

SWCS Workshop “Managing Agricultural Landscapes”
Research Methods: Communicating with Constituencies
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**I-FARM:
A Web-based Model for Quantifying Farm and Regional Scale
Impacts of Bio-refinery Feedstock Supply**

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Goal of the model

Provide an on-line farm-scale and regional scale simulation tool which accounts for socio-economic, and soil, air & water quality effects of sustainable integrated crop and livestock farming and biomass feedstock supply to bio-refineries



Technical approach

- Free access system independent database-driven web-application
- Operating system servers: Windows 2000 Server
- Languages: ASP-VBScript, JavaScript, C# ASP.NET
- Databases: Microsoft SQL Server
- Users: 50 simultaneously per server on 4 servers
- Series of standard input sets
- Save and retrieve features

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I-FARM includes:

- Livestock production systems (beef, dairy, swine)
- Cropping systems (rotation builder; corn, soybean, wheat, oats, switch grass, pasture & forage grasses, alfalfa)
- Biomass harvesting and handling systems
- Manure handling & application systems
- ArcGIS server based field locator map tool

Data

Crop yields (county level)

Machines (properties, investment prices, operation labor requirements, fuel consumption)

Manure production

Soils databases

Topographical maps, aerial images

Nitrogen deposition

Generated weather database

Sources

2002 Ag Census, Oak Ridge Nat Lab

AgEcon Departments, industry

ASABE standard

SOILS5, ISPAID7, SSURGO 2.2

ESRI, ISU on-line image server

NADP

Cligen/WEPP

Incorporated models:

- soil water erosion (RUSLE, modified for corn stover collection)
- soil organic carbon tends (Soil Conditioning Index SCI)

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Simulation result pages:

Field level

- Soil losses (15-day time step) and SCI-index
- N-P-K nutrient budget, fertilizer applied, and aerial emissions

Farm level

- Agronomic crop, forage, and biomass budget
- Livestock production & manure spreading schedule
- Diesel and LPG consumption (traction & drying)
- Labor requirement distribution (15-day time step)
- Annual government payments (Direct, CCP, LDP)
- Investments, loans, and economic evaluation (annual farm income)

