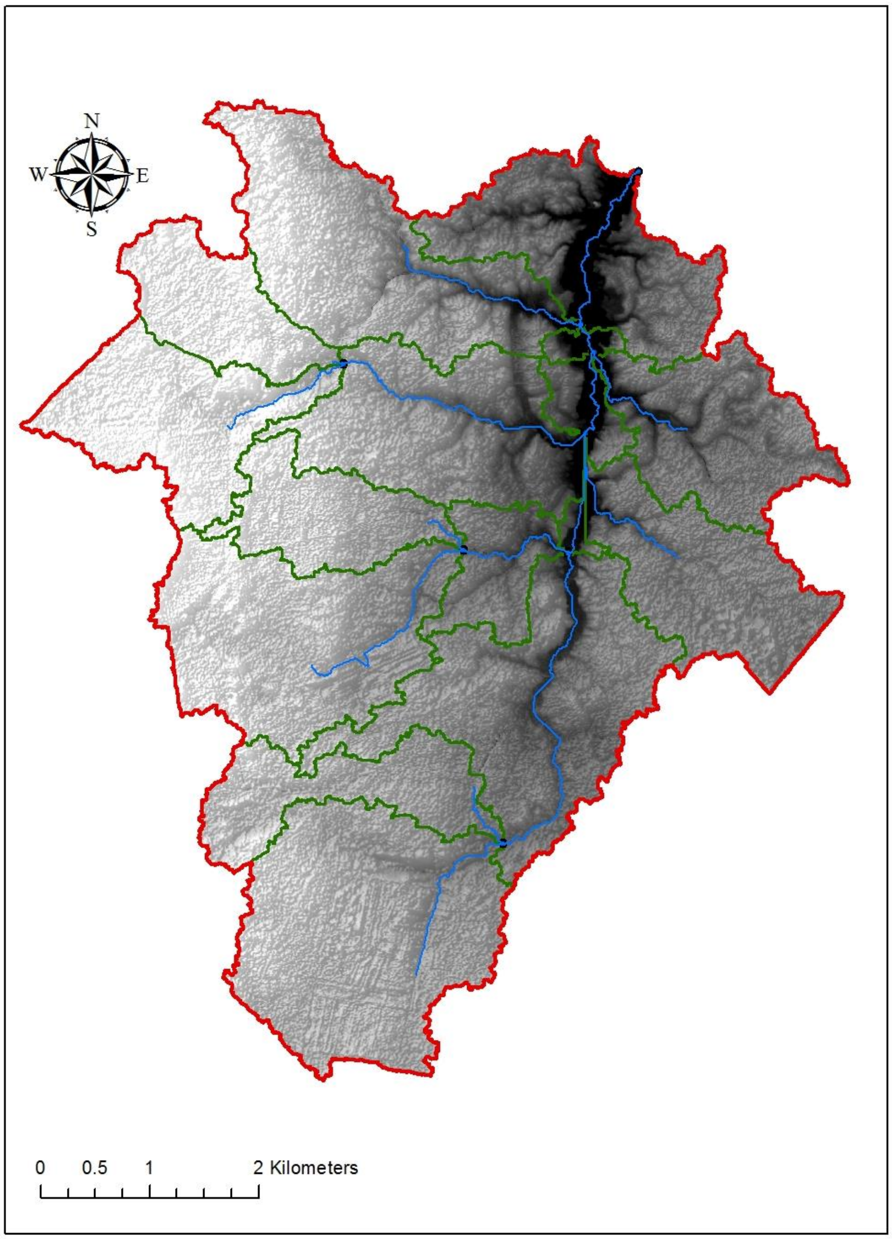
USING ARCSWAT TO EVALUATE EFFECTS OF LAND USE CHANGE ON WATER QUALITY

Adam Gold

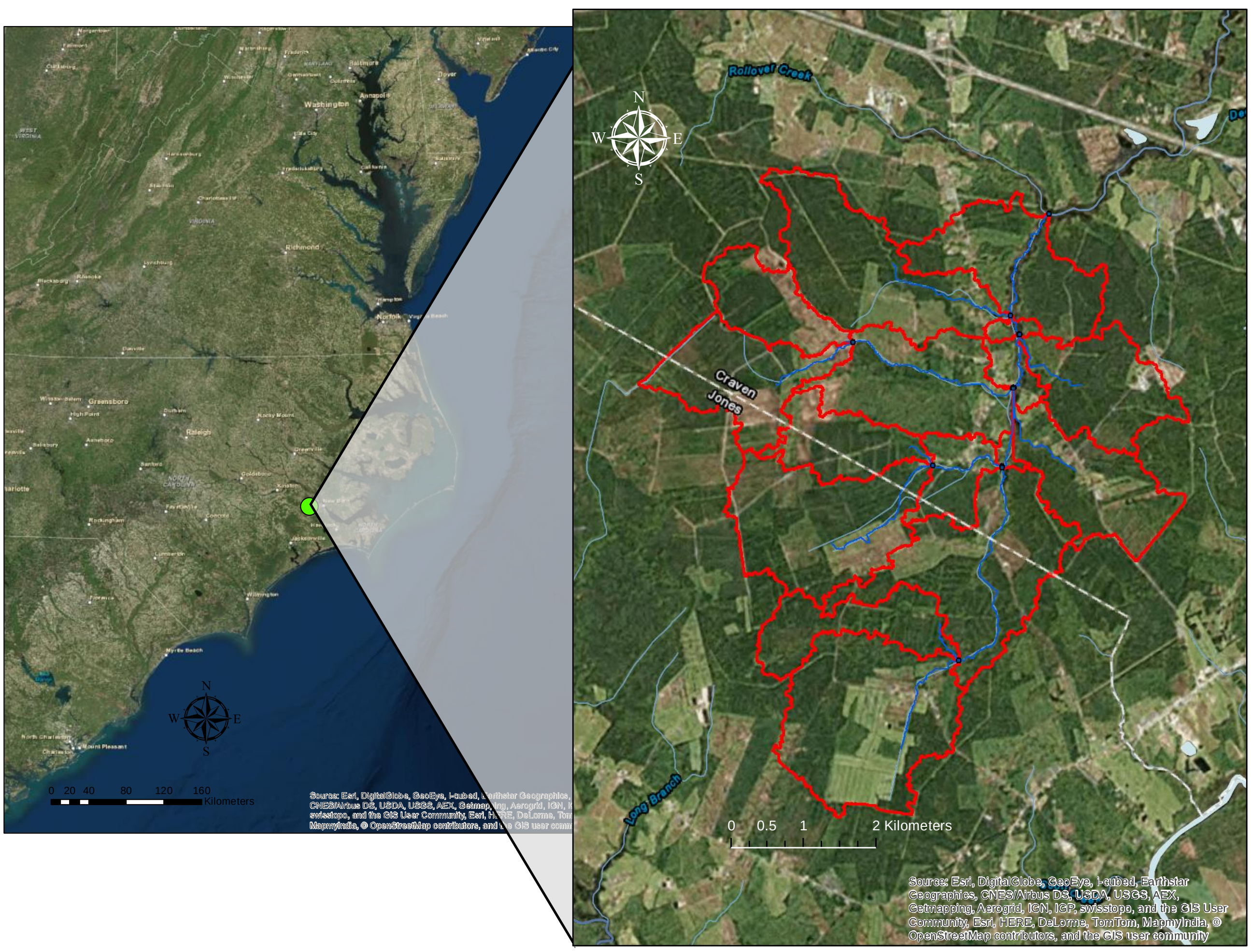
Geog 591



Introduction

The Soil and Water Assessment Tool (SWAT) is a hydrologic transport model with an objective to "predict the effect of management decisions on water, sediment, nutrient, and pesticide yields with reasonable accuracy on large, ungauged river basins." (http://swat.tamu.edu/) The USDA and Texas A&M University jointly developed SWAT, and Texas A&M has developed a graphical and visual interface of SWAT, ArcSWAT, for use with ArcGIS. ArcSWAT significantly improves the ease at which a user can create a SWAT model. ArcSWAT is available for free from http://swat.tamu.edu/software/arcswat/.

