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

Stephen Aultman*
Terry Hurley *
Frances Homans *
Robert Haight#

* University of Minnesota # US Forest Service

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% yield loss)+ (1-S)(25% 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

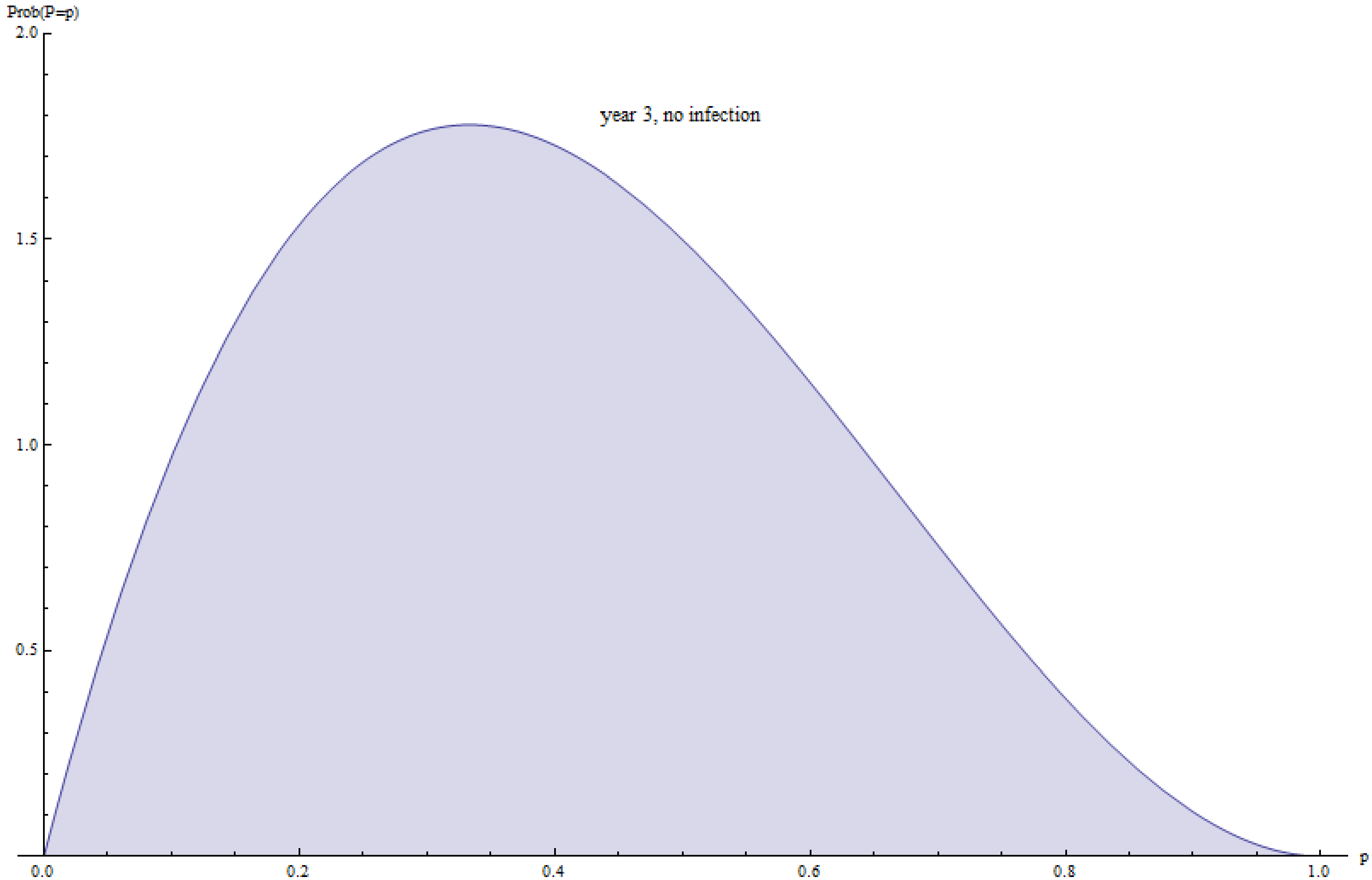
The farmer’s problem

- 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)

