AN ABSTRACT OF THE THESIS OF

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Title: Changes in Model Results as a Function of Changes in Soil Survey Data: A GIS Comparison of Soil Rating for Plant Growth (SRPG) Values Derived from the 1966 and 1999 Versions of the Reno County, Kansas Soil Surveys

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Soils are one of the most essential natural resources required to maintain the health of the environment and the continued prosperity of mankind. The mapping of soil resources can generate a better understanding of soil composition and its functions while aiding the development of improved soil management practices. Traditionally, hardcopy formats of soil survey reports were the end products of field mapping investigations and their interpretations were largely agricultural in nature. Rapidly changing technologies have initiated the need to satisfy increasing numbers of technical soil survey information users. Among these new users of soil survey information are the geographic information systems (GIS) technicians. SSURGO is the digital format of soil survey information currently available in the United States for use with GIS software. GIS technologies

provide an effective means to interpret, analyze, and display digital soil survey information but few GIS practitioners stop to consider the implications of temporal changes in soil survey information on their interpretations from digital soil surveys.

The opportunity to compare two versions of a digital soil survey area to evaluate these temporal changes in mapping within the same study area is rare. The Soil Surveys of Reno County, Kansas published in 1966 and 1999 are both available in digital format and therefore provide a unique opportunity to evaluate temporal differences in soil surveys within a single area. This type of spatial comparison is best conducted using GIS to evaluate the possible differences in soil properties and soil map unit delineations because a GIS approach allows spatial variations of map unit delineations and associated soil attribute information to be investigated simultaneously. The incorporation of a model application, Soils Rating for Plant Growth (SRPG) (NSSC Staff, 1999), which utilized soil survey information to estimate soil productivity, was used to enhance GIS comparison capabilities in the context of a practical application for soil survey data. SRPG indices, calculated for individual map units, reflect a soil's ability to produce commodity crops. Recently, the Division of Property Valuation for the Kansas Department of Revenue has started using SRPG indices to help them assess the tax value of agricultural land.

As a function of re-mapping the land valuations based on soil survey information will potentially change. The cause and extent of these types of changes is currently unknown. SRPG indices, soil map unit delineations, and soil properties are investigated in this study, at a variety of spatial levels, in order to assess the spatial differences between SRPG indices calculated using the 1966 and 1999 versions of the Reno County

Soil Survey. These evaluations conclude that it is difficult to compare the changes between two versions of a digital soil survey area at the county extent. A more detailed investigation is recommended, preferably at the map unit level. Fluctuations in SRPG indices were contributed more to changes in map unit delineations rather then changes in soil property values. The 1999 version of the Reno County Soil Survey area displayed a slightly larger mean SRPG index value when summarized by township polygons. This may be contributed to more knowledge about soils themselves, better mapping techniques and equipment, and/or the result of mapping to a greater detail.

Changes in Model Results as a Function of Changes in Soil Survey Data: A GIS Comparison of Soil Rating for Plant Growth (SRPG) Values Derived from the 1966 and 1999 Versions of the Reno County, Kansas Soil Surveys

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Chapter 1

1.0 Introduction

The opportunity to compare two digital versions (old and new) of a county soil survey is rare. The number of counties within the United States that have two existing digital versions is very limited (NSSC Staff, 2000). The recent re-mapping of Reno County, Kansas presents a unique opportunity to evaluate changes in mapping between versions of a county soil survey. A spatial comparison of the old and new versions of the Reno County Soil Survey can best be conducted by using geographic information systems to evaluate the possible differences in soil properties and soil map unit delineations. The utilization of a model application, such as the Soil Rating for Plant Growth (SQI and NSSC Staff, 1999), was used as an application for comparative analysis. The outcome of this comparison can potentially affect many issues, specifically, property valuation.

1.1 Introduction to Soils

Soil is not just the outer most layer of the solid Earth; it is one of the most essential natural resources necessary to maintain the health of the environment and support the prosperity of humankind. Soils are natural bodies in which plants grow. Soils are composed of "…minerals that were physically and chemically altered from original bedrock, organic matter and biomass, and pores spaces filled with air, water, and dissolved material" (Miller and Gardiner, 1998, pg. 1). Combined with air, water, and sunlight, soils are part of an interrelated system that is responsible for producing and sustaining life on earth.

Soil performs many functions and serves many purposes for humans and nature. Soils filter pollutants from hazardous waste, regulate water distribution, store and transform nutrients, and act as the foundation for natural habitats. Soils are also versatile building materials used to support and protect structures like buildings and highways. Most importantly, soils provide the basis for successful agriculture.

Soil is a finite resource that requires proper maintenance in order for it to continue to be productive. This is particularly important when considering the exploding human population that is putting various stresses on soil resources. Increases in human population lead to greater food and fiber demands and diminishes soil availability for agricultural land, as a result of encroaching development. The need to conserve and protect this important resource is quickly becoming apparent (Brady, 1990).

Through the study of soils we can generate a better understanding of their composition, genesis, and best use. Interpretations of collected soil data can enhance land use planning decisions, agricultural management practices, and the more accurate estimation of yield potentials. The ability to effectively evaluate soil resources should enable us to optimize the usage of soil resources to preserve them for future generations (SQI Staff, 1996).

1.2 Soil Mapping and Soil Surveys

One of the basic necessities for the evaluation of a natural resource is mapping. A "soil survey" is a form of mapping that utilizes field investigations aimed at the collection of soil property information and the delineation of soil map unit boundaries. A soil survey, lead by the United States Department of Agriculture, is a collective effort of many federal and state agencies, with numerous people involved. The collection, storage, maintenance, and distribution of soil survey data in the United States is the responsibility of the National Cooperative Soil Survey (NCSS), which is overseen by the United States. Department of Agriculture's Natural Resources Conservation Service (USDA-NRCS) (NSSC Staff, 1995).

Spatial patterns of soils are predictable and similar soils will form in similar environments. These spatial patterns are dependent on five factors: climate, relief, parent material, living organisms, and time (Miller and Gardiner, 1998). Sampling soils along transects, a series of bore holes in a line and across a particular landform, soil scientists can estimate the composition of the soil bodies present. Transect estimations are then used to develop models that help predict the types of soils that occur in different landscape positions (Soil Survey Division Staff, 1993). These field data are used, in concert with analysis of aerial photographs, to prepare base maps that identify the expected locations of the most extensive soils. Surveyors use these base maps in the field when performing more detailed surveys.

Field data are collected in great detail to establish representative soil property values for individual soil map units (Soil Survey Division Staff, 1993). A surveyor will bore many holes and excavate many pits to study soil profiles in order to determine the characteristics of each soil in the survey area. The characteristics of a soil profile can differ greatly from area to area. Soil profile properties (attributes), such as depth to bedrock, clay content, and salinity, are used to distinguish one soil from another. The goal of the surveyor is to observe and collect sufficient information about the soil profile properties to group similar soils within boundaries that separate them from soils with different properties. Soils are classified in a system used to group similar soils, according to their properties, into spatial units called "map units".

The classification schemes to group similar soils have evolved along with soil survey techniques. The soil classification scheme currently used in the United States is called Soil Taxonomy, which uses chemical, physical, and biological soil properties as specific criteria for soil classification. It also incorporates the presence or absence of certain diagnostic soil horizons to determine the placement of the soil within the classification system. The classification system is broken into six categories that are hierarchically ranked: order, suborder, great group, subgroup, family, and series (Miller and Gardiner, 1998). The system uses a unique naming convention that allows for all categories to be represented in the name of each soil individual. Ultimately, Soil Taxonomy is based on the inherent properties of soils, which is expected to lessen the possibility of controversy over the classification of a given soil.

Map units are designed to meet survey objectives and are selected to include certain information that can be applied to a common use. Every map unit is assigned a unique identifier. Usually the map unit identifier consists of the county FIP (federal identifier of counties within a state) code joined with a two-letter symbol that references the soils found within that map unit. The combination of the spatial and attribute data for a soil survey area results in the creation of a soils map. A soils map "delineates areas occupied by different kinds of soils, each of which has a unique set of interrelated properties characteristic of the material from which it was formed, its environment and its history" (Soil Survey Division Staff, 1993, p. 12) (Figure 1).

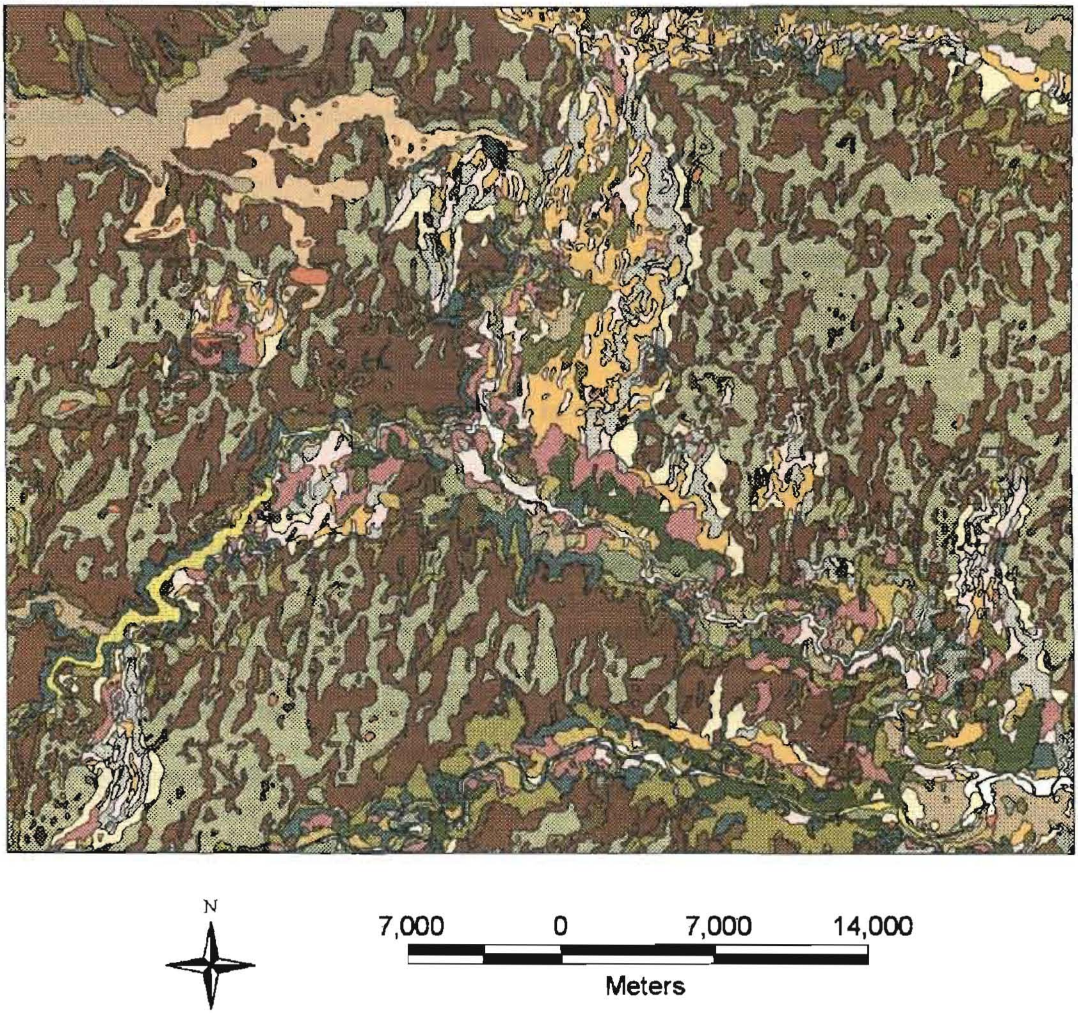


Figure 1. A digital soil survey of Grant County, Kansas. Delineations depict soil map unit boundaries.

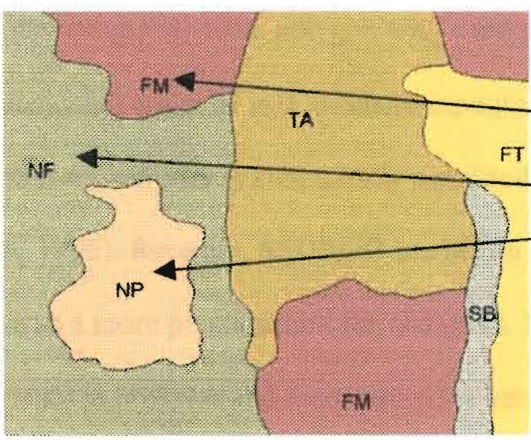
An area for a soil survey is chosen based on its importance to land use management and for the various interests and needs of its users. Historically, soil surveys were produced on a county basis, although larger and smaller areas have been surveyed, depending on soil complexity, topography of the area, and the intended use of the finished soil survey. A completed survey has traditionally been printed as a hardcopy report for public inquiry and includes a soils map, descriptions of soils, a set of tables listing soil property information, a summary of research, discussions of land use and management techniques and predicted yields for common crops under specific management practices. Early surveys concentrated on farming, ranching, and forestry issues but other uses have become increasingly important (Soil Survey Division Staff, 1993).

Changes in objectives require changes in data collection methods to keep soil surveys useful to their growing numbers of users. The collection of large amounts of diverse data and rapidly changing technology has initiated the use of automated data processing methods. The incorporation of Geographic Information Systems (GIS) technology is one method that makes the accumulation, storage, processing, and revision of soil survey data much easier. It also provides an effective means for creating maps that are potentially more accurate in a rapid manner. In addition, the implementation of a GIS can save both time and money when conducting a soil survey project. A soil survey project conducted for the Viotia region in Greece demonstrated the successful use of a GIS. The GIS allowed for increased ease of data collection, revision, and manipulation, all of which resulted in more accurate final maps (Theocharopoulos et al., 1995). The necessity to incorporate the use of GIS technology, in both the process of a soil survey and in the interpretations of the soil survey information, is quickly becoming evident.

1.3 Soil Maps and GIS

The NCSS is aware of the demands of the growing number of technical users and the advantages of implementing GIS technology with soil survey information. In the attempt to satisfy the requirements of new technologies' soil survey information is now accessible as a digital database, as well as hardcopy format. The NRCS-NCSS has developed three databases that represent soil information at different scales and resolutions: the National Soil Geographic (NATSGO) database, the State Soil Geographic (STATSGO) database, and the Soil Survey Geographic (SSURGO) database (NSSC Staff, 1995). All three databases are available in digital format and include metadata (descriptive information about the database), spatial data, and attribute data. Generalizations can be made at each database level but ultimately map scale and soil complexity determines what can be shown on a soils map. Spatial data are digitized according to specifications and standards established by the NRCS for duplicating the original soil survey maps and are stored in graphic file format (NSSC Staff, 1995). Soil attribute data are recorded and stored in a relational table format, linked by shared attributes. Spatial data can be linked to tabular attribute data via unique map unit identifiers (Figure 2).

NATSGO is specifically designed to evaluate national level planning and resource estimations. STATSGO is a state level database that is useful in state, large watershed,



MUSYM	CLAY	OM	SRPG_RTG
FM	20.50	2.00	0.97917
FT	25.75	2.00	0.98542
NF	14.80	2.00	0.96667
NP	8.60	1.50	0.95333
SB	12.00	1.50	0.93750
TA	31.00	2.00	0.99167

Figure 2. Portion of a soils map demonstrating the use of *musym* to relate spatial and attribute data.

and small river basin planning and management. NATSGO and STATSGO relate to the Soil Interpretation Record (SIR) database for their soil attribute information. Both databases are considered to have the greatest variance in probable values assigned to soil properties because of required statistical alterations used to generalize soil properties over large areas. These databases prove to be most useful in assessments encompassing broad geographical areas or landscapes. Neither database is suitable for local applications (Nielsen et al., 1996).

SSURGO is based on traditional printed county soil surveys. SSURGO provides the most detail of all the databases and is designed to make interpretations at the county level, which makes it capable of assisting with site development, land-use proposals, local farm and watershed management, and property tax assessments. SSURGO data are derived from the field data collected for map units. SSURGO is typically mapped at 1:24,000, 1:20,000 and 1:15,840 scales. Spatial data are called coverages and consist of digital line segments that form polygons, which represent soil survey area boundaries, water bodies, soil boundaries, and conventional and special soil features. Each map unit consists of an individual polygon with a unique identifier. Originally, SSURGO was digitized and archived in 7.5-minute topographic quadrangle units and the distribution of a complete soil survey area usually consisted of 10 or more quadrangle units (NSSC Staff, 1995). Recently, SSURGO has begun to be made available by county units, which serve as a more practical unit for end users. However, the certification process is currently in progress and inconsistencies between versions make working with both coverage formats, simultaneously, quite difficult.

The Map Unit Interpretation Record (MUIR) is responsible for providing SSURGO with soil attribute data. MUIR data consist of both estimated and measured data of the physical and chemical properties of soil and soil-related properties for the survey area's map units, components, and layers (Soil Survey Database Staff, 1994). Examples of some properties in SSURGO attribute tables include clay content, organic matter, flooding frequency, depth to bedrock, and shrink-swell potential. Unfortunately not all attribute data are available. Missing, incomplete, or uncollected data are scattered throughout the database. Attribute data are provided in relational tables that are linked by discrete identifiers (Figure 3). Each table is stored as an ASCII text file of a non-fixed length with tab-separated fields. Common tables used with GIS coverages include:

- Comp (map unit component) - stores information that applies to the specific composition of map units.
- Layer (soil layer) - stores characteristics that apply to soil layers for each map unit component.
- Mapunit (map unit) - stores information that applies to all components of a map unit
- Taxclass (taxonomic classification) - stores the taxonomic class for soils in the database

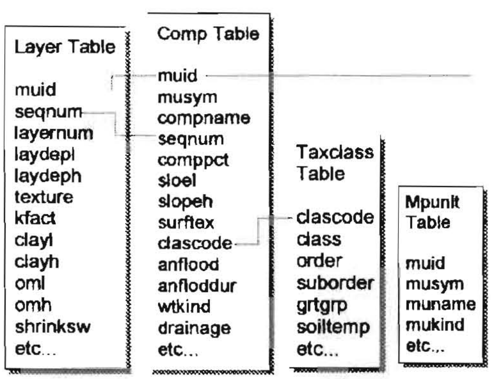


Figure 3. SSURGO relational tables with discrete identifiers that can be used as the relate item.

A system of relational tables creates a one-to-many relationship between map units and their properties. Individual map units represent an area on the land that is made up of one to three components with similar or dissimilar soils. Each component within a map unit can have up to 60 properties and up to six layers. Each layer can have the possibility of twenty-eight soil properties (Figure 4). Property data are recorded as a single value, as a range of values (low and high), or as a string of text (a description or a ranking in a scale).

To use SSURGO data, specifically with GIS, analysis must begin at the lowest level (layers table) and work up to the highest level (map unit table) in order to create a single value per map unit relationship for each soil property, which is preferred when joining attribute data to a coverage. To create this kind of relationship a number of relates between tables, data manipulations, and reclassifications (from text to numeric data) are commonly required. A variety of reclassification methods can be used to accomplish this single value relationship. One example is to simply select the presence or absence of a

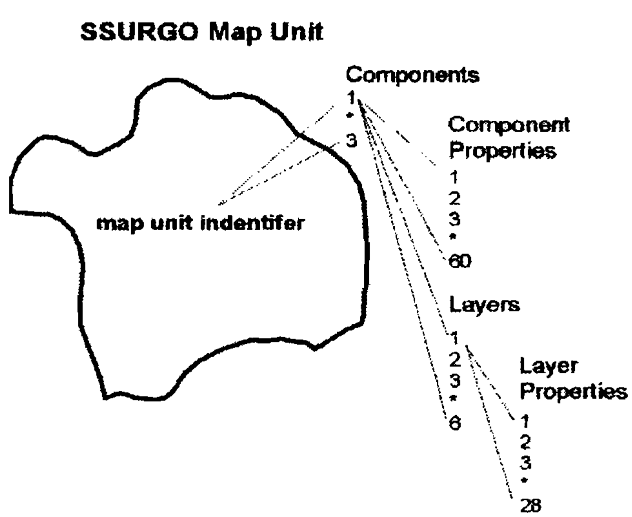


Figure 4. SSURGO map unit: its components, layers, and properties.

specific property within a map unit, such as calcium carbonate. Another example is the selection of a property within a specific layer and averaging its low and high values, such as organic matter in the surface horizon. A more complex example is the aggregation of data by calculating the depth-weighted average of the soil profile and the area-weighted average for each component in the map unit. Each method is feasible but can prove to be awkward, time consuming, and sometimes confusing. In addition, an end-user has to be well versed in the soil science field in order to manipulate the soil information in the relational tables effectively without distorting the data. SSURGO data can be a frustrating resource because of its complexity and inconsistencies. Relational tables, missing or incomplete data, and mismatched identifiers between attributes and spatial data (case sensitive) are all obstacles faced by GIS technicians using SSURGO soil data.

1.4 Soils Light Database

The development of the Soils Light database provides a simple, easy-to-use alternative to SSURGO. The Soils Light database is not meant to replace SSURGO but rather to complement it. Soils Light acts as a tool to achieve greater access to digital soil information and is hoped to relieve some of the frustration experienced by GIS end-users utilizing the current database. Demonstrating user-friendly characteristics, the Soils Light database consists of single-row records (single value relationships) of soil property and interpretation data, stored in a flat file format for each county in Kansas. Funded by the Kansas Water Office, the Soils Light project was developed by the Earth Science Department at Emporia State University (Apolzer and Sleezer, 2000).

The Soils Light database consists of commonly used soil properties and interpretations that define the limitations, suitability, and potential of individual map

MUID	MUSYM	CLAY_A	CLAY_MAX	CLAY
037011BH	011BH	14.38	32.50	20.96
037011EC	011EC	29.30	48.00	35.43
037011LE	011LE	21.00	50.00	35.46
037011MA	011MA	19.50	35.00	25.23
037011RC	011RC	41.63	50.00	42.06
037011ZB	011ZB	50.00	60.00	48.50

Table 1. Portion of a Soils Light table; shows elements depicting the surface layer, maximum value for the soil profile, and depth-weighted average for the clay content property of specific map units.

units in a survey area. Information used to compile the Soils Light database was assembled from SSURGO attribute tables: Comp, Layer, Mapunit, and Taxclass. The type of aggregation used to compile the data varied from property to property, refer to: Kansas Geological Survey Open-file Report Number 2000-33 for details (Apolzer and Sleezer, 2000).

The result is a database of flat tables that do not require any further relates to other tables (Table 1). Flat tables can easily be joined to the spatial data by relating the unique map unit identifier (*muid or musym*) to the soil polygon coverage. Soils Light is SSURGO "cleaned-up" and is meant to help minimize future errors associated with data interpretations and the application of digital soil survey information.

1.5 Re-mapping Effects on Soil Interpretations and Model Results

Soils typically do not change rapidly unless affected by human influences or by accelerated erosion processes, however, the information we collect about soils and the applications we use this information for do change relatively quickly. Improved mapping techniques, better field equipment, changes in soil knowledge and classification schemes, and new interests and needs of end-users all change with time. Where there is intensive agriculture production, some areas have been surveyed several times in order to be update properties and interpretations or to add new data. One such area is Reno County, a large county located in south central Kansas that has large tracts of land in agricultural production (Soil Conservation Service Staff, 1966) (Figure 5).

Reno County was recently re-mapped after an older soil survey had been digitized, making accessible two digital databases of the same soil survey area (1966 and 1999 editions) (NSSC Staff, 2000). The 1966 Reno County Soil Survey (old version) was mapped before Soil Taxonomy was adopted making it incompatible with newer soil surveys. Other differences (possibly reflecting changes in mapping techniques and improved equipment) also justified the re-mapping of the county. The 1999 Reno County Soil Survey (new version) updates and adds information at a greater detail than the 1966 edition. Furthermore, the 1999 Reno County Soil Survey uses Soil Taxonomy as its classification system. Having two soil surveys in digital format for the same soil survey area is a unique situation because older versions of soil survey are rarely digitized.

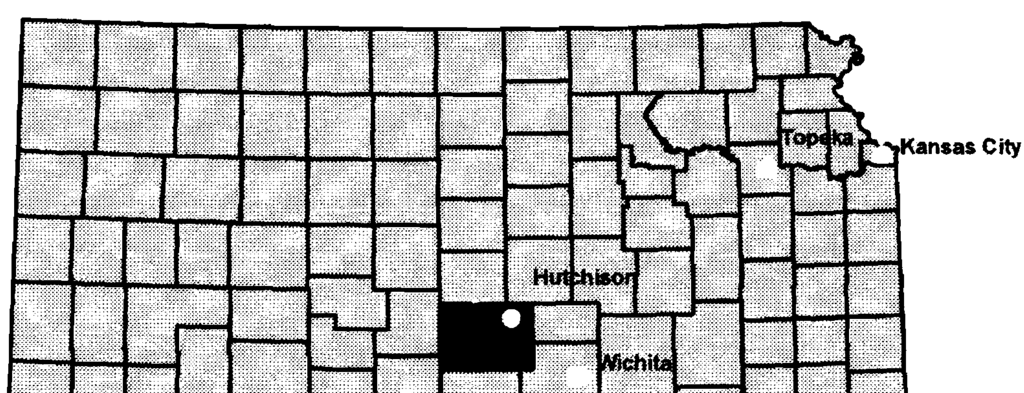


Figure 5. Location of Reno County within the state boundaries of Kansas.

To assess the potential differences between older and newer versions of the Reno County Soil Survey and the effects of re-mapping a soil survey area, GIS technology and the evaluation of model results derived from the old and new versions of the survey were utilized.

The Soil Rating for Plant Growth (SRPG) was developed by the NRCS-NSSC to rate the inherent capacity of the soil to produce commodity crops (NSSC Staff, 1999). As a reasonable indicator of the potential for soils to produce agricultural crops, the Division of Property Valuation for the Kansas Department of Revenue has started using SRPG to help them assess the tax value of agricultural land. SRPG relies on soil survey information to determine a soil index upon which land valuation is based. As a function of re-mapping land valuations may change according to changes in soil survey information. To what extent these changes will affect land valuation is unknown without in-depth investigation.

The conditions necessary to facilitate the use of the SRPG model are: 1) applicability over time and 2) uniformly assessable for every county. Digital soil survey data are used to construct the model because it fulfills these conditions and is also "...up-to-date information that produces consistent standards and is available electronically across the country" (NSSC Staff, 1999, pg. 2). SRPG indices are derived by combining several soil characteristics that are important for crop production into a single index value via a complex algorithm. The data used to calculate SRPG are confined to soil properties in order to limit inconsistencies in the results. Absolute values such as net crop production vary from year to year and prove to be unsuitable as factors to include in the SRPG model. Some soil properties relate directly to crop production whereas others relate to factors that would limit other land uses as well. The SRPG model consists of seven factors each having a number of subfactors that influence a specific soil characteristic. A rating is assigned according to the inferences about the effects each property has on soil productivity. The range of final ratings is from zero (worst) to one hundred (best). Only changes in characteristics that affect the soil permanently will ultimately affect SRPG indices.

The incorporation of GIS technology allows for effective spatial analysis, in addition to quick map production, of the SRPG model results. SRPG index values can be joined to spatial data and displayed with relative ease. Other data, such as Soils Light tables can also be joined to spatial coverages to increase comparison capabilities. The technology utilized to execute these procedures is Arc/Info, a powerful GIS that was developed by the Environmental Systems Research Institute, Inc. (ESRI). Arc/Info is command line software that proficiently manipulates large spatial data sets in a short period of time (ESRI Staff, 1990). The database linking and mapping capabilities of Arc/Info benefit my study by aiding in coverage compilation and linkage of soil attributes with spatial data.

ESRI is also the developer of ArcView software, which offers an easy-to-use interface with exceptional analysis and cartographic capabilities. ArcView has a variety of extensions one of which enables the production of GRIDs (rastor based models) based on map-algebra, that have a numeric value assigned to each grid cell. ArcView, also, has the flexibility to assign and re-assign attribute values to a layer in a view (display module). Custom legends and map layouts are easily created and re-created. ArcView provides extensive geographical and database capabilities and was the primary GIS used in my study for analysis and final map production.

The goal of my research project was to evaluate the effects of changes in soil mapping and associated soil property databases that occur as a function of soil survey updates or remapping. Reno County, Kansas is an excellent location for this type of evaluation because of the availability of digital data from two versions of a county soil survey. The SRPG model provides a convenient index to evaluate changes in soil properties in a practical applied context. GIS technology facilitates the comparison of both the spatial and databases changes in the soil survey to better understand the implications of change at a variety of spatial scales.

I expected that SRPG index values would change significantly as a function of re-mapping. Changes in SRPG index values were anticipated for two major reasons: 1) increased accuracy of the soil property data in the new Reno County Soil Survey database, and 2) changes in the positions and shapes of map unit delineations between the old and new versions of the Reno County Soil Survey. With respect to the first statement, increased knowledge about soil formation processes and the causes for the variability of important soil properties coupled with improved mapping techniques (remote sensing, ground penetrating radar, electromagnetic surveys, etc.) should have resulted in a soil survey that was a more accurate portrayal of the soil properties present in soil map units in Reno County. Therefore, I expected that the new soil survey should provide more detail and should be more accurate than the older version of the soil survey, thus SRPG values derived from the new soil survey should be more accurate. The assumption was that the old Reno County Soil Survey was less accurate than the new

Reno County Soil Survey. Therefore, the more accurately defined properties and calculated index values derived from the new Reno County Soil Survey database should be significantly different because they are more accurate. With respect to the second statement the most important considerations pertain to the spatial aspects of soil survey. In other words where in the landscape are boundaries drawn between soils with different characteristics and how are soils lumped together to show variability. Obviously, changes could occur between the new and old versions of the Reno County Soil Survey as a function of where map unit boundaries are drawn and what soils are lumped together in map units. Notably, the new Reno County Soil Survey has fewer map unit polygons but a greater number of recognized soil series than are found in the old Reno County Soil Survey. This might seem to be a contradictory statement until one realizes that more map units in the new Reno County Soil Survey are complexes. Map units that are complexes by definition have two or three dominant soils series in the same map unit polygons instead of just one. In other words, the new Reno County Soil Survey shows greater variability with fewer map units. I anticipated that area weighted average values for individual soil properties or SRPG index values calculated for these map units would be significantly different than those found in the same areas in the old survey even though averaging would probably mute the results from the new survey somewhat.

