CropSyst-Microbasin model as a tool to inform variable-rate nitrogen management and dryland farm profitability

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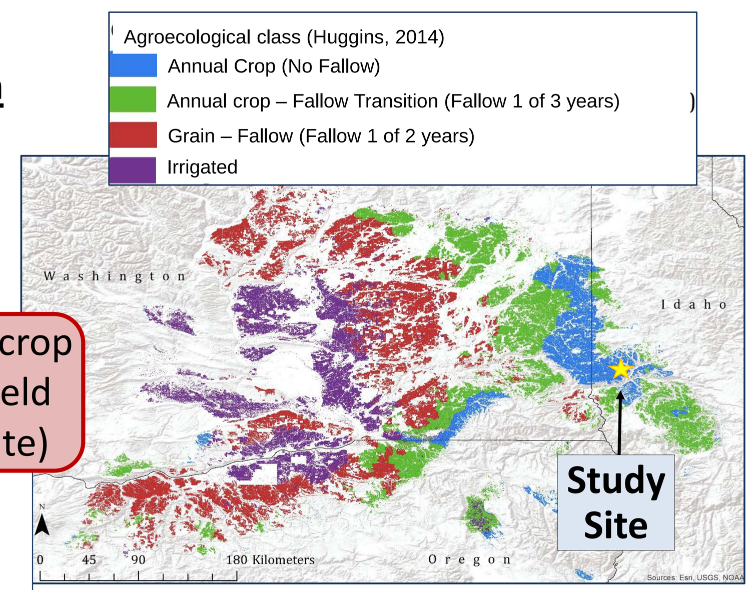
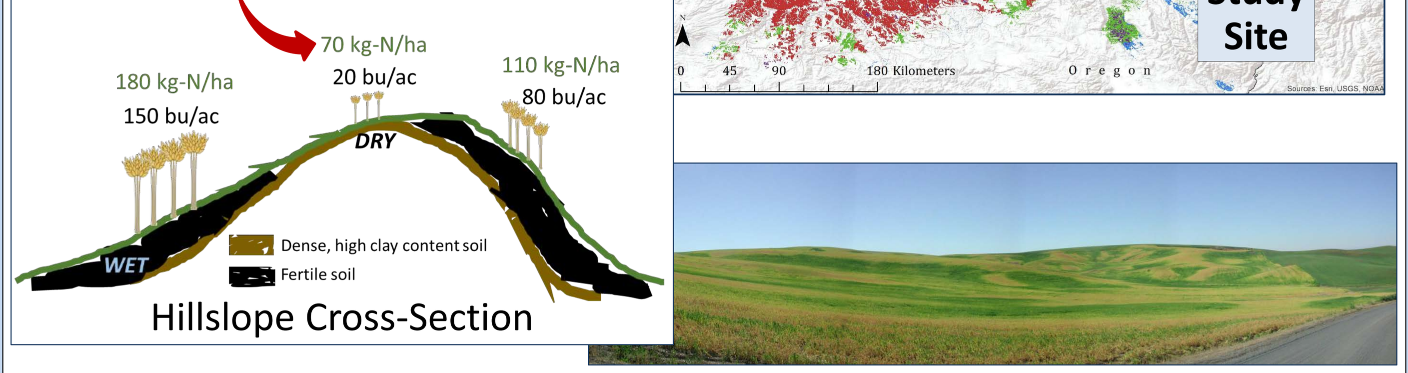
Introduction

Variable-Rate Fertilizer Application is a promising method to lower nitrogen loss in the highly heterogeneous Annual Crop area



More N will not increase yield (WATER limited) ➡ Apply only what the crop can use in a given field position(variable-rate)



Hillslope Cross-Section

For effective variable-rate fertilizer management, we need to understand…

1. The drivers and underlying processes of field-scale variability
2. How to accurately delineate variable-rate fertilizer zones
3. The stability of fertilizer zones through time

Process-based, fully-distributed, cropping systems models are a useful tool to answer these questions ➡ CropSyst-Microbasin

