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ANALYZING THE GEOMORPHIC PARAMETERS OF BEAVER-CREATED MEADOWS ALONG PANTHER BROOK, NY

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INTRODUCTION

Panther Brook is a small stream within Huntington Wildlife Forest of the Adirondack Mountains in upstate New York. This area experienced extensive glaciation during the Pleistocene epoch and, most recently, the Laurentide Ice Sheet produced numerous elongate lakes as well as cirques and eskers. The soils that have formed since glaciation are relatively sandy, acidic, and thin, because they have not had enough time to fully develop since the retreat of the ice sheet (Denny 1974). They have often been incised into by the numerous streams and rivers that cross the mountains. Beaver are quite abundant in this part of the state, influencing the geomorphology of the streams and causing sediment aggradation.

Panther Brook has experienced these beaver-related changes, and it flows northwest in the center of the Adirondacks with a drainage area of 2.5 km^2. The stream drains directly into Catlin Lake, and has six low-gradient meadows along its length. All the meadows are attributed to beaver dams and activity, and beaver lived along the stream as recently as 2014. While they do not currently inhabit the area, many of their dams are still intact and in fair to good condition. The stream channel can be divided into two distinct areas - meadows and boulder-reaches. The meadows, usually containing fallen logs and dead tree stumps, are the result of beaver engineering and dams, and are characterized by grassy open fields. They are located from 0-290 meters upstream of the start of the survey, as well as 450-550 meters, 800-990 meters, 1170-1260 meters, 1450-1510 meters, and 1970-2130 meters upstream of the survey base. The boulder-reaches between these meadows are steep, forested sections of the channel and are not significantly influenced by beaver activity. They contain many large boulders and cobbles, which help distinguish them from the meadows. This project quantitatively determines whether there is a set of geomorphic characteristics that govern the type of habitat beaver prefer in the Adirondacks and what those characteristics are for suitable beaver habitat.

METHODS

There were three main sets of measurements we used to characterize the stream morphology of Panther Brook. We surveyed the length of the stream with a hand level and stadia rod, measuring the longitudinal profile from just above Catlin Lake to the headwaters of Panther Brook. Then we conducted grain size counts, where we measured the length of 300 individual sediment grains every 50 meters along the stream using measuring tapes. I used this information to calculate the median pebble size at each 50 meter interval, which helped characterize the sediment load in meadows and in boulder-reaches. Furthermore, we measured the bank full depth and bank full width at 10 meter intervals along the channel. The bank full width helped calculate total shear stress at those intervals along the stream, since I used the equation total shear stress= ρgds, where ρ is the density of water, g is the acceleration due to gravity, d is the depth of the stream at a given station, and S is the slope the channel at that location. With the help of Dr. Jungers, I used the data from a 10 m DEM to calculate drainage area at each station. Since drainage area can be used as a proxy to find discharge, I substituted the value at each station into the regression equation 49.6*DA(0.849), as provided for the Adirondack region by Mulvihill et al. (2009) to obtain discharge in cubic feet/sec. I then converted these values into cubic meters/sec, and then calculated stream power with the equation $\Omega = \rho g Q S$, where Ω is the stream power at given station, ρ is the density of water (1000kg/m$^{3)}$, g is the acceleration due to gravity, 9.81m/s^2, Q is the calculated discharge at that point, and S is the channel slope at the station. I only calculated these values up to 2000 meters upstream of the survey, because beyond that point the drainage area does not accurately represent discharge.

RESULTS

The data show that suitable beaver habitats along Panther Brook are areas with low gradients, small grains, low shear stress, and low stream power. As the longitudinal profile of the stream shows in Figures 1, the stream gradient is very low directly behind beaver dams. The slope values in these meadow areas range from 0.001 m/m to 0.03 m/m, while the median gradient for meadows is 0.01. In the non-dammed boulder-reaches of the streams the gradient is steeper, ranging from 0.02-0.166, with a median of 0.08.

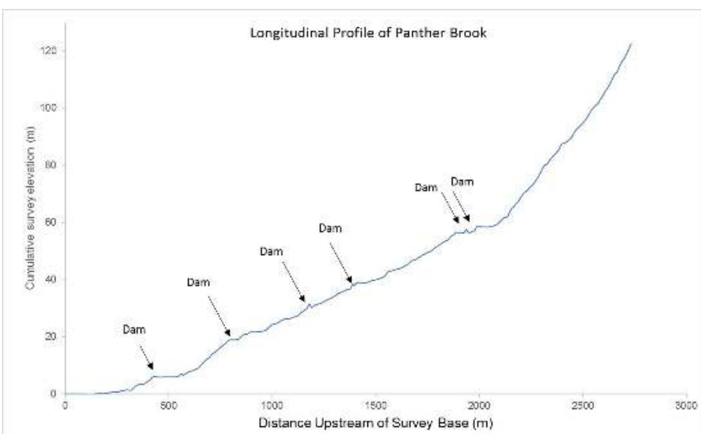

Figure 1. A longitudinal profile of Panther Brook, created from surveying with a hand level and stadia rod. The locations of beaver dams are indicated, and behind them are the flatter beaver meadows.

