Ag Land Property Tax Assessment Oversight Task Force October 17, 2016

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SDSU Recommendations for Productivity Formula

- No recommended changes to current productivity formula (e.g. landlord share, capitalization rates, etc.)
- Continue with research to update HBU classification

SDSU Highest and Best Use Research

Identify 'the reasonably probable and legal use of ag land that is physically possible, appropriately supported, financially feasible, and that results in the highest value. The four criteria the highest and best use must meet are legal permissibility, **physical possibility**, **financial feasibility**, and **maximum productivity'** (Appraisal Institute).

Two Methods to Determine Soil Productivity

- **NRCS Crop Productivity Index** and Range Yields
  - Range yields
    - Field observations
  - CPI
    - Fuzzy Logic Model

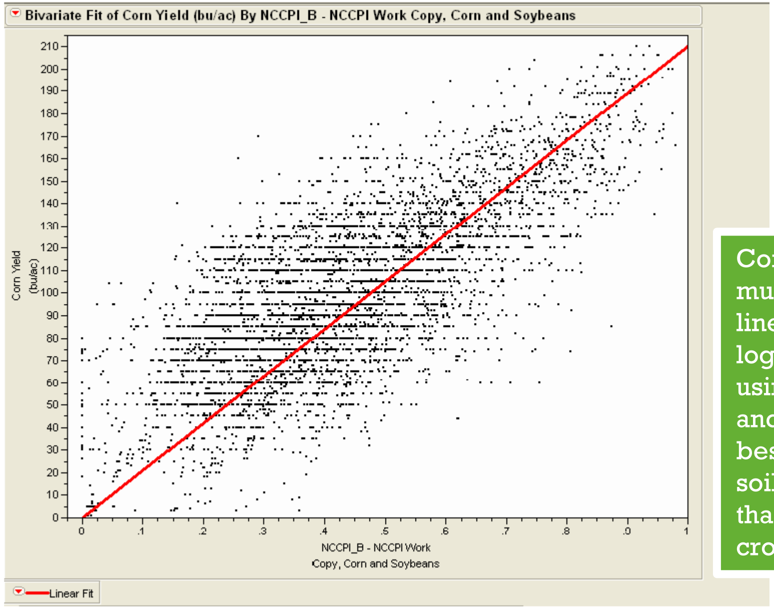
- https://www.youtube.com/watch?v=DJyMAXhPjTE

- **Apex Model** Comprehensive Plant and Environmental Farm/ Watershed Simulation Model
  - http://epicapex.tamu.edu/

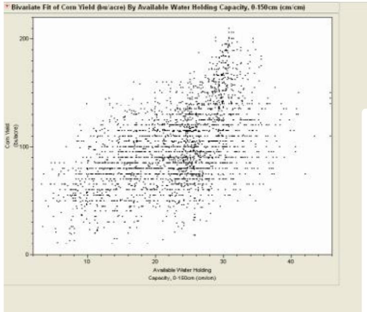
Attributes Analyzed to Derive the CPI

- Available Waterholding Capacity
- Bulk Density
- Cation Exchange Capacity
- Electrical Conductivity (salt content)
- Flooding Frequency
- Frost Free Days
- Soil Depth
- Water Table Index
- Gypsum
- Ksat (vertical water transmission)
- Ponding
- Precipitation
- Organic Matter
- pH
- Rock Fragments
- Slope

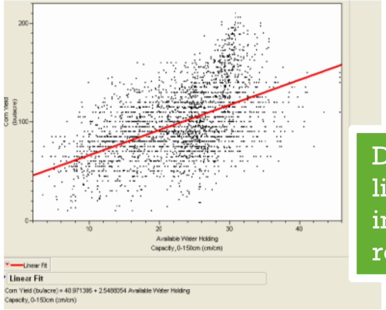
NRCS Development of CPI



Combine multiple fit lines in a fuzzy logic system using weights and rules to best interpret soil attributes that explains crop yield.



