Targeting conservation practices to maximize farm-level economic viability

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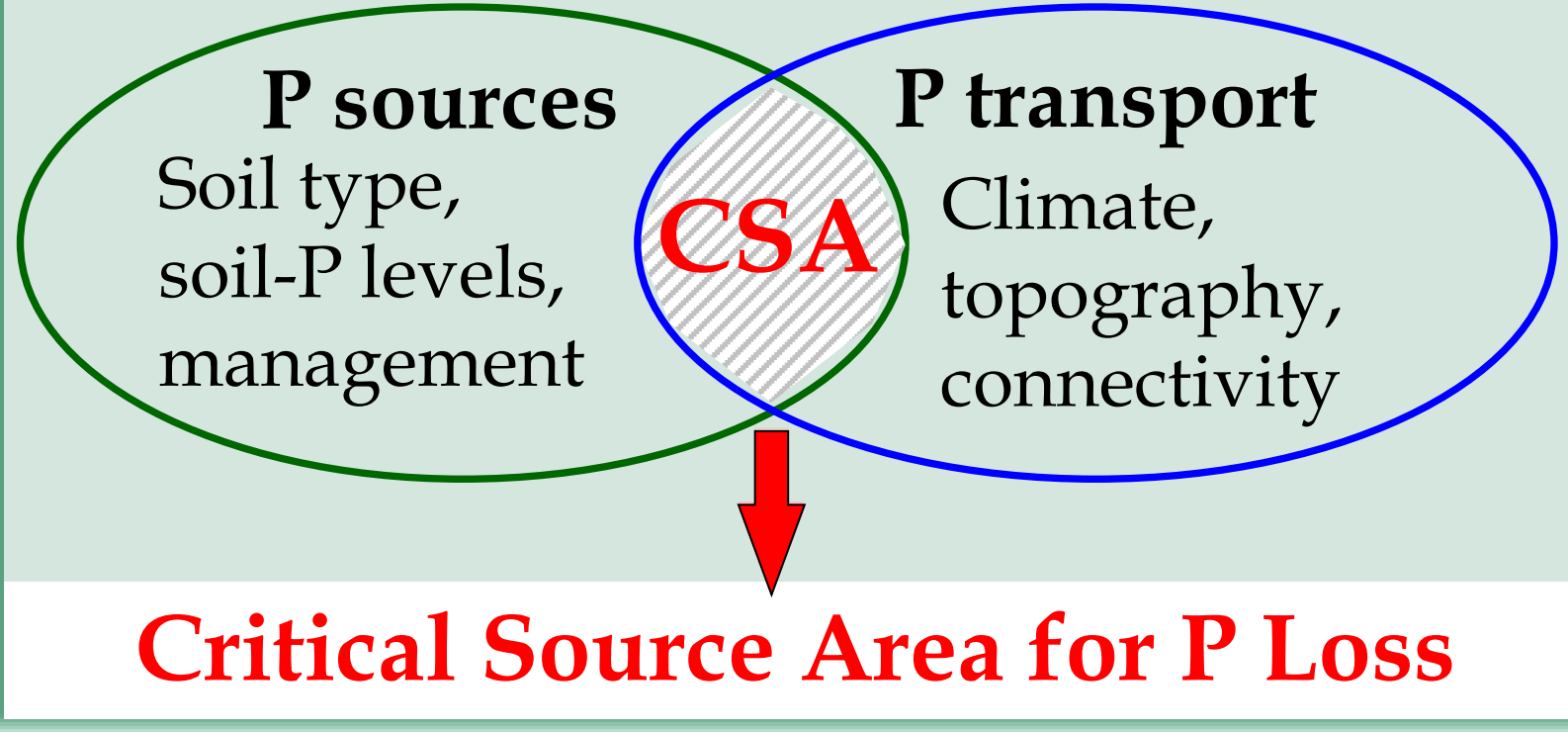
Application Challenges

- Many sources
- Variable contribution
- Limited resources



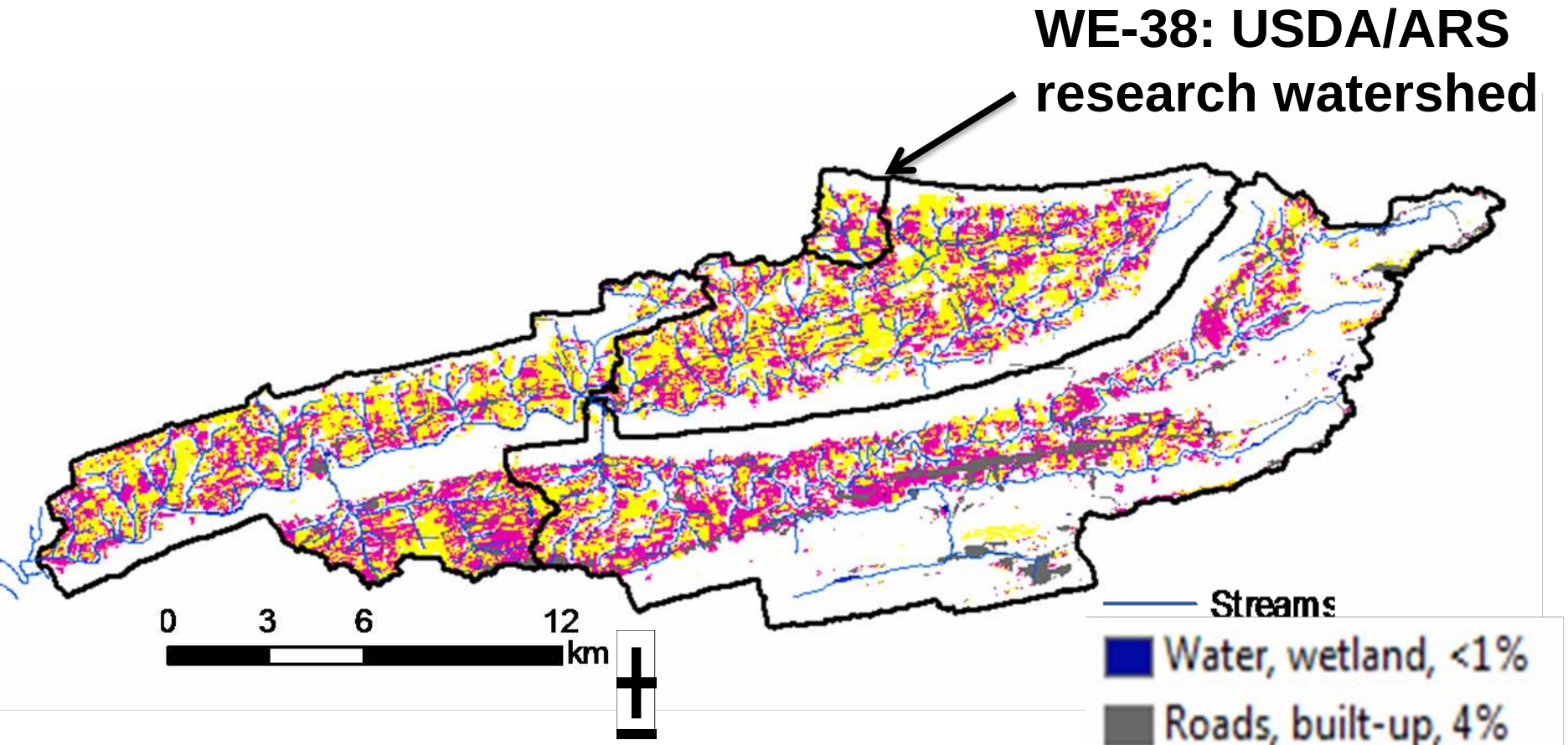
Watershed level needs

- Target NPS pollution
- Assess BMP impact on TMDL goals
- Inform farm-level targeting measures
- Develop plans that watershed farmers (stakeholders) embrace and implement

Components	Tools	Output
Characterize losses	SWAT	Average baseline P & N loads
Estimate effectiveness	BMP tool/database	Site-specific estimates
Determine costs	Annualization	Yearly BMP costs
Optimize what & where	Genetic algorithm	Multiple scenarios

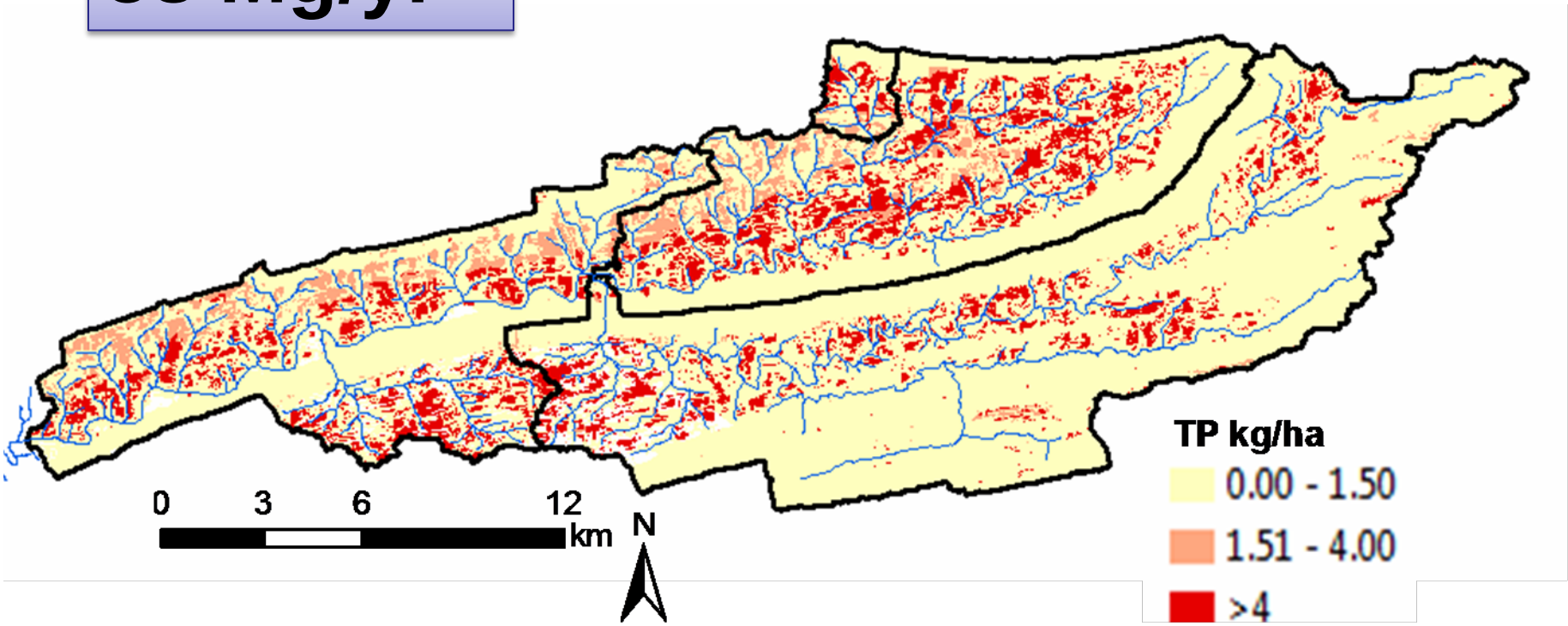
Calculate cost effectiveness ($ spent / kg P (or N) removed / year)