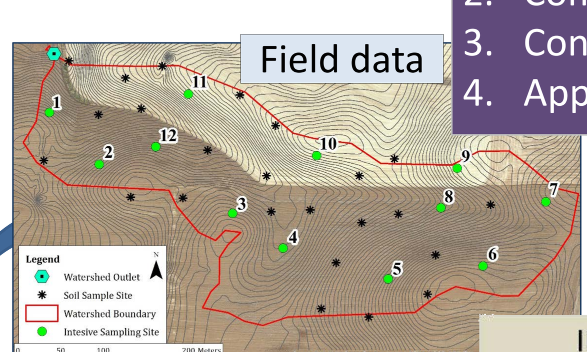
Objectives

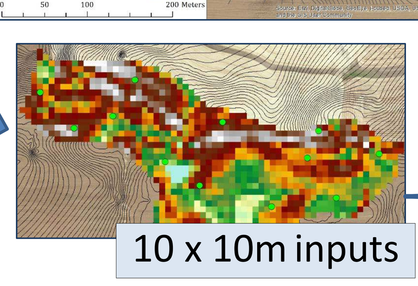
1. Assess the accuracy of CropSyst-Microbasin simulations to observed data
2. Explore hillslope processes driving variability in CropSyst-Microbasin
3. Assess environmental & economic outcomes of variable-rate fertilizer use

Methods

1. Input data from heavily instrumented field site
2. Compare outputs to observed data
3. Conduct basin & hillslope scale fertilizer scenarios
4. Apply economic metrics for practical application

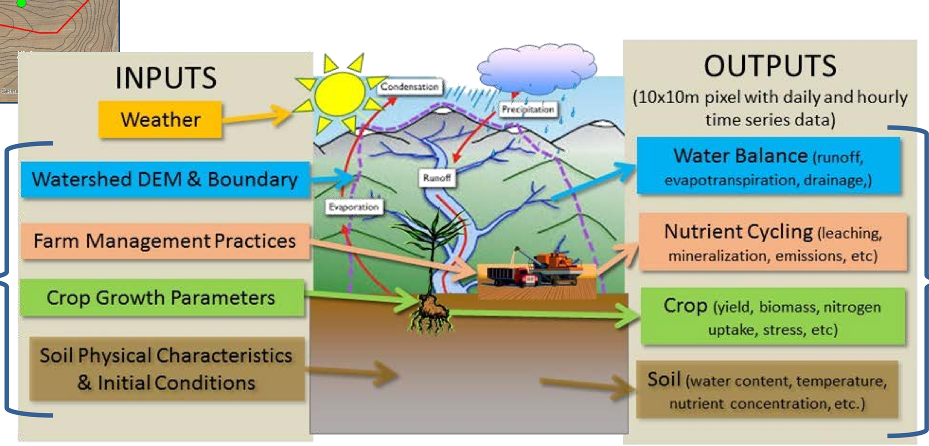
Field data





10 x 10m inputs

CropSyst-Microbasin Model



Economic Assessment: Price, cost of production & cost of fertilizer based on 22 local farm budgets (Hilary Davis Thesis, 2014, U Idaho); yield from model

$$\left[Crop\ Price\left(\frac{\$}{bushel}\right)\times Crop\ Yield\left(\frac{bushels}{acre}\right)\right]$$

$$-Cost\ of\ Production\left(\frac{\$}{acre}\right)$$

$$= \textbf{Returns to Risk}\ (\$/acre)$$

Biophysical Assessment: Root Mean Square Error (RMSE), Nash-Sutcliffe Efficiency (NSE), & % Error used to compare simulated/observed data

