PROGRESS REPORT
For
Gila National Forest Stream Temperature and Intermittency Monitoring Network for Species of Special Interest

Tyler J. Wallin
Graduate Research Assistant
Department of Fish, Wildlife, and Conservation Ecology
Fish, Wildlife and Conservation Ecology, Anticipated Graduation: M.S. degree Spring 2019
2980 South Espiña Street, Knox Hall Rm 116, Las Cruces, New Mexico 88003
twallin@nmsu.edu
(618) 420-6768

Faculty Sponsor
Dr. Colleen A. Caldwell, Professor and Unit Leader
Department of Fish, Wildlife and Conservation Ecology
New Mexico Cooperative Fish and Wildlife Research Unit
Box 30003, MSC 4901, Las Cruces, New Mexico 88003
ccaldwel@nmsu.edu
(575) 646-8126

Problem Statement and Objectives:

The importance of stream temperature in structuring the distribution of native fishes is well recognized[1, 2]. These factors are also strongly coupled with climate variables (air temperature and hydrology), which are expected to significantly change over the 21st century. Recent research by the Faculty Sponsor (Caldwell) demonstrated in the last 45 years, northern New Mexico has experienced an increase in air temperature by 0.29°C per decade and that timing of snowmelt and seasonal flows has shifted 10.6 days earlier in the year[3]. Snow water equivalent has also decreased (5.3% per decade) resulting in less water during the summer months. The combined effects of stream temperature and flow discharge, and increasing occurrence of non-native fishes has profoundly influenced the distribution of native fishes of greatest conservation need and must be taken into consideration when developing management plans into the future. This is especially true for native fishes throughout the arid southwest that have already experienced significant contractions in their historic range. The Gila and Mimbres River basins, located in southwestern New Mexico, supports a unique native fish fauna adapted to the arid stream systems in which they evolved. The Gila River Basin historically supported 13 native fish species, with five of these species endemic to only the Gila River Basin[4]. The high number of native fishes of conservation concern in both drainage basins highlights the need for a greater understanding of how their distribution will be altered by a changing climate. Assessment and characterization of stream temperature and intermittency regimes in the Gila and Mimbres drainage basins will be important for the restoration and protection of critical habitat for these native species in the future. The goal of my master's research will be to predict current and future distributions of native fish species of special concern throughout the Gila and Mimbres basins. Predicted future changes in climate variables of air temperature and precipitation will be obtained from a dynamically downscaled regional climate model and an A2 emission scenario[5]. The downscaled regional climate model will then be used to make predictions of future stream temperature, intermittency, and future distributions of non-native fishes for the 2070-2089 time period. These future conditions will then be used with current native fish distribution models to determine how their distributions may shift in the future and identify critical habitat such as strongholds of persistence. However, to develop the predictive models, a comprehensive stream temperature and intermittency-monitoring network is needed throughout the Gila and Mimbres drainage basins of New Mexico to assess the potential influence of these abiotic factors on the distribution of native and non-native fishes.

My objective of the proposed work through WRRI was to establish a stream temperature and intermittency-monitoring network throughout watersheds containing native fishes of conservation concern in the Gila and Mimbres drainages of New Mexico. The implementation of such a network will not only provide the needed data for model development to assess regional climate change on the distribution of the native fishes, but it will also provide state and federal stakeholders and water managers a better understanding of the dynamics that air and water temperature have on aquatic resources for future water planning needs.

Methodology:

This study was restricted to the Gila and Mimbres River drainage basins in southwestern New Mexico and eastern Arizona. The Gila River drainage basin is located west of the continental divide and drains approximately 17,732 km^2. The Mimbres River drainage basin is located east of the continental divide and drains approximately 11,725 km^2.

As part of this funding authority, a stream temperature, air temperature, and intermittency-monitoring network was developed for the Gila and Mimbres drainage basins in coordination with federal, state, and NGO cooperators. The intention of the network is to extend past the lifetime of this grant. Thus, future maintenance of the monitoring network will be in the hands of multiple partners such as Gila National Forest Service, USFWS, and State agencies. The biological monitoring design focuses on monitoring current known distributions of fish species of conservation concern and will be used to characterize spatial gaps and thus increase the predictive capability of the modeling efforts.

