BMP Effectiveness Assessment for a Pasture Dominated Watershed: Results from Two Years of CEAP Assessment

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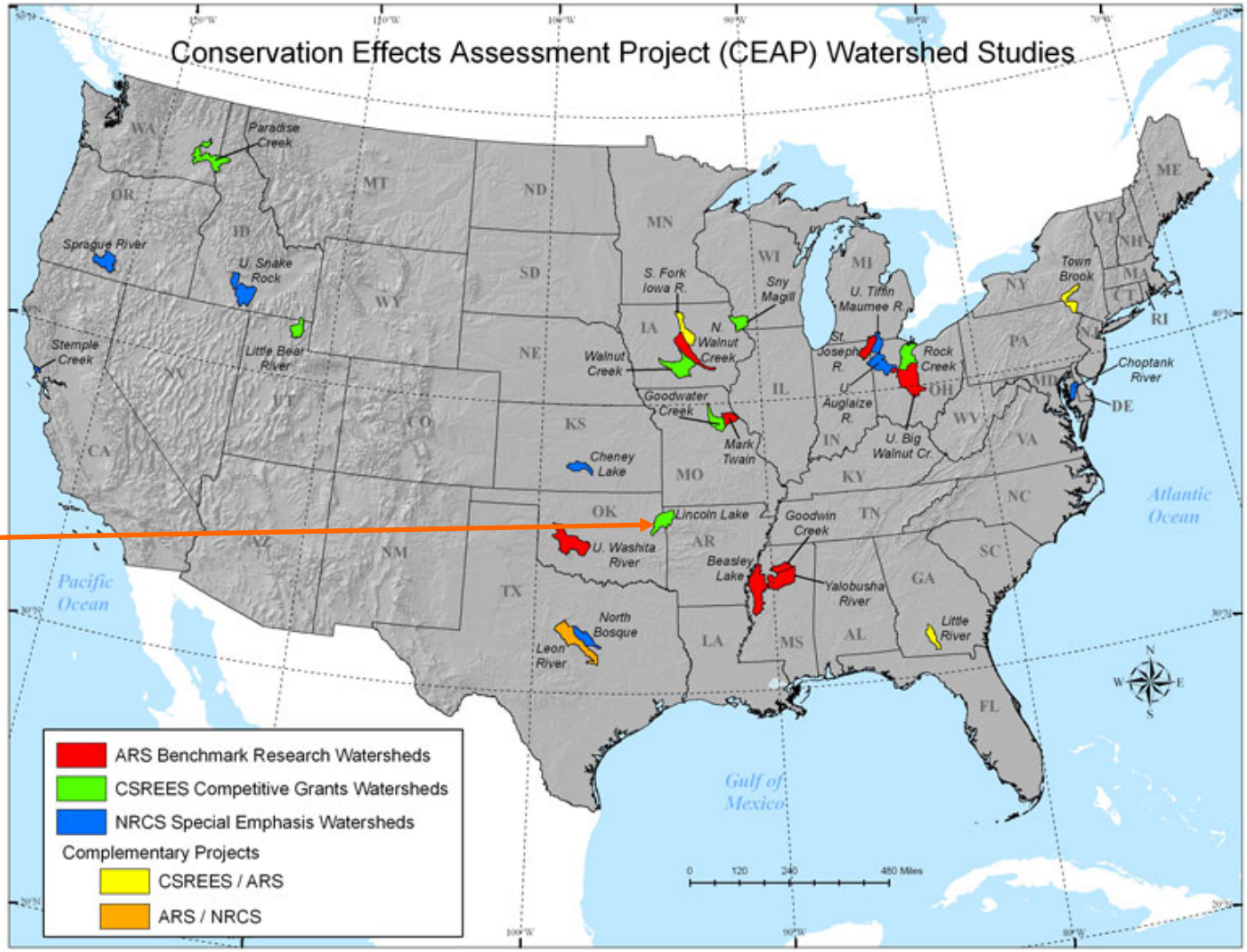
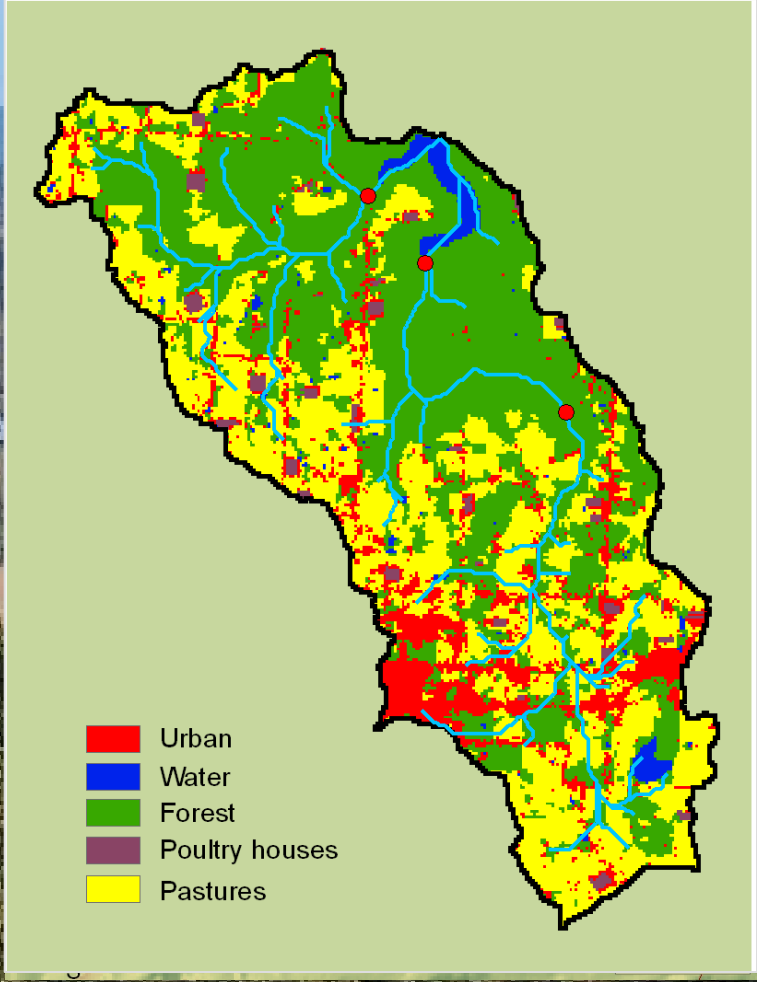
Study Location: Lincoln Lake Watershed

