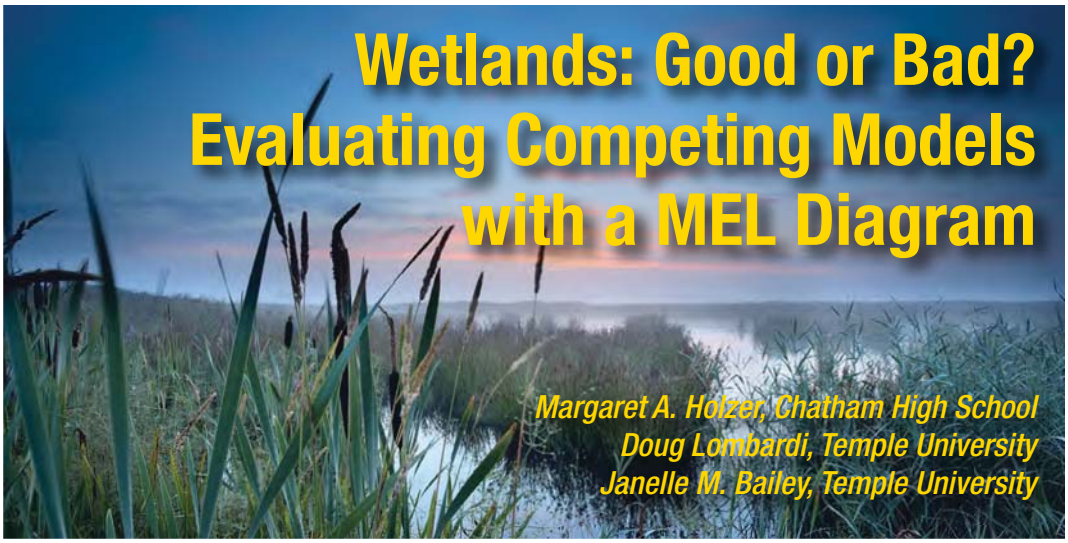

Wetlands: Good or Bad? Evaluating Competing Models with a MEL Diagram

Margaret A. Holzer, Chatham High School
Doug Lombardi, Temple University
Janelle M. Bailey, Temple University

Abstract

Teaching with socio-scientific issues can be a challenge given the tug-of-war between the scientific, social, economic, and political perspectives upon which many topics can be viewed. However, in an Earth science classroom, socio-scientific issues provide a rich stage upon which various lines of scientific evidence can be weighed against alternative viewpoints. This article describes how a Model-Evidence Link (MEL) lesson can effectively be used to assist learners in weighing the plausibility of different viewpoints of the uses of wetlands, a socio-scientific issue.

Our wetlands are caught in the middle of competing viewpoints. For example, a visit to our coastal and inland wetlands generates an olfactory concussion for some and a sense of pleasure for others. The scents created as a by-product of the activity of microbial inhabitants living in them may be perceived as a nuisance to some, and beneficial to others. Some people value what wetlands offer the local environment, such as habitats for all types of organisms and a place for floodwaters to collect away from where people live. Others perceive them as property to develop or as a breeding area for mosquitoes.

These two competing views of wetlands set the stage for a rich lesson on how to evaluate the plausibility of evidence supporting competing socio-scientific models, a scientific practice worthy of developing in our students as noted in the Next Generation Science Standards (NGSS Lead States, 2013). Wetlands, by definition from the Clean Water Act, are "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas" (United States Environmental Protection Agency, 2013). To some, the ecological services, or benefits, provided by wetlands outweigh the economic losses created by not developing these potentially viable pieces of property. As odoriferous as these regions are, they offer our planet numerous ecological services, from their existence. For example, wetlands purify water, control flood waters, and provide habitats for numerous aquatic, avian, and mammalian species. However, some people perceive wetlands as a nuisance and a breeding ground for mosquitoes, and that financially valuable property is lost because many wetlands offer views to city skylines and open-space.

[1] All MEL activities and associated materials may be downloaded for free at our project website: (https://sites.temple.edu/meldiagrams/materials/).

