Economics of Cover Crops

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Wisconsin Cover Crops Conference

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Goal Today

- **Provide a meta-view of cover crop economics**
- Main point: Cover crop economics is very idiosyncratic
  - Depends on the specifics of the farmer, the farm, and the field
  - Cover crop species, crop species, soil, weather, management, pest pressure, …
  - Farmer preferences, attitudes, beliefs, capabilities, values
- Very difficult to generalize about net benefit of cover crops

Benefits of Cover Crops: Environmental

- Erosion Reduction
  - Covering the soil reduces soil erosion, enhances soil quality by not having as much loss
- Reduced Nitrogen Losses
  - Cover crop scavenges the nitrogen and converts it to plant tissue for later release (mineralization)
- Commercial vegetable growers use cover crops after short season crops for wind erosion control and to scavenge N
- Cover crops after corn silage or winter wheat
- Cover crops in 2013 for prevented plant acres

What's the Value of a Ton of Soil?

- Hansen and Ribaudo (2008) Economic Measures of Soil Conservation Benefits: Regional Values for Policy Assessment, USDA-ERS TB-1922
  http://www.ers.usda.gov/publications/tb-technical-bulletin/tb1922.aspx
- Lit review, multiple impacts, by county for policy analysis
- Irrigation ditches & canals, Recreational fishing, Freshwater & marine fisheries, Flood damages, Road drainage ditches, Municipal & industrial water use, Municipal water treatment, Steam power plants, Soil productivity, Dust cleaning, Water-based recreation, Navigation, Reservoir services
- Lower bound on value of eroded/saved soil

- Benefit ranges $8.81 to $6.57/ton in WI
- Most values are constant across WI counties
- Soil Productivity is $1.21/ton

Figure 5
Range and distribution of all water-erosion benefit values, by county

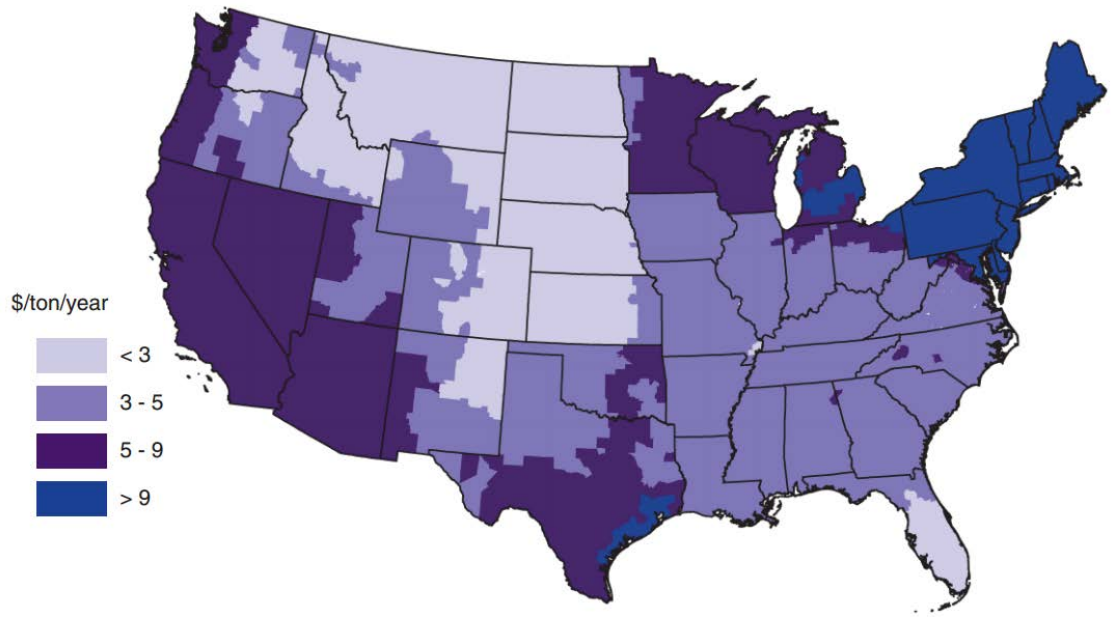
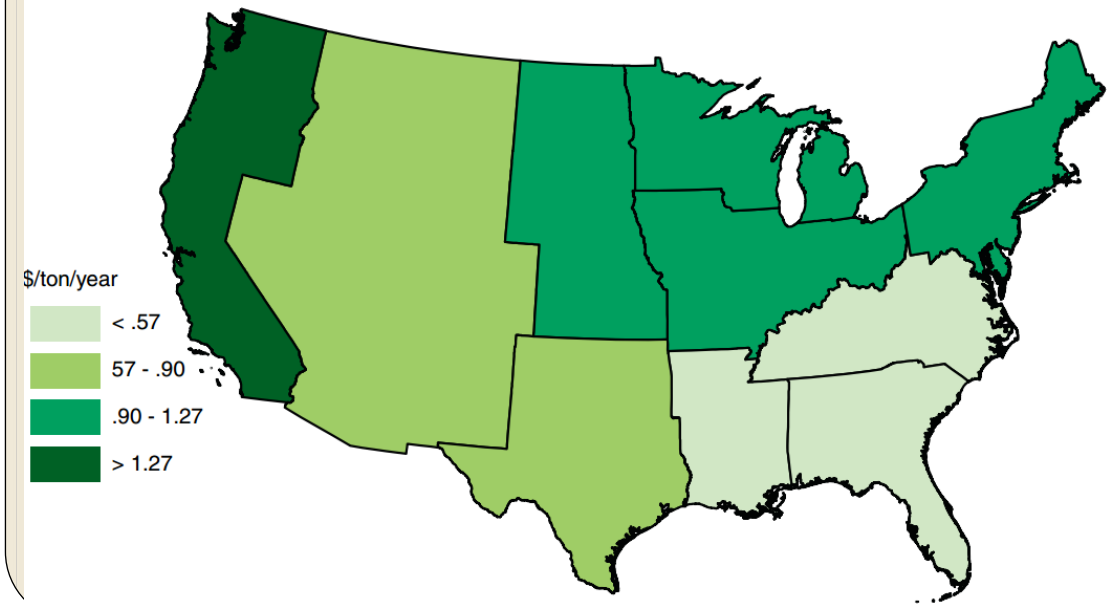


Figure 6
Range and distribution of all wind-erosion benefit values, by county



- Variation is water-based recreation and reservoirs
- High is Door County
- Low is Iowa County

Soil Erosion

- Most of the costs/benefits are off site: public or others pay the costs/get the benefits
- Farmer's direct cost is Soil Productivity: $1.21/ton in 1990 dollars, convert to 2014 dollars using CPI:

  $1.21 x 1.79 = $2.17/A/yr

- Wisconsin state average loss is 4.6 tons/A in 2007

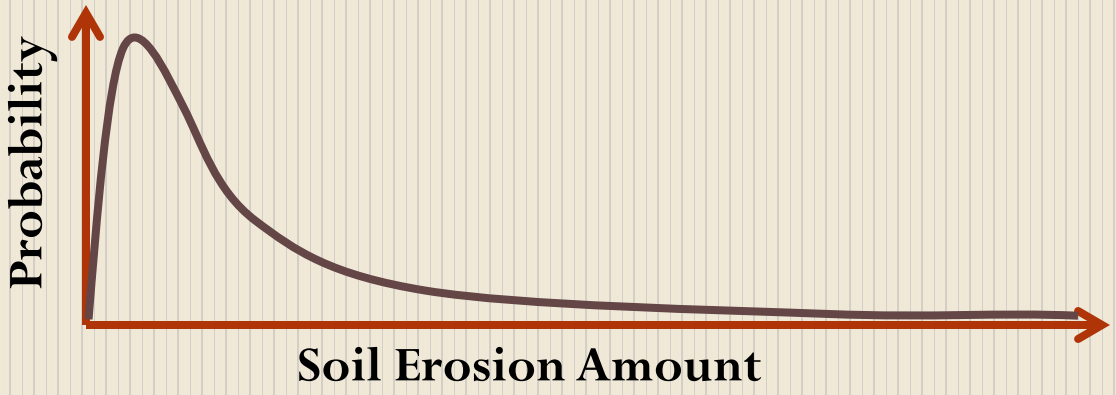
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/?cid=stelprdb1041887

$2.17 x 4.6 = $9.98/A/yr

- Main Point: Soil erosion costs WI farmers on average about $10/A in lost productivity each year

Soil Erosion: Main Point

- Can come up with about $10/A per year as the average value of lost productivity per typical acre
- Reality: this will vary depending on the amount of soil erosion on the specific area, the soil's specific productivity, crop prices, …
- Soil erosion tends to be episodic: Means most of the time soil erosion is low, with a few high losses a few times
- Cover crops can reduce this loss some, but many times it will be small, but how do they perform under high loss events?

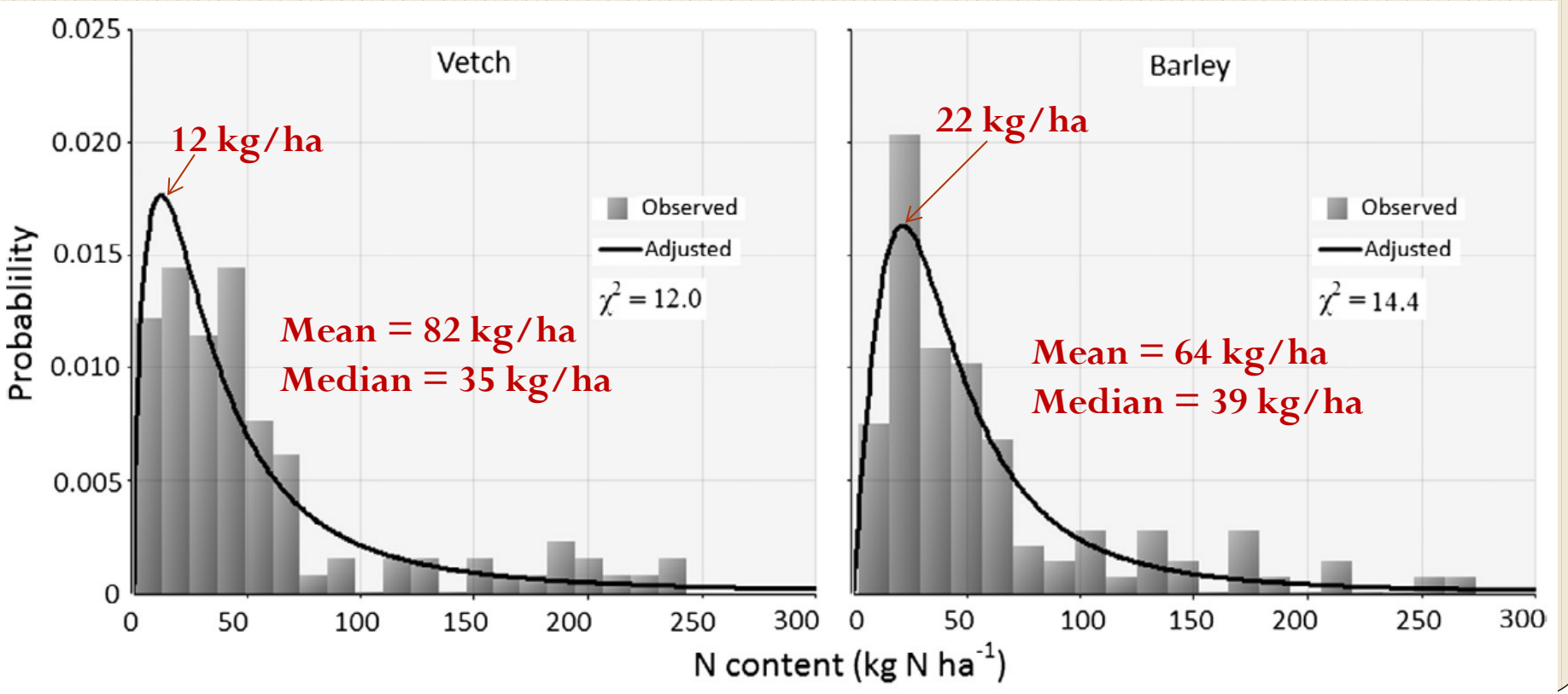


What's the Value of Scavenged N?

- Cover crops scavenge or fix N for follow crops
- How much? It Depends!
- Wide ranges listed that vary based on the type of soil, weather, cover crop species, management, etc.
- Cereals can immobilize 50 lbs N/A, or "cereal rye often showed negative NFRVs [nitrogen fertilizer replacement value], most likely due to N immobilization resulting from decomposition of the high C:N cover crop residues"
- Legumes can immobilize 100 lbs N/A or "Half the studies on hairy vetch indicated a NFRV >70 lbs N/acre while 80% of the studies found NFRVs >50 lbs N/acre"

Cover Crops and Nitrogen

- Gabriel et al. (2013), 5-year study in Spain, cover crops before corn, estimated probability functions
- Very skewed, with lots of low values, some high values



Cover Crops and Nitrogen

- Just because a cover crop immobilizes N does not mean the follow crop gets it
- Crop residues must be mineralized (decompose) and then taken up by the follow crop
- Depends on how terminate cover crop (herbicide versus tillage), soil temperature and moisture, timing relative to the major uptake period of follow crop, cover crop species, …
- Gabriel et al. (2013): average uptake rate by corn: 90% for barley, 81% for vetch, 65% for rapeseed
- Some cover crops can even consumer soil N!
- Ruark and Stute: "Cover Crop Considerations for 2012"

http://ipcm.wisc.edu/blog/2012/08/considerations-for-cover-crops-in-2012/

Cover Crops and Nitrogen

- UW Extension, Ruark and Stute: N credits as vary by cover crop species, size, planting date
- Can credit about 40 lbs N/A, and sometimes a lot more
- What happens if the follow crop does not take up the N?

