Report on DIFM Field Trial
Anonymous_Anonymous_2022

Table 1. Field Management Information

Field Name	Anonymous
Field Size	71 ac
Plot Length	200 - 300 ft
Plot Width	40 ft
Applicator Width	40 ft
Sectional Control?	1
Harvester Width	20 ft
Experimental Design	Latin-Square Trial
Targeted Rates	39, 82, 117, 168, 211lbs
Producer's Status Quo Strategy	117 lbs
Price of corn	$5.50/bu
Price of nitrogen	$0.87/lbs

Summary

Trial implementation was good, though imperfect because the machinery was driven at a heading slightly different from that called for by the trial design. But overall data quality remained high, and relatively little data had to be withheld from the analysis. The management implications coming from the data are that, in a growing season with weather the same as in 2022, site-specific strategies existed that, if implemented, would have raised profits over $51/ac above the status quo strategy of the grower's choice of a uniform application of 116.8 lbs/ac. The optimal whole-field uniform application rate was 155 lbs/ac, and if employed would have provided net revenues approximately $50/ac higher than net revenues from the status quo strategy of applying at 116.8 lbs/ac. Of course, these results are weather-dependent, and might change greatly under different growing conditions. Additional experimentation in future years would provide more information about how different strategies affected the probabilities of various economic outcomes. Since the economically optimal nitrogen rates were consistently at or near the top of the trial's range of rates, we recommend that if similar trials are run in the future, a higher range of rates be employed to examine whether rates even higher than the highest rate of the 2022 trial might be economically optimal in some part of the field.

Trial Design and Implementation

Figure 1 displays the nitrogen rate trial design and the trial's raw as-applied data. The farmer's "status quo" application strategy (that is, the one that the farmer would have used had there been no field trial conducted) was to apply a base N rate of 5 lbs uniformly across the field, then to follow that up with rate of 48 gallons/ac of UAN28/ATS, which in total would apply an N-equivalent of 5 + 48*2.822 = 140 lbs/ac. The status quo rate was assigned to a buffer zone around the perimeter of the trial, but observations from the buffer zone were not included as part of the trial in later analysis. The trial design's targeted total N-equivalent rates were 47, 98, 140, 200, and 248 lbs/ac. Overall trial implementation was good, the data quality was somewhat diminished because the harvester and the applicator seem not to have been driven at the same heading. Figure 1 shows how this led to harvester misalignments of just a few feet in the northern and southern areas of the field. Figure 2 shows that the harvester was driven very close to what was required by the trial design, with the 40-ft harvester passing twice neatly through the 80-ft plots.

