



Evaluating the Wisdom of Monitoring Networks for Invasive Species: The Case of Soybean Rust

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Research Goals

- To develop a mathematical model to value information from sentinel plots
- To use this model to find the optimal placement of sentinel plots



Previous work

- Roberts et al.
- Want to expand on their work in two regards
 - Move from a static to dynamic model
 - Apply farm level model to county level data to optimize placement of sentinel plots



Calculating the value of information

- Information is only valuable if it improves decision making on average
- focus on the benefits of the information, not the cost of generating it



Soybean Rust Management Strategies

- Apply preventative fungicide
- Scout fields for soybean rust and apply curative fungicide if found
- Spray only if rust is detected at a nearby sentinel plot
- No Action



Tradeoffs

- Preventative strategy has lowest yield loss but limits ability to learn
- Curative allows learning but requires scouting
- Following signal from sentinel plot requires accurate signal



Cost of different management strategies (dollars/acre)

Management Strategy	No Infection	Infection
Preventative	\$25.63	25.63+1% yield loss
Curative	\$6.71	\$20.52+7% yield loss
No Action	\$0.00	25% yield loss

Source: Roberts et al. (2007)

Cost of following management strategies, including a within season signal (dollars/acre)

Management Strategy	No Infection	Infection
Preventative	\$25.63	\$25.63+1% yield loss
Curative	\$6.71	\$20.52+7% yield loss
No Action	\$0.00	25% yield loss
Follow the within season signal with accuracy, S	$S*\$0+(1-S)\25.63	$S*(\$25.63+1\% \text{ yield loss})+(1-S)(25\% \text{ yield loss})$



Expected Cost Minimizing Strategy Depends on the Probability of Infection

- Soybeans = \$8.00 a bushel
- Average yield of 37 bu/acre
- If $p < 17\%$ optimal strategy is no action
- If $17\% < p < 59\%$ optimal strategy is curative
- If $59\% < p$ optimal strategy is preventative