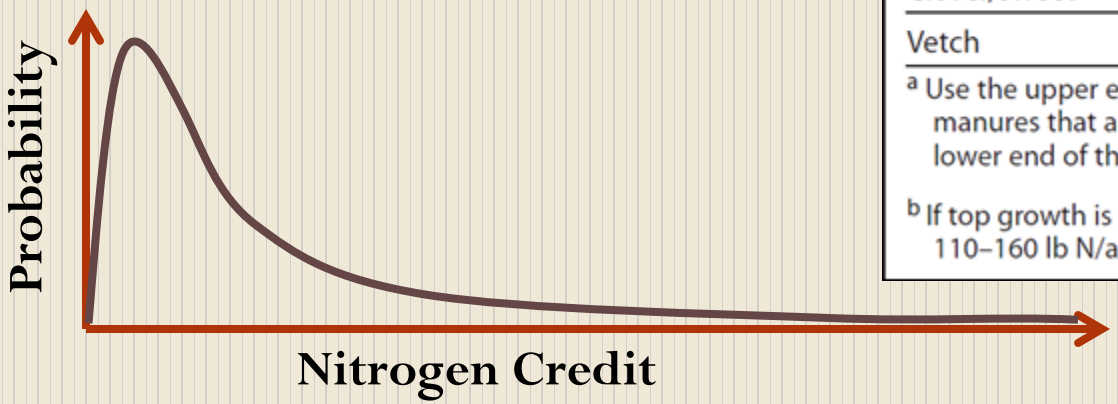


Table 9.5. Green manure nitrogen credits.

Crop	< 6" growth	> 6" growth
	——— lb N/a to credit ———	
Alfalfa	40	60–100 [a]
Clover, red	40	50–80 [a]
Clover, sweet	40	80–120 [a]
Vetch	40	40–90 [a,b]

[a] Use the upper end of the range for spring seeded green manures that are plowed under the following spring. Use the lower end of the range for fall seedings.

[b] If top growth is more than 12 inches before tillage credit 110–160 lb N/a.

What's the Value of Scavenged or Fixed N?

- Multiply 40 lbs/A by N price
- This year about $0.44/lb, or $17.60/A, but with some upside potential for more N

N Price	N Value at 40 lbs/A	N Value at 60 lbs/A
$0.35/lb	$14	$21
$0.40/lb	$16	$24
$0.45/lb	$18	$27
$0.50/lb	$20	$30
$0.55/lb	$22	$33
$0.60/lb	$24	$36
$0.65/lb	$26	$39
$0.70/lb	$28	$42

Benefits of Cover Crops: Agronomic

- After soil productivity and N, it gets much harder to estimate $ values for the benefits
- Weed Suppression
- Insect/Pathogen Suppression
- Soil "Health"
- Yield Effects

Cover Crops and Weed/Pest Control

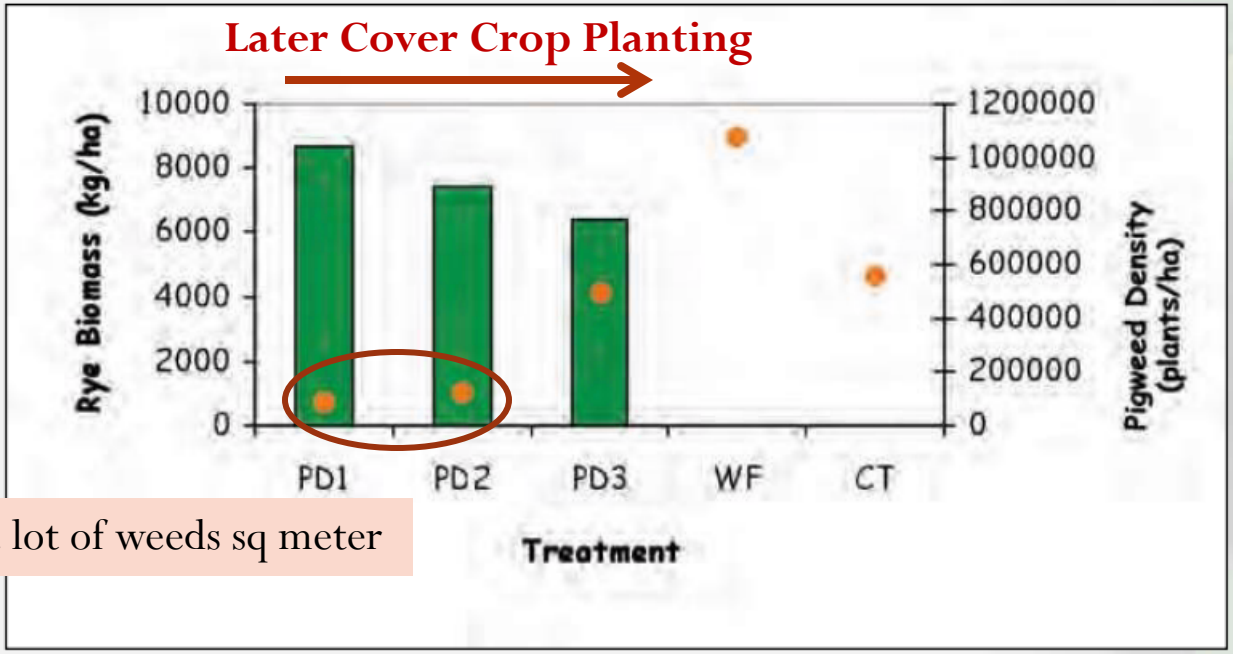
- Cover crops can suppress weeds, break up pest cycles, serve as biofumigants, …
- Many of these effects have been documented, showing statistically significant effects
- 1) Statistical significance ≠ management
- 2) Effective pest control with cover crops usually requires careful management and agro-ecological knowledge to be effective:
  - Cover crop X pest X crop X environment X management effects
- Most farmers usually want better and simpler control than cover crops provide

Weed Suppression using Cover Crops

- Cover crops can suppress weeds: Show a statistically significant reduction in weed population density or biomass
- Statistically significant weed suppression ≠ management
- Weed management often needs one or both of the two big hammers farmers have: herbicide and/or tillage
- Effective weed suppression with cover crops usually requires careful management: good establishment, proper timing of establishment and termination
  - Roller-crimper and rye cover crop can provide effective weed control in some cases, but perennial weeds harder to suppress, need herbicide

Weed suppression by rolling-crimping rye cover crop

Weed suppression related to density of cover crop



Still a lot of weeds sq meter

Pigweed growth is suppressed by cover crop residue, the more the better. Green bars represent rye biomass (left axis); orange dots represent pigweed density (right axis). PD1, PD2, and PD3 correspond to cereal rye planting dates 1, 2, and 3 (4 weeks prior, 2 weeks prior, and on the average first frost date). WF is winter fallow; CT is conventional tillage (multiple disking).