Plot Yield data in NASIS database and Soil Attributes



Derive a Fit line that best interprets the relationship

Soil Productivity Rating (SPR) using Range Yields and NRCS CPI

Map Unit Symbol	% Slope	Land Capability SubClass	WSS NRCS Crop Productivity Index, CPI (%)	Adj WSS Crop Rating, ACR (%)	Range Productivity Normal Year Average (lbs/a)*	Useable Range Yield (lbs/a)*	Range Rating (%)++	Adjusted Range Rating, ARR (%) #	**Soil Productivity Rating, SPR (%)**
Ac	0-2	3w	58	59.2	4400	3274	65.49	52.65	**59.2**
Ad	0-1	5w	34	34.7	6380	2909	58.20	46.79	**46.8**
AeA	0-2	1	96	98.0	4078	3536	70.74	56.87	**98**
Ba	0-1	3w	61	62.2	4484	3390	67.81	54.52	**62.2**
Bb	0-2	1	90	91.8	3735	3105	62.12	49.95	**91.8**
Bf	0-2	2w	86	87.8	4372	3192	63.86	51.34	**87.8**
Bg	0-2	1	91	92.9	3764	3077	61.56	49.50	**92.9**
Bk	0-2	1/6s	64	65.3	4085	2850	57.01	45.84	**65.3**
Bm	0-2	1	83	84.7	3485	2954	59.10	47.52	**84.7**
Bn	0-1	6w	35	35.7	4834	4061	81.25	65.32	**65.3**
Ca	0-2	2w/4w	75	76.5	4938	3877	77.57	62.36	**76.5**
Cc	0-1	6w	38	38.8	5428	4860	97.23	78.17	**78.2**
Cd	0-1	4w	61	62.2	4460	3356	67.15	53.99	**62.2**
DaA	0-2	2s	66	67.3	4820	4026	80.55	64.76	**67.3**
DbB	1-4	2e/2s	68	69.4	4836	4042	80.87	65.02	**69.4**
DcA	0-2	1	90	91.8	4820	4026	80.55	64.76	**91.8**

Strengths and Limitations to NRCS CPI

- Variance of yields explained
- CPI cannot be confidently used to develop a distribution of yields for an economic risk and return analysis when comparing alternative managements for highest and best use classification
- Using CPI to predict yield omits factors that contribute to annual yield changes (e.g. management, specific weather changes and events, and specific topography)
- CPI compares inherent soil properties that have better productivity and less limitations for crop production into a single index.
- Some properties that effect productivity cannot be easily included in other simulation analyses but can be captured by CPI.
- CPI is closely related to the current method for Soil Ratings (traditional approach)

Apex Model (Texas A&M)

- Multiple equations to simulate runoff, plant growth, seed yield, soil characteristic changes, and plant stress in a daily time step using information on weather, management, topography, etc.
  - Change in leaf area index
  - Solar Radiation Use Efficiency
  - Photosynthetic Active Radiation
  - Dry biomass increase per day

Potential increase in biomass for a day can be estimated with the equation (Monteith, 1977),

$$DDM=0.001*PAR*(RUE-WAVP*X1) \quad (275)$$

$$PAR=0.5*RA*(1.0-exp(-0.65*LAI)) \quad (275a)$$

$$X1=max(VPD-1.,-.5) \quad (275b)$$

$$RUE=100.*CO_2/(CO_2+exp(bc1-bc2*CO_2)) \quad (275c)$$

LAI is simulated as a function of heat units, crop stress, and crop development stages. From emergence to the start of leaf decline, LAI is estimated with the equations

$$LAI(i)=LAI_0(i)+dHUF(i)*XLAI(i)*sqrt(REG(i))*LAI_0(i)/TLAI \quad (276)$$

$$HUF(i)=HUI(i)/(HUI(i)+exp(ah(1,i)-ah(2,i)*HUI(i))) \quad (276a)$$

Attributes Included in Apex Model

- Soil albedo
- Soil Hydrologic Group
- Soil Layer Depth
- Bulk Density (dry and wet)
- Precipitation, Temperature, Wind, Relative Humidity, Solar Radiation
- Potential evapotranspiration, evapotranspiration, vapor pressure deficit
- Electrical conductivity
- Soil Porosity
- Sand, silt, and clay content
- pH
- Organic matter
- Cation Exchange Capacity
- Coarse Fragments (Rock)
- Ksat (vertical water flow)
- Lateral Hydraulic Conductivity (horizontal water flow)
- Slope and Slope Length