Mahantango Creek Watershed



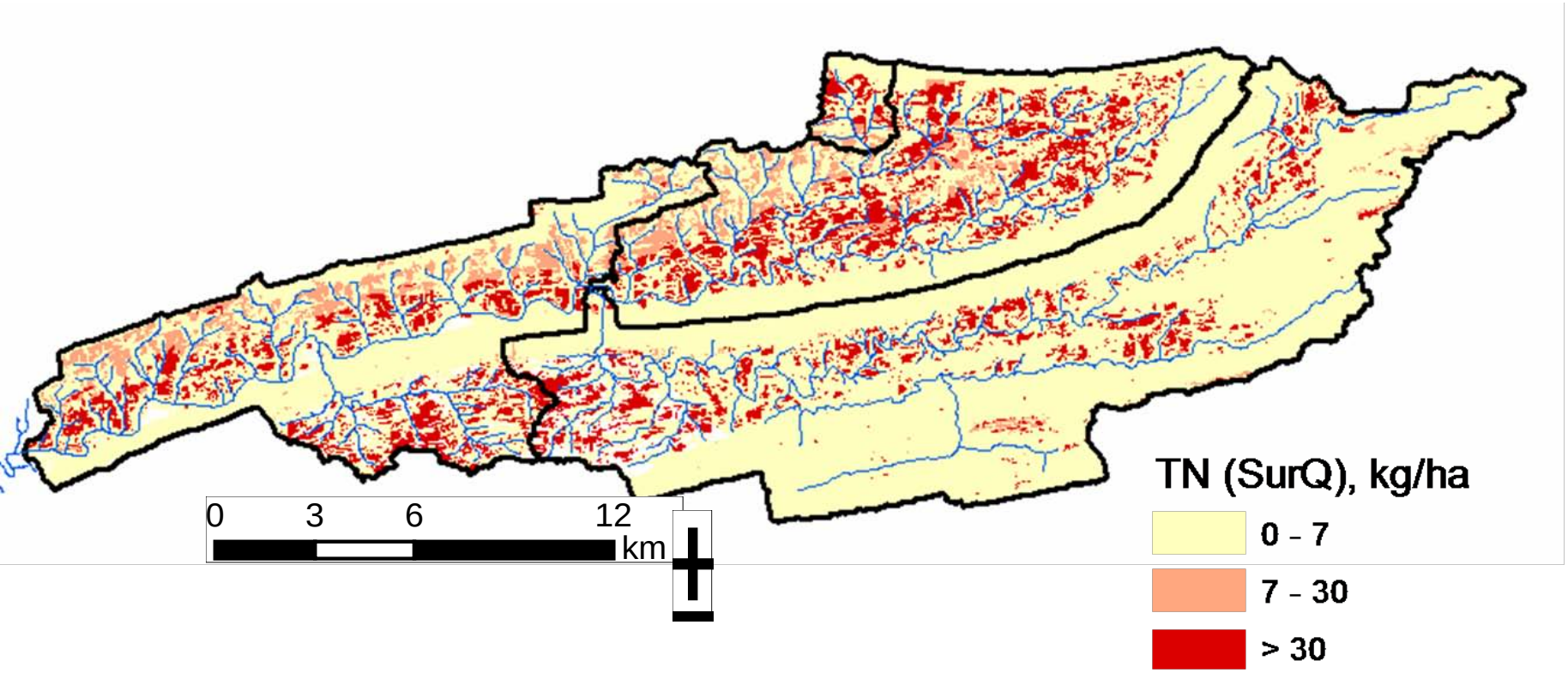
SWAT baseline - TP

58 Mg/yr



SWAT baseline - TN

1016 Mg/yr (surface + ground water)
485 Mg/yr (surface water only)



BMPs considered…

Cropland

- Conservation tillage (CT)
- Contour strip crop (CSC)
- Nutrient management (NMP)
- Riparian forest buffer within 30 m of stream (RFB)
- CT + CSC
- CT + NMP
- CSC + NMP
- CT + CSC + NMP

Pasture

- CSC
- NMP
- RFB
- CSC + NMP

BMP input data…

Target reduction set at 30%

- 41 Mg/yr TP loss
- 340 Mg/yr surface TN loss

Efficiencies	TP	TN	Cost
	% reduction		$/ha
Conservation tillage	60	57	47
Contour strip crop	43	37	24
Nutrient management	51	10	27
Riparian forest buffer	40	47	1300

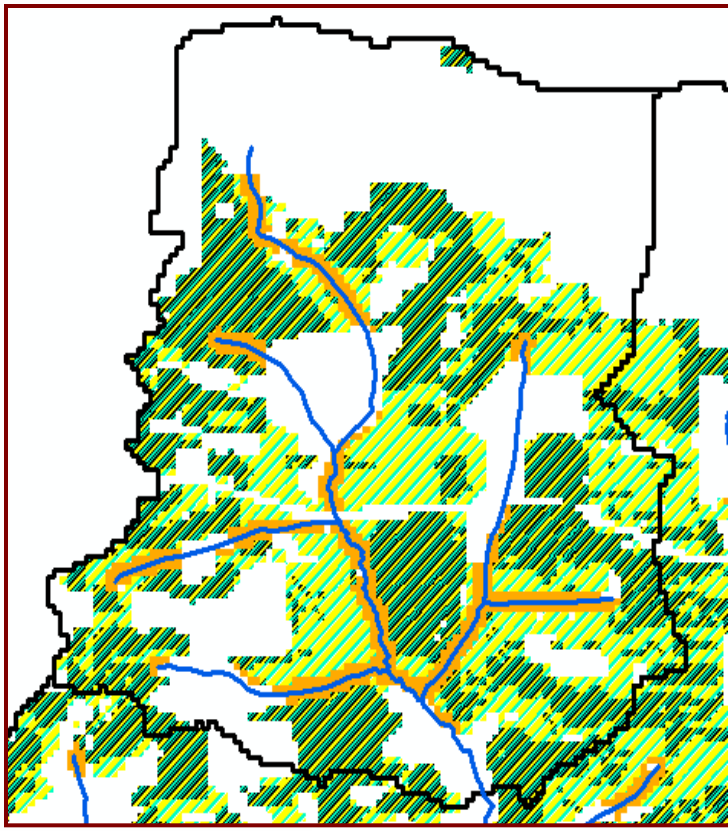
Scenarios simulated …

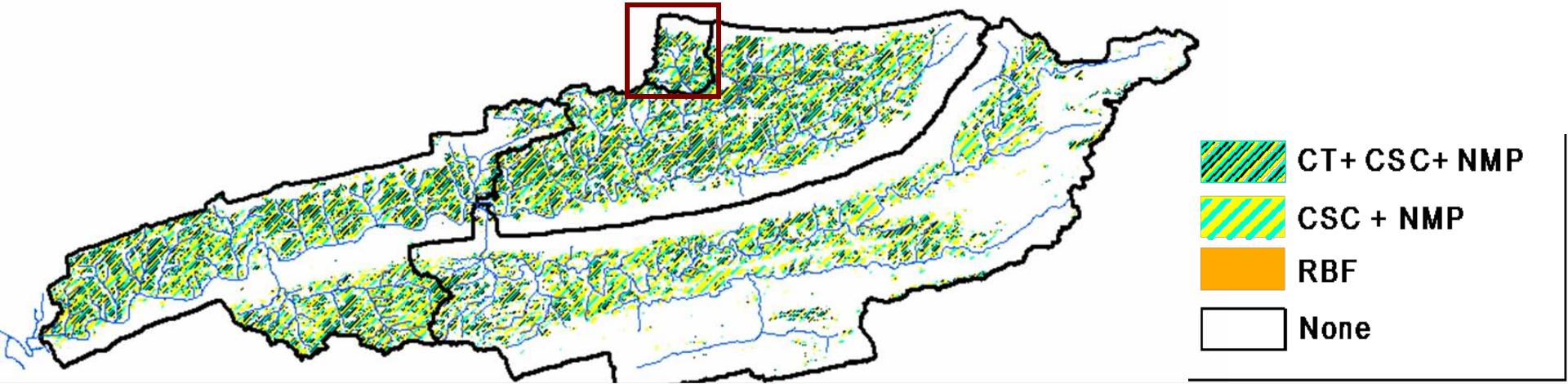
1. Optimize all BMPs on all cropland & pasture
2. Optimize all BMPs *except buffer (RFB)* on all cropland & pasture
3. Optimize all BMPs only on *high phosphorus/nitrogen generating cropland and pasture* (i.e., Target areas with threshold of total P > 1.5 kg/ha or soluble P > 0.3 kg/ha; total N in surface water > 7 kg/ha)
4. Optimize all BMPs on all cropland and pasture BUT *require at least one BMP on every area*
5. No optimization:
   - All cropland and pasture within 30 m of stream get RBF
   - All non-stream cropland gets (CT+CSC+NMP)
   - All non-stream pasture gets CSC+NMP

Scenario 5:

No optimization

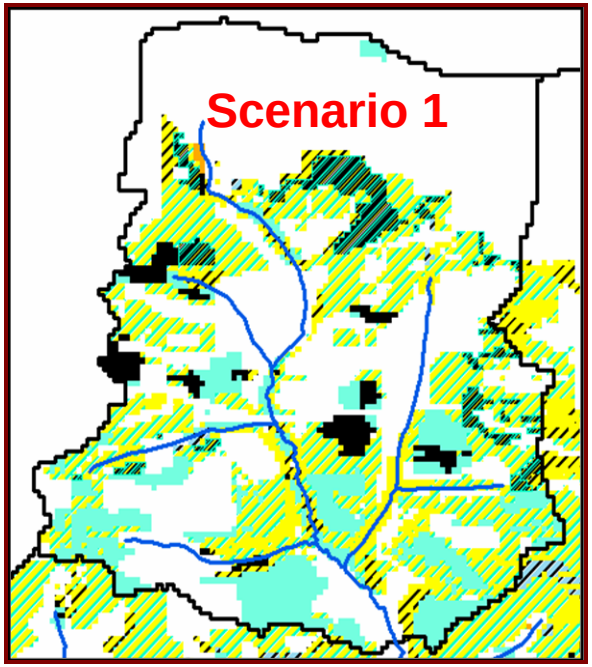
TP reduction from baseline (goal 30%)	81%
Savings by not applying all BMPs uniformly ($ / kg TP removed / yr)	--
BMP coverage of agricultural land	100%

