Using Paleo-Climate Records

To Assess the Current Hydrology of the New Mexico Middle Rio Grande

Karen J. Lewis, Deborah Hathaway *– S. S. Papadopulos & Associates, Inc. Boulder, CO*

Paleo-climate studies are often considered esoteric, scientific projects with little practical application to water management. However, S.S. Papadopulos & Associates (SSPA) has found immediate application of a simple paleo-climate analysis to our current work for the Army Corps of Engineers and the New Mexico Interstate Stream Commission.

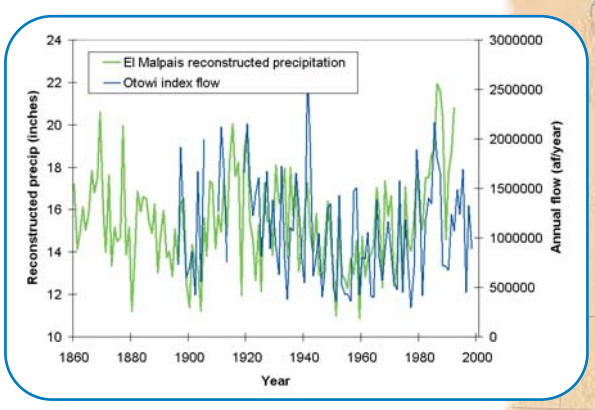
SSPA was tasked with performing a probabilistic analysis of the combined surface and groundwater budget in the Middle Rio Grande region of New Mexico. Initial analysis for this work used the period of record from 1950-1998 (S.S. Papadopulos & Associates, 2000). As part of Phase 3 of this study, SSPA wanted to assess whether this period was appropriate – did it indeed represent average hydrologic conditions in the Middle Rio Grande.

Tree Rings Reveal Accurate Measures

Longer-term continuous flow records for the Rio Grande at Otowi Bridge go back only to 1919 (discontinuously to 1896). This is insufficient to fully assess the 1950-1998 record. So, we turned to tree ring records (9 records were chosen for analysis), in particular the El Malpais record of Henri Grissino-Mayer (Grissino-Mayer, 1996).

We found that trying to use the tree ring records to reconstruct flow at Otowi Bridge was not highly successful; the tree-ring reconstructed flows failed to match outlier events in the annual flow record. However, the general agreement between the tree-ring records and annual flow at Otowi Bridge was good; we obtained correlations of 0.54 to 0.68. Consequently, we used tree-ring records as proxies for flow. As can be seen in the graph below, the reconstructed precipitation at El Malpais and the Otowi index flow track one another very well.

Comparing annual flow at Otowi Bridge with the tree ring records indicate that the period from 1950-1998 includes both a severe drought and a very wet period. The drought during the 1950s and 1960s appears to be roughly a 100-year event. The 1980s and 1990s were abnormally wet, wetter than anything seen over the past 1000 years. Based on this and other analyses, SSPA concluded the 1950-1998 record is lacking average years, but in general looks appropriate for use in water balance modeling, though average flows during this period may exceed flows averaged over the past 200 or more years. We also noted that extending the record back to 1919, the start of the continuous record, is contra-indicated.

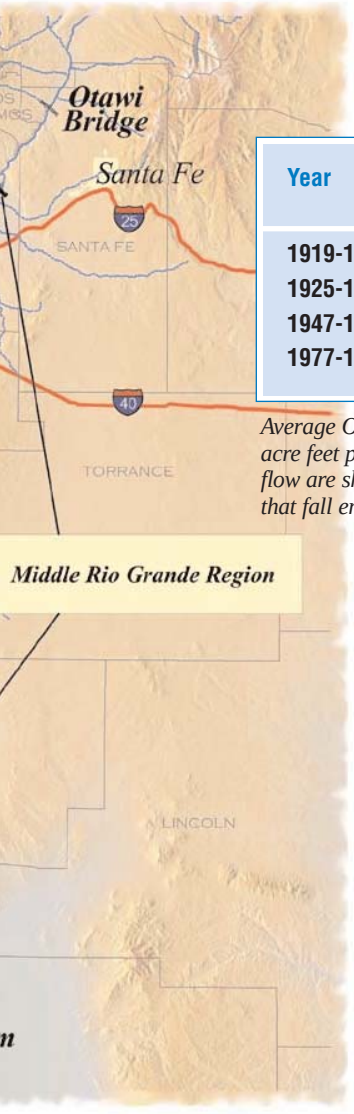


El Malpais reconstructed precipitation versus flow at Otowi Bridge (raw Otowi flow from 1896-1939; Otowi index flow from 1940-1998).

The period from 1919 to the early 1940s is a wet period. Thus, the 1919-1998 period includes two wet spells and one dry spell, biasing the hydrology to wetter-than-average conditions.

Assessing Future Climate

SSPA also looked at climate forcing in hopes of assessing where near-future climate was headed. We noted strong correlation between Otowi flow and El Niño and La Niña events. This is a well-known correlation in the Southwest. Water managers throughout the Southwest are starting to incorporate El Niño and La Niña forecasts into their planning.



Year	Average Otowi index flow	% of 1919-1998 average	PDO phase
1919-1998	1,058,102	100	
1925-1945	1,146,418	108	Positive (warm)
1947-1976	824,647	78	Negative (cool)
1977-1997	1184452	112	Positive (warm)

Average Otowi index flow for selected periods during the 1900s. Average flow (in acre feet per year) and the percent of flow compared with the 1919-1998 average flow are shown. The phase of the Pacific Decadal Oscillation is also show for periods that fall entirely within one phase of the cycle.

SSPA also found a strong correlation between flow at Otowi Bridge and the Pacific Decadal Oscillation (PDO). The PDO is a relatively recent discovery (Mantua, 2000). PDO effects on the Southwest are similar to those of El Niño and La Niña, but the PDO oscillates on a decadal-scale, rather than the 1-3 year scale of El Niño/La Niña. There were three phases of the PDO during the 1900s; average flow at Otowi Bridge during each of these is shown in table below. The PDO appears to have shifted to its negative phase over the past 3 years, suggesting the Southwest may experience below average precipitation for the next one to two decades.

In summary, SSPA has found paleo-climate data very useful. Tree-ring records can be used both to assess the optimal period of record for use in modeling and to indicate where recent conditions fall in relation to the long-term average (one to several hundred years). Paleo-climate data can also be valuable to water managers; climate-forcing information, such as El Niño, can help predict precipitation three to nine months in advance. The Pacific Decadal Oscillation may help predict longer-term trends and allow water managers to prepare for multi-year above or below average flows.

A full copy of SSPA's Middle Rio Grande paleo-climate assessment and the Middle Rio Grande Water Supply Study, Phase 2 can be found at www.sspa.com/ashu/rio/start.htm

Contact Karen Lewis at 303-939-8880 or klewis@sspap.com

References:

Grissino-Mayer, H., 1996. A 2129-year reconstruction of precipitation for northwestern New Mexico, U.S.A. Pages 191-204 in J. S. Dean, D. M. Meko, and T. W. Swetnam, editors. Tree Rings, Environment and Humanity. Radiocarbon, Tucson, AZ.

Mantua, N., 2000. Web site. JISAO, University of Washington. http://www.atmos.washington.edu/~mantua/REPORTS/PDO/PDO_egec.htm

S.S. Papadopulos & Associates, Inc., 2000. Middle Rio Grande water supply study. Prepared for the Army Corps of Engineers and the New Mexico Interstate Stream Commission.