Development of a Kansas Irrigated Productivity Index (KIPI) for the Valuation of Irrigated Lands

Final Report

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Executive Summary

The Soil Rating for Plant Growth (SRPG) model was developed by USDA-National Resources Conservation Service (NRCS) in 1992 to rate soil mapping units according to their plant growth potential. The model uses laboratory data and soil properties contained in a NRCS database named the State Soil Survey Database (SSSD). The SRPG is a mathematical model that arrays soil mapping units relative to their potential to produce crop growth independent of management practices.

In 1998, the Property Valuation Division (PVD) of the Kansas Department of Revenue began determining the use value of croplands using index values provided by NRCS that were generated by the SRPG model. The rating of each mapping unit is calculated based on dryland conditions. Since water greatly affects productivity, a modification of the SRPG model is necessary to accurately reflect the ability of the land to produce under irrigated conditions. An improved version of SRPG, which is called the Kansas Soil Rating for Plant Growth (KS-SRPG), is currently included in the newer NRCS database named the National Soil Information System (NASIS). The KS-SRPG contains enhancements designed to improve the model's reliability of map unit ranking.

This report describes the methodology and results of a procedure designed to use a modification of the KS-SRPG, the Kansas Irrigated Productivity Index (KIPI). The KIPI can be used to determine the productive potential of irrigated lands just as the KS-SRPG model is used to determine the productive potential for dryland conditions.

Briefly, 25 soil series were selected in consultation with NRCS personnel in Kansas. Mechanistic crop simulation models for corn, sorghum, and soybeans were used to simulate both irrigated and dryland yields based on 30 years of weather data for 25 counties in Kansas where the soils occurred.

Ratios of "simulated irrigated yields to simulated dryland yields" were compared with county average ratios of actual yields. These ratios were in close agreement, indicating the simulated data on a "soil series-county basis" can be used to modify the KS-SRPG model.

A good relationship was found between average simulated dryland yields and KS-SRPG indices on a soils series-county basis suggesting the simulation approach was valid. Modification of the KS-SRPG relationships retained only soil properties that could not be negated by irrigation and management. The remaining features were the Landscape Features component and the soil property values for sodium absorption ratio (SAR) and electrical conductivity (EC). Thus, the KS-SRPG was modified to produce a new index, the Kansas Irrigated Productivity Index (KIPI). Ratios of simulated irrigated yields were compared to ratios of the KIPI to the KS-SRPG. The KIPI was shown to have the same relationship to the dryland KS-SRPG as the relationship of simulated irrigated yields to simulated dryland yields. Thus, the KIPI can be computed by NRCS in the NASIS system for any soil series at any location in Kansas.

More detailed description of the methodology and results, example values for KS-SRPG and KIPI, and cautions for use of KIPI are provided in the following report.

Introduction

The USDA Natural Resources Conservation Service (NRCS), in cooperation with Kansas State University (KSU) and the Kansas Agricultural Experiment Station, have completed a soil survey for all counties in Kansas. These surveys include documentation, soil maps and properties and interpretations necessary for making generalized decisions on the use and management of soils. Determination of the relative productivity is one of the many uses of soil survey information.

The Soil Rating for Plant Growth (SRPG) model was developed by NRCS in 1992 to rate soil mapping units according to their plant growth potential (Olson et al., 1996; Scheyer et al., 1992). The model uses laboratory data and soil properties contained in a NRCS database named the State Soil Survey Database (SSSD). The SRPG is a mathematical model that arrays soil map units relative to their potential to produce crop growth independent of management practices. The six groupings of soil properties used by the SRPG model include surface characteristics, water features, soil chemistry, soil climatic factors, physical profile, and landscape features (Appendix A). The model generates a single index value that represents each soil map unit within a specific geographic location.

In 1998, the Property Valuation Division (PVD) of the Kansas Department of Revenue began determining the use value of croplands using index values provided by NRCS that were generated by the SRPG model. The rating of each mapping unit is calculated based on dryland conditions. Since water greatly affects productivity, a modification of the SRPG model is necessary to accurately reflect the ability of the land to produce under irrigated conditions.

A similar version of the SRPG, the Kansas Soil Rating for Plant Growth (KS-SRPG) model has been enhanced, updated, and moved into the newer NRCS database named the National Soil Information System (NASIS). The new evaluation process within the KS-SRPG model is believed to more effectively array soil mapping units according to their properties and climatic influences.

Objectives

An evaluation and modification of the KS-SRPG model was done so that soil mapping unit indices were applicable for irrigated conditions. This approach required a determination of which soil properties affect yields under irrigation for Kansas conditions. In addition, the climatic factors were adjusted for irrigated lands. Specific objectives were:

- Use existing crop-growth models to study the effects of soil properties on irrigated vs. non-irrigated yields.

- Evaluate soil properties that are components of the KS-SRPG model and how they affect yield under irrigation.

- Determine if the existing KS-SRPG model can be modified for irrigation productivity.

- Relate ratings determined with an irrigated KS-SRPG model to those determined with the dryland KS-SRPG model.

Materials and Methods

In consultation with NRCS, a list of 25 soil series (test soils) (Table 1) were selected for model testing. These soils represented a range of soil characteristics and climatic conditions and included the major irrigated soil series in Kansas. NRCS also made available a fully populated dataset, within NASIS, of these 25 test soils. This dataset included the laboratory data and soil properties (Appendix B, Table B-1 and Table B-2) required to run the KS-SRPG model. This dataset uses soil property data that best represents each of the soil series.

1.	Attica	10.	Holdrege	19.	Richfield
2.	Avans	11.	Keith	20.	Roxbury
3.	Bridgeport	12.	Kuma	21.	Satanta
4.	Carwile	13.	Ladysmith	22.	Spearville
5.	Crete	14.	Manter	23.	Tivoli
6.	Dalhart	15.	McCook	24.	Ulysses
7.	Eudora	16.	Naron	25.	Vona
8.	Farnum	17.	Parsons		
9.	Harney	18.	Pratt		

Table 1. List of 25 soil series that were selected for model development and testing.

Within NASIS, an acreage report was generated. This allowed determination of the soil series present in each Kansas county. The county dataset for each of the soils were entered into an MS Access ® database. This information depicted the geographic extent of each of the 25 test soils and aided in the selection of counties for further investigation.

Next, 25 counties were selected for investigation and are shown in Figure 1. The selection process consisted of specific criteria for a county to qualify as a “test county”. The criteria are:

1) a complete and available climate data set, which includes solar radiation, from a weather station located within county boundaries,

2) adequate representation of each test soil across the state, from north to south and east to west,

3) a number of test soils within each county (Table 2).

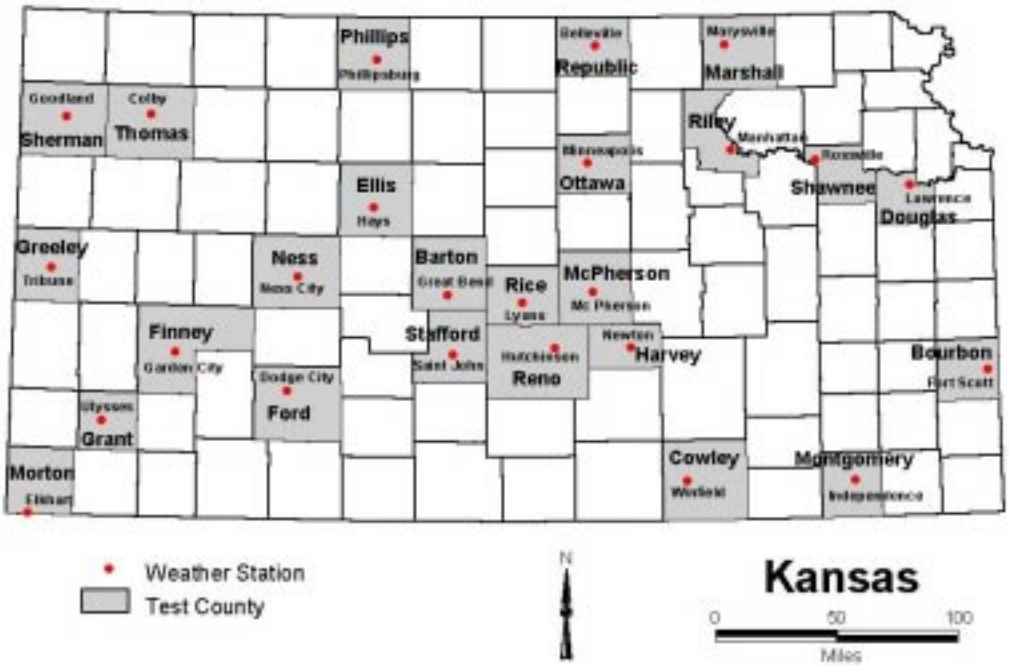


Figure 1. The 25 test counties selected and the weather station utilized for that county.

