TEMPORAL DESERT RIPARIAN SYSTEMS--

THE MOJAVE RIVER AS AN EXAMPLE[1]

Louis A. Courtois[2]

Abstract.--During years of high precipitation, temporal riparian zones form on the dry lake playas within the Mojave River drainage and can exist for several years. This is followed by establishment of pioneer aquatic species which eventually give way to halophytes as surface waters recede. Once surface waters evaporate the alkali sink vegetation becomes reestablished.

INTRODUCTION

Riparian systems are usually associated with permanent water such as lotic (rivers, streams or springs) or lentic (lakes, ponds or seeps) habitats. Riparian vegetation may also be found in areas of intermittent flow such as arroyos. In each situation, riparian systems occupy the moist transition (riparian) zones between the wet aquatic and the dry upland zones (Thomas et al. 1979). Water is the major limiting factor upon which riparian vegetation is totally dependent.

A temporal desert riparian system is also dependent upon water and only becomes established during years of high precipitation. Flash floods, which result from high precipitation, carry water through the drainage until it ultimately reaches dry lake playas (e.g., flat floored bottom of an undrained basin) where it becomes impounded. Inundation of these alkali playas kills the existing plants and provides the necessary water source for establishment of a temporal riparian system. The word temporal best defines this system because, as the surface waters evaporate, the riparian zone slowly advances down into the basin, continually establishing itself along the dry shoreline. Immediately above the riparian zone the drier upland zone allows the alkali sink plant community to become reestablished.

The extent of a temporal desert riparian system is dependent upon the amount of seasonal runoff reaching the old lake basin. The temporal system, like a vernal pool, is filled by seasonal runoff. The vernal pool, however, is a much shorter-lived system, lasting several weeks to a few months. The temporal desert riparian system may last much longer, several months to a few years. The physical characteristics of the soil in these systems are also similar--both are common to older soils which have either a dense claypan or hardpan some depth below the surface. This permits an aquatic habitat to become established, since water cannot seep away into the lower soil column (Holland and Griggs 1976). Vernal pools in California form only during the spring, but temporal riparian systems can form during the winter, spring, or as a result of summer storms.

The Mojave River drainage has both lotic and lentic riparian zones, as well as temporal riparian systems. To better understand these temporal riparian systems we must first understand the drainage characteristics which allow them to form and perpetuate.

HISTORIC DRAINAGE

During the Pleistocene a major portion of the Mojave River drainage consisted of three large lakes, Little Lake Mojave, Lake Mojave, and Lake Manix, which eventually drained into the Colorado River (fig. 1). Buwalda (1914) was one of the first to study Lake Manix and based its pre-existence upon lacustrine deposits, fossils, and ancient shorelines. The outflow from Lake Manix eventually carved out Afton Canyon, which flowed into Little Lake Mojave and Lake Mojave. Little Lake Mojave, the smallest of the three lakes, was intermittent and relatively short-lived. This lake included what today is known as East and West Cronese lakes (fig. 2). Lake Mojave was extensive, covering the present day playas of Soda and Silver lakes (fig. 2). Thompson (1921, 1929) studied the wave-cut cliffs, terraces, beach ridges, sand bars, and lacustrine deposits of Lake Mojave. He also found an "unmistakable outlet channel" which

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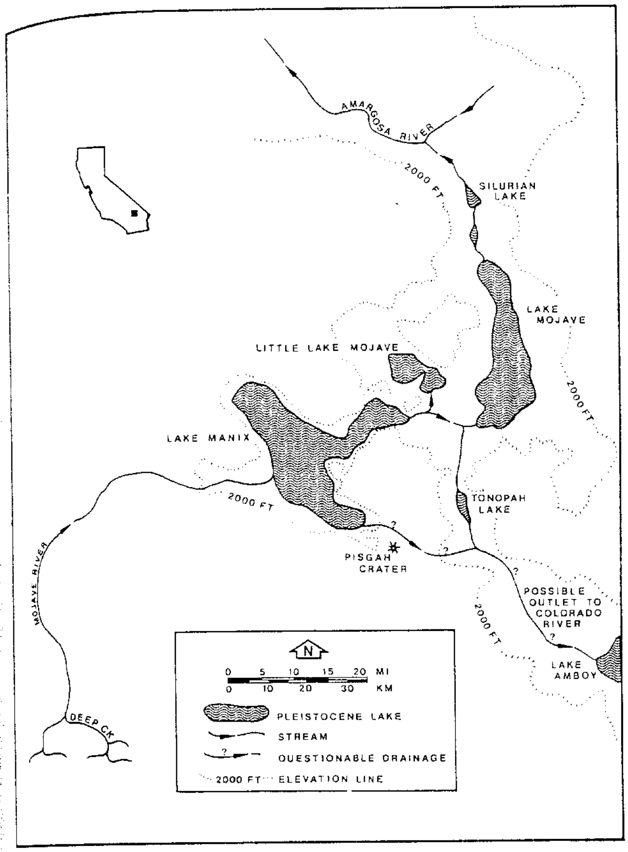

