Partial Budget and Crops vs Livestock Sensitivity Analysis for Integrating Livestock with Crop Production

The Match Made in Heaven project seeks to understand the state of the art of livestock and crop integration on farms in the Upper Mississippi River Basin.

Introduction

Integrating livestock into cropping systems can have many benefits, including spreading farm financial risk over multiple enterprises, creating a pathway for a younger generation to join the farm, providing a manure source for crop nutrients and thereby reducing fertilizer costs, and incentivizing putting acreage in perennial forage and cover crops with an associated reduction in soil loss due to erosion. The very thought of adding a livestock enterprise to a stable crops-only operation can also generate anxiety about the impact on the farm as a whole.

Standard enterprise budgets, Schedule F tax forms, and financial databases such as FINBIN typically do not provide a straightforward way to see the synergies that arise from integration of livestock and crops. Calculator tools have been developed by others for detailed analysis of livestock grazing operations on farms, but require extensive recordkeeping and data entry. The Midwest Perennial Forage Working Group of Green Lands Blue Waters wanted to find a simpler way to show the interaction of crop and livestock enterprises on farms, and a tool to help crop farmers test the potential effects of adding livestock to their farms. The Match Made in Heaven: Livestock + Crops project gave us an opportunity to use real farmers' data to explore ways to accomplish these goals. The result is a spreadsheet-based partial budget and sensitivity analysis framework.

Partial Budget & Sensitivity Analysis Spreadsheets

- Composite Farm Example
- Test Copy
- Blank Template

Partial Budgeting

We adapted the partial budget framework created by Iowa State University Extension[1]. Their partial budgeting tool is intended for farmers to use when considering a change in their enterprises, to help test the likely effect of the proposed change on overall farm finances.

Partial budgets are structured as four quadrants:

Table 1. General Partial Budget Framework

Gains	Costs
income gained from the new enterprise	direct costs of the new enterprise
costs avoided because of the new enterprise	income lost due to the new enterprise

If the total of the two items in the Gains column is greater than the total of the two items in the Losses column, the proposed new enterprise is likely a net gain for the farm:

[1] 1 Partial Budgeting: A Tool to Analyze Farm Business Changes. Iowa State University : https://www.extension.iastate.edu/agdm/wholefarm/html/c1-50.html

(Income gained + Costs avoided) > (New costs + Income lost) = Net gain

If the total of the two items in the Costs column is greater than the total of the two items in the Gains column, the proposed enterprise is a likely net loss for the farm:

(Income gained + Costs avoided) < (New costs + Income lost) = Net los

Data from Integrated Crop and Livestock Farms in the Midwest

Testing the idea of a new livestock enterprise requires a "starter" set of data and some likely ranges for data points, such as livestock cost of production per head and gross income per head sold. One complaint beginning farmers have had about the various livestock calculator tools is that they don't know what numbers to put in when they are just starting out, before they have records to rely on. There could be a similar situation for crop farmers who do not currently have livestock.

To address that gap, we collected farm financial details from 2021 and/or 2022 data provided by five Midwestern farms with successful integrated crop and livestock operations. Farms were located in Wisconsin, Iowa, Illinois, Indiana, and Missouri. The five farms included:

- two cow/calf plus beef feeding operations of different sizes
- one cow/calf operation with a cooperating feeding operation as a dedicated buyer of calves
- one custom dairy heifer grazing operation
- one beef heifer rearing and breeding operation in which the saleable product was cow/calf pairs

Where the farmers' data were incomplete, we inserted estimated values based on crop prices and livestock prices as reported by USDA-AMS, local livestock auctions, and local hay auctions at similar locations and time frames as the farmers' data.

Using these five data sets, we created an adaptation of the partial budget analysis that incorporates both the livestock and the crop sides of a farm operation and accounts for:

- opportunity cost of feeding crops to livestock instead of selling all crops
- value of manure generated by livestock to the cropping enterprise
- value of retained soil due to reduced erosion on acres in perennial forage
- value of retained soil due to reduced erosion on acres cover-cropped and grazed
- reduction in crop production costs due to acres in perennial forage

Then we created a single composite data set, based on median numbers from the five farms. This composite example features a farm with 780 acres: 250 acres in corn, 250 acres in soybeans, 80 acres of hay, and 200 acres of pasture. The 250 acres in corn are cover-cropped. The hay ground is tillable. Fifty acres of the pasture are tillable and can be cut once per season for hay. The remaining 150 acres of pasture is untillable marginal land. The farm operation includes an 85-head beef cow/calf herd and a 100-head feedlot. The example assumes $6/bu corn, $15/bu soybeans, and $140/ton hay. These were typical crop prices in 2022, which is the year of most of the farmers' data collected for this project. The composite farm assumes crop production levels of 180 bu/acre corn, 45 bu/acre soybeans, 2.5 tons/acre hay from the hay ground, and 1.5 tons/acre hay from the tillable pasture.

Composite Farm Example Partial Budget; budget-example tab

In this example, the crop prices are fairly high. High crop prices mean a high opportunity cost of feeding crops instead of selling them, and a high opportunity cost of having land in forages for cattle instead of in cash crops. If we look only at the income from sales of livestock set against these costs, and adjusted for avoided cash grain crop production costs, it looks like livestock are a net loss.

