LTRR-SRP II : The Current Drought In Context: A Tree-Ring Based Evaluation Of Water Supply Variability For The Salt-Verde River Basin

PROGRESS REPORT #3
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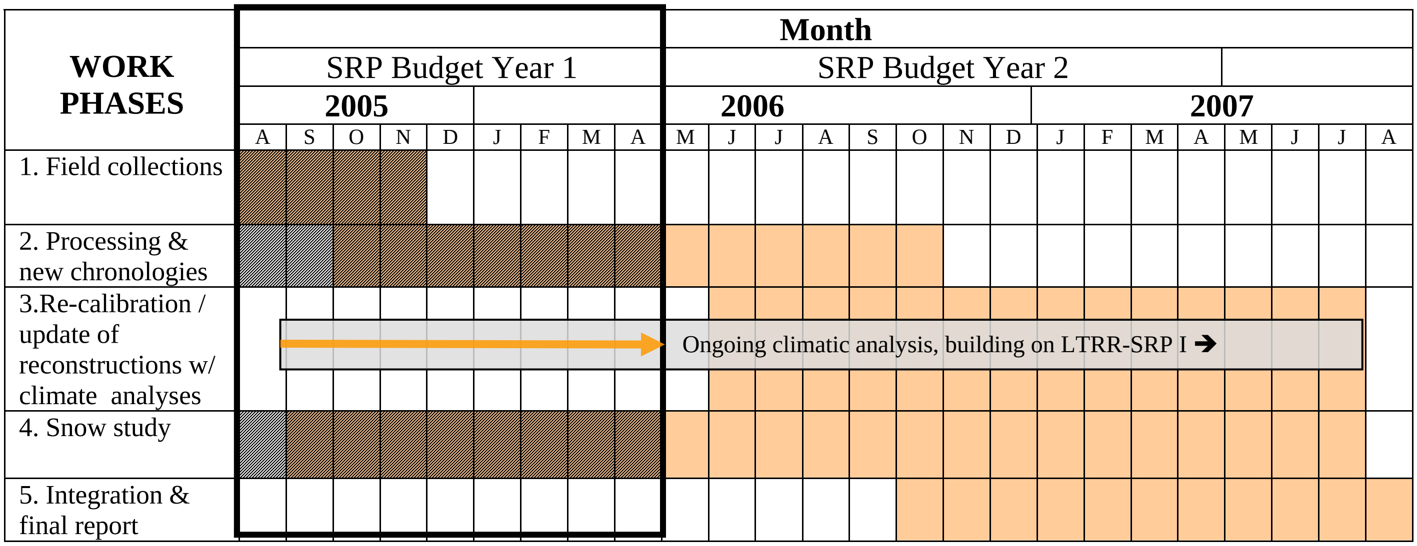

As of the end of April 2006, work has continued on Work Phases (1), (2) and (4) in addition to the continuation of ongoing climatic analysis that is part of Work Phase (3)

WORK PHASE 1: Collection and recollection of tree ring cores from selected sites in order to develop new chronologies and update existing chronologies.

Due to the winter hiatus of the field season, no new collection trips have been completed since the **six field trips** noted in our last report. As shown in **Table 1,** a total of 18 sites have been collected and are currently being processed.

WORK PHASE 2: Processing of the new collections.

Since Report #2, three new site collections have been crossdated to extend the chronology up through 2005, for a total of five updated sites. The newly dated sites expand the update geographically, as far north as the Flagstaff area (see map , **Figure 1**) The cores for several other sites have been mounted and sanded, ready for dating (see **Table 1**). **The newly dated sites continue to confirm the severity of the recent drought, especially the extreme year of 2002.** For example, of 30 trees sampled at Site 6 (Gus Pearson) only two trees contained a ring for 2002 and of 30 trees sampled at Site 10 (Robinson Mountain) only three trees contained a ring for 2002 (see **Figure 2**). When a ring for the year 2002 was formed at these sites, it was a very narrow "micro ring" and often in a younger tree. The trees at these sites also contained false bands. As of April 30, we continue to be on schedule with the sample processing and dating work phase.

