Etowah River Project Runoff & Flow Accumulation Tool

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Abstract

The portion of the Etowah River that runs through Dawson Forest seems to be affected by large amounts of runoff and buildup possibly caused by the development and use of nuclear testing in the area. The first study done in the area occurred during the 1950s and is being revisited to monitor change from the first study and large amounts of silt buildup were noted in the collection points. To estimate the amount of Total Discharge the Etowah River is experiencing in Dawson Forest an automatic ArcGIS Pro toolbox is to be created to simplify the process and allow users with minimal GIS experience to utilize the tool.

Introduction

During the early 1950s a Nuclear Aircraft Laboratory was opened in what is now Dawson Forest. This facility was built to test the effects of nuclear radiation on aircraft systems by dousing components with radiation. This was a concern as the coolant used on the reactor was water sourced from the Etowah River. The water was supposedly cleansed and filtered back into the area but as a precaution a student grant was made so it would be tested every month for a year. Decades later the sites were visited again by UNG students and more samples were taken. They noticed considerable differences in the surrounding topography when compared to the descriptions taken by Dr. William Teitjen, the previous sample taker. Specifically, the depth of water was much lower as noted to be “mid-thigh height” (Dr. Margi Flood, 2020) on Dr. Teitjen, who is ~6’4” tall, when he took his first samples while the water was only “mid-calf” when the most recent samples were taken (Dr. Margi Flood, 2020). It is said this is due to the landscape being in recovery from recent intense agriculture that occurred until the late 1940s/50s.

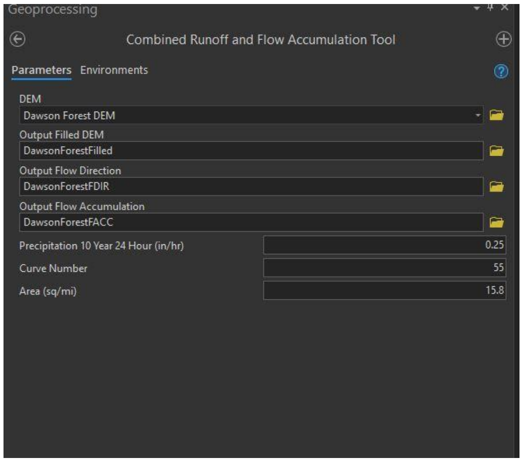
The goal of this project is to find the Flow Accumulation and the Total Discharge of Runoff in Dawsonville Forest and the portion of the Etowah River running through it, and to automate the entire process using ArcGIS Pro’s Python Toolbox. Finding the Total Discharge throughout the Dawsonville Forest will give an idea on how it has been affected since the early 1950s when it was last measured and tested, and will show how it will continue to fill with silts. Using the ArcPy Toolbox will allow for a quick and easy replication as the toolbox, using the same data, will create the same results every time due to it being automated and reducing the chance for user error. This toolbox will make it very easy for someone with little to no experience within the ArcGIS Pro program and throughout GIS in general. Due to the low skill requirement of this toolbox it makes it

Methods

Using ArcGIS Pro's Python Toolbox made it very easy to batch create a flow accumulation map and everything required, beginning with the filled dem. The dem is first filled to ensure there are no abnormalities that may affect the outcome of the layer. Next the Flow Direction tool is used, with the Filled DEM as the input data, to calculate which direction water will flow along the topography. Finally Flow Accumulation is found with the newly created Flow Direction Raster and it will show everywhere water collects to form streams and basins. To easily recreate these tools inside the Python Toolbox, they are first run individually within ArcGIS Pro to ,1) ensure they function correctly and, 2) once a tool has been run ArcGIS Pro gives the ability to save or copy the python script used to run the tool making it much easier to apply the executables within the toolbox.

