Expert Panel Workshop Conducted for
White River and Graham's beardtongues
U.S. Fish and Wildlife Service
June 2, 2017
Vernal, Utah

EXECUTIVE SUMMARY

On June 2, 2017, the U.S. Fish and Wildlife Service (Service) hosted a workshop in Vernal, Utah to elicit scientific data and information from scientific experts regarding Graham's and White River beardtongue ecological settings, morphological diversity, genetic diversity and gene flow. The Service's new Species Status Assessment (SSA) Framework guided the workshop, ultimately directing discussion toward an assessment of the beardtongues representation (defined below):

- Representation – the range of variation found in a species or taxon. This includes genetic and ecological diversity. Genetic diversity includes the number and frequency of unique alleles within and among populations and gene flow that occurs between local populations. Ecological diversity includes physiological, ecological, and phenotypic variation across the range.

Experts who attended the workshop included: Federal agency botanists (current and retired) from the Bureau of Land Management (BLM), U.S. Forest Service (USFS), and Natural Resources Conservation Service (NRCS); botanists (current and retired) from herbaria; and geneticists from two Universities. Jennifer Lewinsohn (Service) guided the discussion and developed the questionnaire that each scientific expert completed.

This workshop complied with the Federal Advisory Committee Act (FACA) and the Administrative Procedures Act (APA). At no time during the workshop were the scientific experts or meeting attendees asked to provide a consensus opinion regarding any topic. Additionally, this workshop in no way discussed or determined a regulatory status for the beardtongues or any other species, subspecies, or population under the Endangered Species Act (ESA), such as threatened, endangered, or not warranted for listing. The Service maintains the authority to make regulatory determinations under the ESA. Prior to the workshop, the Service provided the ground rules to participants that discussed the rules and procedures for the workshop.

The workshop provided an important opportunity for scientific experts from the various agencies and organizations to update the Service on their research and field observations. The workshop fostered an invaluable face-to-face exchange of information and discussion. The scientific experts provided valuable preliminary results regarding White River beardtongue genetic diversity and gene flow, and field observations of phenotypic variation across the beardtongue ranges.

ATTENDEES

Scientific Experts:

Noel Holmgren, PhD. – Botanist, New York Botanical Garden
Jim Spencer – Botanist, USDA-NRCS
Matt Lewis – Botanist, BLM Vernal Field Office
Sherel Goodrich – Botanist, retired from USDA-USFS
Mikel Stevens, PhD. – Geneticist, Brigham Young University (BYU)
Robert Johnson, PhD. – Botanist, BYU, Plant Collections Manager Stanley L. Welsh Herbarium
Christine Cimiluca – Botanist, BLM Vernal Field Office
Jessi Brunson – Botanist, BLM Vernal Field Office
Andrea Wolfe, PhD. – Plant evolutionary biologist, Ohio State University, geneticist, arrived at 8:50am

Others:

Jennifer Lewinsohn – Service Botanist and workshop facilitator
Rita Reisor – Service Botanist and note taker
Mindy Wheeler – State Botanist and note taker
Cathy King – UNPS Board member and observer
Bill King – UNPS Board member and observer
Jason Stettler – PhD candidate at BYU, working under Mikel Stevens at BYU doing genetic analysis for other beardtongues

WORKSHOP NOTES – REVISED AND AMENDED

After the workshop, the Service consolidated the meeting notes to remove redundant statements from multiple note takers. However, the Service retained similar statements made by multiple experts. The Service also revised the notes if, following their review, the scientific experts clarified statements or suggested changes due to note-taking errors.

FACA and APA Procedures:

- Reviewed the Ground Rules Document (see Appendix A)
- Open discussion but no consensus. Seek individual opinions.
- Record of discussion will be available to the public and through a Freedom of Information Act (FOIA) request, including the questionnaire.
- Purpose of the meeting is to gather best available information, only.
- No participants have a conflict of interest.

Overview of Graham's and White River beardtongues

- Presentation by Jennifer Lewinsohn (see Appendix B)
- The number of Graham's beardtongue populations has remained the same since 2013 with 24 populations.
- The number of White River beardtongue populations has increased since 2013, from 8 to 18 populations, due to the results of a BYU genetic study performed by Drs. Stevens and Wolfe. See **White River Beardtongue Genetic Diversity** section, below, for more information.
- The total population size for both beardtongues has increased since 2013, largely due to increased survey effort. The range of Graham's beardtongue has not changed since 2006. The range of White River beardtongue increased due to the results of the BYU genetic study.

- Overview of the 3R's: Resiliency, Representation, Redundancy.
- The focus of the workshop is on Representation.

Uinta Basin Biogeography and Beardtongue Ecological Settings

- Sherel G. stated that Graham's beardtongue occurs in Raven Ridge in CO to Sand Wash in UT; the species is restricted to Parachute layer of the Green River Member. White River beardtongue is confined to Green River Shale.
- Mikel S. stated that the BYU genetic study clarified the range of White River beardtongue. All previously documented *Penstemon scariosus* var. *garrettii* east of the Green River are now considered White River beardtongue (*Penstemon scariosus* var. *albifluvis*). There is no overlap between *Penstemon scariosus* var. *garrettii* and White River beardtongue.
- Jennifer L. asked the experts about questions #1 and #2 in the questionnaire. Is there a diversity of ecological settings within each taxon's range? Are there differences in plant communities across the range? Is plant community type a good way to characterize ecological diversity for the species? Would they consider Baileys Ecoregion IV too coarse a scale to evaluate ecological diversity? Is SW ReGAP too finely detailed or just right? SW ReGAP delineates areas at the plant community level. Individual answers to this and other questions can be found in the questionnaires (see Appendix C).
- Jessi B., Christine C., and Matt L. at the BLM all think LANDFIRE is more accurate than SW ReGAP for delineating plant community types for the beardtongues. LANDFIRE covers Utah and Colorado. LANDFIRE was developed by USGS for fire use originally; the scale is probably at the 30m pixel level. They think that the Bailey's Ecoregion IV is too coarse of a scale for evaluation purposes. The scale used for SW ReGAP or LANDFIRE is better.
- Robert J. asked if the Service is using UTM points or Township Range Section data? He expressed concern about combining modern mapping with old mapping scales for this evaluation.
- Jessi B. suggests that the Service should symbolize GPS points by year, and consider doing analysis using only recent points in order to compare accuracy with older data. This evaluation is helpful to identify areas for resurvey.
- Jennifer L. said the dataset is primarily composed on UTM points that have been recently collected.

Beardtongue Morphological Diversity

- Presentation of photographs by Robert J. and Mikel S. on the morphological diversity of White River beardtongue (see Appendix D). There are significant phenotypic differences between metapopulations which caused the confusion between White River beardtongue and *Penstemon scariosus* var. *garrettii*.
    - Moving from the NE to the SW of the newly described range, the metapopulations of White River beardtongue tend to have broader leaves and overall more leaf size variety.
    - Individual plants are shorter in the new population in the Book Cliffs, possibly due to the harsh, windy, ridgeline habitat and the higher elevation of this population.
    - Flower color tends to be mostly consistent as gentle lavender ("somewhat lavender, gentle pinkish" color) across the range. Other *Penstemon scariosus* varieties typically have some blue in the throat of the flowers.

- Their Dragon Road voucher collection site (right across from the Enefit shale experimental site) has high morphological diversity of leaf shapes for White River beardtongue. Robert J. showed pictures of leaf shape variation at Dragon Road site.
- There is also variation in presence/absence of sterile inflorescences; some plants have many sterile shoots, and some have none.
- Individuals have glandular hairs on the calyx which is similar to *P. cyanomontanus*.

- Matt L. discussed that Graham's beardtongue western populations have more red pigment in the leaves, underside of leaves, inflorescences and flowers than the populations in the east. There appears to be a trend across the range. There may be more anthocyanin production due to genetic or environmental conditions. Perhaps there is year to year variation but the red pigment is always present in flowers on west side of the range.
- Matt L. also stated that eastern populations tend to have more pale pink flowers and more glaucous gray-green leaves than those in the western populations. Something he noticed this year, Graham's beardtongue flowers seem to be smaller in size and more lavender in color than in past years. Could this be a response to nutrients or environmental stress?
- Andrea W. asked if there have there been soil pits and sampling across the range of either beardtongue? Matt L. said no soil sampling has occurred.
- Noel H. stated there is variation in flower size within a single inflorescence for Graham's beardtongue; the terminal flower is usually larger than those below it on the lateral stem. He also observed that plants blooming in the fall from a second monsoonal-induced flowering event will be smaller than the initial flowering event in the spring.
- Mikel S. stated that flower size can be influenced by environmental factors including water stress based on his work in agricultural settings.

White River Beardtongue Genetic Diversity

- Presentation by Mikel S. on White River beardtongue genetic study results to-date. The powerpoint presentation he used was the same one he presented at the 2016 Utah Rare Plant Meeting in Salt Lake City (see Appendix E).
  - He and his team used 10 SSR markers to evaluate the *Penstemon scariosus* complex.
  - Their evaluation clearly distinguishes *P. scariosus* var. *albifluvis* as a distinct entity from the rest of the *P. scariosus* complex. It may very well warrant full species status but their evaluation is too preliminary at this point to say for sure.
  - Within *P. scariosus* var. *albifluvis*, the Book Cliff population is distinct from the rest of their sampled areas based on the SSR markers. The Book Cliffs are higher in elevation, and bloom later, although there may be some overlap in flowering times with the other areas. There is approximately 20 miles between the Book Cliff population and other populations.
- A number of participants stated that there are forests and mountains between the Book Cliffs population and the other White River beardtongue population areas to the north. It is a long distance for pollinators to travel, and we need more information on pollinator travel distances.
- Andrea W. stated that a common garden experiment would be a good way to test whether genetic or environmental factors contribute to flowering period, and other morphological differences identified across the taxon's range. She and Rita R. agreed that a common garden study should occur in the Uinta Basin rather than in Salt Lake City or Wasatch Front

due to climatic differences. Andrea W. said that some studies use clones to have exact genetic replication at multiple garden sites where they compare phenotypic plasticity. Jason S. is performing a common garden experiment for other *Penstemon* in Idaho.

- Andrea W. stated that it appears that the Book Cliff population is diverging from the rest of the taxon based on geography and their preliminary genetic results.

- Presentation by Andrea W. on her lab's genetic analysis and preliminary results for the *Penstemon scariosus* complex and White River beardtongue (see Appendix F).
    - Her lab uses ALFP markers which are much more robust than the microsatellite markers the Steven's lab used. ALFP uses hundreds of markers rather than the 10 markers used for microsatellites. So there are differences between her results and BYU's results.
    - Using the ALFP markers, all varieties in the *Penstemon scariosus* complex have lower observed heterozygosity (Ho) than the expected heterozygosity (He).
    - Inbreeding coefficient (Fis) ranges between 0 (more outcrossing between population areas) and 1 (only inbreeding is occurring within a population area). Andrea W. stated that a general tipping point for plants is at Fis = 0.5. Andrea W. stated that in general, values greater than 0.3 you want to keep an eye on because inbreeding could be a concern. However, values they present today may be misleading because the sample numbers differ between varieties. Fis is 0.48 for White River beardtongue using ALFP markers, it is 0.23 using the SSR markers. These values are for the taxon as a whole and have not been evaluated by sample area. This value means that there is a lack of contact between population areas rather than an indication of pollinator limitation. Population areas are susceptible to genetic drift and have already experienced some degree of habitat fragmentation.
- Jennifer L. asked if these results can be evaluated based on the Service population delineations she just emailed the researchers. It seems like the sample areas correspond to 3 metapopulation areas so it will be good to clarify and be consistent about how the researchers are defining their population areas. Andrea W. said that will be the next step in their evaluation.
- Andrea W. and Mikel S. stated that Utah is the center of diversity for *Penstemon* genus. In particular, the Uinta Basin appears to be an important area of diversity for Utah.
- Jennifer L. asked how long of a time period can be applied to these results, in particular, what is the time period for the inbreeding coefficient? Andrea W. summarized that the Penstemon genus originated roughly 2.5 million years ago and the *Penstemon scariosus* complex is of very recent origin relative to the rest of the genus. The likely age of the *P. scariosus* complex is about 100,000 years old. The trajectory toward inbreeding within metapopulations likely started about 10,000 years ago due to climatic changes. Lake Bonneville dried up around 14,000 years ago, dramatically shifting the climate and causing a drying trend in the Uinta Basin and influencing metapopulations into their current locations. Events within the past 100 years, when humans have been actively developing the Uinta Basin have further fragmented the habitat within the complex.
- Jessi B. stated that energy development within the beardtongue habitat has been and is currently low. The main land use within the habitat for last 100 – 150 years has been grazing. It is difficult to discern the grazing pressure or contribution from the various herbivores (native and domesticated) on the beardtongues. Rabbits may affect the

beardtongues more than domesticated animals. Jessi stated that grazing doesn't cause habitat fragmentation. She visited Wild Horse Bench this year (2017), a location where Bruce Glisson surveyed in either 2008 or 2009. This year, the area had been hammered by wild horses. She found Graham's beardtongue plants in inaccessible "refugia" (a place of refuge) on north facing slopes, where microsite conditions are moister and cooler than other features and are protected from large ungulate herbivory.

- Mikel S. and Andrea W. recommended a genetic study be performed for Graham's beardtongue. Mikel S. said he and his student, Jason S. would be available to perform the study over the next two years. The group discussed leaf collection methods and storage requirements for a genetic study. Jessi B. and Matt L. will see if they can incorporate tissue collection into their field work over the next year. Funding has not been identified and that is the biggest hurdle for initiating this work.

Beardtongue Gene Flow

- Jennifer L. talked about the need to characterize gene flow or functional connectivity between local populations or metapopulations for White River beardtongue. She stated a recently published article that discusses plant functional connectivity and provided that to Andrea W. (Auffret *et al.* 2017). She asked the panel about ways to evaluate functional connectivity for the beardtongues, whether that was best pursued using the genetic results for White River beardtongue or through expert opinion. Andrea W. will take a look at the article and see what can be done with the genetic results.
- Jennifer L. asked the experts to discuss and answer questions #1 and #2 in the Gene Flow section of the questionnaire (pages 8-11) as a way to use expert opinion to evaluate gene flow. She asked if experts had any additional variables to consider when ranking, let the group know so that everyone is considering the same variables. Andrea W. recommended adding soil substrate and rainfall as two additional variables to rank for both taxa.
- Robert J. stated that to understand future connectivity we need to understand the historic connectivity of gene flow. We also need to understand the abundance and frequency of pollinators, as well as travel distance and other food sources.
- Jessi B. and Mikel S. agreed that Graham's beardtongue is more closely associated with Green River shale outcrops than White River beardtongue, except for the western most population of White River beardtongue on Wrinkles Road. Wrinkles Road is slightly higher elevation. This may need further investigation and confirmation.
- Andrea W. thought a simple distance and soil type evaluation may be appropriate proxies for Graham's beardtongue genetic diversity because we don't have genetic information.
- Noel H. asked if anyone has looked at pack rat middens for a historic distribution and genetics of *Penstemon* in the region? The answer from the group is no, not that they are aware of. Jennifer L. stated the Utah Museum of Natural History has evaluated pack rat middens in Range Creek.
- Jim S. reminded everyone there that the gaps between the populations may not be real. It could be the result of lack of survey effort or lack of access to Tribal lands. We don't have true negative data for many of these gaps between populations.

Literature Cited

Auffret, A.G., Y. Rico, J.M. Bullock, D.A.P. Hooftman, R.J. Pakeman, M.B. Soons, A. Suarez-Esteban, A. Traveset, H.H. Wagner, and S.A.O. Cousins. 2017. Essay Review: Plant functional connectivity – integrating landscape structure and effective dispersal. Journal of Ecology © 2017 British Ecological Society, doi: 10.1111/1365-2745.12742, 8 pp.

APPENDIX A: Ground Rules Document for FACA and APA Procedures

Ground Rules for the Gene Flow Expert Panel Workshop Conducted for White River and Graham's beardtongues U.S. Fish and Wildlife Service *May 30, 2017*

Introduction

The U.S. Fish and Wildlife Service invites you to participate in a workshop for scientific experts to address the genetics of the White River beardtongue (*Penstemon scariosus* var. *albifluvis*) and Graham's beardtongue (*Penstemon grahamii*). This workshop, scheduled for June 2, 2017, at the Vernal BLM Office in Vernal, Utah, is part of our process for collecting the best available scientific information for the beardtongues.

An important aspect of this workshop is ensuring that it complies with the Federal Advisory Committee Act (FACA) and the Administrative Procedure Act (APA). The ground rules stated below are intended to serve this purpose. These ground rules are also intended to ensure that the workshop focuses on providing us with the best available scientific information for analyses of the beardtongues status and/or development of conservation measures.

Principles Underlying These Ground Rules

Endangered Species Act (ESA): Under the ESA, we are required to determine whether to list a species based on consideration of the five factors set out in the statute, based solely on the best scientific and commercial data available. As described above, this workshop is part of our effort to collect the best available scientific information for the beardtongues. Thus, we are not asking for input from participants on the determinations that are our responsibility under the ESA. Instead, we are only seeking expert, unbiased input on the questions we have provided you in order to collect scientific information for the beardtongues.

FACA: The purpose of the Federal Advisory Committee Act (FACA) is to ensure that advice provided to the Executive Branch of the Federal government by advisory committees is transparent and accessible to the public. To achieve this purpose, FACA mandates a process for establishing, operating, overseeing, and terminating advisory bodies that are covered by the ESA. Groups that are assembled to provide individual advice to a Federal agency, rather than advice from the group as a whole, are not covered by FACA and hence are not required to comply with FACA's procedural and other requirements. The same is true of groups assembled to exchange facts and information with a Federal agency. The primary purpose of this workshop is to exchange facts and information; and to the extent any advice may be sought on biological or other questions relevant to the beardtongues, that advice will only be sought on an individual basis, not from the group as a whole. Therefore, the intent and structure of this workshop complies with FACA's requirements for advisory committees.

APA: The APA requires Federal agencies to maintain and make available to the public for review all information used by them in developing a final rule, including a final rule to list a species under the ESA. The APA also mandates that judicial review of any final Federal decision be based on the administrative record that includes all records presented to or used by the Federal agency in making the challenged decision. As a result of both of these APA requirements, we must maintain open, public records to document our decision-making process regarding White River and Graham's beardtongues. Therefore, information gained from this workshop will be documented and subject to public disclosure through the processes just described. This documentation will also be subject to release upon request under the Freedom of Information Act (FOIA).

Ground Rules

1. We are only seeking the best available scientific information from the experts participating in this workshop.
2. We have developed a workshop agenda that, among other things, identifies the scientific questions for which we seek the scientific expertise of the participants. The workshop participants should focus their participation in the workshop to providing information that is responsive to these questions.
3. We invited the individuals participating in this expert workshop based solely on their scientific qualifications, rather than as a representative of a particular organization or interested party. Accordingly, the participants should share their scientific expertise during the workshop and not seek to represent any particular position of an agency, their employer, or other interested party.
4. Participants should fully disclose to us and all other participants any potential conflict of interest (e.g., commercial stake in energy resources) that may affect their responses to scientific questions regarding the White River and Graham's beardtongues. We may also ask participants to complete a questionnaire to evaluate and document any potential conflicts of interest.
5. We are not asking for and will not accept input on any future listing determinations we may make under the ESA. We retain full control over any future ESA listing determinations and no pre-decisional assumptions of those determinations will be discussed.
6. Participants should follow standard norms of behavior for effective meetings so that we can receive the information we seek from all participants. We encourage an open, inclusive, and science-based discussion characterized by respectful, orderly dialogue.
7. Any opinion from any participants in this workshop will be provided on an individual basis and not from the group as a whole. Group debate is encouraged, but we do not seek consensus or group advice on issues to be discussed, and such consensus or group advice should not be provided.
8. Information provided by participants through the course of expert workshops will be documented in meeting notes and a written summary report by our office. The notes and corresponding report will become part of the administrative record for use in agency decision-making. The workshop documentation will summarize the biological and other scientific information gained during the workshop. This report will document any advice provided by workshop participants on an individual basis.