Source: http://www.mccc.msu.edu/events/2012/2012Monsanto/16-Soteres.pdf

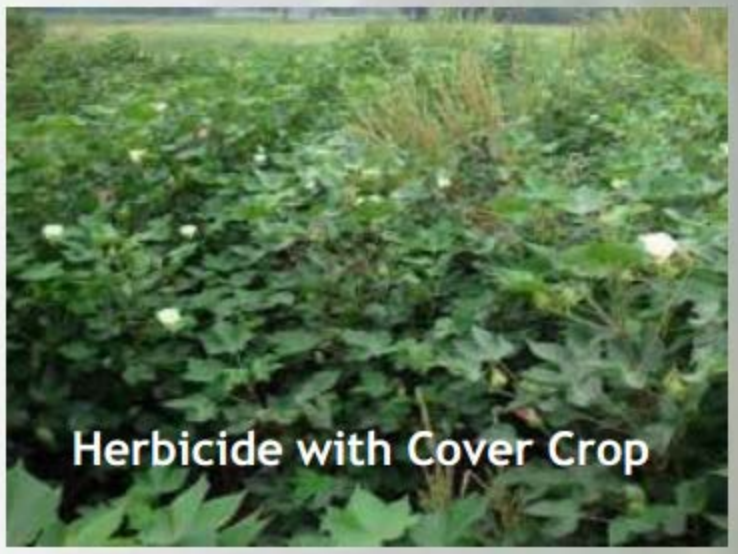
Cover Crop alone may not provide needed weed control…..

Pigweed emerging in the planter row

Source: http://www.mccc.msu.edu/events/2012/2012Monsanto/16-Soteres.pdf

Cover Crops and Weeds

- Cover crops can augment herbicides
  - Potentially useful when have herbicide resistant weeds
- Termination important to keep cover crops from becoming weeds
  - Buckwheat, annual rye grass
- Some cover crops are invasive
- Herbicide restrictions if feed some cover corps



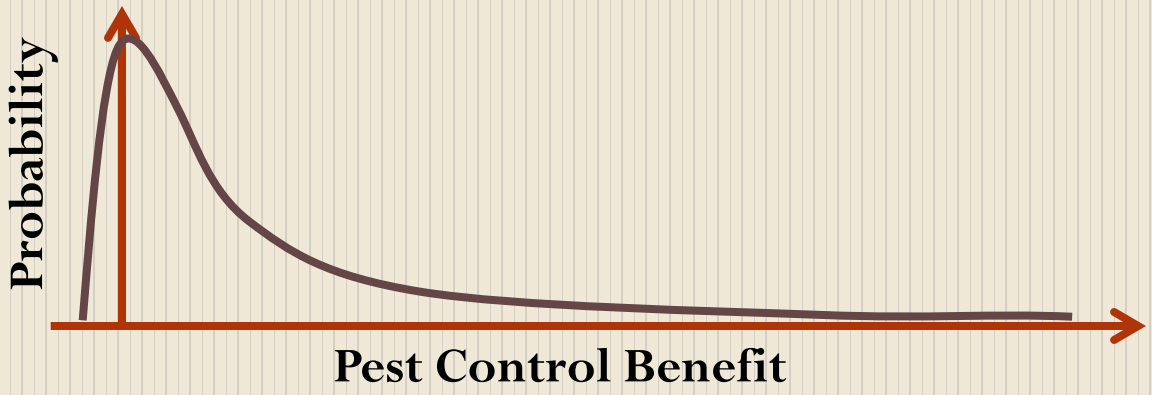
Source: http://www.mccc.msu.edu/events/2012/2012Monsanto/16-Soteres.pdf

Cover Crops and Insects/Pathogens

- Cover crops can provide habitat for beneficial insects and increase insect biodiversity, provide insect suppression
- Break up disease cycles, serve as biofumigants
- Statistically significant suppression ≠ management
- Cover crops can also harbor crop pests and/or pathogens, supporting them at times when they don't have habitat, then they move to crops
- Effective use of cover crops for pest control requires careful management and agro-ecological knowledge
- Cover crop X pest X crop X environment X management effects
- Pesticides are effective, easier to use, and often cheap

Cover Crops and Pests

- Main Point: Cover crop benefits are a harder sell for pest control (weeds, insects, pathogens)
- Cover crop X pest X crop X environment X management effects
- Many interactions mean that pest control with cover corps is managerially complex and inconsistent benefits observed
- Sometimes have great pest control using cover crops, but many times just suppression, sometimes even extra losses



Cover Crops and Soil Moisture

- Cover crop X crop X environment X management interactions matter
- Cover crops use soil moisture, which is good in wet years and heavy soils, bad in dry years and lighter soils
- 2012 drought year versus 2013 wet spring: cover crop effects = ???

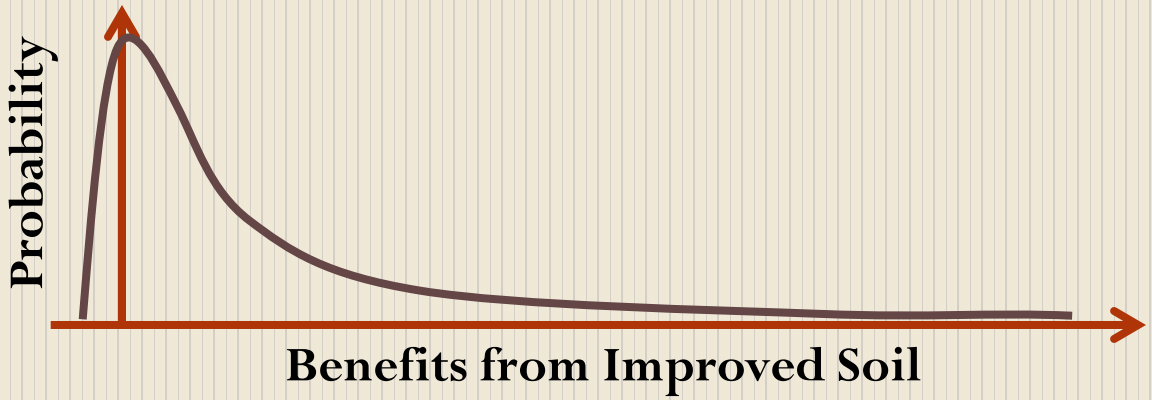
- June 29, 2012, Columbia County, WI
- Rye cover crop harvested May 10th, corn planted in both areas on same day
- Cover crop used soil moisture in a year that it mattered
- Same effect if had used cover crops for 20 years???