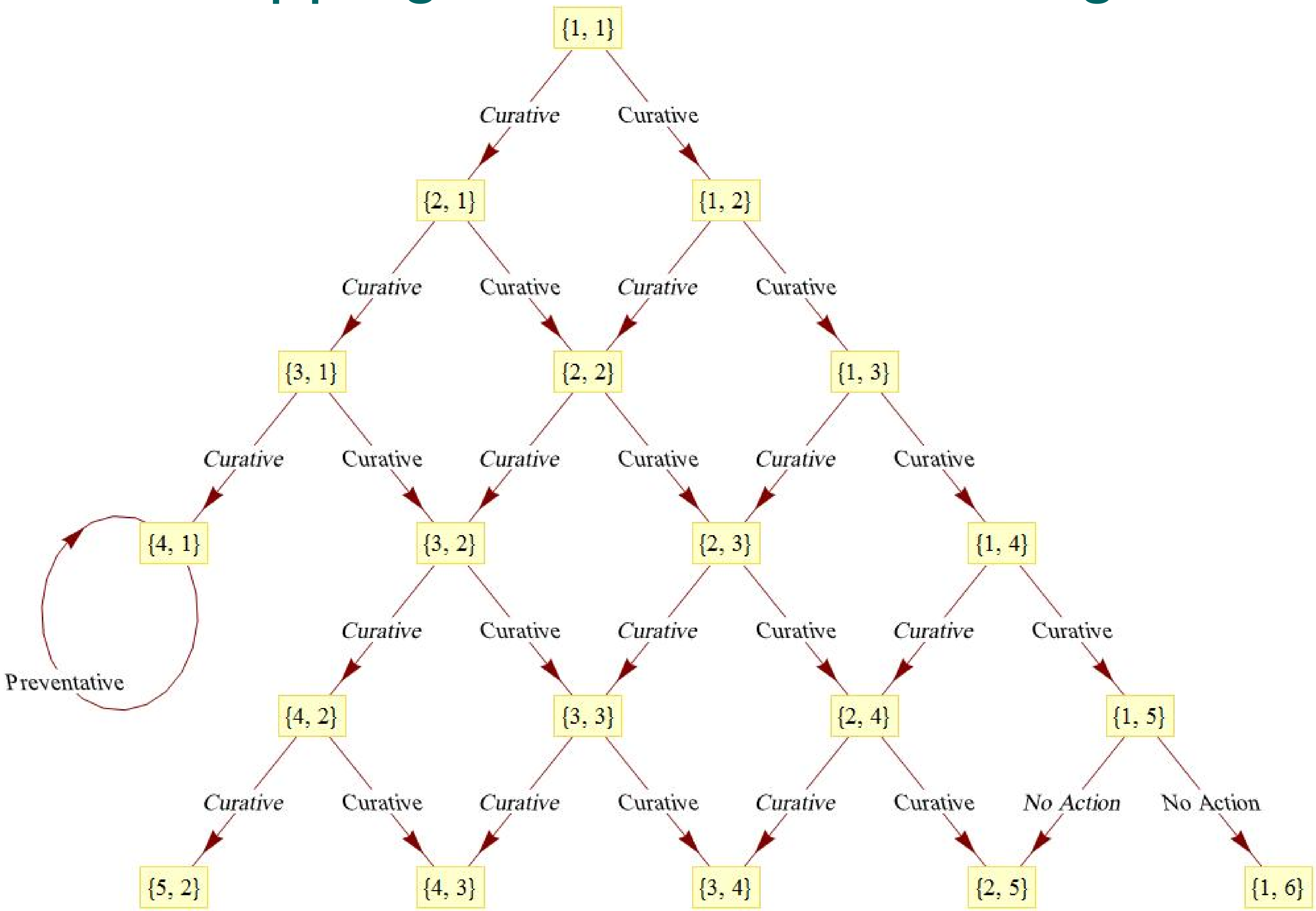
Bayesian updating

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