Figure 1.--Historic lakes present within the Mojave River drainage.

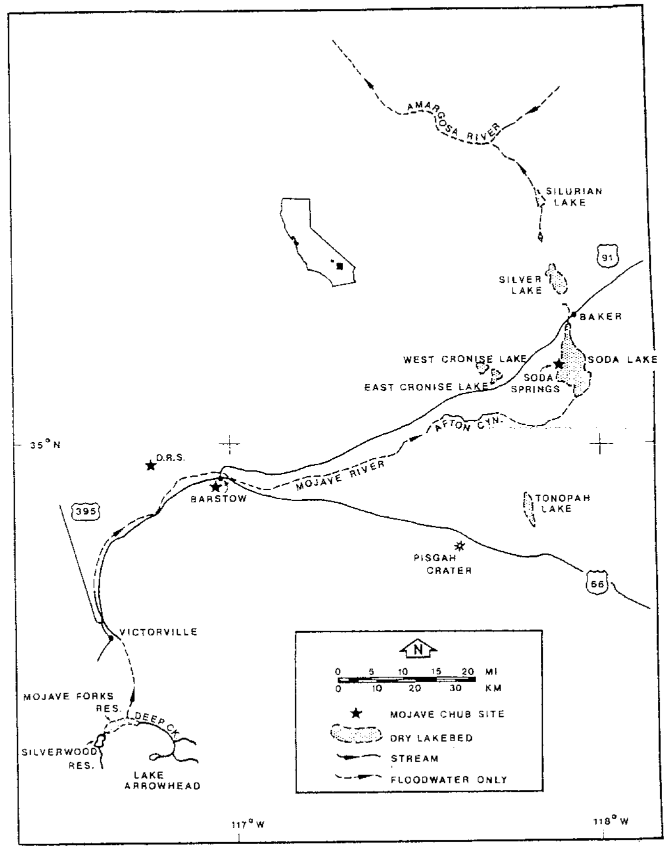

Figure 2.--Present features of the Mojave River drainage.

suggested the Mojave River at one time flowed northward meeting the Amargosa River.

As the climate became more arid, the lakes receded, and a more riverine habitat became established (Hubbs and Miller 1943). Today the Mojave River is an intermittent system of surface and subsurface flows draining into several inland basins. The basin which is the subject of this paper is East Cronese Lake, San Bernardino County, California (fig. 3). Periodic visits were made to this site during 1980-81 to determine what fish species occupied the impounded water. The basin flooded in 1978 following approximately 10 years of desiccation. The narrative which follows describes existing physical characteristics of the drainage and the gradual change in the structure of the plant community following inundation.

Figure 3.--East Cronese Lake basin filled with water (April 1981).

PRESENT DRAINAGE

The Mojave River drainage is fed by two headwater streams which originate in the San Bernardino Mountains (fig. 2): the west fork of the Mojave River, which drains 182.1 km^2 (70.3 mi^2); and Deep Creek, which drains 352 km^2 (136 mi^2). Flows from the two tributaries combine at an area known as "the forks" approximately 9.6 km. (6 mi.) southeast of Hesperia (fig. 2). From there the river flows underground to Victorville where a granite shelf forces it to the surface. Flows at Victorville and in Afton Canyon are nearly permanent and, at a minimum, supply standing pools of water during low-flow years. Afton Canyon (fig. 4) has a permanent riparian community modified only by periodic floods which scour and rearrange the

