IOWA CONSERVATION PRACTICES: HISTORICAL INVESTMENTS, WATER QUALITY, AND GAPS

(Final progress report)

February, 2007

(revised version)

October, 2007

Project Overview

Goals

1. What conservation practices are currently in place in Iowa, what is their coverage, and what is the cost of these practices?
2. What are (and have been) the effects of this investment on water quality?
3. What would it take to improve water quality to obtain specific standards?

Surveys Used

	NRI	**CTIC**
Description	USDA Survey	Reported findings from the USDA's Crop Residue Management Survey
Coverage	Contour Farming Contour Stripcropping Filter Strips Grassed Waterways Terraces Erodibility Measures	CRP Tillage Practices
Years	**1997**	**2004**
Nature of Survey	statistically based survey. Data were collected using a variety of imagery, field office records, historical records and data, ancillary materials, and a limited number of on-site visits	"best estimates" of district conservationist are combined with Cropland Transect Surveys
Positives	1. Records the total coverage of the practices (both those that received financial assistance and those that were installed voluntarily without funding).	1. Records the total coverage of the practices (both those that received financial assistance and those that were installed voluntarily without funding).
Negatives	1. Conservation practice usage is calculated from a sample and so assumptions are made about the population.	1. Aggregate data (at the county level) that cannot be directly used in water quality modeling.

Statewide average cost

Practice	Statewide Average Cost
Grass Waterway	$2,127/acre
Terrace	$3.57/ft
Water & Sediment Control Basin	$3,989/structure
Grade Stabilization Structure	$15,018/structure
Filter Strip	$116.83/acre
Contour Buffer Strip	$78/acre
Riparian Forest Buffer	$486/acre
Wetland Restoration	$245/acre
Nutrient Management	$4.09/acre
Contour Farming	$6/acre
No Till	$17.94/acre
Continuous CRP	$142/acre
General CRP	$97/acre

Statewide Coverage

Practice	Statewide Coverage
Grass Waterway (NRI)	2,225,900 acres
Terrace (NRI)	1,997,900 acres
Contour Stripcropping (NRI)	236,800 acres
Contour Farming (NRI)	5,148,200 acres
Mulch Till (CTIC)	8,290,000 acres
No Till (CTIC)	5,220,000 acres
CRP (CRP program)	1,894,488.2 acres

Total Costs of the Practices

Practice	Cost
Terraces	$692,147,676
Grassed Waterways	$95,090,424
Contour Farming	$30,889,200
Contour Stripcropping	$3,552,000
No-Till	$104,308,740
Much Till	$82,861,900
CRP	$175,878,365