The farmer's problem

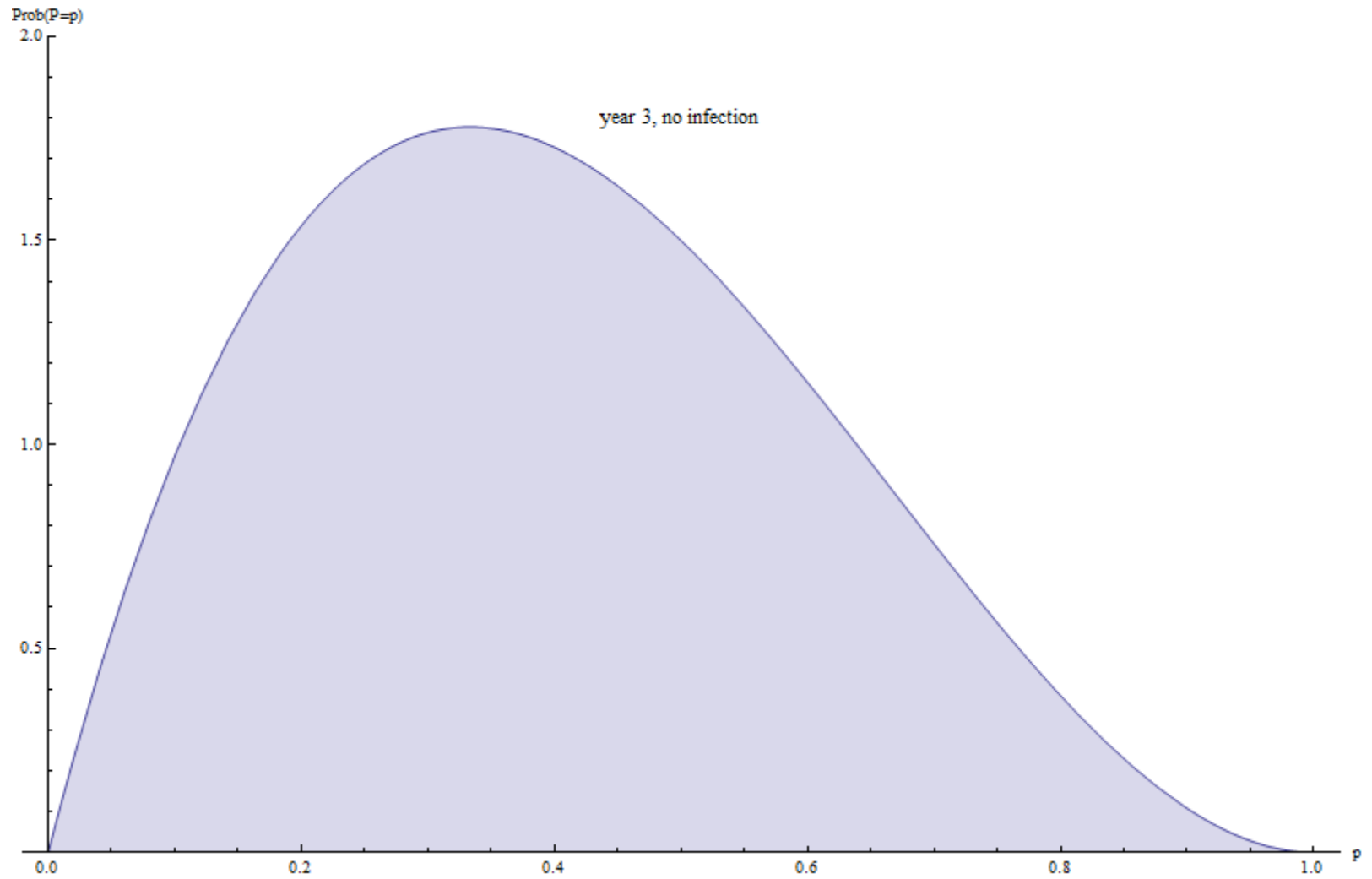
- Minimize the expected cost of managing soybean rust over time
- Focal point: tradeoff between current returns and learning about risk
- 2-armed Bandit Problem -Rothschild (1974)



