Building Collaborative Geodesign Systems in Agricultural Contexts

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Background: Two main projects

Seven Mile Creek, near St. Peter MN

- Years-long, transdisciplinary project
- Several GIS research assistants
- Multiple geodesign applications
- Iterative improvements

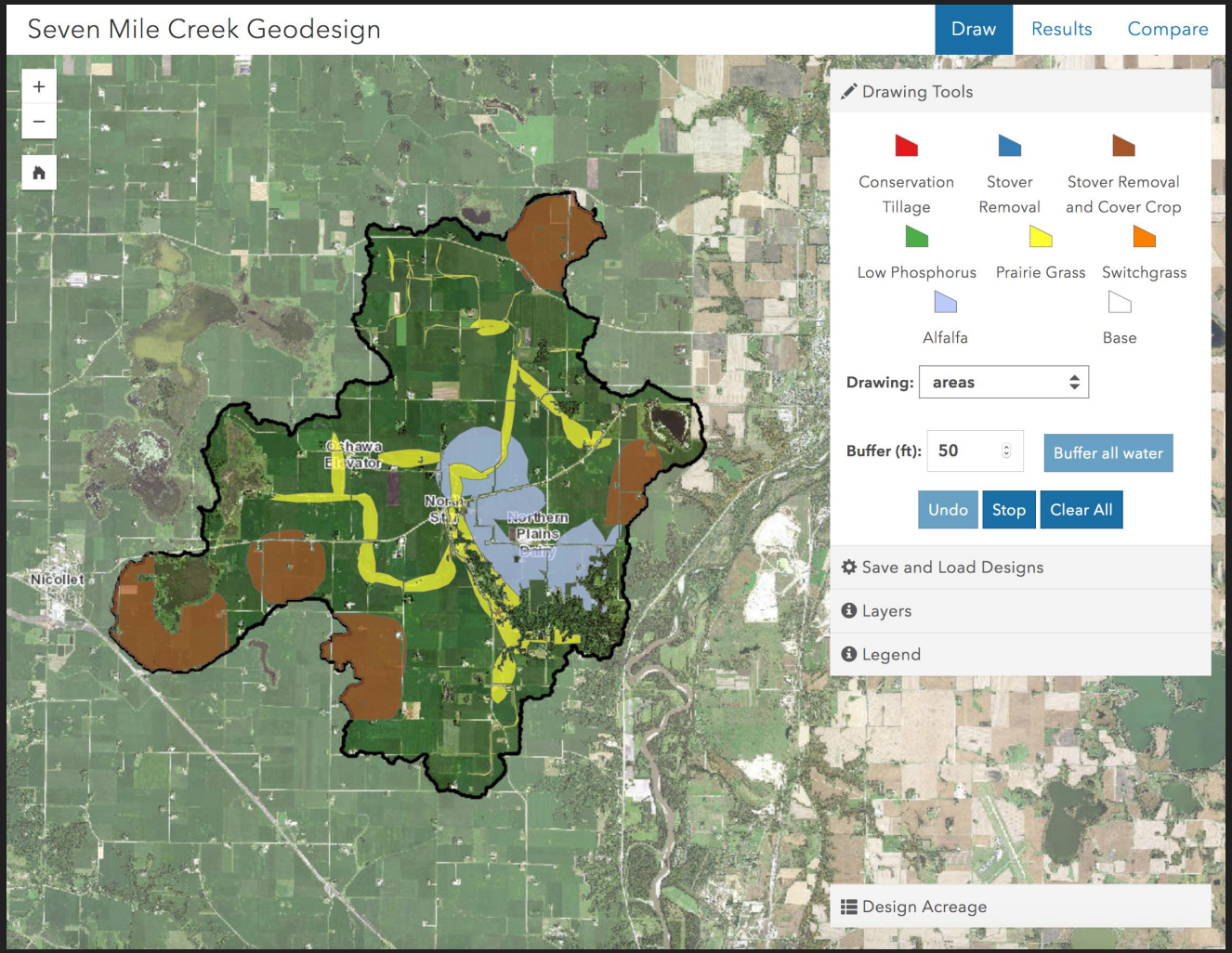
Middle Cedar River Watershed, Iowa

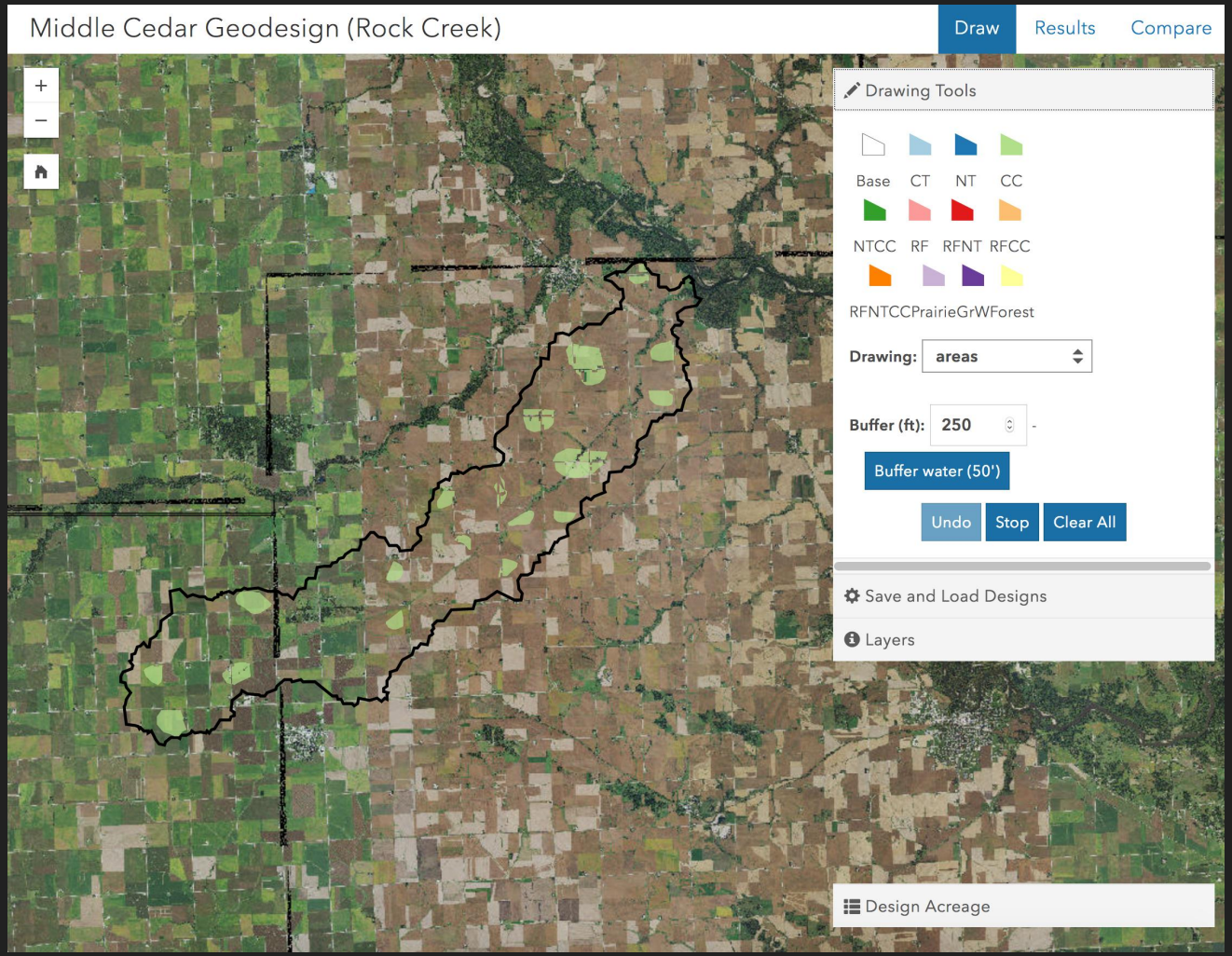
- One geodesign application (copy of 7MC v4)
- Multiple sub-watersheds; one significantly larger AOI (~9.4x editable acreage)

