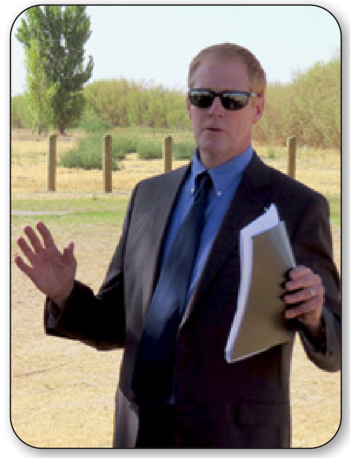
Groundwater/Surface Water Connections

Sam Fernald, Director, New Mexico Water Resources Research Institute



Sam Fernald was appointed director of the New Mexico Water Resources Research Institute (NM WRRI) in July 2013 after having served as interim director since January 2011. As director, he will lead the institute in its mission to develop and disseminate knowledge that will assist the state, region, and nation in solving water resources problems. The NM WRRI, one of 54 water institutes in the nation, encourages university faculty statewide to pursue critical areas of water resources research while providing training opportunities for students, and transfers research findings to the academic community, water managers and the general public. Professor Fernald also is a faculty member in the Department of Animal and Range Sciences at New Mexico State University.

Sam's earned degrees include a 1987 B.A. in international relations from Stanford University, an M.E.M. in 1993 in water and air resources from Duke University, and a Ph.D. in watershed science from Colorado State University in 1997. His primary research interests include water quality hydrology; land use effects on infiltration, runoff, sediment yield, and nonpoint source pollution; and effects of surface water/groundwater exchange on water availability and water quality. Sam received a Fulbright Scholarship to Patagonian National University, Trelew, Argentina in 2008, and another Fulbright Scholarship to the University of Concepcion, Concepcion, Chile in 2000.

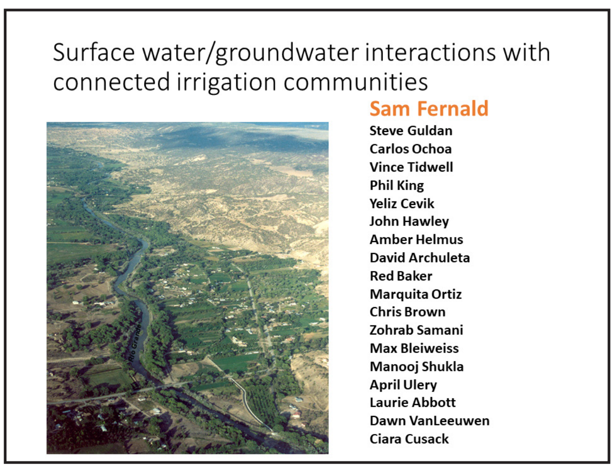


Figure 1. Introduction.

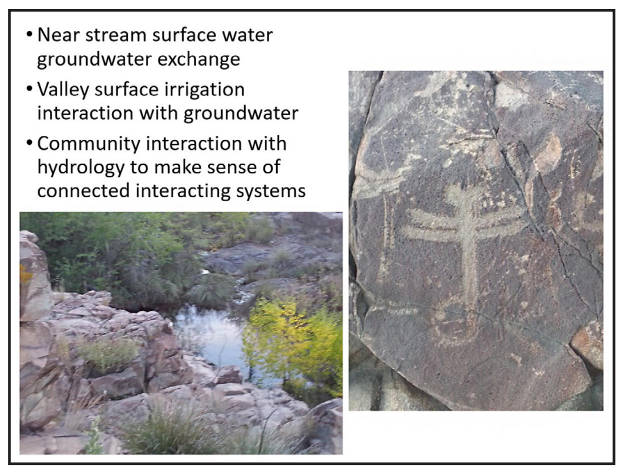


Figure 2. Outline.

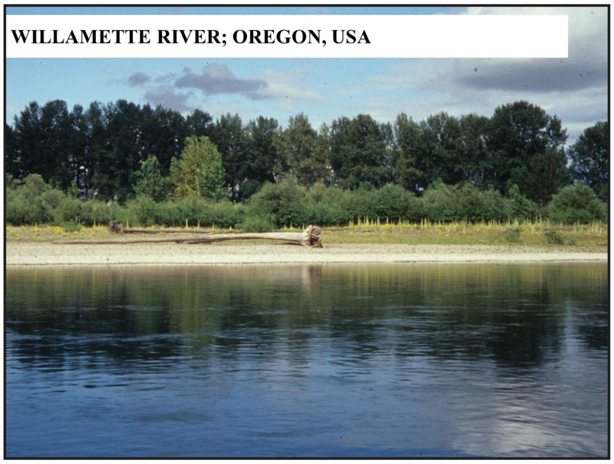


Figure 3. Willamette River in Oregon, USA.

Figure 4. Alcoves favored by endangered salmon.

Figure 5. Studied water quality in rivers and alcoves and surface water groundwater exchange.

Figure 6. Used dye to trace solute movement.

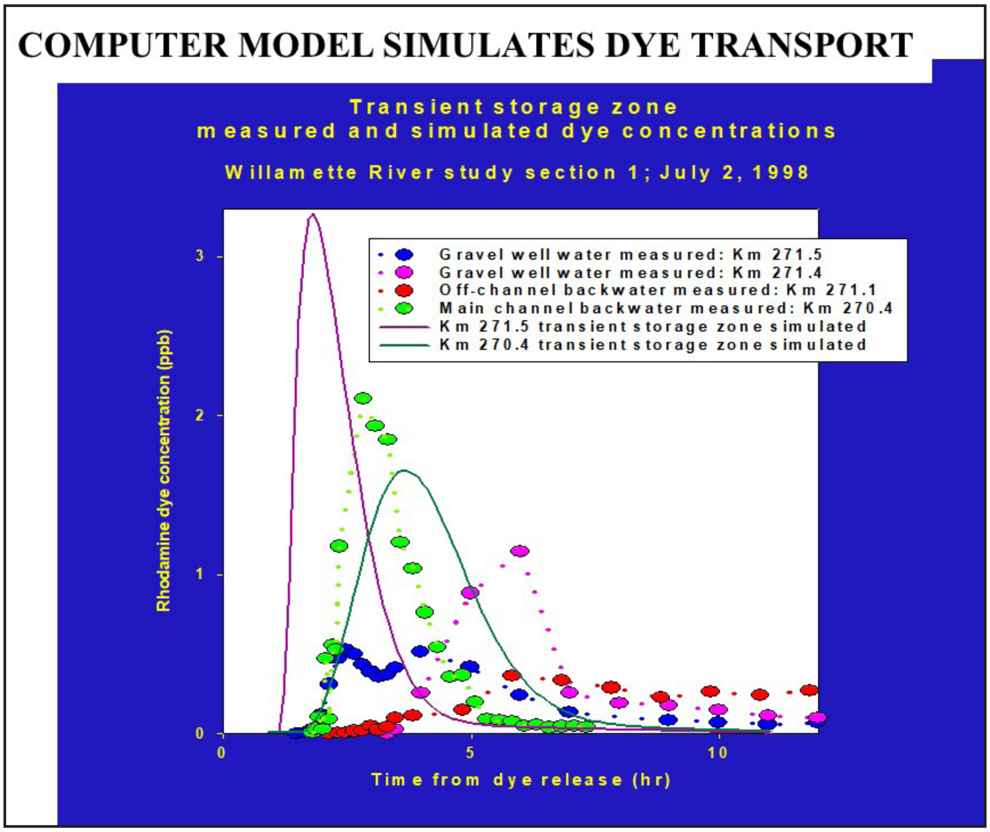


Figure 7. Computer model simulates dye transport.

Figure 8. Gravel bars filter river water so the alcove water is cool and clean for fish.

