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Agricultural Land Management and Downstream Water Quality: Insights from Lake Erie

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2017 Crop Advantage Series, Okoboji, IA, Jan 5th, 2017

Support provided by grants from the Ohio Sea Grant Program and the National Science Foundation Coupled Human and Natural Systems Program (GRT00022685)

Sea Grant
Ohio Sea Grant College Program

The new Mike Duffy

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A Quick Introduction: Dr. Wendong Zhang

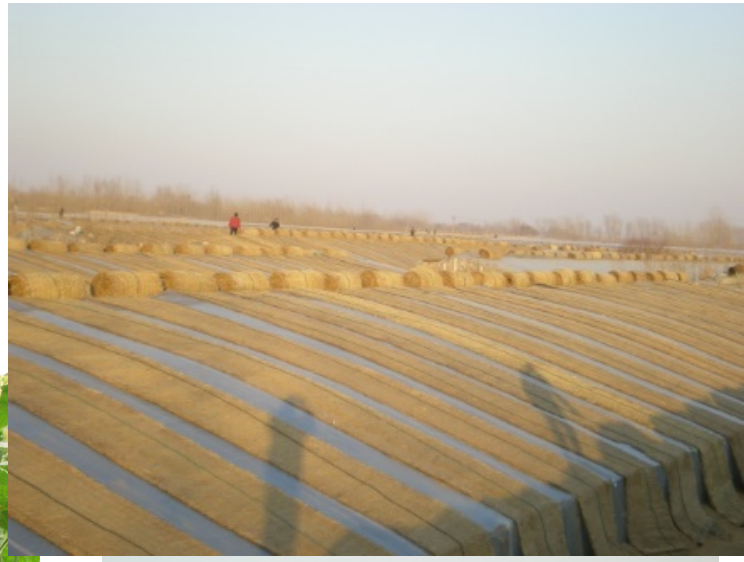
- Grown up in a rural county in NE China
- Attended college in Shanghai and Hong Kong
- Ph.D. in Ag Econ in 2015 from Ohio State
- 2012 summer intern at USDA-ERS on farm economy and farmland values
- Research and extension interests: land value, land ownership, agriculture and the environment, China Ag
- Leads ISU's Iowa Land Value Survey as well as the Iowa Farmland Ownership and Tenure Survey
- **Iowa Farmland Value Portal**
  http://card.iastate.edu/farmland/

China's Provinces

My Hometown: Shenxian, Shandong Province

Intensification of Land-Use in China

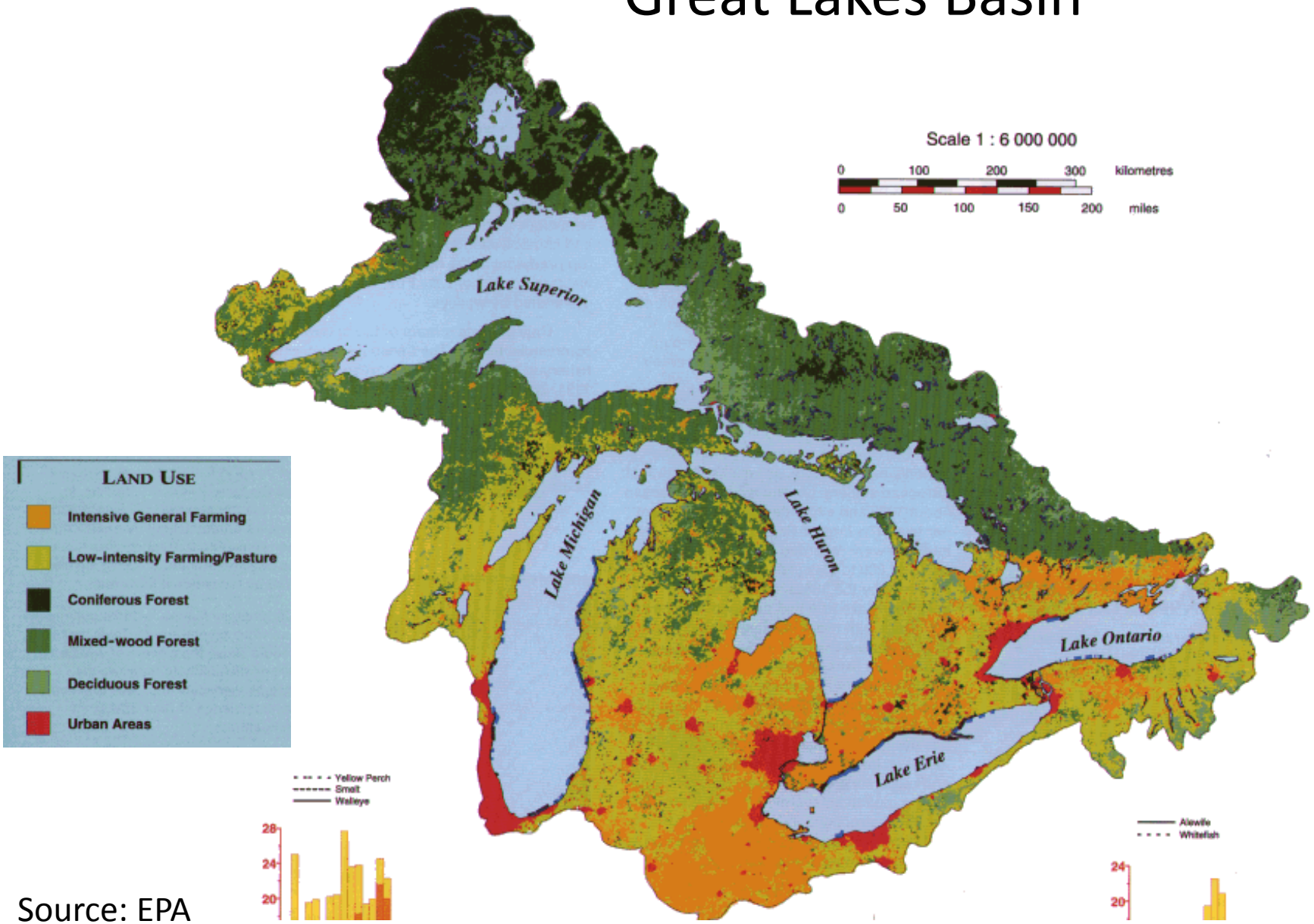
Greenhouse – plastic film - Shandong Province