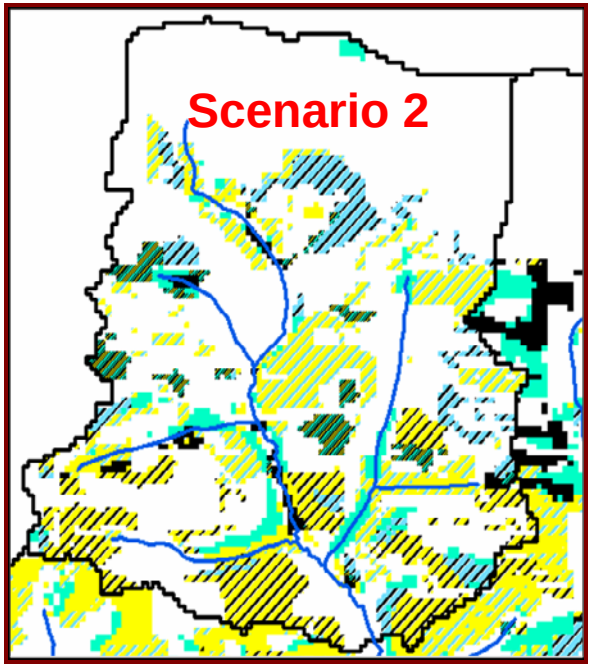


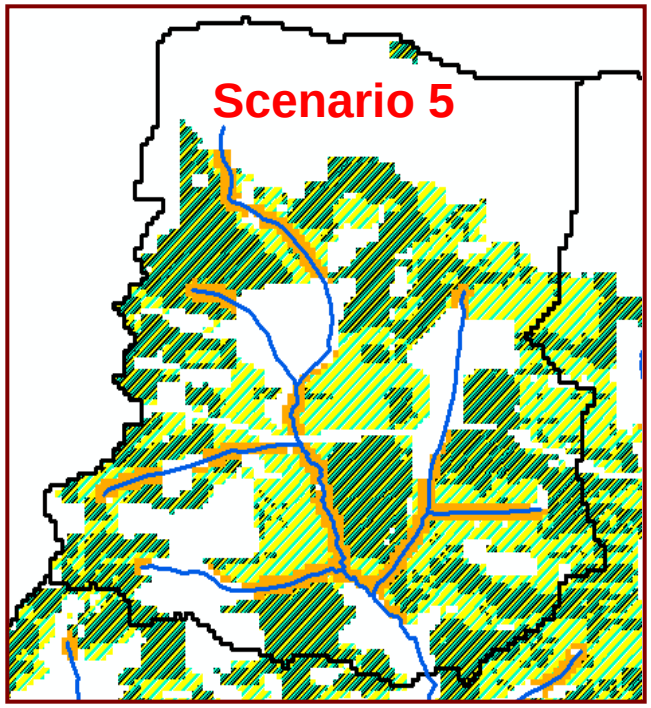


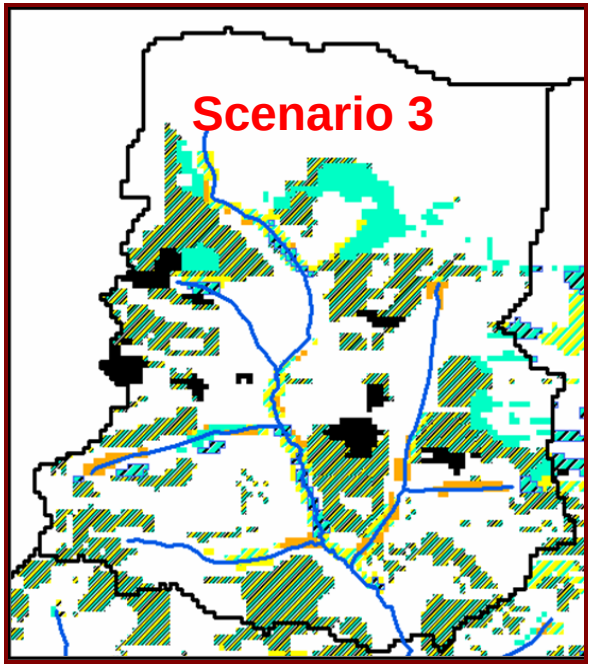
Phosphorus

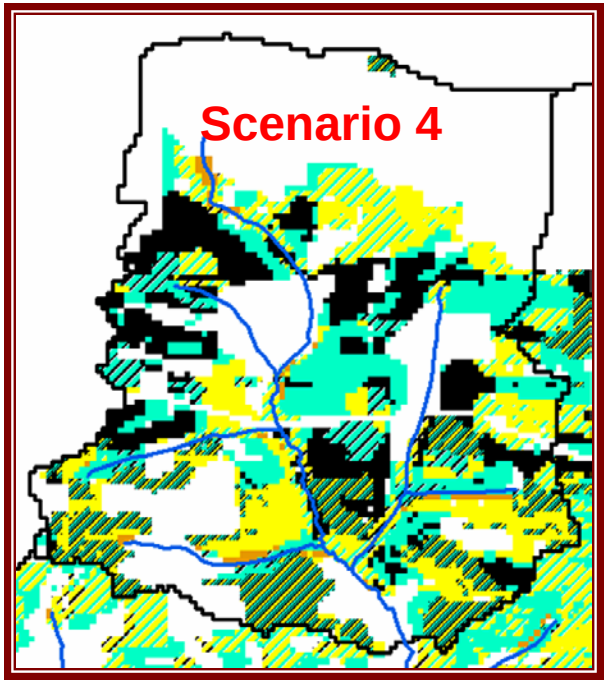
Non-opt (sce. 5) vs. optimized BMPs (sce. 1, 2,3,4)











CT+ CSC+ NMP
CSC + NMP
CT + NMP
CT + CSC
RBF
NMP
CSC
CT
None

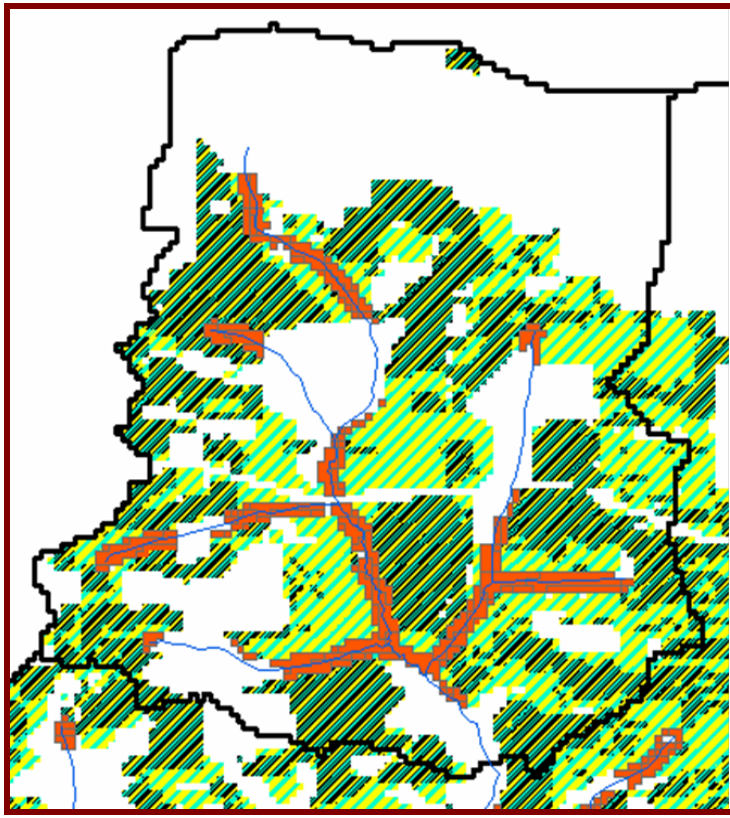
Results ...

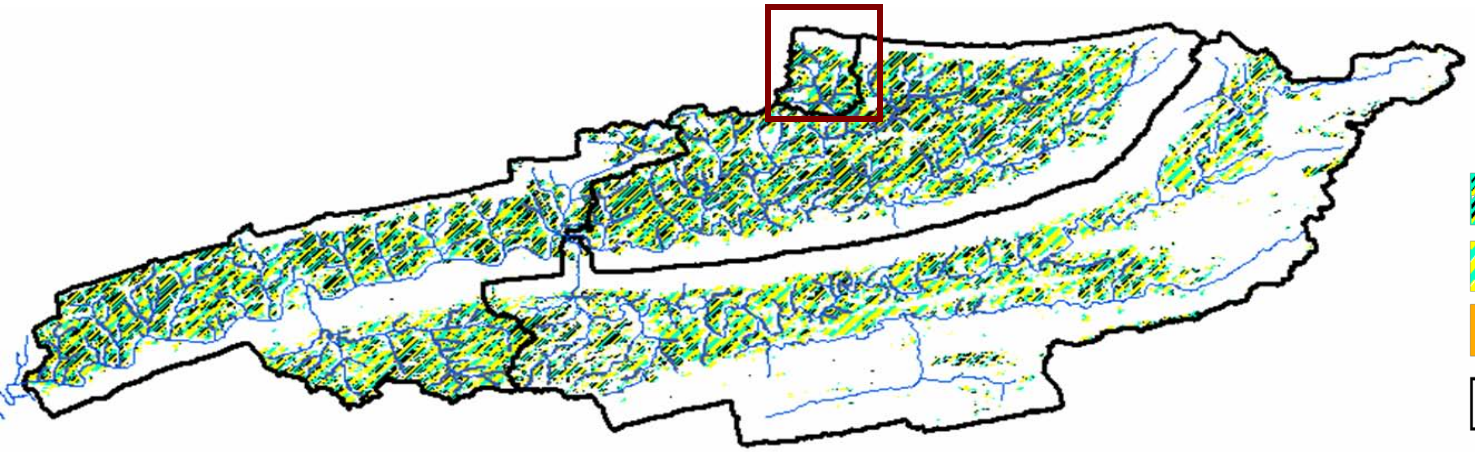
	Base	Sce. 1	Sce. 2	Sce. 3	Sce. 4	Sce. 5
Avg. annual TP loss (Mg/yr)	58	34	25	26	18	11
TP reduction from baseline (%)	-	41	57	56	69	81
Cost increase from baseline ($/yr)	-	687k	582k	650k	1,088k	2,586k
Cost effectiveness ($ spent / kg TP removed / year)	-	**28**	18	20	**27**	55
Total area treated (km^2)	-	111	**128**	**77**	156	156

Scenario 5:

No optimization

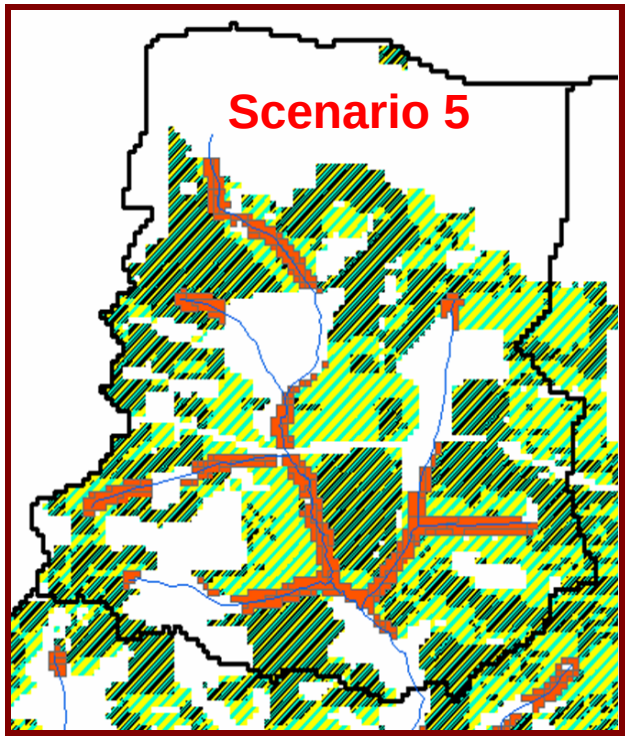
TN reduction from baseline (goal 30%)	71%
Savings by not applying all BMPs uniformly ($ / kg TN removed / yr)	--
BMP coverage of agricultural land	100%

