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The Value of Soil Sampling and Sampling Density: Conceptual Framework (Part 1)

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Market Report	Year Ago	4 Wks Ago	6-26-20
Livestock and Products, Weekly Average			
Nebraska Slaughter Steers, 35-65% Choice, Live Weight.	*	*	*
Nebraska Feeder Steers, Med. & Large Frame, 550-600 lb.	175.56	167.19	169.84
Nebraska Feeder Steers, Med. & Large Frame 750-800 lb.	145.77	*	136.65
Choice Boxed Beef, 600-750 lb. Carcass.	219.55	374.04	210.20
Western Corn Belt Base Hog Price Carcass, Negotiated	NA	*	*
Pork Carcass Cutout, 185 lb. Carcass 51-52% Lean.	72.66	88.08	64.48
Slaughter Lambs, wooled and shorn, 135-165 lb. National.	156.37	NA	103.83
National Carcass Lamb Cutout FOB.	392.01	410.54	415.16
Crops, Daily Spot Prices			
Wheat, No. 1, H.W. Imperial, bu.	3.94	4.13	3.90
Corn, No. 2, Yellow **Columbus**, bu.	4.05	2.90	2.99
Soybeans, No. 1, Yellow **Columbus**, bu.	7.92	7.74	7.92
Grain Sorghum, No.2, Yellow Dorchester, cwt.	6.34	6.30	6.18
Oats, No. 2, Heavy Minneapolis, Mn, bu.	3.20	3.50	3.67
Feed			
Alfalfa, Large Square Bales, Good to Premium, RFV 160-185 Northeast Nebraska, ton.	177.00	*	172.00
Alfalfa, Large Rounds, Good Platte Valley, ton.	*	87.50	*
Grass Hay, Large Rounds, Good Nebraska, ton.	*	80.00	75.00
Dried Distillers Grains, 10% Moisture Nebraska Average.	140.50	123.25	121.29
Wet Distillers Grains, 65-70% Moisture Nebraska Average.	48.50	42.79	33.23
* No Market			

When considering variable-rate nitrogen or seed application, soil sampling can provide farmers and their consultants with valuable information about the spatial distributions of soil properties such as organic matter, micro- and macro-nutrients, and pH. Conceptually, that information may be especially valuable for site-specific input management. But just as farmers make decisions about input applications, they also must make decisions about soil sampling, and in particular, must choose soil sampling density. It is standard practice for U.S. corn and soybean farmers to take soil samples on their fields every three or four years at a density of one sample per 2.5 acres. But whether that 2.5-acre density is economically optimal, and how the optimal density might change under different field and weather situations is largely unknown. Some producers choose one sample per acre and others choose one sample per ten acres. This article aims to present an analytical microeconomic framework to help non-economists systematically address these economic questions.

To address the economic question, we need to consider at least three components:

1. The cost of data acquisition (e.g., soil sampling and chemical analysis),
2. Data accuracy, and
3. The incremental revenue gained by increasing the amount of data collected (revenue = output price × output quantity).

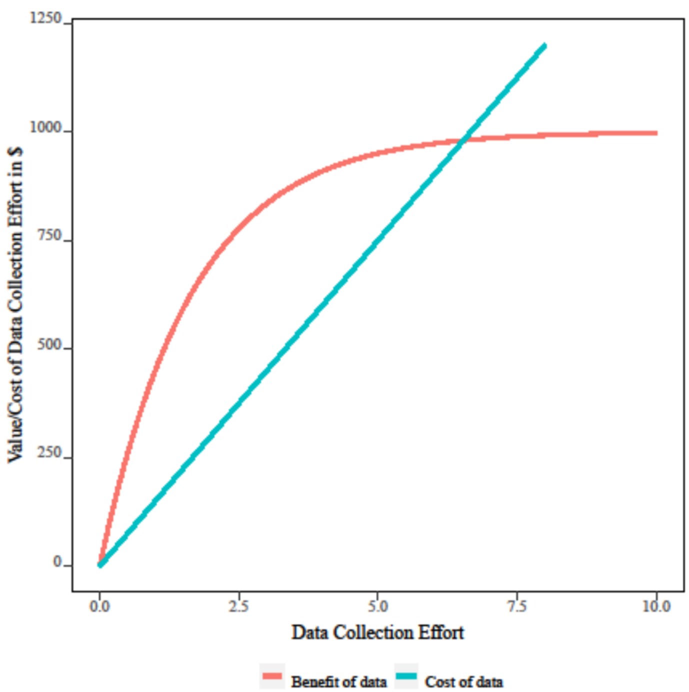
Most discussions about how densely (and how often) farmers should sample are based on only components 1 and 2, but not on 3. This is simply because the quantifying component 3 requires significant amounts of high-quality data, which are generally expensive.