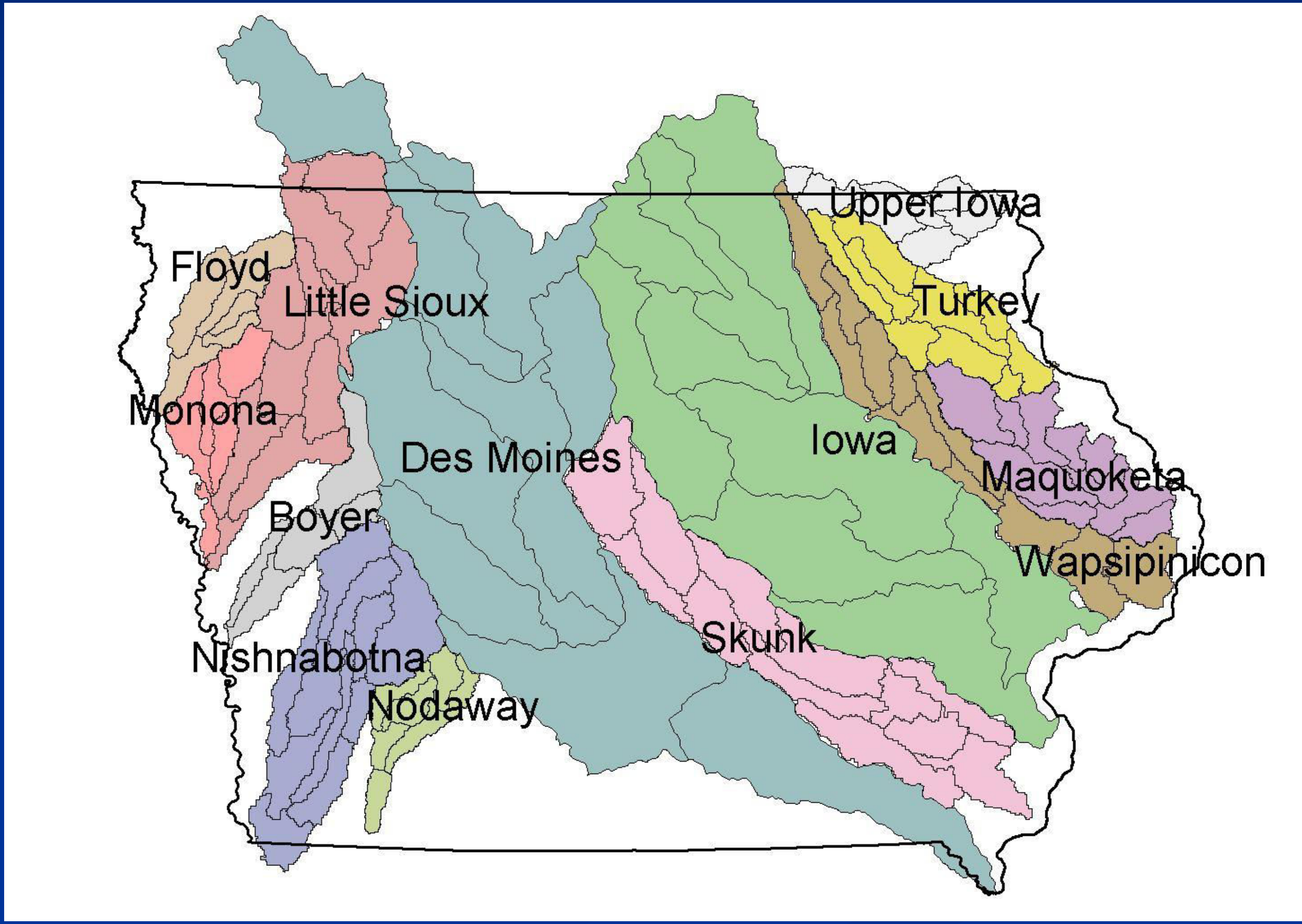
$37,194,949

$397,490,205

- The first two practices are structural practices.
- Divide the installation costs over the lifespan of the practices (terrace: 25yrs, GW: 10 yrs), then the sum of annual payment is: $37,194,949.
- The cost numbers for the rest of the practices are annual payments.
- Then the total annual costs would be:

$37.2million + $397.5million = $434.7

13 Iowa Watersheds



% Improvement due to Existing Practices

	Flow	*Nitrate*	*Org N*	*Min P*	*Org P*	*Total N*	*Total P*
Boyer	-8	23	56	45	50	38	48
Des Moines	-8	14	39	29	37	15	33
Floyd	-4	19	42	41	44	25	42
Iowa	-5	10	41	0	40	13	25
Little Sioux	-7	20	52	40	50	24	47
Maquoketa	-1	8	42	37	42	17	39
Monona	-3	15	49	54	61	26	58
Nishnabotna	-3	21	52	45	47	33	46
Nodaway	-2	28	56	49	51	37	50
Skunk	-6	14	46	40	44	21	42
Turkey	-5	5	38	30	37	18	34
Upper Iowa	-3	7	48	38	47	18	45
Wapsipinicon	-8	6	46	34	45	11	40

What would it take to improve water quality?

- Numerous conservation practices could be implemented on any field, each with different levels of effectiveness and costs

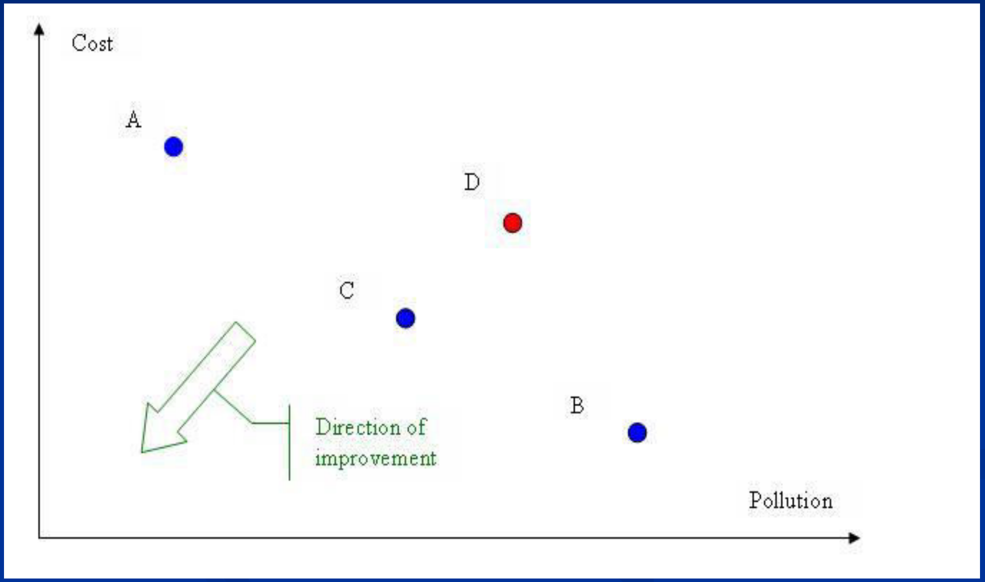
- Solving for the least-cost solution requires comparison among a very large number of possible land use scenarios

