Appendix D4
Cottonwood Recruitment Metrics

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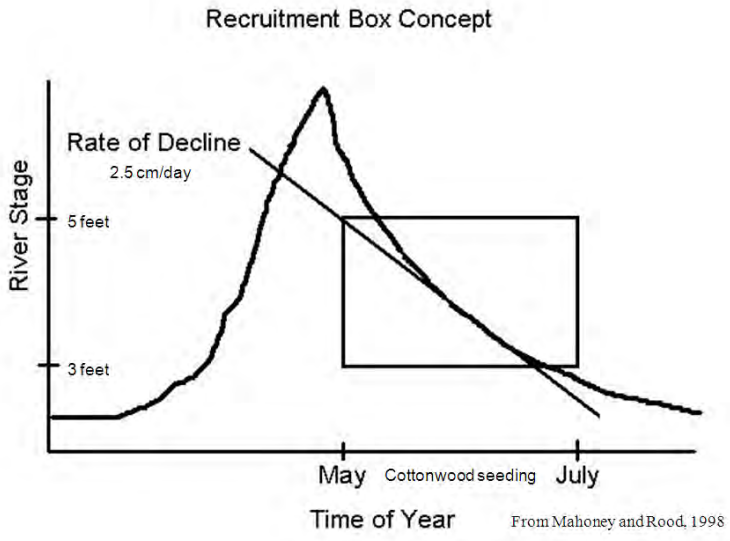
1.0 Introduction

This appendix describes the method used to implement the cottonwood recruitment metric for the aquatic and riparian habitats attribute of interest. The metric is used because healthy cottonwood stands are an indicator of healthy riparian systems and the many species that depend on them; recruitment of new cottonwoods is important in maintaining cottonwood stands as older trees die. As described in Mahoney and Rood (1998), a successful recruitment event is dependent on four main variables: timing of peak flow, the river stage corresponding to the peak flow, the rate of decline from when the peak flow occurs to when the peak has attenuated, and a flood magnitude large enough to create appropriate seed beds for the cottonwood seeds. It is also estimated that a recruitment event should occur about once every 5 to 10 years to maintain a healthy cottonwood stand. Each of these variables has biological importance in the recruitment process, and the metric aims to represent these criteria.

For cottonwood recruitment to take place, many processes must properly align. The recruitment events rely on hydrological processes to prepare the seed beds and maintain proper water levels for the growing seedlings. A large flood magnitude creates the appropriate seed beds: bare, moist sites above the base flow stage of the river (Scott et al., 1997). Research suggests that a 1 in 5-year to 1 in 10-year flood event is associated with successful recruitment in the Rocky Mountain region (Mahoney and Rood, 1998). D4-1 depicts each of the remaining criteria. The peak flow should also properly coincide with seed dispersal (late May through July in most of the western United States) and reach a stage high enough to wet the elevation at which cottonwoods grow. Typically, cottonwood stands are established about 2 to 5 feet above the base flow stage elevation of the stream. Finally, the receding limb should decline slowly enough that a seedling's growing roots maintain contact with the water table or, more specifically, with freely available water in the phreatic zone and capillary fringe above this zone as both recede through the summer. Studies document cottonwoods surviving with the water table dropping about 1 inch per day. The occurrence of all the above conditions are required to create the opportunity for a successful recruitment event. The following section describes the translation of these criteria to parameters that can be modeled as best as possible given current limitations posed by the monthly time-step in the Colorado River Simulation System (CRSS). The approach described below cannot replace a site-specific study on a reach. The recruitment process is complex, and site-specific studies are important to accurately identify the conditions that support recruitment at each individual location.

FIGURE D4-1
The Timing, Stage Height, and Rate of Decline Criteria for Positive Recruitment Conditions



Source: Mahoney and Rood, 1998.

2.0 Methodology

The four criteria that must be met for cottonwood recruitment to be possible were approximated for use in CRSS. The four approximate criteria that were used to identify positive conditions and the process they represent are as follows:

- April through July volume with a 5-year return period:
  - Assumed from the 1 in 5-year to 1 in 10-year range
  - The 5-year flood event was determined based on the April through July volume for each year from historical gage data. Although peak instantaneous flow is typically used to characterize the 5-year flood (Scott et al., 1997), only monthly data are available in CRSS.
- The peak monthly volume should occur in May or June:
  - Because the peak instantaneous flow typically occurs in the month with the peak monthly volume, this approximates that the peak occurs when seeds are dispersed.
- The stage must reach at least 4 feet above the average base flow stage elevation:
  - Assumed from the 2 to 5 feet range.
- Stage should drop by no more than 2.5 feet per month:
  - 1 inch per day converted to a monthly rate.

Using the above criteria that must be met, the following steps list the procedure for determining if all four criteria are met within the CRSS modeling framework:

1. Compute $\bar{S}_{low}$ (the average base flow stage) from historical gage data and a stage-flow table.
2. Compute Q_5: the magnitude of an April through July volume with a return period of 5 years.
3. Check that the peak monthly volume occurs in May or June.
4. If it does not, the remaining criteria do not need to be checked.
5. Is $q_{Apr-Jul}$ (modeled April through July volume) $\geq Q_5$?
6. If it is not, the remaining criteria do not need to be checked.
7. Is $S_{current}$ (the modeled stage in the current month) $\geq \bar{S}_{low} + 4'$?
8. If it is not, the remaining criterion does not need to be checked.
9. Is $S_{current+1\,month} \geq S^{max} - 2.5'$ and $S_{current+2months} \geq S_{current+1\,month} - 2.5'$?
10. If (3), (5), (7), and (9) are all true, then positive conditions exist for cottonwood recruitment.

    Note that whenever stage is referenced, the modeled flow is converted to an elevation using a stage-flow table.

The above procedures identify which years have positive conditions. It is estimated that these positive conditions should occur approximately once every 10 years. The frequency with which the positive conditions occur were compared across scenarios and to the estimated need of occurring once every 10 years.

3.0 Summary

The biological processes that are necessary for cottonwood recruitment had to be approximated for use in a monthly time-step, Colorado River Basin-scale planning model. When all four conditions are met, the conditions are such that recruitment could take place, although recruitment is not guaranteed. Therefore, the metric should not be used to identify specific years in the future that recruitment will occur; rather, it is used to compare the frequency with which the recruitment could take place across scenarios. Furthermore, the variability (or lack of) in the metric's results could be as much due to the coarseness of approximations as the differences between scenarios. That is, if the metric shows there is no change to the frequency of the favorable recruitment conditions between two scenarios, it is unclear if there are truly no differences between scenarios, or if the metric is not sensitive enough to identify the subtle differences between scenarios. Furthermore, this approach does not replace the benefits of site-specific studies on these reaches. The recruitment process is complex, and site-specific studies are important to accurately identify the conditions that support recruitment at each individual location.

4.0 References

Mahoney, J. M., Rood, S. B. 1998. "Streamflow Requirements for Cottonwood Seedling Recruitment—An Integrative Model." *Wetlands* 18(4), 634-645. DOI:10.1007/BF03161678.

Scott, M. L., G.T. Auble, , J.M. Friedman. 1997. *Flood Dependency of Cottonwood Establishment along the Missouri River, Montana, USA*. Ecological Applications, 7(2), 677-690. doi:10.1890/1051-0761(1997)007[0677:FDOCEA]2.0.CO; 2.