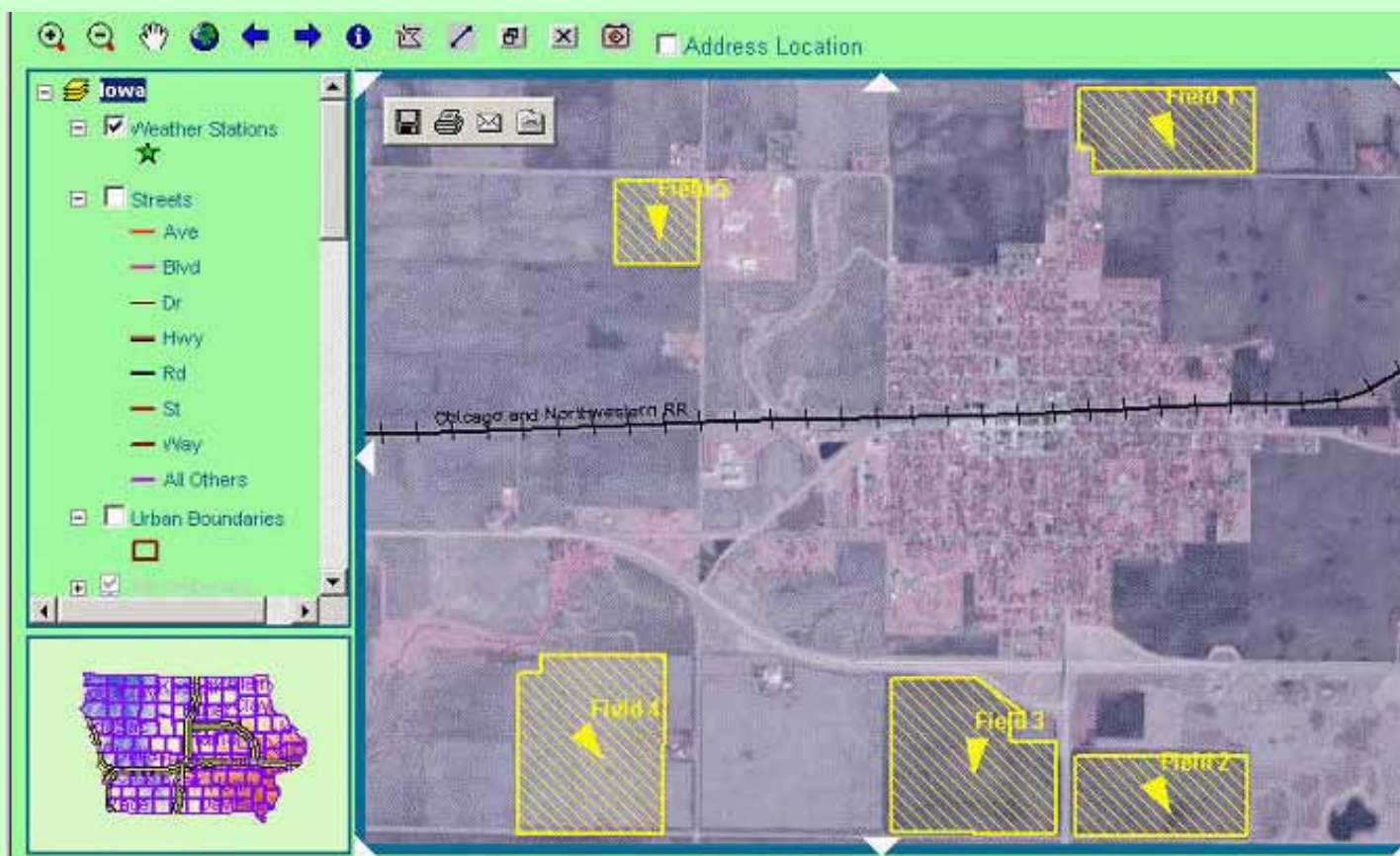


Farm bottom line (\$/year)		
	Revenues	Expenses
Livestock	255,085	183,386
Crops	233,220	155,579
Hired labor		190
Custom farming		11,341
Government payments*	19,477	
Bank loan payments		34,226
	507,782	384,722

Net farm income (before taxes) **123,060** (or 66.47/h or 123.06/acre/year)

*Government payments 10.52/h or 15.8% of farm income

ArcGIS server based farm field locator tool in I-FARM



- Users zoom in into map and draw polygons around their fields
- Software provides per field: dominant soil type and average hill slope and passes these values on to I-FARM through SQL database tables

Field level nutrient budget example

Nutrient balance field 2, 271 acres 2-year rotation: corn for grain soybeans (lbs/year) excl. run-off, leaching/percolation, mineralization and immobilization	import or available for plant growth			export or unavailable for plant growth		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
excreted animal manure applied on the farm	6401	5098	4300			
manure N volatilization (NH ₃ emission)				1728		
chemical fertilizer applied	13000		4860			
atmospheric nitrogen fixation through legumes	21951					
crop harvested				34051	5499	9270
crop N volatilization during senescence (NH ₃ emission)				6045		
atmospheric N deposition (from NADP database)	1689					
soil-N denitrification (8% of N-input, N ₂ & N ₂ O aerial emissions) ^(basis)				1263		
totals	43041	5098	9160	43087	5499	9270

nutrient balance summary	
nitrogen deficit	46 (= 0 lbs/acre/year)
phosphate deficit	401 (= 1 lbs/acre/year)
potassium oxide deficit	109 (= 0 lbs/acre/year)

Aerial emissions from field	lbs/year
NH ₃ -N* (ammonia)	7773
N ₂ O-N** (nitrous oxide)	263
N ₂ -N** (nitrogen gas)	1000

* sum of manure, fertilizer, and crop senescence volatilizations
 ** from soil nitrogen denitrification^{ref}