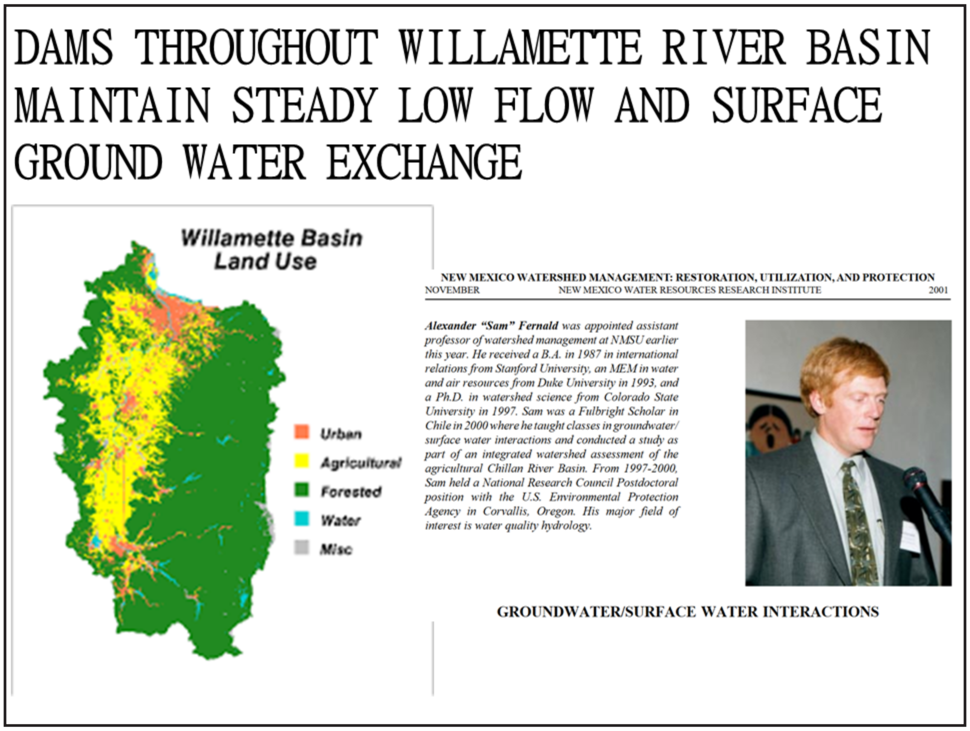


Figure 9. Dams throughout Willamette River basin maintain steady low flow and surface/groundwater exchange.

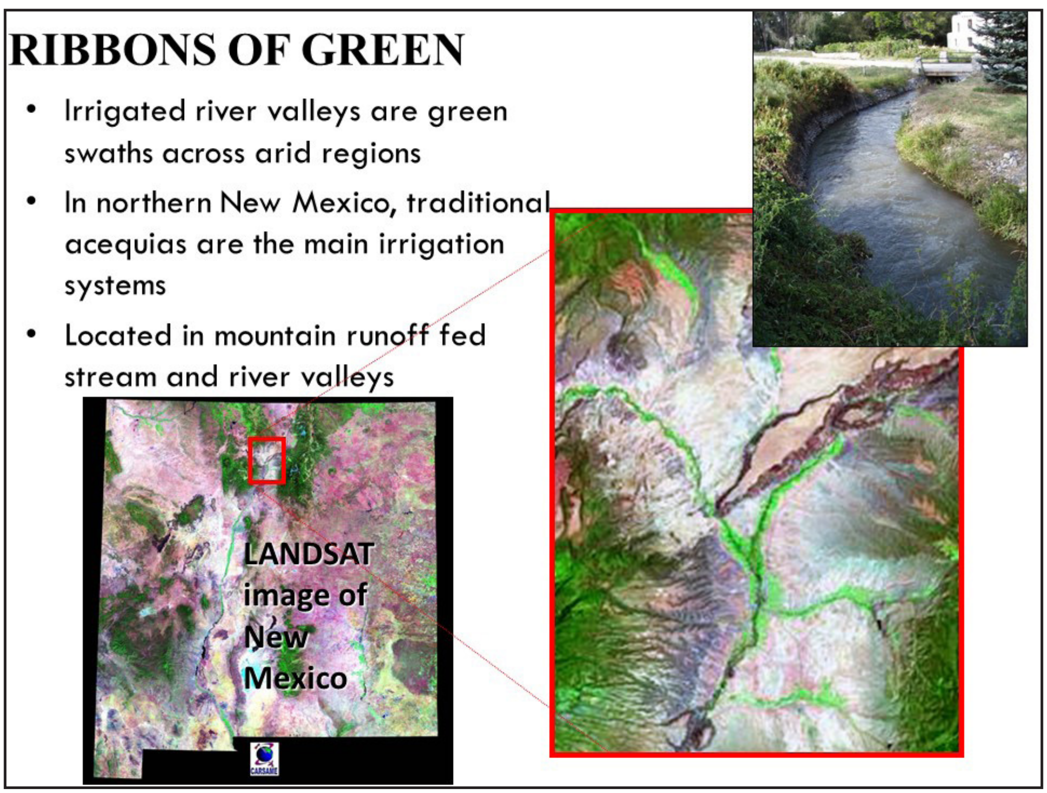


Figure 10. Ribbons of green in northern New Mexico.

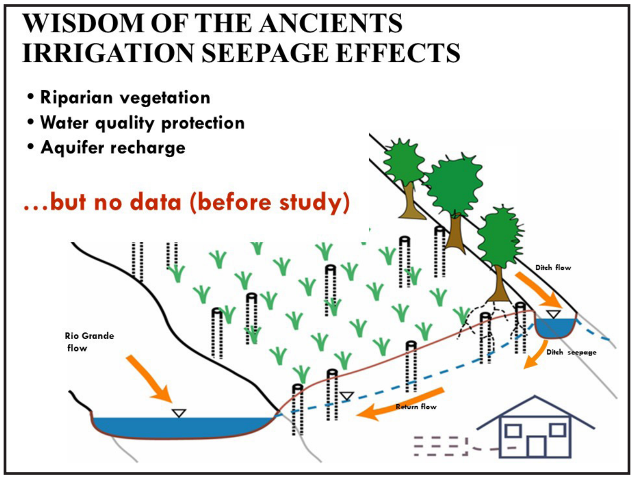


Figure 11. Wisdom of the ancients irrigation seepage effects.

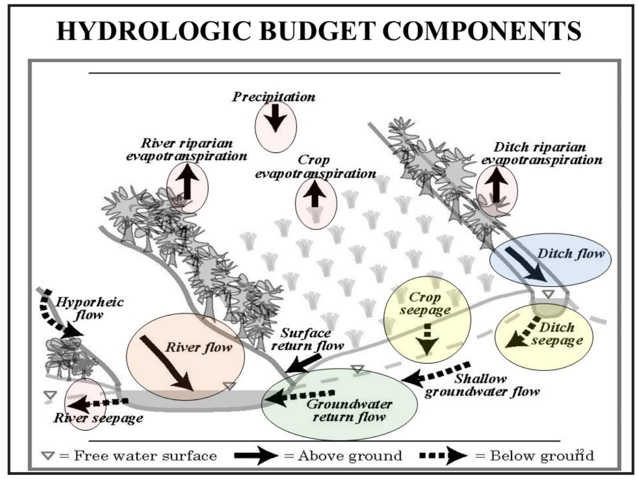


Figure 12. Hydrological budget components.

Alcalde Acequia three year (2005-2007) averaged water balance.

Component		Amount from canal diversion (%)	Range (%)
Surface water return flow	Turnouts	9.5	0 to 14
	Crop field tailwater	8.9	0 to 19
	Canal outflow	40.9	28 to 67
Ground water return flow	Ditch seepage	12.1	5 to 17
	Deep percolation	21.2	9 to 32
Evapotranspiration		7.4	1 to 15
	Total	100.0	

Figure 13. Alcalde Acequia three year (2005-2007) averaged water balance.

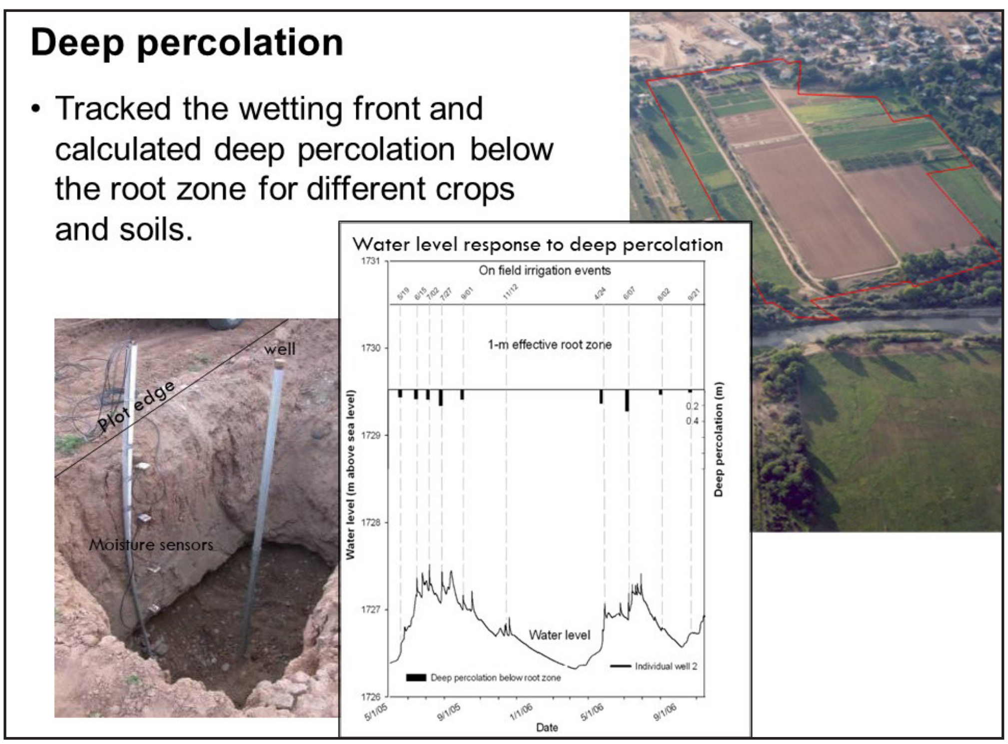


Figure 14. Water level response to deep percolation.

