Beaver-Mediated Riparian Restoration: Understanding Habitat Conditions Associated with New Colonies

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IMPACT STATEMEMENT

Beaver activity provides benefits to stream systems including water storage, sediment retention, and enhanced wildlife habitat. Beavers have therefore become a popular tool for riparian restoration. We studied habitat selection by beavers to provide information for selecting restoration sites that will have the highest probability of colonization.

SUMMARY

The activities of beavers provide a variety of benefits to stream systems by capturing and storing water, retaining sediment, and increasing habitat diversity. Because of these benefits, stream restoration projects that use beavers as a tool to achieve project goals are increasing in popularity. However, there is a need to better understand habitat selection by beavers in unmodified and semi-degraded stream systems that are commonly targeted for restoration projects. We conducted beaver-use surveys in headwater streams in southwest Montana to investigate settlement site selection by beavers colonizing novel areas. Our objective was to evaluate beaver settlement site selection in the context of beaver restoration to improve identification of suitable project locations. We found that habitat conditions influenced settlement site selection at multiple spatial scales. New settlement sites were characterized by low gradients, dense woody riparian vegetation, relatively narrow channels, and variation in stream channel structure. Generally, beavers selected for pre-engineered habitats over unoccupied stream segments, but in relatively unmodified habitats conditions that facilitated stable dam construction appeared to be most important. We suggest managers evaluate habitat suitability at multiple spatial scales when selecting project locations. Additionally, the use of pre-engineered dams and lodges will likely increase the probability of occupancy by beavers.

INTRODUCTION

Beavers (*Castor* spp.) exert profound influence on the habitats they occupy through the construction of dams, digging of channels, and redistribution of woody vegetation. While the effects of beavers occupying an area can vary, beaver activities in smaller headwater stream systems enhance and maintain healthy riparian habitats (Naiman et al. 1988). Beaver dams are particularly beneficial to stream systems both for wildlife habitat and ecosystem services. Beaver dams: 1) buffer against runoff events which protects the stream system from flood damage (Meentemeyer and Butler 1999), 2) capture and store precipitation which can augment low flows in the summer and fall (Naiman et al. 1988, Westbrook et al. 2006), and 3) increase retention of sediments which can expand riparian areas and reconnect streams to their floodplains (Gurnell 1998, Meentemeyer and Butler 1999, Pollock et al. 2014).

Due to the wide range of potential benefits, beavers are increasingly used as a tool for stream and riparian habitat restoration (Pollock et al. 2018). Beaver restoration projects are especially common in the western United States where water conservation and riparian habitat enhancement are prominent objectives for human use and ecosystem health (Pilliod et al. 2017). Because beavers can be effective agents of stream restoration, managers generally want to use them in semi-degraded streams that represent

suboptimal habitat. However, the selection of restoration sites is typically based on an understanding of beaver habitat suitability that may not accurately reflect the selection process in suboptimal habitats. Beavers drastically modify their surroundings which fundamentally alters important information about habitat conditions that promoted colonization. Yet, most beaver habitat suitability studies compare habitat at well-established colonies to unoccupied or abandoned stream sections (Beier and Barrett 1987, Barnes and Mallik 1997, Suzuki and McComb 1998). As a result, many metrics used to assess suitable habitat may be altered by the time researchers collect data, and therefore may not accurately portray the state of the habitat when the colony was first established.

We conducted beaver-use surveys on willow-dominated, mountainous tributary streams in the upper Gallatin and Madison River drainages in southwest Montana to investigate habitat selection by beavers when they are colonizing suboptimal habitats that are relatively unmodified by beaver activity. Our primary research objectives were to: 1) map stream sections that were relatively unmodified by beavers, 2) identify new settlement sites in unmodified habitats, 3) compare multi-scale habitat conditions at new settlement sites with unsettled sites to identify factors associated with colonization, and 4) provide baseline information for evaluation of beaver habitat suitability to identify restoration sites with the highest probability of colony establishment.

