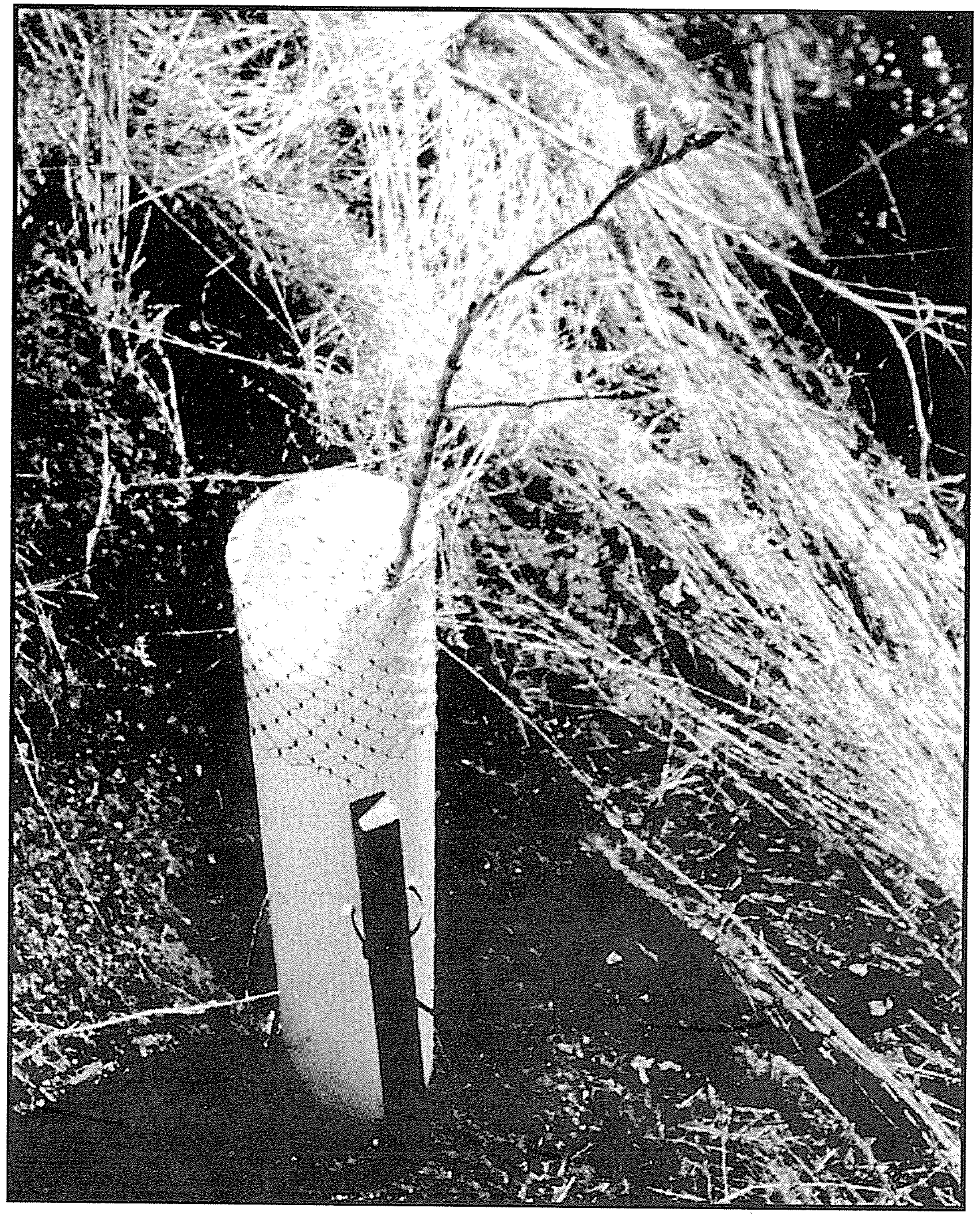


INYO COUNTY WATER DEPARTMENT
163 MAY STREET
BISHOP, CA 93514

THE OWENS VALLEY

MONITOR

INYO COUNTY WATER DEPARTMENT'S FIFTH ANNUAL REPORT ON EVENTS, ACTIVITIES AND CONDITIONS IN THE OWENS VALLEY

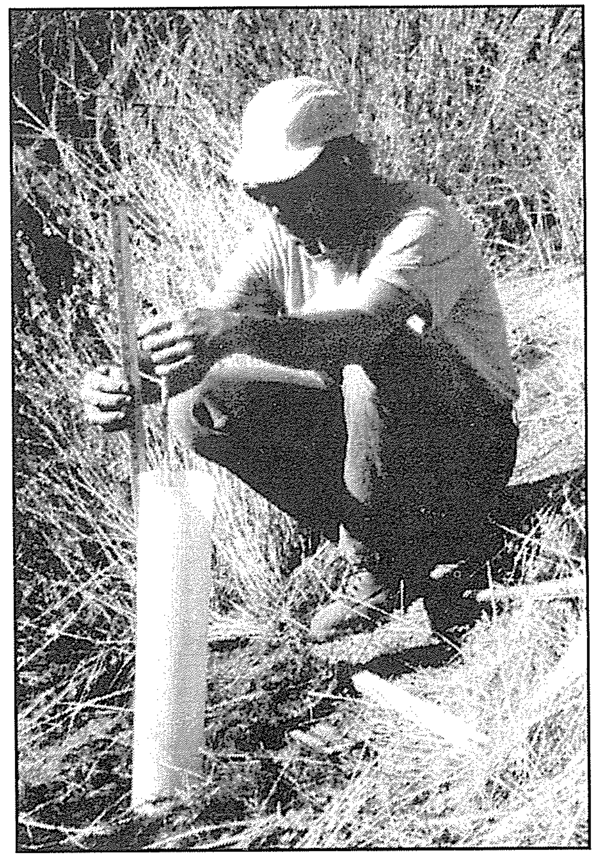
1996

Introduction

This *Owens Valley Monitor* is the Inyo County Water Department's fifth annual report. It covers the year 1996.

The *Monitor* is a compilation of data and results from monitoring and other field and technical work performed by ICWD staff and consultants and the Los Angeles Department of Water and Power (LADWP).

The ICWD was formed in 1980. In accordance with a cooperative Owens Valley water management agreement, ICWD and LADWP monitor water activities in the valley and their impacts on groundwater levels and vegetation. The two agencies also conduct scientific research on methods of improving water management.



Contents

The Owens Valley

Monitor

This annual report was produced by the Inyo County Water Department (ICWD) in Bishop, California. Its purpose is to explain the ICWD's yearly monitoring and management activities in the Owens Valley.

The ICWD also produces a newsletter called the *Owens Valley Water Reporter*. The newsletter covers the activities of the ICWD and water issues in the Owens Valley and the Eastern Sierra. If you would like to receive the newsletter and the annual report, let us know:

Phone: 760-872-1168
FAX: 760-873-5695
E-mail: inyowaterdept@telis.org
Web: http://www.sdsc.edu/Inyo/inyohpg.htm
Write:
Inyo County Water Department
163 May Street
Bishop, CA 93514

Front cover: ICWD's Denise Waterbury runs a line-point transect, Owens Valley.
Back cover: Revegetation project, Millpond.
Above: ICWD's Derik Olson on a revegetation project at Millpond.
All photos by Heidi Walters except front cover by Brian Stange.

This Report is Published on Recycled Paper

FAMILY/SPECIES	COMMON NAME
HYDROPHYLLACEAE	**Waterleaf family**
Hesperochiron pumilus	
Nama demissum	Purple mat
Phacelia bicolor var. *bicolor*	Sticky yellow-throats
Phacelia fremontii	Yellow-throats
Phacelia inyoensis	Inyo phacelia
IRIDACEAE	**Iris Family**
Sisyrinchium halophilum	Nevada blue-eyed grass
JUNCACEAE	**Rush family**
Juncus balticus	Baltic rush
Juncus ensifolius	Swordleaf rush
JUNCAGINACEAE	**Arrow-grass family**
Triglochin concinna var. *debilis*	Weak arrowgrass
LAMIACEAE	**Mint family**
Mentha arvensis	Wild mint
LILIACEAE	**Lily family**
Smilacina stellata	Star-flower
LOASACEAE	**Loasa family**
Mentzelia albicaulis	Little blazing star
Mentzelia nitens	Venus blazing star
Mentzelia torreyi	Torrey blazing star
MALVACEAE	**Mallow family**
Eremalche exilis	White mallow
Malvella leprosa	Alkali mallow/Whiteweed
NYCTAGINACEAE	**Four O'clock family**
Mirabilis alipes	Rose four o' clock
Mirabilis bigelovii	Wishbone bush
OLEACEAE	**Olive family**
Menodora spinescens	Spiny menodora
ONAGRACEAE	**Evening primrose family**
Camissonia claviformis ssp. *integrior*	Pale-eyed primrose
Camissonia claviformis ssp. *lancifolia*	Inyo-Mono yellow primrose
Ludwigia peploides	Water primrose
Oenothera californica ssp. *avita*	
Oenothera elata ssp. *hookeri*	
OROBANCHEACEAE	**Broom-rape family**
Orobanche corymbosa	Sagebrush strangler
POACEAE	**Grass family**
Achnatherum hymenoides	Indian ricegrass
*Cynodon dactylon**	Bermudagrass
Distichlis spicata	Saltgrass
*Echinocloa crus-galli**	Barnyard grass
Hordeum jubatum	Foxtail barley
Leymus cinereus	Basin wildrye
Leymus triticoides	Beardless wildrye
Muhlenbergia asperifolia	Scratchgrass
Paspalum distichum	Knotgrass
Phragmites australis	Common reed
*Polypogon monospliensis**	Annual beardgrass
Spartina gracilis	Alkali cordgrass
Sporobolus airoides	Alkali sacaton
POLEMONIACEAE	**Phlox family**
Eriastrum eremicum	Desert wooly star
Gilia sp.	
Loeseliastrum matthewsii	Desert calico
POLYGONACEAE	**Buckwheat family**
Chorizanthe brevicornu	Brittle spineflower
Chorizanthe rigida	Spinyherb
Eriogonum brachyanthum	Yellow buckwheat
Eriogonum davidsonii	
Eriogonum maculatum	Spotted buckwheat
Eriogonum nidularium	Bird's nest buckwheat
Eriogonum pusillum	Yellow turbans
Goodmania luteola	
Oxytheca perfoliata	Saucerplant
RANUNCULACEAE	**Buttercup family**
Clematis lingusticifolia	Virgin's bower
Ranunculus cymbalaria var. *saximontanus*	Desert buttercup
ROSACEAE	**Rose family**
Potentilla gracilis var. *elmeri*	
SALICACEAE	**Willow family**
Salix exigua	Narrow-leaf willow
Salix laevigata	Red willow
SAURURACEAE	**Lizard's-tail family**
Anemopsis californica	Yerba mansa
SCROPHULARIACEAE	**Figwort family**
Castilleja, sp.	Paintbrush
Cordylanthus maritimus ssp. *canescens*	Alkali bird's beak
Cordylanthus ramosus	Busby bird's beak
Mimulus guttatus	Common monkey flower
Mimulus pilosus	

ICWD Herbarium

The Inyo County Water Department maintains an herbarium to document and store the various plant species found in the Owens Valley. Denise Waterbury maintains the herbarium, which serves several purposes:

- its collection of voucher plant specimens provides an authentic historic and current record of the area's species;
- it helps those studying the area's ecology, including scientists, teachers and students;
- it makes it easier to identify field specimens by comparing them to herbarium specimens;
- it provides specialists with specimens for taxonomic and DNA-level research.