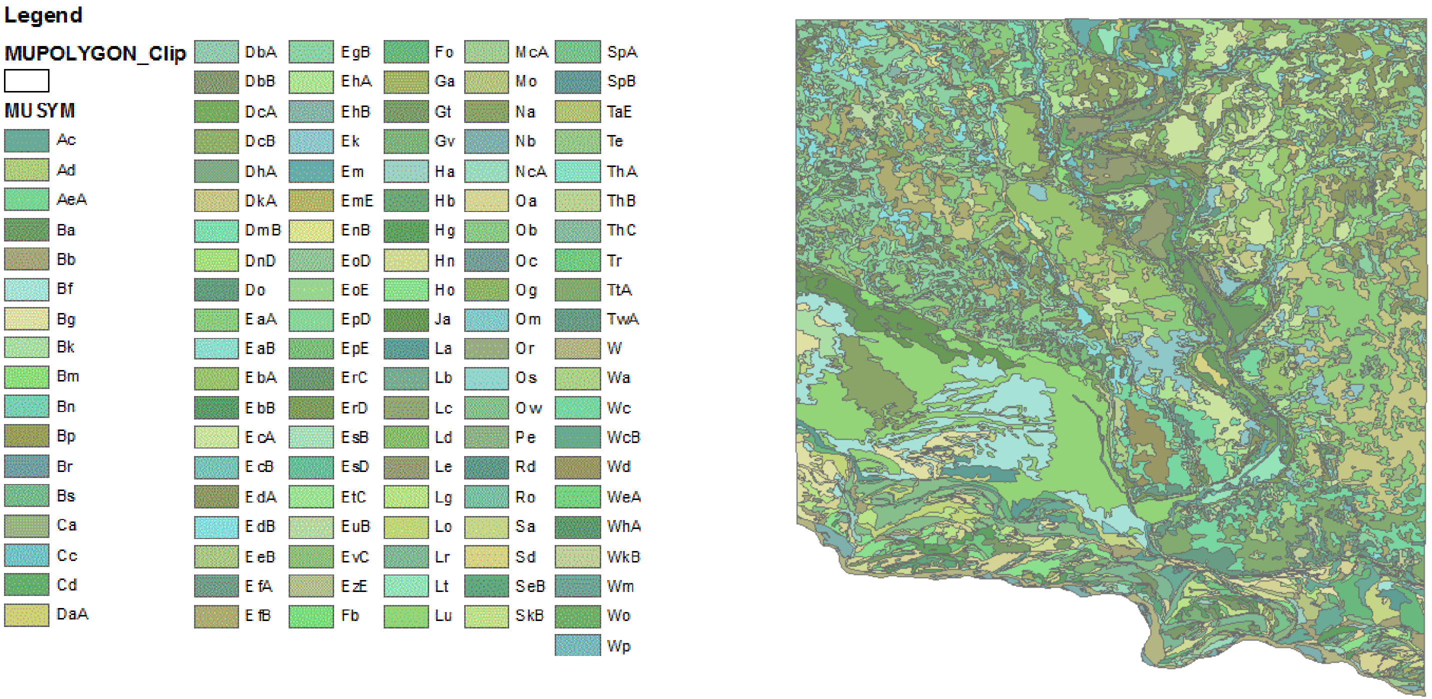
Crop Growth Characteristics

- Optimal Growing Temperature
- Plant density and Plant Mix
- Leaf area index
- Stomatal Conductance
- Non-Stress Leaf Area Growth Potential
- Root and Vegetation Growth Partitioning
- GDDs needed for plant maturity
- Seed yield as a percentage of biomass
- Max root depth
- Max crop height
- Nutrient Uptake
- Technology trend