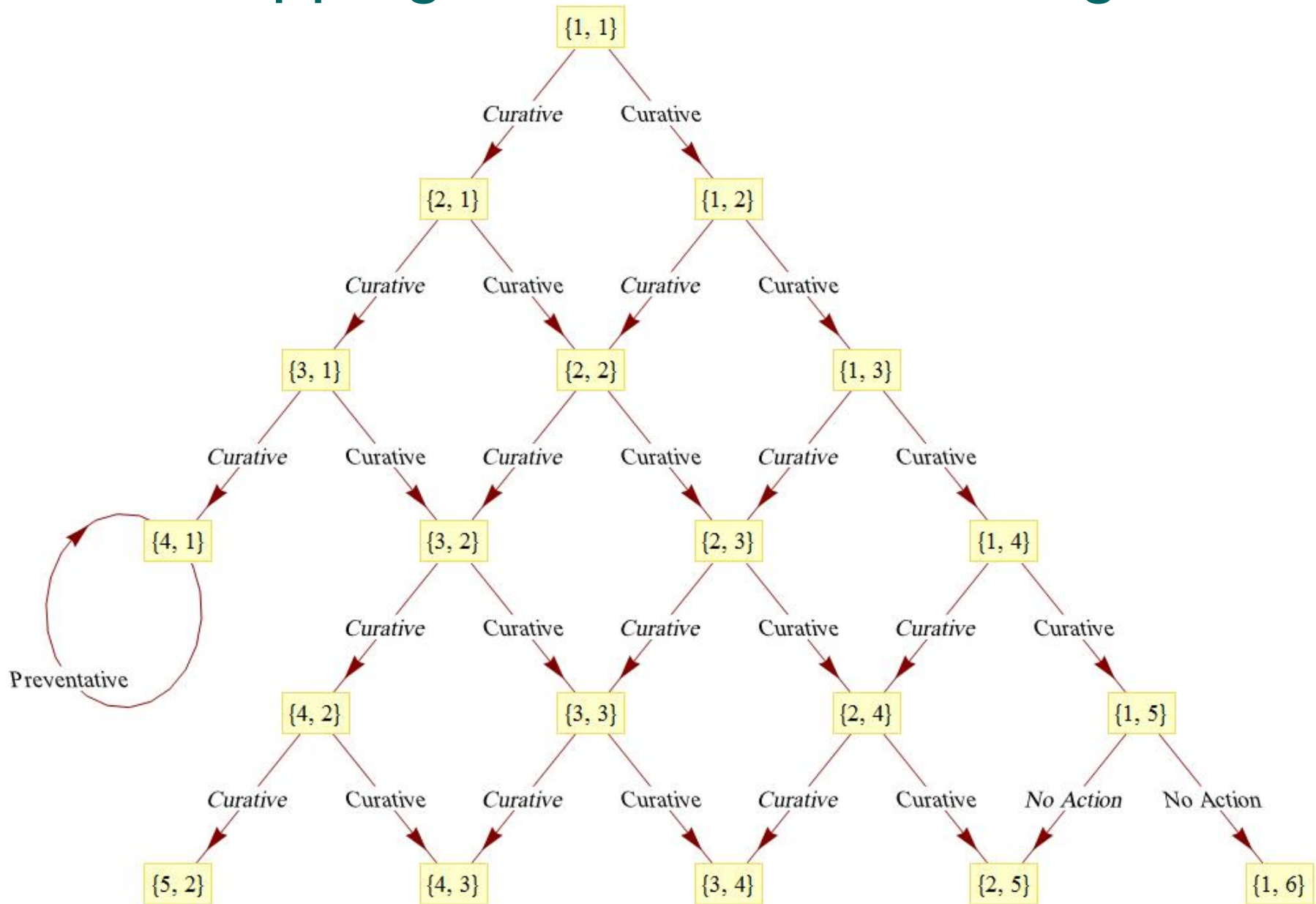
Bayesian updating


- Use Beta distribution
- Start with prior belief $\text{Beta}(m, n)$
- If observe an infection, posterior belief is $\text{Beta}(m+1, n)$
- If do **not** observe an infection, posterior belief is $\text{Beta}(m, n+1)$