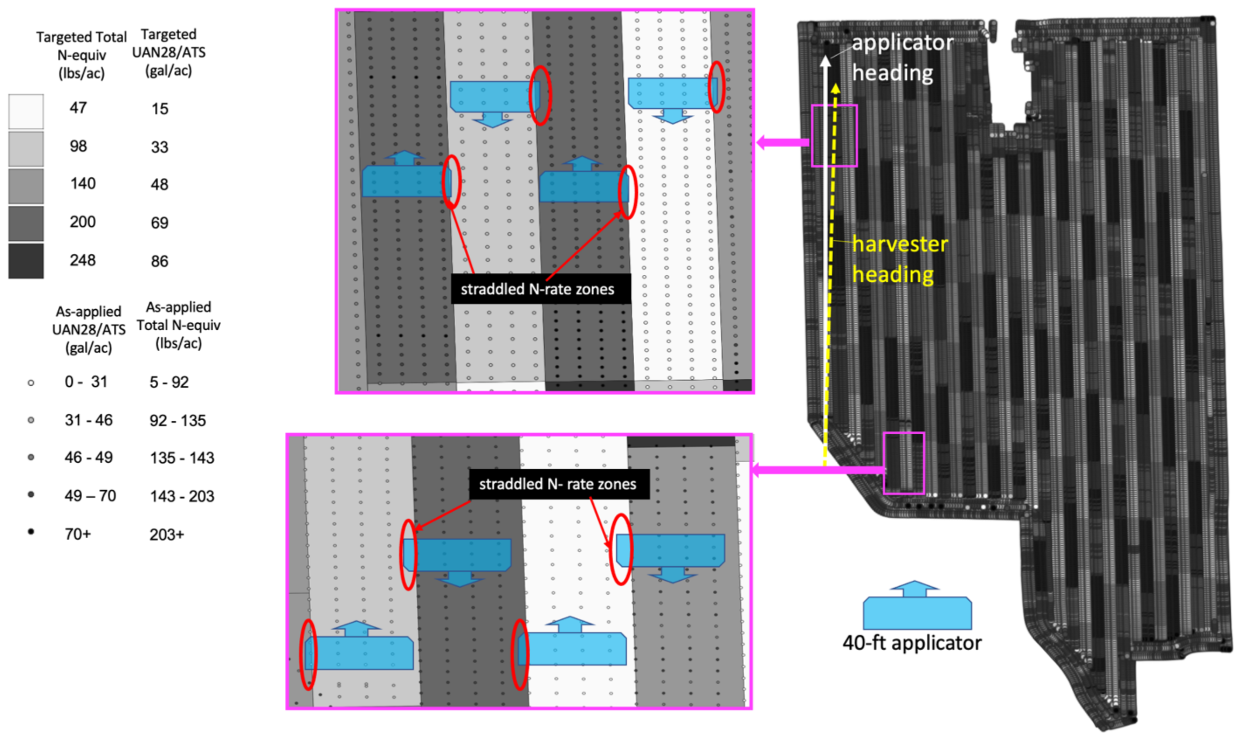

Figure 1: Trial design and implementation

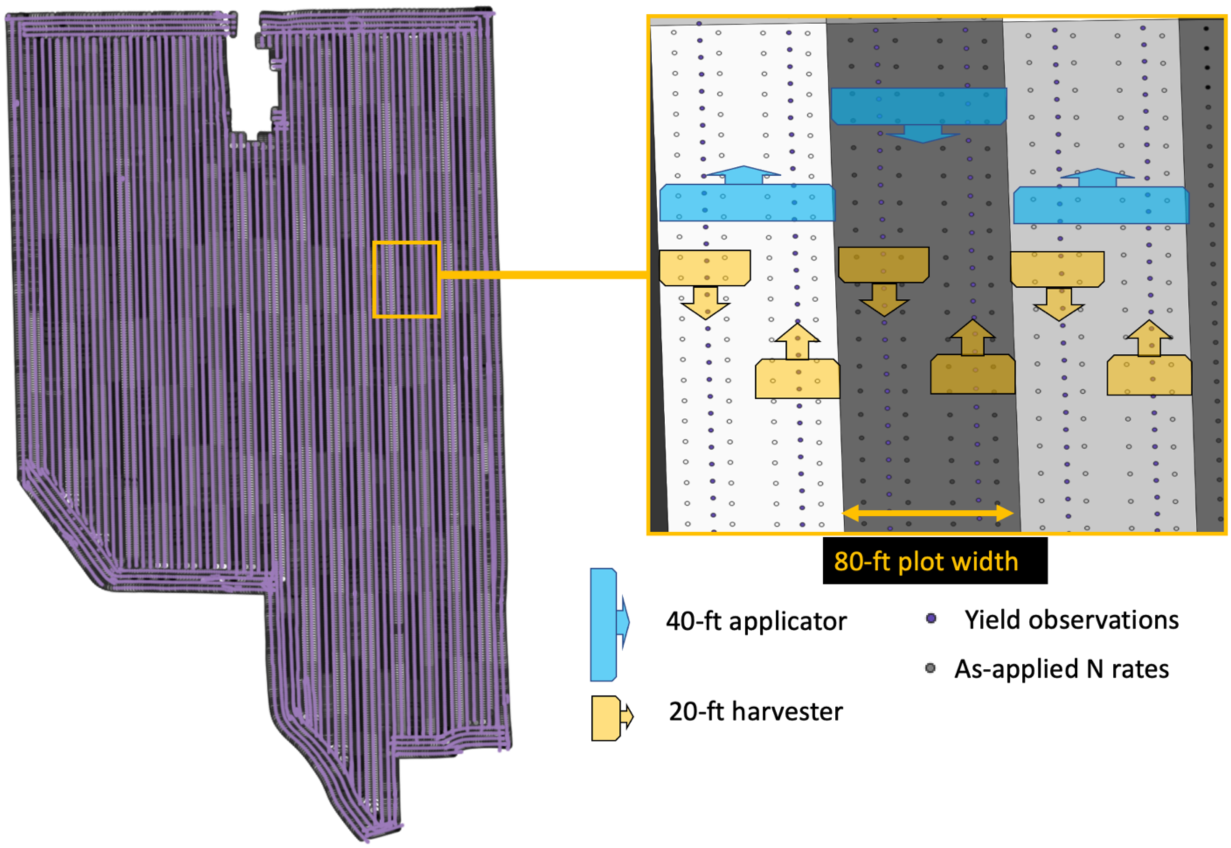

Figure 2: Harvester was accurately aligned with trial design.

Yield Response to Nitrogen Rate: Broad Picture

Figure 3 shows that at low levels of N, average yields responded positively to increased N rates, rising by approximately 72 bu/ac as the N rate rose from 39 lbs/ac to about 150 lbs/ac, after which the yield response curve plateaued, or even turned down slightly.

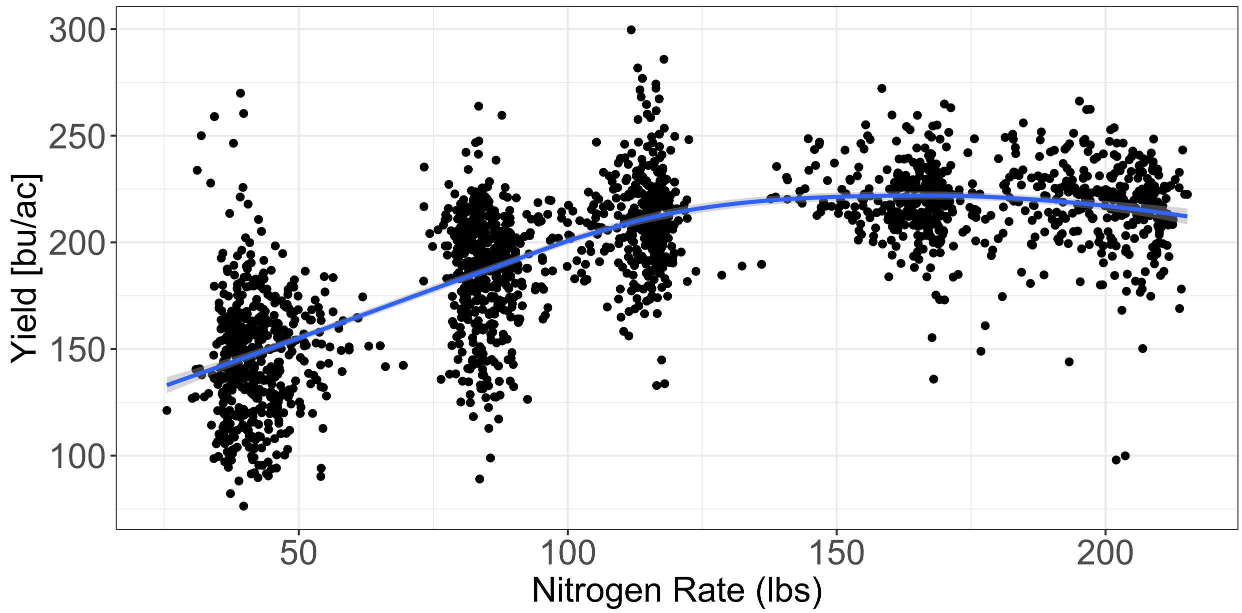

Figure 3: Overall yield response to nitrogen rate

Impacts of Field Characteristics on Yield Response to Nitrogen Rate

The applied machine learning algorithms suggested that elevation and terrain slope might be important covariates that interacted with the nitrogen application rate in impacting yield. Figures 4 and 5 show the yield response curve under different levels of elevation and slope. Obviously yield levels changed with elevation and slope. But the parallel shifts in the yield response curves meant that net revenue would be maximized or nearly maximized at similar N rates across all elevation and slope areas. This result is common, since the AI analysis accounts for simultaneous changes in many variables over space, not just elevation and terrain slope.

