2013 Annual Progress Report for

ASSESSMENT OF DROUGHT IMPACTS ON SELECTED FISH AND WILDLIFE SPECIES IN THE SOUTHWESTERN U.S.

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As outlined in our original proposal, this project is comprised of 4 subprojects on desert bighorn sheep, American pronghorn, Rio Grande cutthroat trout, and scaled quail. Since receiving funding in August 2013, all of the subprojects have been initiated. Following are summaries of research activities for each of the subprojects that have occurred to date.

Influence of Extreme Climatic Variability and Drought on Habitat and Forage Selection of Desert Bighorn Sheep

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Problem statement and implications: We were studying the impacts of drought on desert bighorn sheep on the Cabeza Prieta National Wildlife Refuge in southwestern Arizona from 2002-2005. This period spanned the range of variability in the climatic conditions in the Sonoran Desert and ranged from the worst drought on record for the area, through periods of average precipitation and ending during a wet period. This fortuitous timing, allowed us to collect GPS collar data from over 30 female desert bighorn sheep, data on the seasonal nutritional content of key forage plants, availability of key forage plants obtained from vegetation surveys in foraging areas, and fecal samples from which we were able to determine diet.

Goals and objectives: We propose to utilize this data to assess the responses of desert bighorn sheep to the severe drought observed in 2002. The specific objectives are to investigate: 1) seasonal habitat selection patterns across widely differing climatic periods to determine if desert bighorn use certain habitat features and or behavioral mechanisms to cope with extreme drought; 2) changes in diet selection across climatic periods to determine which forage species are used a buffer resources to maintain populations during droughts; 3) nutritional intake resulting from dietary shifts across climatic periods; and 4) validate the of using vegetation metrics derived from remote sensing data (e.g., NDVI, LAI, EVI) as an index for nutritional quality and abundance of key forage species for desert bighorn sheep. These analyses provide a unique opportunity to assess multiple behavioral responses (e.g., forage selection, habitat selection) of desert bighorn sheep to severe drought through which we hope to identify habitat conditions and key forage species that might buffer desert bighorn populations during future droughts.

Project activities during reporting period and current status:

Data for this project has already been collected. Existing remote sensing data will need to be downloaded and preprocessed prior to beginning analyses. A Postdoctoral Researcher has been hired for the project and will begin work on 4 November 2013

Impact of Drought on Southwestern Pronghorn Population Trends and Predicted Trajectories in the Southwest in the Face of Climate Change

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Problem statement and implications: Many pronghorn populations across the Southwest appear to be declining. In response, managers are applying various techniques in attempts to increase pronghorn numbers often without a clear understanding of the causes of these declines. Some population declines have been associated with drought conditions resulting in reduced forage quality and quantity impacting survival of adults and fawns. Various climate change models predict warmer and drier conditions, which is likely to exacerbate future drought-related population declines, forcing managers to make some difficult decisions regarding the long-term viability of their management practices and the persistence of some pronghorn populations in the Southwest. In collaboration with the USFWS, we will undertake a meta-analysis of pronghorn population trends in the Southwest in relation to climatic conditions, specifically drought.

Goals and objectives: The specific objectives are to: 1) determine how widespread the decline in American pronghorn is in the Southwest; 2) identify causal, climatic factors which best explain these declines; 3) forecast the trend and geographical extent of these causal, climatic factors over the next century based on current climate change models for the region, including downscaled climate models in development at the SW CSC; and 4) relate these climatic forecasts to pronghorn population trends over future decades. Qualifying the relationship between climatic conditions and pronghorn population trajectories is central to developing appropriate management actions for pronghorn in the face of climate change. This project will contribute the development of conservation and management plans for American pronghorn populations across the southwestern U.S. Wildlife managers responsible for managing these pronghorn populations will then be more informed and better able to determine where and when particular management strategies can be applied.