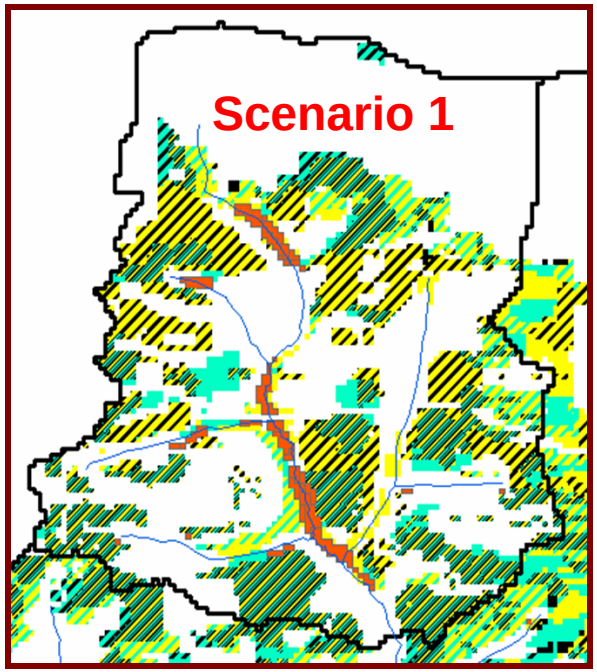


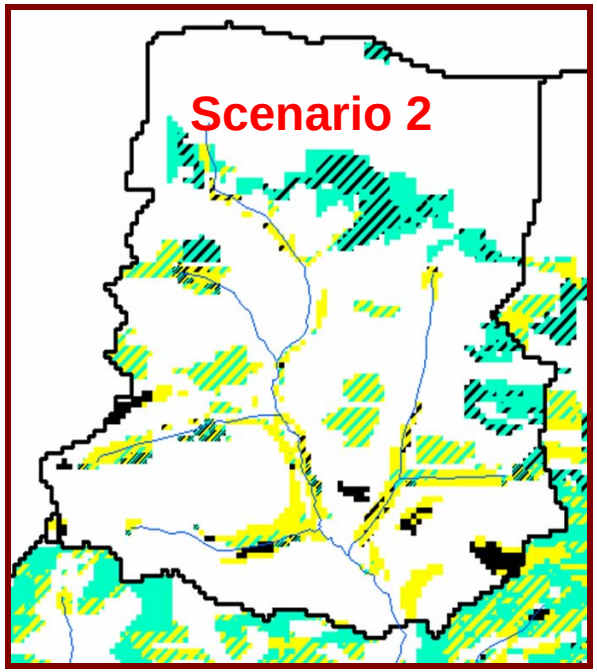


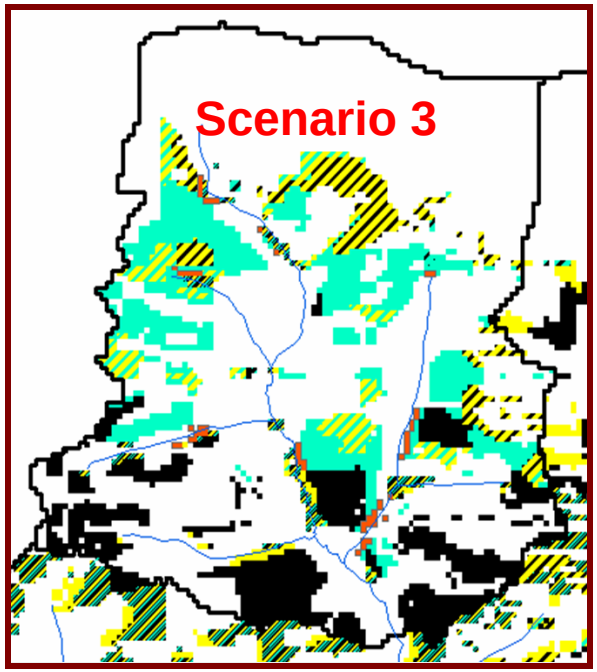
Nitrogen

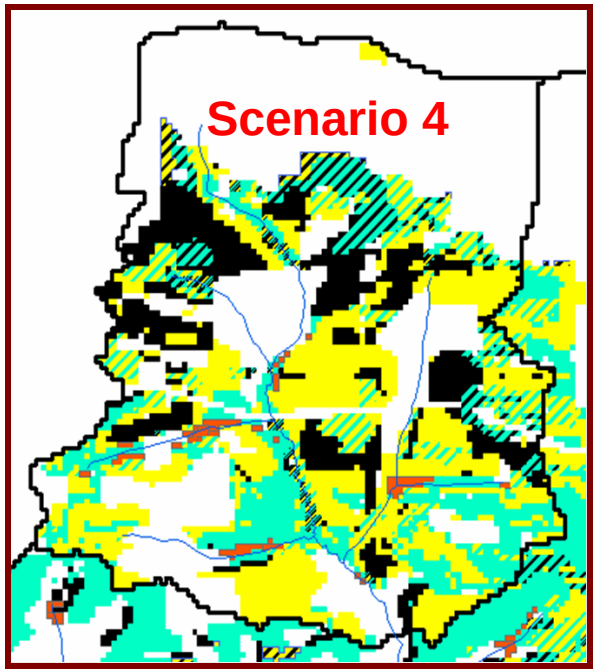
Non-opt (sce. 5) vs. optimized BMPs (sce. 1, 2,3,4)

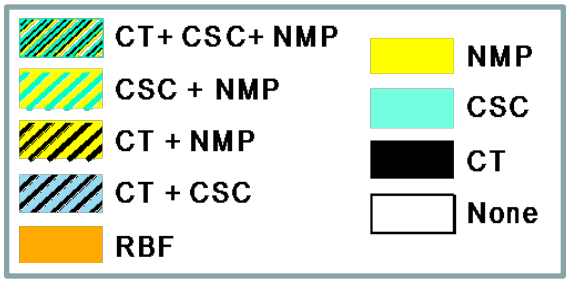








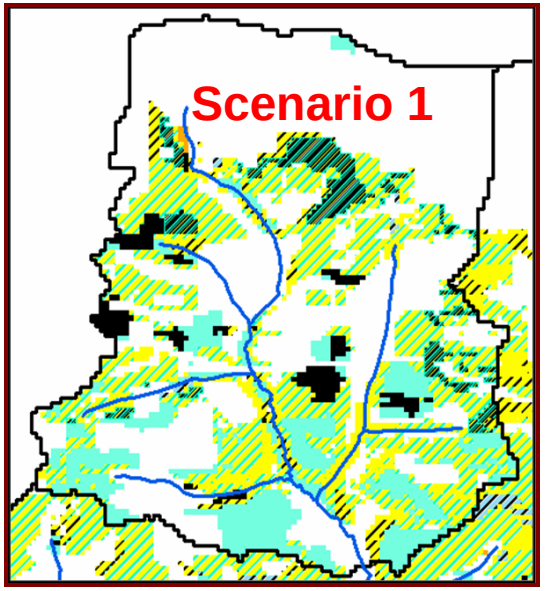


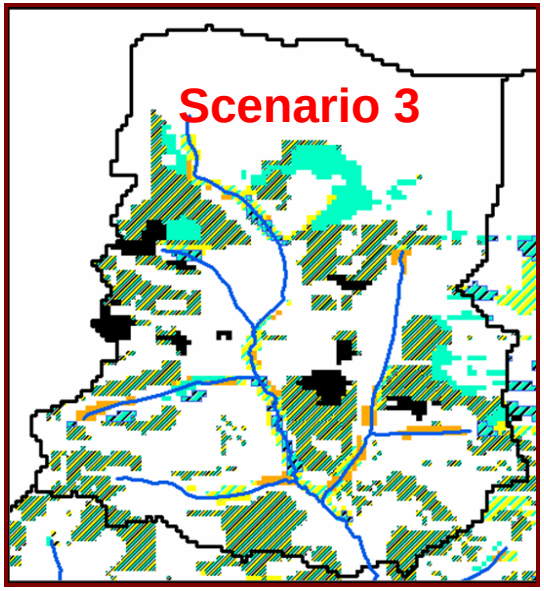


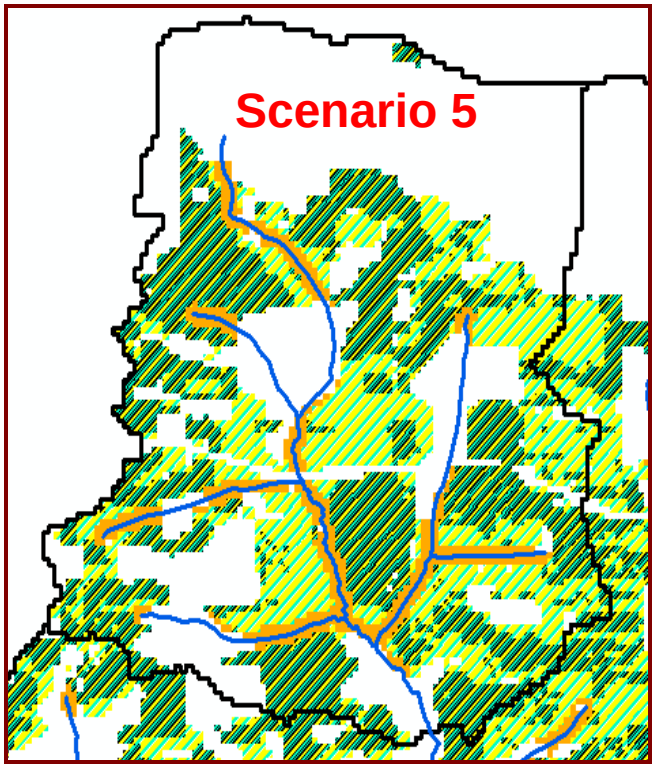
Results …

	Base	Sce. 1	Sce. 2	Sce. 3	Sce. 4	Sce. 5
Avg. annual SurQ TN loss (Mg/yr)	485	241	269	263	258	141
Reduction from baseline SurQ TN (%)	-	50	45	46	47	71
Reduction from baseline watershed TN (%)	-	**24**	21	22	**22**	34
Cost increase from baseline ($/yr)	-	911 k	795 k	606k	1,074 k	2,641 k
Cost effectiveness ($ spent / kg TN removed / year)	-	**5**	4	4	**5**	8
Total area treated (km^2)	-	143	**127**	**81**	156	156