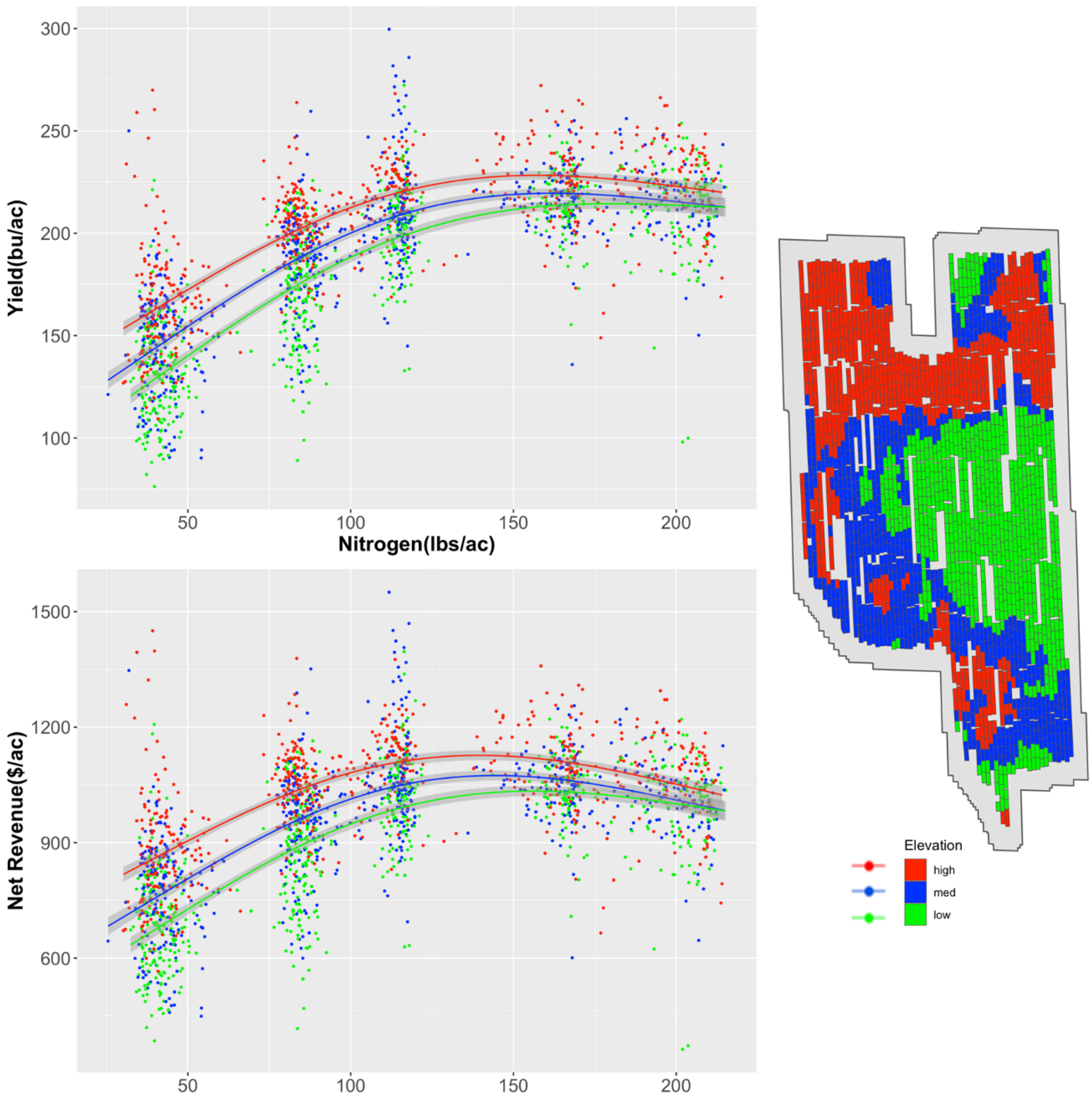

Figure 4: Yields were generally higher in areas of high elevation. But the parallel nature of the yield response curves meant that net revenues were maximized or nearly maximizedat similar N rates across all elevation areas.