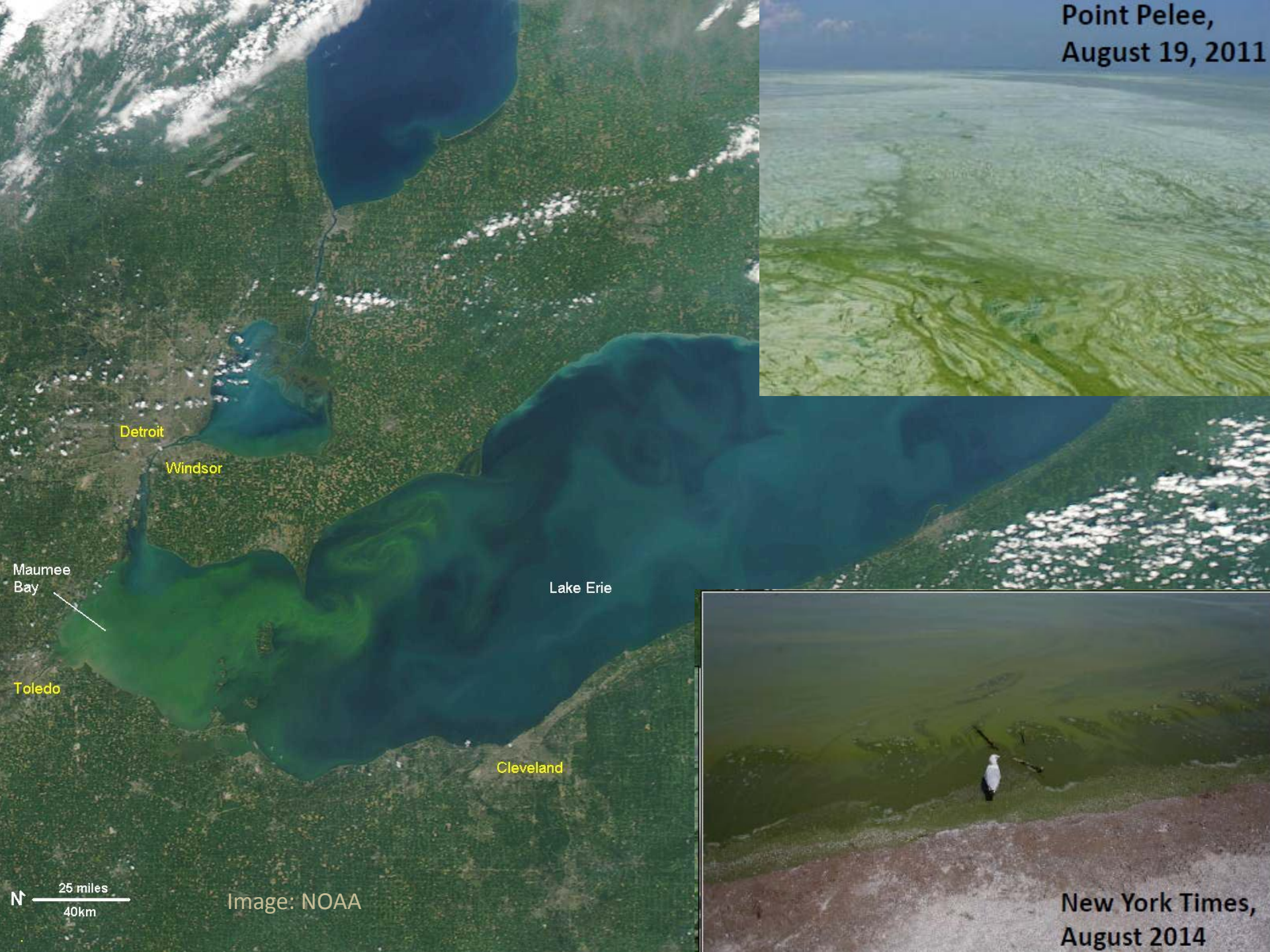
Harmful Algal Blooms are Prevalent in China Too!

Source: New York Daily News; Tsingtao, Shandong Province, China

Great Lakes Basin



Source: EPA


Point Pelee,
August 19, 2011
Detroit
Windsor
Maumee
Bay
Lake Erie
Toledo
Cleveland
25 miles
40km
Image: NOAA
New York Times,
August 2014

Lake Erie Ecosystem Services

- Drinking water for 11 million people
- Power production is greatest water use (over 20 power plants)
- 300 marinas in Ohio alone
- Walleye Capital of the World
- 40% of all Great Lakes charter boats
- Ohio's charter boat industry is one of the largest in North America
- $1.5 billion sport fishery
- One of top 10 sport fishing locations in the world
- Most valuable freshwater commercial fishery in the world
- Coastal county tourism value is $11.6 billion & 117,000 jobs

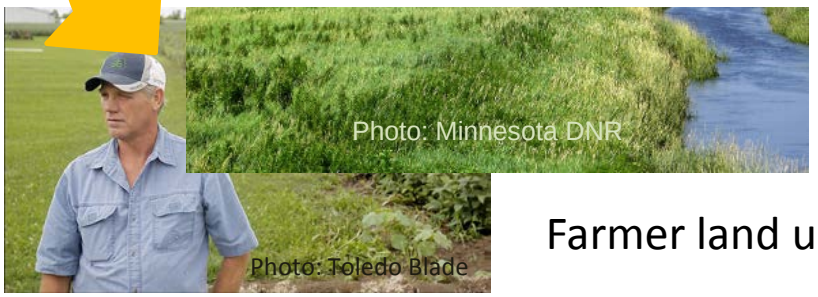
Toledo Water Crisis (Aug. 2-4, 2014)