FIP #	County Name	Soil Series
009	Barton	Attica, Bridgeport, Carwile, Crete, Farnum, Harney, Holdrege, Naron, Pratt, Roxbury, Tivoli
011	Bourbon	Parsons
035	Cowley	Attica, Ladysmith, Tivoli
045	Douglas	Eudora
051	Ellis	Crete, Harney, Holdrege, McCook, Roxbury
055	Finney	Bridgeport, Harney, Manter, Richfield, Roxbury, Spearville, Tivoli, Ulysses, Vona
057	Ford	Attica, Bridgeport, Carwile, Dalhart, Harney, Holdrege, Manter, Pratt, Richfield, Roxbury, Satanta, Spearville, Tivoli, Ulysses
067	Grant	Bridgeport, Dalhart, Manter, Richfield, Satanta, Tivoli, Ulysses, Vona
071	Greeley	Manter, Richfield, Ulysses
079	Harvey	Bridgeport, Carwile, Crete, Farnum, Ladysmith, Naron, Pratt, Tivoli
117	Marshall	Crete, Eudora, Ladysmith
113	McPherson	Attica, Bridgeport, Carwile, Crete, Farnum, Ladysmith, McCook, Naron, Pratt, Roxbury
125	Montgomery	Parsons
129	Morton	Dalhart, Richfield, Satanta, Ulysses,
135	Ness	Bridgeport, Harney, Holdrege, Richfield, Roxbury, Ulysses
143	Ottawa	Carwile, Crete, Harney, McCook, Pratt, Roxbury
147	Phillips	Bridgeport, Harney, Holdrege, McCook, Roxbury
155	Reno	Attica, Avans, Crete, Farnum, Ladysmith, Naron, Pratt
157	Republic	Crete, Eudora, Harney, Holdrege, McCook, Roxbury
159	Rice	Attica, Avans, Carwile, Crete, Farnum, Ladysmith, Naron, Pratt, Tivoli
161	Riley	Crete, Eudora, Ladysmith
177	Shawnee	Eudora, Ladysmith
181	Sherman	Bridgeport, Keith, Kuma, Richfield, Roxbury, Ulysses
185	Stafford	Attica, Carwile, Farnum, Naron, Pratt, Tivoli
193	Thomas	Bridgeport, Keith, Richfield, Roxbury, Ulysses

Table 2. List of test soils found within test counties.

Three existing crop-growth models were used to study effects of soil properties on the irrigated versus the non-irrigated yields:

- Corn - CERES Maize, (Tsuji, et al., 1994).
- Soybean - CROPGRO - Soybean, (Tsuji, et al., 1994).
- Sorghum - SORKAM, (Rosenthal et al., 1989).

These crop models require inputs of:

- daily weather data (temperature, rainfall, and solar radiation);
- management variables, e.g., planting date;
- soils information, e.g., water holding capacity; and
- genetic characteristics of the crop and individual cultivar.

They compute, on a daily basis, crop growth and development, water use and, of particular importance to this project, crop yield. Changes in any of these inputs can be evaluated for changes in computed yields. Therefore, they are appropriate tools to investigate both

1) the differences in dryland and irrigated yields in different areas of the state (temperature and rainfall) and on different soil series and

2) the effects of irrigation on crop yields.

Crop model inputs were established with the objective that they would reflect representative growing conditions for each crop within a particular test county. Irrigation schemes were run as "optimum" conditions (no water stress). Climate data from years 1961 through 1990, the years used to calculate "normal" conditions, were used. Model soil inputs were from the current version of the data made available by NRCS within NASIS (Appendix B, Table B-1 and Table B-2). However, horizons or layers were broken into specific depths; surface horizon ≤ 15 cm, subsurface layers ≤ 30 cm, and total depth ≤ 150 cm.

Representative growing conditions were developed with assistance from a variety of resources. Crop planting dates were determined with the use of the Kansas Crop Progress Calendar (Ruckman et al., 1996). Within this handbook each crop; corn, soybean, and sorghum, has a table representing percent of acreage planted by specific dates, 1990-1994 averages. This table was used to approximate on what date 50 percent of that crop was planted within each Crop Reporting District (CRD). This date was used as the planting date in the appropriate crop-growth model for a particular test county.

The Corn Production Handbook (Hickman and Shroyer, 1994) was used to determine plant population, row spacing, and seed depth for the CERES Maize model. The corn cultivar, B73xMo17, was selected because it is well defined and within the maturity group appropriate for Kansas. CERES-Maize inputs for each CRD are shown in Figure 2. The Soybean Production Handbook (Kok, et al., 1997) was used to determine plant population, row spacing, seed depth, and cultivar (maturity group) for the CROPGRO - Soybean model. CROPGRO-Soybean inputs for each CRD are shown in Figure 3. The Grain Sorghum Production Handbook (Shroyer et al.,

1998) was used to determine plant population, row spacing, and seed depth for the SORKAM model. A medium maturity (18 leaf) sorghum hybrid was selected because it is well defined and within the maturity group appropriate for Kansas. SORKAM-Sorghum inputs for each CRD are shown in Figure 4.