In general, the following relationships hold:

1. Raising soil-sampling density generally increases data quality, but also increases the costs of data acquisition.
2. The higher the quality of the data, the greater is the boost in revenue from additional data.

A graphical illustration of these relationships can further help understand the concept of an economically optimal data acquisition strategy.

Figure 1



In Figure 1, the y-axis registers the benefit and the cost of the data collection effort in dollars. The data collection effort is registered on the x-axis and is assumed to take on values between 0 and 10. At 0, no data is acquired and the decision maker gains no new knowledge. Increasing data collection effort increases the quality and value of the data. But the benefit of the data collection efforts increases at a diminishing rate, meaning that the value of additional efforts depends on how much effort the farmer has already invested. Additional effort provides more if the amount of information already gathered is low. Conversely, the cost of data acquisition increases as effort, and therefore data quality, increases. For simplicity, the figures assume this relationship between data quantity and data cost is linear. The economically optimal amount of data collection effort occurs where the difference between the benefit and cost of data collection efforts (and therefore data quality) is maximized.

Figure 2.

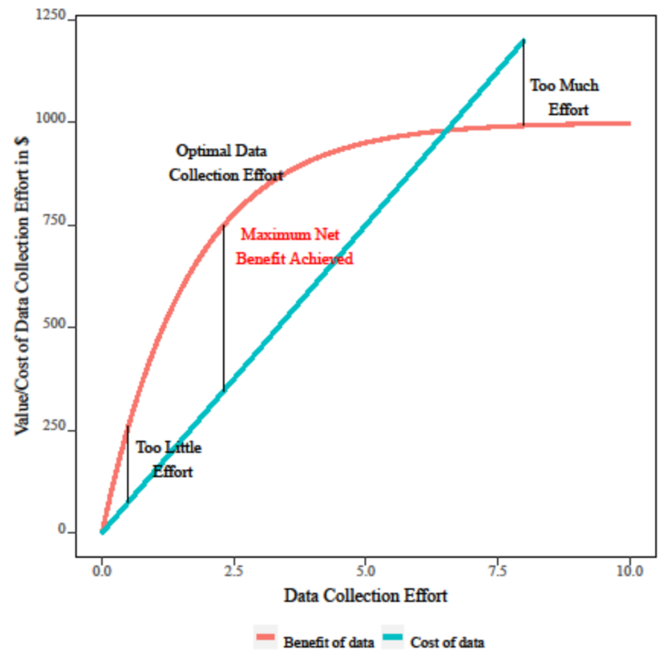
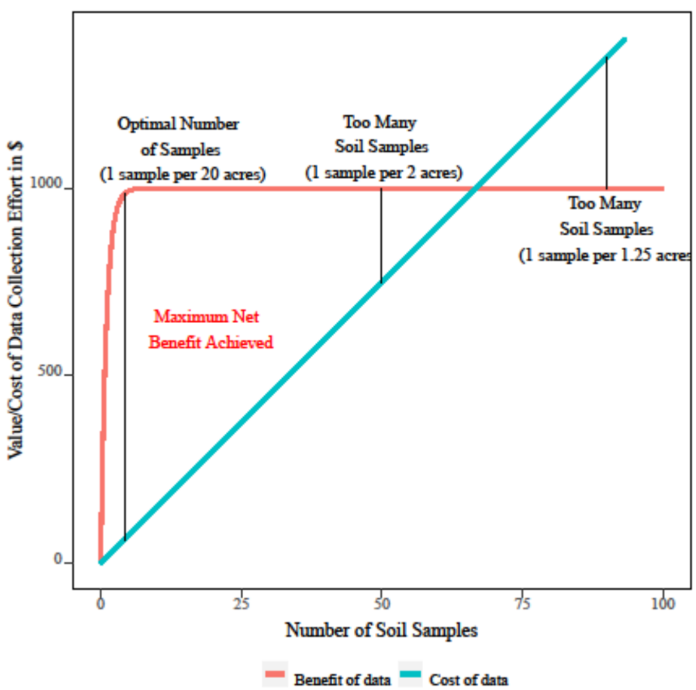


Figure 2 illustrates this point for a particular instance in which data collection effort provides the economically optimal quality of data. At a data collection effort level of 1, the decision maker is collecting too little information because the additional cost of enhancing data quality is lower than the benefit associated with the additional data. On the other hand, the opposite is happening at the data collection effort level of 8. The benefit of additional information is so little and much lower than the cost of the additional information that the decision maker loses money by generating a higher level of data quantity. This example illustrates that from an economic perspective, the quality of the data generated can be too high! Of course, further reflection makes this obvious; if a consultant recommends that a farmer pay for 100 soil samples per acre, the farmer would quickly suspect that at some point, the cost of an additional unit of data quality would dominate the benefit of that additional unit.