Three different types of loggers (Onset Computer Corporation) were deployed in the current monitoring effort: Pro v2 and TidbiTv2 loggers were deployed together to record hourly water temperature across varying environmental conditions. Pro v2 loggers are housed in white PVC pipe and staked into the stream sediments using a 1.0 m framing stake. TidbiTv2 loggers are used in stream habitats consisting of bedrock where a stake cannot be driven in to the sediments. These loggers are epoxied in a PVC housing to bedrock or large, permanent boulders. The third logger, Stream Temperature Intermittency and Conductivity meter (STIC), is a modified HOBO Pendant Temperature/Light data logger. Recent development of the STIC is advantageous in arid systems because it can determine precisely when the logger was submerged and when it was not (i.e., drying events resulting in stream intermittency). If intermittency occurs, it can then be assumed that fish were no longer present in that reach. Hourly data from all loggers are collected every six months by T. Wallin (author of this report) and other cooperators with the Forest Service, U.S. Fish and Wildlife Service, and the New Mexico Department of Game and Fish. Data from each logger underwent error proofing and a series of temperature metrics were calculated for eventual use in the regional climate models and mapping of critical habitat.

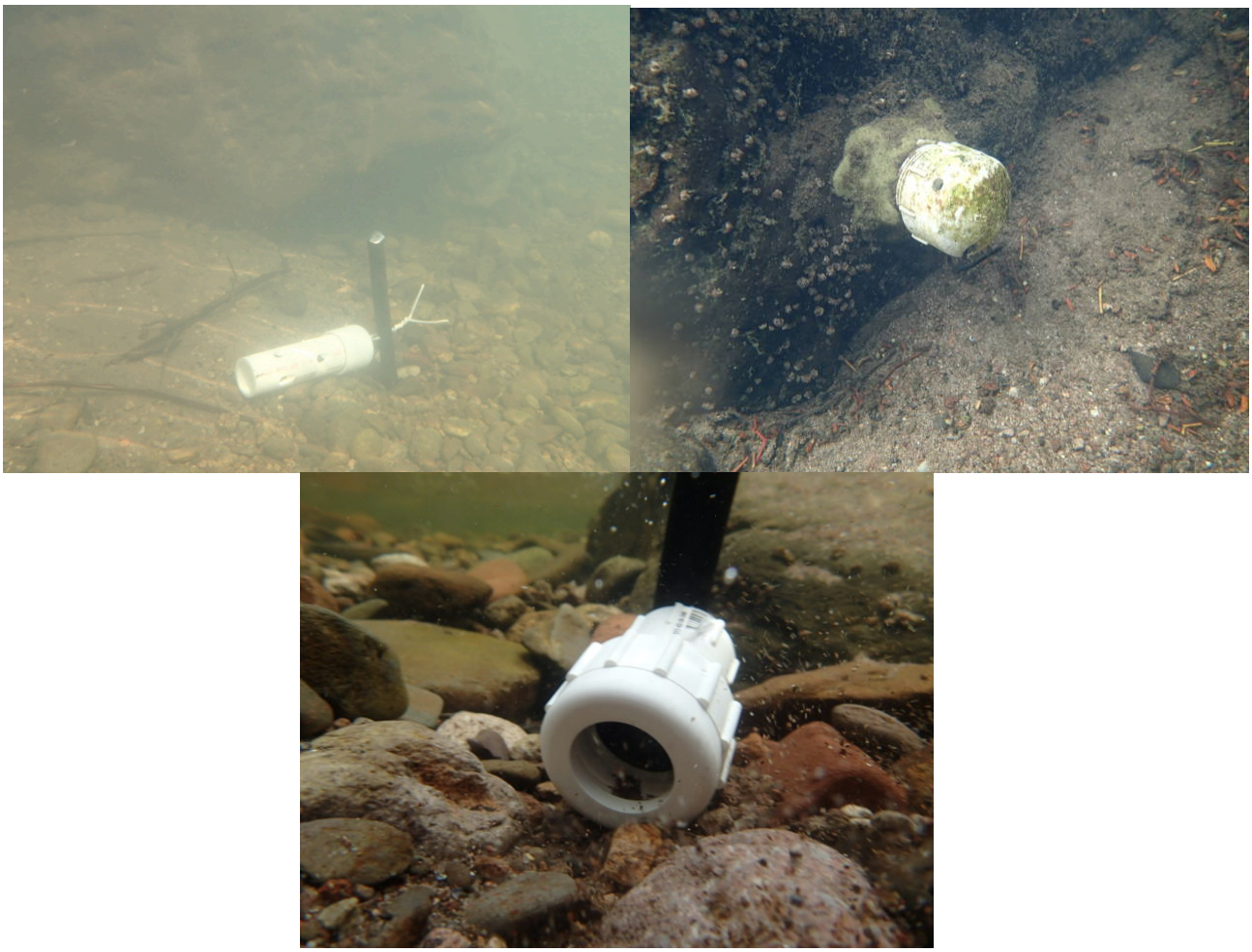

Figure 1: Types of temperature loggers used include ProV2 (top left), Tidbit v2 (top right), and the adapted Stream Temperature, Intermittency, and Conductivity (STIC) logger (bottom). ProV2 and STIC models are anchored with three foot framing stake and ten gauge wire, Tidbit v2 model is affixed to a permanent stream structure using two-part waterproof epoxy.

Final Outcome and Products:

During the summer and fall of 2016, T. Wallin launched the stream temperature and intermittency monitoring network and attended several professional conferences. Between May and November 2016, T. Wallin, along with state, federal, and NGO coordinators, established a total of 60 temperature and STIC loggers throughout the Gila and Mimbres drainages. At the time of this report, the loggers are collecting vital water and air data every hour. A full list of current sites has been included in the report to show the scope of this project across a large montane and heavily forested landscape (Table A). Three sites within the Willow Creek drainage were in place prior to the monitoring network and were used to provide an example of the results from the network (Figure 2).

