Identifying wild populations of **alkali bees** to support sustainable development of managed populations with genetic analysis

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Alfalfa Pollinator Research Initiative

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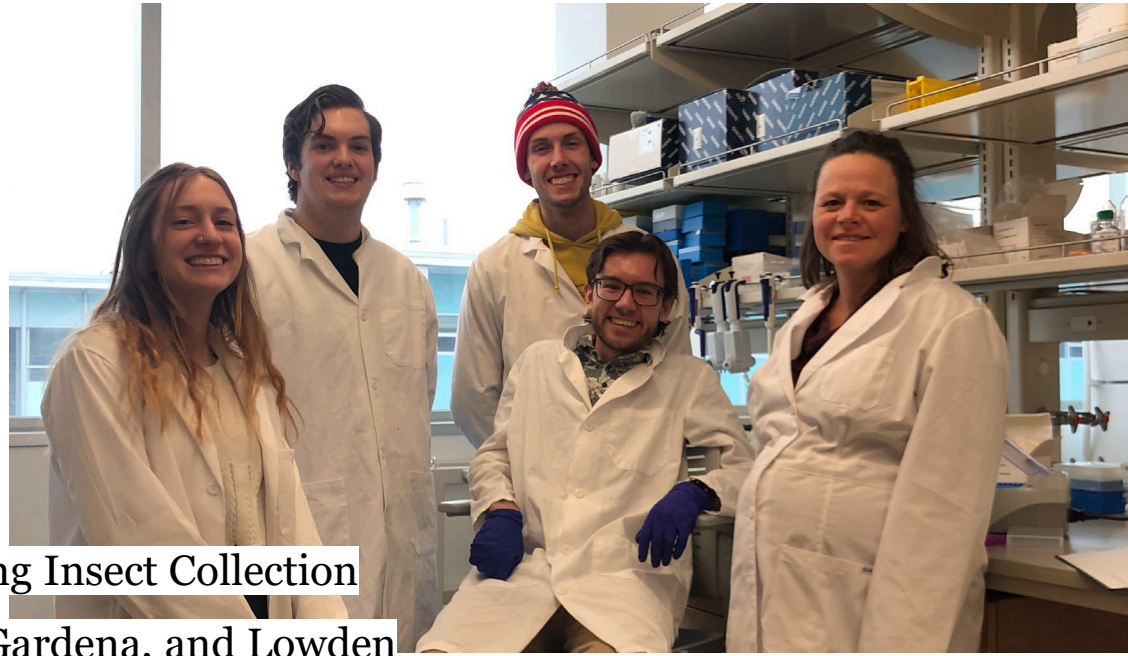
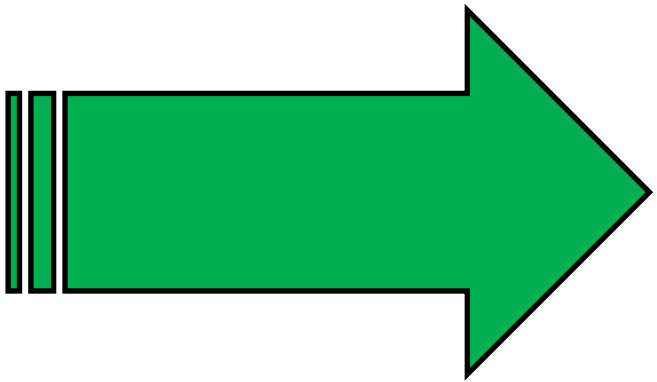
The alfalfa seed growers of Touchet, Gardena, and Lowden



High Genetic Diversity



Resilient to

- climate variability
- changes in market needs
- management practices
- husbandry practices
- parasites
- Pathogens
- Inbreeding

Eversweet Apiaries

Honeybee Breeds

Honeybees are usually selected for their positive traits which are passed down from the queen & the drones she mated with. There are pros & cons for each breeds' traits. These breeds are the most common in the United States.

TRAIT	AFRICAN	BUCKFAST	CARNIOLAN	CAUCASIAN	CORDOVAN	ITALIAN	RUSSIAN
CALM ON COMBS	1	10	8	10	7	5	5
DEFENSIVE BEHAVIOR	10	1	1	1	1	2	7
EARLY BUILD UP	10	8	10	6	5	8	10
FORAGES EARLY	5	10	10	1	5	5	10
HONEY COLLECTION	10	10	10	10	10	10	10
HONEY STORAGE	1	10	10	8	8	10	5
NOSEMA RESISTANT	10	5	6	1	5	5	5
POLLEN COLLECTION	5	5	10	5	5	5	5
PROPOLIS COLLECTION	5	5	2	10	5	5	5
TENDENCY TO SWARM	10	2	5	2	5	2	7
TRACHEAL MITE RESISTANT	8	10	8	3	5	5	9
VARROA RESISTANT	10	3	4	3	3	3	5
WINTERS WELL	1	10	10	10	5	10	10

1 = Low Tendency for Trait **10 = High Tendency for Trait**

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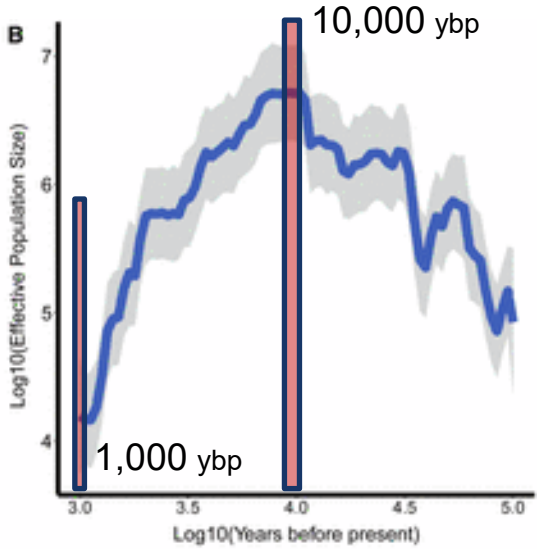
Alkali bees and genetic diversity: Previous work

- No genetic structure across bee beds; i.e., “panmictic” (Kapheim et al. 2019; n = 18 from two bee beds)
- Genetic diversity is “surprisingly low” (Kapheim et al. 2019)
- Genetic data suggests bee bed underwent recent and historic decline (10,000 years, hypothesis: Missoula Floods; Lake Lewis) (Kapheim et al. 2019)
- **But….What is the genetic diversity of a wild aggregation?**



Kapheim et al. 2019
APRI funded project

Research questions

1. **What is the genetic diversity of multiple bee beds?**

- Null Hypothesis: There is *no difference* in the genetic diversity between bee beds.
- Alternative Hypothesis: There is a *difference* in the genetic diversity between bee beds.

2. **How does bee bed genetic diversity compare to a wild population?**

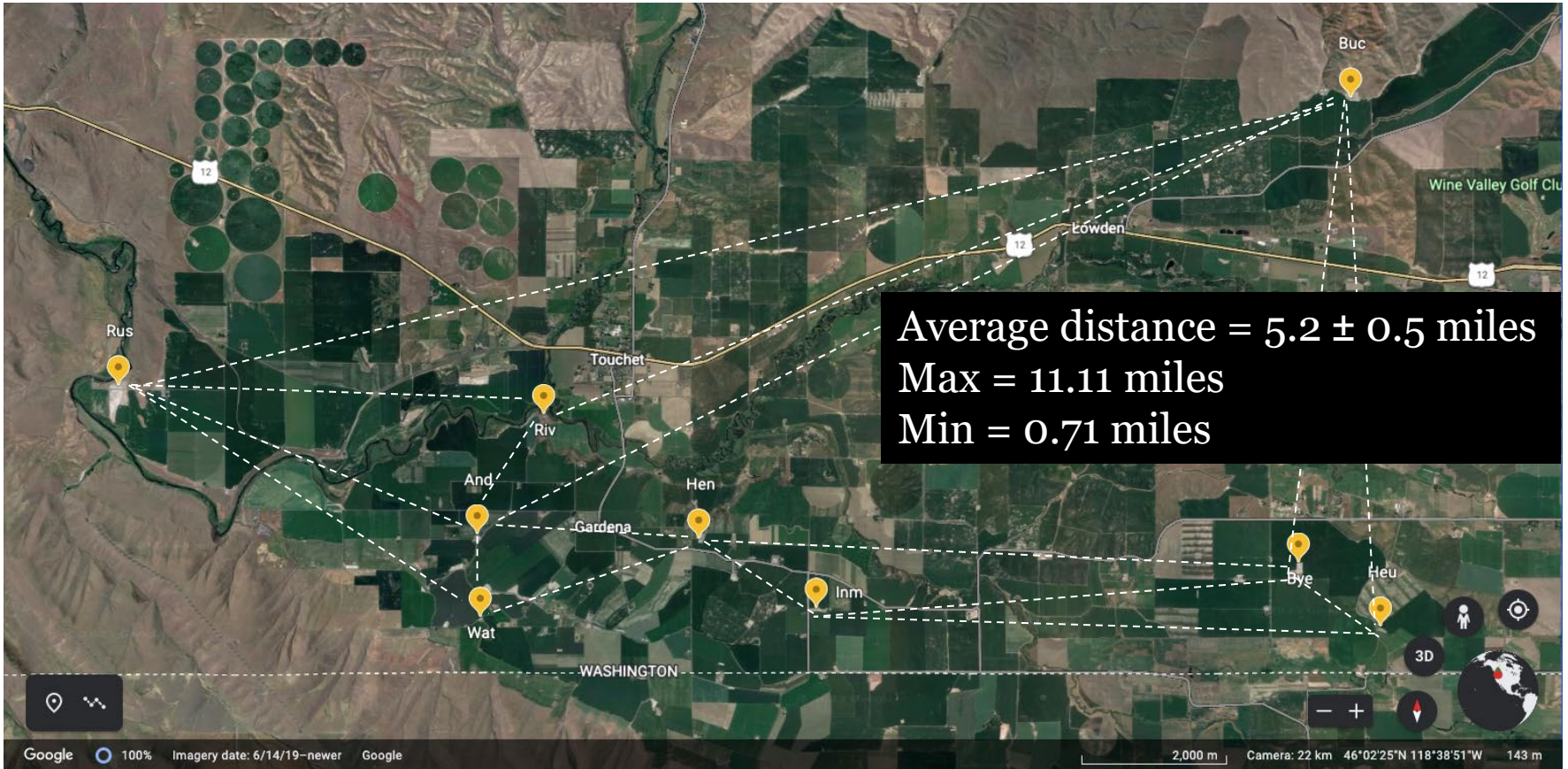
- Null Hypothesis: There is *no difference* in the genetic diversity between the bee beds and a wild population.
- Alternative Hypothesis: There is a *difference* in the genetic diversity between the bee beds and a wild population.