Approach

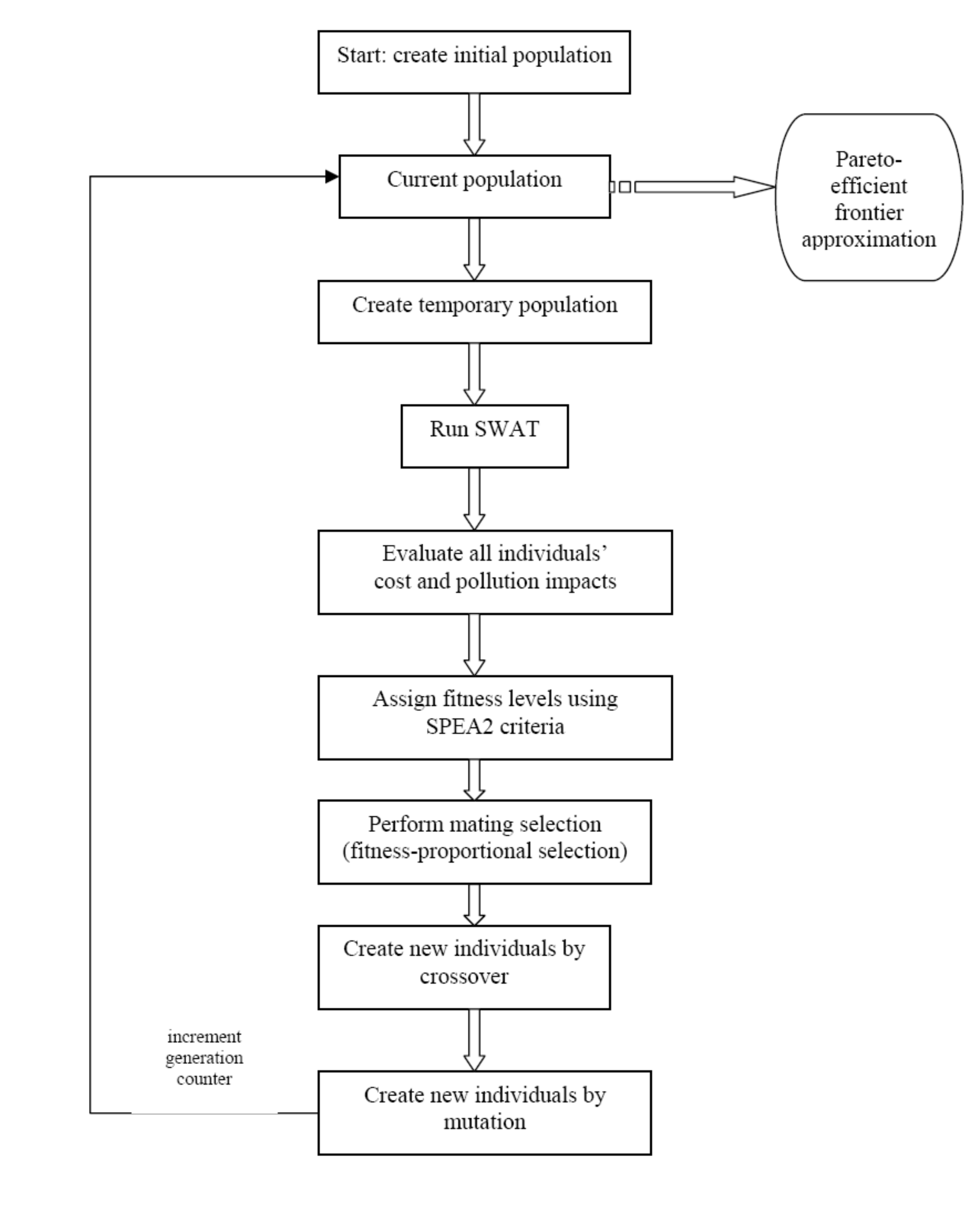
- Evolutionary algorithms provide one search strategy
- mimic the power of evolution, which, in effect, is a method of searching for solutions among an enormous amount of possibilities (Mitchell, 1999)
- Outline basic idea only

Pareto Optimality

- Point A is not clearly preferred to point B (since B has lower costs, but higher pollution)
- Point C ought to be preferred to point D (since D exhibits both lower costs and lower pollution levels)
- We try to identify a frontier like ABC and then push it toward the origin