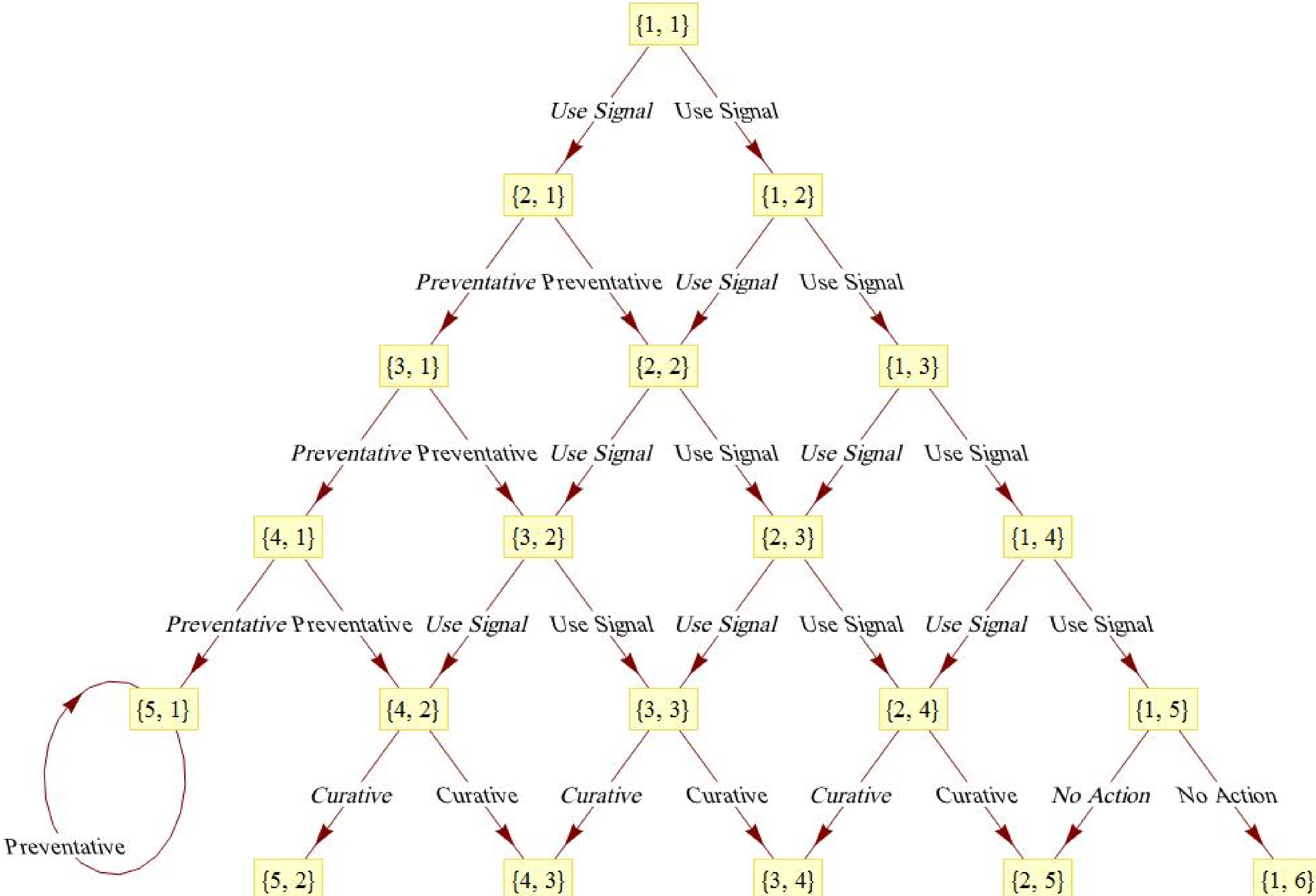
Bayesian Updating Cont



