Main Projects, ESPM5295

We have two related projects that will help structure our learning. One is to analyze rainfall-runoff on the St. Paul Campus. A surprising amount of money and effort is spent by organizations to manage water from storms. Flooding is among the top one or two causes of property damage nationwide in most years, and therefor is the subject of much spatial analysis. It is also a good vehicle to learn new skills and practice old ones.

This first project in part requires our second project. An inexpensive and relatively effective way to mitigate stormwater flow is to increase tree canopy cover. Dense tree canopy typically intercepts between the first 0.1 and 0.4 inches of rainfall in a storm, with the amounts varying due to leaf type, rainfall duration, and intensity. There are several methods to estimate tree canopy extent and density, primarily by 1) interpreting aerial photographs, 2) LiDAR, and 3) stem and crown diameter measurements. We'll use a combination of these to estimate the most recent canopy density values, and evaluate changes through time.

Our primary goals are to estimate the amount of rainwater leaving each of your study areas via the rainwater sewer system overland flow, and to estimate how much additional canopy will reduce storm water exports. To do this you need to estimate the amount of water delivered to each stormwater grate in your study area from a 1", a 2", and a 4" storm. This will involve a very simplified set of analyses. Note that you do not need to worry what "runs on" onto Campus from adjacent areas – much of the St. Paul Campus is generally higher or at the same level as the surrounding parcels. This is less true at the southern end of the Campus then the northern end, but for the sake of brevity we'll restrict our work to a portion of the Campus.

Basically, we will assume that the forest canopy and vegetation intercepts up to the first 1/3 inch of rainfall depending on height and canopy type, that grass, flower beds, and other unpaved/uncompacted areas absorb a percentage of the rainfall based on their soil type, and that impervious surfaces (buildings, streets, sidewalks, etc.) absorb none of the rainfall that falls on them – it all is runoff.

We will assume the two absorption effects are additive, for example tall conifer trees over asphalt will absorb the first 1/3 inch of rain, and these over grass will absorb the 1/3 inch for the canopy, and then as much as the limits set by the soil type.

The amount of canopy absorption depends on the type, height, and density of the canopy. Conifers absorb more than broadleaves, taller canopies absorb more than shorter ones. We will assume that the canopy height generally integrates canopy density. We'll use two simple rules for tree and shrub vegetation. We assume maximum absorption for trees taller than 9 meters (approx. 30 feet). Conifers taller than that absorb the first 1/3 of an inch of any storm, broadleaved species the first ¼ inch. Canopies from 1.5 to 9 meters absorb 1/3 of that (1/6 inch for conifers, 1/8 inch for broadleaved). Shrubs/vegetation shorter than 1.5 meters absorbs at the rate of the underlying soil.

Calculating runoff is not a simple spatial problem, particularly in an urban environment. Here we'll assume two levels of interception, first, the forest canopy, and then second, the surface. Once water reaches the surface, some infiltrates into the ground, and some flows over the surface. It flows over the surface according to gravity-defined flowpaths, and we can use high resolution, recently collected DEMs to estimate surface flow direction. Unfortunately, humans have altered these flowpaths via development. We've constructed sub-surface drainage networks, so once water enters these, it flows underground. Buildings are connected to these drainage networks directly, e.g., when a downspout from a roof connects directly to a stormsewer grate or entry point. This only happens some of the time, so a building may contribute to overland flow.

We will have available both the subsurface drainage network, the storm sewer drains exposed to the surface, and where buildings connect directly to the storm sewer drains. We will use the open stormsewer grates as our "collection points," estimating the amount of surface flow that reaches each one. We can identify high-contributing areas from the net amount at each grate. Buildings that are not connected to the stormsewers can be considered the same as any pavement. Here we will assume the buildings contribute all their runoff to the lowest ground point on the edge of the building. This may require some slight modification of the DEM within the footprint of the building to enforce proper flow direction. We can then estimate the total flow along the various storm sewer lines, and identify main areas responsible for generating flow.

We will calculate the amount of runoff with the landscape "as is," and also add storage to the extent needed to reduce stormsewer exports from i) a ¼" storm, and ii) a 1" storm to zero. These are realistic limits, for example, new design is typically required to store at least the first 1" of rainfall, and some watershed districts in Metro Minnesota requiring storage of the first 2". The recommendation will take the form of a map of additional areas to provide forest canopy, and of areas to build additional infiltration – rain gardens or underground infiltration tanks, and enough supporting narrative and documented calculation to support your chosen alternative.
You have the proviso that you can't lose more than 10% of the car parking spaces in any parking lot, or build any above-ground storage that takes up more than 10% of an existing lawn or other greenspace. You may entertain underground storage, but it is a last resort as it is dreadfully expensive.

You need to do several things, among them:

- Collect ground surface cover, tree/large shrub canopy extent, sewer grate locations, and other data for your project area.
- To do the step above, you'll need to combined aerial photographs from past and present, and collect data from both.

- You'll need to organize the soils data, and come up with estimates of absorption percentage.
- You'll need to create flow-direction and flow accumulation rasters from available DEMs, modify them so that the stormwater grates effectively capture the water flowing to them, identify the "watersheds" for each grate, and calculate the amount of water that enters each grate.
- You'll be provided the network of subsurface pipes on campus, and you'll use these to accumulate the flow input from each grate along the storm sewer paths, so that you can estimate the amount exiting your study area from each "tree" of connected stormwater drains. You can do this step manually, in that you can summarize flow to each drain, and then add together the flow from each "trunk" line that leaves your project area.
- You'll need to identify areas that aren't captured by sewer grates and drain outward from your project area, and calculate the total that flows off your project area from these.

The above is not a complete list of all your tasks, it is rather to give you a rough road map and better idea to help you plan.

We'll work individually or in groups of two or three, but there is one, large, final constraint. You will work on sub-areas (a group of two will have sub-areas double the size of a single, a group of three triple the size), but you'll be working in parallel on adjacent parcels. You need to all build your geodatabases in a form such that the data you'll use in your analysis can be easily and seamlessly merged into a single, campus-wide layer. This means the class needs to agree upon a standard set of layers, layer names, variable types, order, and names, raster resolutions, coordinate system, and all other characteristics required to complete the analysis.

Each person will draft a description of a geodatabase template in a defined week, and we'll discuss and adopt a standard. After data development on individual areas, a subset of folks will have to assemble all the data together into one seamless data layer.

Once we've created a common, seamless data set, each person will also have to think through, and create, a flowchart of their analysis path, and implement it. You'll have to resolve the major steps, check to make sure these can be completed, and string them together in a graph. You'll then apply these steps, develop your recommendations, and write a short report describing your recommendations.

Exercises will form many intermediate steps along this path, as we teach or refresh skills you need to reach our two goals