Preliminary Quantification of Variable Rate Irrigation's Benefits

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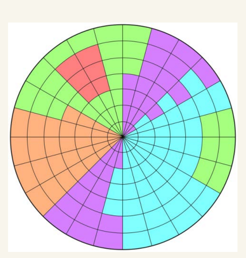
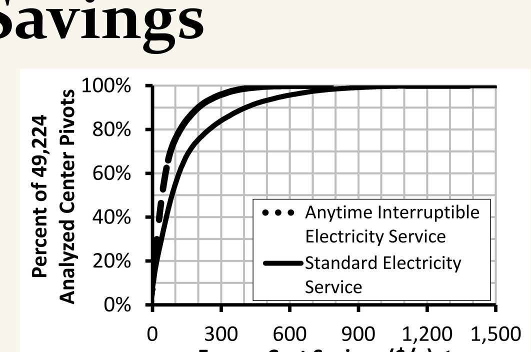
Introduction

- Variable rate irrigation (VRI) can tailor water deliveries to each part of a field based on site-specific crop, soil, terrain, and management characteristics, yet the magnitudes of its benefits have not been well-quantified
- This project compares VRI with well-managed uniform rate irrigation (URI) while assuming these prices:
  - *Typical marginal costs of irrigation pumping are $16.87/ac-ft with 6.24¢/kWh anytime interruptible electricity service and $34.33/ac-ft with 12.70¢/kWh standard electricity service (NASS, 2014; NPPD, 2014)*
  - *Anhydrous ammonia, 82% nitrogen (N), cost 39.6¢/lb of N whereas urea ammonium nitrate (UAN), 28% N, cost 57.1¢/lb of N (Knorr, 2015)*
  - *Farm prices of corn average $3.57/bu (Westcott and Hansen, 2015)*

Energy Cost Savings





- Avoidance of uncropped areas
  - *If average seasonal gross irrigation over the 56-acre example field is 6", then $13-$26 would be saved each year by not irrigating uncropped areas that comprise 2.7% of the total area under the center pivot (left)*
- Reduction of irrigation over soils with larger root zone water holding capacities in order to allow greater extraction of initial soil water captured from natural precipitation
  - *If the withheld volume is not applied elsewhere, estimates based on soil survey data (NRCS, 2014) and a center pivot map (CALMIT, 2007) suggest annual savings exceeding $200-$408, $433-$881, and $693-$1,410 for 10%, 1%, and 0.1% of Nebraska's center pivots not under Natural Resources District-wide groundwater allocations (right)*
  - *If such withholding enables a shift from standard to anytime interruptible electricity service without causing water stress, then up to $1,746 per year may be saved on an 120-acre field with 10" of average seasonal gross irrigation*

Agrochemical Cost Savings

- Decrease of N losses through leaching
  - *If leachate contains 24 ppm of N (Klocke et al., 1999) and if annual leaching is reduced by 2" over the silt loam areas of an 120-acre field that is 90% silt loam but had been managed as sand under URI, then 11 lb/ac less N would be lost through leaching in the silt loam areas, which equals annual savings of $464-669*
  - *Public costs (e.g., environmental degradation and drinking water treatment) of N loading were not included here, but their consideration may become increasingly important if N pollution problems worsen*
- Lowering of application costs while complying with avoidance zones (e.g., open water)
  - *Assume 1 pesticide application and 1 or more mid-season fertilizer application(s), totaling 60 lb/ac of N after 140 lb/ac of N pre-planting, on an 120-acre field*
  - *If ground vehicles are used, custom rates (excluding chemical costs) are $6.81/ac for sprayer and $13.29/ac for anhydrous ammonia applicator (Wilson, 2014)*
  - *If chemigation is used to apply pesticide and UAN with a total of 1" of water, equipment and maintenance costs may average to $700 per year (W. L. Kranz, personal communication, 2015)*
  - *Here, chemigation would save $109-283 each year; also, its timing is easier amidst weather uncertainties*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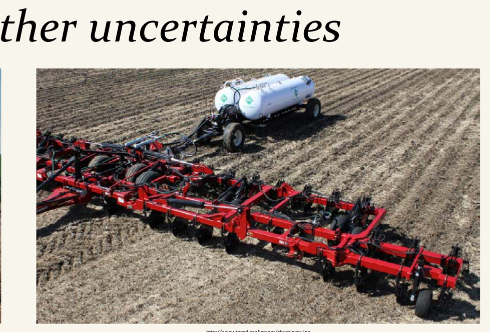
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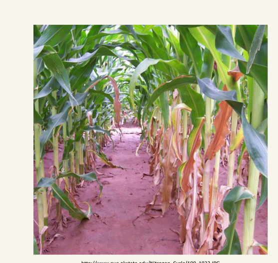
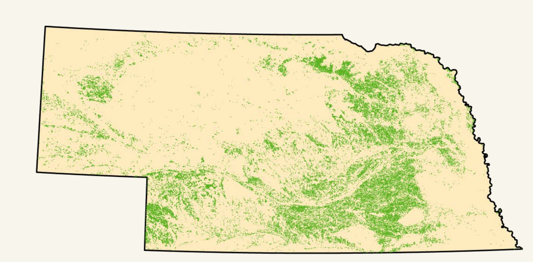
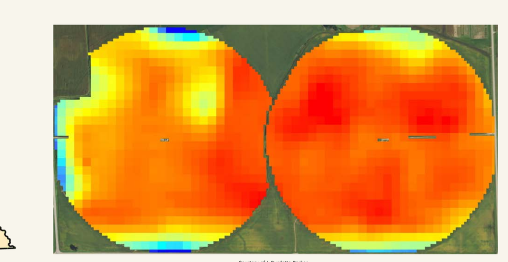
Yield Improvements

- Transfer of irrigation water away from fully-irrigated soils and onto deficit-irrigated soils:
  - *Interannual variability in irrigation requirements is generally larger than spatial variability in readily plant-available water within a given field*
  - *Thus, field-average yield may be increased merely by less than 2 bu/ac or $857 per season in the long term on an 120-acre field under mild single-year groundwater allocations; however, little to no benefit is foreseen under severe multi-year groundwater allocations*
- Minimization of yield losses due to over-irrigation:
  - *Excessive water can encourage N losses, promote plant diseases, and impede root growth and function (Irmak, 2014)*
  - *If a 8-15 bu/ac reduction in corn yield (Irmak, 2014) had been suffered by the silt loam areas of an 120-acre field that is 90% silt loam but had been managed as sand under URI, then revenues could be raised by $3,084-$5,783 per season*

Future Work







- Apply some of these estimates to Nebraska's center pivots and communicate the results to stakeholders
- Explore the role of VRI when system capacity is low
- Develop or adapt mechanistic models to predict over-irrigation's impacts on N and yield
- Incorporate soil moisture, crop status, and evapotranspiration data from ground-based, aerial, and satellite sensors to inform in-season VRI management

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