Chapter 2

2.0 Methods

In order to analyze the spatial and quantitative differences between the old and new versions of the Reno County Soil Survey a variety of techniques were employed. The implementation of the SRPG model generated indices for each map unit in the soil survey area for both versions. These indices were used to compare the changes in the old and new versions of the Reno County Soil Survey. Reno County Soils Light attribute tables (old and new versions) were also utilized to increase comparison capabilities.

The incorporation of GIS technology, specifically Arc/Info and ArcView, allows for quick, easily compiled mapping products and database tables that display model results, select model subfactor ratings, and compare specific soil properties. The execution of statistical tests on model results and specific soil properties analyzed the possibility of statistically significant differences between selected properties. Specific case examples investigated displayed variability in the greatest spatial detail. The methodology is probably best broken down into three major phases: 1) coverage assemblage, 2) the SRPG model, and 3) the comparison of specific soil properties in the Reno County Soil Surveys. These parts are distinct phases of the project that incorporate quite different processing techniques.

2.1 Coverage Assemblage

1999 Reno County Soil Map

The 1999 Reno County Soil Map was downloaded from the USDA-NRCS National Soil Survey Center, National Data Access Facility web site (*http://www.statlab.iastate.edu/soils/nsdaf/*) under the SSURGO database link. The SSURGO database is organized as a list of soil survey areas in alphabetical order by state, then by descending FIP codes that indicate the county within a state for which the data applies. Both SSURGO digital soil maps and attribute information were downloaded from the above web site.

Soil survey maps are stored as Arc/Info coverages and are tiled by county. Coverages are attributed with only the map unit symbol (MUSYM) as a possible relate item. The MUSYM is stored as a character data type.

The attribute data also include the MUSYM, but it is stored as a numeric data type. Mismatched data types for the relate items pose a serious problem when trying to join attribute data to a coverage. Unfortunately the coverage provides only the MUSYM as a possible relate item and it cannot be effectively converted to any other data type. The best available option is the conversion of the attribute table relate item to match the coverage relate item. There is no "quick-fix" that can accomplish this task but rather the MUSYM has to be manually changed for each map unit. This entails the addition of an apostrophe before each map unit's numeric symbol in the attribute table. This procedure was done in MS Excel.

1966 Reno County Soil Map

The 1966 Reno County Soil Map was downloaded from the State of Kansas Data Access and Support Center (DASC) web site (*http://gisdasc.kgs.ukans.edu/dasc_net.html*) under the core database catalog, core databases, soils, and Soils-24K links. Only spatial data are available from this site, which are stored in native Arc/Info format. The data are organized by 7.5-minute topoquads that have been sectioned into a row and column grid. In order to acquire a complete soil survey area a number of topoquads have to be downloaded. There is a map accessible at the above site that aids in locating the rows and columns necessary to include the entire soil survey area of interest.

To isolate just the county extent of the coverage a succession of procedures were performed. The Arc/Info exchange files were imported into Arc/Info as coverages. The individual topoquads were appended, the topoquad boundaries were deleted, the resulting coverage was clipped to the county boundaries and it was edited for slivers and undershoots. The clip coverage was acquired from the statewide county boundary coverage that was also downloaded from DASC @ *ftp://gisdasc.kgs.ukans.edu/gisdata/cdrom2/tiger/kansas/ks_tigcn.zip*.

The resulting coverage has both MUSYM and MUID as attribute data. However, the MUID must be used as the relate item for the soil survey map in order to include map units that cross county boundaries. This is important because it is possible for a map unit to have a MUSYM in one county that represents an entirely different map unit in another county.

The attribute information for the 1966 version of the Reno County Soil Survey was downloaded from the MUIR database. The selection of tables was made by using state abbreviations and county FIP codes to identify soil survey areas of interest (example: KS155). MUIR attribute tables do not have MUID as one of the possible attributes. However, the MUID can be generated, in MS Access, by concatenating the soil survey symbol (ssaid) and the map unit symbol. An additional problem affected by the MUID is case sensitive relates. Each new MUID has to be checked against the corresponding MUID from the coverage to confirm that both are identical. If there were any inconsistencies, the MUID from the attribute table was altered to match the coverage MUID.

Procedures

The method selected to join attribute data to a spatial coverage is via Arc/Info software. Four commands were executed, DBASEINFO, JOINITEM, BUILD, and PROJECT (Kreis, 1995). The DBASEINFO command imports a dbase file into Arc/Info and stores it as an INFO file. The JOINITEM command allows for the INFO file to be joined to the spatial data according to a relate item common to both. The BUILD command re-establishes the topology of the coverage with the new attribute information. The final command, PROJECT, transforms the coverage to a specific map projection; in this study a customized Albers projection was used to ensure the accuracy of area calculations.

2.2 The SRPG Model

The SRPG model utilizes soil survey information in order to determine ratings for different factors that influence a soil's ability to produce commodity crops. The model uses SSURGO data, which is assessable in every county and is specific in highly variable soils, based on detail collected from areas of about 5 acres (NSSC Staff, 1999).

The SRPG model rates several soil characteristics (Appendix A) that are important to crop growth and combines these ratings to generate an index that reflects a soil's possible limitation for crop growth. Most factors relate directly to the function of producing crops, other criteria relate to factors that limit the land, such as boulders or extreme cases of wetness. In some cases one factor can override all other factors and ultimately determines the final SRPG index (SQI and NSSC Staff, 1999). A perfect soil rating, defined as limitation that restricts a soil's ability to support a commodity crop, is one hundred and decreases in suitability as the index value decreases. Class breaks, established by the NRCS-NSSC, that rank soil limitation are: index less than or equal to 30 is considered a severe limitation, index greater than 30 to 70 is considered a moderate limitation, and index that is greater than 70 is considered a slight limitation.

The SRPG model consists of seven factors that include various subfactors, which utilize SSURGO data as input values (Table 2). Each subfactor is assigned a rating according to existing criteria, interpretations, taxonomic classes, and geography. Ratings assigned to subfactors are from 0 to 100 and each is weighted equally within the factor. A factor rating is then calculated (Equation 1) (SQI and NSSC Staff, 1999). Once all seven factors have a rating calculated a SRPG index is calculated (Equation 2) (SQI and NSSC Staff, 1999).

Equation 1. $\text{Factor rating} = \frac{(\text{sum of subfactor ratings})}{(\text{\# of subfactors} \times 100)}$

dividing by 100 converts to a number within the range 0 to 1.

Equation 2. SRPG index = (factors 1 through 7 are multiplied) x (100)

multiplying by 100 converts to a number within the range 0 to 100.

An algorithm was developed and executed in Microsoft (MS) Access to apply the proceeding equations. Databases were designed to handle the factor organization, rating assignment, and calculations. A database designated SRPG_Model_old was designed to

Factor 1: **Surface Structure and Nutrients**
Subfactors:
- 1A. Organic Matter
- 1B. Bulk Density
- 1C. Clay Content
- 1D. Available Water Capacity
- 1E. pH
- 1F. Sodium Adsorption Ration
- 1G. Calcium Carbonate
- 1H. Gypsum
- 1I. Cation-Exchange Capacity
- 1J. Shrink-Swell Potential
- 1K. Gravelly/Cobbly
- 1L. Stones

Factor 2: **Water Features**
Subfactors:
- 2A. Water Table
- 2B. Permeability
- 2C. Available Water Capacity

Factor 3: **Toxicity**
Subfactors:
- 3A. Sodium Adsorption Ratio
- 3B. Salinity
- 3C. Cation-Exchange Capacity

Factor 4: **Soil Reaction**
Subfactor:
- 4A. Soil pH

Factor 5: **Climate**
Subfactors:
- 5A. Moisture Regime
- 5B. Temperature Regime
- 5C. Moisture/Temperature Regime

Factor 6: **Physical Profile**
Subfactors:
- 6A. Physical Root Zone Limitation
- 6B. Root Zone Available Water Capacity
- 6C. Calcium Carbonate

Factor 7: **Landscape**
Subfactors:
- 7A. Slope
- 7B. Other Soil Phase Features
- 7C. Ponding
- 7D. Degree of Erosion
- 7E. Flooding

Table 2 Factors and Subfactors included in the SRPG model.

incorporate the 1966 Reno County Soil Survey information into the SRPG model parameters. A database designated SRPG_Model_new was designed to incorporate the 1999 Reno County Soil Survey information into the SRPG model parameters. Each database mirrors the other except for the input data tables used (Appendix B).

The input data tables required for both SRPG_Model databases were first re-organized in a separate MS Access application, Make_properties. Relates between tables were performed in order to include all map units and soil properties that were required for the SRPG model. The original tables were the mapunit, comp, layers, and taxclass tables from the SSURGO database. The resulting table was named properties_***, where "_***" was either "_old" or "_new" to correspond with the soil survey version it represented. Special attention was paid to include all adjacent county tables in the relates of properties_old in order to include all map units and their information depicted in the Reno County Soil Survey area because of some map units that overlap county boundaries. The properties_*** table was fed into the corresponding SRPG_Model database where queries were executed. Each query was run in a specific order and specific operations were applied to certain tables. These queries and operations are outlined step-by-step in Appendix B.

A table displaying the final SRPG index for each map unit, in the database, was generated. The appropriate (old or new) Soils Light attribute file was imported into the database and stored as an MS Access table. A query designed to append the Soils Light data and the SRPG index for each map unit was executed by using the map unit identifier (MUID) as the relate item, for each version. The resulting table was exported and saved as a dbase 4 file (format used to import file into Arc/Info) and named according to the soil survey version it depicted (SRPG_old or SRPG_new). In addition, a table displaying the individual subfactor ratings for each map unit was prepared, exported, saved as a dbase 4 file, and named accordingly (Rating_old or Rating_new). Inclusion of individual factor ratings allowed for a quick reference to the subfactors that demonstrated the greatest influence (lowest rating) on the final SRPG index. Each dbase file was joined to a digital soil survey coverage by using the dbaseinfo and joinitem commands in Arc/Info.

2.3 Comparison of the Reno County Soil Surveys

Once the coverages had been assembled and the SRPG model results calculated, ArcView was utilized as a quick and efficient method to view and manipulate the results. A view was opened and the coverages of interest were added, in this case SRPG_old and SRPG_new. A legend was constructed by utilizing the NRC-NSSC established class breaks to display the SRPG indexes. This generated a visual depiction of the SRPG index pattern for the extent of Reno County derived from both versions of the Reno County Soil Survey.

Both coverages were converted to GRIDs by using the SRPG index as the value assignment (ESRI Staff, 1998). The GRID cell size was 100 meters and the map extent of the original working coverage was maintained, which resulted in 490 rows and 681 columns. The new Reno County GRID was subtracted from the old Reno County GRID via grid algebra (Figure 6). The resulting GRID map displays the areas that have the greatest change in SRPG values, both negative and positive dependent of the version of soil survey used.

Each GRID (old and new) was overlain with the township and range coverage (available from DASC) for Reno County, Kansas. The Summarize Zones command was

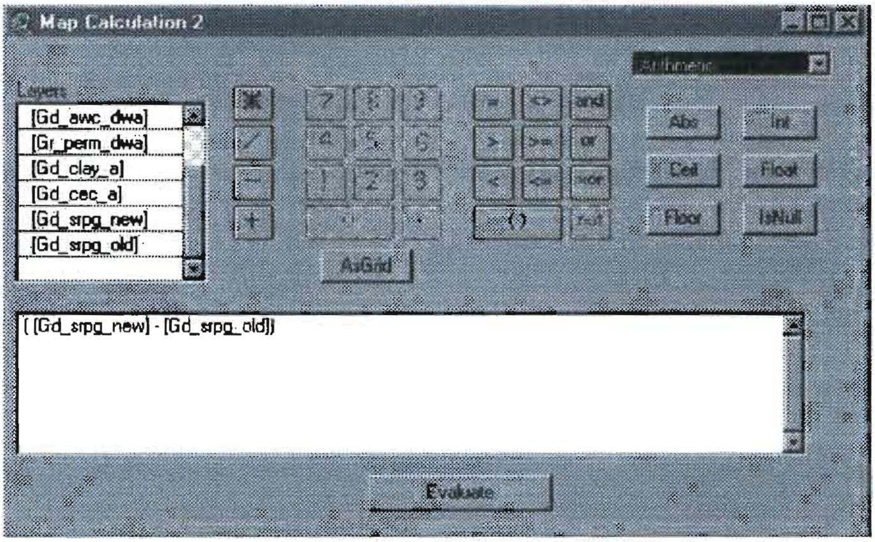


Figure 6. The Map Calculation module performs GRID algebra. It is set up to subtract the new version GRID from the old version GRID, of the Reno County Soil Survey.

executed to return a table of descriptive statistics for each GRID, which summarized the SRPG index values within each township and range polygon. The summarized table included the fields: minimum, maximum, mean, range, standard deviation, and summary of the

SRPG index value for each township and range polygon, for each version (Appendix C). The tables were exported and saved as dbase files that were used in MS Excel to generate graphs of the mean SRPG index values. The mean SRPG value was labeled in the center of each polygon that was overlain on the SRPG index coverage. This allows for a township-by-township look at SRPG values across the county.

With the mean SRPG values for each township and range polygon labeled on the county map it was still difficult to determine specifically where SRPG indexes had changed. Properties included in the SRPG Model were examined individually to deduce which properties caused the greatest change in SRPG index values. The ratings assigned to each property were first examined to determine which property had the greatest variance between old and new versions of the Reno County Soil Survey. Specific properties were chosen to investigate further. Selected properties, including physical root zone limitation and moisture regime, with interpretation descriptions were displayed with the aid of ArcView. Countywide maps of both soil survey versions were made of these properties. Both versions used the same legend classes, which made a side-by-side comparison relatively effective. A visual analysis was used to delineate the geographic extent of areas with the greatest change in the property ratings. Changes in rating assignment should correspond directly to changes in the original property inputs.

Properties representing more concrete data values that also strongly influenced SRPG index values were compared statistically. The properties selected for analysis were, clay content in the surface horizon, cation-exchange capacity in the surface horizon, permeability, available water capacity, cation-exchange capacity (depth weighted average of the soil profile), pH, and slope. These properties were selected because of their fluctuation in rating assignment between soil survey versions.

The GRID created with the SRPG indexes for the 1999 Reno County Soil Survey was summarized with the 1966 Reno County Soil Survey map units. The new mean SRPG values were compared against the old mean SRPG values for the old map units. These procedures were repeated for each of the selected property (Appendix C).

Scatter plots of coordinates were created to display relationships between selected property data derived from the two versions of the soil survey. These graphs also demonstrated any outlying data points as well as correlations between points; a good correlation would produce a straight line of points on the graph. Descriptive statistics were calculated for each selected property with the use of the MINITAB software's DESCRIBE subprogram. Descriptive statistics are the simplest way of summarizing and presenting large amounts of data. The column of data to be described was entered and the output includes a variety of parameters, specifically the first quartile, maximum value, minimum value, and the third quartile (Shaw and Wheeler, 1994) (Appendix D). These four data were used to generate box plot graphs that displayed the variability of the central 50 percent of the data set, and the maximum and minimum values.

Assumptions were developed about the differences in values displayed in these graphs, whether the new version's data was higher, lower or relatively the same as the old version's data. To validate these assumptions the *t*-test and the Mann-Whitney-U test were performed on each set of selected property data to determine whether or not perceived differences in populations were statistically significant (Appendix D). Both tests are designed to examine differences between two data sets. The Mann-Whitney-U test is executed in the MINITAB Mann-Whit subprogram and the t-test is executed in the MINITAB TWOT subprogram. An alpha value of 0.05 was used for both tests (Shaw and wheeler, 1994).

A selection of Public Land Survey Sections was made to "zoom in" and take a closer look at individual map units. These sections were selected based on their spatial proximity and their location within the major Soil Associations of the 1966 Reno County Soil Survey (Figure 7). The Soil Associations that were investigated cover the greatest geographic area within the old version of the Reno County Soil Survey, they were: Pratt-Carwile association, Clark-Ost association, Farnum-Shellabarger association, Farnum-

Naron association, Vanoss-Bethany association, Slickspots-Farnum association, Pratt-Carwile association, Elsmere-Tivoli association, and Carwile-Tabler association (Soil Conservation Service Staff, 1966).

Maps of each section and version of the Reno County Soil Survey were created by using the MUSYM as the unique value. This procedure generated maps that displayed map units with a color combination unique to the version of the soil survey area. The same color map unit in one version does not represent the same map unit in the other version because ArcView was allowed to automatically assign color classifications. The accompanying legend describes the map units that were included in the mapping area. The actual delineations of map units were the important elements in these map displays. Some sections have the exact same map unit delineations where as other sections have quite different map unit delineations between each version of the Reno County Soil Survey area (Figure 8).

Soil profile properties were examined to determine if map units, between old and new versions, that had the same delineations also had the same or similar soil compositions and vice versa for different map unit delineations between old and new versions. These profiles were also used to investigate property similarities or differences between corresponding map unit localities between the old and new versions of the Reno County Soil Survey.

SRPG index fluctuations between versions of the Reno County Soil Survey are also shown at the section level. The same section extents were used to create maps by using the SRPG index as the unique value. The legend was altered to break SRPG index values into intervals of ten, from 0 to 100, which display the differences in more detail than the NRCS-NSSC established class breaks. A summary of zones was also conducted by using old and new GRIDs with the Public Land Survey Section coverage overlain. Only the sections of interest were selected and the SRPG index value was, again, used to generate statistical tables. The mean SRPG value for each section was overlain on the corresponding map in order to make a quantitative comparison.

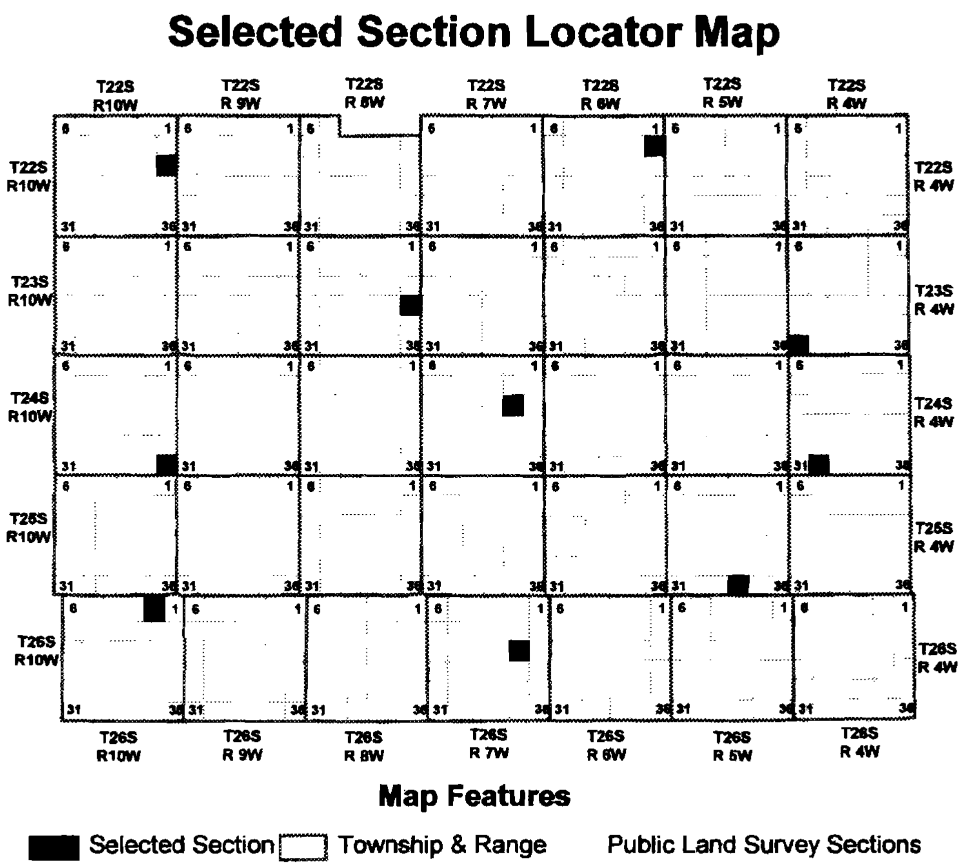


Figure 7. Selected sections within Reno County, Kansas that demonstrate detailed differences between both versions of the Reno County Soil Survey

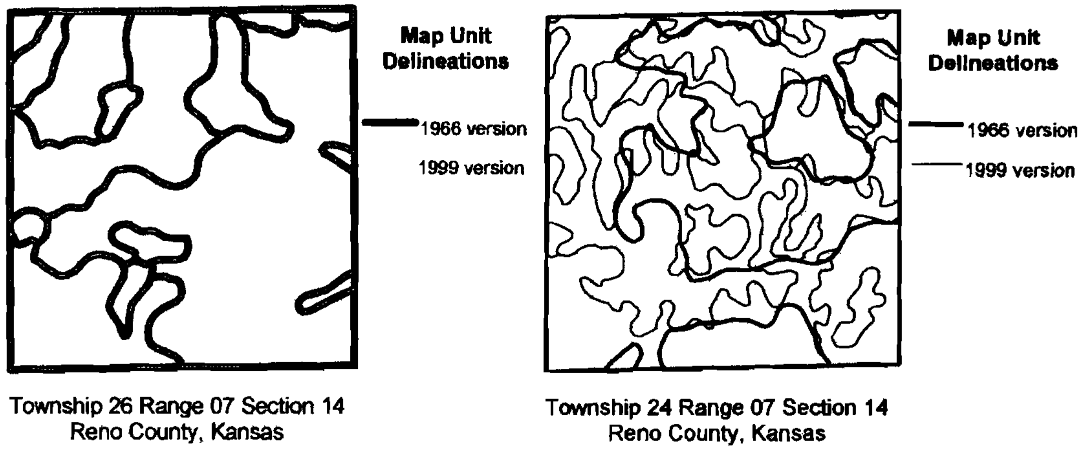


Figure 8. Sections depicting map unit delineations between old and new versions of the Reno County Soil Survey. Examples of identical (left) and very different (right) map unit delineations.

Examples of map units were investigated between old and new versions of the Reno County Soil Survey. In areas where map unit delineations were exactly the same, or similar, two scenarios were possible: 1) an old map unit containing a single component is re-mapped as a new map unit containing a single component or 2) an old map unit containing a single component is re-mapped as a new map unit containing multiple components. In areas where map unit delineations were different two scenarios were possible: 1) an old map unit is broken into multiple new map units or 2) multiple old map units are grouped together to form a new map unit.

Graphical displays were constructed of each scenario using real world examples. Examinations of map unit properties were compared to investigate similarities and differences, between old and new map units in corresponding localities.

Chapter 3

3.0 Results

SRPG index fluctuations between old and new versions of the Reno County Soil Survey were much less noticeable than anticipated. Constraints in the ability to detect visual differences were encountered at the county extent. However, isolated locations, such as urban land areas, did change dramatically. In addition, the old version displayed areas with a severe limitation rating, where as, in the new version the same areas displayed a moderate limitation rating. Statistical analysis of summarized data generated descriptive and graphical results that compared SRPG indices and a selection of individual properties included in the SRPG model. Investigation at greater detail (the section level) found that there consistently was some degree of change, often an increase, in SRPG index values in each sample section. In addition, individual map unit comparisons were made. Graphical representations were used to easily identify similarities and differences between map units in both the old and new versions of the Reno County Soil Survey.

3.1 County Extent

The maps depicting SRPG index values at the county extent of each soil survey version were visually compared. SRPG index values were mapped according to NRCS-NSSC classes (NSSC Staff 1999). The NRCS-NSSC classes make detailed differences relatively difficult to determine due to the lack of detailed division in SRPG index values. However, these classes do a relatively good job of depicting the major soil association patterns and areas with considerable change. There is no obvious pattern to the changes

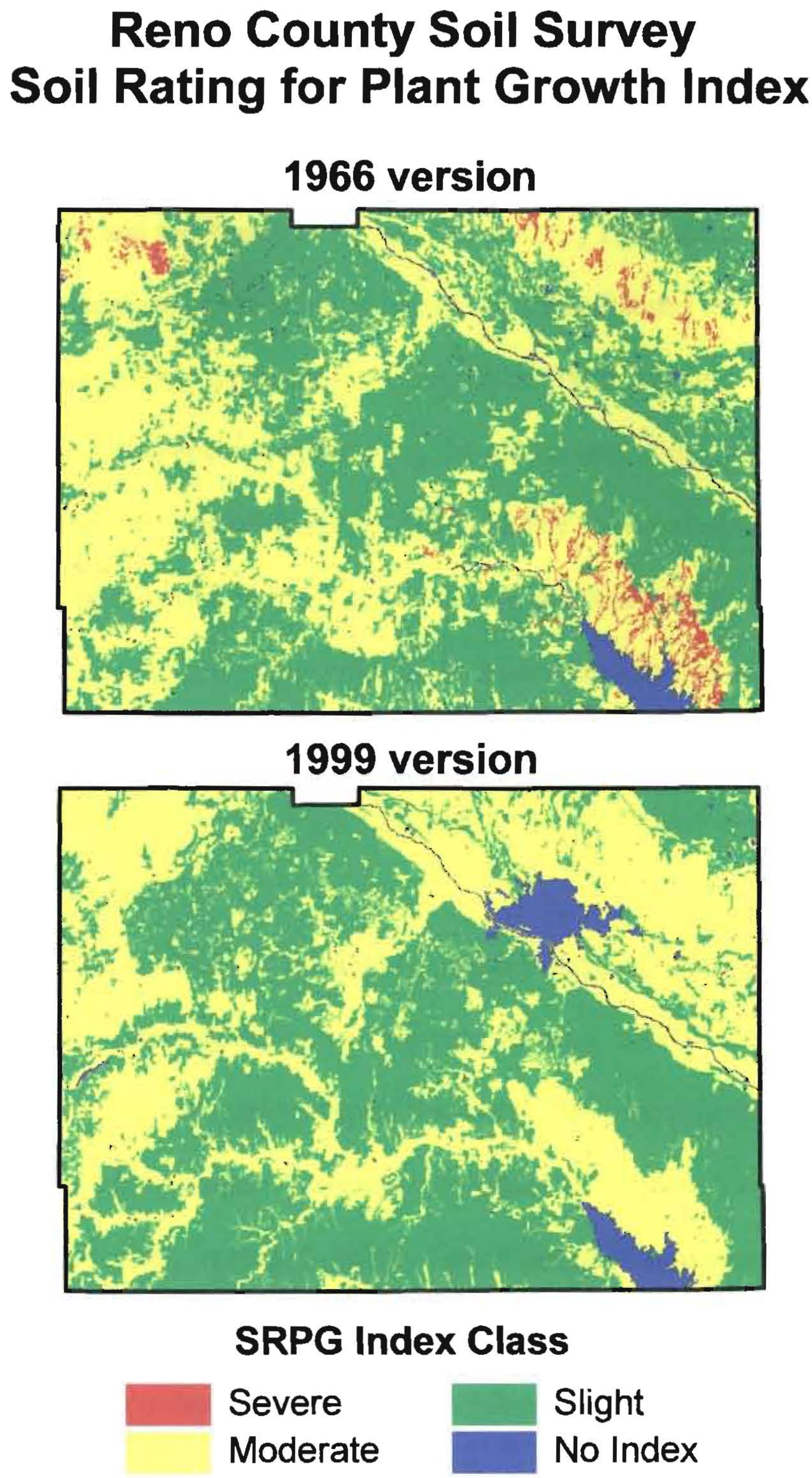


Figure 9. Two views of SRPG Index values within Reno County, Kansas. The view on the top depicts the 1966 version and the view on the bottom depicts the 1999 version, of the Reno County Soil Survey.

in SRPG index values. There are increases, decreases, and no change results scattered throughout the county (Figure 9).

The most obvious change occurs within the boundaries of the Elsmere-Tivoli (NW and NE corners) and the Renfrow-Vernon (SE quarter) 1966 soil associations. Areas within these extents were classified as having severe limitations in the old version but were reclassified as having moderate limitations in the 1999 version.

The map calculation coverage portraying the old version of the SRPG GRID subtracted from the new version of the SRPG GRID clearly shows where the greatest change in SRPG index is located spatially. The coverage displays both positive and negative changes, indicated by the same color in the legend class to demonstrate simply the greatest difference between versions. This map shows that the majority of the county displays a change of less than 10 index points between versions, with the exception of the city of Hutchinson (Figure 10).

Summarized tables of SRPG indexes by township and range polygons provide a quantitative means of comparing differences between versions. SRPG index maps, of each version, were created and used to display the mean SRPG value in the center of each polygon (Figure 11). When comparing township polygons between each version, the mean SRPG index commonly increased slightly. Only 9 out of 35 polygons demonstrated a decrease in mean SRPG index value from old to new versions. A graphical depiction, of these maps, clearly displays these fluctuations. Townships T23s R5w and T23s R6w which include the extent of the city of Hutchinson, fluctuated greatly due to the expansion of map units described as urban land in the new version that were assigned zero values for SRPG (Figure 12).

