Fran Lacroix
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Cost Benefit Analysis Guide

For Cover Crops Use

By *Fran Lacroix*
Oregon State University - Environmental Economics and Policy

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Introduction

This guide identifies potential costs and benefits of covers crops and proposes ways to quantify these factors. Data collected from the Corvallis Plant Material Center will later be used, with the help of this guide, to estimate the net profit or loss of various cover crop treatments.

Such an analysis is beneficial for several reasons. It is a way for farmers to better understand how much using cover crops on their field could actually cost. This allows for better decision-making and financial planning. Understanding the actual cost to farmers can help policy makers identify ways cover crops can reduce externalities. By using cost data, conservation organizations, such as the Benton SWCD, can also better demonstrate the potential of cover crops use and convince farmers to adopt the practice.

About Cover Crops

Cover crops are crops grown to protect and enrich the soil in between planting seasons. They are beneficial to soil quality in a variety of ways. They speed up infiltration of excess surface water, relieve compaction and improve structure of overtilled soil, add organic matter that encourages beneficial soil microbial life, and enhance nutrient cycling (Clark).

Choosing which cover crops to use depend on the management goals of landowners. The first step is to understand the needs of the soil, based on soil testing results and the choice of commodity crop to be planted during the next season. Landowners also need to know when they will be able to plant the cover crop, and how long it can stay in the field until the landowner need to plant the next commodity crop. Planting a diverse mix of cover crops can generate cumulative benefits, as each plant has varying properties (Clark).

The Department of Agriculture and Life Science of Cornell University has made available a Cover Crops Decision Tool, in order to help farmer to choose the crops that would benefit their soil the most. It provides recommendation for a variety of goals, including reducing weeds, improve soil aggregation and nitrogen fixation, or reduce compaction (CU CALS b).

About the Cost Benefit Analysis Process

A cost benefit analysis estimates the "equivalent money value of the benefits and costs" of a project (Watkins). There should be a common unit of measurement, which is commonly a monetary currency. The analysis should represent the consumers or producers as revealed by their actual behaviors. This information can usually be obtained from past choices. By studying how consumers have been deciding, we can design a model that includes their actual preferences. In other words, a value should not be estimated based on what planners think it is worth, but on what consumers, think it is worth, or their willingness to pay (Watkins). Conducting a cost benefit analysis can lead to better decision-making by providing a better understanding of the value of a project. It also gives tangible information that allows for better financial planning and more efficient and profitable outcomes.

When performing a CBA, we should first clearly define each scenario. The goal of the analysis is to assess the results *with* and *without* the project. In the case of the PMC, there are 9 different treatments and one control. Each mix is seeded at 3 seeding rates, 20, 40, and 60 seed/ft^2. Each combination has 4 replications (Haney). The treatment plot is left bare. The PMC plots are organized into 40 plots, 10 per row. Each plot was randomly assigned to a treatment plan. The plots are planted with the following 4 cover crop mixes (Haney):
-control – no cover crop, commodity crop
-rye, crimson clover
-rye, crimson clover, hairy vetch, radish
-rye, crimson clover, hairy vetch, radish, oats, *Brassica sp.*

The cover crops are cut at the end of spring and left on the ground to decompose. The commodity crop, corn is then planted in June, and harvested in August.

Objectives and Methods

The objective of this guide is to provide landowners, policy planners, and conservationists with an approach to evaluate potential costs and benefits, both to private parties and society, of using cover crops.

The information for this guide was collected through conversations with local farmers, Benton and NRCS staff, as well as readings of books and websites on cover crops and cost benefit analysis. A cost benefit analysis on till, conducted by John Williams and Dan Long, researchers at the Columbia Plateau Conservation

Center (USDA-ARS) was used as a model for the design. Spreadsheets and cost data provided by Hal Gordon and Sophia Glenn, economists at the Portland NRCS, also served as examples.

