2015 Annual Progress Report for

Evaluating Adaptive Capacity of Desert Bighorn Sheep to Climate Change: Identifying Genetic Links to Climate Adaptations in Native and Reintroduced Populations

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Since receiving funding in December 2014, this project has been initiated. Following is a summary of research activities for the project that have occurred to date.

Problem statement and implications: As outlined in our original proposal, we are studying the genetic basis for drought and heat tolerance among herds of desert bighorn sheep occupying the southwestern United States. Regional variability in climatic conditions throughout the native range of bighorn sheep suggests strong potential for local adaptation. Increased occurrence of extreme droughts, overall declines in precipitation and increases in temperature due to climate change has the potential to detrimentally affect desert dwelling species such as bighorn sheep. A better understanding of the alleles, or suites of co-adapted alleles, conveying adaptive advantage to specific climatic conditions will help facilitate conservation of this and other species in the face of continued climate change.

Goals and objectives: We propose to conduct reduced-genome scans to identify loci under selection. We will then correlate the presence/absence of alleles at those loci with specific climatic conditions. The overall project objectives are to: 1) assess whether bighorn sheep exhibit local adaptations to desert ecosystems experiencing different seasonal climatic conditions; and 2) develop recommendations for management actions that maximize the evolutionary potential of this taxon. Our hypothesis and predictions are as follows:

> *Hypothesis:* Variation in climatic conditions will create varying selection regimes among desert bighorn herds with regard to water availability, forage quality, heat/cold stress, and disease susceptibility to which individuals will show local adaptation.
>
> > *Prediction 1:* (*Population genomic approach*): Desert bighorn herds subjected to significantly different climatic conditions will have different allele frequencies at loci under selection.
> >
> > *Prediction 2:* (*Landscape genomic approach*): A correlation will exist between the gradient of climate variables and the distribution of allele frequencies at adaptive loci across the landscape.

Project activities during reporting period and current status: A Postdoctoral Researcher has been hired for the project and began work on 7 August 2015. Collection of tissue samples necessary for this project was initiated in January 2015 through collaboration with both state agencies and other university researchers. We will sample 8-10 individuals from as many locations as possible throughout the native range of desert bighorn sheep. Locations from which samples have already been obtained are presented in Fig. 1 and summarized in Table 1.

Climate databases suitable for the project objectives have been identified, and data will need to be downloaded and preprocessed prior to beginning analyses. Initial literature review has indicated a list of climatic variable that may affect the fitness of desert bighorn. These variables are listed in Table 2 and will be included in our analyses.

Table 1. Sample locations for which high quality DNA is either currently held or has been offered. Location numbers correspond to Fig. 1

1	Warren	36	Clark
2	Gibbs	37	Eagle Crags
3	Wheeler Ridge	38	Panamint
4	Sawmill	39	Black
5	Baxter	40	Silver
6	Williamson	41	White
7	Langley	42	Gabbs
8	San Pedro Martir	43	E. Pahranagat
9	Carrizo	44	Muddy
10	Vallecito	45	Zion
11	San Ysidro	46	GMU 12
12	Coyote	47	GMU 13
13	SSRM	48	GMU 15
14	CSRM	49	GMU 16
15	NSRM	50	GMU 44
16	San Jacinto	51	GMU 45
17	San Gabriel	52	GMU 43B
18	Newberry	53	GMU 22/24
19	Cushenbury	54	GMU 31/32
20	San Bernardino	55	GMU 40
21	Queen	56	GMU 37A
22	Eagle Mtn	57	Sonora
23	Orocopia	58	Pelocillo
24	Sheephole	59	Big Hatchet
25	Iron	60	Fra Crystobal
26	Old Woman	61	Ladron
27	Marble	62	Little Hatchet
28	S. Bristol	63	Red Rock
29	Clipper	64	San Andres
30	Granite	65	Beach
31	N. Bristol	66	Sierra Diablo
32	Cady	67	GMU 27/28
33	S. Soda	68	Manzana
34	Old Dad	69	Pecos
35	Hackberry	70	Wheeler Peak

Table 2. List of environmental variables potentially relevant to desert bighorn fitness

