

MEASURING AG SUSTAINABILITY: AN UPDATE FOR WISCONSIN POTATO AND VEGETABLE GROWERS

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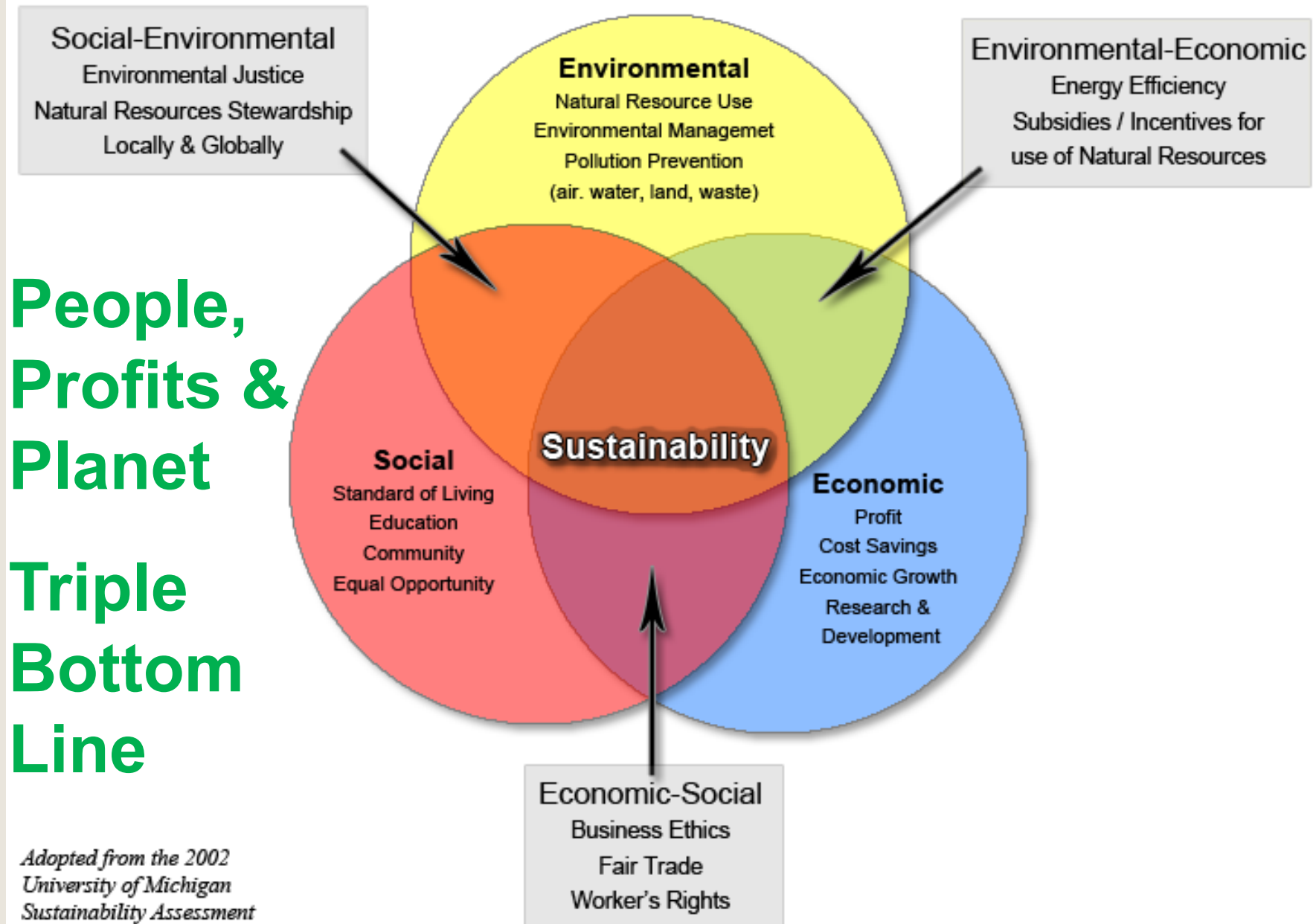
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Sustainability is no longer “Alternative Ag” but has become Mainstream!

- Most companies and commodity & ag groups have sustainability programs and/or initiatives
 - McDonald’s, Cargill, Unilever, WalMart, Del Monte, FritoLay, Sysco, Kettle Chips, etc.
 - Innovation Center for U.S. Dairy, NCGA, USB, National Potato Council, Wisconsin State Cranberry Growers Association, ...
- Crave Brothers Farmstead Cheese: anaerobic digester: “From cow pies to clear skies”
- Wisconsin's Healthy Grown Potato
- Individual WI potato grower efforts
- **Everyone’s talking about sustainability!!!**



The Three Spheres of Sustainability



*Adopted from the 2002
University of Michigan
Sustainability Assessment*

CALS Leadership in Ag Sustainability: Education and Outreach

- **Education:** Sustainability Innovation in Research & Education (SIRE) Grant to develop an experiential food sustainability assessment education program
 - Colquhoun, Bussan, Mitchell, Knuteson, Shaw
 - Undergraduate class in progress this semester
 - Professional Development School for sustainability assessment
- **Outreach:** National Initiative for Sustainable Agriculture
 - Colquhoun and Bussan providing impetus to get it started and now it's officially up and running
 - <http://nisa.cals.wisc.edu/>



Practical Issues

- “People, Profits and Planet” is a grand ideal, but issues remain to make it practical
- What do you measure? How do you measure it?
 - Life Cycle Assessment (LCA)
 - Outcome-based Approach
 - Practice-based Assessment