Plants in the collection include (* = non-native species):

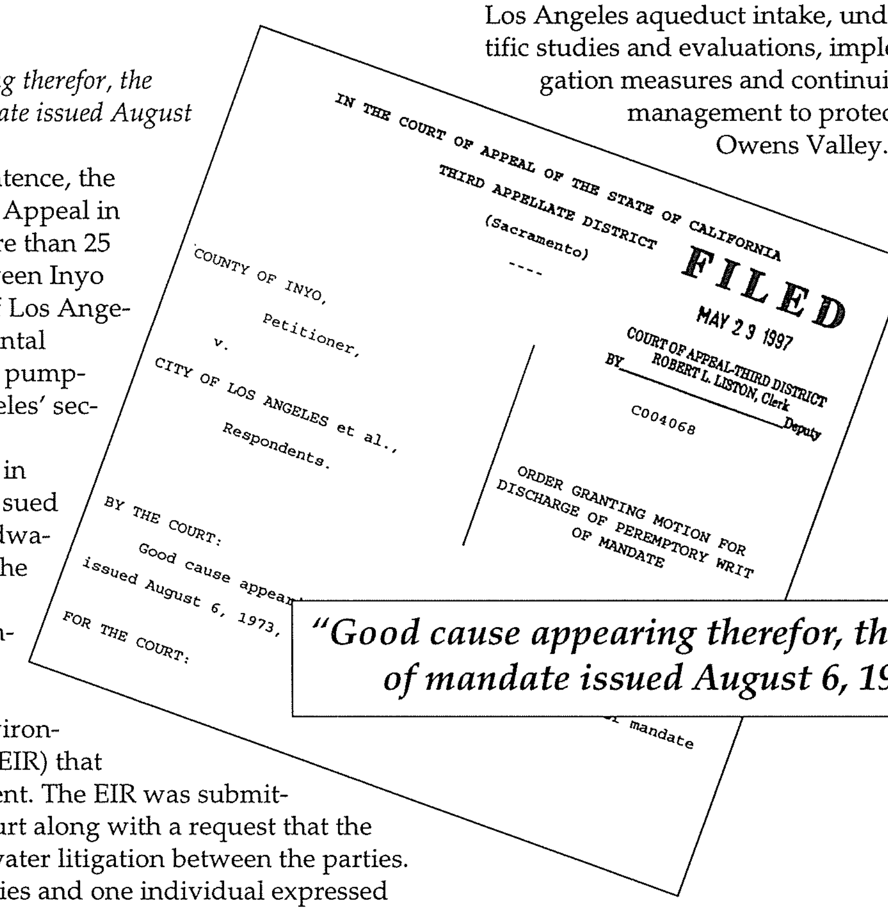
FAMILY/SPECIES	COMMON NAME
ALISMATACEAE	**Water plantain family**
Sagittaria latifoila	
APIACEAE	**Carrot family**
*Daucus carota**	
APOCYNACEAE	**Dogbane family**
Apocynum cannabinum	Indian hemp
ASCLEPIADACEAE	**Milkweed family**
Asclepias fasicularis	Narrowleaf milkweed
Asclepias speciosa	Greek or Showy milkweed
ASTERACEAE	**Sunflower family**
*Acroptilon repens**	Russian knapweed
Ambrosia acanthicarpa	Annual bursage
Artemisia ludoviciana	Western mugwort
Artemesia spinescens	Budsage
Aster ascendens	Long-leaved aster
Bidens frondosa	Stick-tight
Chaenactis stevioides	Desert pincushion
Cirsium mohavense	Desert thistle
Conyza coulteri	Horseweed
Crepis runcinata ssp. *hallii*	Hall's meadow hawksbeard
Ericameria cooperi	Goldenbush
Eriophyllum wallacei	Wallace's wooly sunflower
Grindelia camporum	Gumplant
Hecastocleis shockleyi	Prickle-leaf
Helenium bigelovii	
Helianthus annus	Sunflower
Iva axillaris ssp. *robustior*	Povertyweed
Lessingia lemmonii	Vinegar-weed
Machaeranthera carnosa	Broom aster
Malacothrix glabrata	Desert dandelion
Malacothrix sonchoides	Yellow saucers
Prenanthella exigua	
Psathyrotes annua	Fan-leaf
Pyrrocoma racemosa	Wand aster
Tetradymia glabrata	Cottonthorn/Horsebush

FAMILY/SPECIES	COMMON NAME
BORAGINACEAE	**Borage family**
Heliotropium curassavicum	Heliotrope
BRASSICACEAE	**Mustard family**
*Cardaria pubescens**	Whitetop/Hoary cress
Descuraniania paradisa	
Lepidium flavum	Peppergrass
Lepidium fremontii	Desert alysum
*Lepidium latifolium**	Perennial pepperweed
Rorippa nasturium-aquaticum	Water cress
Streptanthella longirostris	Beaked cress
Thelypodium crispum	
CAPPARACEAE	**Caper family**
Cleome lutea	Yellow beeplant
Cleomella plocasperma	Alkali cleomella
Cleomella obtusifolia	Mojave stinkweed
CHENOPODIACEAE	**Goosefoot family**
Allenrolfia occidentalis	Iodine bush
*Bassia hyssopifolia**	Five-hook bassia
Grayia spinosa	Hopsage
Kochia americana	Green molly
Krascheninnikovia lanata	Winterfat
Nitrophilia occidentalis	Alkali pink
Sueda moquinii	Bush seepweed
CYPERACEAE	**Sedge family**
Carex douglasii	Douglas sedge
Eleocharis macrostachya	
Eleocharis parishii	Parish spikerush
Scirpus acutus var. *occidentalis*	Tule bulrush
Scirpus pungens	
Scirpus microcarpus	Panicled bulrush
ELAEAGNACEAE	**Oleaster family**
*Elaeagnus angustifolius**	Oleaster/Russian olive
FABACEAE	**Legume family**
Astragalus argophyllus var. *argophyllus*	
Astragalus casei	Case milkvetch
Astragalus lentiginosus var. *fremontii*	Freckled milkvetch
Glycyrrhiza lepidota	Wild licorice
*Lotus corniculatus**	Birdsfoot trefoil
Lupinus odoratus	Mojave lupine
*Melilotus alba**	White sweetclover
Psorothamnus arborescens var. *minutifolius*	Indigo bush
Psorothamnus polydenius	Dotted dalea
FRANKENIACEAE	**Frankenia family**
Frankenia salina	Alkali heath

Perspective

by Greg James
ICWD Director

"Good cause appearing therefor, the peremptory writ of mandate issued August 6, 1973 is discharged."


IN THE COURT OF APPEAL OF THE STATE OF CALIFORNIA
THIRD APPELLATE DISTRICT
(Sacramento)

FILED
MAY 23 1997
COURT OF APPEAL-THIRD DISTRICT
ROBERT L. LISTON, Clerk
BY ______ Deputy

COUNTY OF INYO,
Petitioner,
v.
CITY OF LOS ANGELES et al.,
Respondents.

C004068

ORDER GRANTING MOTION FOR DISCHARGE OF PEREMPTORY WRIT OF MANDATE

BY THE COURT:
Good cause appear...
issued August 6, 1973, ... mandate
FOR THE COURT:

With that single sentence, the Third District Court of Appeal in Sacramento ended more than 25 years of litigation between Inyo County and the City of Los Angeles over the environmental effects of groundwater pumping to supply Los Angeles' second aqueduct.

The litigation arose in 1972 when the county sued the city over its groundwater pumping. In 1991, the county and the city approved a comprehensive settlement agreement (long-term water agreement) and an environmental impact report (EIR) that addressed the agreement. The EIR was submitted to the appellate court along with a request that the court end the groundwater litigation between the parties. However, several entities and one individual expressed concerns to the court over the adequacy of the EIR. Over the last five years, the county facilitated settlement discussions over the EIR issues. Early in the process, a settlement was reached with the Owens Valley Indian Water Commission, which withdrew its objections to the adequacy of the EIR.

> **"Good cause appearing therefor, the peremptory writ of mandate issued August 6, 1973 is discharged."**

Six entities reached a settlement, called a memorandum of understanding (MOU), in January 1997. The six are the California Department of Fish and Game, the California State Lands Commission, the Sierra Club, the Owens Valley Committee, the City of Los Angeles and Inyo County. The appellate court's order, which became final on June 2, 1997, granted a motion to end the litigation based upon the MOU.

The end of environmental litigation allowed the entry of the long-term water agreement as a binding judgment of the Inyo County Superior Court. The entry of the judgment became final on June 13, 1997. The principal effect of the end of the litigation and the finalization of the long-term water agreement will be the full implementation of the long-term agreement, the provisions of the MOU and the mitigation measures described in the EIR. These activities had been delayed by the extension of the appellate court litigation.

With the end of the litigation, the Inyo County Water Department is now able to devote its full attention to these activities, including rewatering the Owens River below the Los Angeles aqueduct intake, undertaking numerous scientific studies and evaluations, implementing additional mitigation measures and continuing to improve water management to protect the environment of the Owens Valley.

1997–98 pumping program

The Inyo County/Los Angeles Technical Group agreed to a groundwater pumping limit of 70,000 acre-feet for the 1997–98 runoff year (April 1997–March 1998). This is the lowest pumping level since the county and LADWP began jointly managing groundwater pumping in late 1989. The Technical Group will recommend this pumping amount to the Inyo County/Los Angeles Standing Committee at the committee's next meeting.

Of the 70,000 acre-feet that LADWP may pump in the Owens Valley, approximately 56,000 acre-feet will supply: the Fish Springs and Blackrock fish hatcheries; in-valley uses and Enhancement/Mitigation (E/M) projects that can only be supplied with pumped groundwater; and irrigation needs on the Bishop Cone. Approximately 14,000 acre-feet of water may also be pumped to supply the remaining E/M projects in the valley. The water supplied to the fish hatcheries and any water pumped to replace water supplied to E/M projects will either supply other in-valley uses or will be exported.

Annual pumping program 1996–1997

by Randy Jackson
ICWD Hydrologist

Inyo County and Los Angeles agreed to a maximum pumping limit of about 75,000 acre-feet for the 1996-97 runoff year (April 1, 1996–March 31, 1997). As in prior years, contingency measures were in place so that if the capacity of the aqueduct and capability of beneficial water spreading normally used during wet years were exceeded, surface water would be supplied to those enhancement/mitigation (E/M) projects capable of using the water for as long as such conditions existed. If such an event were to occur, the recommended maximum pumping figure of 75,000 acre-feet would be reduced by the amount of water supplied to the E/M projects during that period of exceeded capacity.

Unlike 1995-96, however, capacity of the aqueduct and spreading facilities was not exceeded during the runoff year, so the contingency was not applied.

Total in-valley uses during the 1996-97 runoff year were about 99,000 acre-feet. These uses included about 46,000 acre-feet for irrigation, about 20,000 acre-feet for stockwater, about 9,000 acre-feet for LADWP recreation and wildlife projects, and about 24,000 acre-feet for E/M projects. LADWP installed the E/M projects under the 1984 interim water agreement between Inyo County and Los Angeles. They include Klondike Lake, Lone Pine riparian park, woodlots in Independence and Lone Pine, several pastures and alfalfa fields, and the lower Owens River rewatering project.

Pumping, April 1, 1996–March 31, 1997

Wellfield	Approx. actual pumping (acre-ft)
Laws	11,200
Bishop	9,900
Big Pine	22,000
Taboose-Aberdeen	5,600
Thibaut-Sawmill	15,500
Independence-Oak	8,000
Symmes-Shepherd	1,500
Bairs-Georges	0
Lone Pine	1,100
Total	74,800

The Inyo/Los Angeles Technical Group develops the pumping program each year based on several factors, including projected runoff derived from snow survey results and monitoring results of vegetation conditions, water tables, and soil water availability. The Inyo/Los Angeles Standing Committee agrees on a pumping limit before adopting the pumping program.

To develop the pumping program, the Technical Group followed guidelines set forth in the Inyo/LA long-term water management agreement, the Green Book (a technical manual for carrying out the agreement), the Drought Recovery Policy agreed upon by Inyo County and Los Angeles in 1990, and the 1984 interim agreement between the county and the city.

Under the Drought Recovery Policy since 1990, Inyo and LADWP have managed groundwater in an environmentally conservative manner. The policy will continue until water tables and soil water and the vegetation recover in the Owens Valley. When the drought began, water tables were at or near their highest levels in about 20 years. But from 1987-1989, groundwater pumping was high and water tables declined. Since 1990, water tables generally have been rising (see "Hydrology," pages 5–7).

Los Angeles' Owens Valley pumping since 1987–88

Runoff year	OV runoff (% normal)	Production wells (acre-ft)	E/M wells (acre-ft)	E/M water use (acre-ft)	Total pumping (acre-ft)
1987-88	65	179,883	29,511	29,360	209,394
1988-89	62	171,012	29,431	30,872	200,443
1989-90	66	133,340	22,563	23,330	155,903
1990-91	52	70,974	18,087	17,949	89,061
1991-92	64	71,736	15,790	20,517	87,526
1992-93	69	71,370	13,765	18,357	85,135
1993-94	117	67,338	8,991	19,310	76,329
1994-95	67	78,143	11,010	20,812	89,153
1995-96	155	57,168	12,572	22,914	69,740
1996-97	123	* 57,894	16,923	23,949	* 74,817

* = Preliminary estimate   E/M = Enhancement/Mitigation

Reports, publications, activities

Conferences

Soil and Water Conservation Society Annual Conference, Keystone, Colo., July 7–10, 1996. Aaron Steinwand. Presented poster *Environmental protection and groundwater management in the Owens Valley,* Calif. A.L. Steinwand and S.J. Manning. *J. of Soil Water Conservation.*

Soil Science Society of America Annual Meeting, Indianapolis, Ind., Nov. 3–8, 1996. Aaron Steinwand. Presented poster *Groundwater utilization by Nevada saltbush in the presence of deep and shallow water tables,* A.L. Steinwand, S.J. Manning, and D. Or. *Agronomy Abstracts.*

California Exotic Pest Plant Council (CalEPPC), San Diego, Calif., Oct. 1996. Brian Cashore, Sally Manning.