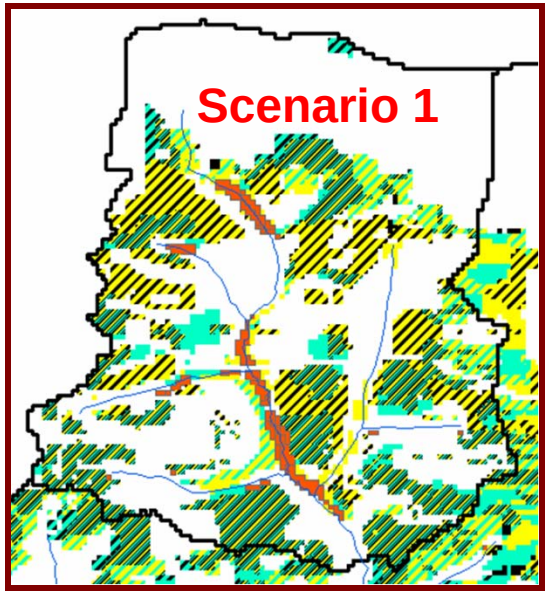
Phosphorus

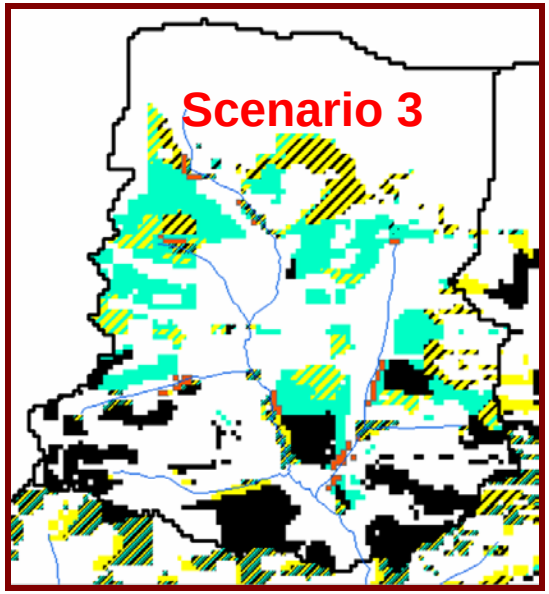


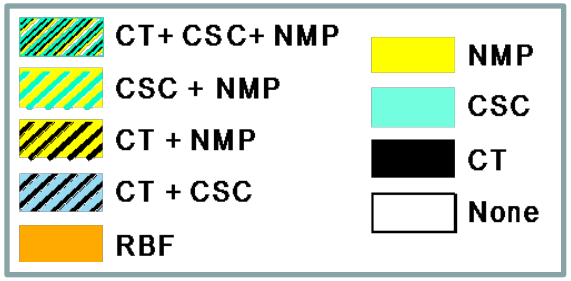




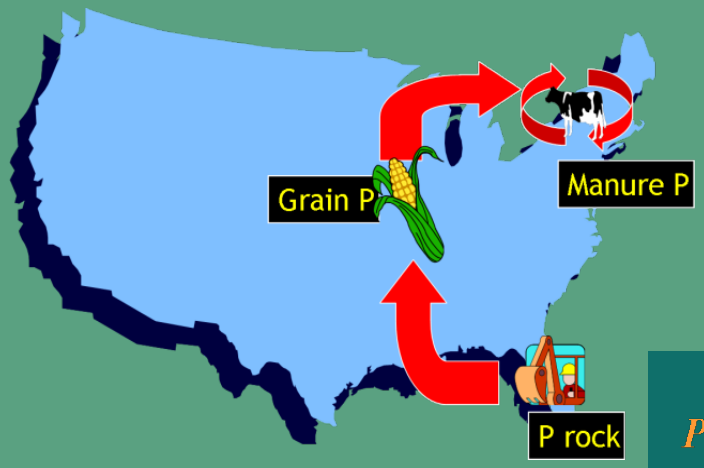
Nitrogen

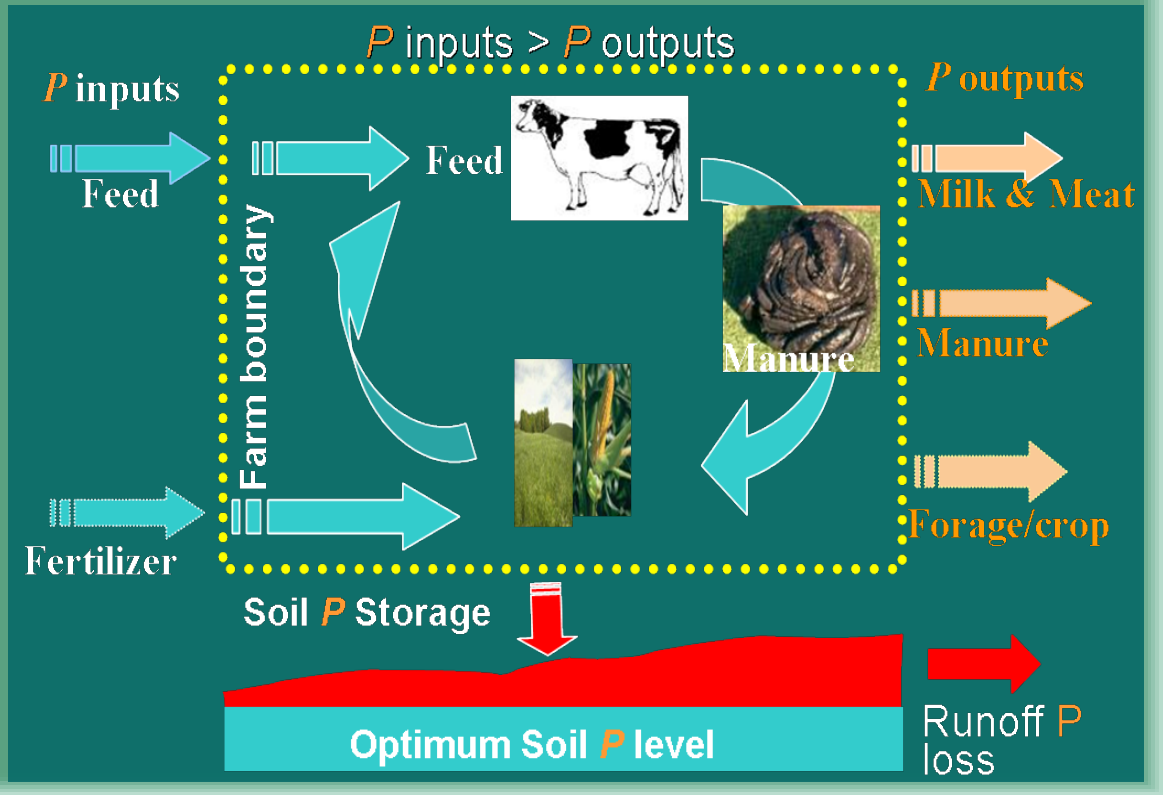






Nutrient Imbalance





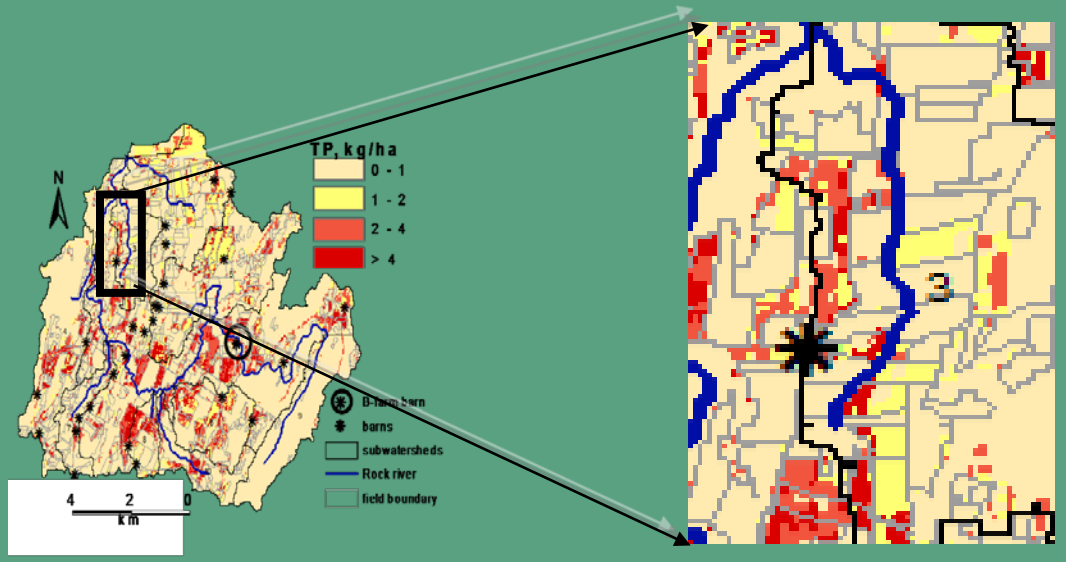
Farm level needs

- Strategies to address soil-P build-up
- Sustainability and economic viability
- Target CSAs at levels at which
  - farm management decisions made
  - legislation directed