Application user needs

Very simplified, assumes existing knowledge (landscape, economics, etc.)

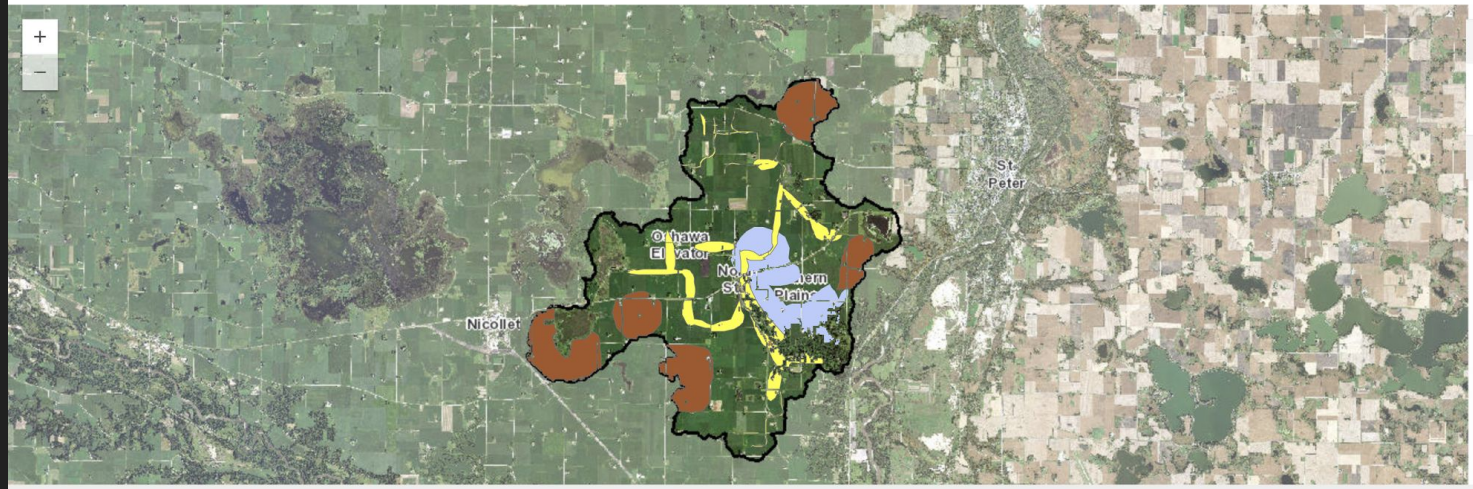
1. Adjust agricultural practice application
2. View and understand the impact of these changes
3. Compare results between designs
4. Iterate


Seven Mile Creek Geodesign
Draw
Results
Compare
Drawing Tools
Conservation Tillage
Stover Removal
Stover Removal and Cover Crop
Low Phosphorus
Prairie Grass
Switchgrass
Alfalfa
Base
Drawing:
areas
Buffer (ft):
50
Buffer all water
Undo
Stop
Clear All
Save and Load Designs
Layers
Legend
Design Acreage
Nicollet
Northern Plains


Middle Cedar Geodesign (Rock Creek)
Draw
Results
Compare
Drawing Tools
Base
CT
NT
CC
NTCC
RF
RFNT
RFCC
RFNTCCPrairieGrWForest
Drawing:
areas
Buffer (ft):
250
Buffer water (50')
Undo
Stop
Clear All
Save and Load Designs
Layers
Design Acreage