Stopping Rules: No Monitoring



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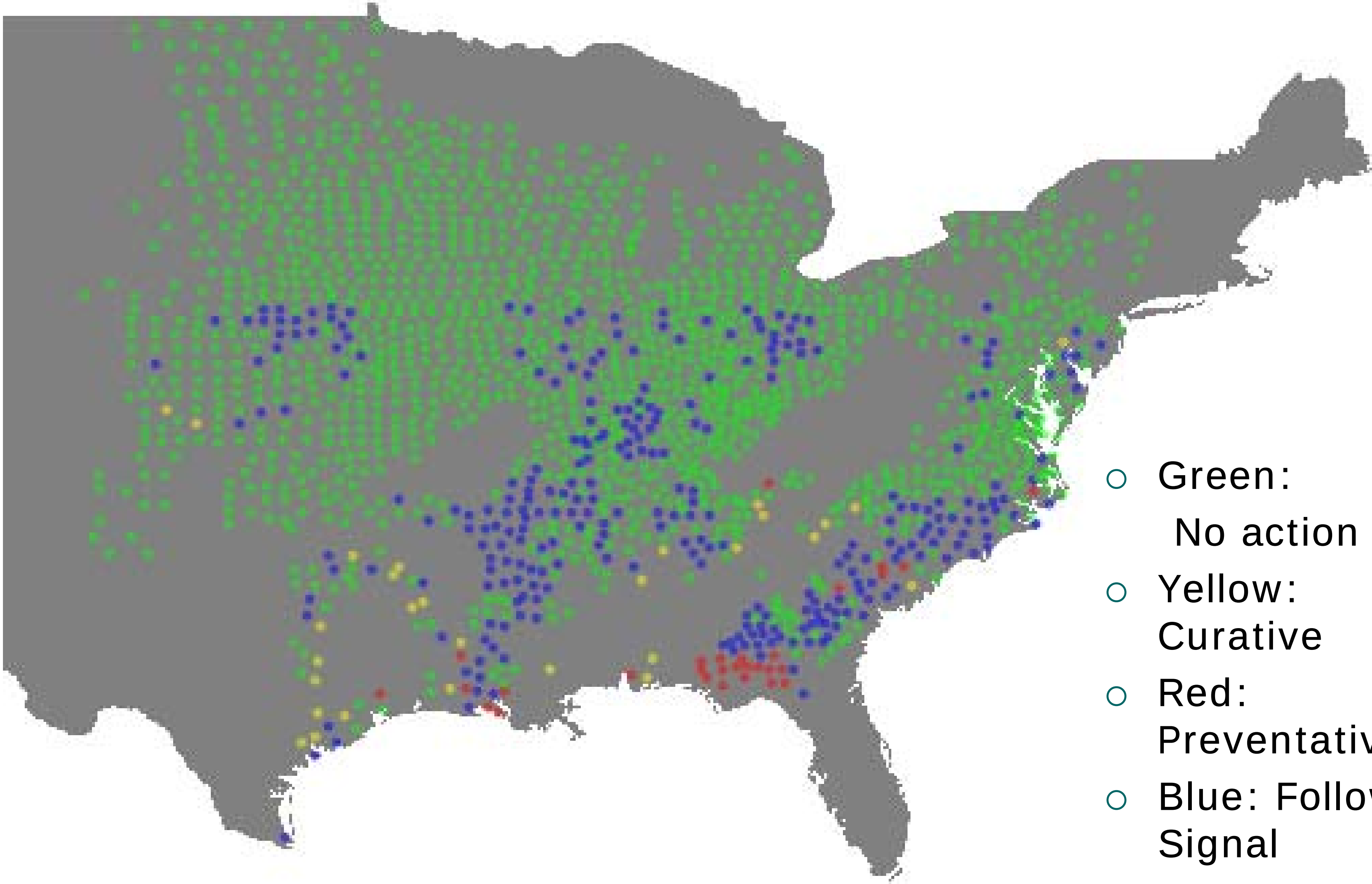
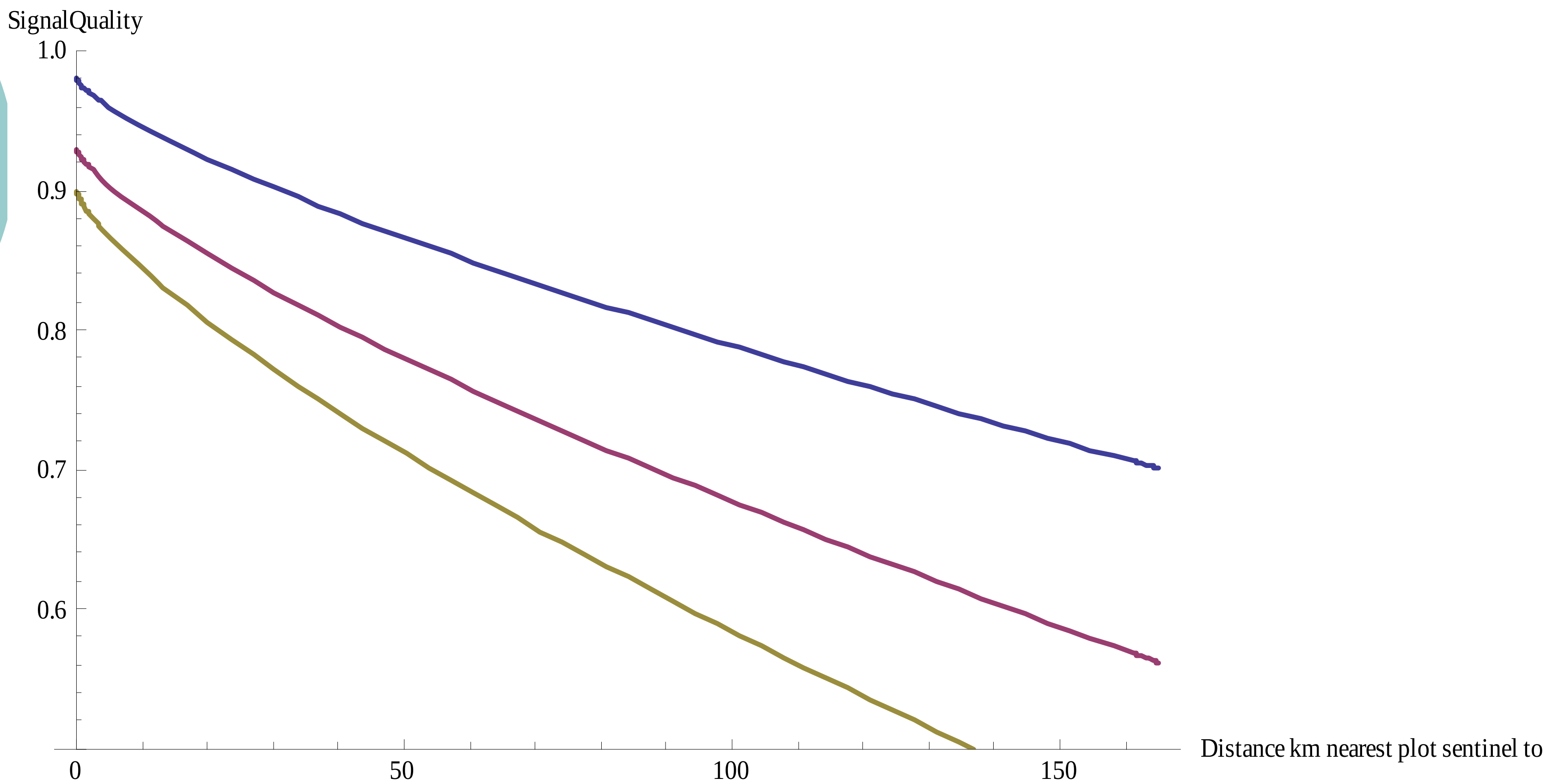