In addition, the student PI also used some of the travel funds to attend the Desert Fishes Council meeting in Albuquerque, New Mexico November of 2016. At the meeting, the student networked with individuals working with desert fishes from across the southwestern United States. This opportunity allowed for beneficial information sharing for the student PI. While at the meeting, fisheries managers showed interest in the monitoring network and were able to get experienced-based answers to their questions about the establishment of temperature loggers in perennial and intermittent stream systems. The student PI provided a number of resources about logger selection, housing design, and anchoring methods to professionals as well as other students. Participation in the conference also presented opportunities for the project to grow with input from Trout Unlimited (TU) to provide finer scale monitoring of a Gila trout population. Networking with TU members at the Desert Fishes Council Meeting in Albuquerque spearheaded a movement to cooperate with the student PI on this grant project. In addition to TU, the New Mexico Council, National Wilderness Stewardship Alliance, and Wilderness Performance Stewardship Partnership provided a grant to Mr. Jim Brooks of JEB Outfitters LLC, Albuquerque, New Mexico to perform an aquatic habitat assessment in conjunction with the temperature and intermittency-monitoring network. Upon further discussion, it was decided that collaboration of resources and effort would result in the most informative observations and management recommendations. To use the resources efficiently, Willow Creek, Gila National Forest, Catron County, New Mexico was selected for the baseline temperature monitoring and habitat assessment.

Due to the timeframe upon which this grant operates and the weather conditions throughout the study area (snow pack), major efforts and data collection did not begin until March of 2017. The temperature monitoring network as previously described is still in progress and the existing loggers will be downloaded October 2017. Thus after the deployment of the temperature loggers across the monitoring network, then a focus of T. Wallin shifted to temperature monitoring on Willow Creek (Figure 2). Three temperature loggers were deployed throughout Willow Creek, March 23, 2017 to capture future temperature data for future studies. Sites descriptions and UTM locations are listed in Table B.

Table A: Existing stream temperature, air temperature, and intermittency logger sites with GPS coordinates.