PROCEDURES

Beaver-use surveys were conducted during July−November, 2015−2017. We walked along streams in the study area and marked all active and inactive beaver sign including dams, lodges, food caches, castor mounds, and foraging areas. We then used the spatial distribution and relative age of sign to classify 1/4-mile stream segments as active, abandoned, relic, or unoccupied. Active stream segments were part of established beaver colonies. Abandoned stream segments had lodges and dams in place but the structures were not being actively maintained by beavers. Relic stream segments had sign of past beaver occupancy, but dams and lodges would need to be completely rebuilt for beavers to occupy the area. Unoccupied stream segments contained no sign beavers ever had a well-established colony in the area. We defined new settlement sites as any beaver colony that was established within two years of the survey and was located in a stream segment previously considered relic or unoccupied.

We measured habitat conditions representing three categories hypothesized to be important to beaver habitat selection: stream geomorphology, woody vegetation resources, and wetland types. We evaluated habitat at two spatial scales. First, we measured habitat conditions using remote-sensing data and a GIS to represent a broad-scale habitat suitability assessment. Second, we measured more fine-scale habitat conditions in the field.

We used logistic regression to compare newly-settled stream segments to unsettled stream segments. We only considered stream segments that were classified as relic or unoccupied for at least one year of the study as available to be newly settled. Therefore, abandoned and active segments were not included in the analysis. We constructed models using combinations of habitat variables we hypothesized would have the greatest impact on the probability a stream segment would be newly settled by beavers.

RESULTS AND DISCUSSION

We surveyed 152 miles of 27 streams in the study area over three years. Within these streams, we surveyed 613 stream segments that were 1/4 mile in length; 370 of which were considered relic or unoccupied for at least one year of the study and were therefore available to be newly settled. Over the study period we identified 27 new settlement sites which accounted for 48 of the 370 available stream segments (13%). Thirty (63%) of the settled segments were classified as relic and 18 (37%) were classified as unoccupied. Thus, beavers apparently selected for pre-engineered settlement sites even if the sites did not provide pre-built dams and lodges. Although not included in our analysis, we noted abandoned stream segments were settled at a high rate,

providing further evidence beavers selected for pre-engineered habitats. The reasons for the selection of pre-engineered habitat is unclear, but it is possible the presence of old dams and lodges is enticing to beavers because they do not have to spend as much time and energy building new structures. Alternatively, beaver activity may improve habitat conditions that encourage future occupancy regardless of previous infrastructure. The fact that relic and abandoned stream segments were settled at a similar rate suggests habitat changes brought about by beaver occupancy may be more important than pre-built dams and lodges.

Beavers selected stream segments with low gradients, dense woody riparian vegetation, narrow stream channels, and low-lying areas next to the stream. Field-based habitat sampling suggested settled segments had greater variation in channel width and depth, and had greater channel complexity in the form of side channels, backwaters, and tributaries. Our results suggest beavers selected for new settlement sites that facilitated stable and efficient dam construction. Low gradient streams reduce stream power acting on the front of the dam (Pollock et al. 2014) and narrower streams may be easier to dam (Suzuki and McComb 1998). Low-lying areas next to the stream may provide a larger flooded area behind the dams and may relieve pressure on the dam during high water periods as water is able to escape the channel into the floodplain. Greater channel complexity and variation in channel form likely provide a variety of microsites to fulfill the requirements of colony establishment (Scrafford et al. 2018). Our field observations indicated most new settlement sites were formed around distinct pools of deeper water next to undercut banks where the initial lodge was located. The first dam was then built at the tail-out of the pool where the water became shallow. By following this pattern, beavers could build a smaller dam to meet their needs while also taking advantage of side channels, midstream rocks, or sandbars that provided critical anchor points for the new dam.

When evaluating potential locations for beaver restoration projects, we suggest managers evaluate habitat suitability at multiple spatial scales. An initial screening of the project area using a GIS and aerial imagery can give managers an overview of suitable habitat, which can then be refined using field-based habitat assessments. Stream segments with previous beaver modifications may be highly sought-after by beavers, even if modifications are old and are no longer directly influencing the stream channel. The selection for modified habitats indicates construction of rudimentary dams and lodges at a restoration site may be a necessary step to encourage beaver occupancy. Whenever possible, such structures should be built in stream segments with characteristics similar to those described by our habitat selection models, with greater channel complexity, more variation in stream channel form, and conditions that can facilitate stable dam construction.

ACKNOWLEDGEMENTS

Thank you to Northwestern Energy, Montana Fish, Wildlife and Parks, the United States Forest Service, and the Montana Agricultural Experiment Station for supporting this research.

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