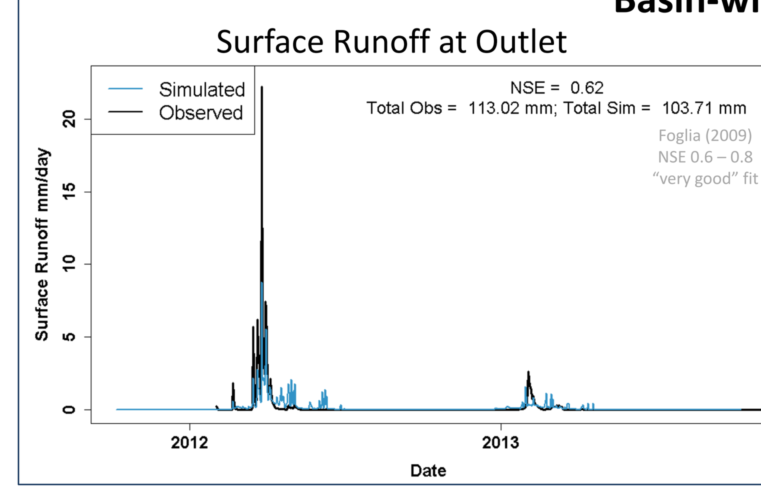
- Crop Yield, Biomass, Nitrogen Uptake
- Nitrogen Loss and Storage
- Runoff, Drainage, Water Storage
- Soil Nutrient Concentrations

Simulated & Field Data

Model accurately simulates:
1) Basin yield, N uptake, runoff
2) Variability in soil WC in space (across field and w/depth)
1) Soil WC through time

Basin-wide Comparison

Surface Runoff at Outlet



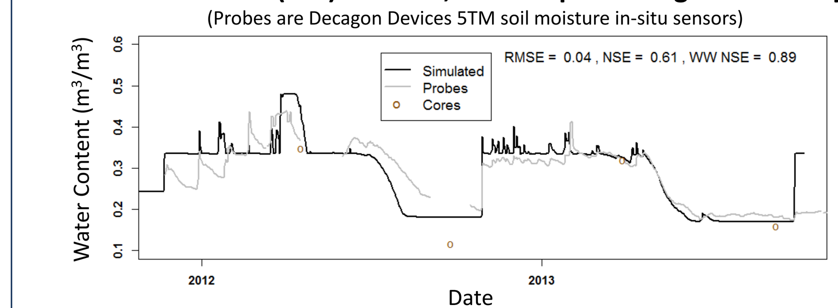
Watershed Average Crop Yield & N Uptake

	Simulated	Observed	RMSE	% error
Yield (bu/ac)	87	91 (Yield Monitor)	14	15.5
N uptake (Kg-N/ha)	138	137 (NDRE)	28	20.4