Table 1. Field collections of tree-ring sites

(Sites **bolded and shaded** have been dated through 2005; **yellow shading** indicates sites whose dating has been completed since Report #2; **P** indicates collections which have been **prepared (mounted and sanded)** since Progress Report #2, and are awaiting dating.)

Map#	Site Name	Species[1]	Lat	Long	Elev(ft)	T [2]	S [3]	Date [4]	N_T [5]
1	Black River Pine	PIPO	33.81	-109.32	7921	B	S	2005-11-17	25
2	**Black River Fir**	**PSME**	**33.81**	**-109.32**	**6754**	**B**	**D**	**2005-09-23**	**20**
3	**Black Mountain Lookout**	**PSME**	**33.38**	**-108.22**	**8692**	**B**	**P**	**2005-10-13**	**16**
4	Dry Creek	PIED	34.89	-111.82	4526	B	R	2005-10-21	0
5	**East Clear Creek**	**PIPO**	**34.55**	**-111.16**	**6706**	**B**	**P**	**2005-11-11**	**19**
6	**Gus Pearson**	**PIPO**	**35.27**	**-111.74**	**7423**	**B**	**D**	**2005-10-27**	**30**
7	**Jacks Canyon**	**PIED**	**34.75**	**-111.11**	**6303**	**B**	**P**	**2005-11-10**	**17**
8	Mogollon Rim West Fir	PSME	34.44	-111.29	7511	B	R	2005-11-03	0
9	Oak Spring Canyon	PIPO	33.92	-111.40	6199	B	R	2005-10-19	0
10	**Robinson Mountain**	**PIPO**	**35.38**	**-111.56**	**7313**	**B**	**D**	**2005-10-27**	**30**
11	**Red Butte**	**PIED**	**35.83**	**-112.08**	**6332**	**B**	**P**	**2005-10-28**	**16**
12	**Rocky Gulch**	**PIPO**	**34.73**	**-111.52**	**6453**	**B**	**P**	**2005-11-10**	**22**
13	Slate Mountain	PIPO	35.52	-111.83	7027	B	S	2005-10-28	31
14	**Sitgreaves Gravel Pit**	**PIPO**	**34.25**	**-109.94**	**6740**	**B**	**D**	**2005-09-24**	**24**
15	**Wahl Knoll**	**PSME**	**34.00**	**-109.39**	**9625**	**B**	**D**	**2005-11-19**	**18**
16	Wolf Head Draw Fir	PSME	33.40	-108.22	6593	B	R	2005-10-13	7
17	Oak Creek Canyon	PSME	35.03	-111.74	5904	E	R	2005-10-21	4
18	Wolf Creek Campground	PIPO	34.45	-112.45	5871	E	R	2005-10-21	4

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[2]T: type of collection (B=chronology building, E=exploratory) [1]Species: PSME = Pseudotsuga menziesii; PIPO = Pinus ponderosa PIED = Pinus edulis [3]S: status (R=reconnaisance or spot-sampled, S=full samples collected, **P=prepared** (mounted and sanded), **D=dated D** = newly dated sites, M=measured, C=chronology built [4]N_T: number of trees sampled