Maumee watershed region

- **Corn**: 4816 farms, 0.79 million acres harvested, 92 million bushel production, $560 million sales
- **Soybean**: 5744 farms, 1.13 million acres harvested, 54 million bushel production, $659 million sales
- **Wheat**: 2625 farms, 0.18 million acres harvested, 12 million bushel production, $79 million sales
- **Livestock**: 1840 farms with $424 million sales in total

-- From the 2012 value of agricultural production in the Lake Erie region NW Ohio crop reporting district

A Complex, Coupled Human-Natural System



Lake & land management policies

Lake Erie ecosystem services

Concentration of toxic algae in Lake Erie

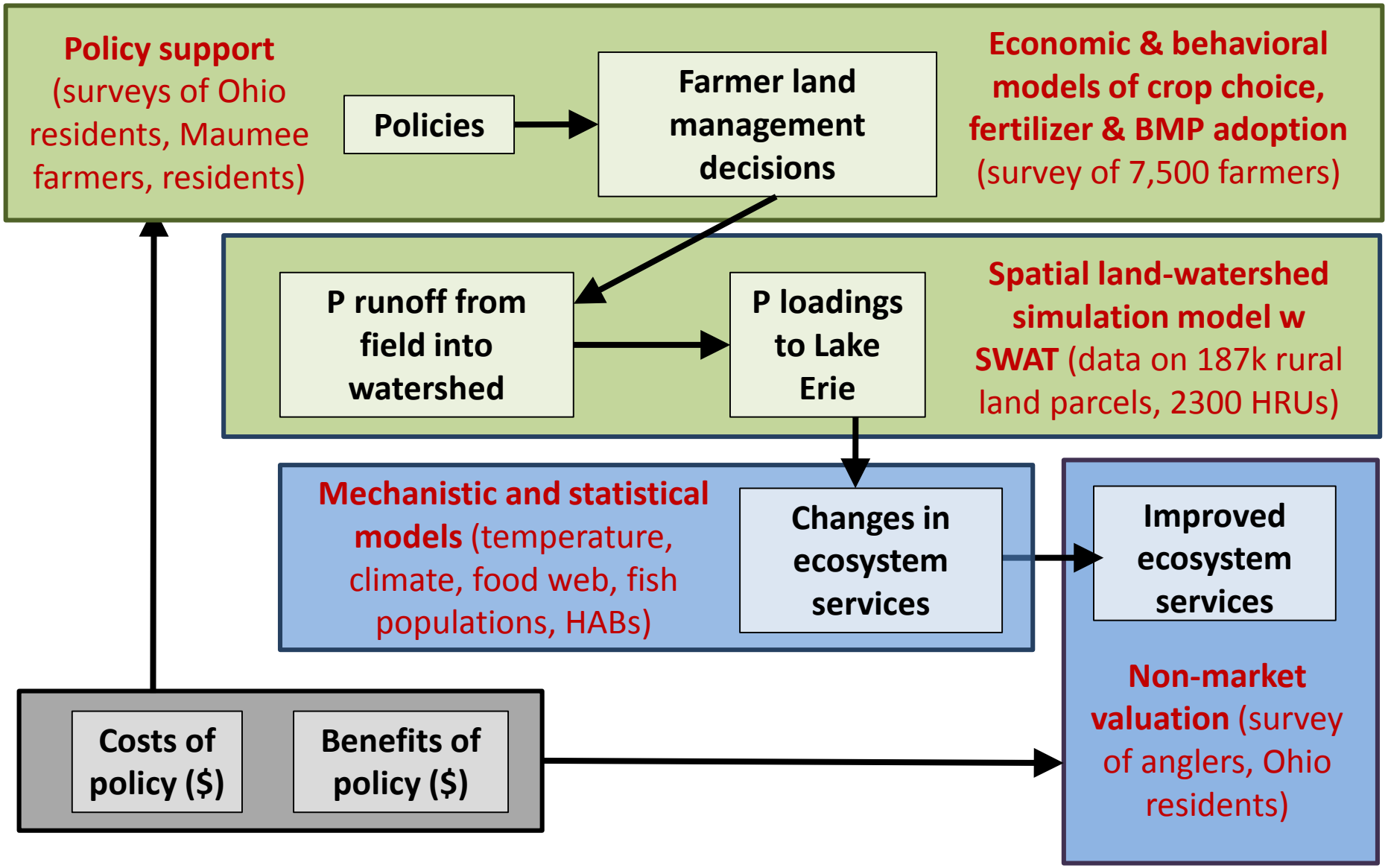
Phosphorus loadings from watershed to Lake Erie

Landscape change: Cumulative land use and runoff from all fields

Fertilizer runoff from field to waterway

Farmer land use & management decisions

Data and integrated modeling needs



Lake Erie coupled human-natural systems research project

Jay Martin, Ohio State (PI)	
Noel Aloysius, Ohio State	Elena Irwin, Ohio State
Elizabeth Burnett, Ohio State	Stuart Ludsin, Ohio State
Na Chen, Ohio State	Erik Nisbit, Ohio State
Carlo DeMarchi, Case Western R. U	Brian Roe, Ohio State
Marie Gildow, AEP	Eric Toman, Ohio State
Alexander Heeren, Ohio State	Robyn Wilson, Ohio State
Greg Howard, East Carolina U	Wendong Zhang, Iowa St