Cover Crops and Soil

- Cover crops can improve soil health, soil structure, soil organic matter, soil water holding capacity, …
- Most of these are slow processes and hard to observe in a short time period: they take a while to be measurable
- Would you notice the productivity impact of soil erosion?
- Improved soil "health" correlates with improved outcomes for agriculture (higher yields, lower costs, etc.)
- Correlation means it's not a perfect one-to-one link, but inconsistent and sometimes not there
  - Sometimes cover crops can make you worse off

Cover Crops and Soil

- Main Point: improving soil has benefits
- Much of the time they are small, even losses if manage wrong (2012 drought), but sometimes quite large
- The benefits will be slow and hard to see and vary year to year, depending on the weather
- Have to pay costs now for future soil benefits that may or may not be noticeable for several years: A hard sell



Benefits of Cover Crops: Yield

- Yield is the Integrator: Yield takes a lot of these benefits and adds them up for the net impact that matters
- Because the benefits are many and variable, the yield effects are variable too: have a probability distribution
- Means sometimes there are benefits, sometimes there are not, which is a definition of Risk
- Cover crops are not sure bet, but are they a good bet?
- Depends on your willingness and capacity to bear risk

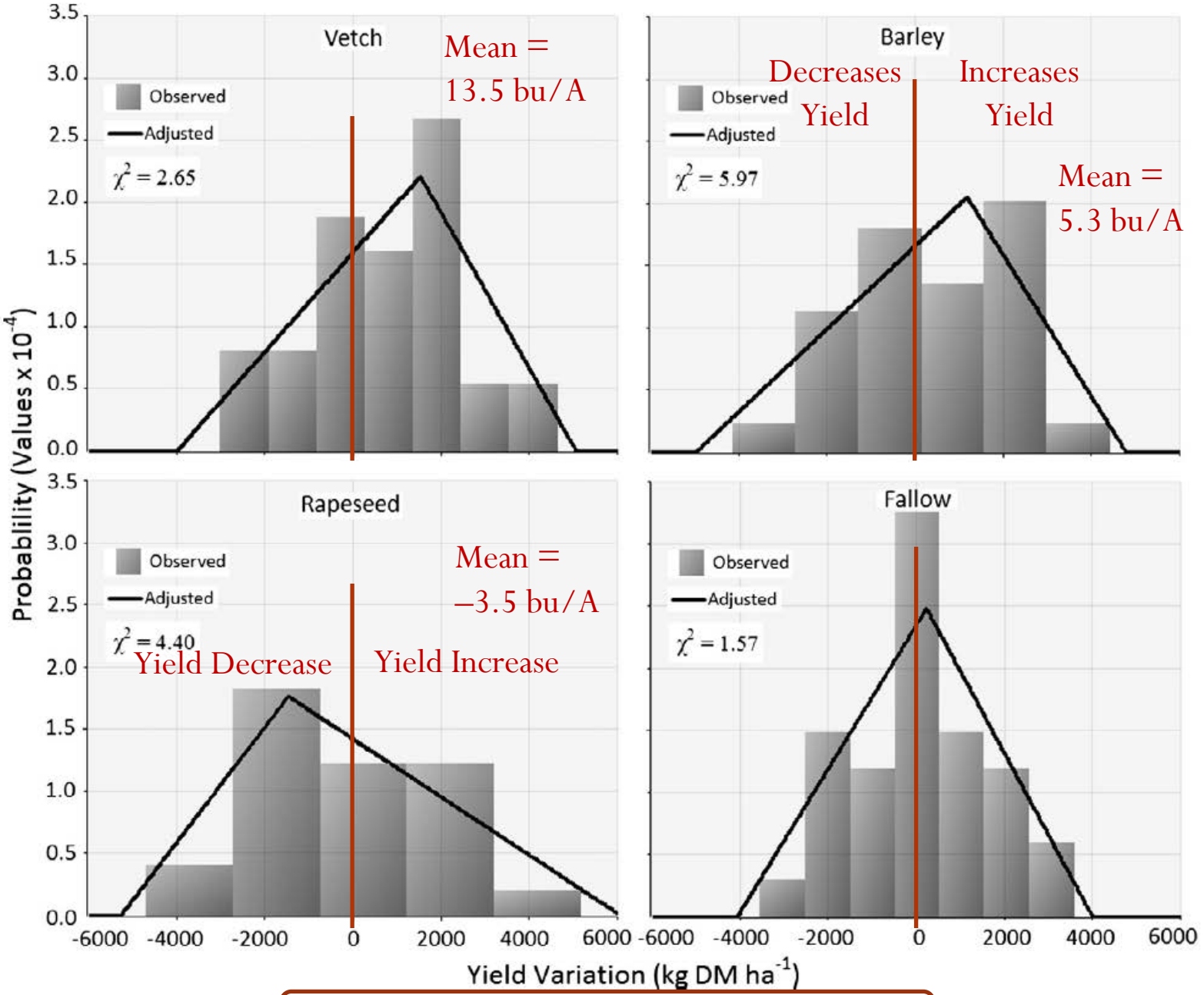
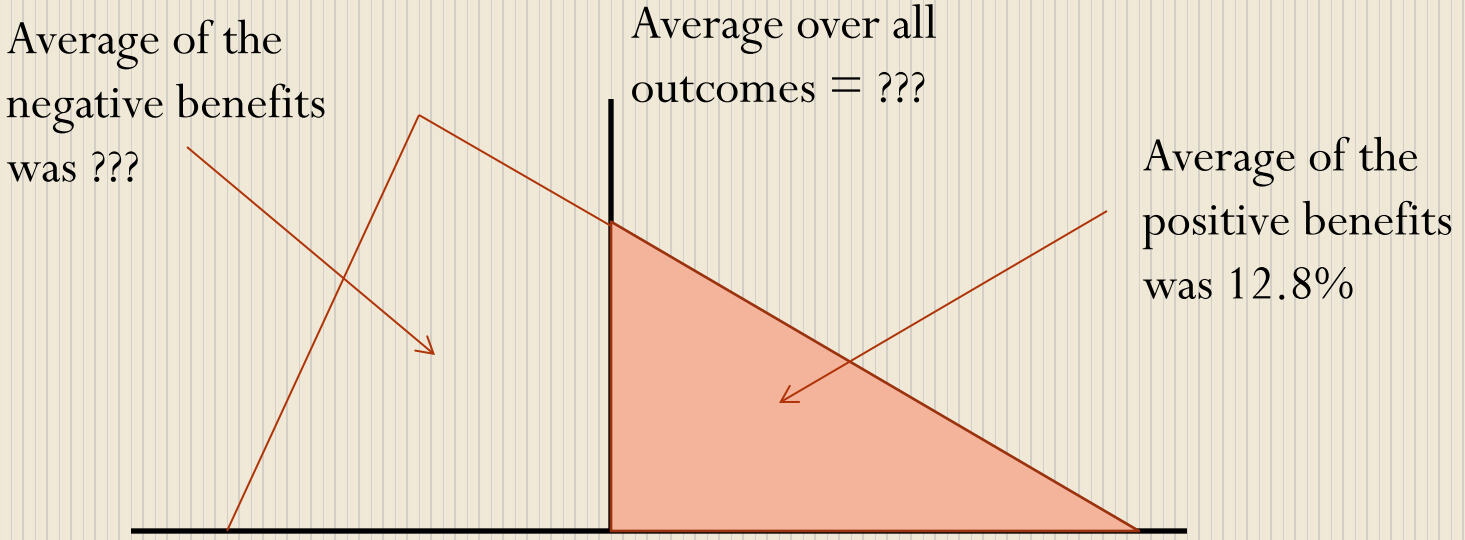