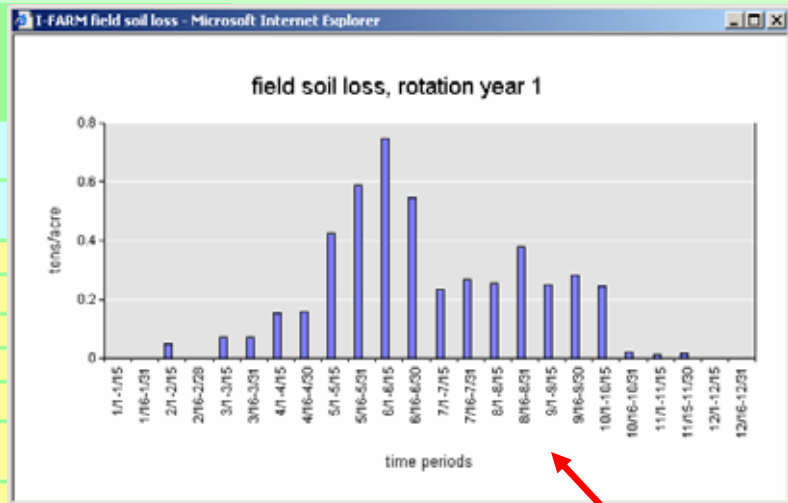
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Erosion simulation example

Soil erosion status of RUSLE modules in I-FARM
 rainfall-runoff erosivity factor (R) for Montgomery-county, IA is: 160
Soil Conditioning Index SCI
 organic matter growth rate for city: Clarinda (Page-county, IA)

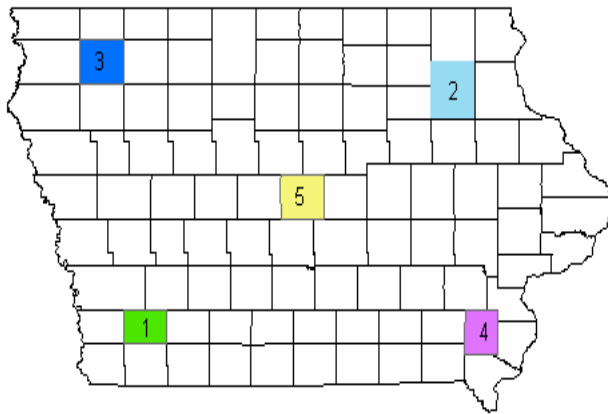
	units	field 1 sequence	field 2 sequence	field 3 sequence
		corn for grain	2-year rotation: corn for grain soybeans	2-year rotation: wheat (winter)soybeans
field area	acres	158	271	270
soil name		COLOCOLO ^{info}	SHELBY ^{info}	SHELBY ^{info}
soil surface texture		silt loam	loam	loam
hill slope	percent	1.0	5.0	5.0
slope length	feet	200	150	150
tolerable soil loss (T)	tons/acre/year	5.00	5.00	5.00
field specific soil loss (A)	tons/acre/year	2.00	4.09	1.88
Soil Conditioning Index		0.25	0.21	0.33



rotation year	15-day period	T _{avg} (F)	precipitation (in)	time-distributed erosivity R-factor	field operations	field status	prior land-use PLU-factor	on-field residue			soil surface			canopy			cover management C-factor	soil loss ton/ac	
								from crop	by mass		roughness R _u (in)	surface roughness subfactor SR	surface cover subfactor SC	canopy land cover F _o (%)	droplet fall height H (ft)	canopy cover sub-factor CC			
									(%)	(lb/ac)									residue cover S _p (%)
1	1/1-1/15	22	0.9	0.00		fallow	0.90	soybeans	54	2,171	53	0.24	1.00	0.16		0.14	0.0000		
1	1/16-1/31	25	1.2	0.00		fallow	0.90	soybeans	49	1,990	52	0.24	1.00	0.16		0.15	0.0000		
1	2/1-2/15	28	0.1	1.60		fallow	0.90	soybeans	49	1,980	52	0.24	1.00	0.16		0.15	0.0504		
1	2/16-2/28	23	0.7	0.00		fallow	0.90	soybeans	47	1,888	50	0.24	1.00	0.18		0.16	0.0000		
1	3/1-3/15	40	2.7	1.60		fallow	0.90	soybeans	38	1,559	42	0.24	1.00	0.23		0.20	0.0697		
1	3/16-3/31	36	0.3	1.60		fallow	0.90	soybeans	38	1,528	42	0.24	1.00	0.23		0.21	0.0714		
1	4/1-4/15	53	0.9	3.20		fallow	0.90	soybeans	35	1,437	40	0.24	1.00	0.25		0.22	0.1532		
1	4/16-4/30	55	0.1	3.20	planting corn for grain	corn for grain growing	0.90	soybeans	35	1,428	39	0.24	1.00	0.26		0.23	0.1590		
1	5/1-5/15	62	2.8	8.00		corn for grain growing	0.90	soybeans	31	1,258	35	0.24	1.00	0.29	5	0.1	0.95	0.25	0.4255

