On the Aggregate Volume of Soil Accumulated over the Cannon River Wilderness Park

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Measuring Soil Volume in the Cannon River Wilderness Park

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ABSTRACT
This study of the Cannon River Wilderness Park examines the volume of soil that has accumulated since regular agricultural practices began around 1860. Limited amount of research in the area has left the volume and the erosion rate relatively unknown. Simple field methods were used to determine a volume based on an average of measurements taken at four points along the riverbed; we estimate the volume to be 101,121.25 cubic meters. For future studies, we suggest that our field methods be refined and that more data be collected regularly in order to determine the rate of erosion and the effect of farmlands on this rate.

INTRODUCTION

The glaciations that swept through modern-day Rice County some one million years ago, then retreated 11,000 years ago, left a succession of hills in this Minnesota area. During the glacial retreat, meltwater began draining to the north through the Lower Cannon River Valley, subsequently creating river valleys as the water supply diminished (Carleton College Geology Dept., 1972). The object of our is study is one such valley, running approximately 900 meters east of its junction with Cannon River in the Cannon River Wilderness Park.

In more recent history, the years between 1856 and 1858 brought a rush of immigration (Rice County Planning and Zoning Department, 2002), on the promise of fertile soil, among others. The earliest statistics for crop growth in Rice county date back to 1860 (Neill, 1882). With this evidence, we assume that farming of the land around the Cannon River also began around this time, and has been the dominant factor of soil erosion into the valley.

Set in Rice County, Minnesota, this valley is the subject of research for the nearby Carleton and St. Olaf Colleges. Dave Tolley (1979), Tillman Farley (1979), and Katja Meyer (2002) of Carleton College, in particular, have done relatively recent work in the Cannon River Wilderness Park, which has contributed to our present study of the valley soil.

Dave Tolley and Tillman Farley wrote their comprehensive exercise project on the soil in the Cannon River Valley. Tolley's portion of their joint effort focused on the bedrock of the valley; Farley's portion focuses on the alluvium that was deposited in the valley. Tolley and Farley aimed to find the age and cause of the alluvium deposits, the age and cause of renewed incision in the valley, and the nature of the ancient channels cut by glaciers and their hydraulic characteristics. They discovered that the alluvium deposits were somewhere between 1,500 and 2,000 years old (Farley and Tolley, 1979). The soil deposited in the valley is immature based upon analysis of heavy minerals and clay. The incisions in the valley were discovered by seismic readings (Farley and Tolley, 1979). Tolley's and Farley's project was primarily focused on the type of soil, not the volume of soil as this project is. Nevertheless, their findings can be used in conjunction with ours in a later study to assess the changing nature of the valley soil, particularly how nearby farmlands have affected erosion.

Katja Meyer's comprehensive exercise helped to familiarize our group with the features and history of Cannon River Wilderness Park. Using field methods and a 3D program of the topography of the Wilderness Park, Meyer mainly studied the relationship between soil erosion and sediments to the amount of carbon dioxide in the Cannon River Wilderness soil. Her research also mentions names and descriptions of soils and discusses the affects of agriculture on the park over time According to her study, "erosion…has removed as much as the top 38cm of soil since settlement for agricultural soils" (Meyer, 2002).

A study of the effect of farmlands and agriculture on erosion into the valley first requires a basic examination of the soil. The prominent topographical feature is a riverbed, spanning the entire length of the valley. In our research, we aim to study the volume of soil accumulated over the bottom of glaciated bedrock and the depth of soil between the bedrock and the riverbed bottom.

Field methods are used to measure soil depth and type. Using these gathered field measurements, we calculate an average depth, height of riverbed banks, and width of the riverbed and the surrounding valley. These averages will then be calculated for total volume of soil.

METHODS

Measurements of width, height, and soil depth are taken at four points along the riverbed, labeled A, B, C, and D (Figure 1). Because of the varying width and depth of the riverbed, two sets of measurements are taken at each interval to increase accuracy (see Table 1). Measuring tape is used to determine the top width and bottom width of the riverbed. We use a measuring stick to approximate the height of the bank. In addition, manual auguring at data points B and D is done to find the depth of soil covering the bedrock below the riverbed. Figure 2 gives a 3D side-view of the valley, displaying each type of measurement with respect to the valley bedrock and riverbed. Soil samples are collected at each of the four points to determine the sources of the soil deposits. At each point, samples are taken from the surrounding valley and the riverbed; soil beneath the bank is drawn at Points B and D.

For a more specific measure of soil volume we make an isolated study at point D. In addition to the data mentioned above, we assess the distances between the slopes of the valley and the topmost edges of the riverbank; data is presented in Table 2.

To approximate our location in the valley at each measuring point, we follow a topography map. This map is also measured to calculate the length of the riverbed as a later reference.

RESULTS

The topography map charts the valley river as having a length of 1013.46 m.