The formula used to find the Total Discharge over an area required the Curve Number, Rainfall Intensity, and the Area in square miles. To begin finding the Curve Number which is found using the "Urban Hydrology for Small Watersheds TR-55" by the USDA. The first step in doing so is properly identifying the land cover type, in doing so allows for easier identification using the hydrologic soil group which ranges from A, B, C, and D. In this instance the soil is "Hayesville Sandy Loam" according to GSSURGO and is labelled as a type B soil meaning it is a medium strength soil. Using this and the knowledge of what land type, in this project Dawsonville National Forest was labelled as Woods cover type in good condition meaning its curve number is equal to 55, with woods being the label as it is woods with little to no grass combination, and good condition as good condition is described by the USDA as ">75% ground cover and lightly or only occasionally grazed". Next the Rainfall Intensity can be identified using a graph showing the average inches per hour across the Continental United States, Dawson County receives 6 inches over a 24-hour period on average every 25 years which turns into 0.25 inches an hour. The Area in square miles depends on the study area, for this project the study area is Dawsonville Forest which is well documented, and the size can be determined without the use of a program such as ArcGIS Pro. Once each of these variables are gathered they can be inputted into the functions beginning with the Total Runoff in inches which is R_e = (Precipitation-0.2s)^2/(Precipitation+0.8s) where s = (1000/Curve Number) – 10. Next the coefficient can be found with C = 16.39 + 14.75(R_e) which will be used in the final equation D = C*M$^{5/6}$ that will give the solution for Total Discharge.

Figure 1: *Toolbox Parameters*



Results and Discussion

The toolbox successfully runs each tool and creates each layer, filled, flow direction, and flow accumulation, with ease. Due to the previous exercises involving the creation of batch flow accumulation toolboxes throughout the class 'Programming for Geo Sci & Tech' taught by Dr. Huidae Cho, the only problems encountered when creating these were only the occasional typo when filling out the parameters within the toolbox, as creating a python toolbox especially with these specific tools were almost second nature. The Digital Elevation Model was imported as a DEM of Georgia and clipped to size creating map seen in Figure 1. Then using the Fill tool in ArcGIS Pro, Figure 2 was produced note there is little to no difference meaning this area did not contain large amounts of irregularities.

The Flow Direction was created using the Flow Direction tool and only required the input of a DEM and preferably a filled DEM which was created in the step before. Unlike the previous two maps the Flow Direction has multiple colors because it has set values with 1 being water that flows down to the east, 2 flows south-east, 4 flows south, 8 flows south-west, 16 flows west, 32 flows north-west, 64 flows north, and 128 flows north-east. All these values flow until they reach an area that has a single flow path which will signify a body of water. This body of water can then be properly identified by using the Flow Accumulation tool which singles out the water and ignores everything else, creating the image shown in Figure 4.

Finding the Total Discharge using the equations listed in the Methods section proved to be difficult when transferring into the ArcGIS Pro python toolbox as the different unit types were interfering with each other. To fix this any parameters that were manually inputted had to be labelled as either a float or an integer to ensure the portions of the hardcoded equation could interact with the inputted data. After this problem was fixed the equations worked well and produced results the same as those from performing the same equations by hand.

