Understanding Land-Use Feedbacks and Ecosystem Service Trade-Offs in Agriculture

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PART I – Creating and Evaluating Your Dream Watershed

Approximate time requirement: 90-120 minutes

Background: Three advantages of PEWI are it allows people to try out different land-use options quickly, at no cost, and without risk. In the real world such changes take a long time, are expensive, and are fraught with risk; they also may have legal or ethical consequences. We're going to take advantage of these strengths and make learning fun by creating our dream watersheds in PEWI: think about what you would like the world to look like, not necessarily how it looks. Use whatever land uses you desire and consider things like:

a) What benefits do I get from different land uses?

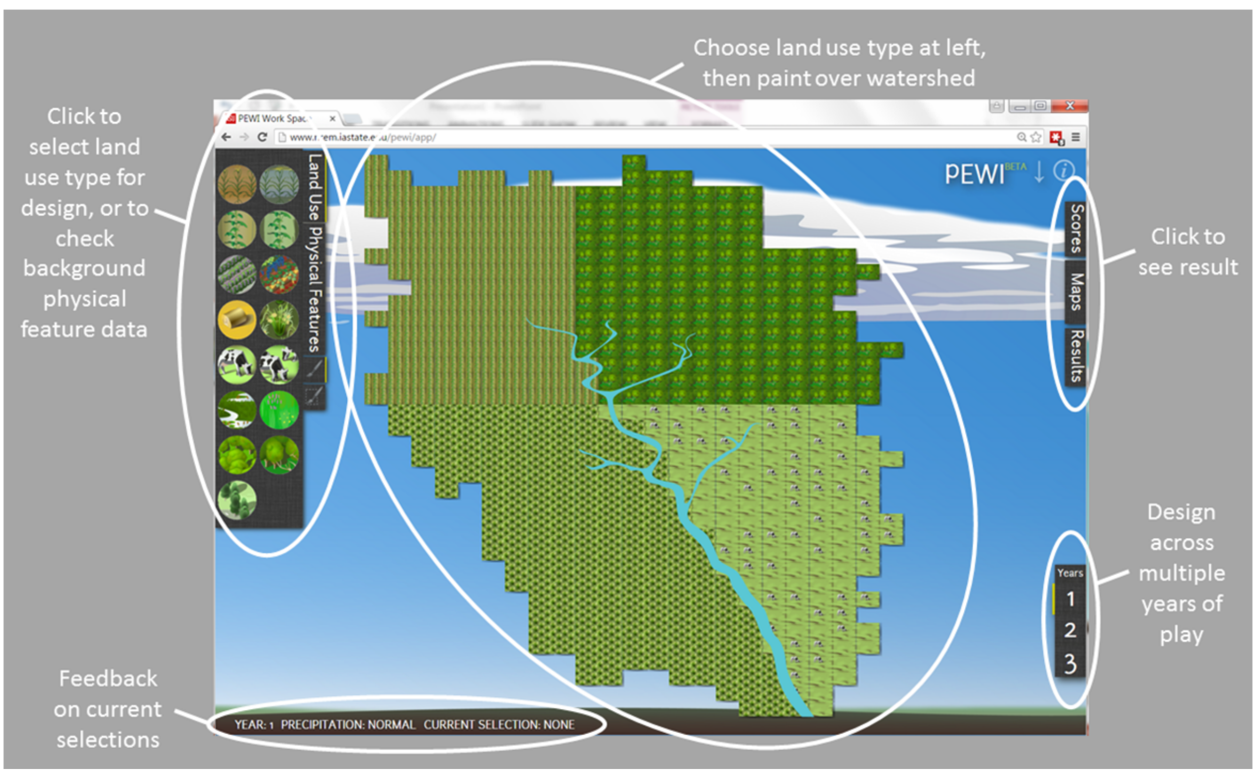
b) What benefits do I want agricultural watersheds to provide?

c) What land uses should go next to the stream?

d) What land uses should go in steep sloping areas?

e) What land uses do better when it's a wet year? What land uses do better when it's a dry year?

Before we get too dreamy, however, we're going to familiarize ourselves a bit with PEWI. Check out PEWI's user controls in the diagram below.



Step 1: On your own, explore the tradeoffs associated with four different land uses: *(1) Conventional Corn, (2) Conservation Corn, (3) Hay, and (4) Prairie.* The key is to change the entire watershed to a single land use, starting with Conventional Corn. For Conventional Corn, make sure to record the four selected PEWI results in the Results Table 1.1 below before moving on to the second land use, and so on. Here are a few hints to get you started:

a) *To select a land use:* Find the "Land Use" pane on the left side of PEWI. Hover over each of the circle icons to see their labels, and click on the desired one. Later, when moving on to a new land use, make sure to refresh the webpage.

b) *To automatically change land use for the entire watershed:* Find the top left rectangle in the watershed. When you hover your mouse, you will see the display "1,1". Double click your mouse on this rectangle. All the rectangles in the watershed should change to the land use you selected.

c) *For results:* Click on the "Results" tab located in the upper right side of PEWI. Scroll down to the second table, "Ecosystem Service Indicator/Measurement." Record the numbers for "Y1" from the "Score" section, which will range from 0-100, for each of the columns in the table below.