Inyo/Mono Pesticide Safety Seminar, Feb. 1997. Brian Cashore (gave saltcedar presentation).

Yucca Mountain Underground Inspection, June 1996. Randy Jackson.

Nevada Water Conference, Feb. 1996. Randy Jackson.

Education

Sally Manning was involved in a number of educational endeavors in 1996, including:

- Invited Instructor: University of California Environmental Biology "Supercourse" (for UC upper division undergraduates). Lectured, led field trip, and advised on individual research projects related to ICWD activities.
- Judge: Home Street School Inventor's Fair (6th Grade) and Inyo County Science Fair (all grades).
- School Science Projects: Lo-Inyo Middle School students and Advanced Biology students at Bishop High School.
- Science Teacher Training Workshops: Eastern Sierra Institute and Project ISSUES — field demonstrations of vegetation inventory technique and application to water resource management.

In addition, Brian Cashore, Denise Waterbury and Irene Yamashita served as judges at Inyo County schools science fairs.

Committees

Deepest Valley Cooperative Native Plant Propagation Center. Irene Yamashita, Denise Waterbury and Sally Manning.

California Native Plant Society, Vegetation Committee (statewide). Sally Manning.

Owens Valley Multi-Species Recovery Task Force. Sally Manning.

Eastern Sierra Institute for Collaborative Education. Sally Manning.

Reports and Publications

Inyo County Water Department staff produced the following documents in 1996 and early 1997:

Hydrology

Well 349 — Recent pumping history and nearby shallow groundwater levels, assessment of linkage of Well 349 to the TA5 monitoring site (Memorandum Report to ICWD staff). Randy Jackson. Sept. 1996.

Reconnaissance survey of water quality in Diaz Lake, Owens Lake Basin, Inyo County, California (Technical Note 96-1). Randy Jackson. Aug. 1996.

Lower Owens River Planning Study: water quality in the Lower Owens River E/M Project, May 1995 through June 1996 (ICWD Report 96-1). Randy Jackson. Aug. 1996.

Evaluation of the linkage of E/M wells 380 and 381 to the TS4 monitoring site (Memorandum Report to Technical Group). Randy Jackson. Jan. 1996.

Vegetation

Germination of Owens Valley seeds: 1996 final test results. Denise Waterbury, Sally Manning, and Irene Yamashita.

Noteworthy collections: California. *Ranunculus hydrocharoides.* Manning, Sara J., Daniel W. Pritchett and Mark O. Bagley. 1996. Madrono. 42 (4): 515-516.

Pocket gophers damage saltcedar (*Tamarix ramosissima*) roots. Manning, Sara J., Brian L. Cashore and Joseph M. Szewczak. 1996. *Great Basin Naturalist.* 56 (2): 183-185.

Line point data analysis, 1996: Overview. Sally Manning. March 1997.

Monitoring results of four revegetation treatments on barren farmland in the Owens Valley — 1995 progress report — Jan. 1996. Irene Yamashita and Sally Manning.

Using plant shelters to increase plant establishment. Irene Yamashita and Sally Manning. May 1996.

Riparian monitoring. Brian Cashore. Jan. 1997.

Soils

Protocol for Owens Valley neutron probe soil water monitoring program. Aaron Steinwand. Aug. 1996. (**Addendum: Conversion to CPN gauge use.** April 1997.)

THE INYO COUNTY WATER DEPARTMENT

1996 ICWD staff and consultants

Greg James, Director

Vegetation

Sally Manning
Vegetation Scientist
Irene Yamashita
Supervising Research Assistant
Brian Cashore
Supervising Research Assistant
Derik Olson
Research Assistant
Denise Waterbury
Research Assistant
Steve Ostoja
Summer Research Assistant
Amy Parravano
Summer Research Assistant

Administrative

Douglas Daniels
Fiscal Operations Supervisor
Leah Kirk
Environmental Specialist
Irene McLean
Secretary, Receptionist

Hydrology

Randy Jackson
Hydrologist
Rick Puskar
Hydrologic Technician

Soils

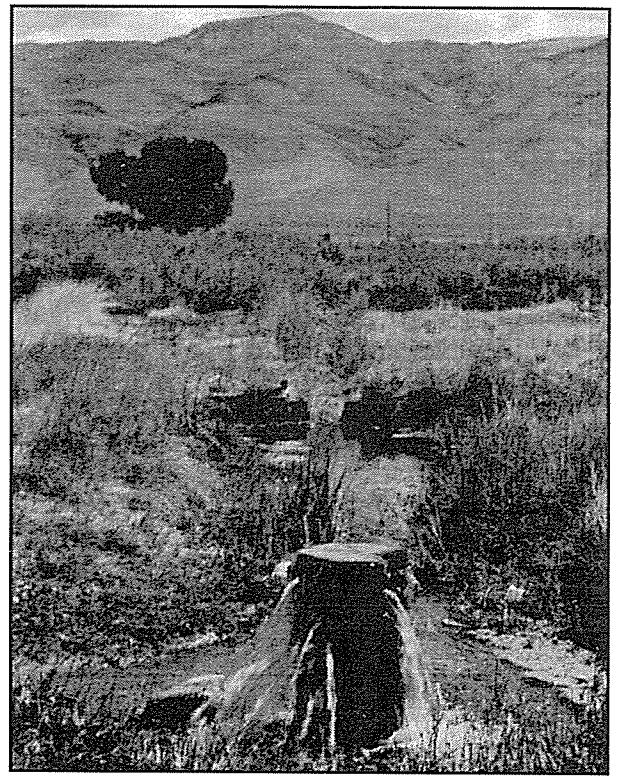
Aaron Steinwand
Soil Scientist

GIS

Chris Howard
Geographic Information Systems Specialist

Consultants

Dani Or
Soil Physicist
David Groeneveld
Plant Ecologist
Bill Hutchison
Hydrologist
Tony Rossmann
Legal Counsel



Artesian well east of Bishop.

ICWD's budget

Inyo County Water Department's general operations budget for fiscal year 1995–96 was $1,093,222. General operations included ongoing monitoring and management in the Owens Valley and administration.

Of the $1,093,222, the Los Angeles Department of Water and Power provided $902,110, the county's geothermal trust fund provided $22,285, and the LADWP/ICWD water trust and the previous year fund balance provided $168,827.

Inyo County Board of Supervisors

Linda Arcularius
Julie Bear
Michael Dorame
Butch Hambleton
Bob Michener

Inyo County Administrator

Rene Mendez

Inyo County Water Commission

Bob Campbell
Ray Gray
Scott Kemp
Harry Holgate
David Miller

Monitoring and managing Owens Valley

Throughout the year, the Inyo County Water Department (ICWD) and the Los Angeles Department of Water and Power (LADWP) monitor the vegetation, groundwater, surface water and soil water in the Owens Valley, as part of the long-term water management agreement between Inyo County and Los Angeles.

The purpose of this monitoring is to document the valley's environmental response to groundwater pumping and other LADWP water activities. The county and the city use these monitoring results to make management decisions to avoid significant decreases or changes in vegetation and to avoid long-term groundwater mining (the depletion of water in the aquifer that exceeds replenishment from recharge over a 20-year period).

ICWD and LADWP monitor for effects of groundwater pumping with a system of monitoring sites throughout Owens Valley. There are 22 permanent sites linked to nearby LADWP wells to monitor vegetation, groundwater and soil water. Eight additional permanent sites are located outside wellfields and serve as controls.

Under the Inyo/LA long-term water management agreement, monitoring results may trigger the mandatory turn-off of some LADWP wells. Wells linked to a monitoring site are turned off on July 1 or October 1 if the amount of water within the vegetation's root zone at the site is inadequate to meet the vegetation's estimated water needs. Wells can only be turned on when this soil moisture — called the available water content (AWC) — recovers to the amount required by the vegetation when the wells were turned off. Sites with adequate AWC are in surplus status; those with insufficient AWC are in deficit status.

Since 1990, however, pumping has been managed according to the Drought Recovery Policy. Under this policy, even some wells connected to sites in surplus status remain off to allow the water table to recover.

Of LADWP's 102 production wells, 60 are linked to the 22 permanent monitoring sites. Two of these are exempt from the turn-off provisions during the irrigation season only. Another 22 wells are exempt because they are the sole supply for town water systems, fish hatcheries or irrigation, or because they are located away from vegetation that depends on groundwater. An additional 20 wells are not linked to monitoring sites: 11 in Bishop, five in Laws, one in Bairs-Georges that supplies Diaz Lake, one domestic well in Big Pine, and two domestic wells in Independence.

The following articles present monitoring results of the valley's hydrology, soil water and vegetation.

HYDROLOGY

by Randy Jackson
ICWD Hydrologist

Precipitation

To augment LADWP precipitation measurements made throughout Owens Valley, Inyo County monitors precipitation using seven rain gages. Table 1 on page 6 shows precipitation totals recorded at each of the county rain gage sites for water years 1995 and 1996 (a water year is from October 1–September 30).

Snowpack and runoff

LADWP's April 1, 1996 snow survey found water content in the Mammoth area snowpack at 114 percent of normal. This was somewhat drier than the wet conditions recorded in 1995, and far different than 1994's April 1 snowpack water content of 55 percent of normal.

Runoff for April 1996–March 1997 was projected at 123 percent of normal. By comparison, the April 1995–March 1996 runoff was estimated at 155 percent of normal.

Surface water

Surface water flows were lower in 1996 than in the very wet 1995. LADWP measures flows in the Owens River and in more than 20 creeks that flow into the valley from the Sierra Nevada and the White Mountains.

LADWP operates three power plants in the Owens River Gorge above Pleasant Valley Reservoir north of Bishop, controlling the amount of water flowing through the reservoir. LADWP keeps a minimum of 100 cubic feet per second (cfs) flowing into the Owens River below the reservoir to protect fish habitat.

Between April 1, 1995 and March 31, 1996 flows in the Owens River from Pleasant Valley Reservoir ranged from highs near 700 cfs to lows around 100 cfs. Flows in 1996 ranged from highs above 600 cfs to lows around 100 cfs, with average flows hovering around 400 cfs.

Groundwater recharge

Recharge is the amount of water percolating into the aquifer. It is estimated for each water year, October through September, based on projected runoff.

In the 1996 water year, total estimated recharge into the Owens Valley was 201,449 acre-feet (see Table 2, page 6). By comparison, for 1995 the total estimated recharge was 216,228 acre-feet. Table 3 on page 6 summarizes aquifer recovery since 1992.

