Instructor's Manual

Module 1: *Air Pollution Impacts in the Mid-Atlantic United States*

A. Typical class length:
45-60 minutes

B. Target students:
General public, or entry-level state employees

C. Module objectives:
The goals of this module are to have the students identify:
• Major air pollution-related public health impacts in the Mid-Atlantic United States
• Major air pollution-related ecosystem impacts in the Mid-Atlantic United States

D. Instructor preparation:
Go to the course web site and download all relevant materials for Module 1:
Instructor's Slides (Powerpoint)
Student Handouts (PDF)
Instructor's Manual Overview (PDF)

http://bigmac.cee.mtu.edu/marama/Modules/Modules.html

Review all the materials, make any changes you feel are necessary for your version of the course, master the material, then deliver your class!

E. Understand the sub-module objectives
Each course module is constructed of a series of sub-modules based on modern learning theory. The sub-module typically focuses on a narrow aspect of the module topic. The module can be viewed as the collection of several discrete topics presented in a fashion more appropriate for the range of learning styles among students in your class. Most sub-modules are constructed around a *motivation-theory-application-analysis* learning cycle. While it is good practice to have this cycle for each sub-module, it is acceptable to have a portion of the sub-modules that do not have all four components of the cycle. In general though, it is poor practice to have only the theory sections, as this will likely achieve the low-retention rates found in lecture-based learning environments. The rest of this manual provides tips and insight into specific slides. Please refer to the *Module 1 Instructor's Slides* to follow along.

Sub-Module 1: Introduction (Slides 1-6)
The primary purpose of these slides is to engage the student almost immediately upon entering the classroom. Educational research suggests that in a typical class, the first ten minutes is lost on most students as they are disconnecting from what they were previously doing. A suggested approach for this phase of the module is:

Slide 1 – Have this projecting before the students enter the classroom. Each module starts with a photograph connected to the content. Most students will subconsciously begin thinking about the course material when looking at a photograph. In this, maybe the students will be wondering how a bird and/or water body is related to air quality.

Slide 2 – Introduce the topic. This will make sure everybody in the room belongs in the class.

Slide 3 – This slide serves as the initial motivation. Feel free to substitute a similar compelling fact, observation, or finding from your own experiences. This slide should be put up long enough for the students to review, and perhaps some short comment from you. In this case, a reasonable comment is that water quality can be linked to air quality in some locations.

Slide 4 – All modules have a preliminary quiz. The purpose of the preliminary quiz is two-fold: (1) it gets the students thinking more about the subject, and (2) gives you a comparative benchmark at the post-module quiz. Feel free to substitute questions with some of your own, but bear in mind that the total time expended here should be about two minutes. Simply have the students circle the answers on their copies of the student handouts, or produce a handout quiz if you want to tally the results. One way to engage the class as a whole is simply to ask for a show of hands for each answer. The solutions to this quiz can be found in the post-course quiz slide below.

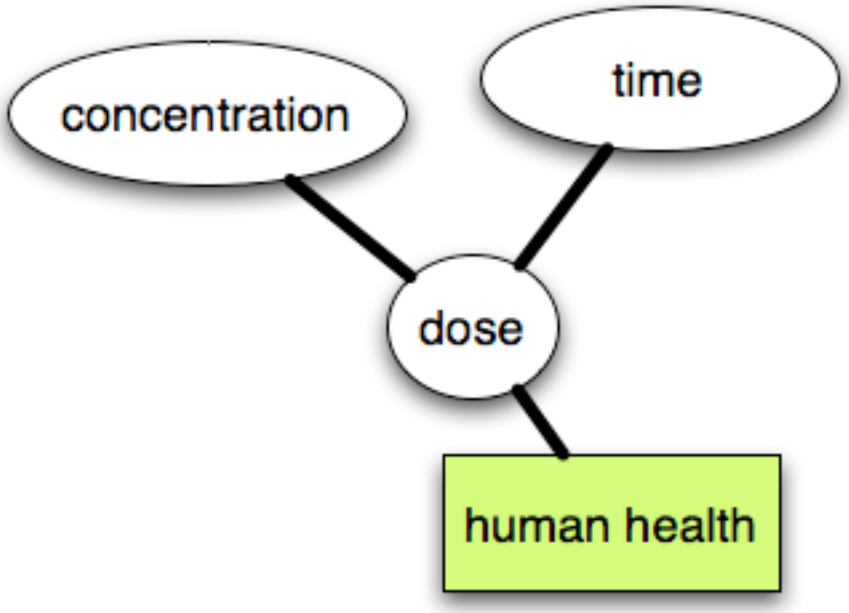
Slide 5 – The point of this activity is to get the students comfortable sharing to the whole class. There are no right or wrong answers, simply experiences. Another benefit of this sharing is, coupled with the quiz if you asked for a show of hands, you will be able to gauge the knowledge level of the students, and perhaps make real-time adjustments in the language you use to describe subsequent topics.