General LCA Graphic

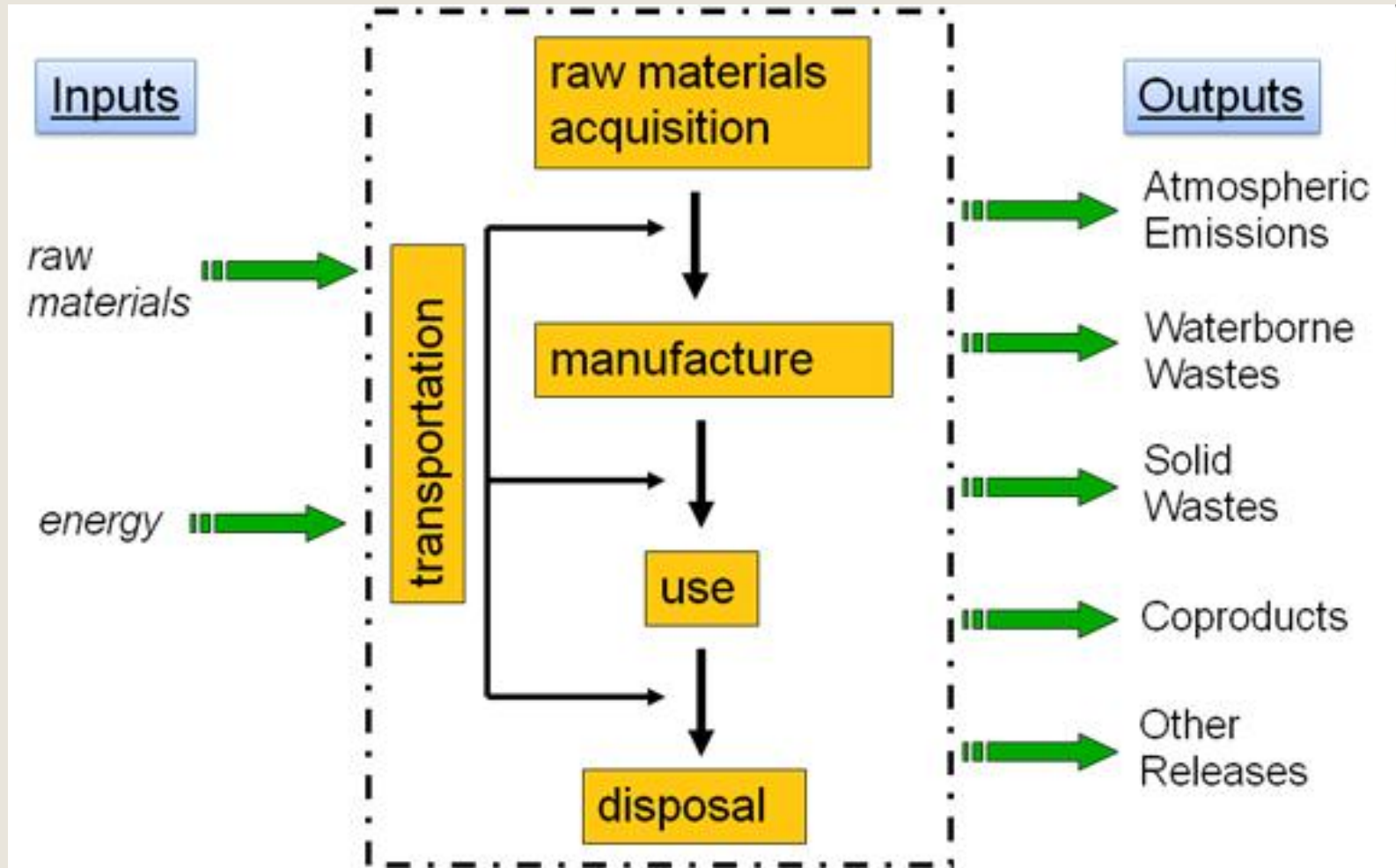


Figure 2. Inputs and outputs for a life cycle assessment.

LCA: Life Cycle Assessment

- Develops measures of “outputs” per unit of good produced over the entire product life cycle
 - Tons of CO₂ and Gallons of water per pound of potatoes sold
 - Capture direct and indirect (embodied) use from “cradle to table”
- Models to predict average direct and indirect use
- Usually aggregate to an industry average, not farmer-specific

Outcome-Based Assessments

- Focus on direct input use (land, water, energy, nutrients, pesticides, etc.) for producing a good
- Includes measures such as soil erosion and greenhouse gas emissions
- Looks for resource use efficiency gains over time
- Field to Market Fieldprint Calculator
- Substantial overlap with LCA in metrics
- Both use models to predict (not measure) many of the outcomes/outputs of interest

Practice-Based Assessment

- Measure farmer adoption of Practices that research shows are correlated with improved sustainability
 - Measure BMP adoption among growers
 - Practices are connected to outcomes with uncertainty
 - Science-based choice of practices
- Already widely used in agriculture because it is low cost, easy to measure and practical
 - Conservation Compliance: Guided by RUSLE2, but farmers under contracts with NRCS for practice adoption, not soil erosion outcomes
 - Bt Corn Refuge: Guided by modeling, but growers required to adopt practices (% acres, distance), not measure and document insect resistance outcomes

Practice-Based Assessment

- Develop a self-assessment tool (survey)
- Collect data from farmers on practice adoption
- Currently four on-going projects at UW using Practice-based Sustainability Assessment
 - 1) Wisconsin Cranberry sustainability assessment
 - 2) National weed resistance management BMP adoption in corn, soybeans, and cotton
 - 3) National Soybean Sustainability Initiative
 - 4) Processing sweet corn and green beans

