Bat foraging preference along the Tuolumne River

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Abstract

Rivers and riparian areas are valuable foraging habitat for bats. Bats are becoming increasingly threatened due to habitat loss, therefore it is crucial to understand how to identify characteristics that make specific areas of a river more preferred than others. The geomorphology of a river can determine diverse aquatic habitats and can affect the ecology of bats by providing sources for food availability, corridors, and shelter. The Tuolumne River was surveyed for aquatic species and flow rate, along elevation difference that spanned the entire Tuolumne River. Based on previous studies on bat habitat preference, four study sites were compared and were relatively ranked among each other to determine the best forging regions. This analysis suggests that the reach surveyed at Early Intake would provide the best foraging habitat among the four sites because of its high aquatic insect abundance and mid-elevation location. The least preferred bat foraging habitat was the Tuolumne meadows due to its low level of aquatic insect abundance and high elevation. The mid elevation site at Merals Pool and low elevation site at the Lower Tuolumne River were considered intermediate bat foraging habitats.

INTRODUCTION

River and riparian areas are known to be important foraging habitat for bats (Russo and Jones 2003, Fukui, Murakami et al. 2006). From a conservation and management perspective, it is important to understand the characteristics associated with their habitat preference. The geomorphology of a river system can result in diverse aquatic habitats. Various biotic and abiotic factors that differ among reaches of a river, such as food availability, corridors, and shelter can influence bat occupation (Rosier 2008). Several studies have shown that resource availability is a primary influence on bat habitat preference. Fukui's study in 2006 suggests that aquatic insect availability can strongly determine the distribution of bats in riverine landscapes. Bat activity can also be affected by elevation and stream flow, which can vary greatly from upper, middle, and lower reaches of a river. Most bats prefer mid to lower elevation and relatively calm waters (Frenckell and Barclay 1987, Grindal, Morissette et al. 1999).

The loss of foraging habitat due to anthropogenic causes has become a major threat to bats, therefore, it is important to identify specific aquatic habitats that can sustain high levels of bat diversity and serve as refuges (Rydell, Entwistle et al. 1996). The Tuolumne River watershed is representative of most watersheds in the Sierra Nevada Mountain range. The Tuolumne River Mainstream flows from high elevation in the east to low elevation in the west and flows into the Sacramento Delta. Its flow regime and natural hydrologic process have been altered by dams and water diversion, like most river systems in the world. The Tuolumne River is an ideal study location for analyzing factors make certain riverine habitats more beneficial to bats than others.

Little is known about the bat occupancy along the entire Tuolumne River. A bat study was conducted in Poopenaut Valley in which 17 bat species were detected in an area that occupies less than 1 kilometer of the Tuolumne River (Greg Stock and Nathan Fronk 2015). This indicates that the Tuolumne River is ecologically valuable area for bats. Four study locations were chosen along the upper, middle and lower Tuolumne. The ecology of bats influenced by the geomorphology of the Tuolumne could give more insight as to where bats are located along the river.

Although many factors could contribute to preferred foraging habitat for bats, I will focus on a few key components that can be compared among various river reaches. The purpose of this study is to determine if there is a significant difference in bat foraging habitat in reaches of the Tuolumne River that differed in aquatic insect diversity, stream flow, and elevation. I will compare these different characteristics to determine which locations along the Tuolumne River could have a greater amount of bat activity based on studies of bat habitat preference. This analysis focuses on indirect factors that can infer that a certain riparian zone is preferred bat foraging habitat. Furthermore, I will correlate my assumptions with a concurrent study that

involved bio-acoustic monitoring of bats within the same river reaches. I predict bats activity will be more abundant in river reaches that have the most insect diversity, slower flows, and mid to low elevation. This analyses could help wildlife management make recommendations on what areas are best to survey acoustically and with mist nets, as well as monitor bat habitat over time in the Sierra Nevada's.

METHODS

Study Site

Our study was conducted in the Tuolumne River, California, USA, from June 16 to June 22 2015. Specific sites were chosen to be at or near sites surveyed by UC Davis Ecogeomorphology students of previous years. I chose four reaches to represent one upper, two lower, and one lower river reach (see Fig. 1b). The site with highest elevation was located at Tuolumne Meadows. The two mid elevation locations were located upstream of Early Intake and Merals Pool respectively. Lastly the low elevation location was located in the lower Tuolumne approximately 11 kilometers downstream Don Pedro Reservoir (See Fig. 2). The climate can vary from hot, dry summers at the base of the mountain ranges to alpine conditions with short summers at the highest elevation (Epke et al, 2010). Although various reaches were observed within the same study sites, I chose to compare the reaches that were closest to the bat detector set up by a concurrent study to compare this analysis with their findings.