My study site was a 36.43 km^2 catchment located Northwest of Havelock, NC. I chose this area because of the organic rich soils, low slopes, and high incidence of land use change.



Objectives

- To use publicly available data to create an ArcSWAT model
- To use an ArcSWAT model to determine effects of land use change on modeled nutrient exports

Methods

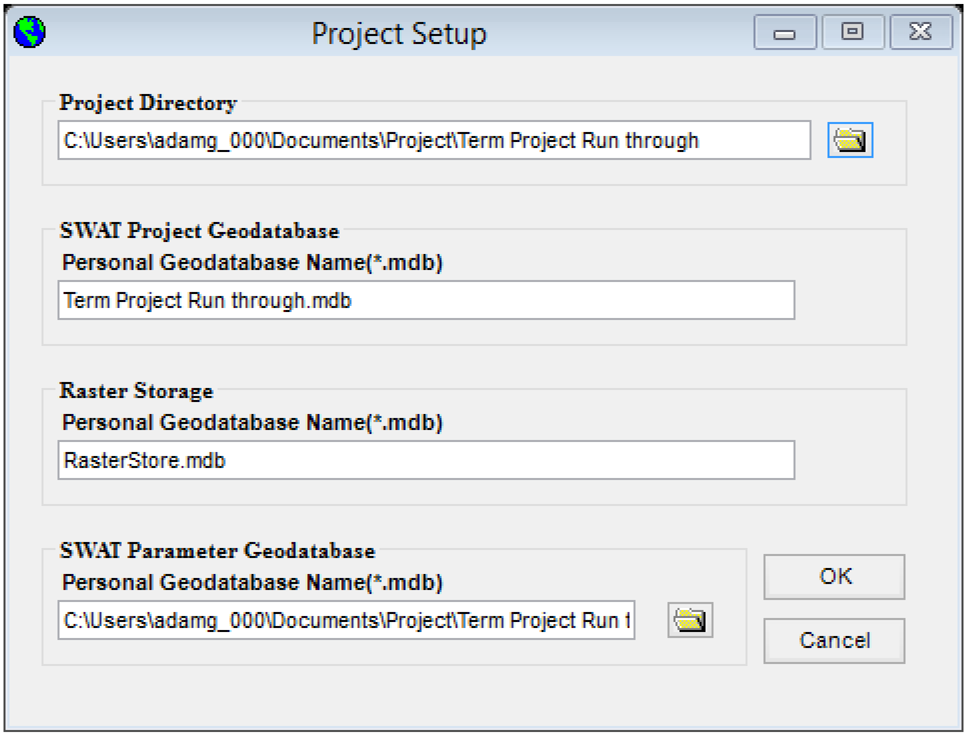
Data Collection

I used publicly available data to create my ArcSWAT model:

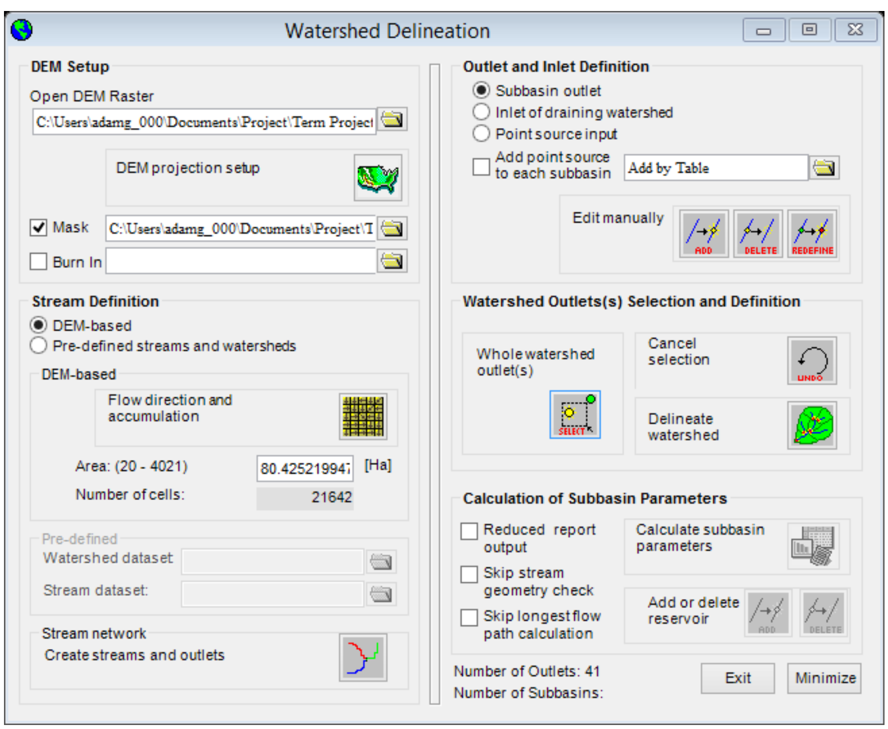
- Land Use Data: 2001, 2006, 2011 NLCD Data
  http://www.mrlc.gov/
- Elevation Data: 20 ft. lidar elevation Data for NC
  http://geodata.lib.ncsu.edu/NCElev/
- Soil Data: Soil Map Units Vector Layer
  ESRI ArcGIS Landscape1 Server, landscape1.arcgis.com_443
- Weather Data: Temperature, Precipitation, Humidity, Solar Radiation, Wind
  http://globalweather.tamu.edu/