Sustainability Analysis Problem

- Once you have the data from a Practice-Based Sustainability Self-Assessment
- How do you Aggregate and Integrate over the data to create information?
 - Can easily have data on adoption of hundreds of practices for each grower
 - **How do you measure sustainability?**
- Want to demonstrate improvements over time
- Want recommendations for growers to improve

Frontiers of Sustainability: Data

Envelope Analysis with Principal Components

- First Principal Component Analysis (PCA) to reduce number of variables in data and to address mathematical issues with the data
- Next Data Envelope Analysis (DEA) to measure how intensely each farmer has adopted sustainable practices relative to peer group
- Output:
 - Score between 0 and 1 for each farmer measuring intensity of sustainable practice adoption relative to peers
 - Document adoption intensity of grower population and identify practices to most improve each grower's score

Principal Components

- Principal Component Analysis (PCA)
- Mathematically creates a new set of principal components (PCs) from the data that
 - Reduces number of variables
 - Removes correlation
 - Converts discrete to continuous variables
- Each PC measures intensity of farmer practice adoption, so larger PC is better

Cranberry Project

- Nov-Dec 2009 mail survey of Wisconsin cranberry growers
- Final data for 95 growers, ~80% Wisconsin harvested acres
- Conducted Non-Negative Sparse Polychoric PCA
- Original data: 16 variables
New data: 9 variables (PC1 to PC9) that now continuous, positive, non-correlated

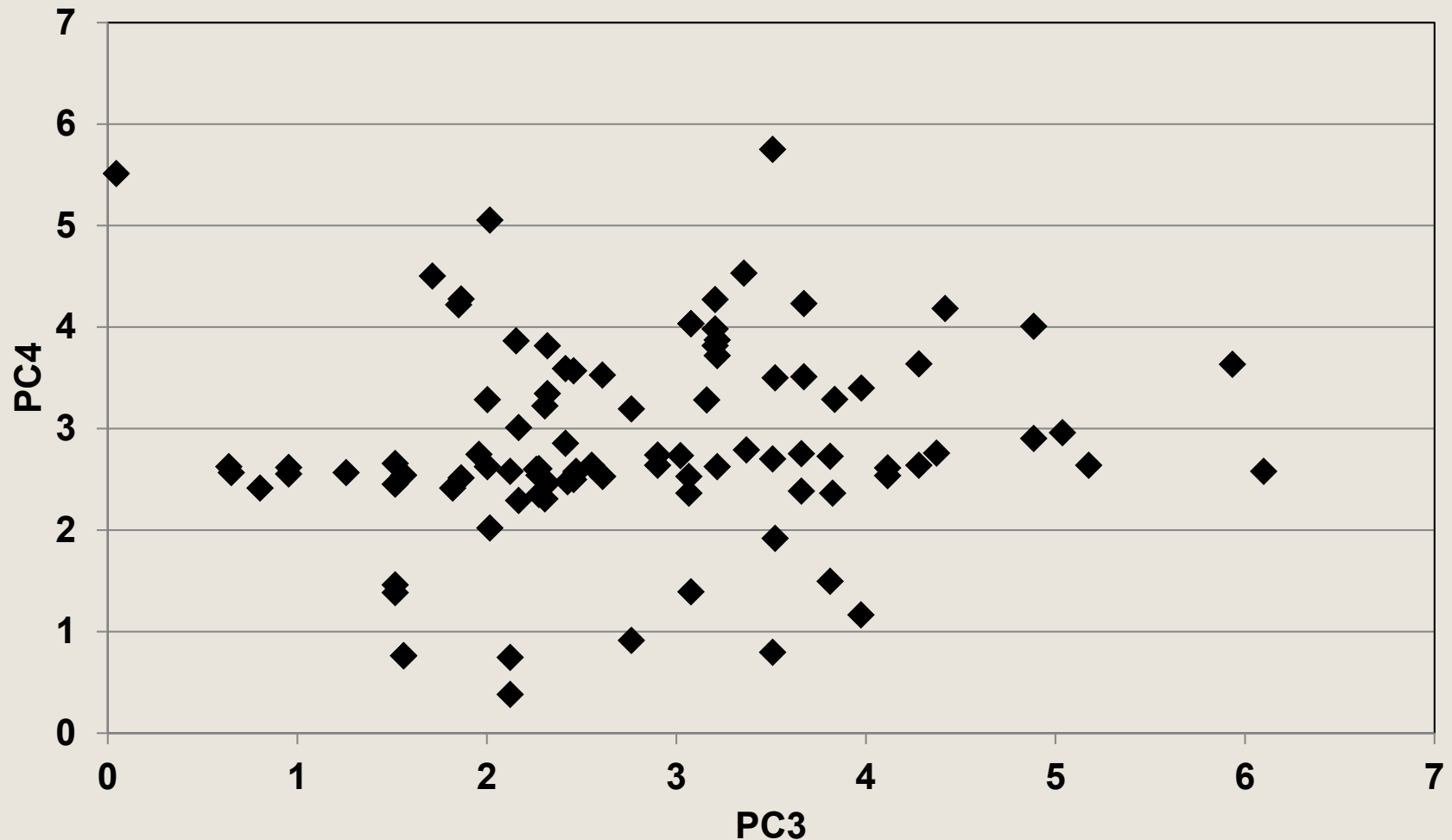
Continuous Variables	Mean
Production area (%) scouted for insects, diseases and weeds	68.1
Average number of times scouted per season	14.3
Average km cranberry crop traveled to a receiving facility	58.7
Discrete Variables (Yes = 1, No = 0)	Mean
Hire a professional pest scout	0.768
Use cultural (non-chemical) practices for pest management	0.874
Fertilizer inputs based on soil tests	0.874
Fertilizer inputs based on cranberry tissue tests	0.884
Weather stations on the marsh	0.442
Use soil moisture monitoring data for irrigation scheduling	0.389
Test uniformity of irrigation system	0.558
Have a nutrient management plan	0.758
Have a conservation plan	0.368
Recycle plastics, cardboard, etc. from the farm	0.789
Provide employees with safety training	0.832
Employees receiving health insurance benefits	0.228
Employees receiving retirement benefits	0.208