OWENS VALLEY PRECIPITATION, 1995 AND 1996

Rain gage	Precipitation (inches) 1995	Precipitation (inches) 1996
RG-1, near Five Bridges	7.60	4.51
RG-2, near Laws	7.80	4.55
RG-3, southeast of Bishop	8.87	4.29
RG-4, south of Big Pine	9.76	6.85
RG-5, near Goose Lake	7.07	5.64
RG-6, near Blackrock	8.67	7.07
RG-7, near Independence	4.88	2.14
Owens Valley average	**7.81**	**5.01**

Table 1: *Owens Valley precipitation, in inches.* *See page 5 for discussion.*

ESTIMATED 1996 RECHARGE BY WELLFIELD

Wellfield	Recharge (acre-ft)
Laws	17,076
Bishop	48,948
Big Pine	33,718
Taboose-Thibaut	41,391
Independence-Symmes-Bairs	43,983
Lone Pine	16,333
Total	**201,449**

Table 2: *Owens Valley groundwater recharge by wellfield.* *See page 5 for discussion.*

SHALLOW AQUIFER WATER LEVEL RECOVERY IN 18 INDICATOR WELLS

		Depth to groundwater in April (feet)					Change in depth April '95–April '96 (feet) + = recovery	Change needed from April '96 to reach pre-drought depth (feet)
Wellfield	Well #	1992	1993	1994	1995	1996		
Laws	436T	Dry at 19	18.5	14.7	15.4	10.8	+4.6	+2.8
	492T	51.3	50.5	41.9	44.5	37.4	+7.1	+4.6
Big Pine	425T	26.6	26.2	24.4	24.1	21.9	+2.2	+7.1
	426T	Dry at 19.7	Dry at 19.7	19.1	19.0	16.6	+2.4	+5.0
Taboose-Aberdeen	418T	17.8	16.8	15.3	14.6	13.0	+1.6	+4.7
	419T	21.8	18.8	15.6	14.5	12.1	+2.4	+5.6
	421T	47.5	45.2	42.6	42.0	38.5	+3.5	+4.6
	502T	Dry at 16	15.7	13.4	13.2	12.0	+1.2	+4.6
Thibaut-Sawmill	415T	33.1	32.4	28.4	29.6	21.6	+8.0	+3.1
Independence-Oak	407T	16.9	15.4	15.6	14.2	12.6	+1.6	+5.3
	408T	9.3	8.3	7.5	6.6	4.9	+1.7	+1.8
	409T	19.4	17.4	12.7	15.4	10.4	+5.0	+0.9
Symmes-Shepherd	401T	25.0	24.4	23.9	23.3	21.6	+1.7	+3.7
	403T	11.4	10.5	10.8	11.0	10.2	+0.8	+4.9
	404T	7.4	6.3	7.3	6.3	5.8	+0.5	+2.2
	447T	47.5	46.4	45.0	46.3	43.6	+2.7	+21.7
Bairs-Georges	398T	7.5	5.4	5.9	5.2	4.2	+1.0	-2.2
	400T	6.8	6.3	6.6	6.1	5.9	+0.2	-0.4

Table 3: *Aquifer recovery since 1992.*

GROWING SEASON AND WATER BALANCE

Site	Year	T_{lf} (cm^3/cm^2)	T_a (cm)	U_{gw} (cm)
Shallow	1995	22.1	25.1	21.2
	1996	30.2	32.4	26.7
Intermed.	1995	23.4	37.4	35.1
	1996	32.7	44.9	41.0
Deep	1996	27.1	12.5	9.8

Table 7: *Plant water balance for three groundwater depths. Growing season of March 26 to Oct. 15 each year. Mean annual precipitation at the site is 12.5cm.* T_{lf} *= Transpiration per leaf area;* T_a *= Actual transpiration;* U_{gw} *= Groundwater transpired*

spired at the sites with shallow and intermediate water table depths. Predicted transpiration using the Green Book procedure did not compare well with values measured during this study. This suggested that we develop an alternative method to calculate transpiration, an analysis that will be completed in 1997.

Remote sensing study of Owens Valley vegetation

In the summer of 1996, ICWD was contacted by earth scientists from Brown University. Brown's Dr. John F. Mustard submitted a research proposal to NASA's highly competitive Mission-to-Planet-Earth program. The project was awarded funding to apply remote sensing technology to the analysis of vegetation changes in the Owens Valley.

The project — "The Dynamics of a Semi-Arid Region in Response to Climate and Water-Use Policy" — is expected to begin in late summer 1997. ICWD vegetation and GIS data will be used in conjunction with satellite images to develop a technique for identifying changes in vegetation and to determine climactic or human-induced causes.

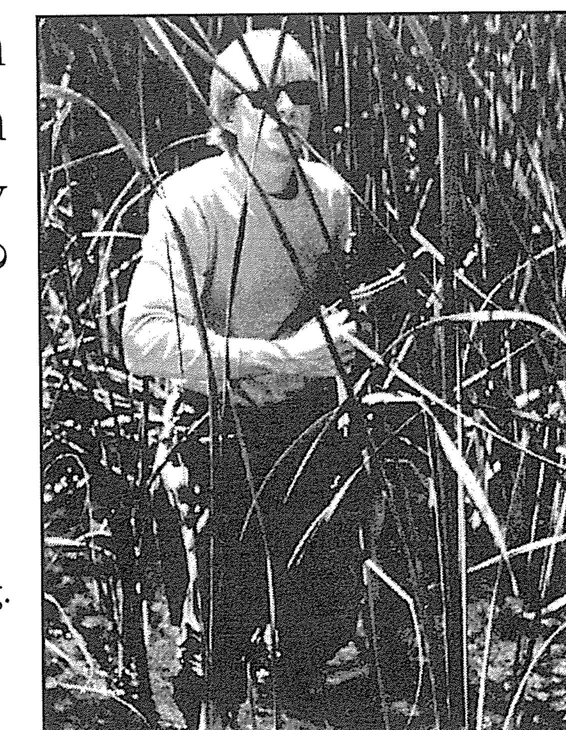
ICWD will not directly receive funds for the study but will be able to access the GIS information generated during the project's three-year course.

Tired of slogging through an impenetrable thicket in search of Owens Valley environmental information?

Look for us on the Web...

http://www.sdsc.edu/Inyo/inyohpg.htm

...our Web page is developing.



ICWD researcher Rick Puskar at work in Owens Valley backwaters

Our E-mail address is: inyowaterdept@telis.org

Groundwater use by Nevada saltbush

by Aaron Steinwand
ICWD Soil Scientist

ICWD soil and vegetation staff along with Utah State University soil physicist Dr. Dani Or began a project in 1995 to investigate groundwater uptake by Nevada saltbush *(Atriplex torreyi).* Nevada saltbush was chosen to study because it is groundwater dependent, and it is a dominant component of many plant communities in wellfield areas. The study continued this past year.

At three sites located near Independence, ICWD staff monitored groundwater depth, soil water, precipitation, leaf area, and plant transpiration. Two sites, one with a shallow (1.5 meters) water table and one with an intermediate (5.8 meters) water table, were established in 1995; another site with a deep water table (>8.5 meters) was established in 1996.

ICWD vegetation staff visited the sites every three weeks during the growing season to measure leaf area and transpiration. Soils staff monitored depth to groundwater and soil water biweekly throughout the year.

The vegetation measurements allow calculation of the amount of water transpired by saltbush for each site. Subtracting growing-season precipitation and soil water losses from the total amount transpired determines the amount of transpired groundwater.

Each year, the water transpired per leaf area at all of the sites was independent of depth to groundwater, except for possible small decreases during the late summer at the deep water table site (see Figure 8). At the shallow and intermediate sites, leaf area was similar, and the total amount of water transpired was about two to three times the mean annual precipitation (see Table 7, page 19). Nevada saltbush utilized groundwater extensively at both sites.

TRANSPIRATION IN NEVADA SALTBUSH, 1995–1996

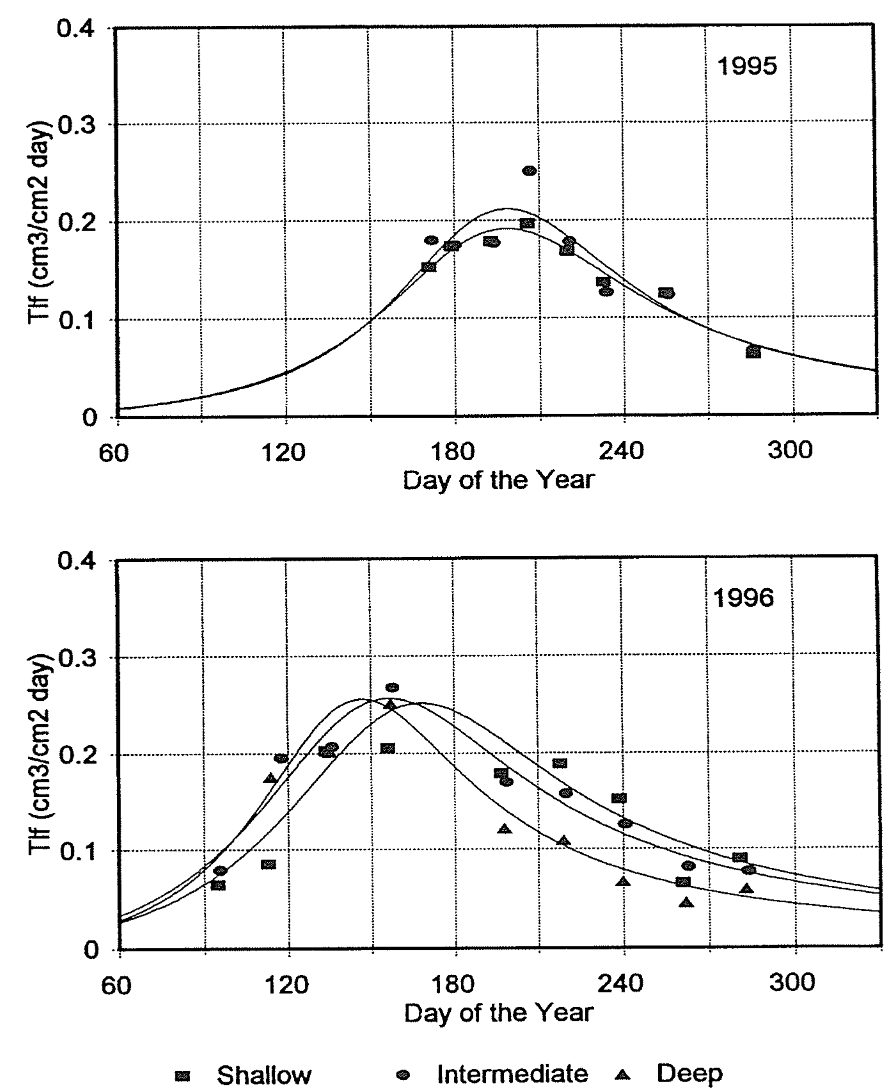


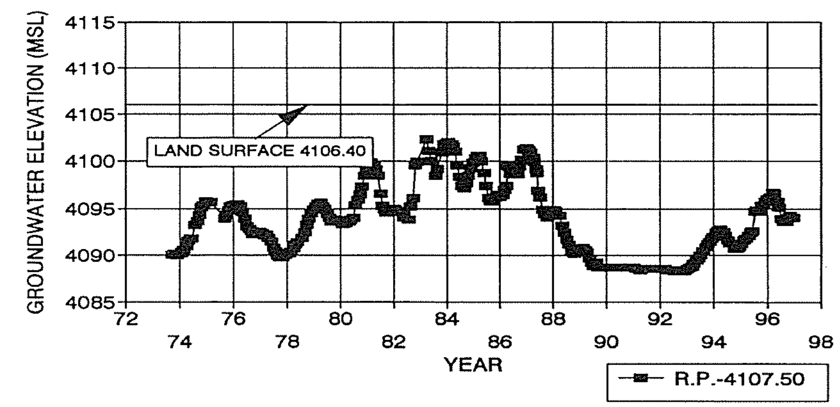
Figure 8: Transpiration per leaf area (Tlf) data and best fit curves for the three sites in 1995 and 1996.

At the deep water table site, however, leaf area was much lower and transpiration equaled average annual precipitation. The vegetation at this site died back in response to extended periods without groundwater; this reduced leaf area to levels sustainable by precipitation alone. Also, the water content of moist soil occurring below seven meters did not change at this site during the study. This suggests that seven meters is about the maximum rooting depth for Nevada saltbush.