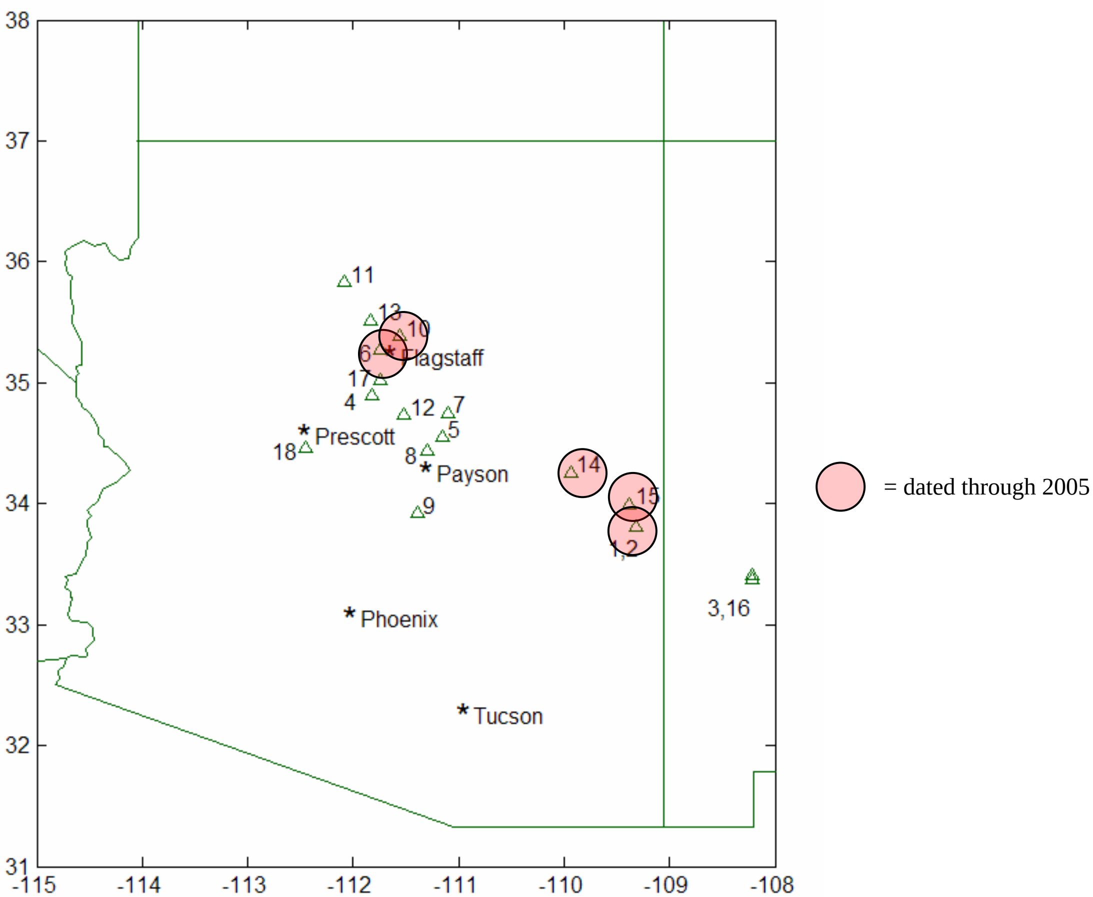


Figure 1. Locations of tree-ring sites which have been collected as of May 1, 2006

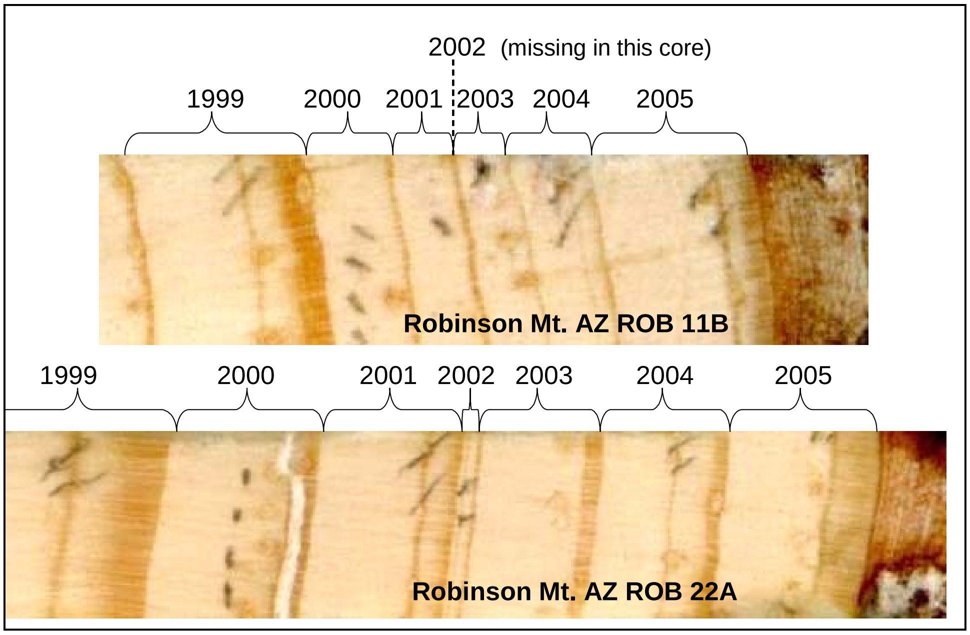


Figure 2. Close up of cores from two different trees at Site 10, located near Flagstaff.
The top core is missing the year 2002 (27 of the 30 trees at this site had no 2002 ring). The bottom core shows a very narrow 2002 "micro-ring" – only 3 trees at this site had a 2002 ring. // = false ring bands

WORK PHASE 3: Analysis of droughts and high flow extreme years in the context of present and past climatic variability.