Seven Mile Creek Geodesign

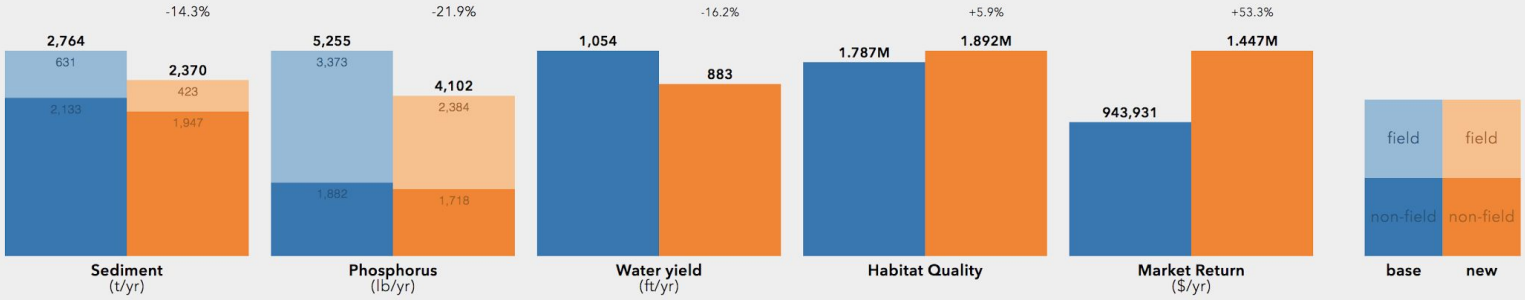
Draw | Results | Compare



View Design Results

Name: prairie grass 2

$ Prices



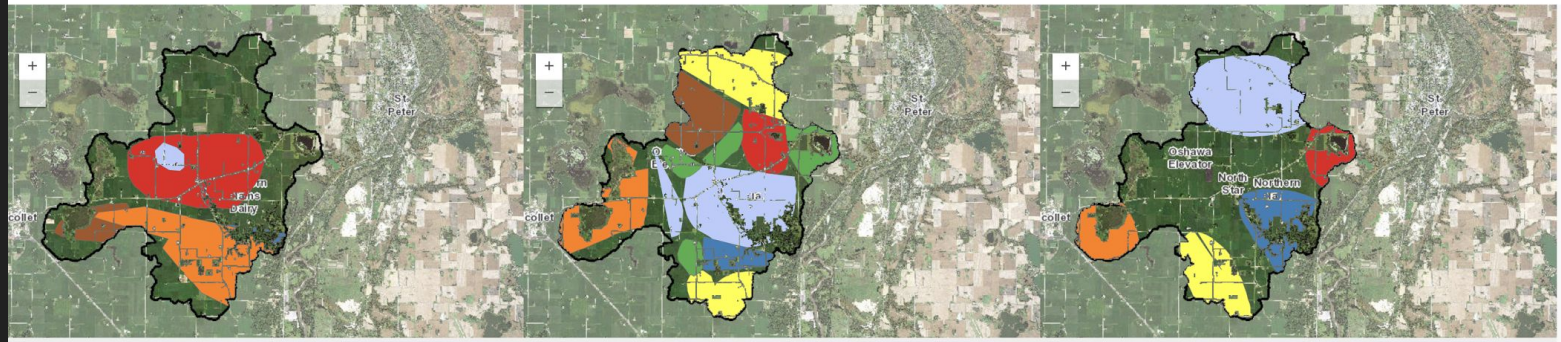
Carbon sequestration

15,874 t/yr

Percent of Acreage by Practice	
Base	65.4%
Alfalfa	8.2%
Conservation Tillage	
Low Phosphorus	
Stover Removal	
Stover and Cover Crop	17.8%
Prairie Grass	8.5%
Switchgrass	0%

Seven Mile Creek Geodesign

Draw | Results | Compare



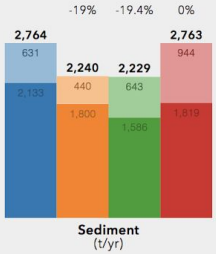
Designs to Compare

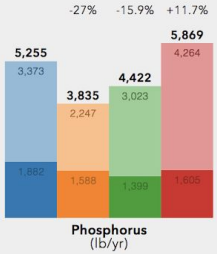
First Design: dave1

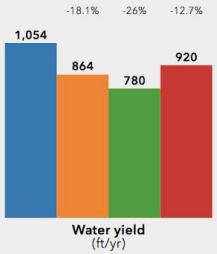
Second Design: meatball

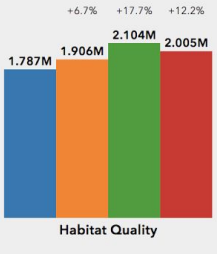
Third Design: james

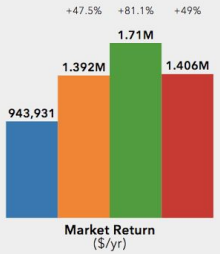
$ Prices

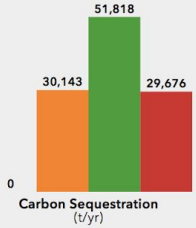


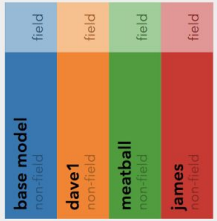










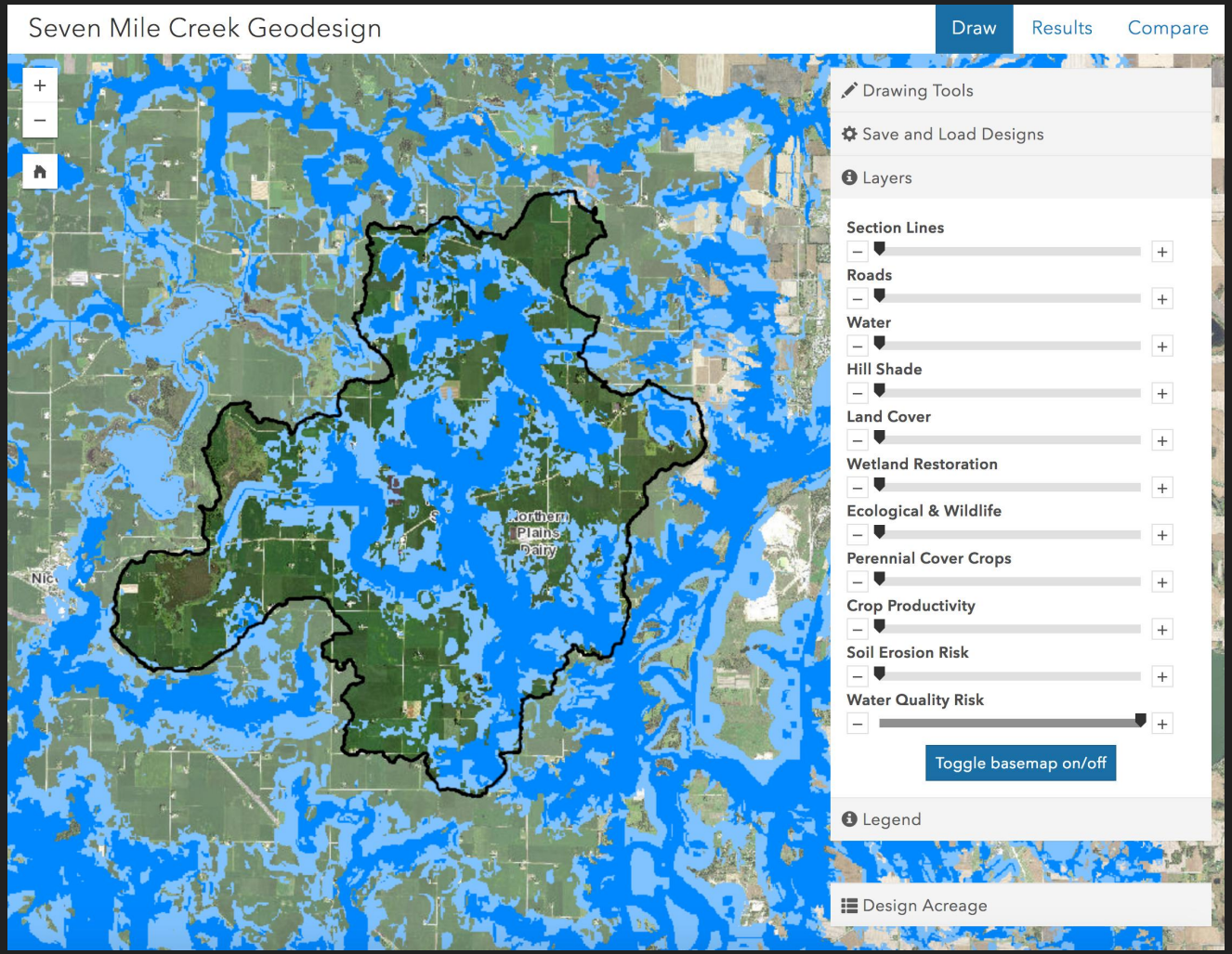


Percent of Acreage by Practice			
	dave1	meatball	james
Base	55.4%	21%	52.2%
Alfalfa	1.7%	20.2%	21%
Conservation Tillage	22.1%	6.5%	3.7%
Low Phosphorus		10.1%	
Stover Removal	0.3%	4%	7.7%
Stover and Cover Crop	3.1%	9.8%	
Prairie Grass		18.9%	9.7%
Switchgrass	17.4%	9.5%	5.8%