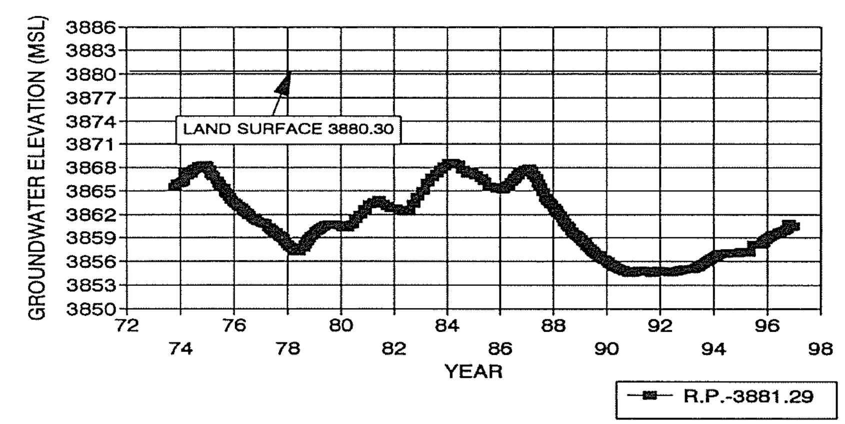
One potentially important result for the monitoring and management program was the large quantity of water tran-

Samples of hydrographs showing groundwater elevations: 1974–1996

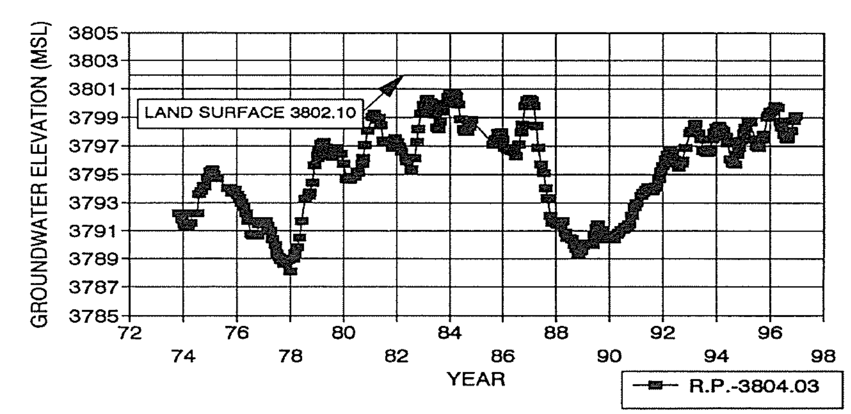
INDICATOR WELL 436T
LAWS WELL FIELD



INDICATOR WELL 425T
BIG PINE WELL FIELD



INDICATOR WELL 398T
BAIRS-GEORGES WELL FIELD



SOIL WATER

ICWD researcher Brian Cashore uses a neutron probe, a more accurate, efficient gauge of Owens Valley soil water conditions.

by Aaron Steinwand
ICWD Soil Scientist

Monitoring site on-off status

December–April precipitation in 1995–96 increased the soil's available water content (AWC) to surplus status at seven monitoring sites. A rising water table put three others in surplus. Since April 1996, ICWD and LADWP have determined monitoring site status using data collected with a neutron probe . On July 1, 1996, the first well turn-off date with the new data, 11 of 19 sites in surplus status went into deficit. Two more went into deficit on October 1. That left six of the 22 sites in surplus status, compared with nine at the same time in 1995.

Seven sites entered surplus status during the winter of 1997, mostly due to precipitation (though two of these also increased due to rising groundwater). Five of these sites are expected to go into deficit on July 1, 1997, when the small soil water reserve from winter precipitation is exhausted.

Soil water monitoring improvements

Until 1996, ICWD relied on psychrometers as the primary instruments to measure AWC. The field procedures and calculations to estimate AWC using this method are described in the Green Book. Beginning in April 1996, ICWD began using the neutron probe for measuring AWC. The new program also included new methods to calculate AWC from field data. The switch to the new program followed several months of parallel monitoring to compare results of the two methods (see Figure 1).

The new monitoring procedures offer several advantages over the previous Green Book procedure. Neutron probe methods provide reliable data and are widely accepted by scientists. In the comparison of monitoring methods, psychrometer data were acceptable in very dry soils, but soil water measurements in dry soil are usual-

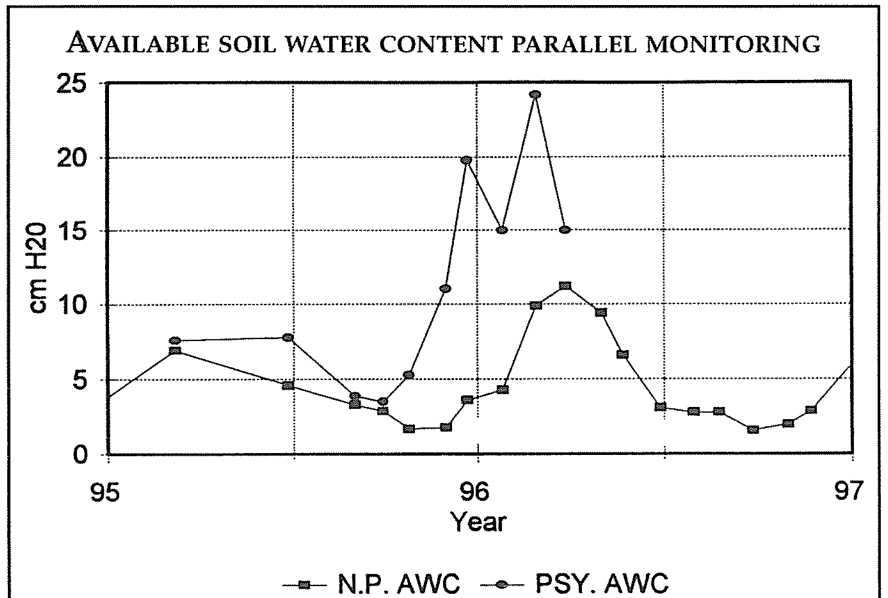


***Figure 1:** Available soil water content (AWC) measured concurrently with the neutron probe (NP) and psychrometers (PSY) at a monitoring site in 1996-97. The spike in psychrometer data is greater than the precipitation that occurred at that time. Similar comparisons were performed at all sites.*

Geographic Information Systems at ICWD

by Chris Howard
Inyo County GIS Specialist

As the Inyo County Geographic Information Systems (GIS) specialist, I devote a portion of my time to building, operating and improving the ICWD's GIS. By employing GIS technology, ICWD can assess the spatial distribution and interaction of environmental conditions and management practices in the Owens Valley. ICWD uses GIS to help integrate its different scientific disciplines: hydrology, soils and vegetation.

A GIS is a set of computer programs and databases that allows input, manipulation and storage of spatial information. It is comprised of digital map layers and their associated databases. In the ICWD GIS, we have compiled many existing digital map layers and databases and developed our own as well.

An example of such a map layer is the Owens Valley vegetation GIS layer. This digital map depicts the valley as thousands of unique vegetation units called parcels. The map is stored electronically and is linked directly to a database containing pertinent quantitative information about each parcel. Thus, we are able to select a vegetation parcel on the screen and quickly access specific vegetation information about that parcel.

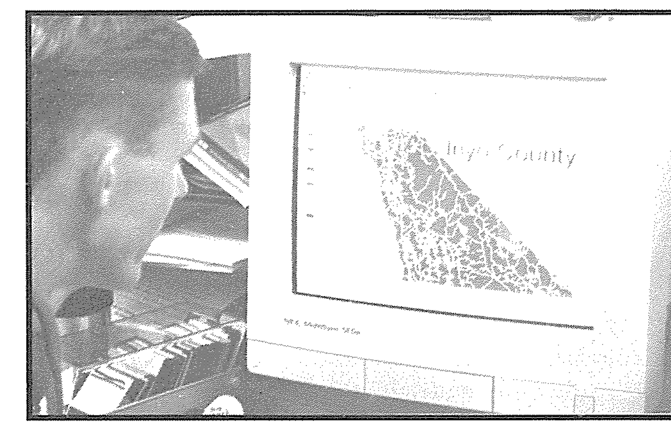
ICWD is constantly researching and analyzing information about the physical and biological properties of the Owens Valley. The research efforts of ICWD scientists are inherently spatially-oriented. The GIS is used to store, retrieve and efficiently analyze this information. It needs to be upgraded frequently, as new data and efficient new tools for analyzing complex data sets become available. Some of my duties as GIS specialist include: transferring new data and incorporating it into the GIS; seeking out new analytical tools that can assist ICWD needs; providing analyses; upgrading and updating the GIS when appropriate; generating maps for reports and presentations; and demonstrating ICWD's GIS to interested groups.

In 1996, ICWD's GIS achievements included:

- Importing 1995 depth-to-groundwater contours and change-in-depth-to-water for 1986-90 and 1986-95.
- Researching applications of ArcView Spatial Analyst software by Environmental Systems Research Institute (ESRI) and other software packages.
- Entering current vegetation data and analyzing depth-to-water changes under vegetation parcels.
- Integrating DWP well locations.
- Developing and implementing a procedure for generating random points for vegetation field research.
- Training staff on new GPS equipment and developing methods to easily incorporate GPS data into GIS.
- Acquiring pertinent data from outside sources.
- Training staff to digitize, produce maps, perform analyses, and otherwise operate GIS.
- Upgrading software to ArcView 2.1.
- Producing Enhancement/Mitigation maps and well-field maps.
- Incorporating Owens Valley precipitation values for 1996 into the GIS.
- Representing Inyo County in the Eastern Sierra Land Information Systems Network.

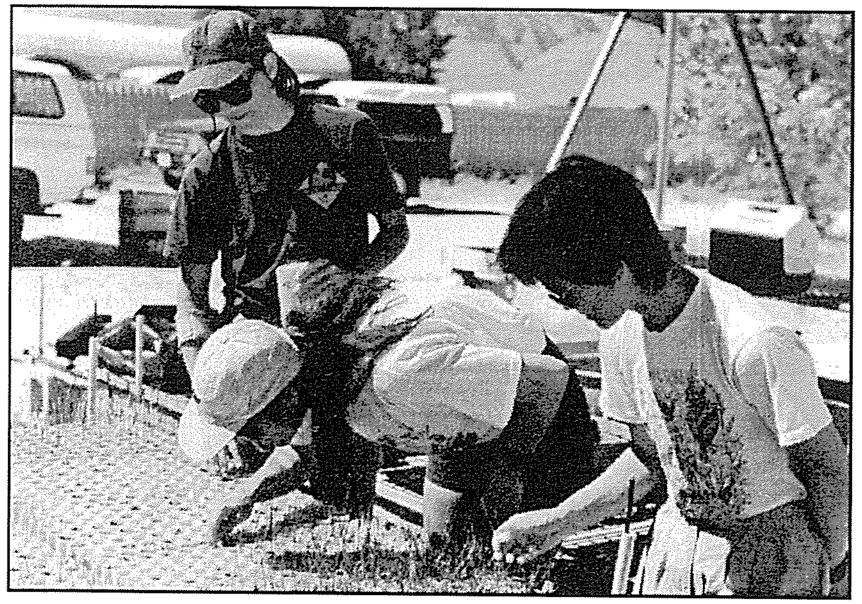
Ongoing GIS analyses

As GIS applications at the ICWD diversify, we are realizing its potential. In the near future, we hope to complete the integration of all the depth-to-groundwater contour layers into the GIS, begin using GIS to assist in the saltcedar control program, and continue to use GIS as an integral part of ongoing environmental analysis. The GIS is proving to be a valuable tool in assessing the complex interactions between different environmental factors. This information gives us more insight into ways to improve the groundwater management program.



Inyo County GIS Specialist Chris Howard displays a digital map of the county.

Revegetation study continues at Laws



ICWD's Irene Yamashita, BLM's Anne Halford, and Karen Ferrell-Ingram, from right, prepare native seedlings for revegetation projects.

by Irene Yamashita
ICWD Supervising Researcher

Since 1991, ICWD has been testing methods of reestablishing native plants on barren lands in the Owens Valley as a means of mitigating the impacts of water export that occurred between 1970 and 1990. This effort is aimed at meeting an EIR mitigation goal of revegetating approximately 1,000 acres with native plants.

One ICWD study involved transplanting 400 fourwing saltbush shrubs on abandoned farmland in the Laws area in late 1991. The shrubs were monitored annually for growth and survival under various growing conditions: with or without irrigation; high- or low-density planting; weeded or unweeded; and with or without fertilizer.

After five growing seasons, we observed that irrigation was the single most important factor for increasing survival. Even two years after ceasing irrigation, these previously watered plants showed the highest survival rates. Irrigation was beneficial for three years for the high-density planting and two years for the lower-density planting. Fertilizer further increased survival for irrigated shrubs but was harmful to unirrigated shrubs.

We also observed that mortality decreased annually. After the first three years, annual losses have been negligible. If healthy plants are transplanted and care is taken to promote their development during the first three years after planting, very high survival rates may be expected at this site. We will continue to monitor the test plot for long-term survival results.

Our hope at the site is to see native seedlings established naturally. Then we could have some assurance that the site will be self-sustaining in the future and provide a model for revegetating other areas of the valley.

New revegetation projects

LADWP constructed an additional site for revegetation tests in early 1996 near Independence. This site will greatly enhance our research opportunities by offering very different environmental conditions than the Laws site. Some of the contrasting conditions: type of impact (groundwater pumping vs. abandoned agriculture); soil type; and physical conditions (southern vs. northern Owens Valley).

In November, 138 plants were planted at the Independence site and 86 at Laws. These plants will be irrigated monthly from April through September and monitored for survival. All plants are from locally collected seeds grown at the Deepest Valley Cooperative Native Plant Propagation Center, located at the White Mountain Research Station in Bishop.