Challenges

Quantifying soil quality factors can be challenging for several reasons. Soil quality relies on many biological, physical, and chemical processes that are highly correlated with each other. This may increase the risk of double counting. It is also difficult to create a standard model that would apply to all properties, because soil types, land uses, and management practices vary widely from one field to another. When conducting soil quality research, there are many unpredictable factors, such as climate, which can make the results uncertain. It is also important to remember that the Plant Material Center is not a typical farm, but a government project. The costs incurred at the PMC to plant and terminate the cover crops may significantly vary from those that would be incurred in most commercial farms. Therefore, the final results of the cost benefits analysis should be interpreted cautiously, as the estimations are not fully accurate.

Analysis Guidelines

Spreadsheet Layout. The Excel workbook includes 4 spreadsheets. The first three, named Year_1, Year_2, and Year_3, calculate the net profit or loss for each year of the PMC program. The fourth worksheet, named Longitudinal_Graph, takes the net profits/losses from each year and displays them in a graph, in order to show the progression of each treatment over time.

Data Input Instructions. Text boxes throughout the guide provide recommendations to find and organize the information needed for the analysis. Once the information has been located, it can be entered in Section B of the Excel spreadsheet, into the bright orange boxes, in . Section A will display the output, calculating the costs (in red cells) and benefits (in green cells). The net profit/loss of the various treatment are located at the bottom of Section B, with the highest results in green 1 and the lowest in yellow -1. If certain costs or benefits are not deemed pertinent to the analysis, enter 0 as the input for all treatments. The note section, blue cells , can be used to keep track of which factors are included in the analysis as well as other details.

Costs

Seeds. The cost of seeds can be retrieved from seed dealers. Landowners can estimate the cost of seeds based on quotes or by past bills provided by their seed provider. The Cornell Cover Crops Decision Tools also provides a list of seed prices as of 2007. Although a bit outdated, these costs may still be accurate enough for our analysis.

In the case of the PMC, the seed company donated the seeds to the NRCS. Since most farmers would need to purchase the seeds, it may be more realistic to include how much the seeds would have cost to the PMC in the study.

Calculating Seed Costs:

- Obtain a quote from the seed provider, or
- Refer to a cover crop decision making tool, such as the following: http://www.hort.cornell.edu/bjorkman/lab/covercrops/decision-tool.php
- Make sure the quote is in the unit chosen for the analysis (such as acre or meter square
- Enter the value for each treatment in Section B, in the row titled ***Seeds***
- This values will be automatically transferred to the table in section A.
- The seed costs should be 0 in the control column of Section A.

Machinery, Tools, and Supplies. The cost of machinery and tools will vary based on field size and seeding methods. In most cases, the seeds will be planted with a seeder or seed drill. It requires a small tractor to pull it across the field. This requires gas, which can be estimated by the gas mileage of the tractor used with the seeder. Smaller hand held pushed seeders can also be used. Most of them also have engines that require gas to function. In the case of hand seeding, no machinery is required, but the process still requires labor. As the PMC owns a seeder, the final analysis will include the cost of gas and, if feasible, the depreciation of the seeder.

Calculating Machinery and Tools Costs:

- Estimate the costs of machinery and tools used for the planting and termination of cover crops
- Convert the costs to match the units chosen (such as per acre)
- Sum all costs in Section B, in the rows titled ***Machinery***, ***Tools***, and ***Supplies***
- These values will be automatically transferred to the table in section A.
- The seeding and termination costs should be 0 in the control column.

Labor. The cost of labor can be estimated in various ways. In the case of the PMC, we can estimate how much time was spent planting and terminating the cover crops and multiply by an hourly rate. The hourly rate may be based off of the salary of the NRCS staff. However, this may not be very representative of labor that would actually be incurred by an average farmer. A better way may be to determine an hourly rate based on average farm salaries in the county, state, or nation.

Calculating Labor Costs

- Estimate how much time was spent planting and terminating on each treatment
- Convert the time to the unit chosen (Eg: per acre)
- Enter the amount of time (in hours) spent per unit in Section B, in the row titled ***Labor_time***
- Sum the hourly labor rates of the workers involved in the project
- Set this total hourly labor rate in Section B, in the row titled ***Hourly_labor_rate***
- The labor cost per unit will be calculated for each treatment in Section A.
- The labor costs for cover crops use should appear as 0 in the control column of section A.

