Model Implementation Details for the Final Project in EEOS 465/627 2009

Last week, we introduced a conceptual model of estimating DOC loadings from landscape to coastal waters as a model template for the final project. The design of the spatial information product, compartments, and systematization of the ecological system into a quantitative model are key training targets in this project. Soon, we will move to the formulation and implementation phase. In order to make this document self-contained, we will review the conceptual model first, and then describe specific objectives of the final project. Please view this document is a model implementation proposal. You have the freedom to modify the objectives or implement the model in your own way. While his document may seem lengthy, most of its contents are data description, calculation details and implementation hints. Unlike a lab exercise, a project proposal describes the objectives and suggested deliveries. It is up to you to make decisions for the details, and additional knowledge and data sets as required. I encourage you to contact possible experts on the subject matter, and search for further information through all available avenues. Please feel free to contact me or Jun during our office hours, before and after classes, and through email messages to get the help you need.

The central objective of this final project is to estimate the DOC sources and mean monthly DOC loading from the Neponset River Watershed to coastal waters. You will build a GIS model which associates DOC concentration to the landscape's biological and hydrological characteristics. We will focus on part of the tasks described in the conceptual model described in the previous week (Figure 1):

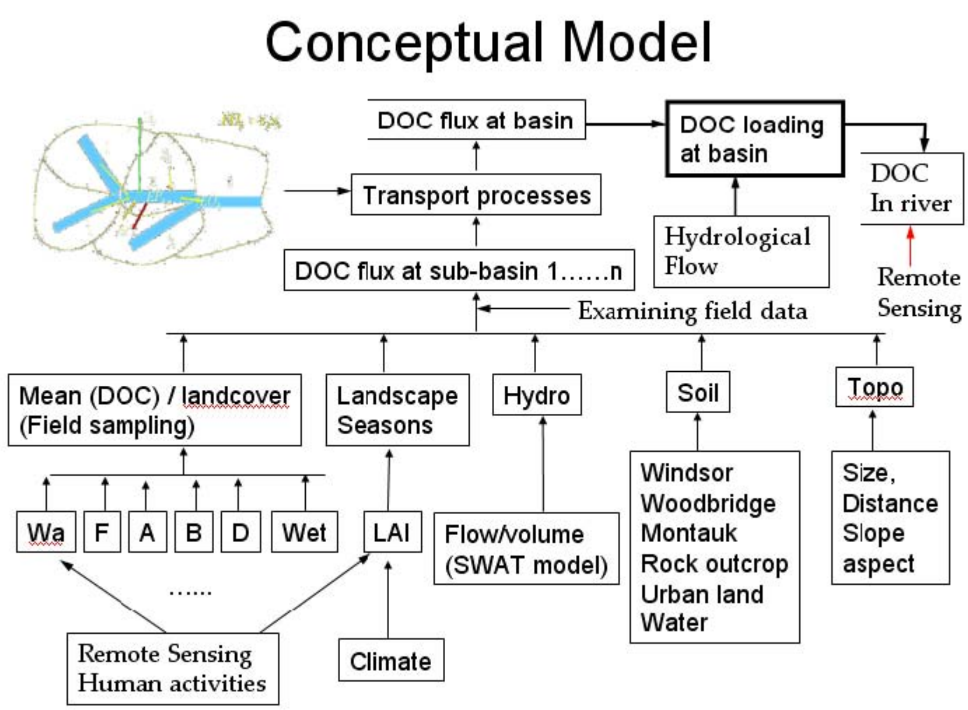

Figure 1: The conceptual model for estimating monthly DOC total loading to coastal water from a coastal watershed

I propose that your modeling scope should (at a minimum), answer the following two required questions:

1. What are the mean monthly DOC concentrations at the outlet of each sub-basin in Neponset Watershed?

2. What is the mean monthly DOC loading to coastal waters from the entire Neponset Watershed?

Available data: The data required for the described tasks are provided and described as follows:

a) Monthly DOC concentrations for Wetland, Developed, and Forest land-covers for 2006 and 2007