Table 2. Partial Budget Including Crop and Livestock Sales and Costs

Livestock Gains		Livestock Costs	
Livestock sales, average per head	$1557	Livestock direct costs	$847
		Opportunity cost of grain crops fed instead of sold	$527
Avoided cash grain crop production costs over & above hay production costs on tillable acres in perennial forage	$253	Opportunity cost of cash grain crops not grown on tillable land in perennial forages	$559
TOTAL GAINS	$1810	TOTAL COSTS	$1933
NET LOSS per head	($123)		

Adding the value of livestock manure generated and the value of soil retained on tillable acreage in perennial forage improves the gains side enough that there is a small net positive for livestock:

Table 3. Partial Budget Including Crops, Livestock, Manure Value, and Retained Soil Value

Livestock Gains		Livestock Costs	
Livestock sales, average per head	$1557	Livestock direct costs	$847
Manure value, average per head	$79	Opportunity cost of crops fed instead of sold	$527
Soil retention value from acres cover-cropped or in perennial forage, average per head	$46		x

Avoided cash grain crop production costs over & above hay production costs on tillable acres in perennial forage	$253	Opportunity cost of cash grain crops not grown on tillable land in perennial forages	$559
GAIN due to livestock	$1935	COSTS due to livestock	$1933
NET GAIN per head			

These calculations make it look like livestock are a very small gain to this farm operation, but this is not the whole story.

Crops and Livestock Sensitivity Analyses

Because of the point-in-time nature of the data, we also created a series of sensitivity analyses showing the shift in overall farm net benefit or drag due to livestock as crop prices and livestock prices change. The sensitivity analysis framework was adapted from Ecotone Analytics, 2021[2].

The two-way sensitivity analyses incorporate crop prices, crop production costs, livestock prices, livestock production costs, and cropped acreage and number of head of cattle from the composite farm example. It sets the scenario with livestock against a hypothetical scenario of all crop production on all tillable acres. Then the calculations are run as crop prices change, 10% at a time, from 50% lower to 50% higher than the base rate of $6 corn and $15 soybeans. In the same calculations, livestock prices change 10% at a time, from 50% lower to 50% higher than the base rate of $1,557 per head (across all classes of livestock sold: fed cattle, cull cows, weaned calves.)

Tab: livestock_sens

The sensitivity analysis of just the livestock enterprise shows that in high crop price years, livestock can be a drag on the farm's potential net income. In high livestock price years, livestock make a positive contribution to farm profitability.

Tab: crops_sens

The sensitivity analysis of just the crop enterprise shows that when crop prices drop by 10% from the baseline of $6 corn and $15 soybeans, the crop enterprise becomes a net negative for the composite farm.

[2] Ecotone Analytics, 2021. Social Return on Investment (SROI) of Perennial Forage and CLC and Technical Documentation

Tab: crops_lvstk_sens

On this tab, the livestock enterprise and crop enterprise are combined to show the overall farm profit or loss as livestock prices and crop prices change. Crop prices generally drive the overall farm performance. As crop prices decrease, it becomes more difficult to overcome net losses in the crop enterprise with net gains from livestock.

Tab: allcrops_sens

This tab shows a scenario in which there are no livestock, all tillable acres are planted to cash grain crops, and all crops are sold. Harvesting cash grain from all tillable acres gives the farm a net profit unless crop prices drop by 30% or more from the baseline of $6 corn and $15 soybeans. A 30% drop in crop prices would be $4.20/bushel corn and $10.25/bushel soybeans.

Tab: farm_vs_allcrops_sens

Here is where we can see the conditions under which having livestock on the farm is a financial advantage over having no livestock and crops on all tillable acres. When crop prices are low and cattle prices are relatively high, the farm with both crops and livestock outperforms the farm with no livestock and all crops on all tillable acres.

Tab: 4scenarios

This tab gives the overall picture of the net benefit or drag of livestock enterprises on this farm.

- When livestock prices are low, the farm with livestock loses more money than it would with all crops and no livestock. (26% of sensitivity chart)
- When crop prices are low and livestock prices are moderately low to moderately high, the farm with livestock loses money but it loses less than it would without livestock. (15% of sensitivity chart)
- When crop prices are low and livestock prices are high, the farm with livestock makes money and it makes more money than it would without livestock. (12% of sensitivity chart)
- The rest of the time, the farm with livestock makes money but it makes less money than it would if there were no livestock and all tillable acres were in cash grain. (47% of sensitivity chart)

The farmer on this composite farm will need to determine the most likely set of crop and livestock prices, and decide the balance of risks and rewards from having livestock.

How to Use the Tools

This set of Partial Budget and Crops vs Livestock Sensitivity Analyses allows both crops-only farmers and farmers with livestock to test scenarios for the future of their farms. The spreadsheet-based templates have all the necessary formulas embedded. The spreadsheet tabs are locked except for cells where you can enter data, so you do not have to worry about accidentally deleting an important formula.