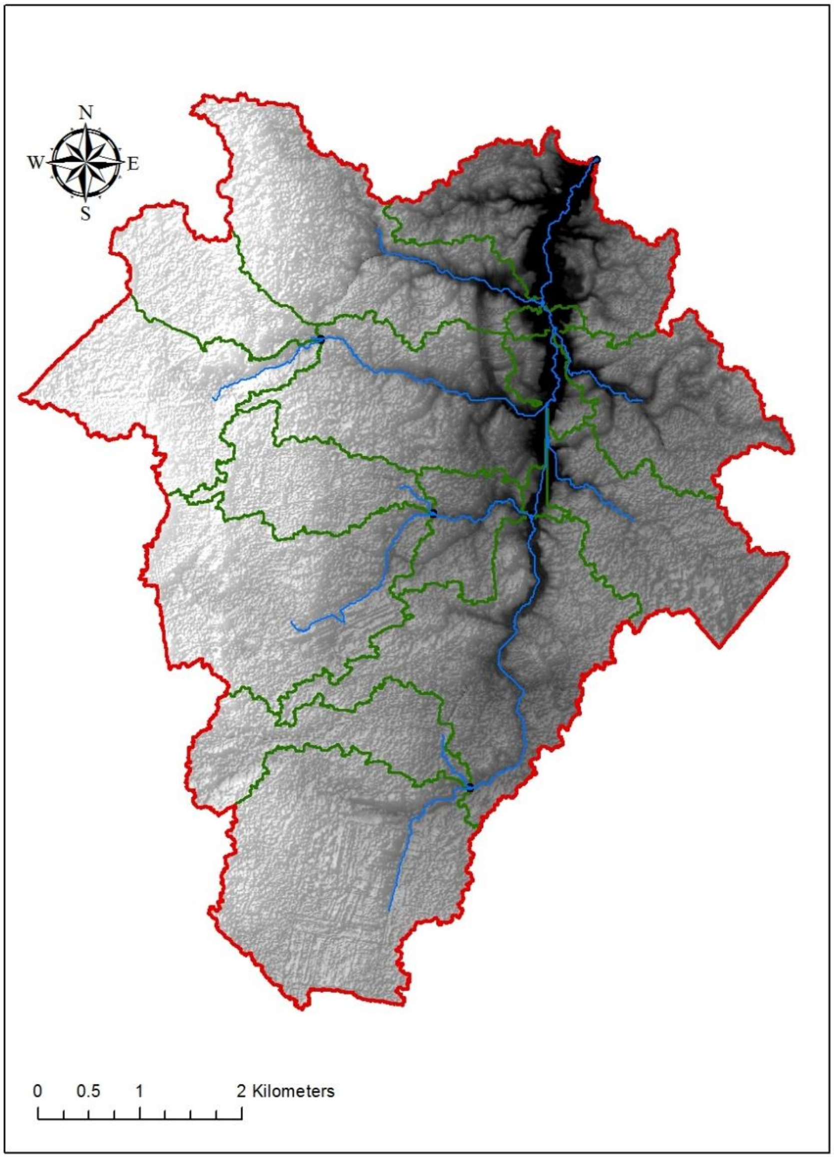
Configuring and Running the Model

1. I imported all of my data into ArcGIS and converted all of the files to the same spatial reference and projection, NAD 1983 (2011) State Plane North Carolina FIPS 3200 (US Feet)
2. I created a new ArcSWAT project and saved it to my hard drive

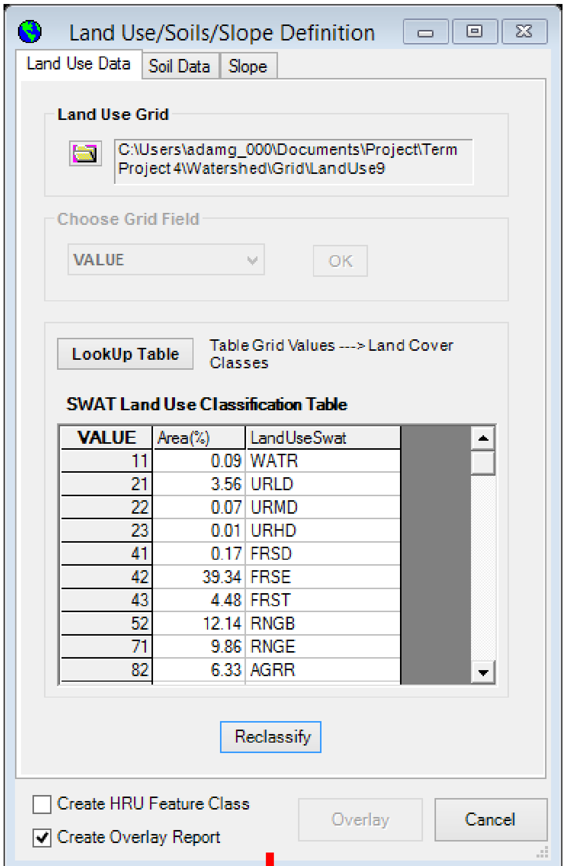


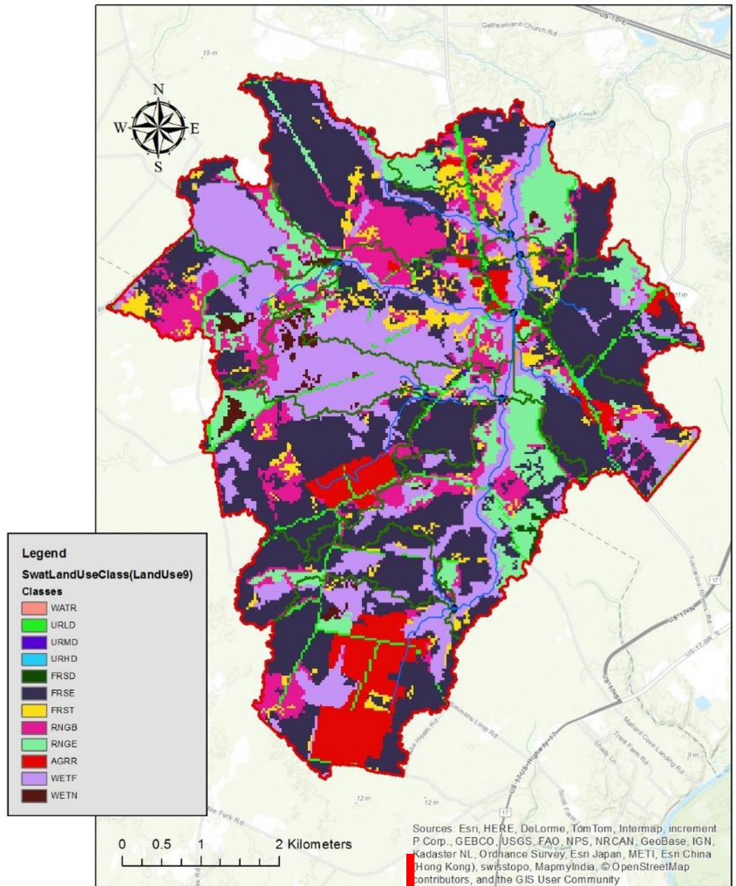
3. I put my source DEM on the map and used the automatic watershed delineator to delineate the watersheds and perform various functions, such as flow direction, flow accumulation, and stream delineation