Lincoln Lake Watershed



Study Site Description

- Tributary Illinois River
- Size - 32 km^2
- Land use
  - Pasture 36%
  - Forest 39%
  - Urban 12%
- Primary concern – phosphorus from land application of animal manure



Objectives

- Synthesize historic watershed BMP, land use, and water quality data in a GIS-linked database
- Quantify linkages among nutrient management, land use, BMP implementation, and water quality
- Develop comprehensive cost-benefit analyses of water quality management practices to optimize BMP implementation, agricultural production, and water quality improvement
- Develop education/demonstration programs

Database Development

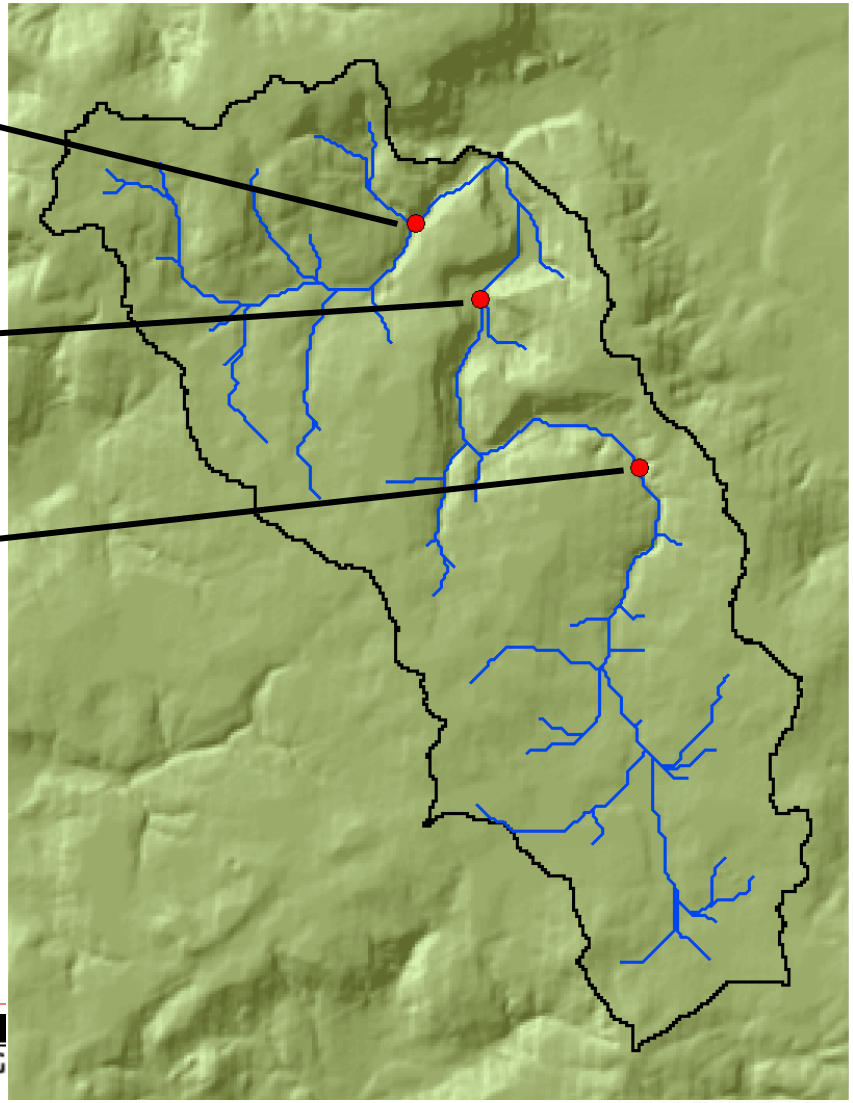
Beatty Branch (Jan 95 – Dec 98)

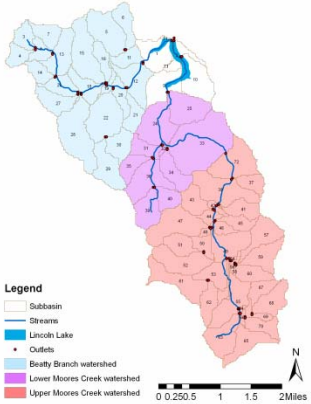
Lower Moore's Creek (Jan 95 – Dec 98)

