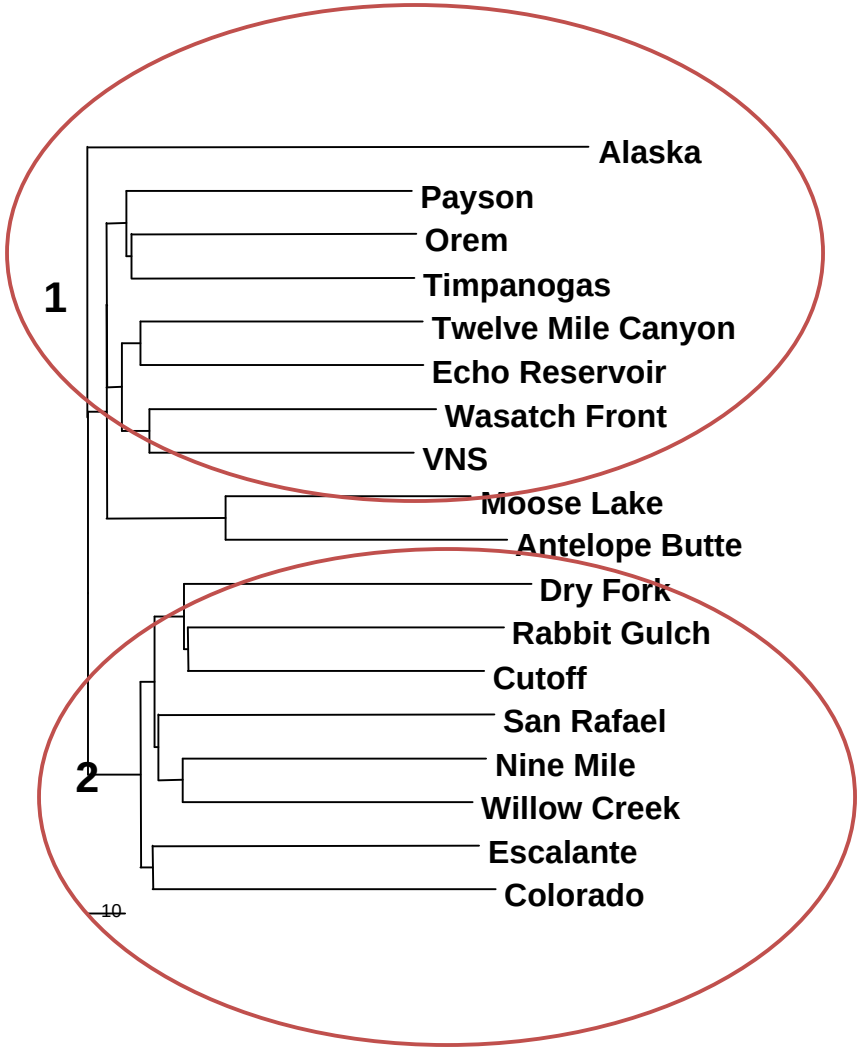
What can DNA bands tell you?