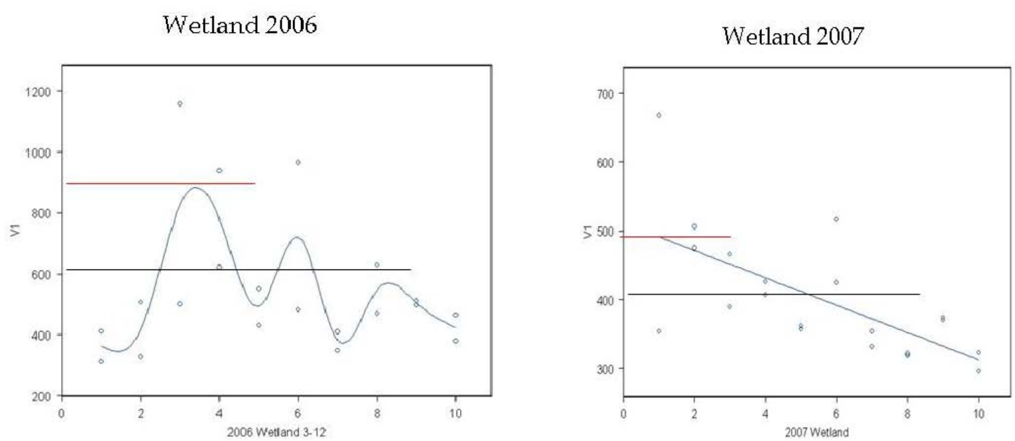

Figure 2, Sampled DOC concentrations for the Wetland LULC. The black horizontal lines are the annual mean and red lines are the annual maximum. The X axis (1: March, 2: April,…….10: December).

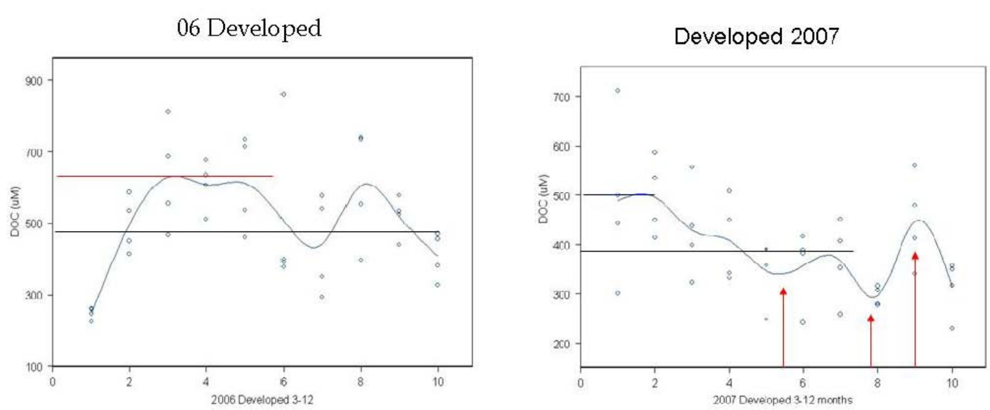

Figure 3, Sampled DOC concentrations for the Developed LULC.

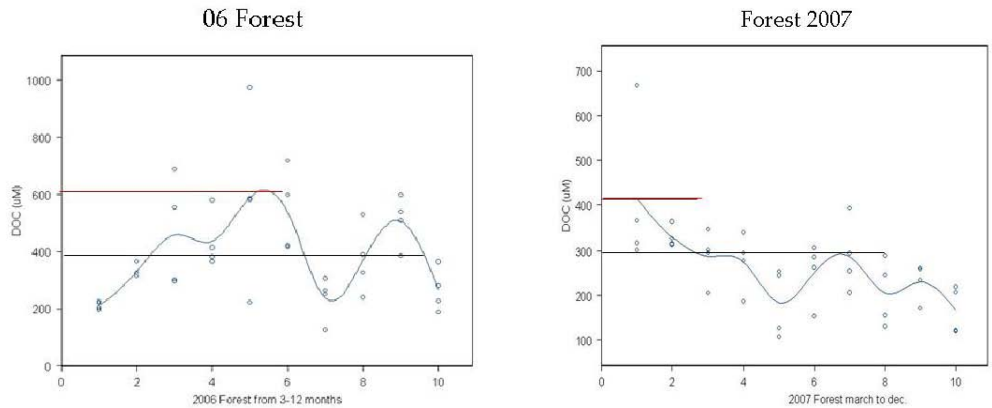

Figure 4, Sampled DOC concentrations for the Forest LULC.