Project activities during reporting period and current status:
We started collating pronghorn population survey data and climate data from across the southwestern U.S. Data collection and pre-processing should be completed by 31 December 2013 with data analyses commencing immediately thereafter. A Postdoctoral Researcher has been hired for the project and will begin work on 4 November 2013.

Drought Effects on Habitat and Stream Connectivity of Rio Grande Cutthroat Trout Conservation Populations

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Problem statement and implications: The Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) is the southern-most subspecies of cutthroat trout in the Western U.S., endemic to the Rio Grande, Pecos, and Canadian River basins in Colorado and New Mexico (Behnke 2002). Historically the subspecies occupied over 10,000 km of streams in this region, but currently occupies less than 12% of its historical range (1,500 km) with as few as 120 remaining conservation populations (Alves et al. 2008). In 2008, *O. c. virginalis* was added to the Endangered Species Act Candidate List, and the potential negative effects of climate change on this subspecies were discussed in detail in the listing package and included concerns about both water temperature and low flow.

To help resolve some of the uncertainty related to climate vulnerability of existing *O. c. virginalis* core conservation populations, our research group initiated a monitoring effort in 2010 to characterize both stream temperature regimes and baseflow hydrology within 40 core conservation populations. Importantly, our fall baseflow measurements revealed that more than 67% of *O. c. virginalis* study streams exhibited discharge levels less than 1.0 cubic feet per second (cfs), with one completely dry site (Figure 1a), despite an above-normal 2010 snowpack throughout the majority of the sub-species range. In 2011, the basin experienced moderate to severe drought-conditions during the early summer, however, late-season rains likely reduced the impact of those early drought conditions. In 2011, fall baseflow conditions were documented with similar percentage of low flow streams within an expanded subset of *O. c. virginalis* streams (Figure 1b). Importantly, because our baseflow measurements occur at a single point during the late fall, the flow conditions during the driest portions of 2011 went undocumented. Low snowpack and resultant potential for flow intermittency and low baseflows has a high likelihood of negatively affecting *O. c. virginalis* populations, as was observed in 2002 when several populations were extirpated by drought due to low snowpack during the previous winter (Japhet et al. 2007; Patten et al. 2007). The extent of negative impact of the 2002 drought is unknown, as only a small subset of *O. c. virginalis* core-conservation populations were visited immediately following the drought to evaluate its impact.

Goals and Objectives: Our objectives are to: 1) determine extent of intermittency throughout each population; 2) characterize refugial habitat (pool number, size, depth, and water quality) and compare with fish presence/absence and fish health (i.e., body condition); and 3) model relationships between landscape features (watershed size, slope, aspect, land use), stream habitat/refugia, and stream intermittency potential to assess which features increase or decrease the RGCT populations' resistance to drought.

Methods: We deployed a network of new sensors/data loggers (the Stream Temperature and Intermittency Logger, or "STIL") to document the frequency and duration of flow intermittency within the smallest of the *O. c. virginalis* streams. The STIL is a modified Hobo Pendant data logger (ONSET, Inc) that enables simultaneous collection of high-resolution water temperature and electrical resistance ("ER") within the same instrument during extended deployments. Further, when properly deployed in an un-gaged stream environment, this single, multi-functional sensor can yield valuable data on both the timing and quality (i.e., temperature) of waters flowing within the stream. In Spring 2013, we deployed STILs within riffle habitats in a network of the smallest of *O. c. virginalis* streams (Table 1) to document if/when these flow sensitive streams go dry, and if they do, the duration for which they remain dry. More than 50 STILs were deployed in 30 streams, with multiple STILs placed in select streams to characterize potential longitudinal differences in stream drying within the system. By monitoring flow status in riffle habitat, we were attempting to document the moment and duration of flow cessation in that flow sensitive habitat. Importantly, even in intermittent streams, fish populations can persist if there is adequate still-water habitat remaining (i.e. pools, ponds, etc…). However, extended durations of hydrological isolation of such disconnected still-water habitats can yield negative fish community responses through the reduction in overall available habitat, loss of connectivity, as well as the eventual degradation of water quality within the pool refugia (e.g., dissolved oxygen and thermal stress). Therefore, our goal was to document the presence/absence of still-water habitats within select RGCT streams exhibiting extremely low flows.