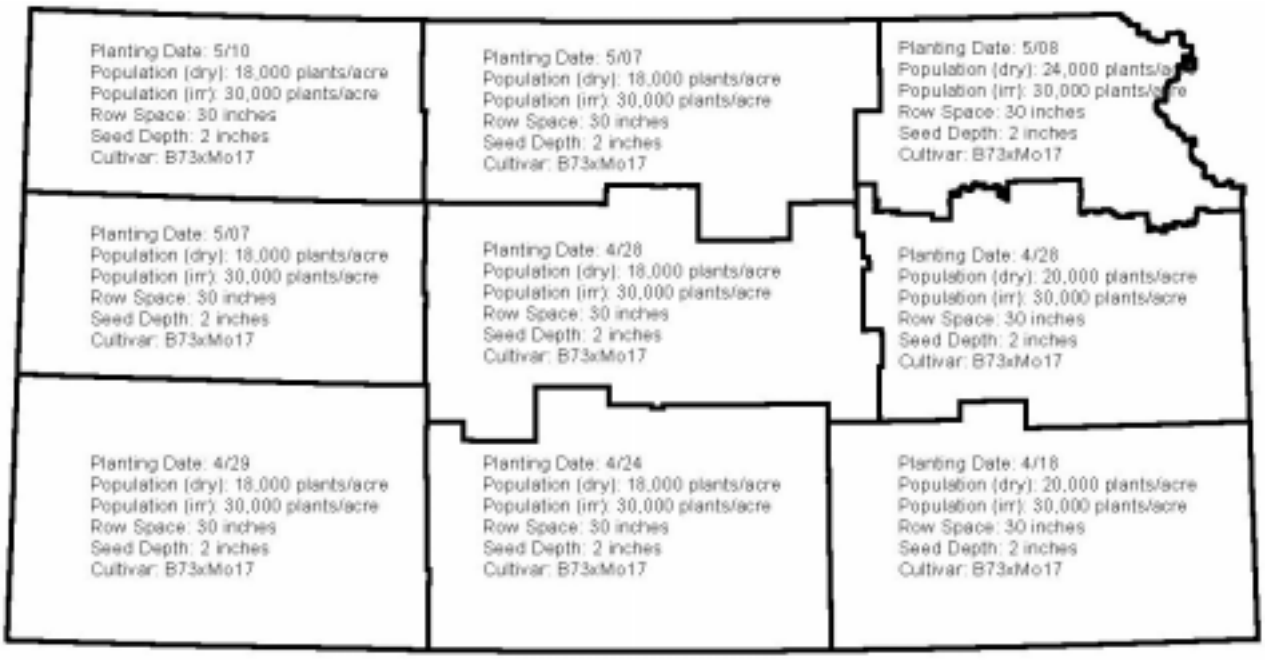
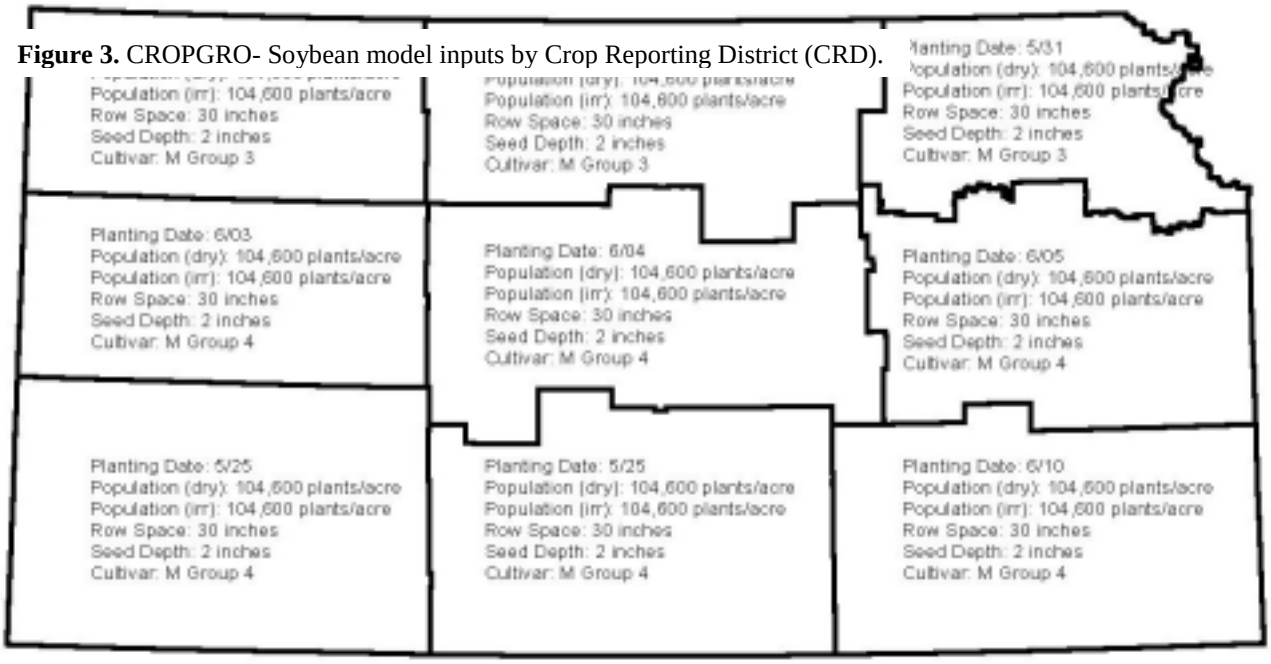


Figure 2. CERES- Maize model inputs by Crop Reporting District (CRD).

Figure 3. CROPGRO- Soybean model inputs by Crop Reporting District (CRD).



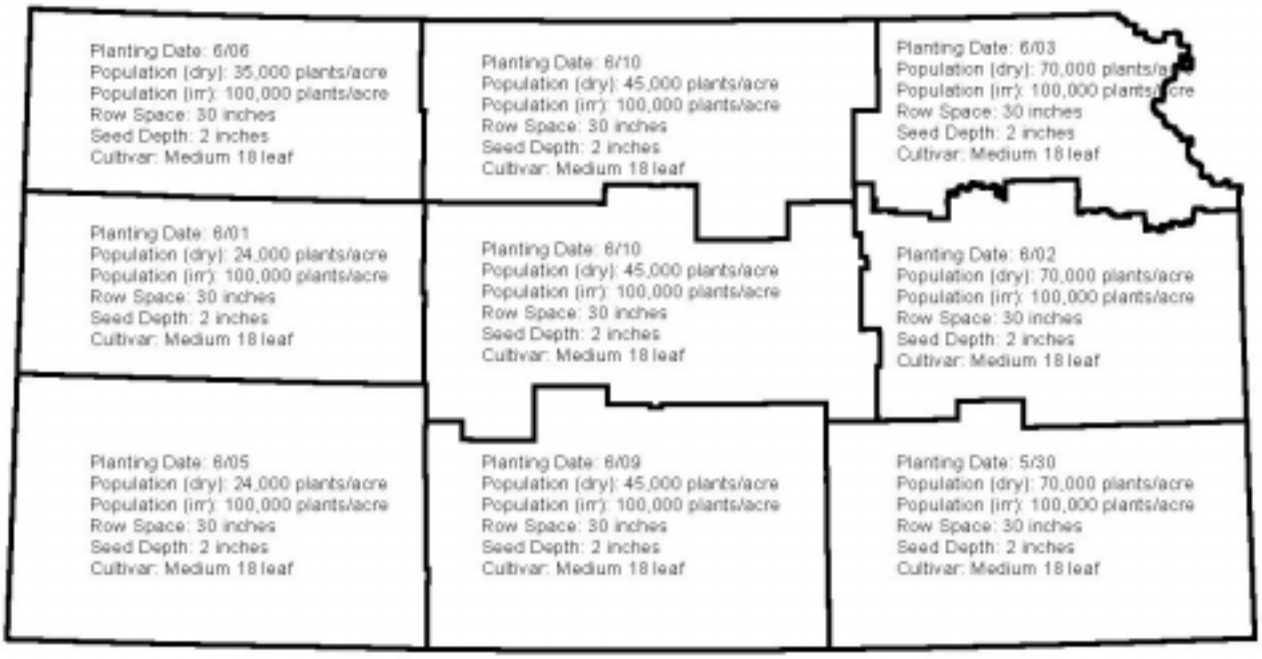


Figure 4. SORKAM- Sorghum model inputs by Crop Reporting District (CRD).

Crop model scenarios were tailored for each specific model, county, soil series, and management practice (irrigated or dryland) combination, with simulations run for all 30 years. Approximately 25,560 crop model simulations were run. Results were averaged over the 30 years of climate data, and a crop ratio (irrigated yield/dryland yield) was calculated for each crop, county, and soil series combination.

Just as the original SRPG model (Scheyer et al., 1992) was developed with corn data, the use of the three crop models was intended to evaluate the effects of soil properties on relative irrigated and dryland yields. The intent was not to provide specific estimates of irrigated and dryland corn, soybean, and sorghum yields.

Accessibility to NASIS is required to run the KS-SRPG model. NASIS contains the soil property database needed to run each of the models as well as the models themselves. NASIS has the capability to run a model for either a single county, multiple counties, or the entire state. The area of interest is indicated, the appropriate model is selected, and NASIS generates the resulting index values.

Development of a method to modify the KS-SRPG model to produce irrigated productivity ratings was considered in the following sequential steps:

1) Determine if the three crop models would produce realistic ratios of irrigated yields to dryland yields.