Data/reference for users

- Imagery*
- Land cover
- Water, roads
- Section lines, parcels, other boundaries
- Hillshade/elevation
- Crop productivity
- Soil erosion risk, water quality risk

** Watch out: NAIP horizontal accuracy*


Seven Mile Creek Geodesign
Draw
Results
Compare
Drawing Tools
Save and Load Designs
Layers
Section Lines
Roads
Water
Hill Shade
Land Cover
Wetland Restoration
Ecological & Wildlife
Perennial Cover Crops
Crop Productivity
Soil Erosion Risk
Water Quality Risk
Toggle basemap on/off
Legend
Design Acreage

Seven Mile Creek app progression

Version	Client App	Drawing	Draw Processing	Design Processing
1	JavaScript	polygon	server	vector
2	Java	polygon	client (and server?)	vector
3	JavaScript	polygon	server	vector
4	JavaScript	polygon buffered line water buffering parcel/section fill	client	raster (mostly)

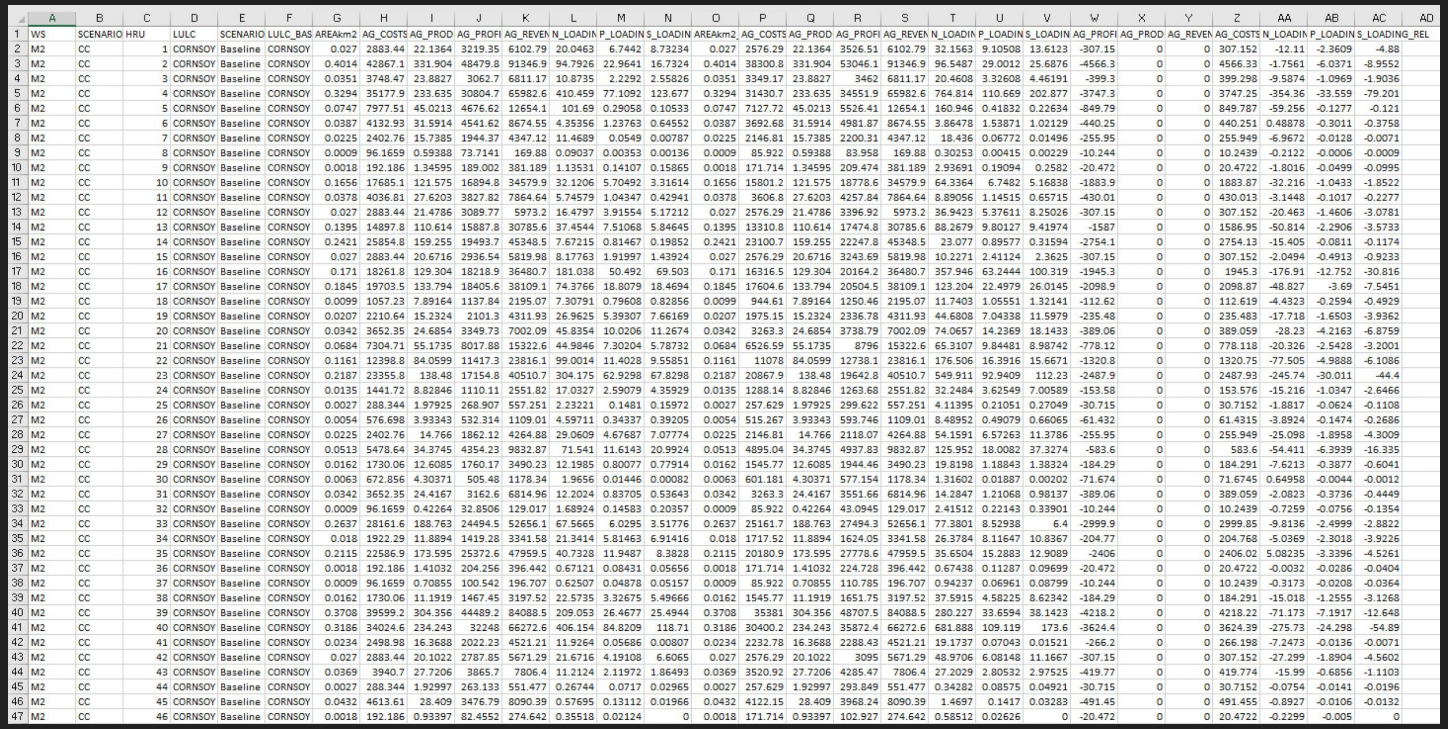
Modeling

- Hydrologic response units (HRUs)

- Models
  - SWAT
  - InVEST
  - Carbon & Habitat
  - UMN Extension Farmgate Economic Model

- Semi pro-tip: Make sure the modelers generating HRUs use a reasonable projection, one you can easily use with something like your web map tools of choice