9. Conference calls, questionnaires, or other communications between us and workshop participants may occur after the workshop to clarify, for documentation purposes, the information discussed at the workshop. Any such communications will also be subject to and follow these ground rules.

APPENDIX B: Service Presentation by Jennifer Lewinsohn

Overview of *Penstemon grahamii* and *P. scariosus* var. *albifluvis*

Penstemon Expert Panel Workshop

June 2, 2017

Jena Lewinsohn

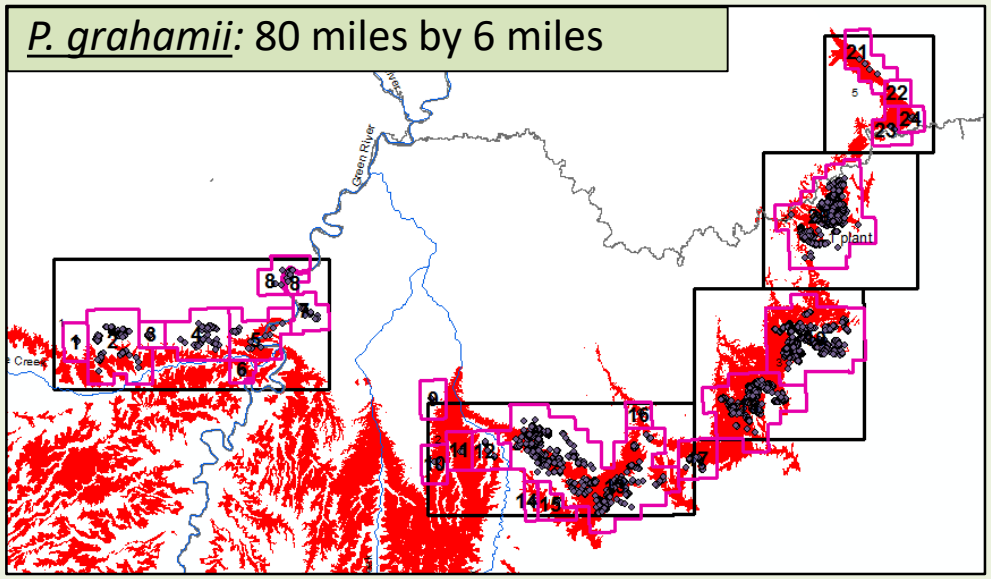
Botanist, USFWS

Range

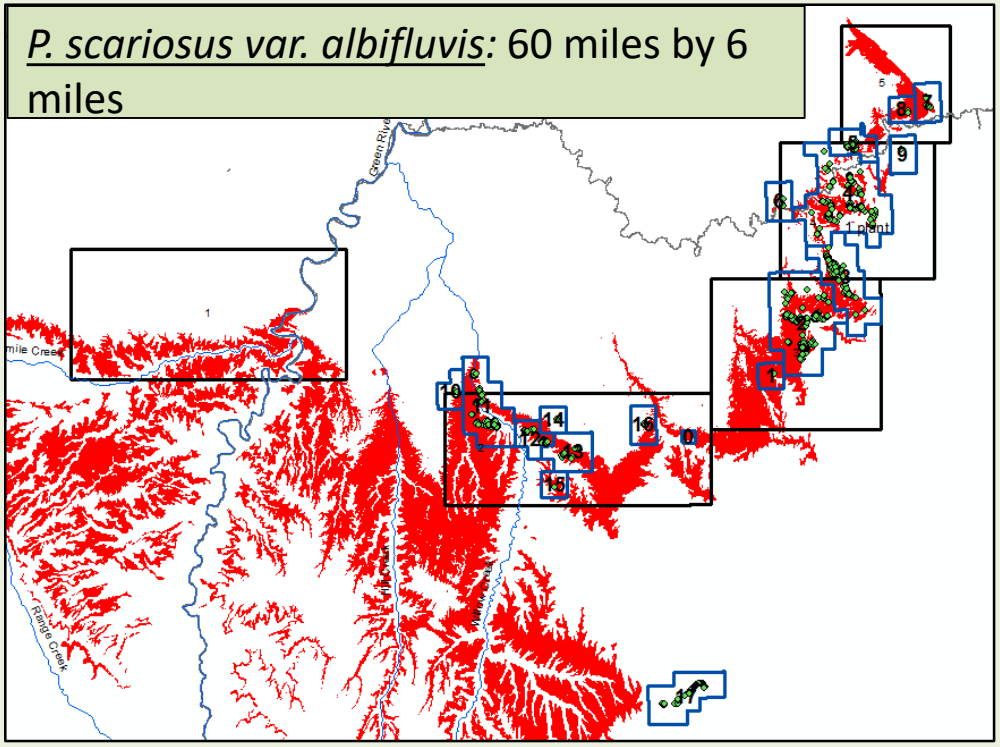
Both taxa are strongly associated with the Mahogany Ledge feature* (Parachute Creek member of Green River formation)

*Shallow layers identified in red in range maps.

P. grahamii: 80 miles by 6 miles



P. scariosus var. albifluvis: 60 miles by 6 miles



Population Size

***P. grahamii*:**
2006 – 6,200 plants
2013 – 31,702 plants
2014 – 40, 333 plants
2017 – 53,168 plants*
Comprising 24 populations

P. scariosus* var. *albifluvis:
2006 –plants
2013 – 11,423 plants
2014 – 12,215 plants
2017 – 22,365 plants*
Comprising 18 populations

*These are draft numbers

Life History Characteristics

***P. grahamii*:**

Life span - long-lived, 30+ years?

Recruitment – low and sporadic

Flowering – low and sporadic

Pollinators –specialist wasp, sweat bees

P. scariosus* var. *albifluvis:

Life span - long-lived, 30+ years?

Recruitment – episodic

Flowering – consistent

Pollinators – native, solitary bees, 1 *Penstemon* specialist (*Osmia brevis*)

Both taxa have a mixed mating system – partially self-compatible, seed set is significantly higher with pollinators

We evaluate viability using the 3 R's

Resiliency: the ability of a species to sustain populations in the face of environmental variation (rainfall and temperature) and transient perturbations (e.g. fire, flooding, storms) of its habitat.

- ❖ Related to population size, growth rate, may be influenced by connectivity

Representation: the ability of a species to adapt to near and long-term changes in the environment.

- ❖ Related to spatial extent of range, and genetic and ecological diversity across the range.

Redundancy: the ability of a species to withstand catastrophic events and requires establishing or maintaining multiple populations in each ecological setting to spread extinction risk.

- ❖ Related to the number and distribution of populations within the species' range.

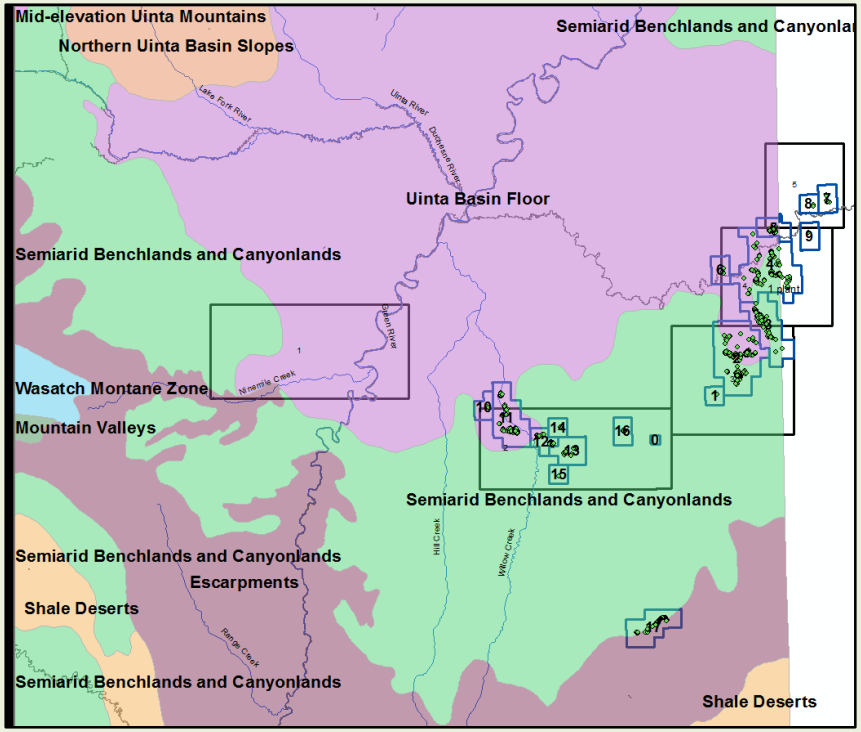
Today's Focus is Representation

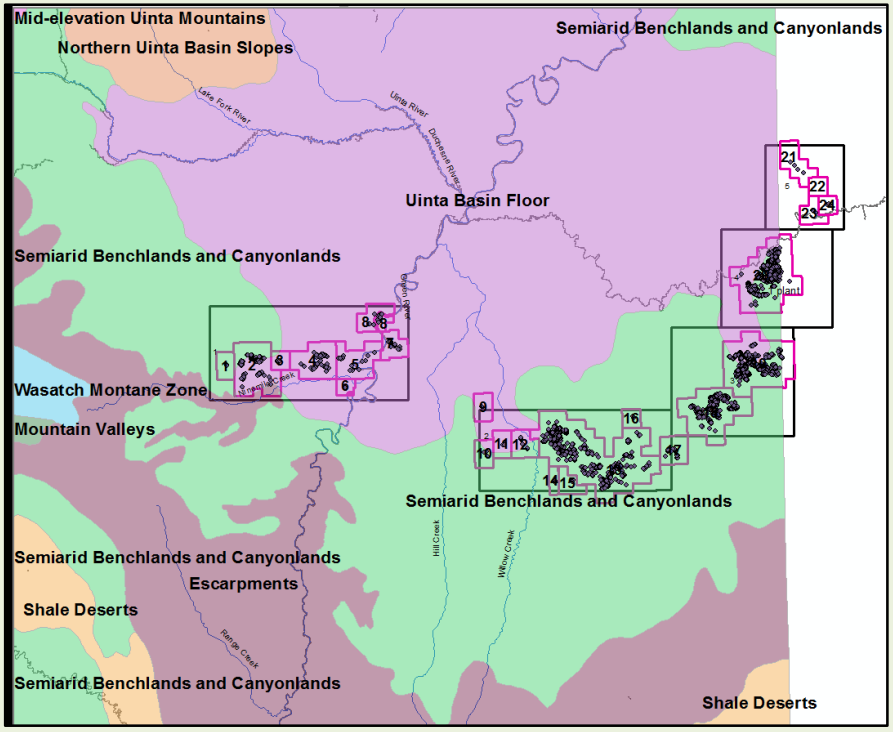
- Consider the range of variation found in a taxon.
- Includes genetic diversity and ecological diversity
- Genetic diversity – the number and frequency of unique alleles within and among populations; maintain gene flow
- Ecological diversity – physiological, ecological, and phenotypic variation across the range

Ecological Diversity: Ecological Settings

1. Discuss ecological settings where the *Penstemons* occur.
2. What is the appropriate scale to evaluate the diversity of ecological conditions within each taxon's range?
   - Bailey Ecoregion IV – too coarse a scale?
     P. grahamii: Semiarid Benchlands & Canyonlands; Uinta Basin Floor
   - SW ReGAP – too fine a scale or just right?
3. Identify potential barriers and corridors for pollen and plant dispersal within both ranges.

Bailey's Ecoregion IV





P. scariosus var. *albifluvis*

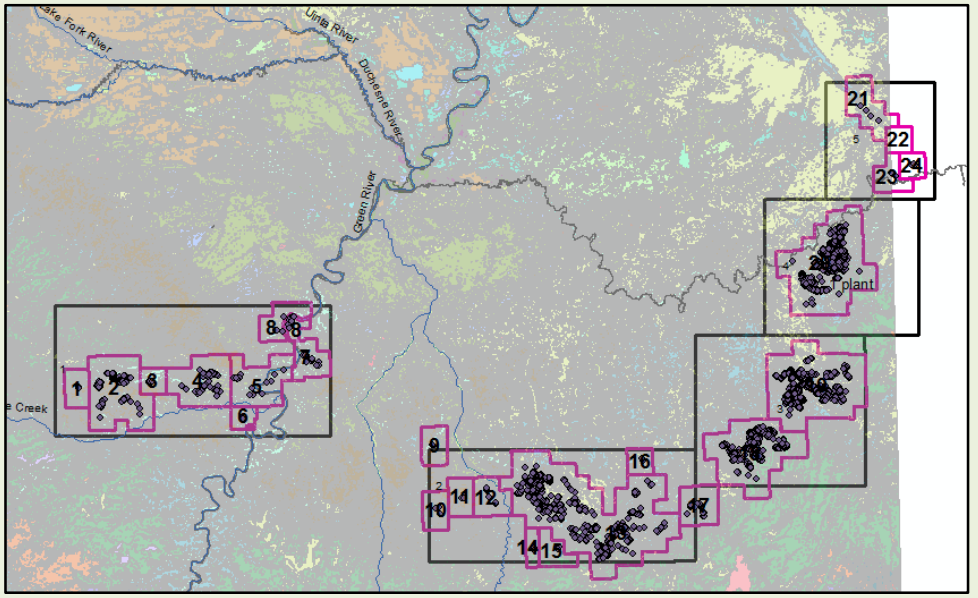
- *Semiarid Benchlands & Canyonlands*
- *Escarpments*
- *Uinta Basin Floor*

P. grahamii

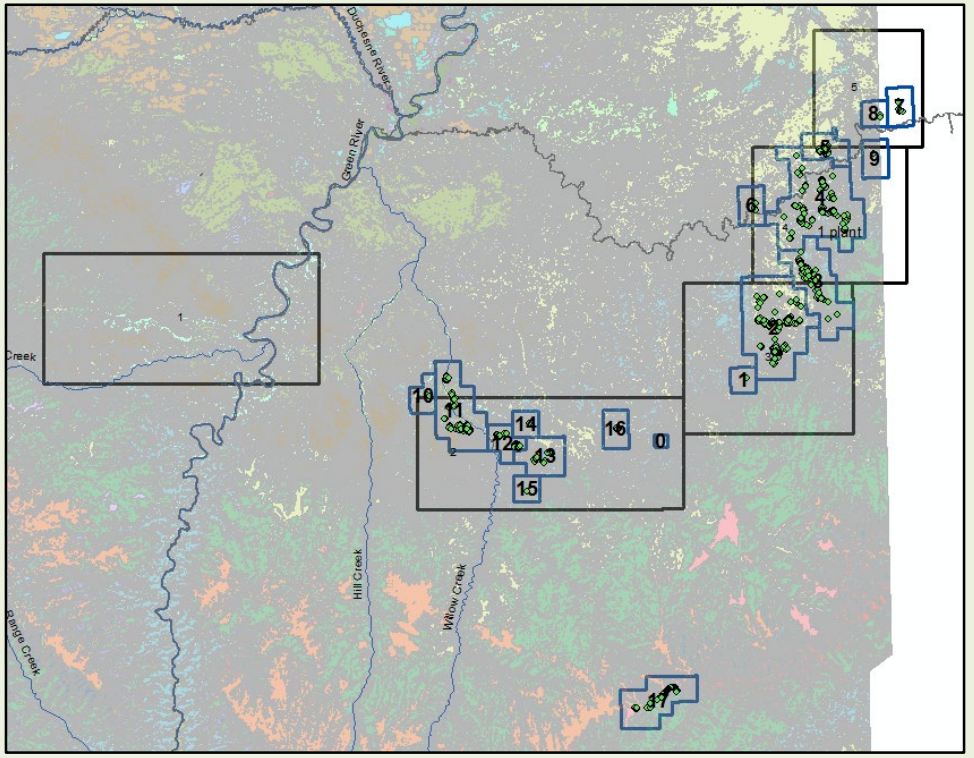
- *Semiarid Benchlands & Canyonlands*
- *Uinta Basin Floor*

SW ReGAP

P. grahamii



P. scariosus var. *albifluvis*



Phenotypic Variation

- Where do we find phenotypic variation across the range?

➢ Identify the variation

➢ Identify locations

Gene Flow

- How are *P. scariosus* var. *albifluvis* populations functionally connected across the landscape?
- How do we evaluate this connectivity?
  - Can we use the Fixation index (F_{ST}) and compare with landscape metrics as a proxy for gene flow?
  - Expert elicitation?
- What are landscape-dependent and landscape independent factors that may affect gene flow?

Questions & Questionnaire Time

APPENDIX C: Scientific Expert Questionnaires

Expert Panel Workshop Conducted for
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U.S. Fish and Wildlife Service
June 2, 2017
Vernal, Utah

Questionnaire

Your Name and Affiliation: Andrea D. Wolfe (Andi)
Dept. EEOB, Ohio State University

Your experience with *Penstemon grahamii* and *P. scariosus* var. *albifluvis* (specify type of research or evaluation, surveys, field experience, etc.):

My lab has been doing a conservation + phylogeography study on the Penstemon scariosus complex. Our data include microsatellite markers, AFLP markers, and morphometrics – this is a collaboration with Mike Stevens lab.

Ecological Settings and Diversity

1. Is there a diversity of ecological settings within each taxon's range? If so, please explain the different settings and important distinctions between them. Circle the confidence category in the table below that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:*

Restricted to oil shale + limited distributions.

P. grahamii is a soil endemic + will not occur on other substrates.

Highly confident.

Confidence Terminology	Explanation
Highly Confident	I'm more than **90% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by documented accounts or research and/or is strongly consistent with accepted conservation biology principles.
Moderately Confident	I'm **70-90% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by some available information and/or is consistent with accepted conservation biology principles.
Somewhat Confident	I'm **50 – 70% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by some available information and/or is consistent with accepted conservation biology principles.
Low Confidence	I'm **less than 50% sure** that this relationship or assumption accurately reflects the reality in the wild as there is no supporting available information and/or there is uncertainty about the consistency with accepted conservation biology principles. Indicates areas of high uncertainty.

b) *P. scariosus* var. *albifluvis:*

. Another soil substrate endemic & it is genetically distinct from other varieties.

Confidence Terminology	Explanation
Highly Confident	I'm more than **90% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by documented accounts or research and/or is strongly consistent with accepted conservation biology principles.
Moderately Confident	I'm **70-90% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by some available information and/or is consistent with accepted conservation biology principles.
Somewhat Confident	I'm **50 – 70% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by some available information and/or is consistent with accepted conservation biology principles.
Low Confidence	I'm **less than 50% sure** that this relationship or assumption accurately reflects the reality in the wild as there is no supporting available information and/or there is uncertainty about the consistency with accepted conservation biology principles. Indicates areas of high uncertainty.

2. What is the appropriate scale to evaluate the diversity of ecological conditions within each taxon's range? Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:*

I have no experience with this.

Confidence Terminology	Explanation
Highly Confident	I'm more than **90% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by documented accounts or research and/or is strongly consistent with accepted conservation biology principles.
Moderately Confident	I'm **70-90% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by some available information and/or is consistent with accepted conservation biology principles.
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b) *P. scariosus* var. *albifluvis:*

I have no experience with this.