2) Determine if the simulated dryland yields were adequately related to KS-SRPG so that simulated irrigated yields could be used to modify KS-SRPG.

3) Determine which soil property factors used in KS-SRPG should be removed or modified to produce irrigated ratings comparable to the crop simulation results.

Failure to successfully complete any of these steps would prevent using this approach to produce irrigated soil series-county level ratings comparable to the soil series-county level dryland KS-SRPG ratings.

The purpose of using three different crop models was to include different approaches to crop simulation and to limit the influence of any crop on yield values. The purpose was not to evaluate these particular crops. Simulated crop ratios were averaged across crops for each county and soil series. The resulting simulated crop ratio was compared to an actual county crop ratio for verification purposes. Crop ratios were used instead of yields because the interest is in the relative yields under irrigation not the absolute yields. The crop models do not account for unpredictable factors such as hailstorms or insect infestation. However, the crop ratios were considered comparable.

Actual yield data were downloaded from the USDA National Agricultural Statistics Service, Published Estimates Data Base (http://www.nass.usda.gov:81/ipedb). Actual average yields for the county were derived from years in which both irrigated and dryland data were available. The actual county crop ratio was calculated the same as the simulated crop ratio (irrigated yield/dryland yield). The actual yields are only provided at the county level and not by soil series, therefore simulated crop ratios were averaged over soil series for each of the test counties before being compared.

If the simulated irrigated to dryland yield ratios are considered realistic, simulated dryland yields will be regressed on soil series-county level KS-SRPG values. A close relationship between these values provides confidence that the irrigated yield values can be used to modify KS-SRPG.

If the simulated dryland yields are adequately related to dryland KS-SRPG values, the ratio of simulated irrigated to simulated dryland yields will be used to determine what soil property factors can be removed or modified in KS-SRPG to produce similar ratios of ‘irrigated KS-SRPG’ to ‘dryland KS-SRPG’ values. As requested, Robert D. Nielsen, Soil Scientist, NSSC, Nebraska, (personal communication) adjusted the KS-SRPG model to make these comparisons.

Results and Discussion

Examples of simulated and actual crop ratios for two counties are shown in Table 3. Although the intent was not to evaluate individual crops, initially ratios for each crop were examined to determine if simulations with all three models should be continued. Although there often was considerable over- or underestimation for a single crop in a given county, the average across all crops generally agreed quite well with county average yield ratios. Consequently, all three crop models were used.

Simulated crop ratios, averaged over soil series for each test county, and actual crop ratios were compared for the 25 test counties. The majority of the comparisons resulted in a conservative simulated crop ratio that tended to be slightly lower than actual crop ratios. Counties in western

Kansas, such as Morton, Grant, and Greeley counties, with higher irrigated yields had slightly higher simulated crop ratios than actual crop ratios. As the crop ratio approached 2.5, the simulated crop ratio exceeded the actual crop ratio (Figure 5). Actual crop ratios accounted for approximately 77% of the variability in simulated crop ratios.

Barton County

Soil Name	Simulated Corn Ratio	Simulated Soybean Ratio	Simulated Sorghum Ratio	Simulated Crop Ratio
ATTICA	1.73	2.51	1.71	1.99
BRIDGEPORT	1.59	3.12	1.84	2.18
CARWILE	1.78	2.56	1.66	2.00
CRETE	1.73	2.39	1.59	1.90
FARNUM	1.61	2.29	1.46	1.79
HARNEY	1.48	1.86	1.37	1.57
HOLDREGE	1.40	1.71	1.27	1.46
NARON	1.62	2.25	1.57	1.81
PRATT	2.31	3.69	2.80	2.93
ROXBURY	1.39	1.67	1.27	1.44
TIVOLI	2.67	4.37	3.57	3.53
Sim. Ratio	**1.76**	**2.58**	**1.83**	**2.06**
Actual Ratio	**2.55**	**1.94**	**1.97**	**2.16**

Ford County

Soil Name	Simulated Corn Ratio	Simulated Soybean Ratio	Simulated Sorghum Ratio	Simulated Crop Ratio
ATTICA	1.87	2.54	2.01	2.14
BRIDGEPORT	1.67	3.21	2.48	2.45
HARNEY	1.54	1.86	1.66	1.68
HOLDREGE	1.45	1.71	1.49	1.55
PRATT	2.41	3.94	3.70	3.35
RICHFIELD	1.67	2.13	1.88	1.90
ROXBURY	1.44	1.68	1.52	1.54
SATANTA	1.63	2.05	1.82	1.83
SPEARVILLE	1.60	1.95	3.53	2.36
TIVOLI	2.81	4.79	5.21	4.27
ULYSSES	1.64	2.14	1.83	1.87
Sim. Ratio	**1.79**	**2.55**	**2.47**	**2.25**
Actual Ratio	**3.20**	**1.72**	**2.13**	**2.35**

Table 3. Examples of simulated county crop yield ratios and actual county crop yield ratios for two counties in Kansas.

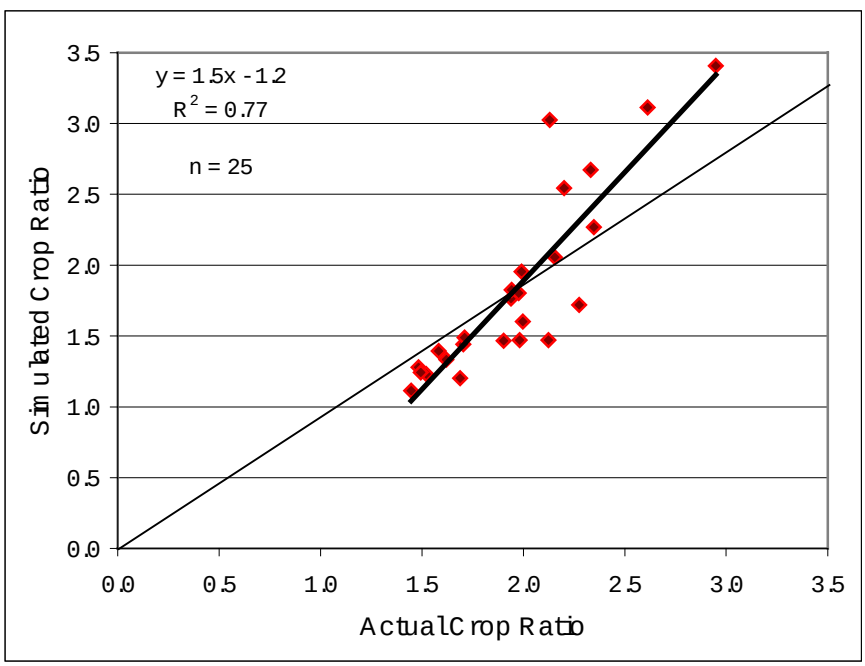


Figure 5. Crop ratio comparisons at the county level for the 25 test counties.

Satisfied that the simulated crop ratios were realistic, the average simulated dryland crop yields were regressed on KS-SRPG values. The purpose was to determine how well the simulated dryland yields were related to the KS-SRPG values. The resulting R^2 was 0.49, accounting for approximately 50% variability (Figure 6). Further investigation indicated reasons for many of the outliers. The Carwile series, which has variable soil properties, did not produce simulated crop yield ratios that related well with their assigned KS-SRPG values of about 20. Soils with high available water holding capacity (AWC), such as Eudora, located in counties with adequate precipitation lie well above the regression line on the upper end of the graph. In contrast, soils with low AWC, such as Tivoli, lay below the regression line on the lower end of the graph. The impact of these deviations from the regression depends on how KS-SRPG is modified to produce irrigated values.