So many spreadsheets



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
1	WS	SCENARIO	HRU	LULC	SCENARIO	LULC_BAS	AREAkm2	AG_COSTS	AG_PROD	AG_PROFI	AG_REVEN	N_LOADIN	P_LOADIN	S_LOADIN	AREAkm2	AG_COSTS	AG_PROD	AG_PROFI	AG_REVEN	N_LOADIN	P_LOADIN	S_LOADIN	AG_PROFI	AG_PROD	AG_REVEN	AG_COSTS	N_LOADIN	P_LOADIN	S_LOADING_REL	
2	M2	CC	1	CORNSOY	Baseline	CORNSOY	0.027	2883.44	22.1364	3219.35	6102.79	20.0463	6.7442	8.73234	0.027	2576.29	22.1364	3526.51	6102.79	32.1563	9.10508	13.6123	-307.15	0	0	307.152	-12.11	-2.3609	-4.88	
3	M2	CC	2	CORNSOY	Baseline	CORNSOY	0.4014	42867.1	331.904	48479.8	91346.9	94.7926	22.9641	16.7324	0.4014	38300.8	331.904	53046.1	91346.9	96.5487	29.0012	25.6876	-4566.3	0	0	4566.33	-1.7561	-6.0371	-8.9552	
4	M2	CC	3	CORNSOY	Baseline	CORNSOY	0.0351	3748.47	23.8827	3062.7	6811.17	10.8735	2.2292	2.55826	0.0351	3349.17	23.8827	3462	6811.17	20.4608	3.32608	4.46191	-399.3	0	0	399.298	-9.5874	-1.0969	-1.9036	
5	M2	CC	4	CORNSOY	Baseline	CORNSOY	0.3294	35177.9	233.635	30804.7	65982.6	410.459	77.1092	123.677	0.3294	31430.7	233.635	34551.9	65982.6	764.814	110.669	202.877	-3747.3	0	0	3747.25	-354.36	-33.559	-79.201	
6	M2	CC	5	CORNSOY	Baseline	CORNSOY	0.0747	7977.51	45.0213	4676.62	12654.1	101.69	0.29058	0.10533	0.0747	7127.72	45.0213	5526.41	12654.1	160.946	0.41832	0.22634	-849.79	0	0	849.787	-59.256	-0.1277	-0.121	
7	M2	CC	6	CORNSOY	Baseline	CORNSOY	0.0387	4132.93	31.5914	4541.62	8674.55	4.35356	1.23763	0.64552	0.0387	3692.68	31.5914	4981.87	8674.55	3.86478	1.53871	1.02129	-440.25	0	0	440.251	0.48878	-0.3011	-0.3758	
8	M2	CC	7	CORNSOY	Baseline	CORNSOY	0.0225	2402.76	15.7385	1944.37	4347.12	11.4689	0.0549	0.00787	0.0225	2146.81	15.7385	2200.31	4347.12	18.436	0.06772	0.01496	-255.95	0	0	255.949	-6.9672	-0.0128	-0.0071	
9	M2	CC	8	CORNSOY	Baseline	CORNSOY	0.0009	96.1659	0.59388	73.7141	169.88	0.09037	0.00353	0.00136	0.0009	85.922	0.59388	83.958	169.88	0.30253	0.00415	0.00229	-10.244	0	0	10.2439	-0.2122	-0.0006	-0.0009	
10	M2	CC	9	CORNSOY	Baseline	CORNSOY	0.0018	192.186	1.34595	189.002	381.189	1.13531	0.14107	0.15865	0.0018	171.714	1.34595	209.474	381.189	2.93691	0.19094	0.2582	-20.472	0	0	20.4722	-1.8016	-0.0499	-0.0995	
11	M2	CC	10	CORNSOY	Baseline	CORNSOY	0.1656	17685.1	121.575	16894.8	34579.9	32.1206	5.70492	3.31614	0.1656	15801.2	121.575	18778.6	34579.9	64.3364	6.7482	5.16838	-1883.9	0	0	1883.87	-32.216	-1.0433	-1.8522	
12	M2	CC	11	CORNSOY	Baseline	CORNSOY	0.0378	4036.81	27.6203	3827.82	7864.64	5.74579	1.04347	0.42941	0.0378	3606.8	27.6203	4257.84	7864.64	8.89056	1.14515	0.65715	-430.01	0	0	430.013	-3.1448	-0.1017	-0.2277	
13	M2	CC	12	CORNSOY	Baseline	CORNSOY	0.027	2883.44	21.4786	3089.77	5973.2	16.4797	3.91554	5.17212	0.027	2576.29	21.4786	3396.92	5973.2	36.9423	5.37611	8.25026	-307.15	0	0	307.152	-20.463	-1.4606	-3.0781	
14	M2	CC	13	CORNSOY	Baseline	CORNSOY	0.1395	14897.8	110.614	15887.8	30785.6	37.4544	7.51068	5.84645	0.1395	13310.8	110.614	17474.8	30785.6	88.2679	9.80127	9.41974	-1587	0	0	1586.95	-50.814	-2.2906	-3.5733	
15	M2	CC	14	CORNSOY	Baseline	CORNSOY	0.2421	25854.8	159.255	19493.7	45348.5	7.67215	0.81467	0.19852	0.2421	23100.7	159.255	22247.8	45348.5	23.077	0.89577	0.31594	-2754.1	0	0	2754.13	-15.405	-0.0811	-0.1174	
16	M2	CC	15	CORNSOY	Baseline	CORNSOY	0.027	2883.44	20.6716	2936.54	5819.98	8.17763	1.91997	1.43924	0.027	2576.29	20.6716	3243.69	5819.98	10.2271	2.41124	2.3625	-307.15	0	0	307.152	-2.0494	-0.4913	-0.9233	
17	M2	CC	16	CORNSOY	Baseline	CORNSOY	0.171	18261.8	129.304	18218.9	36480.7	181.038	50.492	69.503	0.171	16316.5	129.304	20164.2	36480.7	357.946	63.2444	100.319	-1945.3	0	0	1945.3	-176.91	-12.752	-30.816	
18	M2	CC	17	CORNSOY	Baseline	CORNSOY	0.1845	19703.5	133.794	18405.6	38109.1	74.3766	18.8079	18.4694	0.1845	17604.6	133.794	20504.5	38109.1	123.204	22.4979	26.0145	-2098.9	0	0	2098.87	-48.827	-3.69	-7.5451	
19	M2	CC	18	CORNSOY	Baseline	CORNSOY	0.0099	1057.23	7.89164	1137.84	2195.07	7.30791	0.79608	0.82856	0.0099	944.61	7.89164	1250.46	2195.07	11.7403	1.05551	1.32141	-112.62	0	0	112.619	-4.4323	-0.2594	-0.4929	
20	M2	CC	19	CORNSOY	Baseline	CORNSOY	0.0207	2210.64	15.2324	2101.3	4311.93	26.9625	5.39307	7.66169	0.0207	1975.15	15.2324	2336.78	4311.93	44.6808	7.04338	11.5979	-235.48	0	0	235.483	-17.718	-1.6503	-3.9362	
21	M2	CC	20	CORNSOY	Baseline	CORNSOY	0.0342	3652.35	24.6854	3349.73	7002.09	45.8354	10.0206	11.2674	0.0342	3263.3	24.6854	3738.79	7002.09	74.0657	14.2369	18.1433	-389.06	0	0	389.059	-28.23	-4.2163	-6.8759	
22	M2	CC	21	CORNSOY	Baseline	CORNSOY	0.0684	7304.71	55.1735	8017.88	15322.6	44.9846	7.30204	5.78732	0.0684	6526.59	55.1735	8796	15322.6	65.3107	9.84481	8.98742	-778.12	0	0	778.118	-20.326	-2.5428	-3.2001	
23	M2	CC	22	CORNSOY	Baseline	CORNSOY	0.1161	12398.8	84.0599	11417.3	23816.1	99.0014	11.4028	9.55851	0.1161	11078	84.0599	12738.1	23816.1	176.506	16.3916	15.6671	-1320.8	0	0	1320.75	-77.505	-4.9888	-6.1086	