Confidence Terminology	Explanation
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Phenotypic Variation

1. Is there phenotypic variation within each taxon's range? If so, please explain the variation and identify locations. Please try to assign the appropriate population number to each location. We may ask follow up questions to your answer after the meeting.

   b) *P. grahamii:*

   I have no experience with this

b) *P. scariosus* var. *albifluvis:*

There are differences in morphological traits for var. albifluvus compared to the other varieties of P. scariousus. Primary differences are in sepal tip length, # of flowers per stem

Gene Flow

1. Identify potential geographic barriers and corridors for pollen movement and plant dispersal within each taxon's range. Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*

no data

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b) *P. scariosus* var. *albifluvis:*

variety albifluvus is genetically distinct from other varieties & is geographically isolated.

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2. Rank the importance of variables that appear to be associated with frequency of gene flow. The highest rank is 1 and the lowest rank is 5. The rank should correspond to the relative contribution of that variable with the frequency of gene flow. Please explain your rationale or provide additional variables, and circle or identify the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:*

- Elevation ___ (5)
- Distance between populations ___ (2)
- Plant association ___ 7
- River corridor or watershed ___ 6
- Size of local plant population ___ (1)
- soil substrate (3)
- rainfall (4)

Genetic variation is correlated with population size + distance between populations. Distribution is associated with soil substrate, rainfall, elevation.

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b) *P. scariosus* var. *albifluvis:* 5

- Elevation ___
- Distance between populations ___ (2)
- Plant association ___ 7
- River corridor or watershed ___ 6
- Size of local plant population ___ (1)

- soil substrate 3
- rain fall 4

See previous page

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Space to Provide Additional Information on the Topics We Discussed Today:

we can send additional analyses as discussed

Expert Panel Workshop Conducted for
White River and Graham's beardtongues
U.S. Fish and Wildlife Service
June 2, 2017
Vernal, Utah

Questionnaire

Your Name and Affiliation:

Christine Cimiluca
BLM - Green River District

Your experience with *Penstemon grahamii* and *P. scariosus* var. *albifluvis* (specify type of research or evaluation, surveys, field experience, etc.):

Field surveys, data collection and analysis, monitoring of populations, work with Penstemon Conservation Agreement team, development of mitigation and conservation measures to protect species. ~ 4 years experience working w/ these species

Ecological Settings and Diversity

1. Is there a diversity of ecological settings within each taxon's range? If so, please explain the different settings and important distinctions between them. Circle the confidence category in the table below that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*

I have overlain the recent known points of this species (2010-present) with Landfire existing vegetation data, and this shows that these points do occur in a relatively diverse array of ecological settings, although many of these ecological settings have similar dominant and characteristic plant species.

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b) *P. scariosus* var. *albifluvis:*

I have used the same process as with *P. grahamii* to determine the ecological settings where this species occurs. This species occurs over a slightly wider range of ecological settings than *P. grahamii* based on the results of this analysis.

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2. What is the appropriate scale to evaluate the diversity of ecological conditions within each taxon's range? Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:*

I have used Landfile in the past, and I feel that it is an appropriate scale to represent the diversity of ecological conditions. Landfire existing vegetation data is available for the entire range of this species and is fairly accurate.

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b) *P. scariosus* var. *albifluvis:*

See answer for *P. grahamii*

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Phenotypic Variation

1. Is there phenotypic variation within each taxon's range? If so, please explain the variation and identify locations. Please try to assign the appropriate population number to each location. We may ask follow up questions to your answer after the meeting.

   b) *P. grahamii:*

I have observed some phenotypic variation over the range of the species during field surveys. A type of variation seems to occur relatively consistently within a subpopulation; for example, most of the plants within a subpopulation may have paler flowers.

b) *P. scariosus* var. *albifluvis:*

During field surveys I have observed a lot of phenotypic variation, sometimes within a single population. There are notable differences in flower color, leaf width, number of flowering stems per plant, etc.

Gene Flow

1. Identify potential geographic barriers and corridors for pollen movement and plant dispersal within each taxon's range. Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

    a) *P. grahamii:*

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b) *P. scariosus* var. *albifluvis:*

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2. Rank the importance of variables that appear to be associated with frequency of gene flow. The highest rank is 1 and the lowest rank is 5. The rank should correspond to the relative contribution of that variable with the frequency of gene flow. Please explain your rationale or provide additional variables, and circle or identify the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

Rationale is based on field observations and genetic study results. Elevation and precip would be a close tie.

a) *P. grahamii:*

- Elevation 5
- Distance between populations 1
- Plant association 7
- River corridor or watershed 2
- Size of local plant population 4
- Soil Substrate 3
- Precipitation 6

Confidence Terminology	Explanation
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b) *P. scariosus* var. *albifluvis:*

- Elevation 5
- Distance between populations 1
- Plant association 7
- River corridor or watershed 2
- Size of local plant population 4
- Soil Substrate 3
- Precip 6

see rationale for P. grahamii

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Space to Provide Additional Information on the Topics We Discussed Today:

Expert Panel Workshop Conducted for
White River and Graham's beardtongues
U.S. Fish and Wildlife Service
June 2, 2017
Vernal, Utah

Questionnaire

Your Name and Affiliation:

Jessi Brunson, BLM

Your experience with *Penstemon grahamii* and *P. scariosus* var. *albifluvis* (specify type of research or evaluation, surveys, field experience, etc.):

surveys - mostly BLM surface
field monitoring + transplant
lit + data reviews (mostly pre-2014)

Ecological Settings and Diversity

1. Is there a diversity of ecological settings within each taxon's range? If so, please explain the different settings and important distinctions between them. Circle the confidence category in the table below that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:*

Yes, for an endemic. I have seen it in washes, in shale, on ridge tops + nerby slopes, on gentle slopes with cobble + channery. It is mostly assoc. w/ Green River shale, but not exclusively. Different plant communities too, and a relatively broad range

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b) *P. scariosus* var. *albifluvis:*

Pescal has a more limited range than PEGR but seems to grow in denser populations. Have seen this in the field in PJ + shrub + slopes + ridgetops, but not in sites as hot + dry as PEGR. Lower association with Green River shale than PEGR. I would say less ecological variation than PEGR, but denser pops so may have more variation within pops + sub pops but less across range.

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2. What is the appropriate scale to evaluate the diversity of ecological conditions within each taxon's range? Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:*

Landfire – small scale

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b) *P. scariosus* var. *albifluvis:*

Landfire - small scale

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Phenotypic Variation

1. Is there phenotypic variation within each taxon's range? If so, please explain the variation and identify locations. Please try to assign the appropriate population number to each location. We may ask follow up questions to your answer after the meeting.

   b) *P. grahamii:*

Given Mall L's observation of PEGR + color variation, I think the idea that the western pops are paler in flower color is more questionable + anecdotal and I suspect that flower + leaf color varies across subpops + pops rather than across the range as was previously hypothesized. But hard to say without more data.

Moderately confident

b) *P. scariosus* var. *albifluvis:* agree

~~Var~~ I'll ~~hold~~ with what BYU has found that variation within pops is high and may be greater than between pops. Some early observations that Co pops were darker colored aren't really supported by data.

moderately confident

Gene Flow

1. Identify potential geographic barriers and corridors for pollen movement and plant dispersal within each taxon's range. Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*

Green River (West)
ecological separation (soils, elevation, plant community
eastern pops)

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b) *P. scariosus* var. *albifluvis:*

soils + plant community (ecological factors) between Bodie cliffs + northern pops (center of distribution)

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1-7

a) P. grahamii:

- Elevation 5
- Distance between populations 1
- Plant association 3
- River corridor or watershed 6
- Size of local plant population 7
- soil substrate 2
- precip 4

high correlation

high correlation

same for both spp.

* I think that some of these factors incorporate some of the others. & For example, I've ranked size very low, but only because I think distance + size are more or less the same ... more distance between smaller plots. Also, plant communities incorporate elevation + precip, and so on.

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b) *P. scariosus* var. *albifluvis:*

- Elevation 4
- Distance between populations 1
- Plant association 2
- River corridor or watershed 6
- Size of local plant population 7
- soil substrate 3
- precip 5

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Expert Panel Workshop Conducted for
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U.S. Fish and Wildlife Service
June 2, 2017
Vernal, Utah

Questionnaire

Your Name and Affiliation: Jim Spencer, USDA - NRCS

Your experience with *Penstemon grahamii* and *P. scariosus* var. *albifluvis* (specify type of research or evaluation, surveys, field experience, etc.):

Limited Field experience other than presence/absence surveys Bioblitz surveys, Participated on the Uinta Basin Rare Plant Forum with TNC and other Agencies to create a Conservation plan for both species to document threats, Limitations, and potential Conservation actions.

Ecological Settings and Diversity

1. Is there a diversity of ecological settings within each taxon's range? If so, please explain the different settings and important distinctions between them. Circle the confidence category in the table below that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:*

I believe there is some diversity in ecological settings but the differences in the settings, I believe, are subtle. I don't know or have not visited all the populations but my general sense is that the variation is slight.

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b) *P. scariosus* var. *albifluvis:*

Same comments as P. grahamii

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2. What is the appropriate scale to evaluate the diversity of ecological conditions within each taxon's range? Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:*

This is not my area of expertise, but I believe that Bailey's may be too coarse. SWRegap or Landfire may be more appropriate.

Confidence Terminology	Explanation
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Moderately Confident	I'm **70-90% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by some available information and/or is consistent with accepted conservation biology principles.
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b) *P. scariosus* var. *albifluvis:*

Same comments as *P. grahamii*

Confidence Terminology	Explanation
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Phenotypic Variation

1. Is there phenotypic variation within each taxon's range? If so, please explain the variation and identify locations. Please try to assign the appropriate population number to each location. We may ask follow up questions to your answer after the meeting.

b) P. grahamii:

- Plants on the West end of the Range tend to have paler flowers than those on the east.
- Size of leaves/flowers, in my opinion, are affected by stress/climate factors.
- Reddish hues on stems + leaves seem to occur in both West + East populations.

b) *P. scariosus* var. *albifluvis:*

• In my observation color of flowers his highly variable within populations. probably not a great character to divide populations

Gene Flow

1. Identify potential geographic barriers and corridors for pollen movement and plant dispersal within each taxon's range. Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*

There is a Large "gap" between the Eastern + Western groups of metapopulations. I believe the "gap" is mostly due to Land ownership. The Ute tribe has not allowed surveys on the Land between the known Metapopulations. The Green River is also another barrier. pollinators could cross the River but probably not propagules. - In conclusion I suspect pollinators can connect the East + West metapopulations.

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b) *P. scariosus* var. *albifluvis:*

I am not as familiar with this species but I suspect that the crescent shaped group of metapopulations will be genetically and physically connected by pollinators. – The southern metapopulation is less likely to have a physical or pollinator connection. due to elevational gradient and available habitat. between the Crescent shaped Metapopulation and the Southern Book Cliffs Metapopulation.

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2. Rank the importance of variables that appear to be associated with frequency of gene flow. The highest rank is 1 and the lowest rank is 5. The rank should correspond to the relative contribution of that variable with the frequency of gene flow. Please explain your rationale or provide additional variables, and circle or identify the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*
   - Elevation 6
   - Distance between populations 2
   - Plant association 4
   - River corridor or watershed 7
   - Size of local plant population 3

   Soil Substrate 1

   Rainfall 5

– Close tie between #2 + #3

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b) *P. scariosus* var. *albifluvis:*

- Elevation 2
- Distance between populations 3
- Plant association 5
- River corridor or watershed 7
- Size of local plant population 4

Soil substrate 1

Rainfall 6

Close tie between 3 + 4

2 Elevated "Elevation" due to the Southern Metapopulation on the Divide.

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Space to Provide Additional Information on the Topics We Discussed Today:

Additional surveys may prove to link gaps in currently unknown areas. Access to tribal Lands may also increase connectivity. pollinator studies will also contribute to our knowledge base. Sorry for stating the obvious!

Expert Panel Workshop Conducted for
White River and Graham's beardtongues
U.S. Fish and Wildlife Service
June 2, 2017
Vernal, Utah

Questionnaire

Your Name and Affiliation:

Matt Lewis BLM - VFO

Your experience with *Penstemon grahamii* and *P. scariosus* var. *albifluvis* (specify type of research or evaluation, surveys, field experience, etc.):

I have 5 years of field experience surveying for both species.

I helped write the long term demographic monitoring that is part of the Penstemon Conservation agreement.

I also helped to write the Penstemon Conservation Agreement.

Ecological Settings and Diversity

1. Is there a diversity of ecological settings within each taxon's range? If so, please explain the different settings and important distinctions between them. Circle the confidence category in the table below that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*

Yes. This species occurs in several different plant communities. While the species composition is similar, dominant species change. Also this species is found in pink/tan shale sites in addition to white shale that is typical.

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b) *P. scariosus* var. *albifluvis:*

Similar answer to P. grahamii.

This species can be found in washes with rabbitbrush, in sagebrush / Salina wildrye and on typical Green River formation (P/J | Mountain-mahogany). Again on white tan, and pink shale.

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2. What is the appropriate scale to evaluate the diversity of ecological conditions within each taxon's range? Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:*

LANDFIRE EVT (Existing Vegetation Type) or BpS (Bio Physical Setting) or SWReGAP

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b) *P. scariosus* var. *albifluvis:*

Same as P. grahamii

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Phenotypic Variation

1. Is there phenotypic variation within each taxon's range? If so, please explain the variation and identify locations. Please try to assign the appropriate population number to each location. We may ask follow up questions to your answer after the meeting.

   b) *P. grahamii:*

Generally, Plants have more Red in them (Leaves, Stems, Flowers) in the western most distribution when compared to those in the eastern most distribution (in Utah)

b) *P. scariosus* var. *albifluvis:*

no answer

Gene Flow

1. Identify potential geographic barriers and corridors for pollen movement and plant dispersal within each taxon's range. Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*

Green River Seperates P. grahamii populations east/west the island like nature of the shale outcrops and the distances between them are large barriers to dispersal and gene flow.

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b) *P. scariosus* var. *albifluvis:*

Same as P. grahamii

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2. Rank the importance of variables that appear to be associated with frequency of gene flow. The highest rank is 1 and the lowest rank is 5. The rank should correspond to the relative contribution of that variable with the frequency of gene flow. Please explain your rationale or provide additional variables, and circle or identify the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*
   - Elevation 5
   - Distance between populations 1
   - Plant association 7
   - River corridor or watershed 6
   - Size of local plant population 2
   - Soils 3
   - rainfall 4

I could easily swap "Distance" and "Population size". Very close Density of Patch size likely plays a huge role in gene flow.

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b) *P. scariosus* var. *albifluvis:*

- Elevation 5
- Distance between populations 1
- Plant association 7
- River corridor or watershed 6
- Size of local plant population 2
- soils 3
- rainfall 4

Ditto to *P. grahamii*

rainfall/elevation highly correlated

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Space to Provide Additional Information on the Topics We Discussed Today:

Expert Panel Workshop Conducted for
White River and Graham's beardtongues
U.S. Fish and Wildlife Service
June 2, 2017
Vernal, Utah

Questionnaire

Your Name and Affiliation: Mikel Stevens, BYU

Your experience with *Penstemon grahamii* and *P. scariosus* var. *albifluvis* (specify type of research or evaluation, surveys, field experience, etc.):

Research focusing on genetic relationships in Penstemon and especially in P. scariosus. This includes field experience and laboratory genetic research.

Ecological Settings and Diversity

1. Is there a diversity of ecological settings within each taxon's range? If so, please explain the different settings and important distinctions between them. Circle the confidence category in the table below that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*

Geology seems to play the major role in where these species inhabit. Other species inhabit these areas but seem to play less of a roll in where grahamii + albibarbis inhabit.

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b) *P. scariosus* var. *albifluvis:*

ditto on what I stated in P. grahamii.

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2. What is the appropriate scale to evaluate the diversity of ecological conditions within each taxon's range? Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:*

I do not have the background to answer this question.

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b) *P. scariosus* var. *albifluvis:*

ditto to graham statement

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Phenotypic Variation

1. Is there phenotypic variation within each taxon's range? If so, please explain the variation and identify locations. Please try to assign the appropriate population number to each location. We may ask follow up questions to your answer after the meeting.

   b) *P. grahamii:*

- less experience with this species
- The flowers seem this year to be smaller than those seen in 2013. Also those seen this year are deeper Pink than those of 2013.

b) *P. scariosus* var. *albifluvis:*

The taxa has variation in leaf width across its range, from east to west. Plants on the Book Cliffs have appeared to be smaller than those of all other populations. Leaf color can vary from a deeper green to a blue green color.

Plants can be single stem with flowers, to plants with many sterile shoots.

Gene Flow

1. Identify potential geographic barriers and corridors for pollen movement and plant dispersal within each taxon's range. Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) P. grahamii:

No Data

Confidence Terminology	Explanation
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b) *P. scariosus* var. *albifluvis:*

We have a great deal of Data and these data are in the process of being analyzed and summarized for Publication.

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   a) *P. grahamii:*
   - Elevation 6
   - Distance between populations 1
   - Plant association 7
   - River corridor or watershed 4
   - Size of local plant population 2

   Soil Substrate 3
   Rain Fall 5

Confidence Terminology	Explanation
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b) *P. scariosus* var. *albifluvis:*

- Elevation 6
- Distance between populations 1
- Plant association 7
- River corridor or watershed 4
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Soil Substrate 3

Rain Fall 5

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Expert Panel Workshop Conducted for
White River and Graham's beardtongues
U.S. Fish and Wildlife Service
June 2, 2017
Vernal, Utah

Questionnaire

Your Name and Affiliation: Noel Holmgren New York Botanical Garden
Intermountain Flora

Your experience with *Penstemon grahamii* and *P. scariosus* var. *albifluvis* (specify type of research or evaluation, surveys, field experience, etc.):

I've written their descriptions and accommodated them in a key to Intermountain Flora. I also made the varietal placement of P. scariosus var. albifluvis.

Ecological Settings and Diversity

1. Is there a diversity of ecological settings within each taxon's range? If so, please explain the different settings and important distinctions between them. Circle the confidence category in the table below that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) P. grahamii:

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b) *P. scariosus* var. *albifluvis:*

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2. What is the appropriate scale to evaluate the diversity of ecological conditions within each taxon's range? Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*

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b) *P. scariosus* var. *albifluvis:*

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Phenotypic Variation

1. Is there phenotypic variation within each taxon's range? If so, please explain the variation and identify locations. Please try to assign the appropriate population number to each location. We may ask follow up questions to your answer after the meeting.

   b) P. grahamii:

Flower size: the terminal flower in a cyme develops before the lower flowers and it is slightly larger than the lower ones. Sometimes a second flowering during monsoon rains, the flowers seem to be smaller than those in the earlier season.

b) *P. scariosus* var. *albifluvis:*

Gene Flow

1. Identify potential geographic barriers and corridors for pollen movement and plant dispersal within each taxon's range. Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

    a) P. grahamii:

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b) *P. scariosus* var. *albifluvis:*

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2. Rank the importance of variables that appear to be associated with frequency of gene flow. The highest rank is 1 and the lowest rank is 5. The rank should correspond to the relative contribution of that variable with the frequency of gene flow. Please explain your rationale or provide additional variables, and circle or identify the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:* Not enough knowledge about area.

   - Elevation ___
   - Distance between populations ___
   - Plant association ___
   - River corridor or watershed ___
   - Size of local plant population ___

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Same deal as with P. grahamii

b) *P. scariosus* var. *albifluvis:*

- Elevation ___
- Distance between populations ___
- Plant association ___
- River corridor or watershed ___
- Size of local plant population ___

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Space to Provide Additional Information on the Topics We Discussed Today:

I see your distribution maps are more thorough than what I can develope from herbarium specimens, and I never see the results of your thorough population studies in scientific journals. Funding from NSF is impossible to get if results aren't made available in normal outlets.

