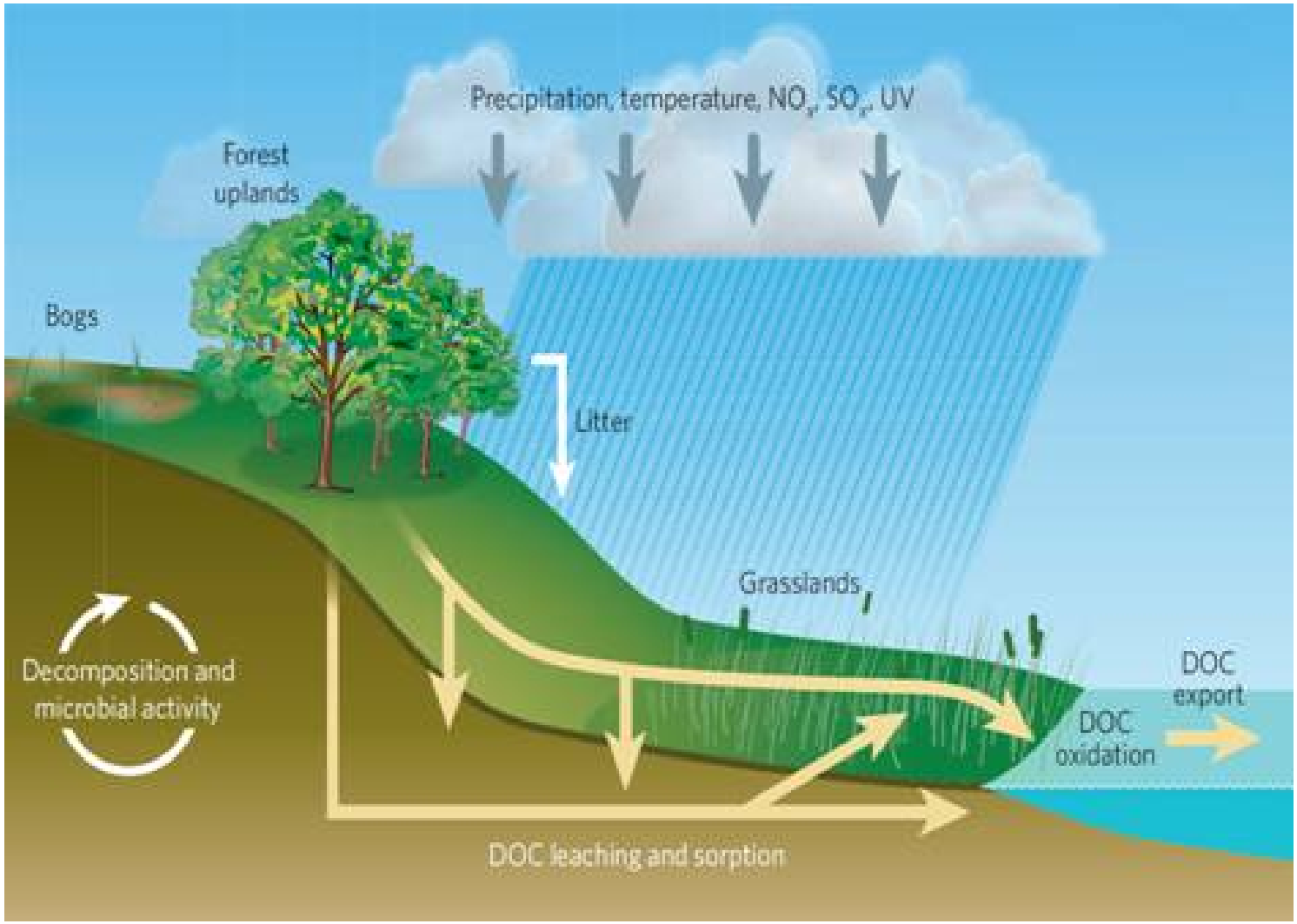
Modeling Riverine Monthly Carbon Flux from the Neponset River Watershed to the Ocean