Fig. 4. Probability distributions of the cover crop effect on maize yield.

Source: Gabriel et al. (2013)

Benefits of Cover Crops: Yield

- Bergtold et al. (2012) survey of 300 Alabama farmers
- 67% had used cover crop in last three years
- 37% of the adopters perceived a yield benefit (63% did not)
- Of those perceiving a benefit, average was 12.8% across crops



Cover Crops and Costs

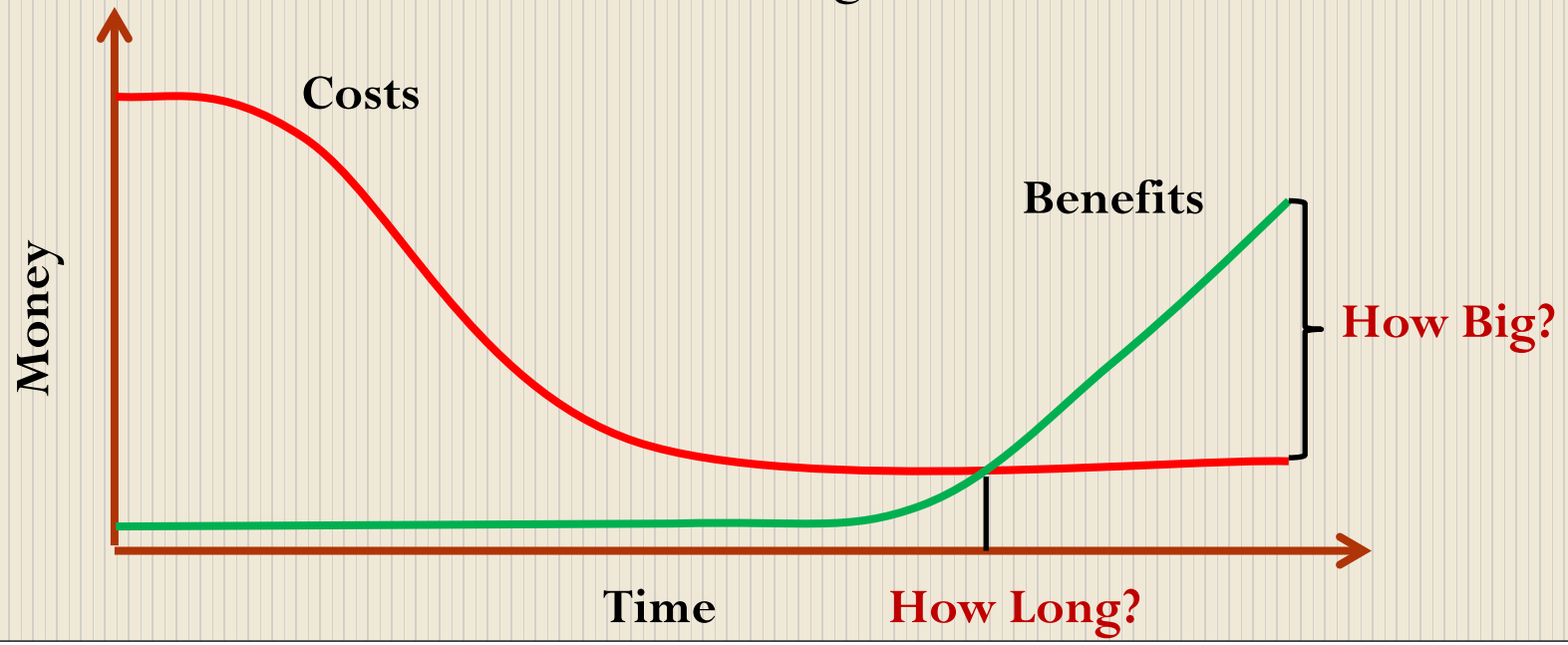
- Direct Costs: most are clear and easy for farmers to calculate: seed, establishment, termination or harvest
  - Managerial Costs: Value of the extra time and effort to manage properly and to acquire the needed knowledge and experience
  - Harder to quantify, varies greatly among farmers
- Indirect Costs: when problems arise: deplete soil moisture, slower soil warming, delayed N release, less flexibility, …
  - Hard to quantify individually, appear as Yield Risk: increased probability of lower yields

Economics of Cover Crops

- Net Benefit: Price x ExtraYield – Extra Costs
- Is the yield increase on average enough to justify the cover crop cost? To justify the risk?
- Is the nitrogen cost savings enough to justify the yield risk?
- Depends on your costs and your willingness and capacity to bear risk, how much you discount the future, and the value you get from the non-monetary benefits of cover crops
- What's the base case for comparison? Extra yield and Extra cost relative to what?