Upper Moore's Creek (Jul 96 – Dec 03)

All Stations (project duration)

Field plot data (4 sites)





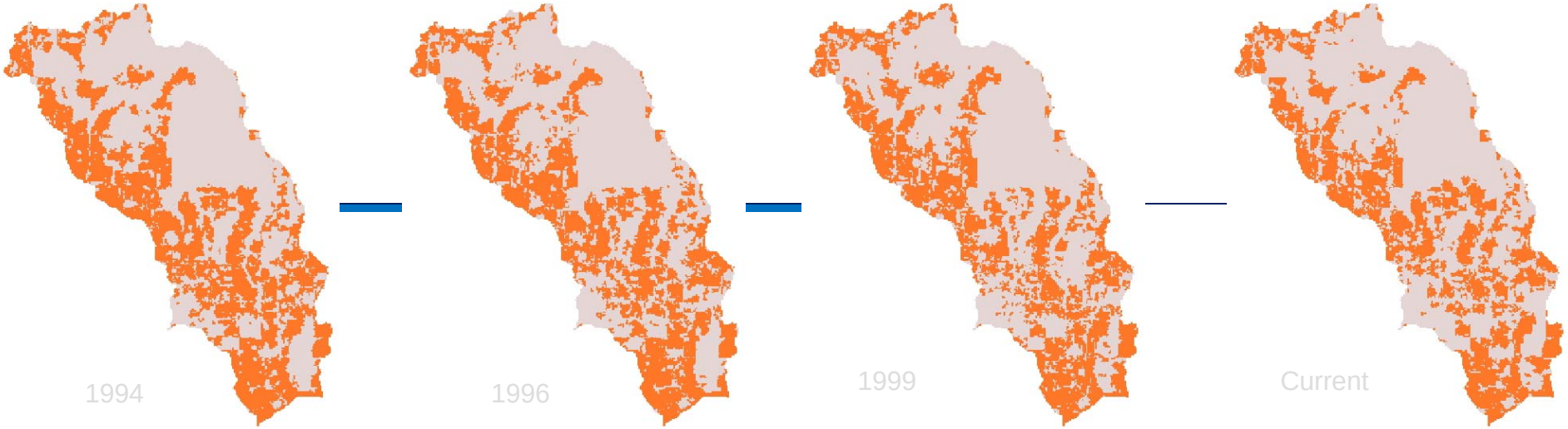
- Base flow: TP had no appreciable change
- Total N was relatively constant over time at each location

- Storm flow: Variable
- TP declined by 40 – 50% compared to 92-94 values
- TN declined 50% compared to 91 – 95 values

	Base flow		Storm flow	
Location	Lowest	Highest	Lowest	Highest
	Total P (mg.L)			
Beatty Branch	0.09	0.17	0.12	0.50
Upper Moore's Creek	0.11	0.21	0.30	0.45
Lower Moore's Creek	0.12	0.19	0.17	0.55
	Total N (mg/L)			
Beatty Branch	0.36	5.22**	0.39	7.13**
Upper Moore's Creek	0.07	0.13	0.08	0.26
Lower Moore's Creek	0.50	4.41**	0.72	4.94**

Land Use and BMPs (1992-present)

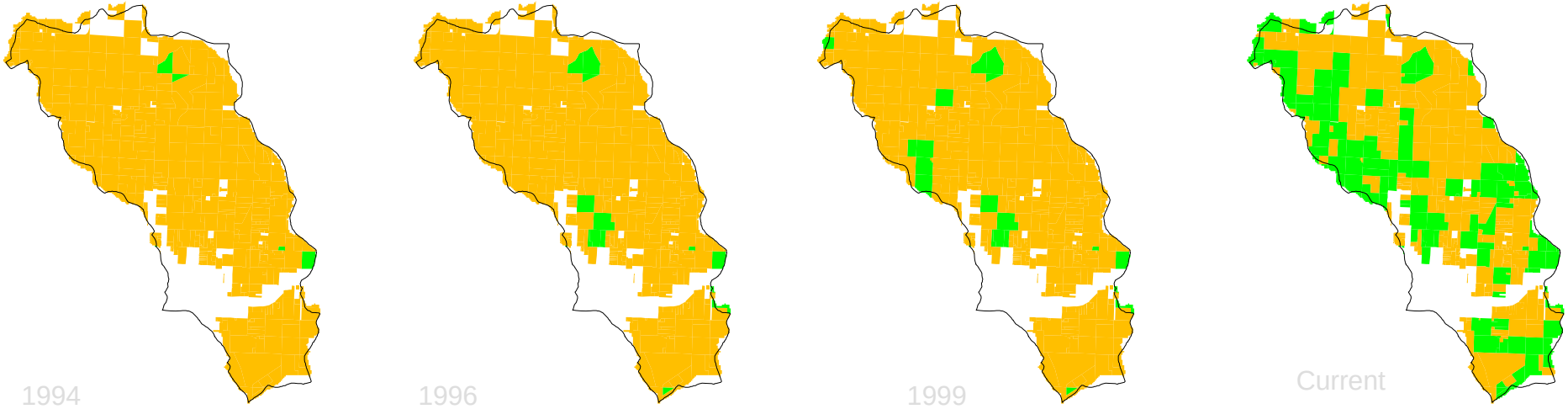
	% of watershed Area					
Land use	1992	1994	1996	1999	2001	Current
Urban	3	4	7	8	11	12
Forest	39	44	40	37	45	39
Transl.	7	7	9	14	5	10
Pasture	47	43	41	38	36	36
Poultry	1	1	1	1	1	2
BMPs	<1	1	3	6	7	34