Methods: Field sampling

1. 9 bee beds were selected in collaboration with growers from the Touchet/Gardena/Lowden area (TGL)
   *Kapheim et al. (2019) sampled 18 bees across 2 bee beds
2. Sampling took place in July 2022

Photo by Dr. Kelsey Graham

Field sampling: Touchet, Gardena, Lowden (TGL)



Field sampling

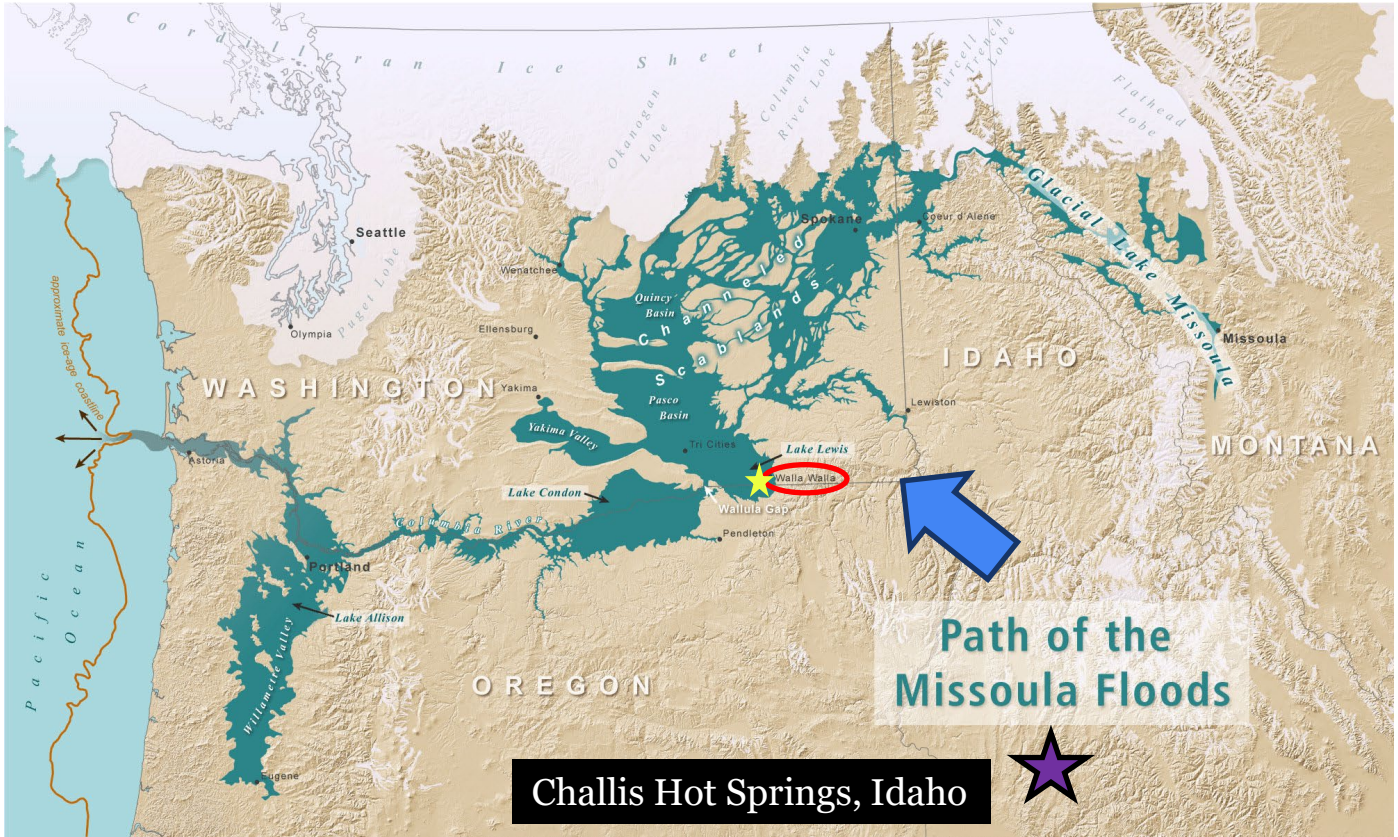
Bee Bed	# of bees	Sex
Riverside	36	M & F
Russel	45	M & F
Heusby	27	F
Byerley	30	F
Henry Garbe	33	F
Buckley	35	F
Watson	33	F
Anderson	35	F
Inman	35	F

N = 309 bees (inc. Challis, ID)

Photo by Dr. Kelsey Graham

Wild population: Challis Hot Springs, IDAHO

Formation of Lake Lewis (21,000 to 16,000 ybp)



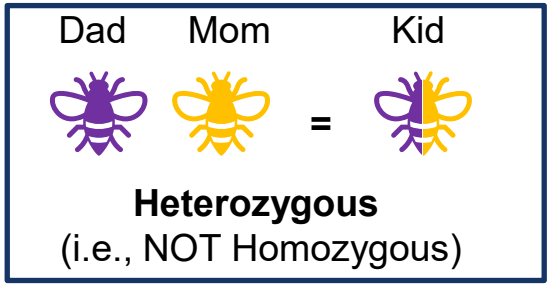
Methods: Genome sequencing

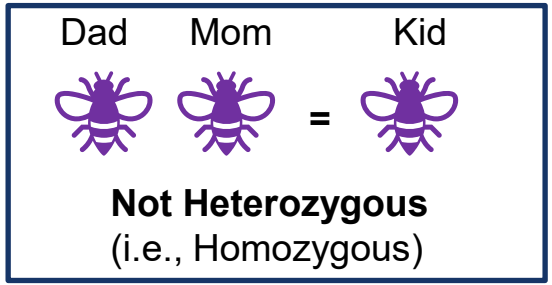
- Sample: 85 bees across 4 bee beds and 1 wild population
- Sequenced thousands of genetic loci across the genomes of each bee with a method called “ddRAD” (Peterson et al. 2012)
- Aligned the genetic loci to the genome generated by Kapheim et al. (2019) with bioinformatics tools
- Calculated 4 genetic diversity metrics with the genetic loci