- Green: No action
- Yellow: Curative
- Red: Preventative
- Blue: Follow Signal

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 Sevice
- 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.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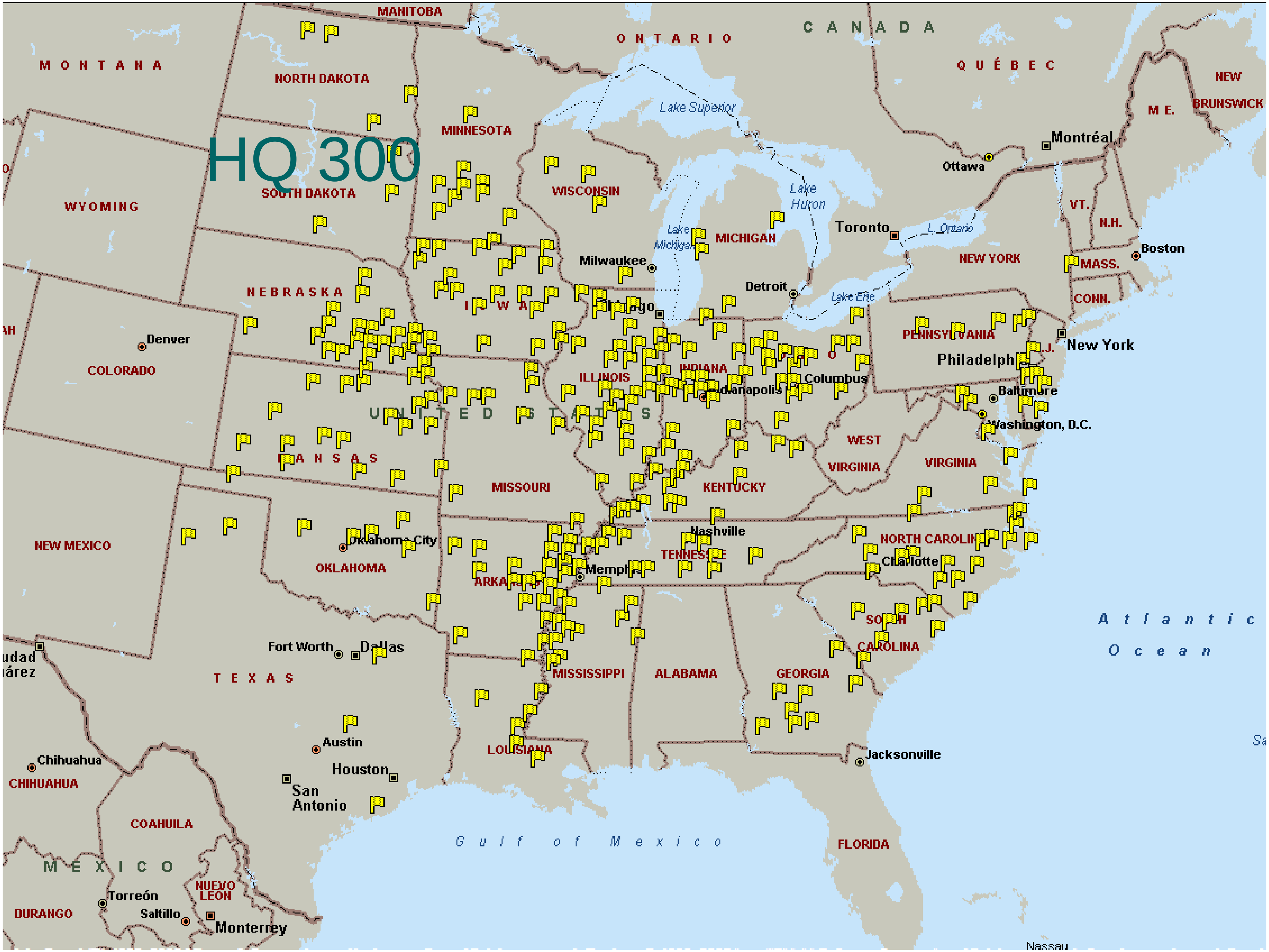