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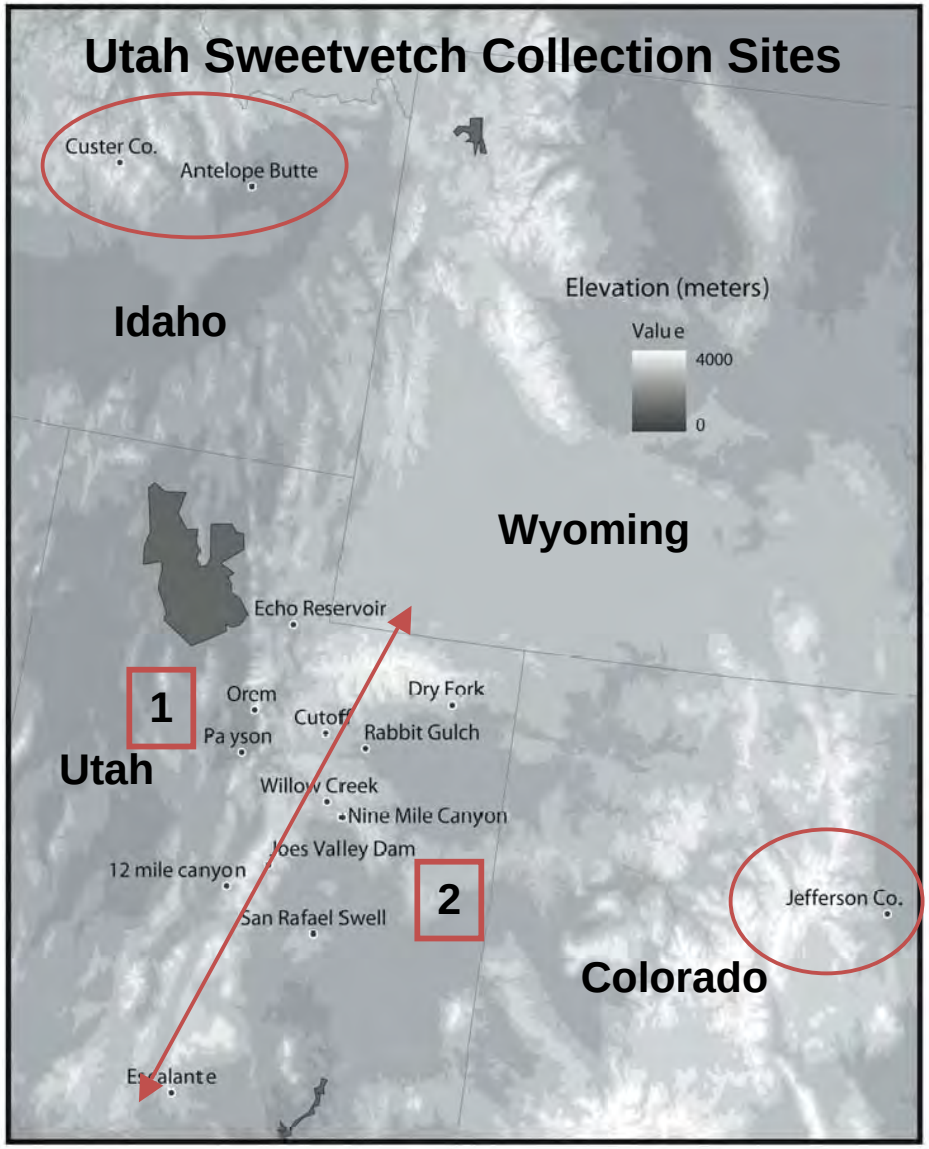
Genotype vs. Phenotype



Habitat is Important

Low Elevation & Water

High Elevation & Low Water

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What you see

		Average of Plant Height cm			Average of Vigor			Average of Seed Prduction		
		Mean	Standard Dev.	Range	Mean	Standard Dev.	Range	Mean	Standard Dev.	Range
Orem	1	42	13	8-68	3.7	1.2	1-5	1.6	1.2	0-5
12 mile canyon		40	11	15-59	3.4	1.1	1-6	2.1	1.6	0-5
Payson		42	9	19-58	4.0	1.1	1-5	1.8	1.4	0-5
T6"TIMP" T6		49	10	28-67	4.2	0.8	3-5	3.3	1.4	1-7
Echo Reservoir		39	10	22-59	4.0	0.8	2-5	2.3	1.2	0-4
Antelope Butte		44	12	25-73	3.5	1.1	2-5	2.5	1.1	1-4
San Rafael		52	14	18-75	3.0	1.1	1-5	1.5	0.8	0-3
Rabbit Gulch		42	9	17-55	3.3	0.7	2-4	0.8	0.6	0-2
Nine Mile Lower	2	34	8	20-51	2.8	0.9	1-4	1.1	1.0	0-3
Cutoff		37	8	21-53	3.1	0.8	2-4	0.9	0.8	0-3
Willow Creek		35	13	4-56	3.3	1.1	1-5	1.0	1.0	0-4
Dry Fork		44	10	23-68	4.3	1.5	1-6	2.8	1.8	0-5
Escalante		41	7	22-54	2.5	0.8	1-4	1.0	1.1	0-4
		Height in cm			**Subjective 1-5**			**Subjective 1-5**		

The ranges and standard deviations are large.

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What you see and don't see

How Many Genes ?

High Elevation & Low Water

How Many Genes ?

Few Genes Big Effects

Environmental Effects

Changes in Population Structure

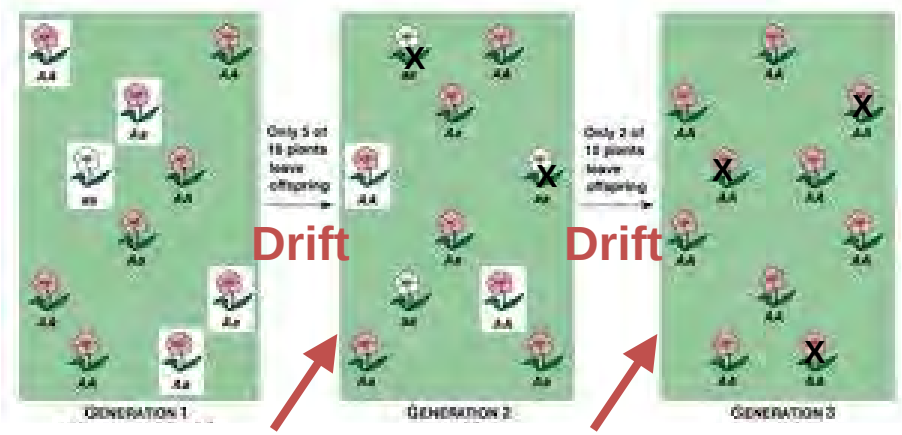
How do populations change?