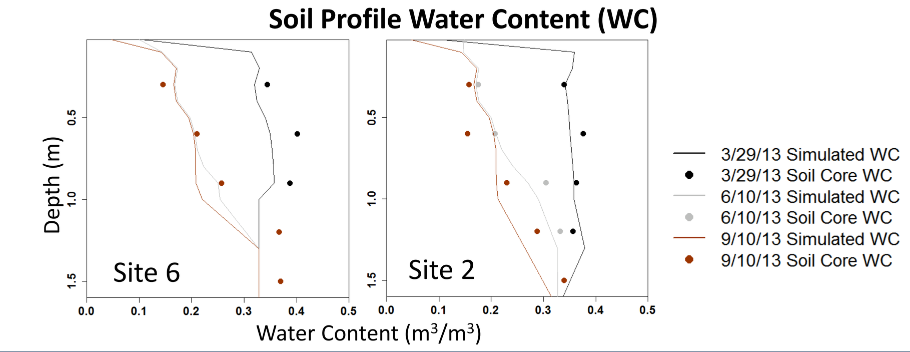
Spatial & Temporal Comparison

Soil Water Content (WC) at Site 5, 0.3m depth during simulation period

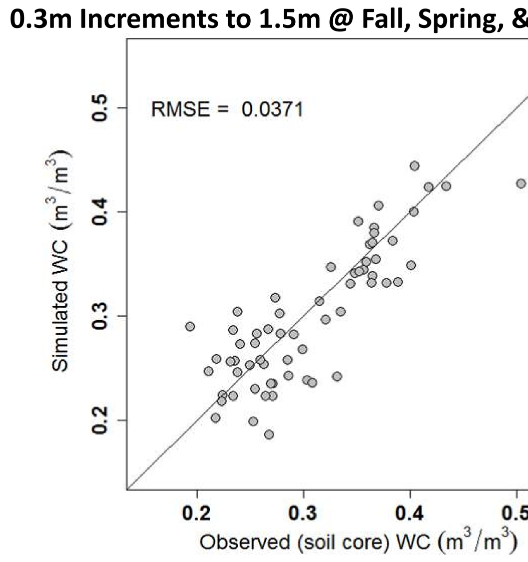
(Probes are Decagon Devices 5TM soil moisture in-situ sensors)



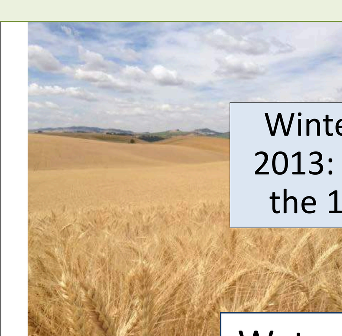
Soil Profile Water Content (WC)



Soil Water Content (WC) at 12 Sites
0.3m Increments to 1.5m @ Fall, Spring, & Summer

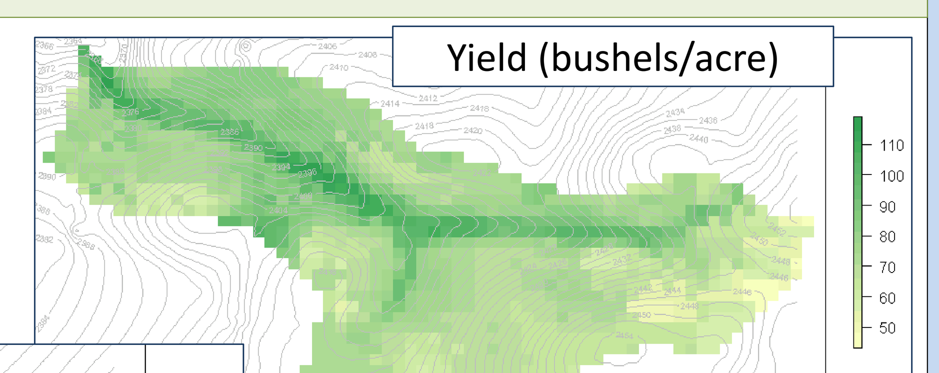


Modeling Field-scale Variability

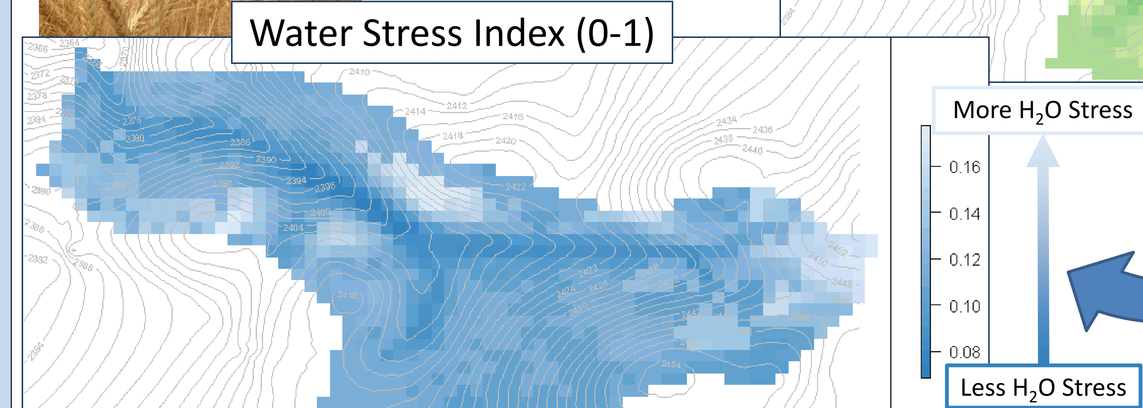


Winter Wheat Harvest Year 2013: 10m x 10m outputs on the 10.9 hectare study site

Yield (bushels/acre)

