Humans as Geomorphic Agents

Catherine Riihimaki, Drew University

Purpose: Hooke (2000), shows us one example of how you can quantify landscape change due to human influence. We will explore the details of Hooke's calculation and get some familiarity with typical sediment transport rates for glaciers and rivers (Hallet et al., 1996).

Your first task is to read Hooke (2000) and prepare to discuss the article in class. As preparation for the discussion, get a sense of the purpose of the article, the author's methodology and results, and the implications of the results.

After class discussion, you will complete the calculations in this problem set, which will walk you through how to read a quantitative article critically. As you read other articles this semester, you should carefully examine any numbers and equations presented. Is the author internally consistent? Do the numbers match your intuition/expectations? What are the implications? Importantly, do not just take the author(s) at his/her/their word that the numbers work out!

Readings:

Hallet, B., Hunter, L., and Bogen, J., 1996, Rates of erosion and sediment evacuation by glaciers: A review of field data and their implications: Global and Planetary Change, v. 12, p. 213-235.

Hooke, R.L., 2000, On the history of humans as geomorphic agents: Geology, v. 28, p. 843-846.

Questions:

1. Hooke (2000) estimates that 115 Gt/yr (1 Gt = 10^9 t = 10^{12} kg) of earth is currently moved by humans. See Figure 4 (provided on the back page of the problem set) and be sure you can see where this number comes from. Let's compare this rate with "natural" rates of sediment transport.

   (a) Critical information (*=look up online) (0.5 pt.):

   *Typical rock density __________________ kg/m^3

   115 Gt/yr = __________________m^3/yr

   *Earth's radius __________________ m

   Earth's surface area __________________ m^2

(b) Suppose we took the volume of one year's worth of human sediment transport and spread it across Earth's continents. How thick would this layer be? Note that the continents cover 29% of Earth's surface. (3 pts.)

(c) Typical rates of sediment transport by glaciers and rivers are 1 mm/yr and 0.1 mm/yr, respectively (Hallet et al., 1996). Glaciers cover about 10% of Earth's continents, and we'll assume that rivers drain the remaining 90% of the continents (note: there is minimal erosion on the seafloor). Determine an expected mass of sediment transported naturally each year. (3 pts.)

Mean rate for glaciers (kg/yr):

Mean rate for rivers (kg/yr):

Total sediment transport (kg/yr):

2. Hooke's "Bottom Line" is that the total earth moved in the past 5000 years would be equivalent to a mountain range that is 4000 m high, 40 km wide, and 100 km long.

   (a) What is the mass of this theoretical mountain range? Assume the range is shaped like a box. Give the result in Gt. (1 pt.)

   (b) Hooke's value comes from integrating the area under his time series of transport rates. Do this manually with a ruler for the Hooke figure, and give the final number below. Show your work on the figure on the back page. (1 pt.)

   (c) To get perspective on this theoretical mountain range, give us the dimensions of two North American ranges. You will need a topographic map and a ruler. Do not worry about the fact that the ranges' topography is complicated. Just use a reasonable mean width, height, and length. (0.5 pt.)

      Sierra Nevada, CA:

      Wind River Range, WY:

3. Based on the calculations that you have done, briefly (1-2 paragraphs) present an argument for whether or not humans have a large impact on landscapes by moving soil and rock. Consider rates of earth moving *and* the total amount of earth moved by humans versus natural processes. (1 pt)

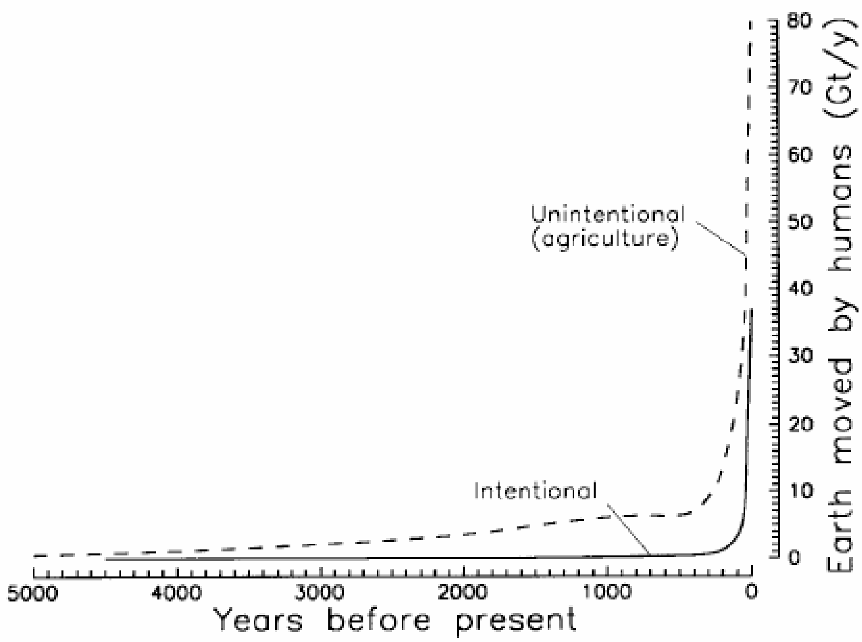

Figure 4. Estimate of total amount of earth moved annually by humans at various times in the past. Curves were obtained by multiplying earth moved per capita (Fig. 2) by population (Fig. 3).