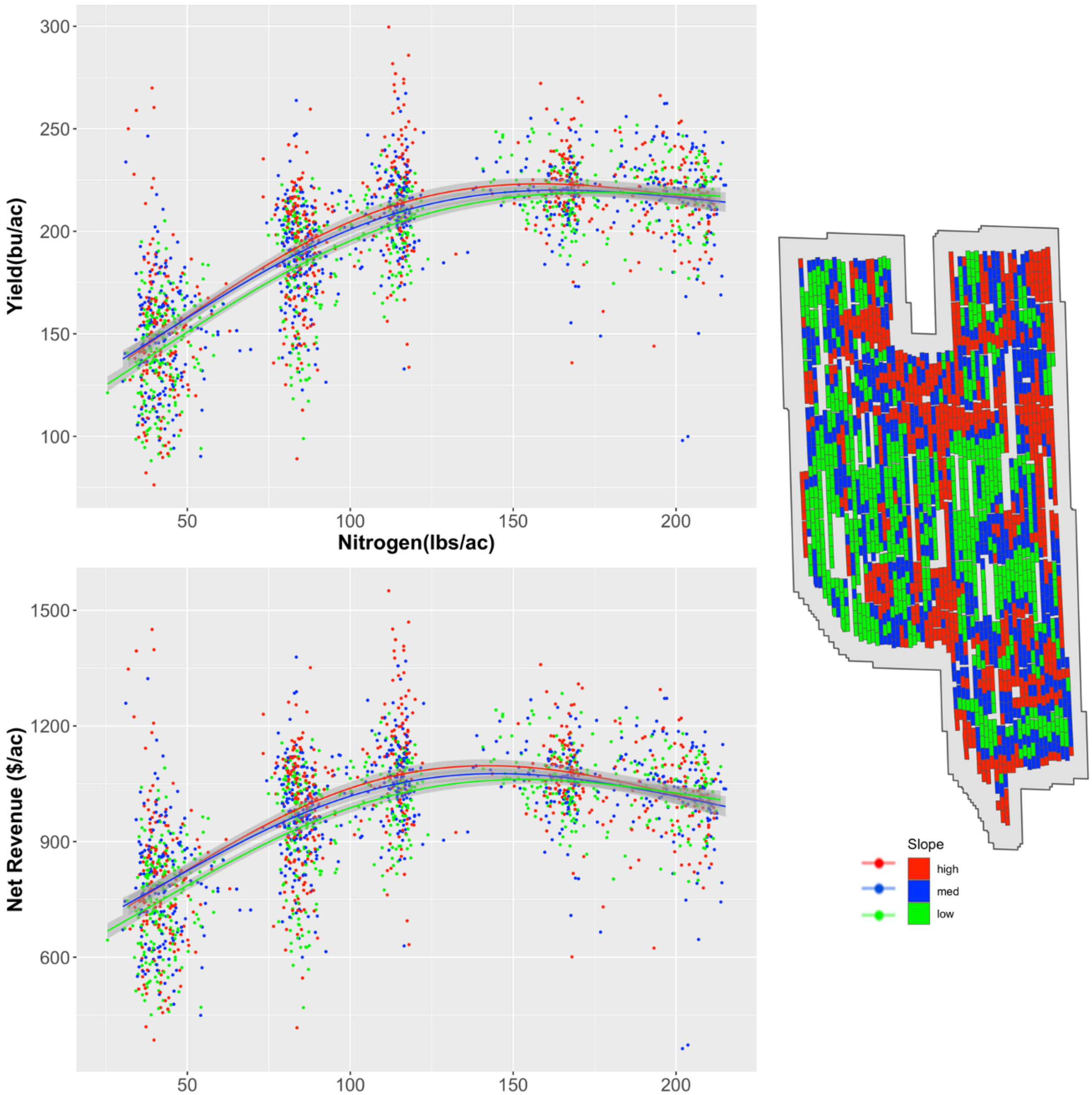

Figure 5: Yields varied little by terrain slope, and net revenues were maximized or nearly maximized at similar N rates across all elevation areas.