Pastures, %of watershed area

43% 41% 38% 36%

Pastures Other



BMPs, %of watershed area

1% 3% 6% 34%

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BMPs Implemented No BMPs

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SWAT Modeling of BMP Effectiveness

- 172 Different BMPs modeled
- 2004 watershed conditions as a baseline – way forward
- Uncertainty in the future weather incorporated using a Monte Carlo Approach: 250 weather scenarios for each BMP

BMP Scenarios Modeled in SWAT

	Buffer Width								
	0 m			15m			30 m		
	Grazing and Pasture Management								
Manure application (tons/acre)	NG	OG	OVG	NG	OG	OVG	NG	OG	OVG
No application	1*	20	39	58	77	96	115	134	153
Spring app									
1A	2	21	40	59	78	97	116	135	154
1.5A	3	22	41	60	79	98	117	136	155
2A	4	23	42	61	80	99	118	137	156
1NA	5	24	43	62	81	100	119	138	157
1.5NA	6	25	44	63	82	101	120	139	158
2NA	7	26	45	64	83	102	121	140	159
Summer									
1A	8	27	46	65	84	103	122	141	160
1.5A	9	28	47	66	85	104	123	142	161
2A	10	29	48	67	86	105	124	143	162
1NA	11	30	49	68	87	106	125	144	163
1.5NA	12	31	50	69	88	107	126	145	164
2NA	13	32	51	70	89	108	127	146	165
Fall									
2A	14	33	52	71	90	109	128	147	166
2.5A	15	34	53	72	91	110	129	148	167
3A	16	35	54	73	92	111	130	149	168
2NA	17	36	55	74	93	112	131	150	169
2.5NA	18	37	56	75	94	113	132	151	170
3NA	19	38	57	76	95	114	133	152	171