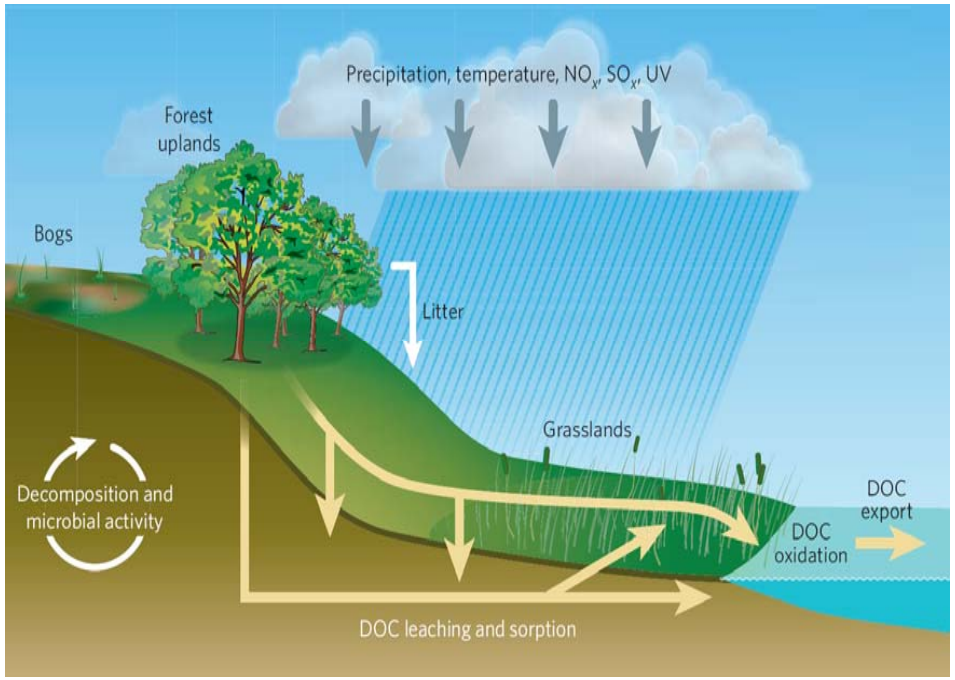


Passage of dissolved organic carbon through the landscape (Roulet & Moore, 2006, *Nature*)

Date	Topic	Background Material	Lab / Project Work
PROJECTS USING ENVIRONMENTAL MODELING WITH RASTER GIS			
03/25/09	Group Formation and Proposal Creation	•Project Outline	•Preliminary Project Work
04/01/09	Project Design and Document Preparation	•Project Implementation	•Progress Report 1, Discussion, and Collaboration
04/08/09	Formulation and Implementation I	•Graduate Reading Assignments	•Graduate Presentations
04/15/09	Formulation and Implementation II	N/A	•Progress Report 2, Discussion, and Collaboration
04/22/09	Verification and Validation	N/A	•Progress Report 3, Discussion, and Collaboration
04/29/09	Document and Presentation Preparation I	N/A	•Progress Report 4, Discussion, and Collaboration
05/06/09	Document and Presentation Preparation II	N/A	•Progress Report 5, Discussion, and Collaboration
05/13/09	Project Presentations	N/A	•Project Presentations

Background Information

- Terrestrial ecosystems: **Significant sources** of marine DOC
- **Impacts**:
  - Coastal ecosystem
  - Carbon cycle
- Crucial to **quantify the sources and transport mechanisms** of DOC to coastal water
- **Challenging** in modeling
  - Field measurement
  - Multiple sources
  - High biogeochemical reactivity



Passage of dissolved organic carbon through the landscape (Roulet & Moore, 2006, *Nature*)

Project Objectives

- **DOC concentration or flux** to runoff **varies** according to the land's physical biological, climatic and hydrological characteristics, including seasonal productivity and soil properties

1. To investigate what **land surface factors** affect the **variability** of the **DOC runoff rate**?
2. To **accurately estimate DOC flux** at the **sub-basin scale**?
3. To **integrate DOC flux** from the sub-basin scale to the **entire watershed's scale**, and to **route fluxes** to the receiving coastal waters by **considering transport processes**

Applications of the Model

- To examine **seasonal trends** of DOC flux to coastal waters in the last two decades
- To examine percent changes of total annual DOC flux **due to land cover type changes** in the past decade (i.e. the impact of human activities)
- To examine **impacts of climate change** on DOC flux to coastal waters

Components of the Model

SIP: **Mean monthly carbon flux at Milton Dam**

Compartments:

- **Photosynthesis** of land biota (f(x) of veg., LULC)
- **Respiration** of land biota (f(x) of veg., LULC)
- **Soil respiration** (soil types)
- **Plant roots** to the soil (soil types and LULC)

Scenarios:

- Deforestation, clearing, litter fall
- Human activities and natural events

Topographic and Location Factors

- Slope
- Aspect
- Distance (from stream)
- Size (of land-use proportion in sub-basin)