Interim Results (15 September-31 October)

Performance of the STILs

The functionality of the STIL technology was deemed acceptable in assessing site-specific stream intermittency (Figure 2). As an example, this STIL was deployed at the bed surface within the thalweg (main channel) of an *O. c. virginalis* stream (Sangre de Cristo Creek near Fort Garland, Colorado) that has been observed to go dry seasonally. The data demonstrates that while the STIL sensor was deployed within a flowing stream (approximately 6/23/13), the stream began to dry later that week. The STIL response dropped from ~60 to 0 reflecting the stream was dry by the end of that week on approximately 6/29/13. Further, the temperature data simultaneously collected by the same STIL validates that the stream went dry during this period. The air temperature signal (6/27 – 6/29) is more jagged than the water temperature signal (6/23 – 6/25).

Assessment of intermittency within RGCT streams (Objective 1)

The majority of STILs were revisited, downloaded, and redeployed in September 2013. Unfortunately, due to the two week government shutdown that began on October 1st 2013, all sites with STILs could not be visited with the majority of the sites restricted by snow and ice. The remaining sites will be visited and data retrieved Spring 2014.

Of the sites for which STIL data is available, many were observed to remain wet for the duration of the summer (Table 1). Importantly, the late summer of 2013 was unusually wet in southern Colorado and northern New Mexico. As such, the instream flow conditions documented by the STILs likely do not represent the low flows that would be anticipated during drought conditions.

However, in spite of the heavy rains and elevated baseflow conditions in these *O. c. virginalis* streams, several streams displayed evidence of intermittent conditions. For example, within Cat Creek, a very small *O. c. virginalis* stream in southern Colorado, the longitudinal deployment of three STILs indicated that while the STILs deployed lower in the drainage remained wet, the uppermost STIL displayed intermittent flow. Similarly, in the North Fork of Carnero Creek, the uppermost site indicated dry conditions for much of the summer.

Stream habitat and electrofishing surveys to assess refugial habitat: population level effects of drought (Objective 2)

On select streams, the presence / absence of still-water habitat was assessed by measuring pool depth and frequency during longitudinal electrofishing surveys. Due to some logistical challenges (extremely long stretches of stream with dense riparian vegetation), the surveys that were conducted in the fall of 2013 were not spatially comprehensive, but instead relied on electrofishing reaches and characterization of pool habitats within relatively close proximity to established STIL sites. Again, because of the two week government shutdown, sites that were slated for fieldwork in early October were unable to be completed.

While the data collected in these surveys is still being processed, field observations suggest that stream intermittency (in the absence of significant still-water refugia) may influence re-establishment of a fishery. For example, in the uppermost segment of Cat Creek, where STIL data indicates highly intermittent conditions, no fish were captured during an electrofishing survey. In contrast, at the adjacent STIL downstream, STIL data indicates persistent flow throughout the summer because *O. c. virginalis* were captured within pool and pond habitats. At the lowest STIL site, in which water temperature data and field observations indicated intermittency, no fish were collected. To summarize, the presence of stable flow and diverse still-water refugia within select stream reaches may allow *O. c. virginalis* to persist, despite evidence of intermittency both above and below these stable reaches. We plan to return to the sites in spring 2014 to retrieve all data and complete the stream habitat and population surveys to evaluate the efficacy of refugial habitat and its relatedness to health of *O. c. virginalis* populations.

Literature Cited

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Table 1: Stream locations of Stream Temperature and Intermittency Loggers ("STILs") deployed in June 2013. Evidence of intermittency is based on initial analysis of data recovered in September 2013. Analysis is ongoing.