Median sediment size also varied in meadows and channels. As the stacked boxplot in Figure 2 shows, the sediment in the meadows is relatively small and fine grained compared to the overall stream. These values range from 0.05 cm to 0.9 cm, and amongst themselves have a median value of 0.5 cm. However, in the narrow boulder-reaches the median sediment size increases and the values range from 0.6 cm-3.8 cm, with an overall average of 1.25 cm.

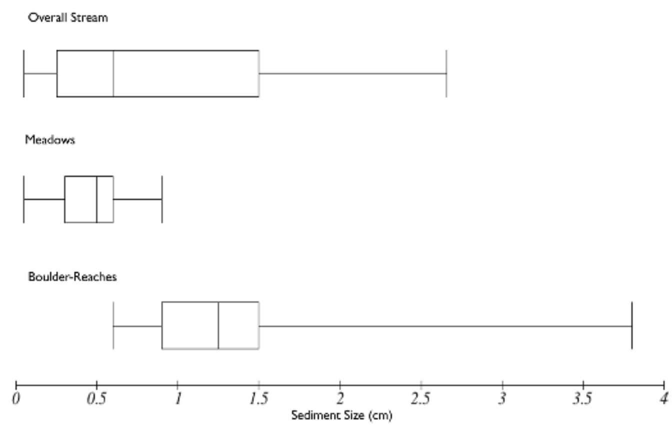

Figure 2: A stacked boxplot of sediment size in meadows, boulder-reaches and the overall stream. For each station along the stream, I calculated the D50 (median) sediment size. These values are plotted in the graph.

Another parameter, total shear stress, is a measure of the force of the stream on the channel bed and it dramatically changes over along the length of Panther Brook. The values at ponds and meadows range between 0 Pa and 142.9 Pa, have a median value of 54.6 Pa, and they do not significantly change between the six meadows. In contrast, bank-full shear stress in the boulder-reaches is more varied with values as large as 1050 Pa, as shown in Figure 3. They have a median value of 284.1 Pa, although the highest shear stress values are at the head of the stream from about 2100 meters upstream to about 2700 meters upstream.

Stream power, the rate at which energy is lost against the channel bed and banks, follows a similar pattern to other useful parameters, decreasing at meadows and rapidly increasing in boulder-reaches. The values

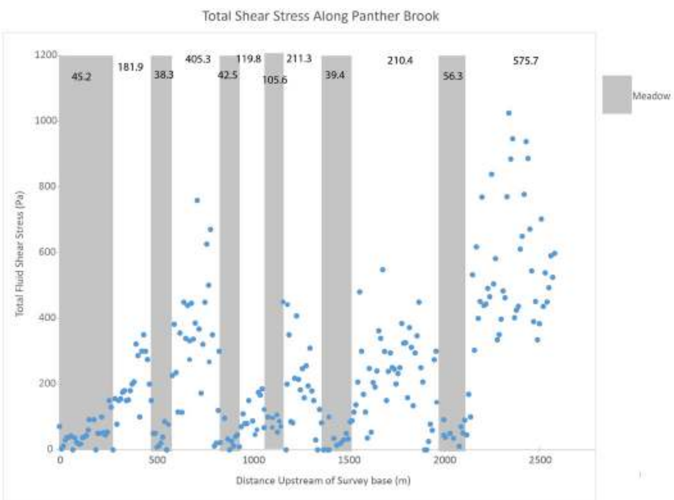

Figure 3. This plot shows how shear stress fluctuates over the length of the stream. The gray areas indicated beaver meadows, while other areas are boulder-reaches. The average value for each individual boulder-reach or meadow section is given as a number at the top of the plot.