Expert Panel Workshop Conducted for
White River and Graham's beardtongues
U.S. Fish and Wildlife Service
June 2, 2017
Vernal, Utah

Questionnaire

Your Name and Affiliation:

Robert Johnson, BYU, Stanly L Welsh Herbarium.

Your experience with *Penstemon grahamii* and *P. scariosus* var. *albifluvis* (specify type of research or evaluation, surveys, field experience, etc.):

Little experience w/ P. grahamii.

Experience w/ P. albifluvis – Plant distribution, morphology, interpretation of genetic structure relative to field / specimen observation / examination. Work with Mike Stevens to understand phylogenetic relationships w/ P. scariosus complex.

Ecological Settings and Diversity

1. Is there a diversity of ecological settings within each taxon's range? If so, please explain the different settings and important distinctions between them. Circle the confidence category in the table below that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*

NA

Confidence Terminology	Explanation
Highly Confident	I'm more than **90% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by documented accounts or research and/or is strongly consistent with accepted conservation biology principles.
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b) *P. scariosus* var. *albifluvis:*

There is diversity in elevation between metapopulations, though geology unifies them all. The Bookcliffs population is the most distinct relative to plant ~~popotatio~~ communities.

Overall low ecological diversity. Abundant similar habitat occurs where P. albifluvis is not found, especially in the large areas between metapopulations, suggesting there is more than just geology influencing ecological distribution

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2. What is the appropriate scale to evaluate the diversity of ecological conditions within each taxon's range? Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:*

NA

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b) *P. scariosus* var. *albifluvis:*

I think it is appropriate to use multiple scales to describe ecology to demonstrate where unifying elements are seen at large scales and distinction at finer scales.

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Phenotypic Variation

1. Is there phenotypic variation within each taxon's range? If so, please explain the variation and identify locations. Please try to assign the appropriate population number to each location. We may ask follow up questions to your answer after the meeting.

   b) P. grahamii:

   NA

b) *P. scariosus* var. *albifluvis:*

Phenotypic variation occurs, deviating ~~from~~ From a typical form with numerous sterile shoots & pale lavender flowers, thin, barely revolute leaves, to occassional to rare plants lacking sterile shoots, broader leaves, and flowers with white tube & throat.

The plants from the southern two metapopulations are more diverse in phenotypic characteristics ~~than~~ deviating from the typical form than the Northern metapopulation, though the Northern population does have sites where the ~~not~~ all the phynotypic extremes occur.

The ~~Book~~ Bookcliffs population is similar within itself, generally shorter plants, though it may be a ridge top effect. I need to review flower color variation here again when ~~pla~~ population is at peak flower. ~~Thes~~ This population flowers ~~after~~ much later than others.

Gene Flow

1. Identify potential geographic barriers and corridors for pollen movement and plant dispersal within each taxon's range. Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*

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b) *P. scariosus* var. *albifluvis:*

Defer to Dr. stevens & Wolfe

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2. Rank the importance of variables that appear to be associated with frequency of gene flow. The highest rank is 1 and the lowest rank is 5. The rank should correspond to the relative contribution of that variable with the frequency of gene flow. Please explain your rationale or provide additional variables, and circle or identify the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:*
      - Elevation ___
      - Distance between populations ___
      - Plant association ___
      - River corridor or watershed ___
      - Size of local plant population ___

NA

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b) *P. scariosus* var. *albifluvis:*

- Elevation 2 — 1
- Distance between populations 3 — 2
- Plant association 5 — 5
- River corridor or watershed 5 — 6
- Size of local plant population 3 — 3

Soil substrate — 4

Rainfall — ?

? – because part of #1

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Space to Provide Additional Information on the Topics We Discussed Today:

Recommend more pollination study
to determine pollination connectivity
via pollinator spp, pollinator habitat requirements,
travel distance, & phenology constraints etc.

Expert Panel Workshop Conducted for
White River and Graham's beardtongues
U.S. Fish and Wildlife Service
June 2, 2017
Vernal, Utah

Questionnaire

Your Name and Affiliation:

Sherel Goodrich USDA Forest Service – Retired

Your experience with *Penstemon grahamii* and *P. scariosus* var. *albifluvis* (specify type of research or evaluation, surveys, field experience, etc.):

Low level of experience –

Ecological Settings and Diversity

1. Is there a diversity of ecological settings within each taxon's range? If so, please explain the different settings and important distinctions between them. Circle the confidence category in the table below that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:* is mostly confined to semi barrens of the Green River Formation within the desert shrub and pinyon-juniper belts. Compared to some other penstemons that occupy various geological strata, P. grahamii is not a plant of diverse ecological settings.

4 of the 9 swReGAP types with P. grahamii have 80% of the total population.

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b) *P. scariosus* var. *albifluvis:* All I know of this plant is that it is found on Green River Shale in Uintah Co. UT.

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2. What is the appropriate scale to evaluate the diversity of ecological conditions within each taxon's range? Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

a) *P. grahamii:* NO Comment

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b) *P. scariosus* var. *albifluvis:*

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Phenotypic Variation

1. Is there phenotypic variation within each taxon's range? If so, please explain the variation and identify locations. Please try to assign the appropriate population number to each location. We may ask follow up questions to your answer after the meeting.

   b) *P. grahamii:* No comment

b) *P. scariosus* var. *albifluvis:*

ND comment

Gene Flow

1. Identify potential geographic barriers and corridors for pollen movement and plant dispersal within each taxon's range. Please explain your rationale and circle the confidence category that best describes the degree of certainty you assign to each response. We may ask follow up questions to your answer after the meeting.

   a) *P. grahamii:* No comment

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b) *P. scariosus* var. *albifluvis:*

NO comment

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   a) *P. grahamii:*
      - Elevation ___
      - Distance between populations ___
      - Plant association ___
      - River corridor or watershed ___
      - Size of local plant population ___

NO Comment

Confidence Terminology	Explanation
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b) *P. scariosus* var. *albifluvis:*

- Elevation ___
- Distance between populations ___
- Plant association ___
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No comment

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Space to Provide Additional Information on the Topics We Discussed Today:

APPENDIX D: Presentation of photographs by Dr. Robert Johnson and Dr. Mikel Stevens (BYU)

APPENDIX E: Presentation about White River beardtongue preliminary genetic study results by Dr. Mikel Stevens (BYU)

Unraveling the *Penstemon scariosus* complex using molecular markers – an update

M.R. Stevens, R.L. Johnson, L.A. Johnson, M.D. Robbins, C.D. Anderson, N.J. Ricks and K.M. Farley

Unraveling the *Penstemon scariosus* complex

- A Utah Flora
  - *P. scariosus* var. *albifluvis*
  - *P. scariosus* var. *cyanomontanus*
  - *P. scariosus* var. *garrettii*
  - *P. scariosus* var. *scariosus*
  - *P. scariosus* var. ??? = *P. fremontii* var. *glabrescens*

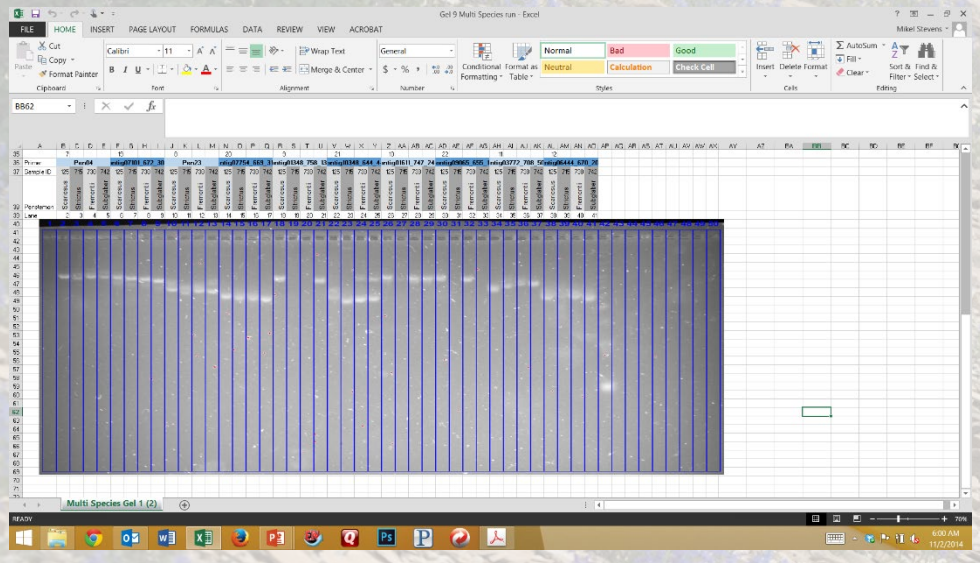
East side of the road

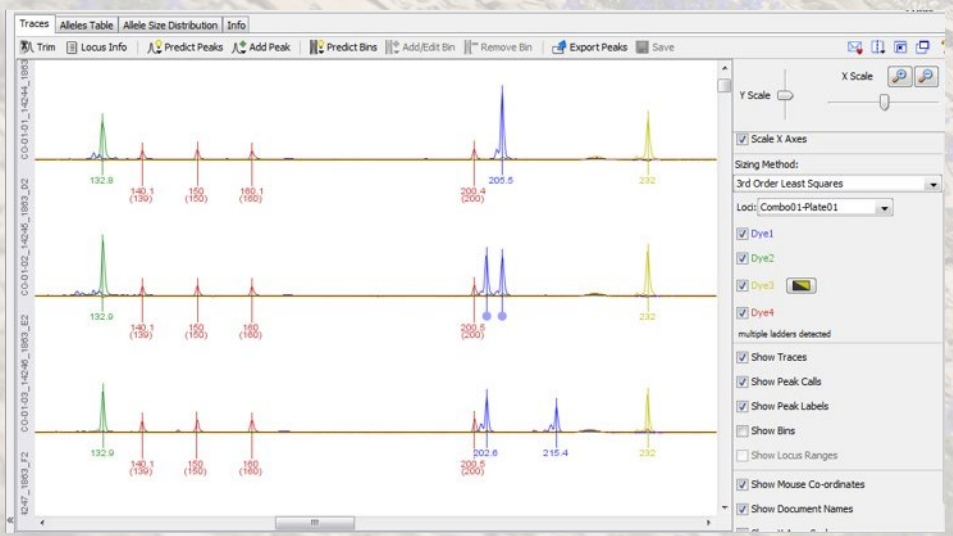
An example of the Issue…

And why study *P. scariosus*…

West side of the road

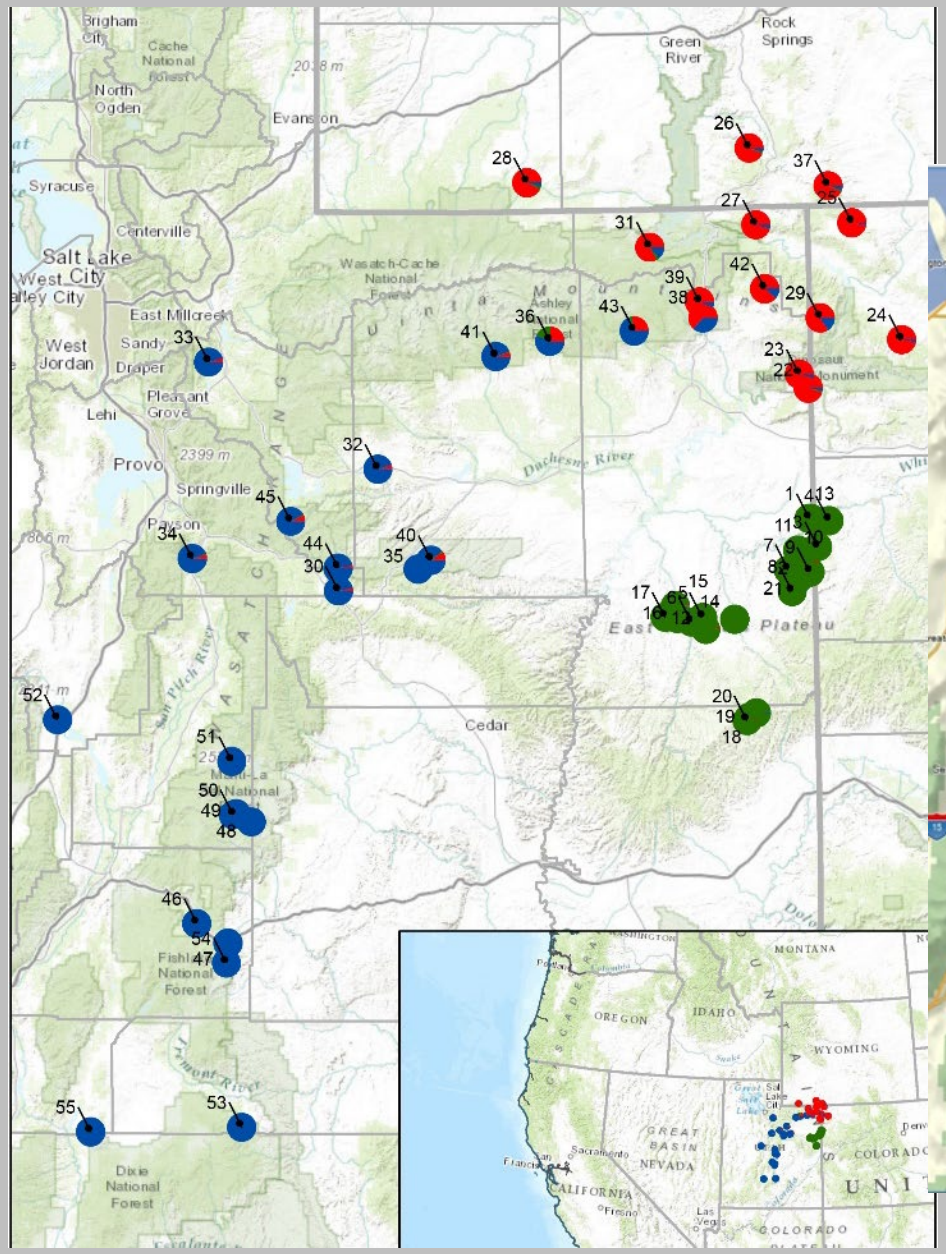
SSR aspect of the study



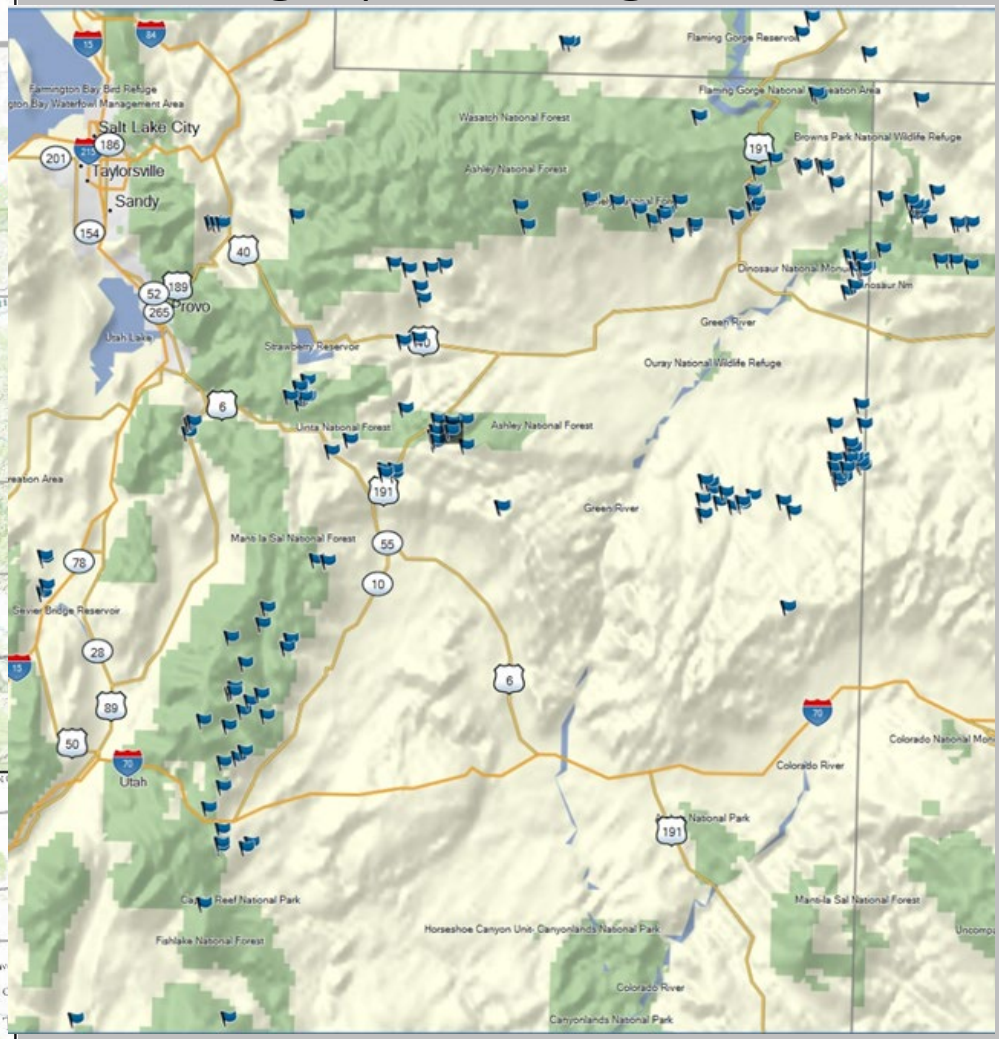


- Started with 192 candidate SSR
  - Validated possible efficacy on agarose gels
- 17 markers selected for florescent labeling
  - One marker proved to be problematic when fluorescently labeled
- Used 10 of these markers to study the genetic diversity of *P. scariosus*

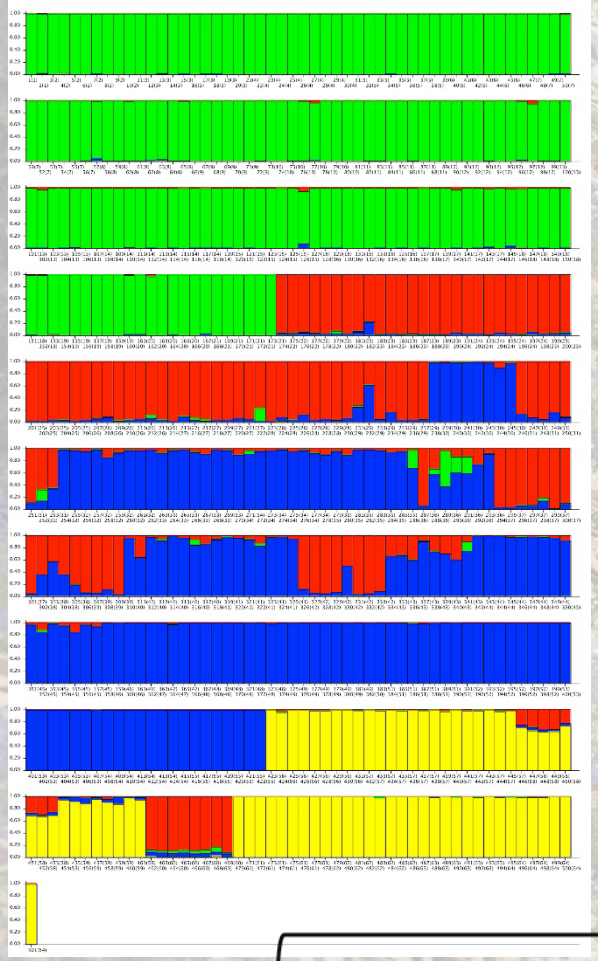
P. scariosus Complex Geographic Range



2013/14 study collections sites (~55 locations)



