ings represent those anthropogenic factors believed most influential in altering attribute states over the last few centuries. The attributes presented are most applicable to the broader, ecosystem level of restoration/rehabilitation planning. They represent common, fundamental ecological features of these types of systems. It is emphasized that application of these attributes (and their indicators) at particular sites will require refinement by experts familiar with the unique properties and environmental conditions found at those sites, as well as the specific goals and objectives of the particular restoration project.

It is important to note that conceptual models will also be derived for each component of the typology. The conceptual models should incorporate each of the generic attributes listed in Table 1, show how they interrelate, and be derived from the same working hypotheses regarding natural system structure and function used to generate the attribute lists. In short, the conceptual models provide a qualitative description of causal links in the system (NRC 1990), including those between stressors and attributes. The indicator framework and the conceptual models are therefore complementary: the generic attributes provide a checklist for the derivation of conceptual models; and the conceptual models help to determine which individual indicators will best reflect the improvements that the CALFED program has committed to effect.

Step 4: Determine the best indicators to use for each of the specific attributes. While attributes represent essential ecological characteristics that should be assessed, they are not always directly measurable. For this reason, ecological indicators—parameters that are directly measurable—must be developed that correspond to each attribute. In some cases, such as water temperature, the attribute and indicator are the same. In other cases, such as habitat continuity, the attribute may be assessed by combining several individual indicator measurements.

In order to be selected for use in the program, we recommend that individual indicators meet two rigorous tests: they must be both ecologically relevant and scientifically defensible. These two criteria are explained in greater detail, and an additional list of useful criteria are presented in Levy *et al.* (1996).

Once the indicator list is developed, we suggest that it be reviewed to determine whether some indicators can be consolidated without losing information, to determine whether some indicators should be revised to facilitate aggregation across levels of hierarchy within the typology and across different geographic regions, and to assure that the essential criteria for indicator selection have been met.

Step 5: Determine optimal numerical ranges, current values, short-term milestones (with schedule), and long-term targeted numerical ranges for each indicator. The methods and criteria that may be used to derive optimal numerical ranges for the indicators have not yet been addressed by the agency/stakeholder group, although considerable background research is underway.

Step 6:Assure that the monitoring program includes the measurements required for each indicator. The monitoring program currently being developed by a consortium of CALFED and other agencies (the Integrated Environmental Monitoring and Research Program) will, we assume, include not only measurement of each of the indicators, but also other components required to implement and adaptively manage the program , as well as conduct focused research projects, provide compliance information, and the like.

Step 7: Assess the results. Evaluating the indicator measurements will require considerable scientific expertise, even with the most transparent and logical system for indicator development. Interpretation of conflicting results also may be necessary, particularly in the early years of the restoration program. One way to address these difficult issues is to convene a standing scientific panel to evaluate indicator results, report to the public, and determine when certain indicators would be updated to reflect advances in ecological science. The panel would be composed of scientists independent of agencies and other parties with a direct stake in the implementation of the restoration program.