Populations change due to fitness or genetic drift

- **Cause plant to plant variation**
- **Cause changes in genetic diversity**

Plants differ in fitness

- **Natural selection and Artificial selection**
  - **Environment + Genetics ---> Fitness ---> Change**



Selection for the fittest

Changes in Population Structure

How do populations change?

Selection causes changes in populations

Selection and drift act to change

Selection and drift can change what you see

Using a knowledge of populations and expected change, population change can be simulated (modeled)

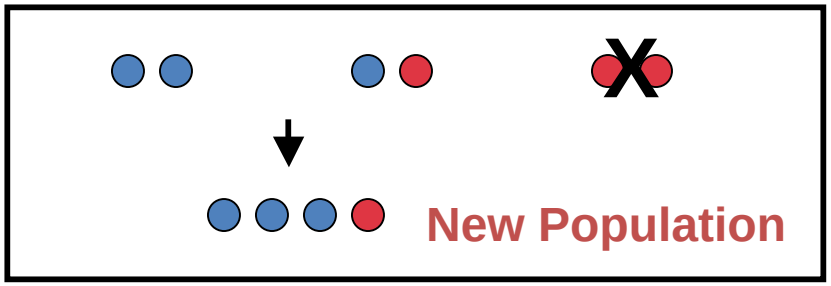
Simulations of genetic change

Factors involved with genetic change

Selection operates to change:

1) The rate of increase of a genotype

2) The probability of survival to reproductive age
3) The amount of off-spring produced
4) The rate of one genotype for another

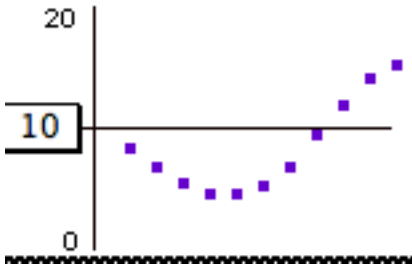


Simulation: Environmental Change

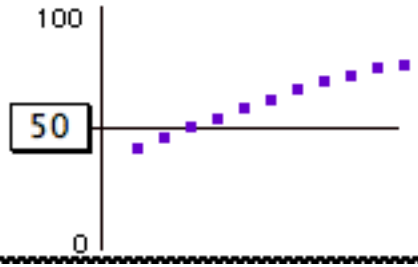
Genetic Drift and/or Selection

Case 1

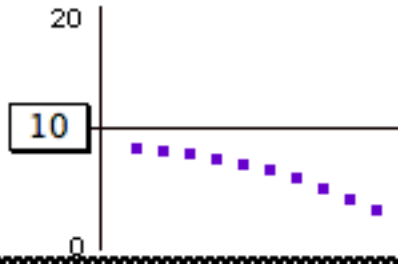
Population 1



Population 2



Population 3

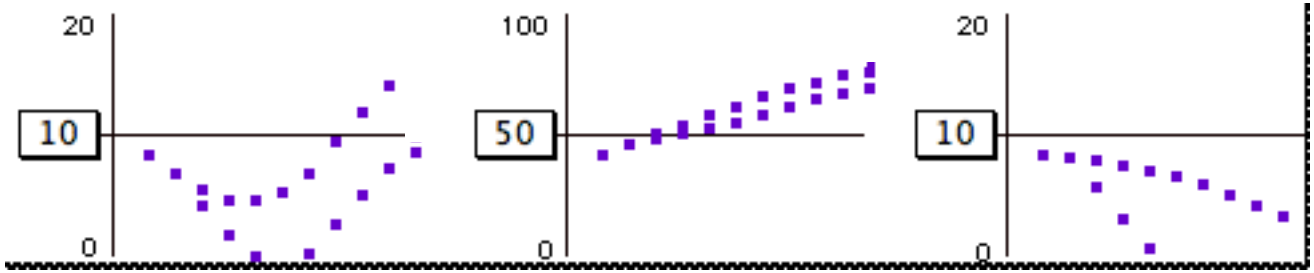


Individuals of a particular genotype fluctuate

Individuals of a particular genotype increase

Individuals of a particular genotype decrease

Case 2



Uniformly changing the probability of survival to a certain age in the early generations (5) and then allowing survival to be resumed at previous rate

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Conclusion:
Genetic drift and selection can cause changes

Plant Collection

Drift & Selection

Seed Production

Drift & Selection

Seed Warehousing

Drift & Selection

Biological Variation

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Planting