- Final count of high-quality loci (SNPs) = 1,552

Methods: Genetic diversity metrics

1. Heterozygosity (H_e)
    - *Inbreeding*

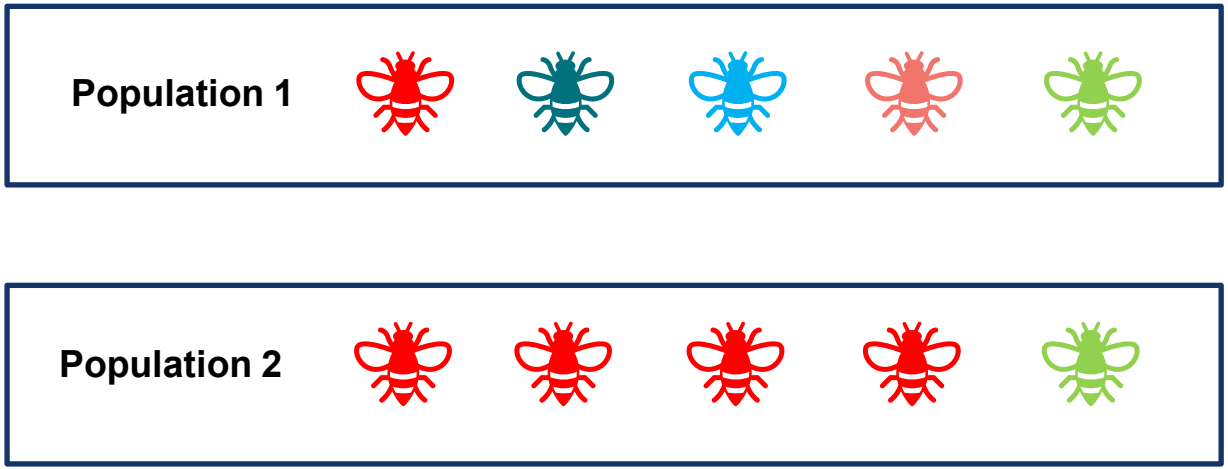




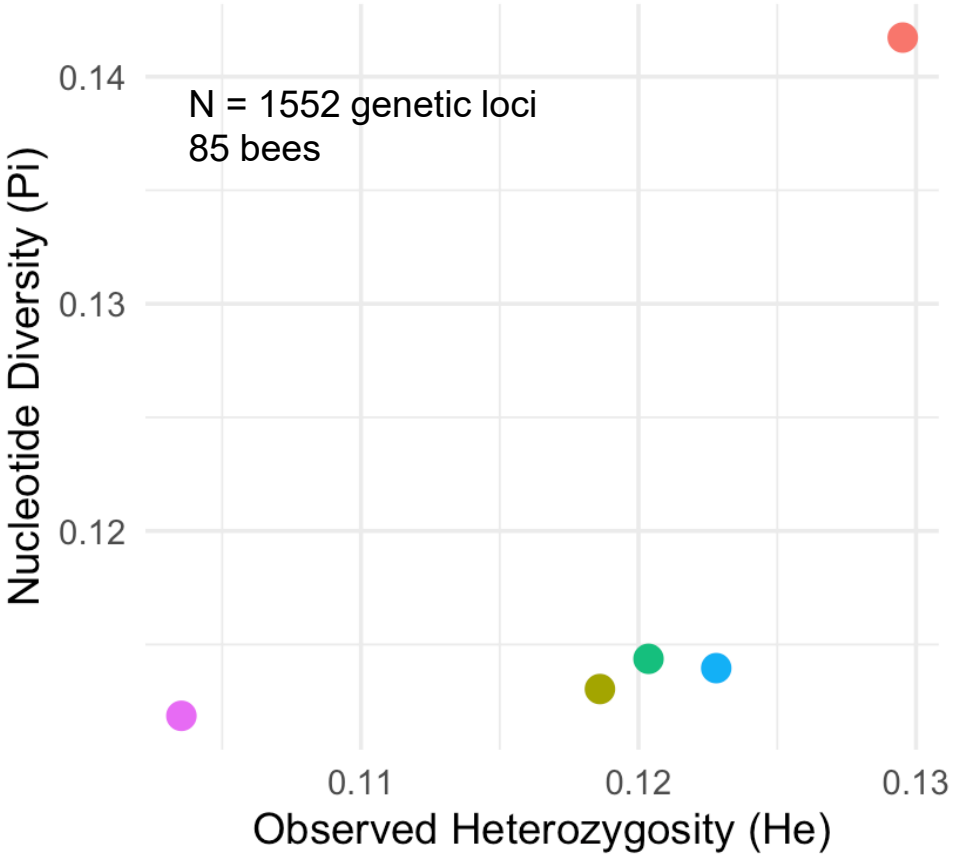
Consequences of Inbreeding in Humans: The "Habsburg jaw", a facial condition that afflicted European kings and queens, was well known. Facial dysmorphism was due to inbreeding (Vilas et al. 2019)

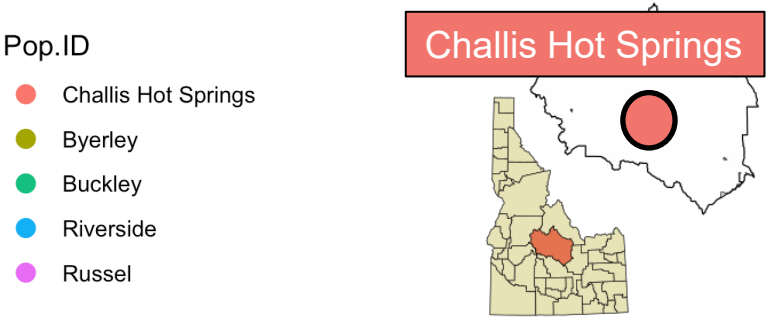
Methods: Genetic diversity metrics

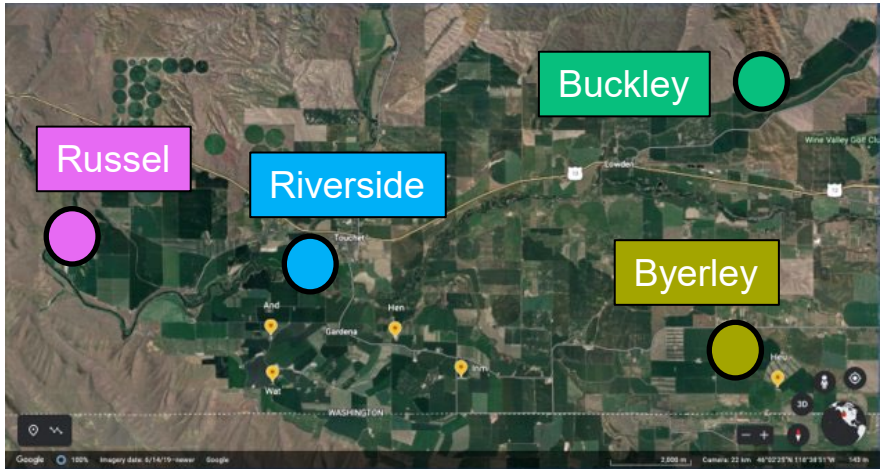
2. *Pi* (Nucleotide Diversity)
    - *Population genetic diversity*