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Water Year 1997-98

By Maurice Roos

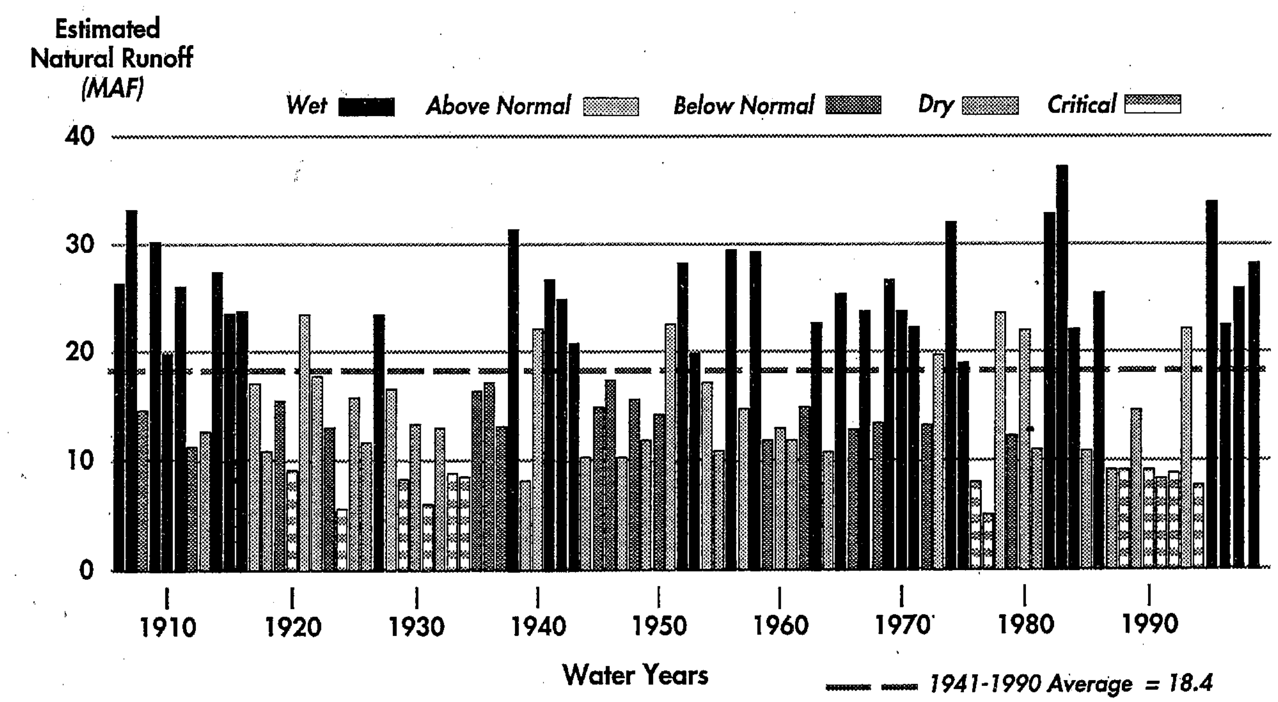
Water year 1997-98 was wet, but a marked contrast to water year 1996-97. Last year saw some extreme flooding from a couple of concentrated storm events. This year saw frequent storms, which generally kept moving with moderate snow levels. As a result, the total rainfall and runoff are expected to be more than last year once the April 1 (160 percent of average) snowpack melts. This year will mark the fourth wet year in a row, a rather unusual string of wet years which has only happened once or twice before this century. One of the century's stronger El Niño events strengthened the southern jet stream track to push storm after Pacific storm into California, especially the coastal region.

Total runoff this year will probably be the fourteenth wettest this century in the Central Valley, less than either 1983 (the last strong El Niño year) or 1995, but more than 1997. See Figure 1 for the history of Sacramento River system runoff. The forecasted 1997-98 amount will rank 12th wettest for Sacramento River unimpaired runoff.

After a slow start in December this winter turned wet. A series of El Niño driven storms delivered twice normal statewide precipitation during January and three times normal precipitation in February. Runoff statewide during February was 250 percent of average, following a January that produced about 160 percent of the monthly average amount.

Most major Central Valley foothill reservoirs operated in the flood control mode during February and March with excess waters released in a controlled manner into the Sacramento and San Joaquin River systems. All Sacramento system fixed weirs flowed most of February and 16 of 48 gates in the Sacramento Weir were opened in early February. The Paradise Cut weir near Tracy on the San Joaquin River also flowed for about three weeks. The San Joaquin River near Vernalis reached within one-third foot of its 29-foot flood stage about mid-February then fluctuated around the 28-foot level as reservoir operations controlled much of the storm runoff.

Most of the winter storms were fairly rapid movers with short breaks between rain events. As such, no



NOTE: The Sacramento River runoff is the sum of unimpaired runoff from the Sacramento River at Bend Bridge, Feather River Inflow to Oroville, Yuba River at Smartville and American River Inflow to Folsom. Categories are based on the 40-30-30 formula.