Site Name:	Zone	Easting	Northing	Elevation	Site Name:	Zone	Easting	Northing	Elevation
AIR Lower Diamond Cr	12 S	765124	3683533		Moreno Springs @ TNC	13 S	220269	3642989	1843
AIR S. Diamond below Burnt Canyon	13 S	230010	3680552	2403	N Fk Mineral Cr	12 s	718540	3697631	2413
Allie Canyon	12 S	774267	3645998	2032	Packsaddle	12 S	734293	3686397	2152
Black Canyon	12 S	764754	3673728	1752	Rawmeat	12 S	735360	3683262	2125
Black Canyon above Aspen	13 S	226599	3673992	2264	S Fk Whitewater Cr 1	12 S	703634	3694045	1729
Black Canyon below Bonner	13 S	221563	3675090	2131	S Fk Whitewater Cr 2	12 S	707808	3689888	2221
E Fk Gila 1	12 S	761288	3675180	1698	S. Diamond #2	13 S	227571	3679351	2344
E FK Gila Propst Perm Site	12 S	767690	3688216	1871	S. Diamond #3	13 S	224085	3678466	2259
E Fk Whitewater Cr	12 S	706660	3690763		S. Diamond below Burnt Canyon	13 S	230010	3680552	2403
Gallinas Cr CG	13 S	233881	3642323	2022	Sacaton STIC	12 S	713974	3680799	2148
Langstroth	12 S	734227	3682800	2254	Sacaton STIC #2	12 S	714519	3681336	2216
Little Cr 1	12 S	757413	3675753	1756	San Fran @ Glenwood	12 S	696107	3686984	1423
Little Cr 2	12 S	755313	3676292	1852	Trout Cr	12 S	755485	3657407	
Little Cr 3	12 S	754271	3676091	1891	W Fk Gila Cliff Dwel Perm	12 S	755160	3680023	1739
Little Cr 4	12 S	752155	3676845	1956	W Fk Gila Hot Springs	12 S	760280	3677040	1697
Little Dry Cr 1	12 S	711552	3681573	2136	WFG below White Cr	12 S	737213	3684103	2067
Little Dry Cr 2	12 S	711537	3681557	2136	White Water RD Crossing	12 S	698508	3689854	1457
Lower Black Canyon CG	12 S	776189	3675473	2049	Whitewater Cr 1	12 S	701287	3694993	1590
Lower Diamond Cr	12 S	765116	3683476	1847	Whitewater Cr 2	12 S	702204	3695003	1671
Lower White	12 S	736724	3684492	2091	Whitewater Cr 3	12 S	703816	3693988	1721
McKenna Cr	12 S	738000	3684102	2049	Whitewater Cr 4	12 S	715279	3690891	
Middle Fork TH PERM	12 S	757012	3679705	1726	Willow Cr 1	12 S	724933	3698200	2409
Mimbres @ Cooney	13 S	221803	3659940	2054	White Cr Above TR Cross	12 S	733512	3684596	2304
Mimbres @ TNC	13 S	219800	3643845	1849	Cub Cr	12 S	732003	3688563	2266
Mineral CR	12 S	702050	3700016	1665	WFG below Turkey Feather	12 S	731734	3689779	2325
Mineral Cr 13	12 S	707158	3698877		Wiskey Cr	12 S	723515	3690270	2447
Mineral Cr 14	12 S	707264	3698850		WFG below Nat Straw	12 S	748563	3683391	1838
Mineral Cr STIC	12 S	699469	3697506	1572	Tularosa Perm Site	12 S	712376	3734676	1086
Moreno Sp Head @ TNC	13 S	220272	3643053	1837	Gila Iron Bridge	12 S	723775	3647163	1356
White Cr Above TR Cross AIR	12 S	733512	3684596	2304					