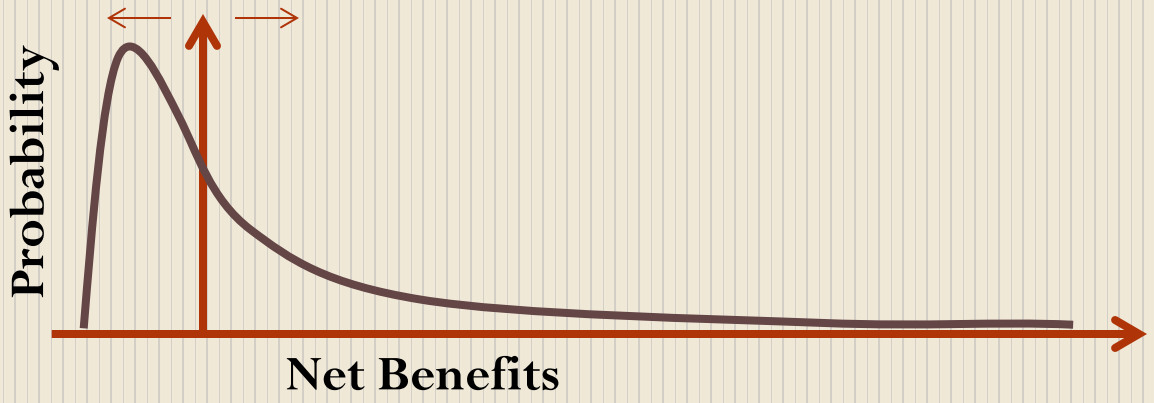
Costs, Benefits, and the Human Condition

- A common issue underlying many human problems
- Pay high costs now and wait a long time before the benefits become apparent and eventually exceed the costs
- Switch costs and benefits labels: Benefits are large now and high costs are not paid until the far off future
- Once add the uncertainty/variability, even more unclear: Good or bad outcomes due to good or bad luck



Summary

- Cover crops are diverse, managerially complicated, with several smaller, difficult to measure and uncertain benefits and costs, so that benefits may or may not justify the costs
- "Typical" shape of the probability function for the net benefit of cover crops in terms of $/A for the farmer
- Each situation moves this net benefit curve around: cover crop, crop, soil, weather, management, pest pressure, etc.
- Very hard to generalize about net benefit of cover crops



Ways to Increase Cover Crop Use

- Reduce the costs
  - Cost share for direct inputs/costs
  - Reduce complexity and risk: develop locally relevant and practical practices and clearly and effectively communicate them
- Increase the benefits
  - Honest assessment of the benefits and risks to manage farmer expectations and to maintain legitimacy/credibility
  - Establish long-term trials, find long-term users to demonstrate the future benefits and inspire long-term investment
- Institutional impediments
  - Crop insurance rules
  - Rental arrangements: Create and distribute example leases that require and reward appropriate cover crop use
- Farmers are preeminently practical – if it works, they will use it

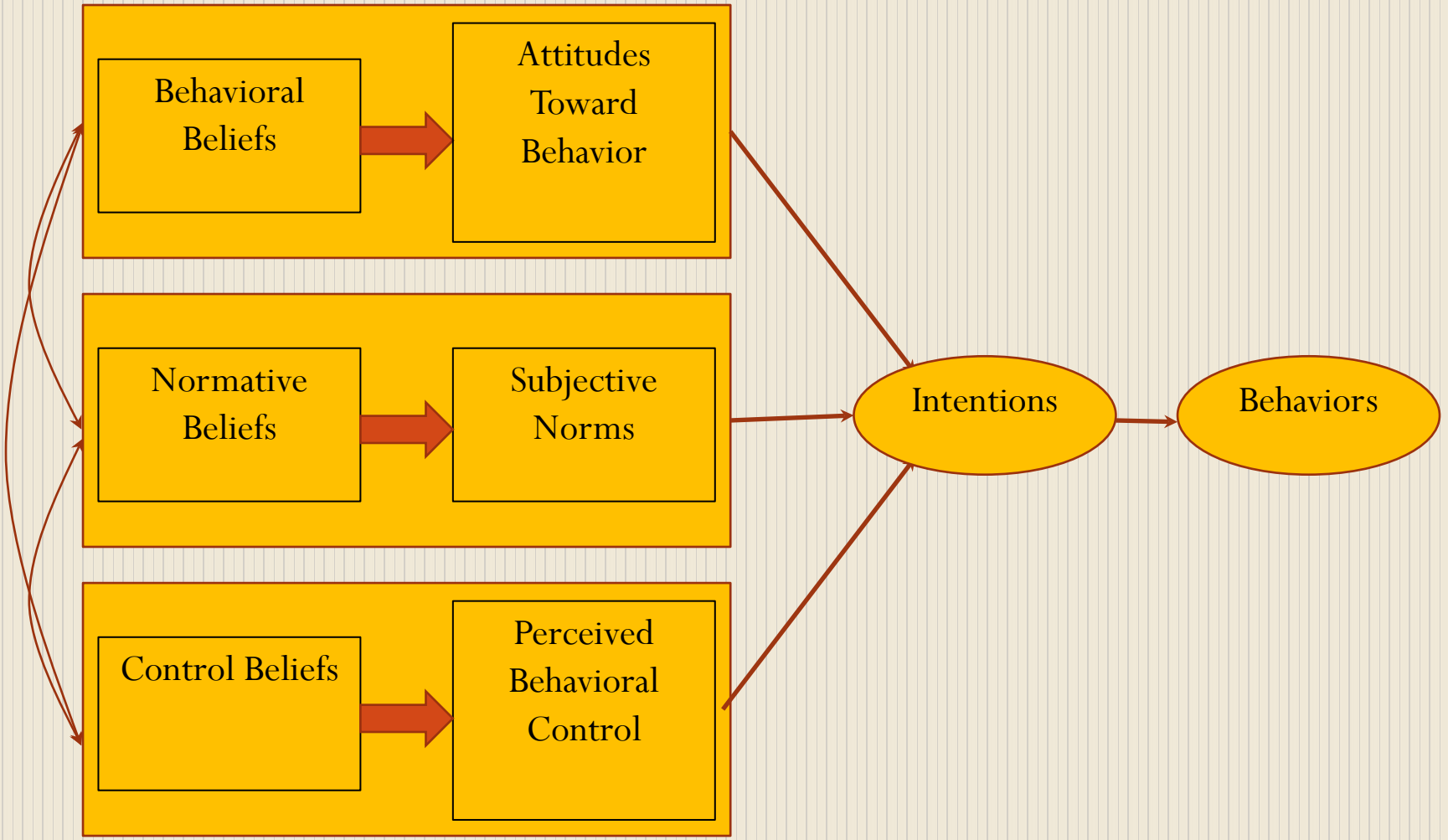
Research In Progress

- Cover crops are not a sure bet, but are they a good bet?
- Depends on your risk preferences, your risk bearing capacity, your discount of the future relative to the present, your valuation of the non-monetary benefits of cover crops, …
- What one person considers an unacceptable risk or a waste of time another person will take on and passionately pursue
- Personal values and specific situation matter when it comes to cover crop adoption and use
- UW Hatch Grant: The ABC's of BMP Adoption: The Role of Attitudes, Beliefs and Characteristics in Cover Crop Adoption

ABC's of BMP Adoption

- Traditional economic models tend to focus on farmer and farm Characteristics to understand what drives adoption
  - Age, education, farm size, crops grown, livestock, debt to asset ratio, average yields, off-farm income, ethnicity, …
- Attitudes and Beliefs play an important role in adoption of some practices on farms, it's not just Dollars and Data
- Can we better understand the adoption process and how to increase adoption if we model the role of attitudes and beliefs
- What can we learn from other behavioral sciences?

