Biomass Production Decision Making Tools and Planning

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U.S. Administration Biofuel Goals

- 35 billion gallons by 2017
- 60 billion gallons by 2030

U.S. petroleum imports \cong 181 billion gallons

US Biomass inventory = 1.3 billion tons



From: Billion Ton Vision, DOE & USDA 2005

What farmers grow now...



1 + Billion tons per year?

The most revolutionary transformation of the landscape in a century...

- The Industrial Revolution
 - Increased worker productivity, urban migration
- The Petroleum Revolution
 - Cheap energy, agricultural mechanization, synthetic fertilizers

What will motivate the Bioeconomy Revolution?

Biomass Planning Tools

- Biomass Supply and Logistics
 - Integrated Biomass Supply and Logistics (IBSAL) model.
 - Oak Ridge National Laboratory, S. Sokhansanj
- Life-cycle energy and emissions
 - Biofuel Energy Systems Simulator (BESS)
 - Corn grain-based ethanol systems
 - University of Nebraska, K. Cassman
- Farm enterprise modeling
 - I-FARM
 - Iowa State University, Robert Anex
 - Pennsylvania State University, Tom Richard

Farmer decisions depend on...

- Experience Tradition, training, technical assistance
- Ability Time, labor, management
- Equipment Owned, leased, contracted
- Profit Income, expenses, subsidies
- Risk weather, markets, insurance
- Environment Recreation, sustainability, stewardship



The I-FARM decision tool

- Web-based
- GIS interface
- Menu driven
- Database algorithms
- Data transparency
- User adjustable
- Free





A brief tour...

i-farmtools.org re-login home

user 1 logout

project: Tom

main menu

internal data miscellaneous on-line tutorials

who is on-line? feed back simple form evaluation form

farm run

report

save retrieve data

> info tools examples FAQ e-news

imperial/US 💌 system 90

change colors, fonts, etc.



I-FARM

integrated crop and livestock production and biomass planning tool



Welcome Tom! You may start I-FARM now.

1. Review user settings

- 2 Click farm in main menu to enter your input or retrieve to load a
- 3. Remember to LOGOUT when you are done!



On-line tutorials

I-FARM tutorial and exercises user 1: Tom

- Exercise 1. Whole farm simulation. Takes approx. 50-60 minutes; start
- Exercise 2. Integrated GIS-tool to identify farm fields and their properties. Takes approx. 30-40 minutes; start.....
- Exercise 3. Conventional and experimental corn stover harvest simulation. Takes approx. 50-60 minutes ; 'Under revision'

Analyze report pages and answer questions:

Go to report page 'crops'.

- 1. How much corn stover (tons/year) is available for export/sales?
- 2. How much wheat straw (tons/year) is available for export/sales?
- 3. How much swithgrass (tons/year) is available for export/sales?
- Go to report page 'fertilizers & manure'.
- 4. How many pounds of nitrogen are applied per year on this farm in the form of chemical fertilizer?
- 5. How many pounds of nitrogen are applied per year on this farm in the form of swine manure?
- Go to report page 'nutrients and aerial emission', and display the nutrient balance for field 1, where corn stover is harvested. Notice that we tried to balance for N, P, and K. Use the calculator from Start/Programs/Accessories
- 6. What is the annual export of N from field 1 (lbs/yr)?
- 7. What is the residue removal fraction (N_residue devided by N_total) of the total N exported from field 1?
- 8. What is the ammonia emission fraction (sum of two N_NH3's devided by N-total) of the total N exported from field 1?

Input farm site and characteristics

I-FAI integrated crop and liv and biomass p	RM vestock production lanning tool	
project user farm name state	Tom *=mandatory input Milk and Honey lowa map default OK why buttons	Michigan Sin Michigan New York
county land form region	2 Southern Iowa Drift Plain, Northwest Iowa Plains, Paleozoic Plateau 💌 map	Dis Indiana Kentucky
weather station soils database	Iowa City (Johnson) in district 💌 map SSURGO 2.2 💽 OK	The second second
closest town farm has livestock manure import from other farms	Des Moines (Polk-county) map for org. matter (SCI index)	- deland
corn stover usage on own farm farm labor availability	0 Sold 3000 (1 people-year) h/yr, of which 300 OK refresh farm menu	Y

GIS Interface



I-FARM farm selector map for lowa 은 🖑 🍐 🏷 🖉 🔊 help plope direction colors 🥔 जिल्ल Current Ethand Plan Abolites Stations Z Streets — A.a. — Ekat 5.4 Miles