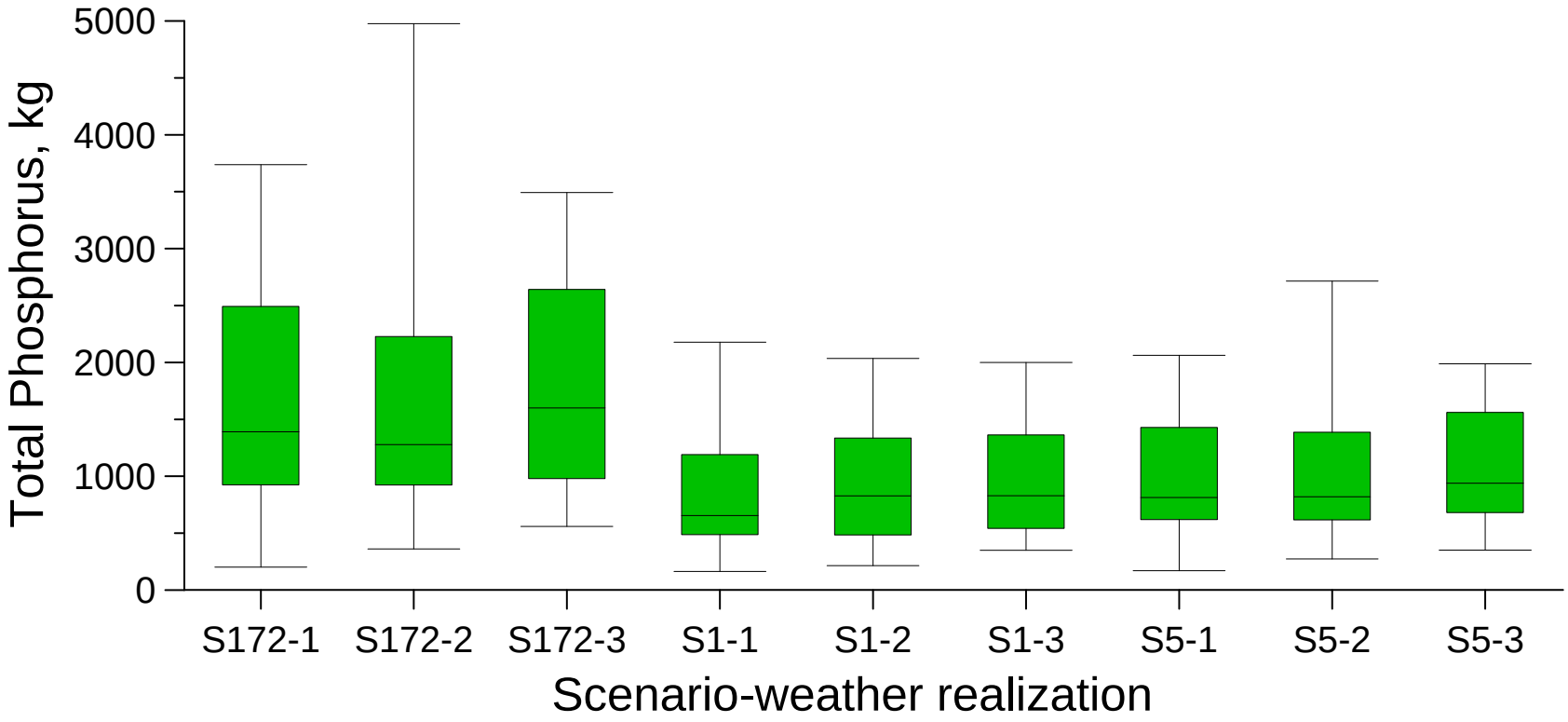
Challenges

- Number of runs
  - 172 BMP scenarios, 250-1000 weather data/scenario = 43,000-172,000 runs
  - Time/run = 8-10 minutes on LINUX, min. 5,700 CPU hrs (single machine)
- Space – temporary storage for output
  - Total 67.5 Mb/run – min 2.5 Tb

Approaches - Condor

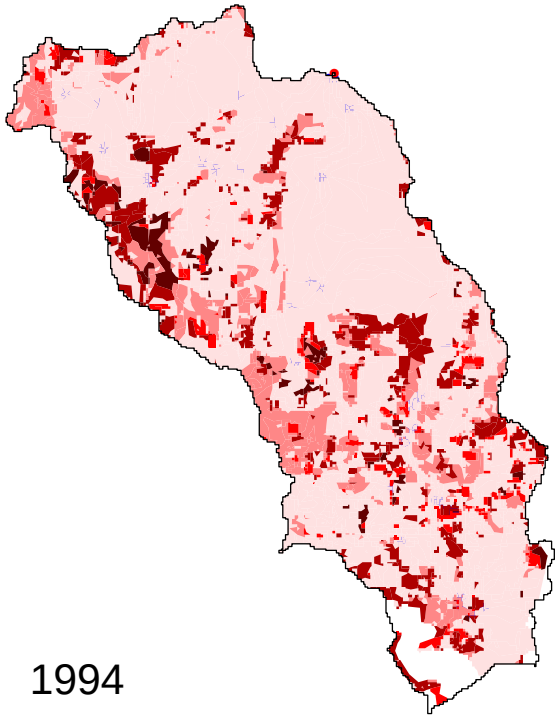
- Modified, configured SWAT to run with Condor and produce minimum required output for each run
- Condor = parallel SWAT run in distributed computing environment
- Developed scripts and post-processing tools to handle model runs and outputs.