Plant shelters

Low-cost plant shelters may help revegetation efforts. In 1995, we studied the effect of plant shelters to protect natural seedlings from wind, sun and herbivory. Unfortunately, many of the shelters were lost, leaving only a small data set, but these data indicated a slight benefit to sheltered seedlings compared to those not sheltered.

Shelters will be used this year on transplanted shrubs and grasses in the Independence and Laws areas.

Millpond tree planting

ICWD staff planted trees along a stretch of McGee Creek at Millpond Recreation Area west of Bishop. The intent of the project is to restore riparian characteristics at the site, connecting it to existing healthy areas nearby.

Birch *(Betula occidentalis)*, cottonwood *(Populus fremontii)* and Goodding's willow *(Salix gooddingii)* were planted. Growth and survival monitoring continues.

—Irene Yamashita

ly low, regardless of the method used. In moist soils, though, neutron probe data were less erratic than psychrometer data, especially after precipitation or water table rise (see Figure 1).

Some of the erratic behavior is due to the meticulous installation, operation, and calibration required for accurate psychrometer measurements. The neutron probe is much less sensitive to these sources of error. Using neutron probe data also eliminates the inaccurate Miller method described in the Green Book for converting psychrometer data to AWC.

There are other practical advantages to using the neutron probe. Measurement and calibration errors are easier to quantify. This allows ICWD to identify sites where additional improvements are necessary. In addition, because the neutron probe measurements are easier and cheaper to replicate, we can monitor the soil profile more completely and at more locations. Currently, each month we collect 1,740 AWC measurements, compared with 99 previously. We have also increased the depth to which we monitor; at most sites we collect measurements to below the root zone or to the top of the water table.

Water table and soil water recovery: site IO1

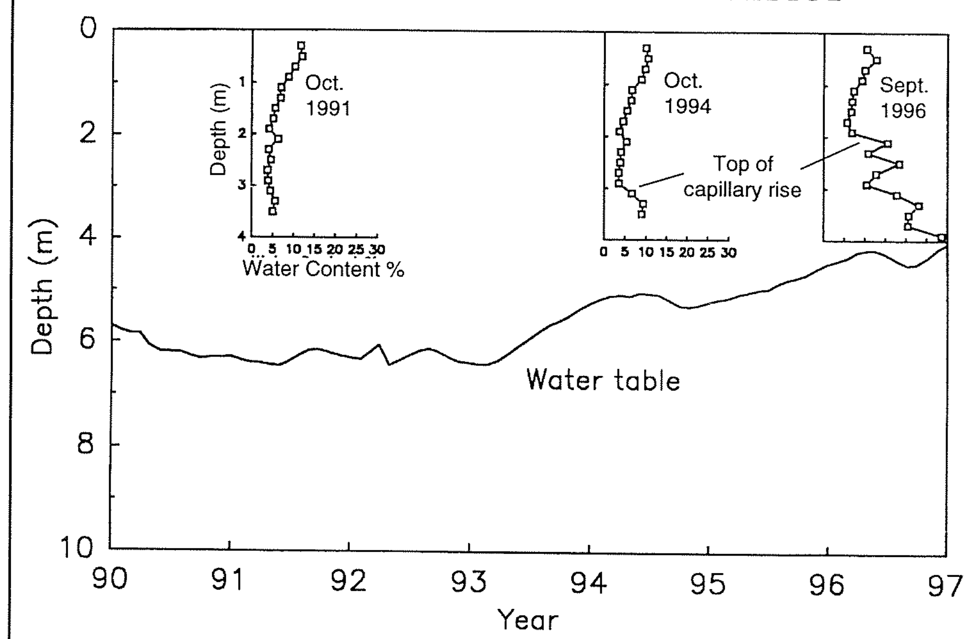


Figure 2: Water table depth (solid line) and soil water profiles for selected dates at monitoring site Independence-Oak I01. Note the increasing soil water below 2–3 meters as the water table rises after 1993. The root zone is two meters.

Monitoring site conditions

For most of the plant communities we monitor, periodic connection of groundwater to the root zone of the vegetation is crucial for long-term survival and for recovery from drought. Yet the monitoring site on-off status alone is not always an accurate indicator of the root zone connection to groundwater. That is because the on-off status also depends on estimated water needs of the vegetation and soil water derived from precipitation.

The expanded soil water monitoring described above is well-suited to evaluate the soil water-groundwater relationship. The rise of water above the water table into dry soil due to capillary action is easily detected (see Figure 2). Using the new data, we can now determine which monitoring sites have root zones connected with the water table and which still need water table recovery.

The data also allows us to empirically predict the water table depth necessary to provide groundwater to the root zone at sites not yet connected. The soil water-groundwater connection at monitoring sites are represented in Figure 3. The connection can be described as:

Owens Valley permanent monitoring sites

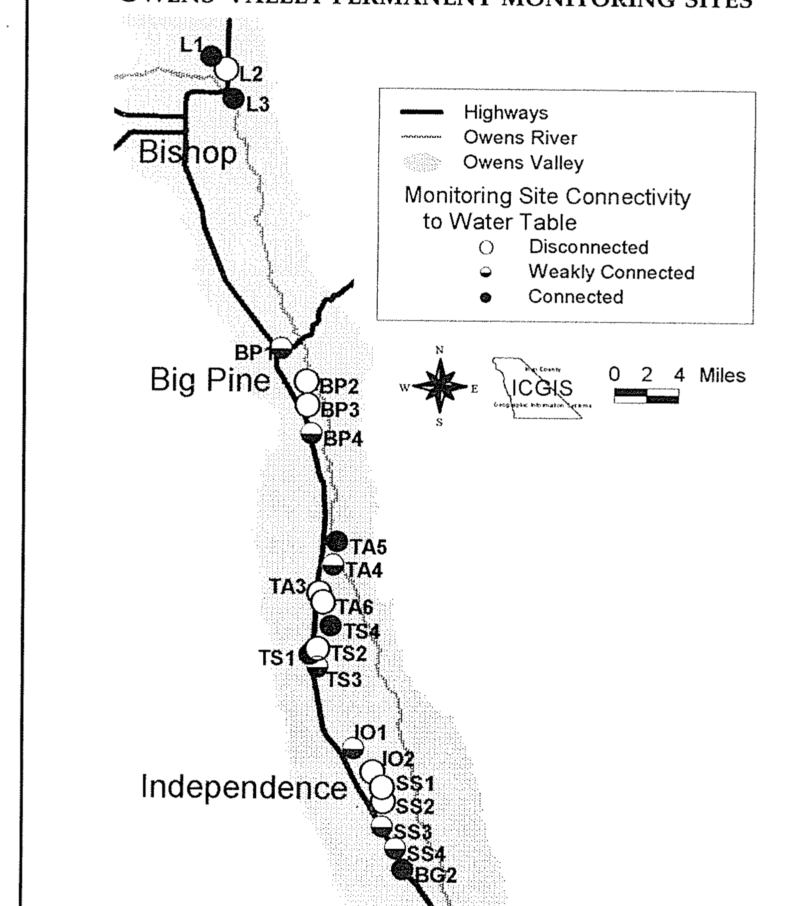


Figure 3: Soil water-groundwater connection categories are identified by symbol shape.

- Disconnected: No groundwater is reaching the root zone. Nine sites occur in this category. At two of these sites the capillary rise is within one meter of the root zone. At the others, it is deeper.
- Weakly connected: Groundwater extends to the very bottom of the root zone. Seven sites occur in this category.
- Connected: Groundwater extends well into the root zone. Six sites occur in this category. Four sites have had water table recovery or were located near water spreading areas; two sites were never dry.

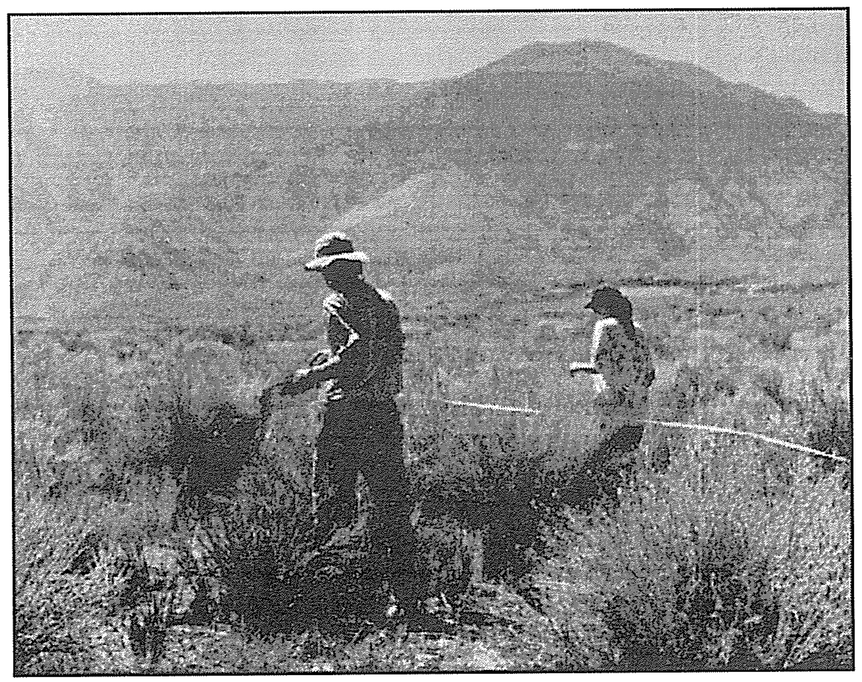
For monitoring purposes, the root zone is assumed to extend to a depth of two meters at grass-dominated sites and four meters at shrub-dominated sites.

The connection between the root zone and groundwater is not simply a function of water table depth. It is also affected by soil characteristics. For example, the water table near L3 (root zone = two meters) is at approximately five meters, but the soil is wetted to less than two meters below the surface. In this case, the site is connected to groundwater because the silty soil supports a very thick capillary rise above the water table.

In contrast, at BP2 (root zone = four meters), the water table is 5.6 meters, but the soil at depth is sandy. Consequently, the soil is wetted only to 4.5 meters.

Soil differences can result in better soil-groundwater connection at shallow rooting sites than at a deeper rooting sites even though water table depths are similar. Identifying these relationships is the first step in establishing a target water table depth necessary to provide groundwater to the root zone after drawdown. Only a small amount of water is added to the soil at the upper limit of capillarity, however. The water table will need to recover above the target to increase AWC enough to meet vegetation needs.

VEGETATION



ICWD assistants Steve Ostoja and Amy Parravano use a line-point transect to monitor vegetation conditions.

by Sally Manning
ICWD Vegetation Scientist

In general, the 1996 percent live cover of perennial plants at the permanent monitoring sites was slightly lower than what it had been in 1995. However, there are several exceptions to this generalization. (Percent live cover for the monitoring sites appears in the graphs of Figure 4, page 11.)

The slightly downward trend in cover between 1995 and 1996 can be attributed to two factors: the availability of soil water (see "Monitoring site on-off status," page 8) and the slightly below average precipitation in the Owens Valley for the 1996 water year.

Return of the water table to at least the lower reaches of the plant root zone occurred at some monitoring sites (see Figure 3, page 9). At some of these sites, the perennial plant cover tended to increase relative to 1995, despite the decrease in precipitation. Regardless of the trend in 1996, no site dropped to the low cover experienced during the very dry years of the early 1990s. Of the 14 sites monitored since 1987, three achieved perennial cover higher than that measured in 1987, the first year of a six-year drought.

Vegetation inventory and conditions

It is difficult to assess valley-wide vegetation trends from the handful of permanent monitoring sites. Therefore, larger parcels of vegetation are inventoried annually to record current conditions and to detect trends that might result from management practices. This program began in 1991.

In 1996, ICWD conducted these inventories on 97 parcels of native vegetation to compare their status to 1984–87 baseline conditions. Of the 97 parcels, 41 were located in control areas, which were not pumped, and 56 were in areas that had undergone water table lowering due to pumping from 1987 to 1990. These 56 parcels were further split in two: 42 remained in a condition of depressed water table relative to baseline, while the water table rose beneath the other 14 parcels by the summer of 1995 to near where it was during the baseline vegetation survey.

Continued on page 12

Riparian monitoring

by Brian Cashore
ICWD Supervising Researcher

A fledgling program is under way to learn about soil, water and vegetation along Owens Valley creeks. This program is designed to document riparian conditions over time. Because streams and surrounding vegetation are naturally dynamic systems, riparian monitoring must assess these changes so that human-caused or other changes can be detected. Accepted indicators of proper stream conditions and function help in assessing riparian health.