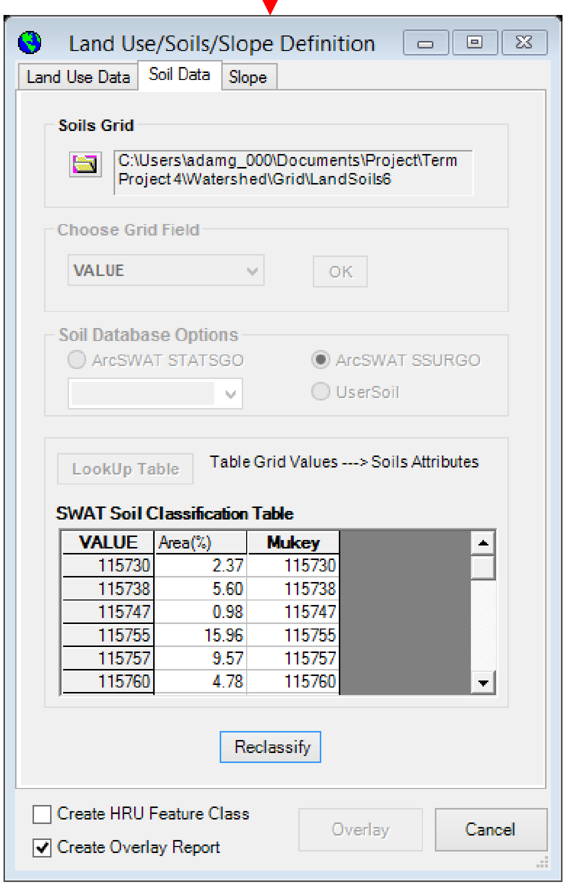


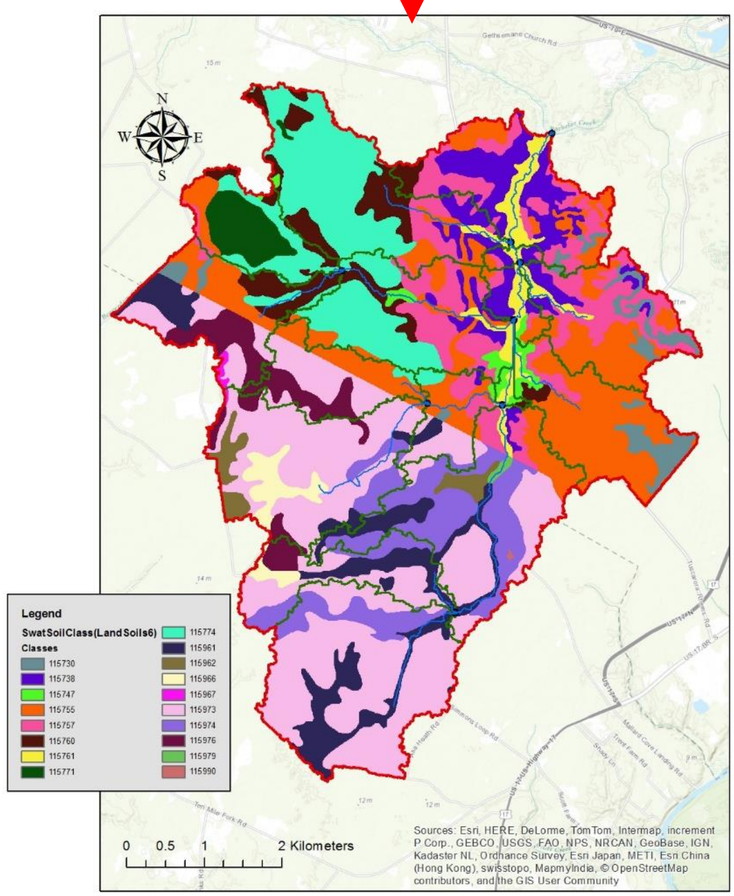


4. I added my land use and soils data to the map. I then used ArcSWAT to delineate HRU's based on the major soil and land use type in each sub-watershed. The study catchment lies in two counties, which are different soil survey districts. This is the reason for the straight line (from NW to SE) through the soils map. (The soils separated by the line are the same soil type, but were reported with slightly different keys.)


Land Use/Soils/Slope Definition
Land Use Data
Soil Data
Slope
Land Use Grid
C:\Users\adamg_000\Documents\Project\Term Project 4\Watershed\Grid\LandUse9
Choose Grid Field
VALUE
OK
LookUp Table
Table Grid Values ---> Land Cover Classes
SWAT Land Use Classification Table
VALUE Area(%) LandUseSwat
11 0.09 WATR
21 3.56 URLD
22 0.07 URMD
23 0.01 URHD
41 0.17 FRSD
42 39.34 FRSE
43 4.48 FRST
52 12.14 RNGB
71 9.86 RNGE
82 6.33 AGRR
Reclassify
Create HRU Feature Class
Create Overlay Report
Overlay
Cancel


N
W
E
S
Legend
SwatLandUseClass(LandUse9)
Classes
WATR
URLD
URMD
URHD
FRSD
FRSE
FRST
RNGB
RNGE
AGRR
WETF
WETN
0 0.5 1 2 Kilometers
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community


Land Use/Soils/Slope Definition
Land Use Data
Soil Data
Slope
Soils Grid
C:\Users\adamg_000\Documents\Project\Term Project 4\Watershed\Grid\LandSoils6
Choose Grid Field
VALUE
OK
Soil Database Options
ArcSWAT STATSGO
ArcSWAT SSURGO
UserSoil
LookUp Table
Table Grid Values ---> Soils Attributes
SWAT Soil Classification Table
VALUE Area(%) Mukey
115730 2.37 115730
115738 5.60 115738
115747 0.98 115747
115755 15.96 115755
115757 9.57 115757
115760 4.78 115760
Reclassify
Create HRU Feature Class
Create Overlay Report
Overlay
Cancel