We have provided TEST COPY and TEMPLATE versions of the spreadsheet.

- TEST COPY shows the numbers for the composite farm example, but you are able to change numbers in columns B - F on the budget tab.
- TEMPLATE has all numbers in columns B - F set to zero.

1. Make yourself a copy

Choose which spreadsheet version you want to use - TEST COPY or TEMPLATE - and make yourself a copy.

- Open the link to the spreadsheet version.
- Under the File menu, choose Make a copy.
- You can rename your copy.
- Under the File menu for your copy, choose Move.
- Navigate through your Drive folders to choose where you want to keep the copy.
- Under the File menu. you could choose Download and download a copy as a Microsoft Excel file. All of the embedded formulas and formatting may not hold up, however.

2. Complete the budget tab

Use the farm's real numbers as much as possible. Enter numbers in columns B through F, except where cells are grayed out or an item does not apply to the farm. The "ranges" tab shows the range and median of numbers obtained from interviews with five farmers. Farmers can pick numbers from the ranges, or enter their own numbers from their Schedule F forms or other sources, in order to try out scenarios.

Columns B through F on the budget tab are the only places where farmer data needs to be entered. All other columns on the budget tab and everything on other tabs automatically calculates from numbers entered in columns B through F. It is fine to put in rough estimates, and then make changes to see what happens in the other columns and tabs.

3. Automatic Calculations

Columns H - J show calculations of crop income, benefit from manure generated by livestock, and benefit from reduced soil loss on untilled or cover-cropped acres. The calculations use numbers entered in columns B - F, and estimates of manure and soil value based on Extension documents and other sources (detailed in the budget tab.) These calculation columns are locked to changes. You can make changes in columns B - F to see how changes there affect the calculations in columns H - J.

4. Partial budget quadrants

The four quadrants of the partial budget for livestock enterprises are shown in columns L - T.

Gains: Columns L - O	**Costs: Columns Q - T**
crop costs avoided because of the livestock enterprise: Lines 16 - 22	crop income lost due to the livestock enterprise: Lines 16 - 22

income gained from the livestock enterprise: Lines 7 - 10	direct costs of the livestock enterprise: Lines 7 - 10
Subtotal of gains due to livestock: Line 24	Subtotal of losses due to livestock: Line 24

Directly below the Partial Budget quadrants, in columns L - O:

- Line 25: Net gain or loss due to livestock
- Line 26: Net gain or loss due to crop enterprises
- Line 27: Other farm income
- Line 28: Total farm gain or loss (sum of lines 25, 26, and 27)

All of these Partial Budget quadrants and the summary lines are locked to changes. You can make changes in columns B - F to see how those changes affect the partial budget and summary of farm income.

5. Sensitivity Analyses

Numbers highlighted in orange on the completed budget tab will carry over to the sensitivity analysis tabs. Sensitivity analysis tabs will automatically calculate how changes in crop and livestock prices affect aspects of farm profitability.

- livestock_sens tab: livestock enterprises net
- crops_sens tab: crop enterprises net
- crops_lvstk_sens tab: combined crop + livestock enterprises net
- allcrops_sens tab: hypothetical situation of all tillable acres in crops
- crops_lvstk_vs_allcrops_sens: relative gain or loss from crop + livestock enterprises, set against the hypothetical of all tillable acres in crops
- 4scenarios tab: pattern of farm profitability or loss across all crop and livestock price combinations

The sensitivity analysis tabs are locked to changes, except for white cells containing estimates of corn and soybean production costs. These cells contain numbers generated from FINBIN reports. Farmers can input different numbers in these cells that are more reflective of their actual crop production costs. All other numbers in the orange cells are pulled over from the farmer's numbers in the budget tab.

6. Interpreting the 4scenarios tab

Determine how likely you think each crop price and livestock price scenario is on the 4scenarios spreadsheet tab. How many years out of 5, or years out of 10, would the farm be better off with livestock than without? Answering this question may require consultation with an experienced farm or farm advisor who has looked at crop and livestock price trends over years and decades.

Farmers currently growing only crops may find that over the majority of the most likely price scenarios, they would have the financial space to start a livestock enterprise - or to allow a younger generation to start one - while still keeping the overall farm profitable.

Adding a livestock enterprise could still seem daunting, with potential drawbacks and barriers that aren't seen in the partial budget and sensitivity analyses. For a look at what integrated crop and livestock farmers see as challenges and benefits of livestock integration, see our Survey Results from 553 farmers across the Midwest: https://greenlandsbluewaters.org/match-made-in-heaven-livestock-crops/#survey

Fair Use of Materials

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Green Lands Blue Waters and partners are conducting essential research, improving the genetics of old and new crops, translating knowledge into Continuous Living Cover farming systems, developing new extension and outreach capacity, working in farm fields, shaping policy, building profitable markets for new crops, and changing the narrative around what's possible through agriculture. The value of Continuous Living Cover farming comes in yields and profits, but also in improved soil health, cleaner water, new economic opportunities, diverse agricultural communities, more wildlife, reduced risk, and resiliency in the face of a changing climate.
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