Data for Apex Model

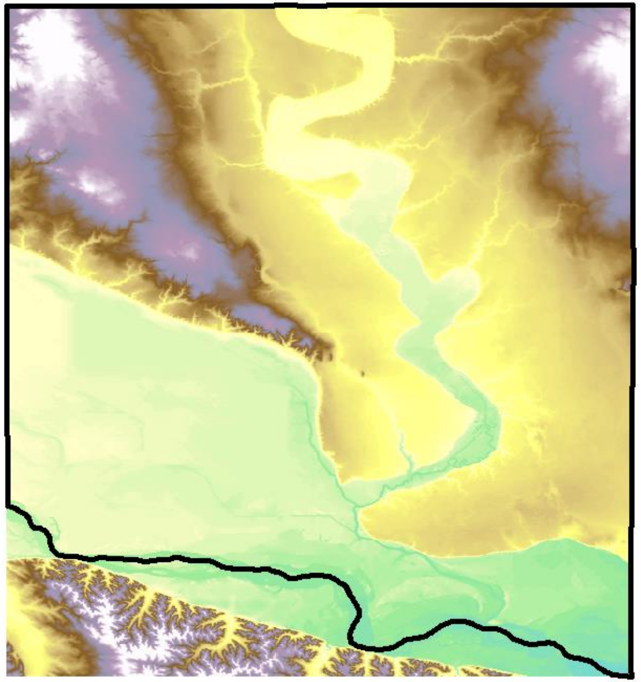
- Soil Data- NRCS SSURGO
- Topography-National Elevation Datasets (30 square meter resolution)
- Watershed characteristics- National Hydrology Datasets
- Weather-NCEP Forecast Reanalysis System (38Km resolution)

Clay County by Soil Map Symbol



Clay County Topography (Elevation (meters) and Slope (%))

Elevation



Legend

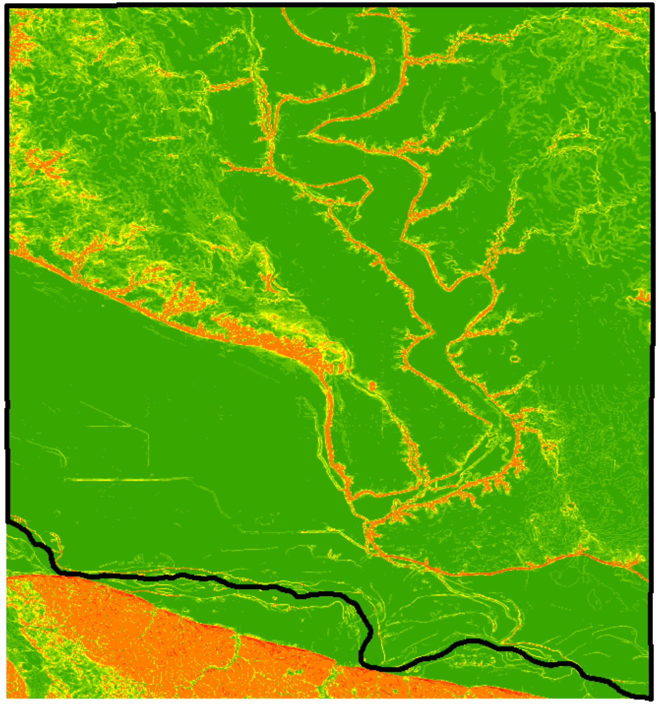
DEM_clay_Clip

Value

High : 470.406

Low : 339.124

Slope



Legend

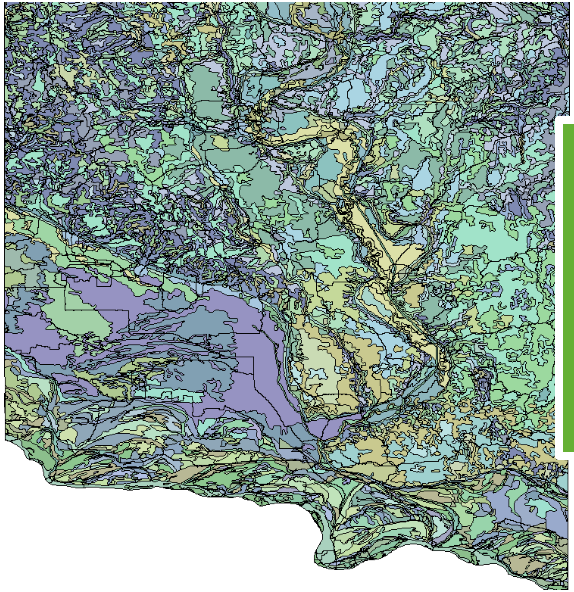
Slope_clay

<VALUE>

- 0 - 1
- 1.000000001 - 2
- 2.000000001 - 3
- 3.000000001 - 4
- 4.000000001 - 5
- 5.000000001 - 6
- 6.000000001 - 25
- 25.00000001 - 50
- 50.00000001 - 80

Clay County Slope Length and Hydrologic Landuse Units (HLU)