Reported herbarium collections sites



P. scariosus

var. *albifluvis*

var. *cyanomontanus*

var. *garrettii*

var. *scariosus*

P. comarrhenus

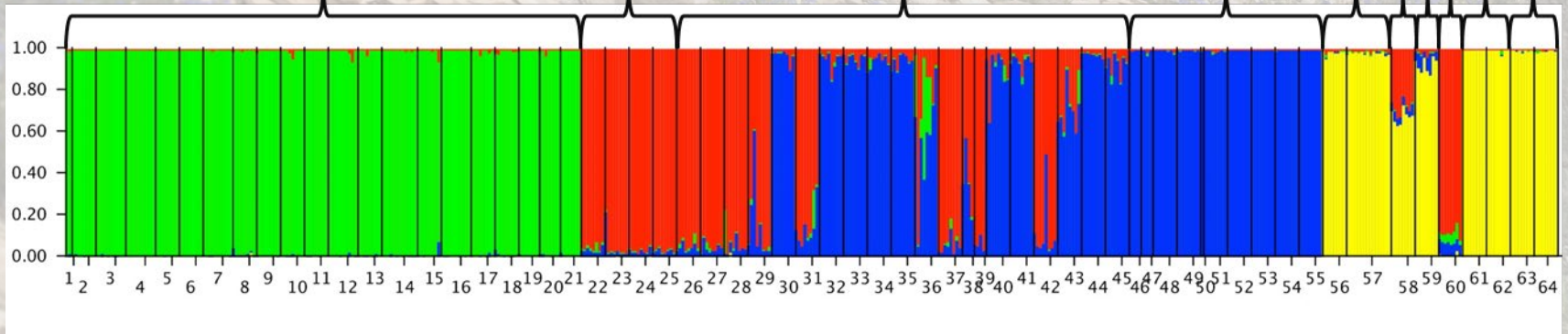
P. compactus

P. cyananthus

P. gibbensii

P. strictus

P. subglaber



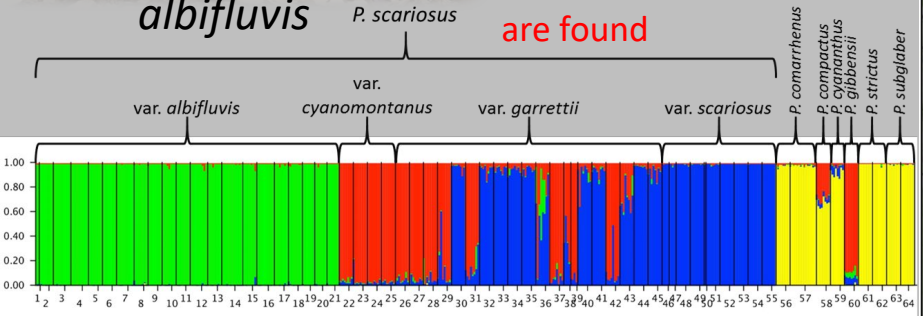
garrettii

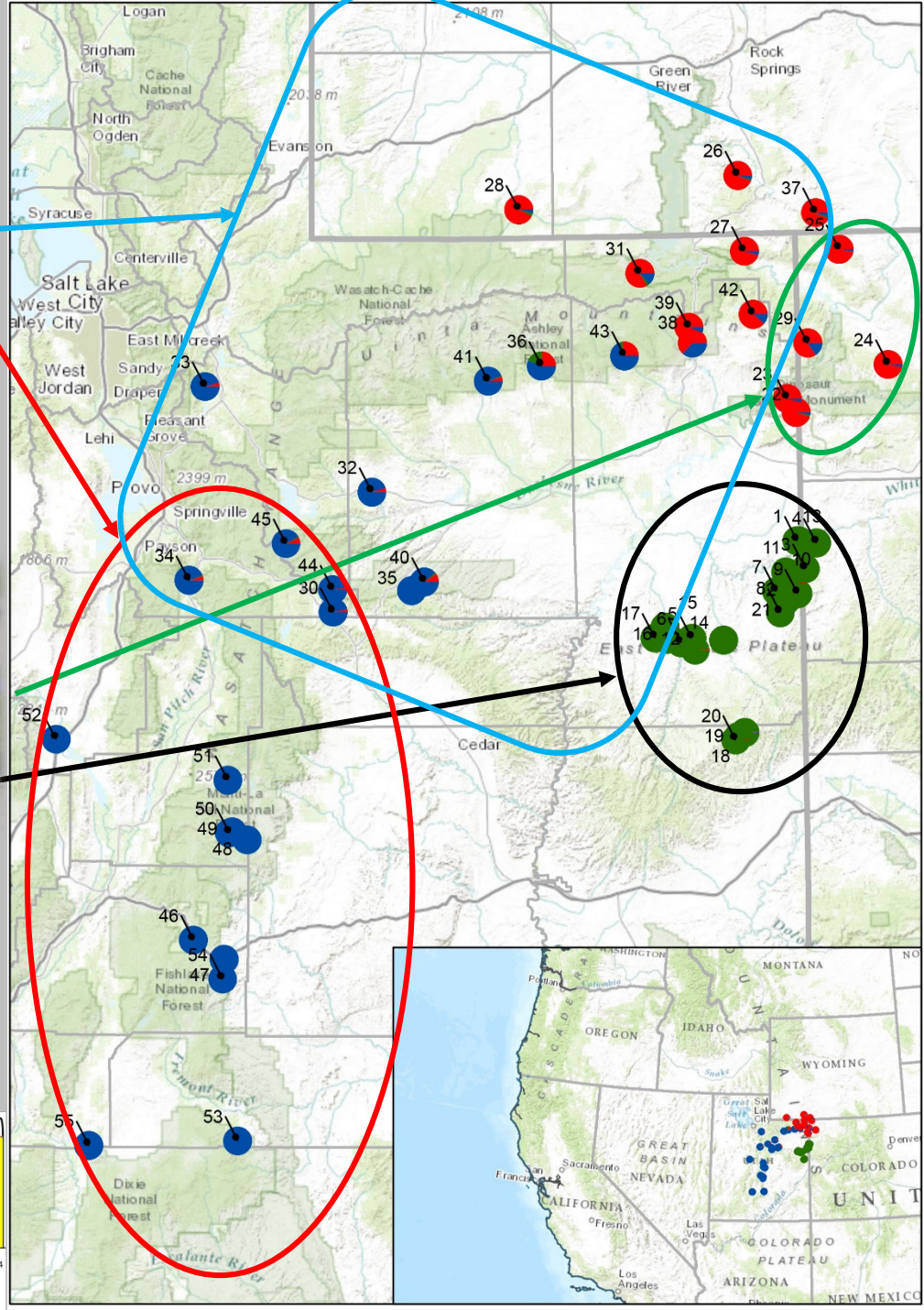
scariosus

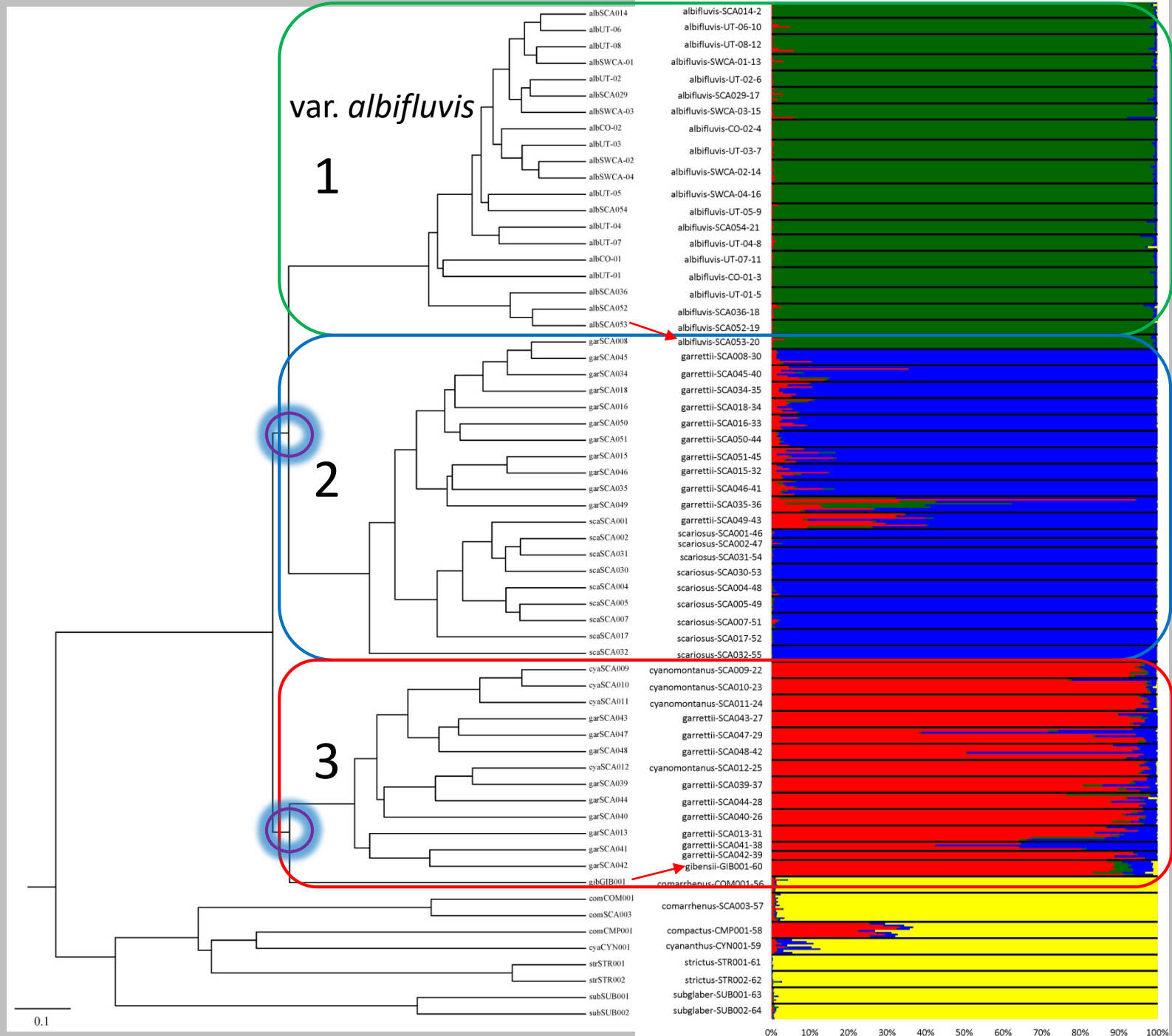
cyanomontanus

albifluvis

A Utah Flora description of where *P. scariosus* varieties are found

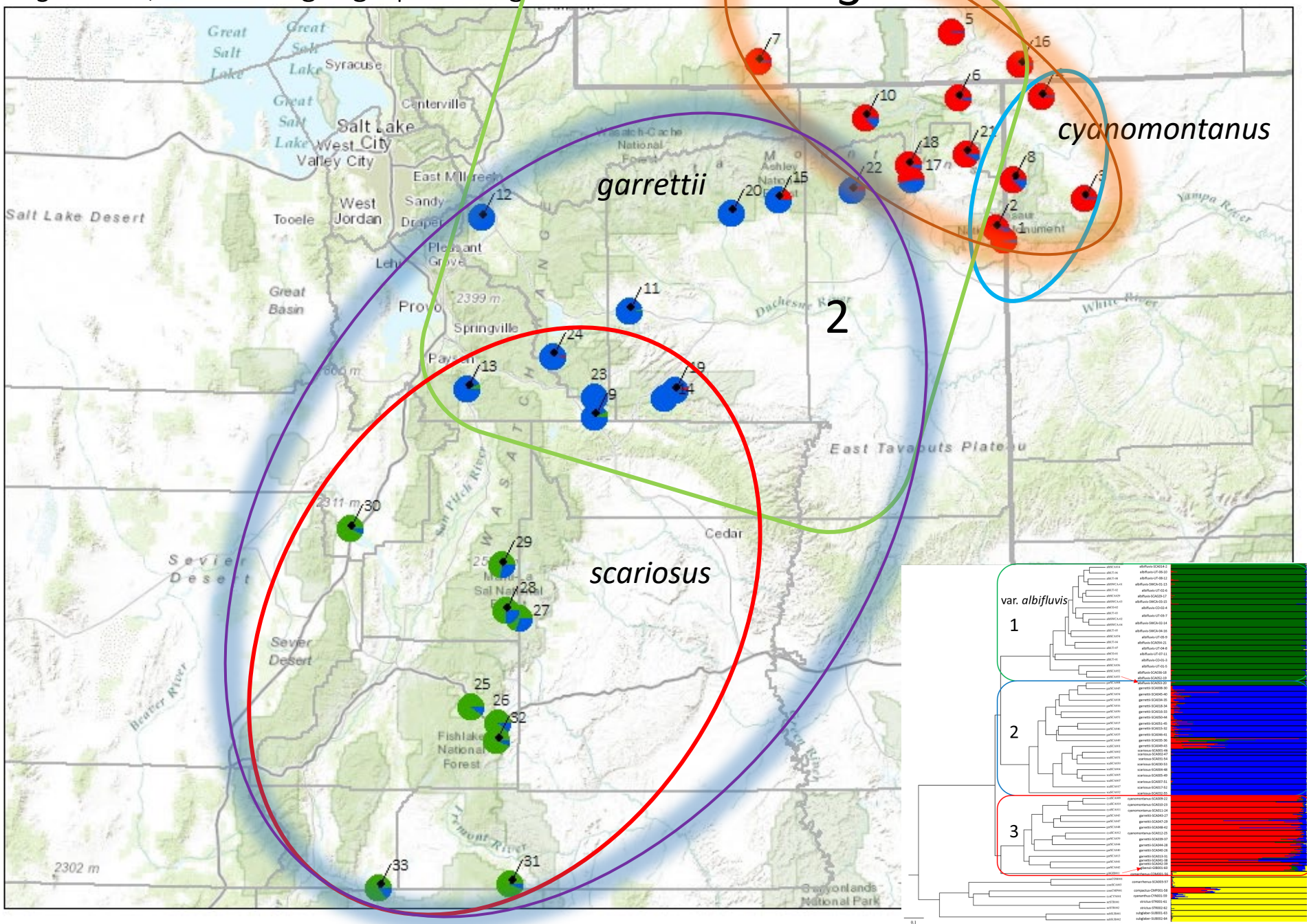




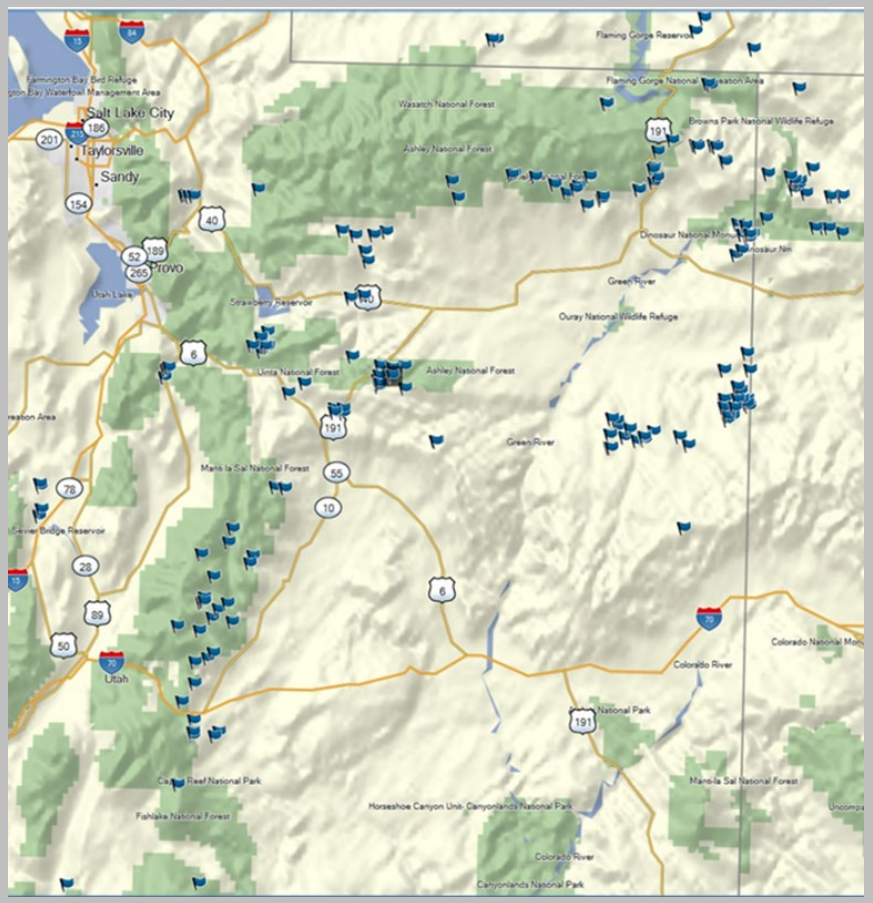

var. albifluvis
1
2
3
albSCA014
albUT-06
albUT-08
albSWCA-01
albUT-02
albSCA029
albSWCA-03
albCO-02
albUT-03
albSWCA-02
albSWCA-04
albUT-05
albSCA054
albUT-04
albUT-07
albCO-01
albUT-01
albSCA036
albSCA052
albSCA053
garSCA008
garSCA045
garSCA034
garSCA018
garSCA016
garSCA050
garSCA051
garSCA015
garSCA046
garSCA035
garSCA049
scaSCA001
scaSCA002
scaSCA031
scaSCA030
scaSCA004
scaSCA005
scaSCA007
scaSCA017
scaSCA032
cyaSCA009
cyaSCA010
cyaSCA011
garSCA043
garSCA047
garSCA048
cyaSCA012
garSCA039
garSCA044
garSCA040
garSCA013
garSCA041
garSCA042
gibGIB001
comCOM001
comSCA003
comCMP001
cyaCYN001
strSTR001
strSTR002
subSUB001
subSUB002
albifluvis-SCA014-2
albifluvis-UT-06-10
albifluvis-UT-08-12
albifluvis-SWCA-01-13
albifluvis-UT-02-6
albifluvis-SCA029-17
albifluvis-SWCA-03-15
albifluvis-CO-02-4
albifluvis-UT-03-7
albifluvis-SWCA-02-14
albifluvis-SWCA-04-16
albifluvis-UT-05-9
albifluvis-SCA054-21
albifluvis-UT-04-8
albifluvis-UT-07-11
albifluvis-CO-01-3
albifluvis-UT-01-5
albifluvis-SCA036-18
albifluvis-SCA052-19
albifluvis-SCA053-20
garrettii-SCA008-30
garrettii-SCA045-40
garrettii-SCA034-35
garrettii-SCA018-34
garrettii-SCA016-33
garrettii-SCA050-44
garrettii-SCA051-45
garrettii-SCA015-32
garrettii-SCA046-41
garrettii-SCA035-36
garrettii-SCA049-43
scariosus-SCA001-46
scariosus-SCA002-47
scariosus-SCA031-54
scariosus-SCA030-53
scariosus-SCA004-48
scariosus-SCA005-49
scariosus-SCA007-51
scariosus-SCA017-52
scariosus-SCA032-55
cyanomontanus-SCA009-22
cyanomontanus-SCA010-23
cyanomontanus-SCA011-24
garrettii-SCA043-27
garrettii-SCA047-29
garrettii-SCA048-42
cyanomontanus-SCA012-25
garrettii-SCA039-37
garrettii-SCA044-28
garrettii-SCA040-26
garrettii-SCA013-31
garrettii-SCA041-38
garrettii-SCA042-39
gibensii-GIB001-60
comarrhenus-SCA003-57
compactus-CMP001-58
cyananthus-CYN001-59
strictus-STR001-61
strictus-STR002-62
subglaber-SUB001-63
subglaber-SUB002-64
0.1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