Impact of Soil Map Unit on Yield Response to Nitrogen Rate

There are two SSURGO Soil Map units that make up at least 10 percent of the trial data. Those were Brookston silty clay loam and Crosby silt loam. Average yields on the Crosby silt loam were consistently higher than on the Brookston silty clay loam. But the best estimates of the N-rates that maximized net revenue on each field were very similar.

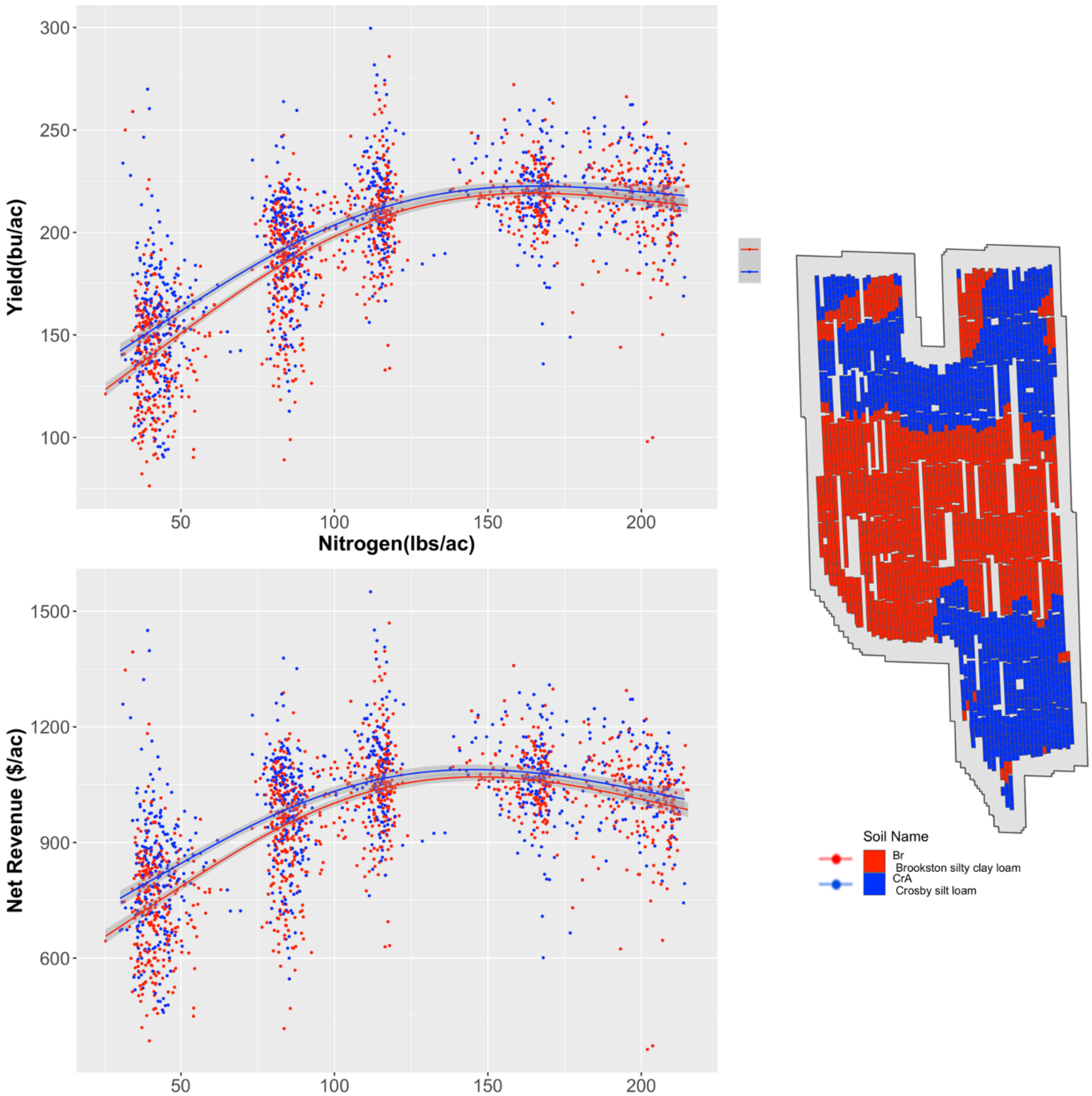

Figure 6: Yield response and net revenue response to nitrogen application rate, by soil map unit