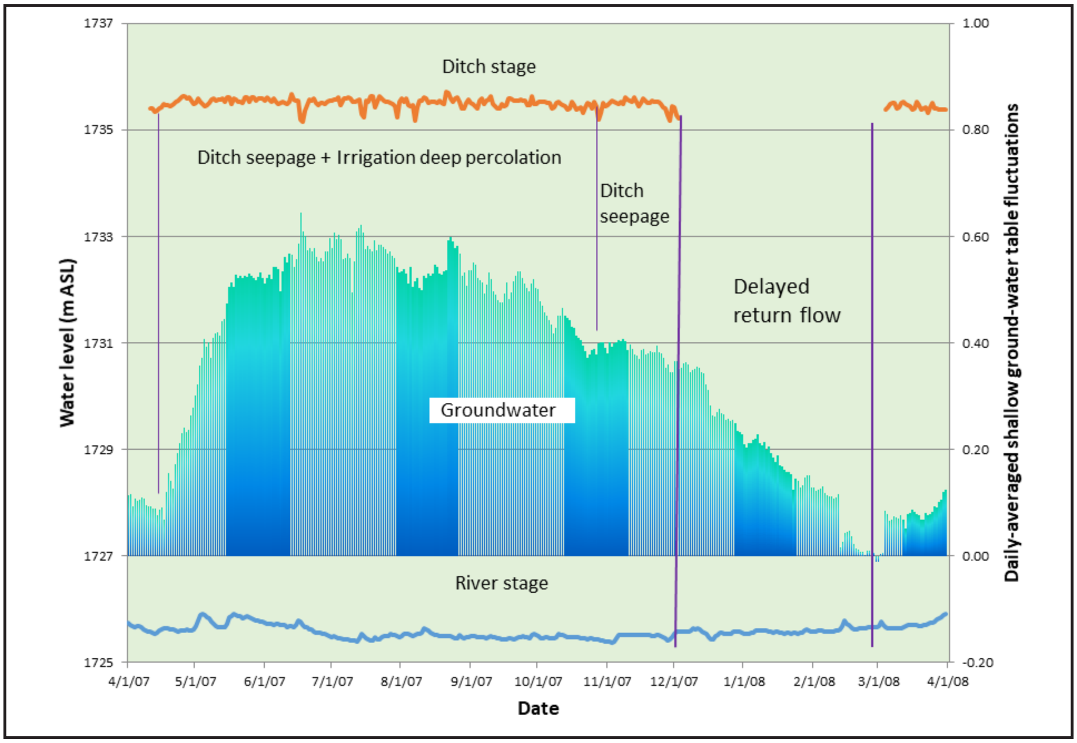


Figure 15. Irrigation recharges groundwater.

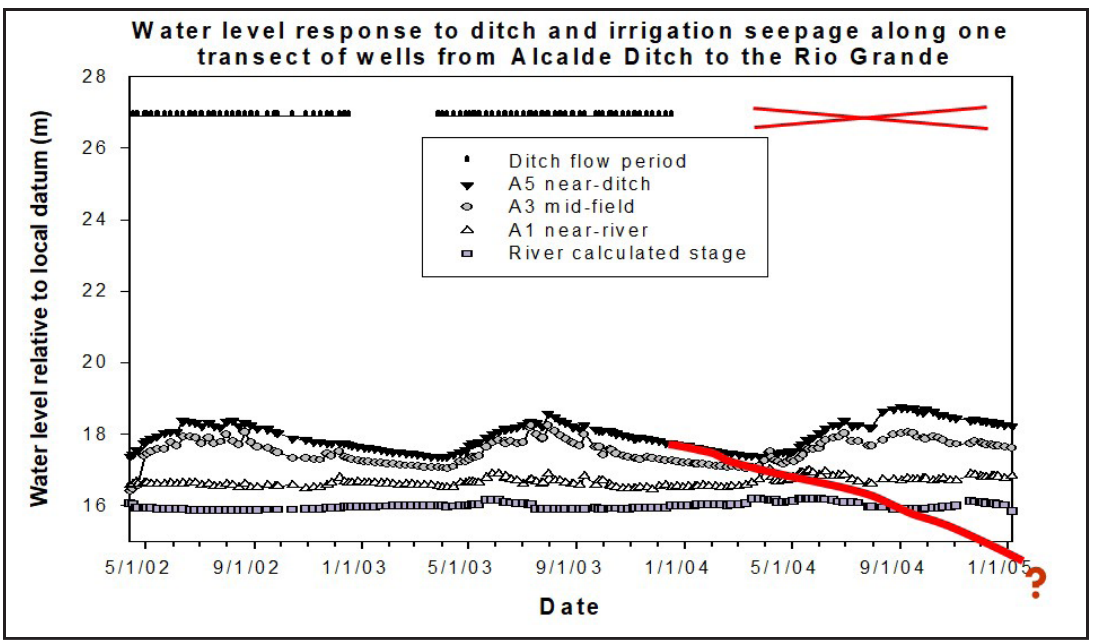


Figure 16. Potential effects of reduced groundwater recharge.

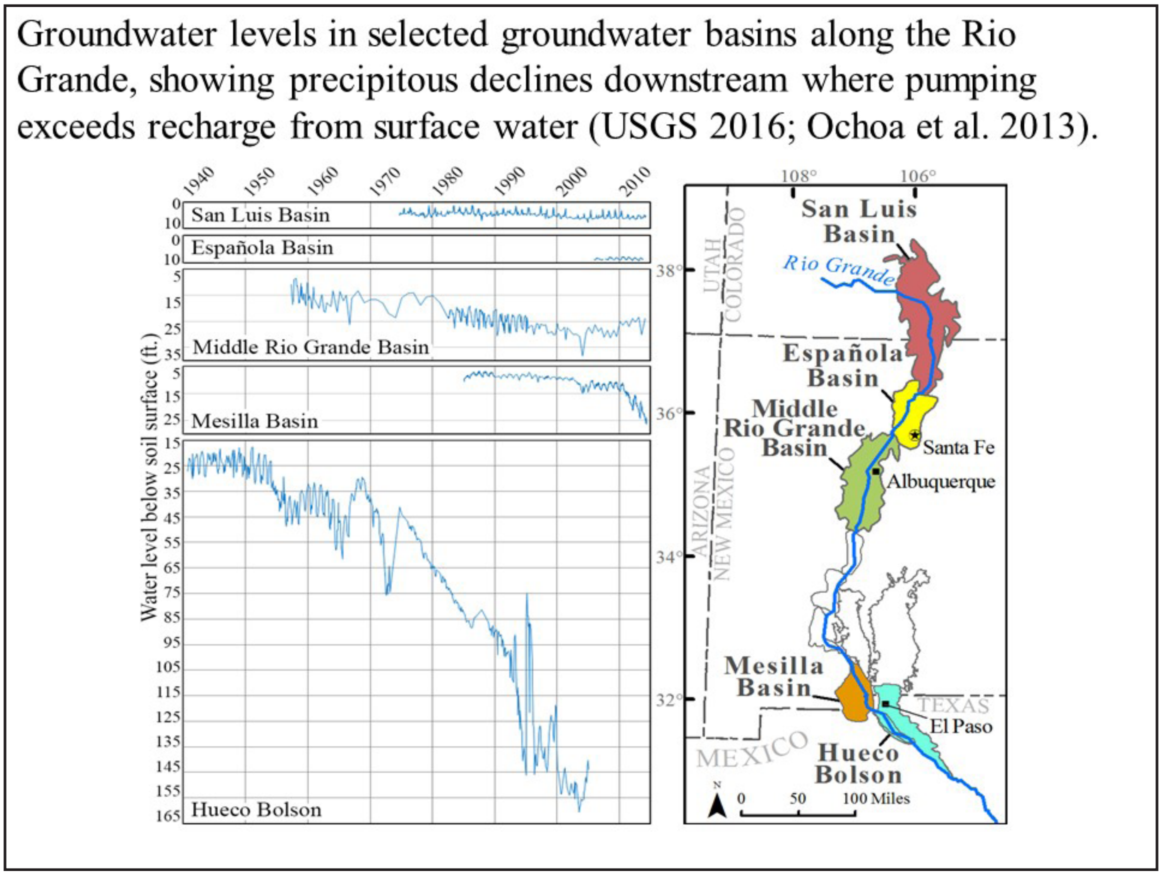


Figure 17. Groundwater levels in selected groundwater basins along the Rio Grande.