Since the sampled DOC concentrations are only available for three land-uses (wetland, developed and forest), we will assume that all other land-uses have a mean DOC concentration of 250 (μM). In order to take best advantage of the measured DOC concentrations for the three land-uses, you might want to reclassify land-use data. For example, you might want to group Agricultural land-use with forest on the basis of their similarity, and group water with wetland etc.

The units of the DOC values displayed in the figures above are micro-molarity (μM). Molarity is a way of expressing concentration. Molarity is the number of moles of solute dissolved in one liter of solution. The units therefore are moles per liter; specifically, this is moles of solute per liter of solution. Rather than writing out moles per liter, these units are abbreviated as M.

$$\textit{Molarity} = \frac{\text{moles of solute}}{\text{liter of solution}}$$

You must be very careful to distinguish between moles and molarity. A quantity of moles measures the amount or quantity of material you have, while molarity measures the concentration of that material. So when you're given information that says that the concentration of the solution is 0.1 M that means that it has 0.1 moles for every liter of solution; it does not mean that 0.1 moles are present. Please be sure to make that distinction.

b) Mean daily flow at Milton Dam, which is the outlet of the entire Neponset Watershed is available for the first 162 days of 2006 and 2007:

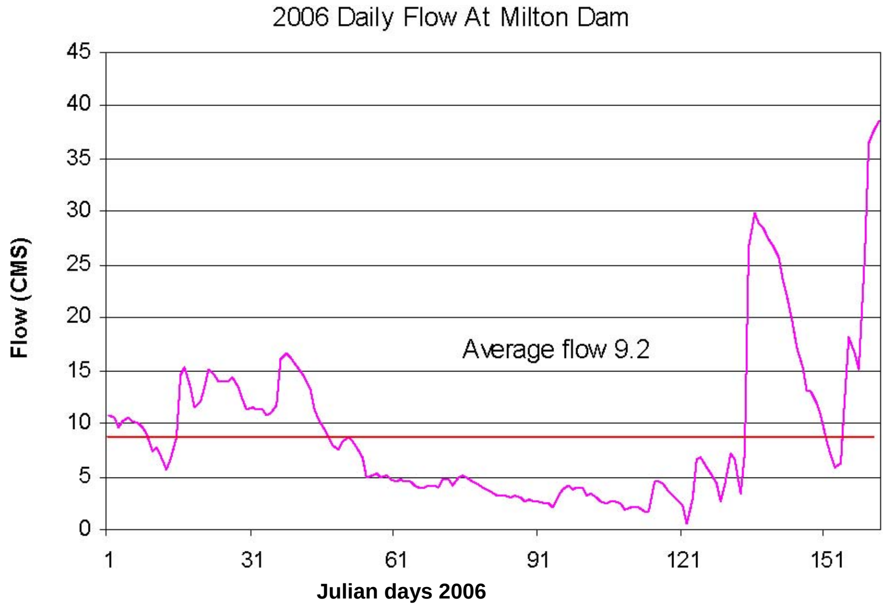

Figure 5: Mean daily flow at the Milton dam for the first 162 days of 2006. CMS indicates the units are cubic meters per second. The average flow for this period is 9.2 CMS.