Figure 1. Sacramento River Unimpaired Runoff Since 1906

special problems were posed to the floodway systems. The one exception was a powerful storm February 2 and 3, which stalled just off the Northern California coast and dumped heavy amounts of rain especially on the Coast Range and the upper end of the Sacramento Valley. Upper Sacramento River flood stages, almost entirely generated below Shasta Dam, reached levels comparable to big floods of the past. The storm had many similarities to the big storm and upper Sacramento flood of March 1, 1983. The valley west side streams gushed large volumes of flow overtaxing the limited drainage capacity of Colusa basin and also later at Clear Lake, which rose to 11.5 feet on February 24, slightly over the 1986 peak stage of record (11.3 feet in February 1986 and nearly as high in March of 1983). Older county records from the Rumsey gage show that Clear Lake was 13.4 feet in February of 1909 and nearly 13.7 feet in January 1890. High tides at Rio Vista exceeded 10 feet on several days during the second week of February. There were problems but no Delta islands were flooded.

On February 3, the Russian River at Guerneville crested 6.5 feet above flood stage, but about 10 feet lower than the peak levels of February 1986 and January 1995. The Napa River at Napa crested nearly two feet above flood stage, which also was well below record levels. Heavy rain on the Central Coast produced a new peak of record on the Pajaro River at Chittenden nearly 2 feet above flood stage. (The previous record was in 1958). The coastal mountains of Southern California also experienced heavy rain which generated large flows in Santa Barbara, Ventura, Orange and San Diego counties.

Peak inflows to major Central Valley reservoirs this winter were quite modest, due primarily to experiencing colder storms with relatively low snow levels. The surprise was two lower elevation reservoirs seldom heard about: Farmington Reservoir east of Stockton and Los Banos Reservoir west of Los Banos. A very strong local storm filled the 52,000 TAF Farmington reservoir on February 8 with a small amount of water going over the spillway. Outlet structure releases into Littlejohn Creek were curtailed to account for the extra water coming over the spillway in order to remain within safe design flow downstream. The reservoir peaked February 9 at about 53,000 AF. Ten days later, on February 19, the reservoir was about 80 percent full, reasonably ready for a new storm. The other surprise was at Los Banos, a 34,600 AF reservoir with 14,000 AF of flood reservation space to protect the California Aqueduct and to provide some