Figure 2: *Digital Elevation Model*

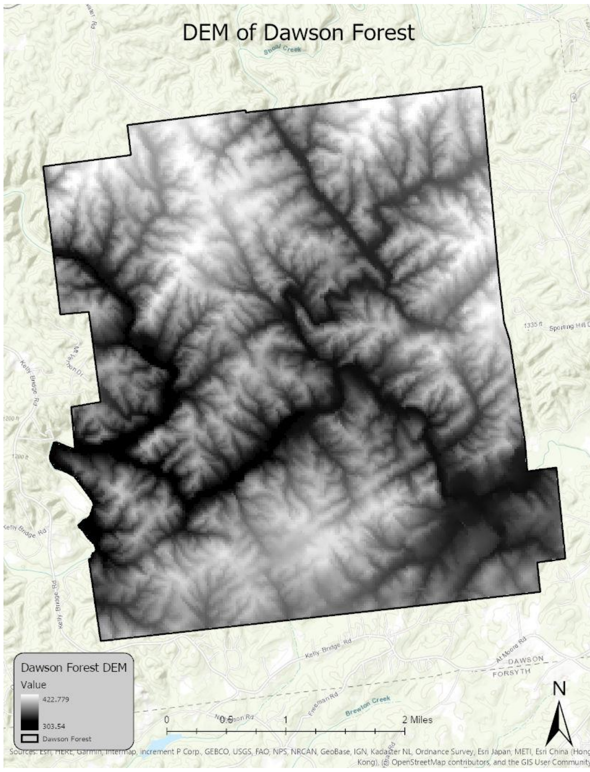


Figure 3: *Filled Digital Elevation Model*

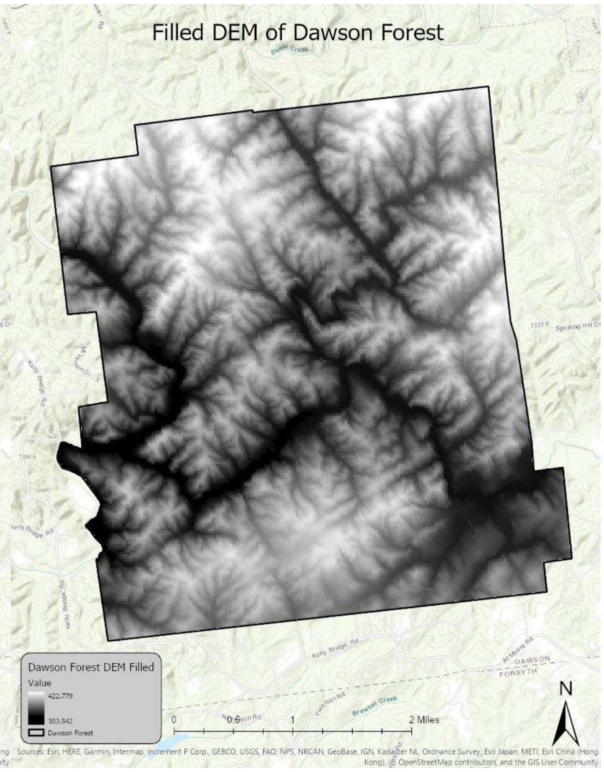


Figure 4: *Flow Direction Model*

Figure 5: *Flow Accumulation Model*

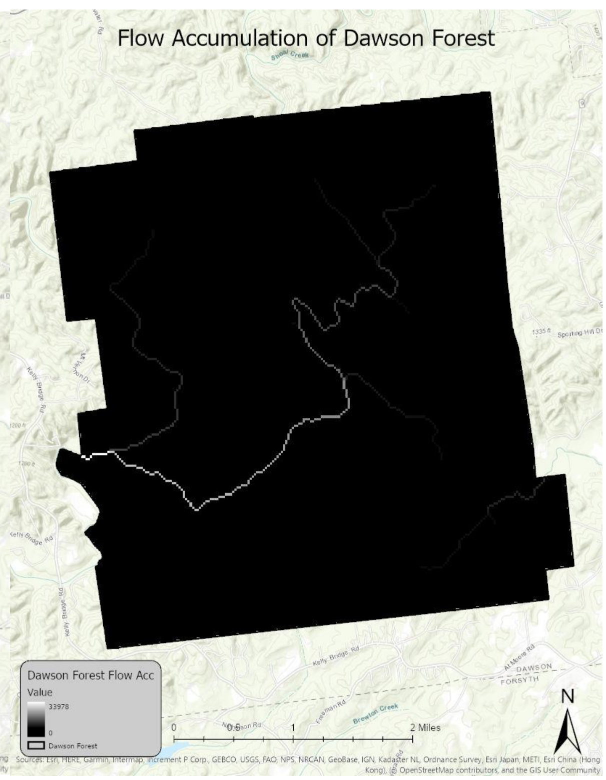
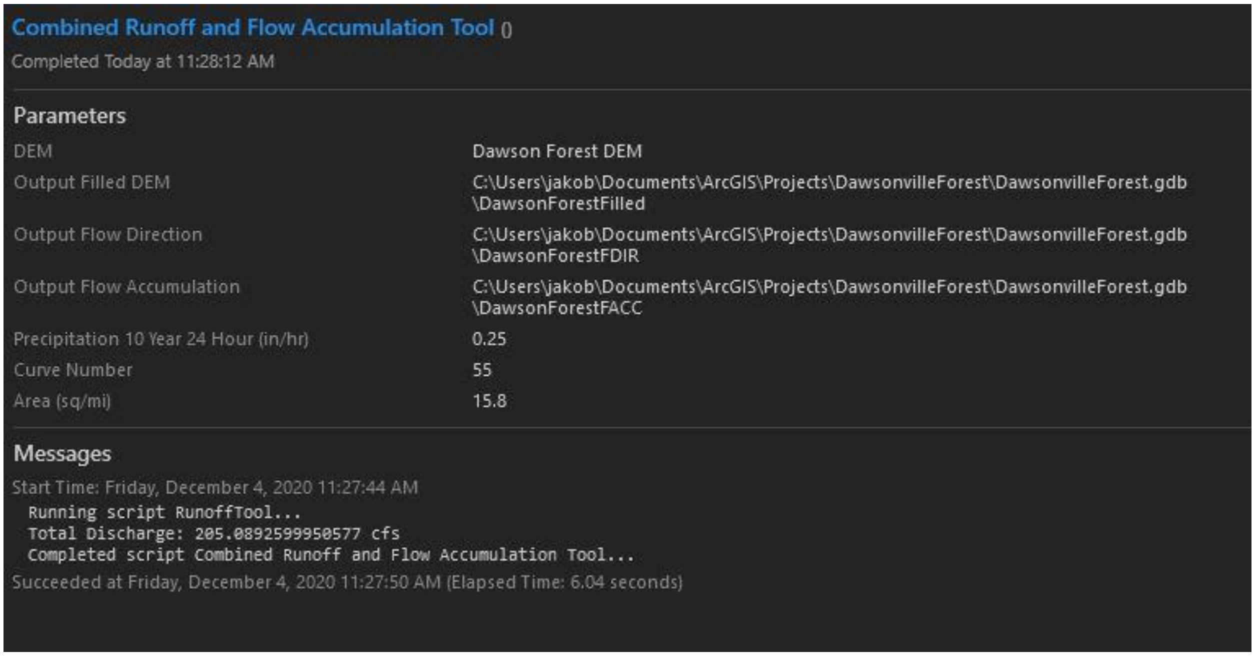