Cranberry Non-Negative Sparse PCA weights

	% Ac Scout	Hired Scout	Times Scout	Dist Travel	Cultrl Pract	Soil Test	Tissue Test	Weathr Station	Soil Moistr	Irrg Unifm Test	Nut Mgmt Plan	Consrv Plan	Recycle	Empl Insrnc	Empl Retrmt	Safety Trng
PC1	1.014	0	0.001	0	0.025	0	0	0	0.008	0.003	0	0	0	0	0	0
PC2	0	0.051	1.012	0	0	0	0.020	0	0	0.002	0	0	0.016	0	0.000	0
PC3	0	0	0.009	0.034	0	0	0	0.958	0.339	0	0	0	0	0	0	0
PC4	0.001	0	0	0.012	0.035	0	0	0	0.062	1.011	0.007	0.026	0	0	0	0
PC5	0	0	0	0	0	0.080	0.605	0	0.091	0	0.822	0.023	0	0	0	0
PC6	0	0.078	0	0.431	0	0	0.018	0	0	0	0	0	0.017	0.914	0	0
PC7	0	0	0	0	0	0.029	0.003	0	0.069	0	0	0.728	0.708	0	0	0
PC8	0	0.008	0	0	0	0	0.011	0.001	0	0	0	0	0.017	0.022	1.014	0.019
PC9	0	0.353	0	0	0.496	0.417	0	0	0.050	0	0	0	0	0	0	0.707

- Final PCA Output: For each farmer k: $PC_{ik} = \sum_j \pi_{ij} X_{jk}$
- Example: PC1 = 1.014 x %AcresScouted + 0.025 x UseCulturalPractices + ... (weighted average)
- PC1 and PC2: Pest scouting practices
- PC3 and PC4: Irrigation practices
- PC5: Nutrient management

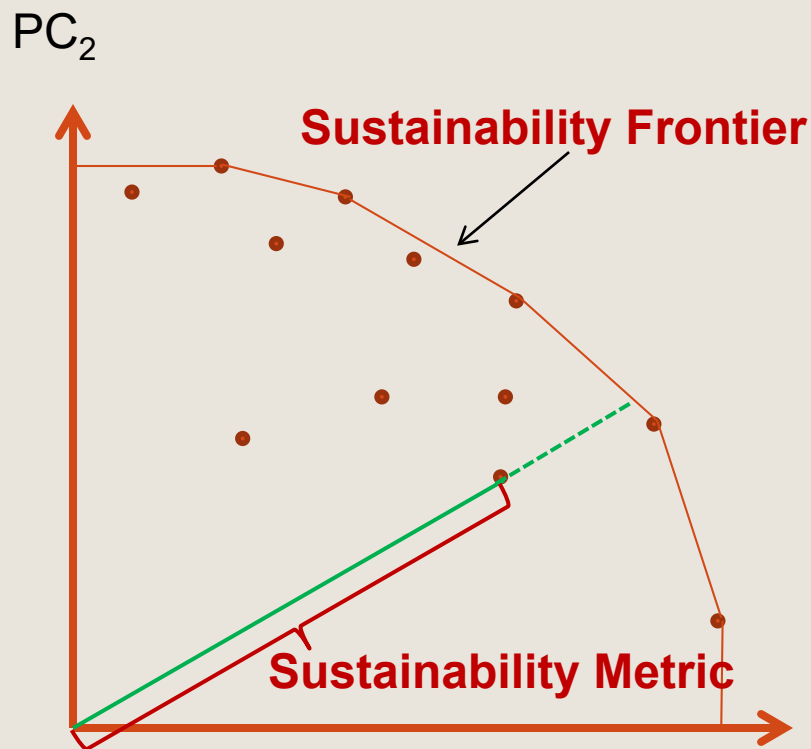
PC4 (irrigation application uniformity testing) vs. PC3 (weather station, soil moisture monitoring)



How do we Measure Sustainability?