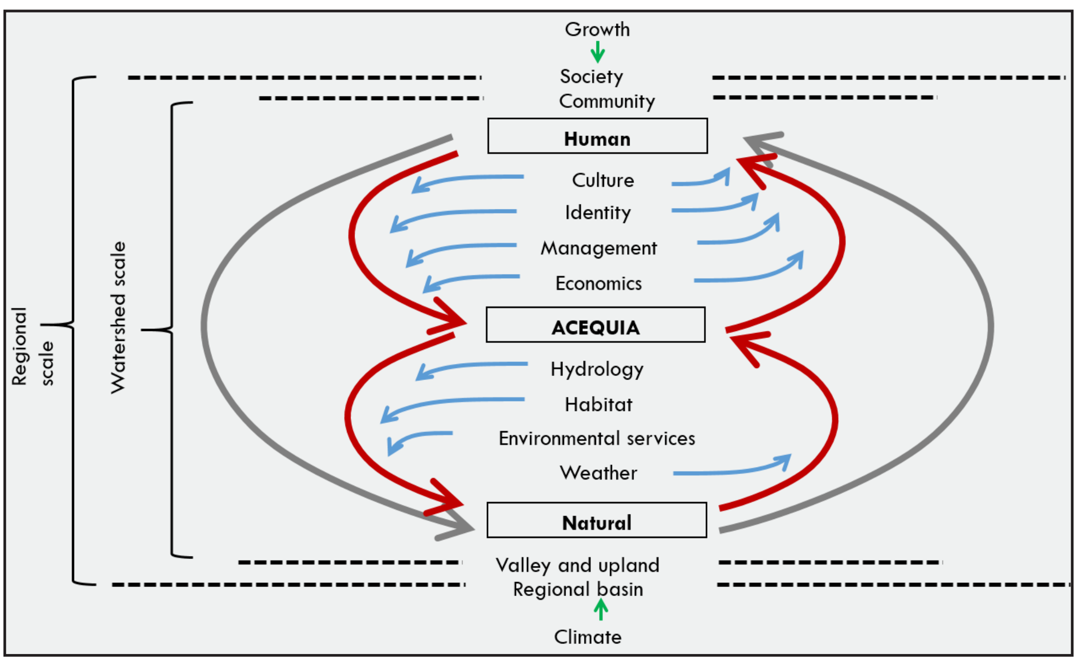


Figure 18. Acequias linking culture and nature. Casual flow chart with human and natural linkages through an acequia.

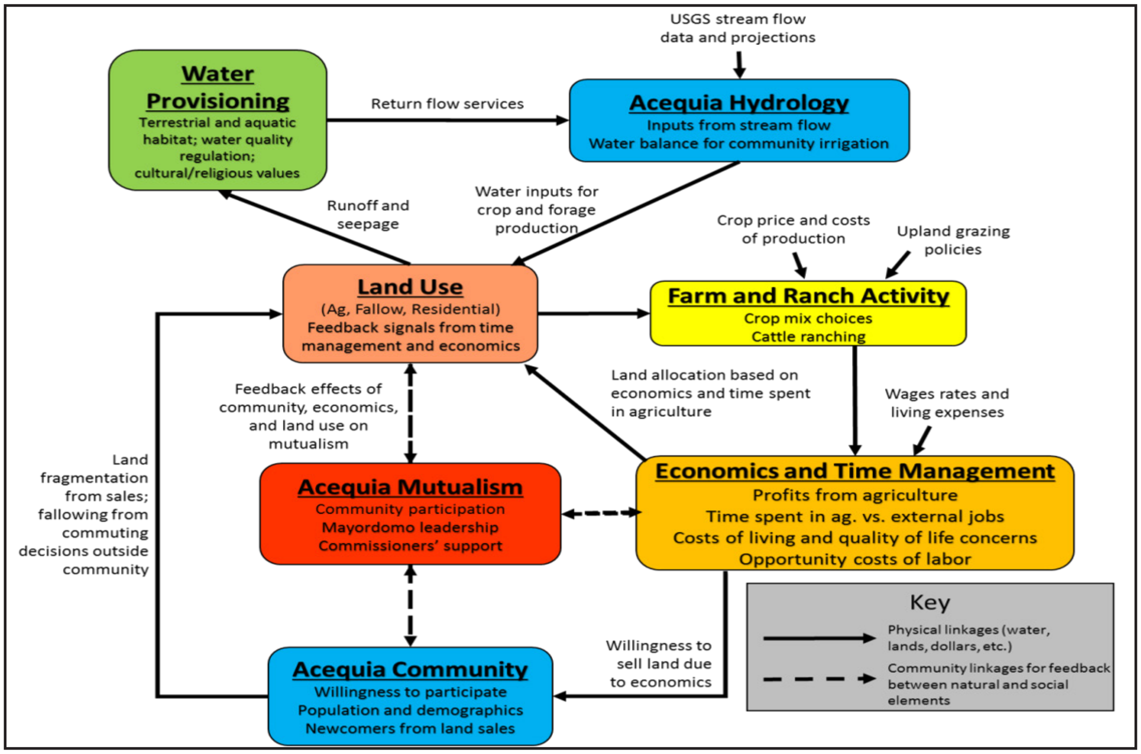


Figure 19. Conceptual diagram showing the major endogenous components within the acequia model and the linkages between them.

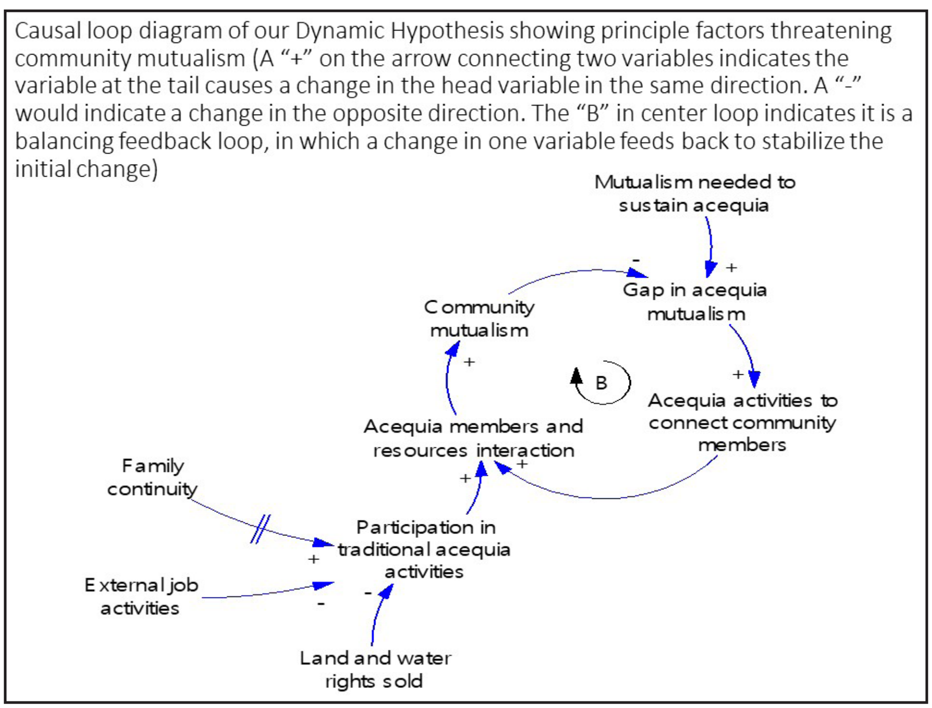


Figure 20. Causal loop diagram of our dynamic hypothesis showing principle factors threatening community mutualism.