Figure 6: *Tool Results showing Total Discharge in Messages*



Conclusion

The Python Toolbox runs as intended and creates all components required for the initial expectations such as the, Flow Accumulation and a Total Discharge number. Although the equations created run off the Cypress Creek Model which is specifically made for areas that experience very little change in slope, such as agricultural land. The use of this tool means that this is most definitely inaccurate. This is due to my inability to find a model I could successfully replicate over the course of three days and, on the third day attempted the Cypress Creek Model unknowing of its intended use. In my rush to achieve even the smallest of victories towards a finished final project the original design of the model was unknown to me until after the model had been finished and implemented into the Python Toolbox. Through my desperation I failed to realize the limitations of the formula used.

References

Bansode, Ashish, and K. A. Patil. "Estimation of runoff by using SCS curve number method and arc GIS." *International Journal of Scientific and Engineering Research* 5.7 (2014): 1283-1287.

Betson, Roger P. "What is watershed runoff?." Journal of Geophysical research 69.8 (1964): 1541-1552.

Cho, Huidae. "The Rational Method Toolbox". GISC 3200K. University of North Georgia. Virtual Meeting. 4 November 2020. Lecture

Domniţa, Matei & Crăciun, Ionuț & Haidu, Ionel. (2009). GIS in determination of the discharge hydrograph generated by surface runoff for small basins. 11-22.

Flood, Margi. Personal communication. September 2020

Toms, Silas, et al. *ArcPy and ArcGIS – Geospatial Analysis with Python*. Packt Publishing, 2015. *EBSCOhost*, search.ebscohost.com/login.aspx?direct=true&AuthType=ip,shib&db=nlebk&AN=959972&site=eds-live&scope=site.

USDA

USGS

Zandbergen, Paul A. *Python Scripting for ArcGIS*. First edition., ESRI Press, 2013. *EBSCOhost*, search.ebscohost.com/login.aspx?direct=true&AuthType=ip,shib&db=cat06568a&AN=ung.994293143702960&site=eds-live&scope=site.