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

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PART III – Monetizing Private Watershed Benefits

Approximate time requirement: 90 – 120 minutes

Background: As explored in the exercises above, patterns of land use in agricultural watersheds mediate the ecosystem functionality of that land and in turn the array of ecosystem driven outcomes. In this section you will calculate the net annual market value of your watershed designs and compare to the baseline, 100% corn production watershed. Some land use choices lead to annualized net revenues while others represent net costs. An exploratory goal of this exercise is to design the most *financially* valuable, environmentally compliant watershed (as per the environmental goals of Part II). You should explore how some land use choices/locations might substitute for others in terms of ecosystem process/function and lead to a more favorable watershed-scale economic result. Note: this economic analysis considers only the *market* value of the various land uses, that is, the values used here are based on current market prices for inputs, outputs, and services (e.g., hunting). What is not considered here are the non-market values of the various ecosystems services generated by your watershed design (non-market values are associated with ecosystem services such as biodiversity or clean air that have no direct markets or directly observable economic value).

What you'll need for this exercise:

1) The PEWI 2.0 model;
2) Your PEWI watershed design from Part II.

Step 1: Review and transcribe some of your watershed data from Part II, comparing to a 100% conventional corn watershed. Also, consider the impacts of precipitation and other constraining outcomes. Discuss these impacts in the text box below, providing the precipitation levels of your "worst" year and preceding year? Also enter required values into RESULTS TABLES 3.1. Use the values from your "worst" year.

RESULTS TABLE 3.1: Numerical Outcomes from Part II	100% Conventional Corn Baseline	Improvement goals relative to conventional corn baseline	Target limits	Final design biophysical outcomes
Erosion Control (Gross Erosion; tons)		≥ 70% reduction		
Sediment Control: In-stream delivery (tons/yr)		≥ 60% reduction		
Phosphorus: In-stream loading (tons/yr)		≥ 30% reduction		
Nitrate Pollution Control: In-stream concentration (PPM)		--	≤ 6.5 PPM	
Carbon sequestration (“new” carbon accumulated; tons)		≥ 4500 tons	≥ 4500 tons	
Biodiversity (1-100 unit-less scale or points out of 10)		≥ 4.5 points	≥ 4.5 points	
Bioenergy yield (total tons/ year)		≥ 43,000 tons	≥ 43,000 tons	

Step 2: Now you will uses your final watershed design from Part II to calculate annualized net returns. Use the net revenue/ cost data in the table below with your PEWI land cover data.

Land Use	**Annualized Net Revenue or Cost per Acre (2015$)***	**Notes regarding calculations**
Corn (after soybeans)	Variable (To be calculated)	See Economic Analysis Parameters below.
Continuous Corn	Variable (To be calculated)	See Economic Analysis Parameters below.
Soybeans (after corn)	Variable (To be calculated)	See Economic Analysis Parameters below.
Net costs of switching to conservation corn or beans	**- $24**	Assumptions: On average in Central Iowa, about .05% of a field could use a grass waterway = cost of $15/ac/year; Aerially seeded, chemically terminated cover crops cost ~ $34/ acre; No-till leads to a total savings = $25/ac/year (mostly from using less diesel, labor and depreciation).
Herbaceous Perennial Bioenergy (switchgrass)	$53	Assumes uniform yields of 6 tons per acre; static input prices and a payment of $90 per ton of biomass. Analysis adapted from: Duffy 2008. www.extension.iastate.edu/agdm/crops/html/a1-22.html
Short Rotation Woody Biomass	$20	Assumes no land rent. With land rent, annualized value is negative. Yield and cost data: R. Hall (Unpublished, Iowa State University). Yield = 5 tons per acre; Price $100/ton; 5 year rotation, 20 years.
Mixed Fruit and Vegetable	$6,812	This value assumes that total acreage in mixed fruits and vegetables (and therefore supply) is limited. Based on 2012 Iowa CSA returns. Data: https://www.extension.iastate.edu/agdm/wholefarm/html/c3-65.html
Alfalfa	$121	Assumes price of $125 per ton; 2 cuttings per year; Average production costs = $97.56/ ton. Data: http://www.extension.iastate.edu/agdm/decisionaidsall.html
Grass Hay	$76	Assumes price of $110 per ton; 2 cuttings per year; Average production costs = $97.56/ ton. Data: http://www.extension.iastate.edu/agdm/decisionaidsall.html
Conventional Forest	$124	Timber data used for analysis from Amana Colonies, Iowa, Compartment 10 located in Upper Amana, Iowa. About 70% of the total basal area (ft^2/acre) is mature white and red oak. Clearcut silviculture is assumed. Stumpage value = $2,198/ acre; Biomass value = $696/ acre. Annualized over a 55-year rotation.
Conservation Forest	$93	Same data as conventional forest. However, in a conservation forest, biomass is not harvested and is left on the forest floor.
Grass fed beef	$250 (per head)	Finished grass-fed beef with hanging weight of around 630 pounds (which usually translates into about 1,000 pounds live weight).
Constructed wetlands	**- $409**	Data: Roley et al. 2016.

USDA CRP payment for Wetlands	$237	Data: Roley et al. 2016.
Restored Prairie	**- $293**	Data: Tyndall et al. 2013.
USDA CRP payment for Prairie	$250	Data: Adapted from Tyndall et al., 2013.
Hunting revenue on all prairie, wetland and forested land (including SRWB plantation)	$340	Data assumes average hunting rental rates per acre across multiple, discrete seasonal hunting opportunities per year (J. Randall, Extension Forester, Iowa State University, Personal communication)

*All annualized net revenue and cost data were calculated using standard discounted cash flow techniques as they relate to Best Management Practices and perennial land use practices; for additional information see Tyndall and Roesch (2014).