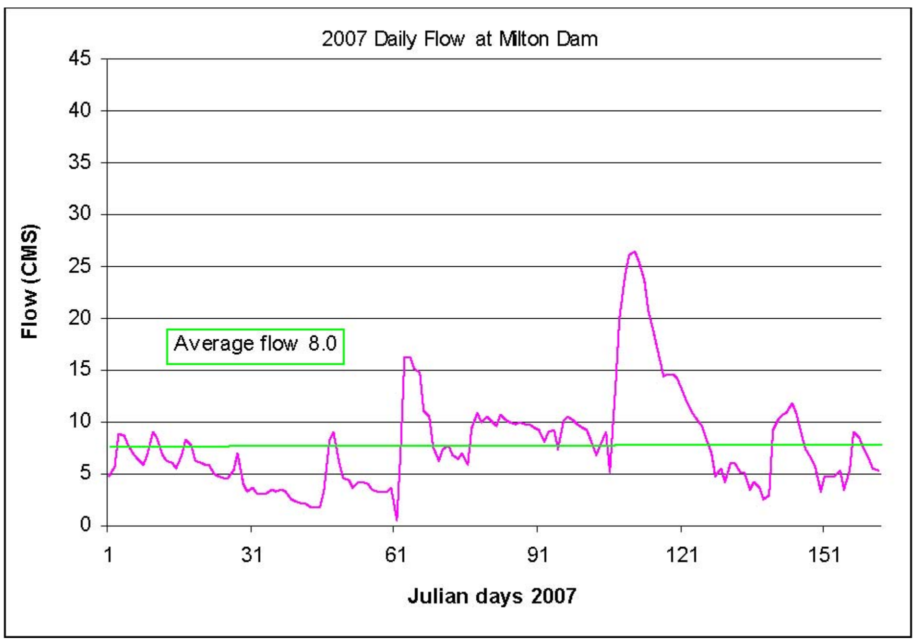

Figure 6: Mean daily flow at Milton dam for the first 162 days in 2007. The average flow is 8 CMS.

The actual flow data is located in the provided final project data directory in miltoflow.xls. Although the daily flow record monitored Milton Dam gauge station is available for the first 162 days of years 2006 and 2007, it is recommended to use average flow only in your project. Because of time limitations, it might not be practical to implement the project using the actual variable flow records. The average flows for both years are shown in Figure 5 & 6. Assume that the flow at the outlet is evenly contributed from every cell within the watershed. Once you figure out the mean runoff from each individual cell within the watershed, you can calculate the mean DOC concentration in each sub-basin, and the total monthly mean DOC loading from each sub-basin.

Leaf area index (LAI) can be substituted by a surrogate, the enhanced vegetation index (EVI) derived from MODIS satellite images. We have an EVI for each month for the years 2006 and 2007. These EVI data are stored in two personal databases in the final project data directory. A description and the metadata information for the MODIS EVI products can be found at http://lpdaac.usgs.gov/modis/dataproducts.asp#mod13 & http://modis-land.gsfc.nasa.gov/vi.htm. Two example EVI data sets for our study area are displayed below (Figure 7):

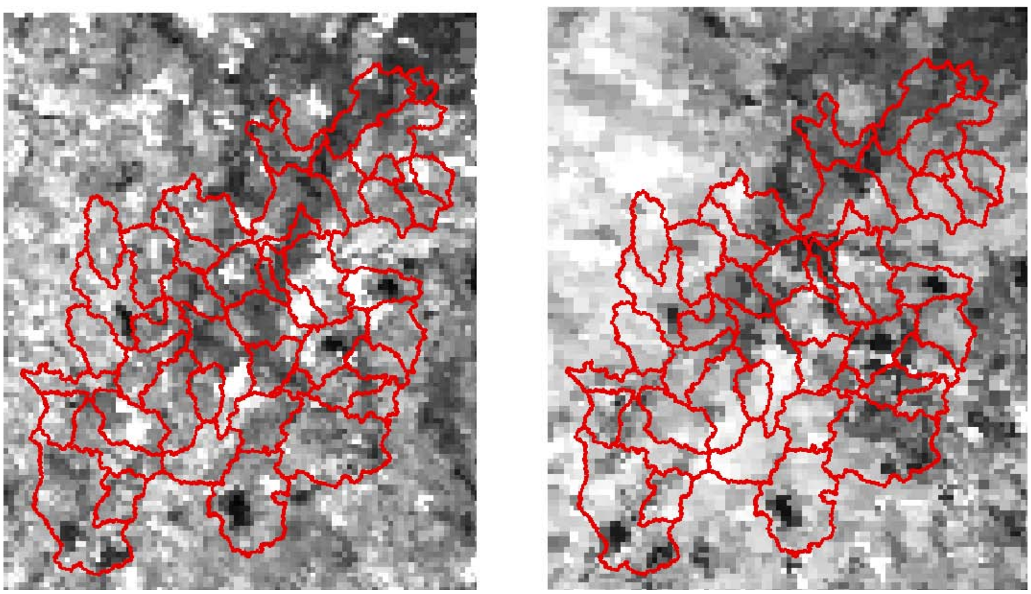

Figure 7: EVI for 2007 January (left) and 2007 August (right)