Table 1

	Top width (m)	Bottom width (m)	Height (m)	Depth of soil (m)	Trapezoidal Area (m)= .5(top width + bottom width)height
Point A (Set 1)	4.09	3.51	0.6	0	2.28
Point A (Set 2)	3.3	3.02	0.6	No Data Taken	1.896
Point B (Set 1)	11.03	1.08	3.25	.94	19.67875
Point B (Set 2)	6.13	1.41	2.78	No Data Taken	10.4806
Point C (Set 1)	3.15	1.12	0.6	No Data Taken	1.281
Point C (Set 2)	3.17	1.2	0.56	No Data Taken	1.2236
Point D (Set 1)	8.36	3.69	3.2	.55	19.28
Point D (Set 2)	12.44	3.69	3.64	No Data Taken	29.3566
Average at Point D	**10.4**	**3.69**	**3.42**	**.55**	**24.3183**
AVERAGE	**6.45875**	**2.34**	**1.90375**	**.745**	**10.68456875**

On Table 2, the term *southern valley width* is the length taken from a point on the southern edge of the riverbank to a perpendicular point lying on the strike line south of that point, where the valley slope intersects the surface of the soil. Uniformly, *northern valley width* refers to the length taken from the northern riverbank to a perpendicular point on its respective northern strike line.

Table 2

	Southern valley width (m)	Northern valley width (m)
Point D(1)	22.15	16.5
Point D(2)	20.26	11.58
AVERAGE	**21.205**	**14.04**

*Point D(2) is 10 m east of Point D(1)

DISCUSSION

At Point A, 49.99 m of dolostone are exposed, and therefore the depth is taken to be 0m. Because this is the only length of riverbed where we observe exposed bedrock, and because this length is relatively small compared to the entire length of the valley, the depth is averaged using only data taken from Points B and D. In addition, the depth taken at Point B is the length of soil unearthed by the augur though bedrock could not be reached. Furthermore, the depth measured at Point D marks the length of soil between the riverbed and the layer of eroded dolostone. For the purpose of our study, and for lack of our ability to reach the layer of dolostone, we proceed to use these depths in calculations because they are our closest approximations while noting that there will be some percentage of inaccuracy when determining the volume.

As the bedrock valley is now covered with the soil we are studying, it was necessary to estimate the shape of the bedrock that is hidden under the soil. Because glaciers formed the valley, we conjecture that the bedrock is perfectly U-shaped (Leet, 1958). That is we assume that opposite sides of the valley are parallel to each other and perpendicular to the bedrock floor (Figure 2).

In our isolated study of determining the volume of a 10 m wide slice of soil at Point D, we use the average bank height, top width, bottom width, and soil depth, and the actual valley widths from two separately collected sets of data. Noting the soil that is carved out by the riverbed, the 10-meter dissection contains 1571.17 cubic meters of soil.

To estimate the volume of soil spanning the length of the valley, we follow the same method as above, excepting that we take the average valley widths measured at Point D to be the average for the entire valley. Calculating in this fashion, we have determined that the volume occupied by soil is 101,121.25 cubic meters.

However, we can predict that this estimate will not remain valid for long. Erosion is constantly taking place along this valley in the Cannon River Wilderness Park, and as a result, the amount of sediment in the valley is constantly changing. Natural processes such as wind and rain erode the soil, though this has probably become more pronounced since farms were developed in the area (Toy, Foster, and Renard, 2002). According to Katja Meyers' study, the soil in this valley "range[s] from loam to sandy loam" (Meyers, 2002). This sandy loam type of soil is eroded fairly easily (Toy, Foster, and Renard, 2002), meaning that the amount of soil in this valley most likely changes rapidly. Agriculture can reduce the amount of ground cover on soil, making it especially vulnerable to both wind and rain. By spreading out the plants in a field and removing grass, farming increases soil's contact with rain and wind, making the area more vulnerable to erosion. The remains of old plants can prevent erosion. They hold soil in place and form a compact and protective layer that prevents small particles from being picked up by wind. Old plant remains can also prevent erosion by acting as pre-existing conduits for water, preventing rain from breaking new paths in the soil. Therefore, the tilling of farms also leads to increased erosion rates (Toy, Foster, and Renard, 2002). As a result, we can predict that the volume of the soil in this valley is affected by the surrounding agricultural areas and is always changing.

CONCLUSION

In this examination, measurements were taken at four points along a riverbed in a small valley in Cannon River Wilderness Park for the purpose of estimating the amount of soil that is currently in the valley and getting an idea of how the amount of sediment is changing over time. Based on the field data we estimated the total volume of soil in the valley to be about 101,121.25 cubic meters.

Our approximation is based on a limited, and in some senses incomplete, gathering of data. Therefore, future data could be collected at more points along the riverbed to provide a more accurate estimate of the volume of the soil throughout the valley. Additional information that would also improve this estimate would include a more accurate measurement of the depth of the soil at each location and measurements of the angle of the slopes on either side of the valley in order to get a better sense of the shape of the rock beneath the soil. Another topic worth exploring would be to compare the soil in the valley with the soil on surrounding farms to find out the sources of the soil in the valley and perhaps get a better understanding of the erosion that is taking place.

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