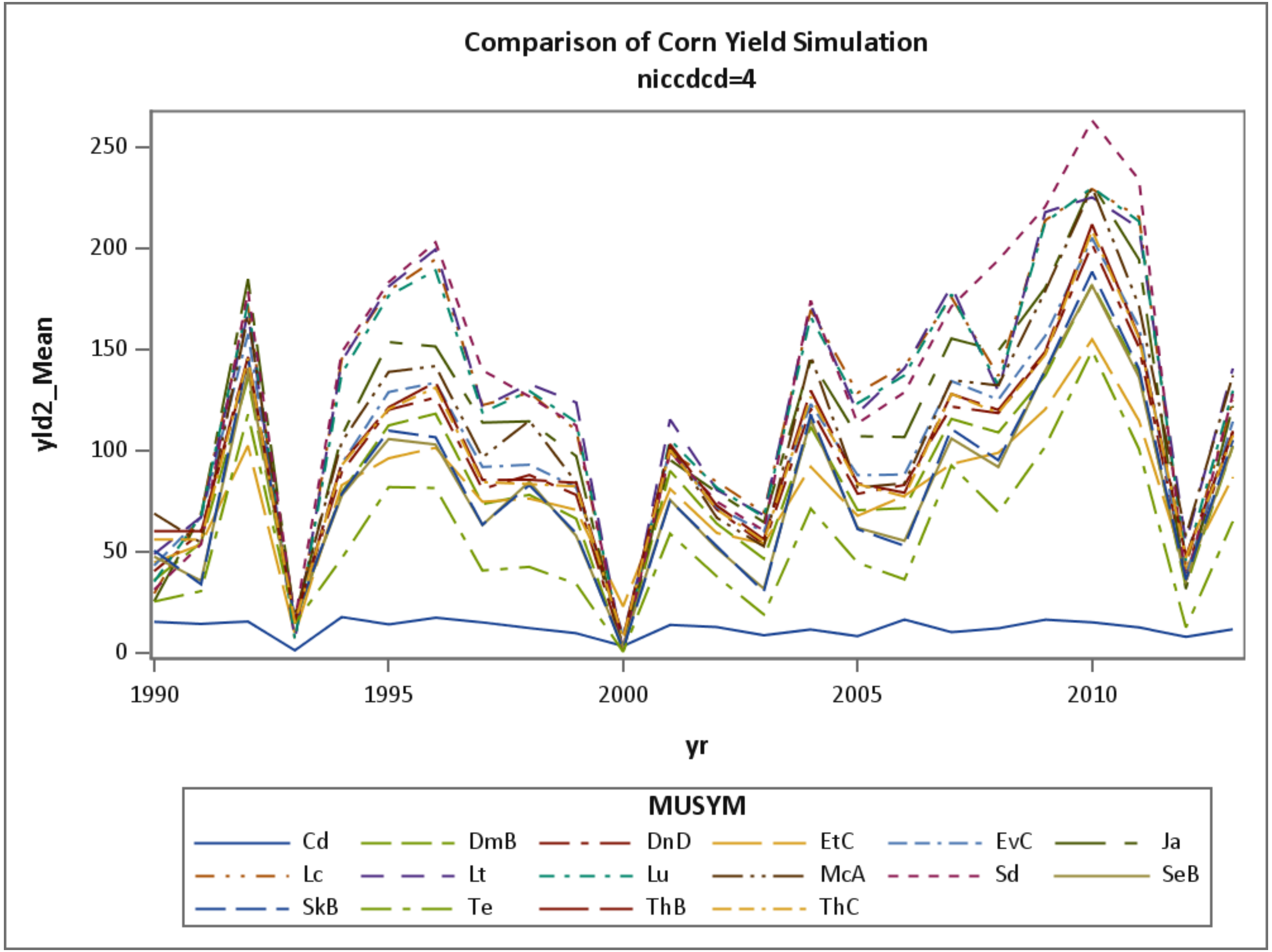
Slope length is the distance from the origin of overland flow along its flow path to the location of either concentrated flow or deposition.