Crop management and yield

	integrated an	I-FARM I crop and livestock I biomass planning	production 1910		£
input methods	number of fields	2 OK refr	esh field navigation too	I.	
farm description	field	1: corn for grain	OK copy fu	nction	
farm menu	area	680 ac			
location/general fields	conservation paractices	no filter strip	none		
biomass handling investments & loans	soil type (Palo Alto-County) SSURGO 2.2	CANISTEO SILTY C	CLAY LOAM, 0 TO 2 PER	CENT SLOPES	
	field is	tiled	denitrification 1009	% farmer owned 📃 💌	I
	land-use	continuous crop	soil test P 0	ppm, method Mehlich-3	▼ OK
	soil field is	non-irrigated 💌	eFOTG slope	%, slope length 61	ft_OK
	сгор	corn for grain	•	plow / tillage 💌 system	
	crop property page	yields 💌	OK why buttons		
	corn yield	159 bu/acre/y	/ear		
	stover harvest	exp. corn/stover 2	(single pass), see metho	ds 🗾 methods	
	residue	10% on field, 90%	removed 💌 residue ma	nagement	
		OK refresh farm m	непи		



data in I-FARM crops

- yields, 2002 Census

- yields, residues
- nutrients in 3 harvested crops
- nitrogen fixation legumes

Preference - Windows Internet Explorer									
🔊 http://www.i-farmtools.org/i-farm/reference.asp?id=19									
Shinners, K.V., B.N. Binversie, and P. Savoie, 2003. Harves feedstock, Paper Number 036088. American Society of Ag 23 pp, download.	st and storage of wet ricultural Engineers. A	and dry co Innual Interr	rn stover as a biomass national Meeting, Las Vegas,						
close window									
Done	🔛 🔛 Inte	ernet	🔍 100% 👻 🏑						
			 atmospheric N-deposition generated weather data 						
storage method	storage time dry ma (months)	tter loss (%)	- precipitation - rainstorm intensity miscellaneous						
outdoors, unprotected on ground 12 25 - topographic factors (eros - ethanol plants									

Databases and references

Whole farm production

I-FARM simulation crops, forages, and for farm 💌 show	bioethano	vearly balance	g o								
	gra	ains, forages, :	silage, stover	r, straw							
	unit	produced	removed	consumed	used	loss	import	,	export		
corn (grain)	bu	108,120						108, re	120 to bio- efinery*		
corn stover (dm)	Ton	3,027	2,725			255			2,470		
*Bioethanol produ Expected bioethano (at a conversion rat	corn stover (dm) Ton 3,027 2,725 255 2,470 *Bioethanol production as a result of this farm *Bioethanol production as a result of this farm 302,736 gal/year Expected bioethanol from the dry-grind grain to bioethanol plant (at a conversion rate of 2.8 callons of bioethanol per bu of corn grain) 302,736 gal/year										

Crop revenue

Economic analysis (\$/year) price list and references for crops, livestock, and manure; custom rates

crop revenue	s method
corn	324,360
corn stover	123,503

* fuel, repairs, utilities, veterinary, hired machinery, marketing, breeding fees, accounting, bedding





Farm nutrient balance

Nutrient balance field 1, 680 acres corn for grain		import o plai	r availabl ht growth	e for	export or unavailable for plant growth			
(lbs/year) excl. run-off, leaching/percolation, mineraliz	ation and immobilization	N	P205	K ₂ 0	N	P205	K ₂ 0	
chemical fertilizer applied		176201	28458	93550				
crop harvested					77864	17728	20828	
removed crop residues					60487	10898	73020	
crop N volatilization during senescence (NH ₃ emission)					15167			
atmospheric N deposition (from NADP datat	base)	4238						
soil-N denitrification (15% of N-input, N ₂ & N	l ₂ O aerial emissions) ^(basis)				27066			
totals		180439	28458	93550	180583	28627	93848	
nutrient balance s	ummary							
nitrogen deficit	144 (= 0 lbs/acre/year)							
phosphate deficit 169 (= 0 lbs/acre/year)								
potassium oxide deficit	298 (= 0 lbs/acre/year)							
required fertilizer (expenses) to meet crop r	utrient balance							