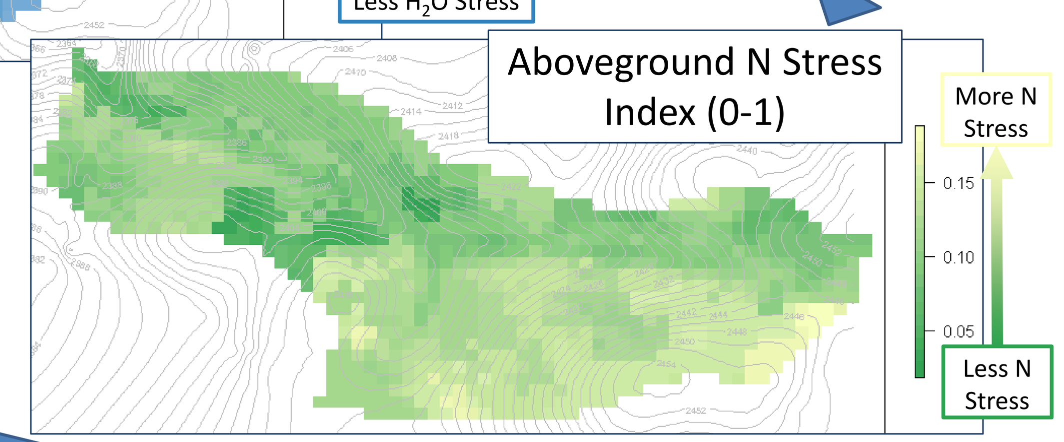


Water Stress Index (0-1)



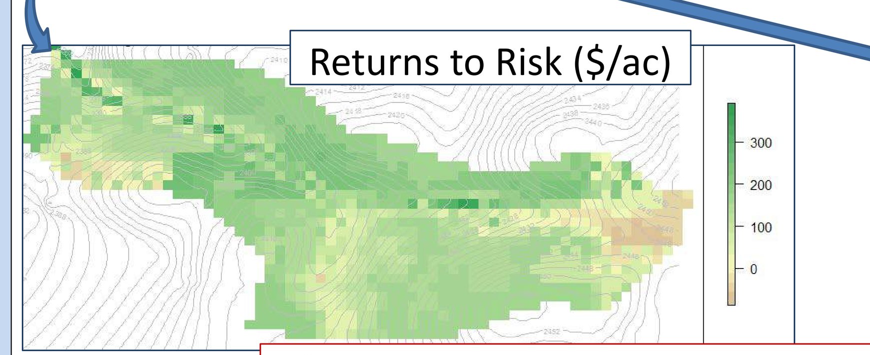
Site-specific drivers of productivity: Water vs. Nitrogen Stress

Aboveground N Stress Index (0-1)

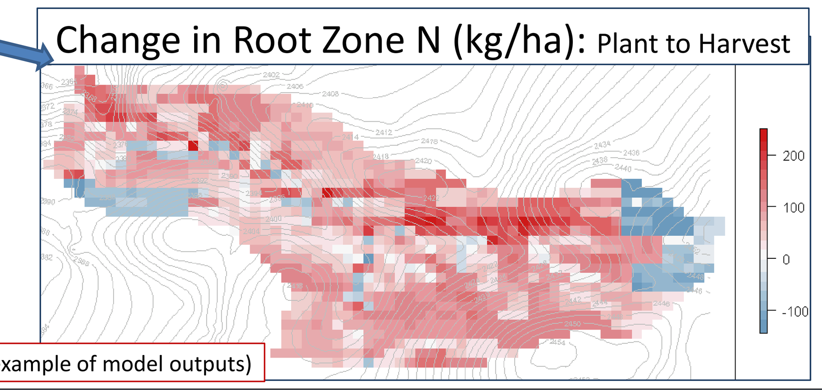


Site-specific areas with higher profitability and root zone nitrogen storage

Returns to Risk ($/ac)



