

Characterizing Hydrologic Variability of the Cosumnes River Floodplain

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Objectives:

1. Characterize the hydrologic variability of the lower Cosumnes River by analyzing a 98-year streamflow record (1908 – 2005).
2. Develop a flood regime classification methodology by separating similar water year types and similar flood types based on magnitude, duration, and timing of flooding.

Background: The Cosumnes River watershed, located southeast of Sacramento, drains a 1989 km² area starting at 2300 m in the Sierra Nevada mountain range and draining into the Mokelumne River at an elevation of 2 m above sea level. Water from the Cosumnes River ultimately flows into the San Francisco Bay – Delta. It is one of the few unimpounded rivers flowing from the Sierra Nevada Range into the Central Valley. With the exception of loss of base flow in the summer and fall (Fleckenstein et al. *in press*), the Cosumnes maintains a relatively unimpaired hydrograph.

Methods: A continuous daily record of discharge data (Figure 3) for the Cosumnes River at Michigan Bar (MHB) from 1908 – 2005 was acquired from the U.S. Geological Survey's National Water Information System. The MHB streamflow record was analyzed for stationarity because many surrounding basins in the Sierra Nevada exhibit trends in variables such as center of mass of annual flow and maximum annual flow due to changes in climatic conditions since 1950. Several hydrogeomorphically significant thresholds for flood magnitude and duration were developed in order to classify flood events. 10 flood types were created based upon the thresholds and the frequencies at which they occurred throughout the record were calculated. These flood types were then used to develop distinct water year types and their frequencies were calculated.

Key Findings:

1. The Cosumnes River floodplain experiences two distinct periods of flooding. The first period, occurring roughly from November to February, is comprised of floods that tend to be flashier and have larger peak flows but sustained flooding is not as common during this period as in the second period. The second period, occurring roughly from March to May, contains smaller peak flows compared to the first period but days of flooding are more abundant. These two distinct periods of the flood season are most likely due to later-season snowmelt contributions and larger shallow groundwater inputs in the second period from sources earlier in the season.
2. This bi-seasonal effect is also reflected in the difference in mean start date for certain flood types – the flood types with larger flood magnitudes and relatively small durations occur early in the season while flood types with longer flood durations and relatively small magnitudes occur later in the season.
3. Flood types 2 and 3, which consist of the floods that can transport sand onto the floodplain, occur at least once in approximately two out of every three years and twice in half of the years. The very large magnitude type 3 floods occur at least once in one out of

every five years on average. The long duration flood types (L and V) occur at least once in roughly six out of every ten years.

4. The flood type classification along with the flood statistics determined for each of the 479 flood events on record can also be used to test the potential long-term frequency of certain biological phenomena observed on the lowland Cosumnes River floodplain such as the “productivity pumping” described in Ahearn et al. (*in review*). Based on historical data, at least one productivity pump flood occurred, on average, in two out of every three years, and at least two effective floods occurred in roughly half of the years.
5. The water year type classification also has the ability to analyze the frequency of certain ecological phenomena but on an annual time-scale. As an example of this connection, Water Year Type (WYT) 7 contains at least one M3 flood, which will most likely create new bare ground in the form of sand deposits, and substantial late-season flooding. Using the Recruitment Box Model (Amlin and Rood 2002), the combination of new bare ground and late-season flooding provides a very favorable condition for the recruitment of cottonwood trees. However, more research is needed to more acutely describe the ecological differences between water year types.
6. The distribution of certain water year types throughout the period of record also illuminated the previously mentioned observation of the inconsistency of certain aspects of the streamflow record with a stationary time series. WYT-3, a year with a relatively dry winter but a relatively wet spring, decreased in frequency in the second half of the streamflow record (post-1956). In contrast, WYT-6, a year with a very wet winter but a relatively dry spring, increased in frequency in the second half of the record. These two opposite trends are consistent with the hypothesis of a rising snow-rainfall transition line, leading to larger winter floods and diminishing the later snowmelt-dominated part of the hydrograph due to increased winter and spring air temperatures since the mid-20th century (Stewart et al. 2005).

Recommendations for management & monitoring: As more complex water resources issues surface in the future, managers need to be informed of the degree of hydrologic variability that aquatic ecosystems critically need for them to continue to provide ecosystem services to humans. Organizing flood events and water years into similar types will allow managers to visualize this variability more effectively. While climate will ultimately drive the frequency at which these important floods occur, as a watershed becomes more regulated the water managers will increasingly become more responsible for maintaining the natural frequencies of specific flood types and water year types. A wide-range of hydrologic events are responsible for maintaining the ecological integrity of aquatic ecosystems by resetting ecological succession during large floods, providing ecological cues, and discouraging the persistence of non-native species that are not adapted to natural conditions (Stewardson and Gippel 2003). By knowing roughly what the natural frequencies of specific flood types and water year types were in the recent past, water managers will be able to more accurately provide these aquatic ecosystems with the variability they require to exist.