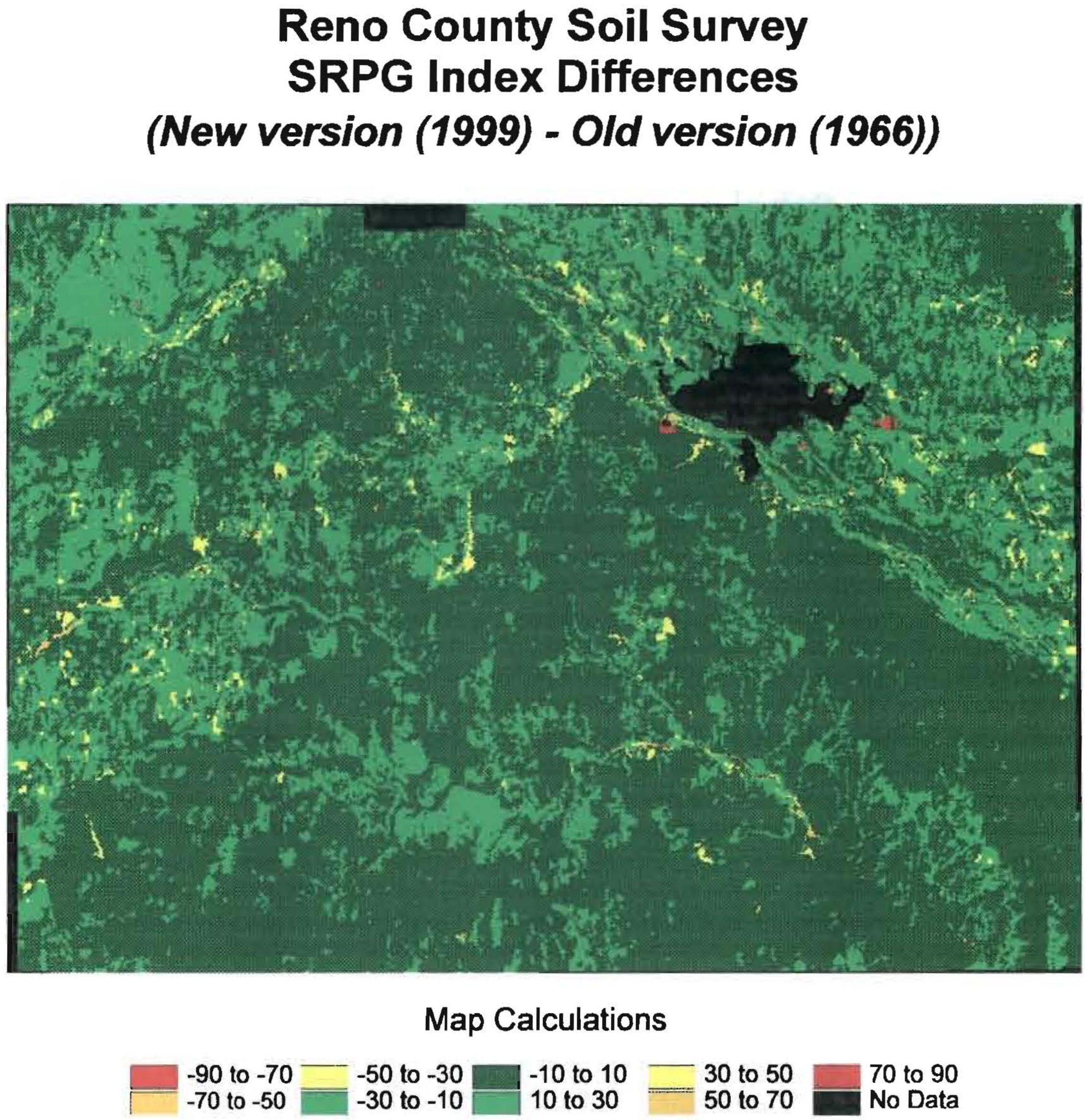


Figure 10. 1966 Reno County Soil Survey SRPG Index GRID subtracted from 1999 Reno County Soil Survey SRPG Index GRID. Both negative and positive differences are displayed with the same color assignment to represent the greatest change.

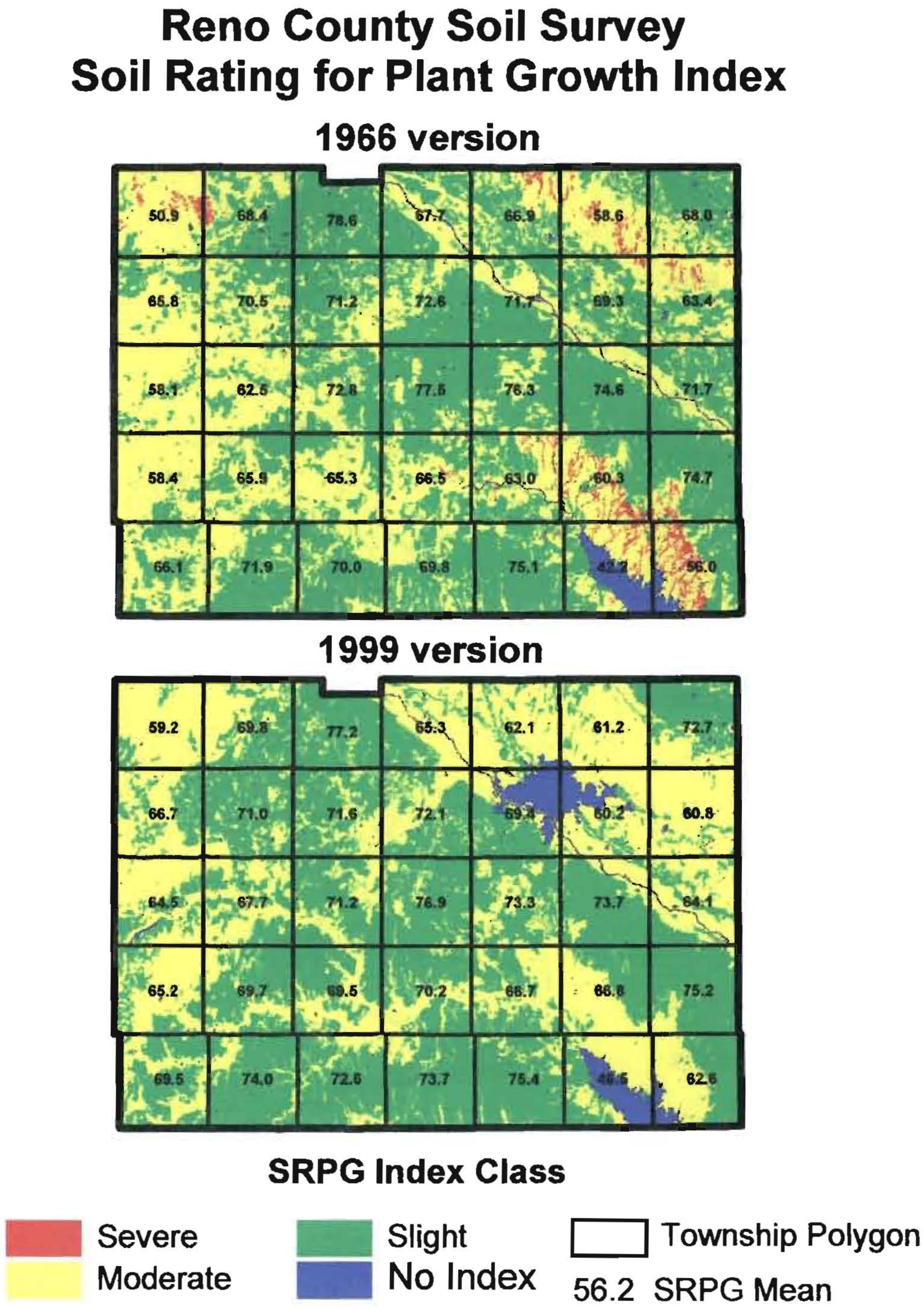


Figure 11. Reno County, Kansas SRPG Index values, 1966 version (top) and 1999 version (bottom) of the Reno County Soil Survey. County extent is overlain with the township and range coverage and the mean SRPG Index value is displayed in the center of each polygon.

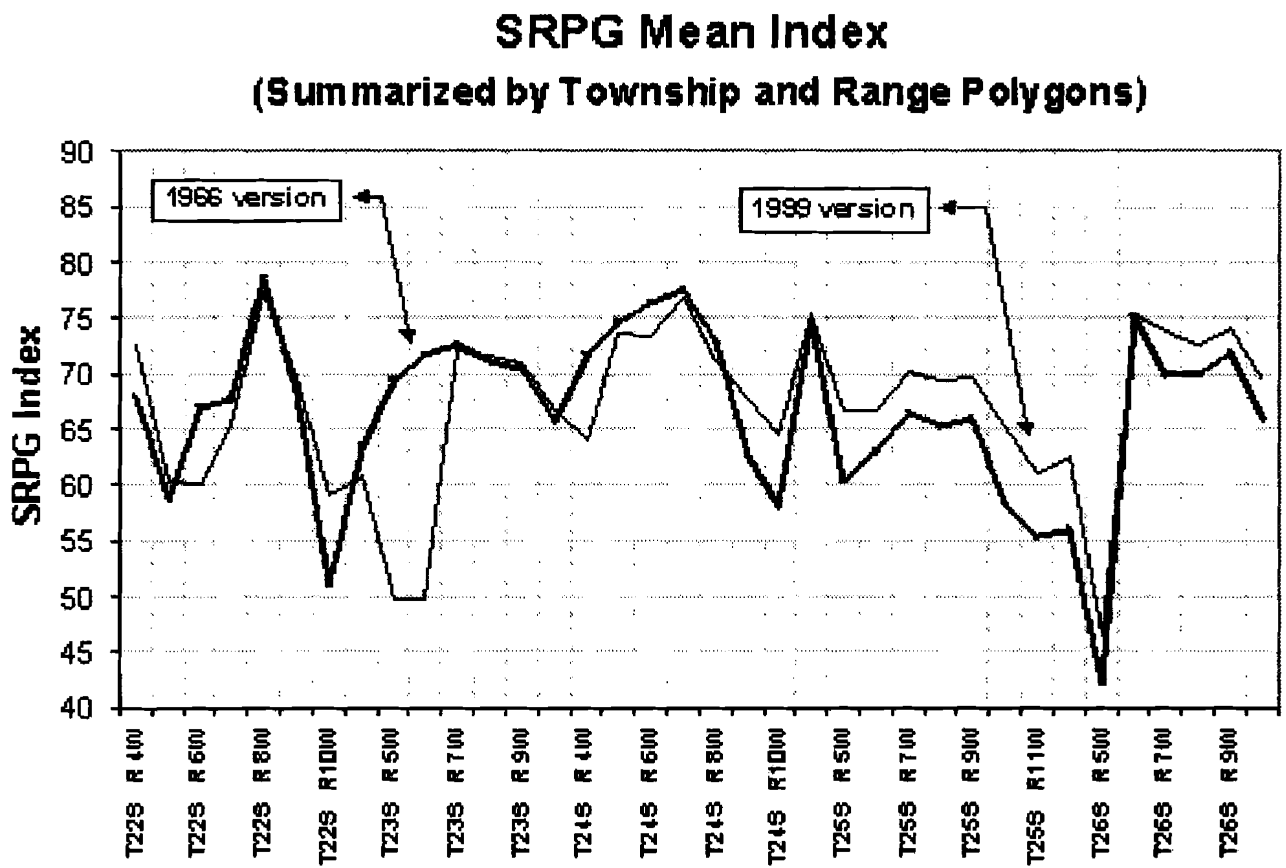


Figure 12. Mean SRPG Index values of both versions of the Reno County Soil Survey. Values were summarized by township and range polygons within ArcView. Minimal fluctuation between versions is depicted, with the exception of township 23 ranges 5 and 6, where the city extent of Hutchinson is located.

3.2 Soil Property Analysis

SRPG factors that relied on property interpretation data, including moisture regime and physical root zone limitation, were mapped at the county extent, with the same legend classes. Moisture regime rating assignments are made from the examination of soil names at the great group, suborder, and order levels in order to determine the soil's moisture regime (SQI and NSSC Staff, 1999). In Reno County, possible moisture regimes were differentiated between ustic and udic with further consideration given to the presence of aquic conditions that indicate soils with prolonged periods of wetness (i.e. Aquolls, and Aqualfs). The physical root zone limitation rating assignment was the resultant of the determination of minimal or maximal soil profile development (by taking the largest clay content value among the inclusive layers and dividing it by the clay content of the surface layer) to determine category of rating assignments for the mean layer depth of the map unit component. In addition, the presence and location within the profile or absence of a root restrictive layer was detected in order to properly assign rating values (SQI and NSSC Staff, 1999). The resulting maps allow for visual comparisons between these interpretation ratings. Great variances are depicted between map versions. The moisture regime maps displayed a general decrease in rating class from old to new version (Figure 13). The physical root zone limitation maps also displayed a general decrease in rating class from old to new versions (Figure 14), despite overall increases in SRPG indices.

Soil properties were investigated in suspicion that they were the factor that influenced changes in SRPG index values between old and new versions of the Reno County Soil Survey. The *t*-test indicated no significant difference between old and new

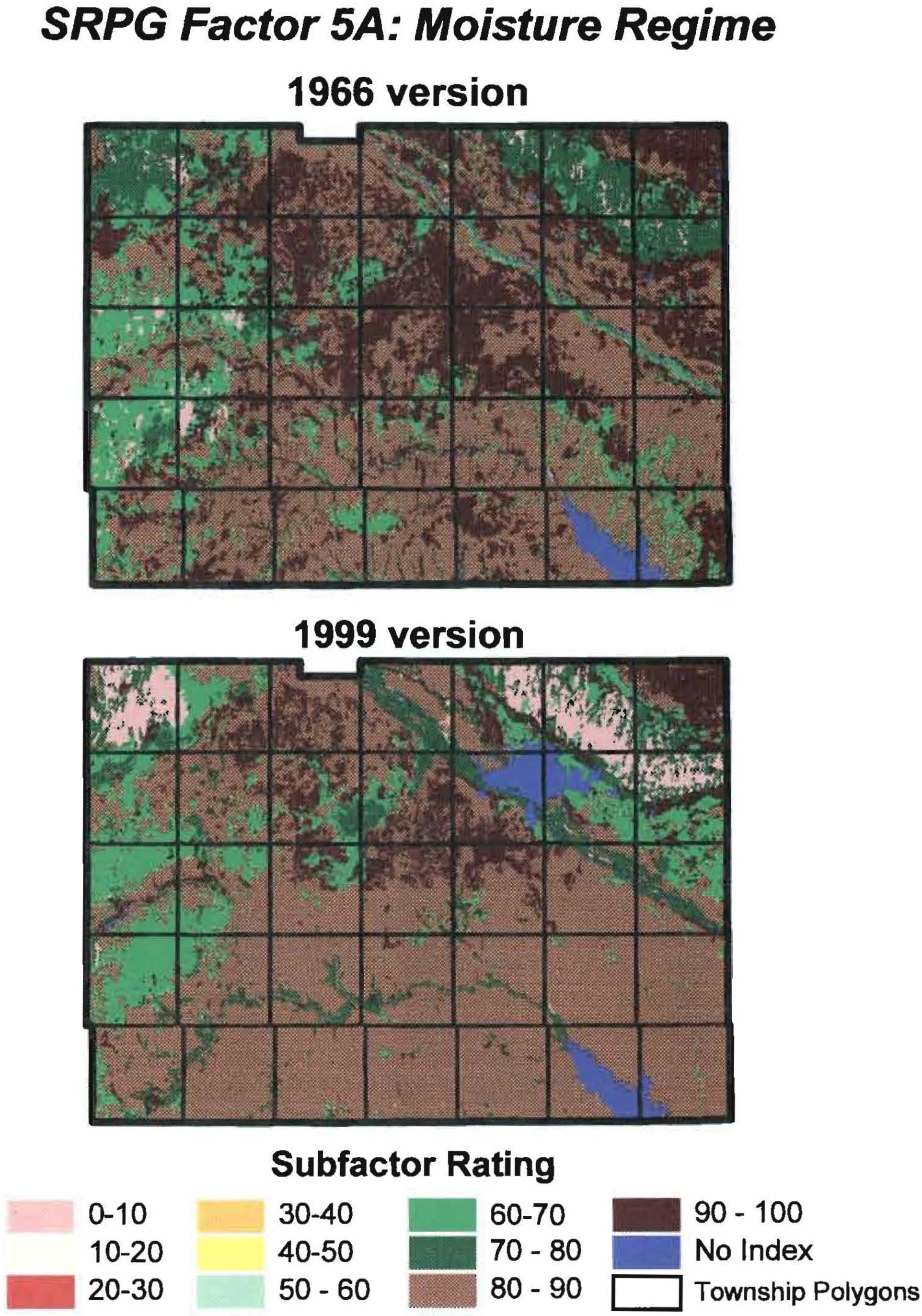


Figure 13. SRPG subfactor rating for moisture regime. The maps depict a decrease in rating assignments from the old version (top) to the new version (bottom) of the Reno County Soil Survey.

SRPG Factor 6A: Physical Root Zone Limitation

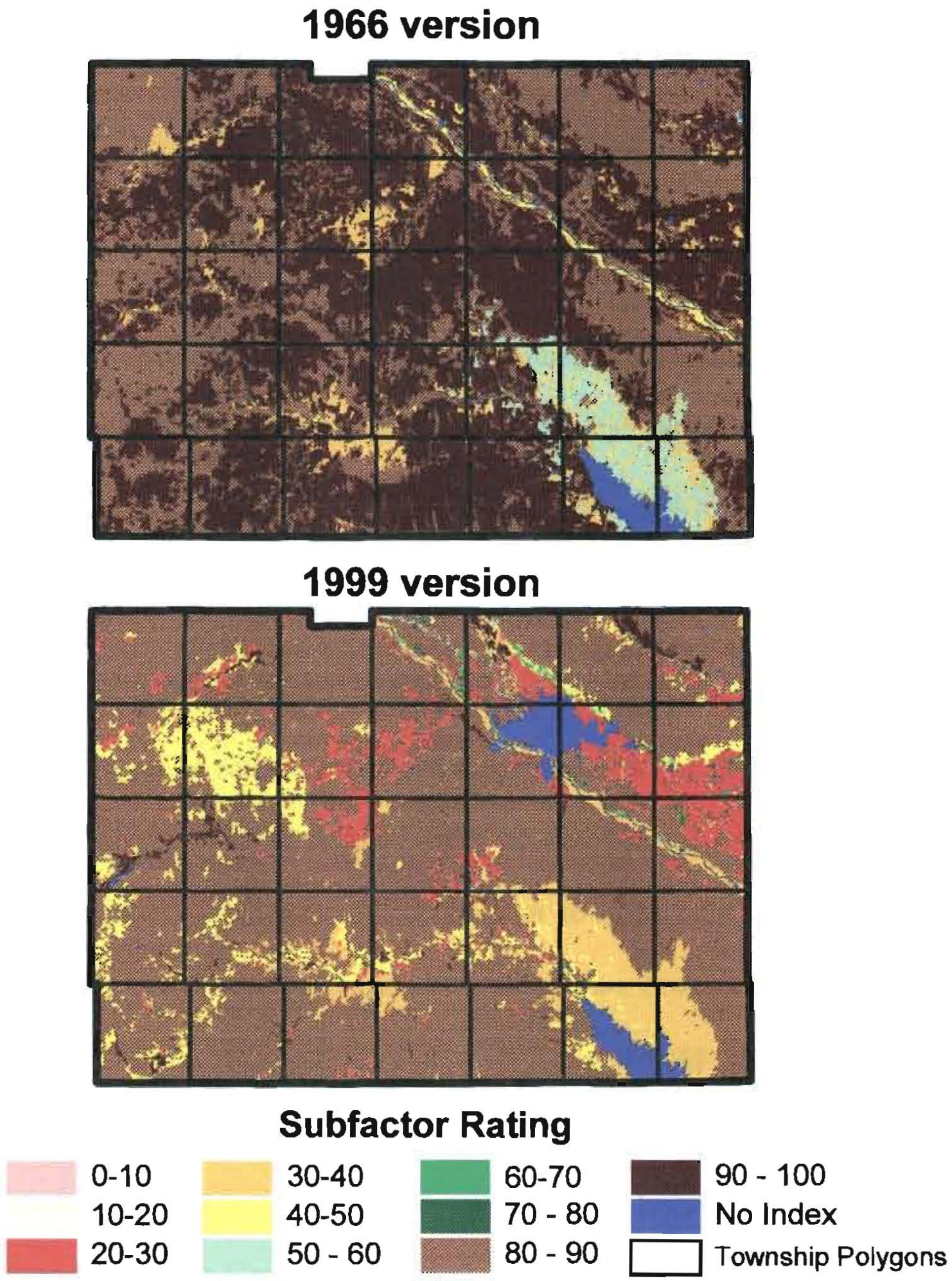


Figure 14. SRPG subfactor rating for physical root zone limitation. The maps depict a decrease in rating assignments from the old version (top) to the new version (bottom) of the Reno County Soil Survey.

versions when the following properties were compared: CEC_A, permeability, CEC, pH, and slope. This statistical test did however indicate a significance difference between SRPG index, Clay_A, and AWC. Despite confidence that the data values and data sets used represented sufficiently large populations with near-normal distributions, there were some concerns about using a parametric test to compare data values that had been manipulated extensively. A non-parametric test was conducted, the Mann-Whitney-U test, to ensure results were reasonable. The Mann-Whitney-U test indicated no significant difference between old and new versions for all properties that were compared: mean SRPG index, Clay_A, CEC_A, permeability, AWC, CEC, pH, and slope.

3.3 Section Level

To investigate at greater detail, individual sections were examined. A total of ten sections that represent major soil associations within the old version of the Reno County Soil Survey were analyzed. A visual comparison concluded that map unit delineations range in variation from exactly the same i.e. no changes, to slightly different, to extremely different map unit boundaries and soil compositions. Some sections included the same number of different map units in the new version as the old version whereas other sections had more or less map units in the new version than in the old version.

SRPG index delineations were also different at varying magnitudes between old and new versions of the Reno County Soil Survey. The majority of the sections had some changes in SRPG values even when map unit boundaries were identical. The mean SRPG indices for each of the sections analyzed was also different between versions, though to a lesser degree than the delineations. A quantitative comparison of changes in the mean SRPG index ranged from 0.88 to 12.76 percentage points. This demonstrated that differences in mean SRPG index between old and new versions were minimal on a percentage change basis.

To streamline analyses, sample sections were categorized into four example groups. The criteria for the example groups were, first, to examine differences between map unit delineations, second, to examine differences in SRPG delineations, and third, to observe differences in mean SRPG indices. Each section was analyzed and then categorized into the appropriate example group. The four example groups were catalogued as:

1) same or very similar map unit delineations and less than 5 percentage points difference between mean SRPG indices.

2) same or very similar map unit delineations and greater than 5 percentage points difference between mean SRPG indices.

3) different map unit delineations and greater than 5 percentage points difference between mean SRPG indices.

4) different map unit delineations and less than 5 percentage points difference between mean SRPG indices.

The first example group includes selected sections 26-07-14 (township-range-section) and 24-04-32. Both sections displayed exactly the same or nearly similar map unit delineations and slightly different SRPG delineations, between old and new versions of the Reno County Soil Survey (Figures 15 and 16). Section 26-07-14 had a slight increase (0.8) from old to new versions, in mean SRPG indices. The SRPG index delineations were virtually the same except for the map unit Albion-Shellabarger Sandy Loams in both the old and new versions. However, the slope rating for the old version was much smaller (indicating a steeper slope class) than in the new version. The net

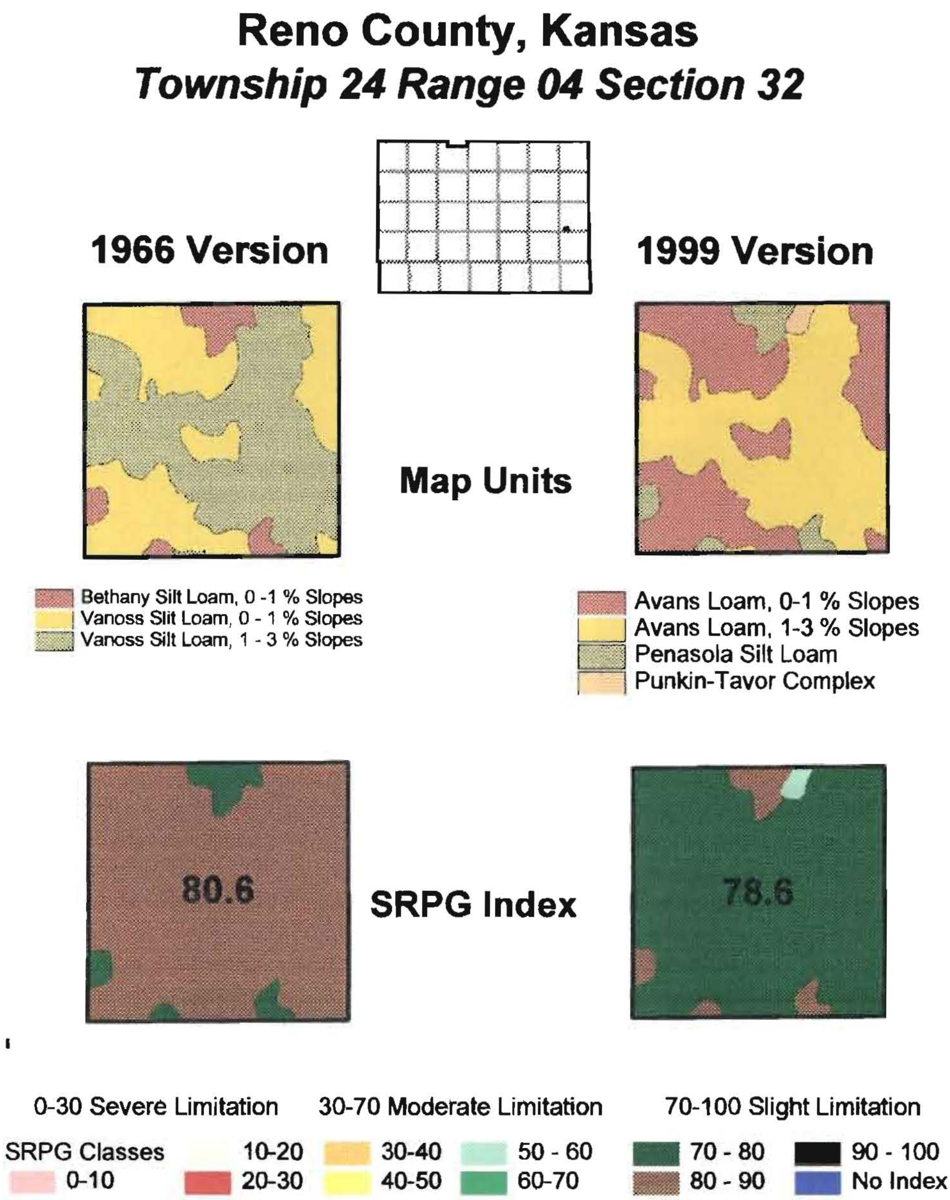


Figure 15. Four views of the selected section 24-04-32. Upper two view's display map unit delineations of old and new versions of the Reno County Soil Survey. Map unit colors are ignored for the map unit boundaries are the primary focus. Lower two views display SRPG delineations and mean SRPG index values for the section between the old and new versions of the Reno County Soil Survey.

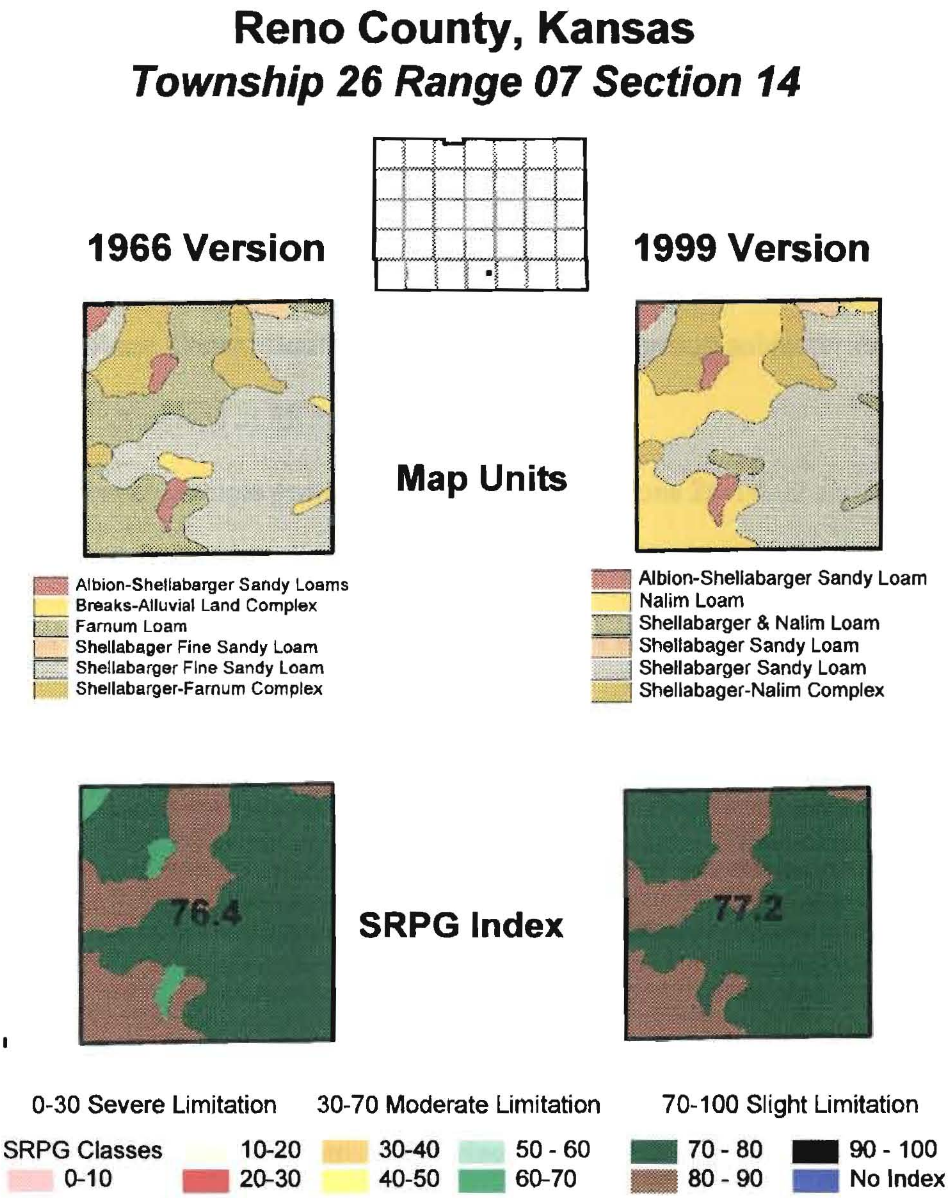


Figure 16 Four views of the selected section 26-07-14. Upper two view's display map unit delineations of old and new versions of the Reno County Soil Survey. Map unit colors are ignored for the map unit boundaries are the primary focus. Lower two views display SRPG delineations and mean SRPG index values for the section between the old and new versions of the Reno County Soil Survey.

result was a slightly smaller final index rating. Section 26-07-14 had a slight decrease (2.0) from old to new versions in mean SRPG indices. The map unit Vanoss in the old version and Avans in the new version occupies the majority of this section. The properties of these two map units that influence this decrease the most are pH, and root zone available water capacity, both having lower ratings in the new version than the old version of the Reno County Soil Survey. In this example group subfactor ratings play the major role in fluctuations in SRPG indices.