Example output – weather realization & scenario output

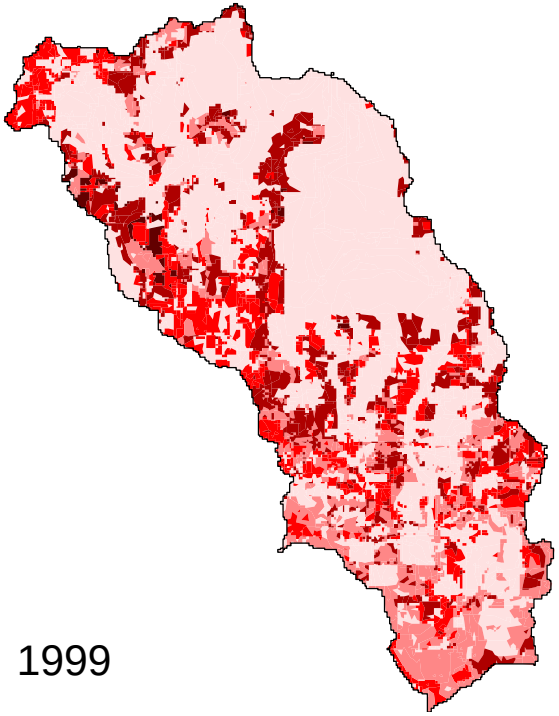


SWAT modeling - results

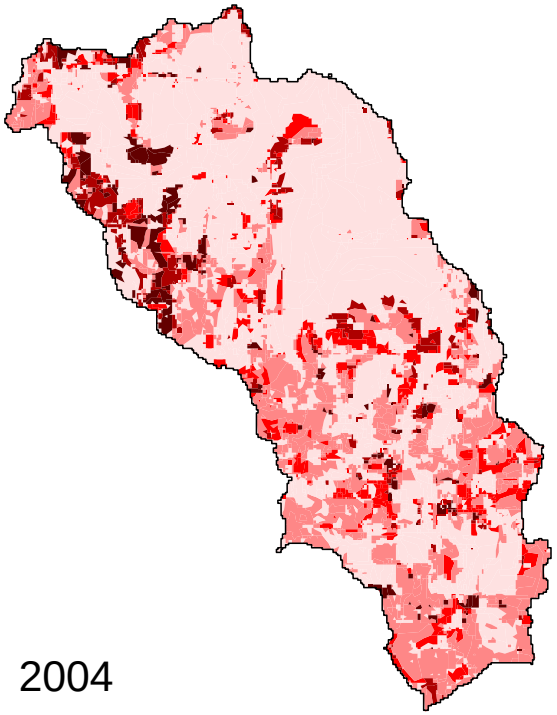
Big picture – whole watershed



1994



1999

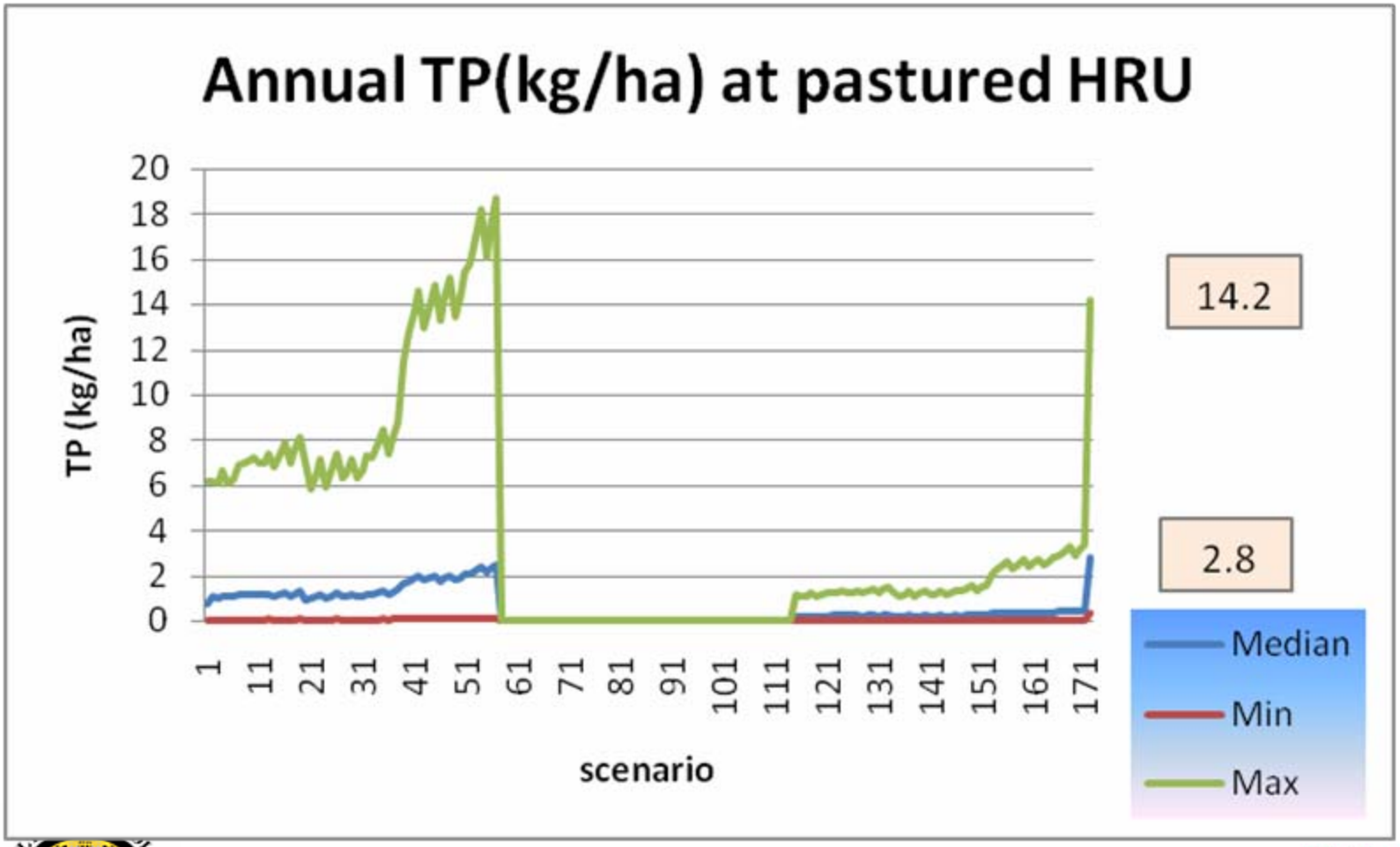


2004

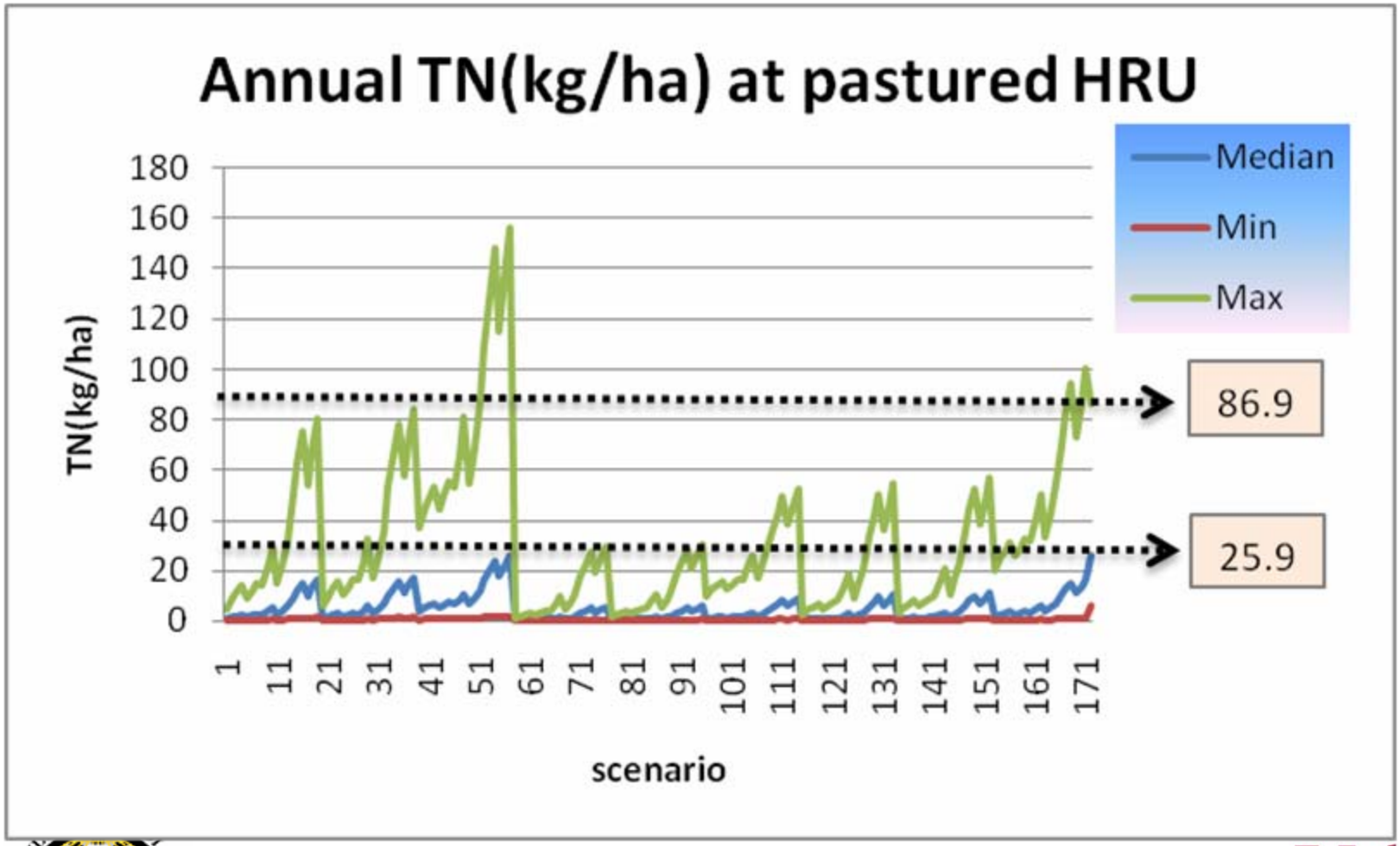
Total P, kg/ha

- < 0.4
- 0.4 - 1.2
- 1.2- 2.2
- 2.2 - 3.5
- > 3.5

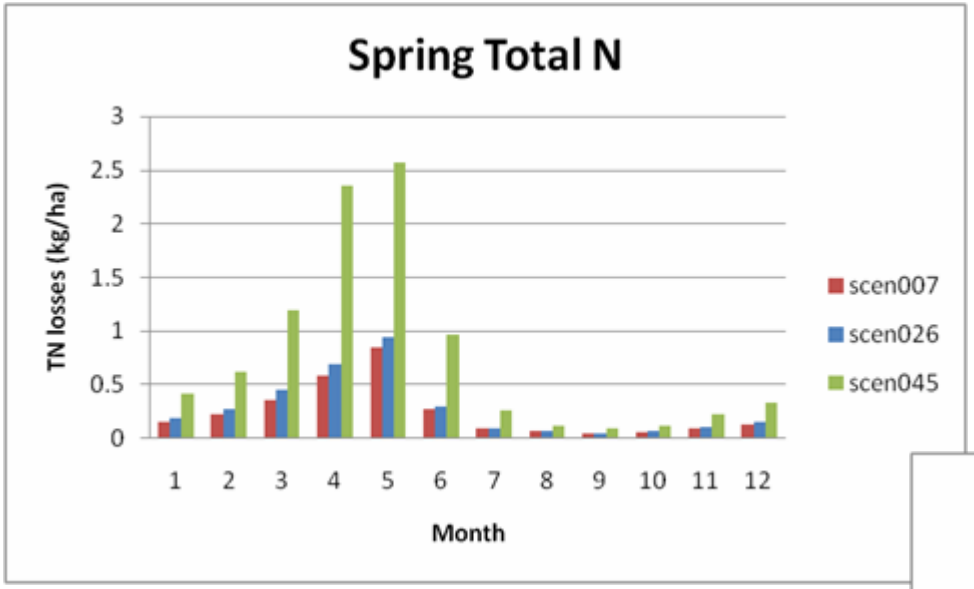
BMP Effectiveness = Total Phosphorus

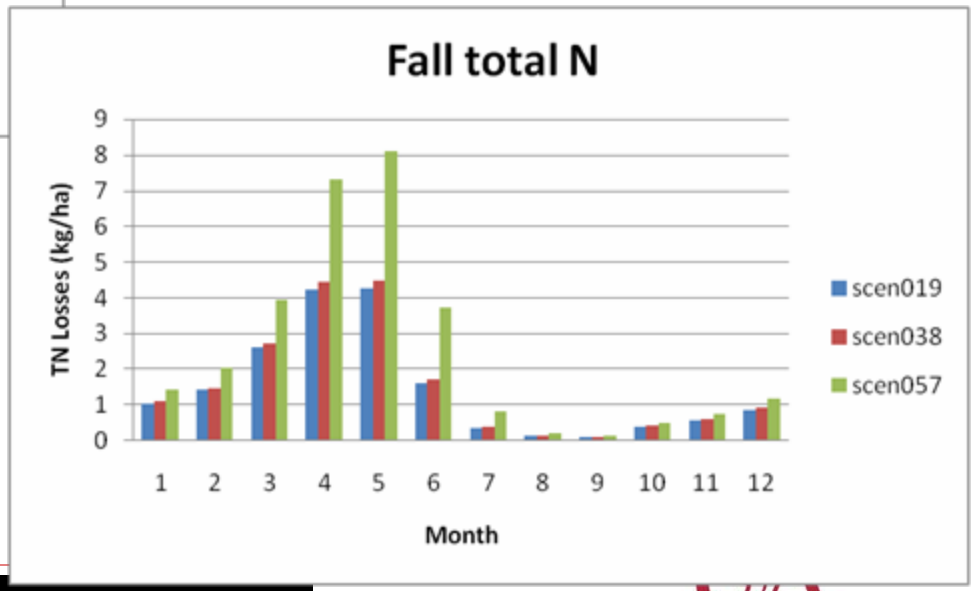


BMP Effectiveness – Total Nitrogen



BMP Impacts on Monthly Losses





Develop comprehensive cost-benefit analyses to optimize BMP implementation, agricultural production, and water quality improvement

- Understand economic importance of agriculture to the region
- Develop agricultural production budgets for cattle/hay producers
- Conduct risk assessment related to BMP cost and effectiveness at meeting water quality goals
- Conduct genetic algorithm to optimize BMP placement in watershed

Direct Economic Impact of Agriculture in Watershed

- Data year 2006, most recent available
- In Washington County, AR, the agriculture sector consists of:
  - Almost 10,000 jobs or 8.3% of all jobs
  - $327M or 7% of all labor income
  - $537M or 7.5% of all value added
- Agriculture is very important to local economy

Initial Stakeholder Meetings

- Introduced the project
- Familiarized the stakeholders more with the watershed concept

- Allowed an early familiarity with the stakeholders needs and fears
- Began the survey process

Factors Evaluated from Stakeholder Surveys

- Opinions of stakeholders on water quality within the watershed