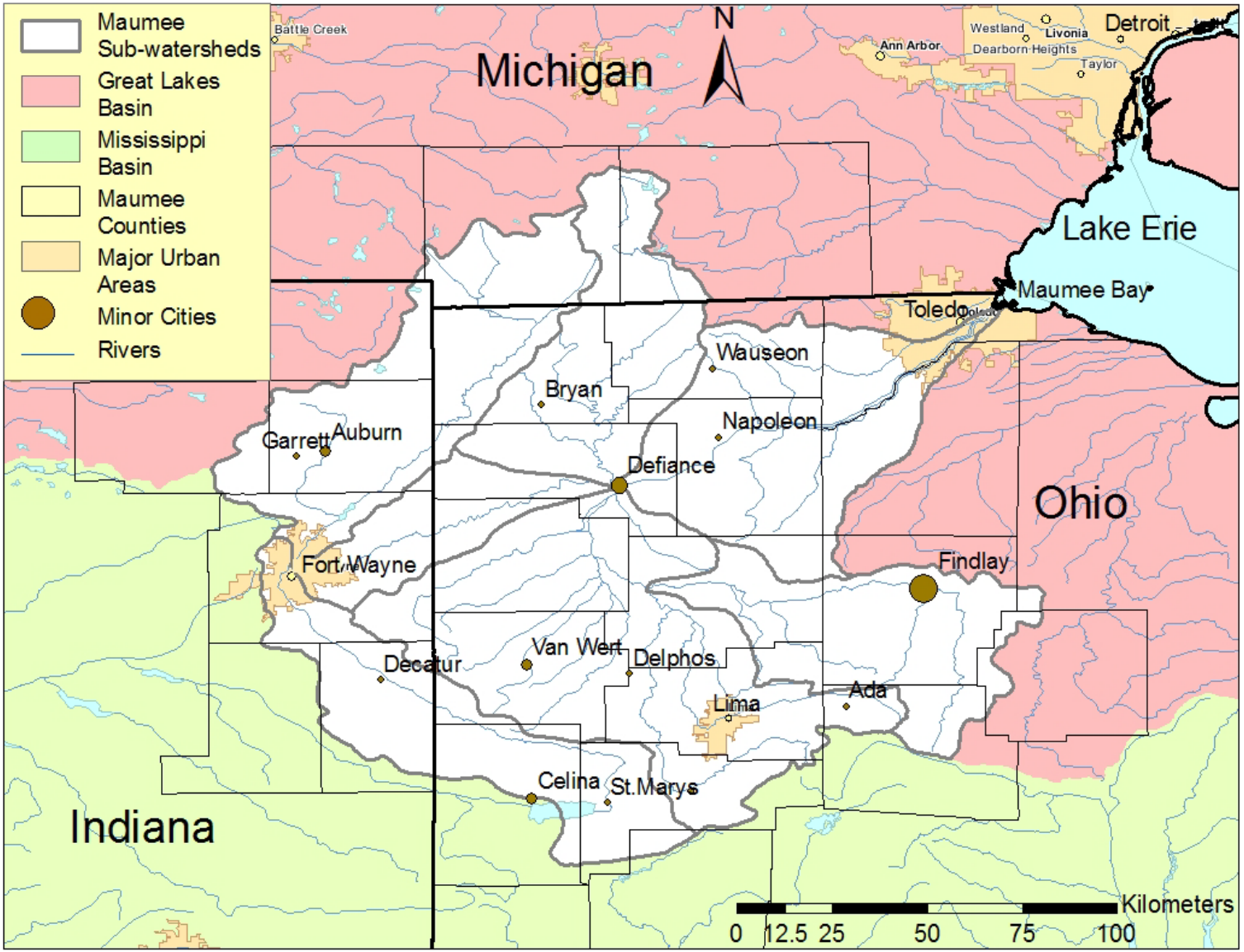
Funding from NSF Coupled Human and Natural Systems Program (GRT00022685) and the Ohio Sea Grant Program

Sea Grant
Ohio Sea Grant College Program

Project Website: http://ohioseagrant.osu.edu/maumeebay

Maumee Watershed

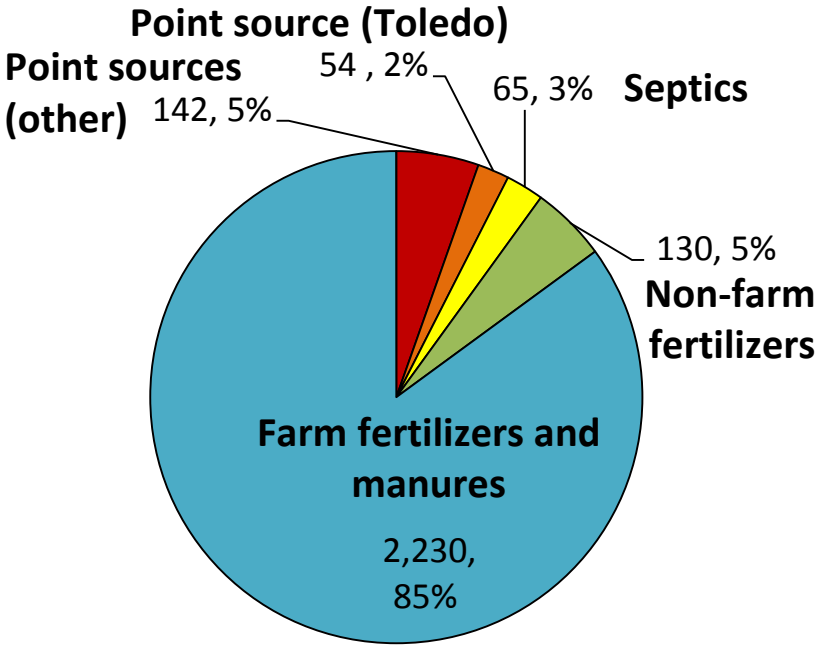
Largest in Great Lakes~17,000km^2, 85% agriculture



Why Focus on Agricultural Sources?