N
W
E
S
Legend
SwatSoilClass(LandSoils6)
Classes
115730
115738
115747
115755
115757
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115771
115774
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115962
115966
115967
115973
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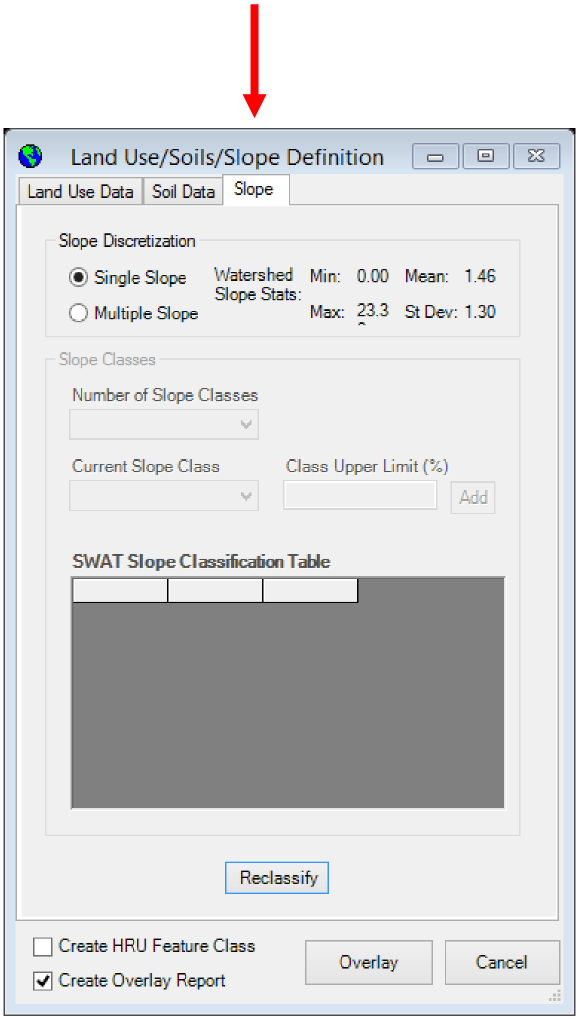
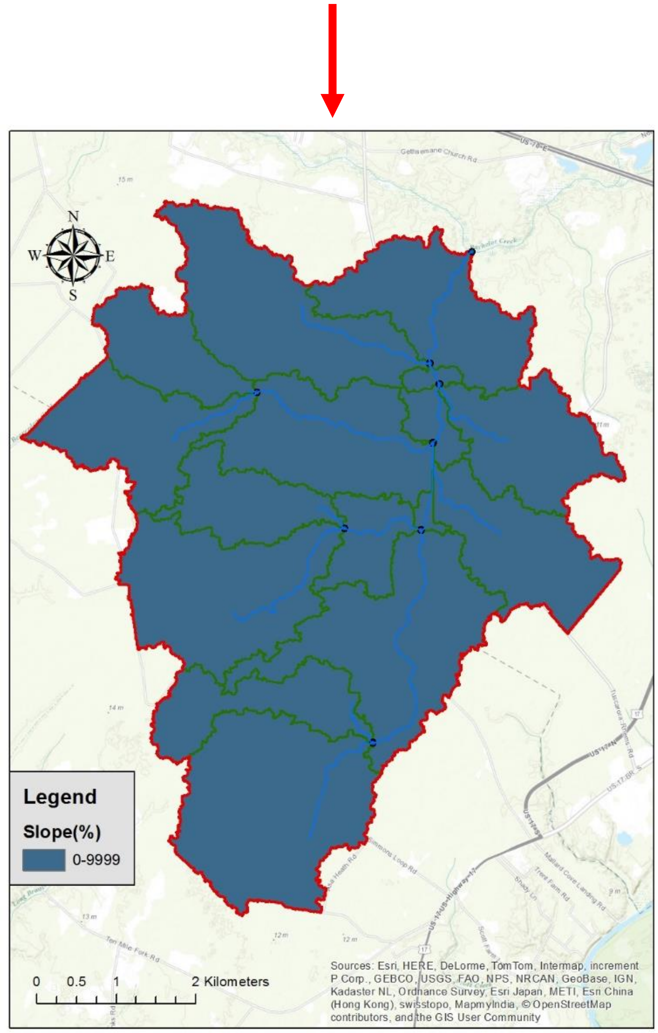
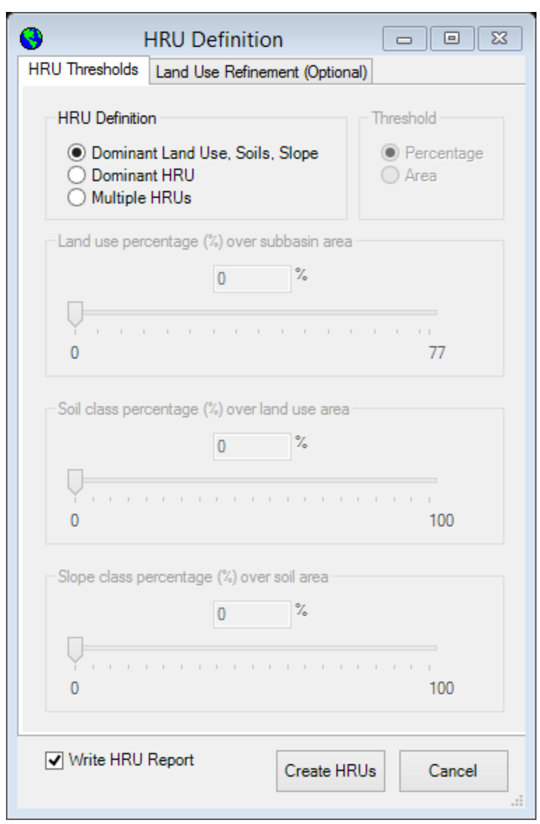
115990
0 0.5 1 2 Kilometers
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