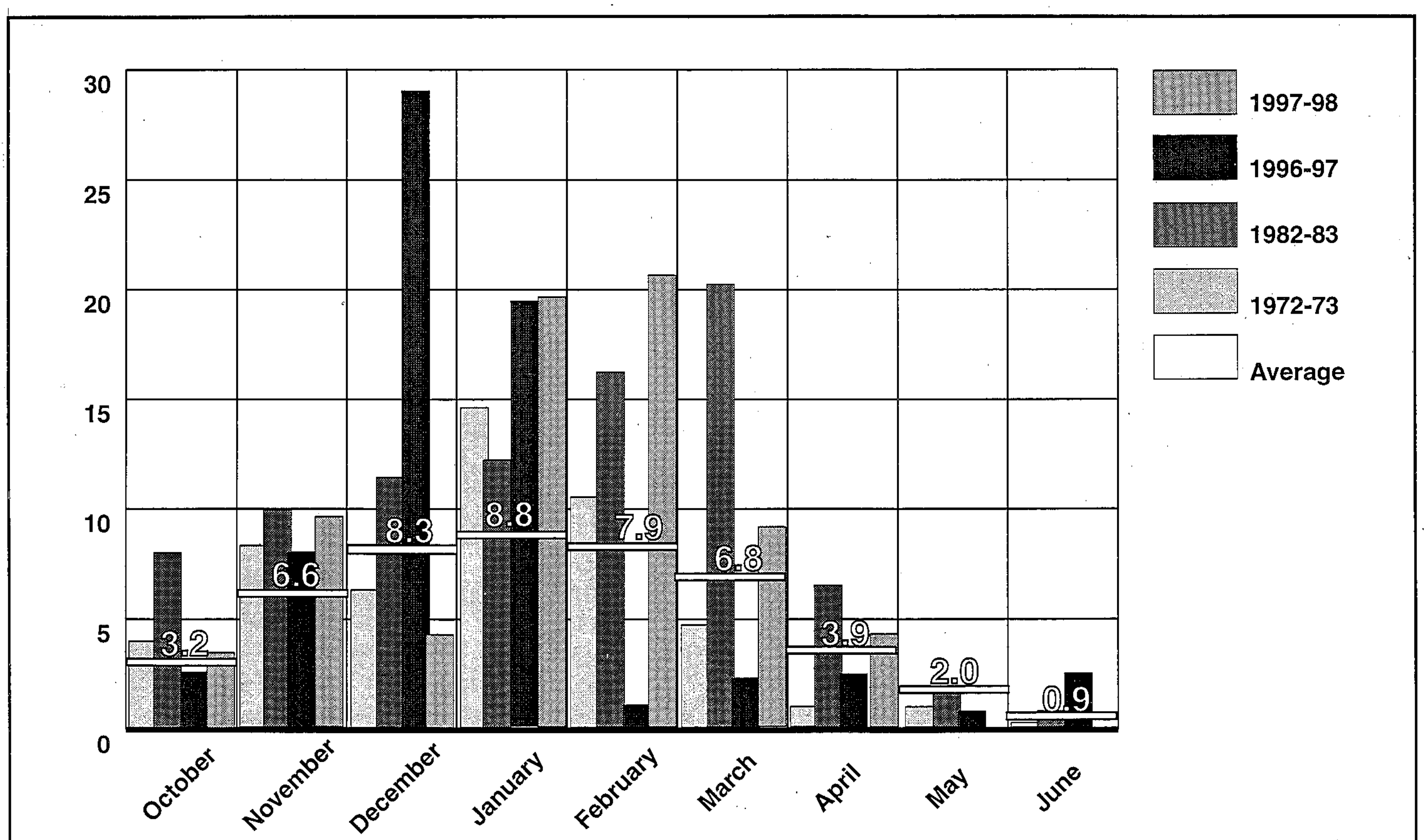


Figure 2. North Sierra precipitation
(in inches)

local recreation. That reservoir filled to about 90 percent of capacity on February 3 and there were fears that another predicted strong storm 2 days later could fill the dam with only partially controlled flow over the spillway. Preparations were made to handle the uncontrolled flow downstream, including intercepting a portion of the peak flows into the California Aqueduct and an emergency dike to protect Los Banos. Fortunately, the second storm turned out to be much smaller, and the reservoir fully controlled inflow.

This winter's storm patterns produced significant creek flows below the foothill reservoirs. Two periods of heavy thunderstorms, one in mid-January and one in late March produced flooding in Merced from local creeks. Bear Creek just east of Merced peaked at record levels near midnight on January 15. Two months later on March 24 heavy thunderstorms produced another sharp rise, exceeding the January peak.

The cold nature of many of the winter's storms produced significant snow accumulations in the Shasta-Trinity and Sierra Nevada watersheds. Snowpack water content increased from 115 percent of average statewide for the date on February 1 to 185 percent on March 1, but then leveled off during March. Relatively dry conditions during the first half of March slowed the rate of snow accumulation with some melting at midmonth at lower elevations then a boost from storms during the last 10 days. By April 1 statewide snowpack was 160 percent of average. For comparison, water year 1983 was 225 percent of average and 1995 was 180 percent of average on April 1. Despite the sizable snowpack, San Joaquin Valley and Tulare Lake Basin reservoirs are expected to control spring snowmelt runoff without significant risk of flooding in the valley floor.

In the northern Sierra, an estimated 66 inches of precipitation had fallen by April 1, which is about 160 percent of average for the date. This represents the 6th wettest year since that record began in 1922. Figure 2 shows monthly precipitation this year (through April 14), last year and the strong El Niño years of 1983 and 1973.

Based on past El Niño experience, the upper Colorado River basin was also expected to be wet. Instead conditions there have been more normal, at least so far. The April 1 forecasted inflow to Lake Powell is 6.8 million acre-feet, 88 percent of average. The basin wide snowpack was 95 percent of average on April 12 according to the Natural Resources Conservation Service. Water storage on the Colorado River in Lakes Powell and Mead is still excellent, over 90 percent of capacity.