The second example group includes selected sections 26-10-02 and 25-05-34. Both sections display the same or similar map unit delineations and very different SRPG delineations (Figures 17 and 18). Both sections have a slight increase in mean SRPG indices, from old to new version. Section 26-10-02 increase 4.4 percentage points, with the slope subfactor being the greatest influence in the final SRPG index rating. The map units in which SRPG index values increased the slope subfactor rating increased from 60 in the old version to 100 in the new version. Section 25-05-24 increased 8.8 percentage points, from old to new versions. The map unit Vernon Soils in the old version that is map unit Jamash Clay Loam in the new version, increased the most from 28.8 to 57.0 SRPG index rating. Properties with influencing ratings include surface horizon clay content, shrink-swell potential, mean permeability, and mean available water capacity. The third example group includes sections 23-04-31 and 24-07-14. Both sections display quite different map unit delineations, different SRPG delineations, but virtually the same mean SRPG index values (Figures 19 and 20). Section 23-04-31 map units have decreased and appear to be group in a more flowing pattern, from old to new versions. The new map unit Dilhut-Elmer complex stretches from the NW corner of the section to

Reno County, Kansas

Township 26 Range 10 Section 02

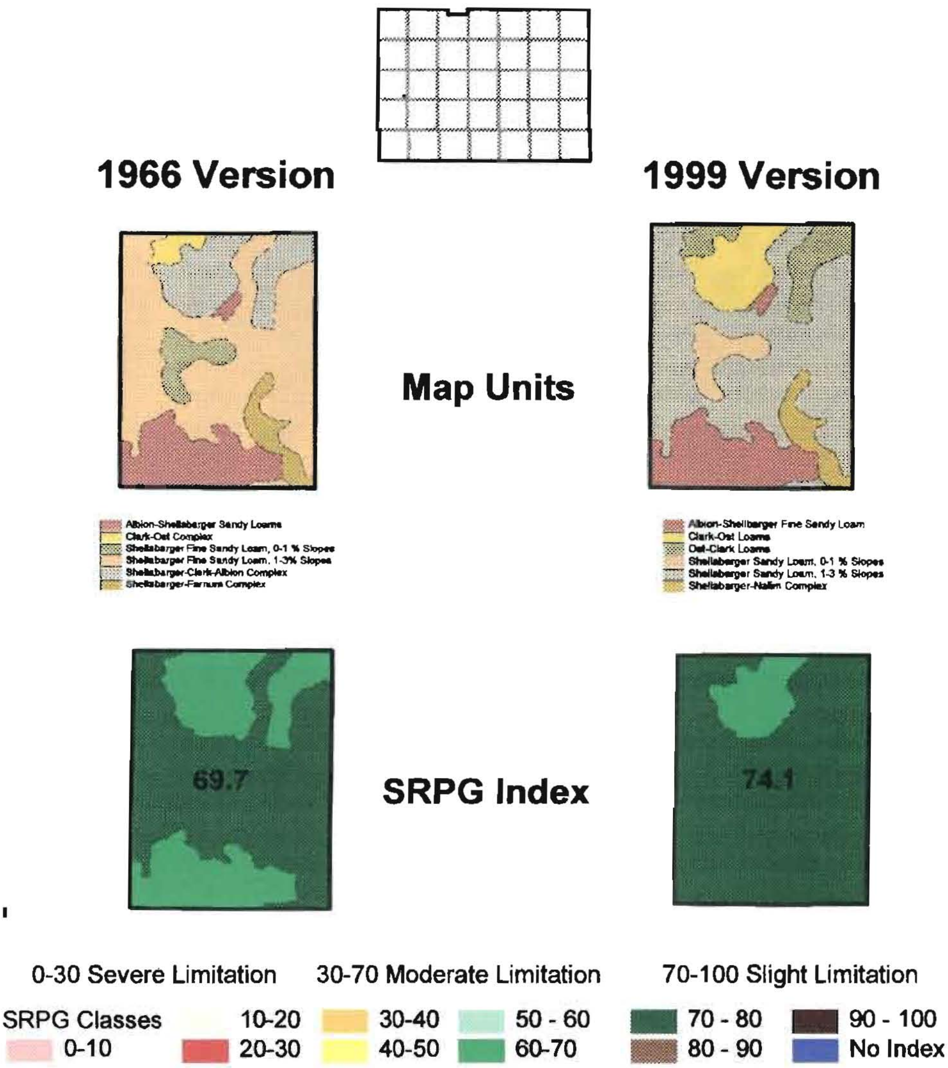


Figure 17. Four views of the selected section 26-10-02. Upper two view's display map unit delineations of old and new versions of the Reno County Soil Survey. Map unit colors are ignored for the map unit boundaries are the primary focus. Lower two views display SRPG delineations and mean SRPG index values for the section between the old and new versions of the Reno County Soil Survey.

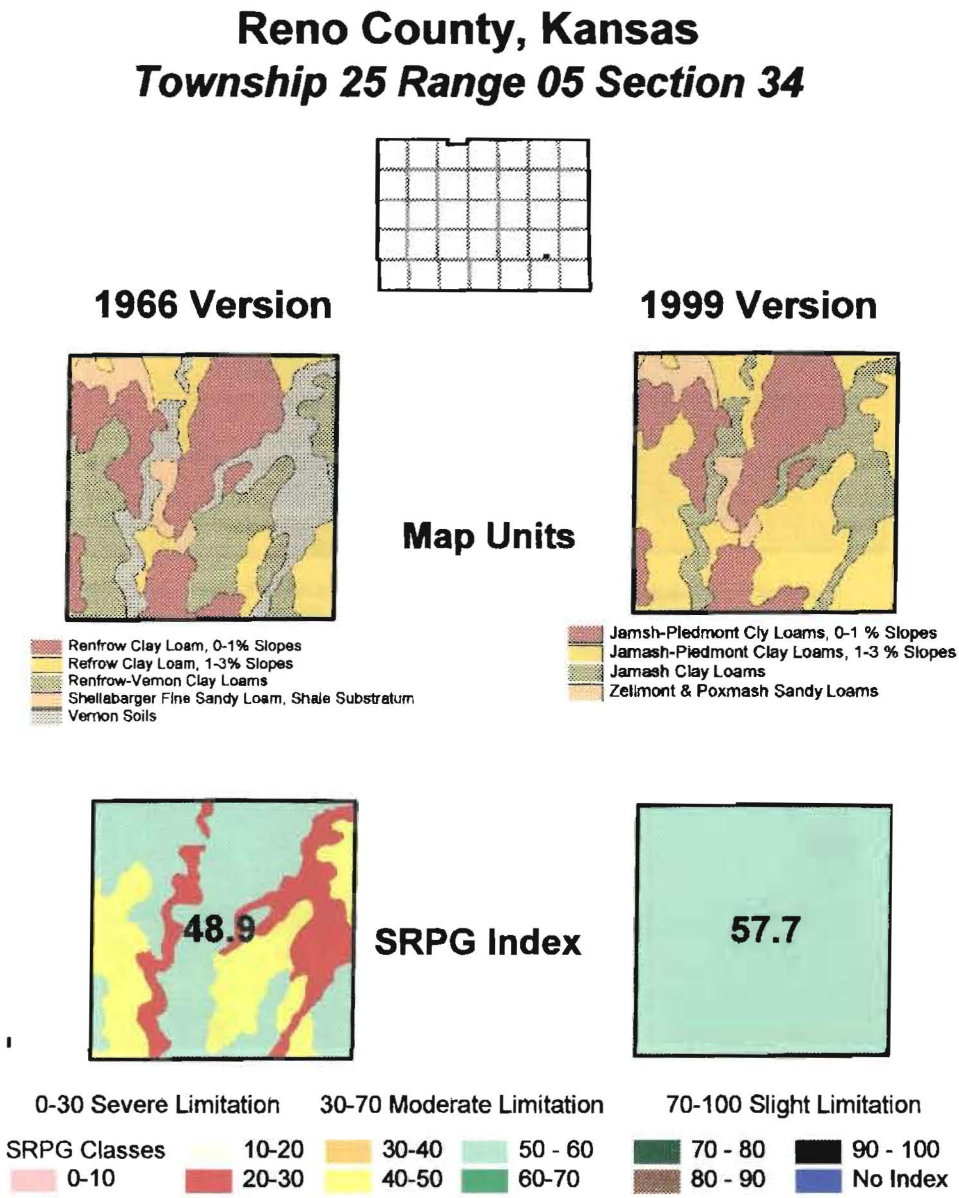


Figure 18. Four views of the selected section 25-05-34. Upper two view's display map unit delineations of old and new versions of the Reno County Soil Survey. Map unit colors are ignored for the map unit boundaries are the primary focus. Lower two views display SRPG delineations and mean SRPG index values for the section between the old and new versions of the Reno County Soil Survey.

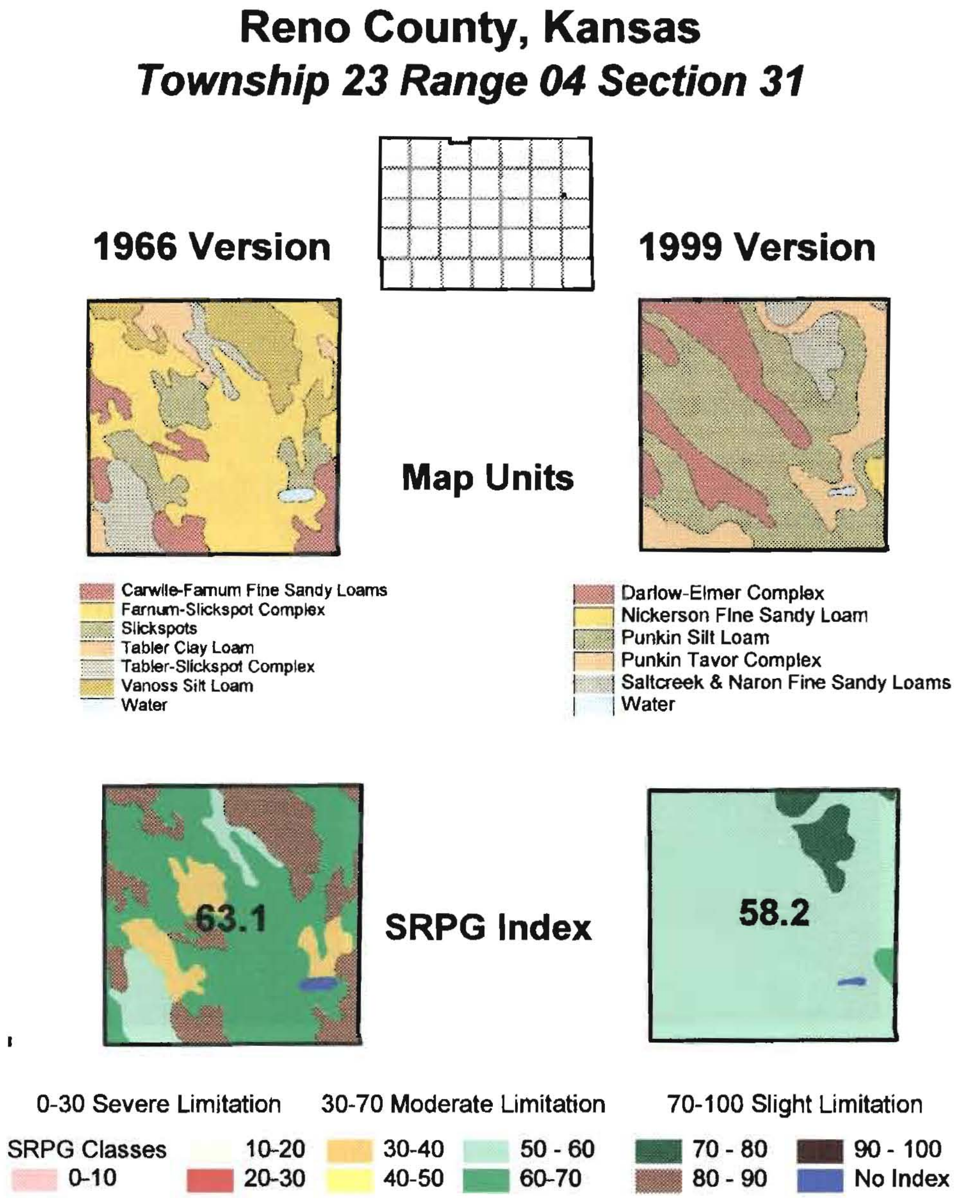


Figure 19. Four views of the selected section 23-04-31. Upper two view's display map unit delineations of old and new versions of the Reno County Soil Survey. Map unit colors are ignored for the map unit boundaries are the primary focus. Lower two views display SRPG delineations and mean SRPG index values for the section between the old and new versions of the Reno County Soil Survey.

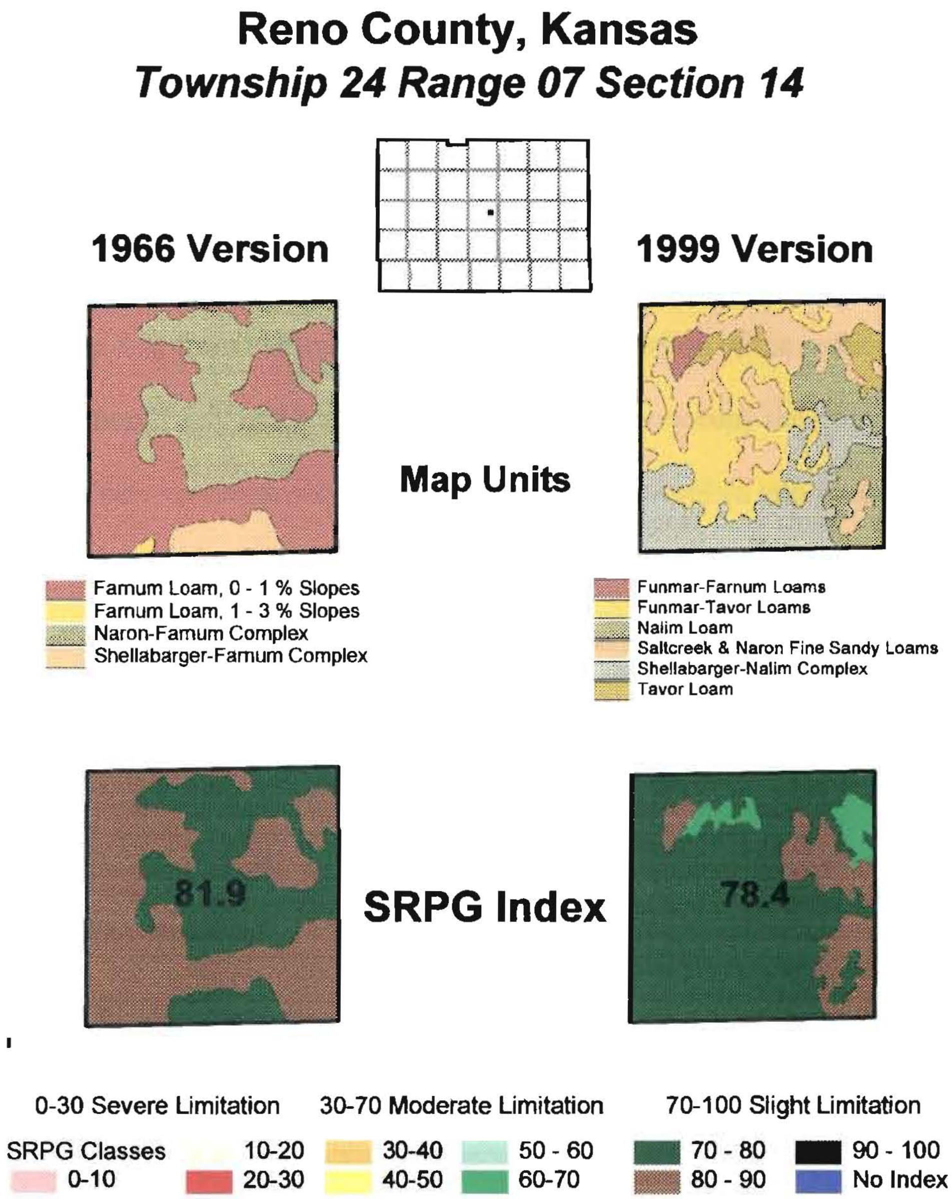


Figure 20. Four views of the selected section 24-07-14. Upper two view's display map unit delineations of old and new versions of the Reno County Soil Survey. Map unit colors are ignored for the map unit boundaries are the primary focus. Lower two views display SRPG delineations and mean SRPG index values for the section between the old and new versions of the Reno County Soil Survey.

approximately the center of the section, and includes old map units Tabler Clay Loam, Vanoss Silt Loam, Tabler-Slickspot complex, Farnum-Slickspots complex, and Slickspots. Property ratings vary from soil component to soil component and subfactor to subfactor but ultimately their calculated average produces similar SRPG index values.

Section 24-07-14 is the opposite of section 23-04-31, in that map units have increased, from 4-6, from old to new versions. The old version of the section displays two map units, Farnum Loam and Naron-Farnum complex that occupy the majority of the section. In the new version these two map units have been broken into Funmar and Farnum Loams, Funmar-Tavor Loams, Nalim Loam, Saltcreek and Naron Fine Sandy Loams, Shellabarger-Nalim complex, and Tavor Loam. Regarding the mean SRPG indices, the old version is 3.5 percentage points greater than the new version, only a slight decrease from old to new versions of the Reno County Soil Survey. Although the old map units have been separated into many new map units the calculated average result in similar SRPG indices.

The fourth example group includes sections 22-06-12, 22-10-13, 23-08-24, and 24-10-36. All four of these sections display different map unit delineations, different SRPG index delineations, and a large increase (9 percentage points or greater) in mean SRPG index values, from old to new versions (Figures 21, 22, 23, and 24). It was determined, after examining map unit subfactor ratings and investigating individual map units within the section, that the map unit components had the greatest influence on the final SRPG index is this example group. In each section the majority of the geographic extent was occupied by map units that consisted of one component in the old version and multiple components in the new version. Furthermore, at least one of the components in

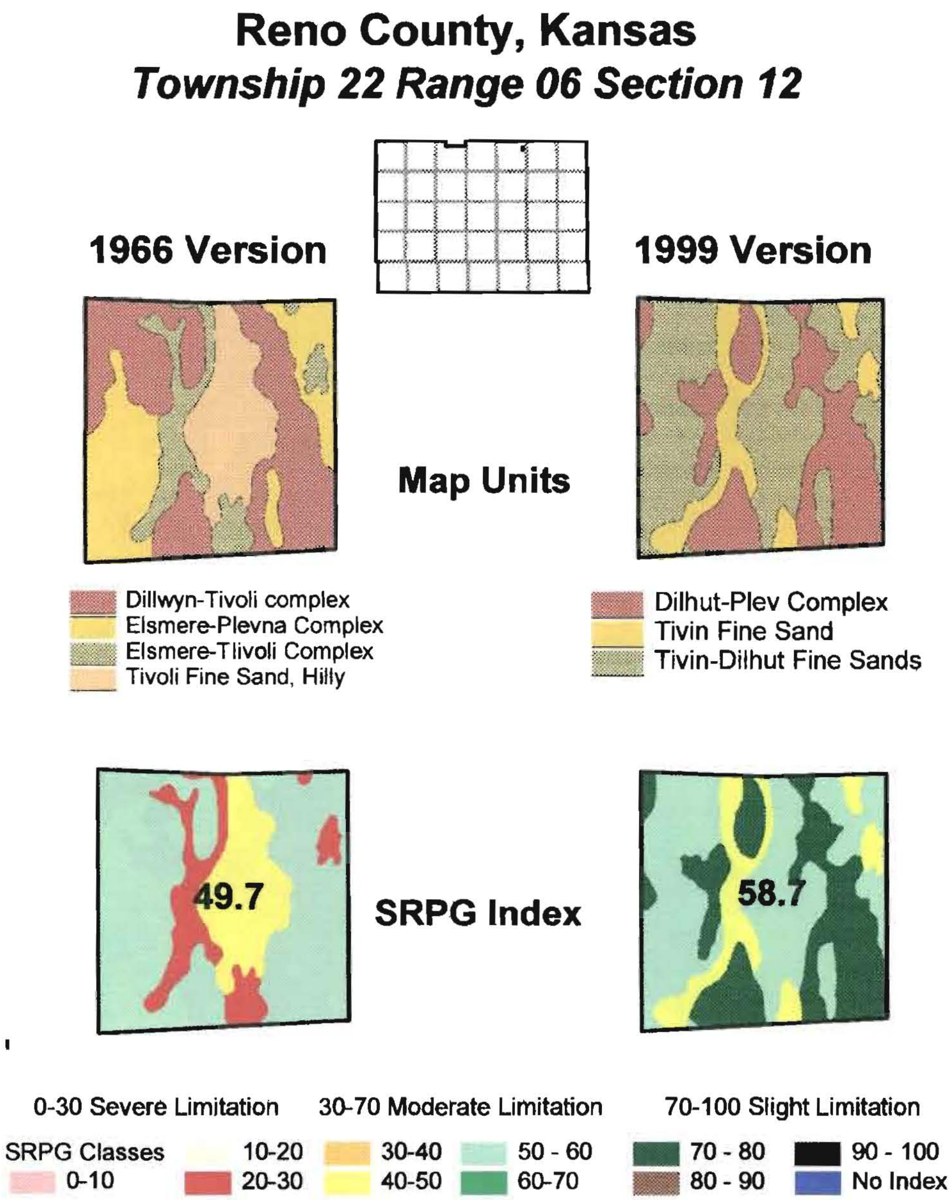


Figure 21. Four views of the selected section 22-06-12. Upper two view's display map unit delineations of old and new versions of the Reno County Soil Survey. Map unit colors are ignored for the map unit boundaries are the primary focus. Lower two views display SRPG delineations and mean SRPG index values for the section between the old and new versions of the Reno County Soil Survey.

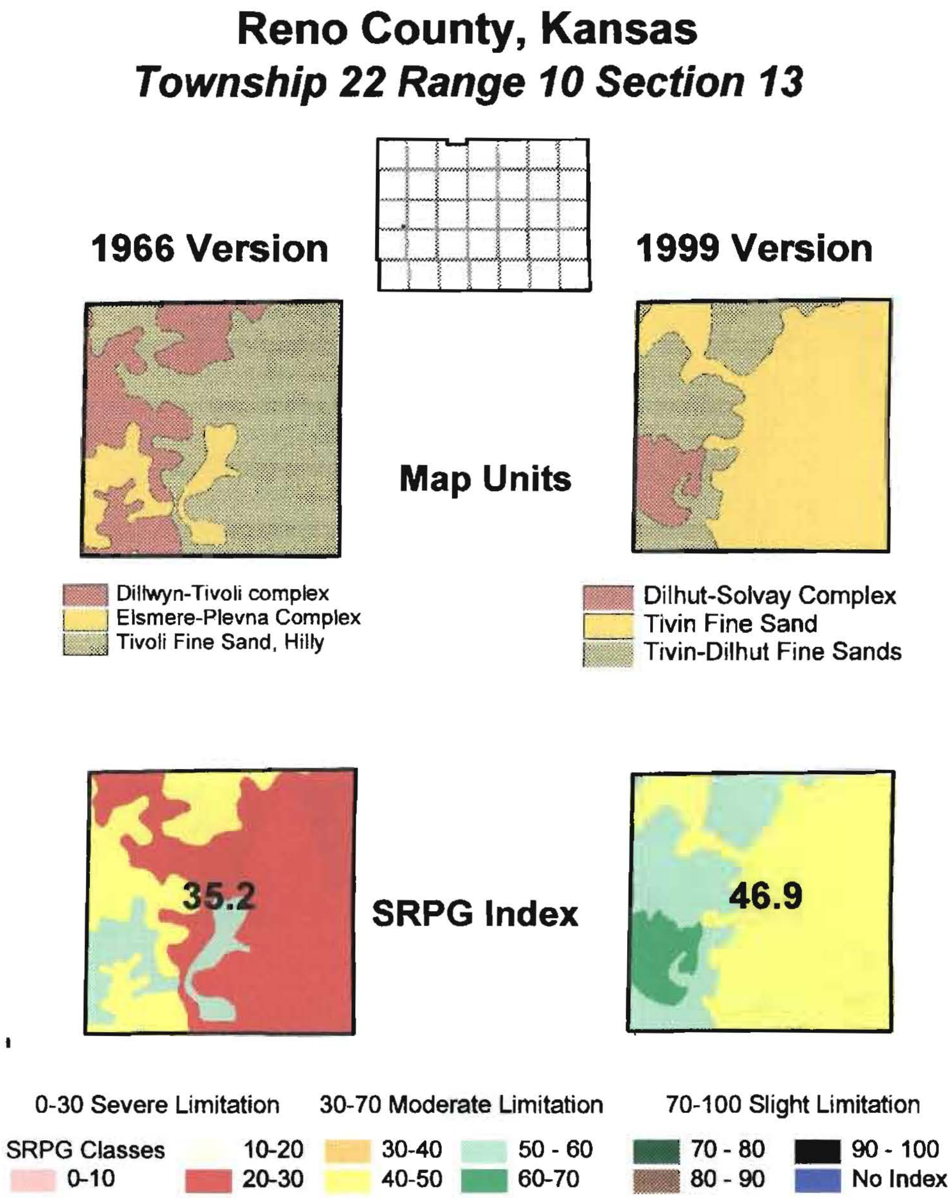


Figure 22. Four views of the selected section 22-10-13. Upper two view's display map unit delineations of old and new versions of the Reno County Soil Survey. Map unit colors are ignored for the map unit boundaries are the primary focus. Lower two views display SRPG delineations and mean SRPG index values for the section between the old and new versions of the Reno County Soil Survey.

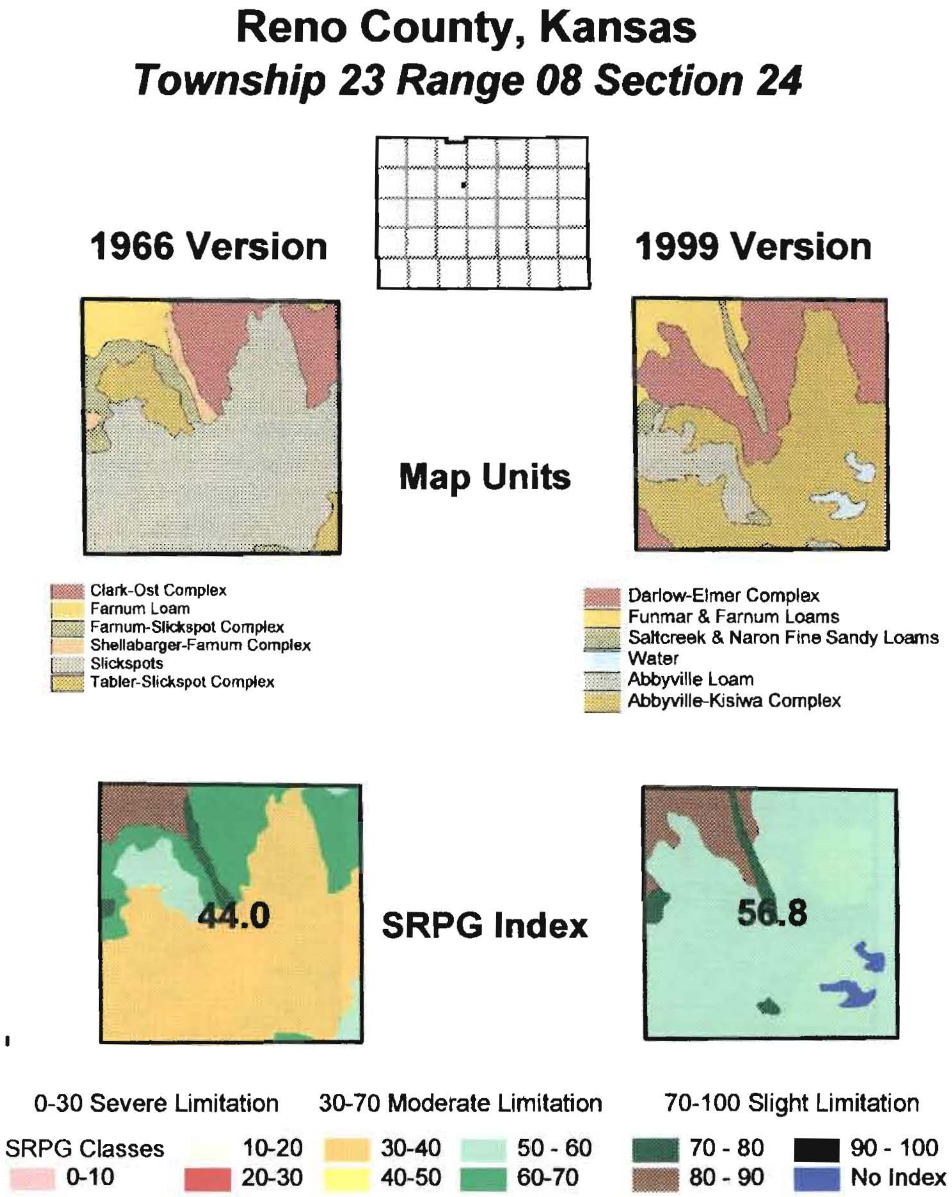


Figure 23. Four views of the selected section 23-08-24. Upper two view's display map unit delineations of old and new versions of the Reno County Soil Survey. Map unit colors are ignored for the map unit boundaries are the primary focus. Lower two views display SRPG delineations and mean SRPG index values for the section between the old and new versions of the Reno County Soil Survey.