Flow diagram



Land use options considered

1. Land Retirement
2. Corn-Soybeans, Conventional Tillage
3. Corn-Soybeans, No-Till
4. Corn-Soybeans, 20% Fertilizer Reduction
5. Contouring
6. Terracing
7. Combinations (as sensible) of above practices

State-wide results

- Apply the evolutionary algorithm to the 13 watersheds
- A challenging task, given the number of HRUs and current computing capacity
  - Results presented are based on over 91 days of CPU time
  - Over 116,000 SWAT model runs

- Overall, the algorithm is able to identify scenarios which result in significant reductions in loadings of nitrates and phosphorus relative to baseline
- Results must be interpreted with caution:
  - it is possible that better solutions could be identified, given enough CPU time

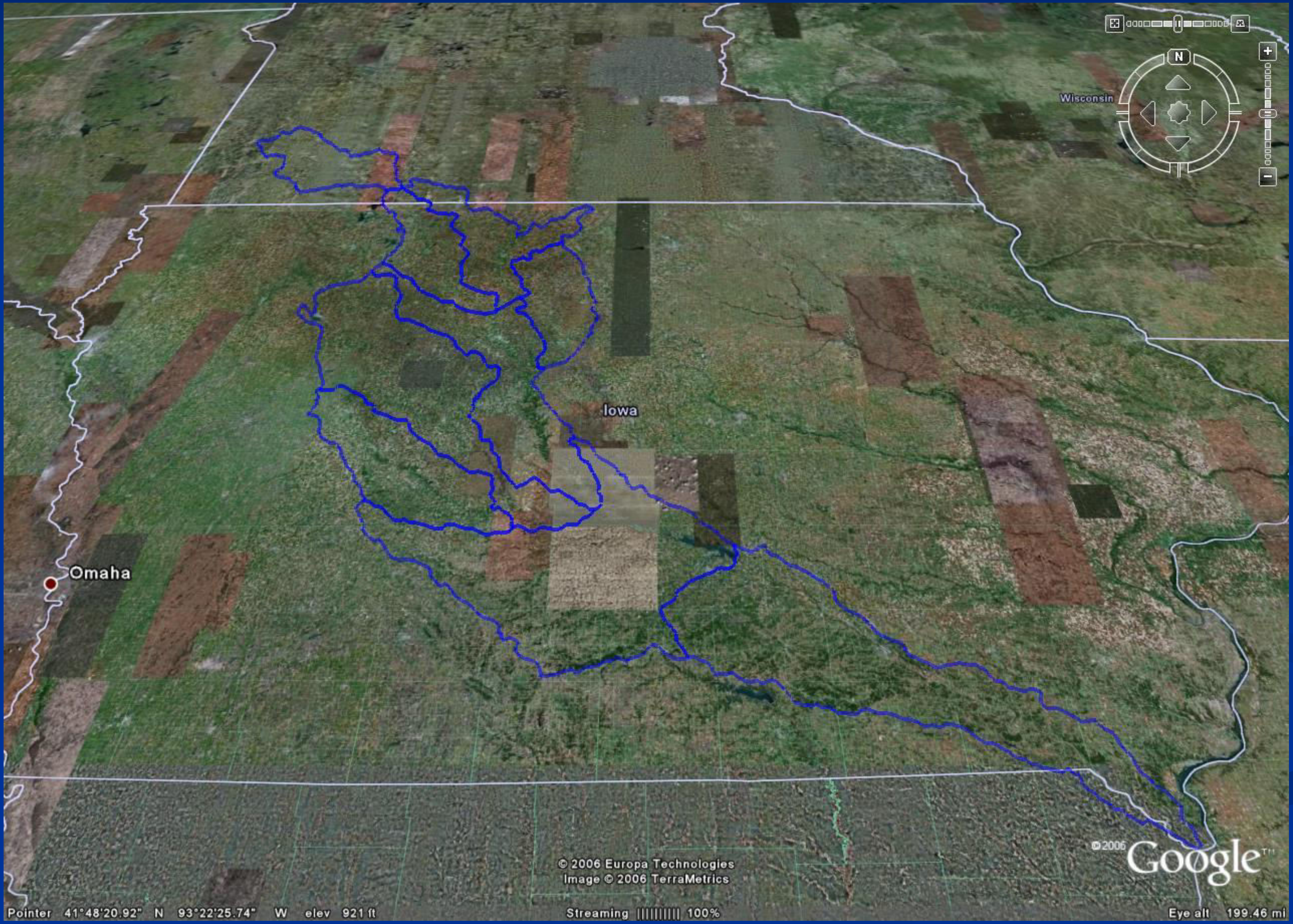
State-wide results: P-N targeting

Watershed	P loading, kg	Actual P loading, % of baseline	P concentration, mg/L	Gross Cost, $	Net cost, $	N loadings, in % of baseline	N concentration, mg/L
Boyer	648,398	59.7	0.742	14,950,585	4,708,885	66.2	2.232
Des Moines	1,482,270	58.387	0.129	190,010,000	145,910,600	75.9048	4.514
Floyd	295,676	52.2	0.560	8,056,582	2,778,832	64.2	4.494
Iowa	2,432,160	67.1	0.206	193,575,632	109,999,532	75.2	6.189
Little Sioux	800,924	57.5	0.491	33,142,350	11,949,650	64.2	3.617
Maquoketa	14,589	39.8	0.323	2,218,699	-15,780,401	60.6	3.682
Monona	200,116	60.3	0.546	7,753,342	-1,491,738	55.1	4.158
Nishnabotna	2,068,920	67.3	0.625	43,579,662	13,676,562	65.1	2.408
Nodaway	354,088	61.6	0.401	8,140,247	3,370,077	72.9	2.049
Skunk	1,842,720	63.6	0.482	50,379,561	29,196,661	75.2	2.595
Turkey	981,900	71.3	0.381	17,057,490	1,707,090	74	2.999
Upper Iowa	130,640	60.5	0.100	11,038,459	3,740,489	75.8	1.635
Wapsipinicon	413,100	67.6	0.135	33,030,359	12,112,059	70	3.861