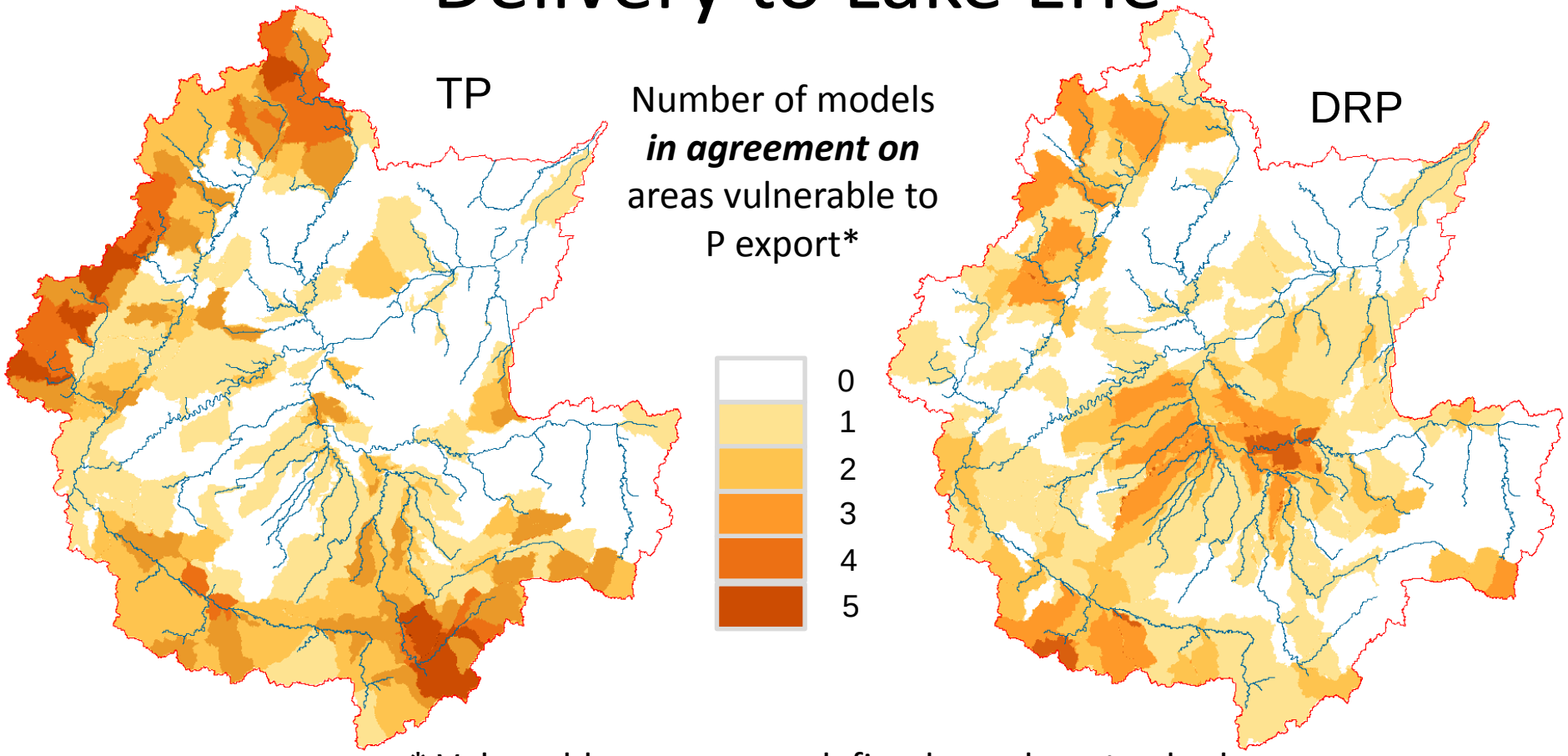
We estimated 85% of P delivered by the Maumee comes from agriculture.

Estimated P **Delivery** from the Maumee River to Lake Erie (*t/y*)



Delivery of Farm Fertilizers & Manures =
Average Load to Lake Erie (2620 t/y) –
Toledo WWTP (54 t/y) –
Other Point Sources (142 t/y) –
Non-farm Fertilizers (130 t/y) –
0.39 * Septics (65 t/y)
= ~ 2230 t/y

Combined Estimate of Potential P Delivery to Lake Erie



* Vulnerable areas were defined as sub-watersheds contributing the 20% highest area-weighted P load. These areas are more vulnerable to P losses if untreated by conservation practices.

Our Farmers

- 98% Male
- Average age of 58 (range 18 to 96)
- 50% HS diploma, 48% at least some college
- 67% 3rd generation, 22% 2nd, 10% 1st
- Average acres: 211 corn/236 soybeans

- *Our sample may over-represent older, more experienced farmers with income over $50K*
- *But they have larger environmental impact*

What do farmers think?*

- 77% think they have a good understanding of the 4Rs of nutrient stewardship
- 82% agree that they think about nutrient stewardship as it relates to water quality and profitability
- 50% have already participated in the private fertilizer applicator certification training
- 56% have changed 4R related practices on their farm in the past three years
- 54% are concerned about their farms contributing to HABs in Lake Erie
  - 77% are concerned about the negative impact of nutrient loss to their farm's profitability

*Based on the valid percentage, or those that responded to the question, 2016 survey

What are farmers doing?*

	2011	2014	2017	Potential Future*	The Need**
Cover crops	8%	17%	22%	60%	58%
Avoiding winter application	25%	49%	56%	85%	--
Avoiding fall application	25%	30%	--	--	--
Delaying broadcasting	--	36%	39%	86%	--
Fertilizer placement	--	33%	39%	68%	50%
Rates based on testing	46%	52%	63%	92%	--

*2017 self-reported behavior + those reporting likely adoption

**Based on multi-modeling scenarios to achieve a 40% reduction in total P, assuming 78% adoption of filter strips

Predictors of BMP Adoption

Recommended BMPs are more likely to be adopted among farmers with greater education, farm income, and acreage

These farmers perceive greater control over nutrient loss, are more willing to take risks, have a greater belief in the efficacy of recommended BMPs, perceive greater responsibility over water quality, and have a greater conservationist identity

Spatial landscape model to simulate nutrient loadings from watershed to Lake Erie using Soil and Water Assessment Tool (SWAT) Model