Reno County, Kansas
Township 24 Range 10 Section 36

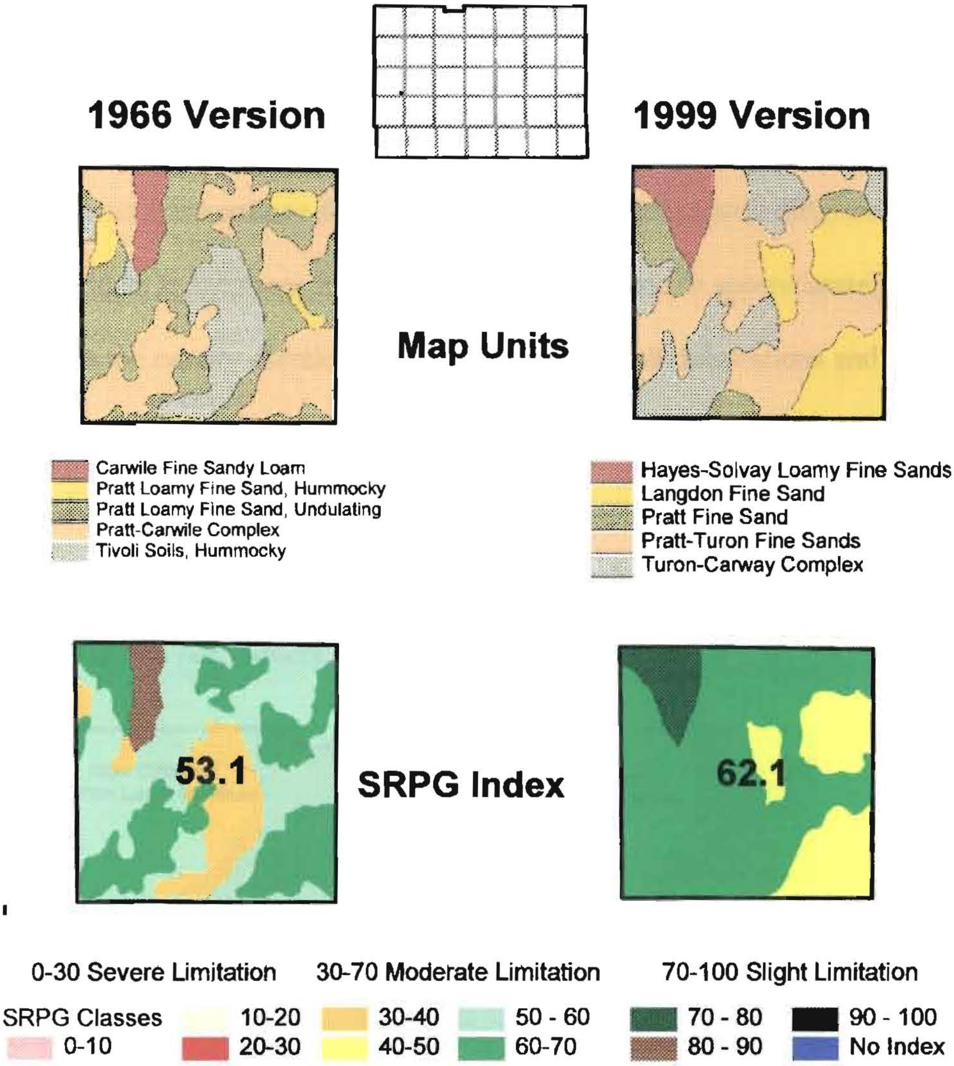


Figure 24. Four views of the selected section 24-10-36. Upper two view's display map unit delineations of old and new versions of the Reno County Soil Survey. Map unit colors are ignored for the map unit boundaries are the primary focus. Lower two views display SRPG delineations and mean SRPG index values for the section between the old and new versions of the Reno County Soil Survey.

the new version was a small percent of the entire map unit but retained a high SRPG index value.

When viewing map unit delineation and SRPG index similarities and differences at the county extent a generalized pattern is noticed (Figure 25). Sections with the same or similar map unit delineations and slight increase in SRPG indices are located in approximately the southern one-fourth of the county. Sections with different map unit delineations and large increases in SRPG indices are located in approximately the NE and NW corners of the county. Sections with different map unit delineations and large increases in SRPG indices are located in approximately the NW three-fourths of the county. Sections with very different map unit delineations and slight decreases in SRPG indices are located approximately in the NE three-fourths of the county. The latter two exclude the NW and NE corners.

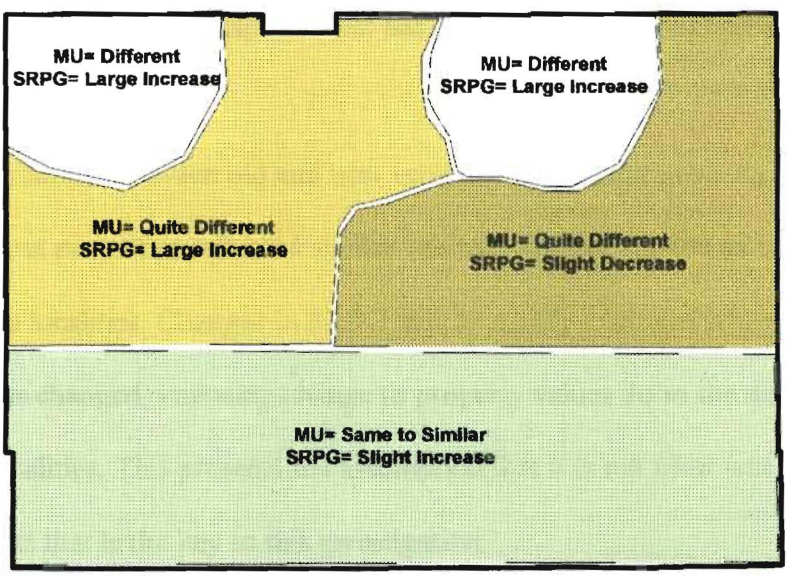


Figure 25 Generalized pattern of map unit delineations and SRPG index fluctuations between old and new Reno County Soil Surveys, based on section analyses. MU represents map unit delineations and SRPG represents SRPG index values.

3.4 Map Unit Case Examples

Investigation of individual map units uncovered a variety of changes (case examples) between old and new versions of the Reno County Soil Survey. Map unit delineations were the prime focus. Four case examples were selected to display graphically the differences in individual map units between old and new versions of the Reno County Soil Survey. The first case example demonstrates that in some cases map unit delineations were exactly the same or similar with a one soil component to one soil component relationship, but not necessarily the same component, between old and new map units (Figure 26). The second case example demonstrates similar map unit delineations that have a one-to-many soil component relationship between old and new map units (Figure 27). The third case example demonstrates multiple old map units that have been merged into a single new map unit (Figure 28). The fourth case example demonstrates a single old map unit that has been broken into multiple new maps units (Figure 29).

Variations between old and new versions of map unit property values were limited. Most properties reflected similar values in the old version as in the new version at the same localities. Changes in SRPG indices mainly occurred when map unit delineations changed, imposing change to property values do to the differences in mapped localities. This presents the assumption that it is not *what* was mapped but *how* it was mapped that is the key to this investigation.

When examining SRPG indices at the map unit level, such as a tax assessor most likely would, important implications concerning how SRPG indices will be interpreted arise. The best example being how map units with one soil component in the old version that now have multiple soil components in the new version are to be handled. Especially when one new soil component constitutes a small percent of the map unit but has a high SRPG index.

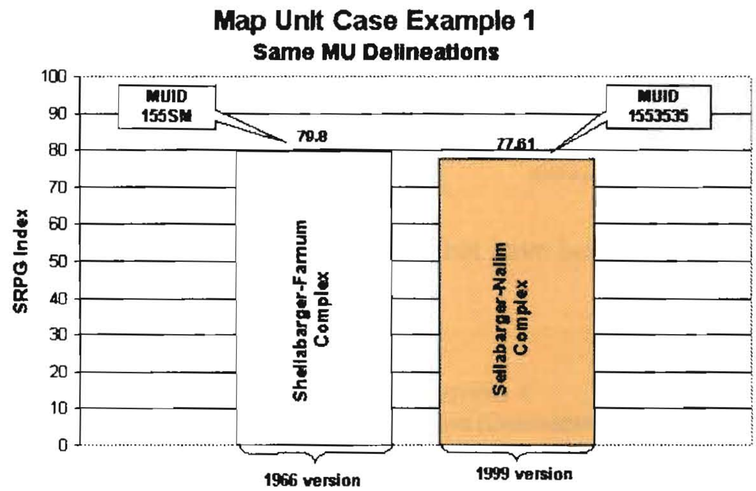


Figure 26. One-to-one soil component relationship between old and new map units.

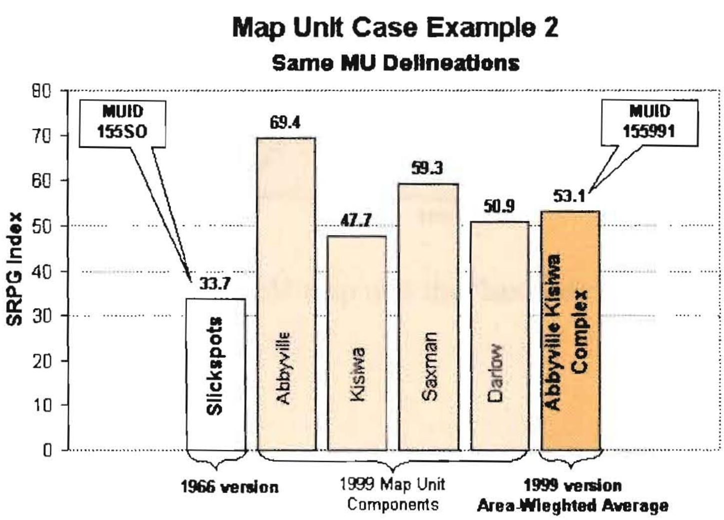


Figure 27. One-to-many soil component relationship between old and new map units.

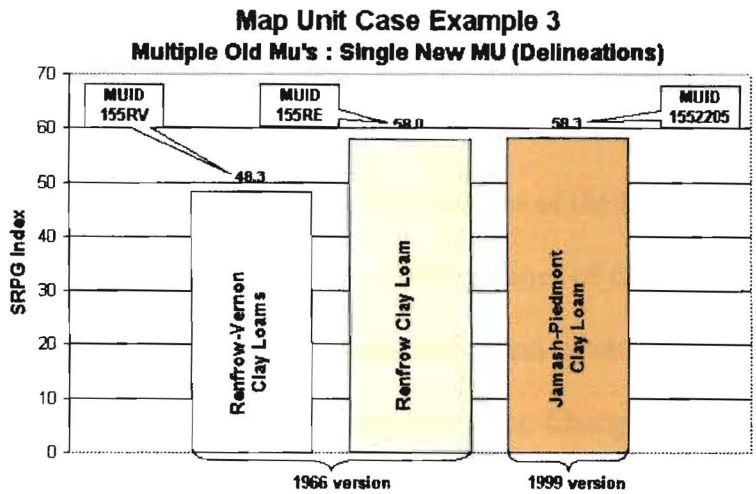


Figure 28. Example of multiple old map units that have been merged into a single new map unit.

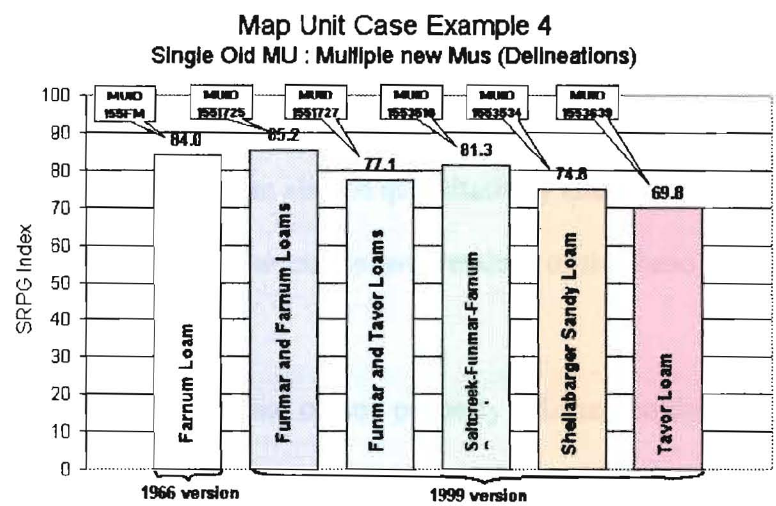


Figure 29. Example of a single old map unit that has been separated into multiple new map units.

Chapter 4

4.0 Discussion

Examination of both the old and the new versions of the Reno County Soil Survey revealed that there are observable changes between versions of this soil survey. These changes include variations in soil property information and in where map unit boundaries are positioned between soils with different characteristics. Changes can range from minor differences to very significant differences between the two versions.

Using a GIS was an appropriate method to compare possible differences in soil surveys and differences in SRPG index values resulting from re-mapping Reno County, Kansas. GIS can be used to target areas of change on a variety of spatial scales because it has the capacity to zoom in from the county extent down to the scale of individual map units. Soil property information can also be quantitatively analyzed and interpreted to determine possible differences between the two versions of the Reno County Soil Surveys.

SRPG index values are based on soil property information derived from soil surveys, therefore changes in the soil property information in soil surveys can potentially result in changes in SRPG index values. Each soil property in the SRPG model is ultimately assigned a rating, based on its expected influence on the soils ability to sustain a commodity crop, which is weighted equally within the final SRPG index value. With this in mind, the changes in soil property information did not affect SPRG index values as much as I expected. One of the major reasons for this can be explained with a simple example. For instance, within a given soil map unit the clay content in the surface horizon may have increased from the old version of the soil survey to the new version resulting in a lower rating for a major factor in the SRPG model. For similar reasons the slope of the landscape may have decreased between versions of the soil survey resulting in a higher rating for another major factor in the SRPG model. The net effect could be that these changes would balance each other out in the final SRPG index and it would appear that little change actually occurred. Therefore, changes in soil property information do not necessarily mean changes in final SRPG index values. In order for changes in SRPG index values to occur a substantial change in a single soil property must happen or an overall change in the same direction (lower or higher) in a number of soil properties must take place. In addition, these changes must occur to a great enough degree for the SRPG index value to be reassigned to a different limitation class (i.e. severe, moderate, or slight).

Consequently, SRPG index values rely not only on the accuracy of the soil property information and the rating each property is assigned but also on the interactions between different factors within the model. This raises the question: "Is the SRPG model accurate enough for something as sensitive as tax assessment?". As an end user you must assume that the soil property information is accurate enough because you simply do not have the time, resources, or expertise to perform field checks for accuracy. In the case of the 1999 Reno County Soil Survey numerous samples were taken to ensure the accuracy of map unit composition and attribute data (Figure 28). With confidence that input information is accurate enough the question of SRPG accuracy turns to the model itself. Once again the end user has to assume that the model is correct or at least consistent given the accuracy limitations of soil property information available and the validity of the assumptions used to create the model. However, it seems highly unlikely that the same soil properties have the same importance in *all* soils, *everywhere*.

Because all soil properties are weighted equally within the SRPG model a change in one soil property can be counter balanced by a change in another soil property. This can result in a SRPG index that does not reflect significant changes that may have occurred in either soil property. In addition, if the soil property that changed was an important factor that influenced the soil's limitations, it might not be recognized in the final SRPG index value based on the new soil survey information. With this scenario in mind the question, "Is the SRPG model accurate enough for something as sensitive as tax assessment?", can be asked again but not really answered without extensive field trials.

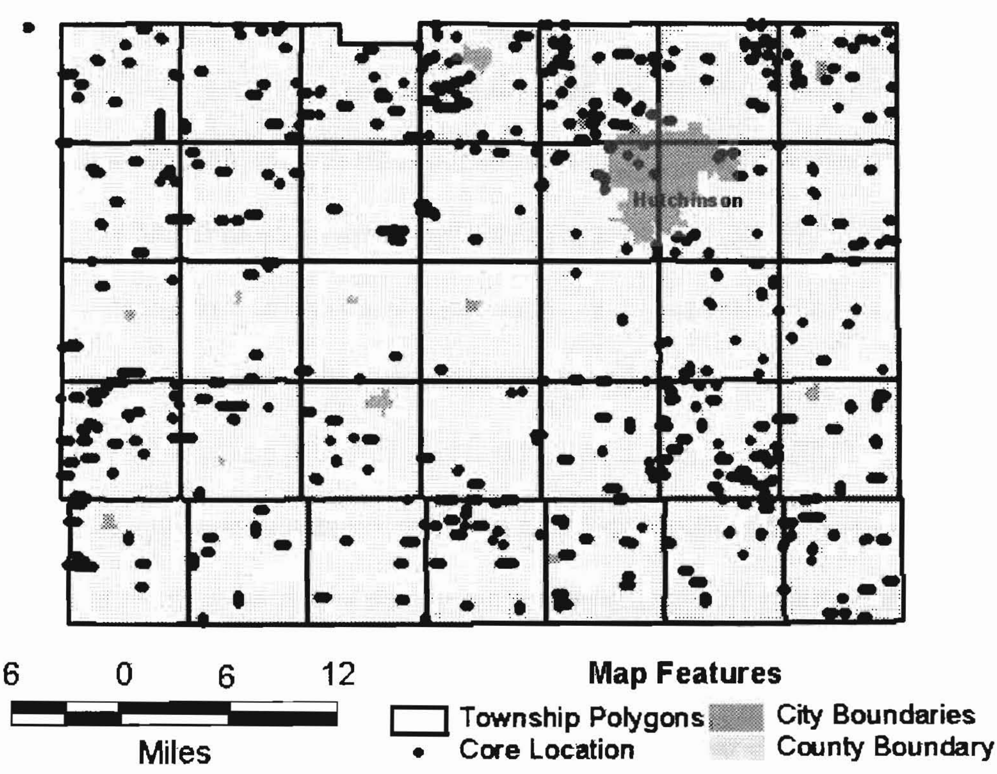


Figure 28. Locations, within Reno County, Kansas, of 1999 soil samples.

There are two entities acutely affected by the implementation of the SRPG model for tax purposes, the landowner and the tax assessor. Both have intense interest in the results. Ideally for such a model to be used, every measure used to calculate the final SRPG index should be thoroughly investigated to support the accuracy of model results. Alternately, the practice of taxing landowners according to the SRPG index should be adjusted as a function of local knowledge about selected factors within the SRPG model that relate specifically to the land in question. Such a combination would increase accuracy and instill greater confidence in both the model and final SRPG index that it assigns. This process should also reassure the landowner that he or she is being assessed accurately and fairly.

As a tax assessor the appeal of a model such as SRPG lies in the fact that it is standardized and tax valuations can be assigned in a quick and consistent manner. However, the methods used in compiling and applying the model can also be questioned. For instance, in a situation where a map unit consists of a single soil component, the application of the SRPG index is less complicated then applying the SRPG index to a map unit that contains two or more soil components. Is it feasible to tax according to a SPRG index that is the result of an area-weighted average of the soil components within such a map unit? Or is would it be more accurate to tax according to SRPG index values for the individual soil components in a map unit and their specific land uses within specific tracts of land? Is the spatial data necessary for this type of assessment even available in compatible formats?

With these questions in mind it should be noted again that changes in SPRG index values that are a function of updating or remapping a soil survey area will result in changes in tax assessments. These changes will invoke an array of reactions from both landowners and tax assessors. Tax assessments ultimately will increase, decrease, or have no change as a result of re-mapping a soil survey area. A landowner has to deal with the potential for a tax assessments to increase, decrease, or remain constant, resulting in differences in the amount of taxes that will be owed on a given parcel of land. A tax assessor will be faced with possible tax appeals, discrepancies, and questions relating to how the SRPG model derives a SPRG index that determines final property value assessments.

GIS can act as an excellent tool for targeting areas of potential tax appeals within a soil survey area. GIS has the capability to utilize both visual and quantitative comparisons. GIS is fast, user-friendly, and flexible with a variety of data input and output capabilities. These options allow for numerous scenario tests in a reasonable time constraint. However, it has to be mentioned that, as with soil properties, comparison abilities for SRPG index values are affected strongly by map scale. A comparison at the county extent works well as a means to quickly identify areas where large changes in SRPG index values have occurred. The addition of mean SRPG index values for township polygons adds additional ability to target localities of substantial change. When a township has been isolated with the need of further investigation, single sections can be evaluated at greater detail. Ideally individual map units should be examined to determine the magnitude of changes in SRPG, and perhaps the soil properties initiating the changes in SRPG. In other words, GIS can work on multiple levels of spatial scale to visually detect where and quantitatively determine how much change in a particular model's results has taken place as a function of re-mapping.

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Appendix A

Soil Characteristics Utilized in the SRPG Model

Attribute	Description
MUID	Map Unit Identification Symbol: A symbol created by concatenation of the soil survey area symbol (ssaid) and map unit symbol (musym). It uniquely identifies a map unit within a state. For example, ssaid 061 and musym 1 is stored as muid 061001.
MUSYM	Map Unit Symbol: The symbol used to identify the soil map unit component on the soil map.
MUNAME	Map Unit Name: Correlated name of the map unit (recommended name or field name for surveys in progress).
SUBORDER	Sub Order: Code for the taxonomic SUBORDER category of the record.
GRTGROUP	Great Group: Code for the taxonomic GREAT GROUP category.
SUBGROUP	Subgroup: Code for the taxonomic SUBGROUP category of the record.
PARTSIZE	Particle Size: Code for the PARTICLE-SIZE class of the Family category of taxonomic classification.
SOILTEMP	Soil Temperature: Code for the SOIL TEMPERATURE class of the Family category of taxonomic classification.
GYPSUM	Gypsum: 1 (present in the soil component) or 0 (not present in the soil component) value for sulfates reported as gypsum ($CaSO_4$) in the soil layer or horizon.
$CACO_3$	Carbonate as $CaCO_3$: 1 (present in the soil component) or 0 (not present in the soil component) value for calcium carbonate ($CaCO_3$) in the soil layer or horizon.
SAR	Sodium Absorption Ratio: 1 (present in the soil component) or 0 (not present in the soil component) value for the Sodium Absorption Ratio (SAR) for the soil layer or horizon.
SALINITY	Salinity: 1 (present in the soil component) or 0 (not present in the soil component) value for soil salinity of the soil layer or horizon.

WTKIND	Water Table Kind: The type of water table.
WTDEP	Water Table Depth: Average depth to the seasonally high water table during specific months.
ANFLOOD	Annual Flooding Frequency: The frequency of annual flooding (flooding likely to occur during the year) that is likely to occur.
ANFLODUR	Flood Duration Class: The duration of annual flooding in a normal year.
GSFLOOD	Growing Season Flooding Frequency: The frequency of flooding during the growing season (season for the common field crops in the area.
GSFLODUR	Growing Season Duration: The duration of flooding during the growing season (season for common field crops in the area).
PNDDUR	Ponding Duration: The duration of surface water ponding.
SLOPE	Soil Slope: The average value for the slope of the soil map unit
ROCKDEP	Depth to Bedrock: The average value for the depth to bedrock of the soil map unit, expressed in inches (blank cells represent no bedrock encountered before 60 inches in depth).
SURFTEX	Surface Soil Texture: Code for the USDA of the soil map unit.
Texture_A	Soil Texture Class, A Horizon: Code for the USDA texture for the surface layer or horizon of the soil.
NO10_A	Weight Percent Greater than 10 inches, A Horizon: The surface layer or horizon value, in percent by weight of the rock fragments greater than 10 inches, of the soil map unit.
CLAY_A	Clay, A Horizon: Surface layer or horizon clay content value of the soil map unit, expressed as a percentage of the material less than 2 mm in size.
CLAY_MAX	Clay, Maximum Value: Max clay content value of the soil map unit, expressed as a percentage of the material less than 2 mm in size.
AWC_A	Available Water Capacity, A Horizon: Surface layer or horizon available water capacity value for the soil map unit, expressed as inches/inch.

AWC	Available Water Capacity: Depth weighted average of the available water capacity value of the soil map unit, expressed as inches/inch.
BD_A	Bulk Density, A Horizon: Surface layer or horizon moist bulk density value of the soil map unit, expressed as grams per cubic centimeter.
OM_A	Organic Matter, A Horizon: Surface layer or horizon organic matter content value of the soil map unit, expressed in percent by weight.
PH_A	Soil Reaction (pH), A Horizon: Surface layer or horizon soil reaction (pH) value of the soil map unit.
PH	Soil Reaction (pH): Depth weighted average of the soil reaction (pH) value of the soil map unit.
CEC_A	Cation Exchange Capacity, A Horizon: Surface layer or horizon cation exchange capacity value of the soil map unit.
CEC	Cation Exchange Capacity: Depth weighted average of the cation exchange capacity value of the soil map unit.
SHRNKSW_A	Shrink-Swell Potential, A Horizon: Soil layer or horizons behavior of changing volume (shrinking and swelling) upon wetting and drying, expressed as a ranked numeric value.
PERM	Permeability Rate: Depth weighted average permeability rate of the soil map unit, expressed as inches/hour.