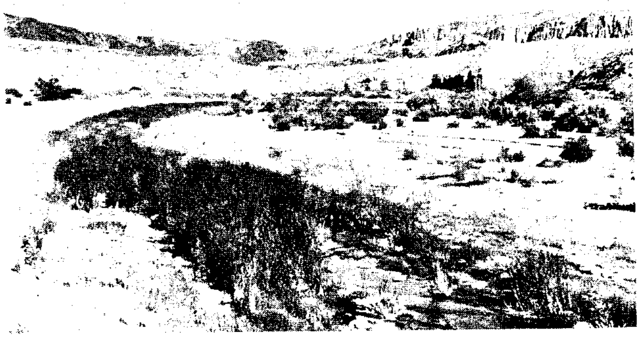

Figure 4.--Afton Canyon has a permanent riparian biotic community.

streamcourse. During periods of high runoff, water flows from Afton Canyon into East and West Cronese lakes and also into Soda and Silver lakes which are the termini for the drainage. When flooded, the surface area of East Cronese Lake is estimated at 517 ha. (analysis of dry lake contours on Cave Mountain, California, 1:62,500 USDI Geological Survey topographic map). Historic records indicate that both Silver Lake and the Cronese Lake basin have previously flooded (1916) to depths of over 3 m. (10 ft.) (Blanc and Cleveland 1961).

RAINFALL AND FLOW PATTERNS

Annual rainfall in the Mojave River drainage varies from 876.1 mm. (34.5 in.) at Deep Creek to 145 mm. (5.7 in.) at Victorville and less than 101 mm. (4 in.) for Cronese Valley (California Department of Water Resources 1964). Flow records which go back to 1930 recorded runoff at Victorville varying between 16,600 acre-feet (AF) (1975) and 290,000 AF (1969) per year (USDI Geological Survey 1930-1979). Runoff at Barstow was 0.3 AF and 146,000 AF per year for those years.

Analysis of surfacewater flow records (ibid.) reveals some interesting factors about the lower Mojave River drainage. During wet years the bulk of the runoff passes through the system over a period of a few days to several weeks (table 1). Victorville and Afton Canyon both had base surface flows recorded every year, but Barstow had no appreciable flow during most years. The system appears to fit an all-or-none flow pattern for Barstow--when seasonal runoff exceeds 150,000 AF at Victorville, the surface flow is continuous from Victorville past Barstow through Afton Canyon and into the Cronese Lake basin. The Cronese Lake basin has flooded at least five times in the past 65 years: 1916, 1922, 1938, 1969, and 1978 (California Department of Water Resources 1964; USDI Geological Survey

Table 1.--Total flow, monthly flow, percent of total flow, and time to reach 50% of total flow (days) at locations within lower Mojave River drainage during high-flow years (from USDI Geological Survey 1930-1979).

Month & Year	Location	Total flow (cfs)	Monthly flow (cfs)	% total flow	Time to reach 50% total flow (days)
Mar. 1978[1]	Afton	23,566	12,854	54.5	18
	Barstow	25,439	15,524	61.0	20
	Victorville	105,427	46,460	44.0	23
Feb. 1969[1]	Afton	36,668	19,752	53.8	4
	Barstow	73,910	36,040	48.8	6
	Victorville	146,758	56,045	38.1	36
Mar. 1943[2]	Barstow	45,865	18,617	40.6	25
	Victorville	64,177	20,147	31.4	47
Mar. 1941[2]	Barstow	48,401	22,880	47.3	25
	Victorville	72,263	25,982	35.9	10
Mar. 1938[1,2]	Barstow	69,622	60,807	87.3	11
	Victorville	94,802	69,103	72.8	13
Mar. 1937[2]	Barstow	52,372	23,870	45.6	36
	Victorville	75,749	26,645	35.1	53

[1]Cronese basin flooded.

[2]No records for Afton Canyon.

1979). Besides these periodic floods, the only other surface flow to the Cronese basin is runoff from the surrounding mountains.

Elapsed time for peak flows to move from Victorville to Barstow range between seven (1969) and 23 hours. Corresponding times from Barstow to Afton Canyon range between six (1969) and 24 hours. Elapsed times appear to depend upon the amount of runoff moving through the system at that particular time.