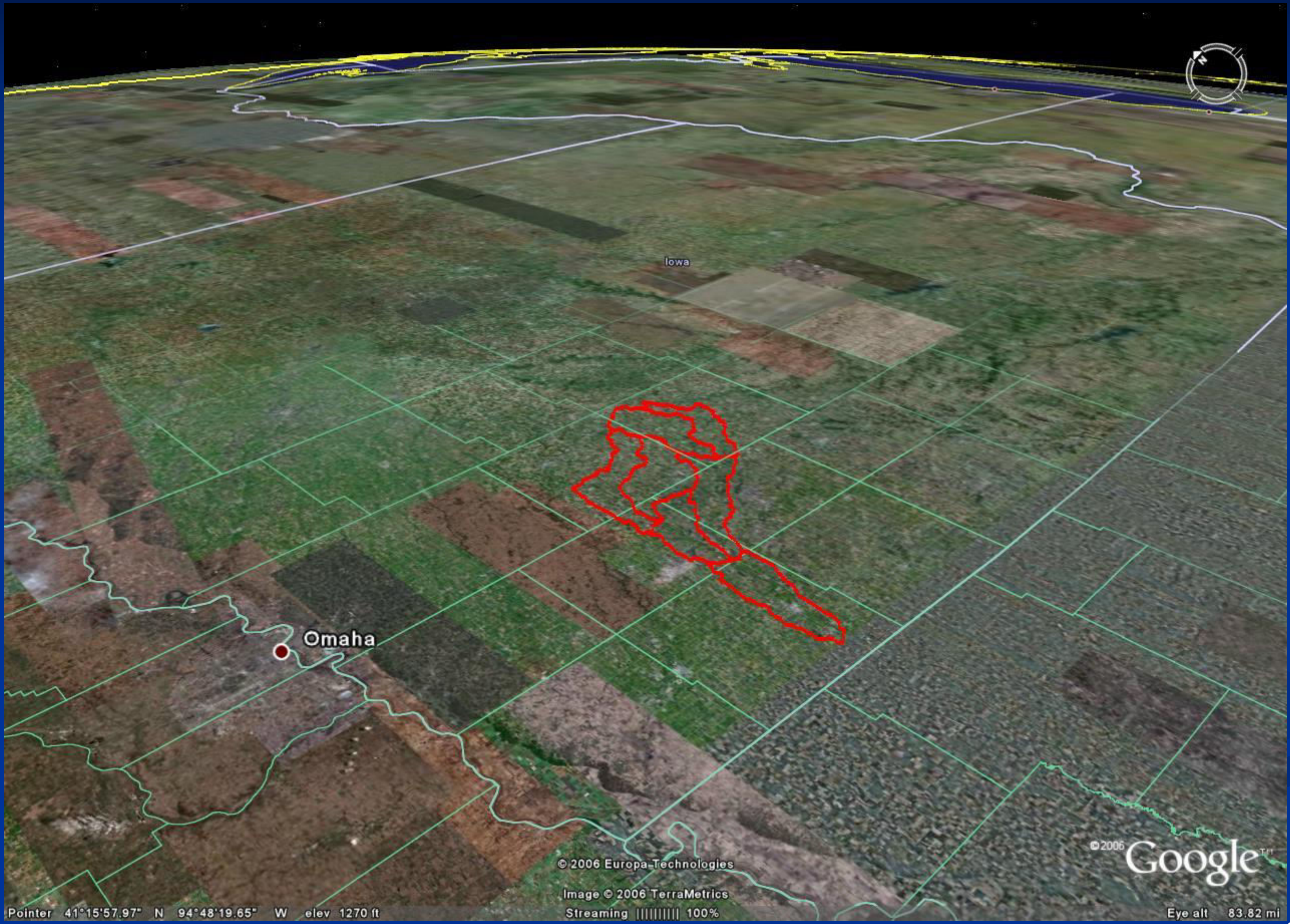
State-wide summary of P-N targeting

- The total gross cost of implementing the management scenarios is almost $613 million a year
- The net cost is estimated to run just under $322 million a year
- Following the prescriptions of the algorithm for each of the watersheds results in the state-wide reduction in phosphorus loadings of over 36%
- would simultaneously result in the state-wide reduction in nitrate loadings of over 31%