Bridging research & application

Watershed Models

Farms

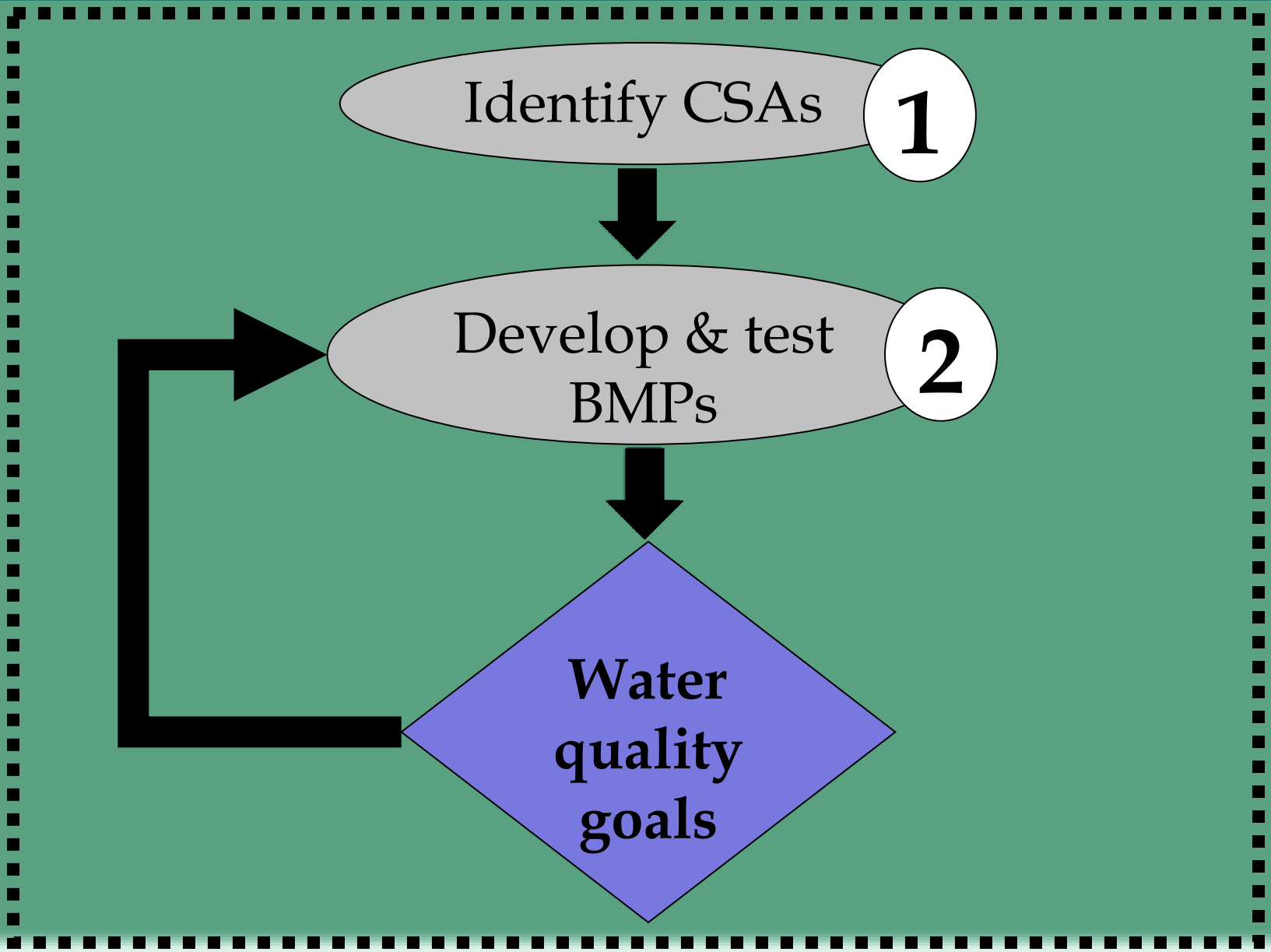


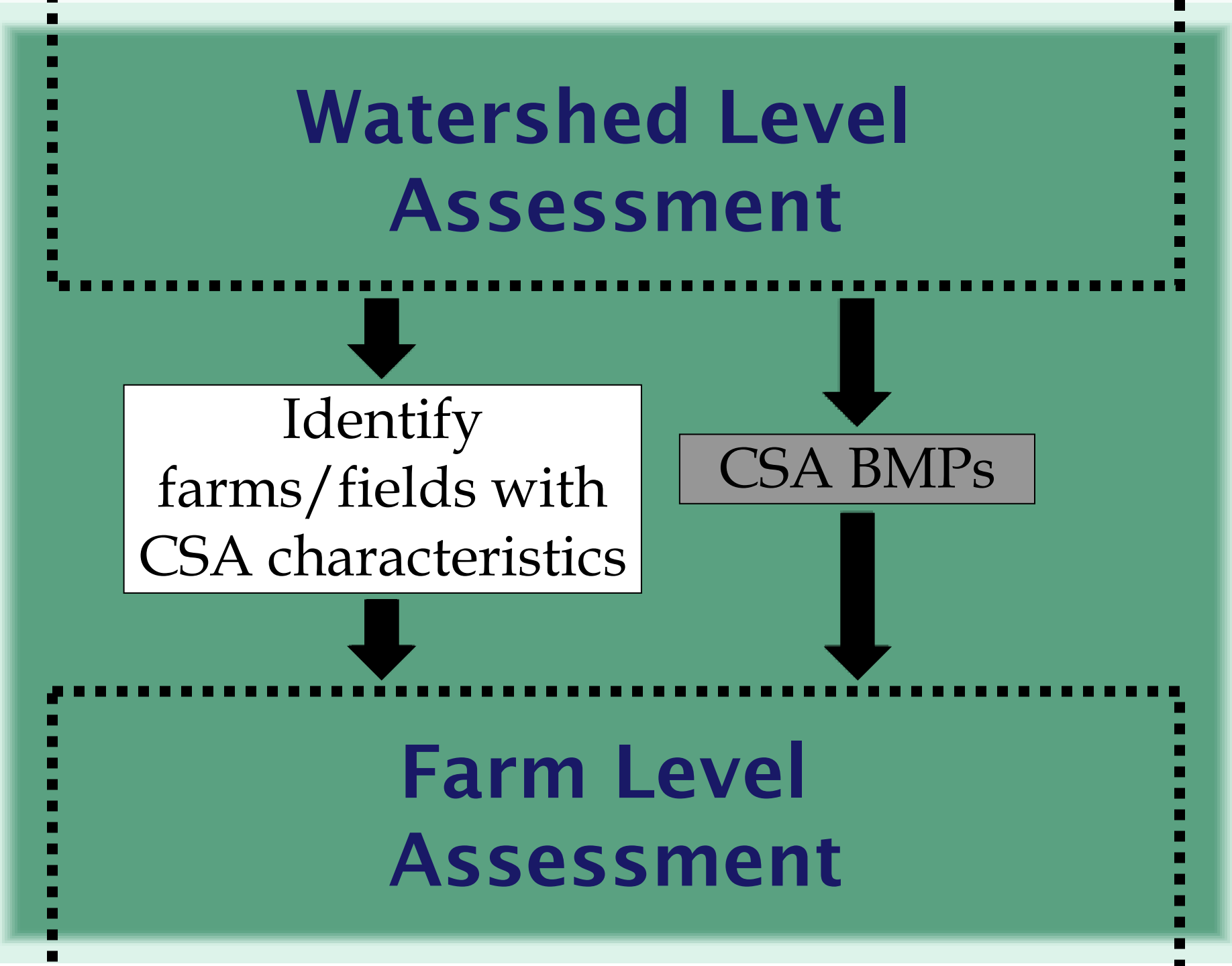
- **Data resolution**
- **Technology transfer**
  - Multi-owner, multi-farm watersheds vs. farm-level application

Integration Framework

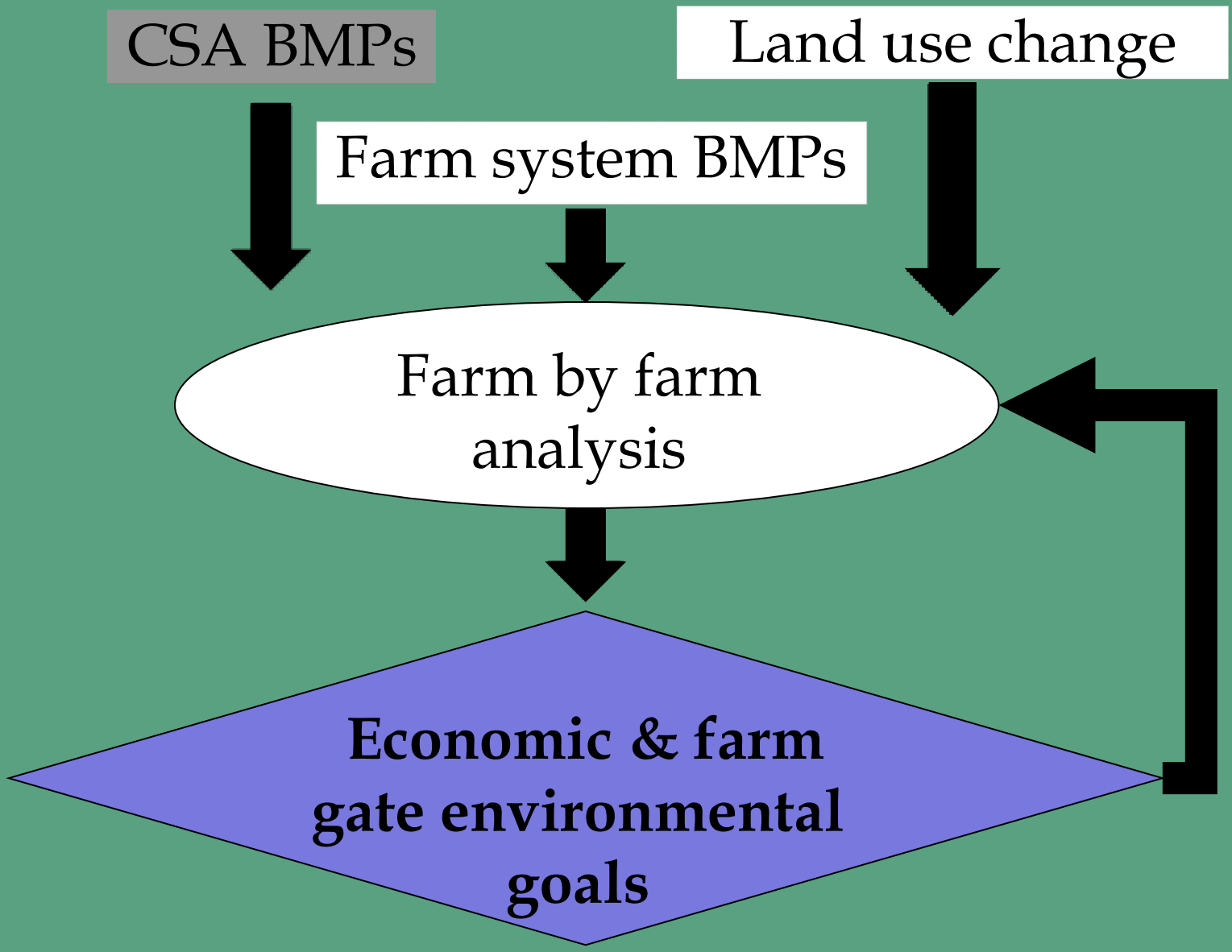
- System-level design of best management practices
- Environmental quality
  - → Watershed level
- Economic viability
  - → farm sustainability