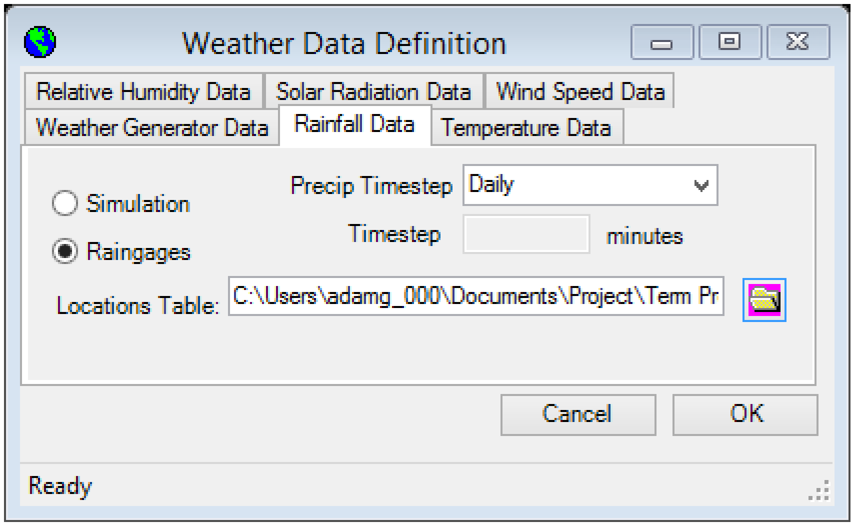




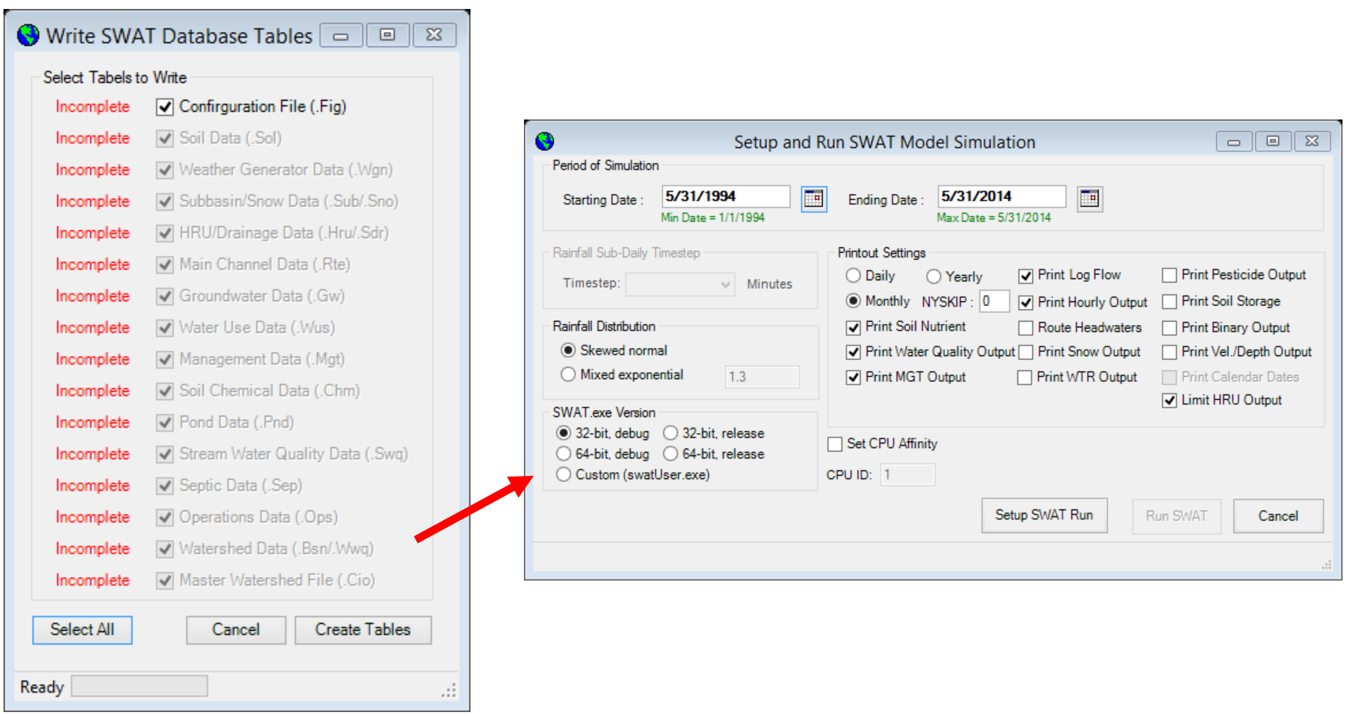
5. I then used ArcSWAT to define the catchment's Hydrologic Response Units (HRU's) based on the land use, soils, and slopes

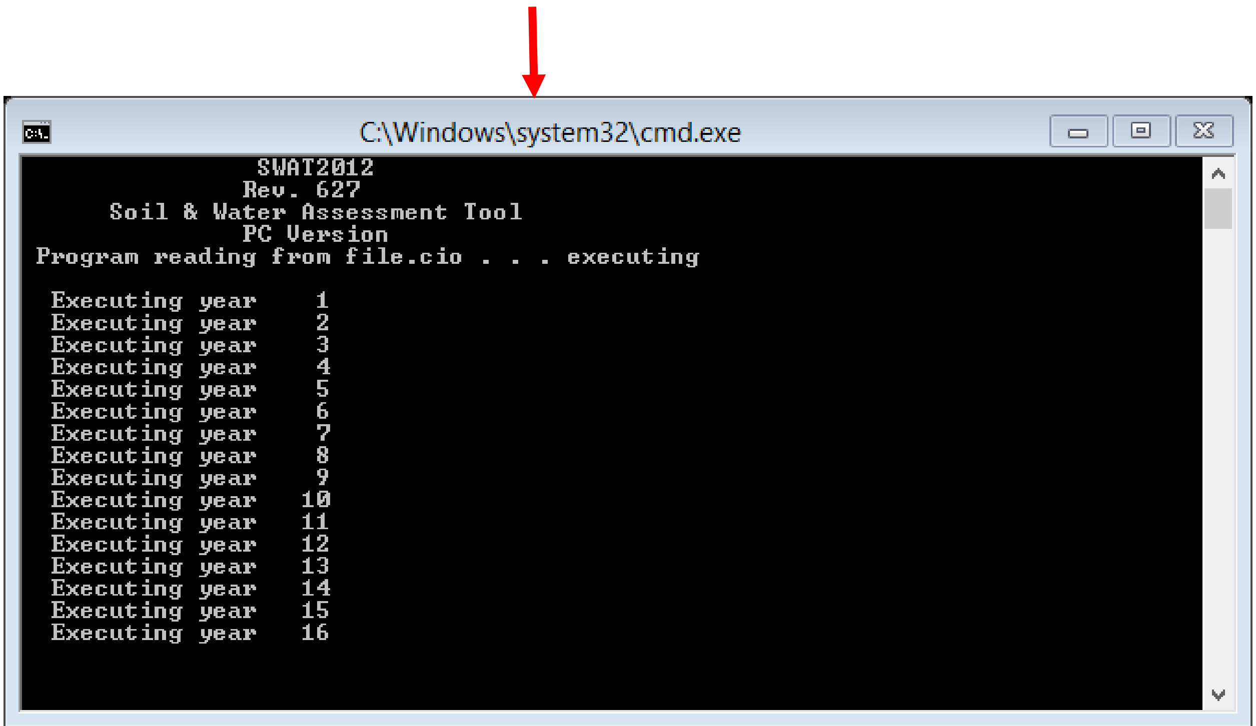


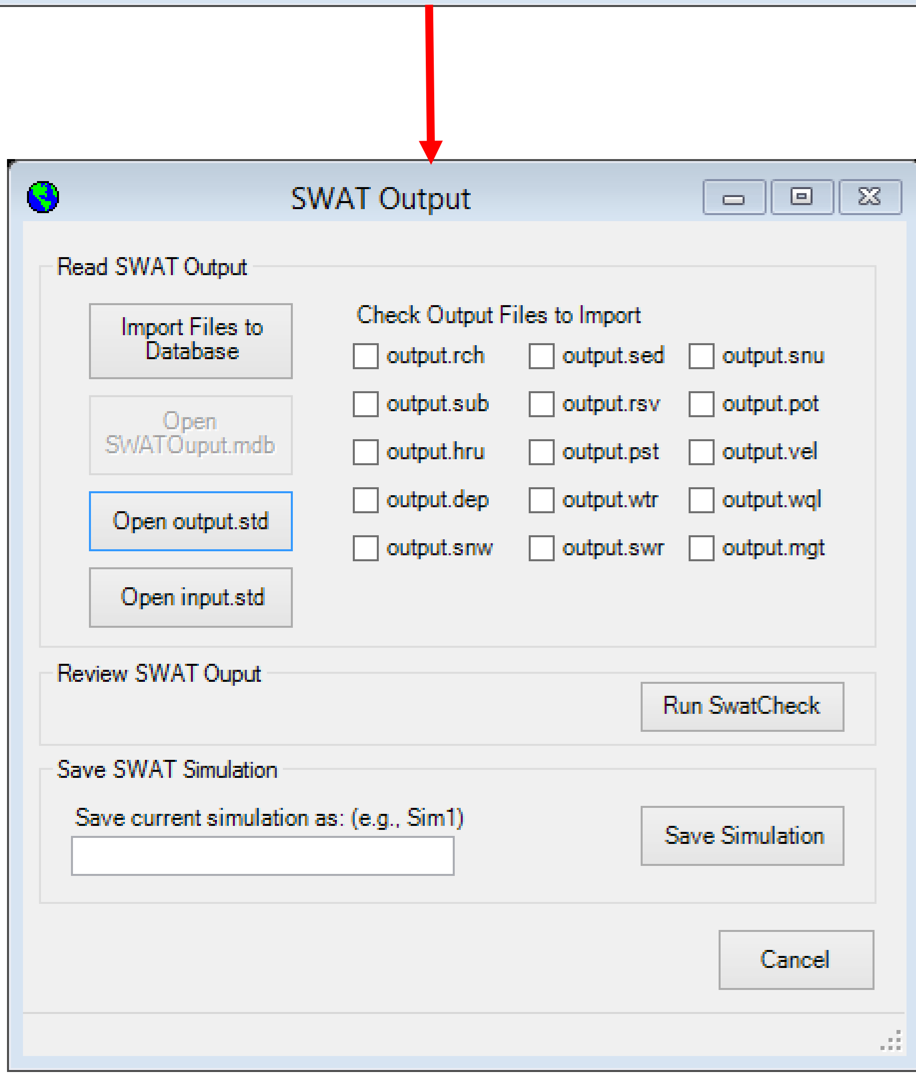
6. Next, I input the weather data (Temperature, Precipitation, Wind, Solar Radiation, and Relative Humidity) I had gathered