Suite	Description
Temperature	1. Annual Mean Temperature[1]
	2. Mean Diurnal Range – Monthly and annual[1]
	3. Isothermality (No. 2/No. 7) (* 100)
	4. Temperature Seasonality (standard deviation *100)
	5. Max Temperature of Warmest Month
	6. Min Temperature of Coldest Month
	7. Temperature Annual Range (No. 5 – No. 6)
	8. Mean Temperature of Wettest Quarter
	9. Mean Temperature of Driest Quarter
	10. Mean Temperature of Warmest Quarter
	11. Mean Temperature of Coldest Quarter
Precipitation	12. Annual Precipitation
	13. Precipitation of Wettest Month
	14. Precipitation of Driest Month
	15. Precipitation Seasonality (Coefficient of Variation)[1]
	16. Precipitation of Wettest Quarter[1]
	17. Precipitation of Driest Quarter[1]
	18. Precipitation of Warmest Quarter
	19. Precipitation of Coldest Quarter
	20. Number of day with > 0.1 mm rain per month[1]
Other	21. Number of days with/without ground frost – Monthly and annual
	22. Wind speed 10 meters above the ground[1]
	23. Relative humidity in percentage[1]
	24. Percent maximum possible sunshine[1]
	25. Altitude

[1] Indicates climate variable that showed significant association with allele frequencies in domestic sheep and goat breeds.
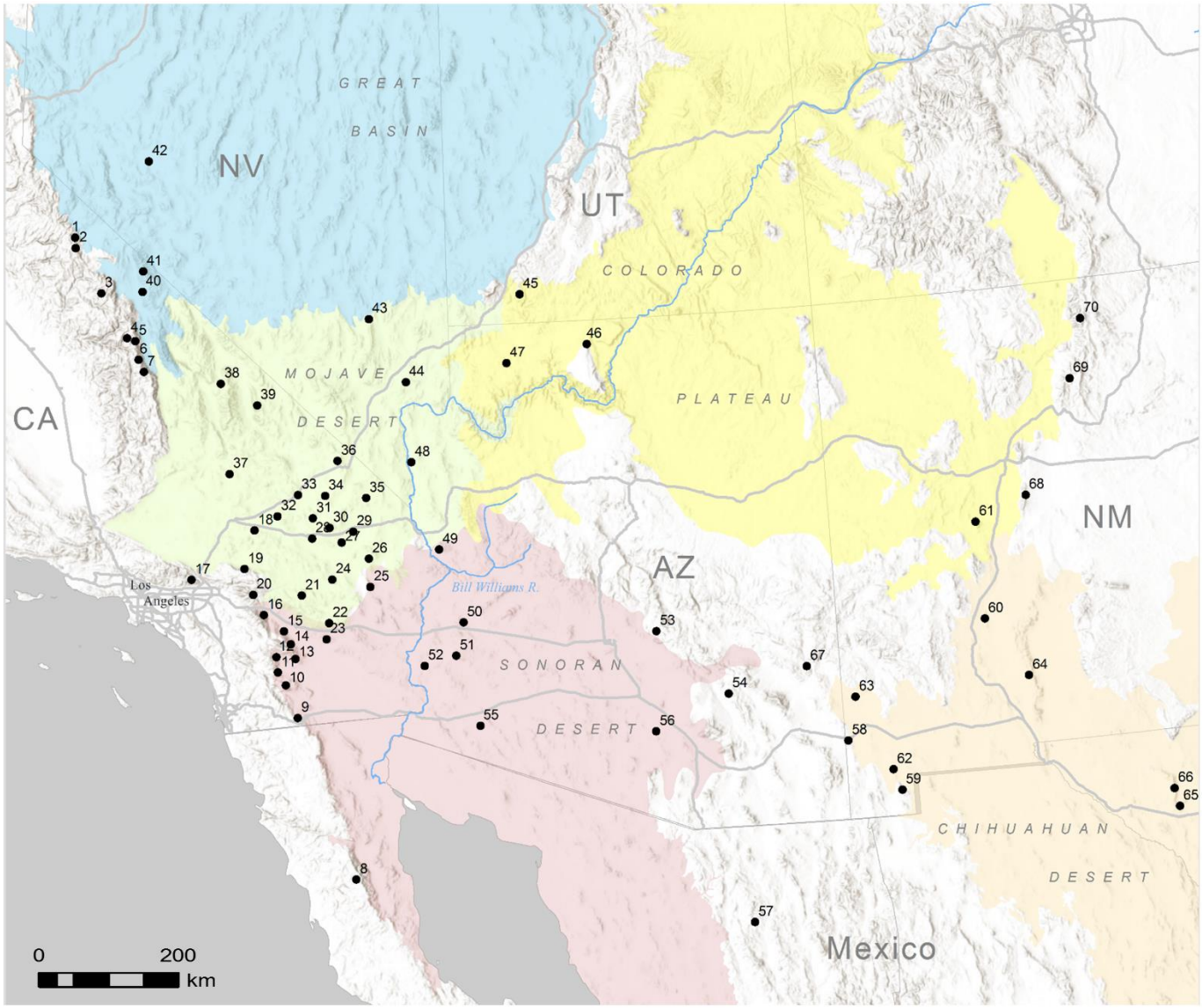
Fig. 1. Sample locations for which high quality DNA is either currently held or has been offered.