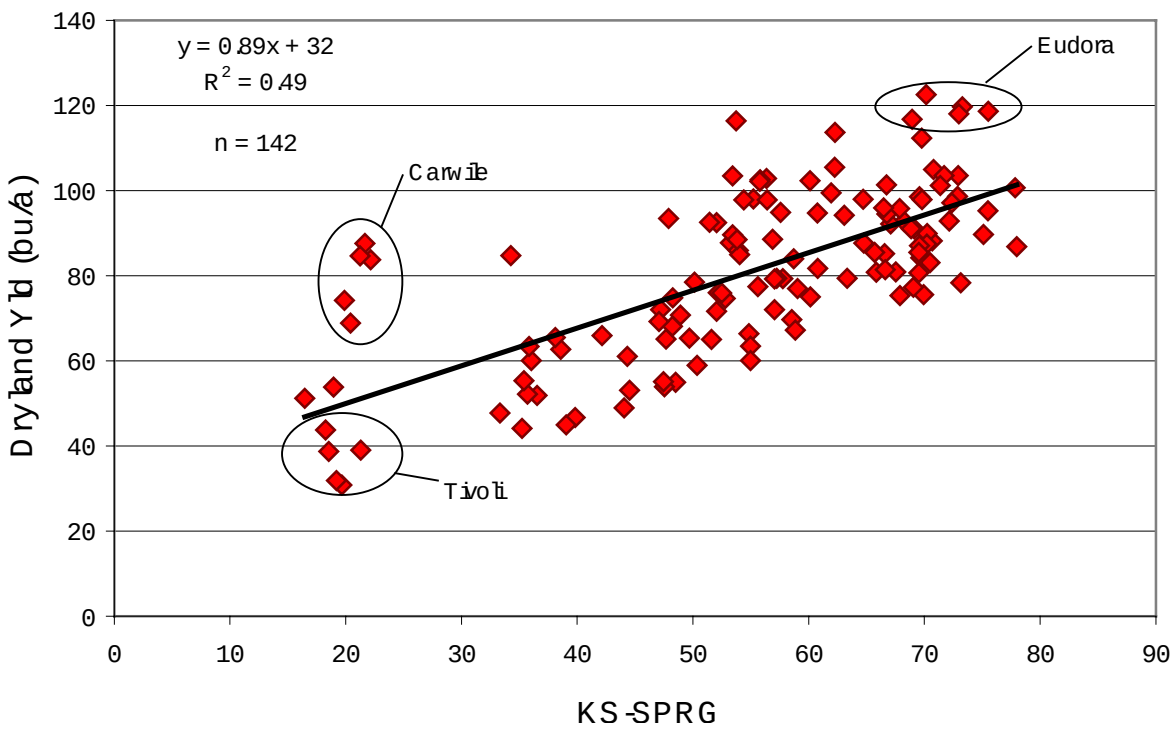


Figure 6. Comparison of simulated dryland crop yields to KS-SRPG.

Initial attempts to adjust the KS-SRPG model to produce irrigated index values consisted of the elimination of water related factors within the model. With the removal of the Soil Climatic Factors component and AWC subcomponent throughout the model, the KS-SRPG index values should not be influenced by the effects of precipitation and available water.

Simulated crop ratios were compared to the ratio of the "adjusted KS-SRPG" (minus precipitation and available water) to the "dryland KS-SRPG" values. Although the relationship accounted for almost 64% of the variability, the ratio of crop yields was more than twice (2.23) the ratio of the KS-SRPG values (Figure 7). These results indicated that irrigation could remove the effects of more than just water related factors.

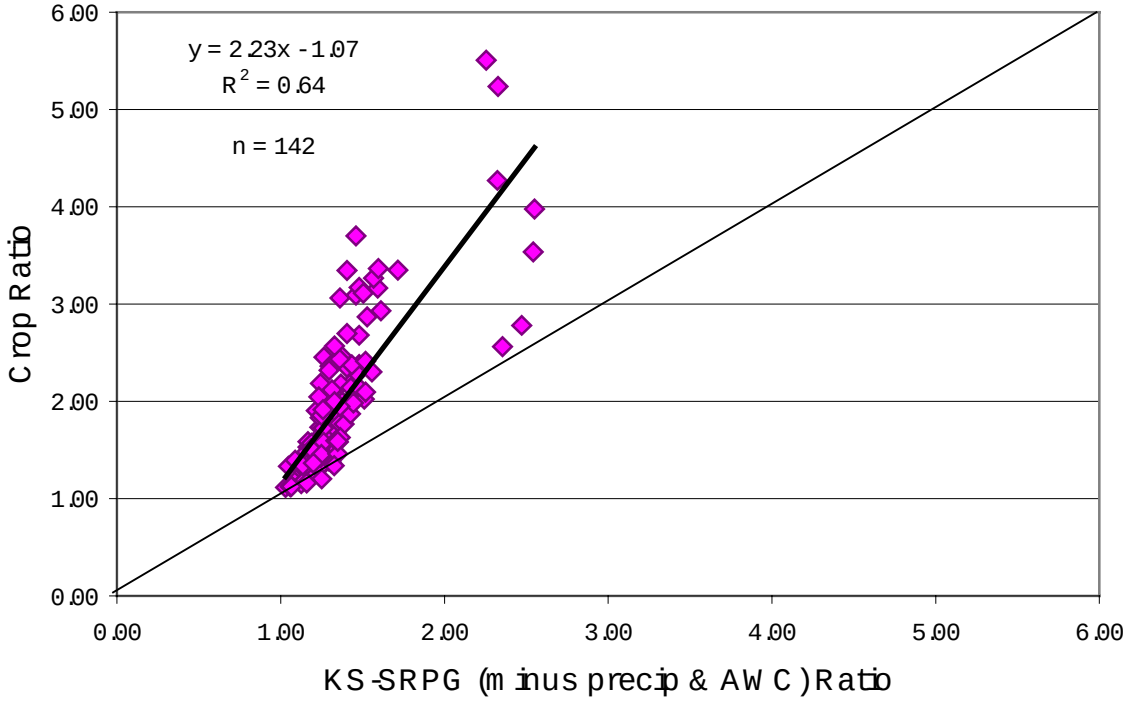


Figure 7. Comparison of simulated crop ratio to ratio from adjusted KS-SRPG model, with precipitation and available water evaluation effects removed.

An alternative approach was attempted which retained only those features and soil properties that could not be dealt with by irrigation and management. The remaining soil properties in the KS-SRPG model were the Landscape Features component and the soil property values for sodium absorption ratio (SAR) and electrical conductivity (EC).

Comparison of simulated crop ratios with adjusted KS-SRPG ratios revealed an R^2 of 0.66 and a relationship essentially the same as a 1:1 line (Figure 8). Thus, this adjusted KS-SRPG model, has been designated the Kansas Irrigated Productivity Index (KIPI) and can be used to calculate irrigated crop productivity indices. Example KS-SRPG and KIPI values for two counties are shown in Table 4. The examples in Table 4 use actual county data from the NASIS database.

The KIPI model in essence is a modified version of the KS-SRPG model with only the evaluation effects of the Landscape Features component and the properties for the sodium absorption ratio (SAR) and electrical conductivity (EC). However, the KIPI values are dependent on the soil property data within NASIS that may be updated or changed according to NRCS needs. An unofficial KIPI has been run and reflects the index for each map unit in Kansas on August 21, 2001 (Attached CD).