7. Finally, I wrote the input tables, set up SWAT, and ran the simulation

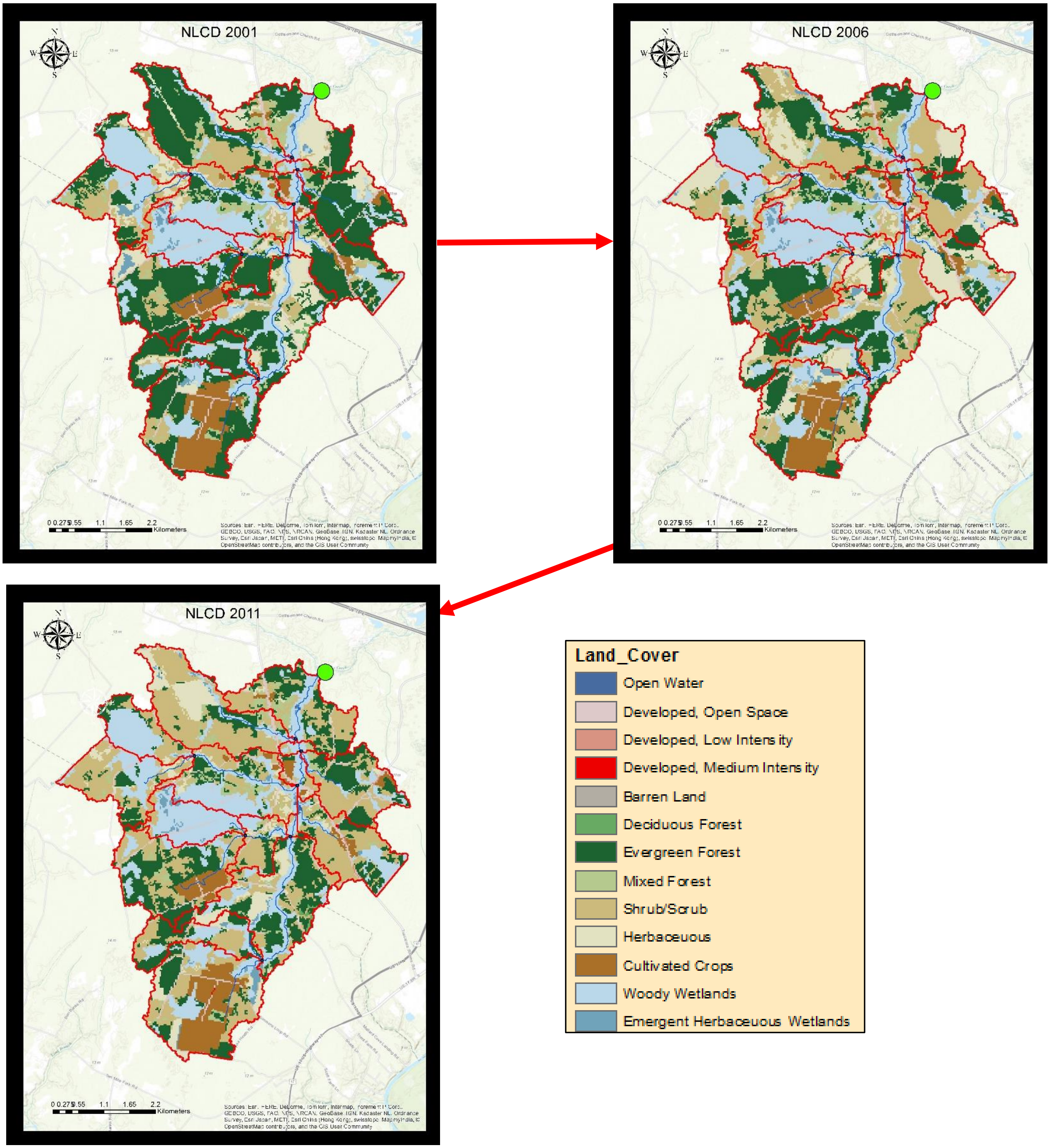



C:\Windows\system32\cmd.exe
SWAT2012
Rev. 627
Soil & Water Assessment Tool
PC Version
Program reading from file.cio . . . executing
Executing year 1
Executing year 2
Executing year 3
Executing year 4
Executing year 5
Executing year 6
Executing year 7
Executing year 8
Executing year 9
Executing year 10
Executing year 11
Executing year 12
Executing year 13
Executing year 14
Executing year 15
Executing year 16


SWAT Output
Read SWAT Output
Import Files to Database
Open SWATOuput.mdb
Open output.std
Open input.std
Check Output Files to Import
output.rch
output.sed
output.snu
output.sub
output.rsv
output.pot
output.hru
output.pst
output.vel
output.dep
output.wtr
output.wql
output.snw
output.swr
output.mgt
Review SWAT Ouput
Run SwatCheck
Save SWAT Simulation
Save current simulation as: (e.g., Sim1)
Save Simulation
Cancel

My Model

I configured three different versions of my model. Each model was identical except for the Land Use Data. The first model used NLCD 2001 Data, the second model used NLCD 2006 Data, and the third model used NLCD 2011 Data. Each model predicted monthly values of various parameters for 21 years.



After running the models, I analyzed the output files for average annual Nitrate (NO_3) and Phosphorus (P) leached as well as average annual sediment transport downstream, surface runoff, and evapotranspiration.