Comparison of selected watersheds: Des Moines



Nodaway



Iowa
Omaha
© 2006 Europa Technologies
Image © 2006 TerraMetrics
Streaming |||||||||| 100%
Pointer 41°15'57.97" N 94°48'19.65" W elev 1270 ft
Eye alt 83.82 mi
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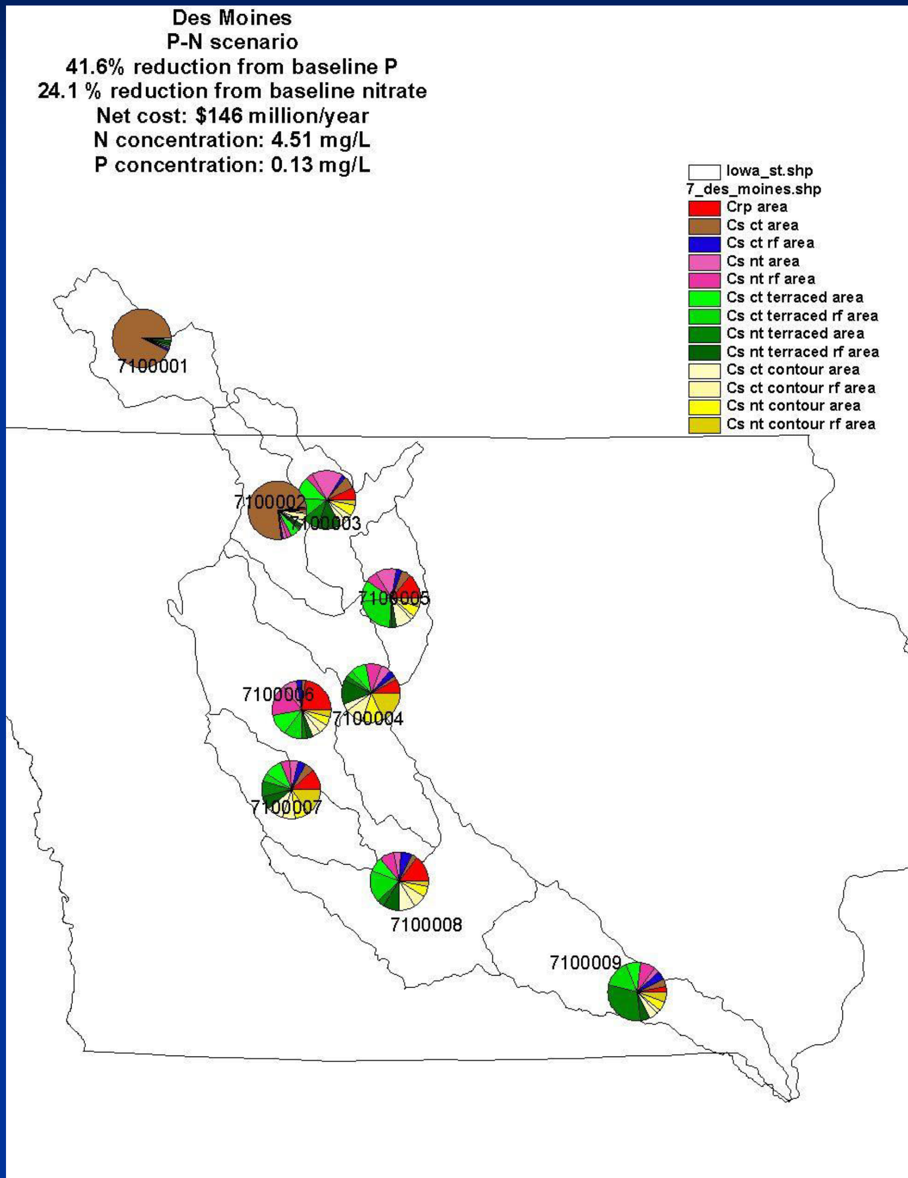
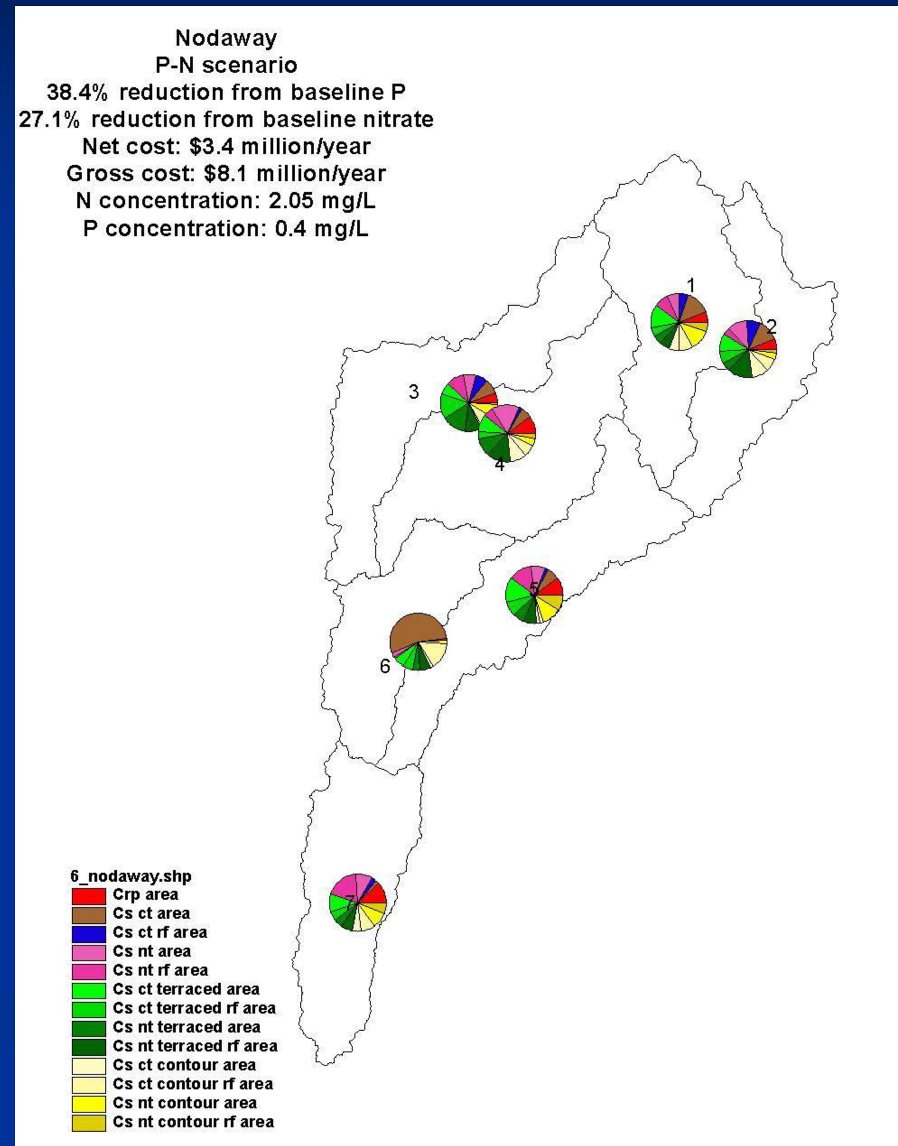
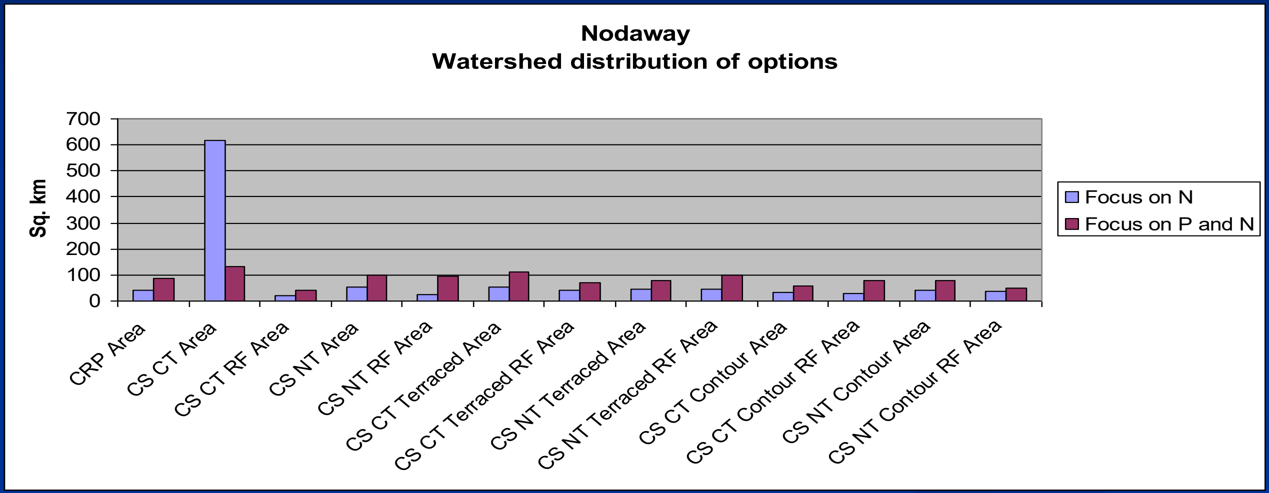
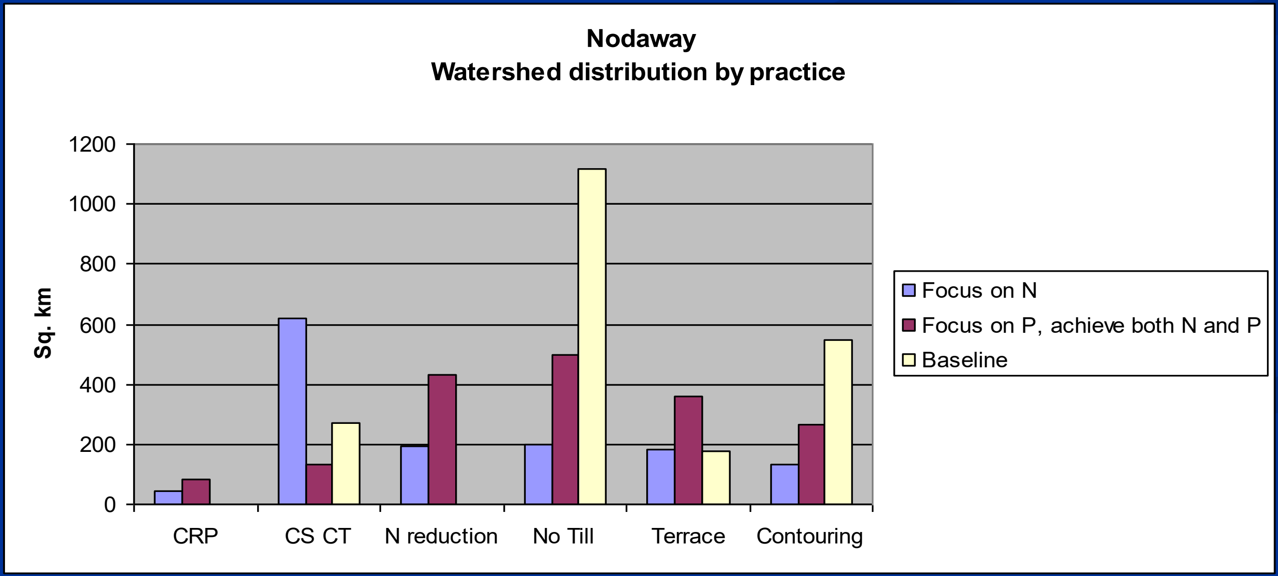
Scenario Maps