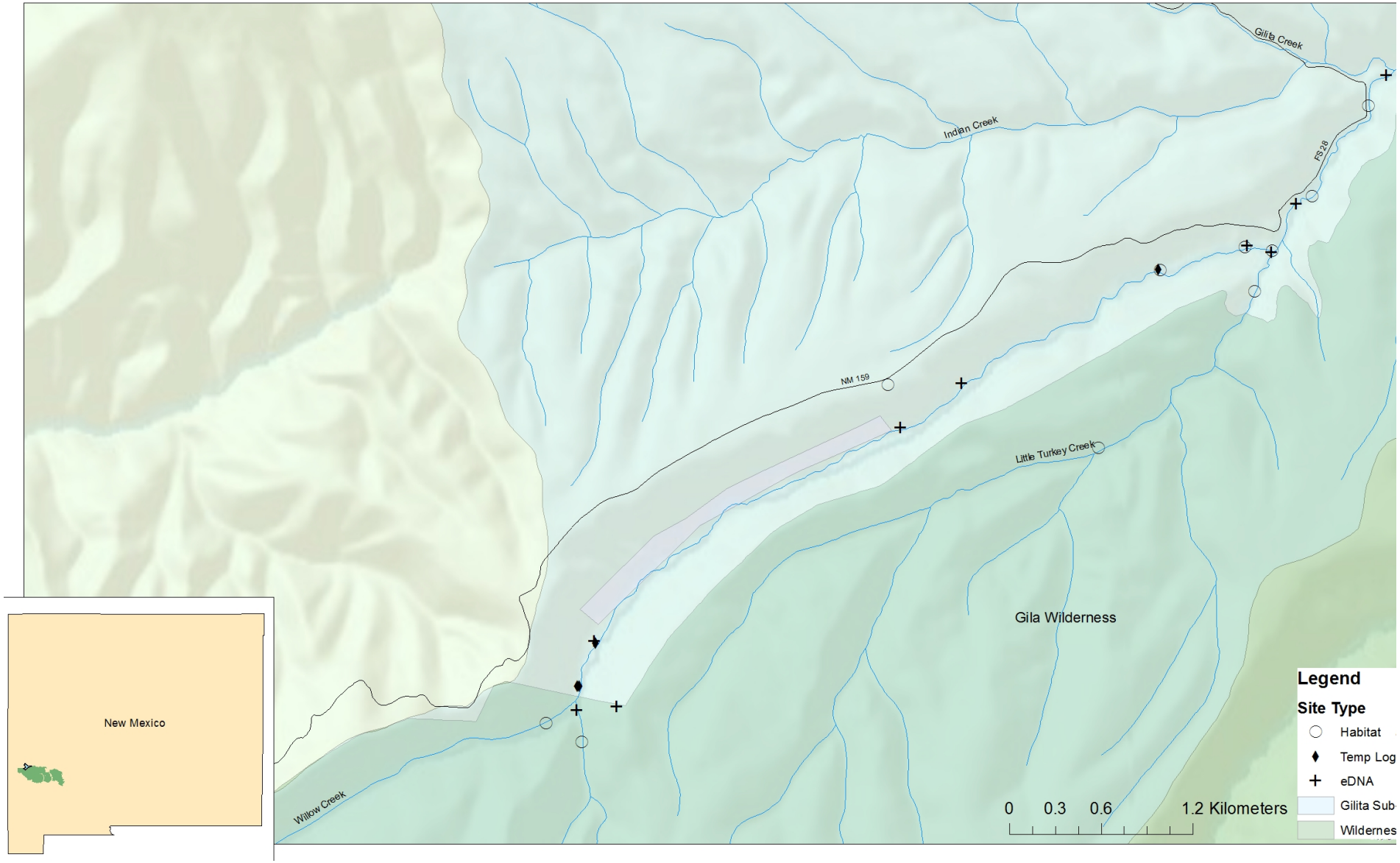

Figure 2: Map of Willow Creek study area showing temperature loggers as well as habitat and environmental DNA sampling locations from collaborative efforts. The gray rectangular section along Willow Creek represents private lands.