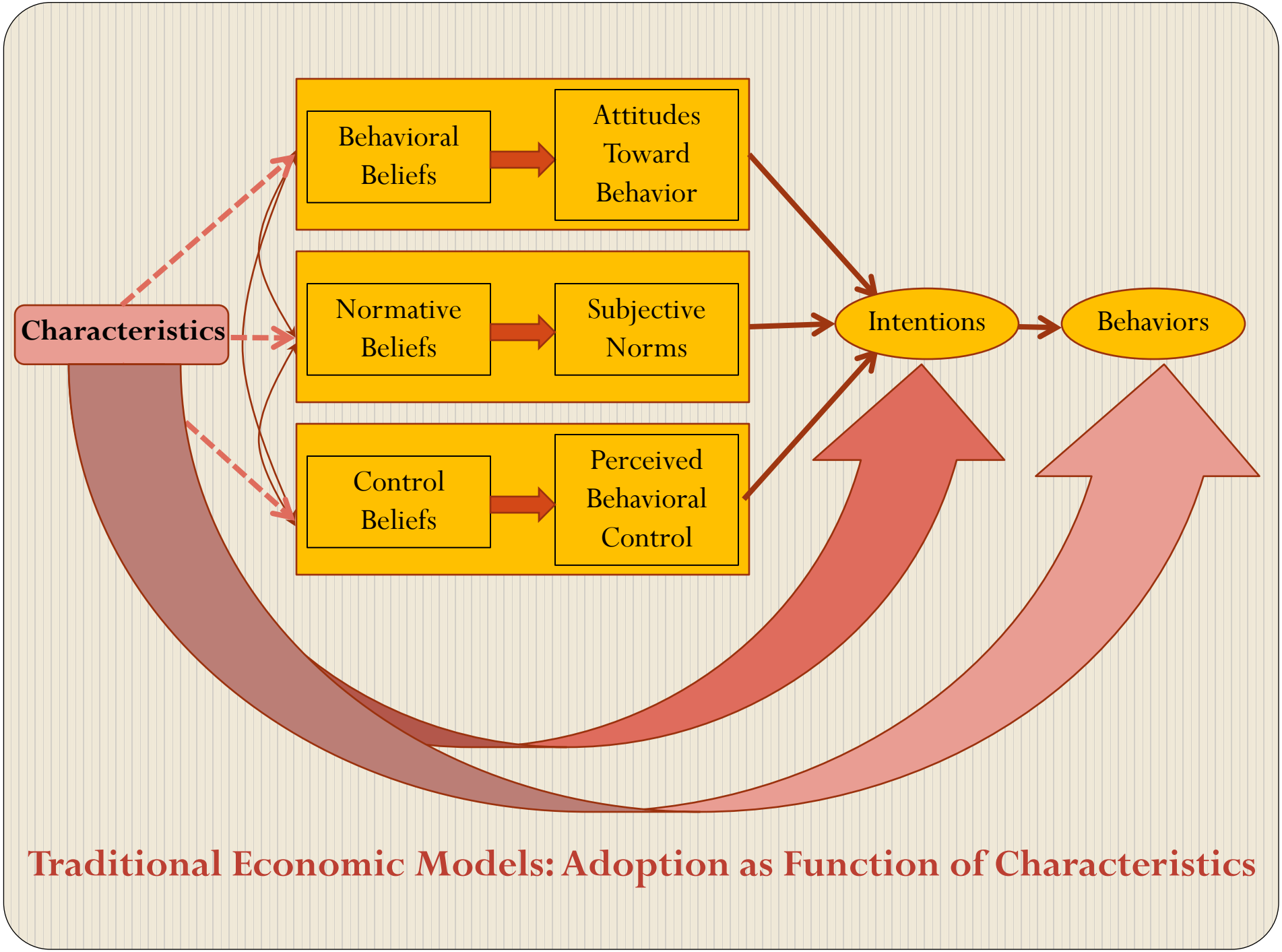
Theory of Planned Behavior (Ajzen 1991)



Adapted from: http://people.umass.edu/aizen/tpb.diag.html

Theory of Planned Behavior (Ajzen 1991)

- Beliefs influence Attitudes that influence Intentions and then Behaviors
- *Behavioral beliefs*: Probability assessments about the consequences of specific behaviors
  - *Attitudes toward a behavior*: Measures the degree that performing the behavior is positively or negatively valued
- *Normative beliefs*: Perception about specific behavior as influenced by significant others
  - *Subjective norms*: Perception of pressures about whether or not a behavior should be performed
- *Control beliefs*: Beliefs about what helps and hinders performing a specific behavior
  - *Perceived behavioral control*: Perceived ease or difficulty for person to perform a specific behavior
- Way to think about how people see the world and what they value



Traditional Economic Models: Adoption as Function of Characteristics

Survey in Progress

- Mail survey this winter of smaller organic and conventional vegetable growers, focused on cover crop use
- Ask about their cover cropping practices: species and issues, plus about their cover cropping Attitudes and Beliefs
- Goal: Compare standard economic model versus the Theory of Planed Behavior model of cover crop adoption
- Which a better predictor of behavior
- Gain insights regarding role of attitudes and beliefs in order to increase appropriate cover crop use among farmers
- Expect results by winter 2014/15

Cover Cropping Attitudes and Beliefs

- Cover cropping improves farm profitability
- Cover cropping improves soil health
- Cover cropping improves fertility
- Cover cropping decreases weed/pest problems
- Cover cropping increases biodiversity/habitat
- Cover crop benefits are more long-term & only become apparent over time
- Most of the vegetable farmers I know use cover crops
- I don't know much about cover cropping
- Using cover crops is complicated

Cover Cropping Attitudes and Beliefs

- My farm's financial situation limits my use of cover cropping
- I experiment with new varieties and approaches to cover cropping
- I try new cover crops and cover crop practices when I see others use them successfully
- I feel pressured to use cover crops by experts & advocates at various events & meetings
- Farmers and experts that I respect use cover crops and encourage others to do so
- I use cover crops because I am supposed to
- I would use less cover crops if I could

Cover Cropping Attitudes and Beliefs

- Cover crops require special equipment
- Cover crops require extra time to manage
- Useful information about cover crops is difficult to find
- Cover crop seed is expensive
- Cover crop residues are difficult to manage
- Cover crops are difficult to establish
- Cover crops increase pest pressure
- Cover crops become weeds
- Planting cover crops instead of a cash crop decreases income
- Cover crops have a short planting window

Thanks for Your Attention!

Questions?

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