Hydrological Factors

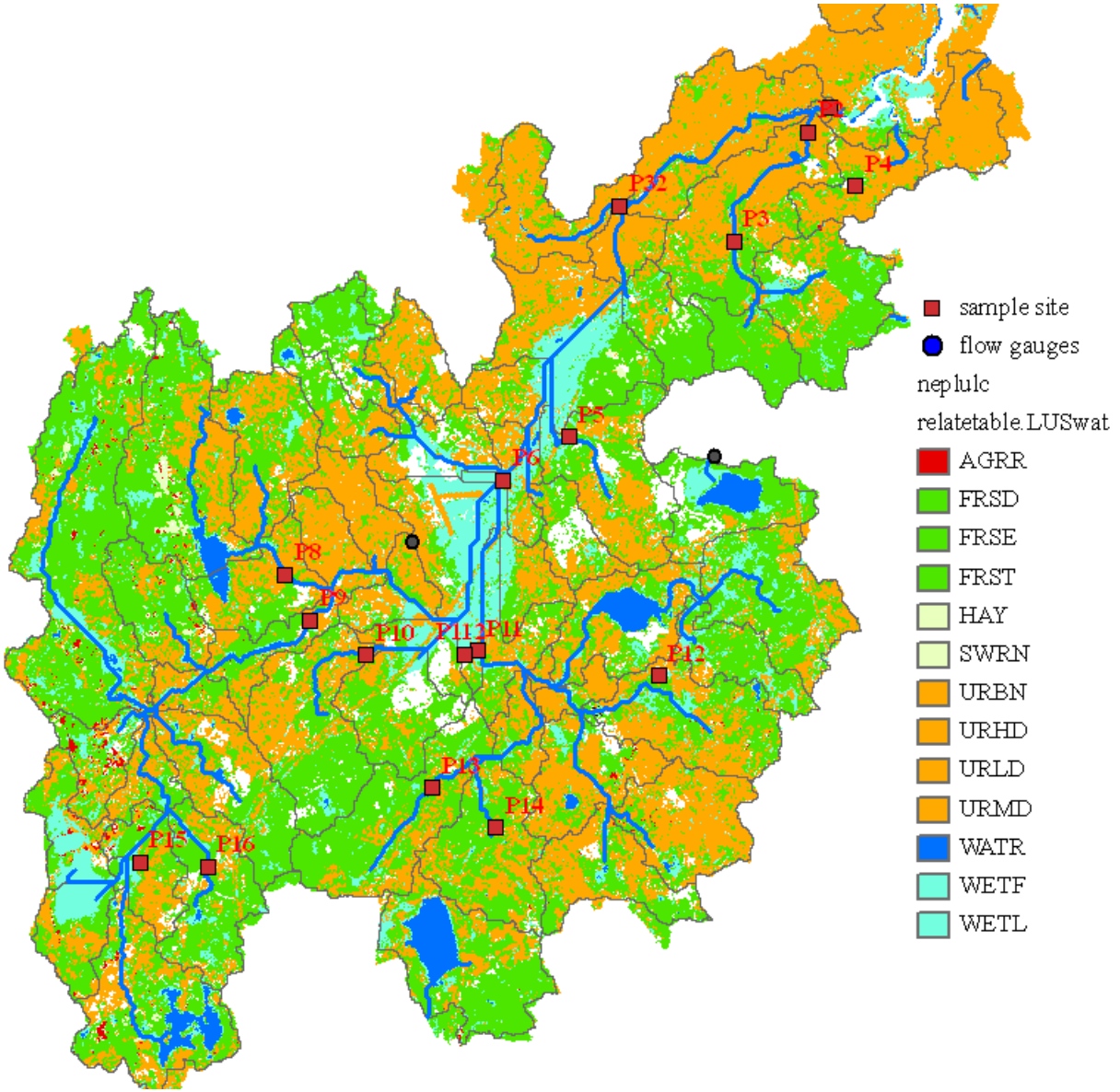
- Precipitation
- Surface runoff production (as volumes)
- Surface flow rate (for routing)
- Sediments

Other Relevant Factors

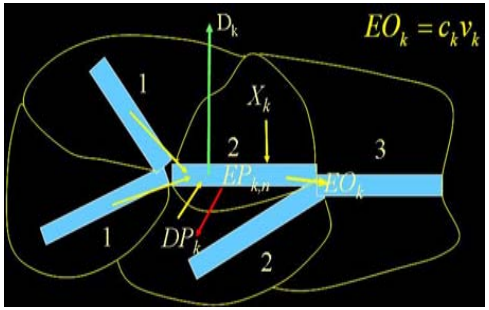
- Climate (in particular, temperature)
- Seasonal Characteristics

Land Cover 2001

- Recalculate % LULC on **sub-basin** basis
- Incorporate **new data** for associated areas
- Use **leaf area index** (LAI) from remote sensing to take into account **seasonal effects**



Productivity?
Decomposition?