Result: H_e vs *Pi*

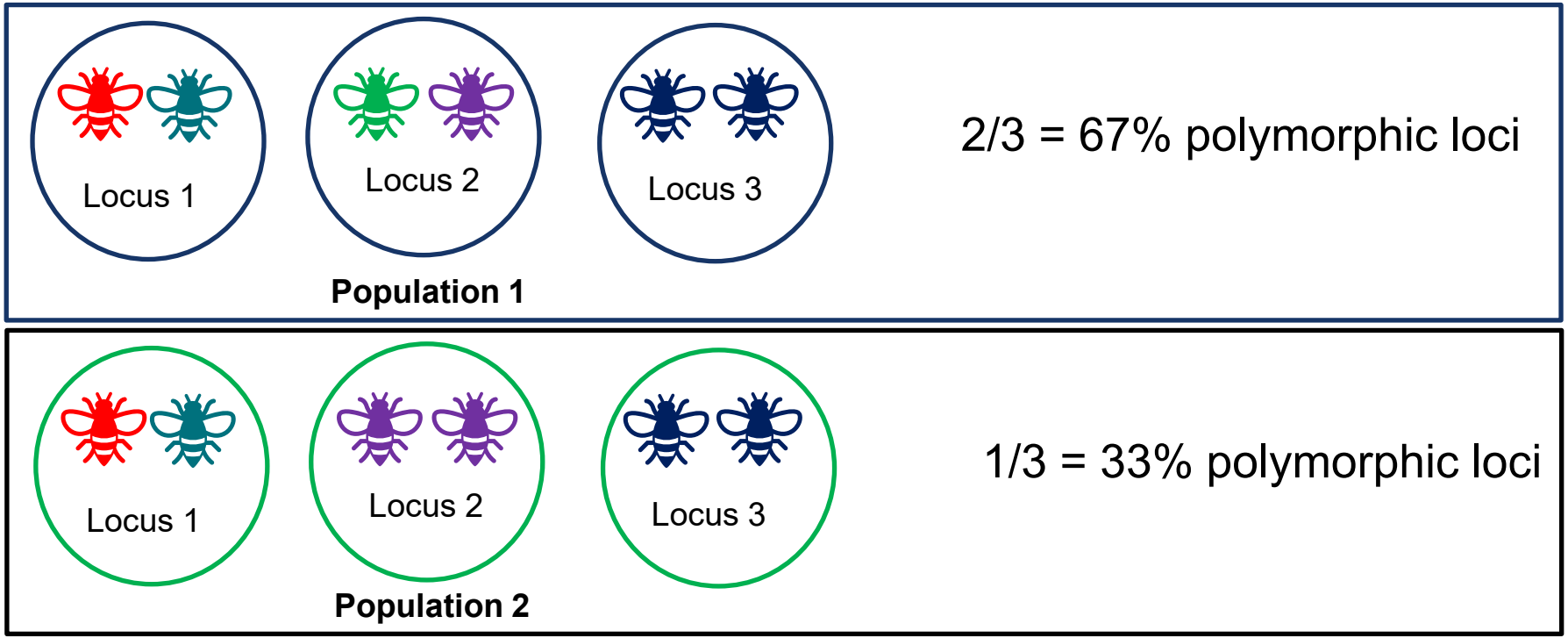






Methods: Genetic diversity metrics studied

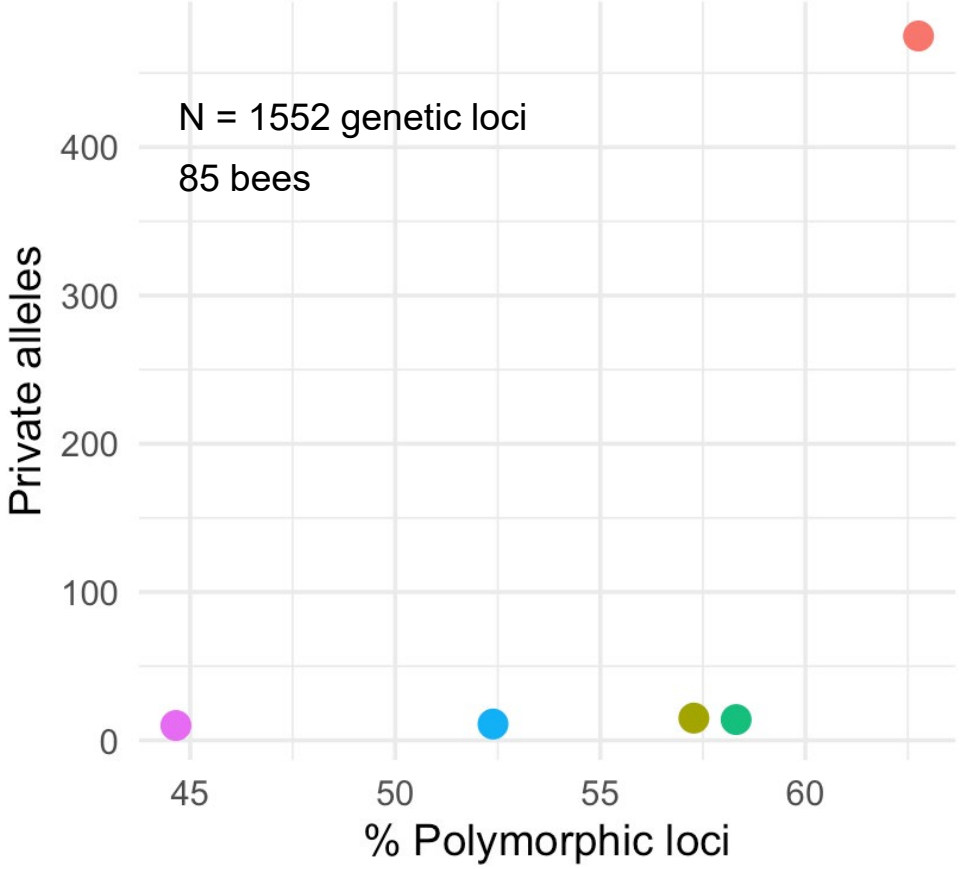
3. % Polymorphic loci

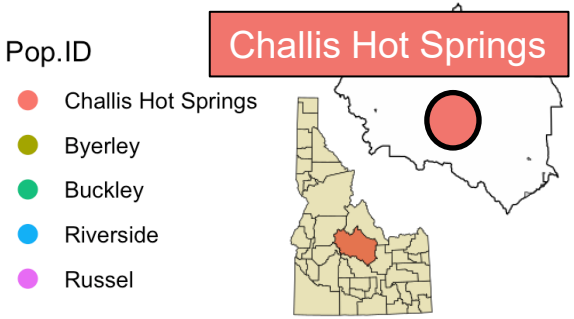


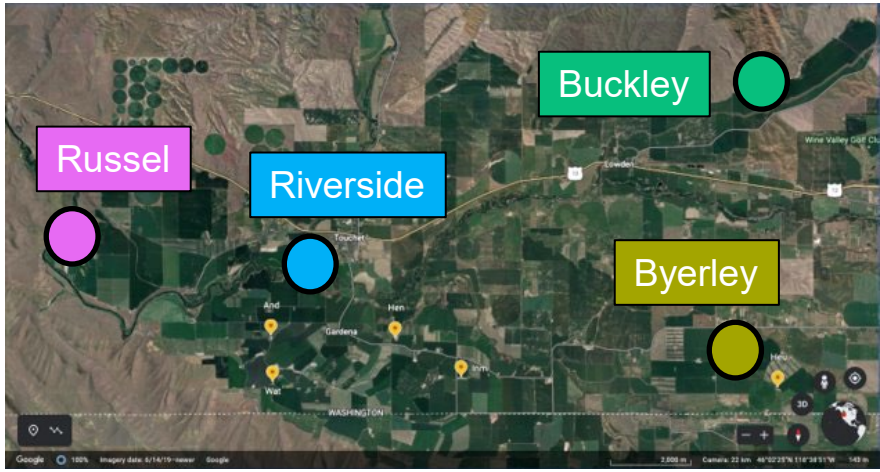
Method: Genetic diversity metrics studied

4. Private alleles
    - *Genetic diversity unique to a population*

Private alleles vs % polymorphic loci

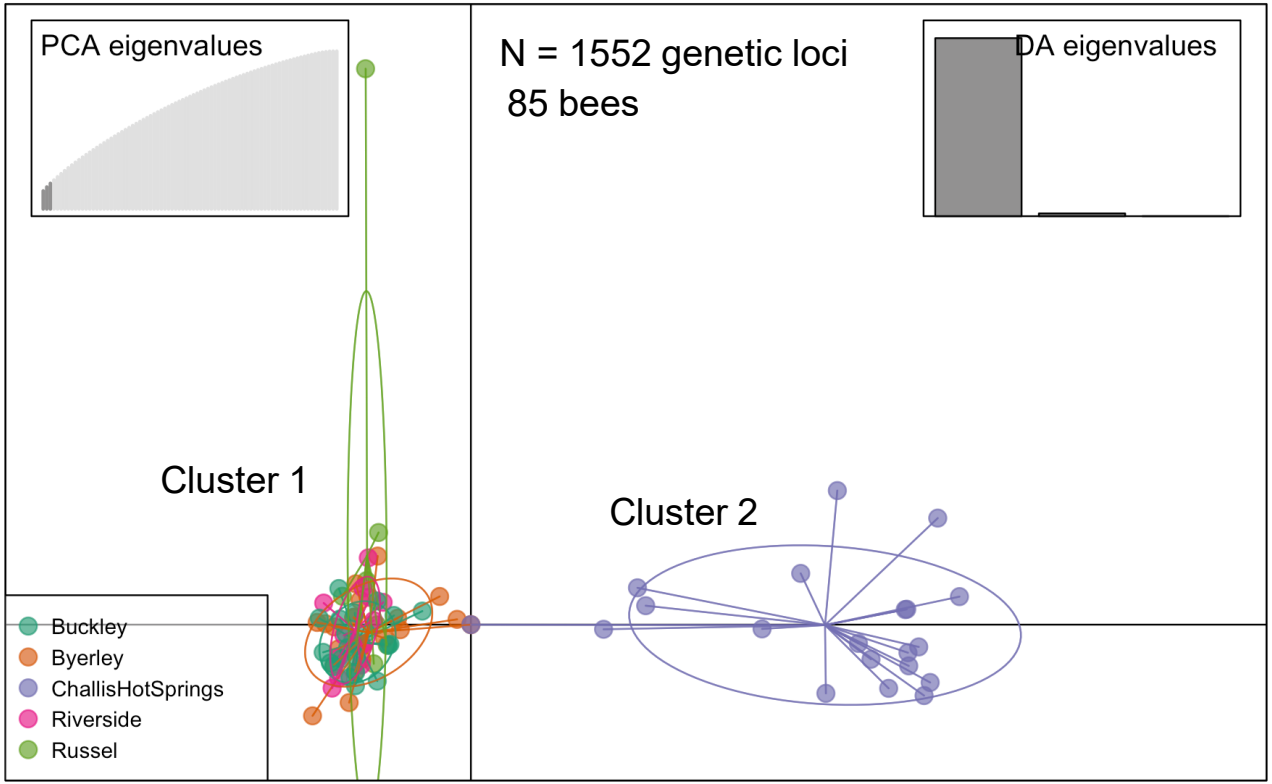






236 miles away from TGL

Population genetic structure (dAPC)



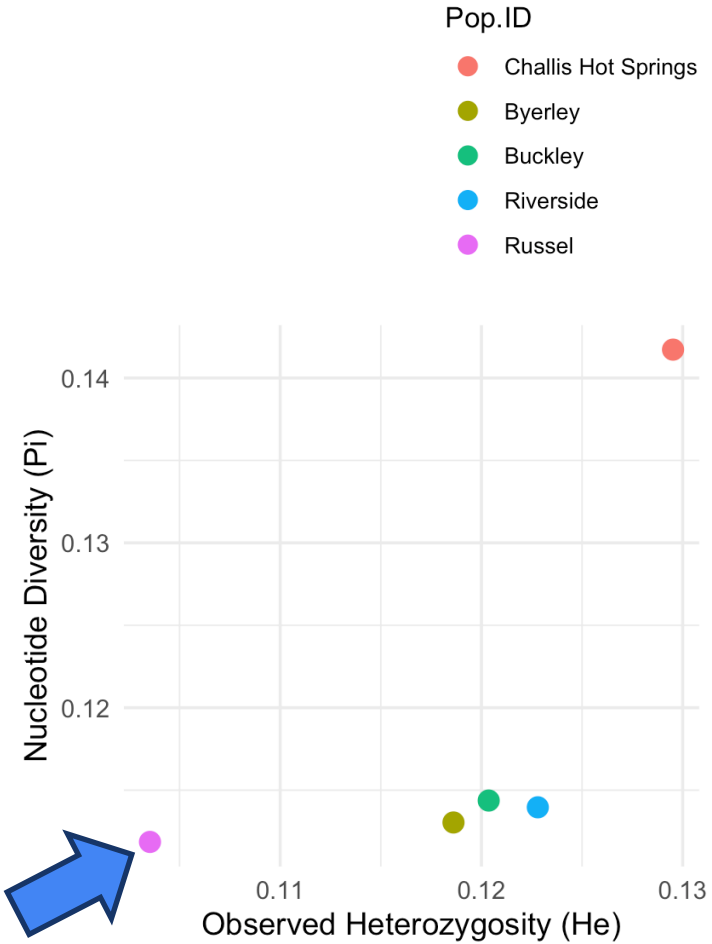
Pairwise F_{ST} (Population differentiation)

	Russel	Byerley	Riverside	Buckley	Challis HS
Russel	0				
Byerley	0.0031	0			
Riverside	0.0033	0.0003	0		
Buckley	0.0038	0.0012	0.0003	0	
Challis HS	0.1332	0.1371	0.1369	0.1367	0