- Opinions of stakeholders on potential sources of water quality degradation
- Interaction of stakeholders and policy makers
- Opinions of stakeholders on the affordability and effectiveness of Best Management Practices (BMPs)

Stakeholder Surveys

Response rates and experience with agricultural and non-agricultural stakeholders

Ag stakeholders:

63 of 75 - 84% response rate

Most farmers that were contacted / reached agreed to do survey

Non-Ag stakeholders:

70 out of 243 - 29% response rate

Four individuals mailed back surveys blank

Specialist stakeholders:

78 out of 160 - 49% response rate

Six institutions were represented

Survey Evaluation of 15 BMPs

- Controlled Grazing
- Vegetative Filter Strips
- Riparian Buffers
- Utilization of Warm and Cool Season Forages
- Stream Bank Stabilization
- Stream Fencing
- Litter Storage Shed
- Soil Testing
- Manure Composting
- Use of Legumes
- Use of NMP
- Manure Fertilization
- Basing Fertilization on Soil Test Results
- Prescribed Grazing
- Cattle Track Stabilization and Improvement

Survey Evaluation of 15 BMPs

- **Why do farmers use BMPs?**
  - Government/University/Extension Recommendations 85 %
  - Personal beliefs that BMPs work to reduce N, P, and sediment loss 88%
  - Farmers want to be early adopters and they anticipate environ. regulations 52 %

Survey Evaluation of 15 BMPs

- **Reasons why don't farmers use BMPs (%)**
  - Cost share assistance is not available 67
  - Using BMPs hurts profitability of farm 56
  - They lack knowledge of BMPs 54
  - Use of BMPs does not improve the perceptions of others that I am a good steward of the land 53

Water Quality Pollution and Protection