DOC flux/mons — flow * mean concentration

Transport processes

DOC flux at sub-basin — flow * mean concentration

Land cover

Seasons

Hydro

Soil

Topo

Wa | F | A | B | D | Wet

LAI

Flow/volume

Windsor
Woodbridge
Montauk
Rock outcrop
Urban land
Water

Size,
Distance
Slope
aspect

Climate

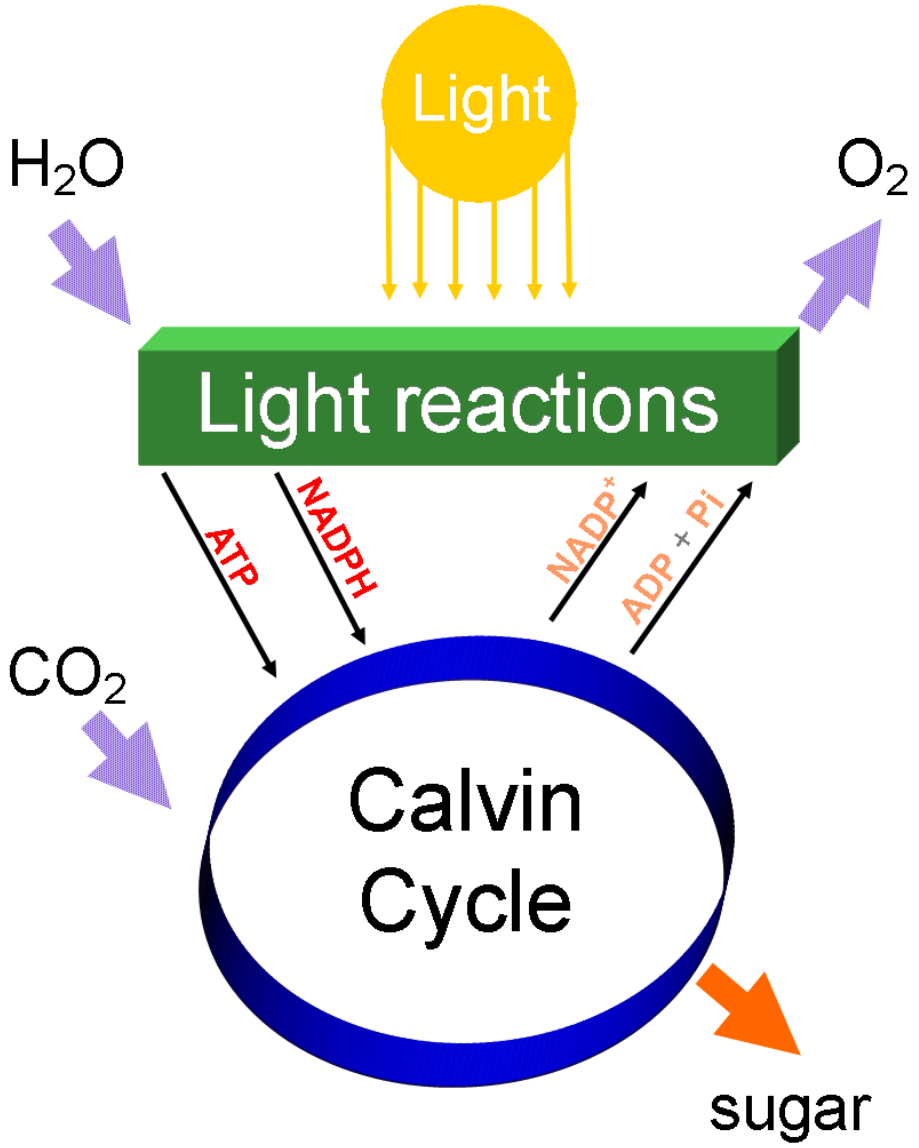
flux is defined as the amount that flows through a unit area per unit time
http://www.epa.gov/mrlc/definitions.html
LAI is the ratio of total upper leaf surface of vegetation divided by the surface area

Photosynthesis

- The **conversion** of **light energy** into **chemical energy** by living organisms
- The **raw materials**:

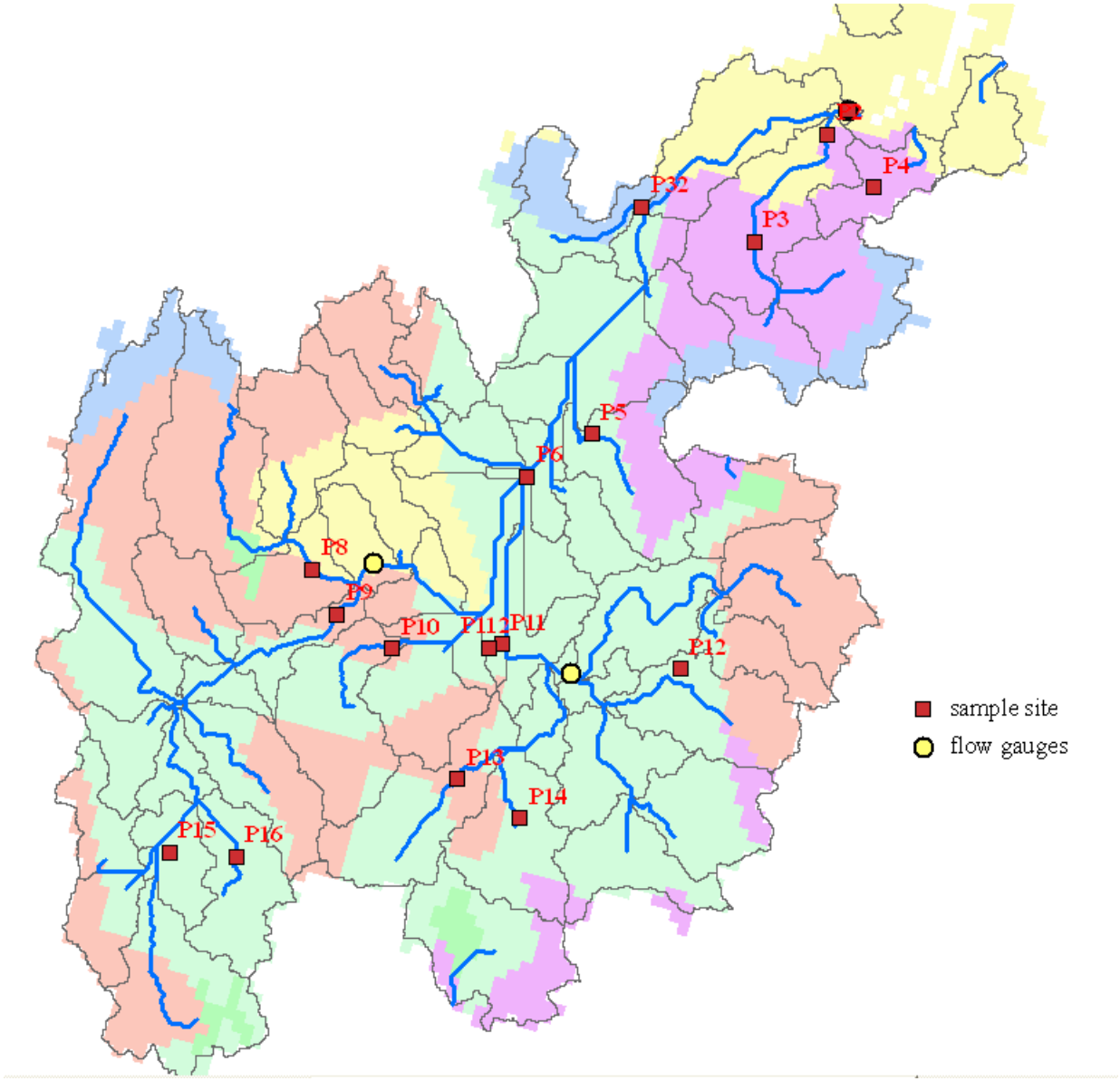
  Carbon dioxide and water (plus sunlight)
- The **end-products**:

  Oxygen and (energy rich) carbohydrates



Soil Types

- **Correlate** soil with DOC samples
- Identify the **dominant and %** of soil types **per sub-basin**
- Also identify **adjacent** soil types

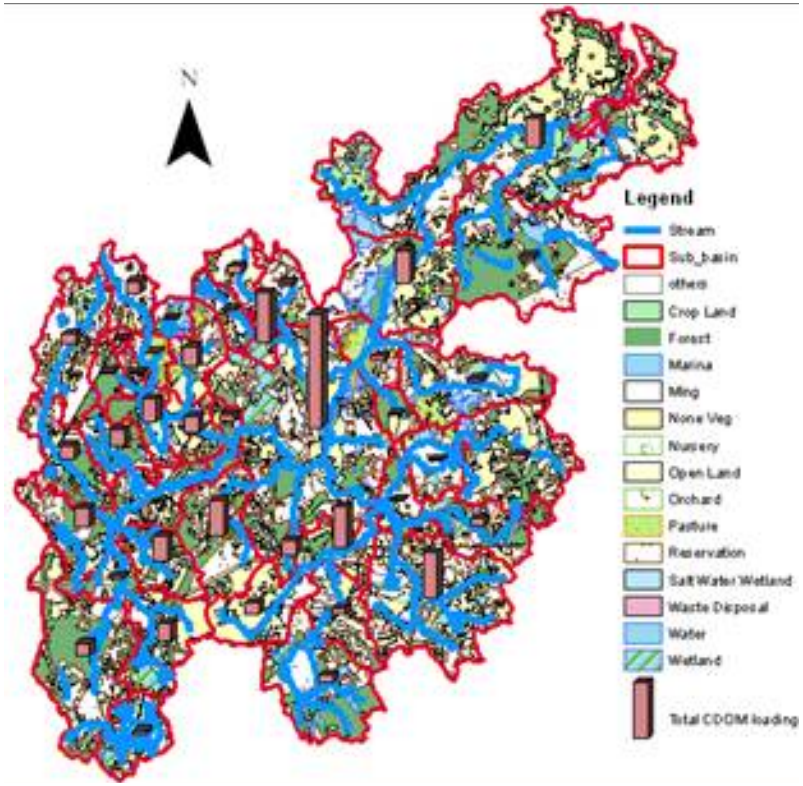


Explore Other Important Variables

- Hydrological processes
- Soil types
- Distance to outlet
- Dominant land cover
- LAI
- Scale (size) of the sub-basin
- Sediment