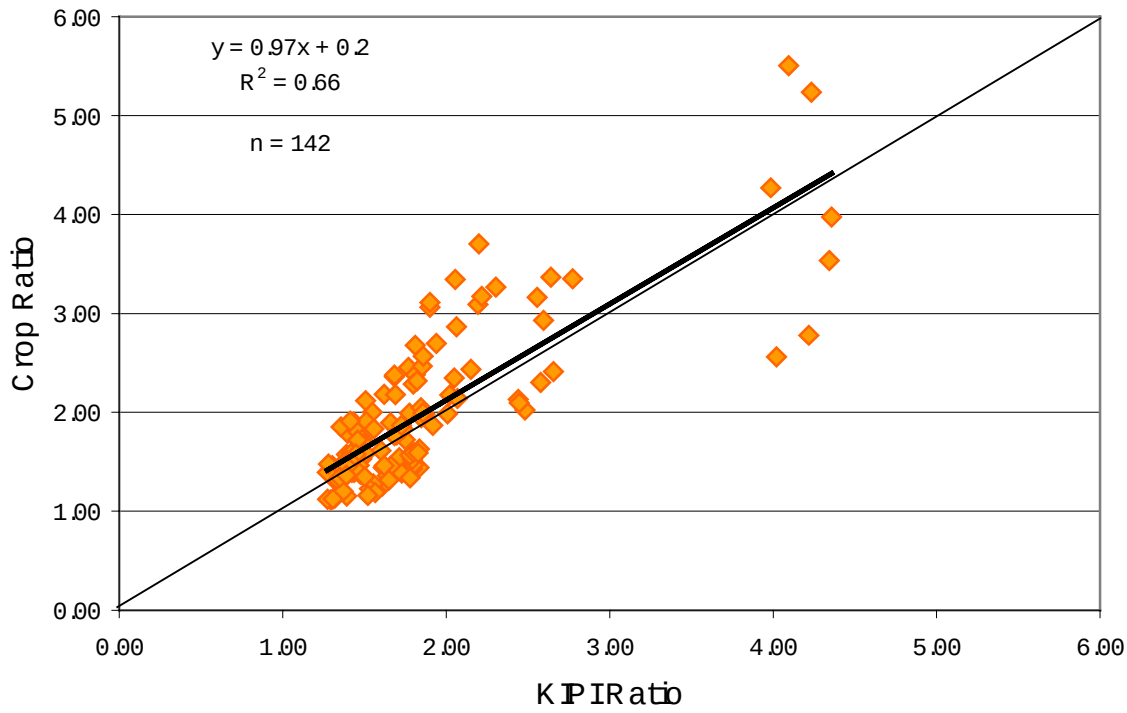


Figure 8. Comparison of simulated crop ratio to ratio from adjusted KS-SRPG model, with only the components Landscape Features, SAR, and EC.

Barton County

Soil Name	KS-SRPG (Dryland)	KIPI (Irrigated)
ATTICA	48	97
BRIDGEPORT	60	98
CARWILE	20	31
CRETE	69	99
FARNUM	70	99
HARNEY	69	97
HOLDREGE	72	98
NARON	68	98
PRATT	36	93
ROXBURY	55	89

Ford County

Soil Name	KS-SRPG (Dryland)	KIPI (Irrigated)
ATTICA	47	97
BRIDGEPORT	48	85
HARNEY	66	98
HOLDREGE	67	99
PRATT	33	92
RICHFIELD	59	98
ROXBURY	52	89
SATANTA	63	99
SPEARVILLE	59	99
TIVOLI	21	85

Table 4. KS-SRPG and KIPI values obtained using the actual county data from the NASIS database for the example soil series and counties shown in Table 3.

Cautions

Although the procedure developed is scientifically based and provides a clear, logical method for producing irrigated indices (KIPI) based on the same procedures and database (KS-SRPG and NASIS) presently being proposed for dryland values, several cautions are appropriate.

1) The procedure assumes the KS-SRPG values are appropriate for dryland cropping potentials.

2) The procedure and example KIPI values have been produced with the current NASIS database and any changes in this database will potentially change both the KS-SRPG and KIPI values.

3) Similarly, if major changes are made to the KS-SRPG model, the relative values of KIPI and KS-SRPG may no longer be appropriate.

4) Since this procedure was developed with a subset of 25 soil series typically cultivated and suitable for irrigation there may be series for which results may not be applicable, e.g., soils with a shallow depth to bedrock. Soils or map units that are not typically cultivated or irrigated may not produce results presented in this study.

5) The KIPI value, as is true for KS-SRPG, does not consider management on availability of irrigation water.

Literature Cited

Hickman, J.S., and J.P. Shroyer. May 1994. Optimum Planting Practices. *In* Corn Production Handbook. p. 8-11. Cooperative Extension Service, Kansas State University. Manhattan, KS.

Kok, H., D.L. Fjell, and G.L. Kilgore. March 1997. Seedbed Preparation and Planting Practices. *In* Soybean Production Handbook. p. 8-11. Kansas State University, Agricultural Experiment Station and Cooperative Extension Service. Manhattan, KS.

Olson, G.L., B.F. McQuiad, K.N. Easterling, and J.M. Scheyer. 1996. Quantifying soil condition and productivity in Nebraska. P. 357-369. *In* J.W. Doran and A.J. Jones (ed.) Methods for assessing soil quality. Soil Sci. Soc. of Am. Special Publ. 49, Soil Science Society of America, Madison, WI.

Rosenthal, W. D., R. L. Vanderlip, B. S. Jackson, and G. F. Arkin. 1989. SORKAM: A grain sorghum growth model. TAES Computer Software Documentation Ser. No. MP-1669. Tex. Agric. Exp. Stn., College Station.

Ruckman, C.R., D. Kolterman, L. Honig, T.J. Byram, and E.J. Thiessen. 1996. Kansas Crop Progress Calendar, District Data 1990-1994 Average, 1990-1994 Average and State Data 1986-1994. NASS-Kansas Agricultural Statistics. Manhattan, KS.

Scheyer, J.M., R.D. Nielsen, and H.R. Sinclair, Jr. 1992. Soil survey use for plant growth rating. P. 113. *In* Agronomy Abstracts. American Society of Agronomy, Madison, WI.

Shroyer, J.P., H. Kok, and D.L. Fjell. May 1998. Seedbed Preparation and Planting Practices. *In* Grain Sorghum Production Practices. p. 5-9. Kansas State University, Agricultural Experiment Station and Cooperative Extension Service. Manhattan, KS.

Tsuji, G.Y., G. Uehara, and S. Balas (ed.). 1994. DSSAT v3. University of Hawaii, Honolulu, HI.

Appendix A

Soil Property Components for the SRPG and KS-SRPG Models

1. **Surface Characteristics** (upper 25 cm)

   Organic Matter, Bulk Density, Clay Content, Available Water Capacity, pH, Sodium Adsorption Ratio, Calcium Carbonate Equivalent, Gypsum, Cation-Exchange Capacity, Shrink-Swell, Rock Content

2. **Water Features** (upper 150 cm)

   Depth to Water Table, Permeability, Available Water Capacity

3. **Soil Chemistry** (upper 100 cm)

   Sodium Adsorption Ratio, Electrical Conductivity, Salinity, Cation-Exchange Capacity, pH

4. **Soil Climatic Factors**

   Moisture Regime, Temperature Regime, Moisture & Temperature Interaction

5. **Physical Profile** (depth to root restrictive layer)

   Physical Root Zone Limitation, Root Zone Available Water, Calcium Carbonate Equivalent

6. **Landscape Features**

   Most restrictive feature used as rating,
   Slope, Ponded, Eroded, Flooded, Gullied/Channeled/Stony/Gravelly/Cobbly/Cherty

Appendix B

Soil Property Input NRCS NASIS Dataset

Table B-1. Soil properties; composition components.