Economic Results and Implications

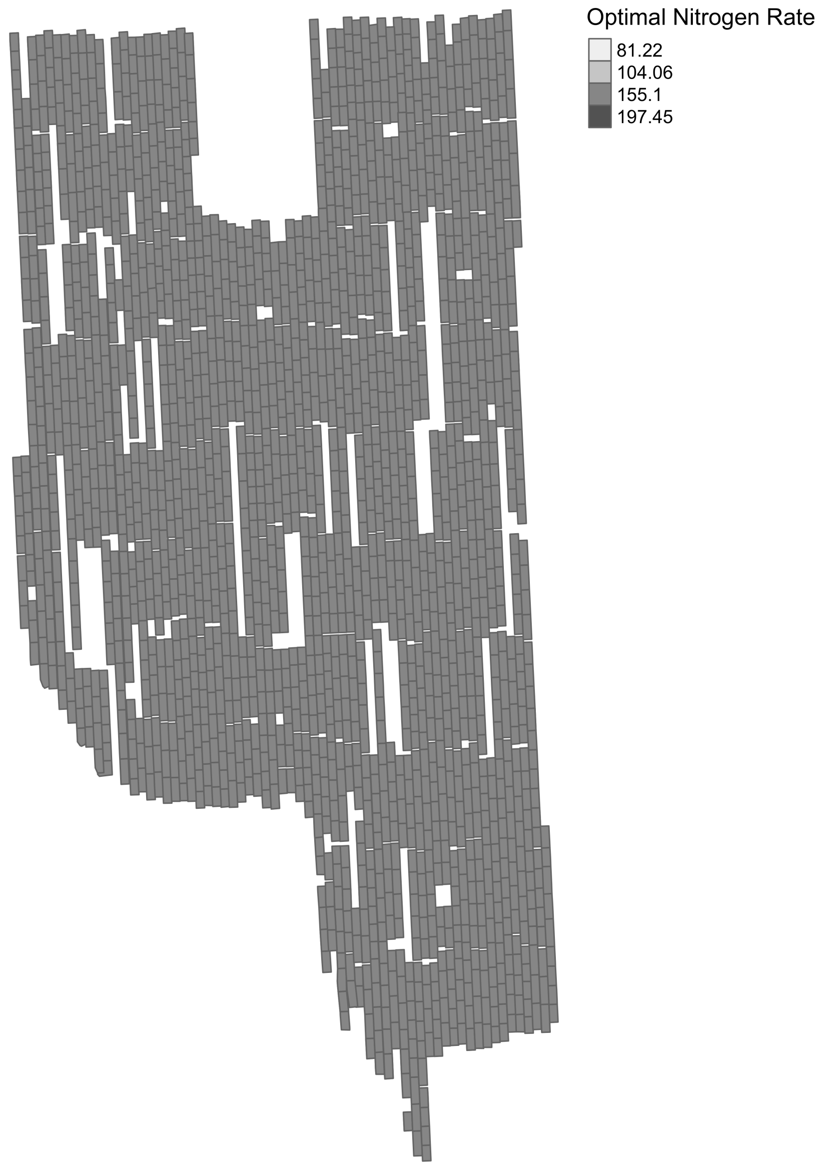

Figure 7: Map of economically optimal nitrogen application application strategy

Figure 7 illustrates that the management implication coming from the data is that, in a growing season with weather the same as in 2022, the bet estimate of the most profitable nitrogen application strategy was to increase total nitrogen application rates to around 155 bu/ac over most of the field, but to use slightly lower planting densities on locations that locations that had lower elevations and steeper terrain. It is estimated that implementing this strategy under the same growing season weather as in 2022 would have raised net revenues over $51/ac relative to status quo net revenues. Approximately $50/ac of those increased net revenues would come from changing to the optimal uniform rate of 155lbs/ac from the status quo rate of 117 lbs/ac. An additional $1 in profit gain would come from using the optimal site-specific strategy in place of the optimal uniform strategy. See table 2.