Bayesian Updating Cont

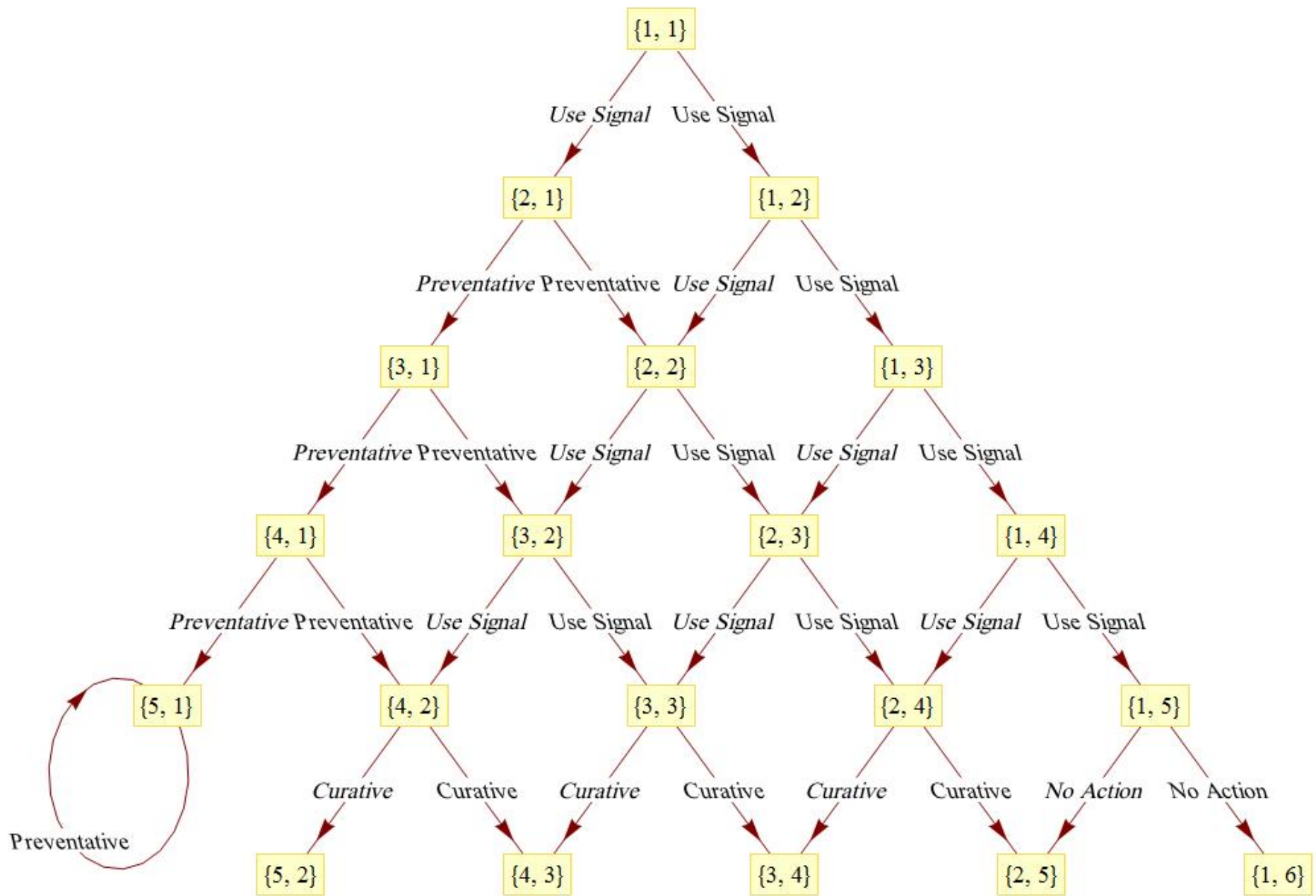


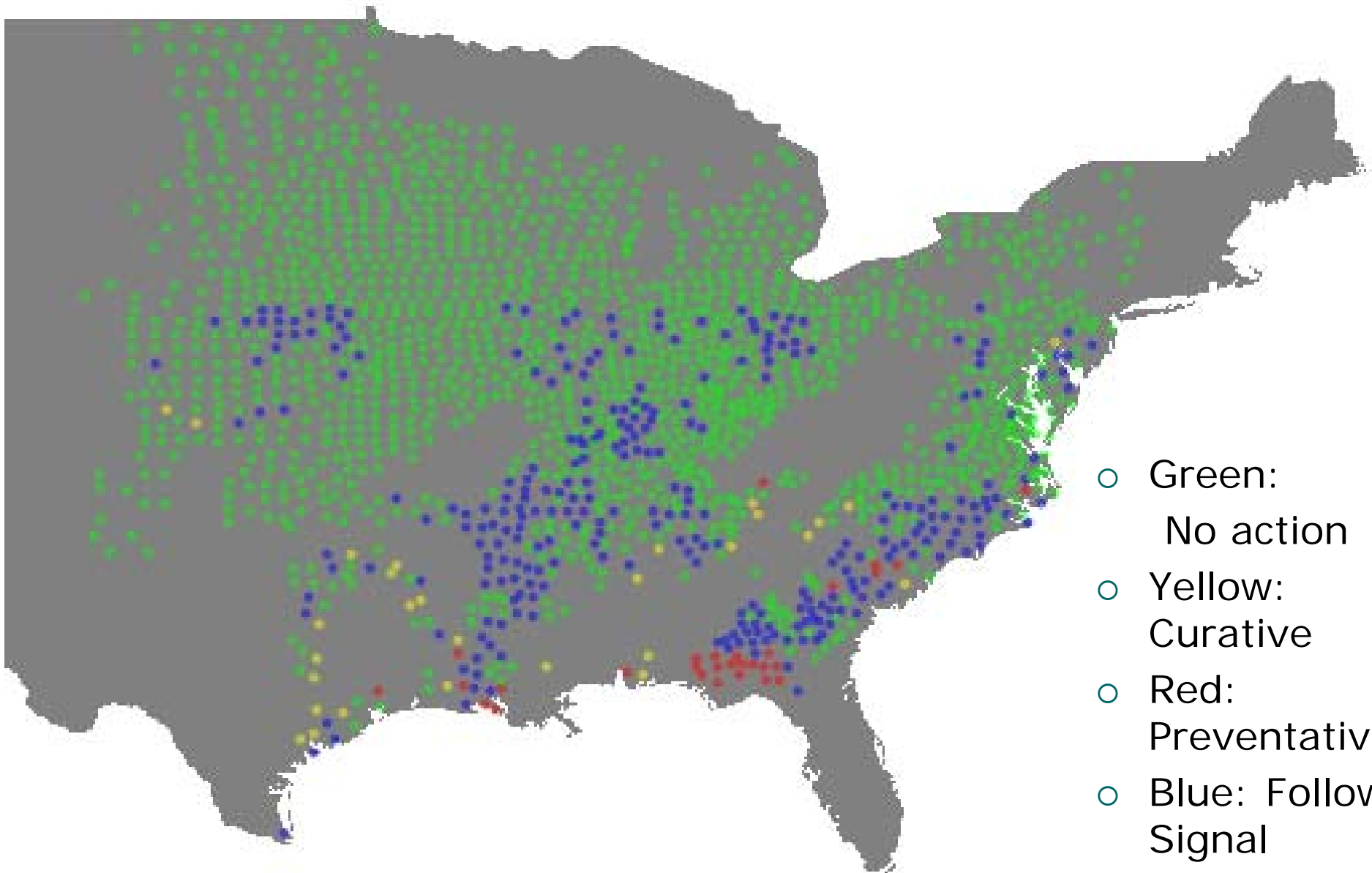
Stopping Rules: No Monitoring





Stopping Rules: 4- Period
Monitoring Network, within season
signal of quality 0.75