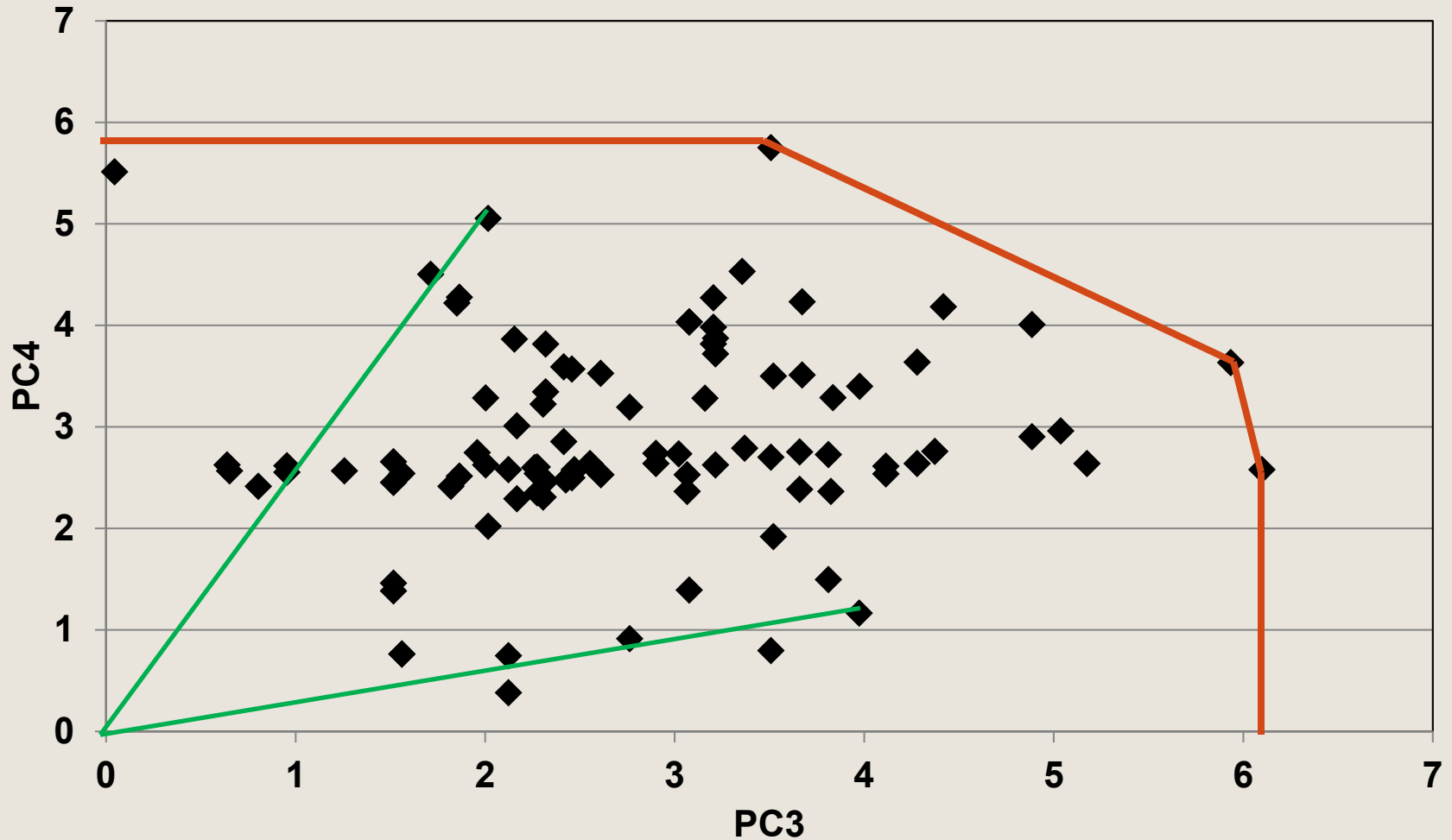
- After PCA, still have lots of variables: 9 instead of 16
- Data Envelope Analysis (DEA) to measure how intensely each farmer has adopted sustainable practices relative to the best of his peer group
- Define a “Frontier of Sustainability” for the PC’s – the best anyone has done, the most intense practice adoption
- Distance from the frontier measures how much less sustainable a set of practices is relative to this frontier
- Distance from origin gives a numerical measure of sustainability that ranks each farmer relative to peers

Frontiers of Sustainability



- Farmer practice adoption gives PC_1 and PC_2
- Plot these points: Each farmer is a point
- DEA Frontier: outer envelope of points
- Radial distance from origin to point measures how intensely farmer practice adoption is relative to frontier

PC4 vs. PC3 (but have a 9 dimensional frontier)