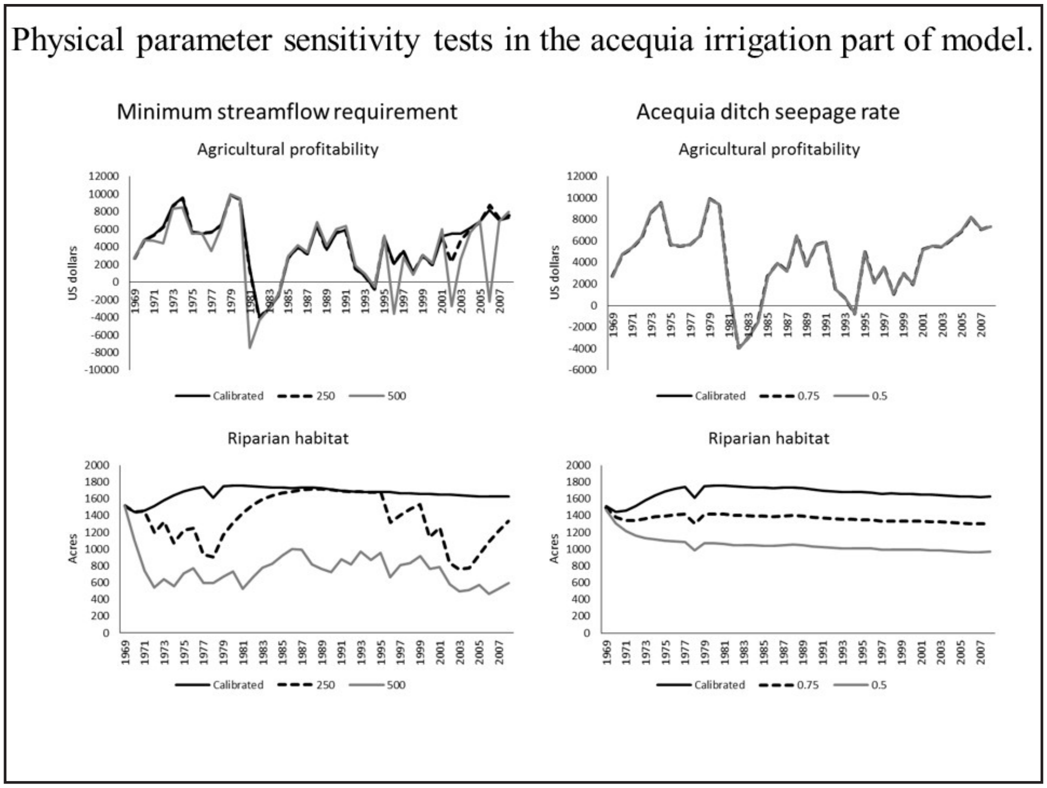


Figure 21. Physical parameter sensitivity tests in the acequia irrigation part of model.

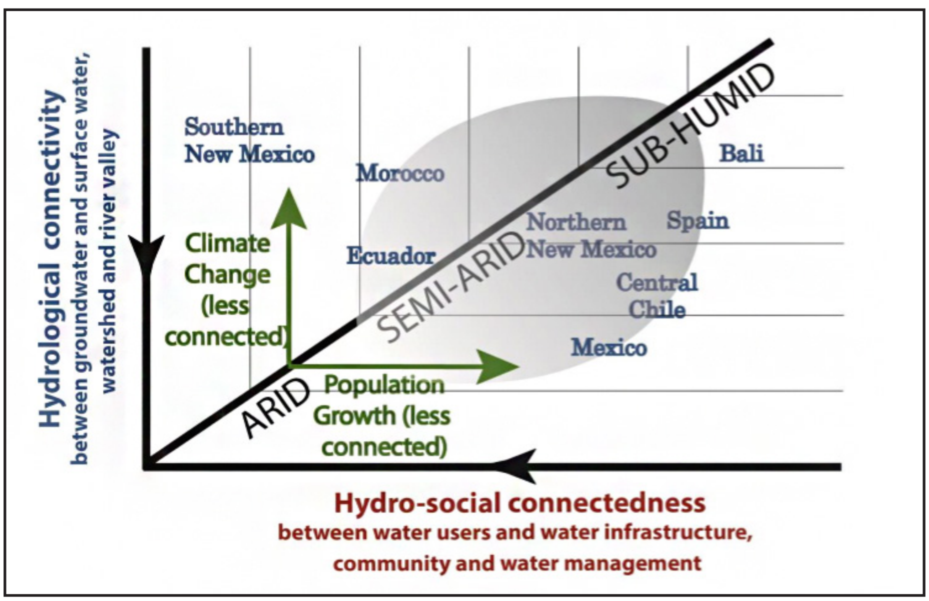


Figure 22. Conceptual diagram of the relationship between resilience and hydrologic connectivity and hydro-social connectedness.

Hydrology Conclusions:

1. Large flows are rapidly exchanged between river, irrigation system, and fluvial aquifer.
2. A significant amount of water being diverted into the valley returns back to the river after completing important production and ecological tasks.
3. The irrigation systems collectively take spring and summer runoff from the river and retransmit the flow to later in the year through seepage and groundwater return flow.
4. Human water management drives surface water groundwater interactions

Figure 23. Hydrology conclusions.

Thriving human hydrologic connections:

1. Humans interface with and reinforce hydrologic connections
2. Incorporating human impact is required to understand and manage surface water groundwater exchange

Figure 24. Thriving human hydrologic connections.

Figure 25. Sponsors for the research.

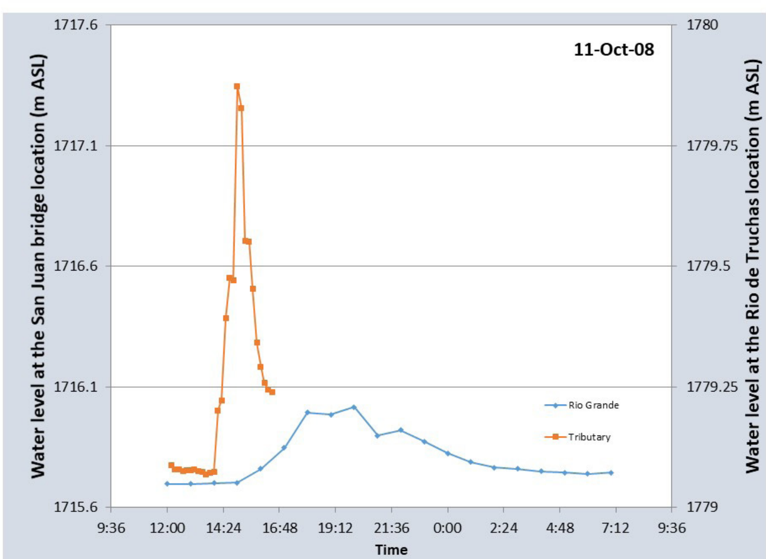


Figure 26. Water level at the San Juan bridge compared to the water level at Rio de Truchas