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The Model-Evidence Link (MEL) lesson discussed in this article differs from the other lessons that our research and development team have designed[1] (see Lombardi, this issue). Specifically, the Wetlands MEL uses two different conceptual models of a socio-scientific issue that focus on value to society, as opposed to two different models of a scientific phenomenon. Even though these may be thought of more as "viewpoints," we will continue to call them models because they evoke mental/conceptual models of the issue that can assist someone in analyzing a situation. Like scientific models, they are productive because they have both predictive and explanatory power for those holding these viewpoints. For example, someone holding the "wetlands as a nuisance" model as their conceptualization of wetlands will not consider the nutrient cycling that occurs there as necessary for the cycling of matter in our ecosystems.

Table 1: Connections to the Next Generation Science Standards (NGSS Lead States, 2013, p.125)

NGSS performance expectations related to the Wetlands MEL
HS-ESS3-3: Earth and Human Activity
Create a computational simulation to illustrate the relationship among the management of natural resources, the sustainability of human populations, and biodiversity.
HS-ESS3-4: Earth and Human Activity
Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

For a science lesson to be congruent with the approaches defined in the NGSS, the lesson should blend disciplinary core ideas, science and engineering practices, and crosscutting concepts. The wetlands MEL blends core ideas from ESS3-C: Human Impacts on Earth Systems with the science and engineering practice of engaging in argument from evidence, and the crosscutting concept of stability and change. Collectively this lesson helps to develop proficiency in multiple high school performance expectations (Table 1) and can serve as one lesson within a larger unit on human impacts.

Introducing the Wetlands MEL Lesson

To begin this lesson, familiarize the students with wetlands if they have not had experience with the concept. Most students have a mental model of wetlands as a coastal phenomenon; however, wetlands can be found in most areas of the United States. As a way to familiarize students with the location of wetlands, consider using a digital mapping program, such as ArcGIS Online where a data layer of the locations of wetlands can be imported and displayed. Students will be surprised to find how predominant wetlands are across the United States. Next, place a population layer on top of the wetlands layer to connect students to the relationship between populations relative to the proximity of wetlands. Brainstorm with the students a number of challenges related to living near wetlands. Now, students should be ready to complete the MEL portion of the lesson.

If students have not completed the plausibility ranking pre-task, they should do so before starting this lesson (see Lombardi, this issue, for more details on this activity). The ranking pre-task introduces the students to the scientific principles of plausibility and falsifiability, principles which govern the evaluation of scientific evidence. In the case of this MEL, it is a person's perception which will govern the plausibility and falsifiability of the evidence presented in the lesson.

Evaluating the Models

This lesson is similar to the other MEL lessons in that students begin by evaluating the two models central to the lesson. They evaluate the models based on a scale of 1-10 where a 10 is equated to highly plausible, and a 1 is equated to greatly implausible (or even impossible)

(Figure 1). Students complete this initial ranking individually, and set it aside until they are finished with the next part of the lesson. Next, pass out the MEL diagram, and ask students to use a pencil to make their initial connections between each model and line of evidence (which we call Evidence Statements, as described in Lombardi this issue). The students are linking four lines of evidence to each of the two models using one of four types of lines, each depicting a level of agreement between the evidence and the model. Now provide students with the evidence texts, and ask them to read the explanations associated with each line of evidence. This can be done as a class, in small groups, or in a way that utilizes cooperative group techniques such as jigsaw. Lead a class discussion on the lines of evidence to clarify any difficult concepts within the evidence text. It is important to this lesson that the clarification focus only on the content of the evidence without swaying the students to side with one model or the other.

Model A:	Model B:
Wetlands provide ecosystem services that contribute to human welfare and help sustain the biosphere.	Wetlands are a nuisance to humans and provide little overall environmental benefit.
A person who supports this model makes the following argument: *Wetlands help nature and the environment by purifying water, providing flood protection, helping to keep shorelines stable, recharging groundwater, and maintaining valuable habitat for fish, birds, other animals, and plants.*	A person who supports this model makes the following argument: *Wetlands create many problems for humans, including flooding at times of heavy rainfall, providing a breeding ground for mosquitos and other pests, and preventing development of commercial and residential areas.*

Figure 1. Model A and Model B for the Wetlands MEL lesson.

