G322 Geomorphology
Intro to Fan Morphometry Exercise

Introduction

Morphometry involves the quantitative analysis of landforms in three dimensions. Landforms are created via erosional and depositional processes, the geometry of which are controlled by the processes that shape them. Morphometric analysis provides data that yield insights into these processes. Classic fan morphometry has focused on measurements of fan and watershed geometry, including: fan shape, fan area, fan slope, drainage basin area, channel slope, and hillslope gradients. This exercise provides an introduction to morphometric approaches that have been applied to fans.

Part 1. Vegetative Cover / Precipitation / Sediment Yield

Average annual precipitation has a strong influence on vegetative cover and sediment yield in drainage basins that feed alluvial fans. The table below shows data relating average annual precipitation to average sediment yield. Data are derived from stream gaging stations and reservoirs.

Average Annual Precipitation (mm)	Average Sediment Yield (metric tons / sq. km)	Vegetative Regime
0	0	The depths of hell
203	235	Desert Shrub
318	274	Desert Shrub
444	193	Grassland
610	193	Grassland
889	140	Forest
1270	77	Forest
216	491	Desert Shrub
254	414	Desert Shrub
279	526	Desert Shrub
483	397	Grassland
698	502	Grassland
902	277	Forest
991	197	Forest
1143	165	Forest
1854	154	Forest

On the graph paper provided, or on your favorite graphing software, plot sediment yield (y axis- linear) vs. annual precipitation (x axis - linear). Fit a curved line through the data, and label vegetative type accordingly.

Question 1-1. Based on your sediment yield-precipitation plots, what types of climate regimes supply the greatest sediment load to fans and why? Explain your graph results in terms of climate change over time. What types of climate conditions will likely trigger fan aggradation? How about fan degradation / erosion. Explain your line of reasoning.

Part 2. Fan Morphometry

Bull (1964) and Hooke (1968) observed that fan area and contributing drainage basin area, on average, exhibit a functional relationship. The size of the drainage basin influences the volume of sediment discharged to the site of fan deposition, and hence should have a control on the size of fan that is constructed over time.

The general relationship between these two morphometric parameters is expressed as an exponential "power" function of the form:

$$A_f = c(A_d)^n$$

where A_f = fan area (units: L^2), A_d = drainage area (units: L^2), and c and n are empirical coefficients and exponents, respectively.

The objective of this lab exercise is use use the MS Excel spreadsheet program to determine the relationships between A_f and A_d for a number of fans located in different geologic settings.

Methdology

Task 1 - Downloading the Data File

I have tabulated some hypothetical fan data in the form of a MS Excel workbook file: *fanex2.xls* This excel file is available for download from the class website (www.wou.edu/taylor ... follow the links to G322). The file is located in the "Lab Data Section".

- from your web browser, click on the file, and you will be asked if you want to open it (using Excel), or save it to disk. You should save to a floppy disk, or some other directory that you will have access to.

In the *fanex2.xls* workbook, there are fan-area / drainage-area data and a log-log graph template to help you get started. The data are grouped into "Domains", that are identified on the basis of varying geologic conditions.

Task 2 - Graphing Relationships for Fans Using Excel

Excel is a widely available spreadsheet program that will enable you to examine morphometric relationships between fan area and drainage area data. Some of you may be Excel experts, or have other software to get the job done. Please feel free to use your creative imagination to complete the exercise. Below are some point-and-click procedures that I have used in Excel to determine the morphometric relationships.

GOAL OF TASK 2: To create separate log-log plots of Fan Area vs. Drainage Area for each Fan Domain (Group 1 through 8). Thus you will have 8 different plots that you will use to determine the power-function relationships, and c and n values respectively.

-In Excel, click on the graph template, highlight, and copy it to a different location of the worksheet, or to a new worksheet. This will provide you an easy way of keeping the template available for each Fan Domain.

- Identify the cell ranges for each Fan Group, for both the Drainage Area and Fan Area columns (for example: Group 1 Drainage Area Cell Range = B6.B10, Group 1 Fan Area Cell Range = C6.C10.