Appendix B

Soil Rating for Plant Growth
Database Description and Procedures

Database

SRPG_Model_new	Access database that assembles SRPG index rating for 1999 Reno County Soil Survey soil properties *Input Table: properties_new*
SRPG_Model_old	Access database that assembles SRPG index rating for 1966 Reno County Soil Survey soil properties *Input Table: properties_old*

Queries **(both databases use the same queries only with different input data)**

#01_mean_root_restrict_layer:

SQL View:
```
ELECT properties.muid, properties.musym, properties.seqnum, properties.layernum,
properties.MLRA, properties.compname, properties.class, properties.rockdepl,
properties.rockdeph, properties.texture, ([properties]![bdl]+[properties]![bdh])/2 AS BD_Mean,
([properties]![clayl]+[properties]![clayh])/2 AS Clay_Mean,
([properties]![phl]+[properties]![phh])/2 AS PH_Mean,
([properties]![awcl]+[properties]![awch])/2 AS AWC_Mean,
([properties]![perml]+[properties]![permh])/2 AS Perm_Mean INTO [Root-Restrict_Mean]
FROM properties;
```

#02_find_root_restrict_layer:

SQL View:
```
SELECT [Root-Restrict_Mean].muid, [Root-Restrict_Mean].musym, [Root-
Restrict_Mean].seqnum, [Root-Restrict_Mean].layernum, [Root-Restrict_Mean].MLRA, [Root-
Restrict_Mean].compname, [Root-Restrict_Mean].class, [Root-Restrict_Mean].rockdepl, [Root-
Restrict_Mean].rockdeph, [Root-Restrict_Mean].texture, [Root-Restrict_Mean].BD_Mean,
[Root-Restrict_Mean].Clay_Mean, IIf([Root-Restrict_Mean]![PH_Mean]<3.5,1,0) AS PH_Class,
IIf([Root-Restrict_Mean]![AWC_Mean]>0.199,1,IIf([Root-
Restrict_Mean]![AWC_Mean]>0.149,2,IIf([Root-
Restrict_Mean]![AWC_Mean]>0.099,3,IIf([Root-Restrict_Mean]![AWC_Mean]>0.049,4,5))))
AS AWC_Class, IIf([Root-Restrict_Mean]![Perm_Mean]>20,1,IIf([Root-
Restrict_Mean]![Perm_Mean]>6,2,IIf([Root-Restrict_Mean]![Perm_Mean]>2,3,IIf([Root-
Restrict_Mean]![Perm_Mean]>0.6,4,IIf([Root-Restrict_Mean]![Perm_Mean]>0.2,5,IIf([Root-
Restrict_Mean]![Perm_Mean]>0.06,6,7)))))) AS Perm_Class INTO [Root-Restrict Layers]
FROM [Root-Restrict_Mean];
```

#03_make_subsurface_layer:

SQL View:

```
SELECT properties.muid, properties.musym, properties.seqnum, properties.layernum,
properties.laydepl, properties.laydeph, properties.MUNAME, properties.MUKIND,
properties.MLRA, properties.PRIMFML, properties.MUACRES, properties.clascode,
properties.class, properties.order, properties.suborder, properties.grtgroup, properties.subgroup,
properties.partsize, properties.reaction, properties.soiltemp, properties.otherfam,
properties.compname, properties.comppct, properties.slopel, properties.slopeh, properties.surftex,
properties.otherph, properties.compkind, properties.compacre, properties.anflood,
properties.anflodur, properties.anflobeg, properties.anfloend, properties.gsflood,
properties.gsflodur, properties.gsflobeg, properties.gsfloend, properties.wtdepl,
properties.wtdeph, properties.wtkind, properties.wtbeg, properties.wtend, properties.pnddepl,
properties.pnddeph, properties.pnddur, properties.pndbeg, properties.pndend, properties.rockdepl,
properties.rockdeph, properties.rockhard, properties.pandepl, properties.pandeph,
properties.panhard, properties.subinitl, properties.subinith, properties.subtotl, properties.subtoth,
properties.hydgrp, properties.frostact, properties.drainage, properties.hydric, properties.corcon,
properties.corsteel, properties.clnirr, properties.clirr, properties.sclnirr, properties.sclirr,
properties.layerid, properties.texture, properties.kfact, properties.kffact, properties.tfact,
properties.weg, properties.inch10l, properties.inch10h, properties.inch3l, properties.inch3h,
properties.no4l, properties.no4h, properties.no10l, properties.no10h, properties.no40l,
properties.no40h, properties.no200l, properties.no200h, properties.clayl, properties.clayh,
properties.lll, properties.llh, properties.pil, properties.pih, properties.unified, properties.aashto,
properties.aashind, properties.awcl, properties.awch, properties.bdl, properties.bdh,
properties.oml, properties.omh, properties.phl, properties.phh, properties.salinl, properties.salinh,
properties.sarl, properties.sarh, properties.cecl, properties.cech, properties.caco3l,
properties.caco3h, properties.gypsuml, properties.gypsumh, properties.perml, properties.permh,
properties.shrinksw, properties.wei INTO [Subsurface Layers]
FROM properties;
```

#04_factor1_surface layers:

SQL View:

```
SELECT properties.muid, First(properties.musym) AS musym, properties.seqnum,
First(properties.comppct) AS comppct, First(properties.MLRA) AS MLRA,
First(properties.clnirr) AS NonIrrClass, properties.sclnirr AS NonIrrSubClass,
First(properties.compname) AS compname, First(properties.class) AS class, First(properties.bdl)
AS bdl, First(properties.bdh) AS bdh, First(properties.oml) AS oml, First(properties.omh) AS
omh, First(properties.clayl) AS clayl, First(properties.clayh) AS clayh, First(properties.awcl) AS
awcl, First(properties.awch) AS awch, First(properties.phl) AS phl, First(properties.phh) AS phh,
First(properties.sarl) AS sarl, First(properties.sarh) AS sarh, First(properties.caco3l) AS caco3l,
First(properties.caco3h) AS caco3h, First(properties.gypsuml) AS gypsuml,
First(properties.gypsumh) AS gypsumh, First(properties.cecl) AS cecl, First(properties.cech) AS
cech, First(properties.shrinksw) AS shrinksw, First(properties.inch3l) AS inch3l,
First(properties.inch3h) AS inch3h, First(properties.inch10l) AS inch10l,
First(properties.inch10h) AS inch10h, First(properties.no10l) AS no10l, First(properties.no10h)
AS no10h INTO [Factor1_surface layer]
FROM properties
GROUP BY properties.muid, properties.seqnum, properties.sclnirr;
```

#05_factor1_mean1:

SQl View:
SELECT [Factor1_surface layer].muid, [Factor1_surface layer].musym, [Factor1_surface layer].seqnum, [Factor1_surface layer].comppct, [Factor1_surface layer].MLRA, [Factor1_surface layer].NonIrrClass, [Factor1_surface layer].NonIrrSubClass, [Factor1_surface layer].compname, [Factor1_surface layer].class, ([Factor1_surface layer]![bdl]+[Factor1_surface layer]![bdh])/2 AS BD_mean, ([Factor1_surface layer]![oml]+[Factor1_surface layer]![omh])/2 AS OM_Mean, ([Factor1_surface layer]![clayl]+[Factor1_surface layer]![clayh])/2 AS Clay_Mean, ([Factor1_surface layer]![clayl]+[Factor1_surface layer]![clayh])/2 AS AWC_Mean, ([Factor1_surface layer]![phl]+[Factor1_surface layer]![phh])/2 AS PH_Mean, ([Factor1_surface layer]![sarl]+[Factor1_surface layer]![sarh])/2 AS SAR_Mean, ([Factor1_surface layer]![caco3l]+[Factor1_surface layer]![caco3h])/2 AS CACO3_Mean, ([Factor1_surface layer]![gypsuml]+[Factor1_surface layer]![gypsumh])/2 AS Gypsum_Mean, ([Factor1_surface layer]![cecl]+[Factor1_surface layer]![cech])/2 AS CEC_Mean, [Factor1_surface layer].shrinksw AS ShrkSW, ([Factor1_surface layer]![inch3l]+[Factor1_surface layer]![inch3h])/2 AS Inch3_Mean, ([Factor1_surface layer]![inch10l]+[Factor1_surface layer]![inch10h])/2 AS Inch10_Mean, ([Factor1_surface layer]![no10l]+[Factor1_surface layer]![no10h])/2 AS No10_Mean INTO Factor1_Mean1
FROM [Factor1_surface layer];

#06_factor1_mean:

SQL View:
SELECT Factor1_Mean1.muid, Factor1_Mean1.musym, Factor1_Mean1.seqnum, Factor1_Mean1.comppct, Factor1_Mean1.MLRA, Factor1_Mean1.NonIrrClass, Factor1_Mean1.NonIrrSubClass, Factor1_Mean1.compname, Factor1_Mean1.class, Factor1_Mean1.BD_mean, Factor1_Mean1.OM_Mean, Factor1_Mean1.Clay_Mean, Factor1_Mean1.AWC_Mean, Factor1_Mean1.PH_Mean, Factor1_Mean1.SAR_Mean, Factor1_Mean1.CACO3_Mean, Factor1_Mean1.Gypsum_Mean, Factor1_Mean1.CEC_Mean, Factor1_Mean1.ShrkSW, (100-[Factor1_Mean1]![No10_Mean])+[Factor1_Mean1]![Inch3_Mean] AS Gravel_Mean, Factor1_Mean1.Inch10_Mean INTO Factor1_Mean
FROM Factor1_Mean1;

#07_factor1_subfact_rtg:

SQL View:
SELECT Factor1_Mean.muid, Factor1_Mean.musym, Factor1_Mean.seqnum, Factor1_Mean.comppct, Factor1_Mean.MLRA, Factor1_Mean.NonIrrClass, Factor1_Mean.NonIrrSubClass, Factor1_Mean.compname, Factor1_Mean.class, IIf([Factor1_Mean]![BD_mean]>0,100,100) AS BD_Rating, IIf([Factor1_Mean]![OM_Mean]=-9999,100,IIf([Factor1_Mean]![OM_Mean]<1,85,100)) AS OM_Rating, IIf([Factor1_Mean]![Clay_Mean]=-9999,100,IIf([Factor1_Mean]![Clay_Mean]>40,75,IIf([Factor1_Mean]![Clay_Mean]>27,90,IIf([Factor1_Mean]![Clay_Mean]>15,100,75)))) AS Clay_Rating, IIf([Factor1_Mean]![AWC_Mean]=-9999,100,IIf([Factor1_Mean]![AWC_Mean]>0.15,100,IIf([Factor1_Mean]![AWC_Mean]>0.1,85,IIf([Factor1_Mean]![AWC_Mean]>0.075,80,IIf([Factor1_Mean]![AWC_Mean]>0.05,75,60))))) AS AWC_Rating, IIf([Factor1_Mean]![PH_Mean]=-

```
9999,100,IIf([Factor1_Mean]![PH_Mean]>=6.1 And [Factor1_Mean]![PH_Mean]<=7.8,100,75))
AS PH_Rating, IIf([Factor1_Mean]![SAR_Mean]=-
9999,100,IIf([Factor1_Mean]![SAR_Mean]>=13,65,IIf([Factor1_Mean]![SAR_Mean]>=8,75,IIf(
[Factor1_Mean]![SAR_Mean]>=4,85,100)))) AS SAR_Rating,
IIf([Factor1_Mean]![CACO3_Mean]=-
9999,100,IIf([Factor1_Mean]![CACO3_Mean]>30,75,IIf([Factor1_Mean]![CACO3_Mean]>15,8
0,IIf([Factor1_Mean]![CACO3_Mean]>2,90,IIf([Factor1_Mean]![CACO3_Mean]<=2,100)))))
AS CACO3_Rating, IIf([Factor1_Mean]![Gypsum_Mean]=-
9999,100,IIf([Factor1_Mean]![Gypsum_Mean]<=2,100,75)) AS Gypsum_Rating,
IIf([Factor1_Mean]![CEC_Mean]=-9999,100,IIf([Factor1_Mean]![CEC_Mean]>=15 And
[Factor1_Mean]![CEC_Mean]<=99,100,75)) AS CEC_Rating, IIf([Factor1_Mean]![ShrkSW]=-
9999,100,IIf([Factor1_Mean]![ShrkSW]>1 And [Factor1_Mean]![ShrkSW]<5,100,75)) AS
ShrkSW_Rating, IIf([Factor1_Mean]![Gravel_Mean]=-
9999,100,IIf([Factor1_Mean]![Gravel_Mean]>75,25,IIf([Factor1_Mean]![Gravel_Mean]>50,50,I
If([Factor1_Mean]![Gravel_Mean]>25,75,100)))) AS Gravel_Rating,
IIf([Factor1_Mean]![Inch10_Mean]=-9999,100,IIf([Factor1_Mean]![Inch10_Mean]>5,-
360,IIf([Factor1_Mean]![Inch10_Mean]>2.5,-240,IIf([Factor1_Mean]![Inch10_Mean]>0,-
120,100)))) AS Stone_Rating INTO Factor1_Subfact_Rtg
FROM Factor1_Mean;
```

#08_factor1_srpg_rtg:

SQL View:

```
SELECT Factor1_Subfact_Rtg.muid AS MUID, Factor1_Subfact_Rtg.musym AS MUSym,
Factor1_Subfact_Rtg.seqnum AS SeqNum, Factor1_Subfact_Rtg.comppct AS [Comp%],
([Factor1_Subfact_Rtg]![BD_Rating]+[Factor1_Subfact_Rtg]![OM_Rating]+[Factor1_Subfact_
Rtg]![Clay_Rating]+[Factor1_Subfact_Rtg]![AWC_Rating]+[Factor1_Subfact_Rtg]![PH_Rating
]+[Factor1_Subfact_Rtg]![SAR_Rating]+[Factor1_Subfact_Rtg]![CACO3_Rating]+[Factor1_Su
bfact_Rtg]![Gypsum_Rating]+[Factor1_Subfact_Rtg]![CEC_Rating]+[Factor1_Subfact_Rtg]![Sh
rkSW_Rating]+[Factor1_Subfact_Rtg]![Gravel_Rating]+[Factor1_Subfact_Rtg]![Stone_Rating])
/(12*100) AS SRPG_Rtg INTO Factor1_SRPG_Rtg
FROM Factor1_Subfact_Rtg;
```

#09_factor2_props:

SQL View:

```
SELECT [Subsurface Layers].muid, [Subsurface Layers].musym, [Subsurface Layers].seqnum,
[Subsurface Layers].layernum, [Subsurface Layers].MUNAME, [Subsurface Layers].MLRA,
[Subsurface Layers].class, [Subsurface Layers].order, [Subsurface Layers].suborder, [Subsurface
Layers].grtgroup, [Subsurface Layers].subgroup, [Subsurface Layers].partsize, [Subsurface
Layers].comppct, [Subsurface Layers].anflood, [Subsurface Layers].anflodur, [Subsurface
Layers].anflobeg, [Subsurface Layers].anfloend, [Subsurface Layers].gsflood, [Subsurface
Layers].gsflodur, [Subsurface Layers].gsflobeg, [Subsurface Layers].gsfloend, ([Subsurface
Layers]![wtdepl]+[Subsurface Layers]![wtdeph])/2 AS WTDepth_Mean, [Subsurface
Layers].wtkind, [Subsurface Layers].pndbeg, [Subsurface Layers].pndend, [Subsurface
Layers].clnirr, [Subsurface Layers].sclnirr, ([Subsurface Layers]![perml]+[Subsurface
Layers]![permh])/2 AS Perm_Mean, ([Subsurface Layers]![awcl]+[Subsurface Layers]![awch])/2
AS AWC_Mean INTO Factor2_properties
FROM [Subsurface Layers];
```

#10_factor2_subfact_rtg:

SQL View:
SELECT Factor2_properties.muid, Factor2_properties.musym, Factor2_properties.seqnum, Factor2_properties.layernum, IIf([Factor2_properties]![Perm_Mean]>=1,100,0) AS SRPG_Rtg, Factor2_properties.MUNAME, Factor2_properties.MLRA, Factor2_properties.class, Factor2_properties.order, Factor2_properties.suborder, Factor2_properties.grtgroup, Factor2_properties.subgroup, Factor2_properties.partsize, Factor2_properties.comppct, Factor2_properties.anflood, Factor2_properties.anflodur, Factor2_properties.anflobeg, Factor2_properties.anfloend, Factor2_properties.gsflood, Factor2_properties.gsflodur, Factor2_properties.gsflobeg, Factor2_properties.gsfloend, Factor2_properties.WTDepth_Mean, Factor2_properties.wtkind, Factor2_properties.pndbeg, Factor2_properties.pndend, Factor2_properties.clnirr, Factor2_properties.sclnirr,
IIf([Factor2_properties]![Perm_Mean]>=20,50,IIf([Factor2_properties]![Perm_Mean]>6,60,IIf([Factor2_properties]![Perm_Mean]>2,75,IIf([Factor2_properties]![Perm_Mean]>0.6,100,IIf([Factor2_properties]![Perm_Mean]>0.06,90,75))))) AS Perm_Rtg,
IIf([Factor2_properties]![AWC_Mean]>0.18,100,IIf([Factor2_properties]![AWC_Mean]>0.15,90,IIf([Factor2_properties]![AWC_Mean]>0.1,85,IIf([Factor2_properties]![AWC_Mean]>0.05,75,60)))) AS AWC_Rtg INTO Factor2_Subfact_Rtg
FROM Factor2_properties;

#11_factor2_srpg_rtg:

SQL View:
SELECT Factor2_Subfact_Rtg.muid AS MUID, First(Factor2_Subfact_Rtg.musym) AS MUSym, Factor2_Subfact_Rtg.seqnum AS SeqNum, First(Factor2_Subfact_Rtg.comppct) AS [Comp%], First(Factor2_Subfact_Rtg.SRPG_Rtg) AS SRPG_Rtg_2, First(([Factor2_Subfact_Rtg]![WT_Rtg]+[Factor2_Subfact_Rtg]![Perm_Rtg]+[Factor2_Subfact_Rtg]![AWC_Rtg])/(3*100)) AS SRPG_Rtg INTO Factor2_SRPG_Rtg
FROM Factor2_Subfact_Rtg
GROUP BY Factor2_Subfact_Rtg.muid, Factor2_Subfact_Rtg.seqnum;

#12_factor3_props:

SQL View:
SELECT [Subsurface Layers (40inches)].muid, [Subsurface Layers (40inches)].musym, [Subsurface Layers (40inches)].seqnum, [Subsurface Layers (40inches)].layernum, [Subsurface Layers (40inches)].MLRA, [Subsurface Layers (40inches)].class, [Subsurface Layers (40inches)].order, [Subsurface Layers (40inches)].comppct, ([Subsurface Layers (40inches)]![sarl]+[Subsurface Layers (40inches)]![sarh])/2 AS SAR_Mean, ([Subsurface Layers (40inches)]![salinl]+[Subsurface Layers (40inches)]![salinh])/2 AS Salin_Mean, [Subsurface Layers (40inches)].salinh AS Salin_h, ([Subsurface Layers (40inches)]![cecl]+[Subsurface Layers (40inches)]![cech])/2 AS CEC_Mean, ([Subsurface Layers (40inches)]![caco3l]+[Subsurface Layers (40inches)]![caco3h])/2 AS CACO3 INTO Factor3_properties
FROM [Subsurface Layers (40inches)];

#13_factor3_subfact_rtg:

SQL View:
```
SELECT Factor3_properties.muid, Factor3_properties.musym, Factor3_properties.seqnum,
Factor3_properties.layernum, Factor3_properties.MLRA, Factor3_properties.class,
Factor3_properties.order, Factor3_properties.comppct,
IIf([Factor3_properties]![SAR_Mean]>29.9,50,IIf([Factor3_properties]![SAR_Mean]>12.9,75,IIf
([Factor3_properties]![SAR_Mean]>4,85,100))) AS SAR_Rtg,
IIf([Factor3_properties]![Salin_Mean]>7.9,75,IIf([Factor3_properties]![Salin_Mean]>4,90,100))
AS Salin_Rtg, IIf([Factor3_properties]![Salin_h]>16,50,0) AS Salin_Max,
IIf([Factor3_properties]![CEC_Mean]>16,100,IIf([Factor3_properties]![CEC_Mean]>6.9,85,75))
AS CEC_Rtg, Factor3_properties.CACO3 INTO Factor3_Subfact_Rtg
FROM Factor3_properties;
```

#14_factor3_subfact_mins:

SQL View:
```
SELECT Factor3_Subfact_Rtg.muid, First(Factor3_Subfact_Rtg.musym) AS musym,
Factor3_Subfact_Rtg.seqnum, First(Factor3_Subfact_Rtg.MLRA) AS MLRA,
First(Factor3_Subfact_Rtg.class) AS Class, First(Factor3_Subfact_Rtg.comppct) AS [Comp%],
Min(Factor3_Subfact_Rtg.SAR_Rtg) AS SAR_Rtg, Min(Factor3_Subfact_Rtg.Salin_Rtg) AS
Salin_Rtg, Max(Factor3_Subfact_Rtg.Salin_Max) AS Salin_Max,
Min(Factor3_Subfact_Rtg.CEC_Rtg) AS CEC_Rtg, Max(Factor3_Subfact_Rtg.CACO3) AS
CACO3 INTO Factor3_Subfact_mins
FROM Factor3_Subfact_Rtg
GROUP BY Factor3_Subfact_Rtg.muid, Factor3_Subfact_Rtg.seqnum;
```

#15_factor3_srpg_rtg:

SQL View:
```
SELECT Factor3_Subfact_mins.muid AS MUID, Factor3_Subfact_mins.musym AS MUSym,
Factor3_Subfact_mins.seqnum AS SeqNum, Factor3_Subfact_mins.[Comp%],
([Factor3_Subfact_mins]![SAR_Rtg]+[Factor3_Subfact_mins]![Salin_Rtg]+[Factor3_Subfact_m
ins]![CEC_Rtg])/(3*100) AS SRPG_Rtg INTO Factor3_SRPG_Rtg
FROM Factor3_Subfact_mins;
```

#16_factor4_props:

SQL View:
```
SELECT [Subsurface Layers].muid, [Subsurface Layers].musym, [Subsurface Layers].seqnum,
[Subsurface Layers].layernum, [Subsurface Layers].MLRA, [Subsurface Layers].class,
[Subsurface Layers].comppct, ([Subsurface Layers]![phl]+[Subsurface Layers]![phh])/2 AS
PH_Mean INTO Factor4_properties
FROM [Subsurface Layers];
```

#17_factor4_subfact_rtg:

SQL View:
```
SELECT Factor4_properties.muid, Factor4_properties.musym, Factor4_properties.seqnum,
Factor4_properties.layernum, Factor4_properties.MLRA, Factor4_properties.class,
Factor4_properties.comppct,
```

IIf([Factor4_properties]![PH_Mean]>7.8,90,IIf([Factor4_properties]![PH_Mean]>5.5,100,IIf([Factor4_properties]![PH_Mean]>4.4,90,IIf([Factor4_properties]![PH_Mean]>3.4,50,10)))) AS PH_Rtg INTO Factor4_Subfact_Rtg
FROM Factor4_properties;

#18_factor4_subfact_mins:

SQL View:
SELECT Factor4_Subfact_Rtg.muid AS MUID, First(Factor4_Subfact_Rtg.musym) AS MUSym, Factor4_Subfact_Rtg.seqnum AS SeqNum, First(Factor4_Subfact_Rtg.MLRA) AS MLRA, First(Factor4_Subfact_Rtg.class) AS Class, First(Factor4_Subfact_Rtg.comppct) AS [Comp%], Min(Factor4_Subfact_Rtg.PH_Rtg) AS PH_Rtg INTO Factor4_Subfact_mins
FROM Factor4_Subfact_Rtg
GROUP BY Factor4_Subfact_Rtg.muid, Factor4_Subfact_Rtg.seqnum;

#19_factor4_srpg_rtg:

SQL View:
SELECT Factor4_Subfact_mins.MUID, Factor4_Subfact_mins.MUSym, Factor4_Subfact_mins.SeqNum, Factor4_Subfact_mins.MLRA, Factor4_Subfact_mins.Class, Factor4_Subfact_mins.[Comp%], ([Factor4_Subfact_mins]![PH_Rtg])/(1*100) AS SRPG_Rtg INTO Factor4_SRPG_Rtg
FROM Factor4_Subfact_mins;

#20_factor5_props:

SQL View:
SELECT properties.muid AS MUID, First(properties.musym) AS MUSym, properties.seqnum AS SeqNum, First(properties.MLRA) AS MLRA, First(properties.comppct) AS [Comp%], First(properties.MUNAME) AS MUName, First(properties.compname) AS CompName, First(properties.class) AS Class, First(properties.order) AS [Order], First(properties.suborder) AS SubOrder, First(properties.grtgroup) AS GrtGroup, First(properties.subgroup) AS SubGroup, First(properties.otherfam) AS OtherFam, First(properties.soiltemp) AS SoilTemp, First(properties.frostact) AS FrostAct INTO Factor5_properties
FROM properties
GROUP BY properties.muid, properties.seqnum;

#21_factor6_props:

SQL View:
SELECT properties.muid, properties.musym, properties.seqnum, properties.comppct, properties.layernum, properties.class, properties.laydepl, properties.laydeph, properties.clayl, properties.clayh, ([properties]![awcl]+[properties]![awch])/2 AS AWC_Mean, ([properties]![caco3l]+[properties]![caco3h])/2 AS CACO3_Mean INTO Factor6_properties
FROM properties;

#22_factor6_AWCrz1:

SQL View:

SELECT [Factor6_surf/60inches_layers].muid, [Factor6_surf/60inches_layers].musym, [Factor6_surf/60inches_layers].seqnum, [Factor6_surf/60inches_layers].comppct, [Factor6_surf/60inches_layers].layernum, ([Factor6_surf/60inches_layers]![laydeph]-[Factor6_surf/60inches_layers]![laydepl]) AS lay_thick, [Factor6_surf/60inches_layers].AWC_Mean, [Factor6_surf/60inches_layers].CACO3_Mean INTO Factor6_AWCrz1
FROM [Factor6_surf/60inches_layers];

#23_factor6_AWCrz:

SQL View:
SELECT Factor6_AWCrz1.muid AS MUID, First(Factor6_AWCrz1.musym) AS MUSym, Factor6_AWCrz1.seqnum AS SeqNum, First(Factor6_AWCrz1.comppct) AS [Comp%], Sum(([Factor6_AWCrz1]![AWC_Mean]*[Factor6_AWCrz1]![lay_thick])) AS AWCrz, Min(IIf([Factor6_AWCrz1]![CACO3_Mean]>30,85,100)) AS CACO3_Rtg INTO Factor6_AWCrz
FROM Factor6_AWCrz1
GROUP BY Factor6_AWCrz1.muid, Factor6_AWCrz1.seqnum;

#24_factor6_subfact_rtg:

SQL View:
SELECT Factor6_AWCrz.MUID, Factor6_AWCrz.MUSym, Factor6_AWCrz.SeqNum, Factor6_AWCrz.[Comp%], IIf([Factor6_AWCrz]![AWCrz]>12,100,IIf([Factor6_AWCrz]![AWCrz]>9,95,IIf([Factor6_AWCrz]![AWCrz]>6,85,IIf([Factor6_AWCrz]![AWCrz]>3,75,60)))) AS AWCrz_Rtg, Factor6_AWCrz.CACO3_Rtg, IIf([Factor6_LayDepth]![Lay_Dep]>59,100,IIf([Factor6_LayDepth]![Lay_Dep]>40,85,IIf([Factor6_LayDepth]![Lay_Dep]>20,60,IIf([Factor6_LayDepth]![Lay_Dep]>10,40,25)))) AS Min_Rtg, IIf([Factor6_LayDepth]![Lay_Dep]>59,90,IIf([Factor6_LayDepth]![Lay_Dep]>40,65,IIf([Factor6_LayDepth]![Lay_Dep]>20,50,IIf([Factor6_LayDepth]![Lay_Dep]>10,30,15)))) AS Max_Rtg, IIf([Factor6_Profile_Development]![Profile_Dev]=1,90,100) AS Restrict_Lay_Rtg INTO Factor6_Subfact_rtg
FROM Factor6_AWCrz INNER JOIN (Factor6_LayDepth INNER JOIN Factor6_Profile_Development ON (Factor6_LayDepth.muid = Factor6_Profile_Development.MUID) AND (Factor6_LayDepth.seqnum = Factor6_Profile_Development.SeqNum)) ON (Factor6_AWCrz.MUID = Factor6_LayDepth.muid) AND (Factor6_AWCrz.SeqNum = Factor6_LayDepth.seqnum);

#25_factor6_B/A_clay:

SQL View:
SELECT [Factor6_surf/40inches_layers].muid AS MUID, First([Factor6_surf/40inches_layers].musym) AS MUSym, [Factor6_surf/40inches_layers].seqnum AS SeqNum, First([Factor6_surf/40inches_layers].comppct) AS [Comp%], Max([Factor6_surf/40inches_layers].clayh) AS Clay_Max, First(([Factor6_surf/40inches_layers]![clayh]+[Factor6_surf/40inches_layers]![clayl])/2) AS Clay_Surf INTO [Factor6_B/A_props]
FROM [Factor6_surf/40inches_layers]

GROUP BY [Factor6_surf/40inches_layers].muid, [Factor6_surf/40inches_layers].seqnum;

#26_factor6_B/A_ratio:

SQL View:
SELECT [Factor6_B/A_props].MUID, [Factor6_B/A_props].MUSym, [Factor6_B/A_props].SeqNum, [Factor6_B/A_props].[Comp%], ([Factor6_B/A_props]![Clay_Max]/[Factor6_B/A_props]![Clay_Surf]) AS [B/A] INTO [Factor6_B/A]
FROM [Factor6_B/A_props];

#27_factor6_profile_dev:

SQL View:
SELECT [Factor6_B/A].MUID, [Factor6_B/A].MUSym, [Factor6_B/A].SeqNum, [Factor6_B/A].[Comp%], IIf([Factor6_B/A]![B/A]>1.3,1,0) AS Profile_Dev INTO Factor6_Profile_Development
FROM [Factor6_B/A];

#28_factor6_laydepth:

SQL View:
SELECT properties.muid, First(properties.musym) AS musym, properties.seqnum, (Max([properties]![laydeph])-Min([properties]![laydepl]))/2 AS Lay_Dep INTO Factor6_LayDepth
FROM properties
GROUP BY properties.muid, properties.seqnum;

#29_factor6_srpg_rtg:

SQL View:
SELECT Factor6_Subfact_rtg.MUID, Factor6_Subfact_rtg.MUSym, Factor6_Subfact_rtg.SeqNum, Factor6_Subfact_rtg.[Comp%], ([Factor6_Subfact_rtg]![AWCrz_Rtg]+[Factor6_Subfact_rtg]![CACO3_Rtg]+[Factor6_Subfact_rtg]![Restrict_Lay_Rtg])/(3*100) AS SRPG_Rtg INTO Factor6_SRPG_Rtg
FROM Factor6_Subfact_rtg;

#30_factor7_props:

SQL View:
SELECT properties.muid AS MUID, First(properties.musym) AS MUSym, properties.seqnum AS SeqNum, First(properties.comppct) AS [Comp%], First(properties.MLRA) AS MLRA, First(properties.MUNAME) AS MUName, First(([properties]![slopeh]-[properties]![slopel])/2) AS Slope_midpoint, First(properties.anflood) AS Flooding1, First(properties.gsflood) AS Flooding2, First(properties.pnddur) AS Ponding INTO Factor7_properties
FROM properties
GROUP BY properties.muid, properties.seqnum;

#31_factor7_subfact_rtg:

SQL View:
SELECT Factor7_properties.MUID, Factor7_properties.MUSym, Factor7_properties.SeqNum, Factor7_properties.[Comp%], Factor7_properties.MLRA, Factor7_properties.MUName, IIf([Factor7_properties]![Slope_midpoint]>20,-100,IIf([Factor7_properties]![Slope_midpoint]>17.5,-80,IIf([Factor7_properties]![Slope_midpoint]>12,-60,IIf([Factor7_properties]![Slope_midpoint]>=7.5,-20,IIf([Factor7_properties]![Slope_midpoint]>=4,20,IIf([Factor7_properties]![Slope_midpoint]>=1.5,60,100)))))) AS [Slope_75/79], IIf([Factor7_properties]![Slope_midpoint]>29,5,IIf([Factor7_properties]![Slope_midpoint]>20,10,IIf([Factor7_properties]![Slope_midpoint]>14,60,IIf([Factor7_properties]![Slope_midpoint]>7,80,IIf([Factor7_properties]![Slope_midpoint]>2,90,100))))) AS [Slope_80/Other], Factor7_properties.Flooding1, Factor7_properties.Flooding2, Factor7_properties.Ponding INTO Factor7_subfact_rtg
FROM Factor7_properties;