HLU in Apex Simulation Soil Map Unit and NHD Catchment

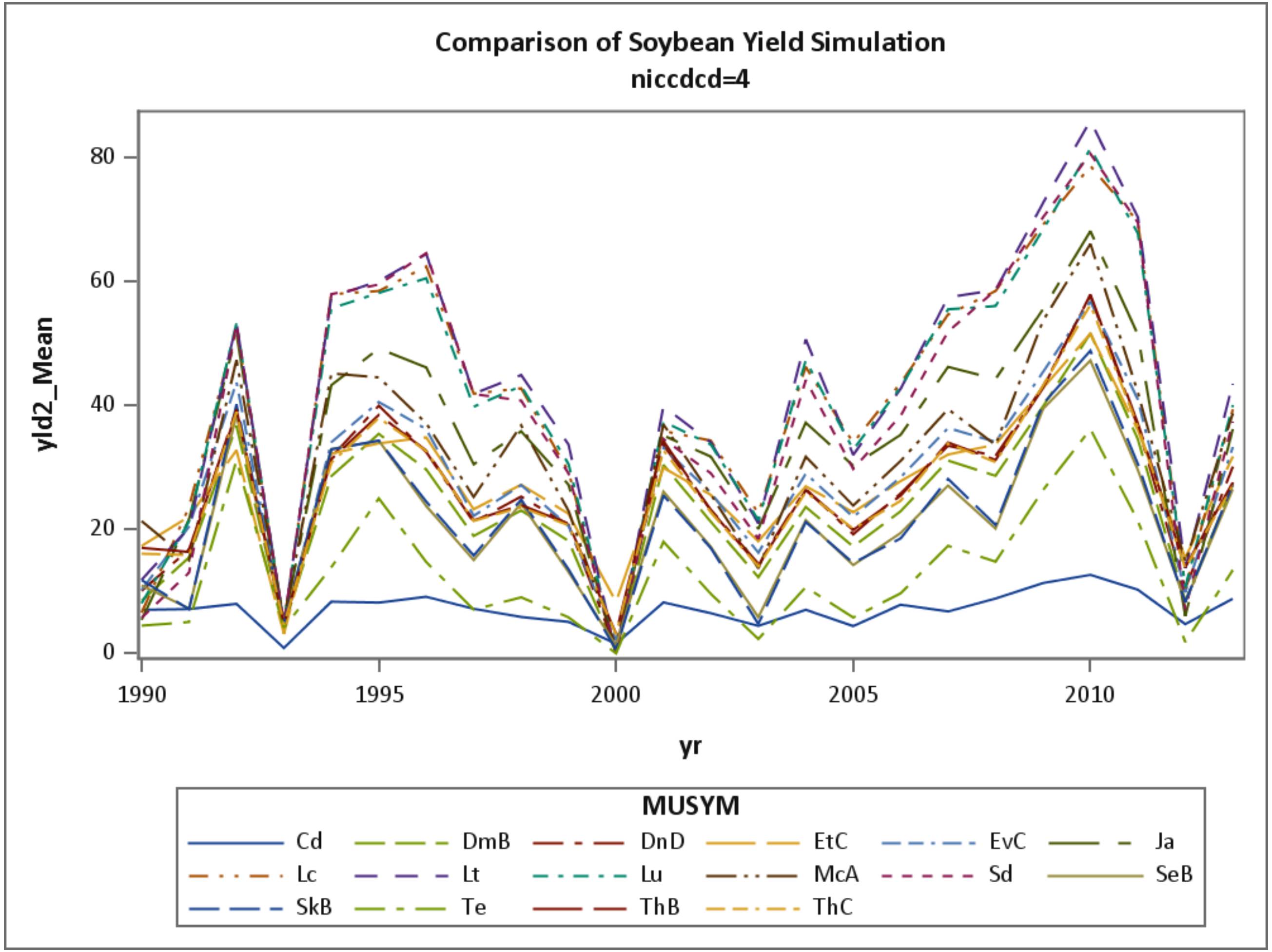
Clay County Growing Season Data in Apex Model Run (May-Aug)