In July 1996, LADWP's Paula Hubbard and I continued riparian vegetation monitoring begun in 1995. We monitor eleven sites on four creeks (Birch, Baker, Taboose and Shepherd), checking physical characteristics of channels and streams (see example in Figure 7) as well as streamside vegetation. Permanent photo points are set up at each site for annual updates. Riparian sites will be monitored again this summer.

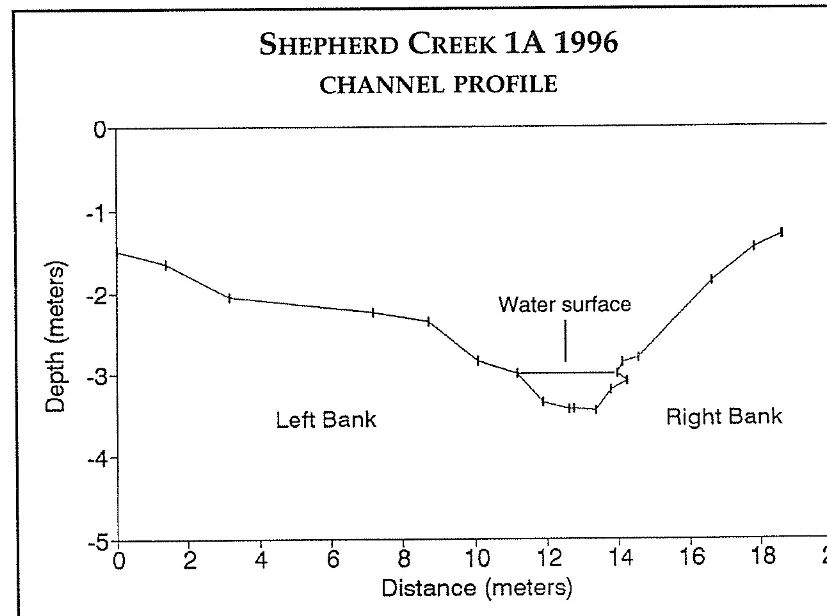


***Figure 7:** Cross-section of Shepherd Creek stream transect. Physical changes in the channel may be detected by measurements over time.*

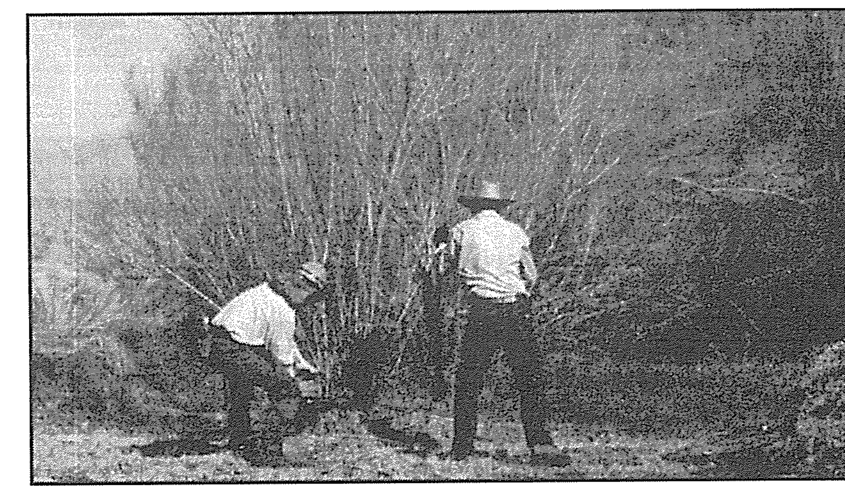
Saltcedar control

Since 1994, ICWD has tested methods to halt the spread of saltcedar *(Tamarix ramosissima).* This pilot project continued in 1996 with 30 days of field work at 10 different sites.

The main emphasis of this project has been to use limited supplies and personnel to keep previously treated areas free of saltcedar, to use higher herbicide concentrations on new outlying plants, and to remove scattered plants near riparian or wetted areas, where there is a high potential for seed germination. The large amount of water from 1995 runoff provided optimal conditions for the dispersal of saltcedar and other weedy species. New seedlings sprouted at water-spreading areas near Laws and Oak Creek, and along Pine Creek.

Much of the 1996 work consisted of follow-up treatments to saltcedar sites cut in northern Owens Valley during the previous three years. Regardless of the season they were originally cut or treated, many of these sites re-sprouted. This may indicate the need for higher herbicide concentrations and the need to plan on repeated treatments. Some areas where saltcedar has been successfully removed over the past two years are: Warm Springs near Bishop; sites at Klondike Lake; part of McNally pasture near Laws; and many scattered individual plants in northern Owens Valley. A few isolated plants were removed from other riparian sites in an attempt to reduce outlying seed sources fueling the weed's spread. Other areas of saltcedar eradication attempts include: Laws-Poleta Road; Dixon Lane area; Five-Bridges area; Owens River between Bishop and Big Pine; Shepherd Creek; and Hogback Creek.

Saltcedar is removed in two ways. The cut-stump method requires cutting the plant at or near ground level with a chain saw, lopper, or axe, then spraying the stump with herbicide within 15 minutes. The basal-bark method involves spraying herbicide on the bottom 12 inches of plants that have stems less than three inches in diameter. Both techniques have been successful and can take place any time during the growing season between March and November. —*Brian Cashore*



Taking on a thicket of saltcedar, one of the more daunting challenges ICWD faces.

Site category	1st-year survival for 1995 ATTO	1st-year survival for 1991 ATTO
wf scrub	23.0%	12.7%
ctl scrub	19.1%	9.9%
wf mdw	43.2%	31.4%
ctl mdw	52.1%	23.4%

ATRIPLEX TORREYI SURVIVAL RATES

Table 6: Site abbreviations: wellfield (wf), control (ctl) and meadow (mdw). ATTO = Atriplex torreyi.

from page 13

but the highest rate of survival occurred in the control meadows. Comparison of the first-year survival for the 1995 ATTO cohort with the first-year survival of the 1991 ATTO cohort (Table 6) revealed two interesting details: about twice the total survival rate for 1995 ATTO in three out of four categories; and a similar pattern of survival rate between the four site categories, with the exception of a higher rate in control meadow sites for 1995 ATTO.

—*Sally Manning*

Rare plant monitoring

Since 1992, ICWD staff has monitored *Sidalcea covillei* (SICO) and *Calochortus excavatus* (CAEX). Both species are perennial herbs endemic to alkali meadows of the Owens River drainage. Their roots (and in the case of CAEX, bulbs) remain buried in the soil year after year. Leaves of both species begin to emerge in late winter. Buds and flowers emerge in May, reaching their maximum height of about 18 inches. By the end of June, both species complete their annual cycle by setting seed and dying back. By late July, virtually no live parts of the plants remain above ground.

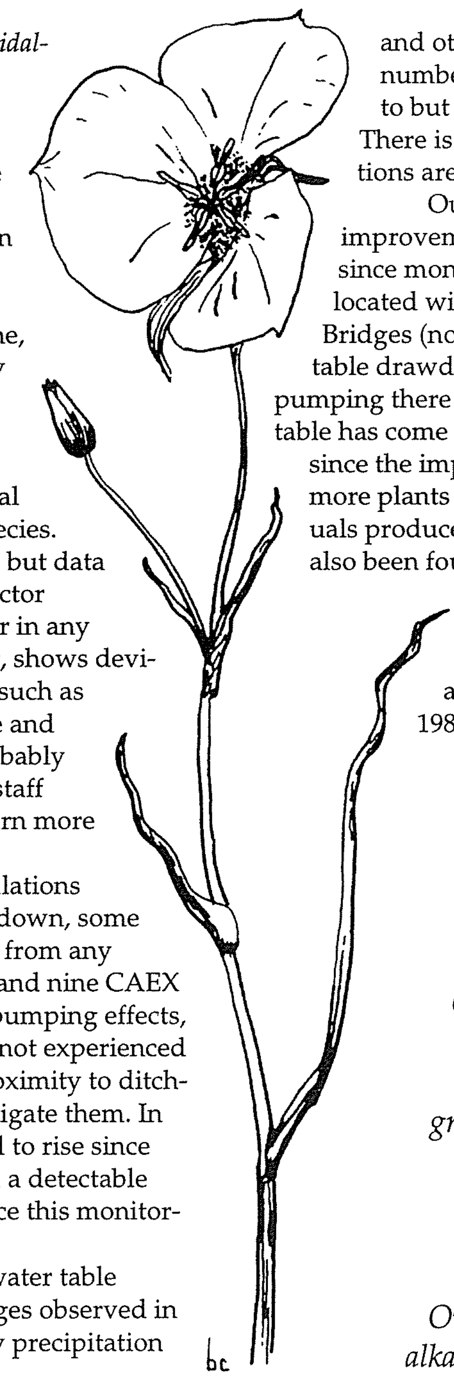
We do not know all of the environmental variables that influence these rare plant species. Certainly annual precipitation plays a role, but data suggest that precipitation is not the only factor affecting whether an individual will appear in any given year. CAEX emergence, in particular, shows deviations from precipitation patterns. Factors such as soil water availability, individual plant age and flowering history, and site disturbance probably all contribute to CAEX emergence. ICWD staff carefully monitor some CAEX plants to learn more about annual variation.

ICWD staff study some rare plant populations that occur within suspected zones of drawdown, some near but outside these zones, and some far from any pumping effects. Even though eight SICO and nine CAEX populations lie within predicted zones of pumping effects, many of the places where they occur have not experienced water table drawdown because of their proximity to ditches or other water bodies that tend to subirrigate them. In addition, because water tables have tended to rise since 1992, no study population has experienced a detectable lowering of the underlying water table since this monitoring program began.

Because rare plant sites did not suffer water table declines in 1996, the relatively minor changes observed in 1996 data must necessarily be explained by precipitation and other factors. In most cases, the total number of plants observed appeared similar to but lower than totals observed in 1995. There is no indication that any of these populations are truly declining.

Our field surveys, in fact, have shown improvements in a few rare plant populations since monitoring began. A small SICO population located within the zone of pumping at Five Bridges (north of Bishop) was affected by water table drawdown in the late 1980s. Since 1990, pumping there has been severely restricted. The water table has come up significantly beneath the population since the impact occurred. Each year since 1991, more plants have appeared. By 1995, many individuals produced flowers and seeds. Seedlings have also been found. A CAEX site near Aberdeen first surveyed in the early 1980s revealed no plants from 1990–94. In 1995, however, several plants emerged, individuals that may have been dormant since 1986. Many emerged again in 1996.

—*Sally Manning*



Calochortus excavatus, a rare, groundwater-dependent perennial herb found in a few Owens Valley alkali meadows.