- Agriculture was the only source of pollution that had a significant difference between groups
- 41% of Non-Ag believed agriculture is a large contributor to water quality problems
- 5% of farmers agree

Education and Outreach Activities

- Has been a highlight of the project
  - 9 CEAP meetings with stakeholders
  - 3 County extension council meetings
  - 1 CEAP focus group meeting
  - 1000 farmers from the watershed and the Washington county have attended these meeting
- Nutrient management plan (NMP) campaign designed and successfully carried out
  - 18 new farmers
  - 23 soon to expire NMPs renewed
  - 4,940 acres of fields sampled for soil test

Education and Outreach Activities

- Various educational posters/hand outs printed and displayed at various locations in the watershed
  - For example: dinners and coffee houses
  - What is a Best Management Practice?
  - Why should I use BMPs on my farm?
  - What are some BMPs that I can use on my farm?
- 10 different newspaper articles written about the project

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Education and Outreach Activities

- BMP sign
  - A direct outcome of the interactions of this project with stakeholders
  - A protocol developed to identify farmers who qualify
  - 52 signs have been put in and around the watershed

Way Forward

- Complete cost-benefit analyses and optimization of BMPs and
- Educate stakeholders on linkages among BMPs and water quality response
  - A series of meetings planned with stakeholders in 2008
- Work with the CEAP Synthesis team
- Write final report

Questions

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