Year	Min Temp (C)	Max Temp (C)	Solar Radiation (MJ/M²)	Precip. (mm)	Range ET (mm)	PET (mm)	Vapor Pressure Deficit (KPA)	Range Root Zone Soil Water (mm)
1990	15.91	29.94	21.88	58.31	60.51	191.97	1.45	12.03
1991	17.64	32.22	23.05	38.83	52.72	216.26	1.71	2.21
1992	12.81	25.12	21.02	115.37	100.94	150.03	0.80	36.79
1993	14.14	24.29	20.13	104.14	92.01	131.77	0.53	33.76
1994	15.58	30.69	24.06	67.96	74.28	201.68	1.46	20.78
1995	15.40	28.54	21.99	113.58	85.65	178.61	1.17	19.52
1996	14.73	27.75	22.16	87.63	64.96	168.22	1.02	16.63
1997	14.91	28.84	22.88	59.62	55.79	184.52	1.26	13.20
1998	15.99	29.69	22.08	52.73	65.66	182.34	1.31	20.23
1999	15.81	29.08	23.42	67.47	58.63	198.18	1.30	10.14
2000	15.73	32.55	24.58	19.96	26.25	227.76	1.97	-3.69
2001	16.09	30.37	23.02	62.15	73.11	201.42	1.51	9.57
2002	16.87	31.95	24.46	52.43	67.68	232.14	1.85	6.74
2003	15.39	30.76	24.13	30.62	43.24	210.98	1.69	9.51
2004	14.17	28.46	22.86	110.98	75.49	192.55	1.24	12.09
2005	16.63	30.72	24.19	51.91	60.37	213.08	1.54	8.08
2006	16.27	31.54	24.19	43.14	57.55	212.73	1.68	-0.96
2007	16.82	30.15	23.50	85.36	93.60	198.82	1.27	15.22
2008	14.65	28.11	23.20	89.14	55.65	177.83	1.12	18.92
2009	13.69	26.83	22.07	69.55	76.62	165.53	0.96	15.03
2010	15.93	28.08	23.36	93.82	94.84	181.43	0.98	11.33
2011	15.26	27.85	22.54	98.46	70.91	170.63	1.00	15.67
2012	16.65	32.89	24.51	58.79	59.66	240.20	1.98	-2.58
2013	15.59	28.36	21.92	74.48	73.77	180.57	1.20	15.23



SDSU Extension

iGrow.org



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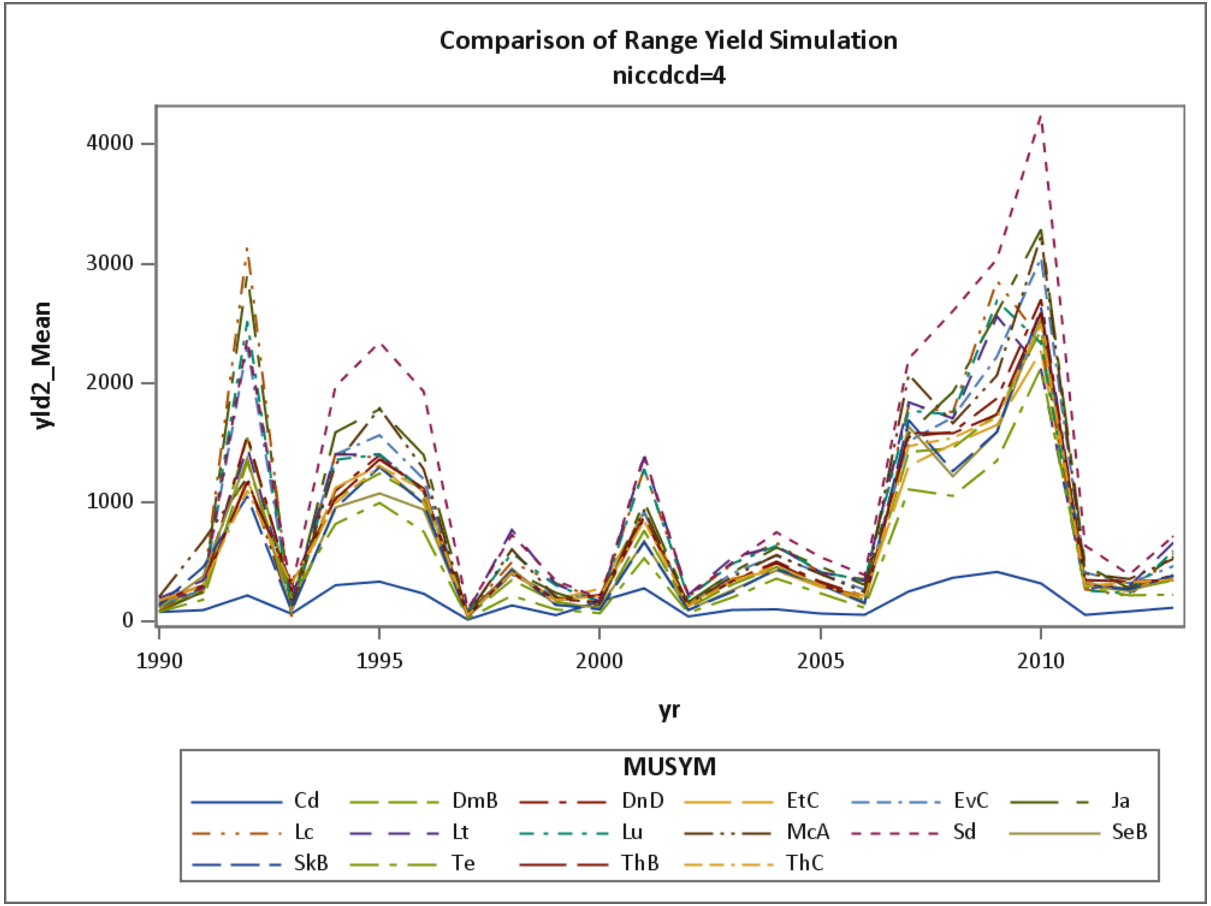