RESULTS TABLE 1.1	**Score (out of 100), Y1**			
Score (out of 100)	**Conventional Corn**	**Conservation Corn**	**Hay**	**Prairie**
Habitat: Biodiversity				
Soil Quality: Carbon Sequestration				
Water Quality: Nitrate pollution control/stream concentration				
Water Quality: Sediment control/in-stream delivery				
Yield: Corn Grain				
Yield: Grass Hay				
Yield: Mixed Fruit & Vegetables				

Look at the data you've compiled in RESULTS TABLE 1.1 above, and describe the patterns you see in the box below.

Step 2: Next change the whole watershed back to *Conventional Corn*, then click the "Y2" and "Y3" button in the lower left corner. Go to the Results tab, and record the requested information for Ecosystem Service Indicators and precipitation in RESULTS TABLE 1.2. Also click the "Maps" button in the upper right hand corner of the screen. Consider the patterns you see in the maps.

Now go back and change the land use in all three years to *Grass Hay*, and again record the requested information in RESULTS TABLE 1.2. Click the "Maps" button in the upper right hand corner of the screen and consider the patterns you see there.

RESULTS TABLE 1.2	**Conventional Corn**			**Grass Hay**		
Measurement: Metric	**Y1**	**Y2**	**Y3**	**Y1**	**Y2**	**Y3**
Soil Quality: Carbon Sequestration (Mg)						
Water Quality: Nitrate pollution control/stream concentration (mg/L)						
Water Quality: Sediment control/in-stream delivery (Mg)						
Yield: Corn Grain (Mg)						
Yield: Grass Hay (Mg)						
Precipitation (cm)						

Look at the data you've compiled in RESULTS TABLE 1.2 above as well as what you say in the "Ecosystem Service Maps," and describe the patterns you see in the box below. Also note any unexpected results, and why you find them curious.

Step 3: Now here's the fun part: select whatever land use you want and put it where ever you want, and create whatever watershed you desire! There are no wrong answers, just different views on what a watershed could look like. You might want to iteratively check the results tab, to see what ecosystem services your watershed produces.

Once you're satisfied with your design, use the data from the results tab to record your values in RESULTS TABLES 1.3 and 1.4 below.

RESULTS TABLE 1.3	Land Use Percent Cover, Y1
Conventional Corn	
Conservation Corn	
Conventional Soybean	
Conservation Soybean	
Mixed Fruits and Vegetables	
Permanent Pasture	
Rotational Grazing	
Grass Hay	
Herbaceous Perennial Bioenergy	
Prairie	
Wetland	
Alfalfa	
Conservation Forest	
Conventional Forest	
Short-rotation Woody Bioenergy	

RESULTS TABLE 1.4	**Ecosystem Service Indicator/Measurement Score (out of 100), Y1**
Habitat: Biodiversity	
Habitat: Game Wildlife	
Soil Quality: Carbon Sequestration	
Soil Quality: Erosion Control	
Water Quality: Nitrate pollution control	
Water Quality: Phosphorus pollution control	
Water Quality: Sediment control	
Yield: Alfalfa	
Yield: Cattle	
Yield: Corn Grain	
Yield: Grass Hay	
Yield: Herbaceous Perennial Biomass	
Yield: Mixed Fruits and Vegetables	
Yield: Short-rotation Woody Biomass	
Yield: Soybeans	
Yield: Wood	
Total Index	

To prepare yourself for a class discussion, consider what you constructed in your dream landscape. Then, in the text box below, answer the following:

- Describe your dream landscape in terms of the land uses you chose and where you put them.
- Why did you do things that way? Did you draw upon any guiding principles? If so, describe them.
- Study your outcomes. What were expected versus unexpected, and why?

Step 4: Generate a vibrant class discussion that everyone shares in by having the whole class visit each student's computer and having each student share her/his dream landscape along with the background story of why s/he constructed it the way s/he did. Thereafter, consider the following questions as a class:

- How and why do results vary among the conventional corn, conservation corn, grass hay, and prairie land uses? Do some results differ more than others? How so? Why?
- How and why do results vary among years?
- What might explain the patterns you observed in the maps?
- What are some of your takeaways from the dream landscape exercise? Did different class members use different strategies in constructing their dream landscapes? Do differences in the land use reflect differences in values? How so? Were personal value expressions consistent with Ecosystem Service Results?
- Were there any "ah-ha" moments? If so, what were they?

Step 5: Turn in your completed lab packet and submit your dream landscape design electronically to your instructor.

References and Supporting Reading:

- *Chennault, C.M., L.A. Schulte, J.C. Tyndall. 2016. PEWI: A web-based learning tool for evaluating ecosystem service tradeoffs from watersheds. Journal of Soil and Water Conservation 71: 31A-36A.*
  - This paper provides a description of PEWI, including how it might be used in learning settings. It should be understandable to all undergraduate and graduate students.
- *Power, A.G. 2010. Ecosystem services and agriculture: tradeoffs and synergies. Philosophical Transactions of the Royal Society B: Biological Sciences, 365(1554), 2959-2971.*
  - This paper will introduce students to the concept of ecosystem services, focusing on services associated with agricultural landscapes. It should be understandable to junior- or senior-level undergraduates as well as graduate students.