FLORAL ASSOCIATIONS

Establishment of a distinct riparian plant community following the filling of the lake playa is a progressive process. The gentle slope of the lake basin provides a shallow littoral zone which, when warmed by the sun, allows the planktonic community to bloom. Green filamentous algae are common to this zone. As the impounded waters slowly evaporate, the water surface recedes, leaving filamentous algal mats along the shoreline. East Cronese Lake had a large amount of filamentous algae hanging from the mesquite (Prosopis sp.) trees. These trees had been originally covered by water in 1978. The algal mats were approximately 1.8 m. (6 ft.) above ground level when observed in early 1981 (fig. 5). These mats appeared to form a continuous ring around the lakebed. Where there were no trees, algae was deposited on the playa, possibly providing a nutrient source for the subsequent plant community. The remains of smaller desert shrubs (creosote bush, sage, and desert holly) were evident on the damp soils near the lake surface. Small mounds of alkali sand covered by leaf litter at the base of these plant skeletons were all that remained (fig. 6).

Figure 5.--Dry algal mats hanging in dead mesquite on the lake playa.

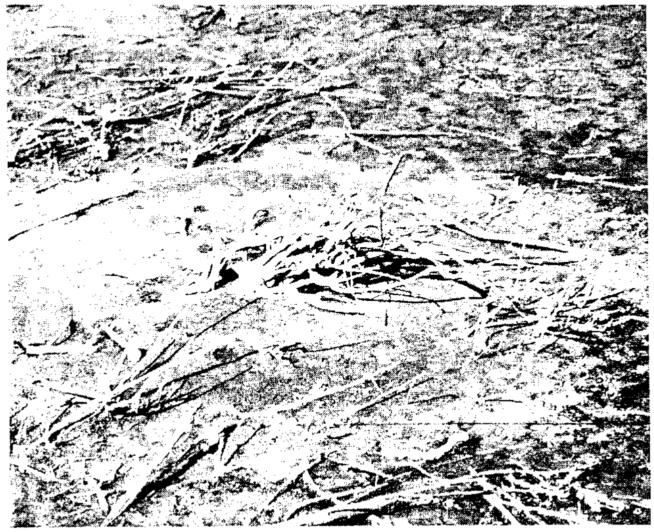

Figure 6.--Skeleton of desert shrub on the lake playa.

Zones of riparian growth were evident around the basin, each in a concentric pattern equidistant from the evaporating water surface (fig. 7). Later that summer (1981) many plant seedlings had grown sufficiently to produce a lush meadow-like area in the desert (fig. 8). Salt cedar (Tamarix sp.), heliotrope (Heliotropium curassavicum) (fig. 9) and sea-purslane (Sesuvium verrucosum) (fig. 10) were the dominant species. These plants commonly grow in alkali sinks but are apparently limited by water availability, especially the heliotrope.

Once the surface water is gone, the vegetation slowly reverts to the pre-flood alkali sink community (Brown 1968).

Figure 7.--Concentric growth zones within the lake basin appear as surface waters recede.

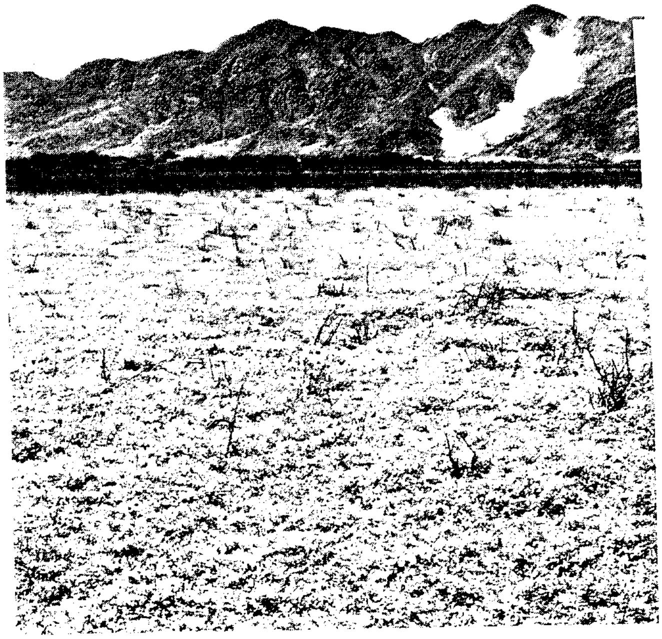

Figure 8.--The lake playa resembles a lush meadow following establishment of a temporal riparian system.