Table B: Description of location for temperature loggers in Willow Creek, Gila National Forest, Catron County, New Mexico

Site Name	Description	Zone	Northing	Easting	Elevation (m)
Ben Lily	500 m downstream of Ben Lily Campground	12 S	724163	3698050	2437
Above Private	100 m Upstream from private property line	12 S	720439	3695616	2506
Below Confluence	100 m below confluence of North Fork and South Fork of Willow Creek	12 S	720339	3695326	2543

Final temperature data was collected 27 June 2017 in time to prepare the report for WRRI. The 'Below confluence' site was out of the water due to stream drying and the air data was trimmed to represent only water temperature. The two loggers that remained submerged in the stream revealed interesting temperature trends (Figure 3). Daily Average temperature is the mean of the hourly readings from 12:00AM to 11:00PM for each day and is a useful metric to track sublethal water temperatures for cold water fish species. In addition, the mean weekly maximum temperature assists with interpreting distribution and persistence of a cold water fish population. The average (or mean) thirty day average temperature is the mean daily average temperature for thirty days and is used to reveal chronic sublethal temperatures. At the time of this report, a total of 96 days of stream temperature were logged at Ben Lily and above the Private site and 42 days of stream temperature were logged Below Confluence site. The maximum 2-h running average revealed maximum temperatures occurred in June (Table C). Note that the maximum temperature range is greater in the lower sites compared to the sites nearer the headwaters. The maximum 7-d weekly average temperature (7-d WAT) was similar across the all sites and are well below the 7-d chronic sub-lethal temperature limit for Gila trout 28.25^{o}C[8]. These temperatures do not encompass the extreme highs of summer heat and loggers were re-launched and are currently collecting hourly water temperature intervals for retrieval fall 2017. While water temperatures were not lethal to the endangered salmonid, the temperature metrics indicate that fish recruitment and growth may be compromised throughout Willow Creek. Additional research is needed to better understand how warm is too warm for this cold water fish.

Table C: Continuous stream temperature (^{o}C) was obtained in Willow Creek from May 23 to June 27, 2017. The exception being the Below Confluence site which emerged and was no longer collecting water temperature on May 03, 2017. Temperature metrics include the 2-h running average (maximum and minimum temperature), maximum daily range, the maximum 7-d weekly average temperature (WAT), and the maximum and minimum mean 30 day average temperature.

	2-h Running Average		Daily Range	7-d WAT	Mean 30 Day Average	
	Maximum	Minimum	Maximum	Maximum	Maximum	Minimum
Above Private	21.3	0.80	11.29	15.19	18.2	11.1
Below Confluence	18.14	0.87	14.38	7.13	6.40	5.38
Ben Lily	20.85	1.03	20.87	15.60	14.11	5.86

Recommendations:

This grant provided the resources needed to establish a baseline temperature network across the range of a community of imperiled desert Southwest fishes. The network set into motion additional research that will relate temperature to habitat, growth, and survival of the severely imperiled Gila trout.