#32_factor7_srpg_rtg:

SQL View:
SELECT Factor7_subfact_rtg.MUID, Factor7_subfact_rtg.MUSym, Factor7_subfact_rtg.SeqNum, Factor7_subfact_rtg.[Comp%], ([Factor7_subfact_rtg]![Other_Rtg]+[Factor7_subfact_rtg]![Flood_Rtg]+[Factor7_subfact_rtg]![Erosion_Rtg]+[Factor7_subfact_rtg]![Pond_Rtg]+[Factor7_subfact_rtg]![Slope_Rtg])/(5*100) AS SRPG_Rtg INTO Factor7_SRPG_Rtg
FROM Factor7_subfact_rtg;

#33_factor5_srpg_rtg:
SQL View:
SELECT Factor5_properties.MUID, Factor5_properties.MUSym, Factor5_properties.SeqNum, Factor5_properties.[Comp%], ([Factor5_properties]![Moist_Rtg]+[Factor5_properties]![Temp_Rtg]+[Factor5_properties]![Moist/Temp_Rtg])/(3*100) AS SRPG_Rtg INTO Factor5_SRPG_Rtg
FROM Factor5_properties;

#40_final srpg_rating:

SQL View:
SELECT Factor1_SRPG_Rtg.MUID, Factor1_SRPG_Rtg.MUSym, Factor1_SRPG_Rtg.SeqNum, Factor1_SRPG_Rtg.[Comp%], ([Factor1_SRPG_Rtg]![SRPG_Rtg]*[Factor2_SRPG_Rtg]![SRPG_Rtg]*[Factor3_SRPG_Rtg]![SRPG_Rtg]*[Factor4_SRPG_Rtg]![SRPG_Rtg]*[Factor5_SRPG_Rtg]![SRPG_Rtg]*[Factor6_SRPG_Rtg]![SRPG_Rtg]*[Factor7_SRPG_Rtg]![SRPG_Rtg])*100 AS SRPG_Rtg INTO [1_Final SRPG Rating]
FROM (((((Factor1_SRPG_Rtg INNER JOIN Factor2_SRPG_Rtg ON (Factor1_SRPG_Rtg.SeqNum = Factor2_SRPG_Rtg.SeqNum) AND (Factor1_SRPG_Rtg.MUID = Factor2_SRPG_Rtg.MUID)) INNER JOIN Factor3_SRPG_Rtg ON (Factor2_SRPG_Rtg.SeqNum = Factor3_SRPG_Rtg.SeqNum) AND (Factor2_SRPG_Rtg.MUID = Factor3_SRPG_Rtg.MUID)) INNER JOIN Factor4_SRPG_Rtg ON

(Factor3_SRPG_Rtg.SeqNum = Factor4_SRPG_Rtg.SeqNum) AND (Factor3_SRPG_Rtg.MUID = Factor4_SRPG_Rtg.MUID)) INNER JOIN Factor5_SRPG_Rtg ON (Factor4_SRPG_Rtg.SeqNum = Factor5_SRPG_Rtg.SeqNum) AND (Factor4_SRPG_Rtg.MUID = Factor5_SRPG_Rtg.MUID)) INNER JOIN Factor6_SRPG_Rtg ON (Factor5_SRPG_Rtg.SeqNum = Factor6_SRPG_Rtg.SeqNum) AND (Factor5_SRPG_Rtg.MUID = Factor6_SRPG_Rtg.MUID)) INNER JOIN Factor7_SRPG_Rtg ON (Factor6_SRPG_Rtg.SeqNum = Factor7_SRPG_Rtg.SeqNum) AND (Factor6_SRPG_Rtg.MUID = Factor7_SRPG_Rtg.MUID);

#50_srpg_rtg_final (muids):

SQL View:

```
SELECT [1_Final SRPG Rating].MUID, First([1_Final SRPG Rating].MUSym) AS MUSym,
Sum(([1_Final SRPG Rating]![Comp%]*[1_Final SRPG Rating]![SRPG_Rtg])/100) AS
SRPG_Rtg INTO [2_srpg_rtg_final (muid)]
FROM [1_Final SRPG Rating]
GROUP BY [1_Final SRPG Rating].MUID;
```

#60_srpg_ratings:

SQL View:

```
SELECT Factor1_Subfact_Rtg.muid AS MUID, Factor1_Subfact_Rtg.musym AS MUSym,
Factor1_Subfact_Rtg.seqnum AS SeqNum, Factor1_Subfact_Rtg.comppct AS [Comp%],
Factor1_Subfact_Rtg.MLRA, Factor1_Subfact_Rtg.BD_Rating AS 1_BD,
Factor1_Subfact_Rtg.OM_Rating AS 1_OM, Factor1_Subfact_Rtg.Clay_Rating AS 1_Clay,
Factor1_Subfact_Rtg.AWC_Rating AS 1_AWC, Factor1_Subfact_Rtg.PH_Rating AS 1_PH,
Factor1_Subfact_Rtg.SAR_Rating AS 1_SAR, Factor1_Subfact_Rtg.CACO3_Rating AS
1_CACO3, Factor1_Subfact_Rtg.Gypsum_Rating AS 1_Gypsum,
Factor1_Subfact_Rtg.CEC_Rating AS 1_CEC, Factor1_Subfact_Rtg.ShrkSW_Rating AS
1_ShrkSW, Factor1_Subfact_Rtg.Gravel_Rating AS 1_Gravel,
Factor1_Subfact_Rtg.Stone_Rating AS 1_Stone, Factor2_subfact_temp_1.Perm_Override AS
[2_Over-ride], Factor2_subfact_temp_1.WT_Rtg AS 2_WT, Factor2_subfact_temp_1.Perm_Rtg
AS 2_Perm, Factor2_subfact_temp_1.AWC_Rtg AS 2_AWC, Factor3_Subfact_mins.SAR_Rtg
AS 3_SAR, Factor3_Subfact_mins.Salin_Rtg AS 3_Salin, Factor3_Subfact_mins.CEC_Rtg AS
3_CEC, Factor4_Subfact_mins.PH_Rtg AS 4_PH, Factor5_properties.Moist_Rtg AS 5_Moist,
Factor5_properties.Temp_Rtg AS 5_Temp, Factor5_properties.[Moist/Temp_Rtg] AS [5_M/T],
Factor6_Subfact_rtg.AWCrz_Rtg AS 6_AWCrz, Factor6_Subfact_rtg.CACO3_Rtg AS
6_CACO3, Factor6_Subfact_rtg.Restrict_Lay_Rtg AS 6_Restrt, Factor7_subfact_rtg.Other_Rtg
AS 7_Other, Factor7_subfact_rtg.Erosion_Rtg AS 7_Erode, Factor7_subfact_rtg.Flood_Rtg AS
7_Flood, Factor7_subfact_rtg.Pond_Rtg AS 7_Pond, Factor7_subfact_rtg.Slope_Rtg AS 7_Slope
INTO 3_SRPG_Ratings
FROM Factor1_Subfact_Rtg INNER JOIN (Factor2_subfact_temp AS Factor2_subfact_temp_1
INNER JOIN ((((Factor3_Subfact_mins INNER JOIN Factor4_Subfact_mins ON
(Factor3_Subfact_mins.muid = Factor4_Subfact_mins.MUID) AND
(Factor3_Subfact_mins.seqnum = Factor4_Subfact_mins.SeqNum)) INNER JOIN
Factor5_properties ON (Factor4_Subfact_mins.MUID = Factor5_properties.MUID) AND
(Factor4_Subfact_mins.SeqNum = Factor5_properties.SeqNum)) INNER JOIN
Factor6_Subfact_rtg ON (Factor5_properties.MUID = Factor6_Subfact_rtg.MUID) AND
(Factor5_properties.SeqNum = Factor6_Subfact_rtg.SeqNum)) INNER JOIN
Factor7_subfact_rtg ON (Factor6_Subfact_rtg.MUID = Factor7_subfact_rtg.MUID) AND
```

(Factor6_Subfact_rtg.SeqNum = Factor7_subfact_rtg.SeqNum)) ON
(Factor2_subfact_temp_1.muid = Factor3_Subfact_mins.muid) AND
(Factor2_subfact_temp_1.seqnum = Factor3_Subfact_mins.seqnum)) ON
(Factor1_Subfact_Rtg.muid = Factor2_subfact_temp_1.muid) AND
(Factor1_Subfact_Rtg.seqnum = Factor2_subfact_temp_1.seqnum);

Procedures

Model Documentation: United States Department of Agriculture, Natural Resources Conservation Service, Soil Quality Institute and National Soil Survey Center. 1999. *Soil Rating for Plant Growth: A System for Arraying Soils According to Their Inherent Productivity and Suitability for Crops*

Special Note: Queries are not run in sequential order!!!

Note: "_***" indicates the extensions "_old" or "_new"

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1. Import "properties_***" table, name it *properties*

a) change ShrkSW data type from text to number data type

PRELIMS

2. Run Queries # 01, 02, 03

#01_mean_root_restrict_layer: *Make Table: Root-Restrict_Mean*
- finds mean values for restricting properties (bd, Clay, PH, AWC, Perm)

#02_find_root_restrict_layer: *Make Table: Root-Restrict Layers*
- assigns ranking values (see Model Documentation) for each property

#03_make_subsurface_layer: *Make Table: Subsurface Layers*
- simply re-arranges the properties table

a) use *Root_Restrict Layers* table to record root-restricting layers, follow Calculations #3 in Model Documentation

b) adjust *Subsurface Layers* table to include only subsurface layers to 60 inches *****(boundary of limiting layer is top of layer)

c) copy *Subsurface Layers* table, paste it as *Subsurface Layers (40 inches)*

d) adjust *Subsurface Layers (40 inches)* table to include only subsurface layers to 40 inches

---

FACTOR 1

---

3. Run Queries # 04, 05, 06, 07, 08

#04_factor1_surface layers: *Make Table: Factor1_surface layer*
- isolates surface layer of only the properties used in factor1

#05_factor1_mean1: *Make Table: Factor1_Mean1*
- calculates the mean for each property

#06_factor1_mean: *Make Table: Factor1_Mean*
- calculates the mean for "Gravel" ((100- mean no10%)+mean 3-10")

#07_factor1_subfact_rtg: *Make Table: Factor1_Subfact_Rtg*
- replaces mean values with SRPG rating

#08_factor1_srpg_rtg: *Make Table: Factor1_SRPG_Rtg*
- calculates SRPG rating for Factor 1

a) open *Factor1_subfact_rtg*, replace BD_Rtg w/ root-restricting rating if surface layer is restricting

b) Re-run Query #8

FACTOR 2

---

4. Run Queries # 09, 10, then #11

#09_factor2_props: *Make Table: Factor2_properties*
- isolates the properties for Factor 2, and calculates the mean for Perm & AWC

#10_factor2_subfact_rtg: *Make Table: Factor2_Subfact_Rtg*
- replaces mean values worth SRPG rating for Perm & AWC, and determines if perm is >/=1, in which case the SRPG Rating for the entire Factor 2 is 100

a) check over-riding perm rating, if any layer in a soil has a rating of 100 then the final Factor 2 SRPG rating is 100

b) open *Factor2_subfact_rtg*, create WT_Rtg column, determine rating

c) Run Query # 11, replace overriding perm rating values into SRPG_Rtg column where necessary

#11_factor2_srpg_rtg: *Make Table: Factor2_SRPG_Rtg*
- calculates SRPG rating for Factor 2

FACTOR 3 and FACTOR 4

5. Run Query # 12 - 19

#12_factor3_props: *Make Table: Factor3_properties*
- isolates the properties for Factor 3, and calculates their mean value

#13_factor3_subfact_rtg: *Make Table: Factor3_Subfact_Rtg*
- replaces mean value with SRPG rating

#14_factor3_subfact_mins: *Make Table: Factor3_Subfact_mins*
- select the minimum for each mapunit as the final rating for the property

#15_factor3_srpg_rtg: *Make Table: Factor3_SRPG_Rtg*
- calculates SRPG rating for Factor 3

#16_factor4_props: *Make Table: Factor4_properties*
- isolates the property for Factor 4, and calculates its mean value

#17_factor4_subfact_rtg: *Make Table: Factor4_Subfact_Rtg*
- replaces mean value with SRPG rating

#18_factor4_subfact_mins: *Make Table: Factor4_Subfact_mins*
- select the minimum for each mapunit as the final rating for the property

#19_factor4_srpg_rtg: *Make Table: Factor4_SRPG_Rtg*
- calculates SRPG rating for Factor 4

FACTOR 5

6. Run Query # 20, then #33

#20_factor5_props: *Make Table: Factor5_properties*
- isolates the properties for Factor 5

a) open *Factor5_properties* table, create Moist_Rtg, Temp_Rtg, Moist/Temp_Rtg columns

b) determine the rating for each factor (see Model Documentation)

c) Run Query #33

#33_factor5_srpg_rtg: *Make Table: Factor5_SRPG_Rtg*
- calculates SRPG Rating for Factor 5

FACTOR 6

7. Run Query #21, then #22, 23, then #25-28, then #24 & #29

#21_factor6_props: *Make Table: Factor6_properties*
- isolates properties for Factor 6

a) copy Factor6_properties table, paste as factor6_surf/60inches_layers and as Factor6_surf/40inches_layers

b) adjust tables to include surface layer to bottom of first limiting layer or to 60/40 inches

c) Run Queries # 22, 23

#22_factor6_AWCrz1: *Make Table: Factor6_AWCrz1*
- calculates layer thickness, and mean values for AWC & CACO3

#23_factor6_AWCrz: *Make Table: Factor6_AWCrz*
- calculates AWCrz (AWC_mean *laythick) and assigns rating for CACO3

d) Run Queries # 25 - 28, then #24 & #29

#25_factor6_B/A_clay: *Make Table: Factor6_B/A_props*
- selects max and surface values for clay

#26_factor6_B/A_ratio: *Make Table: Factor6_B/A*
- calculates B/A (Max/Surface)

#27_factor6_profile_dev: *Make Table: Factor6_Profile_Development*
- determines if soil profile is max or min (1 or 0)

#28_factor6_laydepth: *Make Table: Factor6_LayDepth*
- calculates the thickness of the entire soil

e) Run Query #24

#24_factor6_subfact_rtg: *Make Table: Factor6_Subfact_rtg*
- replaces property values with appropriate SRPG ratings

f) replace SRPG_Rtg with appropriate values (if no limiting layer = leave as is if max profile development(90) = max_rtg, if min profile development(100) = min_rtg

g) Run Query #29

#29_factor6_srpg_rtg: *Make Table: Factor6_SRPG_Rtg*
- calculates SRPG Rating for Factor 6

FACTOR 7

8. Run Query # 30, 31, then #32

#30_factor7_props: *Make Table: Factor7_properties*
- isolates properties for Factor 7

#31_factor7_subfact_rtg: *Make Table: Factor7_subfact_rtg*
- calculates the rating for slope

a) open *Factor7_subfact_rtg*, create columns Other_Rtg, Erosion_Rtg, Flood_Rtg, Pond_Rtg

b) determine ratings for each factor (see Model Documentation)

c) change slope 75/79_rtg to Slope_Rtg, replace rating values to reflect MLRA

d) Run Query #32

#32_factor7_srpg_rtg: *Make Table: Factor7_SRPG_Rtg*
- calculates SRPG Rating for Factor 7

SRPG Index

9. Run Query # 40

#40_final srpg_rating: *Make Table: 1_Final SRPG Rating*
- calculates the SRPG Rating for each mapunit w/components

10. Run Query # 50

#50_srpg_rtg_final (muids): *Make Table: 2_srpg_rtg_final (muid)*
- calculates an area weighted average for each mapunit, determines rating for each Map Unit

11. Run Query # 60

#60_srpg_ratings: *Make Table: 3_SRPG_Ratings*
- isolates each property rating for all factors in the SRPG Model, includes final SRPG Rating

12. Export SRPG_*** and Ratings_*** tables as Excel file

Appendix C

Summarized Data

Township and Range Summary of SRPG Index Values: 1966 version

TWNRNG	MIN_OLD	MAX_OLD	RANGE_OLD	MEAN_OLD	STD_OLD	SUM_OLD
T22S R 4W	0.0	86.5	86.5	68.0	13.9	638187.4
T22S R 5W	0.0	86.5	86.5	58.6	14.9	559795.4
T22S R 6W	0.0	86.5	86.5	66.9	17.3	631739.3
T22S R 7W	0.0	86.5	86.5	67.7	18.1	644261.7
T22S R 8W	0.0	86.5	86.5	78.6	8.6	663655.3
T22S R 9W	0.0	86.5	86.5	68.4	17.6	653258.4
T22S R10W	0.0	86.5	86.5	50.9	14.6	484584.3
T23S R 4W	0.0	86.5	86.5	63.4	16.7	600025.4
T23S R 5W	0.0	86.5	86.5	69.3	17.1	657531.8
T23S R 6W	0.0	84.0	84.0	71.7	17.7	676617.6
T23S R 7W	0.0	86.5	86.5	72.6	16.6	688711.4
T23S R 8W	0.0	86.5	86.5	71.2	16.8	677248.1
T23S R 9W	0.0	86.5	86.5	70.5	12.9	676655.8
T23S R10W	0.0	86.5	86.5	65.8	12.2	620574.4
T24S R 4W	0.0	86.5	86.5	71.7	17.4	674904.4
T24S R 5W	0.0	84.0	84.0	74.6	13.2	708685.2
T24S R 6W	0.0	86.5	86.5	76.3	9.8	711125.9
T24S R 7W	0.0	86.5	86.5	77.5	9.0	737134.0
T24S R 8W	0.0	86.5	86.5	72.8	10.3	698774.4
T24S R 9W	0.0	86.5	86.5	62.5	14.2	606349.7
T24S R10W	0.0	86.5	86.5	58.1	13.0	542161.7
T25S R 4W	0.0	86.5	86.5	74.7	12.3	706094.3
T25S R 5W	0.0	84.0	84.0	60.3	16.1	578129.5
T25S R 6W	0.0	84.0	84.0	63.0	14.1	599164.5
T25S R 7W	0.0	86.5	86.5	66.5	11.1	638269.0
T25S R 8W	0.0	86.5	86.5	65.3	10.7	623407.5
T25S R 9W	0.0	86.5	86.5	65.9	14.1	626276.6
T25S R10W	0.0	86.5	86.5	58.4	12.8	555606.4
T25S R11W	51.0	58.5	7.5	55.5	3.7	277.6
T26S R 4W	0.0	84.0	84.0	56.0	23.7	540699.5
T26S R 5W	0.0	86.5	86.5	42.2	29.3	420257.6
T26S R 6W	0.0	86.5	86.5	75.1	8.8	733688.3
T26S R 7W	0.0	86.5	86.5	69.8	9.6	690559.6
T26S R 8W	0.0	86.5	86.5	70.0	11.2	690403.6
T26S R 9W	0.0	86.5	86.5	71.9	8.8	709978.0
T26S R10W	0.0	86.5	86.5	66.1	11.2	653080.6

Township and Range Summary of SRPG Index Values: 1999 version

TWNRNG	MIN_NEW	MAX_NEW	RANGE_NEW	MEAN_NEW	STD_NEW	SUM_NEW
T22S R 4W	0.0	88.4	88.4	72.7	11.8	681831.7
T22S R 5W	0.0	88.4	88.4	60.3	11.4	576422.1
T22S R 6W	0.0	85.2	85.2	60.2	14.3	568338.8
T22S R 7W	0.0	85.2	85.2	65.3	13.2	621158.8
T22S R 8W	0.0	85.2	85.2	77.2	7.3	652147.9
T22S R 9W	0.0	85.2	85.2	69.8	10.5	666326.3
T22S R10W	0.0	79.9	79.9	59.2	8.0	563702.9
T23S R 4W	0.0	85.2	85.2	60.8	10.0	575699.5
T23S R 5W	0.0	85.2	85.2	49.8	26.1	472475.8
T23S R 6W	0.0	85.2	85.2	49.9	34.9	470407.6
T23S R 7W	0.0	85.2	85.2	72.1	11.5	683957.4
T23S R 8W	0.0	85.2	85.2	71.6	12.1	680743.1
T23S R 9W	0.0	85.2	85.2	71.0	6.6	680780.3
T23S R10W	0.0	85.2	85.2	66.8	5.9	629244.3
T24S R 4W	0.0	85.2	85.2	64.1	13.3	602949.1
T24S R 5W	0.0	85.2	85.2	73.7	12.1	700505.0
T24S R 6W	0.0	85.2	85.2	73.3	8.9	683284.5
T24S R 7W	0.0	85.2	85.2	76.9	8.2	731167.7
T24S R 8W	0.0	85.2	85.2	71.2	8.6	683567.6
T24S R 9W	0.0	85.2	85.2	67.7	8.1	657537.6
T24S R10W	0.0	81.3	81.3	64.5	10.4	601694.3
T25S R 4W	0.0	81.6	81.6	75.2	7.5	711510.6
T25S R 5W	0.0	82.2	82.2	66.8	10.4	640479.3
T25S R 6W	0.0	82.2	82.2	66.7	8.9	633833.3
T25S R 7W	0.0	82.2	82.2	70.2	8.8	673317.1
T25S R 8W	0.0	85.2	85.2	69.5	8.2	663851.1
T25S R 9W	0.0	82.2	82.2	69.7	8.9	662334.5
T25S R10W	0.0	82.2	82.2	65.2	8.1	620569.9
T25S R11W	49.3	68.8	19.4	61.0	9.5	304.9
T26S R 4W	0.0	82.2	82.2	62.6	20.9	604109.3
T26S R 5W	0.0	82.2	82.2	46.5	29.8	462636.4
T26S R 6W	0.0	82.2	82.2	75.4	6.4	735909.3
T26S R 7W	0.0	82.2	82.2	73.7	5.5	729166.5
T26S R 8W	0.0	82.2	82.2	72.6	6.8	716393.9
T26S R 9W	0.0	82.2	82.2	74.0	6.1	730847.1
T26S R10W	0.0	85.2	85.2	69.5	8.3	687396.8

1999 GRID's summarized with 1966 Map Unit Coverage

SRPG Index

1966 MUIDs	1999 Mean	1966 Mean
155AB	68.6	74.6
155AS	63.1	74.6
155BA	75.5	77.4
155BE	75.5	80.0
155BK	71.0	68.3
155CA	68.7	52.1
155CD	86.5	69.0
155CF	83.3	61.6
155Ck	62.6	71.2
155CM	64.9	71.2
155CO	64.6	72.1
155CP	61.6	67.5
155DA	82.2	50.5
155EP	58.5	64.2
155ET	51.0	57.0
155FA	79.4	72.7
155FM	84.0	78.9
155FN	81.2	77.6
155FS	61.2	54.0
155FT	80.7	76.0
155LC	60.3	52.3
155NA	79.3	63.7
155NE	79.3	76.5
155NF	78.9	78.4
155NP	67.9	68.8
155NS	52.4	66.2
155NT	46.0	59.1
155NU	36.2	54.2
155PA	40.1	48.3
155PE	68.3	66.0
155PL	73.5	57.1
155PM	50.8	66.3
155PR	50.8	63.8
155PT	65.0	67.3
155RC	58.0	57.0
155RE	58.0	58.3
155RV	48.3	58.3
155SA	72.3	74.7
155SB	72.3	74.4
155SC	50.6	58.7
155SE	60.8	71.0
155SG	58.9	60.0

1966 MUIDs	1999 Mean	1966 Mean
155SH	64.9	71.4
155SM	79.8	77.3
155Sn	59.8	72.0
155SO	30.7	55.9
155SP	83.6	80.4
155ST	61.9	77.9
155TA	69.7	71.5
155TB	54.5	58.8
155TF	26.8	47.4
155TH	31.5	55.6
155VA	81.0	67.7
155VB	81.0	78.0
155VC	59.9	74.7
155VE	28.8	57.2
155WA	52.1	55.3
155WAT		5.6
155WE	55.2	62.8
079AD	49.5	66.2
079CA	86.5	63.7
079CR	71.5	78.3
079DU	38.5	52.1
079GD	82.1	82.4
079GE	75.5	77.8
079LA	66.7	68.4
079WAT		72.4
095AB	62.6	74.8
095AD	47.6	60.2
095CF	59.6	72.6
095DA	59.7	67.3
095FA	82.2	81.1
095LA	40.3	72.4
095PD	37.4	49.3
095RA	71.6	58.7
095SA	66.6	69.0
095SB	77.6	75.1
095SC	71.4	71.2
095SD	54.3	74.8
095WA	56.3	56.5
113AT	58.1	71.3
113CA	86.5	68.4
113CR	71.5	79.0
113CS	71.5	79.6

1966 MUIDs	1999 Mean	1966 Mean
113GE	82.1	87.0
113LA	67.0	62.2
113TO	72.5	72.2
151PT	44.2	49.6
159CA	66.3	59.9
159CE	59.6	71.8
159DT	43.6	56.5
159DU	54.4	64.2
159FA	82.2	68.9
159FN	77.3	70.9
159GA	82.1	77.3
159GC	57.5	70.2
159KA	77.9	65.3
159LE	60.3	58.2
159NF	76.5	72.8
159PC	54.0	51.8
159PE	65.9	61.4
159PF	50.8	69.6
159PR	63.3	67.7
159PT	40.4	53.2
159TV	28.5	45.8
173CD	59.9	72.6
173RA	77.8	58.2
173RC	59.3	58.3
185AN	57.6	71.8
185CW	83.6	60.5
185CX	64.0	67.1
185NU	32.0	70.1
185PT	44.0	52.5

Clay Surface Layer

MUIDs	Mean99	Mean66
155AB	11.4	11.2
155AS	11.4	10.8
155BA	21.0	20.5
155BE	21.0	21.1
155BK	21.2	16.5
155CA	11.5	9.0
155CD	11.5	9.6
155CF	11.3	12.0
155Ck	15.0	16.3
155CM	24.4	18.4
155CO	23.3	19.2
155CP	23.3	20.0
155DA	31.0	15.4
155EP	5.0	4.8
155ET	5.1	2.8
155FA	11.0	11.9
155FM	20.5	18.6
155FN	20.5	15.7
155FS	22.8	16.3
155FT	25.8	18.1
155LC	31.5	15.7
155NA	11.0	12.7
155NE	11.0	13.8
155NF	14.8	16.0
155NP	8.6	6.4
155NS	15.4	14.4
155NT	16.5	15.8
155NU	17.5	15.8
155PA	5.0	9.4
155PE	13.0	11.0
155PL	31.0	32.3
155PM	5.0	5.1
155PR	5.0	4.1
155PT	7.6	5.6
155RC	31.0	32.9
155RE	31.0	32.9
155RV	33.0	33.3
155SA	12.0	10.1
155SB	12.0	10.5
155SC	16.0	15.0
155SE	7.0	7.3
155SG	11.5	12.1

MUIDs	Mean99	Mean66
155SH	15.0	17.8
155SM	15.0	14.5
155Sn	16.3	14.5
155SO	25.0	16.7
155SP	31.0	30.1
155ST	31.0	30.0
155TA	31.0	19.6
155TB	28.9	17.6
155TF	5.5	1.6
155TH	7.5	3.6
155VA	20.5	19.0
155VB	20.5	20.0
155VC	20.5	20.7
155VE	50.0	33.8
155WA	12.0	8.2
155WE	7.5	10.2
079AD	18.5	26.1
079CA	11.5	7.9
079CR	23.5	23.5
079DU	25.0	21.9
079GD	21.0	20.3
079GE	21.0	29.5
079LA	31.5	29.2
095AB	11.0	10.7
095AD	11.0	12.0
095CF	29.5	19.6
095DA	8.2	10.8
095FA	11.0	19.2
095LA	10.0	12.7
095PD	6.3	2.5
095RA	31.0	13.8
095SA	7.0	7.9
095SB	12.0	10.7
095SC	12.0	15.3
095SD	12.0	10.2
095WA	12.0	6.9
113AT	6.0	8.8
113CA	11.5	7.1
113CR	23.5	23.7
113CS	23.5	24.1
113GE	21.0	23.9
113LA	31.5	36.2

MUIDs	Mean99	Mean66
113TO	22.5	30.2
151PT	6.0	2.5
159CA	11.5	9.9
159CE	29.5	12.0
159DT	5.2	2.5
159DU	29.5	18.6
159FA	11.0	6.8
159FN	20.5	12.0
159GA	21.0	17.8
159GC	23.1	12.9
159KA	22.5	12.1
159LE	31.5	19.5
159NF	11.0	11.7
159PC	14.0	10.5
159PE	13.0	21.2
159PF	5.0	6.9
159PR	7.3	5.4
159PT	6.0	3.2
159TV	5.5	1.4
173CD	29.3	19.6
173RA	31.0	33.4
173RC	33.3	33.4
185AN	11.0	8.2
185CW	11.5	18.5
185CX	21.0	20.3
185NU	14.0	3.6
185PT	5.9	2.8