Plant cover at permanent monitoring sites, 1987–96

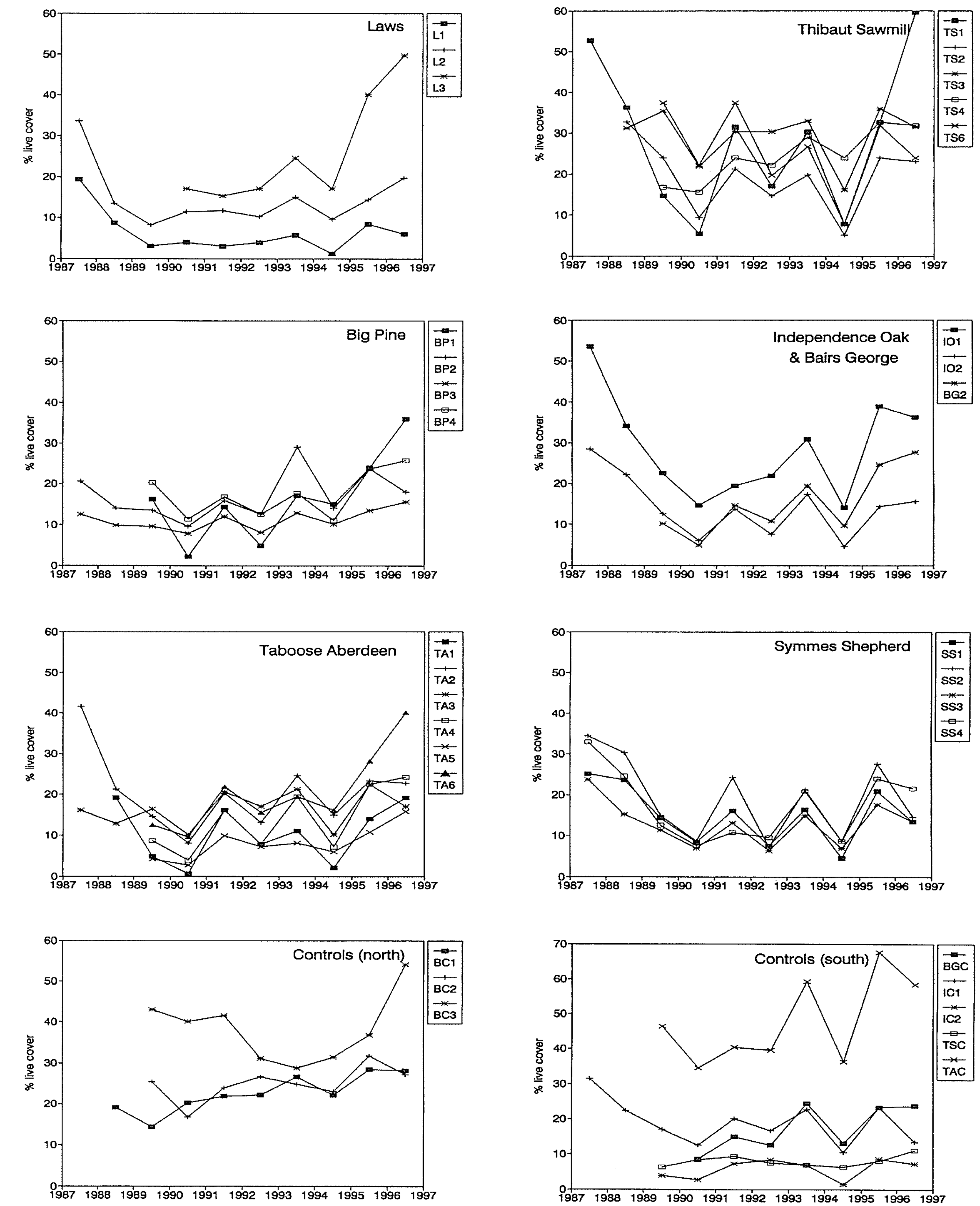


Figure 4: Percent live cover for the 33 monitoring sites established by ICWD and LADWP. Soil water availability and slightly below average Owens Valley precipitation in 1996 account for the small downward trend in cover from 1995 to 1996. See pages 10–12 for discussion.

Percent change in perennial cover 1991–1996

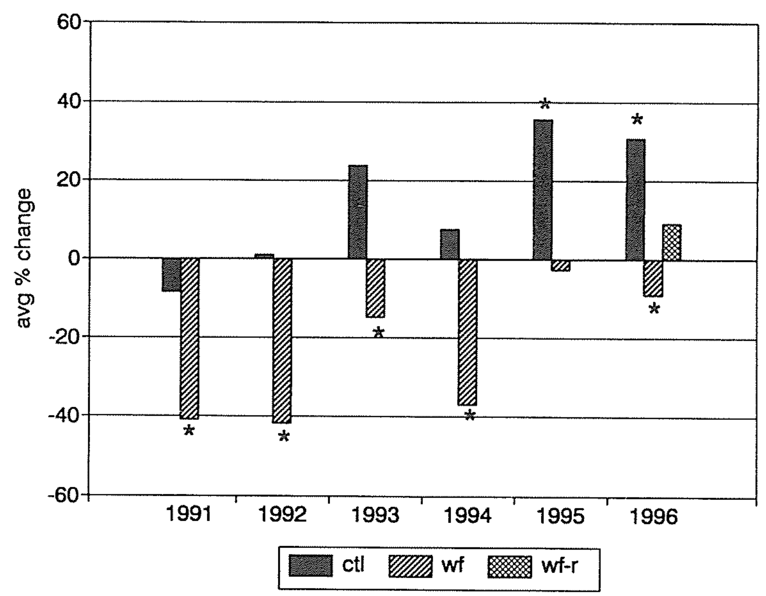


Figure 5: Average change in perennial cover for parcels grouped by wellfield category for all years in which parcels have been inventoried by ICWD. The change is "relativized," that is, the average change is calculated relative to the baseline percent cover. Parcels are categorized as control (ctl), wellfield (wf), or wellfield-recovered (wf-r). See Table 4 for data. Asterisks indicate statistically significant (p≤0.05) change from zero.

Relative change in perennial cover 1991–1996

From baseline year to:	ctl	# parcels	wf	# parcels	wf-r	# parcels
1991	-8.4%	9	**-40.8%**	21	—	
1992	+0.9%	50	**-41.8%**	49	—	
1993	+23.8%	24	**-14.8%**	36	—	
1994	+7.5%	24	**-36.9%**	36	—	
1995	**+35.6%**	30	-3.5%	39	—	
1996	**+30.8%**	41	**-9.0%**	42	+9.1%	14

Table 4: Average relativized change in perennial cover for parcels grouped by wellfield category: control (ctl); wellfield (wf); and wellfield-recovered (wf-r). ***Bold*** *indicates a statistically significant change (p≤0.05). The number of parcels in each category is also presented.*

Perennial cover: change from baseline

The change in perennial cover relative to baseline is summarized for the three groups of parcels in Figure 5 and Table 4. Figure 5 shows that the control parcels experienced a statistically significant increase in cover relative to baseline, similar to 1995 results. During the dry period from 1991–1994, the cover in these control parcels did not change significantly from baseline conditions. Cover in these parcels (as a group) has never fallen significantly below baseline; in the past two years of sufficient precipitation, it has increased.

In the 1996 wellfield group of 42 parcels, perennial cover declined relative to baseline (Figure 5). While not a large decline (-9 percent), it is still below baseline cover. Further, it is significantly different from the response of plant cover in the control parcels. Although the water table underneath many of the wellfield parcels had risen since 1993, it was still, on average, three feet or more below where it had been during the time of the original vegetation inventory. Parcels in this group have not regained plant cover comparable to baseline conditions.

In the 14 parcels that experienced water table recovery to within two feet of levels measured during baseline vegetation years, there was no significant change in 1996 cover relative to baseline cover. (Although Table 4 shows an average change of +9 percent, this value is not statistically significant because there is too much "noise" in this small data set. Thus, we cannot confirm the change.)

These 14 parcels differ from the other wellfield parcels in several important ways. First, these parcels experienced only a small degree of water table drawdown. Second, the period of separation from the water table (1987–94) was less than eight years. Third, during this time period, there was only one "wet" year (1993). In contrast, the unrecovered wellfield parcels have experienced a greater water table drawdown beneath them, a longer period of separation from the water table, and a lack of a water table in the root zone during recent years of above-average precipitation. Therefore, it is difficult to predict recovery in the wellfield parcels based on the response of these 14 recovered parcels. Finally, while plant cover in these 14 parcels may have been comparable to baseline conditions, it was not comparable to control parcel cover, which exceeded baseline in 1996.

In 1997, water tables are expected to continue to rise, and vegetation will continue to be monitored for its response to improving water conditions.

Plant composition

The composition of plants within the parcels appears to be changing. To analyze these changes, each species of plant found in a parcel is assigned to one of three categories: grass, shrub, or weed. "Grass" is composed primarily of native, perennial grasses. "Shrub" includes woody, native species. "Weed" includes nearly all non-native species, both annual and perennial, as well as some invasive native species. Within the control, wellfield, and recovered wellfield groupings, the average percent cover of each of these categories is calculated for baseline years and for 1996. Figure 6 summarizes the changes.

In the 41 control parcels, grass cover stayed the same, while shrub and weed cover increased significantly. Rabbitbrush *(Chrysothamnus nauseosus)* was the primary shrub species that increased in cover in the control parcels. Weed cover increased, but averaged only 1.7 percent in these parcels.

In the 42 wellfield parcels, grasses decreased significantly relative to baseline, while shrubs and weeds remained near baseline. Therefore, loss of grass cover accounted for the overall decline in cover in this group of parcels.

In the 14 recovered wellfield parcels, grasses were significantly below baseline cover levels. Shrubs appeared to increase, but the increase was not statistically significant. Weed cover in the parcels where the water table "recovered" increased significantly and averaged 9 percent.

Percent cover vs year by plant and parcel types

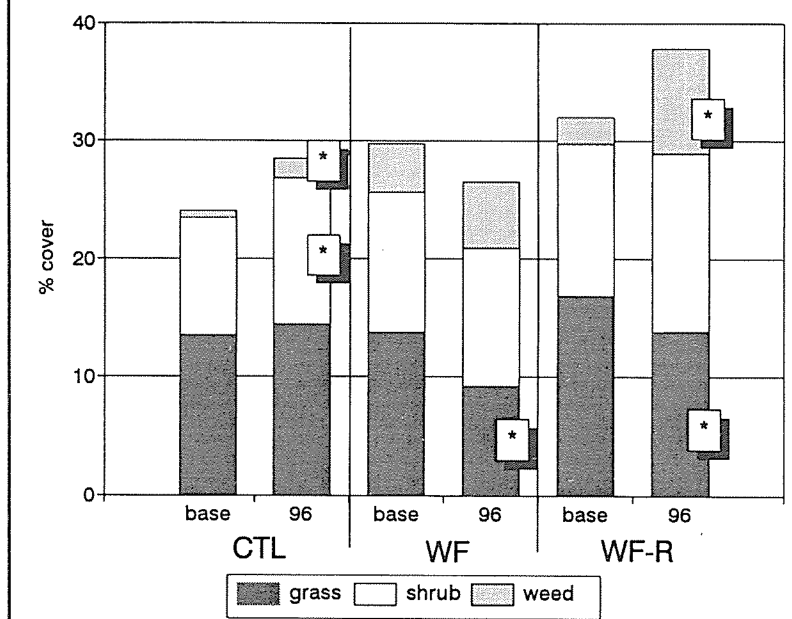


Figure 6: *Stacked-bar graphs showing the average cover of each general plant type (grass, shrub, weed) during baseline year and 1996 for all parcels. Parcels are grouped by category: control (ctl); wellfield (wf); or wellfield-recovered (wf-r). Asterisks within 1996 bars show statistically significant changes (p≤0.05) for that plant type relative to baseline.*

Shrub recruitment

Germination and survival of new shrubs have been followed at the permanent monitoring sites since 1989. During 1996, a negligible amount of newly germinated seedlings appeared. Survival and growth of seedlings that germinated in 1991, 1993 and 1995 — all "wet" years — have been tracked. Those survival results appear in Table 5.

Nevada saltbush (*Atriplex torreyi*, or ATTO) accounted for over 90 percent of shrub seedlings found at the permanent monitoring sites. Its survival rate typically has been higher in meadows than in scrub sites. Because ATTO is a shrub species, this suggests a trend of meadow invasion by shrubs. Also, the trend for the 1991 ATTO cohort — the plants that germinated in 1991 — showed that poorest survival (0.7 percent) of new shrubs was in the wellfield scrub sites. Control scrub sites showed slightly higher ATTO survival. In the meadow sites, ATTO survival was higher in wellfields than in control sites, suggesting that pumped meadow areas are more susceptible to ATTO invasion than non-pumped meadows.

Many ATTO germinated in 1995 and survived their first year. Total first-year survival for the 1995 ATTO cohort was 28 percent (Table 5). Survival rates in meadows were higher than at scrub sites,

continued on page 14

Some 1996 recruitment results

cohort	NUMBER OF RECRUITS SURVIVING 8/91	8/92	8/93	8/94	8/95	8/96	% overall
All 1991 recruits	4374	973	684	521	347	321	7.3
1991 ATTO only	4167	891	620	451	295	273	6.6
wf scrub	1524	194	59	35	13	11	0.7
ctl scrub	548	54	28	16	14	13	2.4
wf mdw	1911	600	513	379	248	230	12.0
ctl mdw	184	43	20	21	20	19	10.3
All 1993 recruits	-	-	739	45	25	23	3.1
1993 ATTO only	-	-	696	23	12	11	1.6
wf scrub	-	-	601	2	1	0	0.0
ctl scrub	-	-	40	3	2	2	5.0
wf mdw	-	-	32	14	8	8	25.0
ctl mdw	-	-	23	4	2	1	4.3
All 1995 recruits	-	-	-	-	21814	6155	28.2
1995 ATTO only	-	-	-	-	19783	5542	28.0
wf scrub	-	-	-	-	11373	2618	23.0
ctl scrub	-	-	-	-	3016	576	19.1
wf mdw	-	-	-	-	5181	2237	43.2
ctl mdw	-	-	-	-	213	111	52.1

Table 5: *ATTO = Atriplex torreyi. Data divide into site categories as follows: control (ctl); wellfield (wf); shrub-dominated sites (scrub); and meadow or grass-dominated sites (mdw).*