c) Other required GIS data sets include the LULC and sub-basin data. The details of the classification schemes for LULC in the MRLC national database can be found at http://www.epa.gov/mrlc/definitions.html. The landuse data is stored in the final project data directory in nepwlualbert1. The filename stands for Neponset Watershed Landuse in Albers projection. The sub-basin layer (red polygons) is also provided in the data directory, named basin.shp.

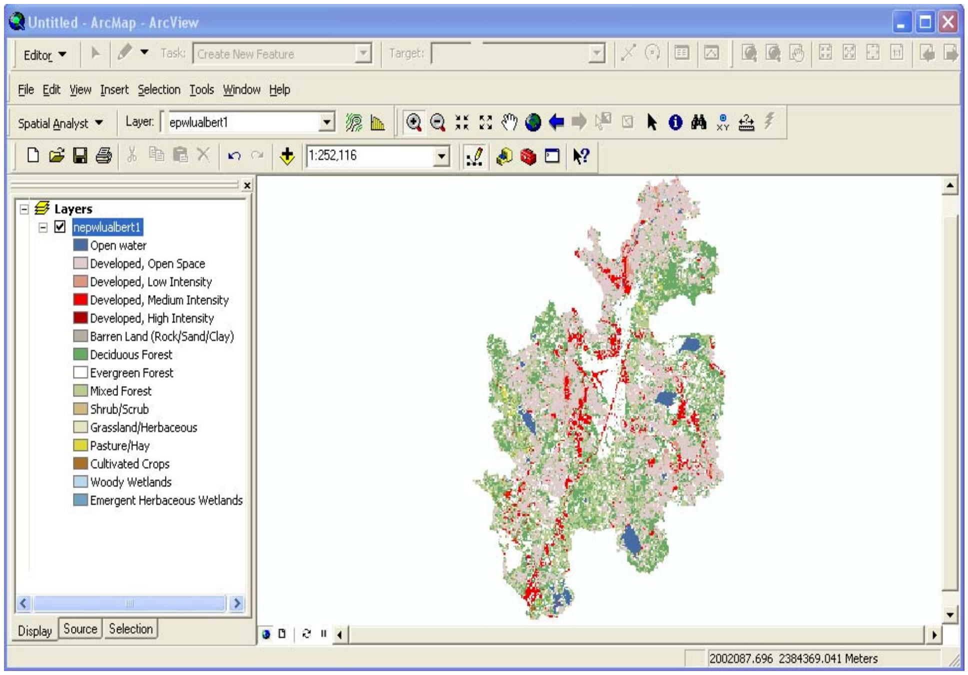

Figure 8: LULC data for the Neponset River Watershed

You can display the standard legend by importing the lulc2001.lyr as displayed below:

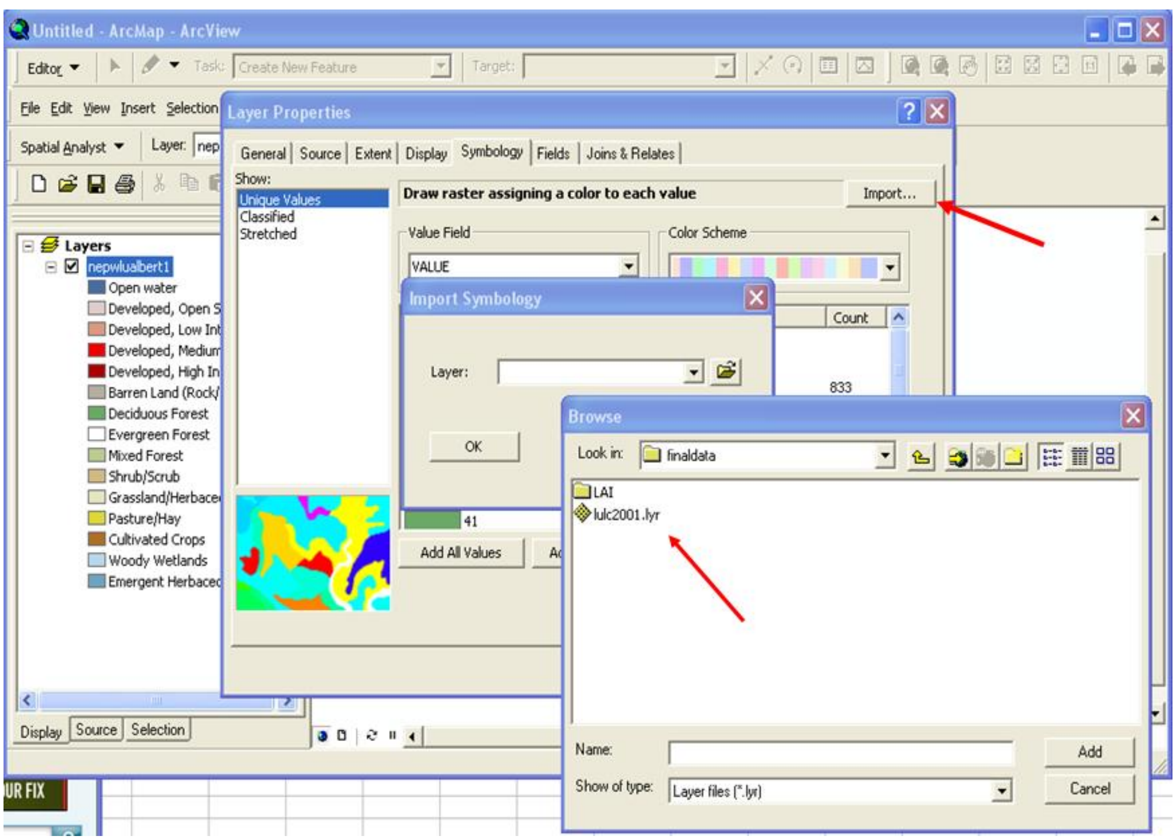

Figure 9: Importing legend for LULC data

The formulae to describe C contribution from our 4-part LULC scheme include four equations:

1) The DOC concentrations should be modified with LAI values as followings

$$C_w' = C_w \times (\frac{l_v}{L_M}) \quad (1)$$

$$C_d' = C_d \times (\frac{l_v}{L_M}) \quad (2)$$

$$C_f' = C_f \times (\frac{l_v}{L_M}) \quad (3)$$

$$C_o' = C_o \times (\frac{l_v}{L_M}) \quad (4)$$

where C_w, C_d, C_f and C_o represent for the mean annual concentrations for wetland, developed, forest and other land-uses respectively as displayed in figures 2-4. C_w' C_d' C_f' and C_o' are the DOC concentrations, varied with vegetation density and biomass for wetland, developed and forest. The enhanced vegetation index (EVI) in raster format is suggested to be used as a surrogate for vegetation biomass and density. l_v is the EVI value for a target cell and L_M is the mean value of EVI in the Neponset watershed. These $C_w' C_d' C_f'$ and C_o' values should be used for calculating the DOC concentration for each individual cell within the watershed:

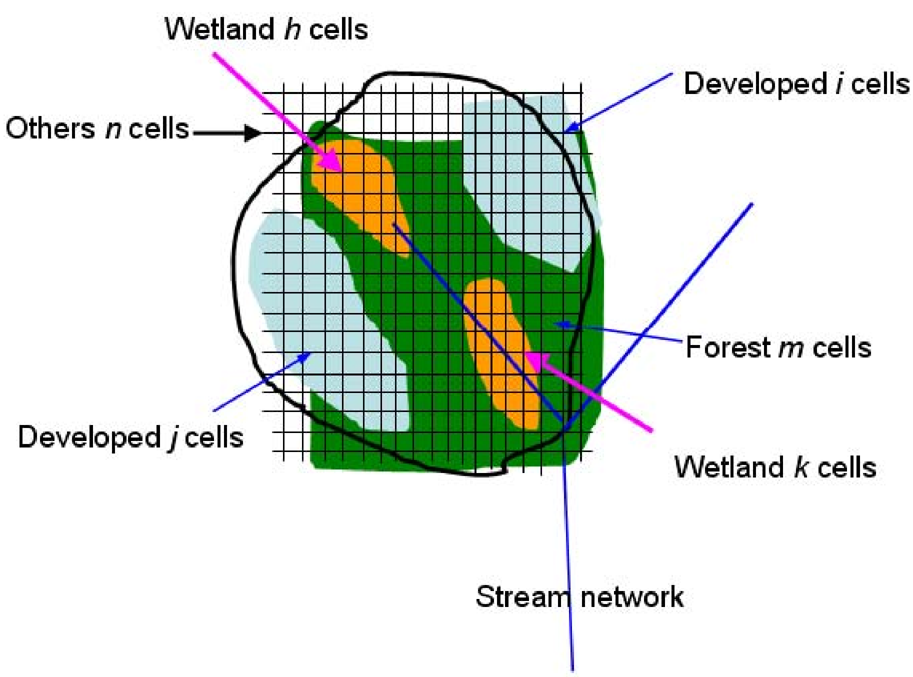

Figure 10: A schematic of the sub-basin DOC concentration calculation. Where i, j, h, k, m, n are the number of cells of each type in the region.

The exemplary sub-basin DOC concentration *C(s)* is calculated as in equation (4) below:

$$C(s) = \frac{(C_d^{'} \times (i+j) + C_w^{'} \times (h+k) + C_f^{'} \times m + C_o^{'} \times n)}{i+j+h+k+m+n} \qquad (5)$$

2) Total mean monthly DOC loading in each sub-basin, *T*(s) can be calculated as:

$$T(s) = C(s) \times Q(s) \qquad (6)$$

where Q(s) is the monthly mean flow volumes in sub-basin *s*. You'll need to search the literature and do some dimensional analysis to figure out the appropriate units for T(s) for our watershed of ~130 square miles. Is kilograms the right unit?

3) Total mean monthly DOC loading in Neponset River Watershed, *T:*

$$T = \sum_{s=1}^{E} C(s) \times Q(s) \qquad (7)$$

where E is the number of sub-basins in Neponset watershed.

You will be required to deliver a final report (10+ pages for graduate research groups, 5+ pages for undergraduate research groups) and a 10-minute presentation (supported by explanatory visual aids, e.g. you may wish to use PowerPoint).

Here are some required deliverables in your final report and presentation:

a) In the report, summarize the critical implementation details and the difficulties encountered (and how they were resolved)
b) Create a table and map for C(s) of each sub-basin similar to Figure 11 (below). You need to provide sufficient explanation/captions for a reader to understand your figures. For example, where are the sub-basin with high DOC concentrations or loadings? Why are those conditions present in those basins?
c) Mean total monthly DOC loading in Neponset River Watershed

Here are some suggested deliverables in your final report and presentation:

a) As an experiment, use different EVI layers (January and April) to see how T responds
b) What is the projected T response when mean monthly DOC conc. is + or - %25?
c) What is the difference between T in 2006 and 2007?
d) If the T in 2006 is X moles higher than that in 2007, and Q in 2006 is Y cubic meters more than that in 2007, is the ratio of X/Y similar to T/Q in 2007 or 2006?

Your final presentation and final report must include the following components:

- A statement of a broad policy or scientific question with issues that will be informed by the results of this project i.e. a statement of the importance of this issue to local government and society as a whole.
- A statement of a specific question that is directly addressed by the results of this project.
- A description of each GIS data source used in the GIS analysis, including the core metadata fields for each data set.
- A diagram of the data model used in the GIS analysis.
- A technical description of the GIS analysis completed, including the reasons for the selection of particular types of analyses.
- A non-technical description of the primary results of the GIS analysis.
- A non-technical description of how the results of the GIS analysis answer the specific question (see above) and how the results inform the policy question.