Conclusion: Research Questions

1. **What is the genetic diversity of multiple bee beds?**

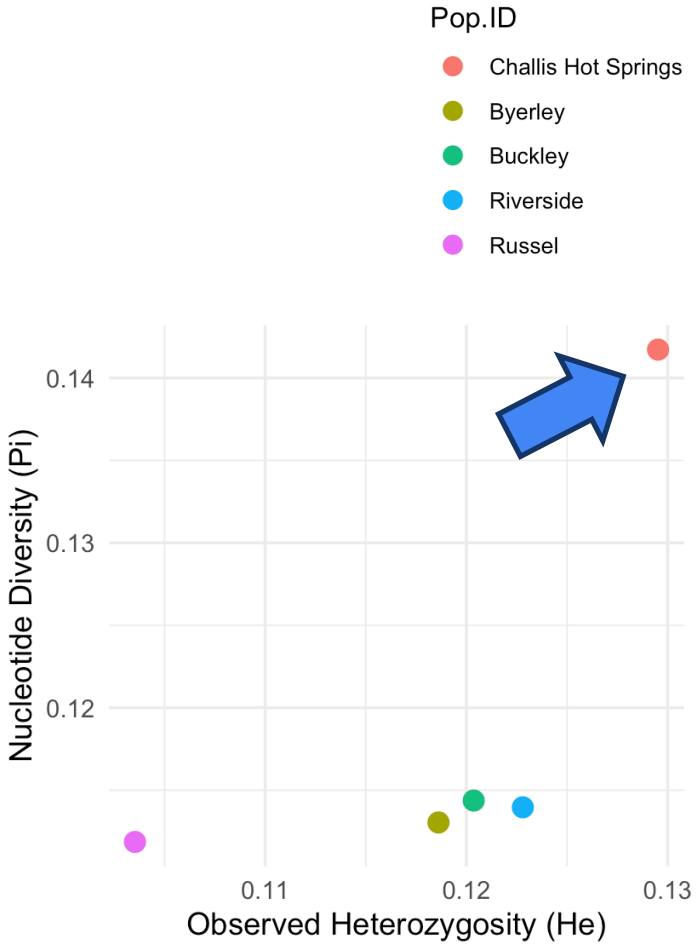
- **Null Hypothesis: There is *no difference* in the genetic diversity between bee beds. BUT what about Russel?**
- Alternative Hypothesis: There is a *difference* in the genetic diversity between bee beds.



Conclusion: Research Questions

2. How does bee bed genetic diversity compare to a wild population (aggregation)?

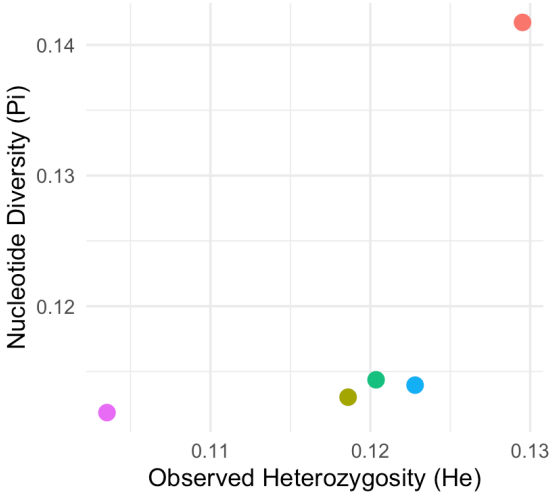
- Null Hypothesis: There is *no difference* in the genetic diversity between bee beds and a wild population.
- **Alternative Hypothesis: There is a *difference* in the genetic diversity between bee beds and a wild population.**

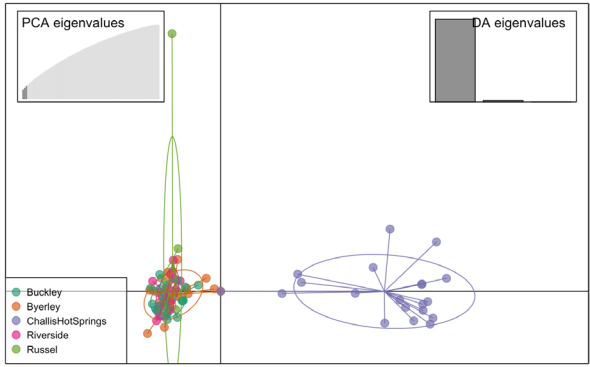


Take home message

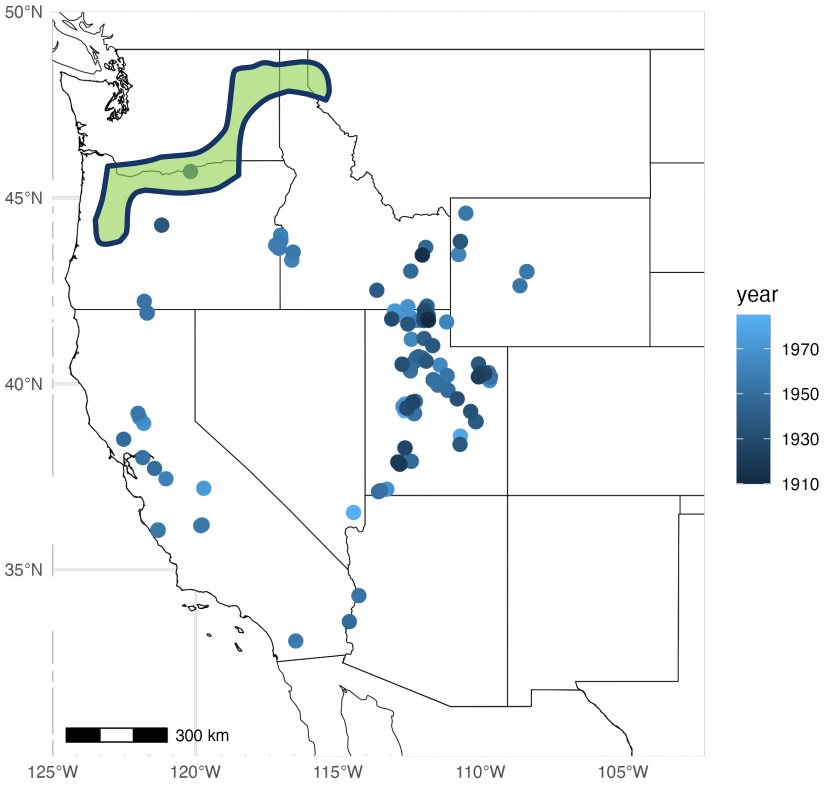
1. Genetic diversity of 4 bee beds studied are exceptionally low
2. Collective genetic diversity of the Challis Hot Springs population higher than managed bee beds
3. Individual genetic diversity in the Challis Hot Springs greater than managed bee beds
4. Genetic diversity associated with the Russel bee bed may be exceptionally different than others

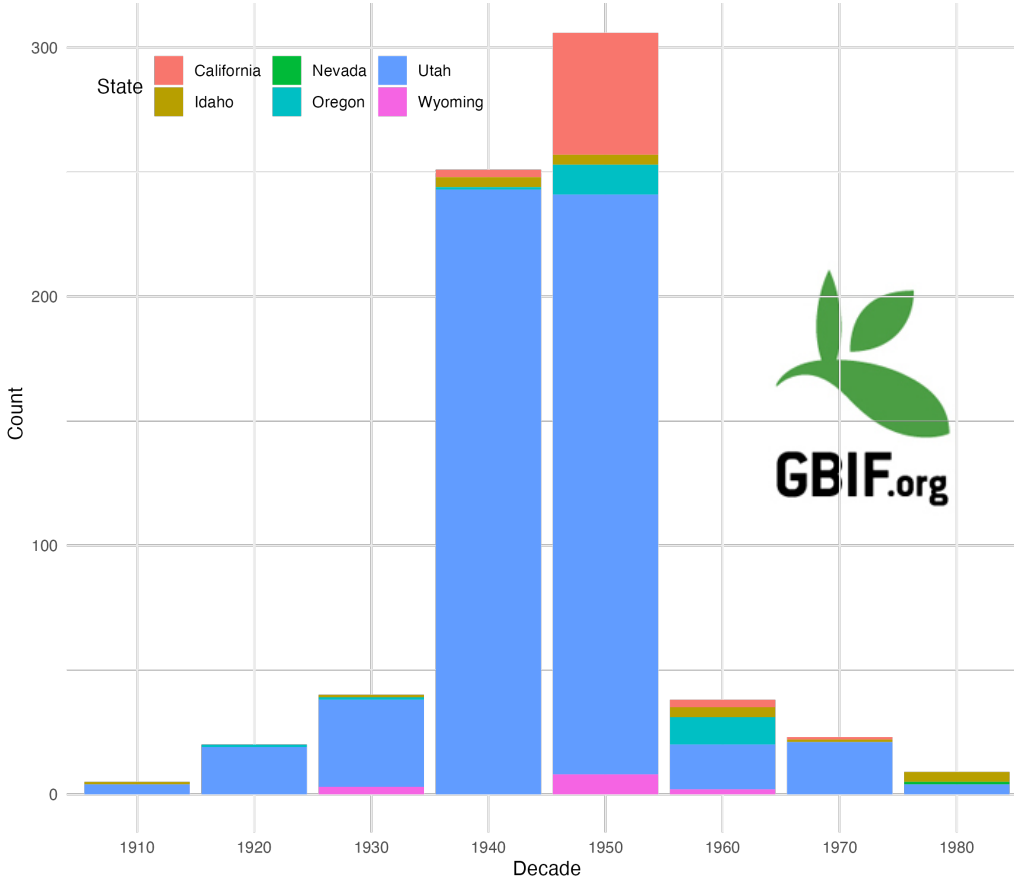
Augment bee bed genetics with wild genetics?