24	M2	CC	23	CORNSOY	Baseline	CORNSOY	0.2187	23355.8	138.48	17154.8	40510.7	304.175	62.9298	67.8298	0.2187	20867.9	138.48	19642.8	40510.7	549.911	92.9409	112.23	-2487.9	0	0	2487.93	-245.74	-30.011	-44.4	
25	M2	CC	24	CORNSOY	Baseline	CORNSOY	0.0135	1441.72	8.82846	1110.11	2551.82	17.0327	2.59079	4.35929	0.0135	1288.14	8.82846	1263.68	2551.82	32.2484	3.62549	7.00589	-153.58	0	0	153.576	-15.216	-1.0347	-2.6466	
26	M2	CC	25	CORNSOY	Baseline	CORNSOY	0.0027	288.344	1.97925	268.907	557.251	2.23221	0.1481	0.15972	0.0027	257.629	1.97925	299.622	557.251	4.11395	0.21051	0.27049	-30.715	0	0	30.7152	-1.8817	-0.0624	-0.1108	
27	M2	CC	26	CORNSOY	Baseline	CORNSOY	0.0054	576.698	3.93343	532.314	1109.01	4.59711	0.34337	0.39205	0.0054	515.267	3.93343	593.746	1109.01	8.48952	0.49079	0.66065	-61.432	0	0	61.4315	-3.8924	-0.1474	-0.2686	
28	M2	CC	27	CORNSOY	Baseline	CORNSOY	0.0225	2402.76	14.766	1862.12	4264.88	29.0609	4.67687	7.07774	0.0225	2146.81	14.766	2118.07	4264.88	54.1591	6.57263	11.3786	-255.95	0	0	255.949	-25.098	-1.8958	-4.3009	
29	M2	CC	28	CORNSOY	Baseline	CORNSOY	0.0513	5478.64	34.3745	4354.23	9832.87	71.541	11.6143	20.9924	0.0513	4895.04	34.3745	4937.83	9832.87	125.952	18.0082	37.3274	-583.6	0	0	583.6	-54.411	-6.3939	-16.335	
30	M2	CC	29	CORNSOY	Baseline	CORNSOY	0.0162	1730.06	12.6085	1760.17	3490.23	12.1985	0.80077	0.77914	0.0162	1545.77	12.6085	1944.46	3490.23	19.8198	1.18843	1.38324	-184.29	0	0	184.291	-7.6213	-0.3877	-0.6041	
31	M2	CC	30	CORNSOY	Baseline	CORNSOY	0.0063	672.856	4.30371	505.48	1178.34	1.9656	0.01446	0.00082	0.0063	601.181	4.30371	577.154	1178.34	1.31602	0.01887	0.00202	-71.674	0	0	71.6745	0.64958	-0.0044	-0.0012	
32	M2	CC	31	CORNSOY	Baseline	CORNSOY	0.0342	3652.35	24.4167	3162.6	6814.96	12.2024	0.83705	0.53643	0.0342	3263.3	24.4167	3551.66	6814.96	14.2847	1.21068	0.98137	-389.06	0	0	389.059	-2.0823	-0.3736	-0.4449	
33	M2	CC	32	CORNSOY	Baseline	CORNSOY	0.0009	96.1659	0.42264	32.8506	129.017	1.68924	0.14583	0.20357	0.0009	85.922	0.42264	43.0945	129.017	2.41512	0.22143	0.33901	-10.244	0	0	10.2439	-0.7259	-0.0756	-0.1354	
34	M2	CC	33	CORNSOY	Baseline	CORNSOY	0.2637	28161.6	188.763	24494.5	52656.1	67.5665	6.0295	3.51776	0.2637	25161.7	188.763	27494.3	52656.1	77.3801	8.52938	6.4	-2999.9	0	0	2999.85	-9.8136	-2.4999	-2.8822	
35	M2	CC	34	CORNSOY	Baseline	CORNSOY	0.018	1922.29	11.8894	1419.28	3341.58	21.3414	5.81463	6.91416	0.018	1717.52	11.8894	1624.05	3341.58	26.3784	8.11647	10.8367	-204.77	0	0	204.768	-5.0369	-2.3018	-3.9226	
36	M2	CC	35	CORNSOY	Baseline	CORNSOY	0.2115	22586.9	173.595	25372.6	47959.5	40.7328	11.9487	8.3828	0.2115	20180.9	173.595	27778.6	47959.5	35.6504	15.2883	12.9089	-2406	0	0	2406.02	5.08235	-3.3396	-4.5261	
37	M2	CC	36	CORNSOY	Baseline	CORNSOY	0.0018	192.186	1.41032	204.256	396.442	0.67121	0.08431	0.05656	0.0018	171.714	1.41032	224.728	396.442	0.67438	0.11287	0.09699	-20.472	0	0	20.4722	-0.0032	-0.0286	-0.0404	
38	M2	CC	37	CORNSOY	Baseline	CORNSOY	0.0009	96.1659	0.70855	100.542	196.707	0.62507	0.04878	0.05157	0.0009	85.922	0.70855	110.785	196.707	0.94237	0.06961	0.08799	-10.244	0	0	10.2439	-0.3173	-0.0208	-0.0364	
39	M2	CC	38	CORNSOY	Baseline	CORNSOY	0.0162	1730.06	11.1919	1467.45	3197.52	22.5735	3.32675	5.49666	0.0162	1545.77	11.1919	1651.75	3197.52	37.5915	4.58225	8.62342	-184.29	0	0	184.291	-15.018	-1.2555	-3.1268	
40	M2	CC	39	CORNSOY	Baseline	CORNSOY	0.3708	39599.2	304.356	44489.2	84088.5	209.053	26.4677	25.4944	0.3708	35381	304.356	48707.5	84088.5	280.227	33.6594	38.1423	-4218.2	0	0	4218.22	-71.173	-7.1917	-12.648	
41	M2	CC	40	CORNSOY	Baseline	CORNSOY	0.3186	34024.6	234.243	32248	66272.6	406.154	84.8209	118.71	0.3186	30400.2	234.243	35872.4	66272.6	681.888	109.119	173.6	-3624.4	0	0	3624.39	-275.73	-24.298	-54.89	
42	M2	CC	41	CORNSOY	Baseline	CORNSOY	0.0234	2498.98	16.3688	2022.23	4521.21	11.9264	0.05686	0.00807	0.0234	2232.78	16.3688	2288.43	4521.21	19.1737	0.07043	0.01521	-266.2	0	0	266.198	-7.2473	-0.0136	-0.0071	
43	M2	CC	42	CORNSOY	Baseline	CORNSOY	0.027	2883.44	20.1022	2787.85	5671.29	21.6716	4.19108	6.6065	0.027	2576.29	20.1022	3095	5671.29	48.9706	6.08148	11.1667	-307.15	0	0	307.152	-27.299	-1.8904	-4.5602	
44	M2	CC	43	CORNSOY	Baseline	CORNSOY	0.0369	3940.7	27.7206	3865.7	7806.4	11.2124	2.11972	1.86493	0.0369	3520.92	27.7206	4285.47	7806.4	27.2029	2.80532	2.97525	-419.77	0	0	419.774	-15.99	-0.6856	-1.1103	
45	M2	CC	44	CORNSOY	Baseline	CORNSOY	0.0027	288.344	1.92997	263.133	551.477	0.26744	0.0717	0.02965	0.0027	257.629	1.92997	293.849	551.477	0.34282	0.08575	0.04921	-30.715	0	0	30.7152	-0.0754	-0.0141	-0.0196	
46	M2	CC	45	CORNSOY	Baseline	CORNSOY	0.0432	4613.61	28.409	3476.79	8090.39	0.57695	0.13112	0.01966	0.0432	4122.15	28.409	3968.24	8090.39	1.4697	0.1417	0.03283	-491.45	0	0	491.455	-0.8927	-0.0106	-0.0132	
47	M2	CC	46	CORNSOY	Baseline	CORNSOY	0.0018	192.186	0.93397	82.4552	274.642	0.35518	0.02124	0	0.0018	171.714	0.93397	102.927	274.642	0.58512	0.02626	0	-20.472	0	0	20.4722	-0.2299	-0.005	0	

