Material and energy flow in engineered and natural systems

Lecture 1: Why this material?

This material is structured that way that it is because traditional environmental science texts teach facts about the current crop of major environmental issues, but generally do a poor job teaching the thinking skills that are central to being a successful environmental scientists.

Environmental scientists need to been skilled in estimation, they need a general understanding of the scale at which things might be a problem, and they need to understand the interactions that occur across scales.

Science is the accepted language of much environmental policy discussion. Science has increasingly become the language of policy analysis. That does not mean that all the underlying issues are scientific, only that much of the debate occurs in the language of science, which means that effective policy makers need to be fluent in the language of science and with scientific methods and ways of thinking.

Even if you have no interest in being an environmental scientist, a little technical knowledge works as a very effective bullshit filter in political discourse. One of us (CB) was once a staff member on Capital Hill and was approached by a lobbyist who told him that it was “impossible to lower aromatic hydrocarbon emissions and benzene emissions simultaneously”. Fortunately, remembering just a little bit of his undergraduate scientific training, CB was able to point out to the lobbyist that benzene is an aromatic hydrocarbon, which forced the lobbyist to retreat in shame.

On this site, we develop tools that accentuate the thinking skills needed to be a skilled environmental scientists or an effective environmental policy maker.

The tools that we focus on developing are:

- Estimation -- How big, how serious, how do we know?
- Back of the envelope calculations
- Modeling
- Laboratory: testing hypotheses that you generated yourself
The site is divided into different modules and the modules are designed to build on each other as they develop increasingly sophisticated thinking skills. Ideally, an environmental scientist would follow this course up with a second course. For the environmental policy student, this course should provide a solid foundation to critical thinking skills in environmental science.

The modules are as follows:
Module 1: Introduction to conservation laws, issues of scale, computer modeling, and statistical analysis, Ecological footprint
Module 2: Urban hydrology, water supply and stormwater management
Module 3: Nutrient dynamics, nutrient processing and eutrophication
Module 4: Carbon cycle, photosynthesis, and greenhouse gasses
Module 5: Toxic metals in the environment – sources, distribution, transformation, and effects
Module 6: “Industrial Ecology”, and material flow through the economy

Throughout the site, we have provided “back of the envelope calculations”. These are problems that are designed to strengthen one’s ability to estimate and think through a problem “on the fly” – or “on the back of an envelop”. While ultimately estimating the size or scope of a problem will require data acquisition, many key features of a problem can be thought through without any data.

For example, “how many video rental outlets are there in Maine?” Is the number of supermarkets in Maine closer to 1000, 5000, or 10,000? Back of the envelope questions are never intended to give exact answers to questions. They can be used to “check one’s work” or to determine whether one needs to do more detailed work or not. Uncertainty is a key feature of many environmental issues (a point we return to later). A back of the envelope problem can help identify the areas where more data is needed and the area where the existing uncertainties are small relative to other areas and hence a more refined answer is not needed.