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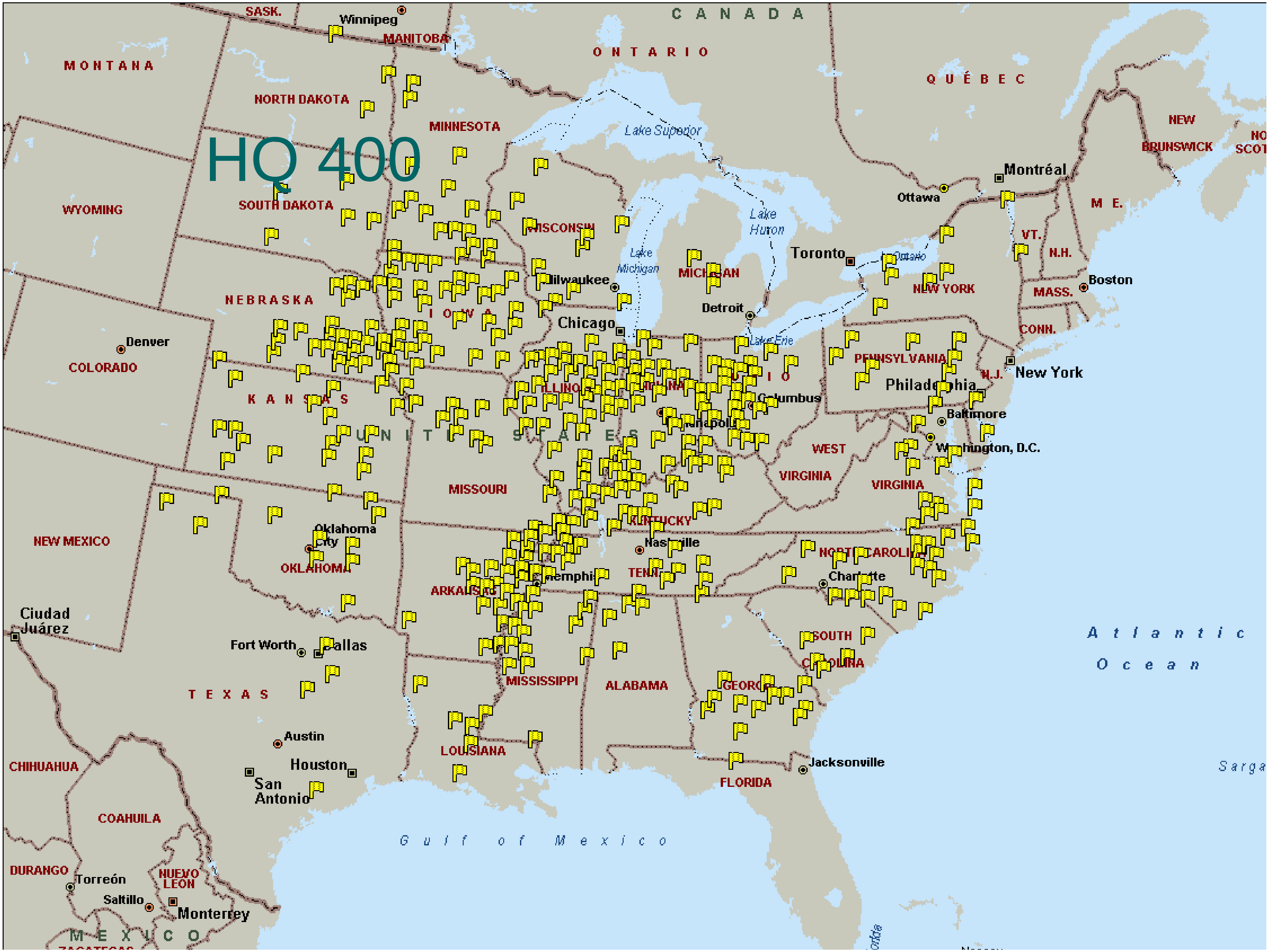
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