Stream Name	HUC	# STILs	Evidence of Intermittency
Rito de las Palomas	Jemez	3	N
Rio de los Pinos	Rio Puerco	1	N
McCrystal Creek	Cimarron	3	
Powderhouse Creek	Upper Rio Grande	3	
La Queva Creek	Upper Rio Grande	1	
Middle Ponil Creek	Cimarron	1	
Grassy Creek	Upper Rio Grande	1	
Comanche Creek	Upper Rio Grande	2	
Vidal Creek	Upper Rio Grande	1	
Tio Grande	Conejos	1	N
Rio Nutritas	Conejos	2	N
Tanques Creek	Conejos	1	N
Osha Canyon	Upper Rio Grande	3	
E F Luna Creek	Mora	2	
Pine Lodge Creek	Arroyo del Macho	2	
Cat Creek	Alamosa-Trinchera	3	Y
Jim Creek	Alamosa-Trinchera	1	N
Torsido Creek	Alamosa-Trinchera	1	N
Cave Creek	Saguache	1	N
Cross Creek	Saguache	1	N
East Pass Creek	Saguache	1	N
M F Carnero Creek	Saguache	4	N
Prong Creek	Saguache	1	N
N F Carnero Creek	Saguache	2	Y
Jacks Creek	Saguache	1	N
Deep Canyon	Alamosa-Trinchera	1	
Sangre de Cristo Creek	Alamosa-Trinchera	5	Y
Torcido Creek	Alamosa-Trinchera	1	N
Wagon Creek	Alamosa-Trinchera	1	N
West Indian Creek	Alamosa-Trinchera	1	N

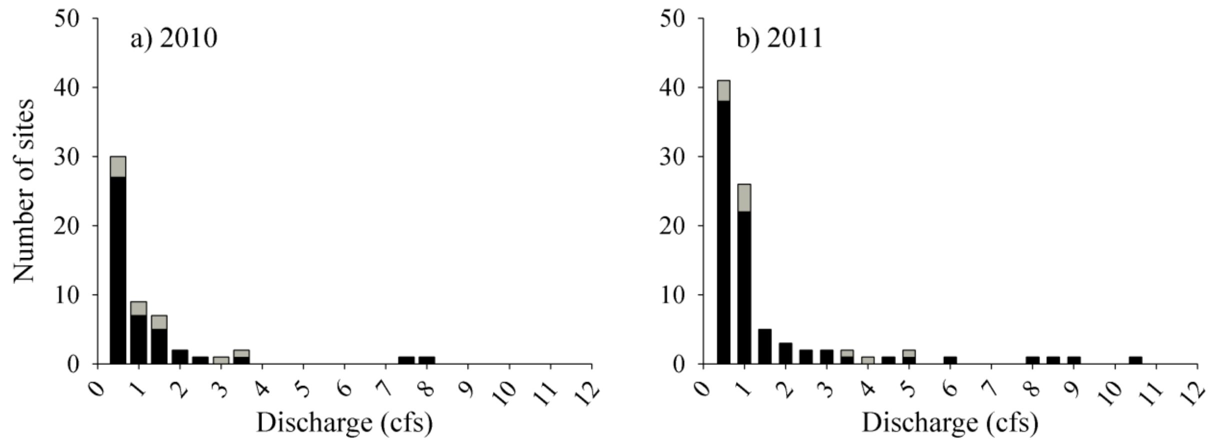

Figure 1: Baseflow discharge measured in select Rio Grande cutthroat trout conservation streams in 2010 and 2011.