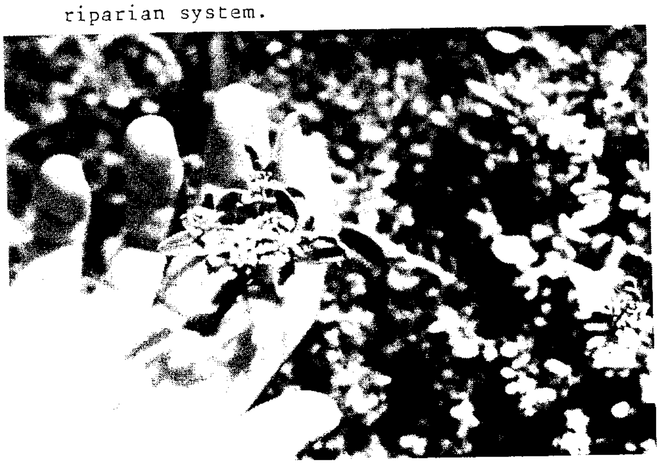

Figure 9.--Heliotrope (Heliotropium curassavicum).

Faunal Associations

There was much evidence of wildlife use of this area--wild horses and cattle were observed grazing on surface vegetation. Bird life, including Brown Pelican (Pelecanus occidentalis), Western Bluebird (Sialia mexicana), Dark-eyed Junco (Junco hyemalis), Common Crow (Corvus brachyrhynchos) and Robin (Turdus migratorius), utilized the trees, shoreline, and lake for feeding and nesting. There were also signs of coyote (Canis latrans) in the area. The only amphibians noted were the Pacific tree frog (Hyla regilla) and the bullfrog (Rana catesbeiana). They were observed either living in the cracks of the drying lake surface or desiccated on the dry lake playa. Black bullhead

Figure 10.--Sea-purslane (Sesuvium verrucosum).

(Ictalurus melas), fathead minnow (Pimephales promelas), green sunfish (Lepomis cyanellus), mosquitofish (Gambusia affinis), and arroyo chub (Gila orcutti), washed into the basin from upstream sources, were collected from surface waters.

The temporal desert riparian system provides an area where impounded fish species rapidly grow, reproduce, and eventually die once surface waters evaporate. The author observed numerous skulls and skeletons of Ictalurus melas and Lepomis cyanellus along the shoreline. Historical records (Thompson 1929) indicate this to be a common cycle--windrows of fish "mummies" being found around the playa once the lake surface totally desiccates. Their loss provides additional nutrient input to the soils.

THE FUTURE

The temporal desert riparian system has some interesting physical and biological features which have been briefly examined in this paper. More study of this type of system is needed to provide a clearer understanding of the interrelationships among the various components. The ultimate fate of this system depends upon an awareness of its unique properties and how they influence the desert community.

Future management of the drainage will most certainly include increased demands for water. Already three flow-regulating dams have been constructed within the drainage: Lake Arrowhead Dam in 1923; Mojave Forks Dam in 1970; and Cedar Springs Dam in early 1972. Each of these structures was build to provide for increased water-related activities such as recreation, flood control, groundwater recharge, and irrigation. Construction of a diversion structure in Afton Canyon by the railroad during the mid-1900s has also modified historic flow patterns. This structure diverts most of the high-water flow into the Cronese Lake basin except during extremes in runoff when water reaches the Soda Lake basin.

Should agricultural development occur in areas downstream from Afton Canyon, the existing ecological balance of the temporal system would be upset. Certainly any permanent agricultural runoff into the Cronese Lake system would provide conditions for establishment of a permanent riparian community. Currently the spread of the exotic salt cedar into the basin has been limited. A more permanent water source, whether surface flow or unbound subsurface water, could provide conditions for the expansion of salt cedar as well as other plants common to permanent riparian communities. One consequence of such vegetation expansion would be the loss of the temporal system. The impact of this loss cannot be fully understood at the present time because of limited biological information. More intensive field surveys and biological studies of this system need to be completed before further modifications occur.

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