Distributions of options (alleles) and practices





Conclusions and Recommendations

- Significant reductions in both phosphorus and nitrogen loadings can be achieved in all of the watersheds in the state
  - The costs are significant
  - But, much smaller than they would be if didn't carefully select which practices go where (targeting)

- Focus on N alone produces a markedly different watershed configuration than when the focus is both on P and N

- Practices which are efficient for phosphorus and erosion control are, in general, not efficient in controlling nitrogen
  - If we wish to focus to both nutrients, combining traditional structural practice with measures directly targeting nitrogen will be necessary

Caveats and Research Needs

- Inclusion of other options will very likely alter results
- Results needed to be interpreted with caution
  - E.g., we do not recommend actual removal of conservation practices or abandonment of conservation tillage
- Lack of detailed spatial data only allows identification of desired conservation option mix at the subbasin level
- Better hydrologic, water quality, land use, and farm-level data would help to add realism to the analysis
- Studying sensitivity of the results to changes in costs, efficiencies of conservation practices and weather conditions would be very helpful in providing

Continuing Work

- Sergey Rabotyagov's PhD thesis, Iowa updates
  - 2007 land and corn prices
  - Added grassed waterways as an option
  - Continued improvements to SWAT
  - 30% N and P reductions ~ $300 million/yr cost
- UMRB work (also Sergey)
- Smaller watershed work (field scale)
  - Walnut Creek (CEAP project – USDA)
  - Boone (USDA-CSREES)
- Application of GA for biofuels sustainability