What HRUs are malleable?

- What land cover/use will you allow to change?

- Realistically, you won't be
  - tearing up roads,
  - razing homes, or
  - removing forest

- In our AOIs, we're commonly switching corn/soy to something else

Putting the pieces together

General approach (server)

The server provides

- data and reference layers,
- agricultural practice choices,
- AOI polygon,
- malleable HRU polygon (dissolved), and
- geoprocessing services (run model, load existing, etc.).

General approach (client)

The client

- works exclusively in vector (excluding ref/data layer display);
- does all the necessary clipping and erasing;
- sends only polygons by practice, group name, design name, watershed name/ID back to the server for processing; and
- handles all the charts and tables.

If you can reasonably expect to do something on the client, do it there. If you're particularly concerned with less powerful, handheld clients, evaluate carefully.

Components

Client

- Designed primarily for 1920x1080, 55" touchscreens
- ArcGIS API for JavaScript 3.x
- Dojo and jQuery
- Esri Calcite Maps
- D3.js
- Custom JS for economics
- More JS to tie it together

Server

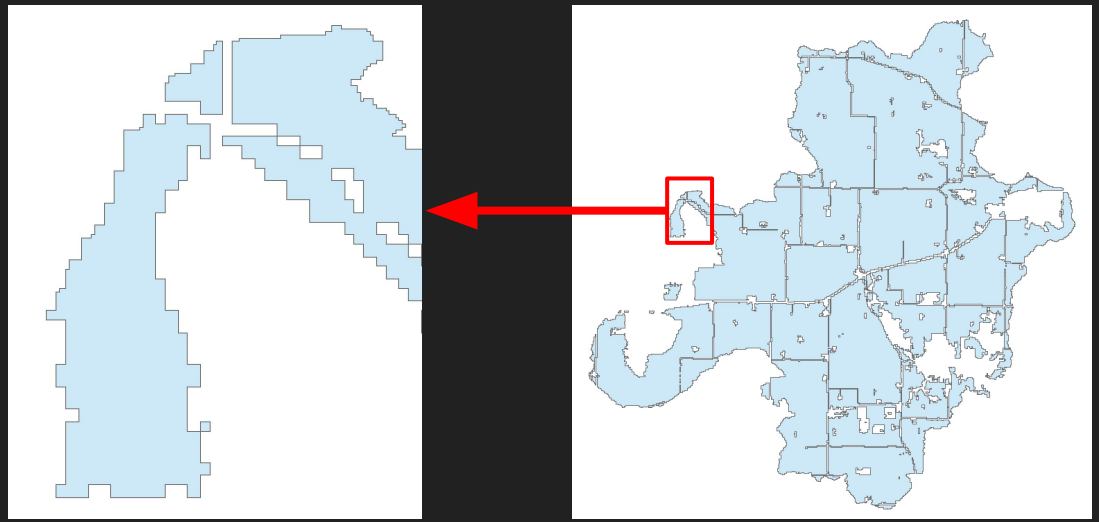
- ArcGIS Server 10.2, 10.4
- PostgreSQL 9.1.8
- PostGIS 2.0.1
- Python 2.7 (ArcPy, psycopg2)

The giant touchscreen experience

The paper legends live on

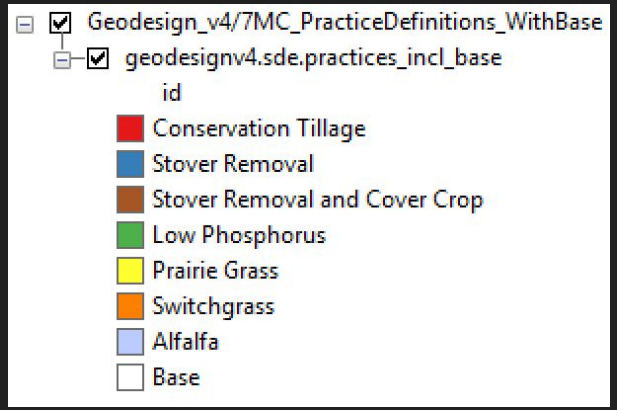
Editable HRUs

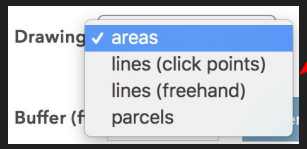
Identify editable HRUs and dissolve into a single, multipart polygon for client use

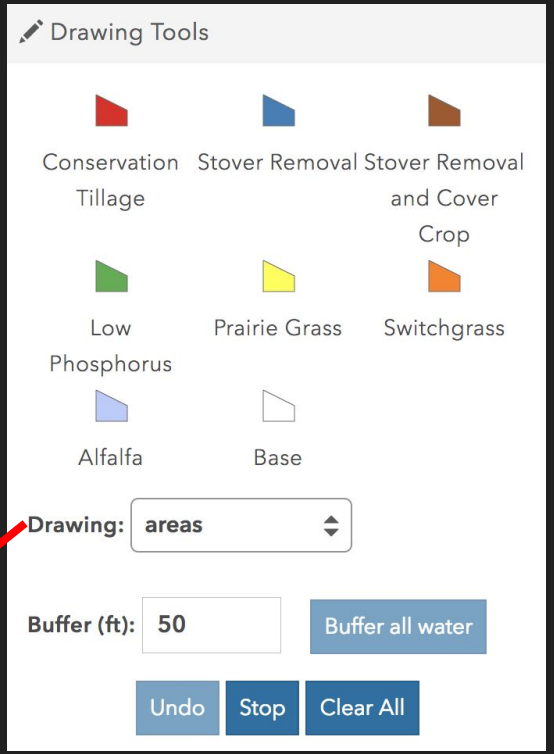


Drawing

- Publish a feature service with each practice to establish templates (just IDs)
- Use Esri's TemplatePicker against the service
- Draw away