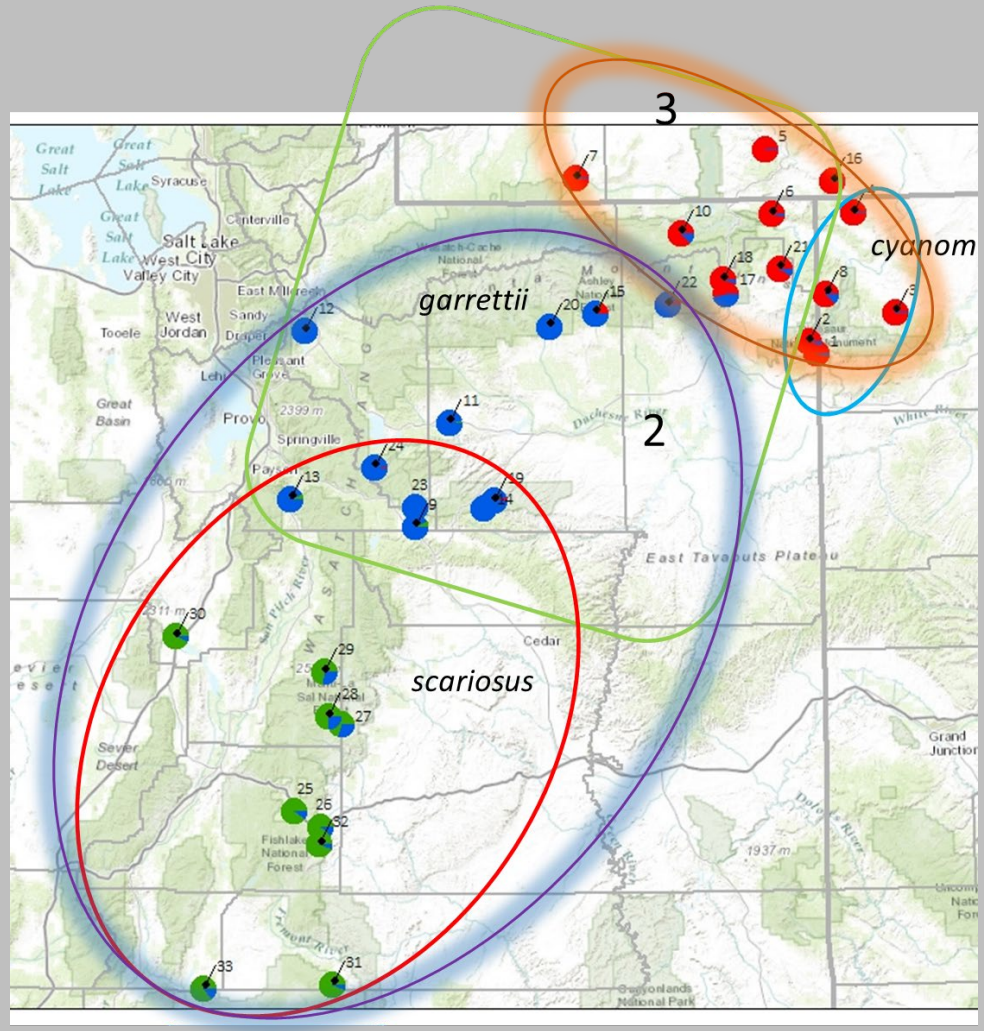
P. scariosus var. *albifluvis* geographic range

P. scariosus var. *cyanomontanus*, *garrettii*, *scariosus* geographic range

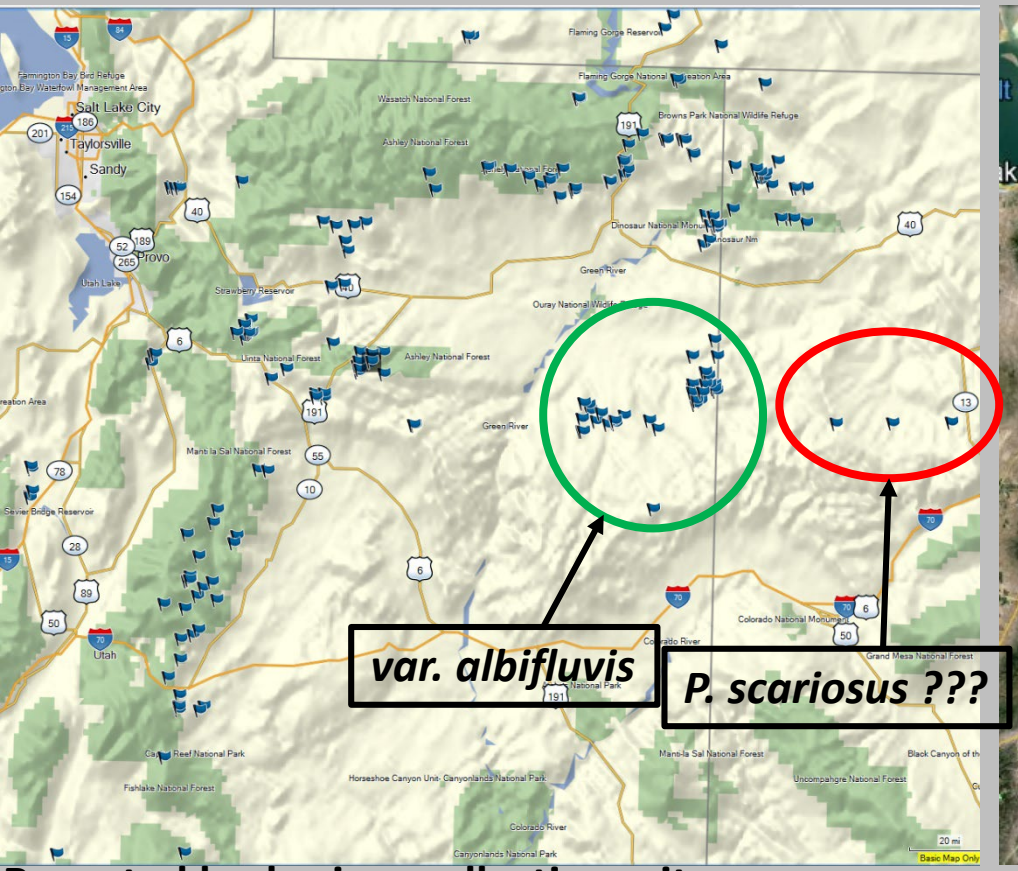


Comparison


Salt Lake City
Taylorsville
Sandy
Provo
Wasatch National Forest
Ashley National Forest
Uinta National Forest
Manti-La Sal National Forest
Dinosaur National Monument
Ouray National Wildlife Refuge
Browns Park National Wildlife Refuge
Flaming Gorge Reservoir
Strawberry Reservoir
Green River
Colorado River
Capitol Reef National Park
Canyonlands National Park
Fishlake National Forest
Utah

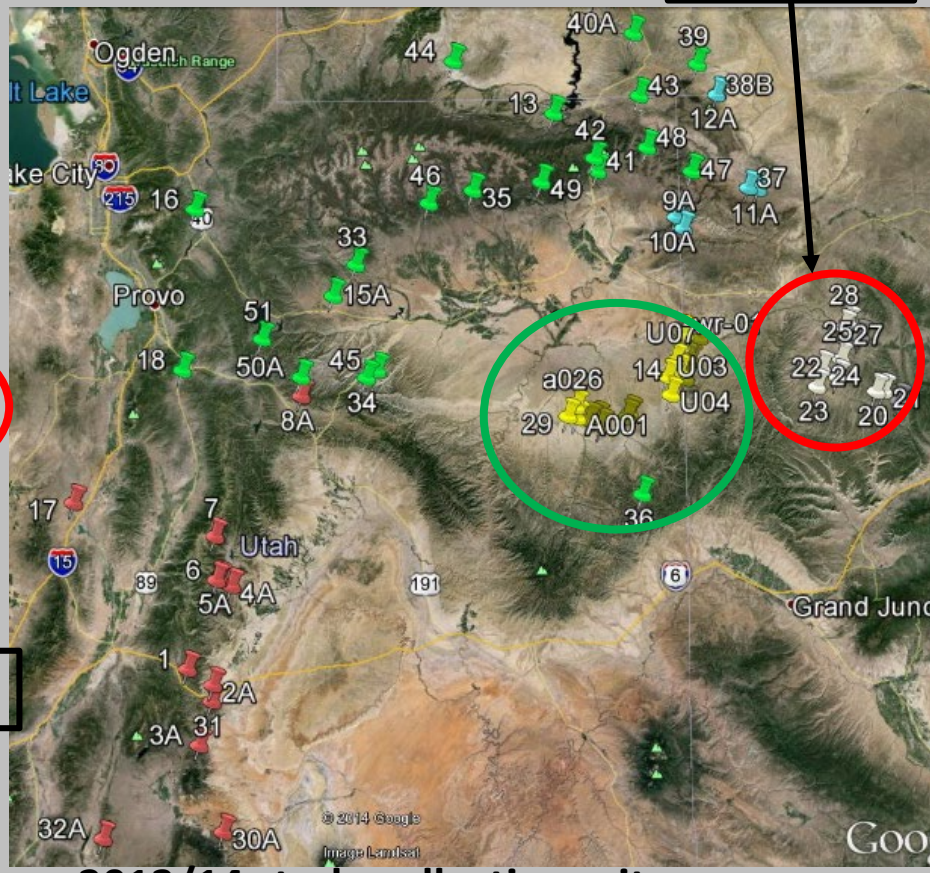

3
2
garrettii
scariosus
cyanom
Salt Lake City
West Valley City
Sandy
West Jordan
Tooele
Provo
Springville
Great Basin
Great Salt Lake
Cedar
Sevier Desert
East Tavaputs Plateau
Grand Junction
Canyonlands National Park

Collected 65 sites



Reported herbarium collections sites

Piceance Basin area

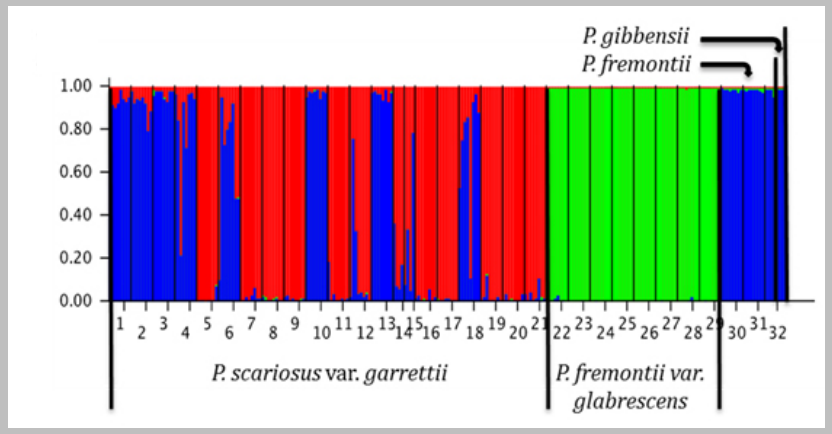


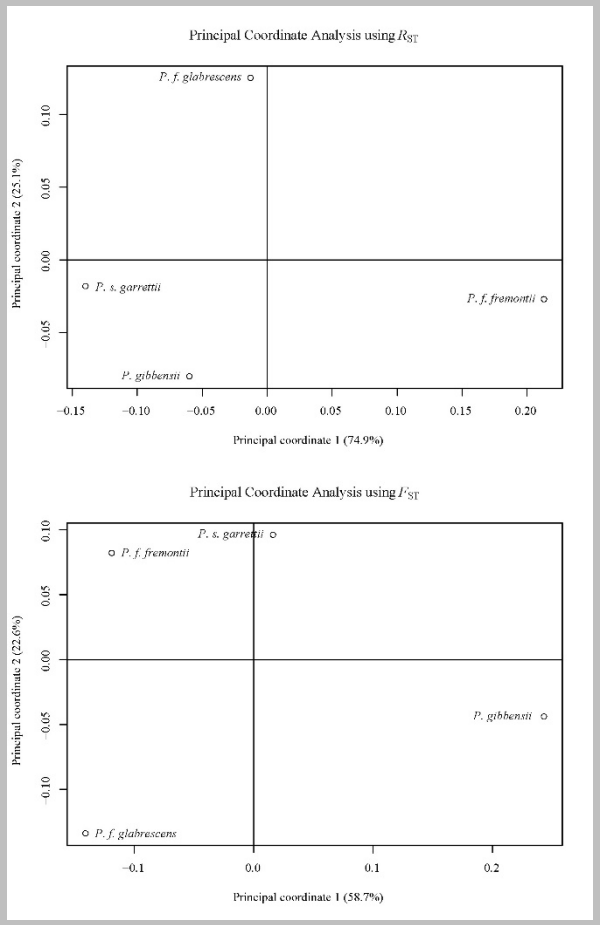
2013/14 study collections sites

Penstemon fremontii var. *glabrescens*???

- Six mislabeled specimens in the BYU herbarium
  - 2 labeled *P. scariosus*
  - 4 labeled *P. gibbensii*
- All had hirtellous stem hairs, a trait not found in *P. scariosus*
- Colorado Flora: Western Slope (Weber and Wittmann 2012
  - "In our opinion, this variety is not closely related to *P. fremontii* and it might be better placed, as a species, closer to the peripheral *P. scariosus* and *P. gibbensii*."

Penstemon luculentus





APPENDIX F: Presentation about White River beardtongue genetic study preliminary results by Dr. Andrea Wolfe (Ohio State University)

Population genetics and delimitation of *Penstemon scariosus* species complex

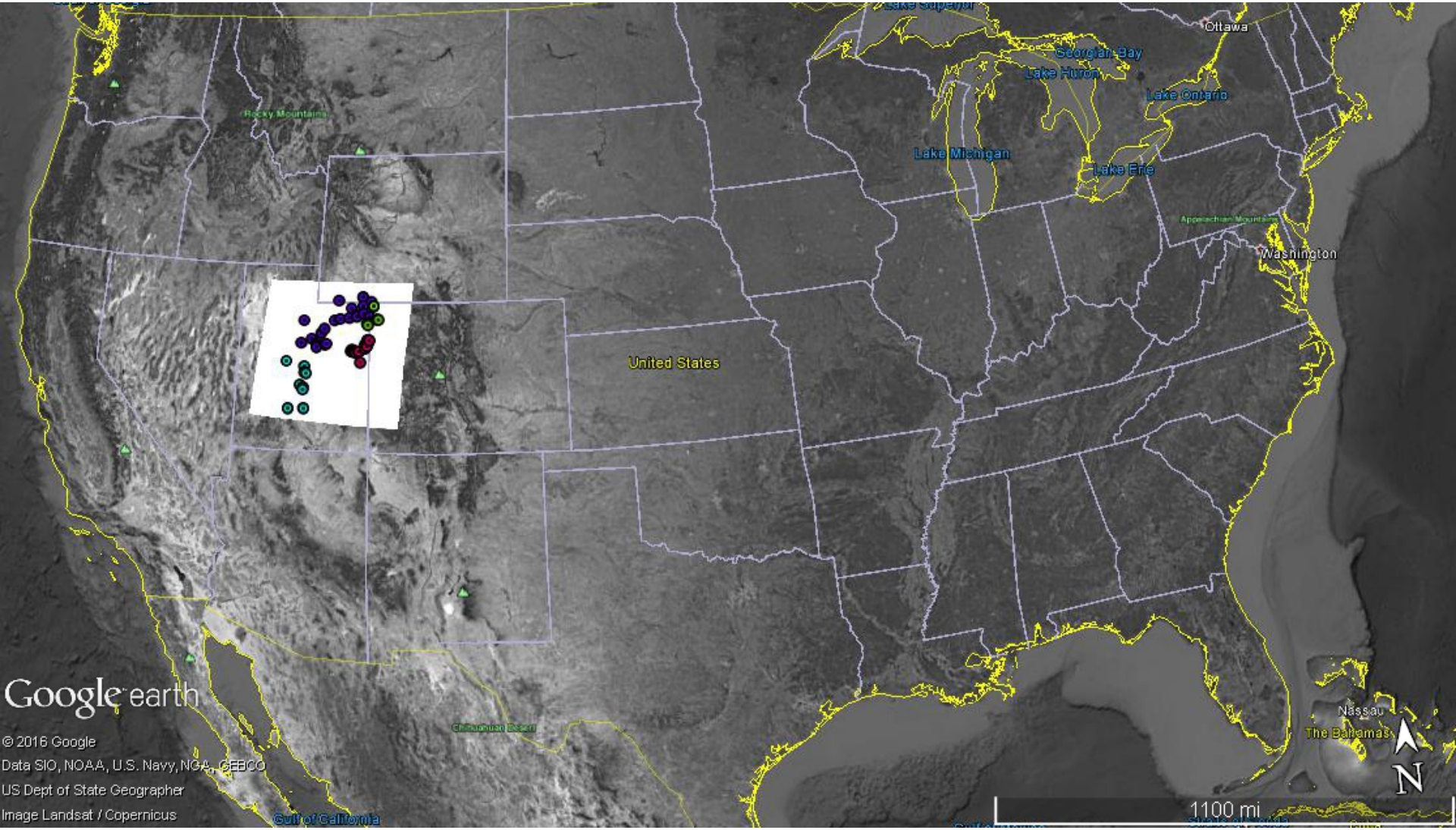
Rodriguez-Pena et al. 2017

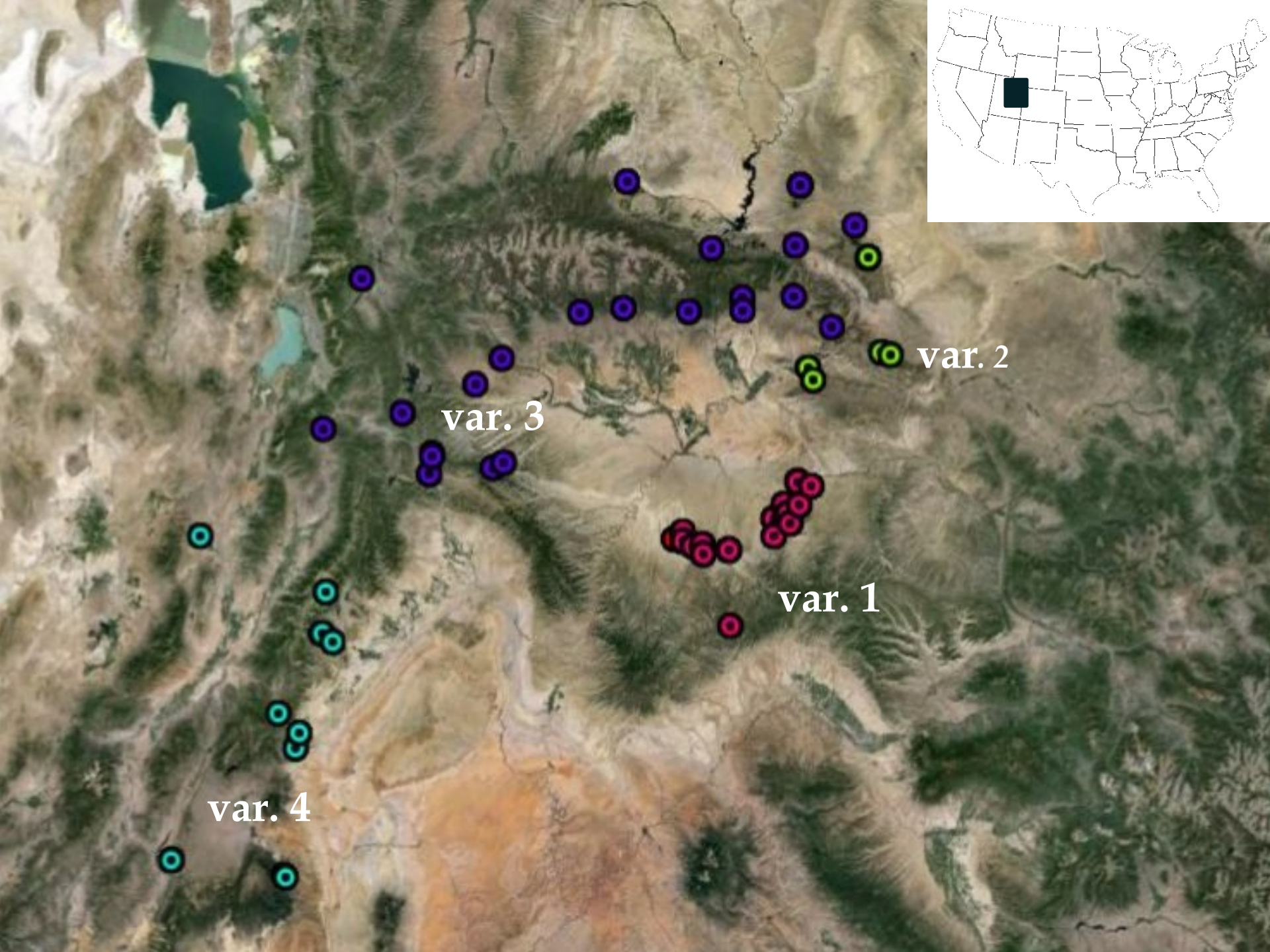
Penstemon scariosus complex

- Four varieties very morphologically similar
  - P. scariosus var. albifluvis for now forward var. 1
    - Endemic to oil shale, shale barrens
  - P. scariosus var. cyanomontanus for now forward var. 2
    - Present in sandstone and quartzite substrate
  - P. scariosus var. garrettii for now forward var. 3
    - Travertine rocks
  - P. scariosus var. scariosus for now forward var. 4
- Their environment is threatened by human activities
  - Energy development




Distribution Map




var. 2
var. 3
var. 1
var. 4

Research questions and motivation

1. Are the varieties distinguishable at the genetic level?
   - Varieties are very similar and they are mostly identify by their distribution
   - Conservation implications
2. What is the appropriate sample size in a population genetic study?
   - We collected all the known individuals and can estimate what is the smaller sample size that we can collect and still make good predictions
3. Do the different markers tell different stories?
   - Some markers affordable and less time consuming than others

Methods

- Sampling
  - We sampled all the known individuals in all the known populations, 561 total
  - 561 individuals AFLP and 421 individual Microsat
- Analysis
  - Population genetics statistics and genetic structure
- Comparison AFLP-Microsat
  - 421 individuals
  - The same individuals were sampled from AFLP and Microsat

Table 1. Sampling distribution of *Penstemon scariosus* varieties.