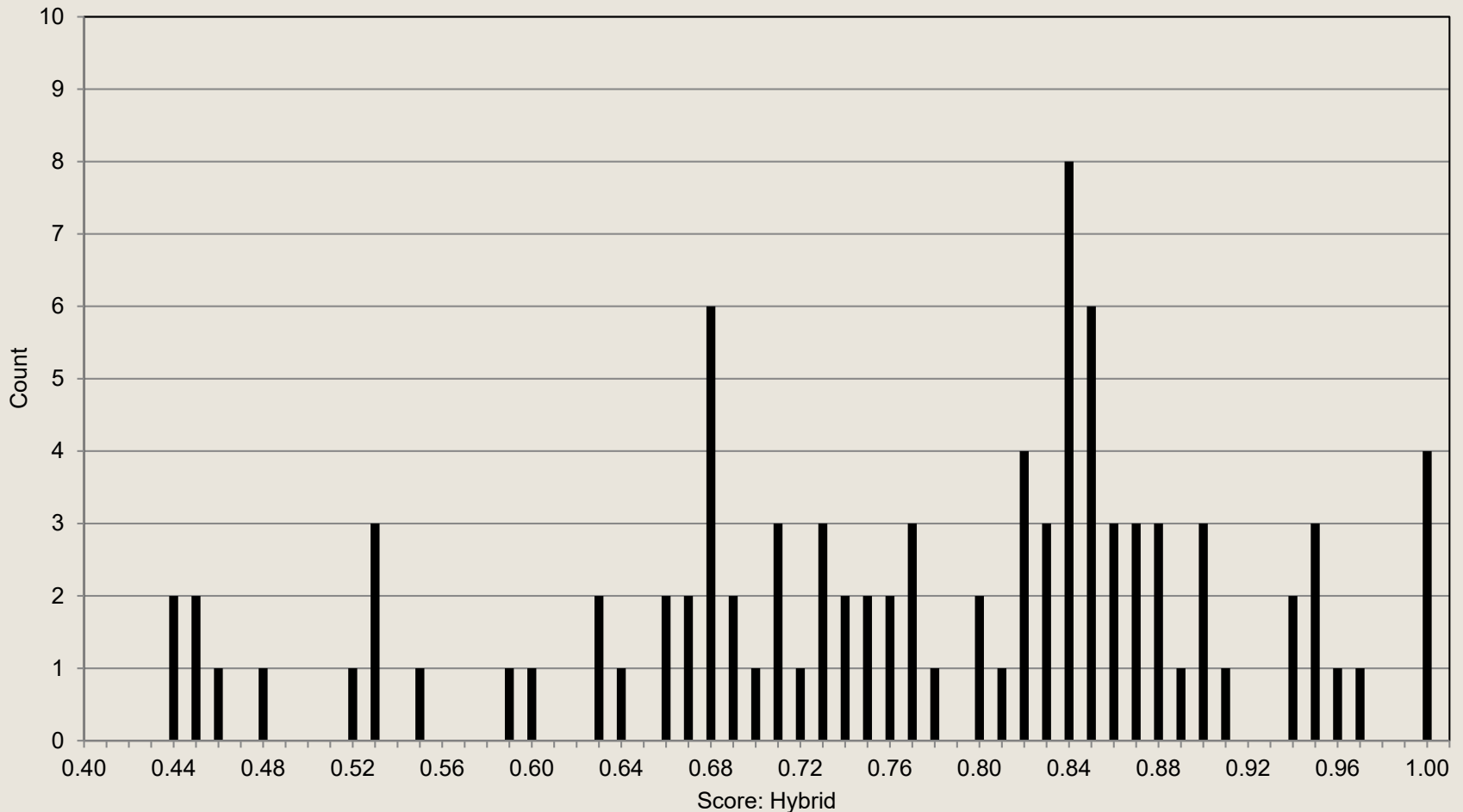
DEA Technical Summary

- Technically use “Common-Weight DEA” so each PC has same weight for calculating distance from frontier (score)
- Different algorithms proposed to find the optimal frontier
 - We developed a new hybrid algorithm

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Weight	0.042	0.021	0.019	0.072	0.008	0.093	0.006	0.030	0.000

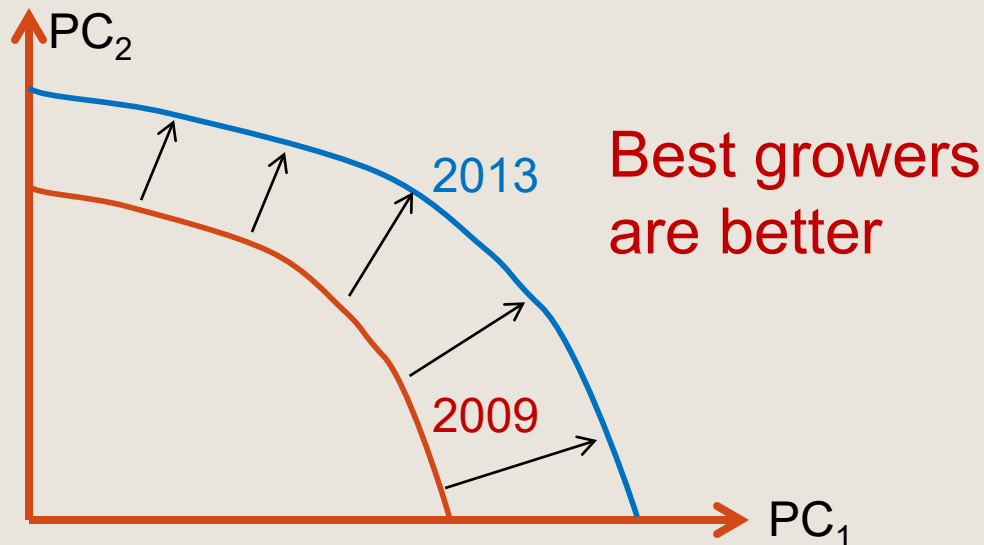
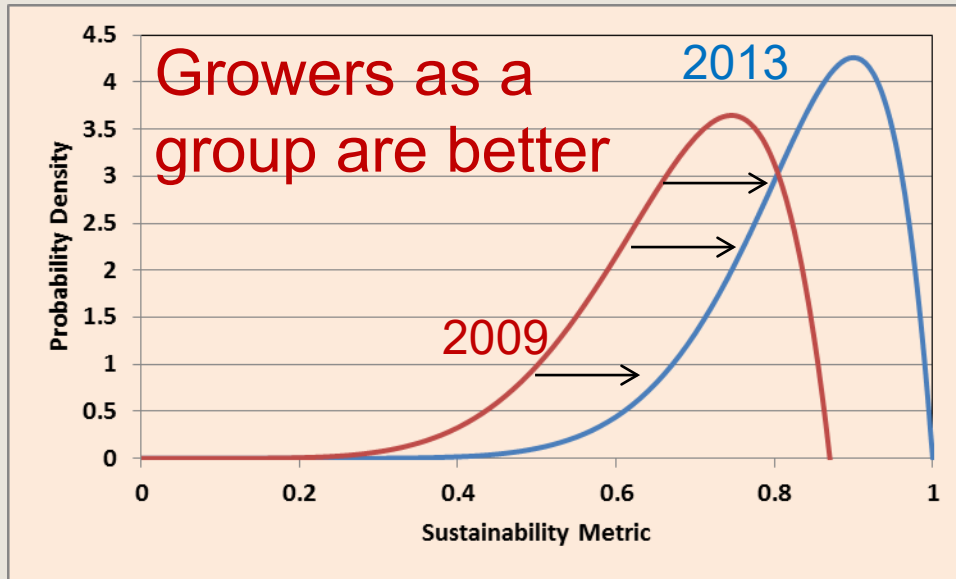
- PC6: Distance, Health Insurance. PC4: Irrigation Uniformity
- Final Output: Sustainability Score = $\sum \omega_i PC_i$
- Can use PCA weights and DEA weights to identify practices for each grower to adopt to most improve score