Results

Table 1. Predicted Parameters from ArcSWAT

Year	N03 (kg/ha)	P (kg/ha)	Sediment (T/ha)	Shrub/Scrub (% of Catchment)	Surface Runoff Q (mm)	ET (mm)
2001	3.246	0.165	1.624	12.08	278.9	799.7
2006	4.103	0.15	3.816	24.81	354.57	761.4
2011	4.164	0.154	3.653	33.7	341.68	765

***All values are average annual values**

Table 2. Land Use Change from 2001 to 2011 in the study catchment

Change, 2001-2011	Change, % of area
Open Water	-0.01
Developed, Open Space	0.01
Developed, Low Intensity	0.02
Developed, Medium Intensity	0.01
Barren Land	0.06
Deciduous Forest	-0.04
Evergreen Forest	-17.05
Mixed Forest	-1.24
Shrub/Scrub	21.63
Herbaceous	-3.16
Cultivated Crops	-0.05
Woody Wetlands	-0.14
Emergent Herbaceous Wetlands	-0.03

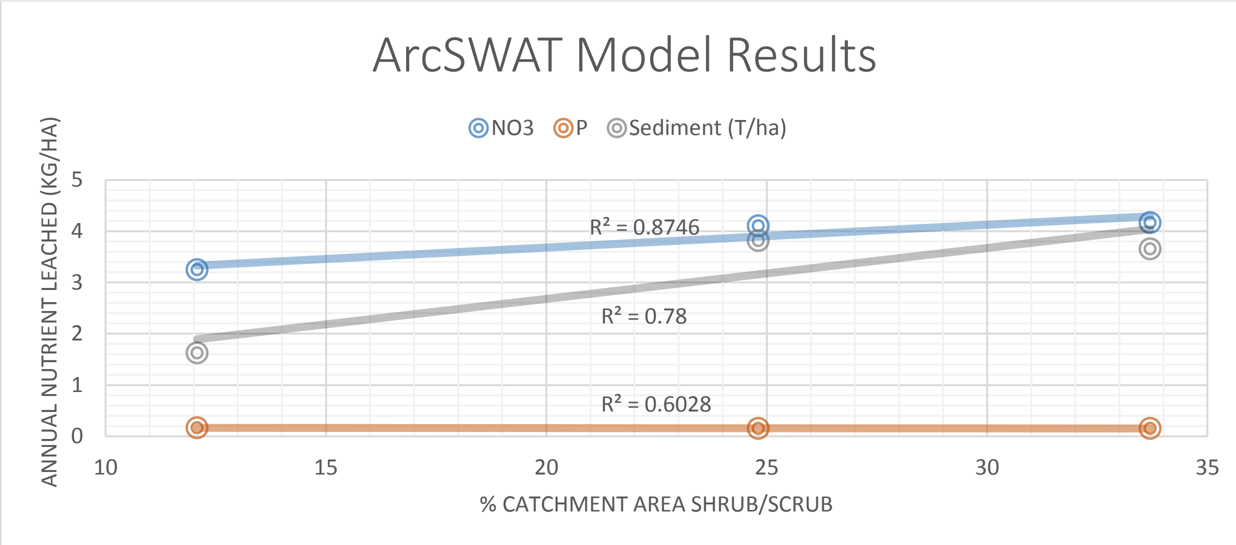


Figure 1. Predicted parameters from three ArcSWAT simulations of differing land use cover

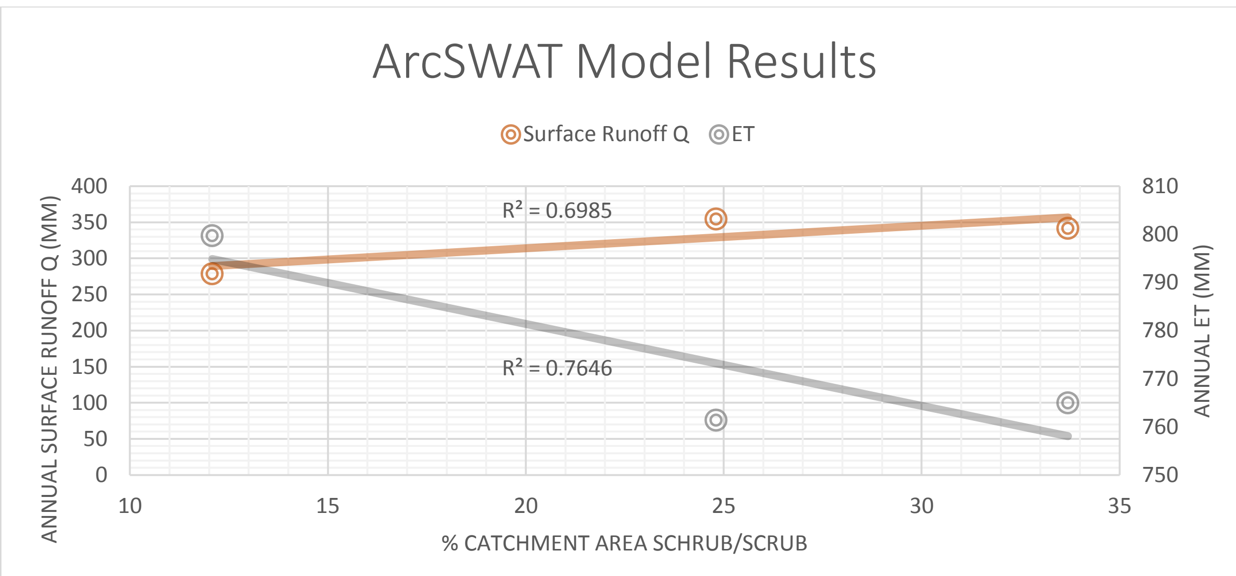


Figure 2. Predicted parameters from three ArcSWAT simulations of differing land use cover

Discussion

Three ArcSWAT models were setup and run to predict monthly parameters for 21 years to increase the amount of iterations and decrease variability in predictions. 252 sets of predictions went in to calculating each parameters average annual value, which makes the trends in Figure 1 and Figure 2 more meaningful.

Of the studied parameters, amount of Nitrate leached was found to be the most correlated to the percent of catchment area Shrub/Scrub (R^2=.875). Average annual Nitrate leached, Phosphorus leached, sediment loading, and surface runoff all increased with increasing percentage of catchment area Shrub/Scrub. Amount of Phosphate leached did not change significantly as the percentage of catchment area Shrub/Scrub increased, and Evapotranspiration decreased as Shrub/Scrub became more prevalent.

Conclusion

ArcSWAT is a powerful tool that makes SWAT much easier to setup and run correctly. A calibrated ArcSWAT model can be extremely useful for predicting water quality and hydrologic dynamics in gauged and ungauged catchments.

Changing the land use of a catchment greatly impacts many of the biotic and abiotic processes affecting water quality and hydrologic dynamics, and my investigation demonstrates this fact. Future work on this project that I hope to complete is to calibrate this model or a similar model with data (stream discharge, nitrate levels, turbidity) that I collect from the site.

It is important to note that my model was not calibrated, so the results from this investigation should not be used to actively predict parameters for this catchment. Actively using this model would require careful calibration and measurements directly from my study catchment. Rather, this investigation should be used to illustrate the viability of ArcSWAT and other models to be used experimentally.

Works Cited

SWAT Information: http://swat.tamu.edu/

ArcSWAT Software: http://swat.tamu.edu/software/arcswat/

Land Use Data: http://www.mrlc.gov/

Soils Data: ESRI Landscape1 Server, landscape1.arcgis.com_443

Elevation Data: http://geodata.lib.ncsu.edu/NCElev/

Weather Data: http://globalweather.tamu.edu/