SDSU Extension

iGrow.org

Use Apex Yield Distributions to Perform Risk and Return Analysis (SERF) in Simetar

- Crop and livestock enterprise budgets from SDSU and other Land Grant Universities to develop input expenses
- Historical Price series for inputs (e.g. fertilizer) and local cash prices for output (e.g. bushels of corn or feeder cattle)
- Adjust some historical costs using PPI
- Use baseline projections from FAPRI to forecast future price expectations
- Rank alternative management of SD soils by their **certainty equivalence**
- The **certainty equivalent** is a guaranteed return that someone would accept rather than taking a chance on a higher, but uncertain, return. Alternatively, the certainty equivalent is the guaranteed amount of cash that would yield the same exact expected utility as a given risky asset with absolute certainty
- http://www.simetar.com/aboutus.aspx

Preliminary Risk and Return Analysis (SERF) of Alternative Management of Soil

Soil Map Symbol	Management	Preference Rank	**Certainty Equivalence Upper**	**Certainty Equivalence Lower**	Mean	Std_Dev	Skewness	Minimum
Ac	Grass	1	**$24.04**	**$24.04**	$24.04	$54.10	1.83	-$20.92
Ac	Corn	2	**-$7.83**	**-$7.99**	-$7.83	$399.16	0.68	-$689.94
Ac	Soybeans	3	**-$52.41**	**-$52.47**	-$52.41	$254.87	0.30	-$530.82
Bb	Corn	1	**$58.64**	**$58.47**	$58.64	$416.53	0.59	-$694.97
Bb	Grass	2	**$26.68**	**$26.68**	$26.68	$61.95	2.11	-$19.66
Bb	Soybeans	3	**$0.46**	**$0.39**	$0.46	$263.92	0.18	-$522.61
Fo	Grass	1	**$5.80**	**$5.80**	$5.80	$30.57	2.41	-$23.14
Fo	Corn	2	**-$40.86**	**-$41.01**	-$40.86	$389.55	0.66	-$701.17
Fo	Soybeans	3	**-$45.64**	**-$45.71**	-$45.64	$262.08	0.35	-$524.67
Sa	Corn	1	**$115.64**	**$115.42**	$115.64	$469.25	0.64	-$684.60
Sa	Soybeans	2	**$95.00**	**$94.88**	$95.00	$346.80	0.14	-$521.67
Sa	Grass	3	**$45.79**	**$45.78**	$45.79	$79.30	1.30	-$20.91

Strengths and Limitations of Apex Model and Simetar Analysis

- More complexity
- Alternative approach
- Not all productivity factors can be modeled accurately
- Adheres to the accepted criteria for HBU classification

Final Analysis: Classification of Highest and Best Use Using Both Methods

- Combine **Soil Productivity Rating** (SPR) and **Certainty Equivalence (CE) Values** to classify **HBU**.
  - Supervised or unsupervised?
    - **Supervised:** classify small sample of soils using **SPR** and **CE** values to train an algorithm to classify all SD soils
    - Report confidence of correct classification