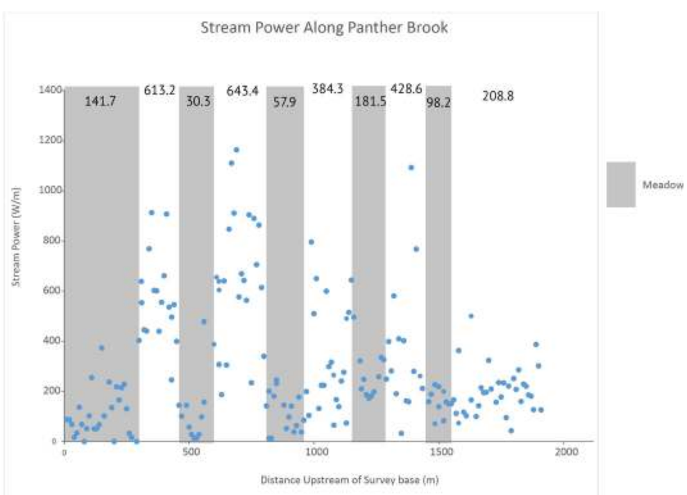

Figure 4. A graph of stream power as a function of distance upstream. The gray areas indicated beaver meadows, while other areas are boulder-reaches. The average value for each individual boulder-reach or meadow section is given as a number at the top of the plot.

for each of the stations are shown in Figure 4. At meadows, values range from 0-513.6 W/m with a median value of 102.9 W/m, but at boulder-reaches, stream power ranges from 65.2 W/m to as large as 1164.1 W/m with a median value of 471.2 W/m.

Unlike shear stress and stream power, there is not an obvious difference between bank full depths and widths of the channel in meadows and in boulder-reaches. The bank full depth of the stream in meadows is slightly higher than in boulder-reaches as it has a median value of 0.54 m in meadows and 0.47 m in the boulder-reaches, but the pattern is not clear throughout all sections of the stream. On the other hand, the bank-full width is slightly larger in the boulder-reaches and lower in meadows, but the difference is again not great enough to show up in a test of significance. In boulder-reaches, the channel has a median width of 3.51 m compared to 3.01 m in meadows, not including ponds.

DISCUSSION

As Figures 2, 3, and 4 show, the areas of finer grained sediment, low shear stress, and low stream power correspond to the flatter meadows represented on the longitudinal profile. Therefore, there is a set of geomorphic parameters that characterize where beaver have inhabited Panther Brook, and these results can be used to predict suitable beaver habitat in the Adirondacks. Beaver prefer to live in calm, flat reaches partly because this kind of environment allows them to easily swim to different parts of a meadow to access food rather than fighting strong stream currents to get where they need to go (Muller-Schwarze 2003). In addition, steeper stream reaches are associated with higher velocity and thus greater shear stress and stream power. That often results in dam washouts and destroys the structures beavers live in and maintain (Butler and Malanson 2005).

The gradients directly behind the dams are lower than in the non-beaver influenced parts of the channel because beaver dams accumulate sediment behind them. As sediment aggrades, it forms a step in the channel and flattens out the stream's profile. Fine grained sediment accumulates in these areas because a flatter profile results in lower stream velocity and reduces the stream's ability to transport larger sediment (Butler and Malanson 2005). Therefore, only the finest, lighter grains can be carried in suspension in the dam-created meadows and ponds. Eventually the finer grained sediment drop out as well.

The resulting lower gradient also helps lower shear stress. Since total shear stress is a measure of the force on a channel bed, channels with steeper slopes will lead to greater velocity and rougher streams, which elevate shear stress levels as it has in the boulder-reaches of Panther Brook. Stream power also decreases at the meadows, because beavers prefer and create aggradational environments where sediment can accumulate, rather than be actively eroded as they would be in reaches with high stream power. Furthermore, erosive stream reaches may destabilize dams by removing mud and sediment that connect the dam to the rest of the bank. That results in free-standing dams that are only secured at the base, which could also experience erosion.

CONCLUSION

Because different parts of the Adirondacks have similar geology and geography to one another, the parameters that indicate suitable beaver habitat along Panther Brook are also likely to indicate potential beaver habitat on other Adirondack mountain stream reaches. Granted, there are other factors such as food and wood availability that determine whether beaver will live in a given reach, but the geomorphic characteristics provide essential context for determining suitable habitat. In fact, Adirondack stream reaches with gradients of approximately 0.001 m/m to 0.025 m/m, sediment of average size 0.05 cm to 0.9 cm. shear stress values under 142.9 Pa, and stream power under 513.9 W/m, may indicate areas that have already accommodated beaver colonies in the past. These parameters are also useful for the reintroduction of beaver. As studies such as Rudemann and Schoonmaker (1938), and Pollock et al. (2004) show, beaver can help slow incision rates. Therefore, if there are streams that are rapidly eroding, the calculated stream characteristics at meadows will serve as guidelines on where to reintroduce the species in the Adirondack Mountains to slow the incision and potentially reverse the process.

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