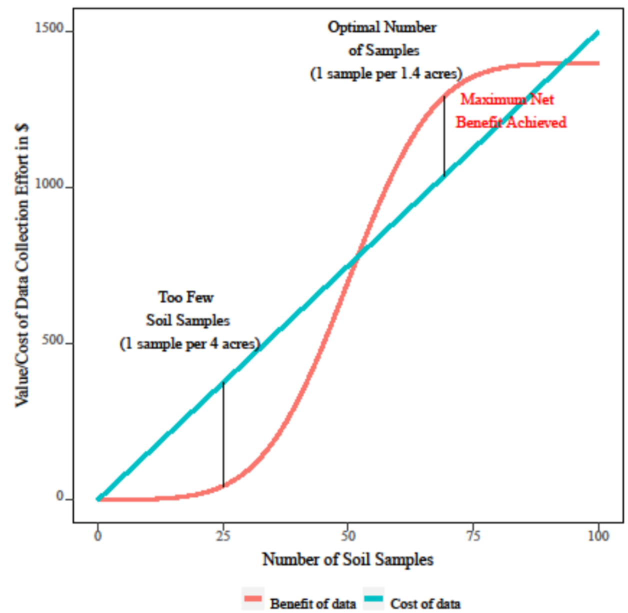
Going back to the case of soil sampling density, what are the shapes of these curves in the real world? Obtaining a good answer to this question currently requires much more empirical research. After all, the answer may vary by field (due to differences in the fields' soil characteristics), by year (due to annual weather fluctuations), and potentially many other factors. Figure 3 shows the case of a spatially homogeneous 100-acre field, where the first few soil samples can tell a lot about the field and save producers from making very unfortunate input application-rate decisions. But, more samples do not provide much information that has not already been provided by the first few samples. So, in this example, five samples for the whole field (1 sample per 20 acres), any additional samples would simply reduce the profit.

Figure 3.



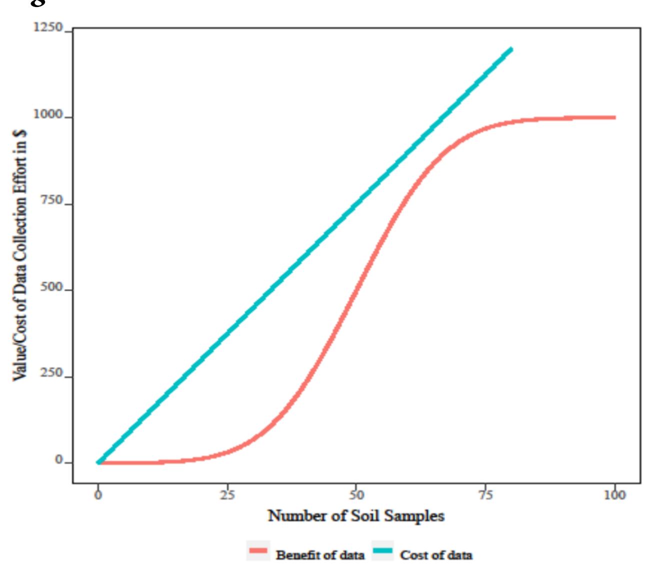
However, Figure 4 illustrates a case when a farmer seeks to apply variable rate management to a heterogeneous field. In this case, the first few soil samples are not very useful because they only give information about only small parts of the field. But, as soil sampling increases, variable rate management can take advantage of the increase in data accuracy. Eventually, of course, the one-thousandth soil sample provides very little information not already provided by the 999th. This creates the S-shaped value curve shown in Figure 4. In this example, 25 samples on the 100-acre field (1 sample per 4 acres) is not sufficient. However, as the sample density increases, the value of the data surpasses the cost of the data, and the maximum net benefit is achieved at 70 samples (1 sample per 1.4 acres).

Figure 4.



The case illustrated in Figure 5 is also entirely possible. In this case, the value of soil sampling never exceeds its value, and the best strategy is to not soil sample at all.

Figure 5.



Finally, returning to a point made initially in this article, finding the best soil sampling density requires understanding the (red) curve, which is how the total value of soil sampling is related to soil sampling density. In the next post, we will talk about ongoing efforts to estimate the red curve.

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