Slide 6 – The course goals slide is a good one to emphasize. Tell the students clearly what they will learn by the end of the class. If you add to, or delete, any material modify the course goals as needed.

Sub-Module 2: Health Impacts (Slides 7-19)
The primary purpose of this sub-module is to address the first course objective, namely identifying potential health impacts from air pollution.

Slide 7 – There is no better way to assess what the current state of knowledge among students than concept mapping. The technique is simple: in the middle of the page write the key concept and put a box around it. In this case it might be "human health". From

there, the student groups simply connect concepts to this central concept. For example one related concept might be "dose", and then connected to dose, might be "air pollutant concentration" and "time of exposure".



There are no right or wrong ways to do this. If possible provide some large sheets of paper and markers so the students can share their work. If such paper is not available, blackboards, or transparencies work. Be careful, you can easily eat up a lot of time on this activity. Tell the students they have five minutes to work on this. This activity also helps the class reach a higher comfort level.

Slides 8 – This slide drives home the point that our bodies do not have many defenses: respiratory system and the skin are about it, and they primarily do a good job at protecting us against pollutants that have been around for eons. Evolution at work.

Slides 9-10 – These slides provide an overview to the human respiratory system, and the stresses that air pollution can exert as the system tries to function normally. A good example is the issue of particulate matter. There are many size particles in the air. The big particles (>10 μm) get trapped in the upper respiratory system (why do you have a nose full of crud after exposure to a dusty environment), smaller particles get trapped deeper in the respiratory system (why do you have a scratchy throat after exposure to a smoky environment).

Slides 11-12 – These slides cover the circulatory system critically linked to the respiratory system for the exchange of respiratory gases (oxygen in, carbon dioxide out). This is also the pathway of air pollutants into internal organs.

Slide 13 – Provides some examples of disease categories, and pollutants that could cause them. Neither list is comprehensive. The slide also serves as a brief pause by asking the

students a question. This question has no right or wrong answer, it is more to see if any students are aware of such issues.

Slide 14 – The slide now presents specific disease outcomes (or morbidity). An important point to mention is that highlighted in the red box.

Slide 15 – Drilling to more specificity, this slide presents two pollutants (ozone and particulate matter) and the known (quantified) and suspected (unquantified) health effects associated with them.

Slide 16 – This slide encourages thoughts about the impacts to society rather than one person. This is a good time to point out how the health burdens of one person or a group of people is shared by all of society (through socio-economic connections). On a related note, a few studies have now demonstrated that people in the lower economic levels of the Mid-Atlantic suffer disproportionately – they tend to be exposed to higher levels of particulate matter, for example.

Slide 17 – This table is from work by the U.S. EPA in an attempt to quantify the benefits of the Clean Air Act Amendments. An interesting point of discussion is how do you come up with the valuations in the table. Is your life worth $4.8 million?

Slide 18 – An EPA estimate of lost productivity in the U.S. due to exposure to outdoor air pollution.

Slide 19 – Some questions to get the students thinking about the next sub-module topic, connecting current knowledge to the next. Simply have the students think for a minute then share with a neighbor. Move on without sharing with the class if time is tight.

Sub-Module 3: Dose-Response (Slides 20-23)
The goal of this sub-module is to bridge the two course objectives, and provide some critical general knowledge between the health and environmental impacts.