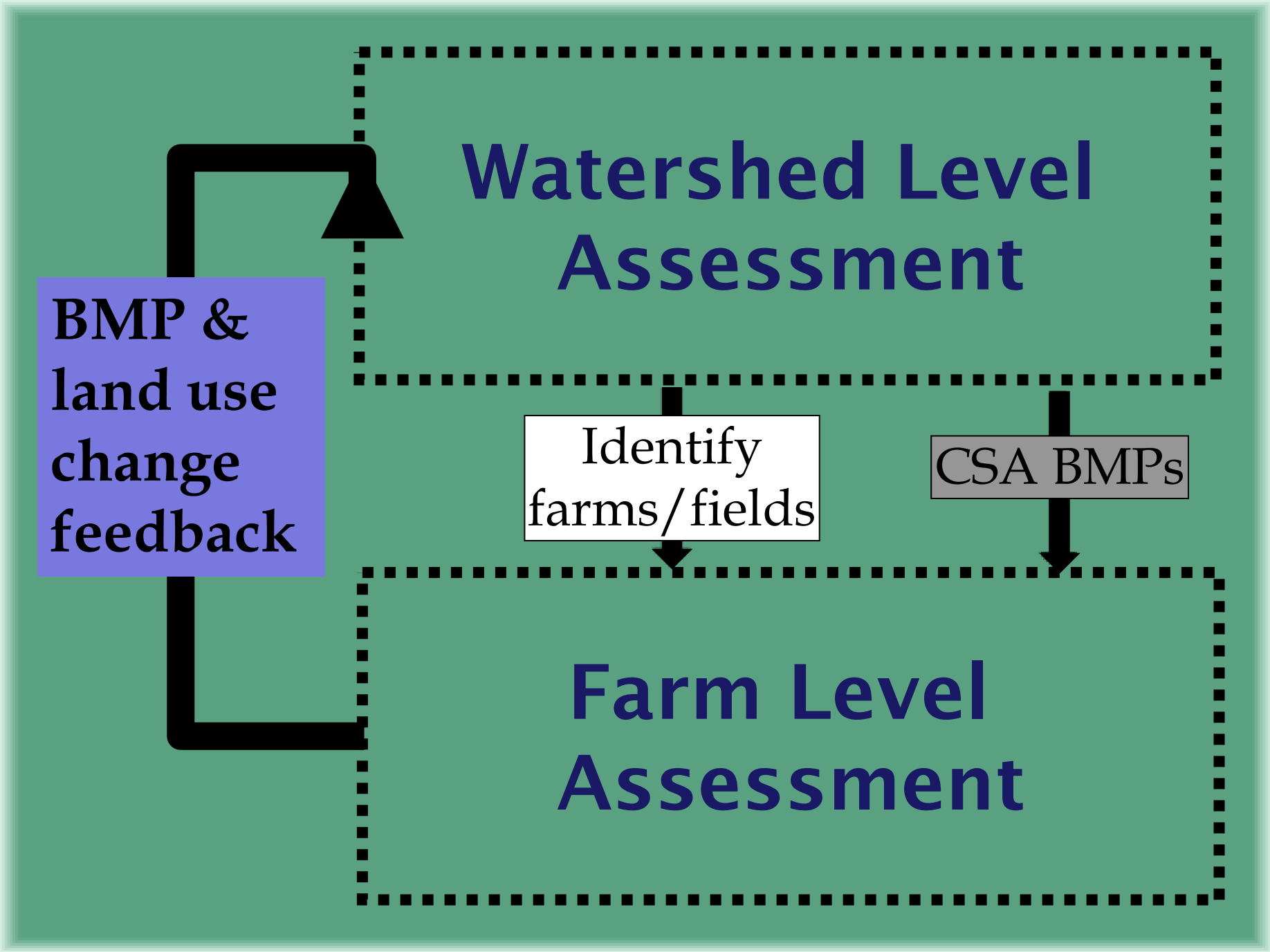
Watershed Level Assessment




Watershed Level Assessment
Identify farms/fields with CSA characteristics
CSA BMPs
Farm Level Assessment

Farm Level Assessment




Watershed Level Assessment
BMP & land use change feedback
Identify farms/fields
CSA BMPs
Farm Level Assessment

Case Study - NY

Cannonsville Reservoir

NY City drinking water

vs.

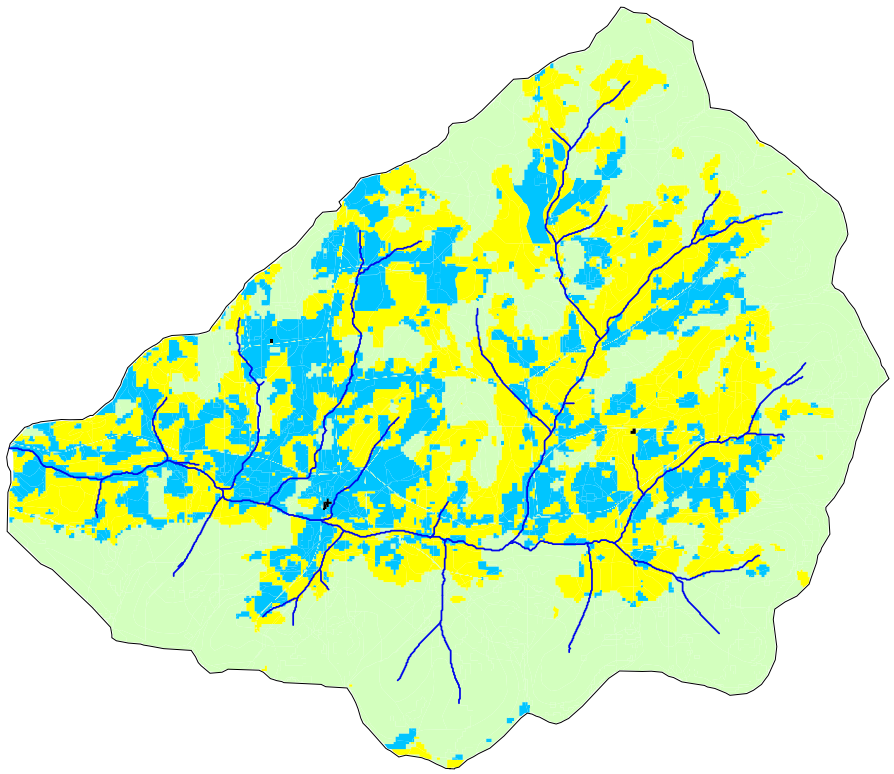
productive agriculture

Typical Agriculture

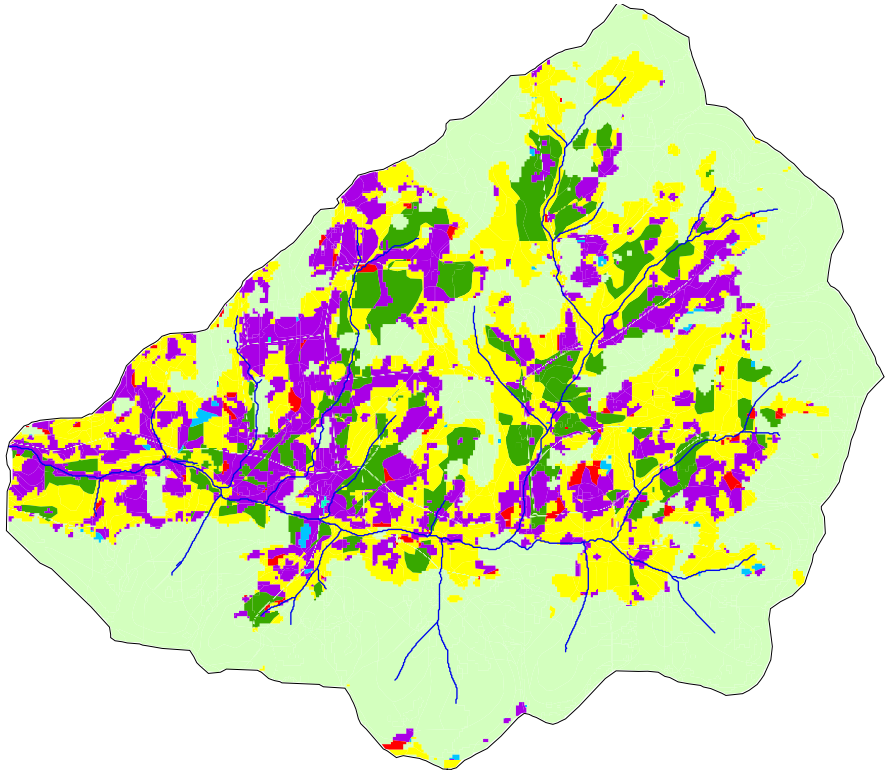
- Dairy farms
  - Corn silage
  - Hay, alfalfa

- Family-owned
  - 89% < 200 cattle
  - 92% < 200 ha
- Noncontiguous

Same TP loss; 30% cheaper



Basic

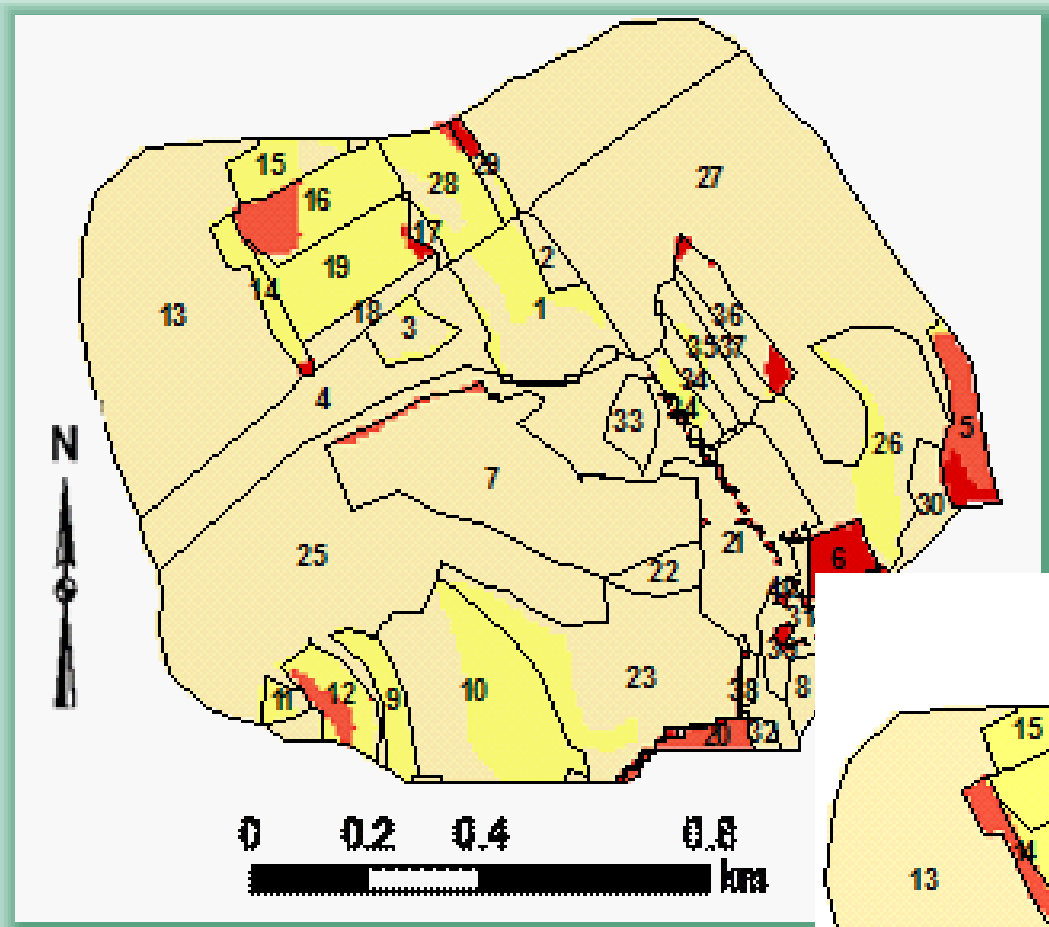


Optimal

- Nutrient management plans
- Crop rotations & nutrient management plans
- Crop rotations & contour strip crop
- Contour strip crop & nutrient management plans
- Riparian forest buffers
- None