Graduate student Ashley Coles has been examining the monthly circulation patterns in LL years (defined in the observed record as part of the SRP-I Project). She has focused on the timing of the apparent early winter/late winter westward shift in the location of a persistent upper-level high pressure anomaly center (ridge) from the western U.S. continent to the Pacific Ocean in the seasonal composite 500 mb maps (see dashed arrow in Jan-Mar map of **Figure 3**).

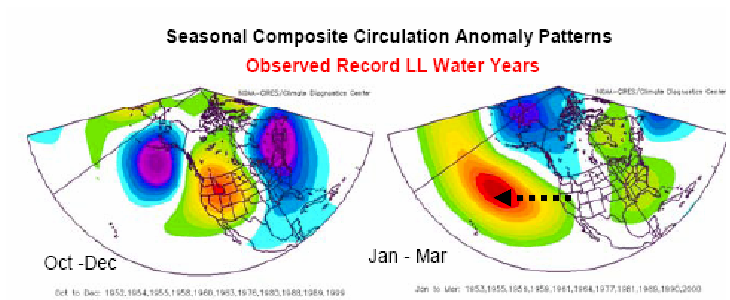


Figure 3 -- Seasonal "signature" shift to the west of the upper-level low pressure anomaly during LL years

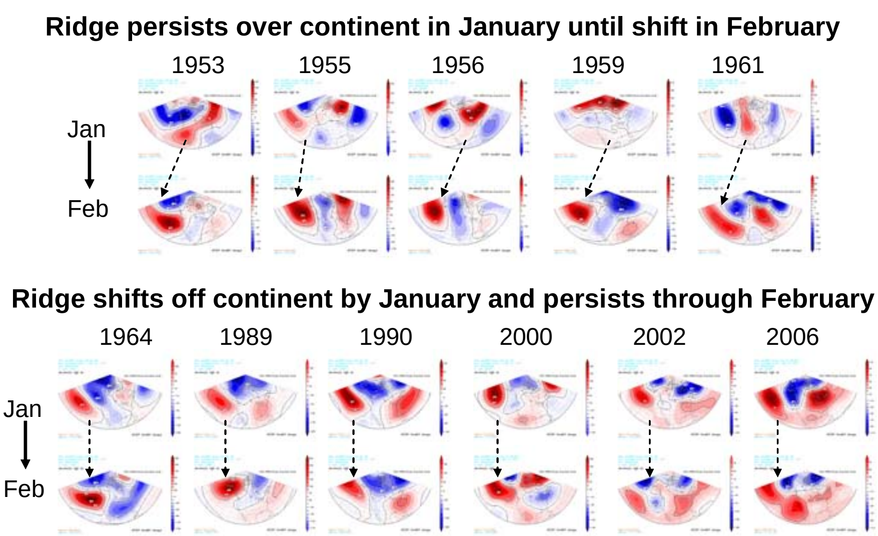


Figure 4 – Timing of westward shift in ridge (dark red anomaly) shown for individual years

In the dry 1950s, the westward shift in the persistent ridge over the continent did not take place until February, but in other years, especially the 2000s, the westward shift seems to have taken place earlier, in January (**Figure 4**).