SoilNo	Series Name	Series Classification	SurfTex	Slope	Hydro Grp	Perm	Drainage
1	ATTICA	Coarse-loamy,mixed,superactive,mesic Udic Haplustalf	fine sandy loam	1 to 5	B	moderately rapid	Well
2	AVANS	Fine-silty,mixed,superactive,mesic Udic Argiustoll	loam	1 to 3	B	moderate	Well
3	BRIDGEPORT	Fine-silty,mixed,mesic Fluventic Haplustoll	clay loam	0 to 2	B	moderate	Well
4	CARWILE	Fine,mixed,thermic Typic Argiaquoll	fine sandy loam	0 to 1	D	slow	Somewhatpoorly
5	CRETE	Fine,smectitic,mesic Pachic Argiustoll	silt loam	0 to 1	C	impermeable	Moderately well
6	DALHART	Fine-loamy,mixed,superactive,mesic Aridic Haplustalf	fine sandy loam	1 to 4	B	moderate	Well
7	EUDORA	Coarse-silty,mixed,mesic Fluventic Hapludoll	silt loam	0 to 2	B	moderate	Well
8	FARNUM	Fine-loamy,mixed,superactive,mesic Pachic Argiustoll	loam	0 to 1	B	moderate	Well
9	HARNEY	Fine,smectitic,mesic Typic Argiustoll	silt loam	0 to 1	B	moderately slow	Well
10	HOLDREGE	Fine-silty,mixed,mesic Typic Argiustoll	silty clay loam	3 to 7	B	moderate	Well
11	KEITH	Fine-silty,mixed,mesic Aridic Argiustoll	silt loam	0 to 2	B	moderate	Well
12	KUMA	Fine-silty,mixed,mesic Pachic Argiustoll	silt loam	0 to 1	B	moderate	Well
13	LADYSMITH	Fine,smectitic,mesic Udertic Argiustoll	silty clay loam	0 to 1	D	very slow	Somewhatpoorly
14	MANTER	Coarse-loamy,mixed,superactive,mesic Aridic Argiustoll	fine sandy loam	2 to 5	B	moderately rapid	Well
15	MCCOOK	Coarse-silty,mixed,mesic Fluventic Haplustoll	silt loam	0 to 1	B	moderate	Well
16	NARON	Fine-loamy,mixed,superactive,mesic Udic Argiustoll	fine sandy loam	7 to 15	B	moderate	Well
17	PARSONS	Fine,mixed,thermic Mollic Albaqualf	silt loam	0 to 1	D	very slow	Somewhatpoorly
18	PRATT	Sandy,mixed,superactive,mesic Lamellic Haplustalf	fine sand	5 to 10	A	rapid	Well
19	RICHFIELD	Fine,smectitic,mesic Aridic Argiustoll	silt loam	0 to 1	B	slow	Well
20	ROXBURY	Fine-silty,mixed,mesic Cumulic Haplustoll	silt loam	0 to 1	B	moderate	Well
21	SATANTA	Fine-loamy,mixed,superactive,mesic Aridic Argiustoll	loam	1 to 3	B	moderate	Well
22	SPEARVILLE	Fine,smectitic,mesic Typic Argiustoll	silty clay loam	1 to 3	C	slow	Well
23	TIVOLI	Mixed,mesic Ustic Torripsamment	loamy fine sand	5 to 15	A	rapid	Excessively
24	ULYSSES	Fine-silty,mixed,superactive,mesic Aridic Haplustoll	silt loam	0 to 1	B	moderate	Well
25	VONA	Coarse-loamy,mixed,mesic Ustollic Haplargid	loamy fine sand	5 to 15	B	moderately rapid	Well

Table B-2. Soil properties; horizon components.

Soil No.	Series Name	No. Layers/ Color	Horizon	Layer Thick (cm)	AWC	Bulk Density, Moist	% Clay	% Silt	% Sand	CEC	ASCS Runoff No.	Stage 1 Co. Eff.	Stage 2 Co. Eff.
1	Attica	7	Ap	15	0.17	1.5	12	20	67	6	76	0.9	0.24
	AT	brown		5	0.17	1.5	12	20	67	6			
			BA	18	0.17	1.5	13	20	67	6			
			Bt1	30	0.15	1.55	15	19	66	8			
			Bt2	30	0.15	1.55	14	19	66	8			
				29	0.15	1.55	14	19	66	8			
			Bt3	23	0.15	1.55	14	19	67	8			
2	Avans	8	Ap1	13	0.22	1.48	20.4	47.6	32.0	12.0	84	0.9	0.4
	AV	gray/brown	Ap2	13	0.22	1.32	20.2	49.1	30.7	12.0			
			BA	10	0.22	1.41	22.4	53.0	24.6	11.0			
			Bt1	13	0.18	1.30	30.6	44.6	24.8	20.0			
			Bt2	28	0.18	1.39	26.7	46.0	27.3	20.0			
			Bt3	30	0.20	1.50	22.3	47.1	30.6	13.0			
			Bt4	28	0.20	1.53	20.9	52.7	26.4	13.0			
			Btk1	15	0.20	1.54	21.8	50.2	28.0	13.0			
3	Bridgeport	5	A	15	0.18	1.4	30	44	27	16	84	1.2	0.51
	BP	gray		18	0.18	1.4	30	44	27	16			
			B	30	0.2	1.45	24	68	8	12			
				30	0.2	1.45	24	68	8	12			
				29	0.2	1.45	24	68	8	12			
4	Carwile	7	A	15	0.16	1.48	12	26	62	8	84	0.9	0.24
	CA	dark gray/		3	0.16	1.48	12	26	62	8			
		brown	Bt1	18	0.16	1.6	32	14	54	17			
			Bt2	30	0.16	1.55	48	3	50	25			
				30	0.16	1.55	48	3	50	25			
			Bt3	30	0.16	1.55	32	14	54	18			
				24	0.16	1.55	32	14	54	18			
5	Crete	8	Ap	15	0.18	1.30	24.0	68.0	8.0	19.7	84	1.1	0.34
	CR	dark gray	A	20	0.17	1.35	30.0	64.0	6.0	21.9			
			BA	13	0.17	1.35	32.0	62.0	6.0	23.9			
			Bt1	23	0.14	1.33	46.0	50.0	4.0	31.9			
			Bt2	18	0.14	1.33	43.0	53.0	4.0	30.9			
			BC	18	0.16	1.36	32.0	62.0	6.0	27.8			
			C	30	0.20	1.33	27.0	67.0	6.0	26.1			
			C	13	0.20	1.33	27.0	67.0	6.0	26.1			
6	Dalhart	7	Ap	15	0.13	1.45	14	20	66	7	84	0.9	0.24
	DH	brown	Bt1	30	0.16	1.58	24	40	36	20			
				30	0.16	1.58	24	40	36	20			
				11	0.16	1.58	24	40	36	20			
			BC	30	0.14	1.58	17	19	64	20			