Termination. Before planting the next commodity crop, the cover crops must be trimmed, turned, or flattened. The debris are then left on the field to compost, releasing nutrients. This process usually requires the use of a mower and rototiller. Turning can also be performed manually, with shovels or garden forks. In both cases, the cost of the tools or gas used for the machinery may be included in the total costs.

Benefits

Increased Yield. Cover crops can enhance soil health by speeding infiltration of excess water, reducing compaction, adding organic matter that favors beneficial soil microbial life, and enhancing nutrient cycling (Clark). This can leads to better plant growth, and potentially, increased yield.

The yield for each treatment will be calculated after harvesting. In the future, any statistically significant difference between the treatments and control plots could become a base estimation for landowners to use when conducting their cost benefit analysis.

Calculating Increased Yield

- Enter the commodity crop yield for each treatment in Section B, in the row titled **Commodity_crop_yield**
- Find the current price of the commodity crop (such as corn) from an exchange market or similar quote
- Enter the current price of the commodity crop in Section B, in the row titled ***Corn_value***
- In section A, the yield row will calculate the yield difference between the control and treatments, and multiply by the value of the commodity crop (corn)

Increased Fertility / Decreased Fertilizer Use. Cover crops can add nitrogen and other chemicals, such as phosphorus, to the soil by scavenging and mining soil nutrients (Clark). Legume cover crops also convert nitrogen gas from the atmosphere into soil nitrogen that can be used by plants. Commodity crops grown in fields subsequently can absorb at least 30 to 60 percent of the nitrogen that was produced by the cover crop (Clark). This reduces the amount of nitrogen fertilizer needed to enrich the soil and boost plant growth.

The PMC will test the soil in order to assess how much nitrogen and phosphorus have been added to the soil by the cover crops. The amount of fertilizer saved can be estimated by calculating the amount of fertilizer that would have been needed to enrich the soil to the same levels. Fertilizer costs are available through agricultural products providers' websites. The OSU Extension Cover Crops Calculator can also calculate the nutrient value (in $) of elements added by various cover crops. The following website also provides valuable information regarding fertilizer application: http://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx#26730.

Calculating Variations in Fertilizer Use

- Enter the nitrogen and phosphorus levels for each treatment, before and after planting, in the rows titled ***Nitrogen*** and ***Phosphorus*** of Section B.
- Estimate the cost of phosphorus and nitrogen per unit by referring to the specifications of chosen fertilizers.
- Enter the cost of nitrogen and phosphorus per unit in the corresponding cases of Section B, titled ***Nitrogen_cost*** and ***Phosphorus_cost***
- The cases ***Phosphorus_app_rate*** and ***Nitrogen_app_rate*** can be used to convert the nitrogen and phosphorus levels to the application rate of the corresponding fertilizer. If the units of PMC data already match the units of

the costs cases ***Nitrogen_cost*** and ***Phosphorus_cost***, then the application rate can be set as 1.

- Section A will then calculate the fertilizer savings by subtracting the levels before planting from the levels at termination, and then multiplying by application rate and cost. The results will be displayed in the row titled ***Fertilizer*** of Section A.
- The table assumes that the fertilizer providing nitrogen is not the same as the fertilizer providing phosphorus. If this is not the case, simply set the cost of one of the chemical as 0, to avoid double counting.

Increased Water Retention / Decreased Watering. Cover crops can conserve soil moisture. Residues from terminated cover crops increase water infiltration and reduce evaporation (Clark). Lightly incorporated cover crops trap surface water and add organic matter to increase infiltration in the root zone (Clark). Timely termination of the cover crops can also avoid the opposite impact of water, by preventing excessive soil moisture (Clark).

The PMC has been monitoring water moisture in each plot. In order to estimate the savings from decreased watering, we could multiply the amount of water that would be needed to reach similar moisture levels by a flat water cost, obtained from the water service bill or through the city or county water service.

Calculating Variations in Irrigation

- Enter the moisture levels for each treamtment in the row of Section B called ***Soil_moisture***
- Enter the cost of water per unit in the case titled ***Water_cost***
- Section A will calculate water savings by subtracting the moisture level of the control plot from the treatment's, and multiplying the result by the water cost. The results are in the row titled ***Irrigation***
- The case Water_app_rate of Section B can be used to convert the moisture levels to a specific water application rate per unit (ie: the amount of water that would need to be applied to reach the same moisture level).