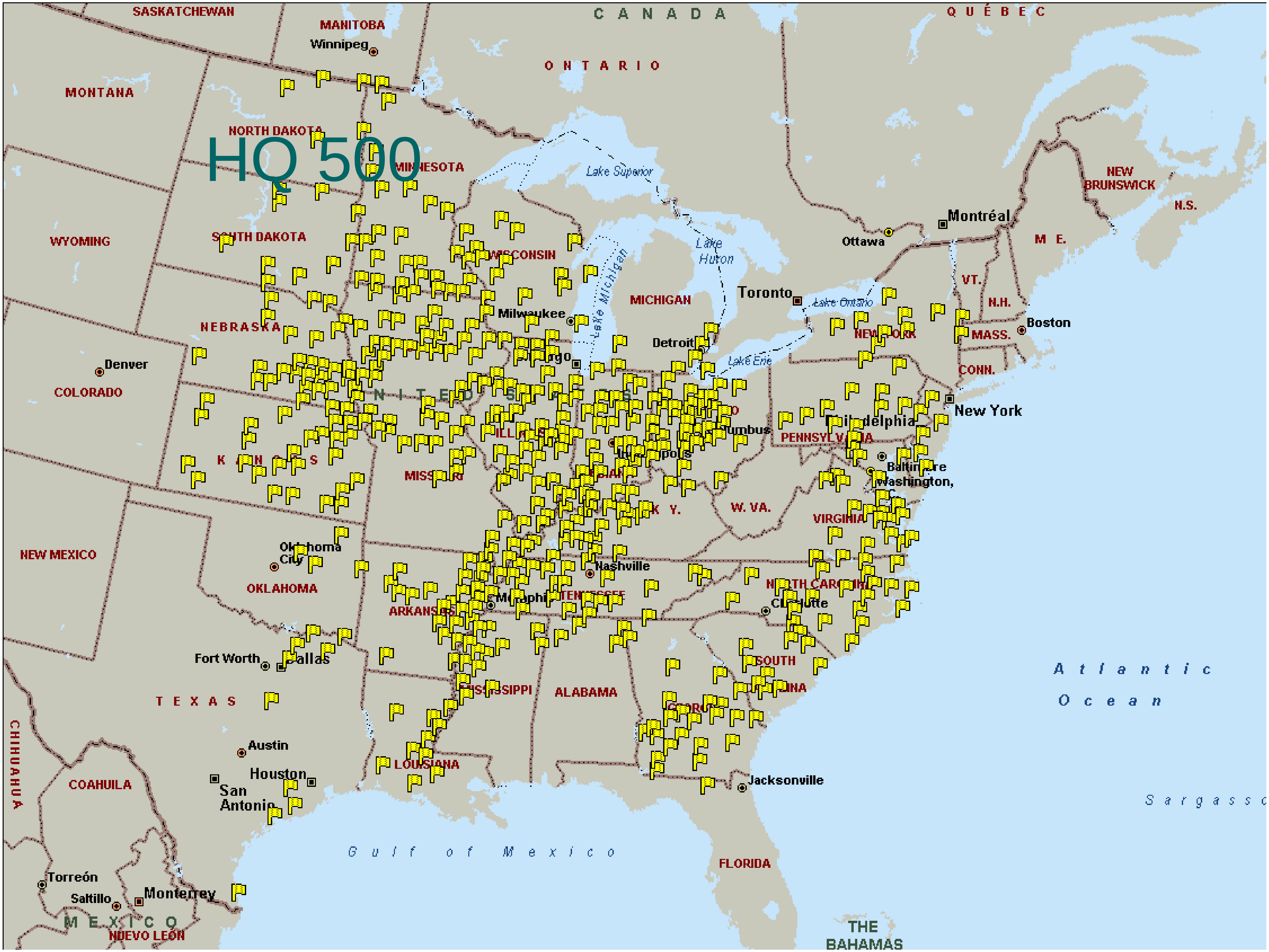

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Conclusions

- 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?