Change in Root Zone N (kg/ha): Plant to Harvest

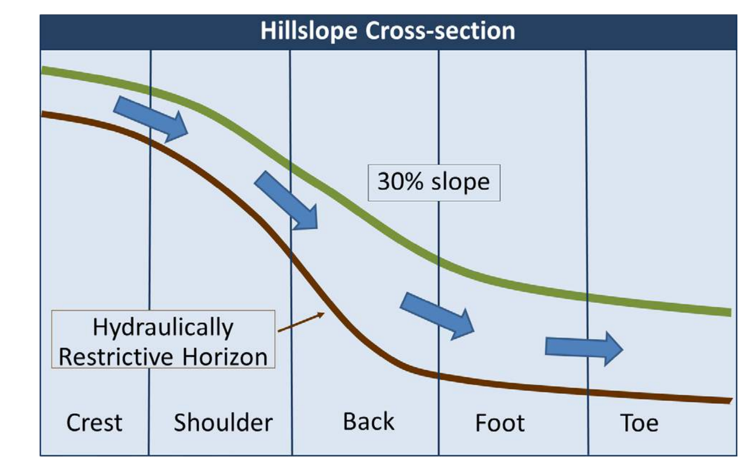


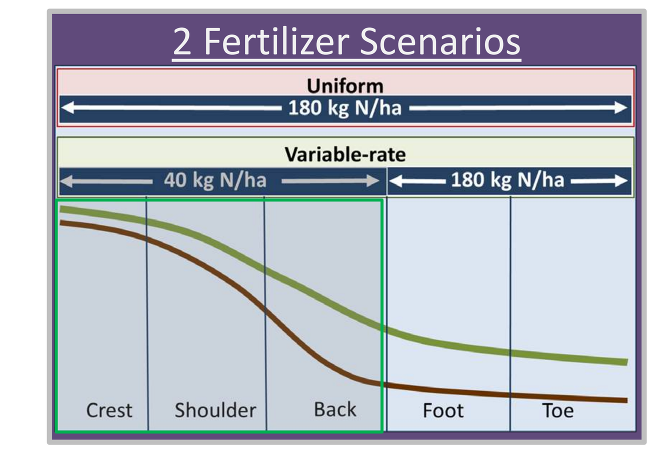
(Different simulation than above results—presented as an example of model outputs)

Modeling Hillslope Variability & Processes

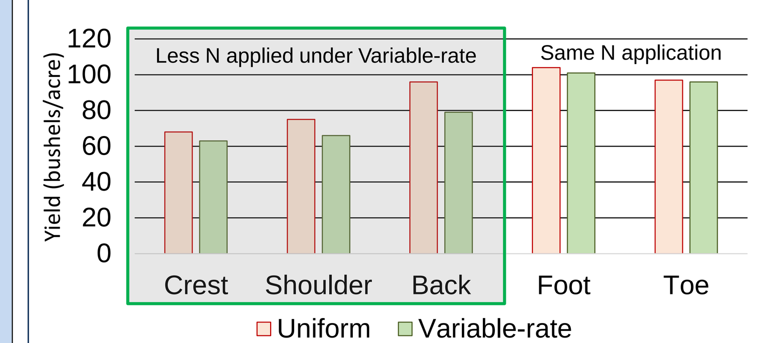
Subsurface lateral flow is a key driver in the *redistribution of water* on a hillslope with hydraulically restrictive horizons

Brooks, Boll (2004). A hillslope-scale experiment to measure lateral saturated hydraulic conductivity. *Water Resources Research*, 40(4).