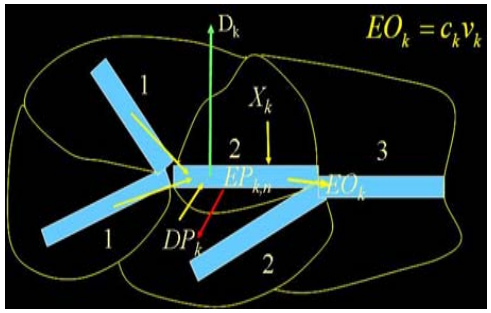
Project Objectives 2

- We are seeking **surrogate variables** which can **link human activities and remote sensing data** to riverine DOC fluxes
- We wish to identify **factors driving DOC dynamics** (Source and transport processes)



- We are attempting to **estimate DOC flux** at the sub-basin and basin scales

Conceptual Model



DOC flux at basin

DOC loading at basin

DOC In river

Transport processes

Hydrological Flow

DOC flux at sub-basin 1……n

Remote Sensing

Examining field data

Mean (DOC) / landcover (Field sampling)

Landscape Seasons

Hydro

Soil

Topo

Wa | F | A | B | D | Wet

LAI

Flow/volume (SWAT model)

Windsor
Woodbridge
Montauk
Rock outcrop
Urban land
Water

Size,
Distance
Slope
aspect

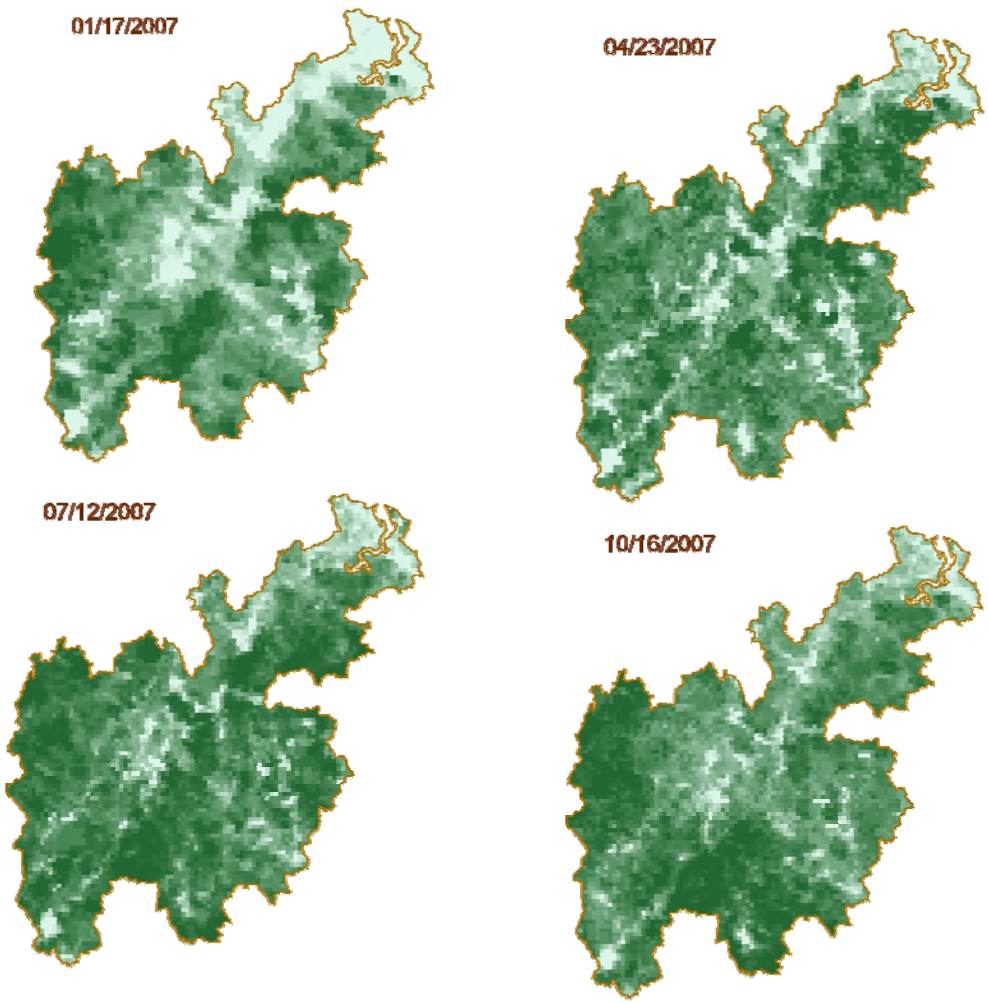
……

Remote Sensing
Human activities

Climate

Seasonal Vegetation Changes and Density (NDVI)

- Land Products Data Acquisition and Archive Center (**LP DAAC**)
- **MODIS** product, 16-day composite
- 250 m cell size