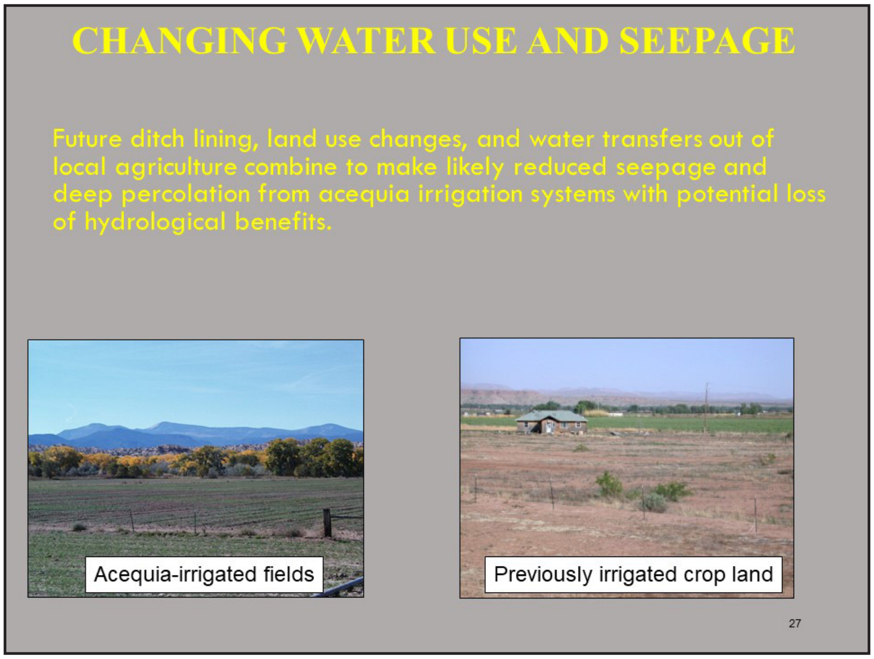
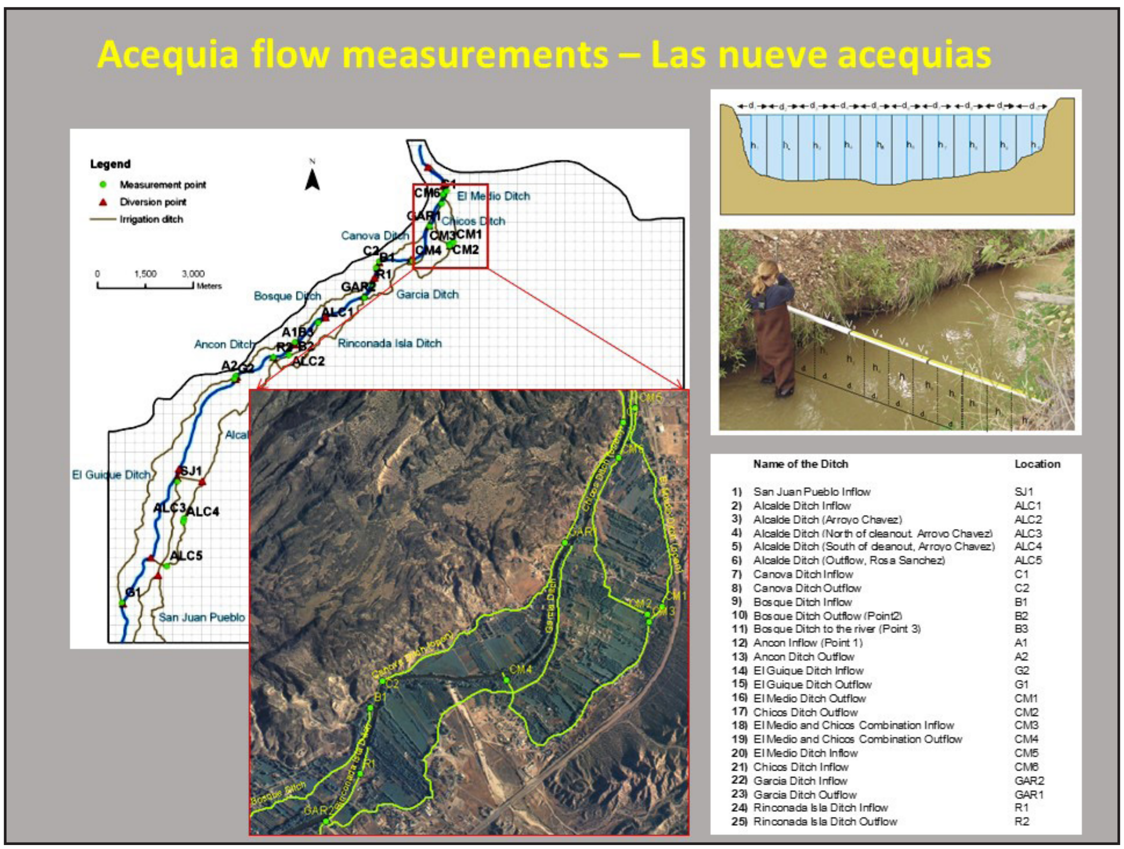


Figure 27. Changing water use and seepage.



	Name of the Ditch	Location
1)	San Juan Pueblo Inflow	SJ1
2)	Alcalde Ditch Inflow	ALC1
3)	Alcalde Ditch (Arroyo Chavez)	ALC2
4)	Alcalde Ditch (North of cleanout. Arroyo Chavez)	ALC3
5)	Alcalde Ditch (South of cleanout, Arroyo Chavez)	ALC4
6)	Alcalde Ditch (Outflow, Rosa Sanchez)	ALC5
7)	Canova Ditch Inflow	C1
8)	Canova Ditch Outflow	C2
9)	Bosque Ditch Inflow	B1
10)	Bosque Ditch Outflow (Point2)	B2
11)	Bosque Ditch to the river (Point 3)	B3
12)	Ancon Inflow (Point 1)	A1
13)	Ancon Ditch Outflow	A2
14)	El Guique Ditch Inflow	G2
15)	El Guique Ditch Outflow	G1
16)	El Medio Ditch Outflow	CM1
17)	Chicos Ditch Outflow	CM2
18)	El Medio and Chicos Combination Inflow	CM3
19)	El Medio and Chicos Combination Outflow	CM4
20)	El Medio Ditch Inflow	CM5
21)	Chicos Ditch Inflow	CM6
22)	Garcia Ditch Inflow	GAR2
23)	Garcia Ditch Outflow	GAR1
24)	Rinconada Isla Ditch Inflow	R1
25)	Rinconada Isla Ditch Outflow	R2

Figure 28. Acequia flow measurements in Las nueve acequias.

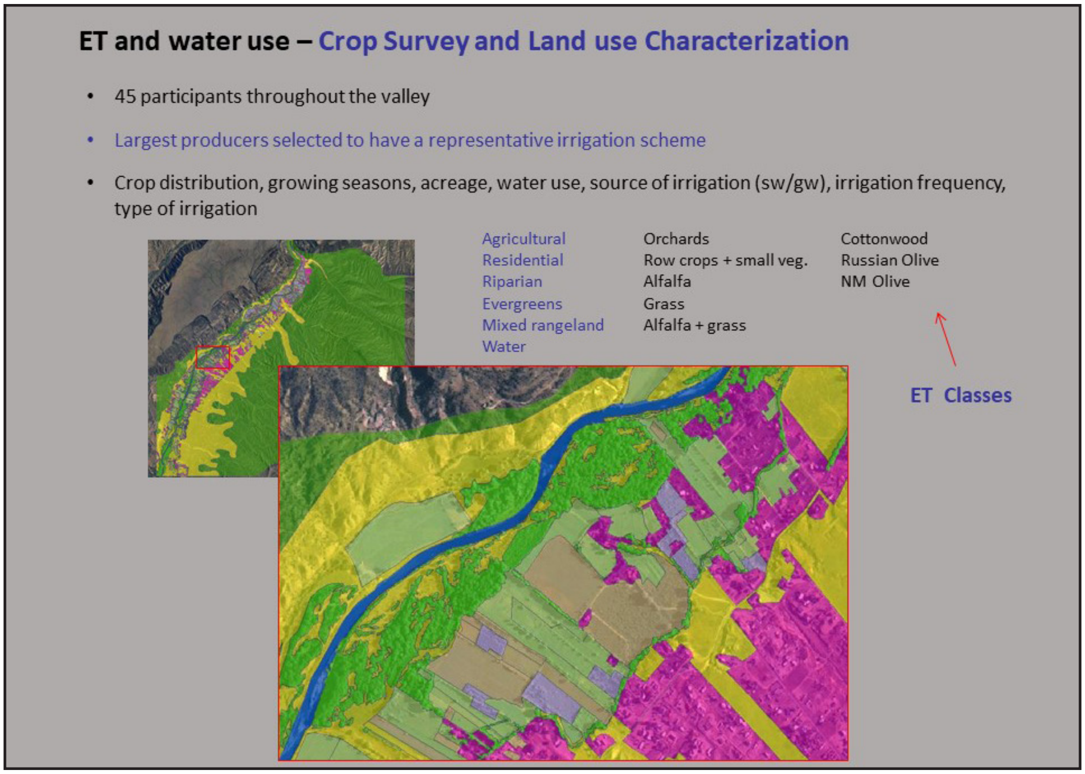


Figure 29. Evapotranspiration and water use using crop survey.