Dong, Mitchell, and Colquhoun (2012)



Min	Mean	St. Dev.
0.432	0.762	0.140

Sustainability Comparisons



- Recollect data and analyze to measure improvement over time by shift in sustainability score distribution and shift in the sustainability frontier
- Documents that more growers are adopting more of the sustainable practices

Update on Current Projects

- 1) Cranberry 2009 Survey: Completed, paper in review: <http://www.aae.wisc.edu/pubs/sps/pdf/stpap568.pdf>
- 2) Weed Resistance Management BMP Adoption by US corn, soybean and cotton farmers
 - Analysis completed, writing up results
- 3) National Soybean Sustainability Initiative (NSSI)
 - Data collected ~300 growers, mostly WI and IL
 - Improving algorithm to speed processing
 - Conducting analysis for Commodity Classic (Mar 1st)
- 4) Processing Sweet Corn and Green Beans
 - Collecting self assessments now in WI, IL, MN

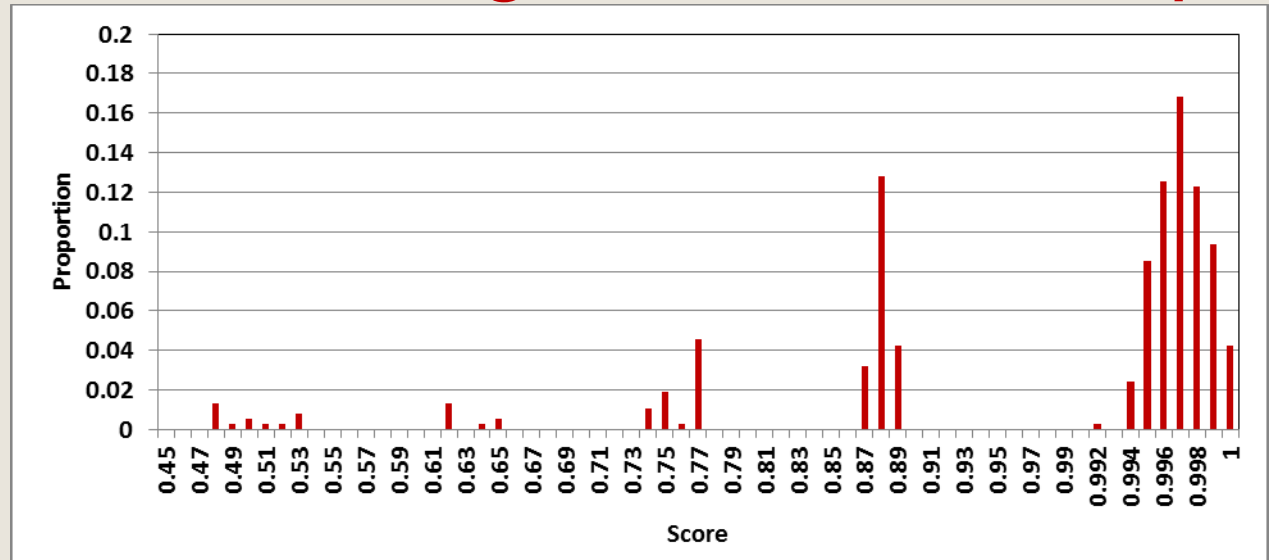
Weed Resistance Management BMP Adoption

Corn Score

Min 0.473

Avg 0.928

StDev 0.120

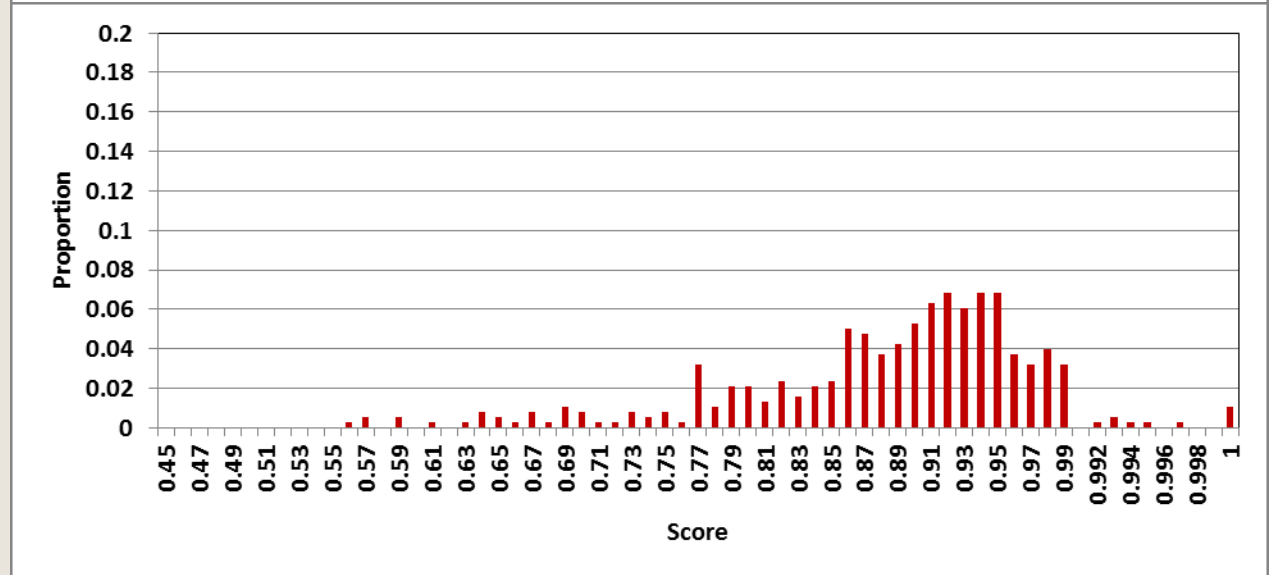


Soyb Score

Min 0.551

Avg 0.876

StDev 0.088

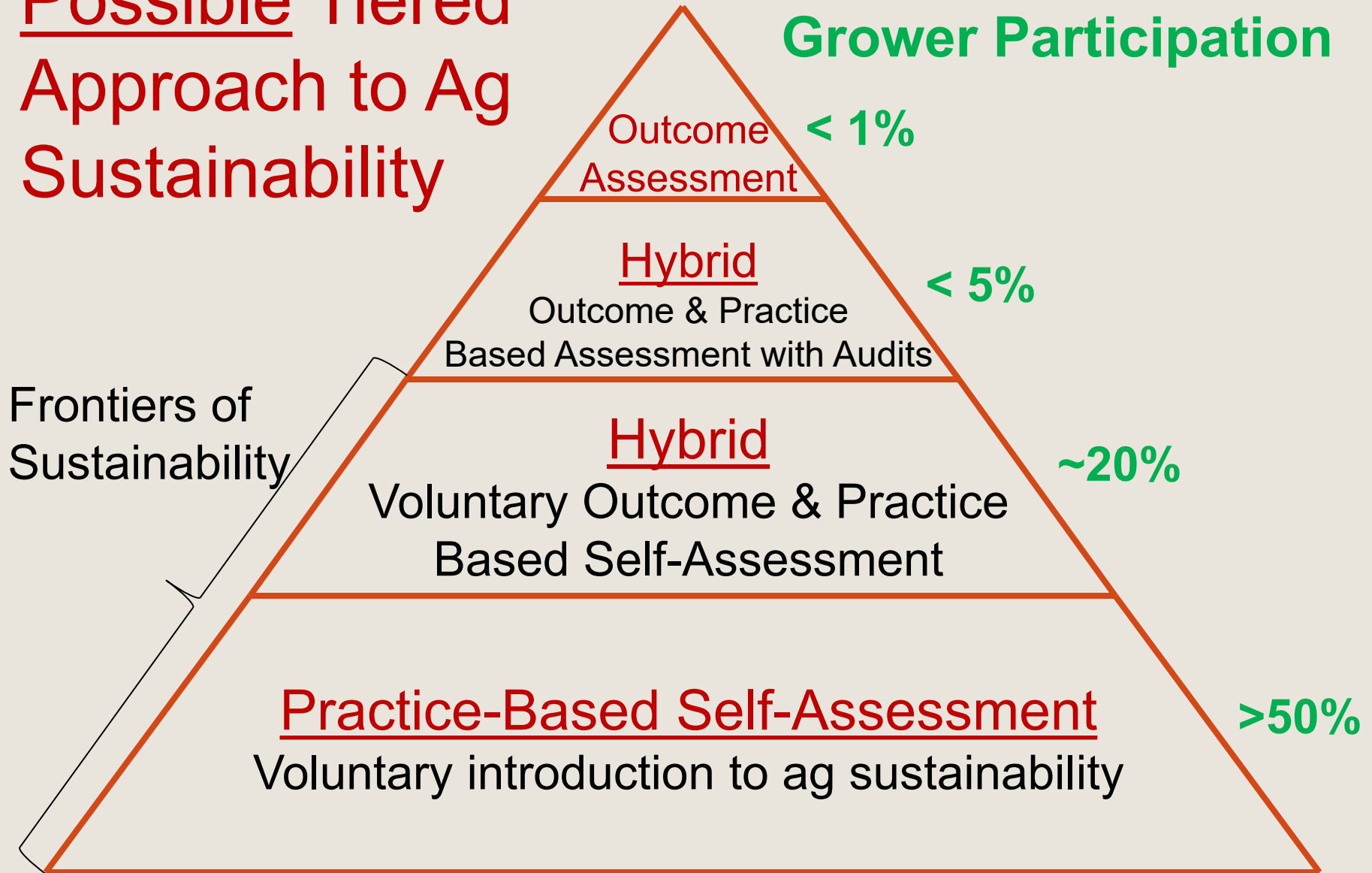


Processing Sweet Corn and Green Beans

- USDA grant (Specialty Crop Research Initiative: SCRI) started September 2013
- Developed Sustainability Self-Assessments for Midwestern sweet corn and green beans
- Working with processors, growers have been completing self-assessments in WI, plus MN and IL (**Thank You!!!!**)
- Data still at MWFPA office waiting to accumulate enough surveys to maintain anonymity
- Will be analyzed this summer/fall
- Expand program for Green Beans in New York and Sweet Corn in Washington/Oregon next year

Possible Tiered Approach to Ag Sustainability

Grower Participation



Summary

- UW CALS providing national leadership on Ag Sustainability in Research, Education and Outreach
- Practice-based approach to ag sustainability as a practical approach that more appropriate to agriculture and more broadly acceptable to growers
- Frontiers of Sustainability: New method for measuring BMP adoption intensity
 - Cranberry: initial work completed
 - Weed resistance management BMPs: almost completed
 - Soybeans in progress: further method refinement
 - Sweet corn & green beans: data collection in progress
- **Developing a model program for multiple crops & regions**

Thanks for Your Attention!

Questions?

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