Lines of Scientific Evidence

The four lines of evidence were selected to challenge students in thinking about the competing views of wetlands. In Evidence Statement #1, students view wetlands as a place where nutrients are cycled, and the supporting Evidence Text #1 provides a little background on the processes taking place in wetlands to enhance the cycling of nutrients. Figure 2, which is from Evidence Text #1, is a schematic of this nutrient cycling process. Wetlands by definition are areas that remain wet, and thus during times of flooding or peak flow of a nearby water body, these areas can be inundated, protecting the surrounding populated areas from flooding. Evidence

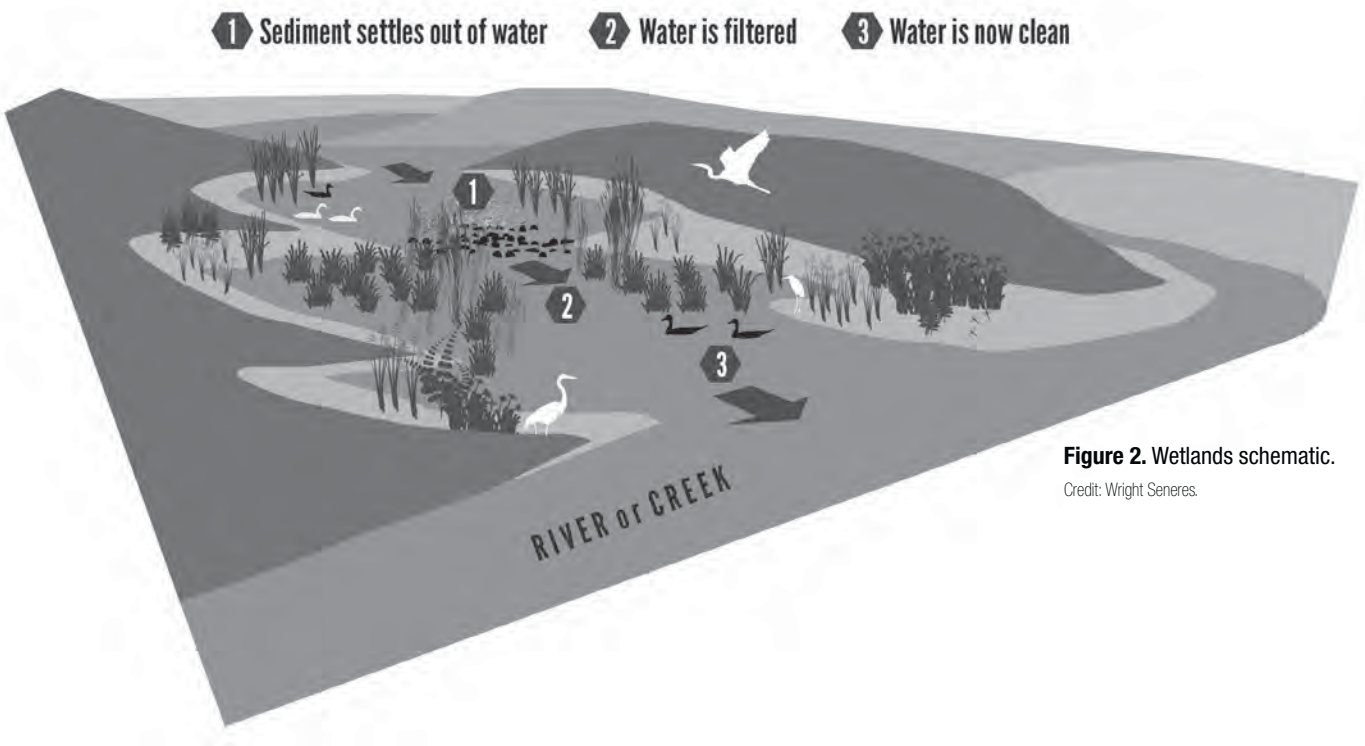

Figure 2. Wetlands schematic.
Credit: Wright Seneres.

Statement #2 describes this aspect of wetlands. Evidence Statement #3 connects wetlands with methane production and greenhouse gas concentrations in our atmosphere. Evidence Statement #4 connects populations living in wetlands and the potential harm to life and property should these wetlands become inundated during flood events, but these wetlands can be valuable pieces of property as well as homes to numerous people who have settled along rivers. This fourth line of evidence addresses the issue regarding developing these areas of real estate, noting that developers who follow regulations set in place by the federal agencies protecting the wetlands should be permitted to convert existing wetlands into commercial and residential property. Collectively, these four lines of evidence provide students with plenty to consider as they argue about the two models of wetlands.