Species Name	Populations and individuals	Number of individuals used for AFLP	Number of individuals used for Microsatellite
P. scariosus albifluvis	228	228	172
P. scariosus cyanomontanus	56	56	32
P. scariosus garretii	188	188	152
P. scariosus scariosus	89	89	65
Total	561	561	421

Table 2. *Penstemon scariosus* genetic statistics based on microsatellite data

Pop	A	Ho	He	uHe	np	nds	P	Fis	Nig	LDL
Var 1	12	0.572	0.74	0.741	13	8	100	0.23	0	44
Var 2	9	0.633	0.79	0.791	4	4	100	0.20	0	21
Var 3	15	0.569	0.8	0.798	24	8	100	0.29	0	84
Var 4	10	0.465	0.74	0.740	7	7	100	0.37	0	74
Mean	11	0.56	0.77	0.767	12	7	100	0.27	0	56

Population genetic statistics are coded as follows: ***P***, percentage of polymorphic loci; ***n*p**, number of private alleles; ***A***, average number of alleles per locus; ***Ho***, observed heterozygosity; ***He***, expected heterozygosity; **uHe**, unbiased expected heterozygosity; ***n*ds**, number of loci that deviate significantly from HWE ($P < 0.05$); ***F*is**, inbreeding coefficient; ***Nig***, number of identical genotype pairs; **LDL**, percentage of paired loci showing significant linkage disequilibrium ($P<0.05$).

Table 5. AFLP AFLP Population genetic statistics

Species	Na	He	uHe	P	np	Fis	Nig
Var 1	1.155	0.064	0.064	57.760	55	0.48	0
Var 2	0.045	0.065	0.065	38.980	14	0.44	0
Var 3	0.780	0.082	0.082	73.880	89	0.30	0
Var 4	0.044	0.064	0.064	55.710	33	0.56	4
Mean	0.506	0.069	0.069	56.580	48	0.445	1

Population genetic statistics are coded as follows: ***P***, percentage of polymorphic loci; ***n*p**, number of private alleles; ***Na***, average number of alleles per locus; ***He***, expected heterozygosity; uHe, unbiased expected heterozygosity ***Fis***, inbreeding coefficient; ***Nig***, number of identical genotype pairs.

Table 7. Average inbreeding coefficient estimates for *P. scariosus* species complex (561 indi)

α, β are parameters of the prior beta distribution used to infer about F, 95 % CI, LogL is the average log-likelihood of data across the Markov Chain; in between parenthesis is the standard deviation of the log-likelihood.

α, β	Fis	95% CI	LogL
Var 1			
0.1	0.4820	[0.4162, 0.5479]	-15708.801(13.003)
1	0.4832	[0.4189, 0.5480]	-15706.845(12.576)
5	0.4854	[0.4186, 0.5512]	-15707.169(12.466)
Mean	0.4835		
Var 2			
0.1	0.4363	[0.3093, 0.5654]	-3588.232(9.699)
1	0.4371	[0.3127, 0.5670]	-3587.871(9.651)
5	0.4380	[0.3111, 0.5682]	
Mean	0.4371		
Var 3			
0.1	0.2974	[0.2303, 0.3699]	-17725.964(14.443)
1	0.3015	[0.2338, 0.3720]	-17726.103(14.260)
5	0.2980	[0.2334, 0.3659]	-17725.273(14.475)
Mean	0.2990		
Var 4			
0.1	0.5647	[0.4612, 0.6642]	-6513.917(11.959)
1	0.5602	[0.4553, 0.6617]	-6514.243(11.862)
5	0.5647	[0.4599, 0.6674]	-6514.854(11.916)
Mean	0.5632		

Table 3. Microsatellite Lower diagonal number of migrant per generation and upper diagonal Fst values

Var 1	Var 2	Var 3	Var 4	
0	0.110	0.102	0.157	Var 1
4.539	0	0.063	0.141	Var 2
4.909	7.928	0	0.056	Var 3
3.179	3.552	8.916	0	Var 4

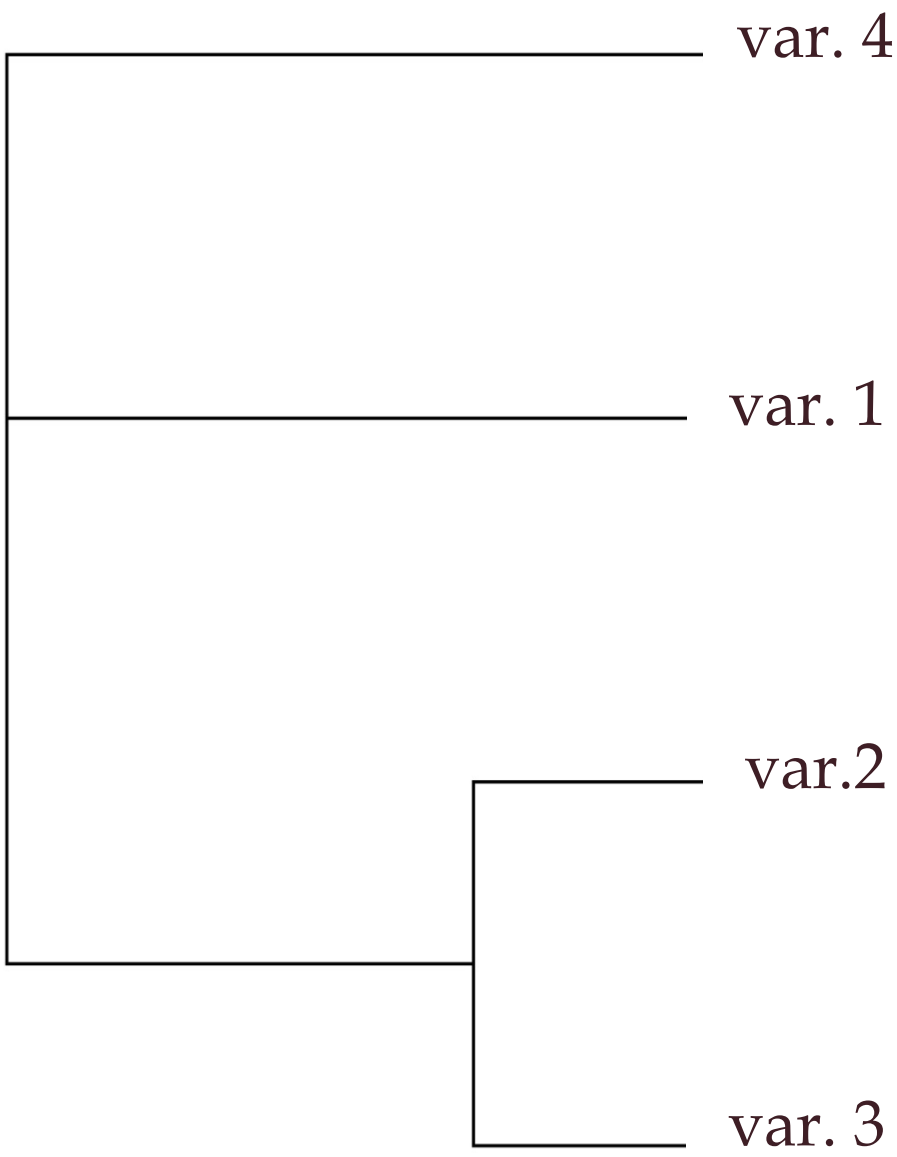
Table 4. Microsatellite Nei Genetic Distance lower diagonal and Genetic differentiation (PhiPT) upper diagonal

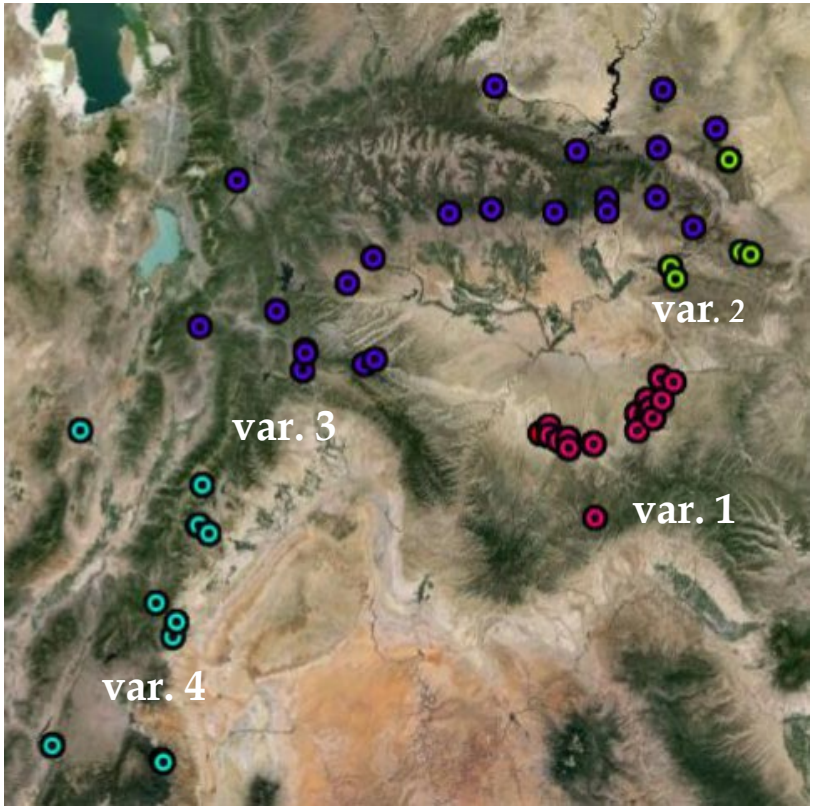
Var 1	Var 2	Var 3	Var 4	
0	0.142	0.131	0.185	Var 1
0.449	0	0.084	0.162	Var 2
0.413	0.319	0	0.072	Var 3
0.607	0.638	0.225	0	Var 4

Table 6. AFLP Nei Genetic Distance lower diagonal and Genetic differentiation (PhiPT) upper diagonal

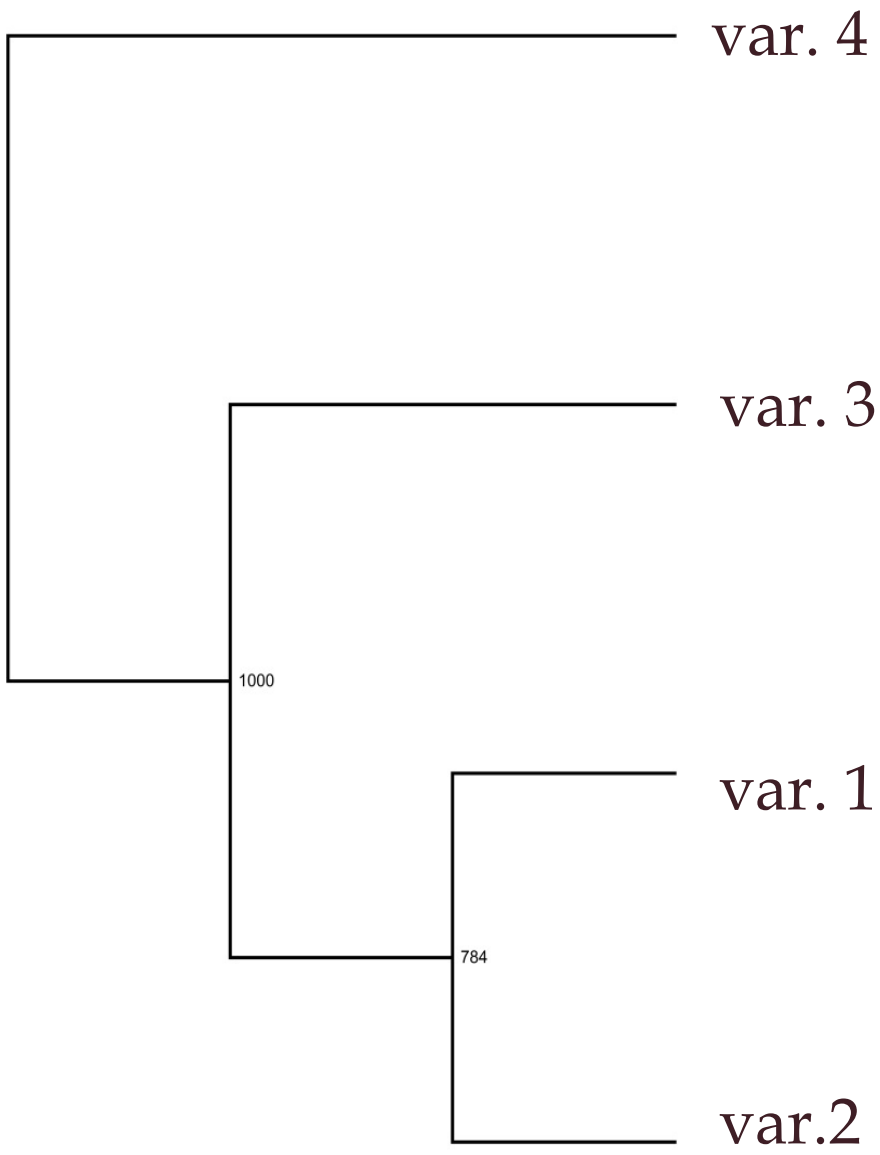
Var 1	Var 2	Var 3	Var 4	
0	0.100	0.224	0.151	Var 1
0.005	0	0.230	0.161	Var 2
0.013	0.015	0	0.160	Var 3
0.007	0.008	0.010	0	Var 4

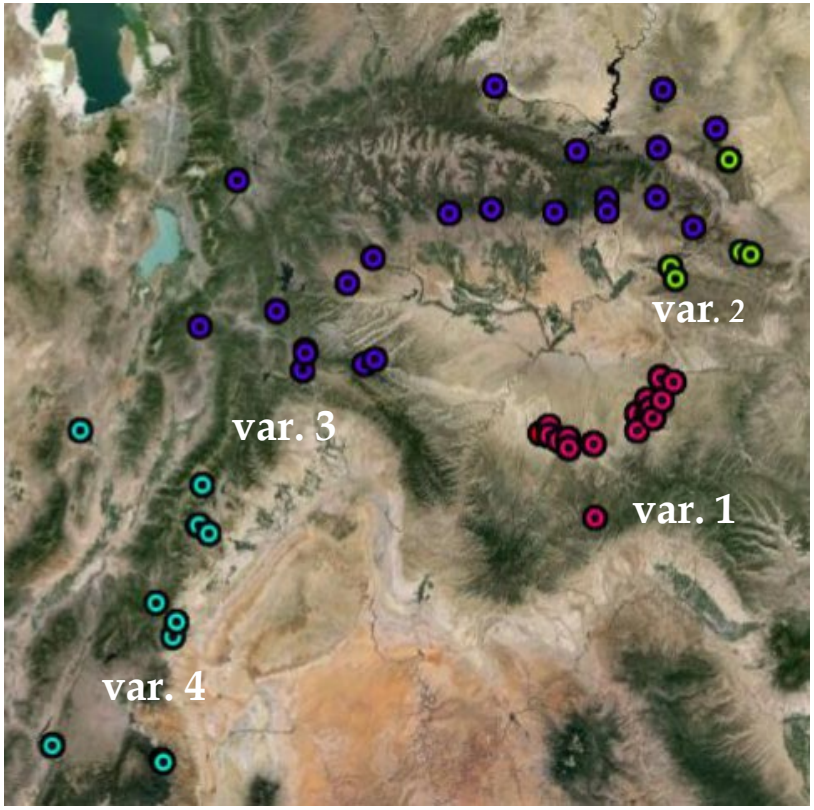
Neighbor joining tree- AFLP





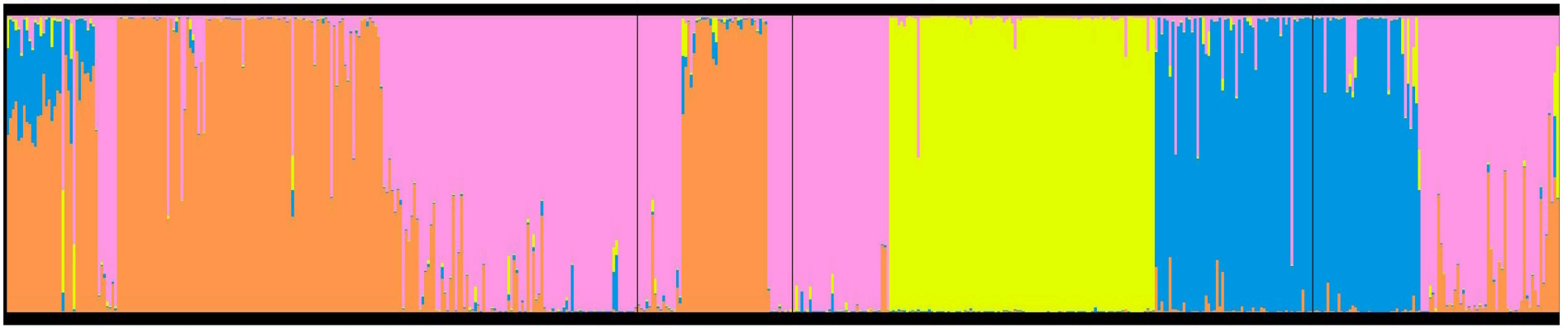
Neighbor joining tree- microsat





Population Structure AFLP

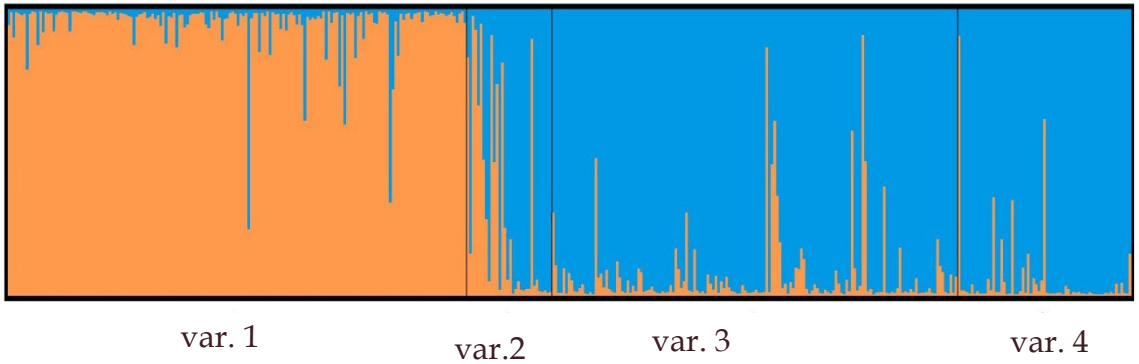
- Structure: Bayesian approach to individual assignments
- Computes the proportion of the genome of an individual originating from each inferred population
- Four clusters "true" K=4 were identify
- All populations are highly admixed