Weed Reduction / Decreased Herbicide Use. Cover crops are an effective way to control weeds. They smother and outcompete weeds for water and nutrients, their leaves or residues alter the frequency of light waves and change the soil surface temperature, preventing weed growth (Clark). Certain cover crops' roots release compounds that have natural herbicidal effects (Clark). By preventing the spread of weeds, cover crops can reduce the amount of herbicide that would need to be used.

The PMC regularly conducts biological assessments on the plots to compare weed types and quantities. We can compare the control plots with the treatments and estimate the difference. We could then assess how much herbicide would have been needed to reach similar weed profiles. The costs can then simply be based on current herbicide prices.

Calculating Variations in Herbicide Use

- Based on the PMC report, create an ordinal scale, with lower values for fewer weeds and higher values for more weeds.
- Place each treatment on the scale.
- Enter the corresponding number for each treatment in the row titled ***Weeds*** of Section B.
- Set an herbicide application rate for the ordinal scale and enter the value in the case titled ***Herbicide_app_rate***
- Set a cost per unit of application and enter the value in ***Herbicide_cost***
- Herbicide savings will be calculated in Section A and displayed in the row titled ***Herbicide***.

Increased Pest Resistance / Decreased Pesticide Use. Cover crops can control the spread of pests in variety of ways. They host beneficial microbial life that discourages diseases and create an inhospitable environment for many soilborne diseases (Clark). They can encourage beneficial insect predators and parasites that can reduce insect damages. Finally, they produce compounds that reduce nematode pest populations and encourage beneficial nematode species (Clark).

The PMC will be conducting biological assessments to compare the insects and pests present on each plot. Based on the results, it may be possible to estimate the difference in beneficial insects and harmful pests between the various treatments and control crops. We could then estimate what types and quantities of pesticides would have been used to reach the same pest and insect profiles. The cost of pesticides can then easily be obtained through agricultural products providers.

Calculating Variations in Pesticide Use

- Based on the PMC report, create an ordinal scale, with lower values for fewer weeds and higher values for more pests.
- Place each treatment on the scale.
- Enter the corresponding number for each treatment in the row titled ***Pests*** of Section B.

- Set an pesticide application rate for the ordinal scale and enter the value in the case titled ***Pesticide_app_rate***
- Set a cost per unit of application and enter the value in ***Pesticide_cost***
- Pesticide savings will be calculated in Section A and displayed in the row titled ***Pesticide***.

Increased organic matter. Some farmers protect and enrich their soils with methods other than cover crops, such as leaves or straw. Planting cover crops would eliminate the need for these other methods. The amount of money saved by not using other soil enrichment methods could also be included in the benefits.

Calculating Organic Matter Savings

- If another method of organic matter addition would have been used, in place of the cover crops, its cost could be included as a saving.
- Enter the cost per acre of the alternative method in Section B, in the row titled ***Alternative_OM***
- This cost will be converted into savings in the treatment columns of Section A, while the control column will show 0.
- Section B also has two rows for organic matter at planting and termination. This is mainly for reference, in case another way to calculate OM savings is identified.

Erosion control. Cover crops can hold soil in place, reduce crusting, and protect against erosion by wind and water. They also improve soil infiltration, which reduce runoffs that can carry away soil. By preventing erosion, cover crops can reduce soil replacement costs or other erosion control costs.

There are two ways we could evaluate the benefits from reduced erosion. The first one is to calculate the soil erosion factor, RUSLE, and the weight of soil that would be lost on the field without an erosion control method (MSU IWR). We can then use soil prices to estimate how much it would cost to replace the soil on the field by bringing in new soil. Another way would be to obtain evaluate the cost of implementing another erosion control method, such as leaving the fields fallow, ceasing tillage, creating a grassed waterway, lined channels, or drop structure, Terracing, leaving crop residues, or adding organic matter, such as leaves or straw (Alberta Agriculture and Rural Development). Such quotes can be obtained by companies who provide some of these services, or if all the work can be performed by the farm's staff, by counting the costs of labor, machinery, tools, and supplies.