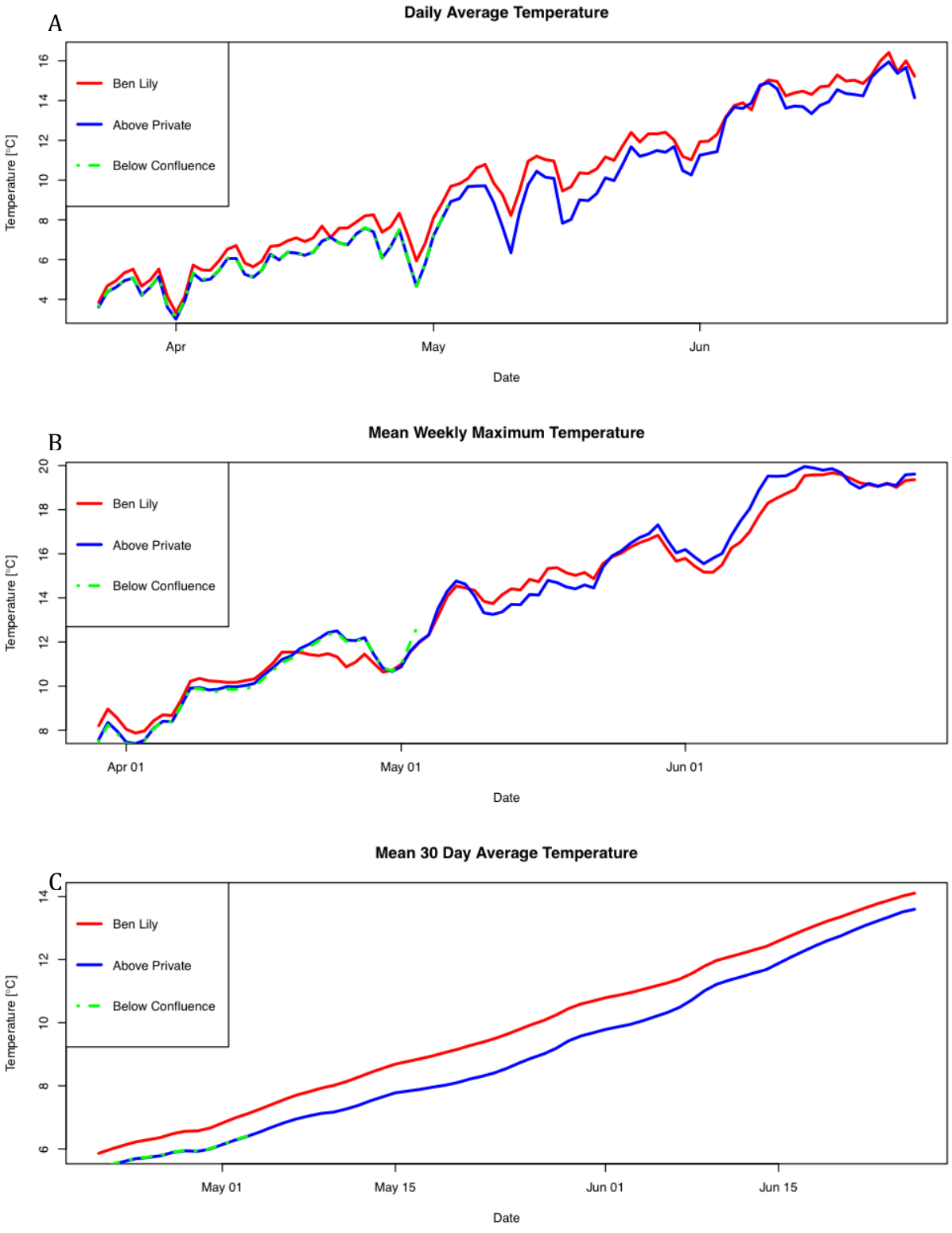

Figure 3: Temperature metrics for loggers in Willow Creek. (A) Daily Average temperature to assess lethal temperature spikes. (B) Mean Weekly Maximum Temperature to asses extended exposure to sub-optimal temperature ranges. (C) Mean 30 Day Average Temperature to assess chronic exposure to temperatures that could affect recruitment, survival, growth, or other vital rates

Project Products:

Brooks, J.E., J. Arterburn, C. Canavan, T. Wallin. Aquatic Habitat Assessment in Willow Creek, Gila National Forest, Catron county, New Mexico, In Support of Gila trout *Onchorhychus gilae* Conservation. Report to National Wilderness Stewardship Alliance. June 2017.

Wallin, T.J., 2016. Gila National Forest Stream Temperature and Intermittency Monitoring Network to Assess Effects of a Changing Climate for Native Fishes of Special Interest. New Mexico Water Resources Research Institute Conference, Silver City, New Mexico. 7 October 2016. [Poster Format]

Wallin, T.J., 2016. Gila National Forest Stream Temperature and Intermittency Monitoring Network to Assess Effects of a Changing Climate for Native Fishes of Special Interest. 48th Annual Meeting of Desert Fishes Council, Albuquerque, New Mexico. 15-19 November 2016. [Poster Format]

Budget Expenditures:

Travel and Registration for Desert Fishes Council……$304.28
Printing for WRRI Poster…… $69.60
Travel to WRRI Conference, Silver City, NM……...$130.68
Research Materials and Texts……$206.28
PIT Tags and Injectors.....…...$1540.50
JEB Outfitters……....$3375.00
Travel and Mileage Reimbursements……..$356.28