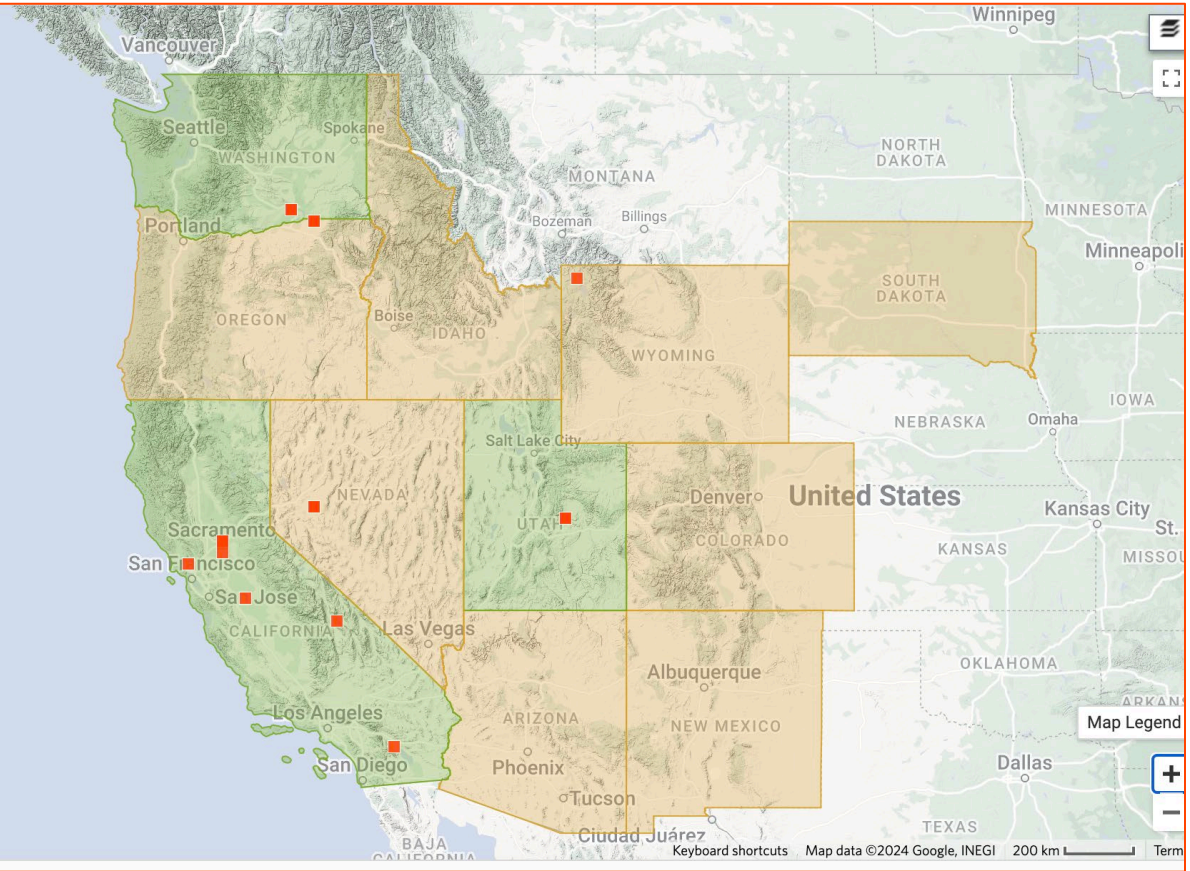


Next steps: Genetic diversity of other wild alkali bee populations?





Contemporary observations of the alkali bee



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Thank you!

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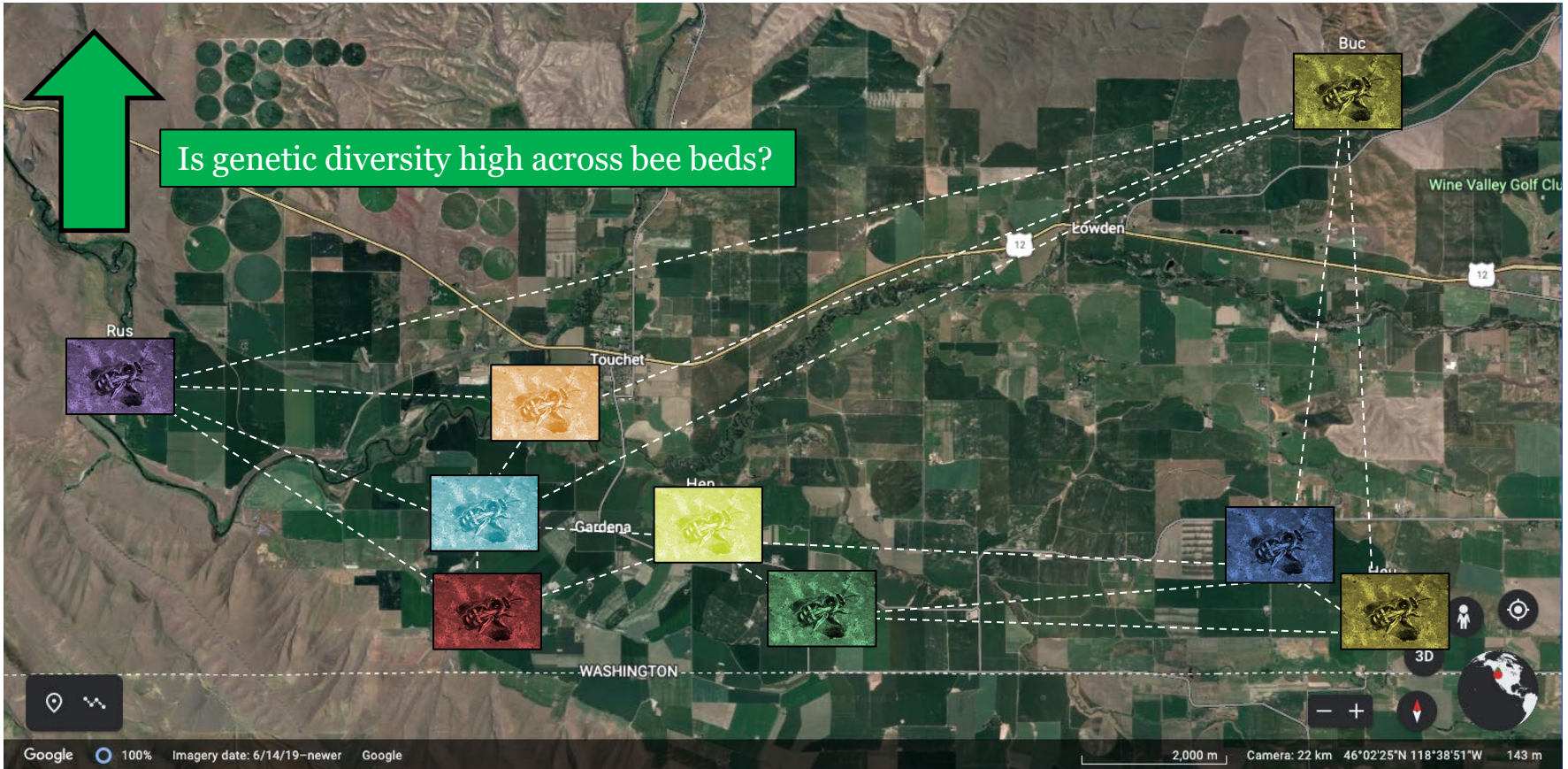
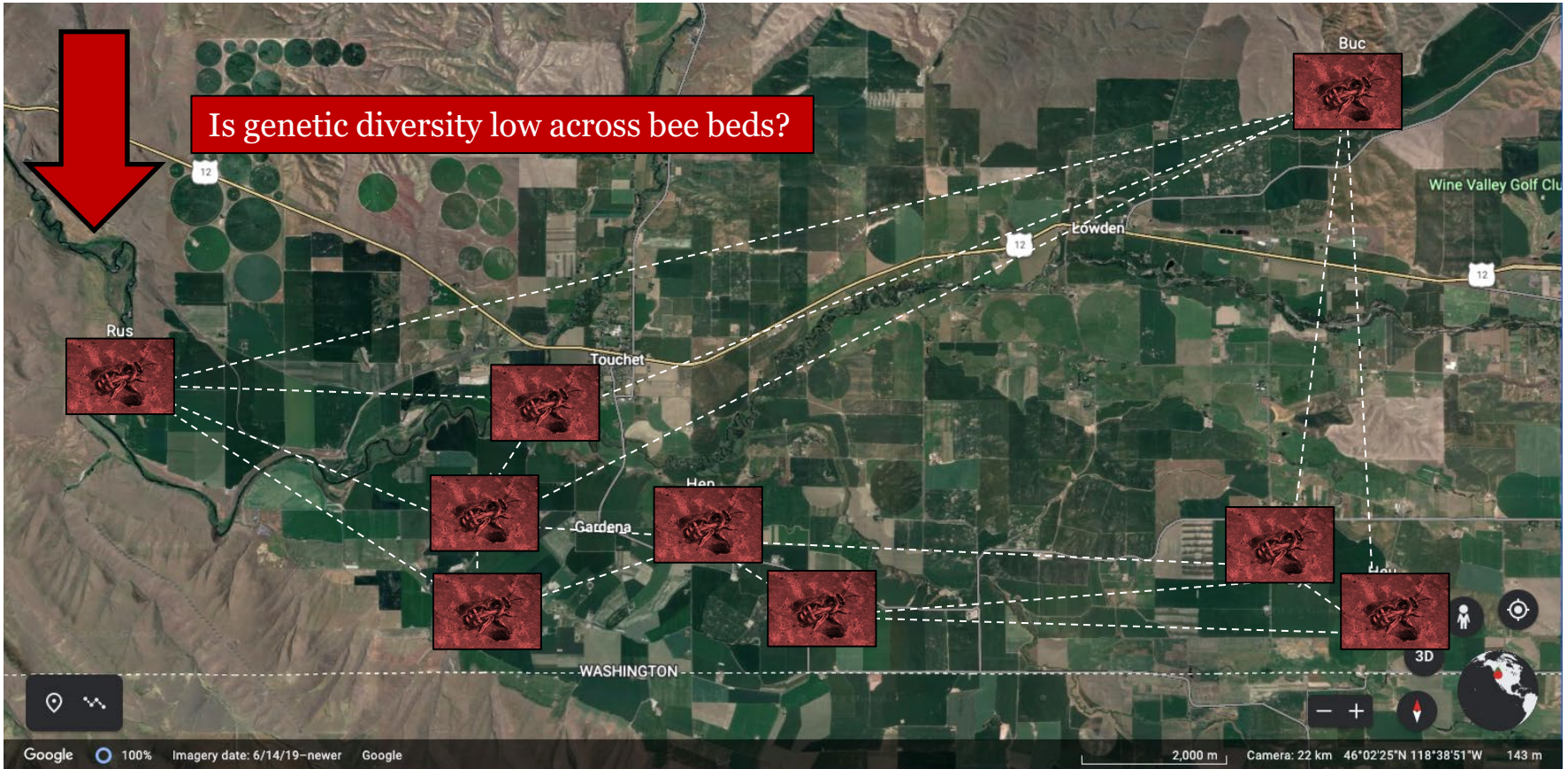
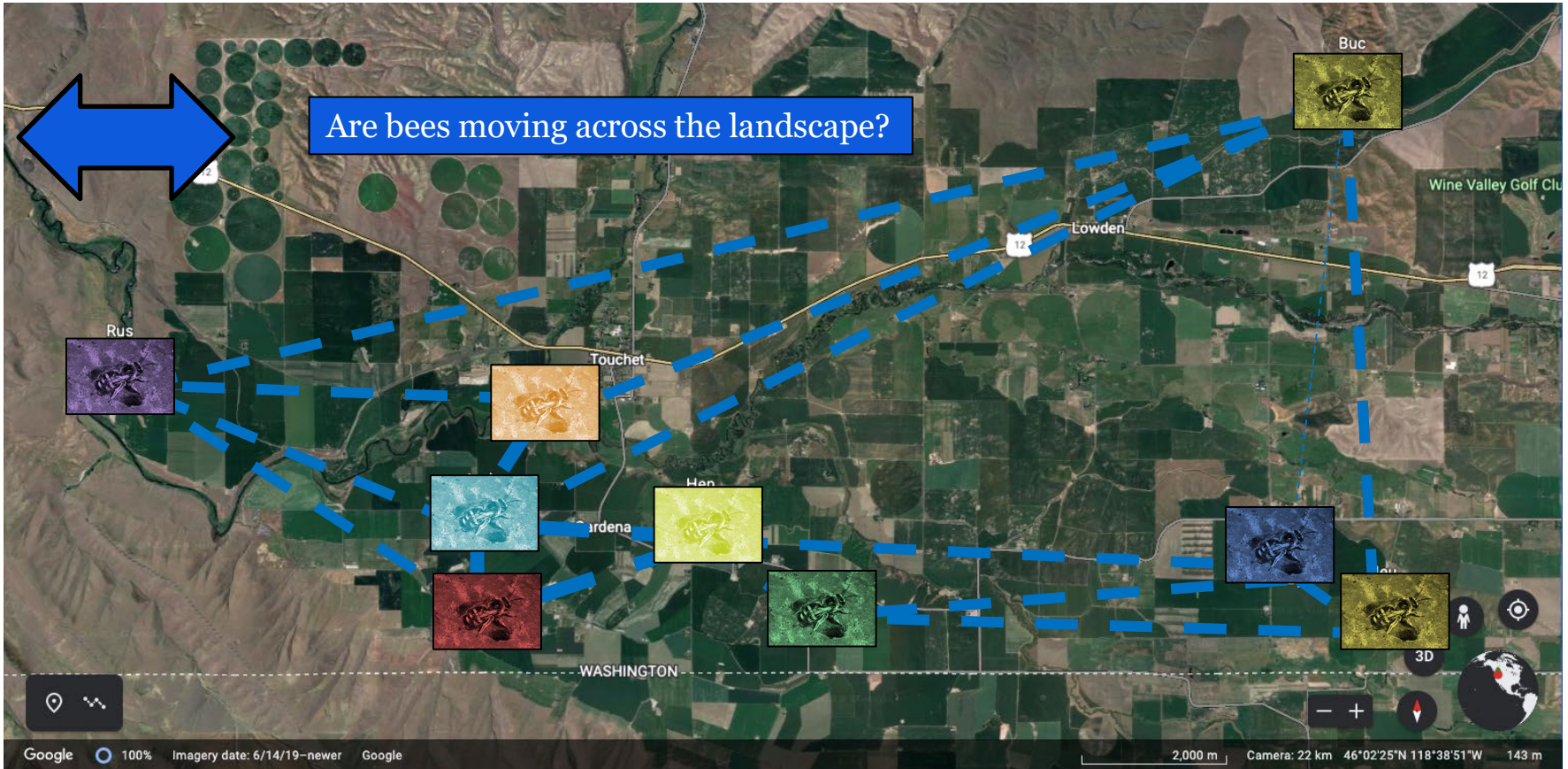
Objective 3: Genetic research opportunities