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Regional scale simulation



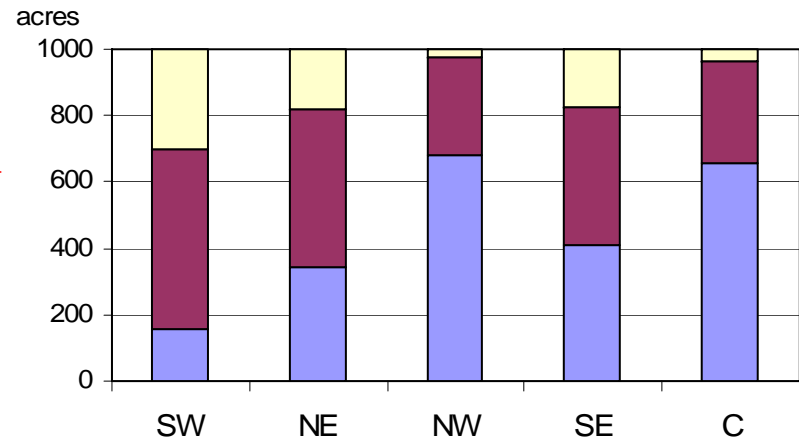
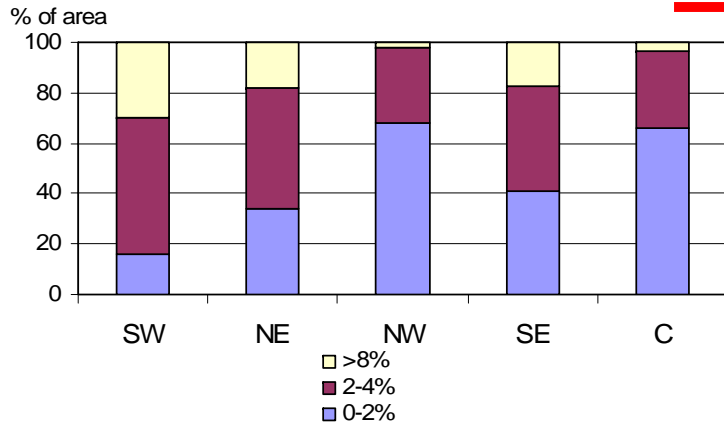
Iowa Counties

- 1 Montgomery
- 2 Fayette
- 3 O'Brien
- 4 Henry
- 5 Story

Four types of hypothetical farms:

- status quo grain farm (baseline)
- more sustainable grain farm
- more sustainable grain and pork farm
- more sustainable grain and biomass (corn stover + switchgrass) farm