Noel Aloysius[1,3], Marie Gildow[1,2], Jay Martin[1] and Stuart Ludsin[3]

[1]Department of Food, Agricultural and Biological Engineering
[2]presently at American Electric Power
[3]Department of Evolution, Ecology and Organismal Biology

Management practices

Management practice	Abbreviation
Fertilizer placement/Injection into ground	Place
50% P application reduction	50% P
Spring application	Spr. App
Fall application	Fall App
Cover crop (cereal rye)	Cover
Continuous no-till	No-till
Continuous corn	Corn
Winter wheat rotation	Wheat
Vegetative filter strips	Filter


Vegetated filter strip


Winter cover crop

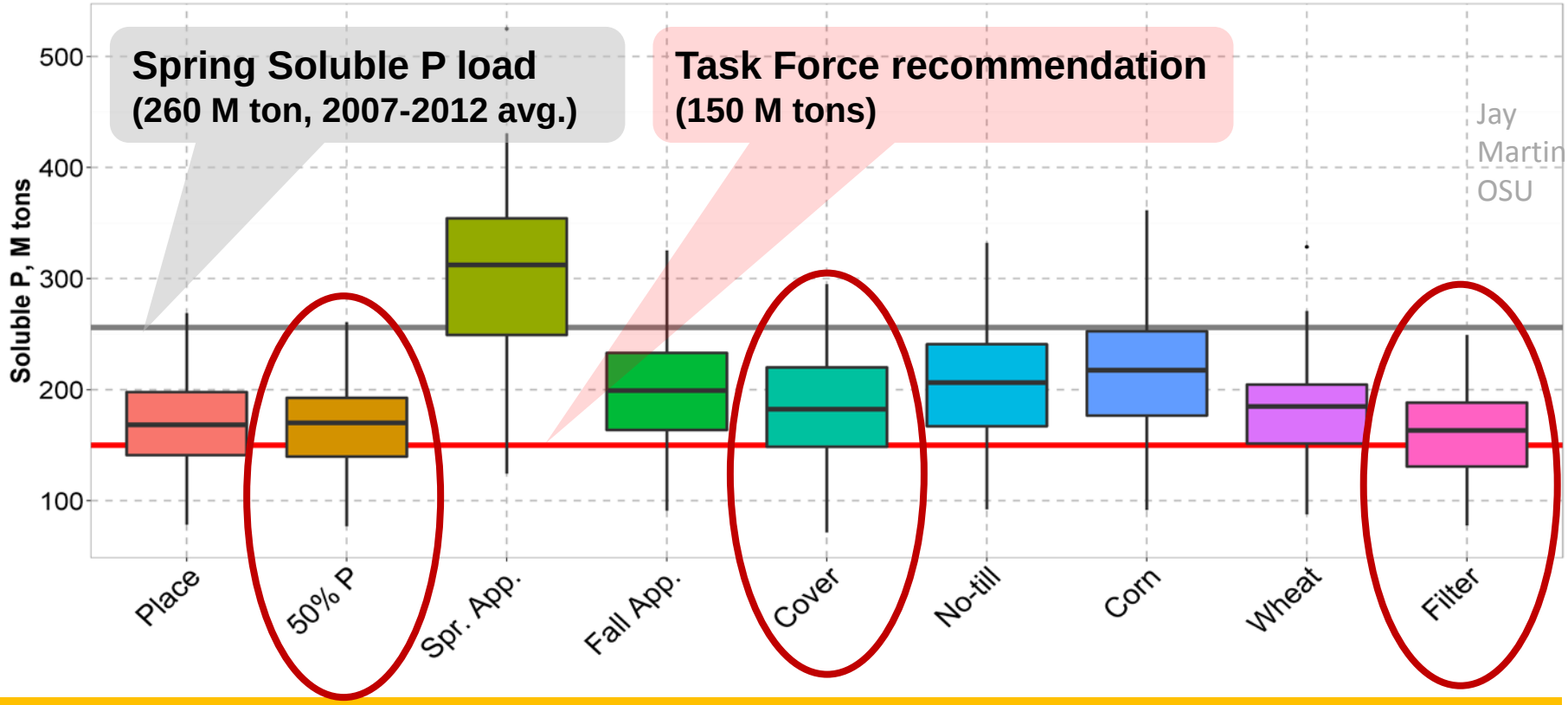
Nutrient management


Conservation tillage

Jay Martin

OSU

Changes in spring soluble P loadings
(M tons, 2005-2014)



50% reduction in application of P could potentially achieve target – but how can we achieve this and at what cost? Farmer model shows that the tax needed to achieve this may be too high; multiple policies are needed