Slide 20 – Some critical points to get across: (1) response is dependent on the dose received by the body or ecosystem, (2) dose is a complex function, but mostly dependent on air pollutant concentration, time of exposure to the pollutant, and how easily the pollutant can get into the system (human body, lake, etc.). Additional topics include whether the exposure is short term (acute) or longer, repeated (chronic); and whether the response occurs at one specific point (local) or is spread throughout (systemic) the body or ecosystem.

Slide 21 – Lead the students through any diagram slowly. Explain the axes and the data. In this case, this example graph shows a typical problem: dose-response experiments are difficult in many ways (can't experiment on humans, concentrations must be elevated to yield measurable results in reasonable research times, etc.). The graph shows hypothetical dose-response data in a range that may be well above where typical doses for people (or ecosystems) are encountered. At these lower doses, we often have to make best guesses

as the nature of the relationship to response, and this has clear issues on policy- and decision-making. If the pollutant has a dose-response threshold relationship, it may be fine to have some exposure to the pollutant (because there is no response until we get to a certain dose). But what if there is no threshold (i.e. there is a response at any dose)? Hence, the estimate of this relationship can be very important (and open to much heated debates). Ask the students if they can think of any way through this dilemma. One reasonable answer could be using epidemiological evidence from special air pollution events. For example, was there any improvement in the public health (say from decreased hospital admissions) following the east coast blackout a few years ago (power plants were offline for some time)? Or following the closure of a polluting factory in a one-factory town?

Slide 22-23 – An example dose-response graph from a research study. The main point is that respiratory inflammation is proportional to ozone dose. Importantly, there seems to be no threshold, if we use the confidence limits presented. In other words, we must claim that any amount of ozone causes inflammation. Knowing that, the tricky question then becomes what level of ozone is acceptable, which is the focus of Slide 23.

Sub-Module 4: Environmental Impacts (Slides 24-41)
The goal of this sub-module is to address the second objective of the course module, identifying environmental impacts from air pollution.

Slide 24 – Introduces four major environmental impacts afflicting the Mid-Atlantic U.S., and differentiates whether they have direct impacts, or work through an intermediary.

Slide 25 – This slide serves two important purposes: (1) to identify the problematic mixture resulting in ozone, and (2) to differentiate the "smog" (or urban ozone) problem form the "ozone hole" (or stratospheric ozone) problem. Most lay people have heard about the latter more than the former, but even then tend to confuse that problem with climate change in various ways.

Slide 26 – A summary of some of the ozone impacts. Like most pollutants, ozone has both health and environmental impacts, but this section of the module highlights environmental impacts. Ozone's aggressive chemical oxidizing capacity irritates plant tissues, similarly to lung tissues.

Slides 27-28 – An example showing possible spatial and temporal variability in ozone. Yellow and orange colors are elevated concentrations. The late afternoon peaks are due to the right combination of sunlight, temperature, and emissions from sources of nitrogen oxides and organic compounds – all the factors needed in making ozone.

Slide 29 – An overview of particulate matter. Health impacts include the obvious respiratory distress, and the not-so-obvious impacts to the pulmonary system, possibly through impacts to the characteristics of blood (thickened by ultrafine particles in one theory). Recent health evidence resulted in adoption of fine particulate air quality standard (PM2.5). Several environmental impacts are provided as examples.

Slide 30 – This figure shows the annual average PM2.5 concentrations (in µg/m3) at various locations. The annual standard is 15 µg/m3. It would be reasonable to first ask the students to explain why there are differences in concentration and composition. Also note the differences in speciation (what the particles are made of). In the East particles are much more likely to be composed of sulfur compounds (from the coal-burning power plants in that area and the Midwest). This difference in chemical composition also has an impact on impacts. Sulfate or nitrate deposition can alter water quality, for example.

Slide 31 – Discusses the impact of particles on visibility. Opacity has the advantage that it can be measured with instrumentation; visual range is perception.

Slide 32 – This is a nice example of how visibility can change, using recognizable landmarks. Additionally, typical visual ranges are provided for the Eastern and Western U.S. (refer back to the figure in Slide 30 for some explanation of this disparity). Also note that historically (going back to pre-industrial revolution) the Eastern U.S. had more limited visibility. Ask the students why that might be? One explanation is the particles generated from gases emitted from certain trees common in the East, absent in the West.