Conclusion

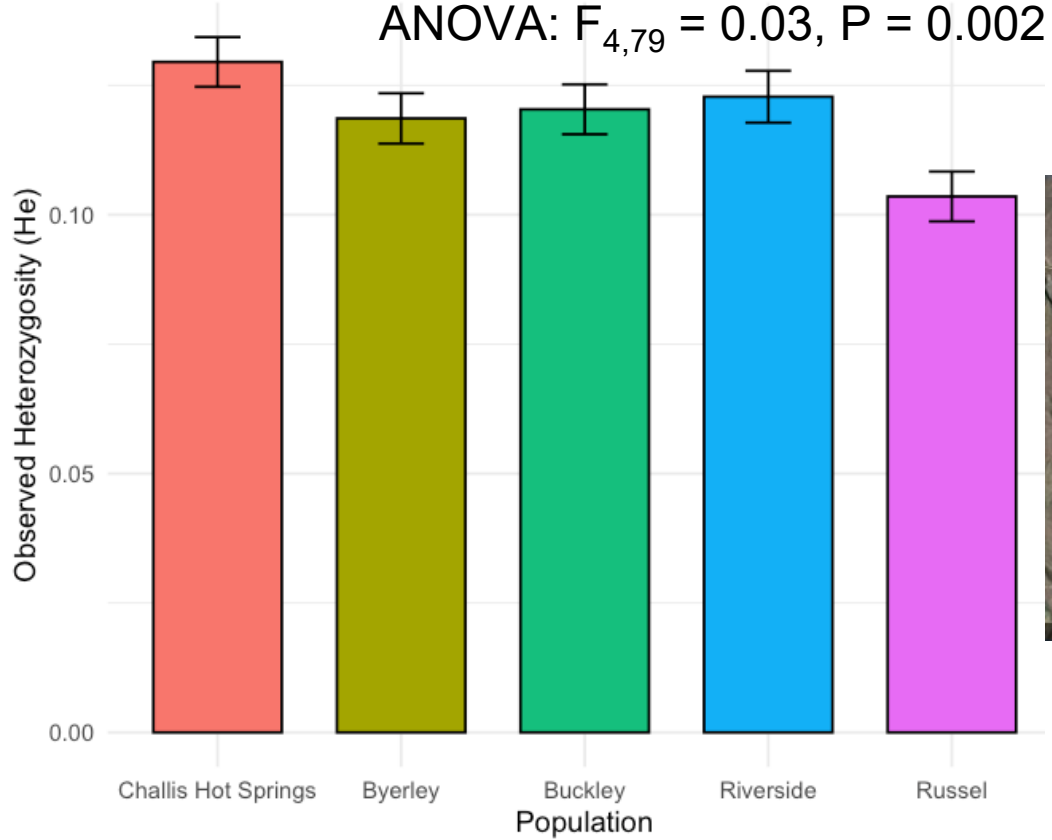

Is genetic diversity low across bee beds?
Buc
Wine Valley Golf Clu
Lowden
Rus
Touchet
Gardena
WASHINGTON
3D
Google
100%
Imagery date: 6/14/19–newer
Google
2,000 m
Camera: 22 km
46°02'25"N 118°38'51"W
143 m

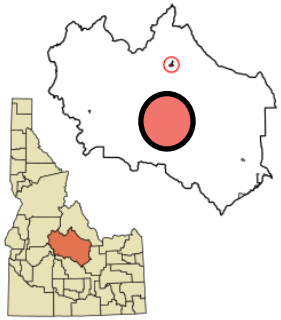
Objective 3: Genetic research opportunities