Bundled Scenarios

Jay Martin OSU

No.	Name	Description
1	**No Point Source Discharges**	All PS discharges were removed (i.e., set to zero).
2a-c	**Cropland conversion to grassland** at 10% (5a), 25% (5b), and 50% (5c) targeted adoption	In these three scenarios designed to test how much land would need to be removed from production if farms adopted no additional conservation practices, 10%, 25%, and 50% of the row croplands with the lowest crop yields and greatest TP losses were converted to switchgrass and managed for wildlife habitat with limited harvesting for forage and no P fertilization.
3	**In-field practices** at 25% random adoption	The following practices were applied together on a random 25% of row cropland: 50% reduction in P fertilizer application, fall timing of P applications, subsurface placement of P fertilizers, and a cereal rye cover crop.
4	**Nutrient management** at 25% random adoption	The following practices were applied to a randomly selected 25% of row crop acreage: a 50% reduction in P fertilizer application, fall timing of P applications, and subsurface placement of P into the soil.
5	**Nutrient management** at 100% adoption	The following practices were applied to 100% of row crop fields: a 50% reduction in P fertilizer application, fall timing of P applications, and subsurface placement of P into the soil.
6	**Commonly recommended practices** at 100% random adoption	The following 4 practices were each applied to separate 25% of the crop acres: a 50% reduction in P fertilizer application, subsurface application of P fertilizers, continuous no-tillage, and medium-quality buffer strips.
7	**Continuous no-tillage and subsurface placement of P fertilizer** at 50% random adoption	A combination of continuous no-tillage and subsurface application of P fertilizers were applied together on a randomly selected 50% of row crop acres.
8	**Series of practices** at 50% targeted adoption	The following practices were targeted to the 50% of row cropland with the highest TP loss in the watershed: subsurface application of P fertilizers, cereal rye cover crop in the winters without wheat, and application of medium-quality buffer strips.
9	**Series of practices** at 50% random adoption	The following practices were applied to a random 50% of row cropland: subsurface application of P fertilizers, cereal rye cover crop in the winters without wheat, and application of medium-quality buffer strips.
10	**Diversified rotation** at 50% random adoption	An alternative corn-soybean-wheat rotation with a cereal rye cover crop all winters without wheat was applied over a randomly chosen 50% of row cropland.
11	**Wetlands and buffer strips** at 25% targeted adoption	Wetlands treating half of overland flow in a sub-watershed were targeted to 25% of sub-watersheds with the greatest TP loading rates and medium-quality buffer strips were targeted to 25% of row cropland with greatest TP loss rates.

Most Effective Scenarios

	No.	Name	Description
DRP	5	**Nutrient management on 100% cropland**	50% reduction in P application, with fall **subsurface application**
Both	8	**Series of targeted practices at 50% adoption**	**50% Subsurface application, additional 50%** of cereal rye cover crop in the winters and medium-quality buffers on **high P-loss cropland.**
TP	9	**Series of random practices at 50% adoption**	**Subsurface application**, cereal rye cover crop in the winters without wheat, medium-quality buffers **applied together on random 50% of cropland**.
TP	11	**Targeted wetlands and buffers on 50% of cropland**	Wetlands and buffers on 25% **of highest P-loss cropland** (intercepting half of overland and tile flow

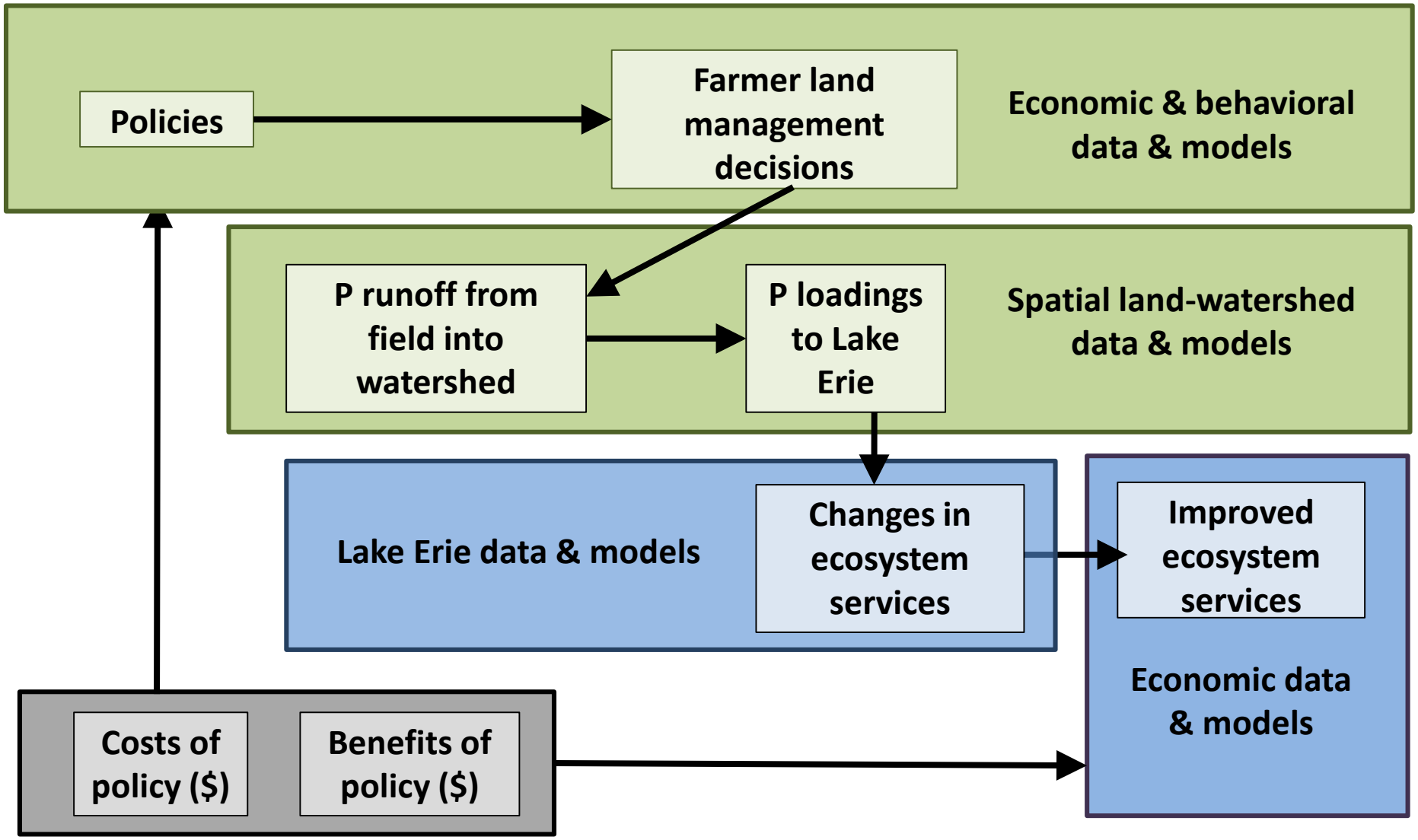
Jay Martin OSU

Management Plan Adoption and Future Needs

	% Cropped Acres			
Survey Year	NRCS 2006	NRCS 2012	Wilson et al. 2012	Wilson et al. 2014
Region	WLEB	WLEB	Maumee	Maumee
Practice				
Cover crops	**2**	**6**	**8**	**16**
P placement	**-**	**-**	**26**	**25**
Buffer Strips	**18**	**31**	**35**	**-**