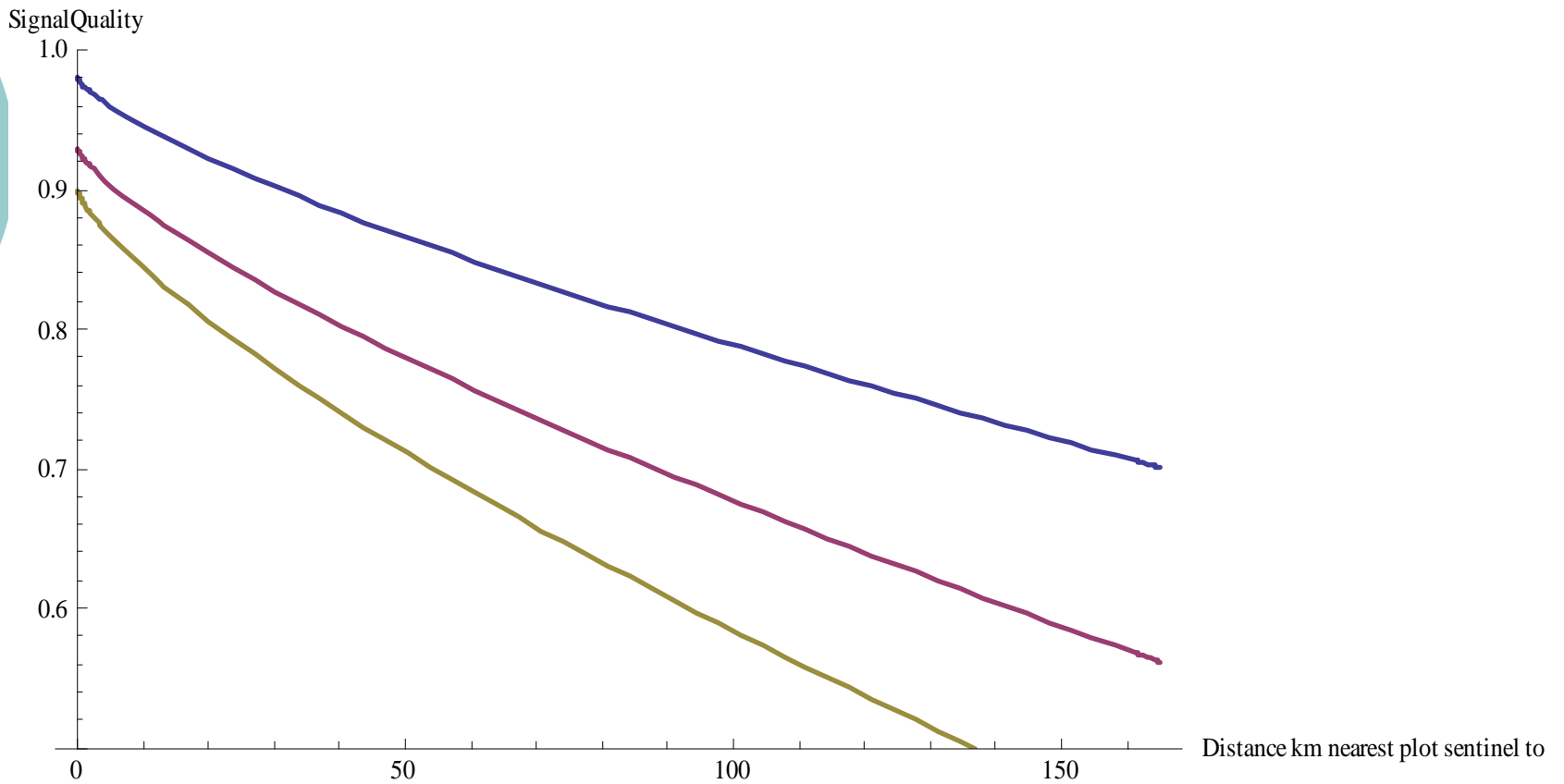
- Green: No action
- Yellow: Curative
- Red: Preventative
- Blue: Follow Signal



Using this model to determine the optimal location of sentinel plots

- Create a representative farmer for each county
- Use data on average soybean yield and production from USDA National Agricultural Statistical Service
- Used estimated risk of rust from Bekkerman, Goodwin and Piggott (2008) for prior beliefs.

Quality of the within season signal as a function of distance to the nearest sentinel plot





Results

	High Quality Signal	Medium Signal Quality Function	Low Signal Quality Function
500 plots	\$106,876,866	\$74,217,175	\$59,901,124
400 plots	\$102,672,631	\$72,055,069	\$57,697,522
300 plots	\$97,919,715	\$69,110,845	\$54,760,403
200 plots	\$92,166,473	\$65,149,613	\$52,435,480