			C1	30	0.14	1.58	17	19	64	15			
				4	0.14	1.58	17	19	64	15			
7	Eudora EU	8 dark gray/ brown	Ap	15	0.22	1.40	14.0	55.0	31.0	14.0	76	1.1	0.34
			Ap	10	0.22	1.40	14.0	55.0	31.0	14.0			
			A1	20	0.22	1.40	14.0	55.0	31.0	14.0			
			Bw	23	0.22	1.40	14.0	58.0	28.0	14.0			
			C1	18	0.20	1.40	12.0	33.0	55.0	12.0			
			C2	30	0.20	1.43	12.0	33.0	55.0	6.5			
			C2	30	0.20	1.43	12.0	33.0	55.0	6.5			
			C2	4	0.20	1.43	12.0	33.0	55.0	6.5			
8	Farnum FA	7 brown	Ap	13	0.21	1.40	16.8	41.4	41.9	12.0	84	0.9	0.4
			A	25	0.21	1.40	19.6	38.8	41.4	12.0			
			Bt1	15	0.18	1.45	23.2	30.7	46.2	13.0			
			Bt2	30	0.17	1.45	24.9	27.2	48.0	16.5			
			Bt3	30	0.17	1.45	25.4	30.3	44.5	16.5			
			Bt4	30	0.17	1.45	28.6	38.8	32.6	16.5			
			Bt5	7	0.17	1.45	27.0	40.1	32.9	16.5			
9	Harney HN	8 gray/brown	Ap	15	0.23	1.35	24	52	24	18	76	1.1	0.34
				8	0.23	1.35	24	52	24	18			
			AB	8	0.23	1.35	29	50	21	23			
			Bt1	15	0.16	1.4	38	54	8	28			
			Bt2	25	0.16	1.4	38	54	8	28			
			BCk	18	0.17	1.35	32	48	20	26			
			Ck	30	0.2	1.3	30	52	18	26			
			C	31	0.2	1.3	30	52	18	26			
10	Holdrege HO	7 gray/brown	A	15	0.22	1.5	32	62	7	17	76	0.9	0.35
				3	0.22	1.5	32	62	7	17			
			Bt1	28	0.19	1.3	32	62	7	16			
			Bt2	15	0.19	1.4	24	68	8	12			
			Bt3	30	0.21	1.5	18	69	14	9			
				30	0.21	1.5	18	69	14	9			
				29	0.21	1.5	18	69	14	9			
11	Keith KE	8 gray/brown	Ap	15	0.22	1.25	21	68	11	12	76	1.1	0.34
				8	0.22	1.25	21	68	11	12			
			Bt1	13	0.16	1.15	29	62	9	10			
			Bt2	23	0.16	1.35	27	64	9	8			
			BC	25	0.21	1.35	20	69	11	8			
			C	30	0.19	1.35	15	71	14	8			
				30	0.19	1.35	15	71	14	8			
				6	0.19	1.35	15	71	14	8			
12	Kuma KU	7 gray	A	15	0.2	1.25	21	68	11	12	76	1.1	0.34
				5	0.2	1.25	21	68	11	12			
			Btk1	30	0.2	1.3	26	66	7	15			
				13	0.2	1.3	26	66	7	15			
			Btk2	30	0.17	1.45	20	72	8	12			
				30	0.17	1.45	20	72	8	12			
				29	0.17	1.45	20	72	8	12			

13	Ladysmith	7	Ap	15	0.22	1.4	32	48	20	22	76	0.9	0.35
	LA	gray		5	0.22	1.4	32	48	20	22			
			Bt1	30	0.13	1.43	50	45	5	28			
			Bt2	28	0.13	1.43	50	45	5	28			
			BC	30	0.15	1.5	45	48	7	28			
			C	30	0.15	1.5	45	48	7	28			
				12	0.15	1.5	45	48	7	28			
14	Manter	7	A	15	0.17	1.4	15	20	65	8	76	0.9	0.24
	MA	gray		26	0.17	1.4	15	20	65	8			
			Bt	30	0.15	1.45	14	20	66	7			
				8	0.15	1.45	14	20	66	7			
			Btk	30	0.11	1.5	10	44	46	6			
				30	0.11	1.5	10	44	46	6			
				11	0.11	1.5	10	44	46	6			
15	McCook	7	A	15	0.22	1.3	18	69	14	10	76	1.1	0.34
	MC	gray		10	0.22	1.3	18	69	14	10			
			B	30	0.19	1.38	14	72	14	8			
				30	0.19	1.38	14	72	14	8			
				30	0.19	1.38	14	72	14	8			
				30	0.19	1.38	14	72	14	8			
				5	0.19	1.38	14	72	14	8			
16	Naron	8	Ap	15	0.16	1.5	10	26	64	10	76	0.9	0.24
	NA			5	0.16	1.5	10	26	64	10			
			Bt1	30	0.17	1.5	20	19	62	12			
				21	0.17	1.5	20	19	62	12			
			Bt2	28	0.17	1.5	20	18	61	12			
			Bt3	30	0.17	1.5	19	19	62	12			
				11	0.17	1.5	19	19	62	12			
			BC	10	0.13	1.58	18	19	63	8			
17	Parsons	6	A	15	0.2	1.4	20	54	26	11	76	1.1	0.34
	PA	gray		18	0.2	1.4	20	54	26	11			
			B	30	0.14	1.55	48	27	25	25			
				30	0.14	1.55	48	27	25	25			
				30	0.14	1.55	48	27	25	25			
				27	0.14	1.55	48	27	25	25			
18	Pratt	7	Ap	15	0.12	1.48	5.8	4.3	90.0	1.0	76	0.6	0.35
	PR	yellow brown	Ap	5	0.12	1.48	5.8	4.3	90.0	1.0			
			Bt	30	0.11	1.50	9.8	3.2	87.0	3.0			
			Bt	11	0.11	1.50	9.8	3.2	87.0	3.0			
			E&Bt	30	0.11	1.50	7.5	3.3	89.3	5.0			
			C	30	0.10	1.53	7.2	3.9	89.1	2.0			
			C	29	0.10	1.53	7.2	3.9	89.1	2.0			
19	Richfield	8	A	15	0.17	1.28	25	51	24	25	76	1.1	0.34
	RF	gray/brown		5	0.17	1.28	25	51	24	25			
			Bt	30	0.16	1.32	37	55	8	27			
				13	0.16	1.32	37	55	8	27			

			Btk	30	0.16	1.32	37	55	8	26			
				11	0.16	1.32	37	55	8	26			
			BCk	18	0.22	1.28	30	50	20	22			
			C	28	0.18	1.3	23	52	25	24			
20	Roxbury	6	A	15	0.23	1.4	22	68	10	12	76	1.1	0.34
	RX	gray		21	0.23	1.4	22	68	10	12			
			Bw	30	0.2	1.45	26	66	7	14			
				30	0.2	1.45	26	66	7	14			
				30	0.2	1.45	26	66	7	14			
				24	0.2	1.45	26	66	7	14			
21	Satanta	8	A	15	0.17	1.35	15	41	44	9	76	0.9	0.4
	SA	gray/brown		5	0.17	1.35	15	41	44	9			
			Bt	30	0.18	1.4	28	38	34	10			
				30	0.18	1.4	28	38	34	10			
				9	0.18	1.4	28	38	34	10			
			Btk	15	0.17	1.45	28	38	34	14			
			2Bk	30	0.18	1.35	28	50	22	16			
				16	0.18	1.35	28	50	22	16			
22	Spearville	6	A	15	0.22	1.25	28	53	20	16	76	0.9	0.35
	SP	gray/brown		3	0.22	1.25	28	53	20	16			
			Bt1	28	0.13	1.4	46	48	6	23			
			Bt2	18	0.16	1.4	42	51	7	22			
			Bt3	30	0.2	1.3	32	50	18	17			
				30	0.2	1.3	32	50	18	17			
				26	0.2	1.3	32	50	18	17			
23	Tivoli	7		15	0.11	1.55	6	7	87	4	76	0.9	0.35
	TV	brown	A	30	0.11	1.55	6	7	87	4			
				6	0.11	1.55	6	7	87	4			
				30	0.08	1.6	5	1	94	2			
			C	30	0.08	1.6	5	1	94	2			
				30	0.08	1.6	5	1	94	2			
				9	0.08	1.6	5	1	94	2			
24	Ulysses	7		15	0.18	1.35	25	66	9	22	76	1.1	0.34
	UL	gray/brown	A	5	0.18	1.35	25	66	9	22			
				30	0.2	1.3	27	66	7	19			
			Bwk	20	0.2	1.3	25	66	9	18			
			BCk	30	0.16	1.34	21	68	11	18			
			Ck	30	0.16	1.34	21	68	11	18			
				20	0.16	1.34	21	68	11	18			
25	Vona	7		15	0.11	1.6	6	16	78	3	76	0.9	0.35
	VN	brown	A	15	0.11	1.6	6	16	78	3			
				30	0.15	1.45	13	20	67	7			
			Bt	30	0.15	1.45	13	20	67	7			
				9	0.15	1.45	13	20	67	7			
				30	0.11	1.5	9	9	82	5			
			Bk	21	0.11	1.5	9	9	82	5			