Slide 33 – This open-ended question has no right or wrong answer, but is a great way to get the class talking about value judgments. Visibility impairment is important to some people in all circumstances, and all people in some circumstances (an example of the latter is visibility in national parks). Get the students to talk in a small group, then have the groups share with the whole class.

Slide 34 – This slide introduces the important concept of how an air pollutant may move into another medium (water, soil, etc.) and influencing the environmental quality therein. An air quality problem becomes a water quality problem, for example. This sets up the next topics.

Slide 35 – Air toxics are the class of pollutants that can create severe impacts on living systems. Some of the more troubling impacts are listed on this slide. The impacts can be found in humans and animals. But like most, the response is highly dependent on the pollutant and organism combination. It's tough to make sweeping generalizations, other than these compounds are called "air toxics" for a reason.

Slide 36 – This slide provides an example of mercury, one important air toxic, in the Chesapeake. The figure on the left shows the emissions of mercury from known sources broken down by county. The figure on the right shows the concentrations of mercury measured in deposition monitors (measuring the amount falling out of the air and landing on surfaces). The two figures are at different scales, but looking at the Chesapeake area of the deposition map, it is clear that the elevated emissions close to the Bay result in higher deposition concentrations (12.0 $\mu g/m^3$ in this case).

Slides 37-38 – This county-level map of the Eastern U.S. is the result of research that depicts (by color) the contribution of sources to mercury deposition in the Chesapeake.

The counties colored red or purple, for example, contribute significantly to the mercury in the Chesapeake. This is a function of the mercury emissions in that country and the likelihood that atmospheric transport patterns will carry the mercury from the source county to the Chesapeake Bay area. Solving such problems must be a regional emission reduction (or better, prevention) solution, which is hopefully the point that emerges from the activity on Slide 38.

Slides 39-40 – An overview of acid deposition. This problem is one of air pollutants being released from sources, changing form in the atmosphere, can causing ecosystem problems via changes to water and soil chemistry (lowering the pH, among other changes). This impact is also introduced as it is one where substantial improvements are being realized (see Slide 40).

Slide 41 – The point of the long conversion time is that the pollutants are traveling in the atmosphere during this time, resulting in the problems (acidification) manifesting far from the pollutant sources. In this case, perhaps a Midwest coal-fired power plant is the source of sulfur, but the sulfuric acid comes raining down in New York.

Sub-Module 5: Conclusion (Slides 42-45)
These slides provide a meaningful ending to the learning. Don't underestimate their importance.

Slide 42 – The post-quiz goes here. The students should only need 30-60 seconds. Collect their responses, if assessment is needed, else a show of hands with discussion is fine. The purpose of the post-quiz is simply to force retention of key points. The answers for this quiz are:

1.) *False*, in the general sense of "air pollution" (but when talking about specific pollutants, ozone for example, it could be true)
2.) Ozone is linked to elevated levels of *a.) respiratory disease*
3.) Which is not an impact? *None.* In other words, all of them are impacts from particulate matter! The students will love you for this "trick" question. In your defense, point out that it doesn't say that one of them must be true.

Slide 43 – This slide has some resources for the students to learn more on their own. Add to it, as relevant. Encourage additional learning with references that you know to be particularly helpful. The WHO reference is nice for those students thinking about the global picture. From there the references focus on more specific geographic regions. The MARAMA Guide is particularly relevant for what's happening closer to home for your class.

Slide 44 – The moment to reflect is an important pause before concluding the class. It helps the student sort and summarize what they have learned, and if desired can be a good summative assessment for your efforts. For example, as an assessment tool, simply ask the students to write their response to the question on a scrap of paper and leave it behind following the class. Read through the responses to adjust any future offerings of

the class. It will be extremely illuminating to learn what the class comes up with as a Top Three Air Impacts list. Is there quick agreement? Substantial disagreement? Again, this activity could take some time, so set time limits up front. Nevertheless, this activity will probably leave the students talking as they leave the course. Exactly what you want!

Slide 45 –Thank the class for coming and for their participation! This is a simple yet powerful way to end the class.