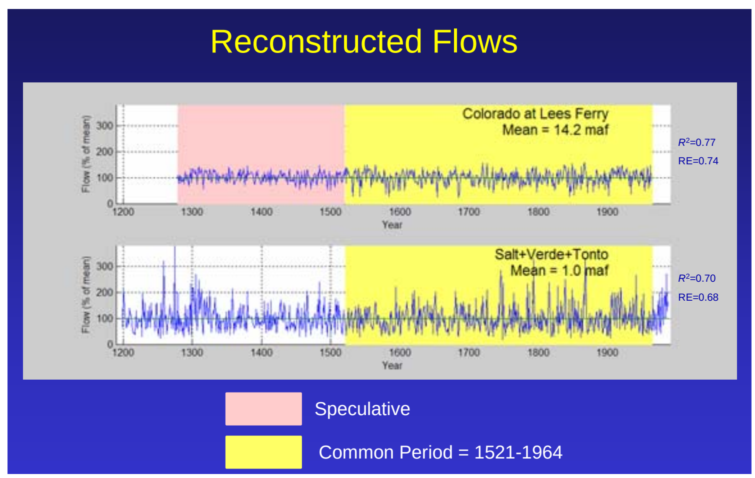
During the 1977 and 1981 LL years *(not shown*) the Oct-Dec early winter signature circulation pattern (**Figure 3**) continued into late winter, through February and March, respectively .

To place the current year in context, Ashley compared the circulation of the 2005-06 winter to these patterns. She found that the 500 mb circulation anomaly maps for the early- and late-cool season of 2005-2006 match fairly closely to the seasonal “signature” composite maps (Figure 3), with the exception of March 2006. February had a high pressure center sitting over northern Mexico that extended out to another high pressure center in the Pacific, which is fairly close to the composite. March 2006 was quite different, however, and was characterized by a low pressure anomaly just off of the Pacific Coast. According to SRP, this pattern *"produced considerable precipitation, although the follow-on disturbances produced less and less through time. The storms from March 11 onward gave the watershed an average of 2.1 inches of precipitation for the month. And most Valley gages recorded between 1 to 2 inches of rain (Sky Harbor set a daily rainfall record for March 11 with 1.40 inches!)"* (Jon Skindlov, personal communication). By examining individual years, seasons and months in this kind of detail, we can begin to sort out the subtle variations in circulation that create problems when large-scale indices (e.g., PNA, SOI, PDO, etc.) are correlated with regional drought. Our approach is to identify regionally specific characteristic “fingerprint” circulation patterns that can be linked to the development and persistence of extreme streamflow episodes in the Salt-Verde-Tonto. Later these will be linked to more standard indices as appropriate.

WORK PHASE 3: Preparation for Re-calibration Update of Reconstructions

As part of a conference presentation [1] on the results of SRP-I Project, Dave Meko reworked some of the data and figures from our earlier project (**Figure 5a**) and developed some new methods for comparing the flow in the two basins (Upper Colorado and Salt-Verde-Tonto) (**Figure 5b**). The complete presentation can be found at: http://fp.arizona.edu/khirschboeck/srp2.htm These analyses have helped to refine some of the techniques that will be used in the second year of the SRP-II Project.

Figure 5a.
New plot of reconstructed Colorado and Salt-Verde-Tonto streamflow series