Very carefully, use the PEWI net revenue/ cost data provided to calculate the following economic analysis parameters:

- To calculate the net revenue for various cropping systems (and your total net value of the baseline watershed), please do the following: Determine average yield per acre for corn and or beans (Go to your PEWI results table: divide total yield by total acres in corn). Go to the following website: https://www.extension.iastate.edu/agdm/crops/html/a1-20.html. Access the spreadsheet for either "Corn following corn" "Corn following soybean" or "Herbicide tolerant soybeans after corn" (your choice of rotation). Examine the spreadsheet. Only change the cells for the following information (keep everything else at the listed default values): 1) "Expected yield" to your watershed's average corn yield/ acre; 2) "Acres" to 5,889 acres; 3) "Cash rent equivalent" divide default rent charge in half (divide by 2 or multiply by 0.5); 4) type in the expected selling price for corn (beans) which can be found at: Daily corn and bean prices http://www.iowaagriculture.gov/agMarketing/dailyGrainPrices.asp. After these changes, your total net returns will be found in the lower right hand cell in the last line labeled "Net Returns".
- 50% of row crop acres are rented (divided evenly across all crop acres); this land tenure issue is accounted for in step 3 above (calculating crop revenue).
- Be sure to account for the net costs of switching "conventional" cropping systems to "conservation" crops.
- For grass fed beef, you are limited to gaining revenue from 400 head maximum.
- For mixed fruits and vegetables, you are limited to gaining revenue from a total of 40 acres.
- For conventional timber, you are limited to gaining revenue from a total of 700 acres.
- You can gain hunting revenue on all prairie, wetland and forested acres (including SRWB plantation).

RESULTS TABLE 3.2	Acres	Per unit $	Total $
Conventional Corn			
Conservation Corn			
Conventional Soybean			
Conservation Soybean			
Mixed Fruits and Vegetables			
Permanent Pasture			
Rotational Pasture			
Grass Hay			
Herbaceous Perennial Bioenergy			
Prairie			
Wetland			
Alfalfa			
Conservation Forest			
Conventional Forest			
Short-rotation Woody Bioenergy			

Step 3: Now consider that some land uses that help meet environmental goals also bring positive net revenue, others might have negative net revenue, and some land uses carry only a costs. Redesign your watershed maintaining your environmental targets, but also improving the economic value of the design. Before you get started, consider some design logic: what biophysical or economic data and watershed qualities can help you to strategically make your land use change determinations? Outline your logic in the text box below and enter your results in RESULTS TABLE 3.3 and 3.4.

RESULTS TABLE 3.3	**Acres**	**Per unit $**	**Total $**
Conventional Corn			
Conservation Corn			
Conventional Soybean			
Conservation Soybean			
Mixed Fruits and Vegetables			
Permanent Pasture			
Rotational Pasture			
Grass Hay			
Herbaceous Perennial Bioenergy			
Prairie			
Wetland			
Alfalfa			
Conservation Forest			
Conventional Forest			
Short-rotation Woody Bioenergy			

RESULTS TABLE 3.4	Summary Metrics
Acres dedicated to row crops	
Dollars from row crops	
Dollars from perennial cover	
Total dollar value	
Most valuable land cover (in dollars)	

Step 4: In the text box below, describe your findings regarding the market value of your final design. Consider the following questions:

- This exercise assumes a before and after watershed comparison with no transitional period between the baseline (100% corn) and your redesign. What are some of the key spatial and temporal issues to think about regarding a transition from the 100% row crop watershed to one with more varied, possibly perennial land cover? (Hint: some perennial practices take years to mature into a commercially productive system.)
- Your financial analysis assumes static pricing. What do you suppose might happen if certain prices for outputs/ inputs increase or decrease? For example, what if the price of corn or soybean doubled?
- As society changes, how might the demand for some of the outcomes of your redesigned watershed change (e.g., the demand for food, fiber, fuel, feed, recreation, water quality protection, biodiversity)?
- Do you believe that outcomes such as clean(er) water and air, non-game wildlife habitat, or landscape aesthetics, have economic value? How so?
- How might the inclusion of non-market economic values for say, clean water and air, non-game habitat, landscape aesthetics, change your analysis?

Step 4: Once you have completed all of your calculations and considered the questions above, pair up with another watershed designer and share your findings. Be prepared to discuss your findings with the whole class.

Step 5: Turn in your completed lab packet and submit your targeted watershed design electronically to your instructor. Also provide a one page summary of your design process, final outcomes, and key findings relative to the 100% corn baseline watershed.

References and Supporting Reading:

- *Kroeger, T., and F. Casey. 2007. An assessment of market-based approaches to providing ecosystem services on agricultural lands. Ecological Economics 64:321-332.*
    - This paper will provide students with a foundation in market-based approaches to conserving ecosystem services, and provides more depth on valuation methods and their potential use in agriculture. It should be understandable to junior- or senior-level undergraduates as well as graduate students.
- *Tegtmeier, E.M., and M.D. Duffy. 2004. External costs of agricultural production in the United States. International Journal of Agricultural Sustainability 2:1-20.*
    - This study estimates external costs of agricultural production in the United States in the areas of natural resources, wildlife and ecosystem biodiversity and human health. This paper serves as a counter balance of sorts to the market value of ecosystem goods.

- *Tyndall, J.C., and G. Roesch. 2014. A standardized approach to the financial analysis of structural water quality BMPs. Journal of Extension 52(3):3FEA10.*
    - This paper overviews in non-technical terms the general procedures used to calculate the revenues and costs of the various land use choices presented in the PEWI model. Special attention is paid to cost bearing land use choices.