Budget Balance as of 6/29/17……...$4.38

	Funds requested from WRRI (Oct 1, 2016- May 31, 2017)
Salary	-
Fringe Benefits	-
Travel	Average round trip from NMSU to Gila and Mimbres basins staging areas to meet up with the outfitter and pack mules; and, to sites that are accessible by vehicle: approximately 355 miles x $0.55 per mile = $195.25/trip. We anticipate 8 trips (4 for Fall 2016 deployment and 4 for Spring 2017 retrieval) = **$1,562**
Supplies	Onset Hobo Loggers: Pendant 64K/STIC $64 each x 5 = $320 HOBO Waterproof Shuttle = 1 x $250 = $250 PVC, Stakes, and Epoxy: • Splash Zone AA-788QT epoxy = 1 x $60 = $60 • 36” framing stakes $4 each x 50 = $200 • Misc PVC pieces for housings ~$75 **Total = $905**
Services	Pack services provided by JEB Outfitter LLC (Albuquerque 505-331-5926; Vendor has been approved by NMSU) $440/day includes labor, trailer use, per diem, and mule cost by outfitter and student PI. Anticipate 8 days (4 days for Fall 2016 deployment and 4 days for Spring 2017 retrieval) = **$3,520 pack services**
Equipment	-
Other	-
Total Direct Costs	**$5,987.00**

References:

[1] Isaak, D.J., C.H. Luce, B.E. Rieman, D.E. Nagel, E.E. Peterson, D.L. Horan, S. Parkes, and G.L. Chandler. 2010. Effects of climate change and wildfire on stream temperatures and salmonid thermal habitat in a mountain river network. Ecological Applications 20:1350-1371.

[2] DeWeber, J. T., and T. Wagner. 2015. Predicting Brook Trout occurrence in stream reaches throughout their native range in the eastern United States. Transactions of the American Fisheries Society 144:11-24.

[3]Zeigler, M.P., A.S. Todd, C.A. Caldwell. 2012. Evidence of recent climate change within the historic range of Rio Grande cutthroat trout: Implications for management and future persistence. Transactions of the American Fisheries Society 141:1045-1059.

[4]Paroz, Y.M., and D. L. Propst. 2007. Distribution of spikedace, loach minnow, and chub species in the Gila River Basin, New Mexico 1908-2007. New Mexico Department of Game and Fish. Final Report submitted to the U.S. Fish and Wildlife Service and U.S. Bureau of Reclamation. 23 p.

[5]Hoestetler, S.W., J.R. Alder, and A.M. Allan. 2010. Dynamically downscaled climate simulations over North America: methods, evaluation and supporting documentation. U.S. Geological Survey Open-File Report 2011-1238. 64 p.

[6]Brooks, J.E. 2015. Non-native trout removal efforts in Willow Creek Drainage, 26-27 June 2015. Trip Report to Joseph McGurrin, Trout Unlimited, Arlington, VA. 9 pp.

[7]Brooks, J.E. 2016. Non-native trout removal efforts with a large Trout Unlimited Volunteer effort for Willow Creek Drainage, 23-26 June 2016. Trip Report to Joseph McGurrin, Trout Unlimited, Arlington, VA. 11 pp.

[8]Lee, Raymond M., Rinne, J.N. Critical Thermal Maxima of Five Trout Species in the Southwestern United States. Transactions of the American Fisheries Society, 109:6, 632-635.

Acknowledgements

The author (T. Wallin) would like to thank the New Mexico Water Resources Research Institute for funding the research. Additional support was provided by New Mexico State University, Department of Fish, Wildlife and Conservation Ecology in the way of vehicles, office space, PC, and software. Additional support in the way of a graduate assistantship was provided for T. Wallin by the U.S. Fish and Wildlife Service - Science Support Partnership. The advising and mentoring of C. Caldwell was a major factor in the success of this grant, the completion of this report, and the author's ability to apply the data and field observation to real world issues. The author would also like to acknowledge D. Myers, J. Brooks, and J. Wick for their tireless field assistance. Deployment of the 60 temperature dataloggers would not have been possible without the spirit of cooperation and from this, Gila trout will once again rise from the ashes.