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The effects of drought, dams, and loss of habitat for *Populus fremontii*

Typically, not far from the bank of the river you will find a riparian corridor. Riparian corridors are an essential part of the ecosystem because they provide habitat and food for wildlife, contribute nutrients to the river system, help prevent erosion of land, protect water quality by filtering out containments from farms and other human sources, and provide shade to the stream (Wilding et al. 2014). Riparian zones contain hydrophilic or "water-loving" flora, which are specialized plants that have adapted to live in wet conditions. These include but are not limited to willows, alders, and cottonwood trees. In California the dominant cottonwood species is the Fremont cottonwood, *Populus fremontii*. Other species, such as *Populus trichocarpa*, and hyrbids of species within the genus Populus can also be found in California.

Fremont cottonwoods along with willows and alders provide shade to the river below helping keep the water cool. In addition, the reduction of light entering the water hampers an over-population of algae. Keeping algae populations at or below the carrying capacity of the water body can help stabilize water chemistry and protect the water quality (Oliver, 2013).

Although riparian zones are an essential component of a river ecosystem, currently many of the riparian zones in the Sierra Nevada mountain range and the Central Valley have been "reclaimed," or significantly altered by humans. Much of the loss is due water supply to farms and urban areas as well as the creation of dams to supply a constant and reliable source of water and provide flood control. The remaining riparian zones are not flourishing as one might hope.

Trees like *P. fremontii* are not thriving in the new environment that consists of altered water regimes and changes in the types of habitat.

Naturally the water regime would consist of a peak runoff in spring when the snowpack in the high Sierra melts. The snowmelt would continue throughout spring providing a continuous but decreasing source of fresh cold water. Currently the water regime is quite different where there are dams in place. The dam catches the snowmelt runoff and saves it for use in the dry season. This results in the loss of a significant peak in discharge and dramatic changes in the water levels (Rivaes et al. 2015). This altered water regime affects the successful recruitment of *P. fremontii*.

P. fremontii has evolved to utilize wind pollination and wind dispersal of its seeds. The seeds are small and have a cottony substance attached to them that helps them be picked up and blown around by the wind. The seeds are dispersed after the snowmelt peak in the river. In the Sierra-Nevada water levels are highest typically in spring due to warmer temperatures creating snowmelt. After peak runoff as the water begins to attenuate, the trees begin to release their seeds (Scott et al. 1996). The trees have evolved to respond to changes in temperatures that coincide with water attenuation in order to release their seeds (Stella et al. 2006).

The majority of the seeds released end up in a nearby river or stream. The seeds then travel downstream with the water until they are deposited in a relatively calm place to germinate. Germination may occur but there are other factors that will affect the survival of the seedling. One important factor is the amount of vegetation present at the site. The young seedlings cannot establish if there is already moderate to thick vegetation. *P. fremontii* saplings have a higher survival rate when the seeds germinate on a vegetation-free spot that has some fine sediments and moderate flows that can rework the landscape (Rood et al. 2007). This reworking of the landscape is an important step that is required for successful recruitment because it scours out sites for the young saplings to take root. This type of scouring occurs during floods events with enough water and energy to scour away vegetation at least 1.25 meters above the base flow stage of the river or stream (Cooper et al. 1999). Flooding events of this magnitude did not occur annually. Studies have shown that these floods likely occurred only once every 5 to 10 years. This time interval has shown to provide the proper habitat required for *P. fremontii* recruitment (Mahoney and Rood 1998).

As flood waters recede, they drop fine sediments on the floodplains. These fine sediments promote recruitment of *P. fremontii*. One possible reason for this is the sediment increases the water and nutrient holding capacity (Stromberg et al. 2007). Currently there is less fine sediment suspended in the river downstream of a dam. There is a significant decrease in the water's velocity in a reservoir above the dam resulting in the deposition of fine sediments within the reservoir. Once the fine sediments drop out of the water column they become trapped in the reservoir and never move downstream where it may be required for *P. fremontii* recruitment (Cooper et al. 1999).

Another factor that can determine the survival rate for the future generation of *P. fremontii* is the water level above and below ground. For successful recruitment, *P. fremontii* seeds must be deposited in a place that has the right amount of water. Too much water and they will drown. Not enough water and they may never germinate or can end up dying from drought stress. The saplings can grow fairly quick. The roots of the trees must be able to grow at a rate that keeps them close to the receding water table (Mahoney and Rood 1998). If the water table and water levels drop too quickly, the saplings will perish. A rate of growth and water recession of approximately 2.5 centimeters per day has shown to be acceptable for survival (Rood et al.

2007). With the post-dam water regime, water levels stay constant during the summer months as water is released from the dams at a relatively constant rate. This leads to the water table remaining at a shallow level restricting vertical root growth. Saplings that are completely inundated with water are five times more likely to perish than saplings that are only inundated with water to the soil's surface (Auchincloss et al. 2012).

A change in the water regime is not solely due to the presence of dams. Currently, California is in a drought and experiencing impacts from climate change. The drought can reduce the amount of water available for *P. fremontii* saplings creating stress for the trees; coupled with hotter than normal temperatures, reduced water levels cause damage to the saplings and many cannot survive. When *P. Fremontii* trees face water stress, their stomata begin to close in an attempt to reduce water loss due to evapotranspiration. This closing of their stomata also makes them vulnerable to heat and light stress (Tozzi et al. 2013). Photosynthesis is reduced leading to a decrease in energy produced and a slower growth rate. This combination of increased temperature and a reduction in the available amount of water results in the trees showing signs of slowed development. When growth rates slow, roots of the saplings are not able to reach the declining water table and young trees begin to wither.

When all the known factors that play a role in the recruitment of *P. Fremontii* are considered, it becomes evident that there is only a small window of time and space in which a new generation of Fremont cottonwoods can successfully germinate and survive. This is referred to as the 'recruitment box' (Mahoney and Rood 1998). The recruitment box concept requires a large enough peak flow to scour clean a site, a receding water level to expose the site and allow root growth, and an adequate distance rom the water's edge (if the seedling takes root too far from the water's edge, it is likely to perish from lack of water). Although the conditions required for the ‘recruitment box’ are limited, all of these factors do not have to align every year. The population of *P. fremontii* can survive if conditions occur every 5-10 years (Mahoney and Rood 1998).

It is not too late for the survival of the *P. fremontii* population. There is still time for the next generation to take root and flourish, if we can replicate conditions similar to the ecosystem the trees have evolved to survive in. Water regimes can be altered to mimic the natural flow regime. Sediments can be transported around dams. There are plausible solutions for the challenges that the cottonwoods are facing, we just have to be willing to try to save this species.

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