Calculating Anti-Erosion Benefits

- Decide which method would be used to control erosion without the use of cover crops:
  -Method 1: Calculate the erosion rate using RUSLE, using http://www.iwr.msu.edu/rusle/, or a similar erosion calculator tool
  -Based on how soil would be lost to erosion, obtain a quote for the price of soil replacement and delivery to the field. (Note: This method is likely to apply only to small plots, as it would be excessively costly for bigger fields).
  -Method 2: Obtain a quote for an erosion control methods. Several methods are listed in the following article:
  http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex2074
  The quote might include labor, machinery, tools, and other supplies incurred to the farmer or to a contracting company to implement the chosen method.
- Divide the total cost of the chosen method to convert it to the unit used in the analysis (such as per acre)
- Enter the cost of erosion per unit in Section B, in the row titled **Erosion_cost**
- Enter 0 in the Erosion_0 (this will set the erosion savings at 0 for the control plot)

Calculating Net Profit

Once data has been collected, it can be entered into the spreadsheet. The net profit or loss is then calculated by subtracting all the costs from all the benefits. Ideally, the project could be worthwhile if one of the following applies (Watkins):
-The net profit is positive
-The discounted present value of the benefits exceeds the discounted present value of the costs
-The ratio of the present value of the benefits to the present value of the costs is greater than 1.

However, despite a net loss, a project may still be viable if the net loss is within a certain range, which will vary based on the type of project.

Social Benefits

Certain benefits of cover crops will not be directly returned to individual landowners, but rather to society or the surrounding community. The positive effects of cover crops on soil quality extend beyond the fields they are planted in. Cover crops can reduce the need for fertilizer and pesticides, which can lower the amount of agricultural runoffs on wildlife habitat, riparian areas, and rivers. By slowing erosion and runoff, cover crops reduce nonpoint source pollution caused by sediments, nutrients, and agricultural chemicals (Clark). By absorbing excess nitrogen, they can also prevent nitrogen leaching to groundwater (Clark). This means cleaner water, for human consumption and stream health. Moreover, as the country experienced with the Dust Bowl, the impact of erosion does not stop at property boundaries, but affect society at large by reducing land productivity and food supply, as well as air and water quality. Less chemical applications also help to safeguard the health of farm neighbors, workers, and the local community.

Non-point source polluters are rarely deemed individually responsible for the damages and do not provide compensation to society. Instead, entire communities, through cleanup or damage costs, pay for these externalities. As cover crops can reduce such externalities, they can eventually decrease their costs to society.

This may have implications in policy-making, as the use of cover crops is sometimes subsidized. The research, such as the PMC, and advocacy programs, such as workshops organized by the SWCD, on cover crops use also cost to government agencies, and by extension to taxpayers. By showing that the money spent to improve field management practices may come back to society in the form of lower externality costs, we could facilitate conservation efforts. For example, by showing that money given to soil quality improvement programs is not lost, funding may be easier to obtain. It may also be easier to show taxpayers why they should allocate funds to their local conservation organizations, such as the Benton SWCD, because the money may ultimately come back to them, in the form of improved quality of life and environment.

Recommendations

The next step in the analysis will be to collect soil quality data from the Plant Material Center, as well as cost data from the Field Office Technical Guide. The information will then be evaluated and methods adjusted to better fit the data. The net profit or loss for each treatment and control plot will be calculated and the results will be assessed and compared. Cost benefit analyses often follow a sequential approach. Once results are obtained, the model is reevaluated and refined to add more details and improve accuracy.

It is also important to note that a cost benefit analysis, despite all efforts to ensure precision, is often not fully accurate. There is not a right or wrong answer to the question of interest. The results are a useful tool to make decisions, but should be used with caution. Even with an analysis showing positive results, a project may not actually be profitable. Similarly, an analysis showing losses does not necessarily signify that the project is not viable. Decisions should be based on the contextual analysis of the results, as well as a good understanding of the project's social and environmental impacts beyond an individual field.

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