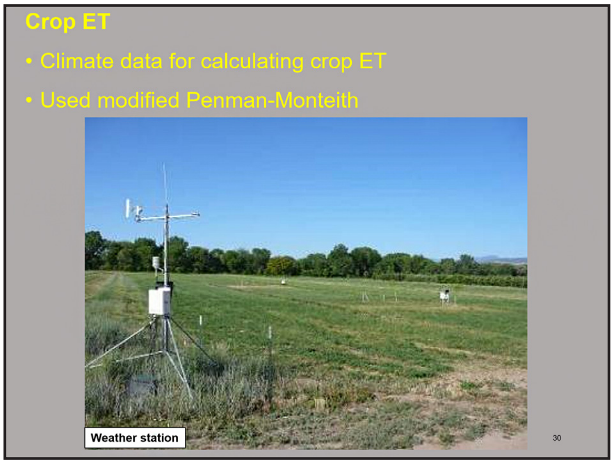


Figure 30. Calculating crop evapotranspiration.

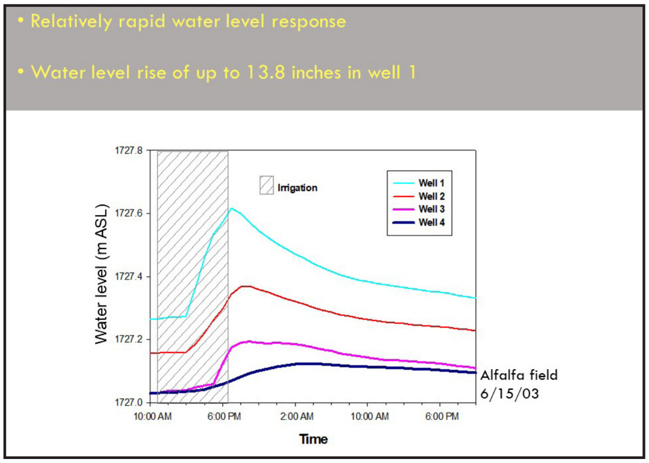


Figure 31. Water level fluctuation in response to deep percolation input.

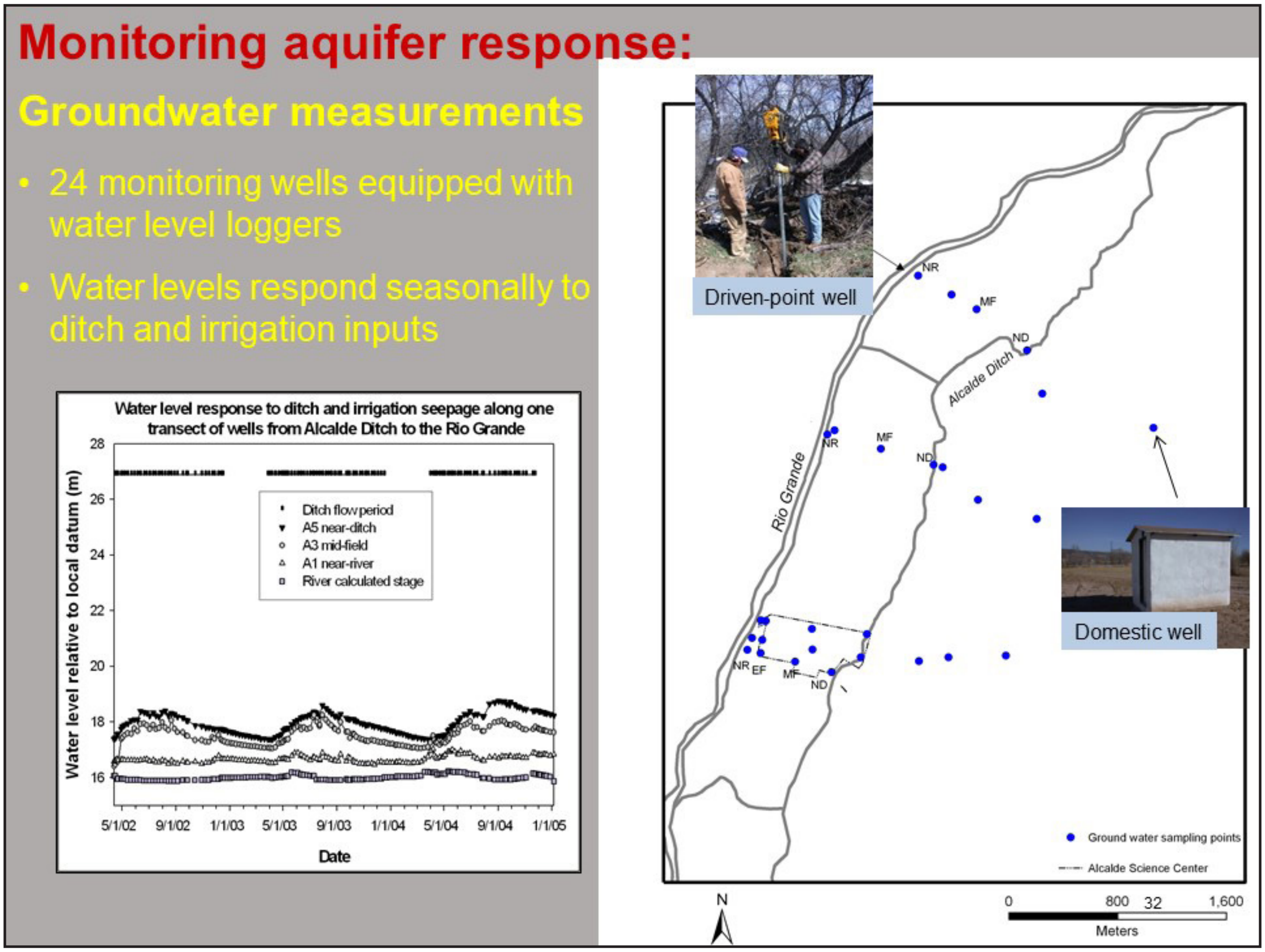


Figure 32. Groundwater measurements to monitor aquifer response.

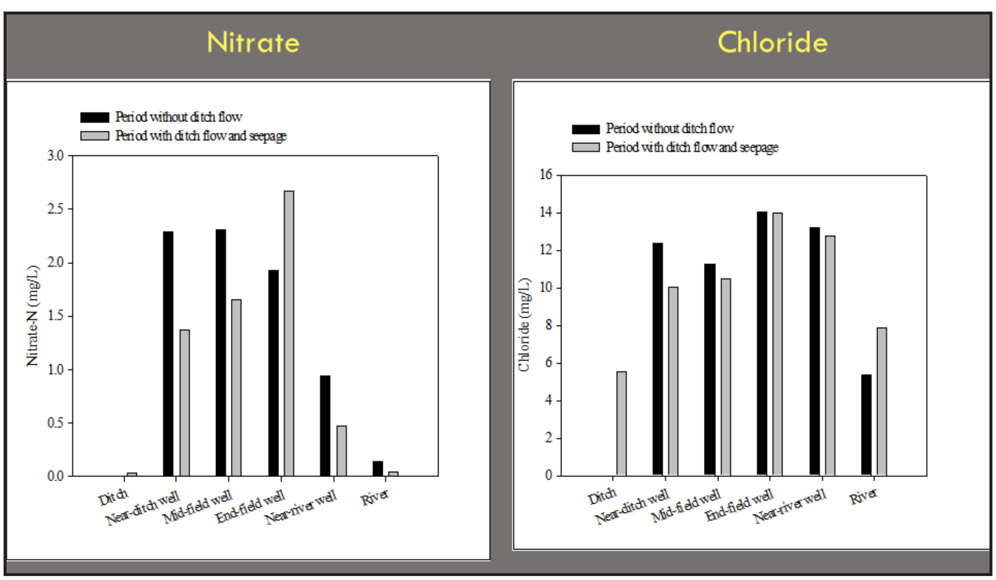


Figure 33. Seepage dilutes groundwater ions.