Conceptual Model

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

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

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

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

Mean monthly DOC flux at basin

Mean monthly DOC loading at basin

DOC In river

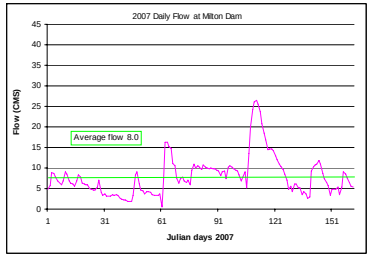
DOC flux at sub-basin 1……n

Mean monthly flow

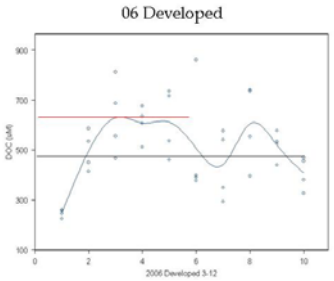
Mean (DOC) / landcover (Field sampling)

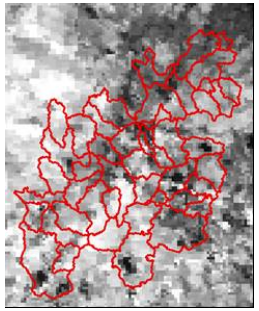
Landscape Seasons

Hydro

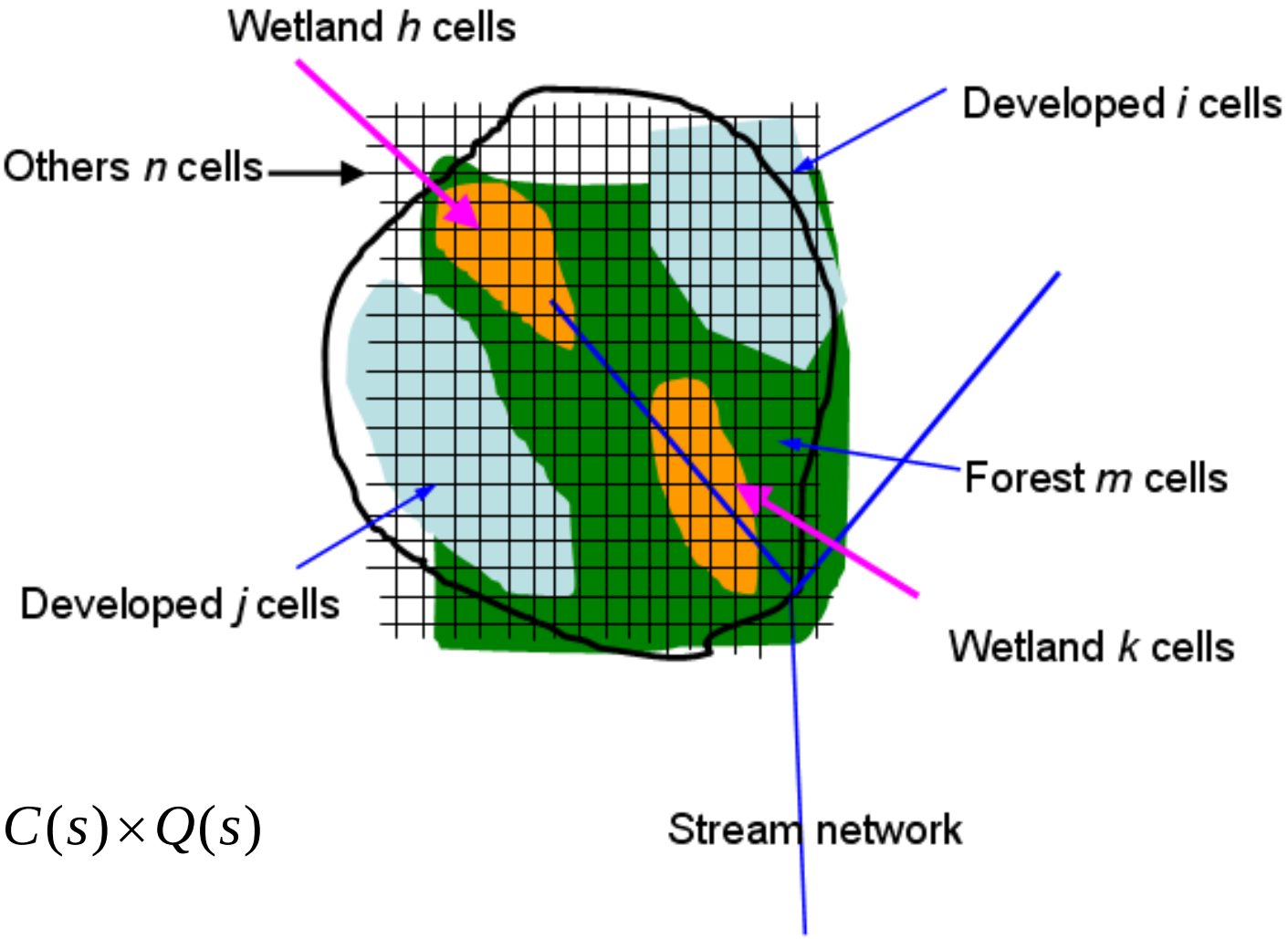


Wa | F | A | B | D | Wet | LAI | Mean monthly Flow/volume





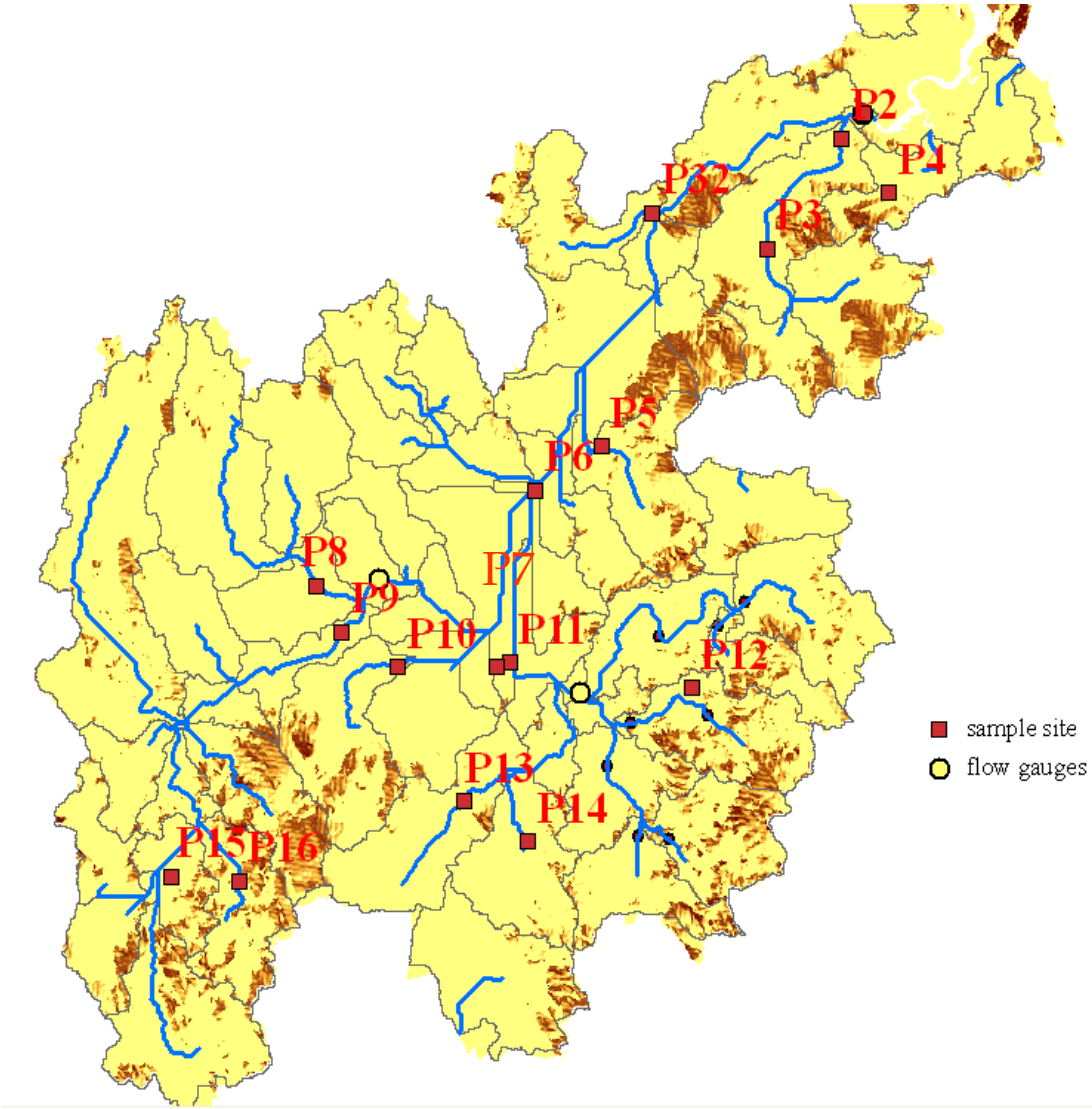
Monthly raster data



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

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

Transport Processes



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

Required Deliverables

- In the report, **summarize** the **critical implementation details** and the difficulties encountered (and how they were resolved)
- Create a **table and map for C(s) of each sub-basin** similar to figure 11. 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?
- **Mean total monthly DOC loading** in Neponset River Watershed

Suggested Deliverables

- As an experiment, use **different EVI layers** (January and April) to see **how T responds**
- What is the **projected T response** when the mean monthly DOC concentration is **+ or - %25**?
- What is the **difference** between T in 2006 and 2007?
- 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?

Final Deliverables

- Project results will be communicated through a **final presentation and a final report**. These 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.

Final Deliverables Cont.

- 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**.
- A 10-minute presentation, **supported by visual aids** (e.g. a PowerPoint slideshow, or other illustrative materials) to the class

Final Deliverables Cont.

- A **final report** of 10 pages, excluding figures and tables (5 pages for undergraduate students), that uses 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)