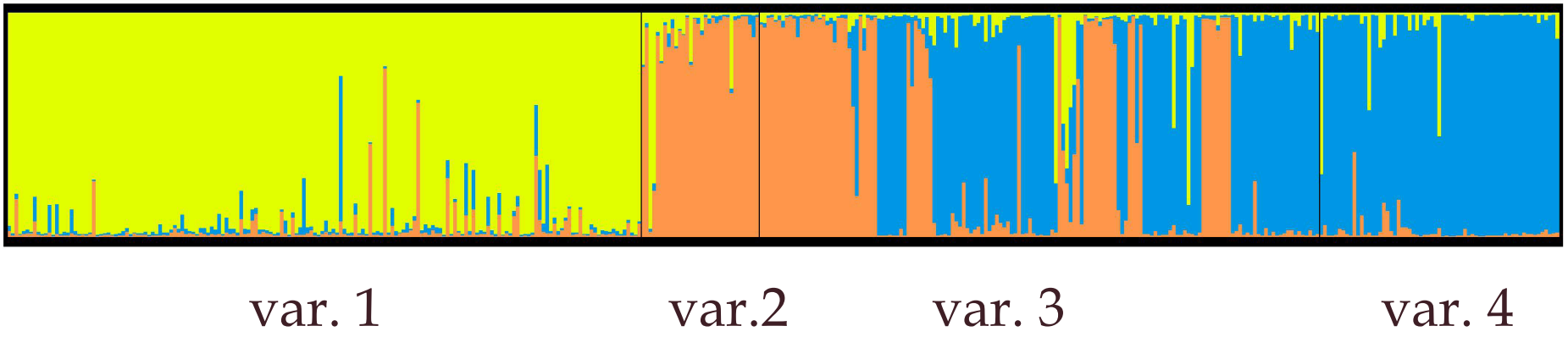


var. 1 var.2 var. 3 var. 4

Population Structure microsat

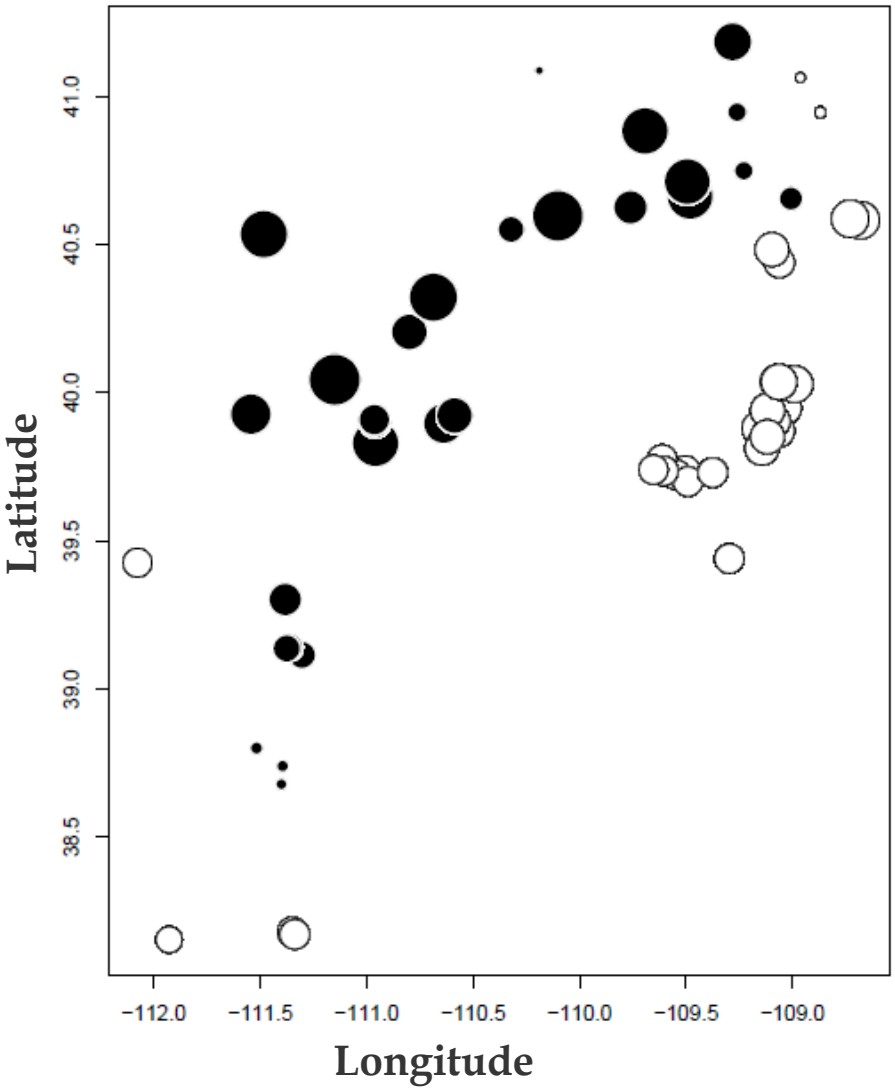
- The most likely value of K was two follow by three

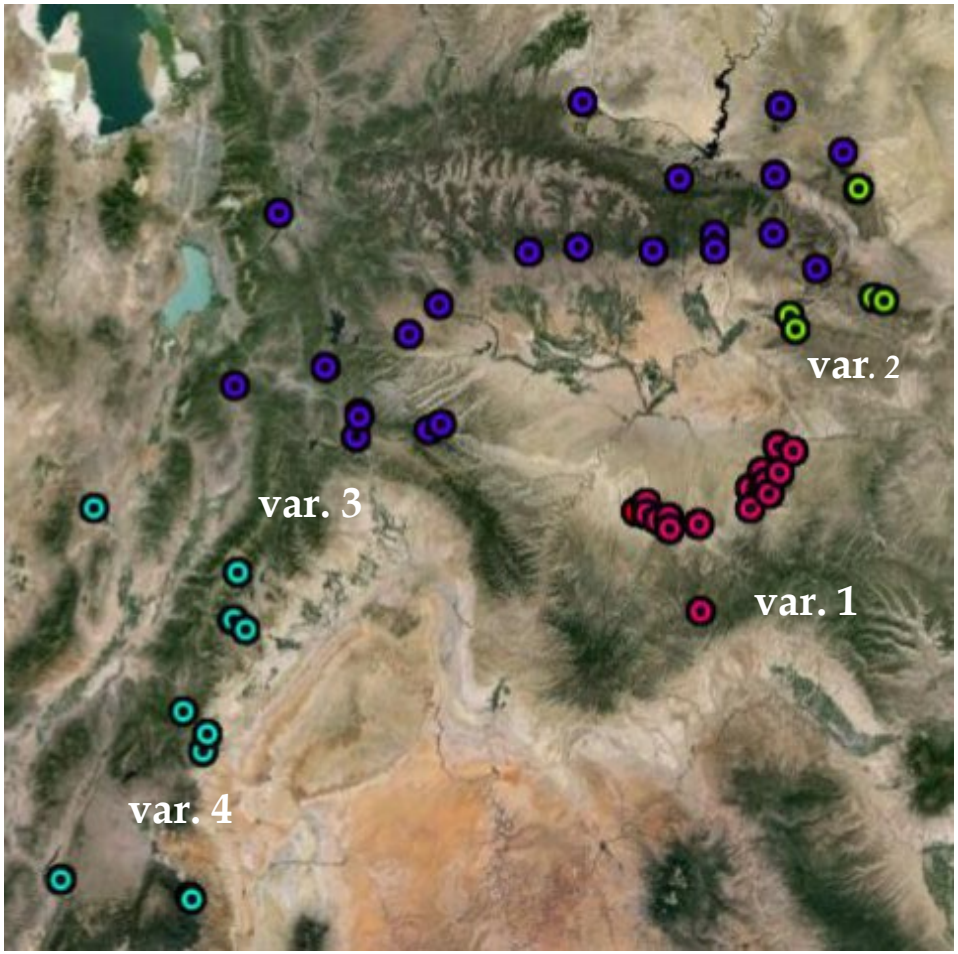




Spatial pattern detection in genetic distance data-AFLP

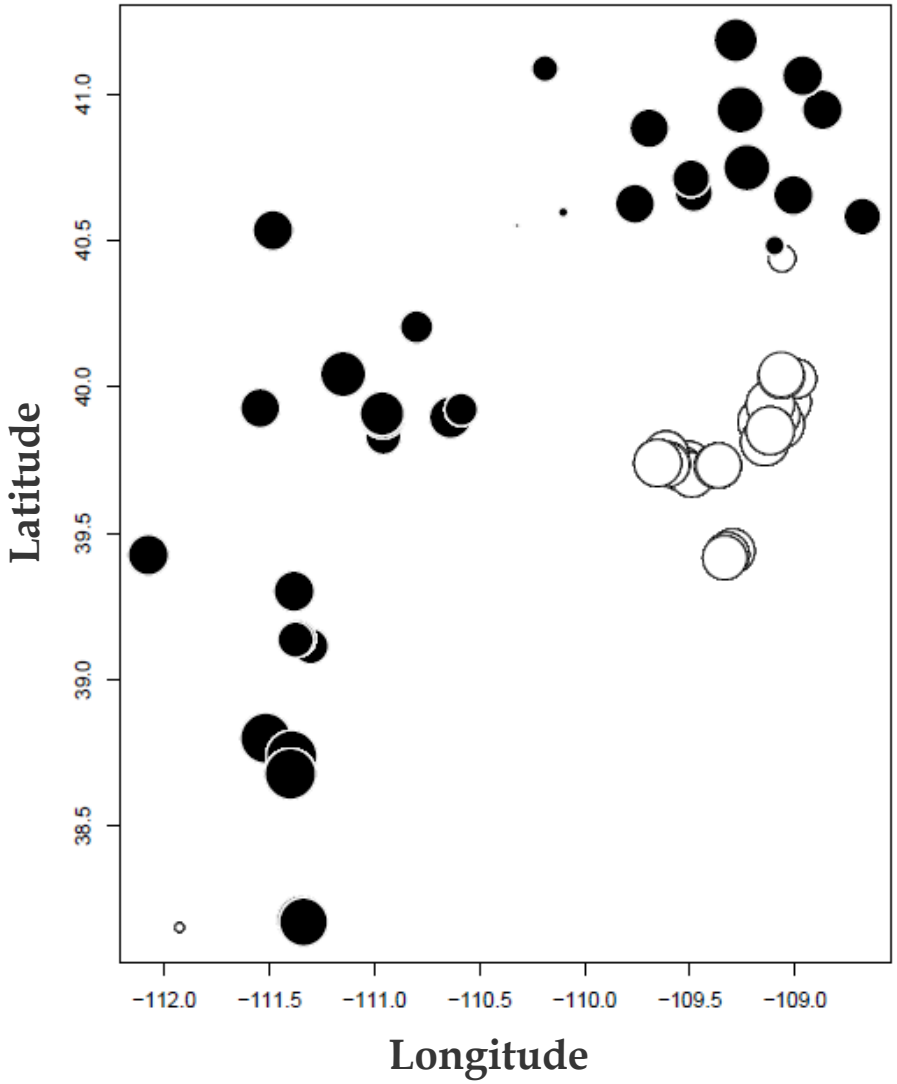
$R^2 = 0.3794464$, P=0.001

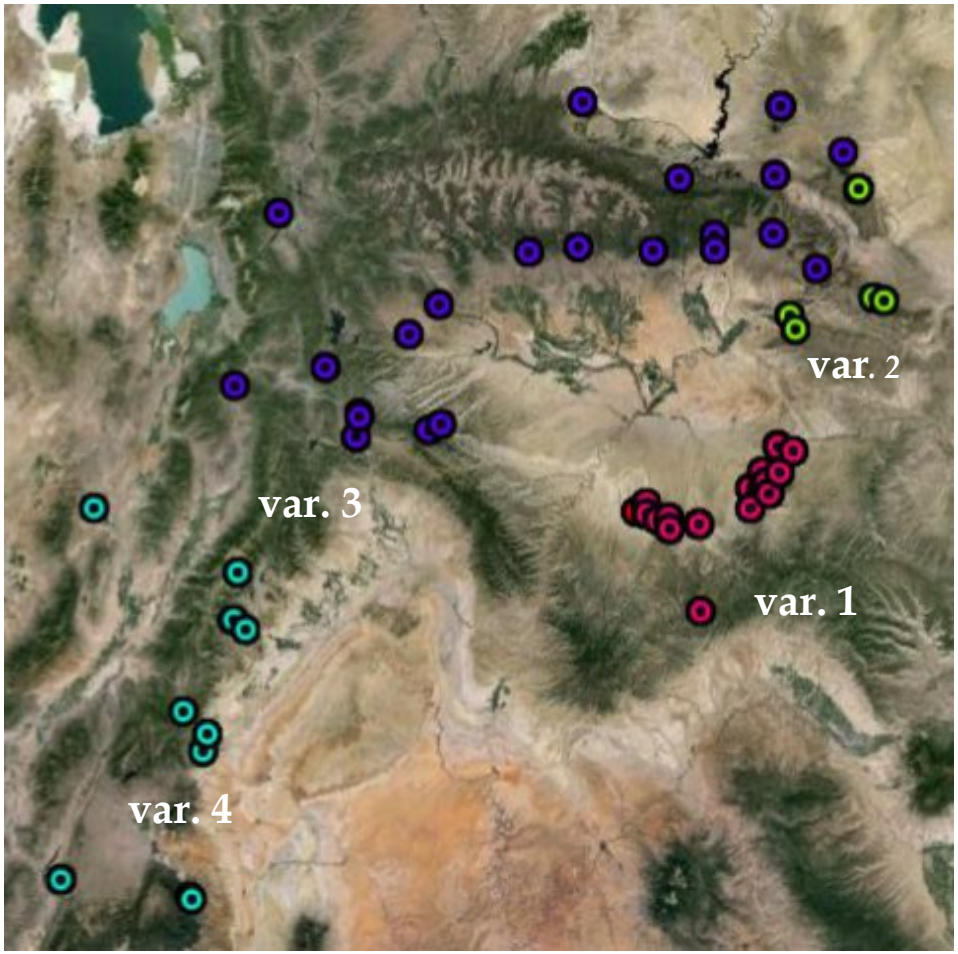




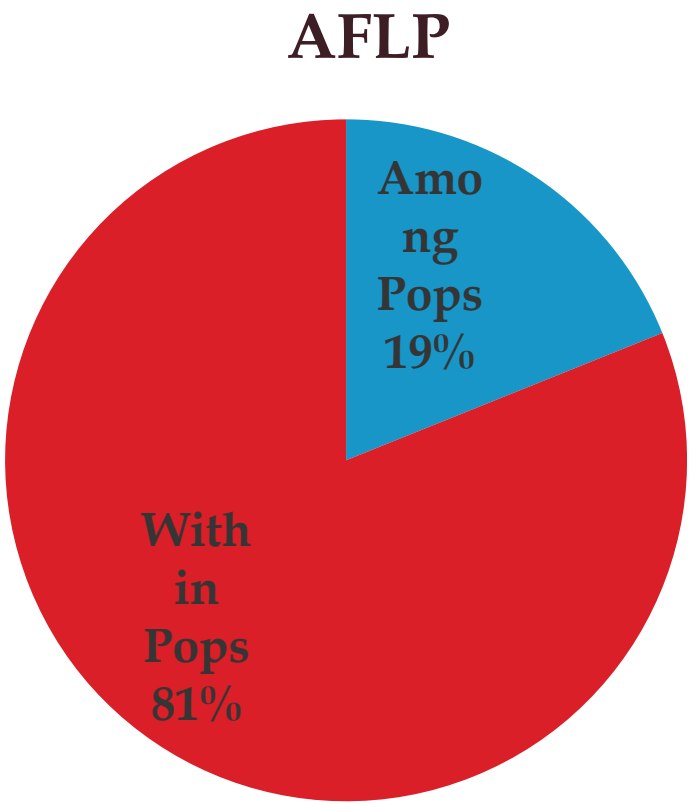
Spatial pattern detection in genetic distance data-Microsat

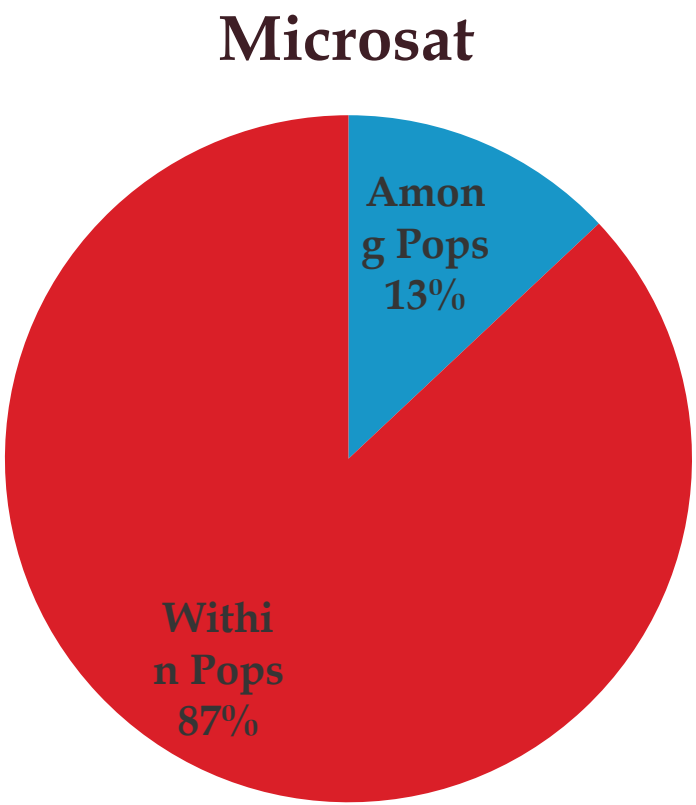
$R^2 = 0.2824073$, P=0.001





Analysis of Molecular Variance: most of the diversity is found within populations





Conclusions

1. All the varieties are highly inbreed and therefore very sensitive to habitat fragmentation
2. *P. scariosus var. albifluvis* seems to form a distinct group; however, our results are not conclusive