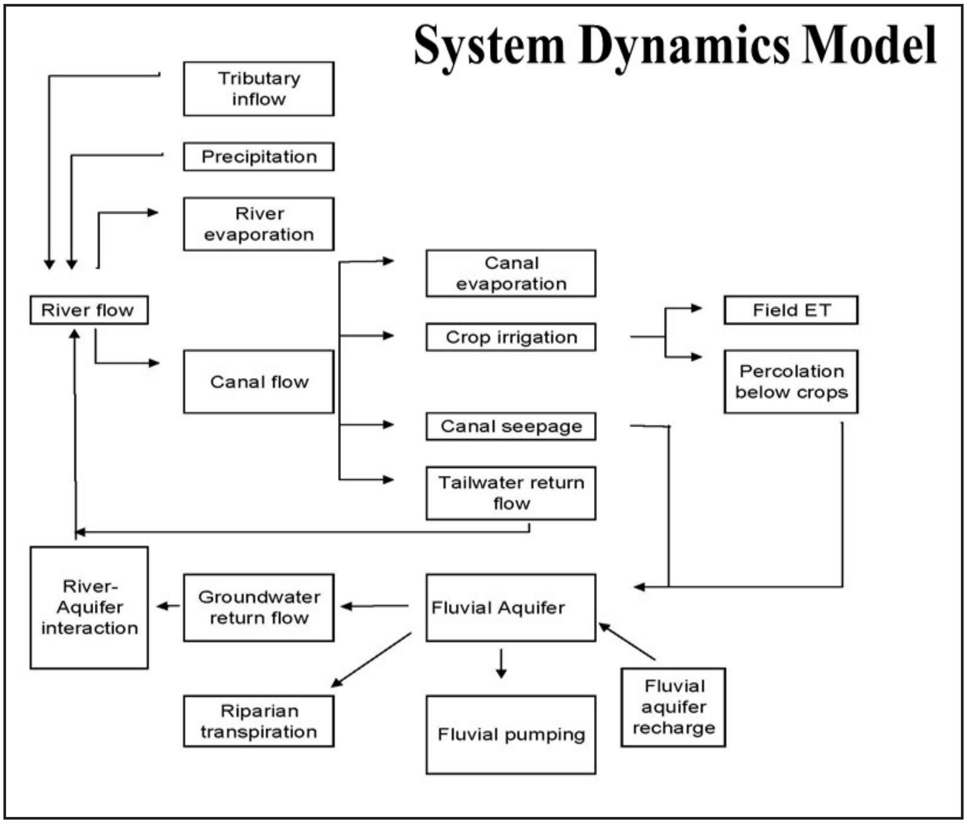


Figure 34. System dynamics model for testing aquifer-river interactions.

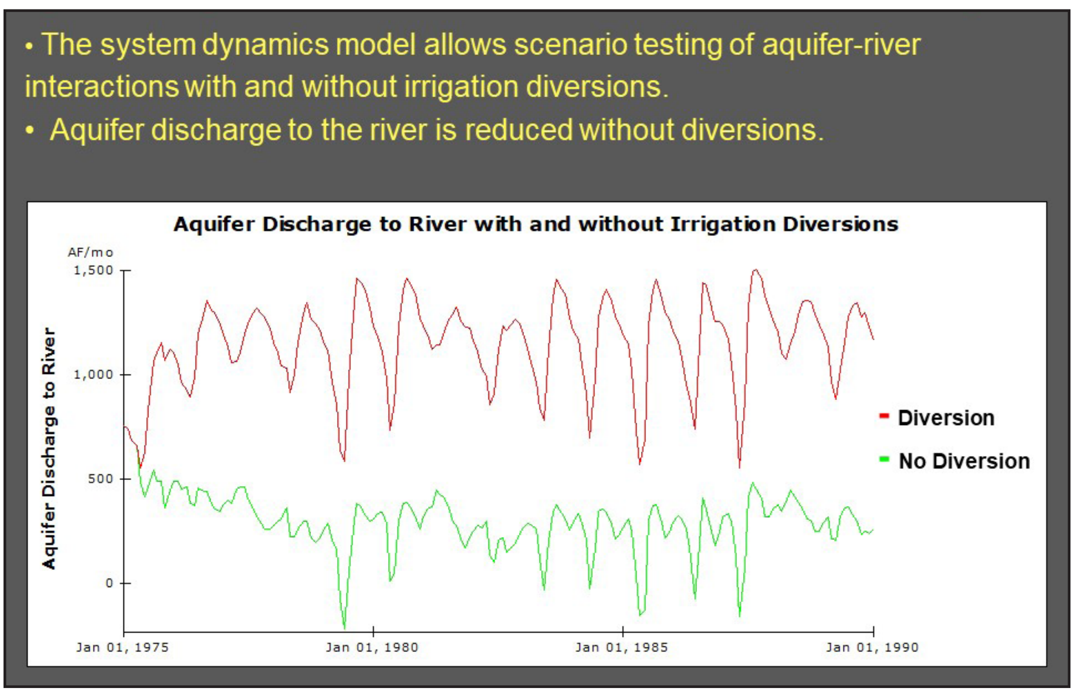


Figure 35. System dynamics model allows scenario testing. For example, aquifer discharge to river with and without irrigation diversions.

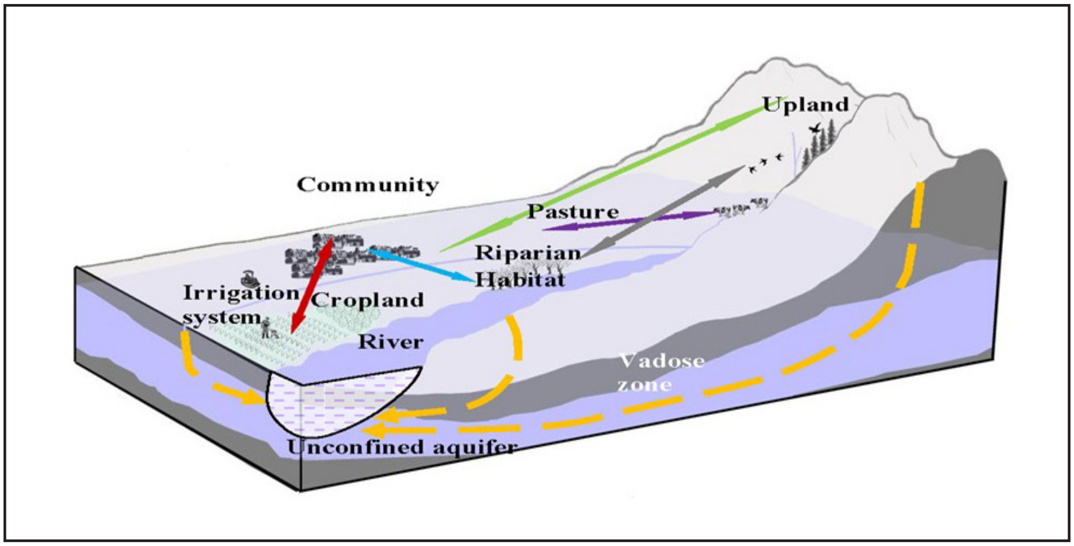


Figure 36. Connections between valley irrigation community and contributing upland watershed.

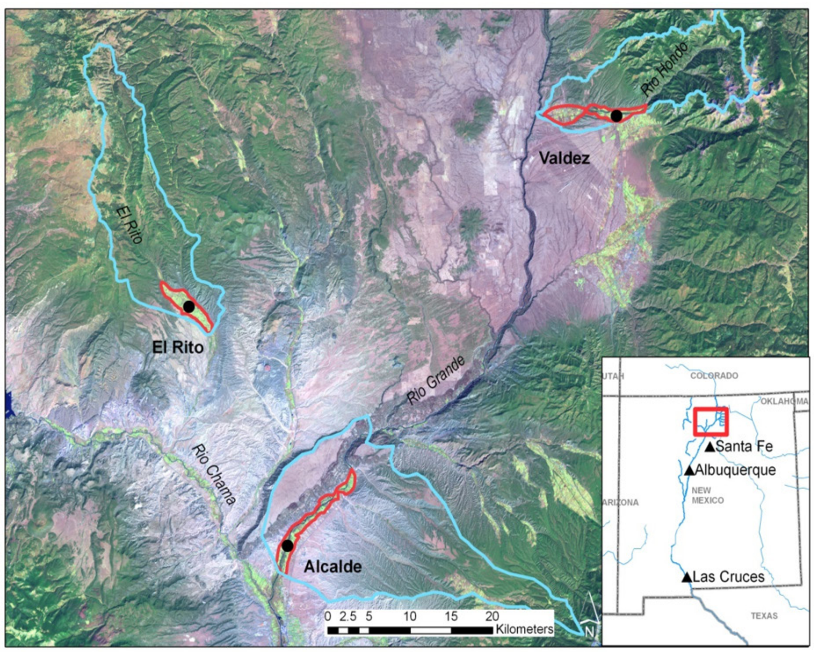


Figure 4. Study sites on Landsat ETM+ image showing: study communities (black circles) and their associated irrigated valleys (red lines) and contributing watersheds (blue lines); other acequia-irrigated areas along streams and rivers show up as light green.

Figure 37. Study sites on Landsat EMT+ image.