Client geometry operations

- GeometryEngine.buffer
- GeometryEngine.contains
- GeometryEngine.difference
- **GeometryEngine.intersect ⇐ reduce drawn areas to editable HRUs only**
- GeometryEngine.intersects
- GeometryEngine.planarArea
- GeometryEngine.union

Raster generation

- Recall the spreadsheet
- For every spreadsheet (ag. practice)
  a. Join the attributes to HRUs (vector)
  b. Rasterize the HRUs, one attribute at a time
  c. Stack the attribute rasters into a multiband GeoTIFF
  d. Load each into its own PG table
- It's not so bad: At 30m, the Seven Mile Creek AOI is only 447x455.

	objectid integer	band smallint	measure character varying(20)
1	1	1	carbonSeq
2	2	2	sediment
3	3	3	phosphorous
4	4	4	waterYield
5	5	5	yieldBiomass
6	6	6	yieldCorn
7	7	7	yieldSoy
8	13	8	yieldAlfalfa
9	8	9	habitat
10	9	10	sedimentField
11	10	11	sedimentNonField
12	11	12	phosphorusField
13	12	13	phosphorusNonField

Generate results / process design

- Geometries for each practice used are passed into a geoprocessing service, along with group and design name
- The GP service primarily relies on **`psycopg2`** to call custom functions in PostgreSQL+PostGIS
- A bit more Python and SQL to wrap the results into a JSON string

```
queryCreateBaseGeometry = """SELECT createBaseGeometry(%(gname)s, %(dname)s);"""
queryClipPracticeRasters = """SELECT clipPracticeRasters(%(gname)s, %(dname)s);"""
queryGenerateDesignResults = """SELECT generateDesignResults13Band(%(gname)s, %(dname)s);"""
```

`createBaseGeometry` and `clipPracticeRasters`

- Base geometry is the base condition of the AOI, be it corn/soy, pavement, water, or something else
- Take the overall AOI and erase out the union of all other practices to get the base geometry
- Once base geometry is created, `ST_Clip` the performance raster for each practice (and base) using the associated geometry

`generateDesignResults`

- Bulk of the work falls on **`ST_SummaryStats`**
  - Generate stats for each band of each raster
- All of our data is absolute; nothing relative
- Default **`NoData`** value of **`NULL`** in **`ST_Clip`** is just fine
- A **`GROUP BY`** query rolls up the sums for each band/measure nicely
- Count of cells (non-null) by band is also a statistic provided; multiply counts by a constant to convert to acres, sq.mi., etc.

More considerations/approaches

- Repeat: Use absolute values, avoid relative
  - Relative values can make comparison more onerous
  - It can be difficult to wrap your head around (just me?)
  - Generate a baseline result (current state) and compare to those absolute values to get changes

- Don't bake in math when non-variable values may change

What is this?

Source (and hint): [Business Insider]

The economics of it all

- Fact: Prices fluctuate

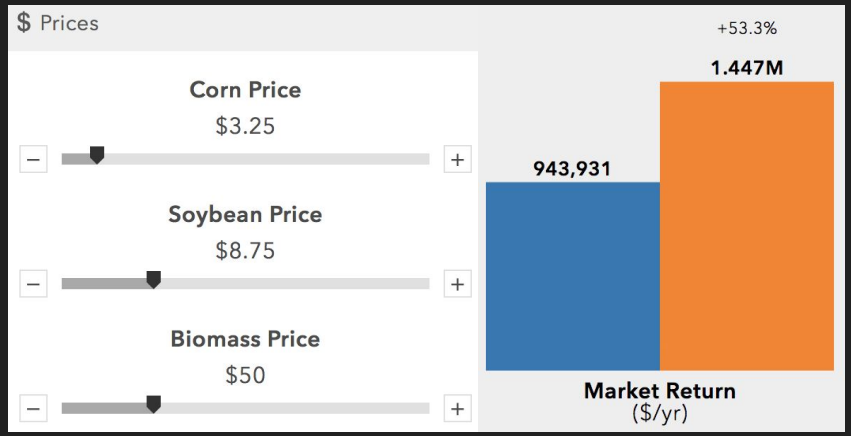
- **Likelihood #1**
  Prices in the model will differ from those when the model is used

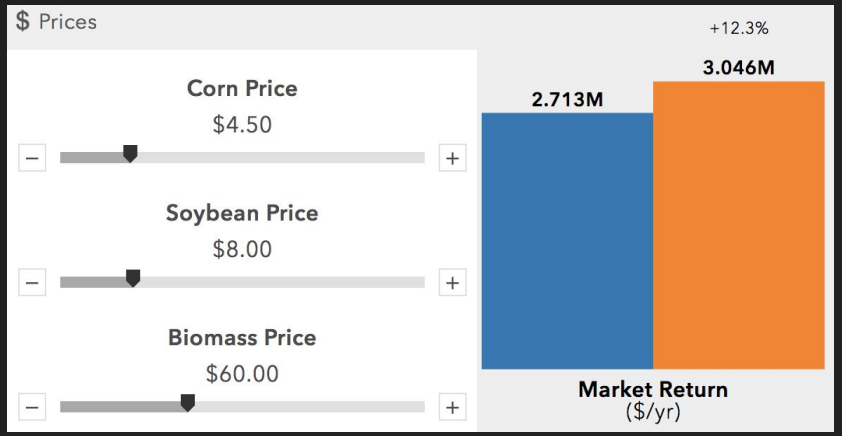
- **Likelihood #2**
  A producer will ask you what prices were used in the model (costs, too)

- **Likelihood #3**
  Users will wonder about profitability of their designs in different times

Yields are your friend

- Use crop yields in the model, not dollars (revenue or profit)
- Work out the equations for costs and revenues and throw them into JavaScript
- Let users control the prices in the application, but set reasonable defaults





Resources

The New Agricultural Bioeconomy website includes links to these applications
http://newagbioeconomy.umn.edu/collaborativegeodesign/

Lightning talk (MN GIS/LIS 2017)
http://z.umn.edu/collabgeodesign

These slides
https://z.umn.edu/collabgeodesign2017

In conclusion

1. Thanks for coming!

2. Questions?

3. You can reach me at wiringa@umn.edu