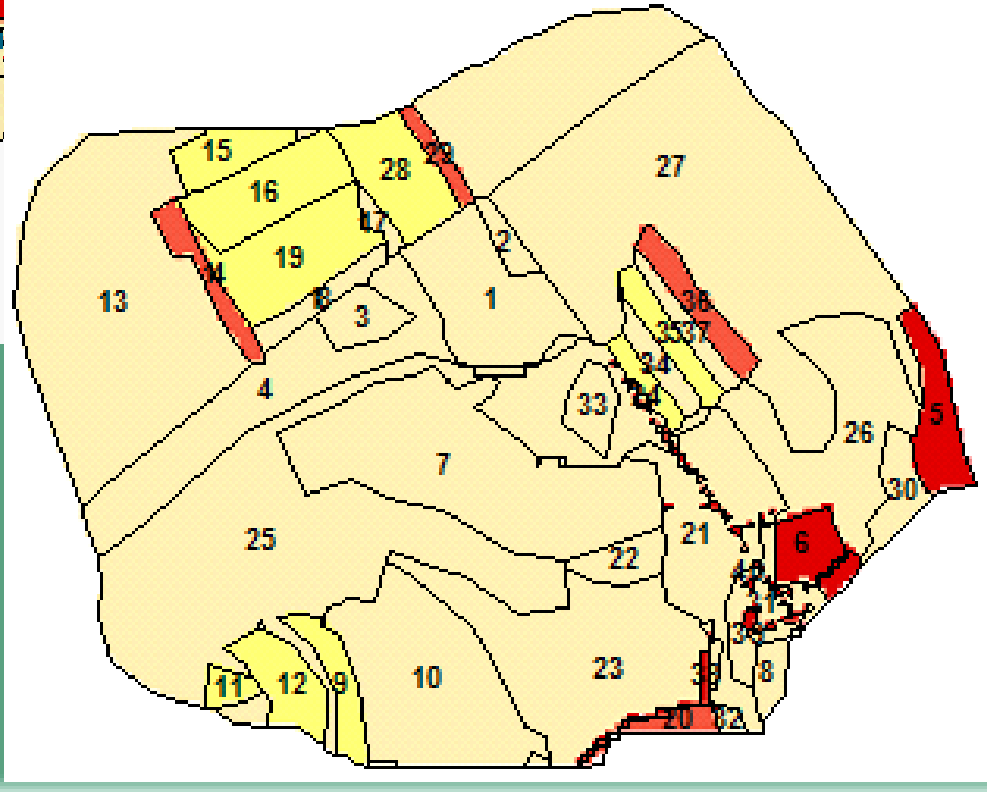
Precision Feeding

- High dietary P
- Forage crop lands under-utilized
- 70 - 80% of annual P inputs remain on farm
- 65 - 85% of imported P = Purchased animal feed

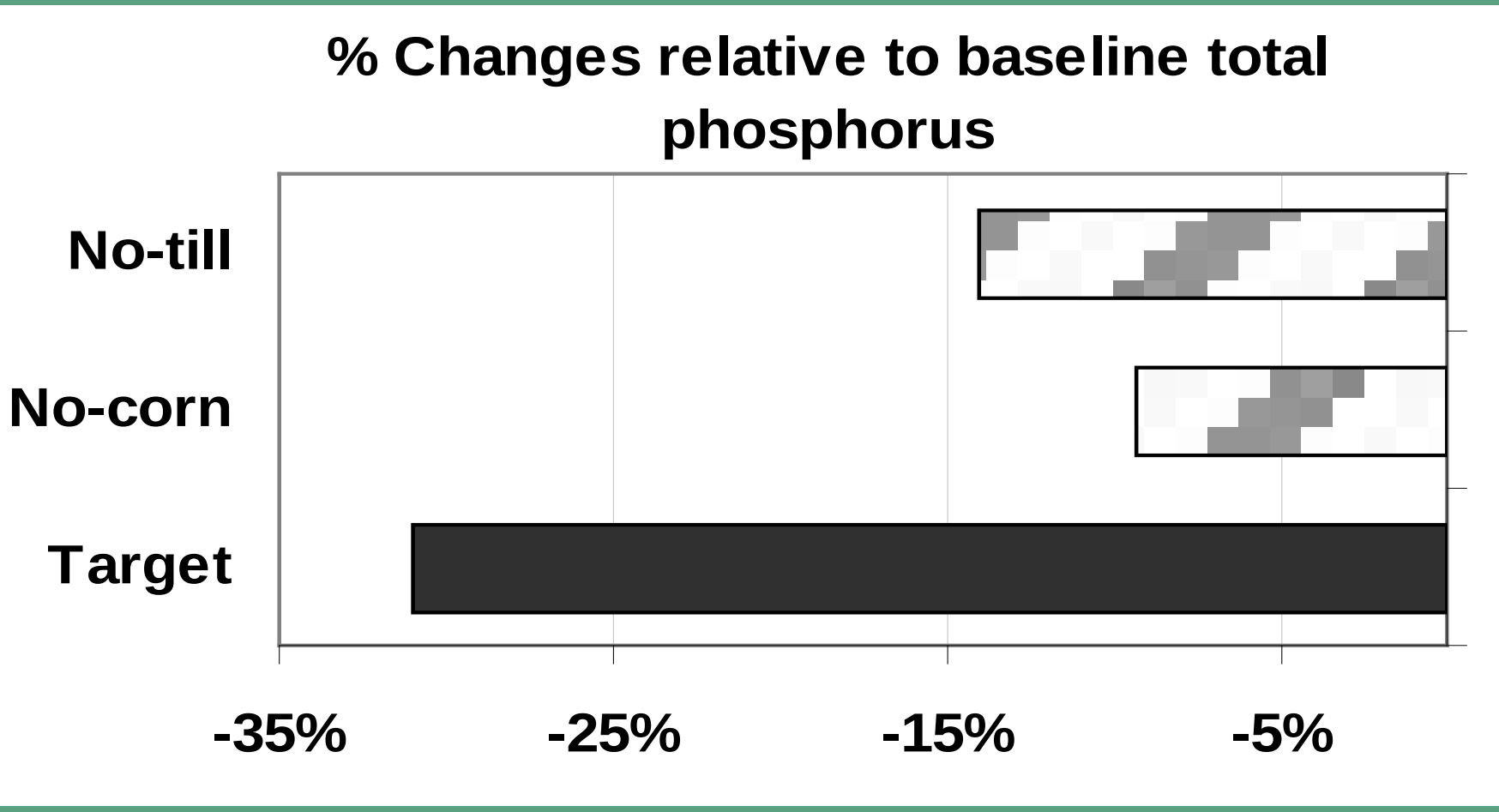


TP kg/ha

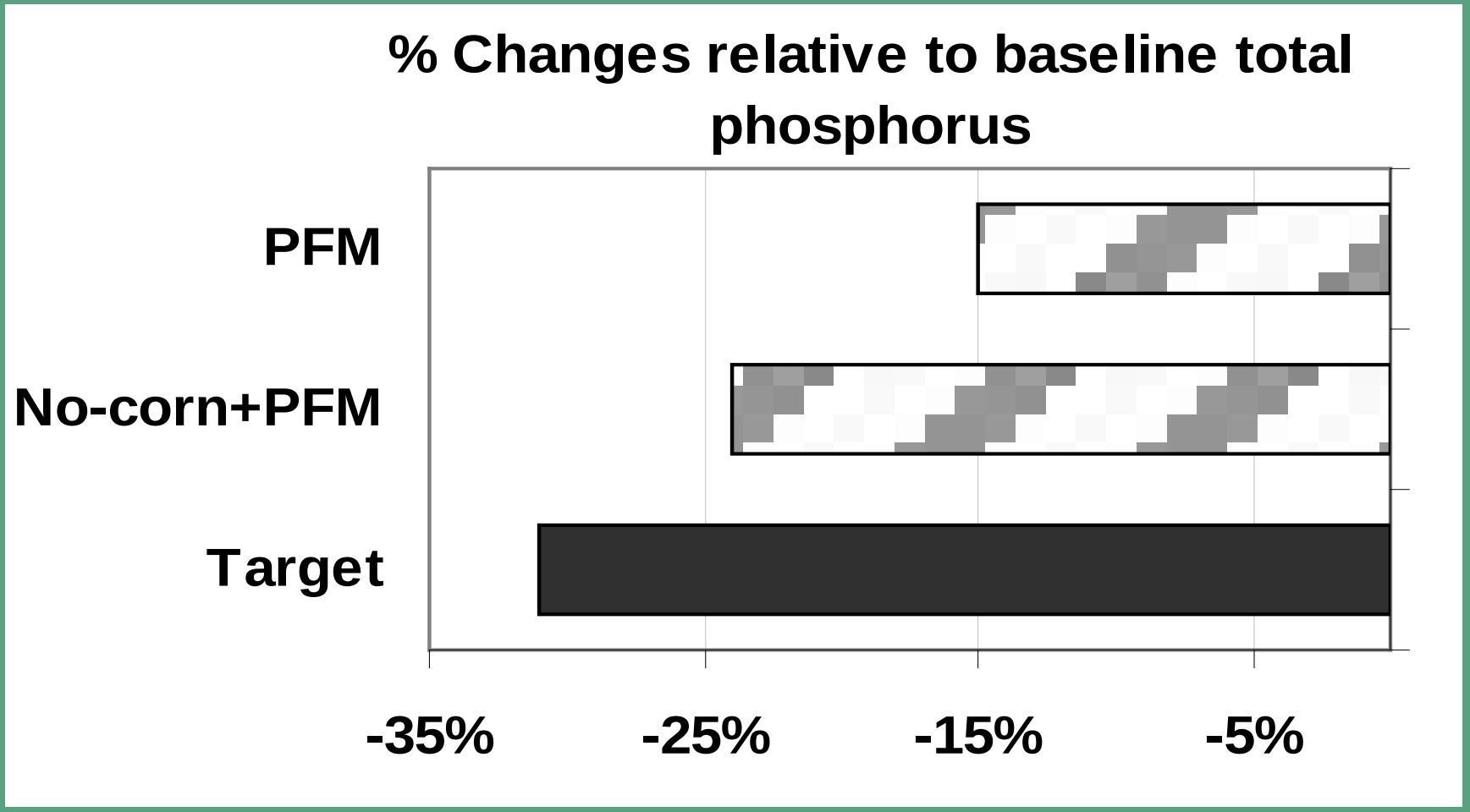
- 0 - 1
- 1 - 2
- 2 - 4
- > 4



Field BMPs


% Changes relative to baseline total phosphorus
No-till
No-corn
Target
-35%
-25%
-15%
-5%

Farm- based BMPs



PFM = reduced dietary phosphorus and increased forage productivity and utilization

% change from baseline

	TP Excess	Farm Net Return
No-corn	1.8	-68
No-till	0	43
PFM	-9.6	237
PFM + No-corn	**-9.8**	**253**

Study Conclusions

- PFM: less P imported, better forage
  - Farm-based BMP
  - Minimal effect on TP loss alone
- Buffers, low-erosion management
  - Field-level BMPs
  - Low incentive for farmer
- Combined:
  - Address P at its source
  - Benefit farms economically

Implications

- Targeting saves!
- Promotes environmental & economical sustainability
- Must consider region AND farm
- Improves information transfer
- Improves implementation and expansion