Insect Diversity

Stream sampling for aquatic macroinvertebrates were studied by conducting kick net surveys. At each reach, four one-minute surveys were conducted along a cross section of the river. Each one minute survey included kicking the gravel for 30 seconds followed by rubbing

the gravel by hand for another 30 seconds directly in front of the kick net. The kick net was then strained with water and insects were sorted by order in an ice cube tray. Shannon's index was used to compare diversity among sites.

Stream Flow

Discharge measurements were taken along or near the same cross section as kick net surveys. Measurements were taken with a wading rod and current meter. Only average stream velocity was used to compare flow rates between sites.

Elevation

Elevation was taken by identifying the reach on Google maps (Fig. 2).

Figure 1a. Map of Tuolumne River, CA (Tuolumne River Trust, 2015)

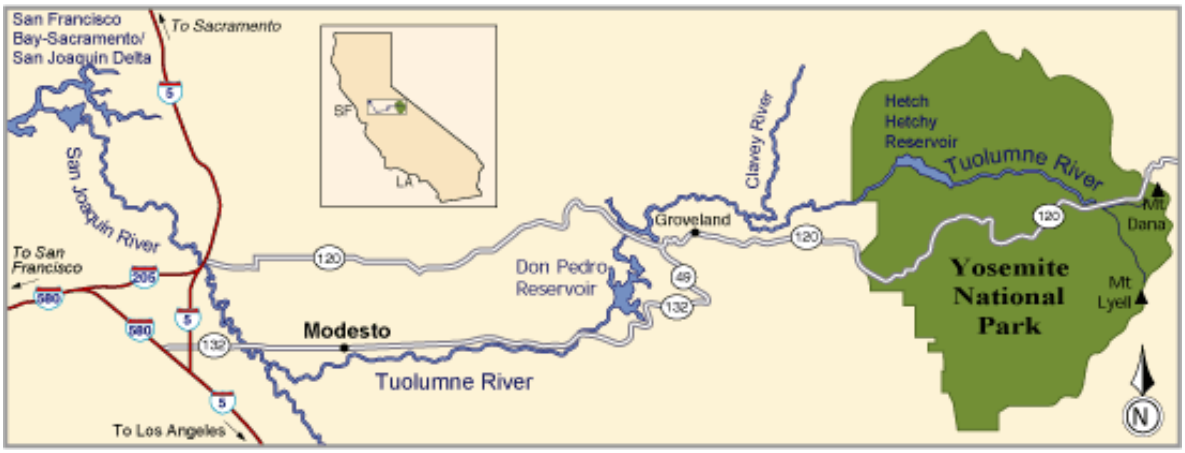


Figure 1b. Map of Tuolumne River study sites. (Tuolumne River, CA, Google Earth, 2015)

Figure 2. Elevation of study sites.

Site:	Aprox. Elevation (ft)	Aprox. Elevation (meters)
1. Tuolumne Meadows	8588	2617
2. Early Intake	2460	750
3. Merals Pool	1420	433
4. Lower Tuolumne	150	46

RESULTS

Aquatic Insect Diversity

Diversity was the highest at the Lower Tuolumne Site (H'= 1.51) and the lowest at Early intake (H'= 0.84). Merals Pool had a value of H'= 1.38 while the Tuolumne Meadows had a value of H'= 1.08. However, when the total amount on insects were compared, Early intake had the most at 220 insect observed using kick nets, followed by the Lower Tuolumne, Merrals Pool and finally the Tuolumne Meadows. Insect orders were dominated by Ephemeroptera, Diptera, Plecoptera, and Trichoptera which are all flying insects.

The Lower Tuolumne site has the fastest flow rate at 0.633 m/s, followed by Tuolumne Meadows, Early Intake and Merals Pool. It is noted that Merrals Pool and Early intake has large

calm bodies of water within a mile radius of the study site which should be noted for analysis. The results of each study site may not be indicative of the overall behavior of water movement in the regions those study sites are in.

Figure 3. Measures of aquatic insect biodiversity by site location.