-In Excel, use the graph template to sequentially plot each Fan Domain. To use the template, click on the outer part of the chart, highlight it, and right-click the mouse.

- Choose the "Source Data" option from the drop-down list.

- From source data menu, you will see the X value and Y value ranges to plot on the graph, it will look something like this:

X Values: ='Raw Data'!$E$6:$E$10
Y Values: ='Raw Data'!$D$5:$D$9

-What you want to do is plot drainage area on the X-axis, and fan area on the Y-axis. Change the cell ranges for each Group of Fan Data according. For example to plot the group 1 data, change the x and y value range to the following:

X Values: ='Raw Data'!$B$6:$B$10
Y Values: ='Raw Data'!$C$6:$C$10

This should highlight the data range, and plot the points on the graph for you.

To change the title on the graph, or any other feature, simply double click on it and you will enter "edit" mode. Title each graph with respect to Group 1, 2, 3... etc. Save the graph, print it, and move on to the next data set using another chart template.

Task 3 - Determining c and n values for the Power Function Relationships

Once you have your log-log plots, you can easily get Excel to determine the power function trends of the data.

- click on the actual points plotted of the graph, highlight them (these are called the "series data")

- On the main Excel menu bar click on:

chart - add trendline
set the trendline type = "power"; under options: check "display equation on chart"

**this action should fit a line to the data points, and list the power-function equation of the form:

$$y = c(X)^n$$

where in this case, the y values are Fan Area (Af), and the x values are Drainage Area (Ad), c and n are the values that you are trying to identify.
** NOTE: once the equation is displayed on the chart, you can click on it, highlight it, and move it to a more convenient location, so you can see it**

Systematically plot Fan Area-Drainage Area Graphs for each Domain, and determine the c and n values of the power function relationship. Fill in the table below, and answer the following questions.

Fan Domain	c coefficent	n exponent
Group 1	______	_______
Group 2	______	_______
Group 3	______	_______
Group 4	______	_______
Group 5	______	_______
Group 6	______	_______
Group 7	______	_______
Group 8	______	_______

Question 2-1. What are the maximum and minimum c values that you determined?

Question 2-2. What are the maximum and minimu n values that you determined?

Question 2-3. Think in terms of the size and drainage basin and the volume of sediment discharged. Assuming that fan area is a direct proxy for fan size (and fan volume), what do the power function relationships say about fan size as the drainage area increases? Another way to think about it, do big drainage areas always produce corresponding big fans? How does this relationship change as the value of "n" changes? (looking at the data, think up some general relations).

Question 2-4. Think in terms of meteorological events that deliver sediment to a fan (say via debris flow). Now think about a thunderstorm cell (high intensity, the kind that would stimulate slope failure / transport in an arid setting). If the drainage area is very large compared to the t-storm cell, how will this influence sediment transport efficiency to the fan? If the drainage area is smaller or the same size as the t-storm cell, how will this influence sediment transport efficiency to the fan?

Question 2-5. Given the relationships in question 4 above, which type of drainage basin will result in a greater degree of depositional activity on the fan per weather event: a large or small basin? explain why.

Question 2-6. Given your intuitive or direct knowledge of landform relationships, which type of drainage basin will have steeper average slopes: a small mountain watershed, or a large drainage basin? Create a generalized graph of the relationship between drainage area and average hillslope gradients.

Question 2-7. Which type of drainage basin will have more sediment in storage (within the basin itself): a large basin with wide valley bottoms, or a small catchment with narrow valley bottoms? Explain your answer in terms of unit stream power, as discussed in lecture.

Question 2-8. Given the relationships in question 7 above, which type of drainage basin will more effectively deliver a greater percentage of sediment to the fan area: a large basin or small? Explain.

Question 2-9. What is a necessary requirement for fan sediments to accumulate at the mouth of a watershed? (you may think of several, but I'm thinking of one in particular that relates to the following thread....) How will this requirement affect the size of the fan and the relationship between Fan Area vs. Drainage Area, with respect to exponent "n". Explain.