After the content is clarified, break the class up into groups of three or four students to reevaluate the lines of evidence and the connections they made between the evidence and models. Students may change the types of arrows they use in their connections based on the discussion; however they should not be compelled to change the type of arrows they use simply because their group members have different arrows or have changed their arrows. This is especially important for this MEL lesson since it involves socio-scientific models, and conceptual models held by the students may be more complex based on their personal experiences with wetlands.

Completing the Explanation Task

Once students have completed the MEL diagram, they are ready to complete the Explanation Task. Ask them to rank the plausibility of the models again. Next, refer them back to their initial rankings, and have them complete the balance of the Explanation Task. After they finish, wrap up the lesson by having a discussion about the competing models, addressing the lines of evidences and their connections. This MEL lesson addresses competing models of a socio-scientific phenomenon, and therefore there are many stakeholders and embedded issues that need to be considered when addressing it. Because of this, allow the class discussion to drift to include comments by students agreeing with either of the two models, but focus students on evidence-based claims as opposed to mere conjecture and opinions. Be sure to debrief all four lines of evidence as there may be a disparity in the way that students viewed each line of evidence, and therefore the arrow they decided to employ in their connections. Evidence Statement #3 and Evidence Statement #4 may elicit the greatest differences. Listen closely to the students' reasoning to ensure they are interpreting both the models and the lines of evidence in the way they were intended to be interpreted.

Using MEL Diagrams to Address Socio-Scientific Issues in the Classroom

The Wetlands MEL lesson was designed to assist students in developing skills to evaluate opposing conceptual models by weighing evidence against claims, and in so doing they are developing scientific reasoning skills as outlined by the NGSS. For example, by the end of twelfth grade, students who are proficient in the scientific practice of engaging in argument from evidence will be able to

- Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
- Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

- Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions. (adapted from NRC, 2012, pp. 50-53; see also NGSS Appendix F, NGSS Lead States, 2013).

The Wetlands MEL lesson assists students in developing proficiency in this practice, and by using other MEL lessons throughout the year it will reinforce this skill. The order of the MELs used should align to local curricular sequencing and pacing.

Socio-scientific issues with competing viewpoints are prevalent in the newspapers as well as in environmental science courses. Students can easily develop a viewpoint that resonates with one side without considering multiple competing lines of evidence that may exist for the issue. The MEL diagram approach is a way to encourage students to seek beyond what is initially evident to them and consider those opposing viewpoints. Teachers are encouraged to develop their own MEL lessons related to socio-scientific issues germane to their courses and their locations. For example, agricultural practices, carbon footprints, and competing views of "commons" are a few issues that would lend themselves to the evaluation of evidence in support of competing models. By the end of the school year, students could demonstrate their proficiency in evaluating evidence by creating their own MEL diagram, or by crafting a research paper demonstrating their skill in evaluating multiple lines of evidence.

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About the Authors

Missy Holzer, Ph.D., teaches science at Chatham High School in New Jersey and is an adjunct professor in the Rutgers University Department of Geography. She holds Master's degrees in science education and geography, and a Ph.D. science education. She was President of the National Earth Science Teachers Association from 2012-2014, has served on many state and national committees, and presents at local, regional, and national conferences. She has received local, state, and national teaching awards. Missy can be reached at mholzer@monmouth.com.

Missy Holzer; Chatham High School; 255 Lafayette Ave, Chatham Township, NJ 07928; home/mobile: 732-770-2171; work: 973-635-9075; mholzer@monmouth.com

Doug Lombardi, Ph.D.
Doug Lombardi; Temple University; 1301 Cecil B. Moore Ave., RH 450, Philadelphia, PA, 19122; home/mobile: 702-513-4415; office: 215-204-6132; doug.lombardi@temple.edu

Janelle M. Bailey, Ph.D.
Janelle M. Bailey; Temple University; 1301 Cecil B. Moore Ave., RH 456, Philadelphia, PA, 19122; home/mobile: 702-513-8763; work: 215-204-5195; janelle.bailey@temple.edu