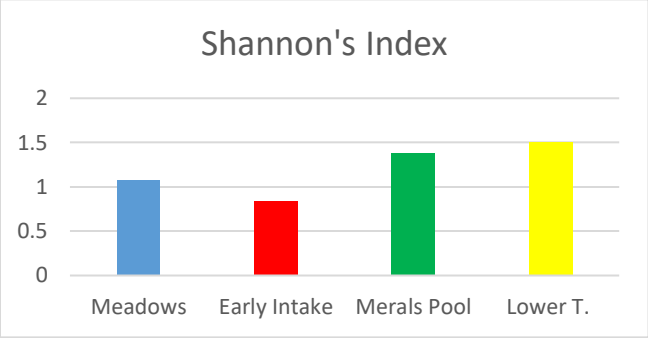


Figure 4. Comparison of total insects observed.

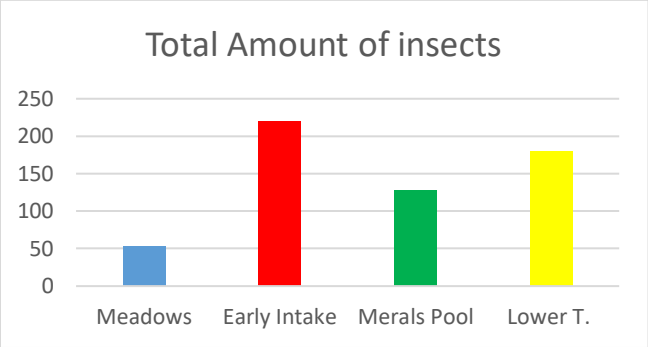
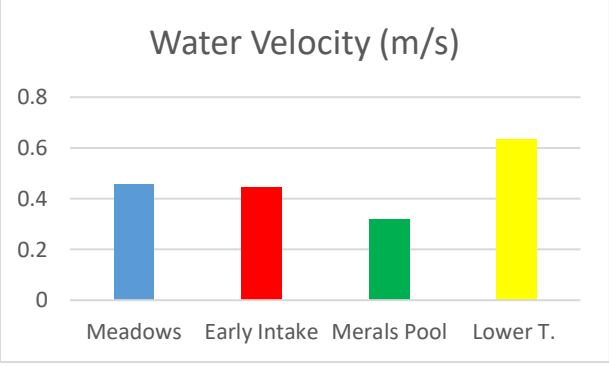


Figure 5. Comparison of flow rates.



DISCUSSION

Aquatic insect diversity using Shannon's index was not representative of good bat foraging habitat. Prey abundance and availability are strong controlling factors for bat abundance. (Fukui, Murakami et al. 2006). Therefore, total insects observed will be a comparative indicator of relative bat habitat preference (although Shannon's index takes into account abundance, the amount of Diptera found at early intake reduced its H' value).

It is unclear how to weigh the significance that elevation, insect diversity and flow rate can have on habitat preference. If all factors were weighted evenly then the analysis would conclude that The Tuolumne Meadows is the region that would expect to have the least amount of bat foraging Due to its high elevation, low insect abundance and intermediate flows. Since Grindal's 1999 study on the effects of elevation gradient did not distinguish a preference between low and mid elevation habitats among bats, then the only factors to distinguish the other three site are insect abundance and flow rate. Early Intake had the most insect abundance and lower water velocity, therefore it can be concluded that this area is the best potential foraging habitat among the four study sites. The lower Tuolumne reach and Merals Pool would be assumed to be intermediate bat foraging habitat according to this analysis.

The concurrent study using bio-acoustic analysis was inconclusive. The data indicated the presence in Eumops perotis and Euderma maculatum (both species of special concern) in the sites with high-to low elevation. No data was collected in the lower elevation reaches. The detection of only low frequency bats could have been due to equipment set up.

Although some habitats might be capable of hosting more bat activity, less preferred area also have ecological value. As mentioned the high elevation site (Tuolumne Meadows) are important refuges for species of special concern and can also be important foraging habitat for

individual males that are required to find adjacent habitats to the dominating mating females that occupy more preferred habitat of warmer temperatures and higher food availability (Grindal, Morissette et al. 1999).

When limiting the comparison of factors that can contribute to habitat preference of bats, many important aspects are overlooked. Bats are complex species with various needs in foraging and roosting. Discussing the influence of vegetation structure, the presence of human structures and disturbance, channel confinement, and adjacent foraging habitat availability are among many aspects that could influence bat activity along a river. When possible all factors should be included in analysis, however, when limitations are required it is possible to look at the geomorphology of a river to make preliminary assumptions as to where the best locations for bat habitat could be found.

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