Land per County by slope class



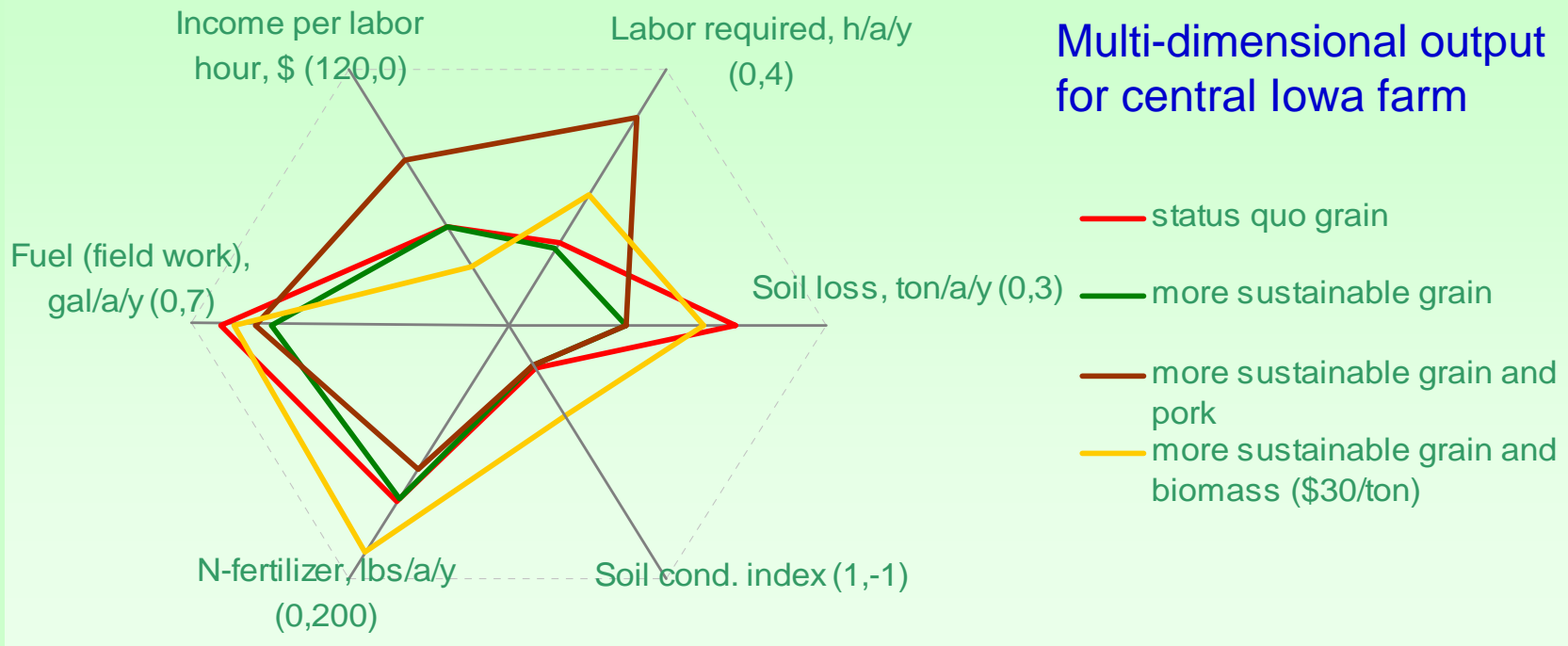
- field 3, non-tiled, slope >8%, land-use: corn/soybeans, CRP or switchgrass
- field 2, tiled, slope 2-8%, land-use: corn/soybean rotation
- field 1, tiled, slope 0-2%, land-use: continuous corn

Land use and land allocation

Topographical distribution

<http://i-farmtools.org>

Results



Required biomass price to achieve equal farm income per labor hour (\$/ton at farm gate)

	SW	NE	NW	SE	C
Status quo grain farm	53	42	26	21	27
More sustainable grain farm	64	46	27	45	29
More sustainable grain and pork farm	52	32	29	38	24

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New components and features recently built into I-FARM

- New harvesting methods based on recent data from experiments, carried out at the University of Wisconsin Madison
- Custom farming, based on recent data from ISU Department of Economics
- Inclusion of NRCS soils database SSURGO 2.2 with tabular survey data (and spatial distribution for I-FARM GIS-module under construction)
- Upgrade from 20 to 50 on-line users per server on 4 servers.
- Upgrade internet connection speed to servers from 10 to 100 Mbps

We ran an I-FARM workshop on the **2006 Biobased Industry Outlook Conference** in August in Ames (IA) for 24 users simultaneously. Tutorial and exercises are on-line at <http://i-farmtools.org>