Soil Erosion



Biomass Removal Rate %

Soil Erosion

Soil erosion status of RUSLE modules in I-FARM rainfall-runoff erosivity factor (R) for Palo Alto-county, IA is: 137 Soil Conditioning Index SCI

organic matter growth rate for city: Clarinda (palo_alto-county, IA)

		field 1	
	units	sequence	farm
		corn for grain	
field area	acres	680	680
soil name		CANISTED SILTY CLAY LOAM, 0 TO 2 PERCENT SLOPES	
soil surface texture		clay loam	
hill slope	percent	1.0	
slope length	feet	61	
tolerable soil loss (T)	tons/acre/year	5.00	
field specific soil loss (A)	tons/acre/year	1.49	
Soil Conditioning Index		0.01	
total soil loss	tons/year	1,012	1,012
v1.187			

Government crop programs



Government Payments

Government payments, Farm Bill 2002, see ERS farm policy web site price list

progr	am		corn s	oybeans	oats	wheat	8	
DP	direct payments	payment rate (\$/bu)	0.28	0.44	0.024	0.52		
	(limit \$40,000/year)	base yield (bu/acre/year)*	159	47	58	53		
		base acres*	680	0	0	0		
CCP	counter cyclical income	target price (\$/bu)	2.63	5.80	1.44	3.92		
	support payments (limit	loan rate (\$/bu)	1.95	5.00	1.33	2.75	80.0	
	\$65,000/year)	national market price (\$/bu)	3.00	6.80	1.90	1.90		
LDP	loan deficiency payments	actual market price (\$/bu)	3.00	6.80	1.90	1.90		
	(limit \$75,000/year)	and the second secon						
CSP	conservation security program							0
CRP	conservation reserve program statistics							0
* bas	ed on historical data of the years 1998 through	1 2001				limit ON	-	calculate
prog	ram		corn	soybeans	; c	oats v	wheat	total
DP		payment acres (85% of base acres)	578	0		0	0	
		DP payments (\$/year)	25,733	0		0	0	25,733
								+
			govern	ment payme	ents (\$/ye	ear)		25,733

Labor, services, loans, etc.

nired labor						
420 hours/year, \$10.00	0/hour		4,200			
custom farming exp	enses					
fertilization						4,760
government paymer	nts calcula	tor 25.7	33	norupa	-	
goronninone paymor	neo carcara	120,11		рег уеа		
bank loane	invest	loan		Interest	constant	
bank loans	invest-	loan amount	term	interest	payment (principal &	
bank loans for investments in	invest- ment	loan amount (\$)	term	interest rate (%)	constant payment (principal & interest)	
bank loans for investments in	invest- ment (\$)	loan amount (\$)	term (yrs)	interest rate (%)	constant payment (principal & interest) (\$/yr)	
bank loans for investments in land	invest- ment (\$) 1,700,000	loan amount (\$)	term (yrs) 30	interest rate (%) 5.9	constant payment (principal & interest) (\$/yr) 0	
bank loans for investments in land machines, power units	invest- ment (\$) 1,700,000 436,550	loan amount (\$) 0 327,413	term (yrs) 30 20	interest rate (%) 5.9 5.9	constant payment (principal & interest) (\$/yr) 0 28,314	
bank loans for investments in land machines, power units machines, implements	invest- ment (\$) 1,700,000 436,550 191,300	loan amount (\$) 0 327,413 143,475	term (yrs) 30 20 15	interest rate (%) 5.9 5.9 5.9	constant payment (principal & interest) (\$/yr) 0 28,314 14,676	

One bottom line

Farm bottom line (\$/year)

	Revenues	Expenses
Crops	447,863	266,944
Hired labor		4,200
Custom farming		4,760
Government payments*	25,733	
Bank loan payments		42,990
	473,596	318,894

Net farm income (before taxes) 154,702 (or 152.03/h or 227.50/acre/year)

*Government payments 25.29/h or 16.6% of farm income

Comparative analysis



Under Development ... Biomass production risk management



Under Development ... Biomass production risk management



Spatially-explicit prediction of stochastic performance.

For example:

- yield
- return
- soil loss



Large-scale biofuel production will require dramatic changes in the agricultural system

New tools are needed to allow land managers and policy makers to "reimagine" an agricultural system that meets food, feed and fuel needs in an economically and environmentally sustainable way.

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	soil surface texture		sitt loam													
	hill slope	percent	4.0													
	slope length	teet	150													
	tolerable soil loss (T)	tons/acre/year	5.00													
	field specific soil loss (A)	tons/acre/year	4.92													
	Soil Conditioning Index		0.20													