Cation-Exchange Capacity Surface Layer

1966 MUIDs	1999 Mean	1966 Mean
155AB	6.7	9.8
155AS	6.7	9.4
155BA	12.0	13.3
155BE	12.0	13.1
155BK	12.2	11.4
155CA	7.5	6.0
155CD	7.5	6.6
155CF	7.1	8.7
155Ck	8.5	14.8
155CM	13.6	16.6
155CO	13.1	17.0
155CP	13.1	17.1
155DA	17.0	9.9
155EP	3.4	3.6
155ET	3.1	2.0
155FA	6.5	7.7
155FM	12.0	11.5
155FN	12.0	10.3
155FS	12.8	12.7
155FT	14.5	11.5
155LC	17.0	10.6
155NA	6.5	8.3
155NE	6.5	9.3
155NF	8.7	10.0
155NP	5.1	4.3
155NS	9.1	8.8
155NT	9.6	10.3
155NU	10.0	10.1
155PA	3.5	7.6
155PE	8.0	7.4
155PL	17.0	18.1
155PM	3.0	3.2
155PR	3.0	2.2
155PT	4.8	3.6
155RC	16.5	18.5
155RE	16.5	18.3
155RV	17.4	18.4
155SA	7.0	7.4
155SB	7.0	8.4
155SC	9.5	9.2
155SE	4.5	5.8
155SG	6.8	10.1

1966 MUIDs	1999 Mean	1966 Mean
155SH	8.7	15.5
155SM	8.8	9.7
155Sn	9.5	9.7
155SO	13.5	13.3
155SP	17.5	18.8
155ST	17.5	19.9
155TA	17.0	12.9
155TB	15.8	14.1
155TF	3.5	1.1
155TH	4.5	2.0
155VA	12.0	12.1
155VB	12.0	13.0
155VC	12.0	14.5
155VE	26.5	18.5
155WA	7.0	6.3
155WE	5.0	6.9
079AD	11.0	19.7
079CA	7.5	5.4
079CR	13.5	19.4
079DU	13.5	17.8
079GD	12.5	18.4
079GE	12.5	22.7
079LA	18.0	21.4
095AB	6.5	9.4
095AD	6.5	10.2
095CF	16.0	17.5
095DA	5.0	7.3
095FA	6.5	11.5
095LA	5.5	8.5
095PD	3.8	1.4
095RA	17.0	8.6
095SA	4.5	6.5
095SB	7.0	8.4
095SC	7.0	10.0
095SD	7.0	8.3
095WA	7.0	5.8
113AT	4.0	5.5
113CA	7.5	5.1
113CR	13.5	19.6
113CS	13.5	19.4
113GE	12.5	22.0
113LA	18.0	22.4

1966 MUIDs	1999 Mean	1966 Mean
113TO	13.0	20.4
151PT	3.6	1.4
159CA	7.5	6.4
159CE	16.0	9.4
159DT	3.2	1.9
159DU	15.5	15.3
159FA	6.5	4.3
159FN	12.0	9.6
159GA	12.5	11.7
159GC	13.4	9.9
159KA	12.5	7.8
159LE	17.0	13.8
159NF	6.5	7.7
159PC	8.0	8.3
159PE	8.0	13.7
159PF	3.0	4.2
159PR	4.6	3.4
159PT	3.6	1.8
159TV	3.5	0.9
173CD	15.9	17.5
173RA	17.0	18.5
173RC	17.9	18.5
185AN	6.5	6.8
185CW	7.5	15.8
185CX	12.0	17.5
185NU	7.5	3.1
185PT	3.5	1.5

Permeability (depth weighted average)

1966 MUIDs	1999 Mean	1966 Mean
155AB	3.2	3.8
155AS	3.2	3.4
155BA	0.7	0.4
155BE	0.7	0.4
155BK	1.1	1.5
155CA	3.5	5.0
155CD	0.4	2.0
155CF	1.0	2.4
155Ck	1.1	0.8
155CM	0.8	0.5
155CO	0.9	0.8
155CP	0.9	0.9
155DA	1.1	3.3
155EP	8.0	5.7
155ET	11.0	7.0
155FA	1.5	1.8
155FM	1.1	0.7
155FN	1.1	1.0
155FS	0.6	0.9
155FT	0.6	0.6
155LC	1.1	3.4
155NA	2.4	1.5
155NE	2.4	1.5
155NF	1.9	1.0
155NP	5.8	2.2
155NS	1.1	1.1
155NT	1.1	1.0
155NU	1.1	1.1
155PA	6.2	4.7
155PE	3.5	3.9
155PL	1.1	0.1
155PM	11.0	2.3
155PR	11.0	2.8
155PT	6.7	1.9
155RC	0.2	0.1
155RE	0.2	0.1
155RV	0.1	0.1
155SA	1.1	1.5
155SB	1.1	1.4
155SC	1.1	1.7
155SE	2.4	2.0
155SG	2.9	1.4

1966 MUIDs	1999 Mean	1966 Mean
155SH	1.6	1.0
155SM	1.1	1.0
155Sn	1.1	1.3
155SO	0.1	1.2
155SP	0.2	0.2
155ST	0.2	0.3
155TA	0.0	0.4
155TB	0.0	0.6
155TF	11.0	9.5
155TH	11.0	5.6
155VA	1.1	1.2
155VB	1.1	1.0
155VC	1.1	1.2
155VE	0.0	0.1
155WA	5.1	6.0
155WE	11.0	3.8
079AD	1.1	1.8
079CA	0.4	1.1
079CR	0.5	0.3
079DU	0.1	0.0
079GD	1.1	1.0
079GE	1.1	0.8
079LA	0.1	0.1
095AB	4.6	3.5
095AD	4.6	1.4
095CF	1.1	0.7
095DA	8.0	4.0
095FA	1.6	0.7
095LA	11.0	2.5
095PD	11.0	8.3
095RA	0.3	1.8
095SA	2.4	1.4
095SB	1.1	1.3
095SC	1.1	0.9
095SD	1.1	1.3
095WA	5.1	6.5
113AT		4.0
113CA		4.3
113CR	0.5	0.3
113CS	0.5	0.3
113GE	1.1	1.0
113LA	0.1	0.2

1966 MUIDs	1999 Mean	1966 Mean
113TO	1.1	0.4
151PT	11.0	8.1
159CA	4.2	6.2
159CE	1.1	2.1
159DT	11.0	7.4
159DU	0.0	2.4
159FA	1.6	2.3
159FN	1.1	2.1
159GA	1.1	1.2
159GC	1.1	2.0
159KA	1.1	5.8
159LE	1.1	1.8
159NF	2.4	2.4
159PC	4.2	4.8
159PE	3.5	2.6
159PF	11.0	1.9
159PR	7.3	1.9
159PT	11.0	6.6
159TV	11.0	9.6
173CD	0.9	0.7
173RA	0.1	0.1
173RC	0.0	0.1
185AN	4.4	4.2
185CW	0.6	0.8
185CX	1.1	0.9
185NU	0.1	6.1
185PT	11.0	6.9

Available Water Capacity (depth weighted average)

1966 MUIDs	1999 Mean	1966 Mean
155AB	0.1	0.1
155AS	0.1	0.1
155BA	0.2	0.2
155BE	0.2	0.2
155BK	0.2	0.1
155CA	0.1	0.1
155CD	0.2	0.1
155CF	0.2	0.1
155Ck	0.2	0.2
155CM	0.2	0.2
155CO	0.2	0.2
155CP	0.2	0.2
155DA	0.2	0.1
155EP	0.1	0.1
155ET	0.1	0.1
155FA	0.2	0.1
155FM	0.2	0.2
155FN	0.2	0.2
155FS	0.1	0.1
155FT	0.2	0.2
155LC	0.1	0.1
155NA	0.2	0.1
155NE	0.2	0.2
155NF	0.2	0.2
155NP	0.1	0.1
155NS	0.2	0.1
155NT	0.2	0.1
155NU	0.2	0.1
155PA	0.1	0.1
155PE	0.1	0.1
155PL	0.2	0.1
155PM	0.1	0.1
155PR	0.1	0.1
155PT	0.1	0.1
155RC	0.1	0.1
155RE	0.1	0.1
155RV	0.1	0.1
155SA	0.1	0.1
155SB	0.1	0.1
155SC	0.2	0.1
155SE	0.1	0.1
155SG	0.1	0.1

1966 MUIDs	1999 Mean	1966 Mean
155SH	0.2	0.2
155SM	0.2	0.2
155Sn	0.2	0.2
155SO	0.1	0.1
155SP	0.2	0.2
155ST	0.2	0.2
155TA	0.2	0.2
155TB	0.1	0.1
155TF	0.1	0.1
155TH	0.1	0.1
155VA	0.2	0.2
155VB	0.2	0.2
155VC	0.2	0.2
155VE	0.1	0.1
155WA	0.1	0.1
155WE	0.1	0.1
079AD	0.2	0.1
079CA	0.2	0.1
079CR	0.2	0.2
079DU	0.1	0.2
079GD	0.2	0.2
079GE	0.2	0.2
079LA	0.2	0.2
095AB	0.1	0.1
095AD	0.1	0.1
095CF	0.2	0.2
095DA	0.1	0.1
095FA	0.2	0.2
095LA	0.1	0.1
095PD	0.1	0.1
095RA	0.2	0.1
095SA	0.1	0.1
095SB	0.2	0.1
095SC	0.2	0.2
095SD	0.2	0.1
095WA	0.1	0.1
113AT	0.1	0.1
113CA	0.2	0.1
113CR	0.2	0.2
113CS	0.2	0.2
113GE	0.2	0.2
113LA	0.1	0.2

1966 MUIDs	1999 Mean	1966 Mean
113TO	0.2	0.2
151PT	0.1	0.1
159CA	0.1	0.1
159CE	0.2	0.1
159DT	0.1	0.1
159DU	0.1	0.1
159FA	0.2	0.1
159FN	0.2	0.2
159GA	0.2	0.2
159GC	0.2	0.2
159KA	0.2	0.1
159LE	0.1	0.1
159NF	0.2	0.1
159PC	0.1	0.1
159PE	0.1	0.1
159PF	0.1	0.1
159PR	0.1	0.1
159PT	0.1	0.1
159TV	0.1	0.1
173CD	0.2	0.2
173RA	0.2	0.1
173RC	0.1	0.1
185AN	0.1	0.1
185CW	0.2	0.1
185CX	0.2	0.2
185NU	0.0	0.1
185PT	0.1	0.1

Cation-Exchange Capcity (depth weighted average)

1966 MUIDs	1999 Mean	1966 Mean
155AB	6.9	6.7
155AS	6.9	6.9
155BA	21.0	20.1
155BE	21.0	19.5
155BK	13.2	12.0
155CA	7.5	6.3
155CD	16.5	12.4
155CF	15.1	13.8
155Ck	13.1	12.9
155CM	12.8	14.2
155CO	13.1	14.0
155CP	13.2	14.6
155DA	14.1	7.4
155EP	3.7	5.9
155ET	2.7	5.0
155FA	11.6	12.9
155FM	13.0	16.6
155FN	13.0	13.8
155FS	13.8	18.4
155FT	18.3	18.4
155LC	7.5	5.8
155NA	10.1	14.6
155NE	10.1	14.5
155NF	11.3	16.3
155NP	7.4	10.0
155NS	7.8	2.9
155NT	8.0	3.6
155NU	8.2	4.1
155PA	1.8	3.3
155PE	5.6	6.0
155PL	14.6	19.0
155PM	3.3	8.8
155PR	3.3	6.5
155PT	8.6	11.2
155RC	11.8	19.4
155RE	11.8	18.6
155RV	13.2	18.7
155SA	8.5	10.0
155SB	8.5	8.1
155SC	13.5	6.0
155SE	8.2	7.7
155SG	7.4	8.3

1966 MUIDs	1999 Mean	1966 Mean
155SH	10.5	13.1
155SM	11.0	12.0
155Sn	11.5	12.2
155SO	11.0	17.6
155SP	21.2	20.1
155ST	21.2	19.0
155TA	23.0	21.9
155TB	18.8	22.3
155TF	3.0	2.2
155TH	3.1	6.5
155VA	13.6	15.7
155VB	13.6	14.9
155VC	13.6	15.9
155VE	20.8	17.8
155WA	3.5	4.2
155WE	3.9	5.2
079AD	12.4	10.8
079CA	16.9	12.6
079CR	19.4	28.5
079DU	23.3	21.4
079GD	14.2	17.3
079GE	14.2	21.3
079LA	24.0	27.0
095AB	4.4	6.9
095AD	4.4	8.4
095CF	14.4	14.2
095DA	3.6	5.4
095FA	12.4	15.0
095LA	5.5	8.5
095PD	3.2	5.0
095RA	22.0	5.1
095SA	8.1	7.5
095SB	9.4	8.2
095SC	9.4	12.2
095SD	9.4	7.8
095WA	4.6	3.4
113AT	5.9	7.9
113CA	17.8	7.9
113CR	19.7	28.7
113CS	19.7	27.7
113GE	14.3	20.0
113LA	24.4	27.4

1966 MUIDs	1999 Mean	1966 Mean
113TO	13.9	19.8
151PT	3.3	5.0
159CA	7.1	5.5
159CE	14.4	12.2
159DT	2.8	4.7
159DU	13.3	14.5
159FA	12.4	11.6
159FN	13.8	12.0
159GA	14.2	14.5
159GC	14.3	12.3
159KA	12.1	7.2
159LE	8.5	12.2
159NF	8.0	11.0
159PC	2.1	3.6
159PE	4.9	7.5
159PF	3.2	10.2
159PR	9.4	9.7
159PT	3.2	5.7
159TV	3.1	2.0
173CD	13.7	14.1
173RA	22.2	18.8
173RC	20.3	18.8
185AN	4.7	6.4
185CW	19.3	22.1
185CX	13.7	14.7
185NU	7.5	4.6
185PT	3.1	5.8

pH (depth weighted average)

1966 MUIDs	1999 Mean	1966 Mean
155AB	6.9	6.9
155AS	6.9	7.0
155BA	7.9	6.9
155BE	7.9	7.1
155BK	6.8	6.9
155CA	6.9	6.5
155CD	6.9	6.6
155CF	7.0	6.8
155Ck	7.9	7.5
155CM	7.8	7.7
155CO	7.9	7.9
155CP	7.9	7.9
155DA	6.7	6.7
155EP	7.0	6.0
155ET	6.7	6.4
155FA	7.1	6.7
155FM	7.0	7.0
155FN	7.1	6.9
155FS	6.4	7.1
155FT	7.1	7.1
155LC	8.1	7.0
155NA	6.7	6.5
155NE	6.7	6.8
155NF	6.8	6.8
155NP	6.6	6.3
155NS	6.4	3.1
155NT	6.3	4.7
155NU	6.3	4.2
155PA	7.5	7.2
155PE	7.5	7.2
155PL	7.8	7.5
155PM	6.5	6.5
155PR	6.5	6.5
155PT	6.7	6.4
155RC	4.2	7.7
155RE	4.2	7.7
155RV	4.7	7.7
155SA	7.0	6.8
155SB	7.0	6.9
155SC	6.6	4.3
155SE	7.0	6.8
155SG	6.9	7.0

1966 MUIDs	1999 Mean	1966 Mean
155SH	7.3	7.7
155SM	6.9	6.9
155Sn	6.9	6.8
155SO	4.2	7.6
155SP	8.2	6.7
155ST	8.2	6.9
155TA	7.5	7.3
155TB	6.3	7.5
155TF	7.2	6.6
155TH	7.2	6.4
155VA	6.3	6.4
155VB	6.3	6.4
155VC	6.3	6.6
155VE	6.4	7.8
155WA	7.9	7.2
155WE	6.7	6.9
079AD	7.9	7.0
079CA	7.0	6.6
079CR	6.7	6.7
079DU	8.4	8.3
079GD	6.8	6.8
079GE	6.8	6.9
079LA	7.0	7.1
095AB	7.1	7.0
095AD	7.1	7.2
095CF	7.9	7.9
095DA	7.0	7.3
095FA	7.1	6.9
095LA	8.1	7.1
095PD	6.9	6.4
095RA	7.2	4.0
095SA	6.8	7.0
095SB	6.8	6.9
095SC	6.8	6.9
095SD	6.8	7.0
095WA	7.9	7.4
113AT	6.6	6.3
113CA	7.0	6.1
113CR	6.9	6.8
113CS	6.9	6.8
113GE	6.8	6.9
113LA	6.9	7.0

1966 MUIDs	1999 Mean	1966 Mean
113TO	7.1	7.0
151PT	6.8	6.4
159CA	7.0	7.1
159CE	7.9	6.8
159DT	6.9	6.5
159DU	4.7	7.2
159FA	7.1	6.5
159FN	7.1	6.8
159GA	6.9	6.5
159GC	7.1	6.8
159KA	6.8	6.9
159LE	8.1	7.7
159NF	6.8	6.7
159PC	7.5	7.7
159PE	7.5	7.8
159PF	6.5	6.5
159PR	6.7	6.3
159PT	6.8	6.4
159TV	7.2	6.5
173CD	7.9	7.9
173RA	7.2	7.7
173RC	6.7	7.7
185AN	7.0	6.2
185CW	7.1	8.1
185CX	7.9	8.0
185NU	3.4	5.7
185PT	6.8	6.4

Slope

1966 MUIDs	1999 Mean	1966 Mean
155AB	0.5	0.6
155AS	2.5	2.0
155BA	0.5	0.7
155BE	2.0	1.8
155BK	2.8	3.2
155CA	0.5	0.8
155CD	0.5	1.4
155CF	1.2	0.9
155Ck	0.5	1.0
155CM	0.5	0.6
155CO	2.0	2.0
155CP	4.5	4.8
155DA	0.5	0.5
155EP	0.8	2.5
155ET	2.2	5.3
155FA	0.5	1.3
155FM	0.5	0.8
155FN	2.0	1.7
155FS	0.5	0.8
155FT	0.5	0.9
155LC	0.5	0.6
155NA	0.5	1.0
155NE	2.0	2.2
155NF	2.0	1.6
155NP	2.8	2.0
155NS	2.4	2.0
155NT	4.5	5.1
155NU	10.5	11.0
155PA	1.0	0.6
155PE	0.5	1.0
155PL	0.5	0.5
155PM	3.5	2.8
155PR	9.0	5.1
155PT	2.3	2.1
155RC	0.5	0.5
155RE	2.0	2.0
155RV	2.5	2.1
155SA	0.5	0.8
155SB	2.0	2.0
155SC	1.5	1.6
155SE	3.0	1.5
155SG	11.0	10.1

1966 MUIDs	1999 Mean	1966 Mean
155SH	4.0	2.5
155SM	2.0	1.9
155Sn	4.8	4.4
155SO	1.0	0.8
155SP	2.0	2.8
155ST	4.5	4.1
155TA	0.5	0.7
155TB	0.5	0.9
155TF	12.5	13.7
155TH	10.0	5.6
155VA	0.5	0.6
155VB	2.0	2.0
155VC	5.0	4.4
155VE	15.5	4.6
155WA	1.0	0.9
155WE	1.0	0.9
079AD	10.0	0.5
079CA	0.5	1.1
079CR	0.5	0.7
079DU	0.5	0.5
079GD	2.0	1.8
079GE	4.5	1.5
079LA	0.5	0.6
095AB	2.0	2.0
095AD	10.5	10.5
095CF	2.5	2.0
095DA	0.5	1.0
095FA	1.0	0.9
095LA	1.0	1.5
095PD	9.3	7.0
095RA	1.5	1.5
095SA	1.5	1.5
095SB	2.0	2.0
095SC	4.5	5.0
095SD	4.5	2.0
095WA	0.5	1.0
113AT	2.5	2.3
113CA	0.5	0.8
113CR	0.5	0.6
113CS	2.0	1.7
113GE	2.0	1.9
113LA	0.5	0.6

1966 MUIDs	1999 Mean	1966 Mean
113TO	1.0	1.0
151PT	10.6	6.9
159CA	0.5	0.6
159CE	2.5	4.5
159DT	5.6	5.3
159DU	0.5	0.9
159FA	1.0	1.9
159FN	1.5	4.9
159GA	2.0	2.6
159GC	5.0	6.5
159KA	0.5	0.5
159LE	1.0	1.2
159NF	2.0	3.5
159PC	0.5	0.7
159PE	0.5	0.7
159PF	3.0	2.8
159PR	2.1	2.5
159PT	10.0	6.2
159TV	22.5	14.4
173CD	2.5	2.0
173RA	2.0	1.9
173RC	2.5	2.0
185AN	2.5	1.5
185CW	0.5	0.7
185CX	2.0	4.9
185NU	0.5	0.7
185PT	8.4	6.2

Appendix D

Statistical Results

MINITAB: Descriptive Statistics

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
SRPG	111	63.09	63.28	63.78	14.96	1.42

Variable	Min	Max	Q1	Q3
SRPG	26.85	86.54	54.32	75.50

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
Mean_SRPG	111	66.423	67.741	66.580	9.269	0.880

Variable	Min	Max	Q1	Q3
Mean_SRPG	45.831	86.995	58.310	72.765

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
CLAY_A	111	17.348	15.000	17.018	9.179	0.871

Variable	Min	Max	Q1	Q3
CLAY_A	5.000	50.000	11.000	23.500

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
Mean_Clay_A	111	15.223	14.479	14.882	8.468	0.804

Variable	Min	Max	Q1	Q3
Mean_Clay_A	1.447	36.156	9.448	19.641

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
CEC_A	111	9.937	8.700	9.788	4.835	0.459

Variable	Min	Max	Q1	Q3
CEC_A	3.000	26.500	6.500	13.500

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
Mean_CEC	111	10.760	9.878	10.681	5.751	0.546

Variable	Min	Max	Q1	Q3
Mean_CEC	0.939	22.683	6.552	15.535

Variable	N	N*	Mean	Median	Tr Mean	StDev	SE Mean
PERM	109	2	2.898	1.095	2.636	3.555	0.341

Variable	Min	Max	Q1	Q3
PERM	0.002	10.954	0.752	3.849

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
Mean_Perm	111	2.299	1.388	2.069	2.248	0.213

Variable	Min	Max	Q1	Q3
Mean_Perm	0.021	9.616	0.786	3.367

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
AWC	111	0.13784	0.15000	0.13889	0.04343	0.00412

Variable	Min	Max	Q1	Q3
AWC	0.03000	0.24000	0.11000	0.17000

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
Mean_AWC	111	0.12857	0.12950	0.12930	0.03526	0.00335

Variable	Min	Max	Q1	Q3
Mean_AWC	0.06000	0.18620	0.10010	0.16060

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
CEC	111	11.259	11.550	11.064	5.906	0.561

Variable	Min	Max	Q1	Q3
CEC	1.840	24.430	6.870	14.220

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
Mean_CEC	111	12.148	12.026	11.813	6.417	0.609

Variable	Min	Max	Q1	Q3
Mean_CEC	1.965	28.696	6.478	16.596

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
PH	111	6.9306	6.9400	7.0184	0.8189	0.0777

Variable	Min	Max	Q1	Q3
PH	3.4300	8.3700	6.7300	7.2300

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
Mean_PH	111	6.8401	6.8944	6.9199	0.7971	0.0757

Variable	Min	Max	Q1	Q3
Mean_PH	3.0722	8.3400	6.5353	7.1808

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
SLOPE	111	2.866	2.000	2.349	3.623	0.344

Variable	Min	Max	Q1	Q3
SLOPE	0.500	22.500	0.500	2.800

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
Mean_Slope	111	2.546	1.841	2.149	2.652	0.252

Variable	Min	Max	Q1	Q3
Mean_Slope	0.500	14.356	0.843	2.808

MINITAB: Mann-Whitnety & *t*-test Results

SPRG Rating

Mann-Whitney Confidence Interval and Test

SRPG_Rtg N = 111 Median = 63.281
Mean_SRP N = 111 Median = 67.741
Point estimate for ETA1-ETA2 is -2.295
95.0 Percent CI for ETA1-ETA2 is (-6.109,1.238)
W = 11793.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.2231
The test is significant at 0.2231 (adjusted for ties)

Cannot reject at alpha = 0.05

Two Sample T-Test and Confidence Interval

Two sample T for SRPG_Rtg vs Mean_SRPG

	N	Mean	StDev	SE Mean
SRPG_Rtg	111	63.1	15.0	1.4
Mean_SRP	111	66.42	9.27	0.88

95% CI for mu SRPG_Rtg - mu Mean_SRP: (-6.6, -0.04)
T-Test mu SRPG_Rtg = mu Mean_SRP (vs not =): T= -2.00 P=0.047 DF= 183

Clay_A

Mann-Whitney Confidence Interval and Test

CLAY_A N = 111 Median = 15.000
Mean_Cla N = 111 Median = 14.479
Point estimate for ETA1-ETA2 is 1.767
95.0 Percent CI for ETA1-ETA2 is (-0.427,4.143)
W = 13153.5
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.0523
The test is significant at 0.0523 (adjusted for ties)

Cannot reject at alpha = 0.05

Two Sample T-Test and Confidence Interval

Two sample T for CLAY_A vs Mean_Clay_A

	N	Mean	StDev	SE Mean
CLAY_A	111	17.35	9.18	0.87
Mean_Cla	111	15.22	8.47	0.80

95% CI for mu CLAY_A - mu Mean_Cla: (-0.21, 4.46)
T-Test mu CLAY_A = mu Mean_Cla (vs >): T= 1.79 P=0.037 DF= 218

CEC_A

Mann-Whitney Confidence Interval and Test

CEC_A N = 111 Median = 8.700
Mean_CEC N = 111 Median = 9.878
Point estimate for ETA1-ETA2 is -0.922
95.0 Percent CI for ETA1-ETA2 is (-2.300,0.564)
W = 11781.5
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.1070
The test is significant at 0.1070 (adjusted for ties)

Cannot reject at alpha = 0.05

Two Sample T-Test and Confidence Interval

Two sample T for CEC_A vs Mean_CEC_A

	N	Mean	StDev	SE Mean
CEC_A	111	9.94	4.84	0.46
Mean_CEC	111	10.76	5.75	0.55

95% CI for mu CEC_A - mu Mean_CEC: (-2.23, 0.58)
T-Test mu CEC_A = mu Mean_CEC (vs <): T= -1.15 P=0.12 DF= 213

Permeability

Mann-Whitney Confidence Interval and Test

PERM N = 109 Median = 1.095
Mean_Per N = 111 Median = 1.388
Point estimate for ETA1-ETA2 is -0.048
95.0 Percent CI for ETA1-ETA2 is (-0.387,0.287)
W = 11875.0
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 12044.5

Two Sample T-Test and Confidence Interval

Two sample T for PERM vs Mean_Perm

	N	Mean	StDev	SE Mean
PERM	109	2.90	3.56	0.34
Mean_Per	111	2.30	2.25	0.21

95% CI for mu PERM - mu Mean_Per: (-0.19, 1.39)
T-Test mu PERM = mu Mean_Per (vs >): T= 1.49 P=0.069 DF= 181

Available Water Capacity

Mann-Whitney Confidence Interval and Test

AWC N = 111 Median = 0.15000
Mean_AWC N = 111 Median = 0.12950
Point estimate for ETA1-ETA2 is 0.01000
95.0 Percent CI for ETA1-ETA2 is (0.00001,0.02021)
W = 13273.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.0306
The test is significant at 0.0305 (adjusted for ties)

Two Sample T-Test and Confidence Interval

Two sample T for AWC vs Mean_AWC

	N	Mean	StDev	SE Mean
AWC	111	0.1378	0.0434	0.0041
Mean_AWC	111	0.1286	0.0353	0.0033

95% CI for mu AWC - mu Mean_AWC: (-0.0012, 0.0197)
T-Test mu AWC = mu Mean_AWC (vs >): T= 1.74 P=0.041 DF= 211

Cation Exchange Capacity

Mann-Whitney Confidence Interval and Test

CEC N = 111 Median = 11.550
Mean_CEC N = 111 Median = 12.026
Point estimate for ETA1-ETA2 is -0.661
95.0 Percent CI for ETA1-ETA2 is (-2.377,0.937)
W = 11947.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.3700
The test is significant at 0.3700 (adjusted for ties)

Cannot reject at alpha = 0.05

Two Sample T-Test and Confidence Interval

Two sample T for CEC vs Mean_CEC

	N	Mean	StDev	SE Mean
CEC	111	11.26	5.91	0.56
Mean_CEC	111	12.15	6.42	0.61

95% CI for mu CEC - mu Mean_CEC: (-2.52, 0.74)
T-Test mu CEC = mu Mean_CEC (vs not =): T= -1.07 P=0.28 DF= 218

PH

Mann-Whitney Confidence Interval and Test

PH N = 111 Median = 6.9400
Mean_PH N = 111 Median = 6.8944
Point estimate for ETA1-ETA2 is 0.0800
95.0 Percent CI for ETA1-ETA2 is (-0.0415,0.2121)
W = 12991.5
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.1991
The test is significant at 0.1990 (adjusted for ties)

Cannot reject at alpha = 0.05

Two Sample T-Test and Confidence Interval

Two sample T for PH vs Mean_PH

	N	Mean	StDev	SE Mean
PH	111	6.931	0.819	0.078
Mean_PH	111	6.840	0.797	0.076

95% CI for mu PH - mu Mean_PH: (-0.123, 0.304)
T-Test mu PH = mu Mean_PH (vs not =): T= 0.83 P=0.40 DF= 219

Slope

Mann-Whitney Confidence Interval and Test

SLOPE N = 111 Median = 2.000
Mean_Slo N = 111 Median = 1.841
Point estimate for ETA1-ETA2 is -0.087
95.0 Percent CI for ETA1-ETA2 is (-0.350,0.159)
W = 11935.5
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.3573
The test is significant at 0.3558 (adjusted for ties)

Cannot reject at alpha = 0.05

Two Sample T-Test and Confidence Interval

Two sample T for SLOPE vs Mean_Slope

	N	Mean	StDev	SE Mean
SLOPE	111	2.87	3.62	0.34
Mean_Slo	111	2.55	2.65	0.25

95% CI for mu SLOPE - mu Mean_Slo: (-0.52, 1.16)
T-Test mu SLOPE = mu Mean_Slo (vs not =): T= 0.75 P=0.45 DF= 201

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