Uniform & Variable-rate Yield



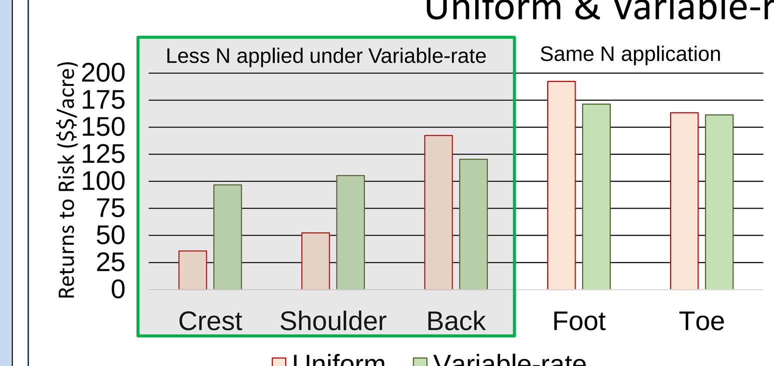
Variable-rate fertilizer in comparison to Uniform
- 1 bu/ac decrease in yield at toe slope position
- 3 bu/ac decrease in yield at the foot slope positions

this loss in yield is a result of less N available at upslope positions to redistribute to the downslope positions

lateral *redistribution of N* contributes to downslope yields

Uniform & Variable-rate Returns to Risk (RR)

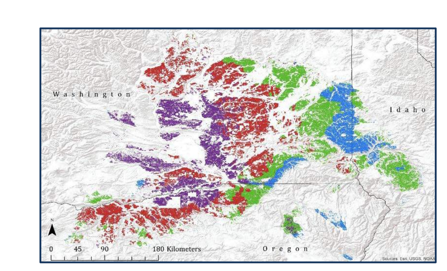
ALSO: ⇩ N loss under variable rate



Under Variable-rate:
- RR are more consistent across hillslope
- $10/ac increase in average hillslope RR

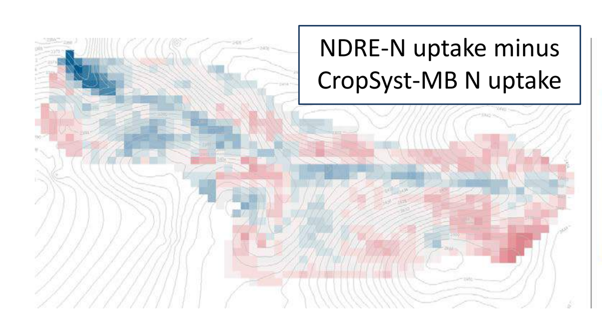
On this hillslope, *variable-rate is more profitable* than uniform

Next Steps



Simulations at field sites across the Annual Cropping area and the REACCH region

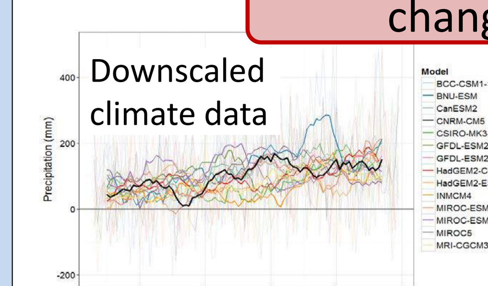
To further understanding of regional variability in precipitation, soil types, yield, risk, etc



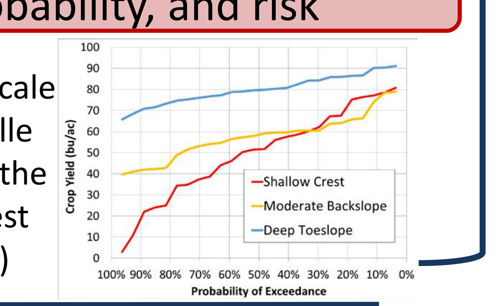
Assess drivers of spatial variability

1. Conduct sensitivity analysis simulations
2. Compare model outputs to remote sensing information and soil physical properties

Long-term, field-scale simulations to asses climate change impacts, yield probability, and risk



Build on the hillslope-scale simulations by Michelle Chaffee (presented at the 2015 Pacific Northwest Climate Conference)



Incorporate into a decision support tool and outreach/education efforts

"Site-specific Climate-friendly Farming (SCF)" (award #2011-67003-30341) and *"Regional Approaches to Climate Change (REACCH)"* (award #2011-68002-30191) are funded through the USDA-National Institute for Food and Agriculture

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