*Continued and **Accelerated** Adoption Needed*

Benefit-cost analysis of various nutrient management **policies** using integrated ecological-economic modeling



Ohio Residents' Perceptions of various policy options (2014)

Place a fee on residential and business water usage bills to fund additional regulatory oversight of farmers' fertilizer use and manure disposal	2.41
Create a special state property levy on farmland to fund additional regulatory oversight of farmers' fertilizer use and manure disposal	3.11
Charge a recreational fee for use (e.g., swimming, boating, fishing, hunting, camping, etc.) of state parks, beaches, and lakes to fund additional regulatory oversight of farmers' fertilizer use and manure disposal	2.85
Create a special sales tax on agricultural fertilizer as a means to reduce fertilizer use and increase regulatory oversight of farmers' fertilizer use and manure disposal	3.58
Require farmers and agribusinesses to create comprehensive management plans to reduce agricultural runoff and water pollution in conjunction with additional regulatory oversight (e.g., fines if they do not comply)	4.66

Regulatory policies

Ohio Residents' Perceptions of various policy options (2014)

Place a fee on residential and business water usage bills to fund new voluntary financial incentives for farmers to reduce fertilizer, manure, and nutrient runoff	2.55
Create a special state property levy on farmland to fund new voluntary financial incentives for farmers to reduce fertilizer, manure, and nutrient runoff	3.85
Encourage farmers and agribusinesses to voluntarily create comprehensive management plans to reduce agricultural runoff and water pollution without any additional government oversight	5.33

Q. Now considering all the options for addressing agricultural runoff, overall, please tell me which of the following statements about proposed policies to address agricultural runoff best reflects your opinion.

	% SELECT STATEMENT					
STATEMENT	Statewide (N=800)	Northwest (N=102)	Northeast (N=302)	Central (N=135)	Southwest (N=191)	Southeast (N=54)
A mix of voluntary actions, financial incentives, and additional government regulations are the best means to reduce agricultural runoff into streams, rivers, and lakes.	**43**	**39**	**55**	**51**	**48**	**46**

Voluntary policies

Ohio Senate Bill 1 – effective July 2015

https://ofbf.org/2015/04/23/what-you-need-to-know-about-ohios-new-nutrient-law/

Where is it in effect?

The **24 Ohio counties** or parts of those counties that make up the Western Lake Erie Basin.

How does the law define fertilizer?

Phosphorus and nitrogen.

When can't fertilizer or manure be applied?

•On frozen or snow-covered soil,

•When the two top inches of soil are saturated with precipitation or

•If the local weather forecast calls for a greater than 50 percent chance of precipitation exceeding one inch in a 12-hour period for fertilizer and one-half inch in a 24-hour period for manure.

Are there any exceptions on the restriction of fertilizer or manure application?

If you can inject fertilizer or manure into the ground, incorporate it within 24 hours or apply it to a growing crop, then you can apply it.

Ohio Senate Bill 1

What's the enforcement process?

It's a complaint-driven process, which means someone will have to contact the Ohio Department of Agriculture (ODA) to report a violation of fertilizer application and ODNR for a violation of manure application. If state officials think the complaint is valid, they can inspect the property and then hold a hearing. Farmers found in violation can be issued a fine and be ordered to comply with the law.

What is the fine?

Up to $10,000 for each violation.

Does this apply to large-scale permitted livestock operations?

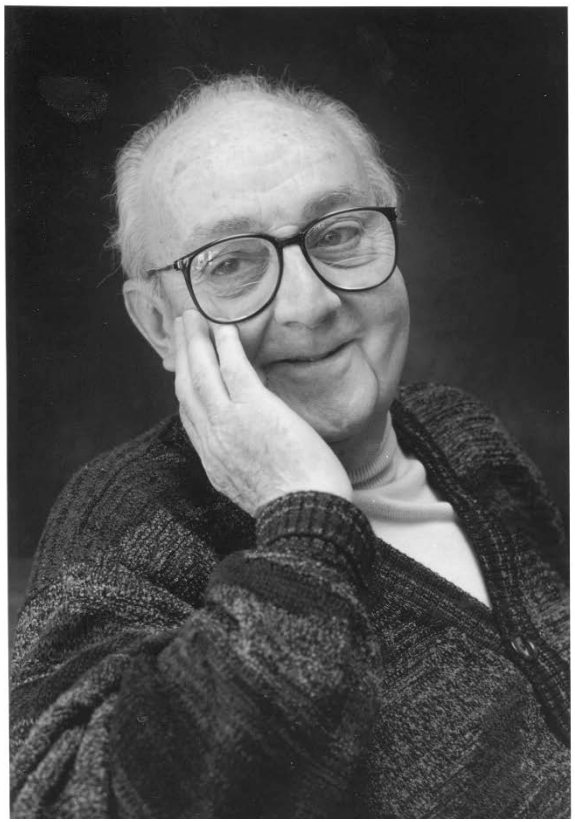
No because they are already regulated under current law.

Is agriculture the only area covered in the bill?

No. Publically owned treatment works will be required to begin monthly monitoring of total and dissolved reactive phosphorus. Open lake dumping of dredging in Lake Erie will be prohibited by 2020. However, dredge material may be dumped into Lake Erie if the director of the Ohio Environmental Protection Agency determines it is suitable and meets the location and purpose.

Conclusion

- Goal is to help stakeholders **understand trade-offs (costs and benefits), which involve multiple interest groups, of different policy options**
- Integrated modeling that links **human changes** (farmer decisions) with **landscape and ecosystem changes** (ecosystem services) is critical for this analysis



“Essentially all models are wrong, but some are useful.” – George Box

Thank You!

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