Stover harvest methods in Wisconsin experiments

		method					
		1	2	3	4	5	6
passes		single (grain only)	single	single	single	two	three***
combine	header	ear snapper	whole plant	stalker/front chopper	ear snapper	-	-
	stover processor	none	rear chopper		rear chopper	-	-
	combine pulled stover cart	none	1	1	1	-	-
	tractor pulled stover carts	none	2	2	2	-	-
	tractor pulled grain carts	1	1	1	1	-	-
	tractors in field	1	3	3	3	-	-
	men in field	2	4	4	4	-	-
forage harvester	header on combine	-	-	-	-	windrow	windrow
	stover processor	-	-	-	-	chopper	chopper
	harvester pulled stover cart	-	-	-	-	1	1
	tractor pulled stover carts	-	-	-	-	2	2
	tractors in field	-	-	-	-	2	2
	men in field	-	-	-	-	3	3
stover removed (%)		0	90	90	90	60	60
types of fractionated stover		0	1	2	1	1	1
theoretical power unit speed (miles/h)		4.5	2.3	3.4	4.2	7	5.5
working width (ft)		15	15	15	15	30	40
field efficiency (%)		80	70	72	75	70	70
machine investment for combine/harvester, and its implements, excl. tractors and carts (\$)		195000	235000	260000	210000	275000*	275000**

* excluding grain combine

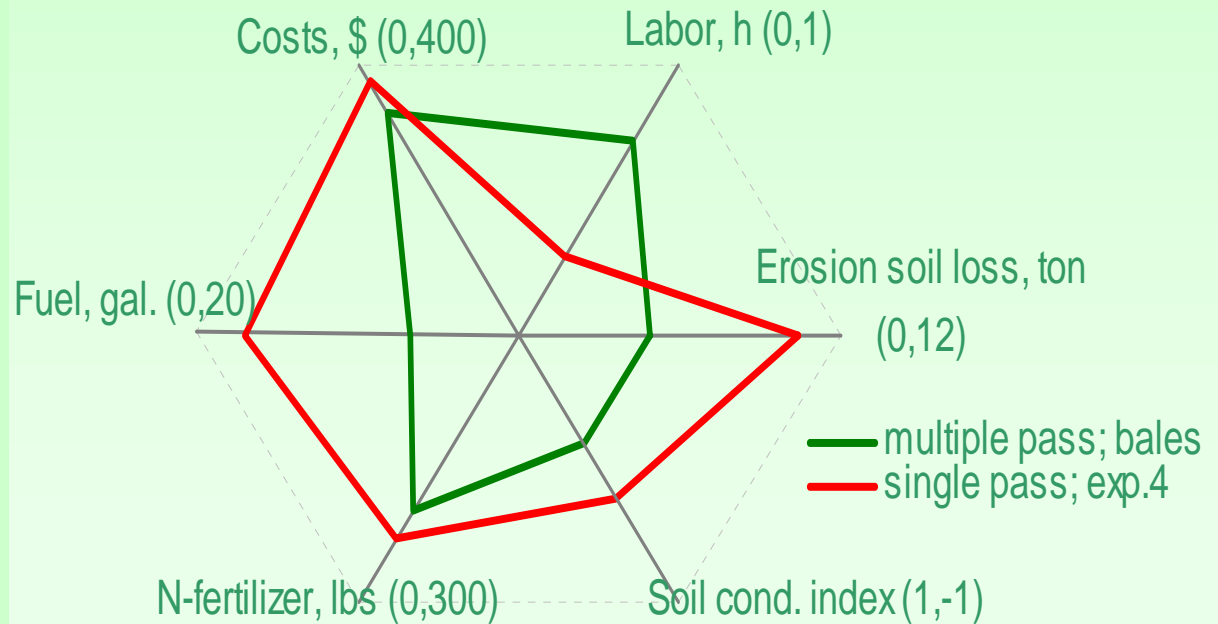
** excluding grain combine and shredder, stover harvest with forage harvester

*** excluding grain combine; shredding stover between grain harvest and stover harvest with forage harvester

Chemical fertilizers applied		
Soil erosion status of RUSLE modules in I-FARM		
I-FARM - Microsoft Internet Explorer		
Farm bottom line (\$/year)		60
	Revenues	Expenses
Crops	374,410	324,588
Hired labor		7,080
Custom farming		9,726
Government payments*	44,795	
Bank loan payments		45,703
	419,205	387,097
field specific soil loss (A) tons/acre/year		4.92
Soil Conditioning Index		0.20

where			
N	P ₂ O ₅	K ₂ O	
(lbs/year)	(lbs/year)	(lbs/year)	
197620			
		99567	
	35550		
197620	35550	99567	
198	36	100	