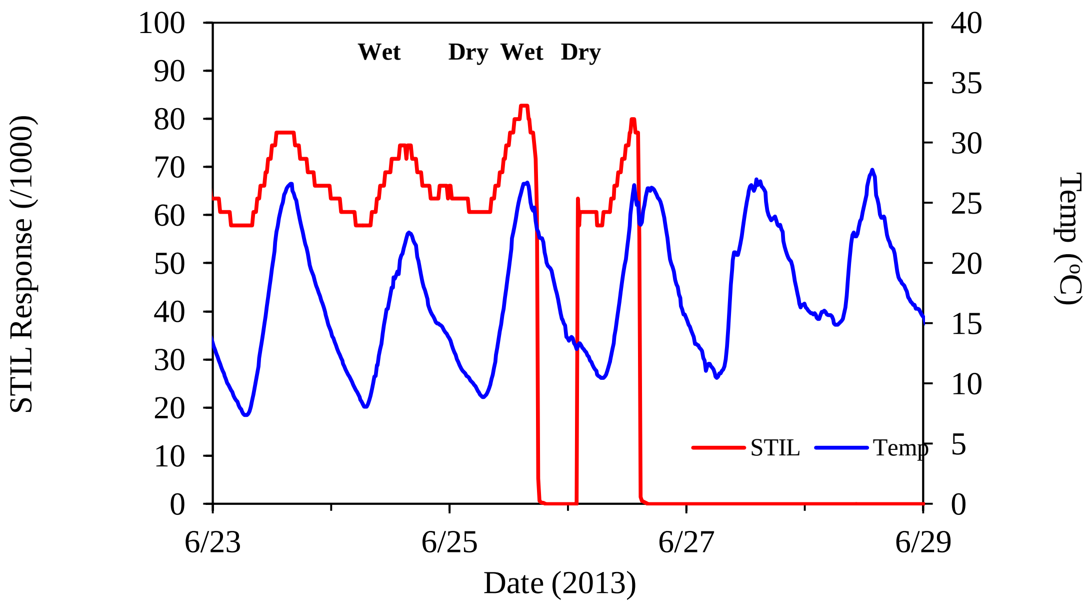

Figure 2: Stream temperature and wet/dry status within the thalweg of Sangre de Cristo Creek near Fort Garland, Colorado.

Effects of Climate on Scaled Quail Reproduction and Survival

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Problem statement and implications: Across the southwestern U.S., long-term declines in populations of scaled quail and contraction of their range-wide distribution have caught the attention of avian ecologists (Cantu et al. 2006). One of the factors hypothesized as a primary cause of this decline is a long-term trend in warmer, drier conditions and reduced monsoonal rainfall across their range. The mechanism believed to be driving this trend is declining nest success due to temperature and humidity levels above a critical threshold for egg and chick survival. While habitat loss cannot be discounted as a possible driver, areas managed specifically for scaled quail in western Texas have seen similar losses in population numbers across the same time frame indicating that these reductions are independent of habitat related factors (Rollins 2000). Coupled with climate models forecasting shifts in the arrival of summer monsoon rains away from the critical reproductive periods of June and July (Cook and Seager 2013), the long-term forecast for scaled quail response to decreased rainfall and higher temperatures is bleak. Scaled quail are considered to be a key indicator species of the health of the habits they occupy across the southwest and are frequently used to assess the success of restoration projects undertaken by federal and state agencies (Coffman 2012). We propose to use this species to study climate effects (temperature, humidity, and precipitation) preceding, during and following the nesting season with a primary focus on how these climate variables affect nest success.

Goals and Objectives: Our primary objective will be to measure nest success in different populations across their range and determine if nest success is related to temperature and humidity measurements taken in incubating nests using ibuttons. This project could be expanded in future years if funding becomes available to compare presence/absence of scaled quail on White Sands Missile Range (where habitat condition is driven by only climate variables because grazing has not occurred in over 50 years) using drought indices to determine if measures of precipitation, temperature and humidity can predict scaled quail abundance.

Project activities during reporting period and current status: An M.S. student has been recruited for this project. Currently, scaled quail needed for this study are still in small family groups and have not "coveyed" up into large aggregations for the non-breeding season. Capturing quail efficiently requires that quail are forming larger groups and moving together. To target quail when they are in the largest groups possible, captures will begin in December 2013 and will continue until April 2014. All scaled quail captured will be fitted with VHF transmitters and then tracked through the breeding season to locate nests. At that time, we will begin the focused data gathering period of our proposed study investigating the impacts of temperature and humidity on nest and brood success.

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