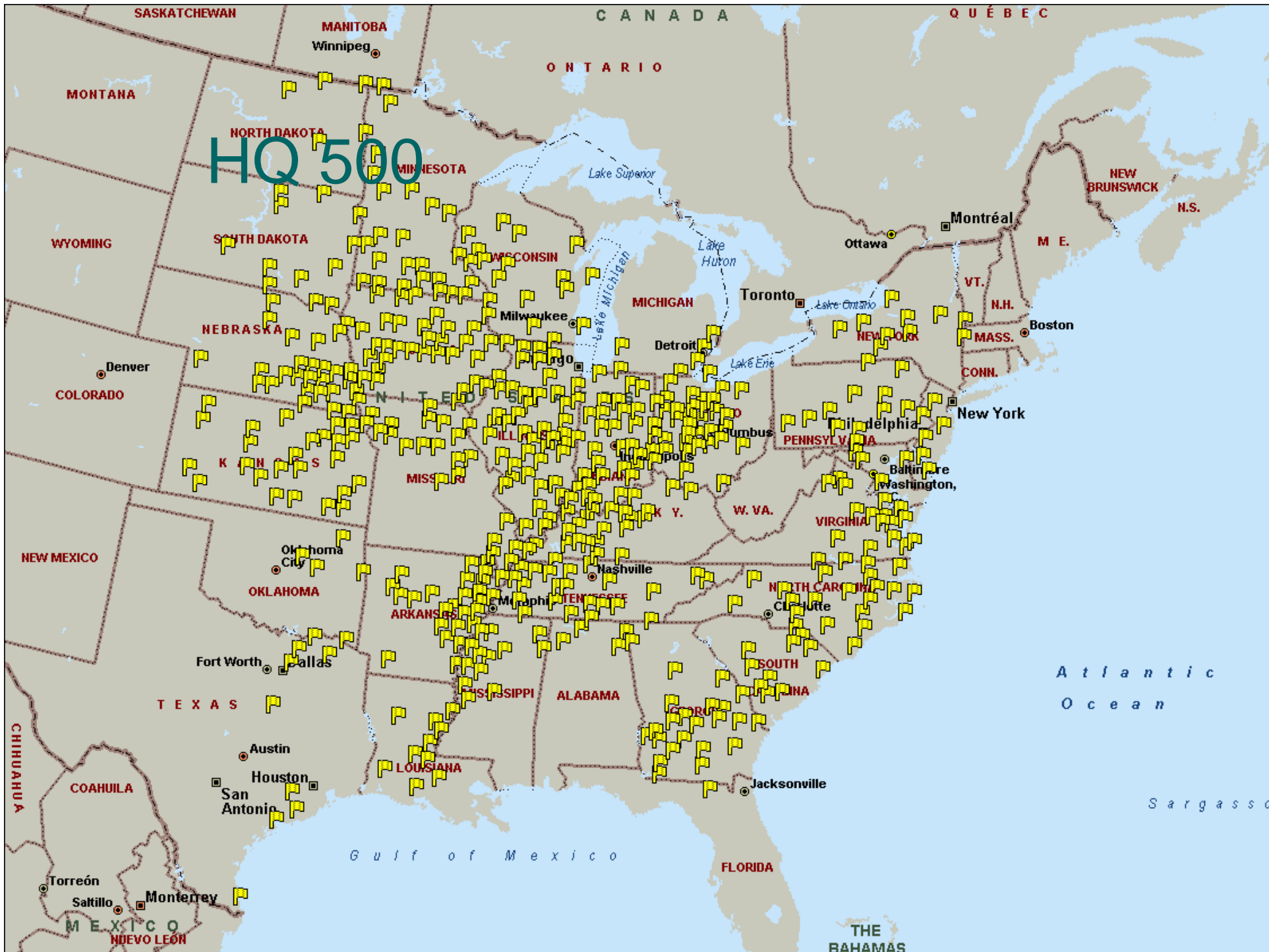
Comparing to Roberts et al

- Roberts et al. considered several scenarios.
- Benefits of monitoring network in scenarios ranged from \$11-\$299 million.











Conclusions

- We looked at the value of information when the context is learning about a stable statistical process
- Estimated value of sentinel plots similar to Roberts et al.
- Value of network is sensitive to farmer's prior beliefs



Questions?