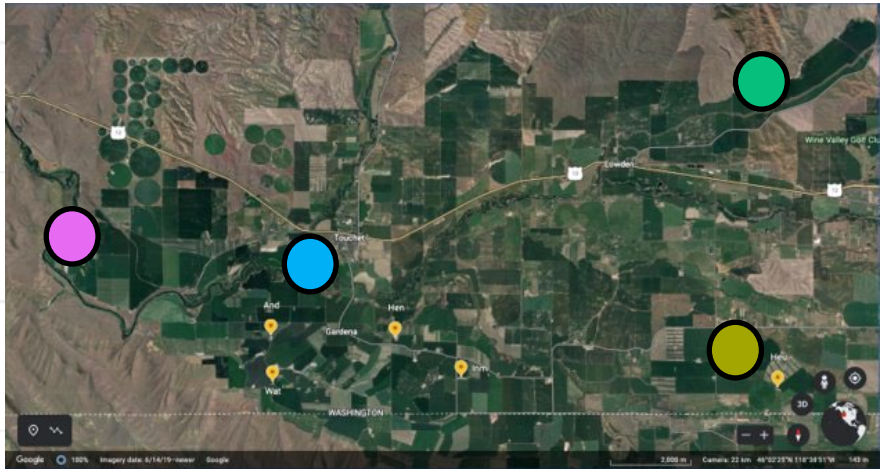


Objective 3: Genetic research opportunities

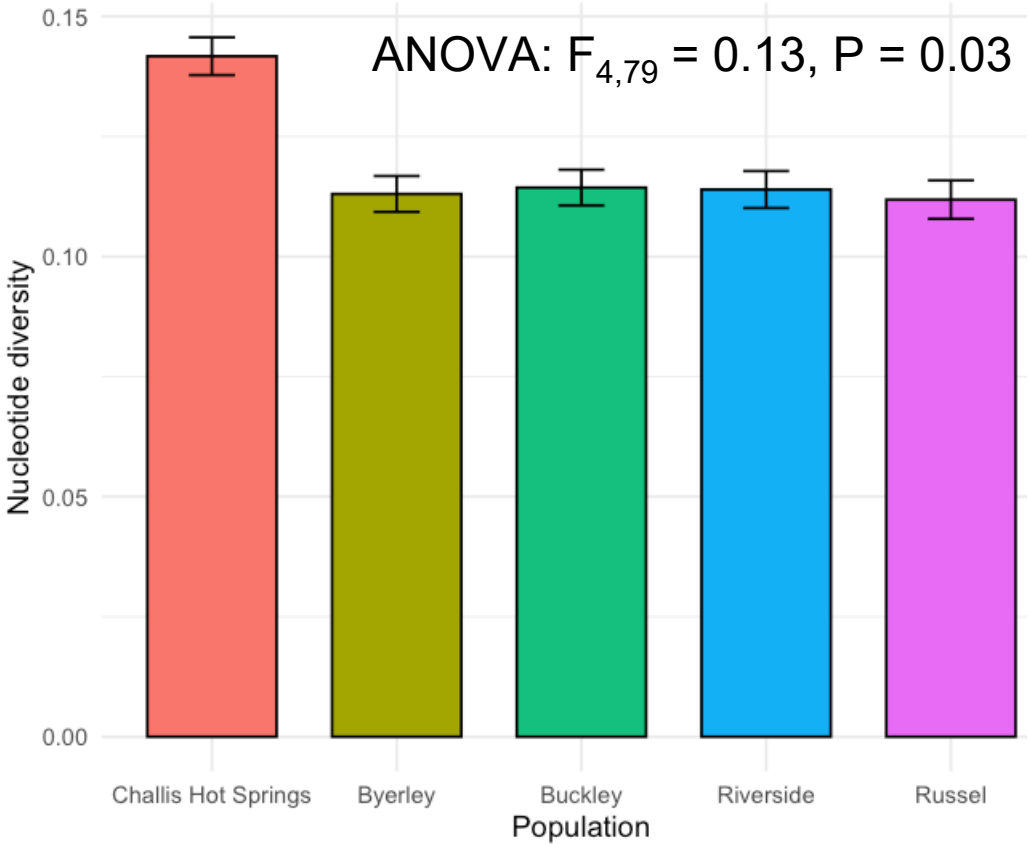
Observed Heterozygosity (H_e)

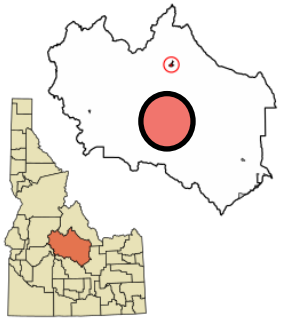


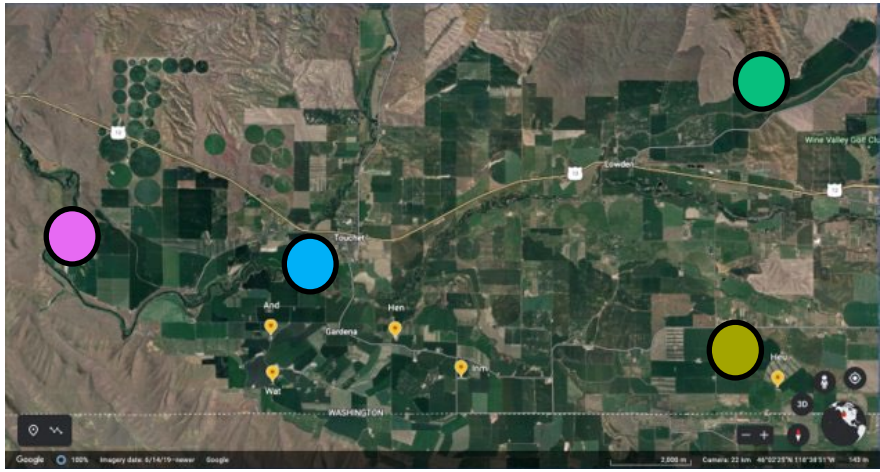




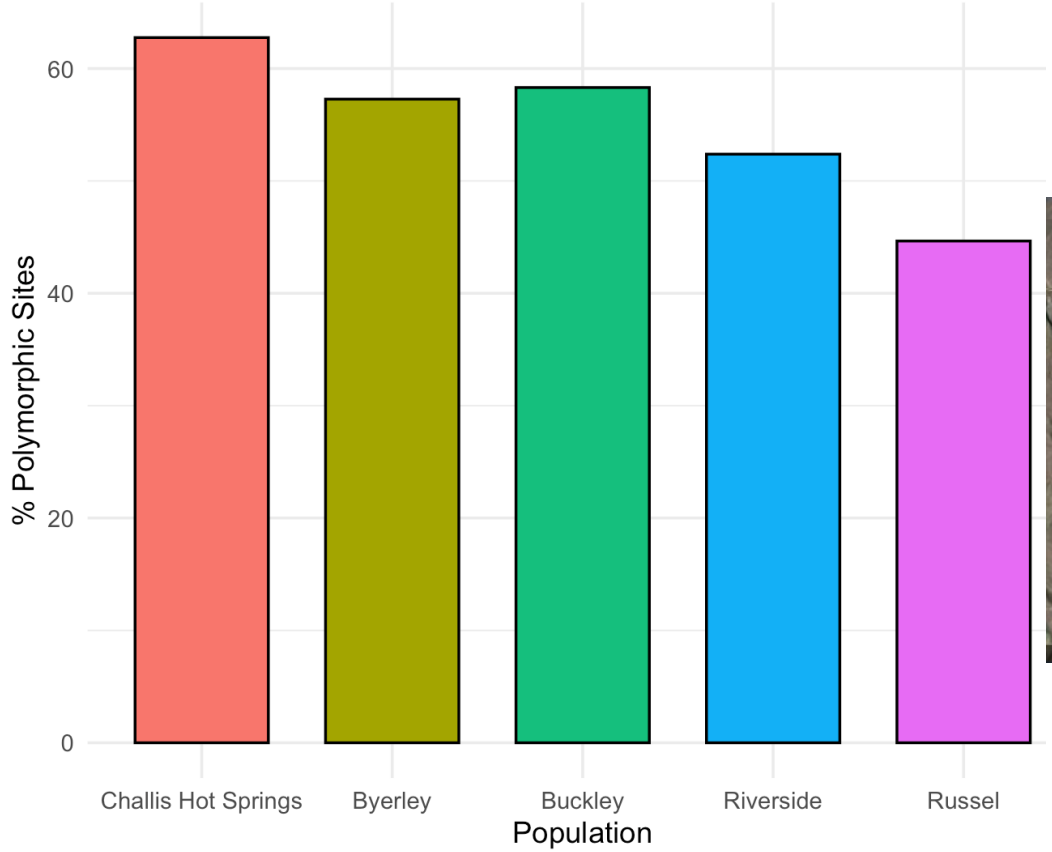
Nucleotide diversity (*Pi*)

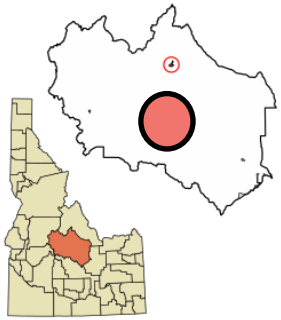


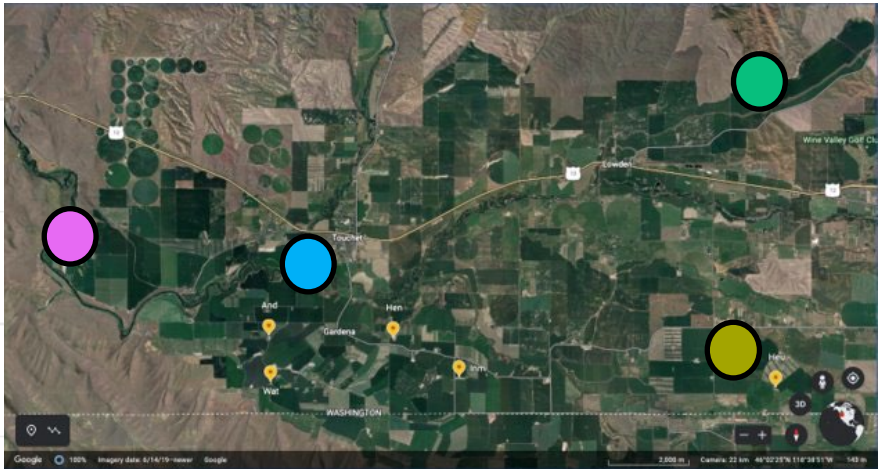




% Polymorphic sites







Observed vs. Expected Heterozygosity