Your final report must use the following format:

1. Title
2. Introduction / Background
3. Objectives
4. Methods / Critical Implementation Details
5. Results and Analysis (be descriptive here!)
6. Discussion (include a few points to lead readers towards an in-depth understanding of the science and technical aspects of the work)
7. Conclusions (with a few brief take-home messages for the reader)

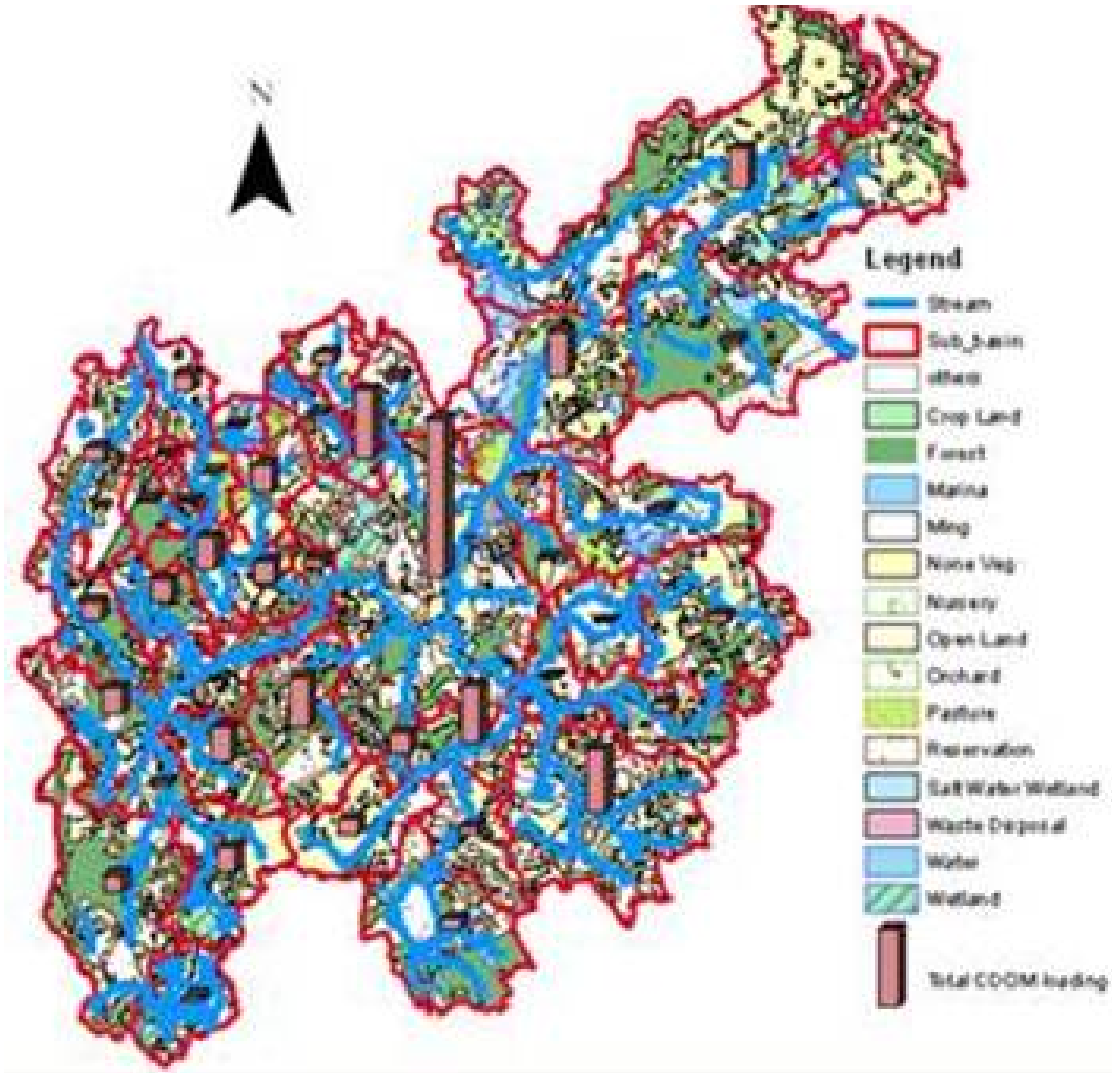

Figure 11: An example mean monthly DOC concentration map for each sub-basin