Multi-dimensional output for corn and corn stover produced on a 4% hill slope (per acre per year)



Communicating with constituencies

Research & Development

- Project groups, 3 large multi-institutional national projects (USDA, DOE, NSF)
- I-FARM Advisory Committee, members: NRCS, Iowa State, Coop. Extension, NSTL, ORNL/DOE, Leopold Center, and erosion consultant.
Annual meetings.
- Ad hoc specialist consulting

Structured interaction with users

- Workshops, seminars
- Peers at conservation and extension agencies
- Education (college and university class rooms)
- Research Focus groups
- Farmers (field days)

Random on-line users

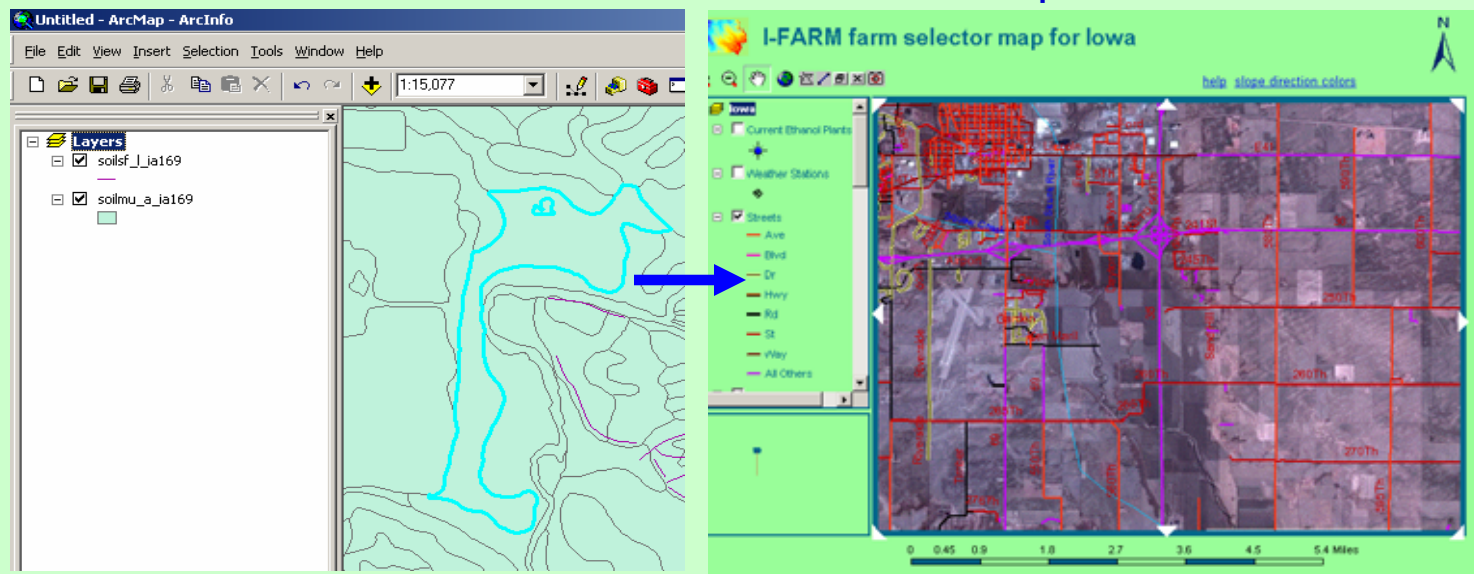
- 8,000 logons in 3 years
- On-line feed-back forms

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I-FARM planning

- Improve erosion module in cooperation with USDA RUSLE2-team
- Adding more perennial and annual biomass crops and cover crops
- Inclusion of radar/spider-diagram generation tool
- Cross-validation with experiments and other models
- Conducting scenario-studies
- Writing an I-FARM manual
- Extend GIS-module with new SSURGO soil database spatial distribution data



- Location specific crop risk assessment tool

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