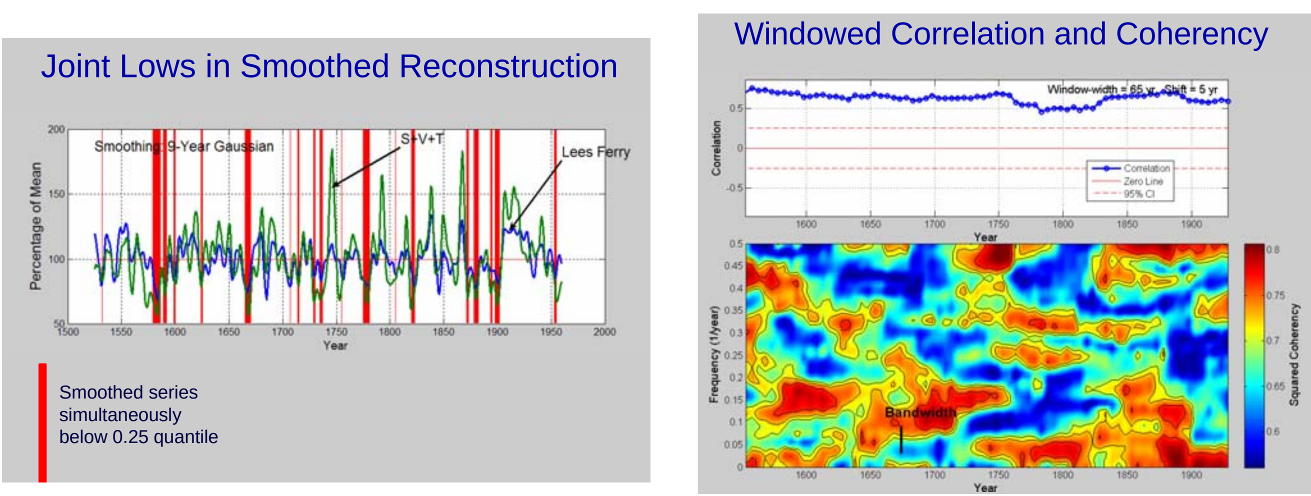


Figure 5b. Examples of figures from new analyses by Dave Meko for examining the relationship between extreme streamflow in the Upper Colorado and Salt-Verde-Tonto Basins.

[1] Meko D. M., Hirschboeck K. K., Czyzowska E., Lee J. and Morino K. (2006) Multi-basin drought and Arizona water supply, a tree-ring perspective. 22nd Pacific Climate Workshop PACLIM, March 26-29. Pacific Grove, California.

WORK PHASE 4: Analysis of the relationship between tree-ring data and snow variables through remotely sensed observations.

Graduate student Ela Czyzowska's Artificial Neural Network (ANN) is now operational in Matlab and has produced simulated fractional snow cover (FSC) based on Landsat imagery. The preliminary results show a significant and consistent relationship between a snow map classification from IKONOS imagery and Landsat TM5 multispectral bands 2, 4 and 5 **(Figure 6).**

The current ANN training and validation for LandsatFSC are based on comparatively small samples (Landsat TM5: 1000-1500; IKONOS 90000-135000 pixels) representing diverse groups of an alpine-forested environment, e.g. snow cover on densely forested north-facing slopes, with steepness between 10-15°, and shadow effects of 0-5%, etc. Further ANN training for Landsat FSC will be focused on final neural network adjustments within the test areas and the implementation of ANN training on samples linking all test areas.

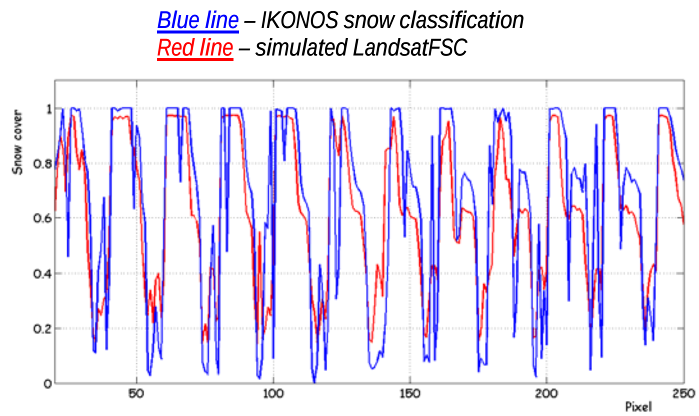


Figure 6. Simulated Landsat FSC (bands: 2, 4 and 5) for south-facing slope with forest area changing from 0 to 100%.

Figure 7. Location of tree-ring (re)collection sites in the San Juan Mountains, Colorado

In March, Ela submitted a renewal proposal to NASA for the continuation of the remote sensing aspects of Year 2 of her project. Her plans for the upcoming summer and fall are to complete validation of her results, integrate a vegetation classification into her algorithms and complete tree-ring data collections and re-collections necessary for winter precipitation reconstruction in the San Juan study area (see **Figure 7**). In addition she will be involved in the ongoing SRP-II work in the Salt-Verde Basin.

SUMMARY

Our progress in each work phase is still on schedule with respect to our estimated time line. The most recent cores analyzed show evidence of missing rings and very narrow "micro-rings" that support our earlier findings about the severity of some of the most recent years of drought in the Salt-Verde Basin. We have begun to identify "fingerprint" circulation patterns linked to severe and persistent drought and will be evaluating their relationship to other circulation indices. Over the next several months we expect to collect cores from remaining field sites, complete the sample processing and dating, and be ready to begin the analyses of winter vs. summer precipitation contributions to ring width, along with the re-calibration needed to produce updated streamflow reconstructions.