Table 1: Economic Results

Change in Management Strategy	Estimated Gain in Net Revenues (per acre)
Substitution of the economically optimal uniform rate strategy for the grower's chosen strategy	$50
Substitution of the economically optimal site-specific strategy for the economically optimal uniform rate strategy	$1

Appendix: Overview of Data Processing

The variable-rate applicator and yield monitor provided raw as-applied and harvest data. An initial cleaning removed observations with extreme yield or as-applied rates ("outliers") from the raw data. Points were also removed from the headlands, where the data is less reliable due to differences in sun exposure, changes in driving speed, potential application overlaps, etc. The yield points were grouped into polygons using the distance between points, swath width, and the headings recorded in the raw yield data. Subplots were created by grouping contiguous yield polygons with similar nitrogen rates into sets of four. (Subplots were treated as the unit of observation in later analysis.)

A yield polygon was judged as having a "dominant treatment" when the standard deviation of the yield values at points within the polygon was below a threshold level. Adjacent as-applied polygons were judged as not being in the same group when the difference in application rates surpassed a threshold level. Polygons without a dominant treatment were not included in the data set used for analysis. This technique also helped eliminate "transition zones, which are areas in which the data show where the harvester and applicator did not immediately adjust to new target rates or yield levels when passing from one plot into another. Each subplot's mean as-applied rate and yield were recorded as data. Finally, for each subplot the means of the electrical-conductivity data, SSURGO soil data, and USGS digital elevation data were recorded. In addition, the values topographical aspect, slope, curvature, topographical position index and topographical wetness index were calculated from the raw data, and each subplot's means of these values were included in the data used for analysis. Figure 8 shows maps of the processed yield and as-applied data.

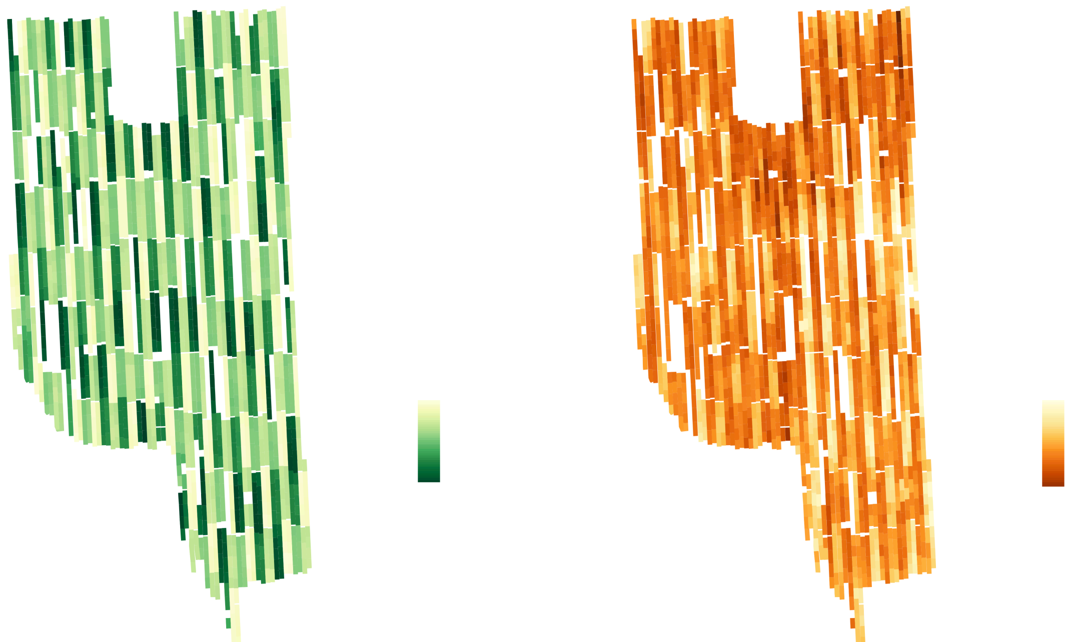

Figure 8: Yield and as-applied nitrogen rates after data processing